User Manual

EN

MST-204
MachinerySwitchgear Tester

HVA-204
High-Voltage Adapter

SPEKTER

Made in Slovenia

MST-204

MachinerySwitchgear Tester

User Manual

2025 MI SPEKTER

Table of Contents MST-204 MachinerySwitchgear Tester:

1. SAFETY INFORMATION, WARNINGS

Measurements of electrical safety on machines, switchgears, welding machines, portable appliances, mains cords, PRCDs and other devices that can be tested by using the MST-204 Tester should only be carried out by properly trained and competent persons!
Carefully read this safety information before using the MST-204 Tester.

A **Warning** identifies conditions and procedures that are dangerous to the user.
A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.
A **Note** gives a general information on conditions and procedures.

Symbols used on the instrument or in this User Manual:

	**Warning of a potential danger, comply with the User Manual.**
	Reference, please pay utmost attention.
	**Earth (ground) terminal.**
	**Do not touch, hazardous voltage, risk of electric shock.**
	**Read the User Manual.**
	**Symbol for marking of electrical and electronic equipment (WEEE Directive).**
	**Conformity symbol, confirms compliance with the applicable European directives. The requirements of the EMC Directive and the Low Voltage Directive with the relevant regulations Standards are also fulfilled.**

⚠ WARNINGS

☞ **This User Manual contains information and references necessary for safe operation and maintenance of the instrument. Prior to using the instrument, the user is kindly requested to thoroughly read the User Manual and comply with it in all sections.**

☞ **If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.**

☞ **Failure to read this User Manual or to comply with the warnings and references contained herein can result in serious bodily injury or instrument damage.**

2. INTRODUCTION

You have acquired a high-quality measurement instrument manufactured by MI SPEKTER, which will enable you to perform repeatable measurements for a very long period of time.

The MST-204 Tester is a measurement instrument for testing the effectiveness of protective measures of machines, low-voltage switchgear and controlgear assemblies, welding equipment, electrical appliances, mains cords, PRCDs etc. and for documentation of test results.

Available Measurements and Features:

- Visual Inspection:
  - Independent function for documentation
- Protective Bonding Resistance RPE:
  - Test current 0.2 A, 10 A and 25 AAC
  - Safety test voltage (SELV)
  - 2-wire and 4-wire measurements
  - Automatic start function allows both-hands measurements on measured objects that are difficult to access
  - Independent compensation of test leads or Commander
  - Available calculation of limit value for RPE measurements
- Prospective Earth Fault Current IPEFC / Prospective Short-circuit Current IPSC and Loop, Line impedance ZL/PE, ZL/L, ZL/N:
  - Input voltage 100 … 440 VAC
  - Standard accuracy (STD, loading resistance 10 Ω) and high accuracy (HIGH, loading resistance 3.3 Ω)
  - Available calculation of limit value for line/loop measurements
  - Automatic start function allows both-hands measurements on measured objects that are difficult to access
  - Independent compensation of test leads or Commander
- Prospective Earth Fault Current IPEFC and Loop Resistance RL/PE without tripping RCD (RCD NO TRIP):
  - Input voltage 100 … 253 VAC
  - Test current 7 mA
- Prospective Earth Fault Current IPEFC / Prospective Short-circuit Current IPSC and Loop, Line Resistance RL/PE, RL/N without tripping Motor Protection Circuit Breaker (MPCB NO TRIP):
  - Input voltage 100 … 253 VAC
  - Test current 100 or 500 mA
- SECundary AC/DC Prospective Short-circuit Current IPSC and Loop Resistance Z:
  - Input voltage 10 … 100 VDC/50/60 Hz
  - Test current adjustable 0.1 … 3.0 A
- Voltage Drop UDELTA:
  - Input voltage 100 … 440 VAC
  - Standard accuracy (STD, loading resistance 10 Ω) and high accuracy (HIGH, loading resistance 3.3 Ω)

- RCD:
  - A, A Ⓢ, A-EV, B/B+, B/B+ Ⓢ, B/B+-MI, F, F-EV, A-K/A-G, AC, AC Ⓢ, AC-K/AC-G types
  - $I_{\Delta N}$ selectable 10 … 1000 mA
  - Input voltage 100 … 253 VAC
  - Fault voltage U_F
  - Trip out time at 0.5×$I_{\Delta N}$, $I_{\Delta N}$, 5×$I_{\Delta N}$
  - Tripping current (RAMP) including trip out time at tripping current
  - AUTO (sequence: 0.5×$I_{\Delta N}$, $I_{\Delta N}$, 5×$I_{\Delta N}$)
- IMD test on IT systems:
  - R_F selectable 5 … 750 kΩ
  - LIMR_F adjustable 5 … 750 kΩ
  - LIMt adjustable 1.0 … 10.0 s
  - AUTO and MAN mode
- RCM test:
  - A and B type
  - Test current 10, 30, 100, 300 and 500 mA
  - Test current multiplier × 0.5 and × 1
- Insulation Resistance R_{INS}:
  - Test voltage adjustable 50 … 1000 VDC
  - Ramp mode (for testing overvoltage protections)
- High-voltage (HV) dielectric test (in combination with HVA-204 Adapter):
  - Test voltage adjustable 250 … 5100 VAC
  - Trip out current adjustable 1 … 100 mA
  - Real and apparent current selectable
  - Two standards (MACHINES and Low-voltage SWITCHGEARS)
  - Three basic measurements (NO RAMP, RAMP ⊓ (RAMP UP) and RAMP ⌒ (RAMP UP/DOWN)
  - Four modes (TRIP OUT, TRIP × mA, BURN and ⩘ TRIP)
- Residual voltage U_{RES}:
  - Input voltage range 0 … 440 VAC / 625 VPEAK
  - Two-wire method
  - Measurement of residual voltage and residual time on plug and inside the machine
  - STANDARD, LINEAR and NON LINEAR mode
- Residual time T_{RES}:
  - U_{STOP} 60 VDC or USER adjustable 25 … 60 VDC
  - LIMt 1 or 5 s or USER adjustable 1 … 300 s
- Load Current I_{LOAD}:
  - Measurement with clamp up to 50 AAC (CL-204-50A AC leakage clamp adapter)
  - Measurement with clamp up to 1000 AAC (CL-204-1000A AC load clamp adapter)
- Leakage Current I_{LEAK}:
  - Measurement with clamp up to 1000 mAAC (CL-204-50A AC leakage clamp adapter)
- Touch Current I_T by using direct method:
  - Probe resistance 1kΩ
- Mains voltage U_{MAINS}:
  - 2-wire measurement (phase-neutral voltage 0 ... 280 VAC) plus THD up to 40th harmonic
  - 3-wire measurement (phase-phase voltages 0 … 490 VAC) plus THD up to 40th harmonic
  - 4-wire measurement (phase-neutral voltages 0 … 280 VAC) plus THD up to 40th harmonic

- Power:
  - 2-wire for single-phase loads, 3-wire and 4-wire measurements for three-phase loads
  - Apparent power S in VA
  - Active power P in W
  - Reactive power Q in var
  - Power factor PF
  - Cos φ
- Phase rotation:
  - 3-wire measurement (phase-phase voltages 25 ... 440 VAC)
  - 4-wire measurement (phase-neutral voltages 15 ... 253 VAC)
  - Negative Sequence Voltage UNSC, Zero Sequence Voltage UZSC
- Protective Extra Low Voltage RMS (PELV):
  - Measuring range up to 440 VAC/DC
- Safety Extra Low Voltage RMS (SELV):
  - Measuring range up to 440 VAC/DC
- Control Voltage RMS (UCONTROL):
  - Measuring range up to 440 VAC/DC
- DC Supply Voltage (DCSUPPLY):
  - Measuring range up to 440 VDC
  - BATTERY, CAR BATTERY and DRIVE MODULE modes
- Documentation and functional tests:
  - Independent function for documentation
- Complete safety testing of Machines according to EN 60204-1 standard.
- Complete testing of Low-voltage switchgear and controlgear assemblies according to EN 61439-1 standard.
- Complete testing of ARC welding devices according to EN 609474-4 standard:
  - In combination with Three-Phase Adapter TPA-204-63A* or TPA-204-32A*
- Complete testing of three phase and single phase supplied portable appliances (PAT) arcoding to EN 50678/DIN VDE 0701 and EN 50699/DIN VDE 0702 standard:
  - In combination with Three-Phase Adapter TPA-204-63A* or TPA-204-32A*
- Complete testing of PRCDs according producer's instructions and in reference to EN 50678/DIN VDE 0701 and EN 50699/DIN VDE 0702 standard:
  - In combination with Three-Phase Adapter TPA-204-63A* or TPA-204-32A*
- Complete testing of mains cords and mains cord extensions according to EN 50678/DIN VDE 0701 and EN 50699/DIN VDE 0702 standard:
  - In combination with Three-Phase Adapter TPA-204-63A* or TPA-204-32A*
- Complete testing of Electric Vehicle charging cables:
  - In combination with Three-Phase Adapter TPA-204-63A* or TPA-204-32A*
- AUTO-TEST mode / automatic test sequence:
  - Customer-created TEST PLAN for machine and low-voltage switchgear testing
  - Factory-programmed and customer-created AUTO-TESTS for PAT testing (including PRCDs, mains cord and charging cables)
- Fully compatible with "SW-MST-204" PC software:
  - To create test reports
- Extremely easy operation by using rotary switches, touch screen or classic buttons and "START/STOP" button.

- Graphic 4.3-inch, 480 × 272 pixels, full colour TFT LCD with resistive touch screen for presentation of measurement values, limit values and test parameters.
- Huge internal memory, see the capacity in technical specifications on page 185. Tree memory structure, 4 levels.
- Integrated interface (USB 2.0) for transfer of measurement results to PC.
- Additional four interfaces (USB 2.0) for connection of optional USB barcode scanner, USB keyboard and USB memory stick, all working in parallel.
- Compact plastic housing with removable case cover.
- Separate soft accessory bag for test leads and other accessories.
- Connection diagrams under the case cover.
- HELP menu (connection, measuring/display ranges, compensation of test leads if actual) available in each measurement.
- Limit values adjustable through measuring range in all functions.
- Visual and acoustic warnings in case of exceeded limit value.
- Adjustable acoustic signal intensity.
- Real time clock for documentation of test results.
- Timer-limited and continuous measurements.
- Adjustable measurement times in timer-limited measurements.
- Commander with START/STOP, SAVE and ENTER keys for very handy operations.
- Two selectable display languages (English and German).
- Two external keyboards supported (English and German).
- Possible assembly into 19-inch Rack Panel, 19-inch rack mount accessory available.

* In development

3. SCOPE OF SUPPLY

1 pc MST-204 MachinerySwitchgear Tester, basic instrument
1 pc IEC - Schuko mains cord, 1.8 m
1 pc IEC - CH mains cord, 2.0 m
1 pc IEC - GB mains cord, 1.8 m
1 pc IEC - IT mains cord, 1.8 m
1 pc CM-204, Commander with START/STOP, ENTER and SAVE functions, 5 m (MST-204 PLUS version only)
1 pc Test lead, both side 4 mm banana, 2.5 mm^2, yellow, 2 m
1 pc Test lead, both side 4 mm banana, 2.5 mm^2, black, 2 m
1 pc Test lead, both side 4 mm banana, 0.75 mm^2, blue, 2 m
1 pc Test lead, both side 4 mm banana, 0.75 mm^2, red, 2 m
3 pcs Test tip 600 V CAT IV, 36 A
4 pcs Crocodile clip 600 V CAT IV, 36 A
1 pc Soft accessory bag
1 pc USB cable
1 pc User Manual booklet in English

4. AVAILABLE OPTIONAL ACCESSORIES

1 pc CM-204
Commander with START/STOP, ENTER and SAVE functions, 5 m
1 pc CC-204-50A
Current Clamp up to 50 AAC, for leakage/load current measurements, cable equipped with three-pin round connector, current ratio 1000:1
1 pc CC-204-1000A
Current Clamp up to 1000 AAC for load current measurements, cable equipped with three-pin round connector, current ratio 1000:1
1 pc TC-204-D
Test Cable with Schuko plug on one side and 3× 4-mm banana on the other side, for measurements on Schuko mains sockets, 2 m
1 pc TC-204-CH
Test Cable with Swiss SEV 1011 plug on one side and 3× 4-mm banana on the other side, for measurements on Swiss SEV 1011 mains sockets, 2 m
1 pc TC-204-I
Test Cable with Italian type L plug on one side and 3× 4-mm banana on the other side, for measurements on Italian mains sockets, 2 m
1 pc TC-204-UK
Test Cable with UK plug on one side and 3× 4-mm banana on the other side, for measurements on UK mains sockets, 2 m
1 pc ZA-204-D
Zero Adapter with Schuko test socket, for compensation of test leads and TC-204-D
1 pc ZA-204-CH
Zero Adapter with Swiss test socket, for compensation of test leads and TC-204-CH
1 pc ZA-204-I
Zero Adapter with Italian test socket, for compensation of test leads and TC-204-I

1 pc ZA-204-UK
Zero Adapter with UK test socket, for compensation of test leads and TC-204-UK

1 pc TLS-204-MST
Test Lead Set for MST-204 Tester, containing:
- 1× test lead, both side 4 mm banana, 2.5 mm2, yellow, 2 m
- 1× test lead, both side 4 mm banana, 2.5 mm2, black, 2 m
- 1× test lead, both side 4 mm banana, 0.75 mm2, red, 2 m
- 1× test lead, both side 4 mm banana, 0.75 mm2, blue, 2 m
- 3× test tip 600 V CAT IV, 36 A
- 4× crocodile clip 600 V CAT IV, 36 A

1 pc EXC-204
Extension Cord, 10 m, for Commander

1 pc BCS-204
BarCode Scanner 1250G

1 pc KB-204-D
KeyBoard German

1 pc KB-204-UK
KeyBoard English

1 pc HVA-204 High-Voltage Adapter
High-Voltage Adapter

1 pc TPA-204-63A* Three-Phase Adapter
Three-phase adapter for test objects up to 63 A

1 pc TPA-204-32A* Three-Phase Adapter
Three-phase adapter for test objects up to 32 A

1 pc RACK-204
19-inch Rack Panel for installation of the MST-204 Tester to 19-inch rack

* In development

5. TRANSPORT AND STORAGE

Please keep the original packaging for potential later transport, e.g. for calibration. Any transport damage due to faulty packaging will be excluded from warranty claims.

The instrument must be stored in a dry and closed area. In case of an instrument being transported in extreme temperatures, a recovery time of minimum 2 hours is required prior to instrument operation.

6. SAFETY MEASURES

The MST-204 Tester has been produced and tested in compliance with valid safety regulations and left the factory in safe and perfect condition. In order to maintain this condition and to ensure safe instrument operation, the user must pay attention to the references and warnings contained within this User Manual.

⚠⚠ WARNING, DANGER OF ELECTRIC SHOCK

- ☞ **In order to avoid electric shock, the valid safety and national regulations regarding excessive contact voltages must receive utmost attention when working with voltages exceeding 120 VDC or 50 VAC RMS.**
- ☞ **The respective accident prevention regulations established by national health & safety board for electrical systems and equipment must be strictly met at all times.**
- ☞ **Prior to any operation ensure that the instrument, test leads, mains cable and accessories are in perfect condition.**
- ☞ **The instrument may only be connected to mains voltage as indicated in the technical specification section.**
- ☞ **The instrument must obligatory be connected to and supplied by properly wired mains socket (PE connector must be earthed) prior to connecting any test lead to any test socket! This is to assure the instrument to be grounded before any further use, otherwise the circumstances may be hazardous!**
- ☞ **The instrument may only be used within operating ranges as specified in the technical specification section.**
- ☞ **Only touch test leads and test probes or Commander at hand-held area behind the protective fingerguard. Never directly touch test probes. Direct contact to measurement connectors or test probes must be avoided at any time.**
- ☞ **The instrument may only be used in dry and clean environments. Dirt and humidity reduce insulation resistance and may lead to electric shocks, in particular for high voltages.**
- ☞ **Never use the instrument in precipitation such as dew or rain. In case of condensation due to temperature jumps, the instrument may not be used.**
- ☞ **A perfect display of measurement values may only be ensured within the temperature range from 0 °C to +40 °C.**
- ☞ **Prior to opening the instrument ensure that it is switched off and disconnected from all live circuits.**
- ☞ **To ensure a safe measurement only use original test leads and accessories.**

- ☞ **If the operator's safety is no longer guaranteed, the instrument is to be put out of service and protected against use. The safety can no longer be guaranteed if the instrument (or accessories):**
  – shows obvious damage
  – does not carry out the desired measurements
  – has been stored for too long under unfavourable conditions
  – has been subjected to mechanical stress during transport
- ☞ **Dangerous voltages may be present on the unit under test (UUT) caused by defective insulation. Do not touch the UUT, danger of electrical shock!**
- ☞ **Start any test series by visual inspection and protective bonding resistance measurement.**
- ☞ **For protective bonding resistance and insulation resistance measurements the unit under test (UUT) must be voltage-free (mains supply). If necessary, check the UUT if it is voltage-free i.e. by using a two-pole tester acc. to IEC/EN 61243-3.**
- ☞ **Accidental measurement of a defective UUT may trip an RCD (Residual Current Device) of mains supply.**
- ☞ **During the earth leakage current test, touch leakage current test and function (load) test, the UUT will be energized by mains voltage. UUT driven by motors or equipped with heating elements may present a danger for the person testing or others (Comply with the User Manual of the UUT!). Please ensure that the UUT is in a safe condition to run prior to testing it.**

7. APPROPRIATE USAGE

⚠⚠ WARNINGS

- ☞ **The instrument may only be used under conditions and for the purposes for which it was designed. For this reason, and particular the safety references, the technical data including environmental conditions and the usage in dry environments must be followed.**
- ☞ **When modifying the instrument, the operational safety is no longer ensured.**
- ☞ **The instrument may only be opened by an authorised service technician. Before opening the instrument, it must be switched off and disconnected from any live circuit.**

8. DESCRIPTION OF WARNING MARKS ON FRONT PANEL

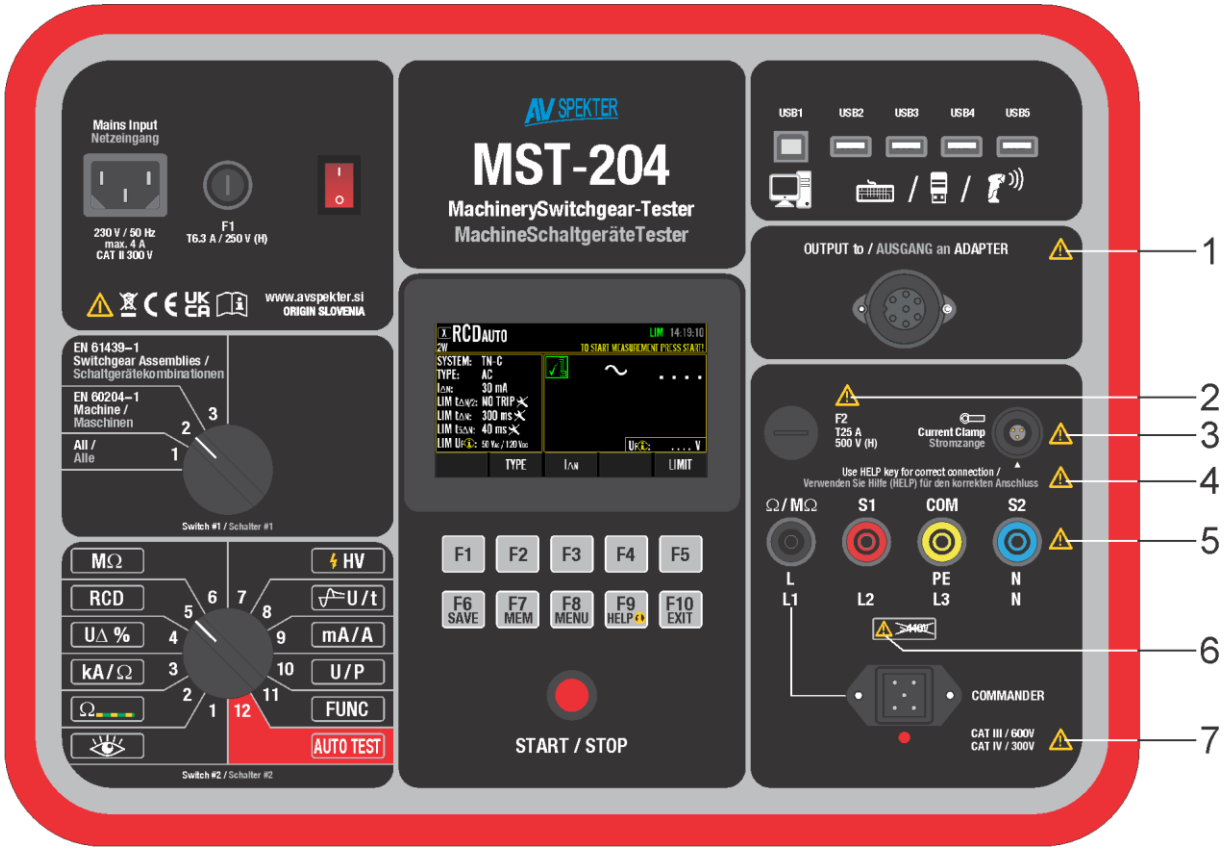


Figure 1: Explanation of warning marks and measurement category (CAT) rating of input/ output terminals

1:

Use this socket to connect HVA-204 High-Voltage Adapter or TPA-204-63A* Three-Phase Adapter or TPA-204-32A* Three-Phase Adapter only.

2:

Disconnect mains cord, Commander and all test leads from test sockets L1, L2, L3 and N prior to removing the fuse F2 cover – danger of electric shock.

3:

Use this test socket for CLAMP connection only! Use the clamp listed in chapter “AVAILABLE OPTIONAL ACCESSORIES” on page 15 only!
Input: Max. 1000 mA / max. 0.2 V!

Caution!

☞ **One terminal is earthed!**

4:

Check correct wiring for each measurement on the connection diagrams under the case cover, inside this User Manual or use “HELP“ function key (F9)!

5:

Use these four test sockets for test purposes only according to instructions presented in this User Manual. Any unforeseen connection may lead to hazardous situation for the operator, for the test instrument or for the UUT.

6:

Do not connect external voltage higher than 440 V_{RMS} between any combination of test sockets!

7:

Respect rated category (CAT III 600 V resp. CAT IV 300 V) at all times! Do not connect external voltage higher than 600 V between any test socket including COMMANDER and earth ⏚!

* In development

9. OPERATIONAL ELEMENTS AND CONNECTORS

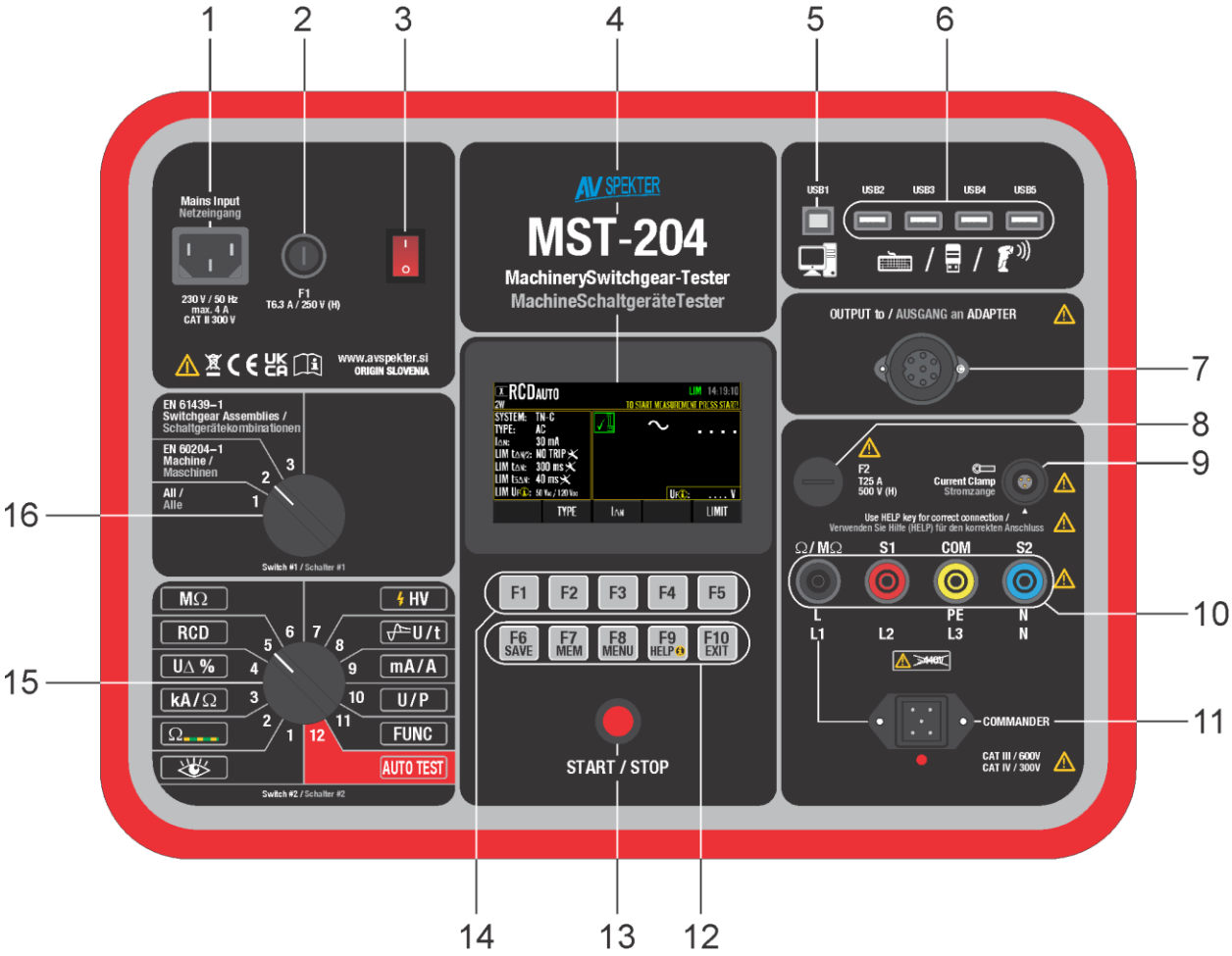


Figure 2: Operational elements and connectors on MST-204 Tester

1 ..... Mains input - IEC socket
2 ..... Mains input fuse F1 T6.3 A (H) / 250 V, 5 × 20 mm
3 ..... ON/OFF mains switch with red pilot lamp
4 ..... Graphic colour LCD with resistive touch screen
5 ..... USB1 interface for connection to PC
6 ..... USB2, USB3, USB4 and USB5 interface for USB barcode scanner, USB keyboard or USB memory stick
7 ..... OUTPUT connector for connection of HVA-204 High-Voltage Adapter or TPA-204-63A* Three-Phase Adapter or TPA-204-32A* Three-Phase Adapter
8 ..... RPE fuse F2 T25 A (H) / 500 V, 6.3 × 32 mm
9 ..... Three-pin CLAMP connector for leakage and load current
10 ..... Test sockets:
- Ω/MΩ / L / L1 - black
- S1 / - / L2 - red
- COM / PE / L3 - yellow
- S2 / N / N - blue
11 ..... COMMANDER connector (equivalent to Ω/MΩ / L / L1 test socket)

12 ..... Function keys “F6” ... “F10” (“SAVE” to save test result, “MEM” to operate with memory for example to recall saved test results, “MENU” to use menu functions, “HELP“ to check correct wiring, measuring/display ranges, compensation if actual etc., “EXIT“ to exit actaul menu level)
13 ..... “START/STOP“ button to start or stop selected measurement
14 ..... Menu keys “F1” ... “F5”, see the meaning of each menu key on touch screen above the menu keys
15 ..... Rotary switch #2 to select measurement function
16 ..... Rotary switch #1 to select the relevant STANDARD (= UUT family). It is important to be avare that actual parameters (test voltage, test current, limit value etc.) of individual measurement (RPE, RINS, LOOP, RCD etc.) are independent in each STANDARD.

* In development

10. GENERAL EXPLANATION OF THE DISPLAY

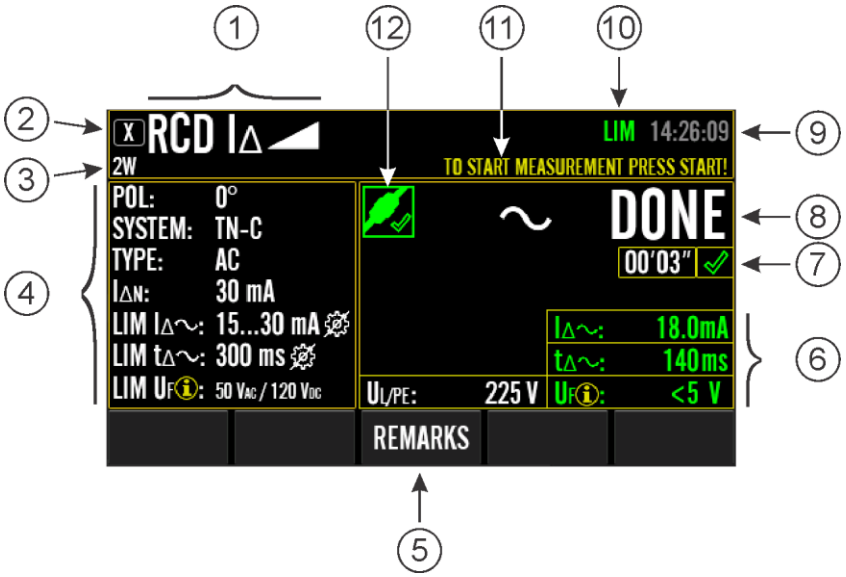


Figure 3: Display (after finishing the RCD IΔ◢ measurement) (example)

1 ..... Currently selected measurement.
2 ..... Step number in “TEST PLANS” or in “MEMORIES” (no meaning in single measurements).
3 ..... Additional explanation of selected measurement (2-wire connection).
4 ..... Test parameters of selected measurement (some parameters can be selected/adjusted directly through measurement screen keys - see the explanation later for each function individually, some can not be selected/adjusted at all - see the ⚙ symbol, some can be selected/adjusted directly or indirectly in ENVIRONMENT TABLE - see the MENU / ENVIRON. menu).
5 ..... “REMARKS” menu key, to enter remarks for displayed result.
6 ..... Sub-results - see the explanation later for each function individually.
7 ..... Measurement duration and overal judgement of test result.
8 ..... Main result - see the explanation later for each function individually.
9 ..... Real time.
10 ..... Actual limit status (ON or OFF). The limit status can be selected in MENU / LIMIT ON/OFF menu, displayed symbol LIM means limit is ON, displayed symbol ~~LIM~~ means limit is OFF). The status is valid for all measurements in general.
11 ..... Information how to start the measurement.
12 ..... Measurement condition status. Green icon = conditions for the measurement are met, red icon = conditions for the measurement are not met.

Note!

- All displayed parameters can be selected either via touch sceen or via menu keys (available double operations)!

Table of displayed symbols and their meanings

Symbol	Explanation
	Parameter marked with this symbol is fixed (not adjustable at all) or it is indirectly adjustable through some other parameters in ENVIRONMENT TABLE, for example through mains SYSTEM and UNOM PHASE TO EARTH (L/PE).
	Input voltage (in some cases two input voltages) are within required range, for example UL/N and UL/PE are within 100 … 153 V, UL/L is within 170 … 440 V, see required input condition(s) later in each measurement individually. Input condition is fullfilled, measurement can be carried out.
	Input voltage (in some cases two input voltages) are out of required range. Input condition is not fullfilled, measurement cannot be carried out.
	Rotating symbol means the measurement is running.
	Internal resistors or transistors are overheated, measurements cannot be continued. Please wait until the tester cools down and the symbol disappears.
	There is an additional information available to describe basic parameter/result. Please check the meaning in individual measurement in HELP menu (press F9).
LIM	Limit values are enabled in MENU / LIMIT ON/OFF menu (selected LIMIT ON). It means test results will be judged on bases of given limit values. The message is valid for all measurements in general.
~~LIM~~	Limit values are disabled in MENU / LIMIT ON/OFF menu (selected LIMIT OFF). It means test results will not be judged at all. The message is valid for all measurements in general.
HVA	HVA-204 Adapter is connected to MST-204 and it is active (Switch #2 is in HV position).
~~HVA~~	HVA-204 Adapter is connected to MST-204 but it is not active (Switch #2 is out of HV position).
	HVA-204 Adapter is connected to MST-204: HVA-204 Adapter is locked (protected against unwished use).
	HVA-204 Adapter is connected to MST-204: HVA-204 Adapter is unlocked (ready to use).
	HVA-204 Adapter is connected to MST-204: Green lamp is ON (the symbol is present in parallell with green warning lamp).
	HVA-204 Adapter is connected to MST-204: Red lamp is ON (the symbol is present in parallell with red warning lamp).
	Commander is connected to MST-204 and it is active.
	Commander is connected to MST-204, but it is not active.

Table 1: Displayed symbols and their meanings

11. CONNECTION DIAGRAMS AND QUICK INSTRUCTION CARD

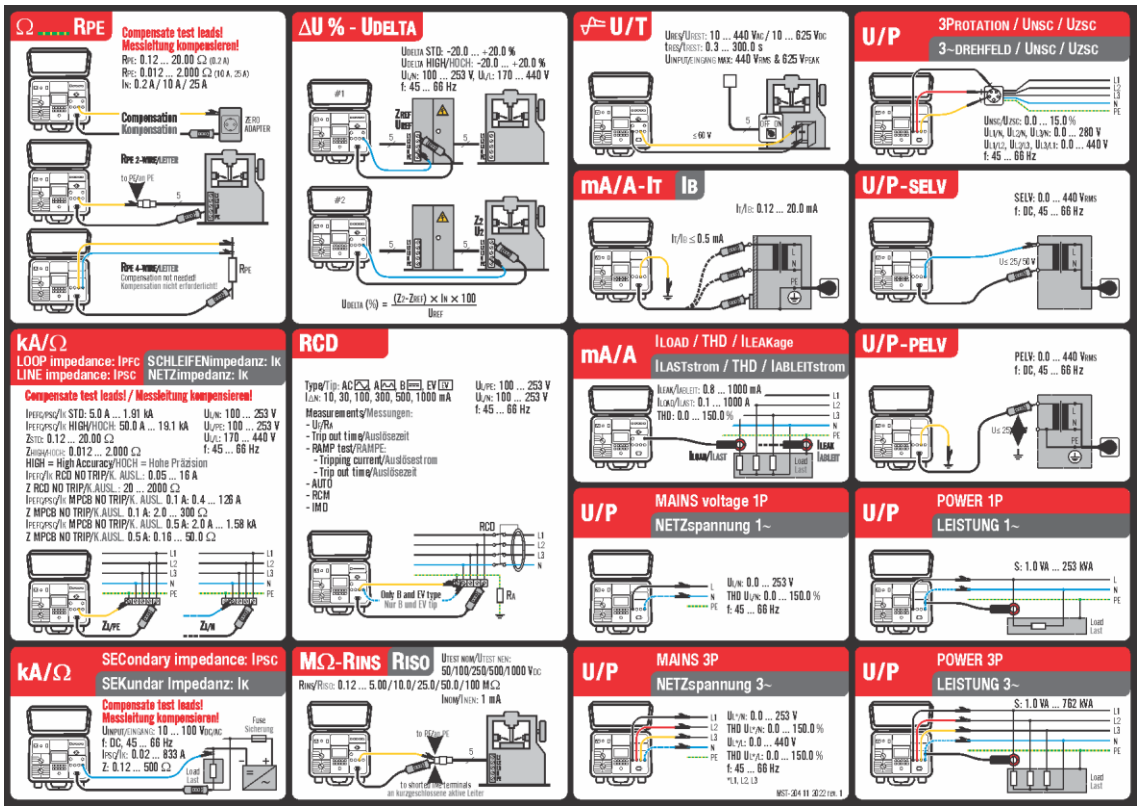
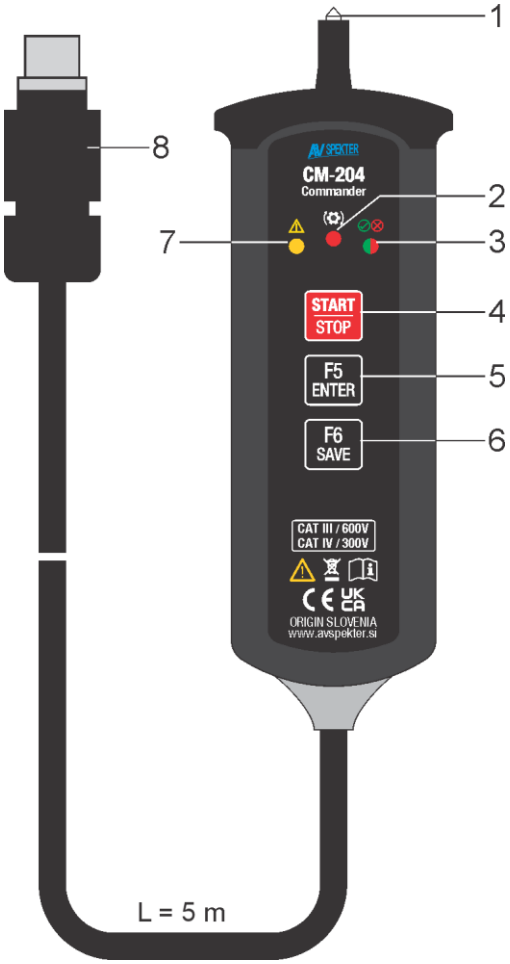


Figure 4: Brief connection diagrams (under plastic case cover)

12. DESCRIPTION OF THE COMMANDER

(Included in MST-204 PLUS version only)

Commander CM-204 is intended to be used in combination with MST-204 Tester only for very handy testing. The Commander is advised to be used when measuring the following parameters: RPE-2WIRE, RPE-4WIRE, ZLOOP/IPFEC, ZLINE/IPSC, SEC/IPSC, UDELTA, RINS, URES/TRES, ITOUCH, PELV, SELV, UCONTROL, UDC SUPPLY, see detailed instructions inside this User Manual for each function individually.



Legend:

1 … 4 mm metal test tip.
2 … Red RUN indicator. It lights when any test is running.
3 … Dual colour, green or red PASS/FAIL indicator. It lights after finishing the measurement (single measurements) and also during the measurement (continuous measurements).
4 … "START/STOP" key to start/stop actual test.
5 … ENTER/F5 button to confirm selected option.
6 … SAVE/F6 button to save test results.
7 … Yellow warning indicator. It lights when some warning is displayed at the MST-204 tester.
8 … 5-pole push-pull connector for connection to MST-204 Tester only.

Figure 5: Commander CM-204

How to use the Commander:

Connect the Commander to "COMMANDER" connector (11) on front panel. Tester will automatically recognize the connection and will internally disconnect the test lead potentially connected to Ω/MΩ / L / L1 test socket. As soon as the Commander will be disconnected, Ω/MΩ / L / L1 test socket will be active (internally connected) again.

How to use the Commander Extension:

Use the Commander Extension (10 m) when the UUT is huge and the Commander itself is too short (5 m). Connect one side of the Commander Extension to the Commander and the other side to "COMMANDER" connector (11) on front panel of MST-204.

Note!

- When adding a Commander Extension in series with the Commander, test lead compensation must be redone (tester will not automatically differentiate between the two options).

13. PREPARATION OF THE MST-204 TESTER

Connection and turning on the MST-204 Tester:

1) Connect the MST-204 Tester to a properly installed schuko mains socket (PE terminal must be properly grounded, otherwise warning HAZARD ERROR – PE DISCONNECTED! TURN OFF THE INSTRUMENT AND DISCONNECT ALL TEST LEADS NOW message will be displayed after switching ON the tester and it will be blocked for any measurement).
2) Use mains "ON/OFF" switch (3) to turn ON the MST-204 Tester.
3) After turning ON the MST-204 Tester, pilot lamp of the power switch (3) will be ON and the display (4) will show booting screen.
   Wait approx. 15 seconds booting to be completed. Then start screen with basic data according to the figure below will be displayed.

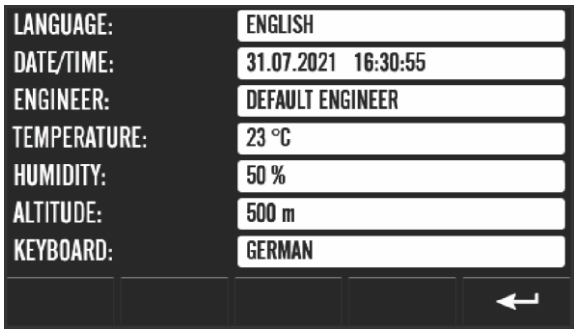


Figure 6: Start screen with basic data, example

The following data is displayed:

LANGUAGE ..... Selected display language (German or English).
DATE/TIME ..... Real date and time running.
ENGINEER ..... Selected engineer (user of the tester), used for record while saving test results.
TEMPERATURE .... Ambient temperature (-10 … 50°C, dislayed value is entered manually), used for record while saving test results.
HUMIDITY ..... Ambient humidity (0 … 100%, displayed value is entered manually), used for record while saving test results.
ALTITUDE ..... Altitude where the measurements will be carried out (0 … 2000 m, displayed value is entered manually), used for record while saving test results.
KEYBOARD ..... Selected keyboard (German or English).

Above data cannot be changed here but they can be edited in MENU/SETUP menu.

4) Check displayed basic data, then press "↵" menu key, display will turn to idle screen of selected function. The MST-204 Tester is now ready to be used for measurements.

14. TEST LEADS COMPENSATION

The MST-204 Tester leaves the factory with uncompensated test leads (in RPE, LOOP, LINE, SEC and UDELTA functions). We recommend the operator to compensate test leads before starting any of above mentioned measurements, otherwise test results may not be correct. There are four independent compensation values available.

- In 2-wire RPE measurement:
  - Compensation of a test lead connected to COM (yellow) test terminal and Commander (or Commander with Extension).
  - Compensation of a test lead connected to COM (yellow) and Ω/MΩ (black) test terminals.
- In LOOP, LINE, SEC and UDELTA measurement:
  - Compensation of a test lead connected to COM (yellow) test terminal and Commander (or Commander with Extension).
  - Compensation of a test lead connected to COM (yellow) and Ω/MΩ (black) test terminals.

Notes!

- Connected test accessories (two test leads or one test lead in combination with Commander) are detected automatically and corresponding compensation value is used. Differentiation of Commander or Commander with Extension is not done automatically, the operator must take care to compensate exactly the combination that will later be used in measurements!
- Use HELP menu (F9) to check how to connect test leads for compensation purpose.
- Note COMPENSATION FAILED! VALUE TOO HIGH will be displayed after pressing “START“ button in compensation procedure if total value to be compensated is higher than 1 Ω. Previous compensation value (if any) will still be used in this case.

How to carry out the compensation in RPE measurements (2-wire only):

1) Set the measurement function selector (15) to RPE position (2).
2) Select 2-wire connection by pressing “MEAS“ menu key first (4-wire connection does not need a compensation) and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected RPE 2W function will appear.
3) Short-circuit two test leads or one test lead in combination with Commander. This can easily be done by using optional ZERO ADAPTER, see the figure below for possible connections.

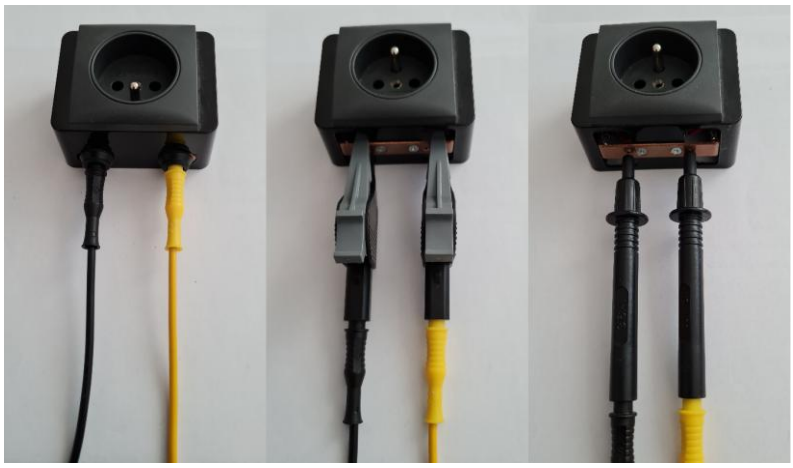


Figure 7: Connection of two test leads with banana (left figure), with test crocodile clip (middle figure) or with test tip (right figure) to Zero Adapter ZA-204-SC.

4) Press “COMPRPE” menu key, actual compensation info will be displayed, see the figure below.

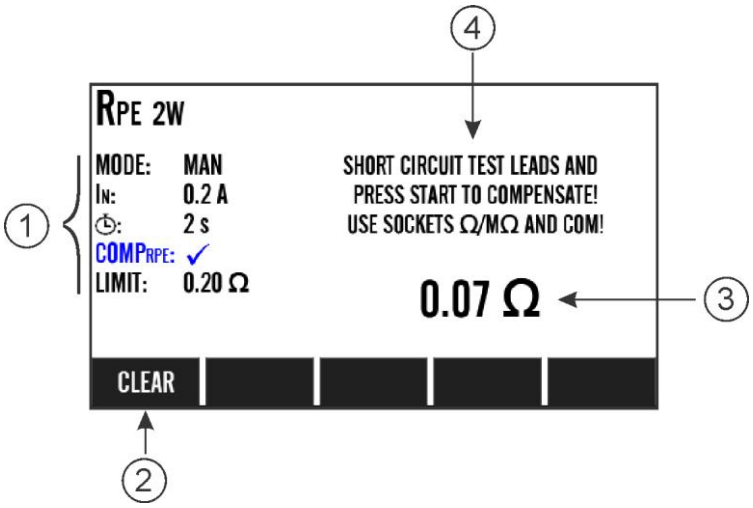


Figure 8: Actual compensation info screen, example

1..... List of RPE settable parameters (blue parameter is currently in process).
2..... “CLEAR” menu key to clear currently compensated value.
3..... Currently compensated value (resistance of test leads that was last compensated). If no compensation was done, no value will be displayed and blue parameter COMPRPE will be marked with cross “X”.
4 ..... Instruction how to proceed.

4) Press “START” button, then wait for a few seconds the compensation to be carried out ⇒ actual compensated value will be displayed for a while. Then a regular measurement will follow in order to check the compensation was properly done ⇒ result in form “Δ: 0.00 Ω“ (IN = 0.2 A) or “Δ: 0.000 Ω” (IN = 10 A or 25 A) will be displayed for a while. Then basic RPE measurement screen will be displayed again. Properly done compensation will be shown as a hook in COMPRPE parameter line on the left side of the display. The instrument is now ready for measurements by using just compensated test leads.

Notes!

- Above compensation will be used in all further 2-wire RPE measurements where the same test leads (two test leads or one test lead in combination with Commander) will be used. The compensation will be retained even when the power is turned OFF.
- Whenever test lead, test probe, crocodile clip or Comamnder is changed, the compensation has to be redone. Wrong compensation will directly influence the test result and may give wrong judgement of the result.
- Compensation is always carried out by using test current of 10 A while following regular measurement is carried out by currently selected nominal current. This might be the reason result of repeating measurement will not be exactly “Δ: 0.00 Ω“ or “Δ: 0.000 Ω” and there might be a small difference of a few digits.

How to carry out the compensation in LOOP, LINE, SEC or UDELTA measurements:

Follow the same procedure as described in chapter “How to carry out the compensation in RPE measurements (2-wire only)” above, but select any other function except RPE, for example LOOP, LINE, SEC or UDELTA. Take care to use the same test leads as they will be used later for regular measurements. These test leads may be different than used in RPE measurements for example test cord with mains plug on one end and three 4 mm bananas on the other end. Please see the figure below how to connect such cable to ZERO ADAPTER.

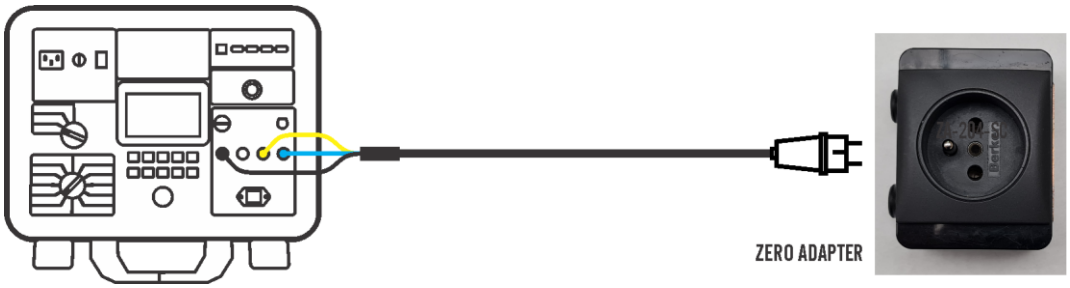


Figure 9: Connection of test cord with mains Schuko plug on one end and three 4 mm bananas on the other end to Zero Adapter ZA-204-SC (schuko)

Attention:
Please consider that compensation is done always via Ω/MΩ socket (or Commander) towards COM socket. But LINE, SEC or UDELTA measurements are always executed against N socket. So either ensure that the test leads for PE and N are exactly of the same type with the same length and square size or redo the compensation always when you switch between LOOP and LINE/SEC/UDELTA measurements and vice versa using actual test leads.

For compensation in function LINE/SEC/UDELTA connect the N test lead to COM socket and place it back to N later to run regular measurements.

Specific information that may be displayed during compensation procedure:

Information displayed	Description
COMPENSATION FAILED! VALUE TOO HIGH!	Compensation was not successfully done due to too high compensation value (>1.00 Ω)! Existing compensation value (if any) will stay actual in this case.

15. LIMIT VALUE

Limit value is offered in any function except in Visual Inspection and Documentation and Functional tests. If set limit value is exceeded during regular measurements, measurement result will be judged as FAIL.

How to set the limit value:

1) Press "LIMIT" menu key in currently selected function ⇒ display will turn to ACTIVE LIMIT INFO screen, see the two examples below.

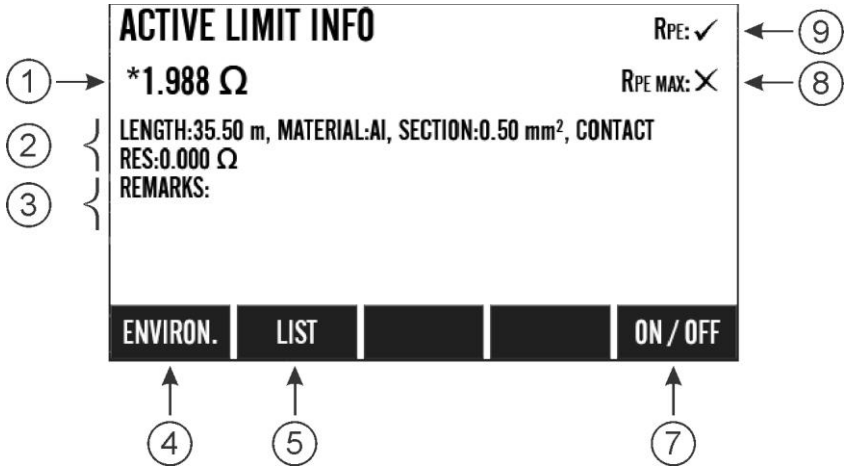


Figure 10: ACTIVE LIMIT INFO screen (RPE function), example

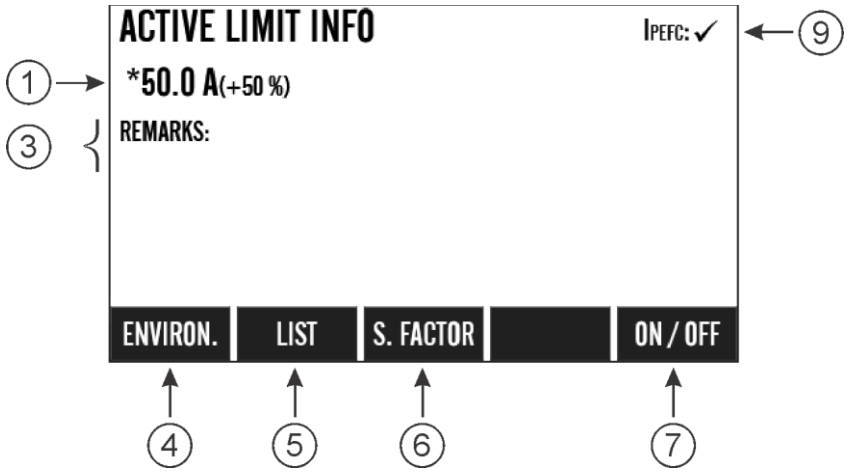


Figure 11: ACTIVE LIMIT INFO screen (LOOP IPEFC (L/PE) function), example

1 ..... Actual limit value (* symbol means the limit was customer-created i.e. not standard, +50 % on the figure above means entered safety factor is +50 %).

2..... Parameters used for calculation of actual limit value (only if actual limit value was calculated on bases of entered LENGTH, MATERIAL, SECTION and CONTACT RESISTANCE).

3..... Related REMARKS to actual compensation, if any.

4 ..... "ENVIRON." (ENVIRONMENT) menu key to get into ENVIRONMENT TABLE (in some functions actual limit value can be taken directly from the ENVIRONMENT TABLE (for example UF in RCD function) or can influence the limit value indirectly (for example UNOM in UDELTA function).

5 ..... "LIST" menu key to get into SELECT LIMIT screen, see the explanation below.

6 ..... “S. FACTOR” menu key to get into SELECT SAFETY FACTOR screen (in LOOP/LINE measurements only). The safety factor takes into account for example the increase of conductor resistance due to increase of temperature.
7 ..... “ON/OFF“ menu key to toggle between enabled (✓) or disabled (X) judgement. Set judgement status is valid for actaully selected function only and can be independently set in each function separately.
8 ..... Sub-result (RPE MAX) is judged (✓) or not (X). Status of the judgement is set by using the “ON/OFF” menu key. Note: Not all measurement functions offer MAX value.
9 ..... Main result (RPE, or IPEFC) is judged (✓) or not judged (X). Status of the judgement is set by using the “ON/OFF” menu key.

2) Use offered menu keys (see the figure 10 or 11 above) to set the limit value. Functions have different possibilities, see the list of available menu keys in each function individually.

Explanation of SELECT LIMIT screen:
SELECT LIMIT screen (if available) will be offered after pressing “LIST” menu key, see the figure below.

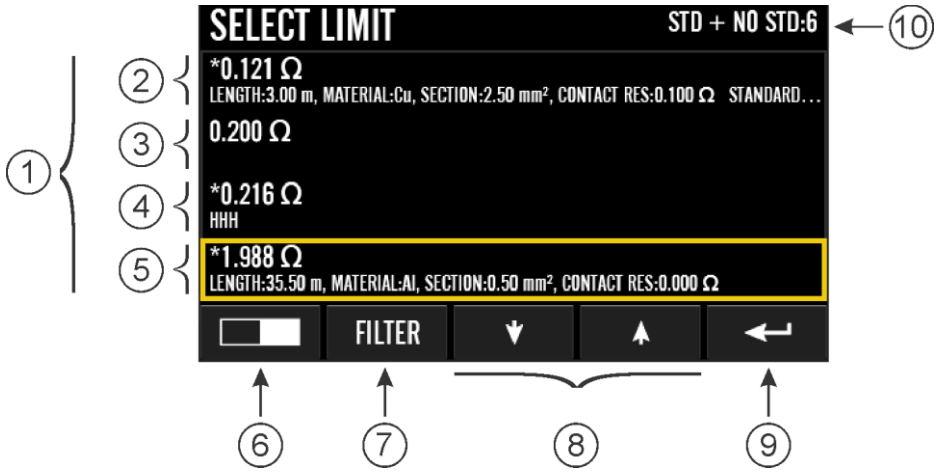


Figure 12: SELECT LIMIT screen, example

1..... List of currently available limits.
2..... Customer-entered limit (marked with *). The limit was entered through calculation, so the calculation parameters are listed in the second line (under limit value). There are also remarks (if any) shown in the same line. Complete calculation parameters and remarks (even if longer than shown in the second line) could be seen on the figure 10 or 11.
3..... Standard limit (factory-entered, without * mark). Standard limits can not be viewed/edited or deleted, but they can be copied.
4..... Customer-entered limit (marked with *). The limit was entered directly through internal numerical keyboard. Potential remarks are shown in the second line (under limit value). Complete remarks (even if longer than one line) could be seen on the figure 10 or 11 if this limit would be currently selected.
5..... Customer-entered limit (marked with *). This limit is currently selected (yellow framed).
6..... “▭” menu key, to switch between two selections of menu keys.
7..... “FILTER” menu key to toggle among **all limits** i.e. custom-entered + factory-entered (STD + NON STD), **standard limits** only i.e. factory-entered (STD) and **non standard limits** only i.e. custom-entered (NON STD).

8..... "↓" / "↑" menu keys to move yellow frame (selected limit) down/up.
9..... "↵" (ENTER) menu key to confirm selected limit.
10..... Counter of total number of limits in currently selected measurement.

Note!

- Limits in general (all limits in all functions) can be enabled or disabled in MENU / LIMIT menu.

16. START OF THE MEASUREMENT

- For single measurement press "START" button and release it. In this case measurement time defined in ⏱ parameter line (if any) on the left side of the display will be used. Elapsed time will be displayed graphically via bargraph and numerically in minutes and seconds (example 01'07'') during the measurement. When measurement time runs off, the measurement will be automatically stopped.
- For continuous measurement press and keep pressing "START" button for 2 seconds until the measurement starts and ⏱ parameter line is darkened. Elapsed time will be displayed numerically in minutes and seconds (example 01'07'') during the measurement. Measurement time is limited to 99 minutes 59 seconds in this case. The user has to stop the measurement manually by pressing "STOP" button.

Measurement functions have different test time possibilities, see the table below.

Rotary switch #2 position	Sub-function	Available test time possibility
👁	All	- Continuous (after single pressing "START" button)
Ω ⚠	All	- Single according to preset timer - Continuous ("START" button for 2 seconds)
kA/Ω	All	- Single (no timer is used)
UΔ %	All	- Single (no timer is used)
RCD	All	- Single (no timer is used)
MΩ	RINS	- Single according to preset timer - Continuous ("START" button for 2 seconds)
	RINS◢	- Single (no timer is used)
HV	Burn	- Continuous (as long the PEDAL is pressed)
	Other	- Single according to preset timer (as long as the pedal is pressed)
U/t	All	- Single (no timer is used)
mA/A	All	- Continuous (after single press to "START" button)
U/P	All	- Continuous (after single press to "START" button)
FUNC	HEADER and SUB HEADER	- No START
	All other	- Continuous (after single pressing "START" button)

Table 2: Available test time possibilities

Elapsed time during measurement (where displayed) can any time be reset to zero by pressing "EXIT" function key regardless of used mode (single or continuous). Measurement will thus start from zero again and min or max displayed value (if any) will be reset.

17. EXTERNAL VOLTAGE DISPLAY

- If there is a dangerous external voltage present on test terminals prior to a test or during it, the warning message “EXTERNAL VOLTAGE!“ will appear on display and start of the measurement will be blocked or the measurement will be stopped. Remove the external voltage!
- If an external voltage is applied to test terminals during the test in RINS function, wrong measurement values may be displayed.

Please remove external voltage from any test terminal immediately if “EXTERNAL VOLTAGE!” warning is displayed.

Function	Test sockets	EXTERNAL VOLTAGE condition
RPE 2W	Ω/MΩ (or Commander) against COM	≥ 9 VAC/DC before starting the measurement
RPE 4W	Ω/MΩ (or Commander) against COM or S1 against S2	≥ 9 VAC/DC before starting the measurement
RPE	Ω/MΩ (or Commander) or COM against PE of supply	≥ 150 VAC/DC before starting the measurement
MΩ	Ω/MΩ (or Commander) against COM	≥ 30 VAC/DC before starting the measurement

Table 3: Available test time possibilities

18. TESTING DEVICES, WARNINGS

⚠⚠ WARNINGS

- ☞ **Before starting any test, please kindly familiarize yourself with a coresponding safety standard like EN 60204-1 “Safety of machinery – Electrical equipment of machines: General requirements” for machines,**

  EN 61439-1 "Low-voltage switchgear and controlgear assemblies: General rules" for low-voltage switchgears

  or EN 50678/DIN VDE 0701 "General procedure for verifying the effectiveness of the protective measures of electrical equipment after repair" and EN 50699/DIN VDE 0702 "Recurrent Test of Electrical Equipment" for portable appliances etc.
- ☞ **Before commencing any test, you are strongly advised to make reference to the local regulations and standards for safety at works regulations and any relevant publications from the Health and Safety Executive.**
- ☞ **The UUT (Unit Under Test) must be switched ON for all tests (mains switch must be turned ON even if the UUT is disconnected from mains voltage e.g. in RPE and RINS tests).**
- ☞ **When conducting tests, do not touch the UUT as some tests involve hazardous voltages and hazardous currents.**
- ☞ **Do not touch the test specimen during the measurements as a high risk may arise in case of faulty test specimen.**
- ☞ **The tests should only be performed by competent persons who are familiar with requirements of the type of tests suitable for the UUT.**
- ☞ **It is potentially hazardous for all three, user, bystanders and the UUT if the wrong type of tests be undertaken or if testing is carried out in an incorrect sequence.**
- ☞ **It is important that you fully understand the various tests required and how they should be performed.**
- ☞ **The UUT must have passed the visual inspection, the protective earth bond resistance test (PC I appliances) and the insulation test (in this sequence) prior to any other test. If any of these tests fail, further testing must be stopped and any fault must be fixed.**
- ☞ **UUT driven by motors or equipped with heating elements may present a danger for the person testing or others (comply with the user manual of the UUT!). Please ensure that the UUT is in a safe condition to run and secure prior to testing.**

19. HELP MENU

HELP menu is a welcome feature that can be used any time during operation with the MST-204 Tester (except during measurement). In order to get into HELP menu, press “HELP” function key (F9), then select one of available HELP sub-menus and confirm it by pressing “↵“ menu key ⇒ display will turn to selected HELP sub-menu. HELP sub-menus are related to selected measurement function (= rotary switch #2 position).
For example RPE function (rotary switch #2 in position 2) offers the following HELP sub-menus:

- CONNECTION (connection diagrams can be checked here)
- RANGES (measuring and display ranges of main result and sub-results)
- COMPENSATION (compensation connection diagram)
- INFO (description of symbol when displayed)

20. DESCRIPTION OF MEASUREMENT FUNCTIONS

There are many measurement functions and sub-functions available in the MST-204 Tester. Please check measuring and display ranges of all main results and sub-results in chapter “TECHNICAL SPECIFICATIONS MST-204 TESTER” on page 183 or in HELP menu, see the chapter “HELP MENU” on page 36 above.

20.1. Visual Inspection

MST-204 Tester offers visual inspection as an independent function in order to properly document test results that can later be transferred to PC for creation of final test report.

Visual Inspection consists of the NAME, TEXT and result, see the figure below.

Visually inspect the UUT before starting any electrical test.
The visual inspection shall take place to detect external mechanical defects and, if possible, to determine the qualification of the suitability of the equipment for the environment. Special attention shall be paid to the following (if applicable):

Machines according to EN 60204-1:
- All visual inspection points must comply with technical documentation;

Switchgear assemblies according to EN 61439-1:
- Switching devices and other apparatus;
- Settings and indicators of relays and releases;
- Conductor connections and markings;
- Protections;
- If all protection classes have been complied with;
- Air and creepage distances;

Portable appliances according to EN 50678/DIN VDE 0701 and EN 50699/DIN VDE 0702:
- Any damage or contamination;
- That all cables and connectors are connected in their intended way;
- Checking by hand to ensure that the anchorages and the inlets of each connector are properly fixed;
- Condition of the mains plug and the mains connectors and conductors;
- Defects of the strain relief of the mains supply cord;
- Defect of the mains lead cord grip;
- Condition of anchorage, cable clip, accessible fuse insert;
- Damage of the housing and protective cover that could give access to live or dangerous moving parts;
- Signs of overload or overheating or unintended use;
- Signs of improper change;
- Signs of corrosion that impacts protective measures and improper aging;
- Blockage of cooling inlets and outlets e.g. air filters;
- Tightness of container for water, air, or other medium, condition of pressure control valve;
- Usability of switches, control and setup equipment;
- Readability and completeness of all safety relevant markings, labels or symbols, of the ratings and of the position indicators;

- All fuses accessible from the outside are complying with the data given by the manufacturer (rated current, characteristics);
- Assess the relevant accessories together with the equipment (e.g. detachable or fixed power supply cords tubing);
- Defect due to bending of cords, cables, hoses and tubing.

How to enter Visual Inspection result:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1, 2 or 3).
2) Select Visual Inspection function by seting the rotary switch #2 to position ⇒ idle screen of last used Visual Inspection function will be displayed (last used NAME and TEXT).
3) Press “EDIT” menu key, to get into extended range of menu keys, see the figure below.

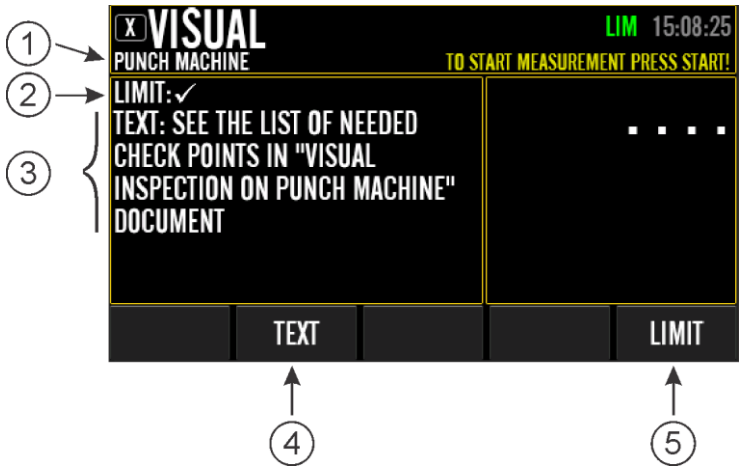


Figure 13: Visual Inspection idle screen with extended range of menu keys (after pressing "EDIT” menu key), example

1 ..... NAME of last used Visual Inspection (17 characters max.), example.
2 ..... LIMIT enabled.
3 ..... TEXT of last used Visual Inspection (500 characters max.), example.
4 ..... “TEXT“ menu key to get into Visual Inspection NAME / TEXT screen.
5 ..... “LIMIT” menu key to get into TURN LIMIT ON/OFF screen.

4) Press “TEXT“ menu key to get into Visual Inspection NAME / TEXT screen (if displayed one is not the wished one).
5) Press “LIST“ menu key to get into SELECT VISUAL INSPECTION screen with a list of available Visual Inspections.
6) Select one of available Visual Inspections or enter a new one and confirm it by pressing “↵” menu key ⇒ display will turn back to Visual Inspection NAME / TEXT screen.

   Note!
   - Operator can also EDIT, COPY or DELETE existing Visual Inspections here.
7) Press “EXIT“ function key to get back to idle Visual Inspection screen with just selected NAME / TEXT. Thus wished Visual Inspection is selected / entered.
8) Press “START“ button ⇒ continuous measurement will start to run.
9) Press “N/A“ (not applicable), “FAIL“ or “PASS“ menu key to stop the measurement ⇒ final result will be displayed, see the figure below.

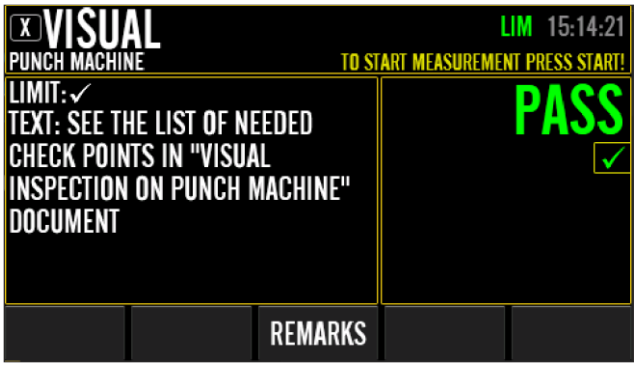


Figure 14: Visual Inspection final result, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.2. Protective Bonding Resistance R_{PE} – 25 A / 10 A / 0.2 A

Protective Bonding Resistance is the resistance measured between PE terminal on mains input (schuko plug or three-phase plug or PE terminal in connection box if the UUT is permanently connected) and accessible conductive part of the UUT. This test applies to PC I UUTs only and can be performed with standard test leads or with Commander.

Compensation of test leads:
Prior to the measurement take care used test leads are properly compensated, see the chapter "TEST LEADS COMPENSATION" on page 28. Please use zero adapter for compensation. For proper test leads connection in compensation procedure see HELP/COMPENSATION menu.

There are three measurements availble namely:
- 2W (two-wire)
- 4W (four-wire)
- 4W TPA (only in combination with Three Phase Adapter TPA-204-63A* or TPA-204-32A*)

* In development

Note!
- For more accurate test results at low values it is recommended to use 4W measurement.

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key):

MODE (F2) = Measurement mode ..... - MAN (manual mode - measurement starts after pressing "START" button)
- AUTO (auto mode - measurement starts automatically after a resistance below 10 kΩ is detected between Commander (or Ω/MΩ) and COM test sockets)

I_N (F3) = Nominal test current* ..... 0.2 A, 10 A or 25 A
⏱ (F4) = Measurement time ..... Adjustable 2 … 120 s
LIMIT (F5) = R_{PE} limit value ..... Adjustable 0.000 … 2.000 Ω, standard values 0.100 Ω and 0.200 Ω

*Switch #1 in "All" or "Machine" position.
In position "Switchgear Assemblies" only 10 A or 25 A test current is available.

Notes!
- Limit value can be entered directly (in Ω) or through calculation (CALCULATE) on bases of entered LENGTH (1.00 … 200.00 m), MATERIAL (Cu or Al), SECTION (0.50 … 100.00 mm2) and CONTACT RESISTANCE (0.000 … 1.000 Ω).
- Compensation of test leads is available in idle R_{PE} screen (before pressing "EDIT" menu key). Press "COMPR_{PE}" menu key for compensation purpose. Compensation status can be checked on display, see the figure below (test leads compensated = ✓, test leads not compensated = X). This parameter is available in 2W measurements only.

Measured quantities:

RPE ..... Main result = Protective bonding resistance.
RPE MAX ..... Sub-result = Max RPE value displayed during the measurement. This value can be reset any time during the measurement by pressing “EXIT“ function key.
IM ..... Sub-result = Actual measuring current.
Timer ..... Sub-result = Measurement time.
xx’ xx’’ ..... Sub-result = Overal test duration.

Test procedure for RPE measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1, 2 or 3).
2) Select Protective Bonding Resistance measurement by setting the rotary switch #2 to Ω position ⇒ idle screen of currently selected RPE measurement will be displayed.
3) Press “MEAS” menu key, select wished measurement (2W or 4W) and confirm it by pressing “↵“ menu key ⇒ display will turn to measurement screen of just selected measurement.
4) Check the status of test leads compensation in COMPRPE parameter line and do the compensation if needed, see the instructions in chapter “TEST LEADS COMPENSATION” on page 28.
5) Press “EDIT“ menu key ⇒ idle screen of currently selected RPE measurement with extended range of menu keys will be displayed, see the figure below.

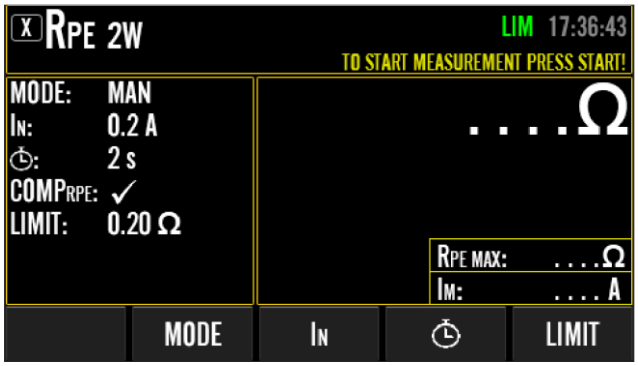


Figure 15: RPE idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

6) Select/adjust all test parameters according to available menu keys shown on the figure above.

Caution!

☞ **Before connecting test leads to a UUT, obligatory assure there is no mains voltage applied to the UUT, otherwise fuse F2 may blow! Especially take care to switch off mains voltage in case of permanently connected UUT!**

Notes!

- Use meaningfully equivalent connections for the other UUTs than shown below, like for example switchgears.
- Possible test leads connections shown in HELP menu depend on selected CONNECTION (2W or 4W).

7) Connect test leads to a UUT according to one of the figures below or see available figures in HELP/CONNECTION menu.

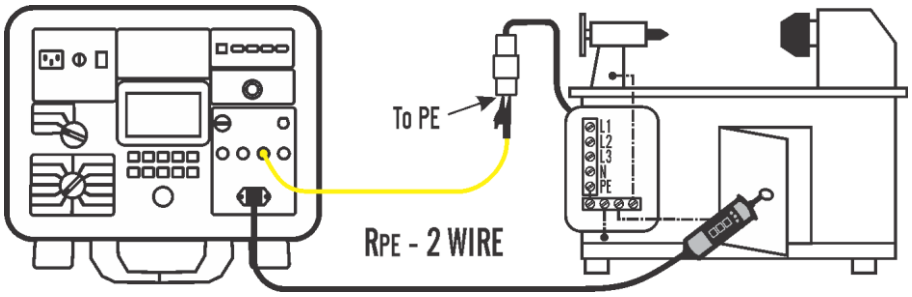


Figure 16: 2W connection (Commander in combination with COM test lead) to plugged machine, example

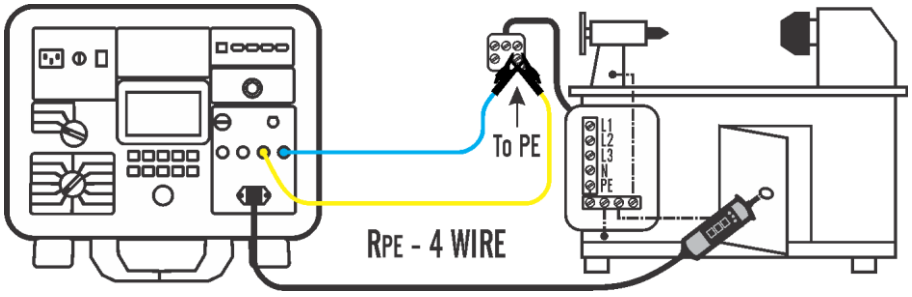


Figure 17: 4W connection (Commander in combination with COM and S2 test leads) to permanently connected machine, example

8) Press “START“ button (on MST-204 Tester or on Commander) to start the measurement. During the measurement flex the flexible PE wire along its length to help find any broken conductors or poor connection joints.

9) Stop the measurement by pressing “STOP“ button (or wait set timer to stop it), final measurement result will be displayed, see the figure below.

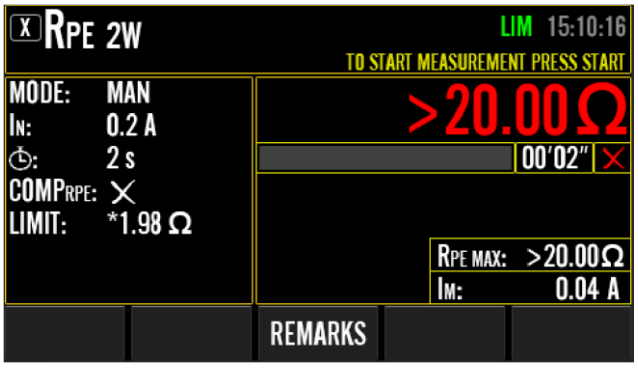


Figure 18: Final result in RPE 2W measurement, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during R_{PE} measurements:

Information displayed	Description
⚠ USE SOCKETS Ω/MΩ AND COM!	Ω/MΩ and/or COM test sockets are not occupied with test leads ⇒ connect test leads.
⚠ EXTERNAL VOLTAGE!	See the chapter “External Voltage Display” on page 34.
CHECK FUSE F2!	Fuse F2 is blown ⇒ replace the fuse.
CHECK COMPENSATION!	Test lead is wrong compensated (negative R_{PE} result ≤ -0.05 Ω @I_N = 0.2 A or ≤ -0.005 Ω @I_N = 10 A/25 A) ⇒ compensate the test leads again.

20.3. Ω/kA LOOP/LINE Impedance, IPEFC/IPSC

There are several reasons why to measure LOOP / LINE impedance (ZL/PE / ZL/N) and Prospective Earth Fault Current / Prospective Shot-circuit Current (IPEFC / IPSC) like:
- To check if short-circuit current is lower than rated breaking capacity of involved over-current protection device.
- To check if over-current protection device reacts before wires are overheated.
- To check if over-current protection device reacts within expected time at short-circuit current.
- To check if short-circuit current is high enough, over-current protection device to react within appropriate time.

⚠ Warning

☞ **LOOP/LINE measurements are carried out at present mains voltage, so valid safety and national regulations regarding excessive contact voltages must receive utmost attention.**

Note!
- This function is available only if Switch #1 is in “All” or in “Machine” position. In “Switchgear Assemblies” position the function is NOT AVAILABLE.

Selectable measurements:

MEAS (F1) - Measurement
- LOOP IPEFC (L/PE) = Prospective Earth Fault Current + LOOP impedance as a sub-result
- LINE IPSC (L/N) = Prospective Short-circuit Current + LINE impedance as a sub-result
- LINE IPSC (L/L) = Prospective Short-circuit Current + LINE impedance as a sub-result
- SEC IPSC (U < 100 VAC/DC) = Prospective Short-circuit Current + impedance Z as a sub-result in secondary circuits

Adjustable/selectable test parameters (keys available after pressing “EDIT” menu key)**:**

MODE (F2) = Measurement mode .....
- MAN (manual = test will start after pressing “START” button only)
- AUTO (auto = test will start automatically after connecting test leads to mains voltage)

ITEST (F3) = Test current.....
- STD (standard = loading resistance 10 Ω, 2 × 10 ms, used when standard accuracy of test result is sufficient)
- HIGH (high = loading resistance 3.3 Ω, 6 × 10 ms, used when high accuracy of test result is required)
- MPCBNO TRIP 0.1A (MPCB = Motor Protection Circuit Breaker, loading current 100 mA RMS = 141 mA for 40 ms + 0 mA for 40 ms, used when an MPCB with rated current of 0.1 A or higher is involved in tested loop)
- MPCBNO TRIP 0.5A (MPCB = Motor Protection Circuit Breaker, loading current 500 mA RMS = 707 mA for 40 ms + 0 mA for 40 ms, used when an MPCB with rated current of 0.5 A or higher is involved in tested loop)
- RCDNO TRIP (loading current 30 mA × 0.33 / 1.41 AC RMS 30 mA × 0.33 for 40 ms + 0 mA for 40 ms, used when an RCD is involved in tested loop)

- Test current in SEC IPSC (U<100V AC/DC) measurement is adjustable within 0.1 and 3.0 A

LIMIT (F5) = LIM IPEFC/IPSC
(LOOP, LINE measurements) ..... - Adjustable 50.0 … 999 A and 1.00 … 2.00 kA
(ITEST = STD or HIGH)
Note!

- Above limit value can be entered directly (A/kA) or through calculation (FUSE) on bases of entered SYSTEM (TN-C, TN-C-S, TN-S, TT or IT), fuse TYPE (gG 5s, gG 0.4s, B, C or K), UNOM (1 … 1000 V) and INOM (2, 4, 6, 10, 25, 32, 35, 40, 50, 63, 80, 100, 125 or 160 A).

- Adjustable 0.4 … 999 A and 1.00 … 1.53 kA
(ITEST = MPCBNO TRIP 0.1A or MPCBNO TRIP 0.5A)
- Adjustable 0.05 … 16 A
(ITEST = RCDNO TRIP)

LIMIT (F5) = LIM IPSC
(SEC IPSC (U<100V AC/DC) meas.) ..... - Adjustable 0.02 … 100.0 A

Note!

- Parameter UNOM (see the figure 19 below) is directly defind in ENVIRONMENT TABLE as follows:
  UNOM in LOOP L/PE and LINE L/N measurement = UNOM PHASE TO EARTH (L/PE)
  UNOM in LINE L/L measurement = UNOM PHASE TO PHASE (L/L)

Measured quantities:

Measured quantity	MEASUREMENT			
	LOOP IPEFC (L/PE)	LINE IPSC (L/N)	LINE IPSC (L/L)	SEC IPSC (U<100V AC/DC)
IPEFC	✓	-	-	-
IPSC	-	✓	✓	✓
ZL/PE (displayed as Z)	✓	-	-	-
ZL/N (displayed as Z)	-	✓	-	-
ZL/L (displayed as Z)	-	-	✓	-
Z	-	-	-	✓
UL/PE	✓	-	-	-
UL/N	-	✓	-	-
UL/L	-	-	✓	-
U	-	-	-	✓
xx’ xx’’ (test duration)	-	-	-	✓

Table 4. Measured quantities in LOOP/LINE measurements

Test procedure for LOOP/LINE measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select LOOP/LINE measurement by setting the rotary switch #2 to Ω/kA position,
   ⇒ idle screen of currently selected LOOP/LINE measurement will appear.
3) Check the status of test leads compensation in COMP parameter line and do the compensation if needed, see the instructions in chapter “Test leads compensation” on page 25.
4) Press “MEAS” menu key, select wished measurement according to the table 4 above and confirm it by pressing “↵“ menu key ⇒ display will turn to measurement screen of just selected measurement.
5) Press “EDIT“ menu key ⇒ idle screen of currently selected LOOP/LINE measurement with extended range of menu keys will be offered, see the figure below.

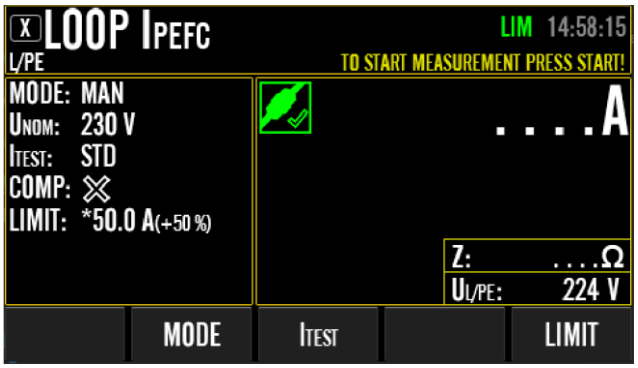


Figure 19: LOOP IPEFC (L/PE) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

6) Select/adjust all test parameters according to available menu keys shown on the figure above.
7) Connect test leads to installation/UUT according to appropriate figure below or see available figures in HELP/CONNECTION menu.
   Green mains icon will be displayed when the connection is properly done and input voltage is within 100 … 253 VAC (L/N or L/PE measurement) or within 100 … 440 VAC (L/L measurement).

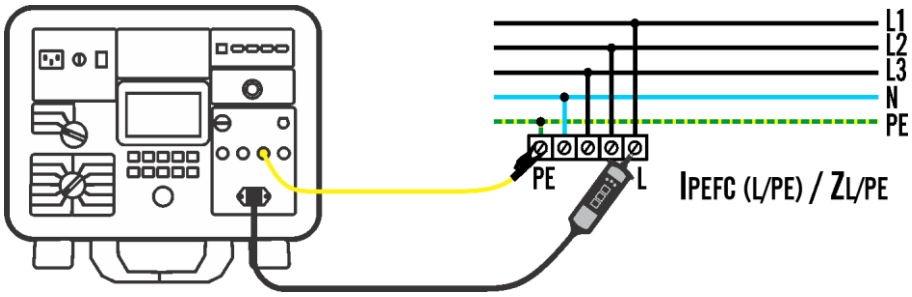


Figure 20: Connection for LOOP L/PE measurement

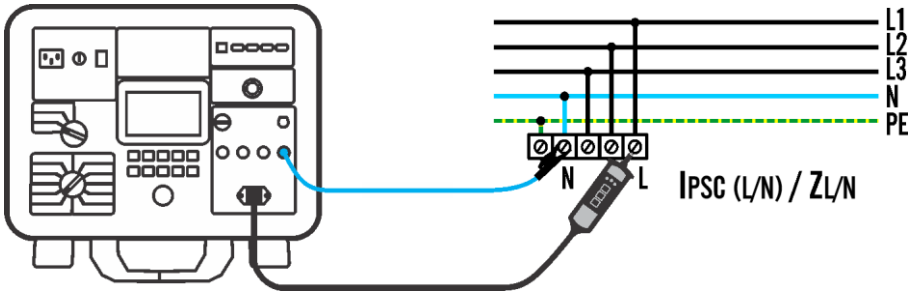


Figure 21: Connection for LINE L/N measurement

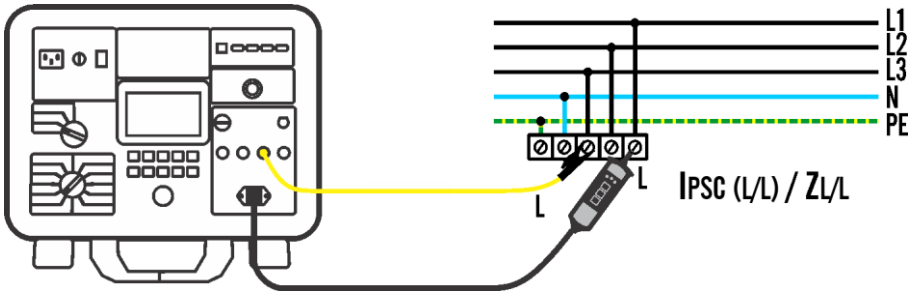


Figure 22: Connection for LINE L/L measurement

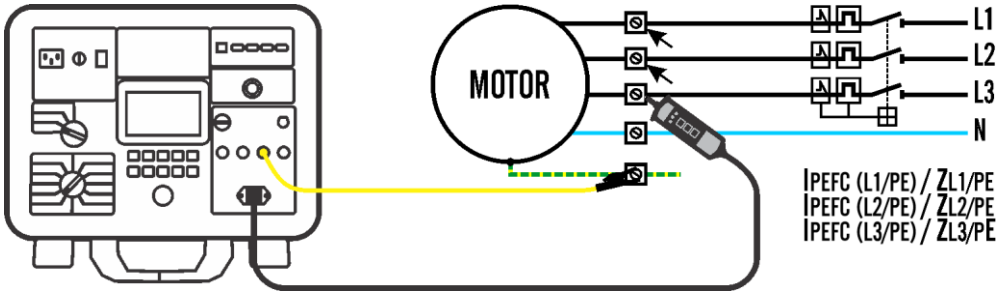


Figure 23: Connection for MPCBNO TRIP L/PE measurement

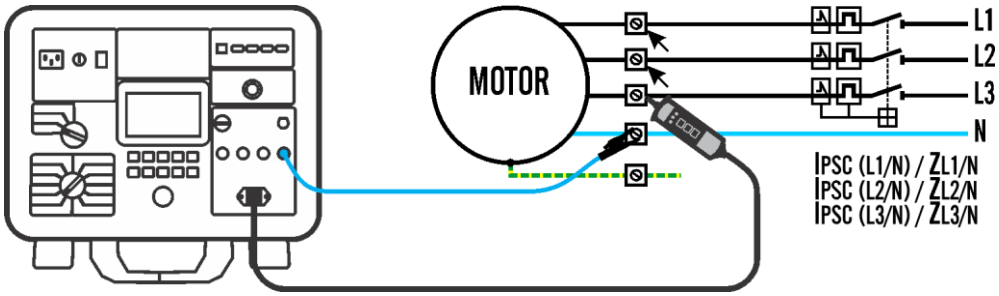


Figure 24: Connection for MPCBNO TRIP L/N measurement

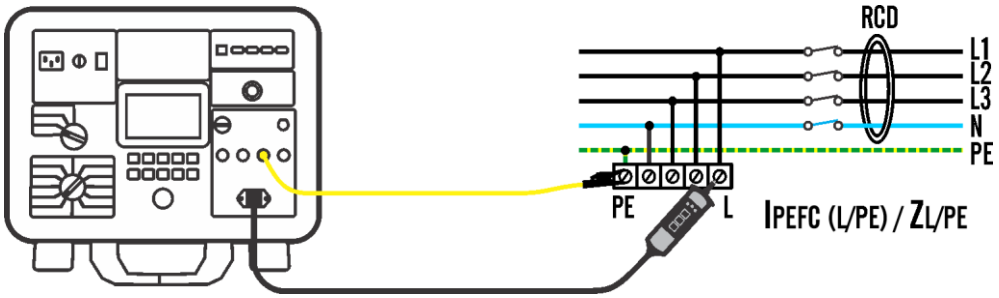


Figure 25: Connection for RCDNO TRIP L/PE measurement

8) Press “START“ button (on MST-204 Tester or on Commander) to start the measurement and wait the result to be displayed, see the figure below.

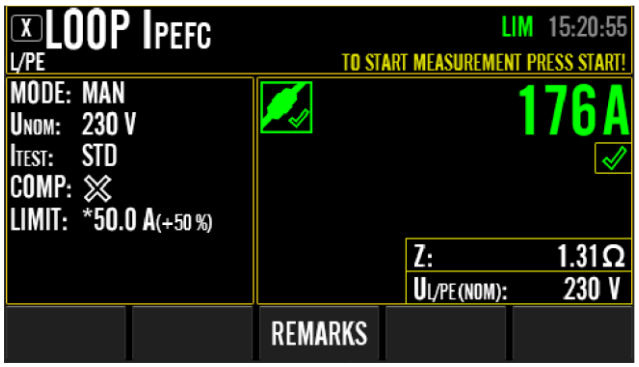


Figure 26: Final result in LOOP IPEFC (L/PE) measurement, example

9) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Test procedure for SEC IPSC (U<100V AC/DC) measurement:

Carry out paragraphs 1 to 3 described in chapter “Test procedure for LOOP/LINE measurement” on page 45.

4) Press “MEAS” menu key, select SEC IPSC (U<100V AC/DC) measurement and confirm it by pressing “↵“ menu key ⇒ display will turn to measurement screen of just selected measurement.
5) Press “EDIT“ menu key ⇒ idle screen of currently selected SEC IPSC (U<100V AC/DC) measurement with extended range of menu keys will be offered, see the figure below.

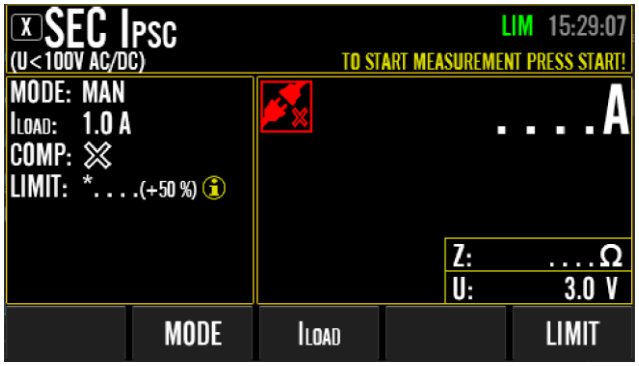


Figure 27: SEC IPSC (U<100V AC/DC) idle screen with extended range of menu keys (after pressing "EDIT” menu key), example

6) Select/adjust all test parameters according to available menu keys shown on the figure above.
7) Connect test leads to a UUT according to one of the figures below or see available figures in HELP/CONNECTION menu.

   Note!

   - Green input voltage icon will be displayed when the connection is properly done and input voltage is within 10 … 100 VAC/DC.

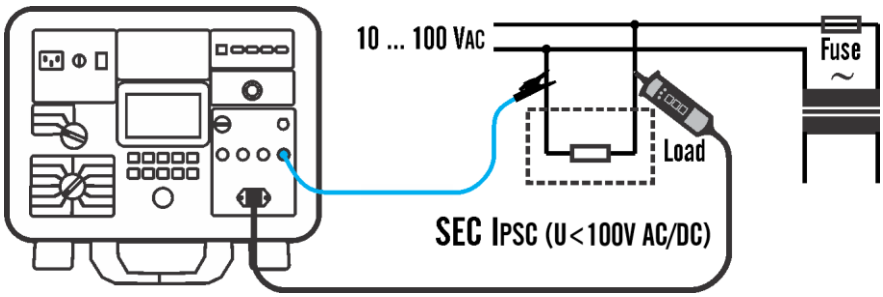


Figure 28: Connection for SEC IPSC (U<100V AC/DC) measurement (AC input voltage)

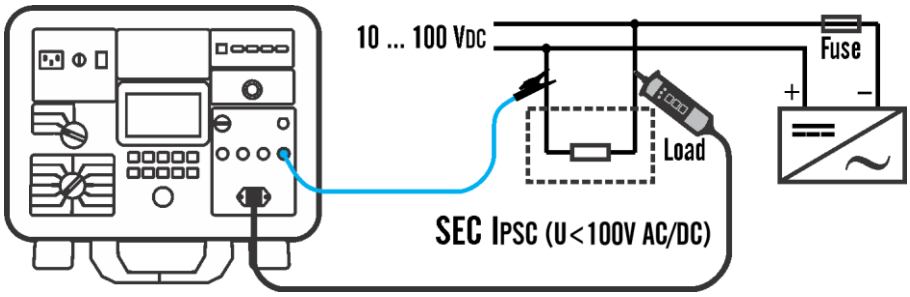


Figure 29: Connection for SEC IPSC (U<100V AC/DC) measurement (DC input voltage)

8) Press “START“ button (on MST-204 Tester or on Commander) to start the measurement and wait the result to be displayed, see the figure below.

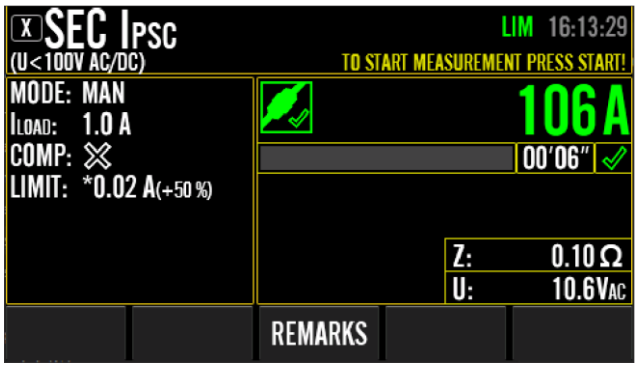


Figure 30: Final result in SEC IPSC (U<100V AC/DC) measurement, example

9) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during LOOP/LINE measurements:

Information displayed	Description
⚠ CHECK FUSE 2!	Fuse 2 is blown ⇒ replace the fuse, please use just original fuse listed in technical specifications!
°C	Internal loading resistors/transistors are overheated ⇒ please wait the tester to cool down and the symbol to disapear!
⚠ IMPEDANCE TOO HIGH!	This message may appear in SEC IPSC (U<100V AC/DC) measurement if measured impedance is too high (set load current cannot be reached) ⇒ reduce load current ILOAD accordingly!

20.4. [UΔ %] UDELTA

UDELTA is a voltage drop displayed in % of referential voltage UREF, measured across the installation from input switchboard terminals to mains wall sockets (or to fixed connection terminals). According to installation standard, the voltage drop shall not exceed 5% of referential voltage at nominal load current the installation is designed for. If the volage drop is too high, then some actions shall be done in order to reduce it like for example:

- Cross section of installation wires shall be increased.
- Potential aluminium wires shall be replaced with copper ones.
- Connection contacts shall be improved in a manner to reduce contact resistance.
- Voltage drop compensation module shall be installed.

Warning

☞ **The UDELTA measurements are carried out at present mains voltage, so in order to avoid electrical shock, the valid safety and national regulations regarding excessive contact voltages must receive utmost attention.**

Note!

- This function is available if Switch #1 is in “All” or in “Machine” position only. In “Switchgear Assemblies” position this function is NOT AVAILABLE.

Adjustable/selectable test parameters (keys available after pressing “EDIT” menu key)**:**

CONN (F1) = Connection ..... - L/L (phase to phase mesurement)
- L/N (phase to neutral measurement)

IN (F2) = Installation nominal current.... 2 A, 4 A, 6 A, 8 A, 10 A, 12 A, 16 A, 20 A, 25 A, 32 A, 35 A, 40 A, 50 A, 63 A, 80 A, 100 A, 125 A, 160 A, 200 A, 250 A, 315 A, 400 A, 500 A or 630 A

ITEST (F3) = Test current..... - STD (standard = loading resistance 10 Ω, 2 × 10 ms, used when standard accuracy of test result is sufficient)
- HIGH (high = loading resistance 3.3 Ω, 6 × 10 ms, used when high accuracy of test result is required)

LIMIT (F5) = LIM UDELTA..... Adjustable 0.0 to 20.0 %, standard value 5.0 %

Measured quantities:

UDELTA .... Main result = Voltage drop in % = (ZΔ × IN × 100)/UREF (calculated value)

ZREF ..... Sub-result = Referential impedance measured at input switchboard terminals (the value can also be entered manually)

Z2 ..... Sub-result = Impedance measured at mains wall socket or at fixed connection terminals

ZΔ ..... Sub-result = Impedance difference = Z2 – ZREF (calculated value)

UREF ..... Sub-result = Referential voltage measured at input switchboard terminals (the value can also be entered manually or copied from nominal voltage defined in ENVIRONMENT TABLE)

U2 ..... Sub-result = UREF – ZΔ × IN = Hypothetical voltage that would be present at measured mains wall socket or at fixed connection terminals in case input voltage is equal to referential one @ nominal load current (calculated value)

UΔ ..... Sub-result = Voltage drop in Volts = UREF – U2 (calculated value)

How to get into UDELTA measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select UDELTA measurement by setting the rotary switch #2 to [UΔ %] position ⇒ idle screen of currently selected UDELTA measurement will be displayed, see the figure below.

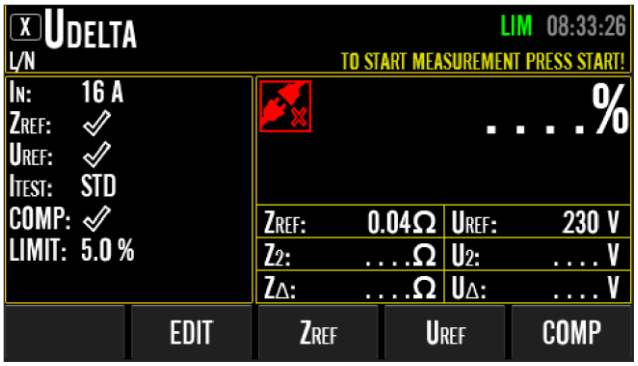


Figure 31: Idle screen in UDELTA measurement, example

How to define referential impedance ZREF:

Referential impedance ZREF can be either measured or entered manually.

How to measure ZREF:

1) Connect test leads according to the figure below, see also HELP/CONNECTION menu. Green mains icon will be displayed when the connection is properly done and input voltage is within 100 … 253 VAC (L/N connection) or within 170 … 440 VAC (L/L connection).

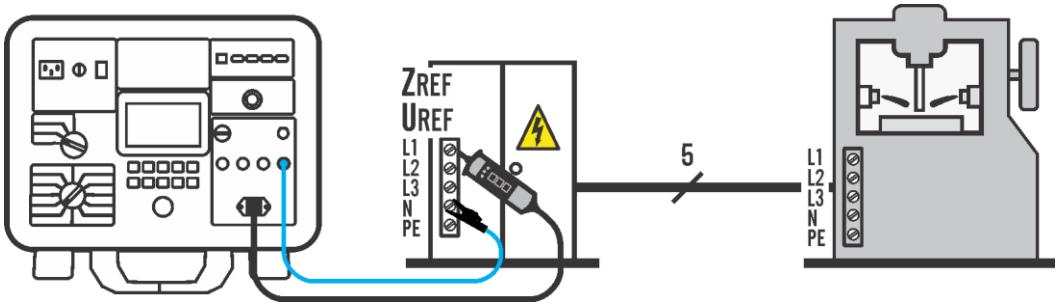


Figure 32: Connection for ZREF and UREF measurement (L/N connection), example

2) Press "ZREF" menu key ⇒ two options will be offered i.e. MEASURED or ENTERED.
3) Select MEASURED option and confirm it by pressing "↵" menu key ⇒ "MEASUREMENT ZREF FOLLOWS!" warning will be displayed.
4) Press "CONTINUE" (F5) menu key and wait measurement to be done, measured ZREF will be displayed.

How to enter ZREF value manually (start from the figure 31 above):

1) Press "ZREF" menu key ⇒ two options will be offered i.e. MEASURED or ENTERED.
2) Select ENTERED option and confirm it by pressing "↵" menu key ⇒ display will turn to ZREF adjustment screen with numerical keyboard, see the figure below.

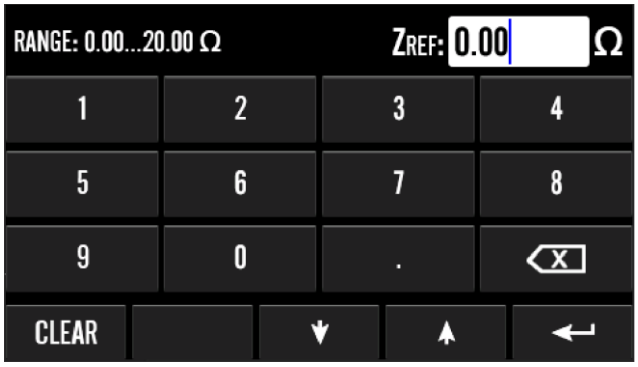


Figure 33: ZREF adjustment screen with numerical keyboard

3) Enter wished ZREF value and confirm it by pressing "↵" menu key ⇒ display will turn back to measurement screen of UDELTA function with displayed just entered ZREF value.

How to define referential mains voltage UREF:

Referential mains voltage can be either created from ENVIRONMENT TABLE (copied nominal voltage UNOM), measured or entered manually.

How to define UREF from ENVIRONMENT TABLE (start from figure 31):

1) Press "UREF" menu key ⇒ three options will be offered i.e. UNOM, MEASURED and ENTERED.
2) Select UNOM option and confirm it by pressing "↵" menu key ⇒ display will turn to ENVIRONMENT TABLE screen, actual nominal voltage field will be yellow framed.
3) Select wished nominal voltage, see the instructions in chapter "ENVIRONMENT TABLE description" on page 147.
4) Press "EXIT" function key once the nominal voltage is selected ⇒ display will turn back to idle screen of UDELTA function (see the figure 31) with displayed referential voltage.

How to measure UREF (start from figure 31):

1) Connect test leads according to figure 32, red mains icon will turn to green as a confirmation the connection was properly done and input mains voltage is within 100 and 253 V (L/N connection) or within 170 and 440 V (L/L connection).
2) Press "UREF" menu key ⇒ three options will be offered i.e. UNOM, MEASURED and ENTERED.
3) Select MEASURED option and confirm it by pressing "↵" menu key ⇒ "MEASUREMENT UREF FOLLOWS!" warning will be displayed.
4) Press "CONTINUE" (F5) menu key and wait measurement to be done ⇒ display will turn back to idle measurement screen with displayed just measured referential voltage UREF.

How to enter UREF value manually (start from figure 31):

1) Press "UREF" menu key ⇒ three options will be offered i.e. UNOM, MEASURED and ENTERED.
2) Select ENTERED option and confirm it by pressing "↵" menu key ⇒ display will turn to UREF adjustment screen with numerical keyboard, see the figure below.

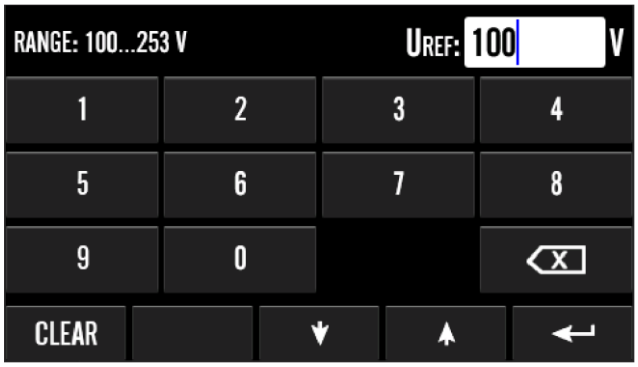


Figure 34: UREF adjustment screen with numerical keyboard, example

3) Enter wished UREF value (within 100 and 253 V for L/N connection or within 170 and 440 V for L/L connection) and confirm it by pressing "↵" menu key ⇒ display will turn back to measurement screen of UDELTA function with just entered UREF value.

Compensation of test leads:

Check the status of test leads compensation in COMP parameter line (see the figure 31) and do the compensation if needed, see the instructions in chapter "Test leads compensation" on page 25.

Test procedure for UDELTA measurement (start from figure 31)**:**

1) Press "EDIT" menu key ⇒ idle screen of currently selected UDELTA measurement with extended range of menu keys will be offered, see the figure below.

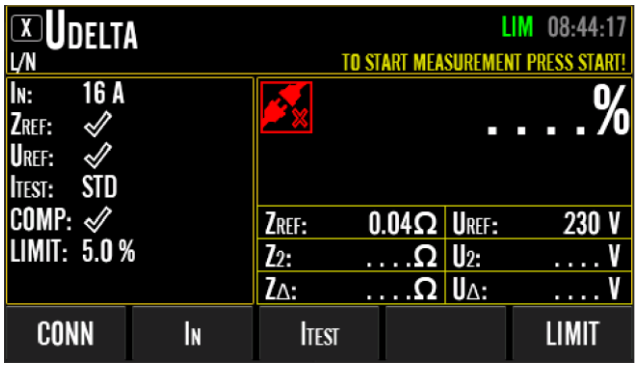


Figure 35: UDELTA idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

2) Select/adjust all test parameters according to available menu keys shown on the figure above.
3) Connect test leads according to the figure below, see also HELP/CONNECTION menu.

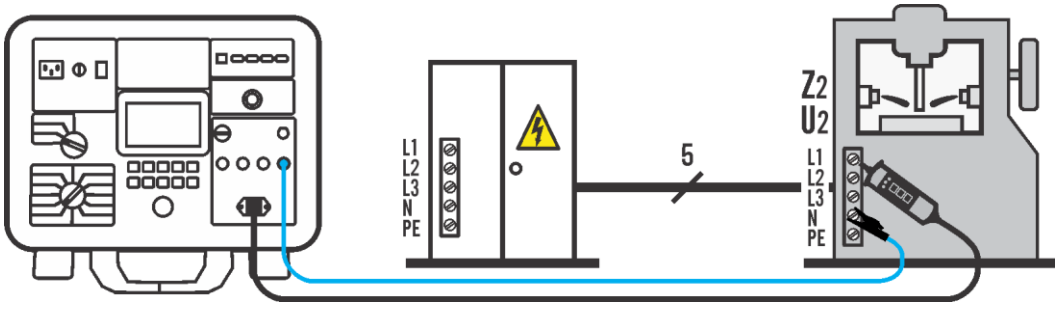


Figure 36: Connection for Z2 measurement, example

Green mains icon will be displayed when the connection is properly done and input voltage is within 100 … 253 VAC (L/N connection) or within 170 … 440 VAC (L/L connection).

4) Press “START“ button (on MST-204 Tester or on Commander) to start the measurement and wait the result to be displayed, see the figure below.

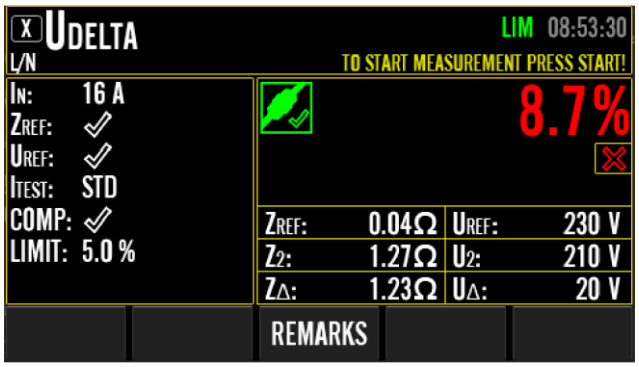


Figure 37: Final result in UDELTA measurement, example

5) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during UDELTA measurements:

Information displayed	Description
Z2 LOWER than ZREF!	It can appear after finishing the measurement ⇒ check measured/entered referential impedance ZREF!
MEASUREMENT ZREF FOLLOWS!	ZREF measurement will follow after pressing “CONTINUE” menu key (F5) ⇒ check again if test leads are properly connected!
MEASUREMENT UREF FOLLOWS!	UREF measurement will follow after pressing “CONTINUE” menu key (F5) ⇒ check again if test leads are properly connected!
	Internal loading resistors are overheated ⇒ please wait the tester to cool down and the symbol to disapear!

20.5. RCD RCD (Residual Current Device)

RCD is a protection device that constantly monitor residual currents in electrical systems. This current is calculated as the sum of the currents of all conductors, apart from the protective earth (PE), which feed into the system. Residual currents are typically the result of insulation faults, leakage currents or EMC filter leakage currents for example.
Residual currents caused by the failure of insulation can constitute a significant risk to safety in electrical systems. Purpose of the RCD is to switch off mains system in case residual current exceeds a safety value.
There are various types of RCD devices available on the market. Each type has it's own features and has to be tested accordingly.

Explanation of RCD test currents:
See the figures below for test current shapes with regard to test current polarity.

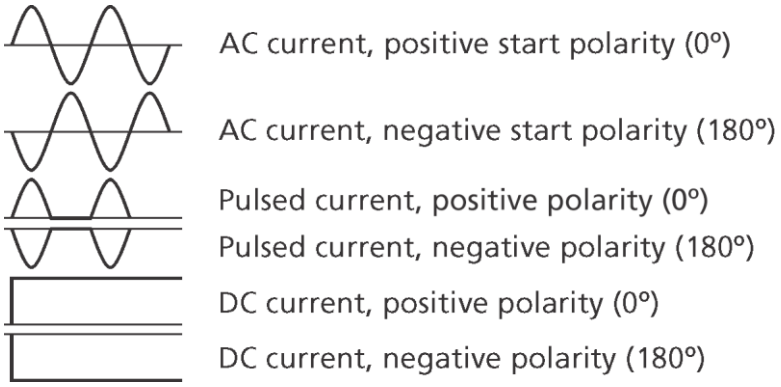


Figure 38: Test current shapes with regard to selected polarity in trip time measurement

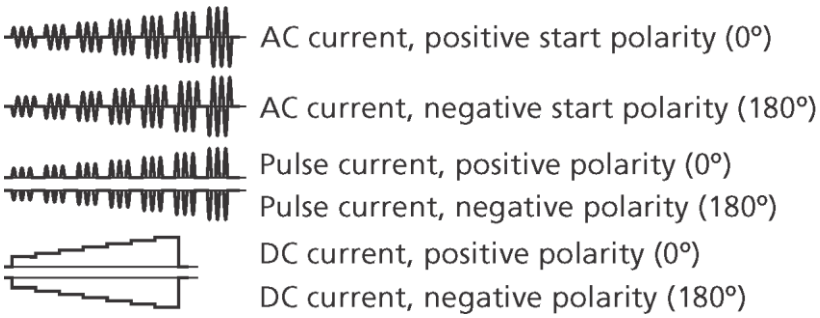


Figure 39: Test current shapes with regard to selected polarity in RAMP test

There are six measurements availble (after pressing "MEAS" menu key):
- RCD U_F@$I_{\Delta N}$ (Fault voltage at nominal differential current)
- RCDt (Trip out time)
- RCD I_Δ (Tripping current = RAMP test and trip out time at tripping current)
- RCDAUTO (AUTO test)
- IMD (Insulation Monitor Device test)
- RCM (Residual Current Monitor test)

Warning!

☞ **The RCD measurements will be carried out at present mains voltage, so, in order to avoid electrical shock, the valid safety and national regulations regarding excessive contact voltages must receive utmost attention.**

20.5.1. RCD RCD UF@I∆N (Fault Voltage at Nominal Differential Current)

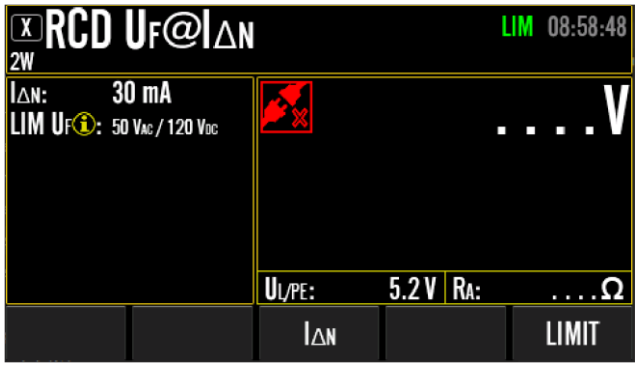


Figure 40: Idle screen in RCD UF@I∆N measurement with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

I∆N (F3) = Nom. differential current ..... 10, 30, 100, 300, 500 or 1000 mA,
test current is 1/3 of selected I∆N
LIMIT (F5) = LIM UF ..... The value is directly defined in ENVIRONMENT TABLE

Measured quantities:

UF@I∆N .... Main result = Fault voltage scaled to selected nominal differential current
UL/PE ..... Sub-result = Voltage between L and PE terminals measured just after pressing "START" button
RA ..... Sub-result = LOOP impedance measured between L and PE terminals
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for RCD UF@I∆N measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1, 2 or 3).
2) Select RCD measurement by setting the rotary switch #2 to RCD position ⇒ idle screen of currently selected RCD measurement will appear.
3) Press "MEAS" menu key to get into sub-function selection screen (if wished sub-function is not selected yet), six measurements will be offered.
4) Select RCD UF@I∆N sub-function and confirm it by pressing "↵" menu key ⇒ idle screen of currently selected RCD UF@I∆N sub-function will appear.
5) Press "EDIT" menu key to get into idle screen with extended menu keys, see the figure above.
6) Select/adjust all test parameters according to available menu keys shown on the figure above.
7) Connect test leads according to the figure below, see also HELP/CONNECTION menu. Green mains icon will be displayed when the connection is properly done and input voltage UL/PE is within 100 … 253 VAC.

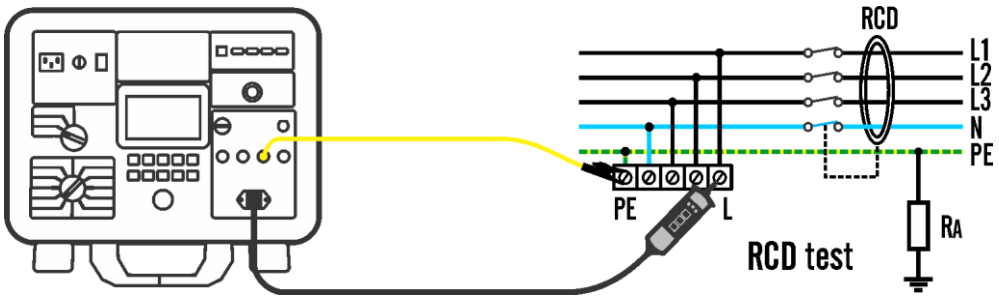


Figure 41: Connection for RCD UF@I∆N measurement, example

8) Press “START” button and wait the measurement to be done. See the figure below for an example of measurement result.

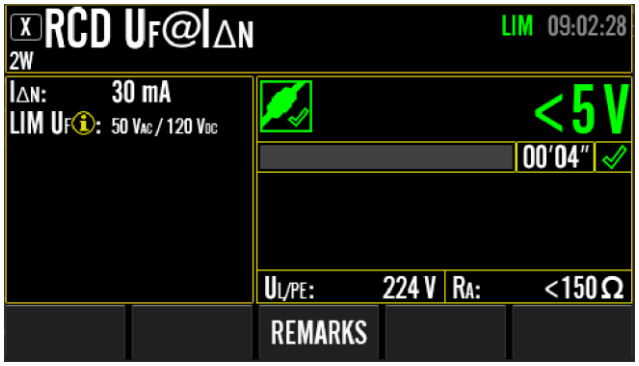


Figure 42: RCD UF@I∆N measurement result, example

6) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.5.2. RCD RCDt (Trip Out Time)

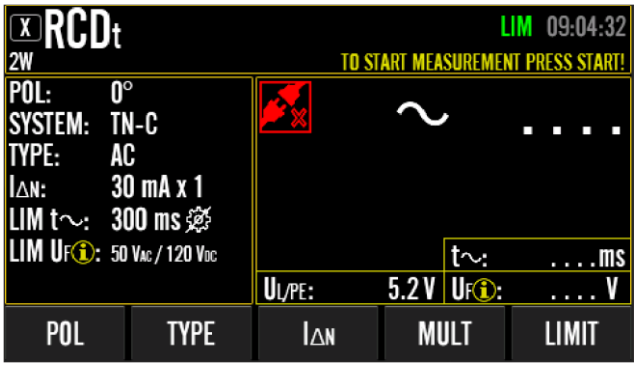


Figure 43: Idle screen in RCDt measurement with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

POL (F1) = Polarity of test current..... 0° (positive) or 180° (negative)
TYPE (F2) = Type of RCD ..... A, A S, A-EV, B/B+, B/B+ S, B/B+MI, F, F-EV, A-K/A-G, AC, AC S or AC-K/AC-G
IΔN (F3) = Nom. differential current..... 10, 30, 100, 300, 500 or 1000 mA
MULT (F4) = Multiplyer of IΔN..... IΔN × 1/2, IΔN × 1 or IΔN × 5 (IΔN = 10 mA and 30 mA only)
LIMIT (F5) = LIM t and LIM UF ..... LIM t is indirectly defined in ENVIRONMENT TABLE and depends on selected mains SYSTEM and UNOM PHASE TO EARTH (L/PE).
LIM UF is directly defined in ENVIRONMENT TABLE.
See also the Table 11 on page 148.

Notes!

- Symbol ⚙ means the parameter is fixed (not adjustable at all) or it is indirectly adjustable through some other parameters in ENVIRONMENT TABLE (for example through mains SYSTEM and UNOM PHASE TO EARTH (L/PE)).
- Parameter SYSTEM (see the figure above) is directly defined in ENVIRONMENT TABLE.

Measured quantities:

Overal result ... Main result = "DONE" or "...." (not done)
t ..... Sub-result = Trip out time at selected differential current
UL/PE ..... Sub-result = Voltage between L and PE terminals measured just after pressing "START" button
UL/N ..... Sub-result = Voltage between L and N terminals measured just after pressing "START" button (the voltage is displayed just at B types)
UN/PE ..... Sub-result = Voltage between N and PE terminals measured just after pressing "START" button (the voltage is displayed just at B and EV types)
UF ..... Sub-result = Fault voltage scaled to selected nominal differential current
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for RCDt measurement:

Carry out paragraphs 1 to 3 described in chapter “Test procedure for RCD U_F@$I_{\Delta N}$ measurement” on page 53.

4) Select RCDt sub-function and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected RCDt sub-function will appear.
5) Press “EDIT” menu key to get into idle screen with extended menu keys, see the figure 43 above.
6) Select/adjust all test parameters according to available menu keys shown on the figure 43 above.
7) Check selected SYSTEM and LIM U_F and modify them if needed in ENVIRONMENT TABLE.
8) Connect test leads according to the figure below, see also HELP/CONNECTION menu. Green mains icon will be displayed when the connection is properly done and input voltages $U_{L/N}$ (B or EV type only) and $U_{L/PE}$ are within 100 … 253 VAC.

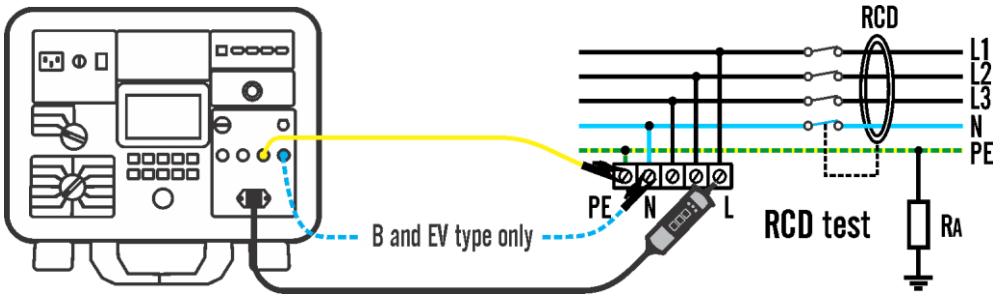


Figure 44: Connection for RCDt measurement, example

9) Press “START” button and wait the measurement to be done. See the figure below for an example of measurement result.

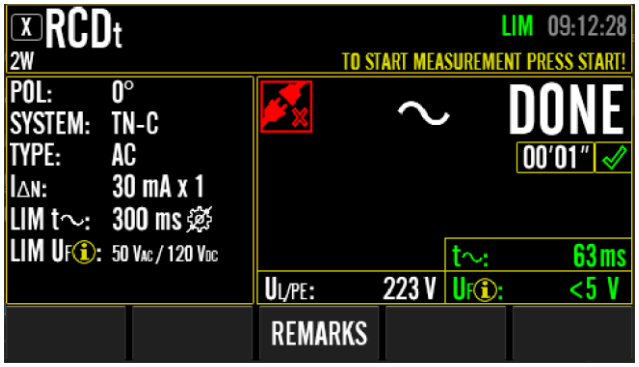


Figure 45: RCDt measurement result, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.5.3. RCD RCD IΔ (Tripping Current = Ramp Test)

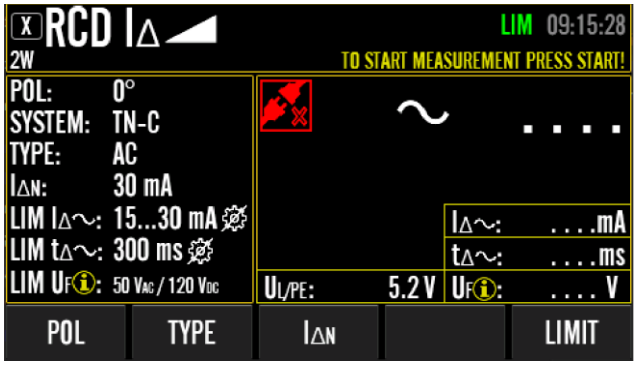


Figure 46: Idle screen in RCD IΔ measurement with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

POL (F1) = Polarity of test current ..... 0° (positive) or 180° (negative)
TYPE (F2) = Type of RCD ..... A, A S, B/B+, B/B+ S, F, A-K/A-G, AC, AC S or AC-K/AC-G
IΔN (F3) = Nom. differential current ..... 10, 30, 100, 300, 500 or 1000 mA
LIMIT (F5) = LIM IΔ, LIM tΔ and LIM UF . LIM IΔ (limit tripping current) and LIM tΔ (limit trip out time at tripping current) are indirectly defined in ENVIRONMENT TABLE and depend on selected mains SYSTEM and UNOM PHASE TO EARTH (L/PE).
LIM UF is directly defined in ENVIRONMENT TABLE.
See also the Table 11 on page 148.

Notes!

- Symbol ⚙ means the parameter is fixed (not adjustable at all) or it is indirectly adjustable through some other parameters in ENVIRONMENT TABLE (for example through mains SYSTEM and UNOM PHASE TO EARTH (L/PE)).
- Parameter SYSTEM (see the figure above) is directly defind in ENVIRONMENT TABLE.

Measured quantities:

Overal result ... Main result = "DONE" or "…." (not done)
IΔ ..... Sub-result = Triping current
tΔ ..... Sub-result = Trip out time at tripping current
UL/PE ..... Sub-result = Voltage between L and PE terminals measured just after pressing "START" button
UF ..... Sub-result = Fault voltage scaled to selected nominal differential current
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for RCD IΔ◢ measurement:

Carry out paragraphs 1 to 3 described in chapter “Test procedure for RCD UF@IΔN measurement” on page 57.

4) Select RCD IΔ◢ sub-function and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected RCD IΔ◢ sub-function will appear.
5) Press “EDIT” menu key to get into idle screen with extended menu keys, see the figure 46 above.
6) Select/adjust all test parameters according to available menu keys shown on the figure 46 above.
7) Check selected SYSTEM, UNOM PHASE TO EARTH (L/PE) and LIM UF and modify them if needed in ENVIRONMENT TABLE.
8) Connect test leads according to figure 44 on page 59, see also HELP/CONNECTION menu. Green mains icon will be displayed when the connection is properly done and input UL/N and UL/PE voltages are within 100 … 253 VAC.
9) Press “START” button and wait the measurement to be done. See the figure below for an example of measurement result.

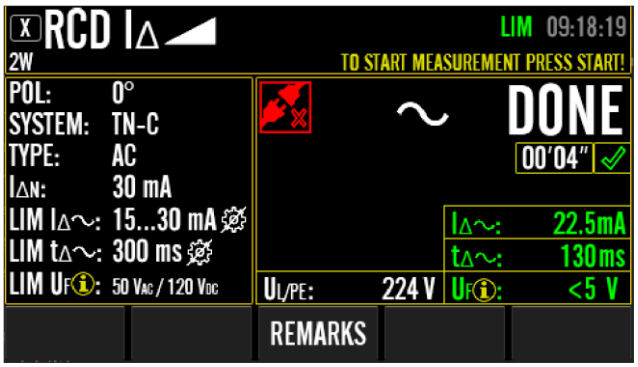


Figure 47: RCD IΔ◢ measurement result, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.5.4. RCD RCDAUTO

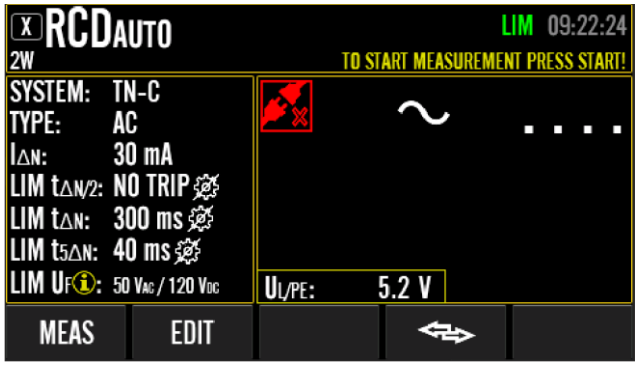


Figure 48: Idle screen in RCDAUTO measurement, example

Note!

- Use "⇦⇨" menu key to switch among three sub-result screens.

Press "EDIT" menu key to get into extended range of menu keys, see the figure below.

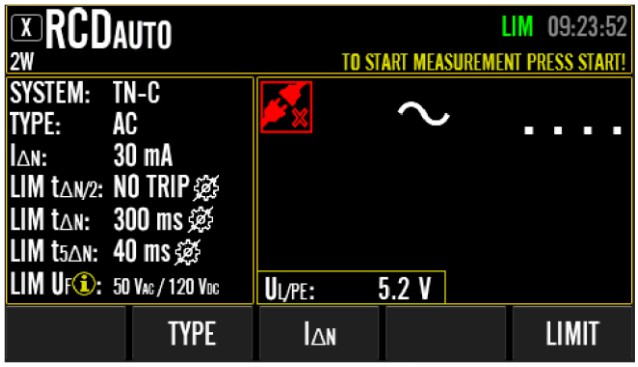


Figure 49: Idle screen in RCDAUTO measurement with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

TYPE (F2) = Type of RCD	A, A Ⓢ, A-EV, B/B+, B/B+ Ⓢ, B/B+MI, F, F-EV, A-K/A-G, AC, AC Ⓢ or AC-K/AC-G
IΔN (F3) = Nom. differential current	10, 30, 100, 300, 500 or 1000 mA
LIMIT (F5) = LIM tΔN), LIM 5tΔN and LIM UF	LIM tΔN and LIM t5ΔN are indirectly defined in ENVIRONMENT TABLE and depend on selected mains SYSTEM and UNOM PHASE TO EARTH (L/PE). LIM UF is directly defined in ENVIRONMENT TABLE.

Notes!

- Symbol ⚙ means the parameter is fixed (not adjustable at all) or it is indirectly adjustable through some other parameters in ENVIRONMENT TABLE (for example through mains SYSTEM and UNOM PHASE TO EARTH (L/PE)).
- Parameter SYSTEM (see the figure above) is directly defind in ENVIRONMENT TABLE.

Measured quantities (AC type)**:**

Overal result ..... Main result = “DONE” or “….” (not done)
$U_{L/PE}$ ..... Sub-result = Voltage between L and PE terminals measured just after pressing “START” button
t@$I_{\Delta N/2}$ (AC) ..... Sub-result = Trip out time at $I_{\Delta N/2}$ (both polarities)
t@$I_{\Delta N}$ (AC) ..... Sub-result = Trip out time at $I_{\Delta N}$ (both polarities)
t@5$I_{\Delta N}$ (AC) ..... Sub-result = Trip out time at 5$I_{\Delta N}$ (both polarities)
U_F ..... Sub-result = Fault voltage scaled to selected nominal differential current
xx’ xx’’ ..... Sub-result = Overal test duration

Measured quantities (A type)**:**

Overal result ..... Main result = “DONE” or “….” (not done)
$U_{L/PE}$ ..... Sub-result = Voltage between L and PE terminals measured just after pressing “START” button
t@$I_{\Delta N/2}$ (pulsed)..... Sub-result = Trip out time at $I_{\Delta N/2}$ (both polarities)
t@$I_{\Delta N}$ (pulsed)..... Sub-result = Trip out time at $I_{\Delta N}$ (both polarities)
t@5$I_{\Delta N}$ (pulsed)..... Sub-result = Trip out time at 5$I_{\Delta N}$ (both polarities)
t@$I_{\Delta N/2}$ (AC)..... Sub-result = Trip out time at $I_{\Delta N/2}$ (both polarities)
t@$I_{\Delta N}$ (AC)..... Sub-result = Trip out time at $I_{\Delta N}$ (both polarities)
t@5$I_{\Delta N}$ (AC)..... Sub-result = Trip out time at 5$I_{\Delta N}$ (both polarities)
U_F ..... Sub-result = Fault voltage at selected nominal differential current
xx’ xx’’ ..... Sub-result = Overal test duration

Measured quantities (B type)**:**

Overal result ..... Main result = “DONE” or “….” (not done)
$U_{L/N}$ ..... Sub-result = Voltage between L and N terminals measured just after pressing “START” button
$U_{N/PE}$ ..... Sub-result = Voltage between N and PE terminals measured just after pressing “START” button
$U_{L/PE}$ ..... Sub-result = Voltage between L and PE terminals measured just after pressing “START” button
t@$I_{\Delta N/2}$ (DC)..... Sub-result = Trip out time at $I_{\Delta N/2}$ (both polarities)
t@$I_{\Delta N}$ (DC)..... Sub-result = Trip out time at $I_{\Delta N}$ (both polarities)
t@5$I_{\Delta N}$ (DC)..... Sub-result = Trip out time at 5$I_{\Delta N}$ (both polarities)
t@$I_{\Delta N/2}$ (pulsed)..... Sub-result = Trip out time at $I_{\Delta N/2}$ (both polarities)
t@$I_{\Delta N}$ (pulsed)..... Sub-result = Trip out time at $I_{\Delta N}$ (both polarities)
t@5$I_{\Delta N}$ (pulsed)..... Sub-result = Trip out time at 5$I_{\Delta N}$ (both polarities)
t@$I_{\Delta N/2}$ (AC)..... Sub-result = Trip out time at $I_{\Delta N/2}$ (both polarities)
t@$I_{\Delta N}$ (AC)..... Sub-result = Trip out time at $I_{\Delta N}$ (both polarities)
t@5$I_{\Delta N}$ (AC)..... Sub-result = Trip out time at 5$I_{\Delta N}$ (both polarities)
U_F ..... Sub-result = Fault voltage at selected nominal differential current
xx’ xx’’ ..... Sub-result = Overal test duration

Test procedure for RCDAUTO measurement (example for AC type)**:**

Carry out paragraphs 1 to 3 described in chapter “Test procedure for RCD UF@IΔN measurement” on page 57.

4) Select RCDAUTO sub-function and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected RCDAUTO sub-function will appear, see the figure 48.
5) Press “EDIT” menu key to get into idle screen with extended menu keys, see the figure 49 above.
6) Select type of RCD (AC) to be tested by pressing “TYPE” menu key first.
7) Select/adjust all test parameters according to available menu keys shown on the figure 49 above.
8) Check selected SYSTEM, UNOM PHASE TO EARTH (L/PE) and LIM UF and modify them if needed in ENVIRONMENT TABLE.
9) Connect test leads according to figure 44 on page 59, see also HELP/CONNECTION menu. Green mains icon will be displayed when the connection is properly done and input UL/N and UL/PE voltages are within 100 … 253 VAC (UL/N is required for B and EV types only).
10) Press “START” button and wait the measurement to be done. See the figure below for an example of measurement result.

Figure 50: RCDAUTO measurement result, example

11) Check other sub-results if needed, by using “⇦⇨” menu key.
12) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during RCD measurements:

Information displayed	Description
⚠ FAULT VOLTAGE > 23VAC!	LIM UF = 25 VAC AC fault voltage higher than safety level (with reserve). The message can appear in case AC type is selected ⇒ check loop impedance.
⚠ FAULT VOLTAGE > 32VPEAK!	LIM UF = 25 VAC Pulsed fault voltage higher than safety level (with reserve). The message can appear in case A type is selected ⇒ check loop impedance.
⚠ FAULT VOLTAGE > 55VDC!	LIM UF = 25 VAC DC fault voltage higher than safety level (with reserve). The message can appear in case B type is selected ⇒ check loop impedance.
⚠ FAULT VOLTAGE > 45VAC!	LIM UF = 50 VAC AC fault voltage higher than safety level (with reserve). The message can appear in case AC type is selected ⇒ check loop impedance.
⚠ FAULT VOLTAGE > 65VPEAK!	LIM UF = 50 VAC Pulsed fault voltage higher than safety level (with reserve). The message can appear in case A type is selected ⇒ check loop impedance.
⚠ FAULT VOLTAGE > 110VDC!	LIM UF = 50 VAC DC fault voltage higher than safety level (with reserve). The message can appear in case B type is selected ⇒ check loop impedance.
⚠ VOLTAGE FAILED DURING MEASUREMENT!	Mains voltage was disconnected during the measurement ⇒ check the connection of test leads or impedance of tested loop!
	Internal transistors are overheated ⇒ please wait the tester to cool down and the symbol to disapear!

20.5.5. RCD RCM (Residual Current Monitoring)

RCM is a protection device similar to RCD that constantly monitor residual currents in electrical systems. In case the residual current exceeds a certain value, the RCM gives a visual or sound alarm without disconnecting mains system. Some RCM types will switch off mains system if the residual current exceeds safety value.

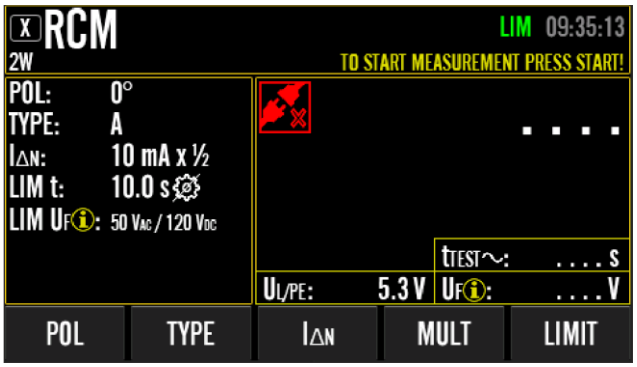


Figure 51: Idle screen in RCM measurement with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

POL (F1) = Polarity of test current ..... 0° (positive) or 180° (negative)
TYPE (F2) = Type of RCM ..... A or B
$I_{\Delta N}$ (F3) = Nom. differential current ... 10, 30, 100, 300 or 500 mA
MULT (F4) = Multiplyer ..... $I_{\Delta N} \times ½$ or $I_{\Delta N} \times 1$
LIMIT (F5) = LIM t (signalling time)
and LIM U_F..... LIM t@IΔN/2 is set to 10.0 s (fixed value),
LIM t@IΔN is adjustable 0.0 … 10.0 s, standard value 10 s,
LIM U_F is directly defined in ENVIRONMENT TABLE.

Measured quantities:

Overal result ... Main result = "DONE" or "…." (not done)
$U_{L/N}$ ..... Sub-result = Voltage between L and N terminals measured just after pressing "START" button (displayed at B type only)
$U_{N/PE}$ ..... Sub-result = Voltage between N and PE terminals measured just after pressing "START" button (dislayed at B type only)
$U_{L/PE}$ ..... Sub-result = Voltage between L and PE terminals measured just after pressing "START" button
t_{TEST} ⎓ ..... Test time (DC reaction time) (displayed at B type only)
t_{TEST} ~ ..... Test time (AC reaction time)
U_F ..... Sub-result = Fault voltage at selected nominal differential current
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for RCM measurement:

Carry out paragraphs 1 to 3 described in chapter “Test procedure for RCD U_F@$I_{\Delta N}$ measurement” on page 57.

4) Select RCM sub-function and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected RCM sub-function will appear.
5) Press “EDIT” menu key to get into idle screen with extended menu keys, see the figure 51 above.
6) Select/adjust all test parameters according to available menu keys shown on figure 51 above.
7) Check selected LIM U_F and modify it if needed in ENVIRONMENT TABLE.
8) Connect test leads according to the figure below, see also HELP/CONNECTION menu. Green mains icon will be displayed when the connection is properly done and input voltage $U_{L/N}$ (in case of B type only) and $U_{L/PE}$ voltage is within 100 … 253 VAC.

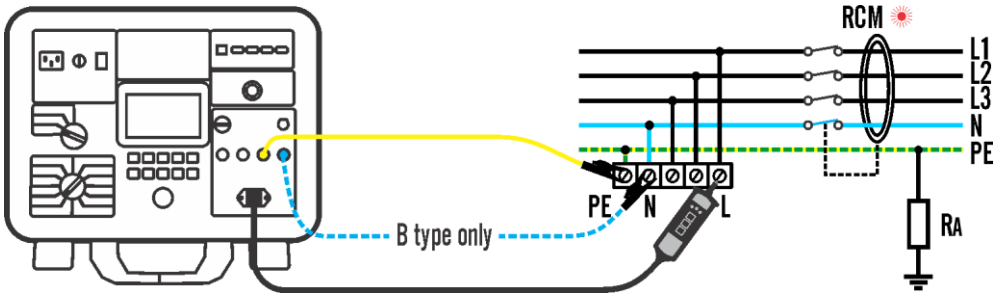


Figure 52: Connection for RCM measurement, example

9) Press “START” button to start the measurement.

Procedure for A type:

The measurement will be done in one test step.

After pressing “START” button the tester starts to generate constant pulsed current for 11 s (current according to preset $I_{\Delta N}$ and multiplyer) and test time $t_{TEST\sim}$ starts to run. During above test observe tested RCM and press “STOP” button as soon as visual or acoustic signal generated by tested RCM arises. The measurement will be stopped and test result will be displayed, see the figure below.

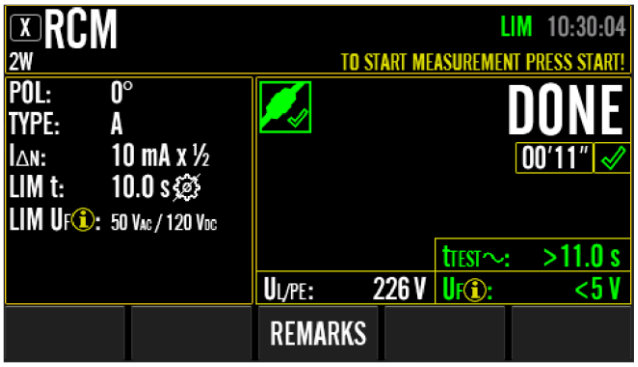


Figure 53: RCM (A type) measurement result, example

Procedure for B type:
The measurement will be done in two test steps.

First test step (DC ramp and then constant DC current):
After pressing “START” button the tester starts to generate DC ramp current for 5 s (20 % to 50 % of IΔN (MULT = IΔN × ½) or 20 % to 200 % of IΔN (MULT = IΔN × 1)) and “RAMPING…” message is displayed. After reaching final ramp current (max value), the same constant current continues to be generated for additional 11 s and test time tTEST⎓ starts to run, see the figure below.

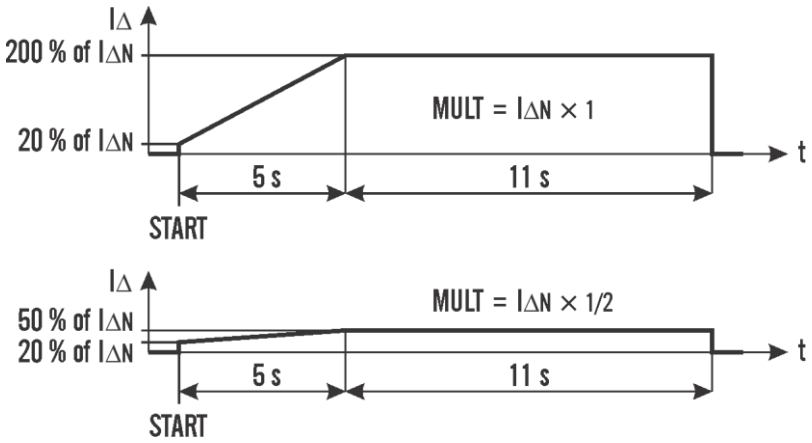


Figure 54: Generated DC test current

During the test observe tested RCM and press “STOP” button as soon as visual or acoustic signal generated by tested RCM arises.

Second test step (AC constant current):
After finishing the first test step the tester automatically starts with the second one i.e. with AC constant current for 11 s (current according to preset IΔN and multiplyer) and test time tTEST∼ starts to run. During the test observe tested RCM and press “STOP” button as soon as visual or acoustic signal generated by tested RCM arises.

After finishing the third test step the measurenent will be stopped and final measurement result will be displayed, see the figure below.

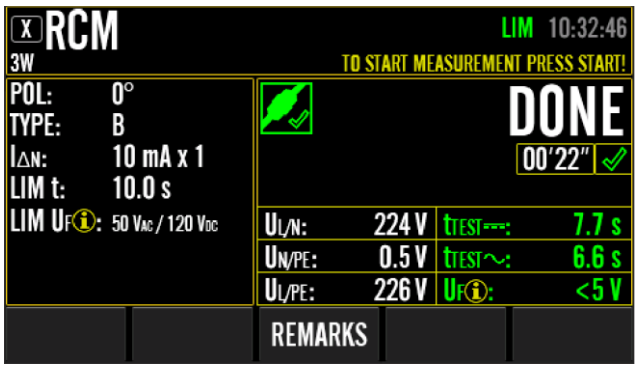


Figure 55: RCM (B type) measurement result, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during RCM measurements:

See the table “Specific information that may be displayed during RCD measurements” on page 65.

20.5.6. RCD IMD (Insulation Monitoring Device)

IMD is a device used in IT mains systems (for example hospitals) that constantly watch insulation resistance between L/N terminals and PE. In case the insulation is dangerously decreased, the IMD gives a visual or sound alarm without disconnecting mains voltage.

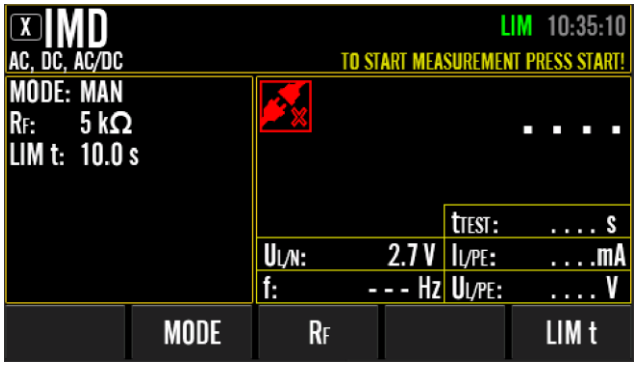


Figure 56: Idle screen in IMD measurement (MAN mode) with extended range of menu keys (after pressing “EDIT” menu key), example

Adjustable/selectable test parameters (MAN mode) (keys available after pressing “EDIT” menu key)**:**

MODE (F2) = Test mode ..... MAN (preset R_F resistance) or AUTO (automatic decreasing of R_F resistance)

R_F (F3) = Loading fault resistance..... 750 kΩ down to 5 kΩ, see technical specifications in chapter “IMD TEST mode (IT systems)” on page 175

LIM t (F5) = Limit test time ..... Adjustable 1.0 … 10.0 s, standard value 10.0 s

Adjustable/selectable test parameters (AUTO mode) (keys available after pressing “EDIT” menu key)**:**

MODE (F2) = Test mode ..... MAN (preset R_F resistance) or AUTO (automatic decreasing of R_F resistance)

R_{START} (F3) = Start fault resistance... Selectable 750 kΩ down to 5 kΩ, see technical specifications in chapter “IMD TEST mode (IT systems)” on page 175.

LIM R (F5) = Limit fault resistance (lowest alloved value) ..... Selectable, the same values are available as listed for R_{START} parameter above.

LIM t (F5) = Limit test time..... Adjustable 1.0 … 10.0 s, standard value 10.0 s

Measured quantities (MAN mode)**:**

Overal result ... Main result = “DONE” or “….” (not done)

t_{TEST} ..... Sub-result = Test time

$U_{L/N}$ ..... Sub-result = Voltage between L and N terminals, measured just after pressing “START” button

f ..... Sub-result = Frequency of mains $U_{L/N}$ voltage, measured just after pressing “START” button

$I_{L/PE}$..... Sub-result = Current flowing from L1 to PE terminal via R_F resistor during the measurement, calculated value $I_{L/PE} = U_{L/PE} / R_F$

$U_{L/PE}$ ..... Sub-result = Voltage between L and PE terminals, measured during the measurement
xx' xx'' ..... Sub-result = Overal test duration

Measured quantities (AUTO mode)**:**

Overal result ... Main result = "DONE" or "...." (not done)
R_F ..... Sub-result = Fault resistance value where IMD activated alarm signal (STOP button was pressed)
t_{TEST} ..... Sub-result = Test time at displayed R_F value
$U_{L/N}$ ..... Sub-result = Voltage between L and N terminals, measured just after pressing "START" button
f ..... Sub-result = Frequency of mains $U_{L/N}$ voltage, measured just after pressing "START" button
$I_{L/PE}$ ..... Sub-result = Current flowing from L1 to PE terminal via R_F resistor during the measurement, calculated value $I_{L/PE} = U_{L/PE} / R_F$
$U_{L/PE}$ ..... Sub-result = Voltage between L and PE terminals, measured during the measurement
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for IMD measurement (MAN mode)**:**

Carry out paragraphs 1 to 3 described in chapter "Test procedure for RCD $U_F@I_{\Delta N}$ measurement" on page 57.

4) Select IMD sub-function and confirm it by pressing "↵" menu key ⇒ idle screen of currently selected IMD sub-function will appear.
5) Press "EDIT" menu key to get into idle screen with extended menu keys, see the figure 56 above.
6) Select MAN mode by pressing "MODE" menu key first ⇒ idle screen of currently selected IMD sub-function (MAN mode) will appear.
7) Select/adjust all test parameters according to available menu keys shown on the figure 56 above.
8) Connect test leads according to figure below, see also HELP/CONNECTION menu.
   Green mains icon will be displayed when the connection is properly done and input voltage $U_{L/N}$ is within 100 … 253 VAC.

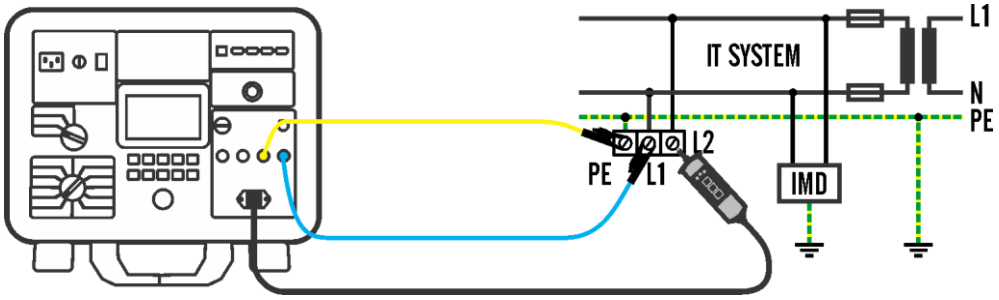


Figure 57: Connection for IMD measurement, example

9) Press "START" button and observe visual or sound alarm generated by tested IMD.
   Tester applies resitor R_F between (L1 or Commander) and PE test terminals and measurement time starts to run from 0.0 up to 60.0 s.
   As soon as the alarm arises, press "STOP" button again to stop the measurement.
   Measurement will be stopped and result displayed, see an example on the figure below.

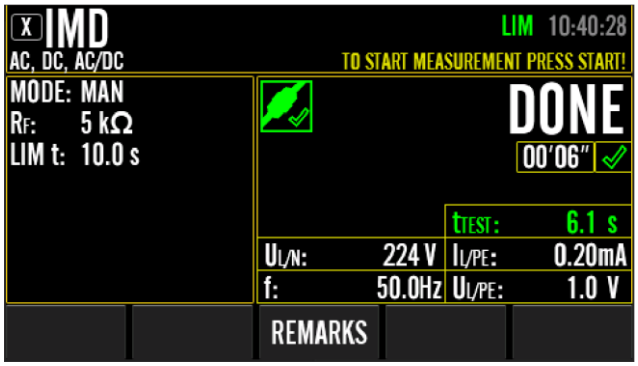


Figure 58: IMD (MAN mode) measurement result, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Note!

- Repeat the test also at reversed polarity of L and N test terminals. Reverse the polarity manually, tester will not reverse it automatically.

Test procedure for IMD measurement (AUTO mode)**:**

Carry out paragraphs 1 to 3 described in chapter “Test procedure for RCD U_F@$I_{\Delta N}$ measurement” on page 57.

4) Select IMD sub-function and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected IMD sub-function will be displayed.
5) Press “EDIT” menu key to get into idle screen with extended menu keys, see the figure 56 on page 69.
6) Select AUTO mode by pressing “MODE” menu key first ⇒ idle screen of currently selected IMD sub-function (AUTO mode) will be displayed, see the figure below.

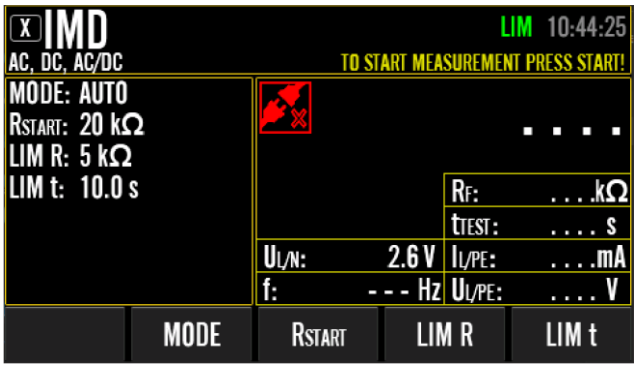


Figure 59: Idle screen in IMD measurement (AUTO mode) with extended range of menu keys (after pressing “EDIT” menu key), example

7) Select/adjust all test parameters according to available menu keys shown on the figure above.
8) Connect test leads according to the figure 57, see also HELP/CONNECTION menu.
Green mains icon will be displayed when the connection is properly done and input voltage $U_{L/N}$ is within 100 … 253 VAC.
9) Press “START” button and observe sound or visual alarm generated by tested IMD.
Tester starts with the first test step i.e. RSTART resistor applied between (L1 or Commander) and PE test terminals. Currently applied fault resistance is displayed as a sub-result R_F, see the figure below. Measurement time starts to run from zero up to set test time t_{TEST} plus 3 seconds and it is displayed as sub-result t_{TEST}, see the figure below.
If there is no detection of alarm signal on tested IMD during the first test step (no activation of “STOP” button), then tester will automatically decrease fault resistance for one step and start the second test step. The procedure will be continued until “STOP” button is pressed.
As soon as the alarm arises, press “STOP” button again to stop the measurement.
Measurement result will be displayed, see an example on the figure below.

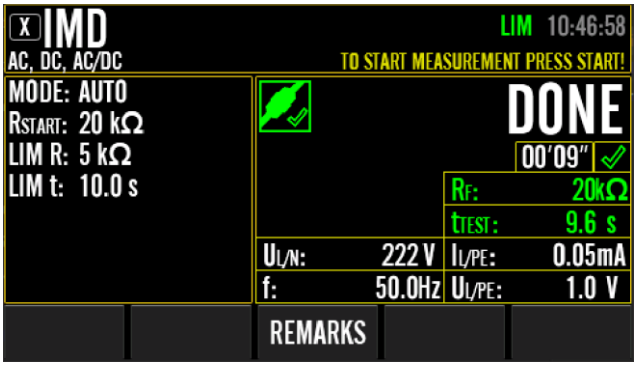


Figure 60: IMD (AUTO mode) measurement result, example

13) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Note!

- Repeat the test also at reversed polarity of L and N test terminals. Reverse the polarity manually, tester will not reverse it automatically.

Specific information that may be displayed during IMD measurements:

Information displayed	Description
⚠ IT INSULATION PROBLEM! VOLTAGE $U_{L1/PE}$ TOO HIGH!	Voltage $U_{L1/PE}$ higher than $U_{L1/PE}$ max (too high power on internal resistor R_F). *Improve the insulation between L2 and PE terminals of tested installation!* Note! • Max. voltage $U_{L1/PE}$ depends on used R_F resistor, see below: R_F = 5 kΩ, $U_{L1/PE}$ max = 120 V R_F = 10 kΩ, $U_{L1/PE}$ max = 160 V R_F = 15 kΩ, $U_{L1/PE}$ max = 180 V R_F = 20 ... 350 kΩ, $U_{L1/PE}$ max = 200 V R_F = 400 ... 750 kΩ, $U_{L1/PE}$ max = 253 V
⚠ PE SOCKET NOT GROUNDED!	PE socket is not grounded after pressing “START” button. *Ground PE socket.*

20.6. MΩ Insulation Resistance RINS

Insulation Resistance is the resistance measured between PE terminal on mains input (schuko plug or three-phase plug or PE terminal in connection box if the UUT is permanently connected) and short-circuited active terminals (L1, L2, L3, N) of the UUT.
This test could be performed with or without Commander.

⚠ Warnings

- ☞ **Disconnect mains voltage before starting any Insulation resistance test!**
- ☞ **Test voltage is settable to a value between 50 V and 1000 VDC. Do not touch the appliance during the insulation test! If the test fails, any metal part of the appliance could become live!**
- ☞ **Always make sure that the test has completed before disconnecting the test leads to ensure that all capacitances have discharged!**

⚠ Cautions

- ☞ **Do not perform the Insulation test on UUTs that failed visual inspection and protective bonding resistance test.**
- ☞ **Please ensure that mains switch of the UUT is closed during the test.**
- ☞ **The insulation test may not be suitable for some UUTs (i.e. electronic devices or IT-devices). For these UUTs an alternative test may be conducted such as touch leakage current, earth leakage current or substitute leakage current. It is essential to refer to the local UUT test standards and/or reference material for the safe applicability of these alternative tests.**
- ☞ **Test voltage higher than 250 V may not be suitable for some UUTs that contain overvoltage protection devices (e.g. varistors) in their input circuits. Please refer to the local test standards and/or follow the manufacturer's recommendations.**

There are two measurements availble (after pressing "MEAS" menu key):
- RINS (insulation resistance measurement)
- RINS◢ (ramp mode for overvoltage protection testing)

20.6.1. MΩ RINS measurement:

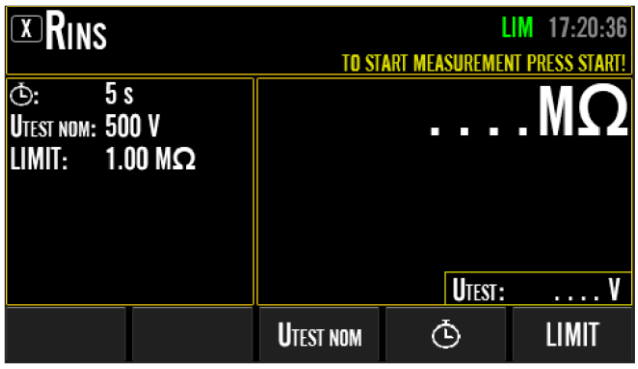


Figure 61: RINS idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

UTEST NOM (F3) = Nominal test voltage* ... 50, 100, 250, 500, 1000 V or USER adjustable 50 … 1000 V in steps of 1 V
⏱ (F4) = Measurement time ..... Adjustable 4 … 300 s
LIMIT (F5) = LIM RINS ..... Adjustable 0.00 … 50.0 MΩ in steps of 0.01 MΩ, standard values** 0.25 MΩ, 0.30 MΩ, 0.50 MΩ, 1.00 MΩ and 2.00 MΩ

* Valid if switch #1 is in "All" position.
In "Machine" position, 250 V, 500 V, 1000 V and USER adjustable 250 … 1000 V are available.
In "Switchgear Assemblies" position, 500 V, 1000 V and USER adjustable 500 … 1000 V are available.

** Valid if switch #1 is in "All" position.
In "Machine" or "Switchgear Assemblies" position, 0.50 MΩ and 1.00 MΩ are available.

Measured quantities:

RINS ..... Main result = Insulation resistance
UTEST ..... Sub-result = Actual test voltage applied
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for RINS measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1, 2 or 3).
2) Select Insulation Resistance measurement by setting the rotary switch #2 to MΩ position ⇒ idle screen of currently selected RINS measurement will appear.
3) Press "MEAS" menu key, select RINS measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected RINS function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected RINS measurement with extended range of menu keys will be displayed, see the figure above.
5) Select/adjust all test parameters according to available menu keys shown on the figure above.
6) Connect test leads to a UUT according to one of the figures below or see available figures in HELP/CONNECTION menu.

Cautions!

☞ **Before connecting test leads to a UUT, obligatory assure there is no voltage applied to the UUT, otherwise test result may be affected!**

☞ **Disconnect mains cable (unscrew mains terminals) in case permanently connected machine is to be tested.**

Notes!

- Connect yellow test leady always to grounded part of the UUT (PE), otherwise the result may be affected by internal resistance of the MST-204 Tester.
- Use meaningfully equivalent connections for the other UUTs than shown below, like for example switchgears.

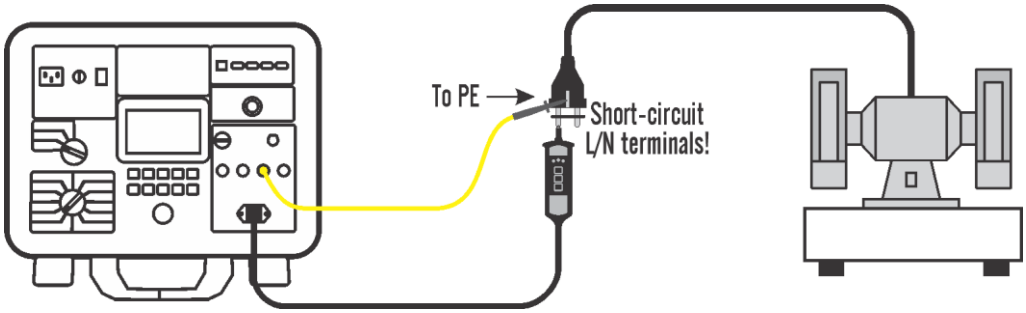


Figure 62: Insulation resistance test connection to the machine with mains plug.

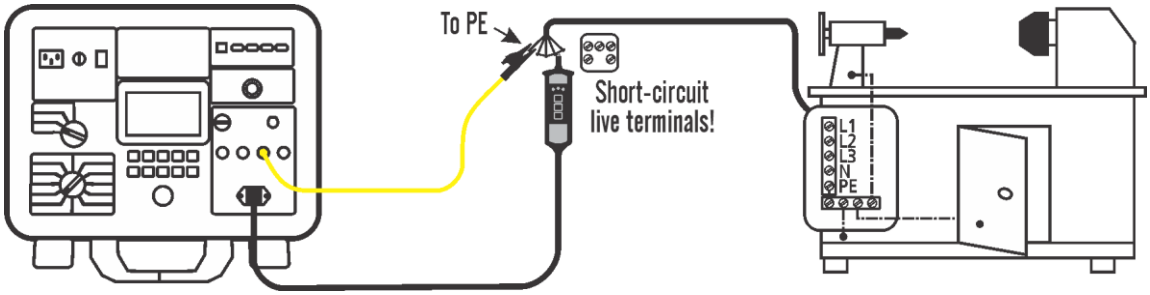


Figure 63: Insulation resistance test connection to permanently connected machine.

7) Press “START“ button (on MST-204 Tester or on Commander) to start the measurement.
8) Stop the measurement by pressing “STOP“ button (or wait set timer to stop it), discharging of the UUT will be done and then final measurement result will be displayed, see an example on the figure below.

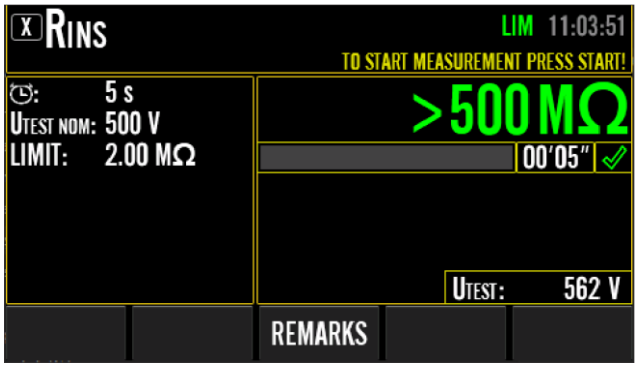


Figure 64: Final result in RINS measurement, example

Notes!

- Discharging of the UUT is started automatically after finishing the measurement and it lasts until the voltage drops below 60 VDC! Discharging time depends on used test voltage and capacitance of the UUT.

Warning!

- **Do not disconnect test leads until ”DISCHARGE” message disappears!**

9) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during RINS measurements:

Information displayed	Description
⚠ USE SOCKETS Ω/MΩ AND COM!	Ω/MΩ and/or COM test sockets are not occupied with test leads ⇒ connect test leads.
⚠ EXTERNAL VOLTAGE!	See the chapter “External Voltage Display” on page 31.
DISCHARGING	This message is displayed after finishing the measurement and it is present until the UUT is discharged ⇒ leave test leads connected until the message disappears.

20.6.2. MΩ RINS measurement (overvoltage protection test):

Test voltage always starts at 50 V and it is continuously rised up to LIM UMAX + 20% (limit in MENU / LIMIT ON/OFF menu enabled i.e. LIM ON) respectively up to USTOP (adjustable 60 … 1200 V) (limit in MENU ON/OFF disabled i.e. LIM OFF). Test is stopped and final result (test voltage @1 mA) is displayed when test current of 1 mA is reached.

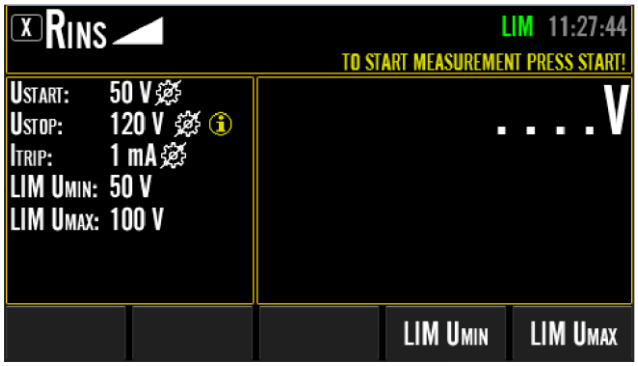


Figure 65: RINS idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

@ LIM ON (inside MENU):
LIM UMIN (F4) = Low limit value ..... Adjustable 50 … 1000 V, standard value 50 V
LIM UMAX (F5) = High limit value..... Adjustable 50 … 1000 V, standard value 100 V

@ LIM OFF (inside MENU):
No directly adjustable parameters here (adjustable through menu keys), see the notes below

Notes!

- Symbol ⚙ means the parameter is fixed (not adjustable at all) or it is calculated from other parameters.
- Parameter USTART (start voltage) is set to 50 V (fixed value).
- Parameter USTOP (stop voltage) is calculated from LIM UMAX (USTOP = LIM UMAX + 20 %).
- Parameter ITRIP (threshold current) is set to 1 mA (fixed value).

Measured quantities:

Threshold voltage .. Main result = Test voltage @1 mA or NO TRIP
xx' xx'' ..... Sub-result = Overal test duration

Test procedure for RINS measurement:

Carry out paragraphs 1 and 2 described in chapter "Test procedure for RINS measurement" on page 76.

3) Press "MEAS" menu key, select RINS measurement and confirm it by pressing "↵" menu key ⇒ display will turn to measurement screen of just selected RINS function.
4) Press "EDIT" menu key to get into extended range of menu keys, see the figure above.
5) Select/adjust all test parameters according to available menu keys shown on the figure above.
6) Connect test leads to a UUT according to the figure below or see available figures in HELP/CONNECTION menu.

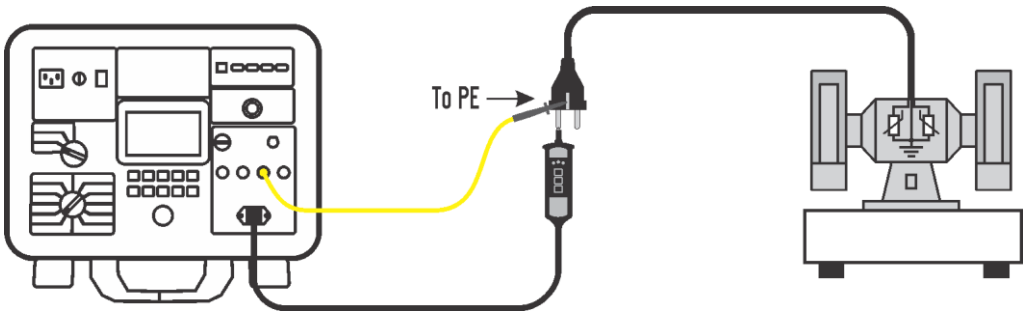


Figure 66: Overvoltage protection test connection in machine with mains plug.

7) Press “START“ button (on MST-204 Tester or on Commander) to start the measurement and wait untill the measurement is finished and result displayed, see the figure below.

Note!

- Test voltage in form of increasing value is displayed during the test. Test voltage increment depends on actual test voltage value and it is as follows:

Test voltage range (V)	Increment (V)
50 … 100	10
100 … 1200	20

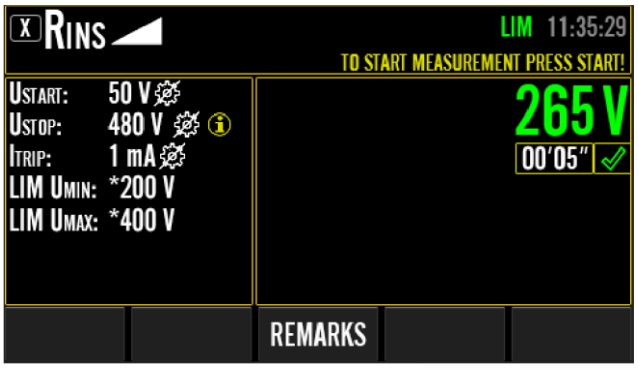


Figure 67: Final result in RINS measurement, example

8) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during RINS / RINS measurements:

Information displayed	Description
⚠ USE SOCKETS Ω/MΩ AND COM!	Ω/MΩ and/or COM test sockets are not occupied with test leads ⇒ *connect test leads.*
⚠ EXTERNAL VOLTAGE!	See the chapter “External Voltage Display” on page 31.
⚠ LIMIT UMIN SHOULD BE LOWER THAN LIMIT MAX!	RINS measurement: Set LIMIT UMIN is higher than set LIMIT UMAX ⇒ *adjust the limits accordingly.*
DISCHARGING	The message is displayed after finishing the measurement and it is present until the UUT is discharged (time depends on the charge of capacitance) ⇒ *leave test leads connected until the message disappears.*

20.7. HV HV Dielectric Test

HV dielectric test can be done by using the MST-204 Tester in combination with HVA-204 High-Voltage Adapter. All operations like adjustment of test parameters, adjustment of limit values, displaying of test results, memorizing of test results etc. will be done on MST-204 Tester, while HV adapter is used as a HV generator.

Safety information and warnings

- ☞ **Test voltage is adjustable within 250 and 5100 VAC, danger of electric shock.**
- ☞ **Do not touch the object under HV dielectric test – live dangerous!**
- ☞ **Please refer to all safety instructions and warnings given in this User manual and in User manual for HVA-204 High-Voltage Adapter!**

See the table below for correlation between used STANDARD (= UUT family = rotary switch #1), measurements, modes, test parameters, main results and sub-results.

STD (Rotary switch #1)	MEASUREMENT	MODE	Adjustable parameters	Main result	Sub-results
All Test Voltage adjustable 250 … 5100 V	NO RAMP	BURN	MODE UTEST NOM LIMIT (I)	I	IMAX UTEST
		TRIP	ITRIP MODE UTEST NOM LIMIT (TRIPOUTS)	UTEST MAX	% of UTEST NOM TRIPOUTS PULSES
		TRIP OUT	MODE UTEST NOM TIME LIMIT (I)	I	IMAX UTEST
		TRIP × mA	ITRIP MODE UTEST NOM TIME LIMIT (I)		
	RAMP ⊓ (RAMP UP)	TRIP OUT	MODE U TIME LIMIT (I)		
		TRIP × mA	ITRIP MODE U TIME LIMIT (I)		
	RAMP ⊓\ (RAMP UP/DOWN)	TRIP OUT	MODE U TIME LIMIT (I)		
		TRIP × mA	ITRIP MODE U TIME LIMIT (I)		

<table>
<tr><td rowspan="3">Machine

Test Voltage adjustable 1000 … 2000 V (depends on UNOM L/PE)</td><td rowspan="3">NO RAMP (fixed = not selectable)</td><td>BURN</td><td rowspan="2">MODE
UTEST NOM
LIMIT (I)</td><td rowspan="3">I</td><td rowspan="3">IMAX
UTEST</td></tr>
<tr><td>TRIP OUT</td></tr>
<tr><td>TRIP × mA</td><td>ITRIP
MODE
UTEST NOM
LIMIT (I)</td></tr>
</table>

Switchgear Assemblies	TYPE TEST HVAC MAIN CIRCUITS: Test voltage (1000 … 2200 V) depends on selected UNOM PHASE TO PHASE (L/L) defined in ENVIRONMENT TABLE AUXILIARY CIRCUITS: Test voltage (250 … 2200 V) depends on selected UNOM PHASE TO PHASE AUX (L/L) defined in ENVIRONMENT TABLE Note! See the Table 6 below.	BURN TRIP OUT	MODE UTEST NOM LIMIT (I)	I	IMAX UTEST
		TRIP × mA	ITRIP MODE UTEST NOM LIMIT (I)		
	TYPE TEST ALTERNATIVE SURGE Test voltage (2100 … 5100 V) depends on rated voltage against GND and CAT rating, both defined in ENVIRONMENT TABLE Notes! • Test voltage within 2100 and 5100 V can be entered also directly, please use "UTEST NOM" option in this case. • See the Table 7 below.	BURN TRIP OUT	MODE UTEST NOM LIMIT (I)		
		TRIP × mA	ITRIP MODE UTEST NOM LIMIT (I)		
	TYPE TEST HVAC ENCL./OP. HANDL. Test voltage (1500 … 3300 V) depends on selected UNOM PHASE TO PHASE (L/L) defined in ENVIRONMENT TABLE Notes! • Test voltage within 1500 and 3300 V can be entered also directly, please use "UTEST NOM" option in this case. • See the Table 8 below.	BURN TRIP OUT	MODE UTEST NOM LIMIT (I)		
		TRIP × mA	ITRIP MODE UTEST NOM LIMIT (I)		
	ROUTINE TEST HVAC See test voltages in TYPE TEST HVAC above.	BURN TRIP OUT	MODE UTEST NOM LIMIT (I)		
		TRIP × mA	ITRIP MODE UTEST NOM LIMIT (I)		

Table 5: Available standards, measurements, modes, test parameters and test results

UNOM PHASE TO PHASE (L/L) UNOM PHASE TO PHASE AUX (L/L) (V)	UTEST NOM (MAIN CIRCUITS) (V)	UTEST NOM (AUXILIARY CIRCUITS) (V)
1 … 12	1000	250
13 … 60	1000	500
61 … 300	1500	1500
301 … 690	1890	1890
691 … 800	2000	2000
801 … 1000	2200	2200

Table 6. Nominal test voltages UTEST NOM in Switchgear standard, TYPE TEST HVAC measurement

Rated voltage against GND (V)	UTEST NOM (V)			
	CAT I	CAT II	CAT III	CAT IV
50	-	-	-	-
100	-	-	-	2100
150	-	-	2100	3400
300	-	2100	3400	5100
600	2100	3400	5100	×

Table 7. Nominal test voltages UTEST NOM in Switchgear standard, TYPE TEST ALTERNATIVE SURGE measurement

Notes!

- Symbol “-“ in above table means test voltage is not definded in standard.
- Symbol “×” in above table means required test voltage is too high, the test can not be done with HVA-204 Adapter.

UNOM PHASE TO PHASE (L/L) (V)	UTEST NOM (V)
1 … 60	1500
61 … 300	2250
301 … 690	2835
691 … 800	3000
801 … 1000	3300

Table 8. Nominal test voltages UTEST NOM in Switchgear standard, TYPE TEST HVAC ENCL./OP. HANDL measurement

20.7.1. HV Explanation of Available Measurements

(rotary switch #1 in “All” position)

20.7.1.1. HV NO RAMP measurement

Test voltage will be applied to test guns in a jump from zero to preset test voltage 3 seconds after pressing PEDAL trigger (or “START” switch on both HV guns) and will be switched off immediatelly after releasing the PEDAL trigger (or “START” switch on HV guns), see graphic explanation on instruction card under the case cover of HVA-204 Adapter. Delay time of 3 seconds mentioned above is implemented in order to establish test circitry inside the Adapter and also to enable the operator to apply test guns to UUT before test voltage is generated and timer starts to run.

There are four available test modes:

- BURN
- /\/\/\ TRIP:
- TRIP OUT
- TRIP × mA

BURN mode:

Test voltage will be applied to test guns regardless of the value of leakage current. Even in case of short circuit the test will not be stoped, take care to respect INTERMITTENT use in this case, see the techical specifications in User Manual HVA-204 High-Voltage Adapter on page 261. Limit leakage current can be adjusted to 1 … 100 mA and it is used for final evaluation of test result only.

This mode shall be used when for example the weakest point of the UUT’s insulation is to be marked (burnt).

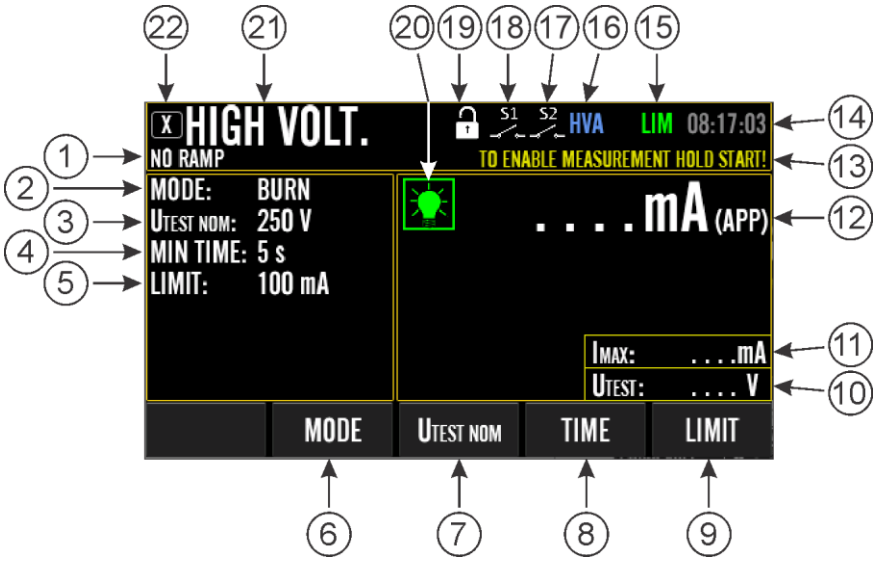


Figure 68: HV (NO RAMP measurement, BURN mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

1 ..... Selected MEASUREMENT (NO RAMP, RAMP/‾| (RAMP UP) or RAMP/‾\ (RAMP UP/DOWN).
2 ..... Selected MODE (BURN, /\/\/\ TRIP, TRIP OUT or TRIP × mA).
3 ..... Set nominal test voltage UTEST NOM (250 … 5100 V).
4 ..... Minimal required test time MIN TIME (fixed value 5 s or 1 s or adjustable 1 … 60 s, depends on selected standard, see the notes below.

5 ..... Limit value of leakage current (sub-result) (adjustable 1 … 100 mA), standard value 100 mA. This limit value serves for judging of test result only, test will not be stopped even if leakage current exceeds set limit value.
6 ..... "MODE" menu key (BURN, ⩘ TRIP, TRIP OUT or TRIP × mA).
7 ..... "UTEST NOM" menu key.
8 ..... "TIME" menu key, value 1 … 60 s can be selected.
9 ..... "LIMIT" menu key, value 1 … 100 mA can be selected. Max. leakage current IMAX (sub-result) or actual leakage current I (main result) can be judged here.
10 .... Sub-result UTEST (actual test voltage during the test, last value before finishing the test will be displayed.
11 .... Sub-result IMAX (max. value of main result during the test).
12 .... Main result I (leakage current), apparent value (suffix APP). Apparent or active character of displayed result can be selected in MODE selection screen.
13 .... Instruction how to enable the test. Press "START" button for 2 seconds ⇒ test system will get to "ready" mode (red warning lamp will go ON) meaning, the test system is ready to start the test by using PEDAL trigger (or "START" switch on both HV guns). "Ready" mode is available for 30 seconds, then "START" button is required again.
14 .... Real time.
15 .... LIM symbol. Present symbol means general limits are enabled, see the instructions in chapter "LIMIT ON/OFF" on page 179.
16 .... HVA symbol. Present symbol means HVA-204 Adapter is connected to MST-204 Tester.
17 .... Safety Circuit 2 status (open or closed), see the User Manual HVA-204 Adapter, chapter "SAFETY CIRCUIT 1 / 2 sockets" on page 19. For normal operation of HV function the switch must be closed if it is enabled in MENU / HV SAFETY / SAFETY CIRCUIT 2 menu.
18 .... Safety Circuit 1 status (open or closed), see the User Manual HVA-204 Adapter, chapter "SAFETY CIRCUIT 1 / 2 sockets" on page 19. For normal operation of HV function the switch must be closed if it is enabled in MENU / HV SAFETY / SAFETY CIRCUIT 1 menu.
19 .... Safety lock status (HV function unlocked or locked). For normal operation of HV function the tester must be unlocked.
20 .... Warning lamp status (red/green lamp is ON ⇒ red/green symbol is present). The symbol is especially actual if red/green warning lamp is not used.
21 .... Name of selected function (HIGH VOLTAGE).
22 .... Step number in "TEST PLANS" or in "MEMORIES" (no meaning in single measurements)

Notes!

- Parameter MIN TIME (see above figure) is used for evaluation of test result only. If test time is higher or equal to displayed MIN TIME value and there was no flashover during the test (leakage current lower than set limit value), then final result is judged as PASS in green. If test time is shorter than displayed MIN TIME value and there was no flashover during the test, then final result is judged as PASS in yellow = conditionally PASS. If leakage current is higher than set limit value (even just temporarily), then final result is judged as FAIL in red.
- MIN TIME depends on selected standard and it is as follows:
  - Adjustable 1 … 60 s (standard "All")
  - 5 s (standard "Switchgear Assemblies")
  - 1 s (standard "Machine")
- Max leakage current IMAX (sub-result) or actual leakage current I (main result) can be judged here. Select wished limit by pressing "LIMIT" menu key first.

- See graphic explanation of the mode on instruction card under the case cover of HVA-204 Adapter.

TRIP mode:

Test voltage will be generated in pulses. The test voltage in each pulse starts at zero and it is gradually increased up to set value (if set limit leakage current is not reached during the pulse test) or up to the value where set leakage current is reached. The cycles are periodic.
This mode shall be used when max. withstanding voltage of the UUT's insulation is to be defined.

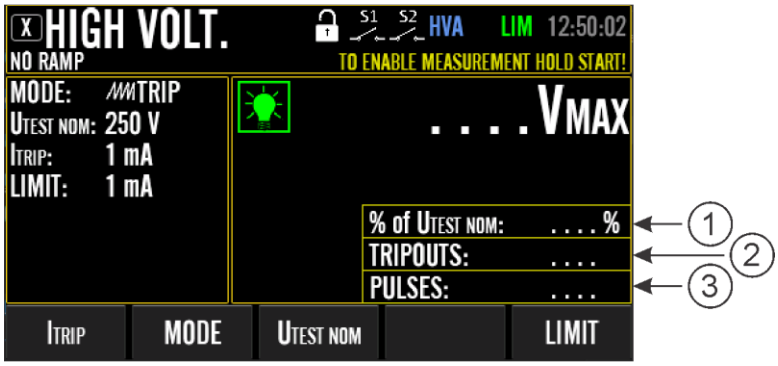


Figure 69: HV (NO RAMP measurement, TRIP mode) idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

1 ..... Value of reached test voltage during the pulse test before flashover occures (= max. withstanding voltage) in % of UTEST NOM.
Example: If UTEST NOM is set to 5100 V and max. withstanding voltage is 3000 V, then this value will be displayed as 59 %.

2 ..... Number of tripouts (flashovers). If flashover occures in each pulse test, then this number is equal to the total number of pulses.

3 ..... Total number of pulses.

Notes!

- TRIPOUTS (sub-result) can be judged here. If at least one tripout occures during the whole test, then final result will be judged as failed (red cross under main result) and vice versa, if no tripout occures, final result will be judged as passed (green hook under main result). Select the judgement by pressing "LIMIT" menu key first.
- See graphic explanation of the mode on instruction card under the case cover of HVA-204 Adapter.

TRIP OUT mode:
Test voltage will be applied to test guns and will be automatically switched off when PEDAL (or "START" switches on HV guns) is released or when set test time elapses (adjustable 1 … 60 s) or when leakage current reaches 100 mA (fixed value).
This mode shall be used when the test is to be done according to dielectric measurement standard (usually leakage current capability of 100 mA is required by standards).

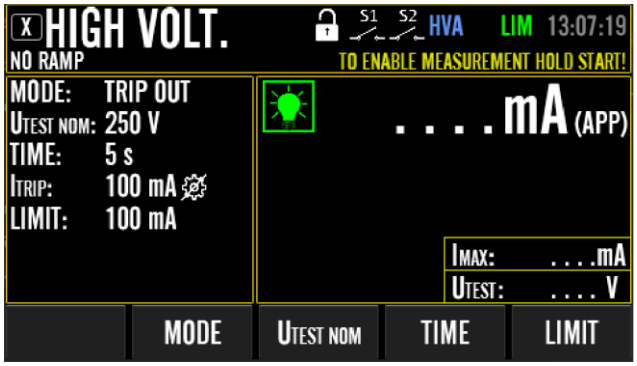


Figure 70: HV (NO RAMP measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

Notes!

- Actual leakage current I (main result) can be judged here. Select wished limit by pressing "LIMIT" menu key first.
- See graphic explanation of the mode on instruction card under the case cover of HVA-204 Adapter.

TRIP × mA mode:
Test voltage will be applied to test guns and will be automatically switched off when PEDAL (or "START" switches on HV guns) is released or when set timer elapses (adjustable 1 … 60 s) or when leakage current reaches set limit value (adjustable 1 … 100 mA).
This mode shall be used when the test is to be done in safer mode for the UUT (lower limit leakage current in comparison with TRIP OUT mode) in order not to damage the UUT.

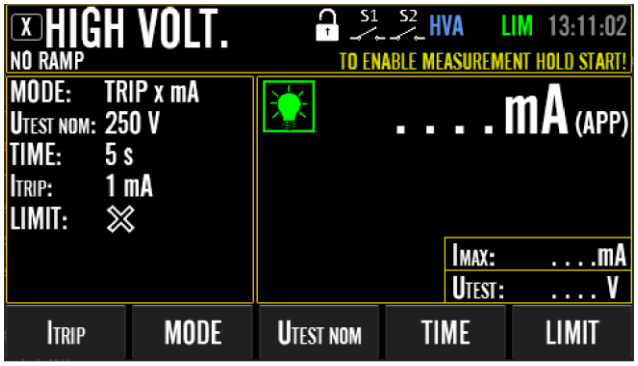


Figure 71: HV (NO RAMP measurement, TRIP × mA mode) idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

Note!

- Actual leakage current I (main result) can be judged here. Select wished limit by pressing "LIMIT" menu key first.
- See graphic explanation of the mode on instruction card under the case cover of HVA-204 Adapter.

20.7.1.2. HV RAMP ⌐ (RAMP UP) measurement

(rotary switch #1 in “All” position)

Test voltage will be switched ON through a start ramp and will be switched OFF immediatelly after finishing the test, see graphic explanation on instruction card under the case cover of HVA-204 Adapter.

There are two available test modes:

- TRIP OUT
- TRIP × mA

TRIP OUT mode:

See the explanation in chapter “TRIP OUT mode” on page 87.

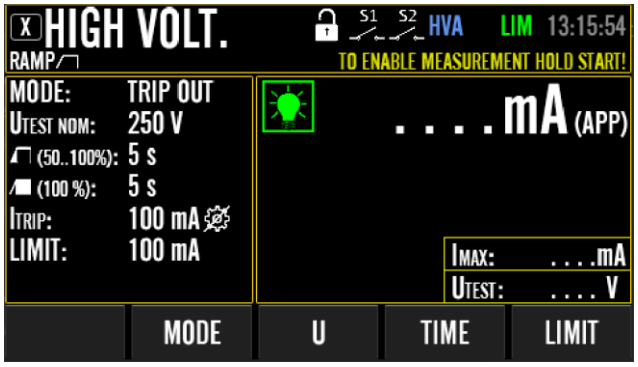


Figure 72: HV (RAMP ⌐ measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Note!

- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

TRIP × mA mode:

See the explanation in chapter “TRIP × mA mode” on page 88.

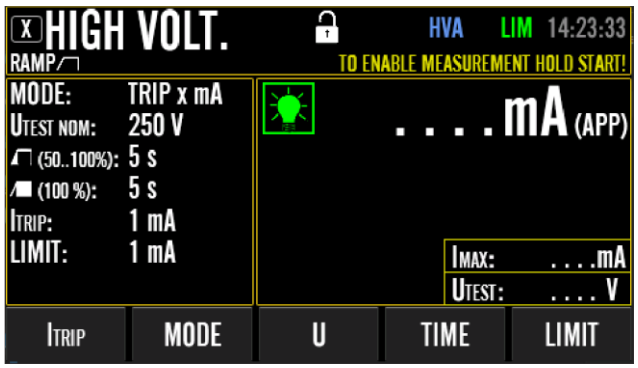


Figure 73: HV (RAMP ⌐ measurement, TRIP × mA mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Note!

- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

20.7.1.3. HV RAMP (RAMP UP/DOWN) measurement (rotary switch #1 in “All” position)

Test voltage will be switched ON through a start ramp and will be switched OFF through a stop ramp, see graphic explanation on instruction card under the case cover of HVA-204 Adapter.

There are two test modes available:

- TRIP OUT
- TRIP × mA

TRIP OUT mode:

See the explanation in chapter “TRIP OUT mode” on page 87.

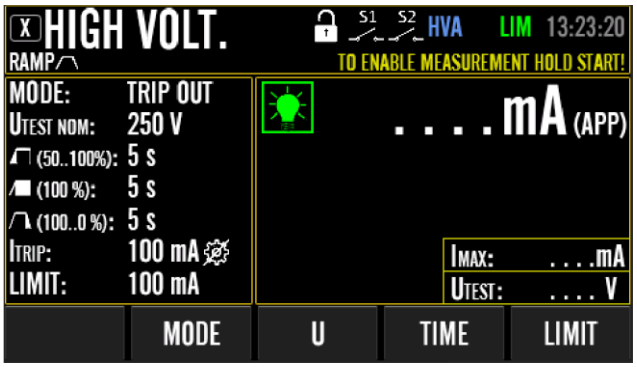


Figure 74: HV (RAMP measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Note!

- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

TRIP × mA mode:

See the explanation in chapter “TRIP × mA mode” on page 88.

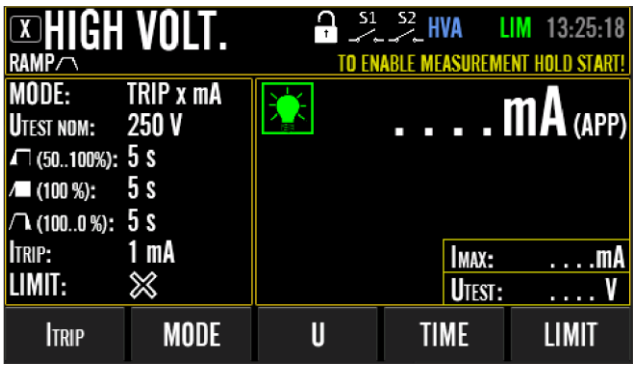


Figure 75: HV (RAMP measurement, TRIP × mA mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Note!

- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

20.7.2. HV Explanation of Available Measurements
(rotary switch #1 in “Machine” position)

20.7.2.1. HV NO RAMP measurement
(only this measurement is available)

See the explanation in chapter “NO RAMP measurement” on page 84.

There are three available test modes:
- BURN
- TRIP OUT
- TRIP × mA

BURN mode:
See the explanation in chapter “BURN mode” on page 84.

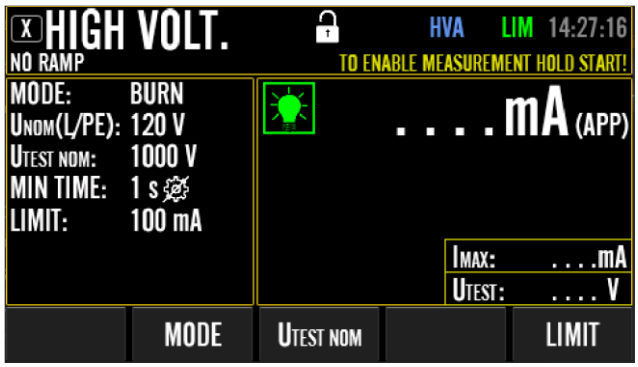


Figure 76: HV (BURN mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!
- Parameter UTEST NOM (see above figure) depends on UNOM (L/PE) defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Parameter MIN TIME (see above figure) is used for evaluation of test result only. If test time is higher or equal to displayed MIN TIME value and there was no flashover during the test (leakage current lower than set limit value), then final result will be judged as PASS in green. If test time is shorter than displayed MIN TIME value and there was no flashover during the test, then final result will be judged as PASS in yellow = conditionally PASS. If leakage current is higher than set limit value (even just temporarily), then final result will be judged as FAIL in red.
- MIN TIME value is fixed and it is set to 1 s.
- See graphic explanation of the mode on instruction card under the case cover of HV-204 Adapter.

TRIP OUT mode:
Test voltage will be applied to test guns and will be automatically switched off 1 second (fixed value) after starting or when leakage current reaches 100 mA (fixed value).
This mode shall be used when the test is to be done according to dielectric measurement standard (usually leakage current capability of 100 mA is required by standards).

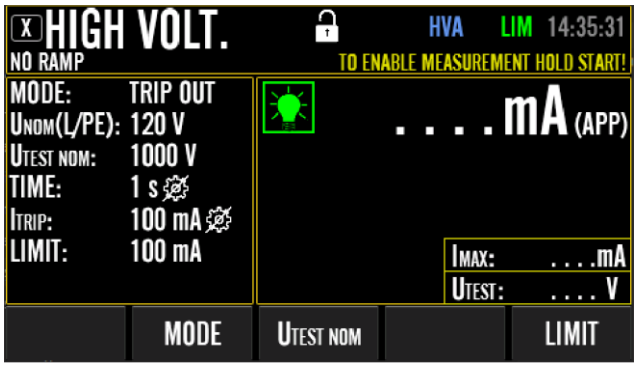


Figure 77: HV (TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!

- Parameter UTEST NOM depends on UNOM (L/PE) defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.
- See graphic explanation of the mode on instruction card under the case cover of HVA-204 Adapter.

TRIP × mA mode:
Test voltage will be applied to test guns and will be automatically switched off 1 second (fixed value) after starting or when leakage current reaches set limit value (adjustable 0 … 100 mA). This mode shall be used when the test is to be done in safer mode for the UUT (lower limit leakage current in comparison with TRIP OUT mode) in order not to damage the UUT.

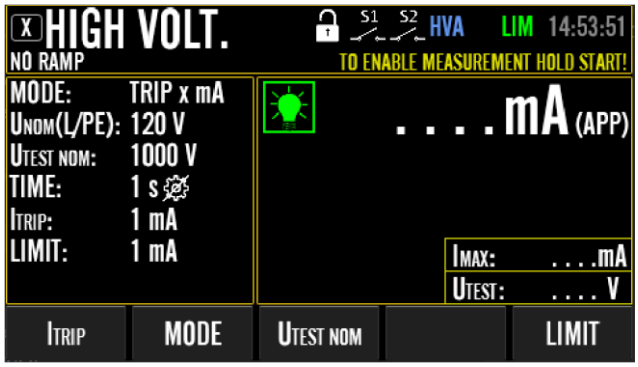


Figure 78: HV (TRIP × mA mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!

- Parameter UTEST NOM depends on UNOM (L/PE) defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.
- See graphic explanation of the mode on instruction card under the case cover of HVA-204 Adapter.

20.7.3. HV Explanation of Available Measurements
(rotary switch #1 in “Switchgear Assemblies” position)

There are four measurements available:

- TYPE TEST HVAC
- TYPE TEST ALTERNATIVE SURGE
- TYPE TEST HVAC ENCL./OP.HANDL. (type test for enclosures and operational handles)
- ROUTINE TEST HVAC

Note!

- Test voltage in all above four measurements is generated as in NO RAMP measurement.

Each measurement offers three test modes as follows:

- BURN
- TRIP OUT
- TRIP × mA

See general explanation of above modes in chapter “NO RAMP measurement” starting on page 84.

20.7.3.1. HV TYPE TEST HVAC

The meaurement shall be used for type tests on main or auxiliary circuits.

The figure below shows an example of TRIP OUT mode screen.

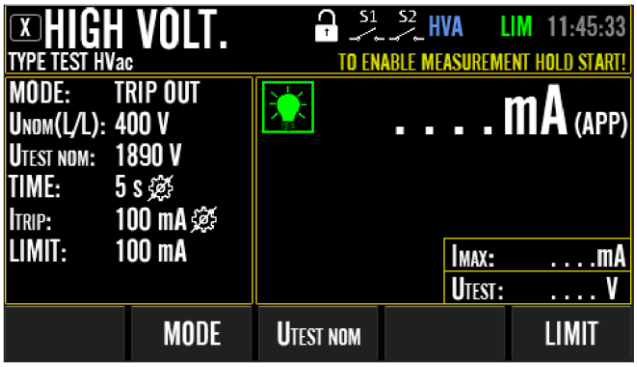


Figure 79: HV (TYPE TEST HVAC measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!

- Test voltage UTEST NOM depends on the circuit to be tested (MAIN CIRCUITS or AUXILIARY CIRCUITS) and UNOM PHASE TO PHASE (L/L) voltage (main circuits) respectively UNOM PHASE TO PHASE AUX (L/L) voltage (auxiliary circuits), both defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

20.7.3.2. HV TYPE TEST ALTERNATIVE SURGE

The meaurement may be used for type tests on main or auxiliary circuits as an alternative to impulse withstand voltage test. Test voltage will be generated for 5 periods (100 ms) according to EN 61439-1 clause 10.9.3.3.

The figure below shows an example of TRIP OUT mode screen.

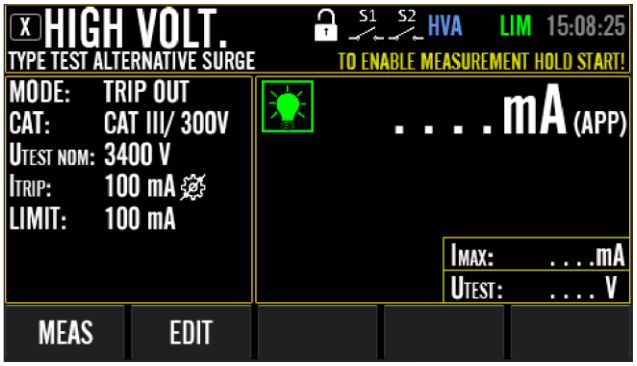


Figure 80: HV (TYPE TEST ALTERNATIVE SURGE measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!

- Test voltage UTEST NOM depends on CAT rating and voltage against GND, both defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

20.7.3.3. HV TYPE TEST HVAC ENCL./OP.HANDL.

The meaurement shall be used for type tests on enclosures and operational handles according to EN 61439-1 clause 10.9.4.

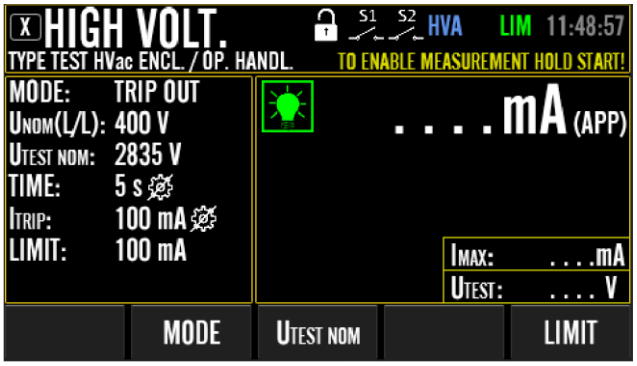


Figure 81: HV (TYPE TEST HVAC ENCL./OP.HANDL. measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!

- Parameter UTEST NOM depends on UNOM (L/L) defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

20.7.3.4. HV ROUTINE TEST HVAC

The meaurement shall be used for routine tests on main or auxiliary circuits. Test voltage depends on the circuit to be tested (MAIN CIRCUITS or AUXILIARY CIRCUITS) and UNOM L/L voltage defined in ENVIRONMENT TABLE.

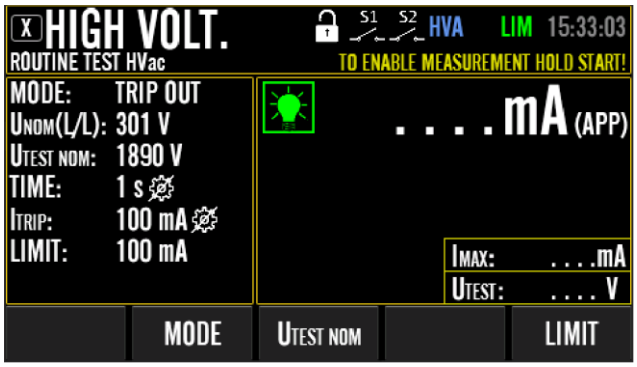


Figure 82: ROUTINE TEST HVAC measurement, TRIP OUT mode) idle screen with extended range of menu keys (after pressing “EDIT” menu key), example

Notes!

- Parameter UTEST NOM depends on UNOM (L/L) defined in ENVIRONMENT TABLE. It can also be selected directly, press “UTEST NOM“ menu key first.
- Actual leakage current I (main result) can be judged here. Select wished limit by pressing “LIMIT” menu key first.

SELF-TEST:

Purpose of the SELF-TEST is to check the whole HV test circuitry (generator, internal wiring, external test leads and HV test guns). SELF-TEST is required to be carry out always after powering up HVA-204 Adapter through MST-204 Tester.

Required SELF-TEST will be announced on display with popup “SELF TEST REQUIRED” for 2 seconds.

SELF-TEST is always performed with test voltage of 250 V, expected leakage current is >200 mA. If this is the case, the SELF-TEST will pass otherwise it will fail.

SELF-TEST procedure:

When SELF-TEST is required press PEDAL trigger (or “START” switch on both HV guns) and make short circuit at HV test guns. Test will start after preset delay time and will be finished latest in 5 s.

Test procedure for HV test:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1, 2 or 3).
2) Select HV measurement by setting the rotary switch #2 to HV position ⇒ idle screen of currently selected HV measurement will appear.
3) If “ALL” standard is selected: Press “MEAS” menu key, select wished measurement (NO RAMP, RAMP ⟋⎴ or RAMP ⟋⎺⟍) and confirm it by pressing “↵“ menu key ⇒ display will turn to idle screen of just selected measurement.
   If “MACHINE” standard is selected: There is only one measurement available (fixed measurement NO RAMP) that is why “MEASUREMENT” menu key is not offered here.
   If “Switchgear Assemblies” standard is selected: Press “MEAS” menu key, select wished measurement (TYPE TEST HVAC, TYPE TEST ALTERNATIVE SURGE, TYPE TEST HVAC ENCL/OP.HANDL. or ROUTINE TEST HVAC) and confirm it by pressing “↵“ menu key ⇒ display will turn to idle screen of just selected measurement.
4) Press “EDIT“ menu key ⇒ idle screen of currently selected HV measurement with extended range of menu keys will be offered, see the figure above.

Note!

- The following adjustments vary with regard to selected standard (rotary switch #1), actual measurement and mode!

5) Select/adjust needed test parameters (use all offered menu keys).
6) Connect HVA-204 Adapter to MST-204 Tester according to the figure below or see available figures in HELP/CONNECTION menu.
7) Connect HV test leads to a UUT according to one of the figures below or see available figures in HELP/CONNECTION menu.

   Caution!

   ☞ **Before connecting test leads to a UUT obligatory assure there is no voltage applied to the UUT, otherwise the UUT or HV adapter may be damaged!**

   ☞ **Disconnect mains cable of the UUT or unscrew mains terminals in case permanently connected machine or switchgear is to be tested.**

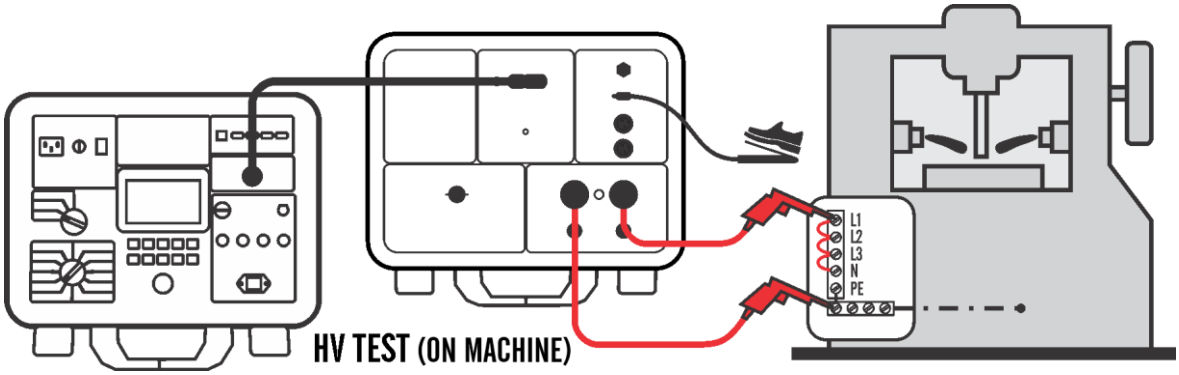


Figure 83: Connection to machine.

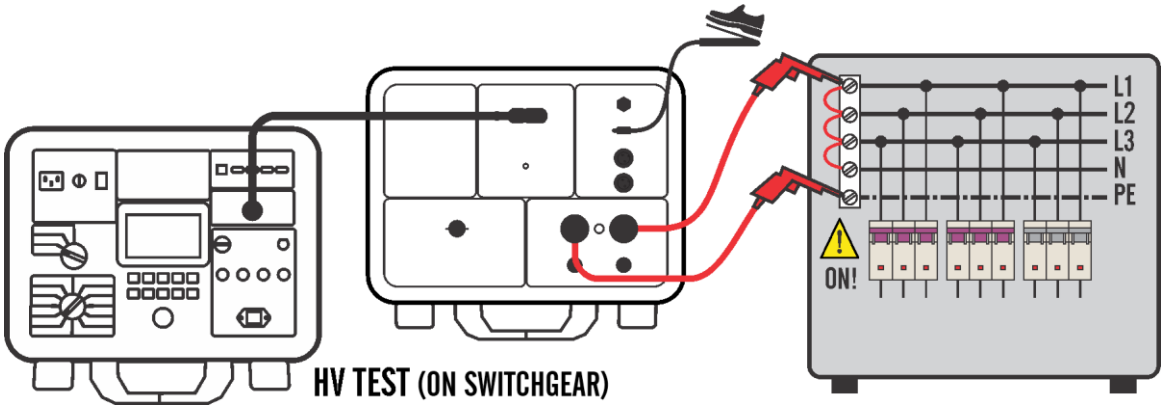


Figure 84: Connection to switchgear.

8) Press “START“ button on MST-204 Tester for 2 seconds to get into “READY” mode of the test system (green warning lamp will turn to red).

   Note!
   - SELF-TEST may be required after getting to “READY” mode, see instructions how to proceed in this case in paragraph “SELF-TEST” above.

9) Press and keep pressing PEDAL trigger (or “START” switches on both HV guns) to activate HV generator, then apply test tips to the UUT. HV generator will start to generate test voltage 3 seconds after pressing PEDAL trigger (or “START” switches on both HV guns).
10) Stop the measurement by releasing PEDAL trigger (or “START” switches on HV guns) or wait set timer to stop the measurement, measurement result will be displayed, see the figure below.

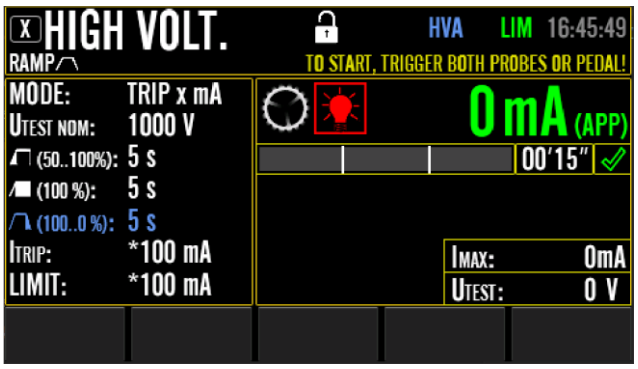


Figure 85: Final result in HV test, example

11) Press START button to stop active HV mode or wait timer to stop it (30 s), final measurement result will be displayed ready for entering remarks and memorizing.

12) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that may be displayed during HV test:

Information displayed	Description
HOLD TRIGGERS, MEASUREMENT STARTS in xx s!	3 s of delay between activation of the PEDAL (or both “START” switcheh on HV guns) and applying the test voltage ⇒ connect test guns to UUT during the delay and wait the measurement to start.
⚠ SELF-TEST REQUIRED!	SELF-TEST is required, see the chapter “SELF-TEST” on page 98.
HOLD TRIGGER, SHORT-CIRCUIT TEST PROBES UNTIL SELF TEST IS FINISHED!	3 s of delay between activation of the PEDAL (or both “START” switches on HV guns) and applying the test voltage ⇒ connect test guns to UUT during the delay and wait the measurement to start.
⚠ ENABLE MEASUREMENT FIRST – HOLD START BUTTON FOR 2 s!	Press “START” button on MST-204 for 2 seconds first in order to turn the test system to “READY” mode (red warning lamp will turn from green to red). The “READY” mode will be available for 30 s, then “START” button is required again. PEDAL trigger (or “START” switches on HV guns) is active until test system is in “READY” mode.
⚠ PULL TRIGGERS ON BOTH TEST PROBES!	Both “START” switches are required to be pulled to run the test.
⚠ HVA-204 LOCKED!	Lock key on HVA-204 is in LOCK position ⇒ unlock it for operation.

Note!

- See the instructions in User Manual HVA-204 High-Voltage Adapter how to use safety inputs and warning lamp!

20.8. U/t Residual Voltage (URES), Discharge Time (TRES)

Note!

- This function is available only if Switch #1 is in “All” or in “Machine” position. In “Switchgear Assemblies” position the function is NOT AVAILABLE.

20.8.1. U/t Residual Voltage URES

Residual voltage measurement is required by EN 60204-1 standard for machines. The residual voltage can be caused e.g. by built in decoupling capacitors, EMC filters or subsequent generators.
According to above mentioned standard, accessible live parts connected to dangerous voltage must discharge down to 60 V within 5 seconds (internal accessible live parts) or within 1 second (mains plug terminals) after the machine is switched off or disconnected from mains voltage.

- Residual voltage at mains plug (plugged-in machines) is the voltage that remain present at mains plug terminals even after disconnecting the plug from mains socket at switched on mains switch.
- Residual voltage at internal accessible live parts (plugged-in and permanently connected machines) is the voltage that remain present at internal accessible live parts even after disconnecting mains plug from mains socket or switching off the machine.

  Caution!

  ☞ **Some internal live parts of a machine may become accessible after disconnecting mains plug from mains socket or switching off the machine.**

- In the event of non-compliance, additional measures (discharge devices, warning information, mechanical covers etc.) according to EN 60204-1 must be taken.
- MST-204 Tester can measure residual voltage in STANDARD, LINEAR or NON LINEAR mode, see the explanation of each mode on further pages.

How to get into URES measurement:

1) Select appropriate STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select URES/TRES measurement by setting the rotary switch #2 to U/t position ⇒ idle screen of currently selected URES/TRES measurement will appear, see the figure below.

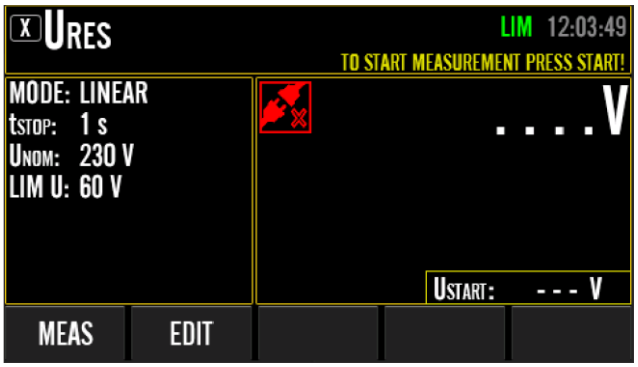


Figure 86: Idle screen in URES measurement, example

3) Press “MEAS” menu key to get into sub-function selection screen (if appropriate sub-function is not selected yet), two sub-functions will be offered (URES and TRES).
4) Select URES sub-function and confirm it by pressing “↵“ menu key ⇒ idle screen of currently selected URES sub-function will appear.

20.8.1.1. U/t URES measurement on mains plug terminals

When the measurement is to be done on mains plug terminals, LINEAR mode is advised to be used.

Required conditions for LINEAR mode:

- There are only RC components involved in mains circuitry of tested machine causing exponential discharging characteristic.
- Input mains voltage is pure sinusoidal.

Advantage of LINEAR mode against STANDARD or NON LINEAR is that only one measurement is required (each test result is appropriate for documentation) as displayed result is always scaled to peak value of nominal voltage (UNOM) increased by 10 %.

Note!

- If discharging characteristic is not exponential or it is unknown, then STANDARD or NON LINEAR mode is advised to be used.

LINEAR mode:

Explanation of LINEAR mode:

In linear mode displayed result is scaled to peak value of selected nominal voltage UNOM increased by 10 % in order to evaluate most critical situation, see the figure below. Therefore, the UNOM of installation is required to be selected before the measurement is done.

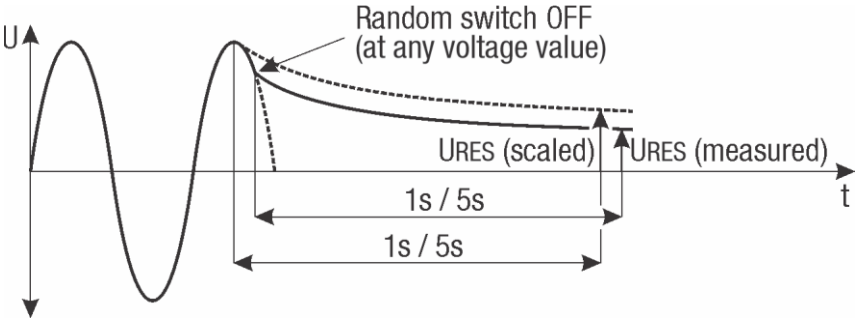


Figure 87: Discharge diagram in linear circumstances

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

MODE (F2) = Test mode ..... STANDARD, LINEAR or NON LINEAR
tSTOP (F3) = Measurement stop time .. 1 s, 5 s or USER (adjustable 1 … 300 s)
UNOM (F4) = Nominal voltage UL/PE .... Defined in ENVIRONMENTAL TABLE
LIM U (F5) = Limit URES voltage..... 60 V, USER (adjustable 25 … 60 V) or OFF (result is not judged)

Measured quantities:

URES ..... Main result = Residual voltage
USTART ..... Sub-result = Input start voltage measured just before switching off mains voltage or disconnecting mains plug
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for URES measurement in LINEAR mode:

Take into account the first four paragraphs described on page 101 are done already.

5) Press “EDIT” menu key to get into idle screen with extended menu keys.
6) Select measurement mode (LINEAR) by pressing “MODE” menu key first.
7) Select tSTOP time by pressing “tSTOP” menu key first.
8) Select nominal UL/PE voltage by pressing “UNOM” menu key first.
9) Select limit URES voltage by pressing “LIM U” menu key first.
10) Connect test leads according to the figure below, see also HELP/CONNECTION menu. Switch ON the UUT, green mains icon will be displayed when the connection is properly done and input voltage UL/PE is stable and within 0 … 440 VRMS. Sub-result USTART will follow actual input voltage.

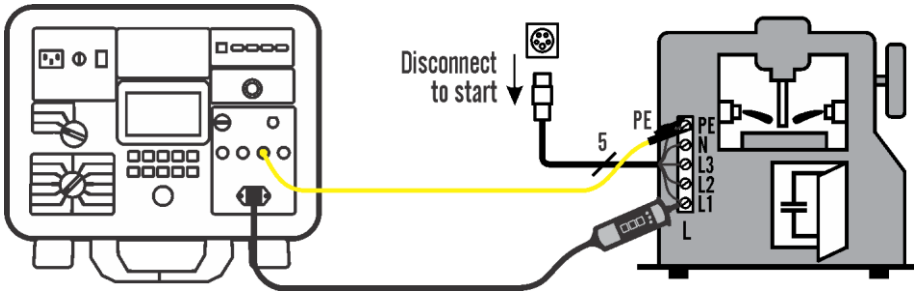


Figure 88: Connection for URES measurement, example

11) Press “START” button, instruction “READY, SWITCH OFF / DISCONNECT UUT!” will be displayed.
12) Disconnect mains plug, measurement will start and result will be displayed after a while. See the figure below for an example of measurement result.

Figure 89: URES measurement result in LINEAR mode, example

Notes!

- LINEAR mode requires mains voltage to be switched off at 20 to 100 % of peak value. There is a possibility that this will not be the case at any switch off, but the switching will be required to be repeated. Message “REPEAT! SWITCH ON / RECONNECT AND SWITCH OFF / DISCONNECT UUT!” will be displayed in this case.
- If peak value of input voltage is lower than set limit value, then the measurement will be done automatically after pressing “START” button and result will be displayed (e.g. “< 60 V” if ULIM = 60 V).

13) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.8.1.2. U/t URES measurement on internal accessible parts

When the measurement is to be done on internal accessible parts under hazardous voltage, NON LINEAR or STANDARD mode is advised to be used as discharging characteristic is usually not known.
Required conditions for NON LINEAR mode:

- Input mains voltage is pure sinusoidal.
- Tested machine must not use zero-cross switching-off system.
- It requires no disturbance at input voltage when the machine is switched off for measurement purpose (mains switch of tested machine must be in good condition in order not to cause some disconnection spikes or other disturbances).

Advantage of NON LINEAR mode against STANDARD one is that the first displayed result is appropriate for documentation, but disconnection of mains plug or switching off tested machine may be required to be repeated several times as momentary input start voltage at disconnection moment must be within 90 and 100 % of peak value.

Note!

- If above required conditions are not fulfilled, then STANDARD mode is advised to be used.

NON LINEAR mode:

Explanation of NON LINEAR mode:

In NON LINEAR mode it is assumed there are also "non linear" or unknown components involved in discharge process (relays, gas lamps etc.) and therefore discharge characteristic is non-exponential or it is unpredictable, see the diagram below.

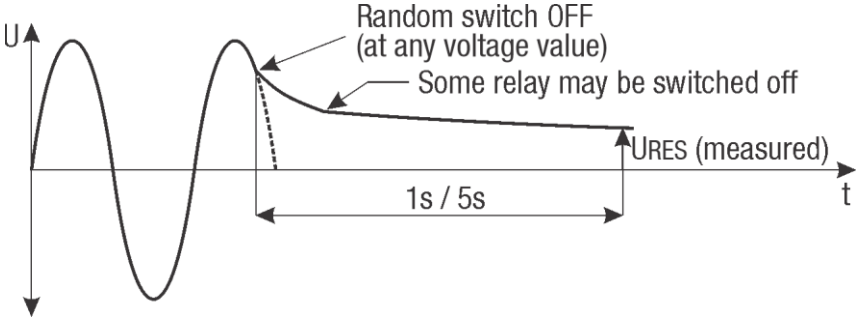


Figure 90: Discharge diagram in non-linear circumstances

In this case result can not be scaled to peak value, so it must be assured that switch off occurs at max. input voltage i.e. at peak value, otherwise measured result is not relevant.

Adjustable/selectable test parameters (keys available after pressing “EDIT” menu key)**:**

MODE (F2) = Test mode ..... STANDARD, LINEAR or NON LINEAR
tSTOP (F3) = Measurement stop time .... 1 s, 5 s or USER (adjustable 1 … 300 s)
LIM U (F5) = Limit URES voltage..... 60 V, USER (adjustable 25 … 60 V) or OFF (result is not judged)

Measured quantities:
See “Measurement quantities” described in LINEAR mode on page 102.

Measuring range:
For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for URES measurement in NON LINEAR mode:

Take into account the first four paragraphs described on page 101 are done already.

5) Press “EDIT” menu key to get into idle screen with extended menu keys.
6) Select measurement mode (NON LINEAR) by pressing “MODE” menu key first.
7) Select tSTOP time by pressing “tSTOP” menu key first.
8) Select limit URES voltage by pressing “LIM U” menu key first.
9) Connect test leads according to the figure below, see also HELP/CONNECTION menu. Switch ON the UUT, green mains icon will be displayed when the connection is properly done and input voltage UL/PE is stable and within 0 … 440 VRMS. Sub-result USTART will follow actual input voltage.

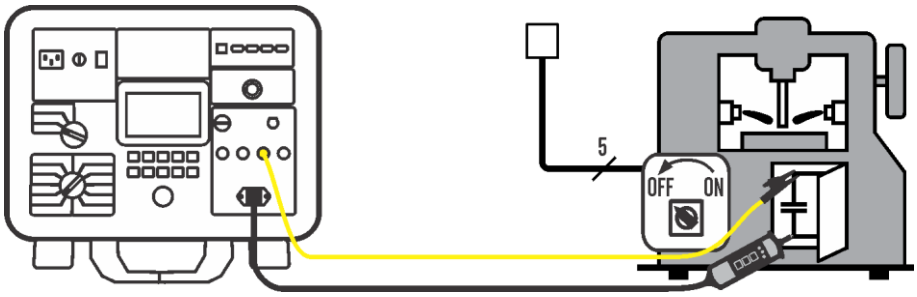


Figure 91: Connection for URES measurement, NON LINEAR mode, example

10) Press “START” button, message “READY, SWITCH OFF / DISCONNECT UUT!” will be displayed.
11) Switch off mains switch, measurement will be started and result will be displayed after a while. See the figure below for an example of measurement result.

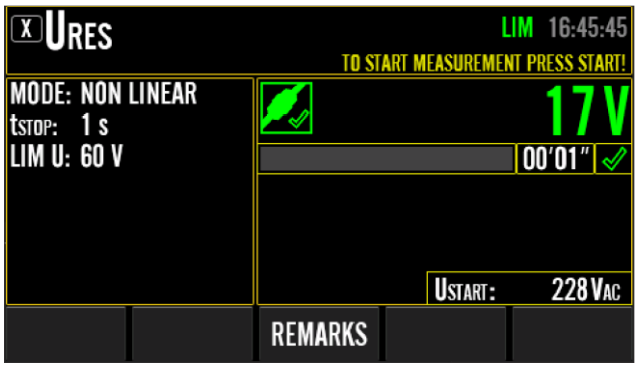


Figure 92: URES measurement result in NON LINEAR mode, example

Notes!

- NON LINEAR mode requires mains voltage to be switched off at 90 to 100 % of peak value. It is very likely that this will not be the case at any switch off, but the switching will be required to be repeated several times. Message “REPEAT! SWITCH ON / RECONNECT AND SWITCH OFF / DISCONNECT UUT!” will be displayed in this case.
- If peak value of input voltage is lower than set limit value, then the measurement will be done automatically after pressing “START” button and result will be displayed (e.g. “< 60 V” if ULIM = 60 V).

12) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

STANDARD mode:

STANDARD mode can be used for measurements on mains plug terminals as well as on internal accessible parts, especially when conditions for LINEAR or NON LINEAR mode are not fulfilled (measurements in LINEAR or NON LINEAR mode are not successful).

But STANDARD mode requires the measurement to be repeated several times as switch-off or disconnection of mains plug can occur at any momentary value of input voltage from minus peak to plus peak value. Any new URES result will be compared with maximal one obtained within actual measurement cycle and will overwrite it if higher. Measurement is advised to be repeated until switch-off at approx. peak value of input voltage is reached, or at least 10 times in order to reach switch-off at approx. peak value at least once or until the first failed result is reached (in this case final result failed anyway), whichever condition is sooner.

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

MODE (F2) = Test mode ..... STANDARD, LINEAR or NON LINEAR
tSTOP (F3) = Measurement stop time .... 1 s, 5 s or USER (adjustable 1 … 300 s)
LIM U (F5) = Limit URES voltage..... 60 V, USER (adjustable 25 … 60 V) or OFF (result is not judged)

Measured quantities:

URES ..... Main result = Residual voltage of each measurement
COUNTER ..... Number of measurements inside one cycle
URES MAX ..... Sub-result = Maximal residual voltage of all partial measurements
USTART @ MAX . Sub-result = Input start voltage measured just before switching off mains voltage or disconnecting mains plug (this value belongs to displayed maximal URES voltage)
USTART ..... Sub-result = Start voltage of actual measurement
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for URES measurement in STANDARD mode:

Take into account the first four paragraphs described on page 101 are done already.

5) Press "EDIT" menu key to get into idle screen with extended menu keys.
6) Select measurement mode (STANDARD) by pressing "MODE" menu key first.
7) Select tSTOP time by pressing "tSTOP" menu key first.
8) Select limit URES voltage by pressing "LIM U" menu key first.
9) Connect test leads according to figure 91 on page 105, see also HELP/CONNECTION menu. Switch ON the UUT, green mains icon will be displayed when the connection is properly done and input voltage UL/PE is stable and within 0 … 440 VRMS. Sub-result USTART will follow actual input voltage.
10) Press "START" button, message "READY, SWITCH OFF / DISCONNECT UUT!" will be displayed.
11) Switch OFF mains switch of the UUT or disconnect mains plug, measurement will be started and the first result will be displayed after a while. See the figure below for an example of the first measurement result.

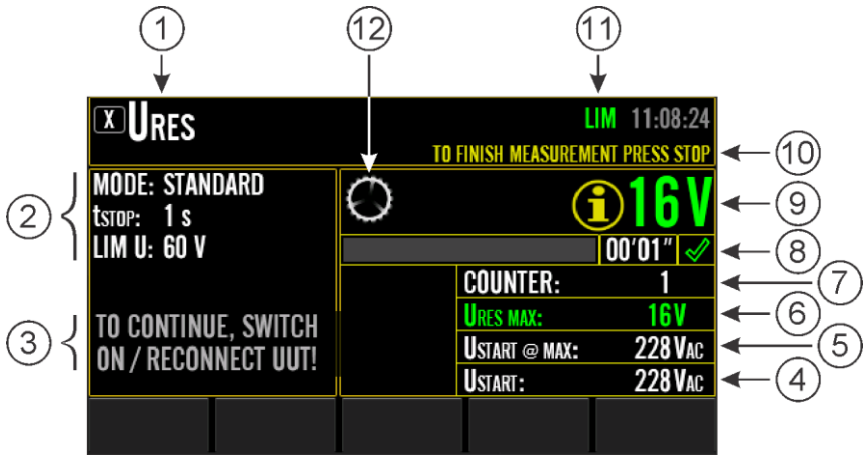


Figure 93: URES first (partial) measurement result in STANDARD mode, example

1..... Measurement (URES)
2..... Test parameters
3..... Instruction how to proceed
4..... Start voltage which belongs to actual URES result (position 9), RMS value
5..... Start voltage which belongs to currently displayed maximal URES MAX voltage, RMS value
6..... Maximal URES voltage of all measurements done inside actual measurement cycle
7..... Total number of measurements done inside actual measurement cycle
8..... Overal judgement of test result (URES MAX is judged and must be lower than or equal to set limit value to be judger as PASS)
xx' xx'' … measurement time
9..... Actual measurement result. Symbol ⓘ means that start voltage was AC or AC+DC and therefore the result is not necessary appropriate for documentation as it may not be maximal. Repetition of switching-off is needed. In case of DC start voltage there will be no ⓘ symbol, meaning the result is trustfull and no repetition of switching-off is needed (measurement cycle will be automatically stopped).
10..... Instruction how to finish the measurement
11..... Limit is on (results will be judged)
12..... Static progress symbol (measurement cycle is still in progress)

12) Switch on the UUT again (if ⓘ symbol is displayed near displayed result), wait until the message "READY, SWITCH OFF / DISCONNECT UUT!" is displayed, then repeat switching-off UUT again.
13) Repeat the procedure described in paragraph 11 above until:
- 10 measurements are carried out within actual measurement cycle or
- the first failed result is displayed, whichever condition is sooner
then stop the measurement cycle by pressing "STOP" button. An example of final result is shown on the figure below.

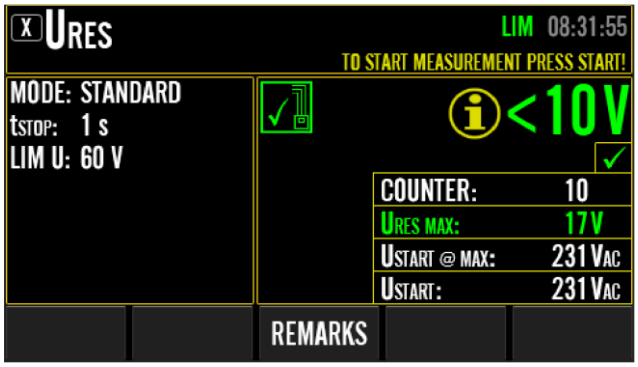


Figure 94: URES measurement result in STANDARD mode, example

Note!

- If peak value of input voltage is lower than set limit value, then the measurement will be done automatically after pressing “START” button, result will be displayed (e.g. “< 60 V” if ULIM = 60 V) and measurement cycle will be finished. It means switch ON the UUT and connect test leads before pressing “START” button.

14) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.8.2. U/t Discharge Time TRES

How to get into TRES measurement:

1) Select appropriate STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select URES/TRES measurement by setting the rotary switch #2 to U/t position ⇒ idle screen of currently selected URES/TRES measurement will be displayed.
3) Press "MEAS" menu key to get into sub-function selection screen (if appropriate sub-function is not selected yet), two sub-functions will be offered (URES and TRES).
4) Select TRES sub-function and confirm it by pressing "↵" menu key ⇒ idle screen of currently selected TRES sub-function will be displayed.

Figure 95: Idle screen in TRES measurement, example

MST-204 Tester can measure discharge time in STANDARD, LINEAR or NON LINEAR mode, see the explanation of each mode in chapter "Residual Voltage URES".

LINEAR mode:

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

MODE (F2) = Test mode ..... STANDARD, LINEAR or NON LINEAR
USTOP (F3) = Measurement stop voltage . 60 V or USER (adjustable 25 … 50 V)
UNOM (F4) = Nominal voltage UL/PE..... Defined in ENVIRONMENTAL TABLE
LIM t (F5) = Limit discharge time ..... 1 s, 5 s, USER (adjustable 1 … 300 s) or OFF (result is not judged)

Measured quantities:

tRES ..... Main result = Discharge time
USTART ..... Sub-result = Input start voltage measured just before switching off mains voltage or disconnecting mains plug
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for tRES measurement in LINEAR mode:

Take into account the first four paragraphs described on page 111 are done already.

5) Press “EDIT” menu key to get into idle screen with extended menu keys.
6) Select measurement mode (LINEAR) by pressing “MODE” menu key first.
7) Select USTOP voltage by pressing “USTOP” menu key first.
8) Select nominal UL/PE voltage by pressing “UNOM” menu key first.
9) Select limit tRES time by pressing “LIM t” menu key first.
10) Connect test leads according to figure 88 on page 103, see also HELP/CONNECTION menu. Switch ON the UUT, green mains icon will be displayed when the connection is properly done and input voltage UL/PE is stable and within 0 … 440 VRMS. Sub-result USTART will follow actual input voltage.
11) Press “START” button, instruction “READY, SWITCH OFF / DISCONNECT UUT!” will be displayed.
12) Disconnect mains plug, measurement will start and result will be displayed after a while. See the figure below for an example of measurement result.

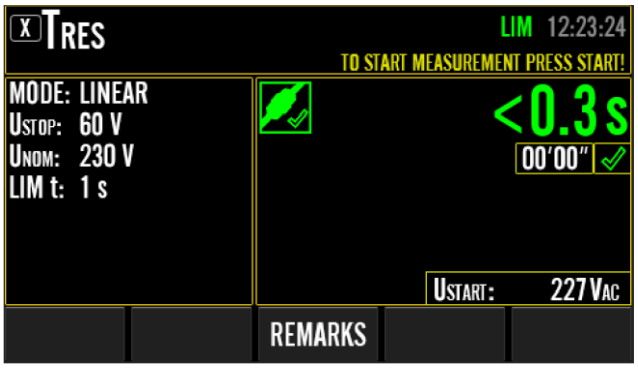


Figure 96: tRES measurement result in LINEAR mode, example

Note!

- LINEAR mode requires mains voltage to be switched off at 20 to 100 % of peak value. There is a possibility that this will not be the case at any switch off, but the switching will be required to be repeated. Message “REPEAT! SWITCH ON / RECONNECT AND SWITCH OFF DISCONNECT UUT!” will be displayed in this case.

13) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

NON LINEAR mode:

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

MODE (F2) = Test mode ..... STANDARD, LINEAR or NON LINEAR
USTOP (F3) = Measurement stop voltage ..... 60 V or USER (adjustable 25 … 50 V)
LIM t (F5) = Limit discharge time..... 1 s, 5 s, USER (adjustable 1 … 300 s) or OFF (result is not judged)

Measured quantities:

tRES ..... Main result = Discharge time
USTART ..... Sub-result = Input start voltage measured just before switching off mains voltage or disconnecting mains plug
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for tRES measurement in NON LINEAR mode:

Take into account the first four paragraphs described on page 111 are done already.

5) Press "EDIT" menu key to get into idle screen with extended menu keys.
6) Select measurement mode (NON LINEAR) by pressing "MODE" menu key first.
7) Select USTOP voltage by pressing "USTOP" menu key first.
8) Select limit tRES time by pressing "LIM t" menu key first.
9) Connect test leads according to figure 91 on page 105, see also HELP/CONNECTION menu. Switch ON the UUT, green mains icon will be displayed when the connection is properly done and input voltage UL/PE is stable and within 0 … 440 VRMS. Sub-result USTART will follow actual input voltage.
10) Press "START" button, instruction "READY, SWITCH OFF / DISCONNECT UUT!" will appear.
11) Disconnect mains plug, measurement will start to run and result will be displayed after a while. See the figure below for an example of measurement result.

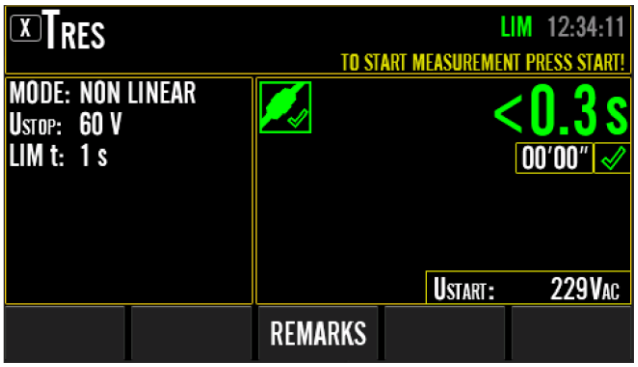


Figure 97: tRES measurement result in NON LINEAR mode, example

Note!

- NON LINEAR mode requires mains voltage to be switched off at 90 to 100 % of peak value. It is very likely that this will not be the case at any switch-off, but the switching will be required to be repeated several times. Message "REPEAT! SWITCH ON / RECONNECT AND SWITCH OFF / DISCONNECT UUT!" will be displayed in this case.

12) Enter REMARKS if needed and save measurement result, see the chapter "MEMORIZING EXAMPLE" on page 175.

STANDARD mode:

STANDARD mode can be used for measurements on mains plug terminals as well as on internal accessible parts, especially when conditions for LINEAR or NON LINEAR mode are not fulfilled (measurements in LINEAR or NON LINEAR mode are not successful).

But STANDARD mode requires the measurement to be repeated several times as switch-off or disconnection of mains plug can occur at any momentary value of input voltage from minus peak to plus peak value. Any new tRES result will be compared with maximal one obtained within actual measurement cycle and will overwrite it if higher. Measurement is advised to be repeated until switch-off at approx. peak value of input voltage is reached, or at least 10 times in order to reach switch-off at approx. peak value at least once or until the first failed result is reached (in this case final result failed anyway), whichever condition is sooner.

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

MODE (F2) = Test mode ..... STANDARD, LINEAR or NON LINEAR
USTOP (F3) = Measurement stop voltage ..... 60 V or USER (adjustable 25 … 50 V)
LIM t (F5) = Limit discharge time..... 1 s, 5 s, USER (adjustable 1 … 300 s) or OFF (result is not judged)

Measured quantities:

tRES ..... Main result = Actual discharge time
COUNTER ..... Number of measurements inside one cycle
TRES MAX ..... Sub-result = Maximal discharge time of all partial measurements within one measurement cycle
USTART @MAX .. Sub-result = Input start voltage measured just before switching off mains voltage or disconnecting mains plug (this value belongs to displayed maximal tRES time)
USTART ..... Sub-result = Start voltage of actual measurement
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for tRES measurement in STANDARD mode:

Take into account the first four paragraphs described on page 86 are done already.

5) Press "EDIT" menu key to get into idle screen with extended menu keys.
6) Select measurement mode (STANDARD) by pressing "MODE" menu key first.
7) Select USTOP voltage by pressing "USTOP" menu key first.
8) Select limit tRES time by pressing "LIM t" menu key first.
9) Connect test leads according to figure 88 on page 103 or according to figure 91 on page 105, see also HELP/CONNECTION menu.
   Switch ON the UUT, green mains icon will be displayed when the connection is properly done and input voltage UL/PE is stable and within 0 … 440 VRMS. Sub-result USTART will follow actual input voltage.
10) Press "START" button, message "READY, SWITCH OFF / DISCONNECT UUT!" will be displayed.

11) Switch off mains switch of the UUT or disconnect mains plug, measurement will be started and the first result will be displayed after a while. See the figure below for an example of the first measurement result.

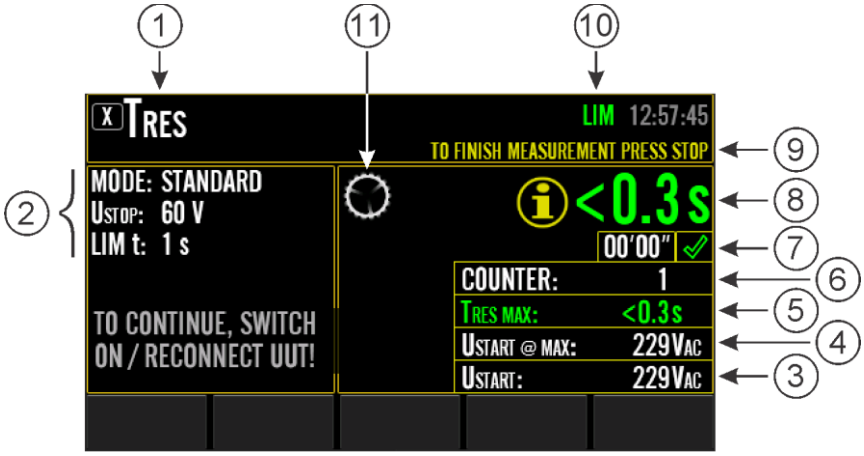


Figure 98: tRES first (partial) measurement result in STANDARD mode, example

1..... Measurement (tRES)
2..... Test parameters
3..... Start voltage which belongs to actual tRES result (position 8)
4..... Start voltage which belongs to currently displayed maximal tRES MAX voltage, RMS value
5..... Maximal tRES time of all measurements done within actual cycle
6..... Total number of partial measurements done within actual cycle
7..... Overal judgement of test result (tRES MAX is judged and must be lower than or equal to set limit value) to be judger as PASS.
xx' xx'' … measurement time
8..... Actual partial measurement result. Symbol ⓘ means that start voltage was AC or AC+DC and therefore the result is not necessary appropriate for documentation as it may not be maximal. Repetition of switching-off is needed. In case of DC start voltage there will be no ⓘ symbol, meaning the result is trustfull and no repetition of switching-off is needed (measurement cycle will be automatically stopped).
9..... Instruction how to finish the measurement
10..... Limit is on (results will be judged)
11..... Static progress symbol (measurement cycle is still in progress)

12) Switch on the UUT again (if ⓘ symbol is displayed near displayed result), wait until the message "READY, SWITCH OFF / DISCONNECT UUT!" is displayed, then repeat switching-off UUT again.
13) Repeat the procedure described in paragraph 12 above until:
- 10 measurements are carried out within actual measurement cycle or
- the first failed result is displayed, whichever condition is sooner
then stop the measurement cycle by pressing "STOP" button. An example of final result is shown on the figure below.

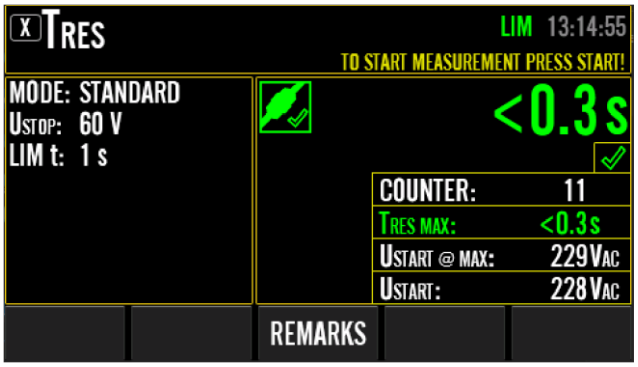


Figure 99: tRES measurement result in STANDARD mode, example

14) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

The following specific information can be shown on the display during the URES/tRES measurement:

Information displayed	Description
REPEAT! SWITCH ON / RECONNECT AND SWITCH OFF / DISCONNECT UUT!	- This message can be displayed in LINEAR mode if the UUT voltage was switched-off at too low momentary value (<20 % of peak value) and therefore measured result could not be scaled to peak value ⇒ repeat the measurement. - This message can be displayed in NON LINEAR mode if the UUT was switched off at too low momentary value (<90 % of peak value) and therefore measured result would not be relevant ⇒ repeat the measurement.
READY, SWITCH OFF / DISCONNECT UUT!	It will be displayed when the measurement (URES/tRES) is started by pressing “START” button and input voltage is stable within 0 … 440 VRMS.

20.9. mA/A Load Current (ILOAD), Earth Leakage Current (ILEAK), Touch Current (IT)

There are three measurements availble (after pressing “MEAS” menu key):
- ILOAD (load current)
- ILEAK (Earth leakage current)
- IT (Touch current)

Note!
- This function is available only if Switch #1 is in “All” or in “Machine” position. In “Switchgear Assemblies” position the function is NOT AVAILABLE.

20.9.1. mA/A Load Current (ILOAD)

The measurement can be done by using an external AC current clamp type CC-204-50A (up to 50 AAC) or type CC-204-1000A (up to 1000 AAC).

Adjustable/selectable test parameters (keys available after pressing “EDIT” menu key)**:**

LIM f (F3) = Frequency limit value ..... Adjustable ± (0.0 … 10.0 %) of fNOM, standard value ± 1 % of fNOM
LIM THD (F4) = THD limit value ..... Adjustable 0.0 … 150.0 % (2^{nd} … 40^{th} harmonic), standard value 12.0 % (2^{nd} … 30^{th} harmonic)
LIM I (F5) = Current limit value..... Adjustable 0.1 … 1000 A, standard value 3.5 A

Note!
- Parameter fNOM (nominal frequency) is directly defind in ENVIRONMENT TABLE.

Measured quantities:

ILOAD ..... Main result = Load current
ILOAD MAX ..... Sub-result = Max value of load current during the measurement
THD ..... Sub-result = Current Total Harmonic Distortion
f ..... Sub-result = Current frequency
xx’ xx’’ ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for ILOAD measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Current measurement by setting the rotary switch #2 to mA/A position ⇒ idle screen of currently selected Current measurement will be displayed.
3) Press “MEAS” menu key, select ILOAD measurement and confirm it by pressing “↵“ menu key ⇒ display will turn to measurement screen of just selected ILOAD function.
4) Press “EDIT“ menu key ⇒ idle screen of currently selected ILOAD measurement with extended range of menu keys will be offered, see the figure below.

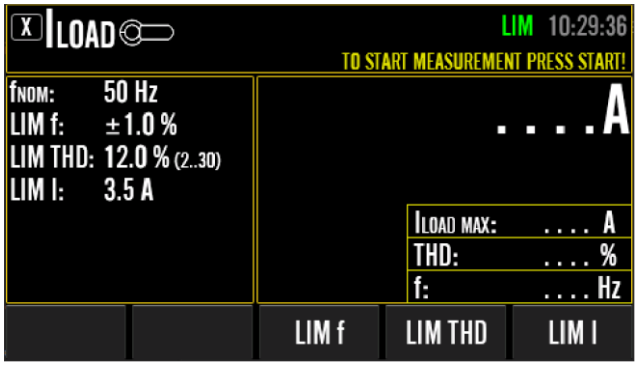


Figure 100: ILOAD idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Adjust wished frequency limit (0.0 … 10.0 %) of fNOM by pressing "LIM f" menu key first.
6) Adjust wished THD limit (0.0 … 150.0 %) by pressing "LIM THD" menu key first.
7) Adjust wished current limit (0.1 … 1000 A) by pressing "LIM I" menu key first.
8) Connect current clamp to a UUT according to the figure below or see available figures in HELP/CONNECTION menu.

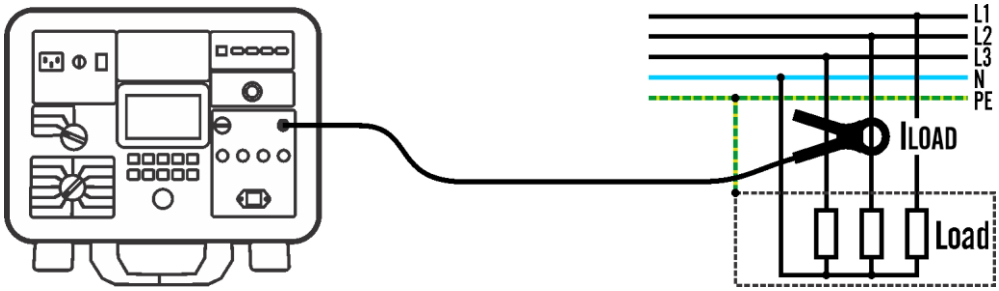


Figure 101: Load current measurement connection, example.

9) Press "START" button to start the measurement, continuous measurement will start to run.
10) Stop the measurement by pressing "STOP" button, final measurement result will be displayed, see the figure below.

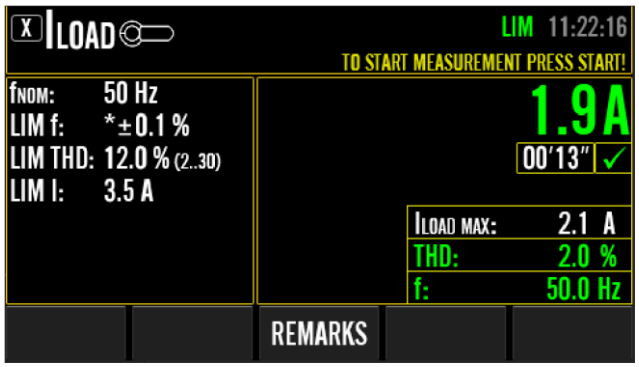


Figure 102: Final result in ILOAD measurement, example

11) Enter REMARKS if needed and save measurement result, see the chapter "MEMORIZING EXAMPLE " on page 175.

20.9.2. mA/A Earth Leakage Current (ILEAK)

The measurement can be done by using an external AC current clamp type CC-204-50A (up to 50 AAC), current ratio 1000:1.

Adjustable/selectable test parameter (key available after pressing "EDIT" menu key)**:**

LIMIT (F5) = Leakage current limit value ..... Adjustable 0.5 … 1000 mA,
standard values 3.5 and 10.0 mA

Measured quantities:

ILEAK ..... Main result = Earth leakage current
ILEAK MAX ..... Sub-result = Max. earth leakage current during the measurement
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for ILEAK measurement:

Take into account the first two paragraphs described on page 116 are done already.

3) Press "MEAS" menu key, select ILEAK measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected ILEAK function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected ILEAK measurement with extended range of menu keys will be displayed, see the figure below.

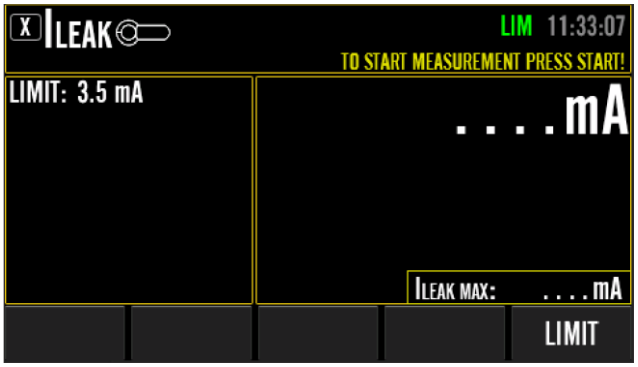


Figure 103: ILEAK idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Adjust wished earth leakage current limit (0.5 … 1000 mA) by pressing "LIMIT" menu key first.
6) Connect current clamp to a UUT according to the figure below or see available figures in HELP/CONNECTION menu.

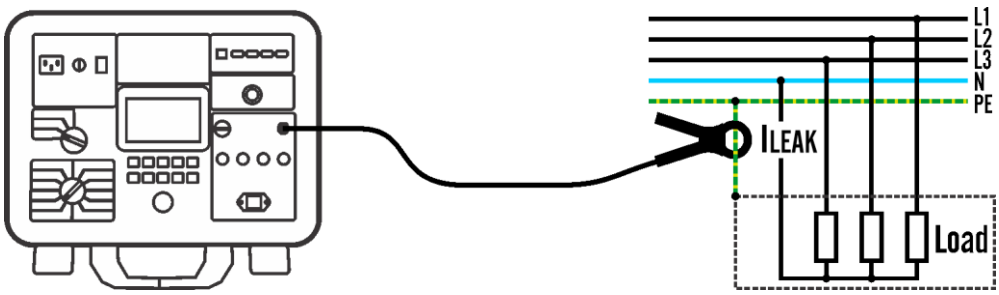


Figure 104: Earth leakage current measurement connection, example.

7) Press “START“ button to start the measurement, continuous measurement will start to run.
8) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

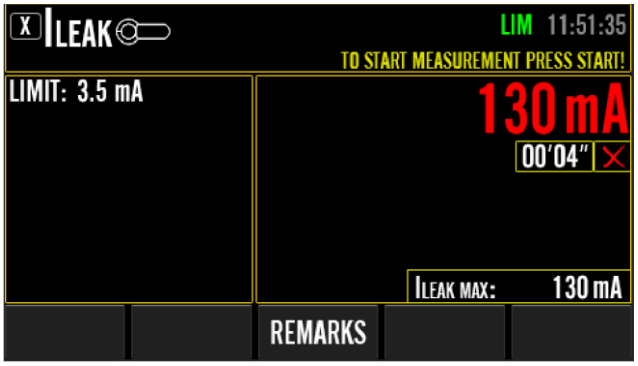


Figure 105: Final result in ILEAK measurement, example

9) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.9.3. mA/A Touch Current (IT)

Potential touch leakage current flows from exposed conductive parts of the UUT via L test lead and internal resistance of 1 kΩ to PE socket and then to earth (PE socket must be earthed).

Warnings

☞ **NEVER carry out this test unless you have first carried out a thorough visual inspection, followed by a test of the protective earth bond resistance (for PC I devices) and then a test of insulation resistance. You must verify that these tests have passed before engaging the touch leakage current test. Please observe the relevant standards and regulations.**

☞ **Live test! The UUT will be energized by mains voltage. For this purpose, switch on the UUT. Devices driven by motors or equipped with heating elements may present a danger for the person testing or others (comply with the user's manual!). Ensure that the UUT is in a safe condition to run and secure it prior to testing.**

Adjustable/selectable test parameter (key available after pressing "EDIT" menu key)**:**

LIMIT (F5) = Touch current limit value .... Adjustable 0.02 … 20.0 mA,
standard value 0.50 mA

Note!

- Parameter RINTERNAL is 1 kΩ (fixed value).

Measured quantities:

IT ..... Main result = Touch current
IT MAX ..... Sub-result = Max touch current during the measurement
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for IT measurement:

Take into account the first two paragraphs described on page 116 are done already.

3) Press "MEAS" menu key, select IT measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected IT function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected IT measurement with extended range of menu keys will be offered, see the figure below.

Figure 106: IT idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Adjust wished touch current limit (0.02 … 20.0 mA) by pressing “LIMIT” menu key first.
6) Connect test leads to a UUT according to the figure below or see available figures in HELP/CONNECTION menu.

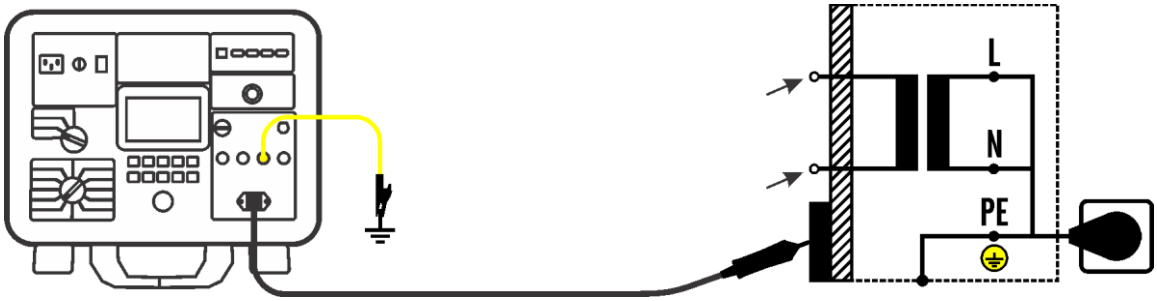


Figure 107: Touch current measurement connection, example.

7) Press “START“ button to start the measurement, continuous measurement will start to run.
8) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

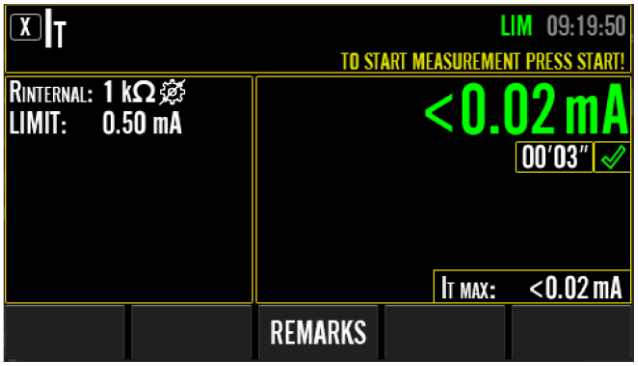


Figure 108: Final result in IT measurement, example

9) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that can be shown on the display

Information displayed	Description
⚠ $U_{L/PE}$ VOLTAGE TOO HIGH, RCD COULD TRIP!	I_T measurement: Pre-test after pressing “START” button, expected leakage current would be higher than 4 mA what may cause tripping out installation RCD ⇒ check for possible inconvenience before continuing.
⚠ PE SOCKET NOT GROUNDED! GROUND AND PRESS START BUTTON AGAIN!	I_T measurement: Ground PE socket (for safety reason it is not grounded internally).
⚠ USE SOCKETS L AND PE!	I_T measurement: Test leads are not connected to L and PE sockets.
>20.00mA	I_T measurement: I_T value higher than 20.00 mA (overrange).
⚠ CURRENT OVERRANGE!	I_T measurement: I_T current was higher than 22 mA for 2 s or higher than 30 mA for 40 ms - safety switch OFF occured.
>1000mA	I_{LEAK} measurement: I_{LEAK} value higher than 1000 mA (overrange).
>1000A	I_{LOAD} measurement: I_{LOAD} value higher than 1000 A (overrange).

20.10. U/P Voltage (U), Power (P)

There are seven measurements availble (after pressing “MEAS” menu key):
- UMAINS (single and three-phase mains voltages)
- POWER (single and three-phase power)
- 3PROTATION (Phase rotation)
- PELV (Protective Extra Low Voltage)
- SELV (Safety Extra Low Voltage)
- UCONTROL (AC and DC Control Voltage)
- UDC SUPPLY (DC Supply Voltage)

Note!
- This function is available only if Switch #1 is in “All” or in “Machine” position. In “Switchgear Assemblies” position the function is NOT AVAILABLE.

20.10.1. U/P Mains Voltage (UMAINS)

The measurement can be done by using two, three or four-wire connection.

Adjustable/selectable test parameters (keys available after pressing “EDIT” menu key)**:**

CONN (F1) = Connection ..... - L/N (two-wire connection, phase to neutral voltage)
- L1/L2/L3 (three-wire connection, three phase to phase voltages)
- L1/L2/L3/N (four-wire connection, three phase to neutral voltages)

LIM f (F3) = Frequency limit value..... Adjustable ± (0.0 … 10.0 %) of fNOM, standard value ± 1.0 %

LIM THD (F4) = THD limit value ..... Adjustable 0.0 … 150.0 % (2^{nd} … 40^{th} harmonic), standard value 12.0 % (2^{nd} … 30^{th} harmonic)

LIM U (F5) = Voltage limit value ..... Adjustable ± (0 … 15 %) of UNOM P/E, standard value ± 10 % of UNOM P/E

Notes!
- Parameter UNOM is directly defind in ENVIRONMENT TABLE as follows:
  UNOM in MAINS 2W and MAINS 4W measurement = UNOM PHASE TO EARTH (L/PE)
  UNOM in MAINS 3W = UNOM PHASE TO PHASE (L/L)
- Parameter fNOM is directly defind in ENVIRONMENT TABLE.

Measured quantities (L/N connection):

UL/N ..... Main result = L/N voltage
THD ..... Sub-result = Total Harmonic Distortion of UL/N
f ..... Sub-result = Frequency of UL/N
xx’ xx’’ ..... Sub-result = Overal test duration

Measured quantities (L1/L2/L3) connection):

UL1/L2 ..... Main result = L1/L2 voltage
UL2/L3 ..... Main result = L2/L3 voltage
UL3/L1 ..... Main result = L3/L1 voltage
THD UL1/L2 ..... Sub-result = Total Harmonic Distortion of UL1/L2
THD UL2/L3 ..... Sub-result = Total Harmonic Distortion of UL2/L3

THD $U_{L3/L1}$ ..... Sub-result = Total Harmonic Distortion of $U_{L3/L1}$
f ..... Sub-result = Frequency of $U_{L1/L2}$ (if $U_{L1/L2}$ is not present, then frequency $U_{L2/L3}$ or frequency of $U_{L3/L1}$ is measured)
xx' xx'' ..... Sub-result = Overal test duration

Measured quantities (L1/L2/L3/N) connection):

$U_{L1/N}$ ..... Main result = L1/N voltage
$U_{L2/N}$ ..... Main result = L2/N voltage
$U_{L3/N}$ ..... Main result = L3/N voltage
THD $U_{L1/N}$ ..... Sub-result = Total Harmonic Distortion of $U_{L1/N}$
THD $U_{L2/N}$ ..... Sub-result = Total Harmonic Distortion of $U_{L2/N}$
THD $U_{L3/N}$ ..... Sub-result = Total Harmonic Distortion of $U_{L3/N}$
f ..... Sub-result = Frequency of $U_{L1/N}$ (if $U_{L1/N}$ is not present, then frequency of $U_{L2/N}$ or frequency of $U_{L3/N}$ is measured)
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for U_{MAINS} measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting the rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will be displayed.
3) Press "MEAS" menu key, select U_{MAINS} measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected U_{MAINS} function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected U_{MAINS} measurement with extended range of menu keys will be displayed, see the figure below.

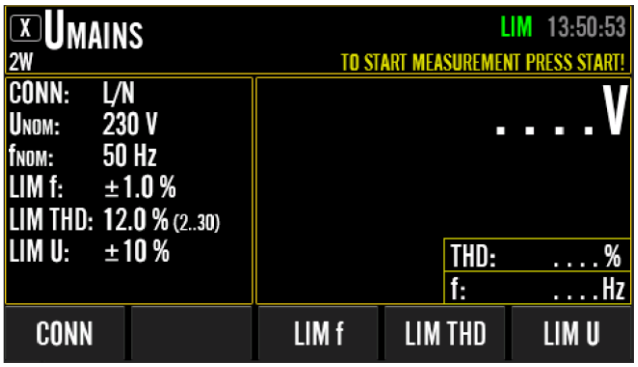


Figure 109: U_{MAINS} idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Select wished connection by pressing "CONN" menu key first.
6) Adjust wished frequency limit (0.0 … 10.0 %) of f_{NOM} by pressing "LIM f" menu key first.
7) Adjust wished THD limit (0.0 … 150.0 %) by pressing "LIM THD" menu key first.
8) Adjust wished voltage limit (0 … 15 %) by pressing "LIM U" menu key first.
9) Connect test leads to the installation according to one of the figures below or see available figures in HELP/CONNECTION menu.

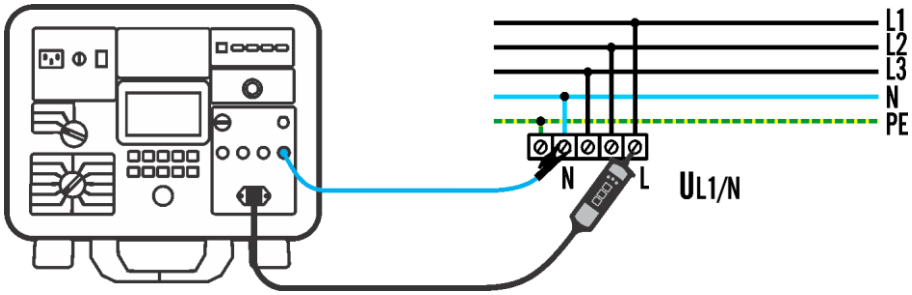


Figure 110: UL/N voltage measurement connection, example.

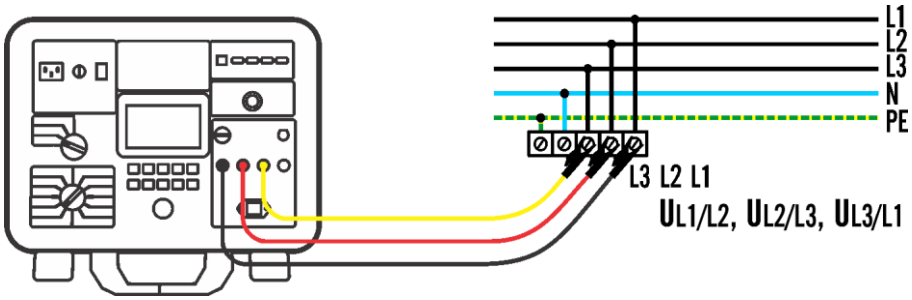


Figure 111: Connection for phase to phase voltages measurement, example.

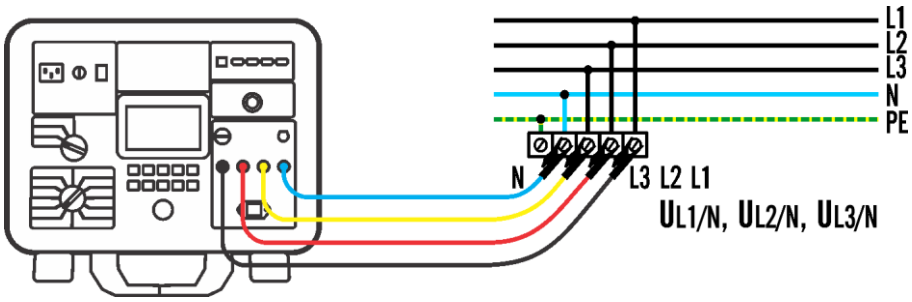


Figure 112: Connection for phase to neutral voltages measurement, example.

10) Press “START“ button to start the measurement, continuous measurement will start to run.
11) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

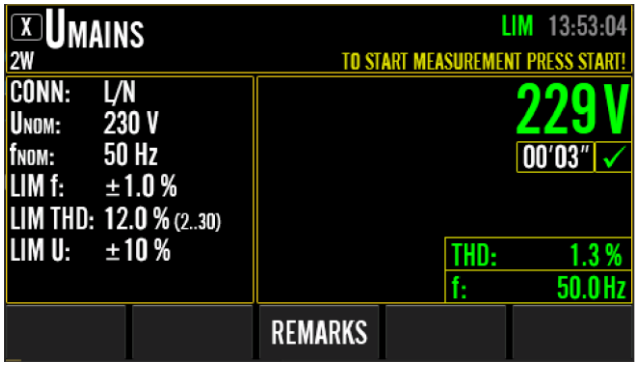


Figure 113: Final result in UMAINS measurement, example

12) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.10.2. U/P Power (POWER)

The measurement can be done on single-phase UUTs by using two-wire connection or on three-phase loads by using three or four-wire connection. Voltages are measured directly, while current is measured through external AC current clamp type CC-204-50A (up to 50 A_{AC}) or type CC-204-1000A (up to 1000 A_{AC}).

Adjustable/selectable test parameter (key available after pressing "EDIT" menu key)**:**

CONN (F1) = Connection ..... - L/N (two-wire connection, single-phase power)
- $L_1/L_2/L_3$ (three-wire connection, three-phase power)
- $L_1/L_2/L_3/N$ (four-wire connection, three-phase power)

Note!

- ENVIRONMENT TABLE (F5) contains no parameters that could influence any of POWER measurements.

Measured quantities (L/N connection):

S ..... Main result = Single-phase apparent power in VA
P ..... Sub-result = Single-phase active power in W
Q ..... Sub-result = Single-phase reactive power in var
I_1 ..... Sub-result = Phase current
$U_{L1/N}$ ..... Sub-result = Phase to neutral voltage
COSφ ..... Sub-result = Cosφ
PF ..... Sub-result = Power Factor
xx' xx'' ..... Sub-result = Overal test duration

Measured quantities ($L_1/L_2/L_3$ connection):

S ..... Main result = Three-phase apparent power in VA
P ..... Sub-result = Three-phase active power in W
Q ..... Sub-result = Three-phase reactive power in var
I_1 ..... Sub-result = Phase current
$U_{L1/L2}$ ..... Sub-result = Phase to phase voltage
$U_{L2/L3}$ ..... Sub-result = Phase to phase voltage
$U_{L3/L1}$ ..... Sub-result = Phase to phase voltage
COSφ ..... Sub-result = Cosφ
PF ..... Sub-result = Power Factor
xx' xx'' ..... Sub-result = Overal test duration

Note!

- It is considered all three-phase currents to be alike (only one is measured).

Measured quantities ($L_1/L_2/L_3/N$ connection):

S ..... Main result = Three-phase apparent power in VA
P ..... Sub-result = Three-phase active power in W
Q ..... Sub-result = Three-phase reactive power in var
I_1 ..... Sub-result = Phase current
$U_{L1/N}$ ..... Sub-result = Phase to neutral voltage
$U_{L2/N}$ ..... Sub-result = Phase to neutral voltage
$U_{L3/N}$ ..... Sub-result = Phase to neutral voltage
COSφ ..... Sub-result = Cosφ

PF ..... Sub-result = Power Factor
xx' xx'' ..... Sub-result = Overal test duration

Note!
- It is considered all three phase currents to be alike (only one is measured).

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for POWER measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting the rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will be displayed.
3) Press "MEAS" menu key, select POWER measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected POWER function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected POWER measurement with extended range of menu keys will be displayed, see the figure below.

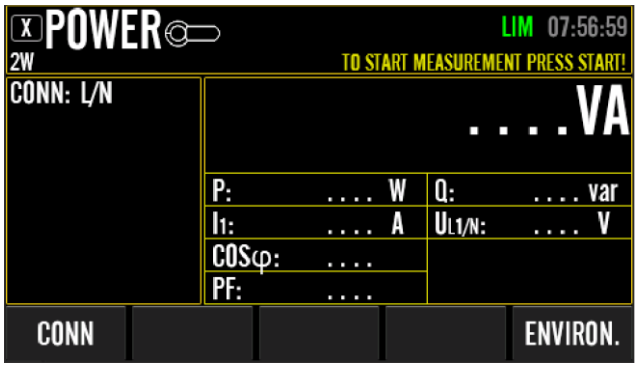


Figure 114: POWER idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Select wished connection by pressing "CONN" menu key first.
6) Connect test leads to UUT according to one of the figures below or see available figures in HELP/CONNECTION menu. Take care to turn used clamp correctly, see the arrow on below figures.

Figure 115: Direction marked on current clamp type CC-204-1000A

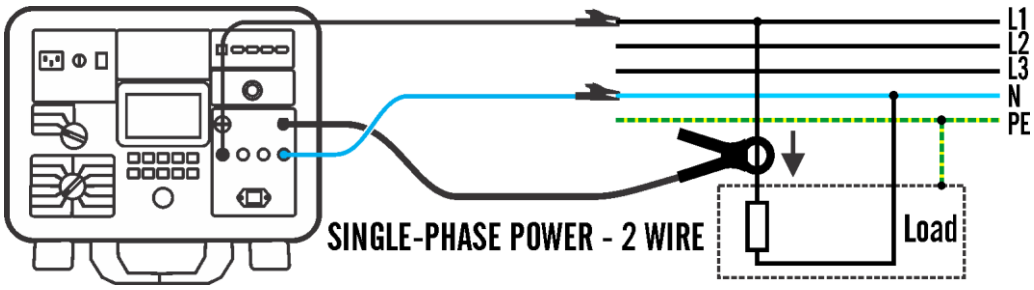


Figure 116: 2-wire connection for single-phase POWER measurement, example

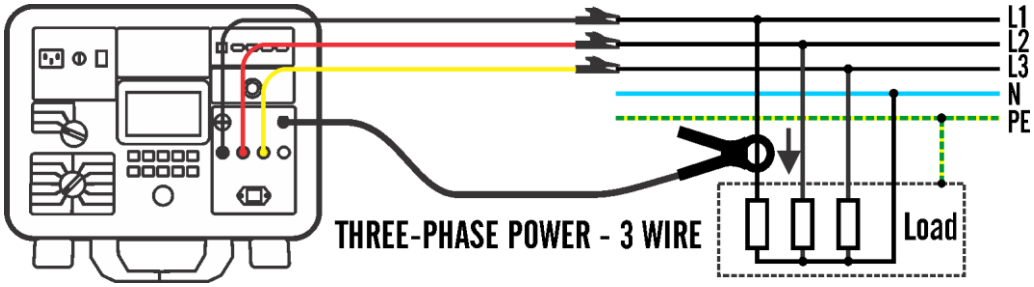


Figure 117: 3-wire connection for 3-phase POWER measurement, example

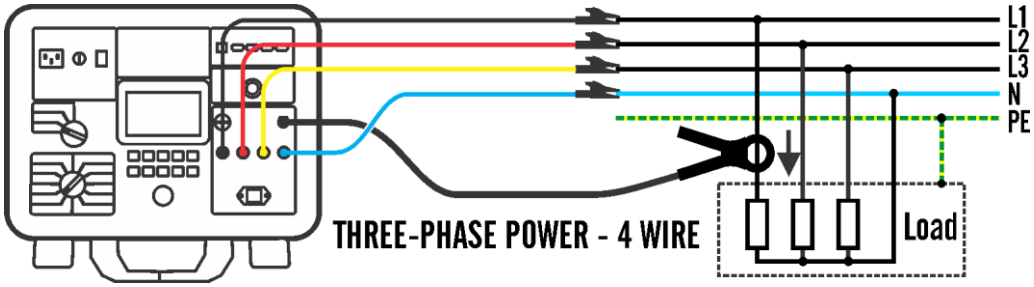


Figure 118: 4-wire connection for 3-phase POWER measurement, example.

7) Press “START“ button to start the measurement, continuous measurement will start to run.
8) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

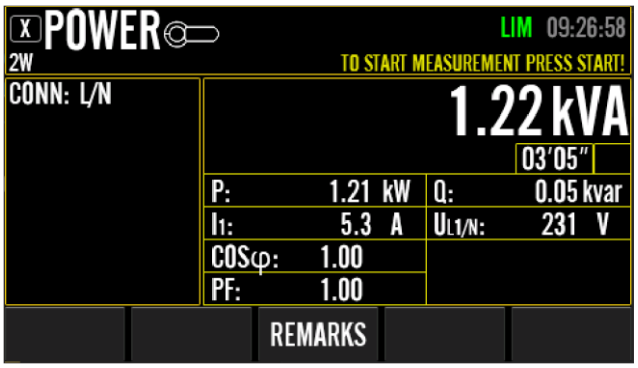


Figure 119: Final result in POWER measurement, example

9) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.10.3. U/P Phase Rotation (3PROTATION)

The measurement can be done by using three or four-wire connection.

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

CONN (F1) = Connection ..... - L1/L2/L3 (three-wire connection, three phase to phase voltages)
- L1/L2/L3/N (four-wire connection, three phase to neutral voltages)

LIMROT (F3) = Rotation limit ..... Selectable ↻, ↺ or OFF
LIM UZSC (F4) = UZSC limit value ..... Adjustable 0.0 … 15.0 %, standard value 2.0 % (available in 4-wire connection only)
LIM UNSC (F5) = UNSC limit value ..... Adjustable 0.0 … 15.0 %, standard value 2.0 %

Measured quantities (L1/L2/L3 connection):

3PROTATION ..... Main result = ↻ or ↺
UL1/L2 ..... Main result = L1/L2 voltage
UL2/L3 ..... Main result = L2/L3 voltage
UL3/L1 ..... Main result = L3/L1 voltage
UNSC ..... Sub-result = Negative sequence voltage
xx' xx'' ..... Sub-result = Overal test duration

Measured quantities (L1/L2/L3/N connection):

3PROTATION ..... Main result = ↻ or ↺
UL1/N ..... Main result = L1/N voltage
UL2/N ..... Main result = L2/N voltage
UL3/N ..... Main result = L3/N voltage
UNSC ..... Sub-result = Negative sequence voltage
UZSC ..... Sub-result = Zero sequence voltage
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for 3PROTATION measurement:

1) Select wished STANDARD (= UUT family) by using rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will be displayed.
3) Press "MEAS" menu key, select 3PROTATION measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected 3PROTATION function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected 3PROTATION measurement with extended range of menu keys will be offered, see the figure below.

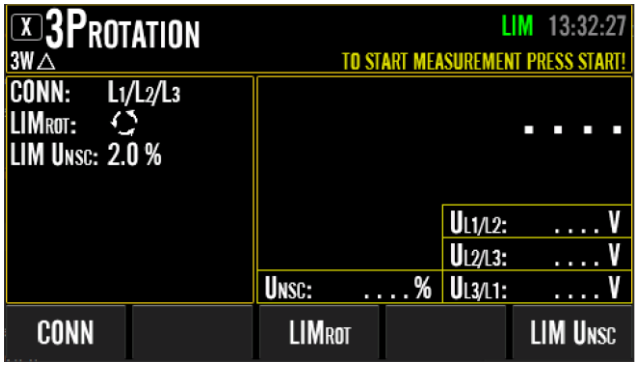


Figure 120: 3PROTATION idle screen with extended range of menu keys (after pressing "EDIT" menu key), example

5) Select wished connection by pressing "CONN" menu key first.
6) Select wished rotation limit (↻, ↺ or OFF) by pressing "LIMROT" menu key first.
7) 4-wire connection only: Adjust wished UZSC limit (0.0 … 15.0 %) by pressing "LIM UZSC" menu key first.
8) Adjust wished UNSC limit (0.0 … 15.0 %) by pressing "LIM UNSC" menu key first.
9) Connect test leads to the installation according to one of the figures below or see available figures in HELP/CONNECTION menu.

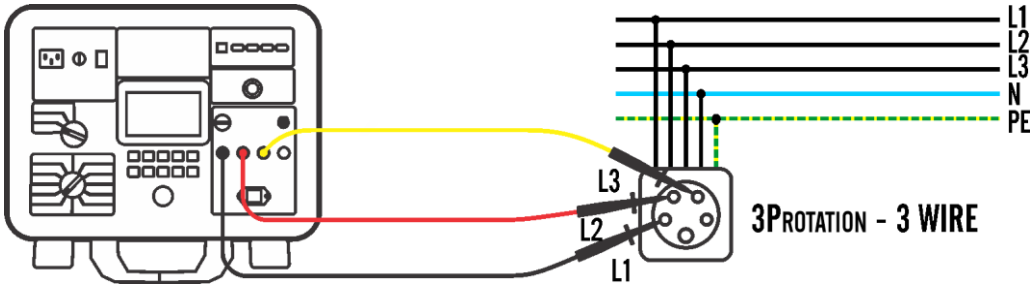


Figure 121: 3-wire connection for phase rotation measurement, example.

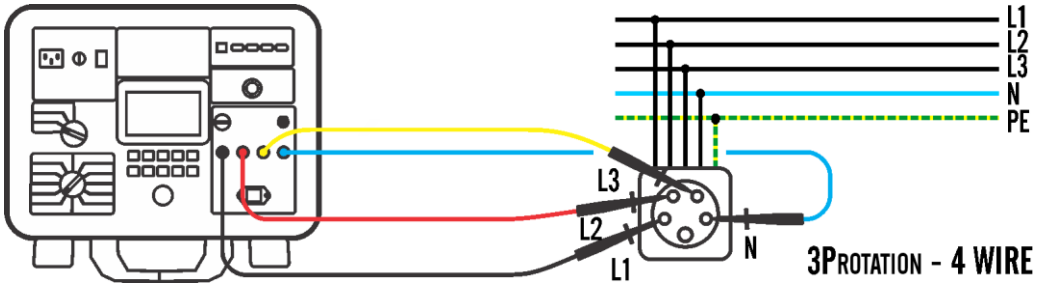


Figure 122: 4-wire connection for phase rotation measurement, example.

10) Press "START" button to start the measurement, continuous measurement will start to run.
11) Stop the measurement by pressing "STOP" button, final measurement result will be displayed, see the figure below.

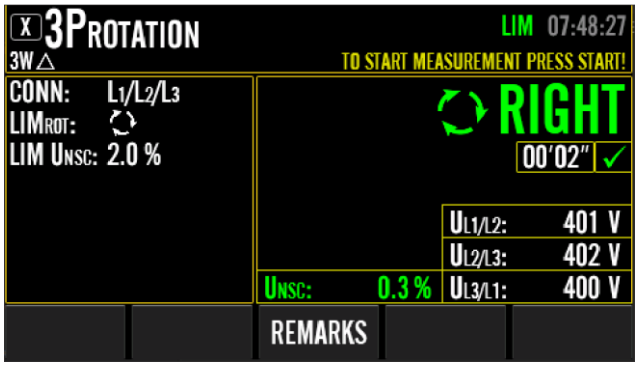


Figure 123: Final result in 3PROTATION measurement, example

12) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.10.4. U/P Protective Extra Low Voltage (PELV)

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

LIM AC (F5) = AC voltage limit value ..... Adjustable 0.0 … 440 V,
standard values 6.0 V and 25.0 V
LIM DC (F6) = DC voltage limit value ..... Adjustable 0.0 … 440 V,
standard values 15.0 V and 60.0 V

Note!

- Parameter CONN (connection) is L/PE (fixed value)

Measured quantities:

U_{AC+DC} ..... Main result = PELV (TRMS value)
U_{AC} ..... Sub-result = AC voltage (AC component only) (TRMS value)
$U_{AC\ MAX\ ABS}$ ..... Sub-result = Max. value of AC voltage during the measurement (absolute value)
U_{DC} ..... Sub-result = DC voltage (DC component only)
$U_{DC\ MAX\ ABS}$ ..... Sub-result = Max. value of DC voltage during the measurement (absolute value)
f ..... Sub-result = Frequency of AC voltage
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for PELV measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting the rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will be displayed.
3) Press "MEAS" menu key, select PELV measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected PELV function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected PELV measurement with extended range of menu keys will be displayed, see the figure below.

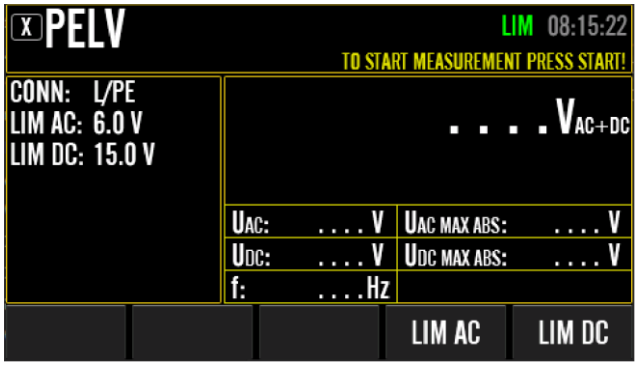


Figure 124: PELV idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Adjust wished AC voltage limit value (0.0 … 440 V) by pressing "LIM AC" menu key first.
6) Adjust wished DC voltage limit value (0.0 … 440 V) by pressing "LIM DC" menu key first.

7) Connect test leads to UUT according to the figure below or see available figures in HELP/CONNECTION menu.

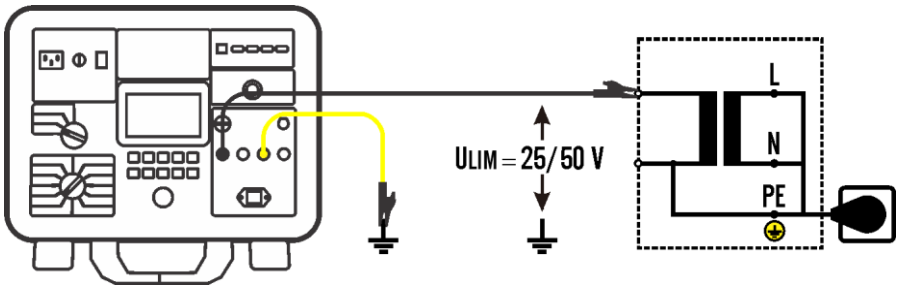


Figure 125: Connection for PELV measurement, example.

8) Press “START“ button to start the measurement, continuous measurement will start to run.
9) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

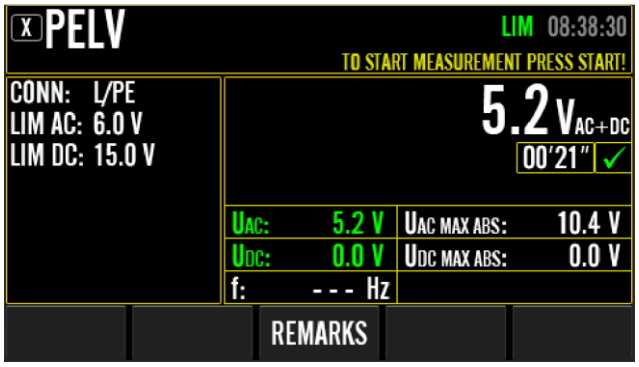


Figure 126: Final result in PELV measurement, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that can be shown on the display

Information displayed	Description
⚠ PE SOCKET NOT GROUNDED!	Ground PE socket (for safety reason it is not grounded internally).
⚠ USE SOCKETS L AND PE!	Test leads are not connected to L and PE sockets.

20.10.5. U/P Safety Extra Low Voltage (SELV)

Adjustable/selectable test parameters (keys available after pressing “EDIT” menu key)**:**

LIM AC (F5) = AC voltage limit value ..... Adjustable 0.0 … 440 V,
standard values 6.0 V and 25.0 V
LIM DC (F6) = DC voltage limit value ..... Adjustable 0.0 … 440 V,
standard values 15.0 V and 60.0 V

Note!

- Parameter CONN (connection) is L/N (fixed value)

Measured quantities:

U_{AC+DC} ..... Main result = SELV (TRMS value)
U_{AC} ..... Sub-result = AC voltage (AC component only) (TRMS value)
$U_{AC\ MAX\ ABS}$ ..... Sub-result = Max. value of AC voltage during the measurement (absolute value)
U_{DC} ..... Sub-result = DC voltage (DC component only)
$U_{DC\ MAX\ ABS}$ ..... Sub-result = Max. value of DC voltage during the measurement (absolute value)
f ..... Sub-result = Frequency of AC voltage
xx’ xx’’ ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for SELV measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting the rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will appear.
3) Press “MEAS” menu key, select SELV measurement and confirm it by pressing “↵“ menu key ⇒ display will turn to idle measurement screen of just selected SELV function.
4) Press “EDIT“ menu key ⇒ idle screen of currently selected SELV measurement with extended range of menu keys will be displayed, see the figure below.

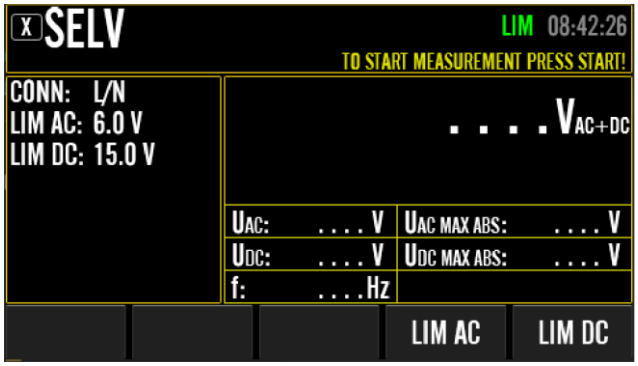


Figure 127: SELV idle screen with extended range of menu keys, example (after pressing “EDIT” menu key)

5) Adjust wished AC voltage limit value (0.0 … 440 V) by pressing “LIM AC” menu key first.
6) Adjust wished DC voltage limit value (0.0 … 440 V) by pressing “LIM DC” menu key first.

7) Connect test leads to UUT according to the figure below or see available figures in HELP/CONNECTION menu.

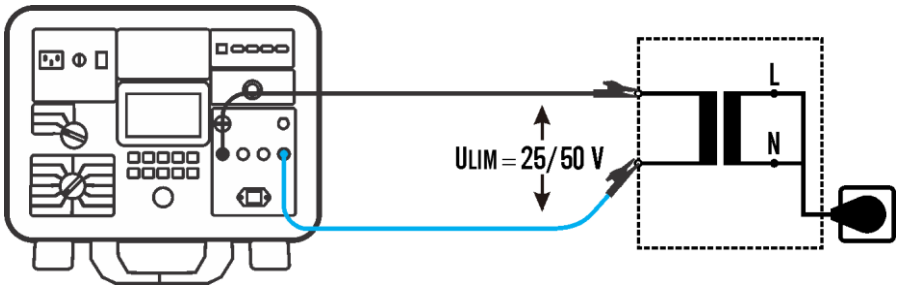


Figure 128: Connection for SELV measurement, example.

8) Press “START“ button to start the measurement, continuous measurement will start to run.
9) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

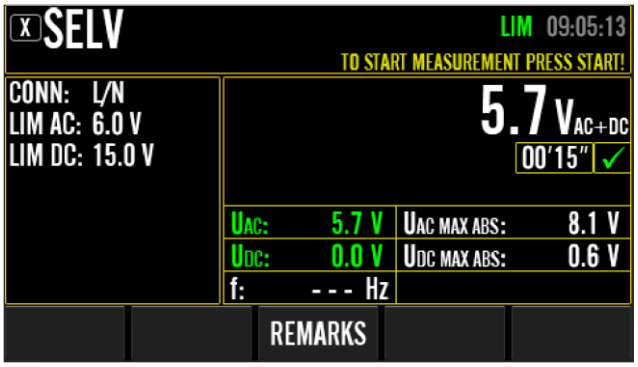


Figure 129: Final result in SELV measurement, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

Specific information that can be shown on the display

[11]

Information displayed	Description
⚠ USE SOCKETS L AND N!	Test leads are not connected to L and N sockets.

20.10.6. U/P Control Voltage (UCONTROL)

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

LIM AC (F5) = AC voltage limit value ..... Adjustable 0.0 … 440 V,
standard values 227 V (60 Hz) and 230 V (50 Hz)
LIM DC (F6) = DC voltage limit value ..... Adjustable 0.0 … 440 V,
standard value 220 V

Note!

- Parameter CONN (connection) is L/N (fixed value).

Measured quantities:

UCONTROL AC+DC ..... Main result = UCONTROL (TRMS value)
UAC ..... Sub-result = AC voltage (AC component only) (TRMS value)
UAC MAX ABS ..... Sub-result = Max value of AC voltage during the measurement (absolute value)
UDC ..... Sub-result = DC voltage (DC component only)
UDC MAX ABS ..... Sub-result = Max value of DC voltage during the measurement (absolute value)
f ..... Sub-result = Frequency of AC voltage
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for UCONTROL measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting the rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will appear.
3) Press "MEAS" menu key, select UCONTROL measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected UCONTROL function.
4) Press "EDIT" menu key ⇒ idle screen of currently selected UCONTROL measurement with extended range of menu keys will be displayed, see the figure below.

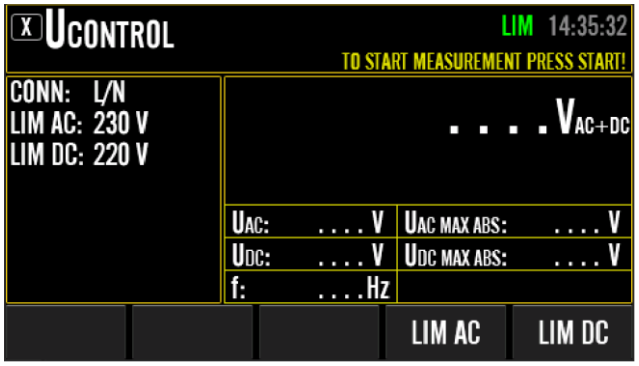


Figure 130: UCONTROL idle screen with extended range of menu keys, example (after pressing "EDIT" menu key)

5) Adjust wished AC voltage limit value (0.0 … 440 V) by pressing "LIM AC" menu key first.

6) Adjust wished DC voltage limit value (0.0 … 440 V) by pressing “LIM DC” menu key first.
7) Connect test leads to UUT according to the figure below or see available figures in HELP/CONNECTION menu.

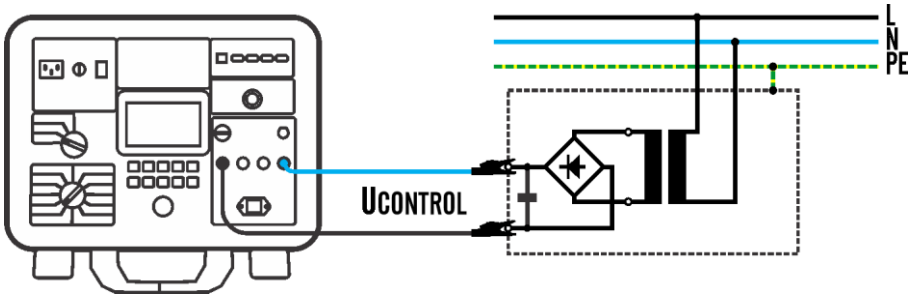


Figure 131: Connection for UCONTROL measurement, example.

8) Press “START“ button to start the measurement, continuous measurement will start to run.
9) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

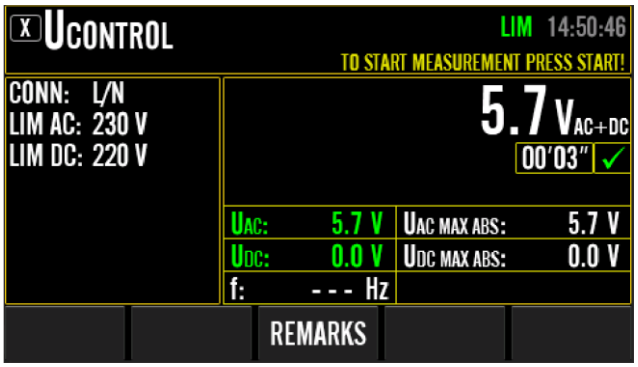


Figure 132: Final result in UCONTROL measurement, example

10) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.10.7. U/P DC Supply Voltage (UDC SUPPLY)

Adjustable/selectable test parameters (keys available after pressing "EDIT" menu key)**:**

MODE (F2) = Measurement mode ..... Selectable BATTERY, CAR BATTERY or DRIVE MODULE
UNOM DC (F3) = Nominal DC voltage ..... Adjustable 10 … 100 V

Mode BATTERIES:
LIM U (F5) = LIM UMIN, LIM UMAX
LIM UMIN = Voltage low limit value ..... Adjustable 0 ... 100 % of UNOM, standard value 85 % of UNOM
LIM UMAX = Voltage high limit value ..... Adjustable 100 ... 150 % of UNOM, standard value 115 % of UNOM

Mode CAR BATTERIES:
LIM U (F5) = LIM UMIN, LIM UMAX
LIM UMIN = Voltage low limit value ..... Adjustable 0 ... 100 % of UNOM, standard value 70 % of UNOM
LIM UMAX = Voltage high limit value ..... Adjustable 100 ... 150 % of UNOM, standard value 120 % of UNOM

Mode DRIVE MODULES:
LIM U (F5) = LIM UMIN, LIM UMAX
LIM UMIN = Voltage low limit value ..... Adjustable 0 ... 100 % of UNOM, standard value 90 % of UNOM
LIM UMAX = Voltage high limit value ..... Adjustable 100 ... 150 % of UNOM, standard value 110 % of UNOM
LIM RIPPLE = Ripple limit value (peak-peak) .... Adjustable 0 ... 50 % of UNOM, standard value 15 % of UNOM

Note!
- Parameter CONN (connection) is L/N (fixed value).

Measured quantities:

UDC SUPPLY ..... Main result = DC supply voltage
URIPPLE ..... Sub-result = Ripple voltage (peak to peak value of superimposed AC voltage) (DRIVE MODE mode only)
UMAX ..... Sub-result = Max DC supply voltage during the measurement
UMIN ..... Sub-result = Min DC supply voltage during the measurement
xx' xx'' ..... Sub-result = Overal test duration

Measuring range:

For measuring and display ranges see HELP/RANGES menu or technical specifications, for other details see the technical specifications in this booklet.

Test procedure for UDC SUPPLY measurement:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1 or 2).
2) Select Voltage/Power measurement by setting the rotary switch #2 to U/P position ⇒ idle screen of currently selected Voltage/Power measurement will appear.
3) Press "MEAS" menu key, select UDC SUPPLY measurement and confirm it by pressing "↵" menu key ⇒ display will turn to idle measurement screen of just selected measurement.
4) Press "EDIT" menu key ⇒ idle screen of currently selected UDC SUPPLY measurement with extended range of menu keys will be offered, see the figure below.

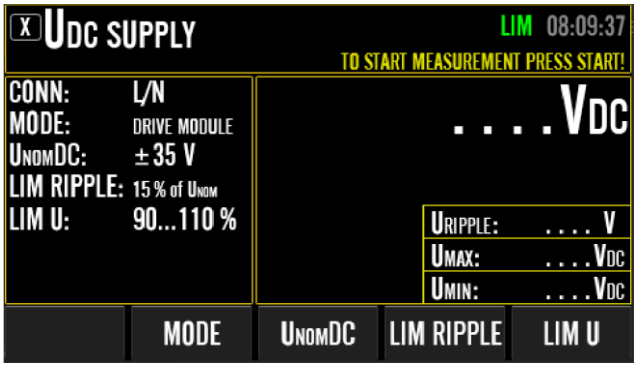


Figure 133: UDC SUPPLY idle screen with extended range of menu keys, example (after pressing "EDIT" menu key), example

5) Select appropriate mode (BATTERY, CAR BATTERY or DRIVE MODULE) by pressing "MODE" menu key first.
6) Adjust wished UNOM DC voltage (10 … 100 V) by pressing "UNOMDC" menu key first.
7) DRIVE MODULE mode only: Adjust wished ripple voltage limit value (0 … 50 % of UNOM) by pressing "LIM RIPPLE" menu key first.
8) Adjust wished DC supply voltage limit range (LOW limit adjustable 0 … 100 % of UNOM, HIGH limit adjustable 0 … 150 % of UNOM) by pressing "LIM U" menu key first.
9) Connect test leads to UUT according to the figure below or see available figures in HELP/CONNECTION menu.

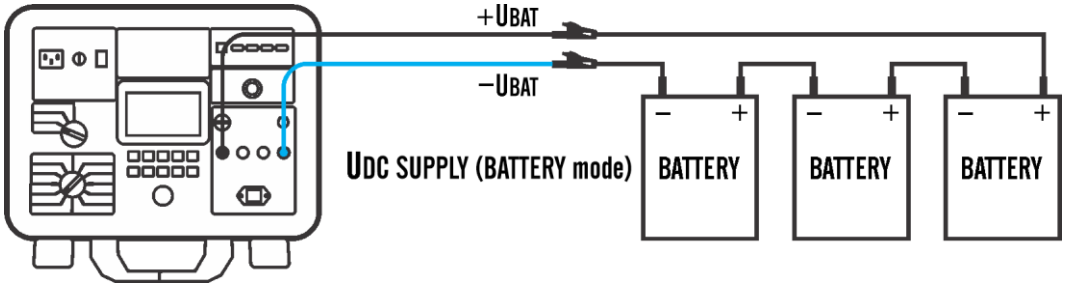


Figure 134: Connection for UDC SUPPLY measurement (BATTERY mode), example.

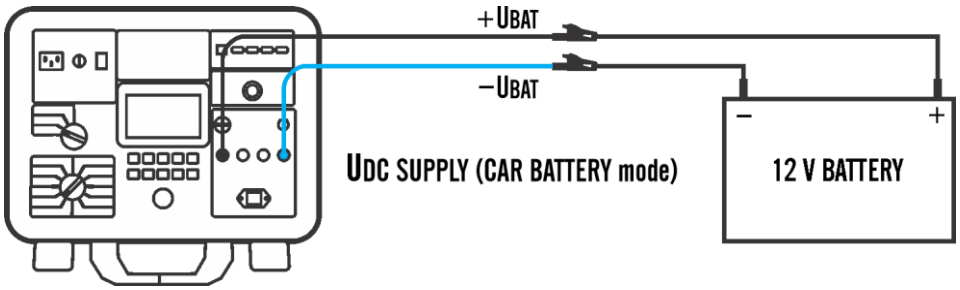


Figure 135: Connection for UDC SUPPLY measurement (CAR BATTERY mode), example.

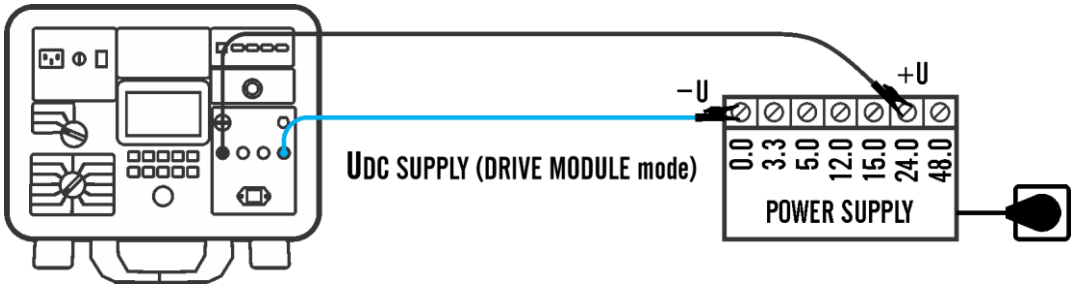


Figure 136: Connection for UDC SUPPLY measurement (DRIVE MODULE mode), example.

10) Press “START“ button to start the measurement, continuous measurement will start to run.
11) Stop the measurement by pressing “STOP“ button, final measurement result will be displayed, see the figure below.

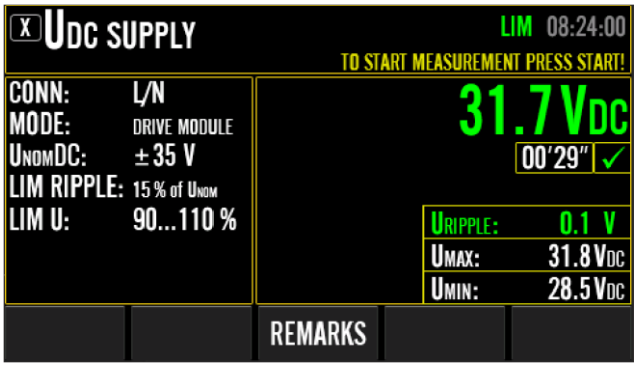


Figure 137: Final result in UDC SUPPLY measurement, example

12) Enter REMARKS if needed and save measurement result, see the chapter “MEMORIZING EXAMPLE” on page 175.

20.11. FUNC Documentation and Functional Test

MST-204 Tester offers documentation and functional test as an independent function in order to properly document all test results that can later be transferred to PC for creation of final test report.

The following sub-functions are available (after pressing “MEAS” menu key):
- DOCUMENTATION (user manual, safety instructions, warnings etc.)
- FUNCTIONAL TEST (rotating parts, moving parts, lamps, heating elements, magnets etc.)
- INSTRUCTION (test procedure, test hints etc.)
- HEADER (main part of the UUT like switchgear 1, switchgear 2 etc.)
- SUB HEADER (sub-part of the UUT like motor, fuse loop etc.)
- INFO (potential deviations, improvement advices etc.)

In any of above sub-functions an operator can enter a DOCUMENTATION NAME and DOCUMENTATION TEXT to discribe the sub-function, press the “TEXT” menu key first. Sub-functions DOCUMENTATION and FUNCTIONAL TEST offer also the possibility to enable or disable the judgement of test result by pressing “LIMIT” menu key first and then togling between ON and OFF options.

How to carry out Documentation and Functional test:

1) Select wished STANDARD (= UUT family) by using the rotary switch #1 (position 1, 2 or 3).
2) Select Documentation and functional test by seting the rotary switch #2 to FUNC position ⇒ idle screen of currently selected Documentation and functional test (last used sub-function) will be displayed.
3) Press “MEAS“ menu key to get into sub-function selection screen, then select wished sub-function and confirm it by pressing “↵“ menu key ⇒ display will turn back to just selected sub-function idle screen.
4) Press “EDIT” menu key to get into idle screen with extended menu keys, see the figure below.

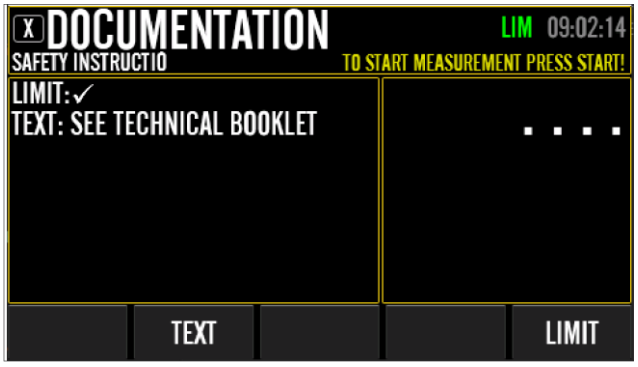


Figure 138: Documentation and functional test (sub-function DOCUMENTATION) idle Screen, example

5) Press “TEXT“ and then “LIST” menu key to get into SELECT DOCUMENTATION screen.
6) Enter NEW documentation name (17 characters max.) or EDIT, COPY or DELETE offerd one. Once documentation name is edited, confirm it by pressing “↵“ menu key ⇒ display will turn to EDIT DOCUMENTATION TEXT screen with querty keyboard.

7) Edit/enter documentation text (500 characters max.), then confirm it by pressing "↵" menu key ⇒ display will turn back to SELECTION DOCUMENTATION screen with a list of actual documentations. Select and confirm actual one by pressing "↵" menu key again (use ⇒ ◨ menu key if needed to reach "↵" option) ⇒ display will turn to DOCUMENTATION screen with all entered details (documentation name and belonging text).
8) Press "EXIT" function key to get back to DOCUMENTATION idle screen.
9) Press "START" button to start the measurement and then manually select the result by pressing "N/A" (not applicable), "FAIL" (checked documentation failed) or "PASS" menu key (checked documentation passed). The measurement stops, test result is ready to be saved, see the figure below.

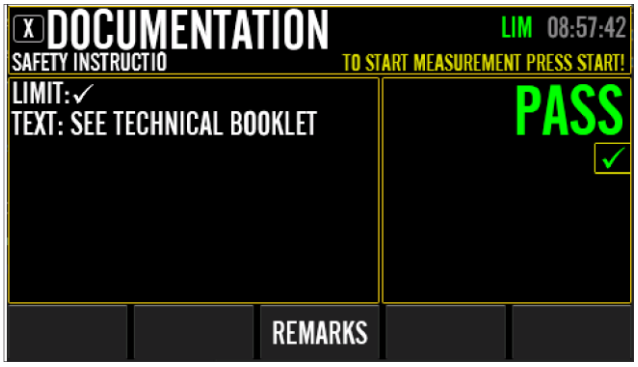


Figure 139: Documentation and functional test result (sub-function DOCUMENTATION), example

10) Enter REMARKS if needed and save measurement result, see the chapter "MEMORIZING EXAMPLE" on page 175.

20.12. AUTO-TEST AUTO FUNCTION

(available for “Machines” or “Switchgear Assemblies” only, not available when switch No. 1 is in “All” position)

Basic idea of AUTO function is to create a “TEST PLAN” (a list of desired measurements) first and then to convert it to a so called “MEMORY” (a kind of a “workspace”) and carry out and save the measurements inside the “MEMORY”.
AUTO function is intended to be used for carrying out any set of measurements on a certain object like machine, switchgear, welding machine, portable appliance, PRCD, mains cable extension, EV connection cable or similar. It is very flexible and simple to use and it leads a test engineer through the whole test procedure.

20.12.1. AUTO-TEST “TEST PLAN” description

“TEST PLAN” is a list of test steps (RPE, RINS, LOOP, RCD etc.) with pre-set test parameters (test current, test voltage, connection, working mode etc., depends on selected test step) and limit values (max. resistance, max. trip out time, max. current, max. voltage etc., depends on selected test step). A “TEST PLAN” has no results.
If the operator wishes to carry out the measurements according to a “TEST PLAN”, then the “TEST PLAN” shall be converted to a “MEMORY” first (it is not possible to carry out and save measurements inside a “TEST PLAN”).
Each “TEST PLAN” is equipped with:
- “TEST PLAN” CODE (mandatory, each “TEST PLAN” CODE is unique and can therefore be used only once, characters according to code 39 can be used, 17 characters max.).
- “TEST PLAN” NAME (mandatory, “TEST PLAN” NAME is not unique and can therefore be used manyfold, all characters can be used, 17 characters max.).

An independent ENVIRONMENT TABLE copied from MENU / SETUP / ENVIRON. is assigned to each “TEST PLAN” created from scratch. This ENVIRONMENT TABLE can later be modified according to the “TEST PLAN” needs.
If a new “TEST PLAN” is copied from existing “TEST PLAN” or created from existing “MEMORY”, then ENVIRONMENT TABLE is inherited from origin “TEST PLAN” or “MEMORY” and can also be modified later according to the “TEST PLAN” needs.

There is also a PROTECTION table assigned to each “TEST PLAN”, which enables/disables certain operations to be done by the operator. The following operations may be enabled/disabled in any “TEST PLAN”:
- ADD/DELETE SINGLE TEST STEPS
- EDIT TEST PARAMETER AND TEST DESCRIPTION
- EDIT POSITION INFO
- TEST SEQUENCE IS MANDATORY

All above operations in “TEST PLANS” and MEMORIES” created on MST-204 Tester are open (status ENABLED/DISABLED for the first three operations is always ENABLED and for the forth one it is DISABLED meaning TEST SEQUENCE is also open). The Protection in “TEST PLANS” and “MEMORIES” can only be modified by PC software “SW-MST-204” (currently this possibility is not implemented yet), it cannot be modified at MST-204 Tester. Usage of the Protection helps i.e. to avoid that an operator makes unwanted changes to a “TEST PLAN” which would leed to a “wrong” testing of the UUT. “TEST PLAN” can be created for a certain object to be tested or a group of similar objects. Prior to creating “TEST PLAN” please kindly familiarize yourself with the unit to be tested, then start creating the “TEST PLAN” directly on MST-204 Tester.

20.12.2. AUTO-TEST Test step description

Test step is a certain measurement inside a “TEST PLAN” or “MEMORY” equal to SINGLE measurement. It includes all needed test parameters and limit values.
Each test step inside a “TEST PLAN” may be equipped with (not mandatory):
- POSITION (information where the measurement shall be carried out)
  This information consistes of 4 levels i.e. of MAIN PANEL NAME, SUB PANEL NAME, CONTROL PANEL/LOAD and TEST POINT.
- DESCRIPTION (for example any kind of measurement instruction or UUT information)

There is also an independent ENVIRONMENT TABLE assigned to each test step. It is copied from “TEST PLAN” or “MEMORY” when entering the test step, and can later be modified according to the test step needs in case a subpart of the UUT has different ratings. The ENVIRONMENT TABLE OF SINGLE TEST STEP can be view/edited in measurement screen of the test step.

20.12.3. AUTO-TEST “MEMORY” description

“MEMORY” is a kind of “workspace” with a list of test steps where in opose to “TEST PLAN”, measuremets can be carried out and results saved.
Preferred way is to create a “MEMORY” from “TEST PLAN” and then to carry out the measurements inside created “MEMORY”.
But there is also a possibility to manually create a “MEMORY” from scratch in parallel with exploring the UUT. This can be done by entering test steps one by one and carrying out the measurements in parallel or after all test steps are entered.

Each “MEMORY” is equipped with “MEMORY” NAME (mandatory, “MEMORY” NAME is not unique and can therefore be used manyfold).

An independent ENVIRONMENT TABLE copied from MENU/SETUP/ENVIRONMENT is assigned to each “MEMORY” created from scratch. This ENVIRONMENT TABLE can later be modified according to the “MEMORY” needs.
If a new “MEMORY” is created from existing “TEST PLAN”, then ENVIRONMENT TABLE is inherited from origin “TEST PLAN” and can later also be modified according to the “MEMORY” needs.

There is also a PROTECTION table assigned to each “MEMORY”, see the instructions in chapter ““TEST PLAN” description” on page 142 above.

Text formats:

Text	Max. length	Unique	Allowed characters
Machine/Appliance name	17	NO	ALL
Machine/Appliance code	17	YES	Code 39
Client name	17	NO	ALL
Client code	17	YES	Code 39
Site name	17	NO	ALL
Site code	17	YES	Code 39
Location name	17	NO	ALL
Additional information	500	NO	ALL
Serial number	17	NO	ALL
Manufacturer	17	NO	ALL
Inventory number	17	NO	ALL
Test result name	17	NO	ALL
Test plan name	17	NO	ALL
Test plan code	17	YES	Code 39
Auto test name	17	NO	ALL
Auto test code	3	YES	Numeric
Main panel	500	NO	ALL
Control panel	500	NO	ALL
Sub panel	500	NO	ALL
Test point	500	NO	ALL
Visual inspection name	17	NO	ALL
Visual inspection description	500	NO	ALL
Documentation name	17	NO	ALL
Documentation description	500	NO	ALL
Functional test name	17	NO	ALL
Functional test description	500	NO	ALL
Engineer name	17	NO	ALL

Table 9. Texts, their max. lengths and available characters

Allowed characters:
Code 39:

- A-Z
- 0-9
- - . $ / + %
- space

File name characters:
All except < > : " / \ | ? *

ALL valid characters:

UNICODE	SIGN	UNICODE	SIGN	UNICODE	SIGN
\u0020	<space>	\u004d	M	\u007a	z
\u0021	!	\u004e	N	\u2265	≥
\u0022	"	\u004f	O	\u007c	|
\u0023	#	\u0050	P	\u25ca	◊
\u0024	$	\u0051	Q	\u007e	~
\u0025	%	\u0052	R	\u00a0	<nbsp>
\u0026	&	\u0053	S	\u00a1	¡
\u0027	'	\u0054	T	\u00a2	¢
\u0028	(	\u0055	U	\u00a3	£
\u0029	)	\u0056	V	\u00a4	¤
\u002a	*	\u0057	W	\u00a5	¥
\u002b	+	\u0058	X	\u00a6	¦
\u002c	,	\u0059	Y	\u00a7	§
\u002d	-	\u005a	Z	\u00a8	¨
\u002e	.	\u005b	[	\u00a9	©
\u002f	/	\u005c	\	\u00aa	ª
\u0030	0	\u005d	]	\u00ab	«
\u0031	1	\u005e	^	\u00ac	¬
\u0032	2	\u005f	_	\u00ad	<soft-hyphen>
\u0033	3	\u0060	`	\u00ae	®
\u0034	4	\u0061	a	\u00af	¯
\u0035	5	\u0062	b	\u00b0	°
\u0036	6	\u0063	c	\u00b1	±
\u0037	7	\u0064	d	\u00b2	²
\u0038	8	\u0065	e	\u00b3	³
\u0039	9	\u0066	f	\u00b4	´
\u003a	:	\u0067	g	\u00b5	µ
\u003b	;	\u0068	h	\u00b6	¶
\u003c	<	\u0069	i	\u00b7	·
\u003d	=	\u006a	j	\u00b8	¸
\u003e	>	\u006b	k	\u00b9	¹
\u003f	?	\u006c	l	\u00ba	º
\u0040	@	\u006d	m	\u00bb	»
\u0041	A	\u006e	n	\u00bc	¼
\u0042	B	\u006f	o	\u00bd	½
\u0043	C	\u0070	p	\u00be	¾
\u0044	D	\u0071	q	\u00bf	¿
\u0045	E	\u0072	r	\u00c0	À
\u0046	F	\u0073	s	\u00c1	Á
\u0047	G	\u0074	t	\u00c2	Â
\u0048	H	\u0075	u	\u00c3	Ã
\u0049	I	\u0076	v	\u00c4	Ä
\u004a	J	\u0077	w	\u00c5	Å
\u004b	K	\u0078	x	\u00c6	Æ
\u004c	L	\u0079	y	\u00c7	Ç
\u00c8	È	\u00f6	ö	\u201c	“
\u00c9	É	\u00f7	÷	\u201d	”
\u00ca	Ê	\u00f8	ø	\u201e	„

\u00cb	Ë	\u00f9	ù	\u2020	†
\u00cc	Ì	\u00fa	ú	\u2021	‡
\u00cd	Í	\u00fb	û	\u2022	•
\u00ce	Î	\u00fc	ü	\u2026	…
\u00cf	Ï	\u00fd	ý	\u2030	‰
\u00d0	Ð	\u00fe	þ	\u2039	‹
\u00d1	Ñ	\u00ff	ÿ	\u203a	›
\u00d2	Ò	\u0106	Ć	\u20a3	₣
\u00d3	Ó	\u0107	ć	\u2122	™
\u00d4	Ô	\u010c	Č	\u2202	∂
\u00d5	Õ	\u010d	č	\u2206	∆
\u00d6	Ö	\u0111	đ	\u220f	∏
\u00d7	×	\u011e	Ğ	\u2211	∑
\u00d8	Ø	\u011f	ğ	\u2212	−
\u00d9	Ù	\u0130	İ	\u2215	∕
\u00da	Ú	\u0131	ı	\u2219	·
\u00db	Û	\u0141	Ł	\u221a	√
\u00dc	Ü	\u0142	ł	\u221e	∞
\u00dd	Ý	\u0152	Œ	\u222b	∫
\u00de	Þ	\u0153	œ	\u2248	≈
\u00df	ß	\u015e	Ş	\u2260	≠
\u00e0	à	\u015f	ş	\u2264	≤
\u00e1	á	\u0160	Š		
\u00e2	â	\u0161	š		
\u00e3	ã	\u0178	Ÿ		
\u00e4	ä	\u017d	Ž		
\u00e5	å	\u017e	ž		
\u00e6	æ	\u0192	ƒ		
\u00e7	ç	\u02c6	ˆ		
\u00e8	è	\u02c7	ˇ		
\u00e9	é	\u02d8	˘		
\u00ea	ê	\u02d9	˙		
\u00eb	ë	\u02da	°		
\u00ec	ì	\u02db	˛		
\u00ed	í	\u02dc	˜		
\u00ee	î	\u02dd	˝		
\u00ef	ï	\u03a9	Ω		
\u00f0	ð	\u03c0	π		
\u00f1	ñ	\u2013	–		
\u00f2	ò	\u2014	—		
\u00f3	ó	\u2018	‘		
\u00f4	ô	\u2019	’		
\u00f5	õ	\u201a	‚		

Table 10. ALL valid characters

20.12.4. AUTO-TEST ENVIRONMENT TABLE description

ENVIRONMENT TABLE is a list of general parameters that can be independently assigned to a "TEST PLAN", "MEMORY" or even to a single test step inside a "TEST PLAN" or "MEMORY". Basic ENVIRONMENT TABLE ("SINGLE MEMORY") is defined in MENU/ENVIRON. menu and it is imported from there any time when new "TEST PLAN" or "MEMORY" is created from scratch.

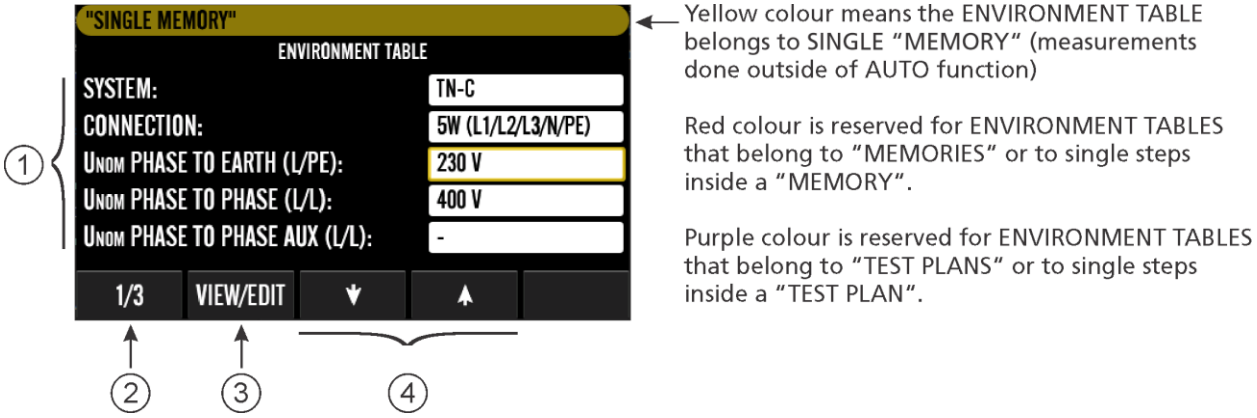


Figure 140. ENVIRONMENT TABLE of a "SINGLE MEMORY", example

1..... List of parameters included in the ENVIRONMENT TABLE (page 1/3).
2..... Page selection soft key (three pages are available).
3..... "VIEW/EDIT" soft key to get into view or edit screen of selected parameter.
4..... "▼" / "▲" menu keys to select wished parameter.

The following parameters are included in the table:

- SYSTEM (Mains system: TN-C, TN-C-S, TN-S, TT, IT)
- CONNECTION (Mains system connection: 2W (L1/L2), 3W (L/N/PE), 3W (L1/L2/PE), 4W (L1/L2/L3/PE), 5W (L1/L2/L3/N/PE))
- UNOM PHASE TO EARTH (L/PE) (Nominal voltage phase to earth: 120 V, 230 V, 400 V, 690 V, 1000 V, 1 … 1000 V customer editable)
- UNOM PHASE TO PHASE (L/L) (Nominal voltage phase to phase: 208 V, 400 V, 690 V, 1 … 1000 V customer editable)
- UNOM PHASE TO PHASE AUX (L/L) (Auxiliary nominal voltage phase to phase: No factory value available, 1 … 1000 V customer editable)
- FNOM (Nominal mains frequency: 50 Hz, 60 Hz)
- PROTECTION CLASS (UUT protection class: PCI, PCII)
- CAT RATING (UUT protection category rating: CAT I, CAT II, CAT III, CAT IV with voltage 50 V, 100 V, 150 V, 300 V, 600 V and 1000 V)
- FAULT VOLTAGE (Max. allowed fault voltage: 25 VAC / 60 VDC, 50 VAC / 120 VDC)
- MAXIMAL CURRENT (Max. allowed current: No factory value available, 0.1 … 1000.0 A customer editable)
- MAXIMAL POWER (Max. allowed power: No factory value available, 0.1 … 1000.0 kW customer editable)
- COMPRESSED AIR PRESSURE (Compressed air pressure: No factory value available, 0.1 … 1000.0 bar customer editable)

Some of above listed parameters directly influence the measurement (test parameters and/or limit values) while some are just of informative nature, see the table below:

Parameter	Influenced function
SYSTEM	- RCD trip out time limit - LOOP IPSC/IPEFC limit (calculated from FUSE table)
CONNECTION	- None (just assigned info)
UNOM PHASE TO EARTH (L/PE)	- LOOP IPSC/IPEFC limit (calculated from FUSE table) - UDELTA, UREF voltage - RCD trip out time limit - RCD tripping current limit - UNOM value in URES/TRES measurement (LINEAR mode) - Result evaluation in UMAINS - UTEST NOM selection in HV measurement
UNOM PHASE TO PHASE (L/L)	- LOOP IPSC/IPEFC limit value (calculated from FUSE table) - UDELTA, UREF voltage value - Result evaluation in UMAINS - UTEST NOM selection in HV measurement
UNOM PHASE TO PHASE AUX (L/L)	- UTEST NOM selection in HV measurement
fNOM	- Result evaluation in ILOAD - Result evaluation in UMAINS - Result evaluation in UCONTROL
PROTECTION CLASS	- UTEST NOM selection in HV measurement
CAT RATING	- UTEST NOM selection in HV measurement
FAULT VOLTAGE	- UF voltage limit in RCD and RCM measurements
MAXIMAL CURRENT	- None (just assigned info)
MAXIMAL POWER	- None (just assigned info)
COMPRESSED AIR PRESSURE	- None (just assigned info)

Table 11. Parameters in ENVIRONMENT TABLE and their influence

See the instructions how to get into the ENVIRONMENT TABLE during creation of a “TEST PLAN” or “MEMORY” in further paragraphs, when actual.

How to get into ENVIRONMENT TABLE of an existing “TEST PLAN” and view/edit it:
Carry out paragraphs 1 and 2 described in chapter “Detailed explanation how to create new “TEST PLAN” from scratch” on page 152.

3) Select “TEST PLAN” operation if not selected yet, by pressing “TEST PLAN” menu key ⇒ last used “TEST PLAN” in background will be displayed and three options will be offered as follows:
   - CONTINUE (Continue operations on selected “TEST PLAN” in background).
   - SELECT (Select one of available “TEST PLANS” if displayed one is not the wished one, then continue operations on this “TEST PLAN”).
   - CREATE (Create new “TEST PLAN” from scratch or from existing “MEMORY” or on bases of some existing “TEST PLAN” (copy)).

   Note!
   - If wished “TEST PLAN” to be continued is already displayed in the background, then simply press “CONTINUE“ key and skip next two steps.

- Select SELECT option and confirm it by pressing “↵“ menu key ⇒ SELECT “TEST PLAN” screen with a list of available “TEST PLANS” will be displayed.

- Select wished “TEST PLAN” to be continued and confirm it by pressing “↵“ menu key ⇒ display will turn to “TEST PLAN” screen with basic information i.e. with QTY OF TEST STEPS, CREATED date and LAST EDITED date, see the figure 144 on page 153.
- Press “INFO“ menu key ⇒ four options will be offered as follows:
  - VIEW/EDIT “TEST PLAN” CODE
  - VIEW/EDIT “TEST PLAN” NAME
  - VIEW/EDIT ENVIRONMENT TABLE
  - VIEW/EDIT PROTECTION
- Select VIEW/EDIT ENVIRONMENT TABLE option and confirm it by pressing “↵“ menu key ⇒ ENVIRONMENT TABLE of selected “TEST PLAN” will be displayed.
- View/edit offered ENVIRONMENT TABLE by using available menu keys, see the Table 11 on page 148.

How to get into ENVIRONMENT TABLE of an existing “MEMORY” and view/edit it:

Carry out paragraphs 1 and 2 described in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

3) Select “MEMORY” operation if not selected yet, by pressing “MEMORY” menu key ⇒ last used “MEMORY” in background will be displayed and three options will be offered as follows:
   - CONTINUE (Continue operations on selected “MEMORY” in background).
   - SELECT (Select one of available “MEMORIES” if displayed one is not the wished one, then continue operations on this “MEMORY”).
   - CREATE (Create new “MEMORY” from “TEST PLAN” or from scratch)

   Note!
   - If wished “MEMORY” to be continued is already displayed in the background, then simply press “CONTINUE“ key and skip next two steps.

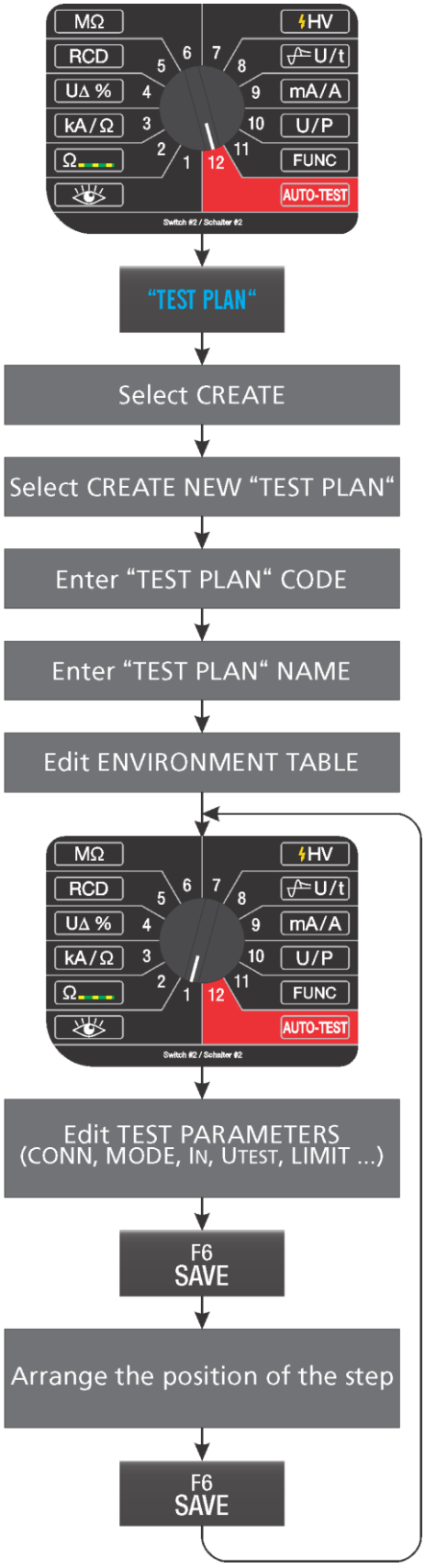
- Select SELECT option and confirm it by pressing “↵“ menu key ⇒ SELECT “MEMORY” screen with a list of available “MEMORIES” will be displayed.
- Select wished “MEMORY” to be continued and confirm it by pressing “↵“ menu key ⇒ display will turn to “MEMORY” screen with basic information, see the figure 155 on page 164.
- Press “INFO“ menu key ⇒ four options will be offered as follows:
  - VIEW/EDIT “MEMORY” NAME
  - VIEW/EDIT ENVIRONMENT TABLE
  - VIEW PROTECTION
  - VIEW/EDIT MACHINE INFO

  Note!
  - SINGLE »MEMORY« has no info.

- Select VIEW/EDIT ENVIRONMENT TABLE option and confirm it by pressing “↵“ menu key ⇒ ENVIRONMENT TABLE of selected “MEMORY” will be displayed.
- View/edit offered ENVIRONMENT TABLE by using available menu keys, see the list of parameters included in the ENVIRONMENT TABLE below.

20.12.5. AUTO-TEST Create “TEST PLAN” on MST-204 Tester

Graphic explanation of how to create new “TEST PLAN” from scratch



1) Turn rotary switch #1 (standards) to appropriate position (2 or 3), depends on the object to be tested.

2) Turn rotary switch #2 (functions) to AUTO position (12).

3) Press “TEST PLAN” menu key, “TEST PLAN” operation will be displayed in purple.

4) Select CREATE option and confirm it by pressing “ENTER“ menu key, three options will be offered.

5) Select CREATE NEW “TEST PLAN” option and confirm it by pressing “ENTER“ menu key, EDIT “TEST PLAN” CODE screen with querty keyboard will be displayed.

6) Enter “TEST PLAN” CODE and confirm it by pressing “ENTER” menu key, EDIT “TEST PLAN” NAME screen with querty keyboard will be displayed.

7) Enter “TEST PLAN” NAME and confirm it by pressing “ENTER” menu key, ENVIRONMENT TABLE screen will be displayed.

8) Edit ENVIRONMENT TABLE, see the chapter “ENVIRONMENT TABLE” and confirm it by pressing “ENTER” menu key, “TEST PLAN” screen with already entered test steps will be displayed (first time no test step will be entered yet, so the list will be empty).

9) Turn rotary switch #2 (functions) to the function that shall be selected as a test step inside the “TEST PLAN” (test step order can also be modified later), for example to VISUAL position, measurement screen of selected function will be displayed.

10) Edit test parameters and limits inside selected measurement screen, then confirm the test step by pressing “SAVE” function key, list of already saved test steps under new “TEST PLAN” will be displayed.

11) Just saved test step field will be purple filled meaning ready to move up/down. Arrange wished position of the test step by using ▼ / ▲ keys and confirm it by pressing ENTER key (or SAVE key), display will turn back to measurement screen of selected function.

12) Turn rotary switch #2 (functions) to the next function to be entered as a test step inside the “TEST PLAN”, for example to RPE position and repeat the procedure as just described for the first step (steps 10 and 11).

Once the last wished test step is saved, the “TEST PLAN” is ready to be used.

Figure 141. Graphic explanation of how to create a “TEST PLAN” from scratch

Notes!

- Each “TEST PLAN” has an independent ENVIRONMENT TABLE. When new test step is added to a “TEST PLAN”, ENVIRONMENT TABLE of the “TEST PLAN” or ENVIRONMENT TABLE from menu (single measurement) if the ENVIRONMENT TABLES are different, can be assigned to it. Customer need to deside which one to be used by pressing “ADOPT” or “DECLINE” touch screen key when message “THIS ENVIRON. TABLE DIFFERS FROM ENVIRON. TABLE OF THE “TEST PLAN”/”MEMORY”” is displayed.
- See the Table 9 on page 144 and Table 10 on page 146 when entering various codes, names or other strings for available characters to be used and maximal lengths of the entries.
- An external keyboard may be used for quicker and more flexible entering required data instead of using display’s querty keyboard.
- Barcode scanner can also be used for quicker and more flexible entering required data, see the instruction in chapter “ENTRY OF VARIOUS DATA BY USING A BARCODE SCANNER“ on page 178.

Detailed explanation of how to create new “TEST PLAN” from scratch

This option shall be used if there is no “TEST PLAN” or “MEMORY” available in the MST-204 Tester, that would suit or approximately suit to the new UUT.
Prior to creating “TEST PLAN” from scratch please kindly familiarize yourself with the object to be tested, then start creating the “TEST PLAN”.

1) Turn rotary switch #1 (standards) to appropriate position (position 2 or 3), depends on the object to be tested.
2) Turn rotary switch #2 (functions) to AUTO position ⇒ display will turn to AUTO start screen, see the figure below. Last used operation (“TEST PLAN” in purple or “MEMORY” in red if any, respectively in brown if none) with three options will be displayed. Darkened last used “TEST PLAN” if any or “MEMORY” will be displayed in background.

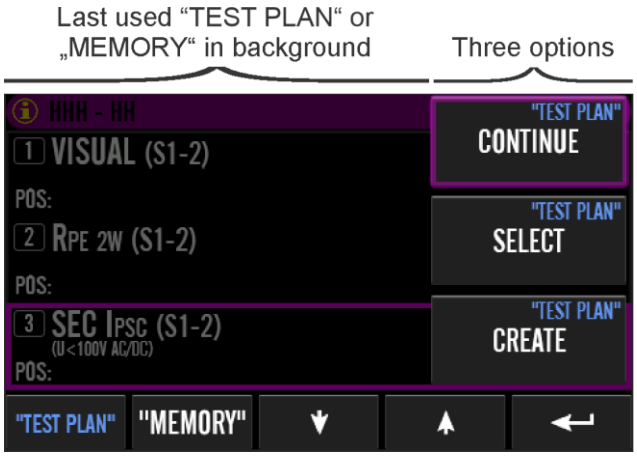


Figure 142. AUTO start screen i.e. last used “TEST PLAN” or “MEMORY” with three options, example

3) Select “TEST PLAN” operation if not selected yet, by pressing “TEST PLAN” menu key ⇒ last used “TEST PLAN” in background will be displayed and three options will be offered as follows:
   - CONTINUE (Continue operations on selected last used “TEST PLAN” in background).
   - SELECT (Select another “TEST PLAN”).
   - CREATE (Create new “TEST PLAN”).
   - Select CREATE option and confirm it by pressing “↵“ menu key ⇒ three new options will be offered as follows:
     - CREATE NEW “TEST PLAN” (Create new “TEST PLAN” from scratch).
     - CREATE NEW “TEST PLAN” FROM EXISTING “MEMORY” (New “TEST PLAN” will be created on bases of already saved “MEMORY” and can later be adapted for new UUT).
     - COPY EXISTING “TEST PLAN” (Selected “TEST PLAN” will be copied and can later be adapted for new UUT).
4) Select CREATE NEW “TEST PLAN” option and confirm it by pressing “↵“ menu key ⇒ EDIT “TEST PLAN” CODE screen with querty keyboard will be displayed.
   - Enter “TEST PLAN” CODE and confirm it by pressing “↵“ menu key ⇒ EDIT “TEST PLAN” NAME screen with querty keyboard will be displayed.
   - Enter “TEST PLAN” NAME and confirm it by pressing “↵“ menu key ⇒ ENVIRONMENT TABLE applied to currently creating “TEST PLAN” will be displayed. Offered independent ENVIRONMENT TABLE is coppied from the menu (“SINGLE MEMORY”).

- View/edit offered ENVIRONMENT TABLE by using available menu keys. See detailed explanation in chapter “ENVIRONMENT TABLE description” on page 147.
  Confirm edited ENVIRONMENT TABLE by pressing “↵“ menu key
  ⇒ “TEST PLAN” screen with empty list of test steps will be displayed in background and instruction TO ADD NEW TEST STEP TURN ROTARY SWITCH #2 TO DESIRED MEASUREMENT FUNCTION AND PRESS SAVE KEY (F6), see the figure below.

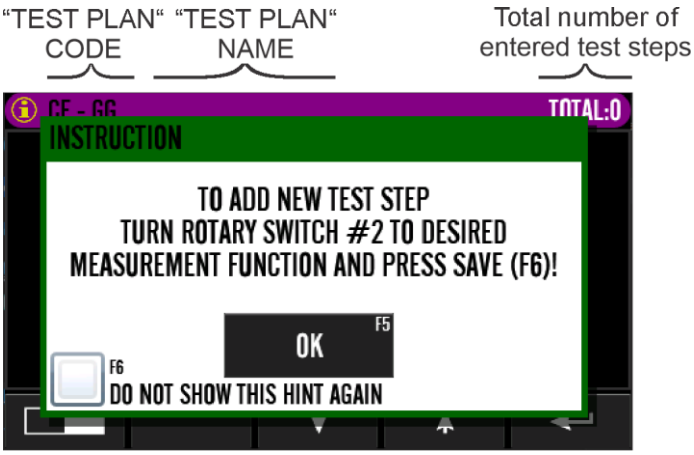


Figure 143. “TEST PLAN” with empty list of test steps, example

Press F5 menu key to remove above mentioned instruction.

Thus new “TEST PLAN” without test steps is created, continue with entering test steps as described below.

Notes!

- If needed, press “MEM“ function key during the following procedure in AUTO function to turn to “TEST PLAN” screen with basic information i.e. with QTY OF TEST STEPS, CREATED date and LAST EDITED date, see the figure below.

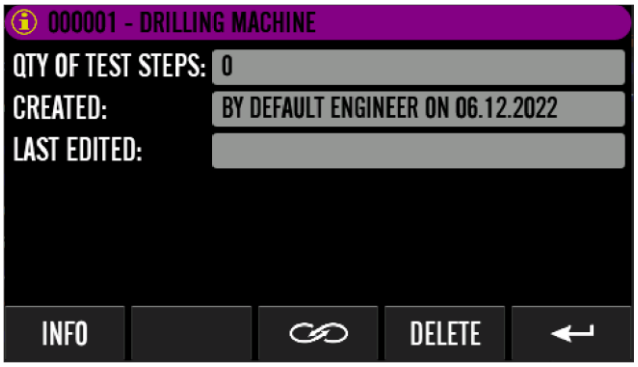


Figure 144. “TEST PLAN” with basic data, example

- If needed, press “∞“ menu key in above case to turn back to AUTO start screen, see the figure 142 on page 152 above.

5) Add test steps as follows:
   - Turn rotary switch #2 (functions) to the function to be added as a test step inside just created “TEST PLAN”, for example to VISUAL position ⇒ measurement screen of selected function will be displayed, see the figure below.

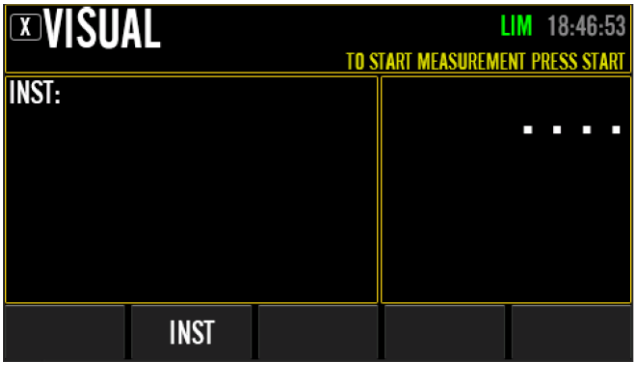


Figure 145. Measurement screen of selected function (VISUAL), example

- Edit test parameters and limits inside selected measurement screen, then confirm the step by pressing “SAVE“ function key ⇒ list of saved test steps under selected “TEST PLAN” will be displayed. Just saved test step will be purple filled meaning ready to move up/down, see the figure below.

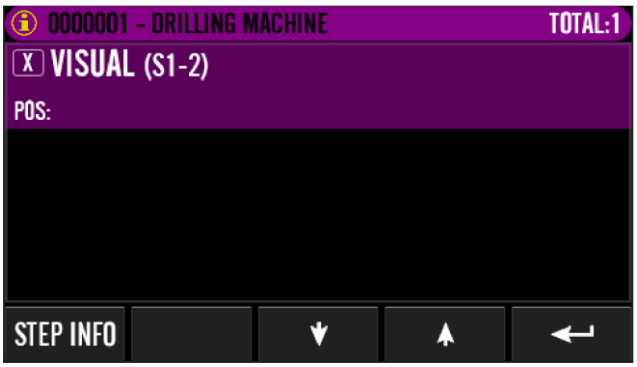


Figure 146. List of saved test steps under selected “TEST PLAN”, example

- Arrange wished position of the test step by using “🡻” / “🡹” menu keys and confirm it by pressing “SAVE“ (or “↵“) key ⇒ display will turn back to measurement screen of selected function.
- Turn rotary switch #2 (functions) to the next function to be selected as an additional test step inside created “TEST PLAN” for example to RPE position and repeat the procedure as just described for the first step (above two indents).
- Continue the procedure for other test steps until the last wished one is added.

Note!

- Just saved test steps inherited the ENVIRONMENT TABLE from currently creating TEST PLAN and can be edited individually for each test step (get into the third level of test step inside the TEST PLAN and edit the table if needed).

6) If needed again, view/edit test steps. For this purpose turn rotary switch #2 to AUTO position (12), press CONTINUE to turn to “TEST PLAN” with basic data (see the figure 144 on page 153), and then press “↵“ menu key to turn to “TEST PLAN” with a list of test steps.
   - View/edit test steps on the first view/edit level meaning move them up/down, copy or delete. Use “▢■“ menu key to get into the second set of menu keys.
   - Once test steps are viewed/edited on the first view/edit level, select wished test step to be continued and confirm it by pressing “↵“ menu key (figure above) ⇒ display will turn to the second view/edit level of selected test step, see the figure below.

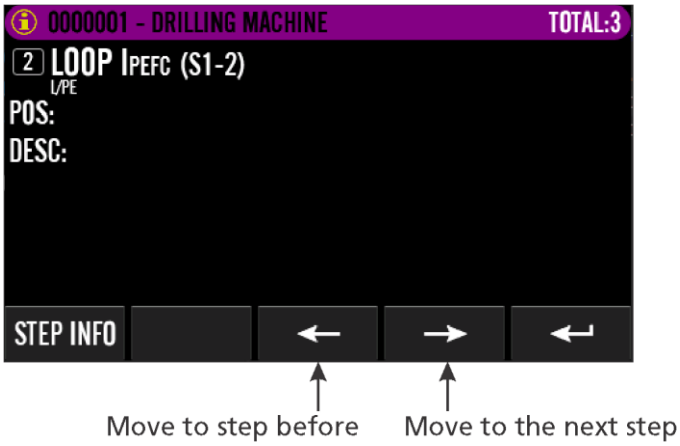


Figure 147. Selected test step (LOOP) on the second view/edit level, example

- View/edit the POSITION and DESCRIPTION information of selected test step by pressing "STEP INFO" menu key first. Once the POSITION and DESCRIPTION are viewed/edited, press "EXIT" function key twice to turn back to the second view/edit level (figure above).
- Press "↵" menu key ⇒ display will turn to the third view/edit level i.e. measurement screen of selected test step, see the figure below.

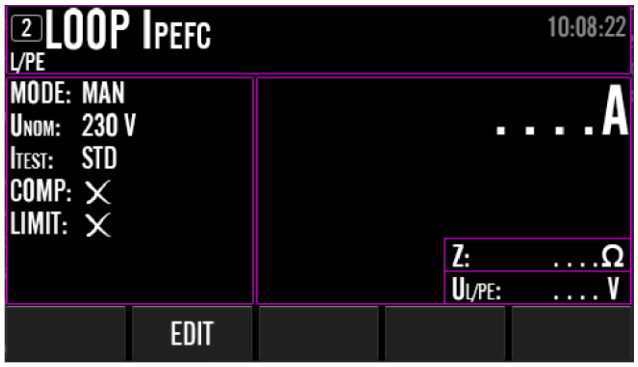


Figure 148. Selected test step (LOOP) on the third view/edit level i.e. measurement screen, example

- View/edit test parameters and limits including ENVIORONMENTAL TABLE of selected test step, use the same operations as in single measurement via EDIT.
- Once all test parameters and limits of selected test step are viewed/edited on the third level, press "EXIT" function key to turn back to selected "TEST PLAN" screen with a list of test steps on the first view/edit level.
- Select the next test step to be viewed/edited and repeat the same procedure as just described for the first one (above 5 indents).
- Once all test steps are viewed/edited on all three view/edit levels, "TEST PLAN" is ready to be used. For this purpose, see the instructions in chapter "Graphic explanation of how to create "MEMORY" from a "TEST PLAN", carry out the measurements and save test results inside the "MEMORY"" on page 162 or "Detailed explanation of how to create "MEMORY" from a "TEST PLAN", carry out the measurements and save test results inside the "MEMORY"" on page 163.

How to create new “TEST PLAN” from existing “MEMORY”

If there is a “MEMORY” existing in MST-204 Tester which test steps best suit to a new UUT, then it is advisable to create “TEST PLAN” from the “MEMORY”. For this purpose follow the next procedure.

Carry out paragraphs 1 … 3 described in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

4) Select CREATE NEW “TEST PLAN” FROM EXISTING “MEMORY” option and confirm it by pressing “↵“ menu key ⇒ SELECT “MEMORY” screen with a list of available “MEMORIES” will be displayed, see the figure below.

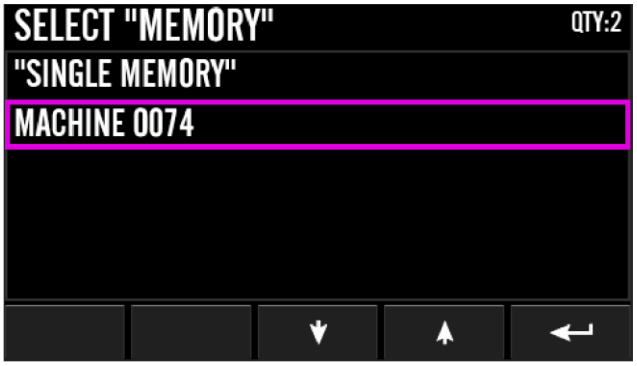


Figure 149. List of available “MEMORIES”, example

Note!

- New tester (empty) will offer only SINGLE MEMORY possibility.

5) Select wished “MEMORY” which new “TEST PLAN” shall be created from and confirm it by pressing “↵“ menu key ⇒ EDIT “TEST PLAN” CODE screen with querty keyboard will be displayed and copied “MEMORY” serial number will be offered as a new “TEST PLAN” CODE.
   - Edit “TEST PLAN” CODE or confirm offered one by pressing “↵“ menu key ⇒ EDIT “TEST PLAN” NAME screen with querty keyboard will be displayed and copied “MEMORY” NAME will be offered as a new “TEST PLAN” NAME.

   Notes!

   - “MEMORY” serial number is automatically chronologically assigned to each “MEMORY” when creating it.
   - New tester (empty) contains only “SINGLE MEMORY” (“MEMORY” automatically created from single measurements, even empty). Serial number of the “SINGLE MEMORY” is “0” which will therefore be offered as a new “TEST PLAN” CODE in this case.
   - New tester (empty) will offer “SINGLE MEMORY” possibility as a new “TEST PLAN” NAME.

   - Edit offered “TEST PLAN” NAME or confirm offered one by pressing “↵“ menu key ⇒ ENVIRONMENT TABLE applied to currently creating “TEST PLAN” will be displayed. Offered independent ENVIRONMENT TABLE is coppied from used “MEMORY”.
   - View/edit offered ENVIRONMENT TABLE by using available menu keys. See detailed explanation in chapter “ENVIRONMENT TABLE description” on page 147.
     Confirm edited ENVIRONMENT TABLE by pressing “↵“ menu key ⇒ new created “TEST PLAN” with test steps copied from selected “MEMORY” will be displayed, see the figure below.

Note!

- All potential test results from used “MEMORY” will be deleted (“TEST PLAN” has no results).

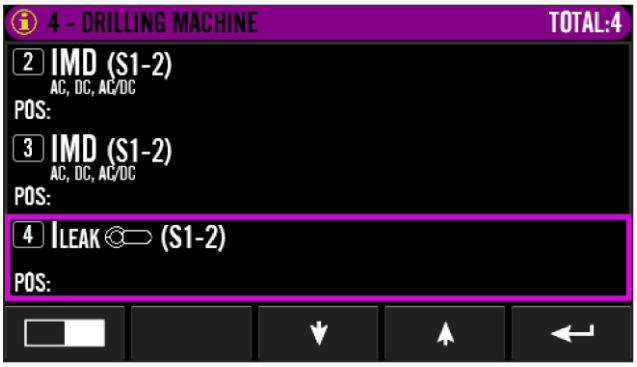


Figure 150. New “TEST PLAN” with a list of copied test steps, example

6) View/edit test steps as follows:
   - See the chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

   How to add new test steps:
   - See the instructions in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

How to copy existing “TEST PLAN”

If there is a “TEST PLAN” existing in MST-204 Tester that best suits to a new UUT, then it is advisable to copy it and adjust copied “TEST PLAN” to the new UUT. For this purpose follow the next procedure.

Carry out the paragraphs 1 … 3 described in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

4) Select COPY EXISTING “TEST PLAN” option and confirm it by pressing “↵“ menu key ⇒ SELECT “TEST PLAN” screen with a list of available “TEST PLANS” will be displayed, see the figure below.

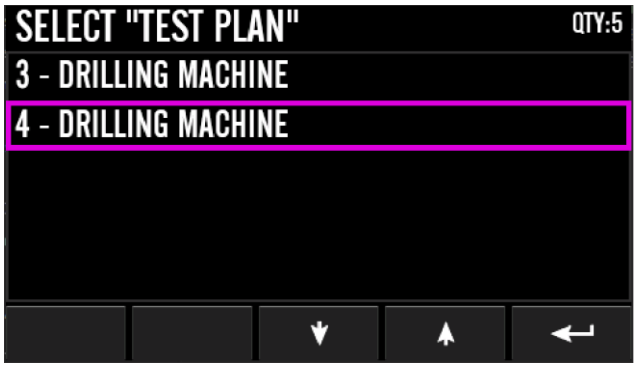


Figure 151. List of available “TEST PLANS”, example

Note!

- New tester (empty) will offer empty list of “TEST PLANS”.

5) Select wished “TEST PLAN” to be copied and confirm it by pressing “↵“ menu key ⇒ EDIT “TEST PLAN” CODE screen with querty keyboard will be displayed and the code of copied “TEST PLAN” will be offered as a new “TEST PLAN” CODE.
   - Edit offered “TEST PLAN” CODE and confirm it by pressing “↵“ menu key ⇒ EDIT “TEST PLAN” NAME screen with querty keyboard will be displayed and the name of copied “TEST PLAN” will be offered as a new “TEST PLAN” NAME.

     Note!
     - Offered “TEST PLAN” CODE above must obligatorily be altered as any code is unique. “TEST PLAN” NAME is not unique and can therefore be used manyfold.

   - Edit “TEST PLAN” NAME or confirm offered one by pressing “↵“ menu key ⇒ ENVIRONMENT TABLE applied to currently creating “TEST PLAN” will be displayed. Offered independent ENVIRONMENT TABLE is inherited from copied “TEST PLAN”.
   - View/edit offered ENVIRONMENT TABLE by using available menu keys. See detailed explanation in chapter “ENVIRONMENT TABLE description” on page 147.
     Confirm edited ENVIRONMENT TABLE by pressing “↵“ menu key ⇒ new created “TEST PLAN” with test steps copied from selected “TEST PLAN” is displayed, see the figure below.

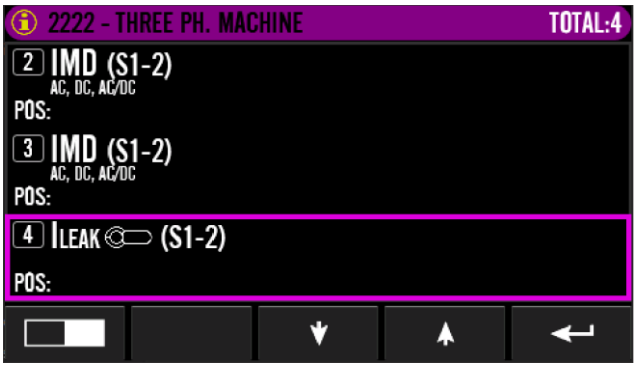


Figure 152. New “TEST PLAN” with a list of copied test steps, example

6) View/edit new “TEST PLAN”, see the instructions in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

   How to add new test steps:
   See the instructions in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

How to continue operations on a “TEST PLAN”

Note!

- The following procedure can be used also just to check “TEST PLANS”.

Carry out paragraphs 1 and 2 described in chapter “Detailed explanation how to create new “TEST PLAN” from scratch” on page 152.

3) Select “TEST PLAN” operation if not selected yet, by pressing “TEST PLAN” menu key ⇒ last used “TEST PLAN” in background will be displayed and three options will be offered as follows:
   - CONTINUE (Continue operations on selected last used “TEST PLAN” in background).
   - SELECT (Select another “TEST PLAN”).
   - CREATE (Create new “TEST PLAN”).

   Note!
   - If wished “TEST PLAN” to be continued is already displayed in the background, then simply press “CONTINUE“ key and skip next two steps.

   - Select SELECT option and confirm it by pressing “↵“ menu key ⇒ SELECT “TEST PLAN” screen with a list of available “TEST PLANS” will be displayed.
   - Select wished “TEST PLAN” to be continued and confirm it by pressing “↵“ menu key ⇒ display will turn to “TEST PLAN” screen with basic information i.e. with QTY OF TEST STEPS, CREATED date and LAST EDITED date, see the figure 144 on page 153.
   - Press “↵“ menu key ⇒ display will turn to “TEST PLAN” screen with a list of already entered test steps.
4) View/edit displayed “TEST PLAN”, follow the procedure described in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

   How to add new test steps:
   - See the instructions in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

20.12.6. AUTO-TEST Carry Out the Measurements

In case the object to be tested is known, check if an appropriate “TEST PLAN” for such object already exist in the MST-204 Tester. If so, most convenient procedure is to convert this “TEST PLAN” to a new “MEMORY” and carry out the measurements inside the new “MEMORY”, see the instructions in chapter “Graphic explanation of how to create “MEMORY” from a “TEST PLAN”” on page 162 or in chapter “Detailed explanation of how to create “MEMORY” from a “TEST PLAN”, carry out the measurements and save test results inside the “MEMORY”” on page 163 below.

If an appropriate “TEST PLAN” does not exist yet, it is recommended to create it first and then to carry out the measurements as described above.

Graphic explanation of how to create “MEMORY” from a “TEST PLAN”, carry out the measurements and save test results inside the “MEMORY”

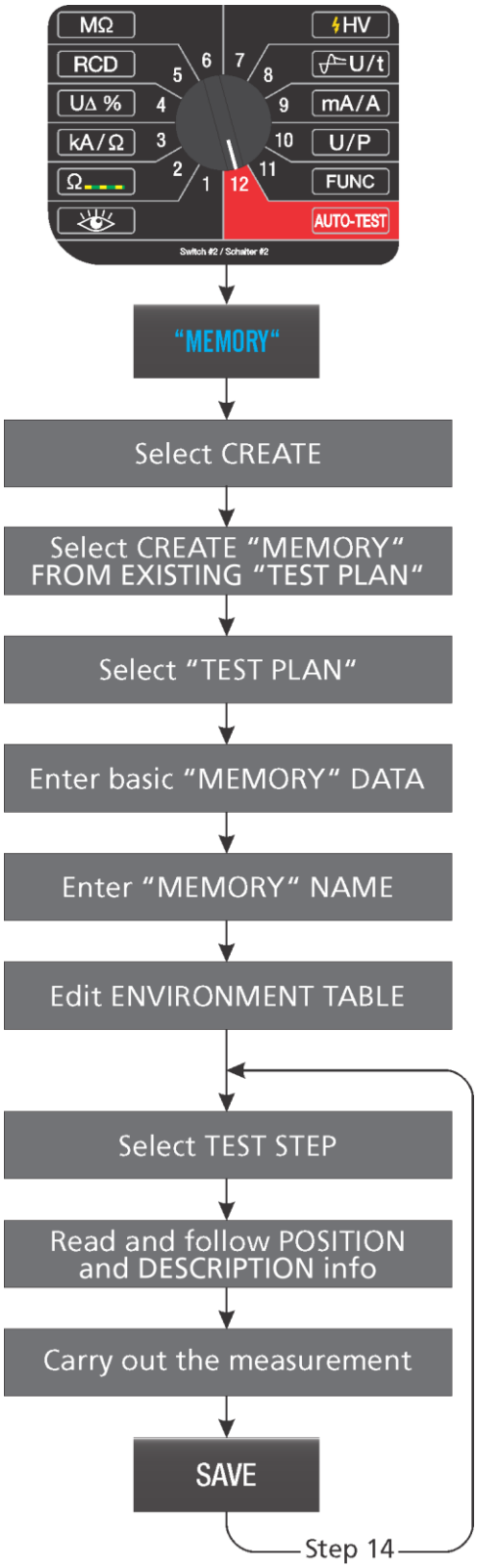


Figure 153. Graphic explanation of how to create “MEMORY” from a “TEST PLAN”

1) Turn rotary switch #1 (standards) to appropriate position (2 or 3), depends on the unit to be tested.

2) Turn rotary switch #2 (functions) to AUTO position (12).

3) Press “MEMORY” menu key.

4) Select CREATE option and confirm it by pressing ENTER key ⇒ two options will be offered.

5) Select CREATE “MEMORY” FROM EXISTING “TEST PLAN” option and confirm it by pressing ENTER key ⇒ SELECT “TEST PLAN” screen with a list of available “TEST PLANS” will be displayed.

6) Select wished “TEST PLAN” to be used and confirm it by pressing ENTER key ⇒ “MEMORY” screen with basic “MEMORY” data will be displayed.

7) Enter basic “MEMORY” data (only MACHINE CODE is obligatory, **see also the note marked bold on page 164** and confirm it by pressing ENTER key ⇒ EDIT “MEMORY” NAME screen will be displayed and “TEST PLAN” NAME will be offered as a new “MEMORY” NAME.

8) Edit “MEMORY” NAME or confirm offered one by pressing ENTER key ⇒ ENVIRONMENT TABLE screen will be displayed.

9) View ENVIRONMENT TABLE, see the chapter “ENVIRONMENT TABLE description” on page 147 and confirm it by pressing ENTER key ⇒ “MEMORY” screen with a list of test steps copied from selected “TEST PLAN” will be displayed.

10) Select first test step where the measurement is to be carried out and confirm it by pressing ENTER key ⇒ test step with entered POSITION and DESCRIPTION will be displayed.

11) Read and follow POSITION and DESCRIPTION info and confirm it by pressing ENTER key ⇒ display will turn to measurement screen of selected test step.

12) Carry out the measurement by pressing “START” button ⇒ result will be displayed.

13) Save the result by pressing SAVE key ⇒ display will turn back to “MEMORY” screen with a list of test steps.

14) Select next test step where the measurement is to be carried out and repeat the procedure just explained for the first test step (steps 11, 12 and 13).

Once the measurements in all test steps are carried out and results saved, the “MEMORY” is completed.

Detailed explanation of how to create “MEMORY” from a “TEST PLAN”, carry out the measurements and save test results inside the “MEMORY”

This is most common way to carry out the measurements on a certain object.

1) Turn rotary switch #1 (standards) to appropriate position (position 2 or 3, depends on the object to be tested).
2) Turn rotary switch #2 (functions) to AUTO position ⇒ display will turn to AUTO start screen. Last used operation (“TEST PLAN” in purple or “MEMORY” in red if any, respectively in brown if none) with three options will be displayed. Darkened last used “TEST PLAN” or “MEMORY” will be displayed in background, see the figure 142 on page 152.
3) Select “MEMORY” operation if not selected yet, by pressing “MEMORY” function key ⇒ last used “MEMORY” screen in background will be displayed and three options will be offered as follows:
   - CONTINUE (Continue operations on selected last used “MEMORY” in background).
   - SELECT (Select another “MEMORY”).
   - CREATE (Create new “MEMORY”).
4) Select “CREATE” option and confirm it by pressing “↵“ menu key ⇒ two additional options will be offered as follows:
   - CREATE “MEMORY” FROM EXISTING “TEST PLAN” (Create new “MEMORY” by transferring “TEST PLAN” to a new “MEMORY” and then to carry out the measurements inside the new “MEMORY”).
   - CREATE NEW “MEMORY” (Create new “MEMORY” manually from scratch in parallel with exploring the UUT. This can be done by entering test steps one by one and carring out the measurements in parallel or after all test steps are entered).
5) Select CREATE “MEMORY” FROM EXISTING “TEST PLAN” and confirm it by pressing ↵ menu key ⇒ SELECT “TEST PLAN” screen with a list of available “TEST PLANS” will be displayed.
   - Select wished “TEST PLAN” new “MEMORY” to be created from and confirm it by pressing “↵“ menu key ⇒ data of the new MACHINE (UUT) will be displayed, see the figure below.

Figure 154. Data of a new MACHINE

The data consist of:
- MACHINE CODE (obligatory)
- MACHINE NAME
- CLIENT CODE
- CLIENT NAME
- SITE CODE
- SITE NAME

- LOCATION
- MANUFACTURER
- ADDITIONAL INFO
- SERIAL NUMBER
- INVENTORY NUMBER
- CONSTRUCTION DATE
- TEST INTERVAL

Notes!

- **Only MACHINE CODE is obligatory to be entered! But PC software "SW-MST-204" which may later be used for creation of test report, will filter downloads through CLIENT NAMEs. This is why it is recommended to enter CLIENT NAME too.**
- Use FILTER function (SELECT CLIENT TO FILTER) if needed when entering MACHINE CODE. Thus only MACHINE CODES belonging to selected CLIENT will be offered. This is a wellcome help if there are many clients and belonging machines already entered.
- See the Table 9 on page 144 and Table 10 on page 146 when entering various codes, names or other strings for available characters to be used and maximal lengths of the entries.
- An external keyboard or barcode scanner may be used for quicker and more flexible entering of required data instead of using display's querty keyboard. External keyboard or scanner can be used always when flashing cursor is offered.

- Enter MACHINE CODE and confirm it by pressing "↵" menu key
⇒ EDIT "MEMORY" NAME screen with querty keyboard will be displayed and used "TEST PLAN" NAME will be offered as a new "MEMORY" NAME.
- Edit "MEMORY" NAME or confirm offered one by pressing "↵" menu key
⇒ ENVIRONMENT TABLE copied from used "TEST PLAN" applied to currently creating "MEMORY" will be displayed.

Notes!

- If needed, press "MEM" function key during the following procedure in AUTO function to turn to a new "MEMORY" screen with basic information, see the figure below.

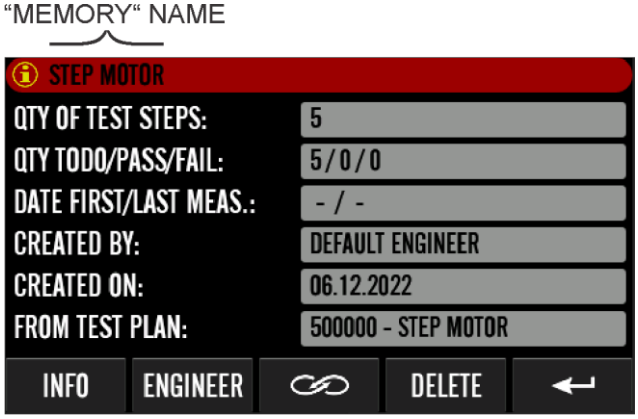


Figure 155. New "MEMORY" with basic data, example

- If needed, press "⛓" menu key in above case to turn back to AUTO start screen, see the figure 142 on page 152.

- View/edit offered ENVIRONMENT TABLE by using available menu keys. Confirm edited ENVIRONMENT TABLE by pressing "↵" menu key ⇒ new created "MEMORY" with test steps copied from selected "TEST PLAN" will be displayed, see the figure below.

Figure 156. New created “MEMORY” with test steps copied from selected “TEST PLAN”

Note!

- Use “FILTER” menu key to toggle among available possibilities:
  - TOTAL (total number of test steps = PASSED + FAILED)
  - TODO (number of test steps still to be carried out)
  - PASSED (number of PASSED test steps)
  - FAILED (number of FAILED test steps)

6) Carry out the measurements

- Select first test step where the measurement is to be carried out and confirm it by pressing “↵“ menu key ⇒ display will turn to the second view/edit level of selected test step.
- Read and follow POSITION and DESCRIPTION of the test step and confirm it by pressing “↵“ menu key ⇒ display will turn to the third level i.e. measurement screen of selected test step.
- Carry out the measurement.
- Add REMARKS for measurement result if needed, by pressing “REMARKS“ menu key ⇒ REMARKS start screen will be displayed. Press “EDIT“ menu key ⇒ WRITE REMARKS screen with querty keyboard will be displayed. Enter REMARKS and confirm them by pressing “↵“ menu key ⇒ display will turn back to REMARKS start screen. Press “EXIT“ function key to turn back to measurement screen with test result.
- Save the test result by pressing “SAVE“ function key ⇒ display will turn back to selected “MEMORY” screen with a list of test steps, proposing the next test step.
- Select next test step where the measurement is to be carried out and repeat the same procedure as just described for the first test step.
- Once the measurements in all test steps are carried out and result saved, the job is done and “MEMORY” is completed.

Note!

- It is possible to repeat the measurement on already saved test step, in this case three possibilities will be offered namely:
  - ADD (new test value will be added on the top of existing one)
    Example: Already existing RPE test value is on position 2, meaning it is displayed for example as 2 RPE 0.17Ω. Added value will reindex existing result to 2.a RPE 0.17Ω and add a new one displayed as 2.b RPE 1.23Ω.
  - UPDATE (existing test value will be overwritten)
  - CANCEL (new test value will be canceled)

How to add new and view/edit existing test steps:
See the instructions in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

How to create a “MEMORY” from scratch

This option shall be used if there is no “TEST PLAN” or “MEMORY” available in the MST-204 Tester, that would suit or approximately suit to the new UUT.
Prior to creating “MEMORY” from scratch please kindly familiarize yourself with the object to be tested, then start creating the “MEMORY”.

Carry out paragraphs 1 to 4 described in chapter “Detailed explanation of how to create “MEMORY” from a “TEST PLAN”, carry out the measurements and save test results inside the “MEMORY”” on page 163.

Note!

- Offered independent ENVIRONMENT TABLE is in this case coppied from the menu (“SINGLE MEMORY”).

5) Select CREATE NEW “MEMORY” option and confirm it by pressing “↵“ menu key
   ⇒ new MACHINE data will be displayed, see the figure 154 on page 163.
   - Enter new MACHINE data and confirm it by pressing “↵“ menu key
     ⇒ EDIT “MEMORY” NAME screen with querty keyboard will be displayed.
   - Enter “MEMORY” NAME and confirm it by pressing “↵“ menu key
     ⇒ ENVIRONMENT TABLE is copied from the menu.
   - View/edit offered ENVIRONMENT TABLE by using available menu keys. See detailed explanation in chapter “ENVIRONMENT TABLE description” on page 147.
     Confirm edited ENVIRONMENT TABLE by pressing “↵“ menu key
     ⇒ new created “MEMORY” with empty list of test steps will be displayed, see the figure below.

Figure 157. Just created “MEMORY” with empty list of test steps, example

6) Add test steps as follows:
   - Turn rotary switch #2 (functions) to the function to be selected as a test step inside just created “MEMORY”, for example to VISUAL position ⇒ measurement screen of selected function will be displayed, see the figure 145 on page 154.
   - Edit test parameters and limits inside selected measurement screen, then confirm the step by pressing “SAVE“ function key ⇒ list of saved test steps under created “MEMORY” will be displayed.
     Just saved test step will be red filled meaning ready to move up/down, see the figure below.

Figure 158. “MEMORY” screen with already entered test steps, example

- Arrange wished position of the test step by using “▼” / “▲” menu keys and confirm it by pressing “SAVE“ (or “↵“) key ⇒ display will turn back to measurement screen of selected function.
- Turn rotary switch #2 (functions) to the next function to be selected as an additional test step inside created “MEMORY” for example to RPE position and repeat the procedure as just described for the first step (above two indents).
- Continue the procedure for other test steps until the last wished one is added.

7) If needed again, view/edit test steps. For this purpose turn rotary switch #2 (functions) to AUTO position (12), press CONTINUE to turn to actual “MEMORY” with basic data, see the figure 155 on page 164, and then press “↵“ menu key to turn to “MEMORY” with a list of already entered test steps. Then follow the procedure described in chapter “Detailed explanation of how to create new “TEST PLAN” from scratch” on page 152.

Note!

- Measurements can also be carried out in parallel with creating the “MEMORY” inside paragraph 7 above. Therefore please setup the test step first (like step 6) and then setup measurement screen of selected test step (third view/edit screen), press “START“ button and after finishing the measurement press “SAVE“ function key twice.

How to add new test steps:

- Any time during above procedure (paragraphs 6 and 7) turn rotary switch #2 (functions) to the function to be selected as an additional test step inside actual “MEMORY” for example to LOOP position ⇒ measurement screen of selected function will be displayed.
- Edit test parameters and limits inside selected measurement screen, then confirm the step by pressing “SAVE“ function key ⇒ list of saved test steps under actual “MEMORY” will be displayed again. Just saved test step field will be red filled meaning ready to move up/down.
- Arrange wished position of the test step by using “▼” / “▲” menu keys and confirm it by pressing “↵“ menu key ⇒ display will turn back to measurement screen of selected function.

How to continue operations on a “MEMORY”

Note!

- The following procedure can be used also just to check the status of a “MEMORY”.

Carry out the paragraphs 1 to 3 described in chapter “Detailed explanation of how to create “MEMORY” from a “TEST PLAN”, carry out the measurements and save results inside the “MEMORY”” on page 163.

4) Select “CONTINUE” option and confirm it by pressing “↵“ menu key ⇒ “MEMORY” screen with basic data will be displayed (see the figure 155 on page 164).
5) Check displayed basic information of select “MEMORY” then confirm it by pressing “↵“ menu key ⇒ “MEMORY” with a list of test steps will be displayed.
6) Follow the instructions described in chapter “Detailed explanation of how to create “MEMORY” from a “TEST PLAN”, carry out the measurements and save results inside the “MEMORY””, paragraph 6 on page 165.

21. MENU mode

There are many general settings available in MENU mode. To get into the MENU mode press “MENU” function key (F8), the following options will be offered.

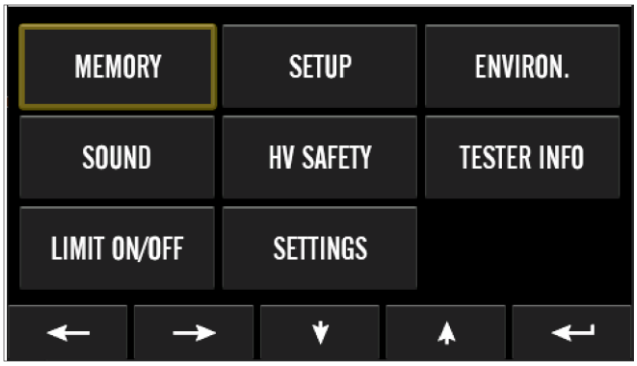


Figure 159: MENU display

21.1. MEMORY

Figure 160: MEMORY menu

The following information is available after selecting the MEMORY menu, see the figure above:

MACHINES/SWITCHGEARS:	Number of entered machines/switchgears (0 … 100 of total 100).
“TEST PLANS”:	Number of entered “TEST PLANS” (0 … 100 of total 100).
“MEMORY”:	Number of “MEMORIES” (0 … 1000 of total 1000).
USED SPACE:	Used memory space (0.0 … 100.0 %).

The memory (all saved test results, belonging test parameters, remarks, addresses etc.) can be exported to USB stick by pressing “EXPORT” menu key first followed by entering and confirming the export file name.

MACHINES/SWITCHGEARS, “TEST PLANS” and “MEMORIES” can also be imported from USB stick by pressing “IMPORT” menu key first and then selecting and confirming one of available files.

Note!

- See the capacity of the memory space in technical specifications on page 184.

21.2. SETUP

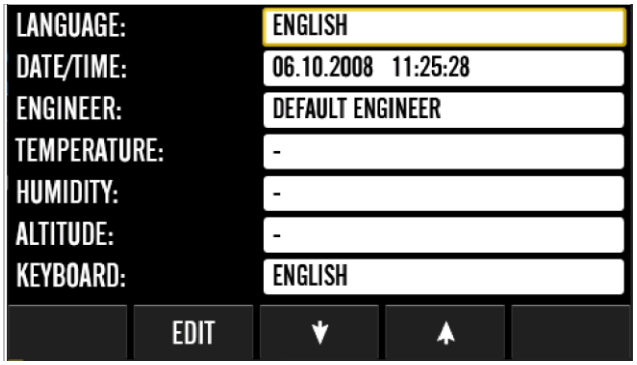


Figure 161: SETUP menu

The following settings are available tobe viewed/edited after selecting the SETUP menu, see the figure above:

LANGUAGE:	Display language, English or German.
DATE/TIME:	Actual date and time.
ENGINEER:	Test operator, factory entered default engineer (new instrument) is DEFAULT ENGINEER, max. 100 engineers.
TEMPERATURE:	Ambient temperature, adjustable -10 … 50°C.
HUMIDITY:	Ambient humidity, adjustable 0 … 100 %.
ALTITUDE:	Altitude where testing is carried out, adjustable 0 … 2000 m
KEYBOARD:	Keyboard language version, English or German.

21.3. ENVIRON. (EVIRONMENT TABLE)

See the chapter “ENVIRONMENT TABLE description” on page 147.

21.4. SOUND

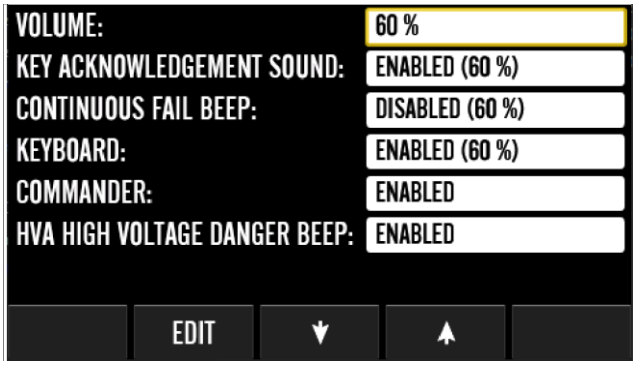


Figure 162: SOUND menu

The following settings are available to be viewed/edited after selecting the SOUND menu, see the figure above:

VOLUME:	General volume of the instrument's speaker, selectable 0 … 100 % in steps of 20 %.
KEY ACKNOVLEDGEMENT SOUND:	Key sound enabled or disabled.
CONTINUOUS FAIL BEEP:	Sound during continuous measurement (for example RPE) in case of failed result (red), enabled or disabled. Note! • The sound is in continuous beep form and it is different than final fail sound.
KEYBOARD:	External keyboard sound, enabled or disabled.
COMMANDER:	Commander key sound, enabled or disabled.
HVA HIGH VOLTAGE DANGER BEEP:	Beep-beep-beep… warning sound during running test enabled or disabled.

21.5. HV SAFETY

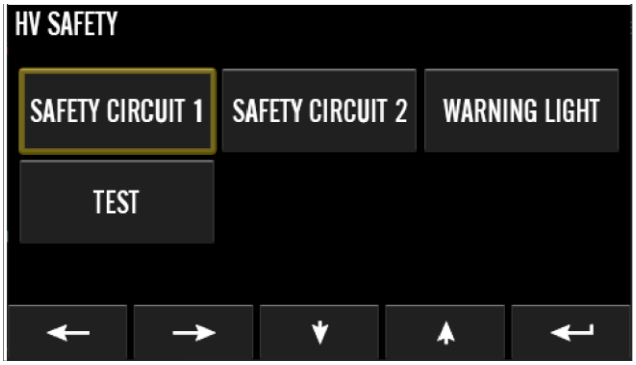


Figure 163: HV SAFETY menu

The following settings are available to be viewed/edited after selecting the HV SAFETY menu, see the figure above:

SAFETY CIRCUIT 1: Safety circuit 1 can be enabled or disabled here. If it is enabled, then safety switch connected to SAFETY CIRCUIT 1 must be closed for normal operation of HVA Adapter.

SAFETY CIRCUIT 2: Safety circuit 2 can be enabled or disabled here. If it is enabled, then safety switch connected to SAFETY CIRCUIT 2 must be closed for normal operation of HVA Adapter.

WARNING LIGHT: Green/red warning light on HVA-204 Adapter can be enabled or disabled here. If the light is enabled, then it must be connected to WARNING LAMP connector and both lamps must be in good condition for normal operation of HVA Adapter.

TEST: Some functional tests on HVA-204 Adapter can be done here as follows:
TEST PROBE INPUT: Only type SP03 with “START” switch can be tested here.
Connection of HV test gun 1 and HV test gun 2 (PROBE CONTROL connector) and operation of “START” switches on both HV test guns can be observed.
SAFETY CIRCUIT: State of SAFETY CIRCUIT 1 and SAFETY CIRCUIT 2 can be observed.
WARNING LIGHT: Red/green warning light (both colours) can be tested by manual switching them on/off.
LOCK: Operation of lock/unlock key can be observed.
CONTROL OUTPUTS (PEDAL, CONTROL INPUT-OUTPUT connector): Functions PREPARED (READY), RUNNING, PASS and FAIL can be tested here.
CONTROL INPUTS (PEDAL, CONTROL INPUT-OUTPUT connector): Functions START / STOP (START BUTTON), TRIGGER (PEDAL), SAFETY CIRCUIT 1 and SAFETY CIRCUIT 2 can be tested here.

21.6. TESTER INFO

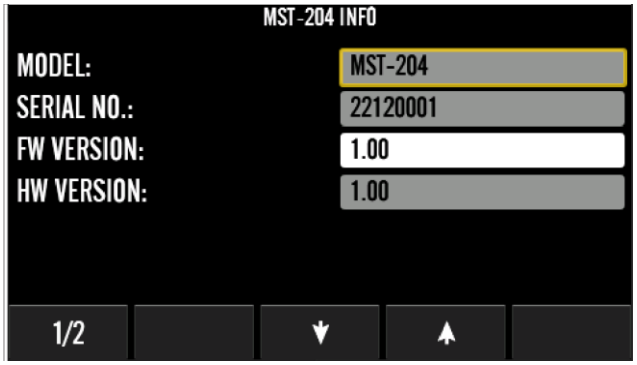


Figure 164: TESTER INFO menu

The following data are available to be viewed/updated after selecting the TESTER INFO menu, see the figure above:

MODEL: Model of the MST-204 Tester.

SERIAL NO.: Serial number of the MST-204 Tester.

FW VERSION: Actual firmware version uploaded to MST-204 Tester.

Note!

- The firmware contains firmware for basic instrument MST-204 Tester, HVA-204 High-Voltage Adapter, CM-204 Commander and for TPA-204* Three-Phase Adapter and can be uploaded/upgraded to MST-204 tester from USB stick. High-Voltage Adapter, Commander and Three-Phase Adapter will be automatically upgraded when they are connected to MST-204 Tester (if MST-204 carries newer FW version than currently installed in connected device).

HW VERSION: Actual hardware version of the MST-204 Tester.

COMMANDER SERIAL NO.: Commander serial number (it will be displayed only if the Commander is connected to MST-204 Tester).

COMMANDER HW VERSION.: Actual hardware version of the Commander (it will be displayed only if the Commander is connected to MST-204 Tester).

HV ADAPTER SERIAL NO.: Serial number of the HVA-204 Adapter (it will be displayed only if the adapter is connected to MST-204 Tester).

HV ADAPTER HW VERSION: Actual hardware version of the HVA-204 Adapter (it will be displayed only if the adapter is connected to MST-204 Tester).

TP ADAPTER SERIAL NO.: Serial number of the TPA-204-63A* or TPA-204-32A* Adapter (it will be displayed only if the adapter is connected to MST-204 Tester).

TP ADAPTER HW VERSION: Actual hardware version of the TPA-204-63A* or TPA-204-32A* Adapter (it will be displayed only if the adapter is connected to MST-204 Tester).

* In development

21.7. LIMIT ON/OFF

Limits in general (all limits in all functions) can be enabled (LIMIT ON) or disabled (LIMIT OFF). Even if the limits in general are enabled, they can still be disabled individually in each function.

21.8. SETTINGS

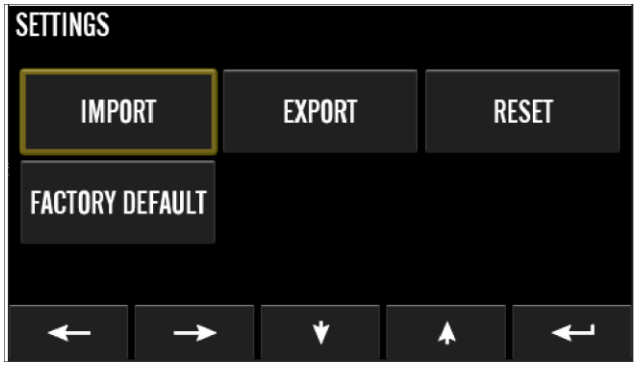


Figure 165: SETTINGS menu

The following settings are available after selecting the SETTINGS menu, see the figure above:

IMPORT: Import settings. All setings from one tester (test parameters of single measurements, MENU settings etc.) can be exported to USB stick first and then imported to this tester here. For this purpose select one of available files on connected USB stick and confirm it by pressing "↵" menu key ⇒ wait until all actual settings are overwritten and start screen with basic data according to figure 6 on page 27 is displayed again.

EXPORT: Export settings. All setings (test parameters of single measurements, MENU settings etc.) from this tester can be exported to USB stick here. For this purpose create a fine name first (all characters except <>:"/\|?* can be used, max. 17 characters) and confirm it by pressing "↵" menu key ⇒ wait until all settings are exported and SETTINGS menu screen is displayed again.

RESET: All settings (test parameters of single measurements, MENU settings etc.) will be reset to default values here.

FACTORY DEFAULT: All settings (test parameters of single measurements, MENU settings etc.) will be reset to default values and test results will be cleared (like the instrument coming from factory).

22. MEMORIZING EXAMPLE

22.1. Memorizing of a single measurement

In order to save single measurement result (measurement done with rotary switch #2 in any position except in AUTO) follow the next instructions.

Take into account the measurement is done and result is displayed.

1) Enter REMARKS to displayed result if needed by pressing “REMARKS“ menu key first followed by “EDIT” one. Use offered keyboard screen or external keyboard. Confirm entered REMARKS by pressing “↵“ menu key ⇒ display will turn to REMARKS full screen. Press “EXIT“ function key to turn back to final measurement result screen.
2) Press “SAVE” function key (F6), display will turn to “SINGLE MEMORY” screen, see the figure below.

Figure 166: Screen with single measurement result to be saved to SINGLE MEMORY, example

1 ..... Memory name (brown background is reserved for single measurements). Name SINGLE MEMORY is used for all single measurement results (rotary switch #2 out of AUTO position).
2 ..... “STEP INFO” menu key. Use it if you wish to view/edit the POSITION where the measurement was done or view/edit the TEST DESCRIPTION attached to the measurement result to be saved.
3 ..... “ENTER” menu key.
4 ..... Line with actual measurement result to be saved.
5 ..... Line with last already saved measurement result.
6 ..... Total number of already saved measurement results (includng with the last one where memorizing is still to be confirmed).

3) View/edit step info if needed by pressing “STEP INFO” menu key first.
4) Press “SAVE” function key (F6) or “ENTER” menu key again to confirm saving of the result ⇒ display will turn back to measurement screen of selected function without test result.

Note!

- Entering various data like measurement REMARKS, POSITION or TEST DESCRIPTION can be much easier done by using an external USB keyboard or USB barcode scanner, see the chapter “ENTRY OF VARIOUS DATA BY USING AN EXTERNAL KEYBOARD” on page 177 or chapter “ENTRY OF VARIOUS DATA BY USING A BARCODE SCANNER“ on page 178.

22.2. Memorizing of AUTO Measurement

Each partial measurement result (each step) done in AUTO function must be saved individually.

1. Once appropriate result within a certain test step is displayed, press “SAVE” function key, result will be saved and display will turn back to the list of test steps with saved results within selected “MEMORY”. Cursor will move to the next step regardless whether the measurement in this step has already been done and result saved or not, see the figure below.

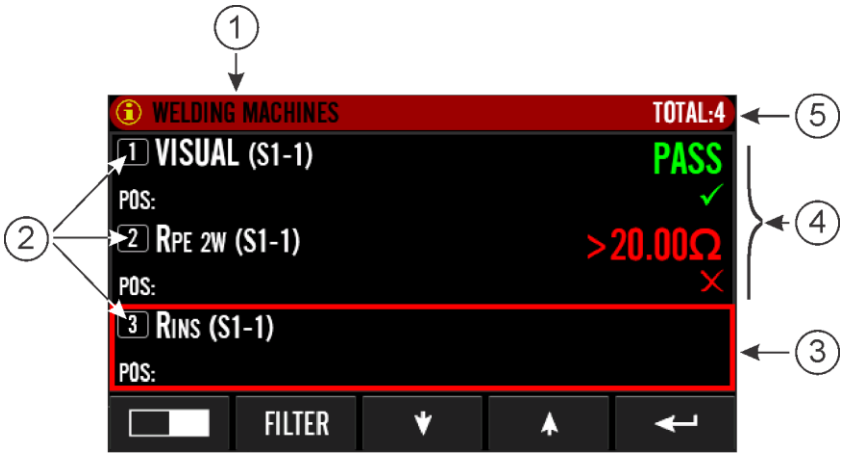


Figure 167: “MEMORY” screen with a list of test steps in AUTO function. Some test steps are done already, some not yet, example.

1 ..... Memory name (red background is reserved for AUTO MEMORY = results done in AUTO function = rotary switch #2 in AUTO position).
2 ..... Step serial numbers (actual in “TEST PLANS” and “MEMORIES” only).
3 ..... Line with proposed next test step to be carried out.
4 ..... Lines with already done test steps.
5 ..... Total number of test steps inside actual “MEMORY” (WELDING MACHINES).

2. Select next test step to be carried out by using “🡻” / “🡹” menu keys and confirm it by pressing “↵“ menu key.
3. Get into the second level of the test step by pressing “↵“ menu key. Position and Description can be viewed/edited here by pressing “STEP INFO” menu key first.
4. Get into the third level of the test step by pressing “↵“ menu key ⇒ display will turn to measurement screen of selected test step.
5. Carry out the measurement and repeat memorizing procedure just described for the first step, see paragraph 1. above.

23. ENTRY OF VARIOUS DATA BY USING AN EXTERNAL KEYBOARD

The optional external keyboard is a welcome accessory when entering various data like “TEST PLAN” CODE, “TEST PLAN” NAME, MACHINE CODE, MACHINE NAME, CLIENT CODE, CLIENT NAME, SITE CODE, SITE NAME, LOCATION, MANUFACTURER, ADDITIONAL INFO, SERIAL NUMBER, INVENTORY NUMBER, REMARKS, POSITION, TEST DESCRIPTION etc., to make it short, whenever blinking cursor is offered. Connect the USB keyboard to USB2, USB3, USB4 or to USB5 connector, three sound signals will follow after plugging it (wait a few seconds) as a confirmation of USB device recognition.

Notes!

- Use the USB keyboard listed in the “Optional Accessories” section only, otherwise it may not be recognized by the MST-204 Tester.
- All four USB inputs/outputs (USB2, USB3, USB4 and USB5) can be used simultaneously!
- Before using an external keyboard (German or English) please make sure this keyboard is selected in MENU / SETUP menu.

24. ENTRY OF VARIOUS DATA BY USING A BARCODE SCANNER

The optional USB barcode scanner is a welcome accessory when entering various data like “TEST PLAN” CODE, “TEST PLAN” NAME, MACHINE CODE, MACHINE NAME, CLIENT CODE, CLIENT NAME, SITE CODE, SITE NAME, LOCATION, MANUFACTURER, ADDITIONAL INFO, SERIAL NUMBER, INVENTORY NUMBER, REMARKS, POSITION, TEST DESCRIPTION etc., to make it short, whenever blinking cursor is offered. Connect the USB barcode scanner to USB2, USB3, USB4 or to USB5 connector, three sound signals will follow after plugging it (wait a few seconds), as a confirmation of USB device recognition.

Notes!

- Use the USB barcode scanner listed in the “AVAILABLE OPTIONAL ACCESSORIES” section only, otherwise it may not be recognized by the MST-204 Tester.
- All four USB inputs/outputs (USB2, USB3, USB4 and USB5) can be used simultaneously!

Instruction how to re-configure the Barcode scanner 1250G (Honeywell type Voyager 1250G-2USB-1)

Before first use of the above mentioned barcode scanner, it is required to configure it as follows:

- Connect the barcode scanner to MST-204 Tester (or to PC) and switch on the MST-204 Tester (or PC) in order to assure proper power supply.
- Do the start configuration of the Barcode scanner by scanning the following four codes one after another, then disconnect the barcode scanner and connect it again.

25. REMOVABLE CASE COVER

In case plastic case cover of the MST-204 Tester is disturbing to the operator, one can simply remove it following the next steps:

- Pull out two metal axes from the hinges on the back side (one on the left, one on the right side).
- Remove the case cover and push metal axes back to original holes of the case cover hinges (in order not to lose them).

26. MAINTENANCE

When using the instrument in compliance with the User Manual no special maintenance is required. However, should functional errors occur during normal operation, our after sales service will repair your instrument without delay.

26.1. Cleaning

If the instrument is needed to be cleaned after daily usage, it is advisable to use a wet cloth and a mild household detergent.

Prior to cleaning, disconnect the MST-204 Tester from all measurement circuits and from mains.

Never use acid-based detergents or dissolvent liquids for cleaning.

After cleaning it, do not use the instrument until it is completely dried up.

26.2. Calibration Interval

We suggest a calibration interval of one year. If the instrument is rarely used the calibration interval can be extended on up to 2 years.

26.3. Fuse Replacement

If due to overload or improper operation, a fuse blows, it is necessary to obey the following general notes for replacement:

⚠ WARNINGS

- ☞ **Prior to replacement of any blown fuse, the machinery tester must be disconnected from all measuring circuits and mains supply cord must be disconnected from mains supply.**
- ☞ **Use only fuses specified and rated in technical specifications.**
- ☞ **Use of unspecified fuses and in particular shorting fuse-holders is prohibited.**
- ☞ **Spare fuses can be obtained in electric supplies wholesale shops or in our factory service.**

Fuse replacement, mains input fuse F1:
The fuse F1 (T 6.3 A (H) / 250 V, 5 x 20 mm) may be blown if display stays “dead” after connecting the MST-204 Tester to mains voltage and switching it on by using the ON/OFF mains switch (3).

To replace blown fuse F1 proceed as follows:

1) Unscrew fuse holder cap by using an appropriate flat screwdriver.
2) Remove the defective fuse and replace it with a new one.
3) Return the fuse holder cap.

Fuse replacement, measurement input (e.g. R_{PE} function) fuse F2:
The fuse F2 (T25 A (H) / 500 V, 10 x 38 mm) is blown if warning “CHECK FUSE F2!“ appears on the display. This fuse blows for example if test tips are connected to mains voltage during the R_{PE} test by mistake.

To replace the blown fuse F2 proceed as follows:

1) Obey the warning mark placed nearby the fuse holder

⚠ Disconnect mains cord, Commander and all test leads from test sockets L1, L2, L3 and N prior to removing protection cover of the fuse F2 – danger of electric shock.

2) Unscrew fuse holder cap by using an appropriate flat screwdriver.
3) Remove the blown fuse and replace it with a new one.
4) Return the fuse holder cap.

Cautions!

- ☞ **If any fuse blows several times (for example in case of operating error) the instrument must be sent in to the service department in order to be checked.**
- ☞ **Use only fuses defined in technical specifications. Using alternative fuses may cause a safety risk!**
- ☞ **There are no user replaceable fuses inside the instrument!**

26.4. Service

All instruments that are sent in for repair or calibration within or beyond the warranty period must contain the following data: Name of the client, name of the company, address, contact telephone number and a proof of purchase. Please enclose also the test leads and a short description (or a service form) of the problem detected or of desired maintenance.

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26.5. List of Possible Errors Displayed

The following errors can be displayed during operation with MST-204 Tester alone or in combination with HVA-204 Adapter:

ERROR 1:
Internal relay circuitry (Rel2 and Rel7) is damaged. The circuitry is tested after any switch on the instrument and after any disconnection of the Commander.
Service intervention is needed.

ERROR 2:
Internal relay circuitry (Rel3 and Rel6) is damaged. The circuitry is tested after any switch on the instrument and after any disconnection of the Commander.
Service intervention is needed.

ERROR 9:
Internal protection circuitry (varistor Var1, Var2, Var3, Var4 and relay Rel5) is damaged. The circuitry is tested after any switch on the instrument and after finishing any RISO measurement.
Service intervention is needed.

ERROR 10:
Not sufficient communication between PROC PCB and MEAS PCB (no communication at all, timing problem). The test is done after switching on the MST-204 Tester.
Service intervention is needed.

ERROR 20:
Internal fuse F1 (63 mA) on POWER PCB is blown, the instrument is not operational.
Service intervention is needed.

ERROR 21:
Signal from internal watchdog circuitry is missing, the instrument is not operational.
Service intervention is needed.

ERROR 36:
Mechanical problem on HV rotary switch (HVA-204 Adapter), the HVA-204 Adapter is not operational.
Service intervention is needed.

ERROR 37:
Electronic generator circuitry in HVA-204 Adapter is damaged, the HVA-204 Adapter is not operational.
Service intervention is needed.

ERROR 38:
Output voltage circuitry in HVA-204 Adapter is damaged, the HVA-204 Adapter is not operational.
Service intervention is needed.

ERROR 103:
Thermistor on LINE/LOOP power transistors is damaged (open or short-circuited), the instrument is not operational where the transistors are used.
Service intervention is needed.

ERROR 105:
Thermistor on RCD power transistors is damaged (open or short-circuited), the instrument is not operational where the transistors are used.
Service intervention is needed.

ERROR 107:
LINE/LOOP power thyristor damaged (short-circuited), the instrument is not operational where the thyristor is used.
Service intervention is needed.

27. TECHNICAL SPECIFICATIONS MST-204 TESTER

27.1. General Features

Standards used	EN 60204-1 (Safety of machinery - Electrical equipment of machines: General requirements) EN 61439-1 (Low-voltage switchgear and controlgear assemblies: General rules) EN 60974-4 (Arc welding equipment: Periodic inspection and testing) EN 50678/DIN VDE 0701 (General procedure for verifying the effectiveness of the protective measures of electrical equipment after repair) and EN 50699/DIN VDE 0702 (Recurrent Test of Electrical Equipment) EN 61557-1 (Equipment for testing, measuring or monitoring of protective measures: General requirements) EN 61557-2 (Insulation resistance) EN 61557-3 (Loop impedance) EN 61557-4 (Resistance of earth connection and equipotential bonding) EN 61557-6 (Effectiveness of RCD) EN 61557-7 (Phase sequence) EN 61557-10 (Combined measuring equipment for testing, measuring or monitoring of protective measures) EN 61557-11 (Effectiveness of RCM) EN 61557-14 (Equipment for testing the safety of electrical equipment of machinery) EN 61557-16 (Equipment for testing the effectiveness of the protective measures of electrical equipment and/or medical electrical equipment)
CE directives	Low Voltage Directive LVD 2014/35/EU Electromagnetic Compatibility EMC 2014/30/EU
Safety standards	EN / IEC 61010-1:2010 (Third edition) (Safety requirements for electrical equipment for measurement, control and laboratory use – General requirements) EN / IEC 61010-2-030:2010 (Safety requirements for electrical equipment for measurement, control and laboratory use - Particular requirements for equipment having testing or measuring circuits) EN / IEC 61010-031:2015 (Safety requirements for hand-held and hand-manipulated probe assemblies for electrical test and measurement) EN / IEC 61010-2-034:2017 (Safety requirements for measurement equipment for insulation resistance and test equipment for electric strength)
EMC standard	EN 61326-1:2013 (industrial environment)
Measurement category	CAT III 600 V / CAT IV 300 V

Power supply	230 V +10 %/-15 % or 240 V +6 %/-10 %, 50 Hz, CAT II 300 V
Max. power consumption (w/o HVA-204 Adapter)	230 VA @ $R_{PE\ 25A}$ function
Max. power consumption (w/ HVA-204 Adapter)	850 VA
External fuses (customer replaceable)	F1 = T6.3 A / 250 V, ceramic type, breaking capacity 1500 A, dimensions 5.0 x 20 mm, *use only type 0001.2512 produced by Schurter* F2 = T25 A / 500 V, ceramic type, breaking capacity 10 kA, dimensions 10 x 38 mm, *use only type FNQ-25 produced by Bussmann*
Display	4.3-inch colour TFT LCD with resistive touch screen
Limit value setting	See each function separately
Warning in case of exceeded limit values	Optic and acoustic
Acoustic signal	Loudspeaker 1W
Internal memory	Tree memory structure, 4 levels One location means one single measurement including all sub-results. One AUTO test occupies as many memory locations as many steps are included there. Memory limitations:

Parameter	Max. number
Engineers	50
Visual inspections	50
Functional tests	50
Documentations	50
Compensation descriptions	50
Limits	50
Safety factors	50
ENVIRONMENT TABLE items	50
Clients	100
Sites	100
Locations	100
Manufacturers	100
Machines	100
Appliances	1000
Test plans	100
Test results	1000
Auto tests	100
Executed Auto tests	1000
Test steps in Test plan	1000
Test steps in Auto test	100
Repeated measurements on test step	10

PC interface	USB 2.0 device, connector type “B”
USB keyboard, USB memory stick, USB barcode scanner	4 x USB 2.0 host, connector type “A” Note! • USB 3.0 speed not supported. **Caution!** ☞ **Max. output current per connector or in total: 500 mA continuously / 800 mA short time.**
USB memory stick requirements	FAT12, FAT16 or FAT32 with a sector size of 512 Byte
Dimensions (W × L × H)	405 x 330 x 180 mm
Weight (without accessories)	11.6 kg
IP protection class	IP65 (closed case cover) IP40 (open case cover, mating connectors connected to test sockets and COMMANDER connector) IP20 (4 mm test sockets and COMMANDER connector)
Position	Front panel 0° (basic horizontal position) or front panel 90° or in between
Reference temperature range	+23 °C ± 5 °C

Note!

- Accuracies defined in this specifications are valid for 1 year in reference temperature conditions. Temperature coefficient outside these limits is 0.1 % of measured value per °C plus 1 digit, if not otherwise noted.

Reference humidity range	10 ... 60 % relative humidity w/o condensation
Working temperature range	0 ... +40 °C
Working humidity range	10 ... 85 % relative humidity w/o condensation
Storage temperature range	-10 ... +60 °C
Storage humidity range	< 85 % relative humidity w/o condensation
Pollution degree	2
Protection class	I (all test terminals are double insulated acc. to IEC 61010-1 and IEC 61010-2-030)
Altitude above sea level	2000 m max.

27.2. Functions

Protective Bonding Resistance RPE

RPE - 25A

Measurement principle	Two-wire or four-wire connection
Measurement terminals 2-wire	Ω/MΩ (black) and COM (yellow) or COMMANDER and COM (yellow)
Measurement terminals 4-wire	Current path: Ω/MΩ (black) and COM (yellow) or COMMANDER and COM (yellow) Voltage path: S1 (red) and S2 (blue) or COMMANDER and S2 (blue)
Measurement duration	Adjustable timer 3 … 120 s, resolution 1 s or continuous **Warning!** ☞ **Intermittent use should be respected. Max. ratio (current on time) / (current off time) = 1 / 3, max. current on time = 1 min.**
Test current IM	25.0 AAC +5A/-3A @ RPE ≤ 0.100 Ω & Mains voltage 230 V +10 %/-15 % & - 2× standard test leads 2.5 mm² 2 m or - Commander 5 m + 1× standard test lead 2.5 mm² 2 m Note! • Use of Commander Extension 10 m in combination with Commander 5 m and 1× standard test lead 2.5 mm² 2 m may decrease measurement current down to 15 A (depends on mains voltage and measured RPE).
Short-circuit test current	25.0 AAC +5A/-3A @ Mains voltage 230 V +10 %/-15 % & - 2× standard test lead 2.5 mm² 2 m or - Commander 5 m + 1× standard test lead 2.5 mm² 2 m or - Commander Extension 10 m + Commander 5 m + 1× standard test lead 2.5 mm² 2 m
Open-circuit test voltage	4 … 6 VAC, SELV, floating output
Protection against ext. voltage	- External voltage > 9 V approx. between Ω/MΩ (black) and COM (yellow) test terminals or between COMMANDER and COM (yellow) or between S1 and S2 test terminals (4W measurement only) detected before RPE measurement is started - Fuse F2 during RPE measurement (blown fuse detected and warning displayed in case of blown fuse)
AUTO-START mode	Yes, automatic start after connecting test leads to a UUT
Operational error	± 30 % (within 0.012 … 2.000 Ω acc. to EN 61557-4) ± 15 % (@ 0.300 Ω acc. EN 61557-16)
Operation mode	Single or continuous measurement

Main result RPE:

Measuring range	0.012 ... 2.000 Ω
Display range	0.000 ... 2.000 Ω
Resolution	0.001 Ω
Accuracy	± (3 % rdg + 3 digits)

Note!

- Max. resistance of voltage sense test leads (S1 and S2) in 4-wire measurement is 1 Ω each. In case of higher resistance above accuracy may be affected.

Limit value

- Direct entry:
  Adjustable 0.000 ... 2.000 Ω, standard values 0.1 Ω and 0.2 Ω
- Entry through calculation:
  LENGTH: Adjustable 1.00 … 100.00 m, resolution 0.01 m
  MATERIAL: Selectable Cu or Al
  SECTION: Adjustable 0.50 … 100.00 mm^2, resolution 0.01 mm^2
  OFFSET: Adjustable 0.000 … 1.000 Ω, resolution 0.001 Ω

Note!

- Limit value for main result RPE and sub-result RMAX is uniform in any RPE function (2-wire or 4-wire) regardless of used test current. It can be entered or modified in any RPE function.

Judgement: RPE ≤ LIMIT … result OK

Test lead compensation: Up to 1.000 Ω (2-wire measurement only)

Note!

- There are two independent compensation values available:
  - One for test lead connected to COM socket (yellow) and COMMANDER
  - One for test leads connected to COM socket (yellow) and Ω/MΩ socket (black)

  Appropriate compensation value is automatically selected on bases of connected /not connected Commander.
  Compensation values are uniform for all RPE measurements (rotary switch No. 2 in position 2).
  The compensation can be carried out in any RPE measurement where it is offered.

Sub-result RPE MAX - max value of RPE:
See “Main result RPE” above.

Sub-result Test Current IM:

Measuring range	0.0 ... 30.0 A
Resolution	0.1 A
Accuracy	± (3 % rdg + 3 digits)

RPE - 10A

Measurement principle	See “Measurement principle” on page 186
Measurement terminals 2-wire	See “Measurement terminals 2-wire” on page 186
Measurement terminals 4-wire	See “Measurement terminals 4-wire” on page 186
Measurement duration	Adjustable timer 3 … 120 s, resolution 1 s or continuous
Test current IM	10.0 AAC +5A/-0A @ RPE ≤ 0.300 Ω & Mains voltage 230 V +10 %/-15 % & - 2× standard test lead 2.5 mm² 2 m or - Commander 5 m + 1× standard test lead 2.5 mm² 2 m or - Commander Extension 10 m + Commander 5 m + 1× standard test lead 2.5 mm² 2 m
Short-circuit test current	10.0 AAC +5A/-0A @ Mains voltage 230 V +10 %/-15 % & - 2× standard test lead 2.5 mm² 2 m or - Commander 5 m + 1× standard test lead 2.5 mm² 2 m or - Commander Extension 10 m + Commander 5 m + 1× standard test lead 2.5 mm² 2 m
Open-circuit test voltage	See “Open-circuit test voltage” on page 186
Protection against ext. voltage	See “Protection against ext. voltage” on page 186
AUTO-START mode	See “AUTO-START mode” on page 186
Operational error	See “Operational error “ on page 186
Operation mode	See “Operation mode” on page 186

Main result RPE:

See “Main result RPE” on page 187.

Sub-result RPE MAX – max value of RPE:

See “Main result RPE” above.

Sub-result Test Current IM:

Measuring range	0.0 … 15.0 A
Resolution	0.1 A
Accuracy	± (3 % rdg + 3 digits)

RPE – 0.2A

Measurement principle	See “Measurement principle” on page 186
Measurement terminals 2-wire	See “Measurement terminals 2-wire” on page 186
Measurement terminals 4-wire	See “Measurement terminals 4-wire” on page 186
Measurement duration	See “Measurement duration” on page 188
Test current IM	> 0.2 AAC @ Mains voltage 230 V +10 %/-15 % & external resistance ≤ 4 Ω & - 2× standard test lead 2.5 mm² 2 m or - Commander 5 m + 1× standard test lead 2.5 mm² 2 m or - Commander Extension 10 m + Commander 5 m + 1× standard test lead 2.5 mm² 2 m
Short-circuit test current	< 0.4 AAC @ Mains voltage 230 V +10 %/-15 % & - 2× standard test lead 2.5 mm² 2 m or - Commander 5 m + 1× standard test lead 2.5 mm² 2 m or - Commander Extension 10 m + Commander 5 m + 1× standard test lead 2.5 mm² 2 m
Open-circuit test voltage	See “Open-circuit test voltage” on page 186
Protection against ext. voltage	See “Protection against ext. voltage” on page 186
AUTO-START mode	See “AUTO-START mode” on page 186
Operational error	See “Operational error “ on page 186
Operation mode	See “Operation mode” on page 186

Main result RPE:

Measuring range	0.12 ... 20.00 Ω
Display range	0.00 ... 20.00 Ω
Resolution	0.01 Ω
Accuracy	± (3 % rdg + 3 digits)
Limit value	See “Main result RPE/Limit value” on page 187
Test lead compensation	See “Main result RPE/Test lead comp.” on page 187

Sub-result RPE MAX - max value of RPE:

See “Main result RPE” above.

Sub-result Test Current IM:

Measuring range	0.00 ... 1.00 A
Resolution	0.01 A
Accuracy	± (3 % rdg + 3 digits)

Resistance measurement

This is extended R_{PE} 200 mA function and it is used in combination with TPA-204-63A* or TPA-204-32A* Adapter for resistance measurement between PP and PE conductors in EV cables, see the technical specifications TPA-204-63A* / TPA-204-32A*.

Measurement principle	Two-wire
Main result R_{PP}:	
Measuring range	12 ... 2000 Ω
Display range	0 ... 2000 Ω
Resolution	1 Ω
Accuracy	± (3 % rdg + 3 digits)
Limit value	See the technical specifications TPA-204-63A* / TPA-204-32A*.
Test current Im	> 0.2 A_{AC} @ measured resistance ≤ 20 Ω > 5 mA_{AC} @ measured resistance 20 … 2000 Ω
Short-circuit test current	< 0.4 A_{AC}
Open-circuit test voltage	4 … 6 V_{AC}, SELV, floating output @ mains voltage 230 V

LOOP: I_{PEFC}, Impedance $Z_{L/PE}$ / LINE: I_{PSC}, Impedance $Z_{L/N}$ – standard accuracy

Ω/kA

Input voltage range ($U_{L/N}$, $U_{L/PE}$)	100 … 253 V, 45 … 66 Hz
Measurement terminals	
for Line / $I_{PSC\ L/N}$	L (black) and N (blue) or COMMANDER and N (blue)
for Loop / $I_{PEFC\ L/PE}$	L (black) and PE (yellow) or COMMANDER and PE (yellow)
Loading resistance	10 Ω, 2 × 10 ms (I_{TEST} = STD)

Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}:

Calculation	I_{PSC}, I_{PEFC} = $U_{NOM\ L/PE}$ / Z ($U_{L/N}$ or $U_{L/PE}$ = $U_{NOM\ L/PE}$ ± 10 %) I_{PSC}, I_{PEFC} = ($U_{L/N}$ or $U_{L/PE}$) / Z ($U_{L/N}$ or $U_{L/PE}$ = outside above range)
Measuring range	5.0 A @ (100 V / 20 Ω) ... 2.11 kA @ (253 V / 0.12 Ω)
Display range	5.0 … 99.9 A, 100 ... 999 A, 1.00 … 9.99 kA, 10.0 … 25.3 kA
Resolution	0.1 A, 1 A, 0.01 kA, 0.1 kA
Accuracy	Calculated value, consider accuracies of $U_{L/N}$ or $U_{L/PE}$ and Z measurements
Limit	- Adjustable 50.0 ... 99.9 A, 100 … 999 A, 1.00 … 2.00 kA - Limit value can also be defined through fuse selection table Note! • Above limit value is unified for the following measurements (key F1 = MEAS): - LOOP I_{PEFC} (L/PE), - LINE I_{PSC} (L/N) and - LINE I_{PSC} (L/L) and for the following test currents (I_{TEST}): - I_{STD} - I_{HIGH} The limit can be entered/selected in any of above three measurements. Judgement: I_{PSC}, $I_{PEFC} \geq$ LIMIT … result OK
Safety Factor	Adjustable 0 ... 50 % of set limit value (in 1 % steps) Note! • Safety factor is unified for all measurements where it is required. It can be entered in any measurement where it is offered.
Test lead compensation	Up to 1.000 Ω Notes! • There are two independent compensation values for LOOP measurement available: - One for test lead connected to PE socket (yellow) and Commander - One for test leads connected to PE socket (yellow) and L socket (black)

Appropriate compensation value is automatically used on bases of connected /not connected Commander. Compensation values are uniform for all LINE/LOOP measurements (rotary switch No. 2 in position 3) and UDELTA measurements (rotary switch No. 2 in position 4). The compensation can be carried out in any LINE/LOOP or UDELTA measurement where it is needed.

- There is no separate compensation for LINE measurement, but the same is valid as done in LOOP function. So, in LINE measurement always use the same cables as compensated in LOOP function. Especially if you use 3 cables (L + N + PE) or 2 cables (N + PE) + Commander, take care the cables have same length and cross section and are exactly of the same type.

Sub-result LINE/LOOP Impedance $Z_{L/N}$, $Z_{L/PE}$:

Measuring range	0.12 ... 20.00 Ω
Display range	0.00 ... 20.00 Ω
Resolution	0.01 Ω
Accuracy	± (3 % rdg + 3 digits)

Sub-result Voltage $U_{L/N}$, $U_{L/PE}$:

Measuring range	10.0 ... 280 V, 50/60 Hz
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 280 V)
Input resistance $U_{L/N}$	440 kΩ (2-wire connection)
Input resistance $U_{L/PE}$	440 kΩ (2-wire connection)
Total input resistance $U_{L/N+PE}$	330 kΩ (3-wire connection)

LINE: IPSC, Impedance ZL/L – standard accuracy Ω/kA

Input voltage range (UL/L)	170 … 440 V, 45 … 66 Hz
Measurement terminals	L1 (black) and L3 (yellow) or COMMANDER and L3 (yellow)
Loading resistance	10 Ω, 2 × 10 ms (ITEST = STD)

Main result Prospective Short circuit Current IPSC:

Calculation of IPSC	IPSC = UNOM L/L / 1.73 / ZL/L (UL/L = UNOM L/L ± 10 %) IPSC = UL/N / ZL/L (UL/L = outside above range) UL/N = UL/L / 1.73
Measuring range	5.0 A @ (98 V (UL/N) / 20 Ω) ... 2.11 kA @ (253 V (UL/N) / 0.12 Ω)
Display range	5.0 … 99.9 A, 100 ... 999 A, 1.00 … 9.99 kA, 10.0 … 25.4 kA
Resolution	0.1 A, 1 A, 0.01 kA, 0.1 kA
Accuracy	Calculated value, consider accuracies of UL/L and Z measurements
Limit	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.
Safety Factor	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.
Test lead compensation	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.

Sub-result LINE Impedance ZL/L:

See “Sub-result LINE/LOOP Impedance ZL/N, ZL/PE” on page 192.

Sub-result Voltage UL/L:

Measuring range	10.0 ... 440 V, 50/60 Hz
Display range	0.0 ... 99.9 V, 100 … 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Input resistance UL/L	440 kΩ (2-wire connection)

LOOP: I_{PEFC}, Impedance $Z_{L/PE}$ / LINE: I_{PSC}, Impedance $Z_{L/N}$ – high accuracy Ω/kA

Input voltage range ($U_{L/N}$, $U_{L/PE}$)	100 … 253 V, 45 … 66 Hz
Measurement terminals	
for Line / $I_{PSC\ L/N}$	L (black) and N (blue) or COMMANDER and N (blue)
for Loop / $I_{PEFC\ L/PE}$	L (black) and PE (yellow) or COMMANDER and PE (yellow)
Loading resistance	3.3 Ω, 6 × 10 ms (I_{TEST} = HIGH)

Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}:

Calculation	I_{PSC}, I_{PEFC} = $U_{NOM\ L/PE}$ / Z ($U_{L/N}$ or $U_{L/PE}$ = $U_{NOM\ L/PE}$ ± 10 %) I_{PSC}, I_{PEFC} = ($U_{L/N}$ or $U_{L/PE}$) / Z ($U_{L/N}$ or $U_{L/PE}$ = outside above range)
Measuring range	50.0 A @ (100 V / 2 Ω) ... 21.1 kA @ (253 V / 0.012 Ω)
Display range	50.0 … 99.9 A, 100 ... 999 A, 1.00 … 9.99 kA, 10.0 … 99.9 kA, 100 … 253 kA
Resolution	0.1 A, 1 A, 0.01 kA, 0.1 kA, 1 kA
Accuracy	Calculated value, consider accuracies of $U_{L/N}$ or $U_{L/PE}$ and Z measurements
Limit	See “Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}” on page 191.
Safety Factor	See “Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}” on page 191.
Test lead compensation	See “Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}” on page 191.

Sub-result LINE/LOOP Impedance $Z_{L/N}$, $Z_{L/PE}$:

Measuring range	0.012 ... 2.000 Ω
Display range	0.000 ... 2.000 Ω
Resolution	0.001 Ω
Accuracy	± (3 % rdg + 3 digits)

Sub-result Voltage $U_{L/N}$, $U_{L/PE}$:

See “Sub-result Voltage $U_{L/N}$, $U_{L/PE}$” on page 192.

LINE: IPSC, Impedance ZL/L – high accuracy Ω/kA

Input voltage range (UL/L)	170 … 440 V, 45 … 66 Hz
Measurement terminals	L1 (black) and L3 (yellow) or COMMANDER and L3 (yellow)
Loading resistance	3.3 Ω, 6 × 10 ms (ITEST = HIGH)

Main result Prospective Short circuit Current IPSC:

Calculation of IPSC	IPSC = UNOM L/L / 1.73 / ZL/L (UL/L = UNOM L/L ± 10 %) IPSC = UL/N / ZL/L (UL/L = outside above range) UL/N = UL/L / 1.73
Measuring range	49.2 A @ (98 V (UL/N) / 2 Ω) ... 21.1 kA @ (253 V (UL/N) / 0.012 Ω)
Display range	49.2 … 99.9 A, 100 ... 999 A, 1.00 … 9.99 kA, 10.0 … 99.9 kA, 100 … 254 kA
Resolution	0.1, 1 A, 0.01 kA, 0.1 kA, 1 kA
Accuracy	Calculated value, consider accuracies of UL/L and Z measurements
Limit	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.
Safety Factor	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.
Test lead compensation	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.

Sub-result LINE Impedance ZL/L:

See “Sub-result LINE/LOOP Impedance ZL/N, ZL/PE” on page 194.

Sub-result Voltage UL/L:

See “Sub-result Voltage UL/L” on page 193.

SEC I_{PSC} (U<100V AC/DC), Impedance Z Ω/kA

Input voltage range	10 … 100 V, DC, 45 … 66 Hz
Common mode voltage	253 V max
Measurement terminals	L (black) and N (blue) or COMMANDER and N (blue)
Load current I_{LOAD}	Adjustable 0.1 … 3.0 A in steps of 0.1 A
Accuracy of load current I_{LOAD}	± 10 % of set value

Main result Prospective Short circuit Current SEC I_{PSC} (U<100V AC/DC):

Calculation: SEC I_{PSC} = U / Z

Note!

- Displayed SEC I_{PSC} result may not correspond to actual measured system if the system is not linear like for example current-limited power supplies, low-power transformers, batteries etc. Please note that the SEC I_{PSC} result is obtained on bases of Z value which is measured by using relatively low test current (0.1 … 3.0 A).

I_{TEST} (A)	Display range SEC I_{PSC} (A)	Resolution SEC I_{PSC} (A)	Measuring range SEC I_{PSC}* (A)
0.1 … 0.4	0.02 … 1.00 k	0.01, 0.1, 1, 10	0.02 … 83.3
0.5 … 3.0	0.10 … 10.00 k		0.10 … 833

* SEC I_{PSC} is calculated value, consider measuring range of U and Z measurements.

Accuracy: SEC I_{PSC} is calculated value, consider accuracy of U and Z measurements

Limit: Adjustable 0.02 … 0.99 A, 1.0 … 100.0 A

Note!

- The limit is valid in this measurement only.

Judgement: SEC $I_{PSC} \geq$ LIMIT … result OK

Safety Factor: See “Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}” on page 191.

Test lead compensation: See “Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}” on page 191.

Sub-result LINE Impedance Z:

I_{TEST} (A)	Display range (Ω)	Measuring range (Ω)	Resolution (Ω)	Accuracy	Measurement duration (s)
0.1 … 0.4	0.0 … 99.9	1.2 … 500*	0.1, 1	± (5 % rdg + 3 digits)	5 (DC) 5…15** (AC)
	100 … 500*				
0.5 … 3.0	0.00 … 9.99	0.12 … 100.0*	0.01, 0.1		
	10.0 … 100.0*				

* Display and consequently measuring range will be reduced in case set test current cannot be reached during the measurement due to too high impedance or too low voltage. Warning “IMPEDANCE TOO HIGH” will be displayed in this case.

** Depends on selected test current, measured value and stability of mains voltage!

Sub-result Voltage U:

Measuring range	10.0 ... 100 V, DC, 50/60 Hz
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1 V, 1V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V)
	± (2 % rdg) (100 … 280 V)
Input resistance $U_{L/N}$	440 kΩ (2-wire connection)

Note!

- LINE Impedance Z is in fact resistance as inductive component is practically negligible in comparison with resistive one.

LOOP: I_{PEFC}, Impedance $Z_{L/PE}$ – RCD NO TRIP Ω/kA (for RCD with $I_{\Delta N}$ ≥ 30 mA)

Input voltage range ($U_{L/PE}$)	100 … 253 V, 45 … 66 Hz
Measurement terminals	L (black) and PE (yellow) or COMMANDER and PE (yellow)
Test current	Fixed 30 mA × 0.33 / 1.41 AC RMS (30 mA × 0.33 for 40 ms + 0 mA for 40 ms)
Accuracy of test current	± (10 %)
Measurement duration	5 … 40 s (depends on stability of mains voltage and measured value)

Main result Prospective Earth Fault Current I_{PEFC}

Calculation	$I_{PEFC} = U_{NOM\ L/PE} / Z_{L/PE}$ if $U_{L/PE} = U_{NOM\ L/PE}$ ± 10 % $I_{PEFC} = U_{L/PE} / Z_{L/PE}$ if $U_{L/PE}$ = outside above range
Measuring range	0.05 A @ (100 V / 2000 Ω) ... 16 A @ (253 V / 15 Ω)
Display range	0.05 … 0.99 A, 1.0 ... 9.9 A, 10 … 16 A
Resolution	0.01 A, 0.1 A, 1 A
Accuracy	Calculated value, consider accuracies of $U_{L/PE}$ and $Z_{L/PE}$ measurements
Limit	Adjustable 0.05 … 0.99 A, 1.0 … 9.9 A, 10 … 16 A Note! • The limit is valid in this measurement only. Judgement: $I_{PEFC} \geq$ LIMIT … result OK
Safety Factor	See "Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}" on page 191.

Sub-result LOOP Impedance $Z_{L/PE}$:

Measuring range	20 ... 2000 Ω
Display range	15 ... 2000 Ω
Resolution	1 Ω
Accuracy	± (5 % rdg + 5 Ω) the accuracy may be affected by unstable mains voltage
Test lead compensation	See "Main result Prospective Short circuit Current I_{PSC}, Prospective Earth Fault Current I_{PEFC}:" on page 191.

Sub-result Voltage $U_{L/PE}$:

Measuring range	10.0 ... 280 V, 50/60 Hz
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 280 V)
Input resistance $U_{L/PE}$	440 kΩ (2-wire connection)

Note!

- LINE Impedance $Z_{L/PE}$ is in fact resistance as inductive component is practically negligible in comparison with resistive one.

LOOP: IPEFC, Impedance ZL/PE / Line: IPSC, Impedance ZL/N – MPCB NO TRIP

Ω/kA

MPCB = Motor Protection Circuit Breaker

Input voltage range (UL/N)	100 … 253 V, 45 … 66 Hz
Measurement terminals	
for Line / IPSC L/N	L (black) and N (blue) or COMMANDER and N (blue)
for Loop / IPEFC L/PE	L (black) and PE (yellow) or COMMANDER and PE (yellow)
Test current	100 mA RMS (141 mA for 40 ms + 0 mA for 40 ms) or 500 mA RMS (707 mA for 40 ms + 0 mA for 40 ms)
Accuracy of test current	± 5 %
Measurement duration (100 mA)	5 … 25 s (depends on stability of mains voltage and measured value)
Measurement duration (500 mA)	5 … 15 s (depends on stability of mains voltage and measured value)

Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC:

Calculation	IPSC, IPEFC = UNOM L/PE / Z if UL/N or UL/PE = UNOM L/PE ± 10 % IPSC, IPEFC = (UL/N or UL/PE) / Z if UL/N or UL/PE = outside above range
Measuring range (100 mA)	0.4 A @ (100 V / 300 Ω) ... 126 A @ (253 V / 2.0 Ω)
Measuring range (500 mA)	2.0 A @ (100 V / 50 Ω) ... 1.58 kA @ (253 V / 0.16 Ω)
Display range (100 mA)	0.4 … 99.9 A, 100 … 999A, 1.00 ... 2.53 kA
Display range (500 mA)	2.0 … 99.9 A, 100 … 999A, 1.00 ... 9.99 kA, 10.0 ... 25.3 kA
Resolution (100 mA)	0.1 A, 1 A, 0.01 kA
Resolution (500 mA)	0.1 A, 1 A, 0.01 kA, 0.1 kA
Accuracy	Calculated value, consider accuracies of U and Z measurements
Limit	Adjustable 0.4 … 1.99 A, 2.0 … 99.9 A, 100 … 999 A, 1.00 … 1.53 kA - Actual limit range for test current 100 mA is 0.4 A … 1.53 kA - Actual limit range for test current 500 mA is 2.0 A … 1.53 kA Note! • The limit is valid in this measurement only. Judgement: IPSC, IPEFC ≥ LIMIT … result OK
Safety Factor	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.
Test lead compensation	See “Main result Prospective Short circuit Current IPSC, Prospective Earth Fault Current IPEFC” on page 191.

Sub-result Impedance $Z_{L/N}$, $Z_{L/PE}$ (100 mA):

Measuring range	2.0 ... 300 Ω
Display range	0.0 ... 99.9 Ω, 100 ... 300 Ω
Resolution	0.1 Ω, 1 Ω
Accuracy	± (5 % rdg + 5 digits) the accuracy may be affected by unstable measured voltage

Sub-result Impedance $Z_{L/N}$, $Z_{L/PE}$ (500 mA):

Measuring range	0.16 ... 50.0 Ω
Display range	0.00 ... 1.99 Ω, 2.0 … 50.0 Ω
Resolution	0.01 Ω, 0.1 Ω
Accuracy	± (4 % rdg + 4 digits) the accuracy may be affected by unstable measured voltage

Sub-result Voltage $U_{L/N}$, $U_{L/PE}$:

See “Sub-result Voltage $U_{L/N}$, $U_{L/PE}$” on page 192.

Note!

- LINE Impedance $Z_{L/N}$ and $Z_{L/PE}$ is in fact resistance as inductive component is practically negligible in comparison with resistive one.

Voltage Drop UDELTA – standard test current [U△%]

Input voltage range ZL/N	100 … 253 V, 45 … 66 Hz
Input voltage range ZL/L	170 … 440 V, 45 … 66 Hz
Measurement terminals ZL/N	L (black) and N (blue) or COMMANDER and N (blue)
Measurement terminals ZL/L	L1 (black) and L3 (yellow) or COMMANDER and L3 (yellow)

Main result Voltage Drop UDELTA:

Calculation	UDELTA = IN × (Z2 – ZREF)
Measuring range	-20.0 ... 20.0 %
Display range	-20.0 ... 20.0 %
Resolution	0.1 %
Accuracy	± (3 % rdg + 3 digits)
Limit	Adjustable 0.0 ... 20.0 %, standard value 5 % Judgement: UDELTA ≤ LIMIT … result OK
IN	Selectable 2 A, 4 A, 6 A, 8 A, 10 A, 12 A, 16 A, 20 A, 25 A, 32 A, 35 A, 40 A, 50 A, 63 A, 80 A, 100 A, 125 A, 160 A, 200 A, 250 A, 315 A, 400 A, 500 A or 630 A
ZREF	- MEASURED, see "Sub-results ZREF, Z2 and ΔZ" below - ENTERED within 0.00 … 20.00 Ω
UREF (L/N)	- UNOM (based on ENVIRONMENT TABLE, parameter NOMINAL VOLTAGE PHASE TO EARTH) - MEASURED within 100 … 253 V - ENTERED within 100 … 253 V
UREF (L/L)	- UNOM (based on ENVIRONMENT TABLE, parameter NOMINAL VOLTAGE PHASE TO PHASE) - MEASURED within 170 … 440 V - ENTERED within 170 … 440 V

Sub-results ZREF, Z2 and ΔZ:

See "Sub-result LINE/LOOP Impedance ZL/N, ZL/PE" on page 192.

Sub-results UREF, U2 and U△:

See "Sub-result Voltage UL/N, UL/PE" on page 192 for L/N measurements and "Sub-result Voltage UL/L" on page 193 for L/L measurements.

Notes!

- Display range and measuring range for sub-result U△ in L/N measurements is -280 … +280 V.
- Display range for sub-result U△ in L/L measurements is -490 … +490 V.
- Measuring range for sub-result U△ in L/L measurements is -440 … +440 V.

Voltage Drop UDELTA – high test current U∆%

Input voltage range ZL/N	100 … 253 V, 45 … 66 Hz
Input voltage range ZL/L	170 … 440 V, 45 … 66 Hz
Measurement terminals ZL/N	L (black) and N (blue) or COMMANDER and N (blue)
Measurement terminals ZL/L	L1 (black) and L3 (yellow) or COMMANDER and L3 (yellow)

Main result Voltage Drop UDELTA:

Calculation	UDELTA = IN × (Z2 – ZREF)
Measuring range	-20.0 ... 20.0 %
Display range	-20.0 ... 20.0 %
Resolution	0.1 %
Accuracy	± (2 % rdg + 2 digits)
Limit	Adjustable 0.0 ... 20.0 %, standard value 5 % Judgement: U∆ ≤ LIMIT … result OK
IN	Selectable 2 A, 4 A, 6 A, 8 A, 10 A, 12 A, 16 A, 20 A, 25 A, 32 A, 35 A, 40 A, 50 A, 63 A, 80 A, 100 A, 125 A, 160 A, 200 A, 250 A, 315 A, 400 A, 500 A or 630 A
ZREF	- MEASURED, see "Sub-results ZREF, Z2 and ∆Z" below - ENTERED within 0.000 … 2.000 Ω
UREF (L/N)	- UNOM (based on ENVIRONMENT TABLE, parameter NOMINAL VOLTAGE PHASE TO EARTH) - MEASURED within 100 … 253 V - ENTERED within 100 … 253 V
UREF (L/L)	- UNOM (based on ENVIRONMENT TABLE, parameter NOMINAL VOLTAGE PHASE TO PHASE) - MEASURED within 170 … 440 V - ENTERED within 170 … 440 V

Sub-results ZREF, Z2 and ∆Z:

See "Sub-result LINE/LOOP Impedance ZL/N, ZL/PE" on page 194.

Sub-results UREF, U2 and ∆U:

See "Sub-result Voltage UL/N, UL/PE" on page 192 for L/N measurements and "Sub-result Voltage UL/L" on page 193 for L/L measurements.

Notes!

- Display range and measuring range for sub-result U∆ in L/N measurements is -280 … +280 V.
- Display range for sub-result U∆ in L/L measurements is -490 … +490 V.
- Measuring range for sub-result U∆ in L/L measurements is -440 … +440 V.

RCD test RCD

Measurement terminals for types: A, A S, F, A-K/A-G, AC, AC S, AC-K/AC-G	L (black) and PE (yellow) or COMMANDER and PE (yellow)
for types: A-EV, B/B+, B/B+ S, B/B+-MI, F-EV	L (black), PE (yellow) and N (blue) or COMMANDER, PE (yellow) and N (blue)
RCD types	A, A S, A-EV, B/B+, B/B+ S, B/B+-MI, F, F-EV, A-K/A-G, AC, AC S, AC-K/AC-G
Measurement modes	- **UF** (no trip-out, test at 33 % of I∆N, UF calculated to 100 % of I∆N) - **RCD t** (trip-out time) - **RCD ramp** (tripping current and trip-out time at tripping current as a sub-result) - **AUTO** (sequence: ×1/2, ×1, ×5)
Nominal differential currents I∆N	10, 30, 100, 300, 500 and 1000 mA

Notes!

- Values of all actual flowing test currents at AC and A types are TRMS (True Root Mean Square).
- Values of actual flowing test currents at B type see separately in chapters “RCD t (trip-out time) mode”, “RAMP TEST mode” and “AUTO test mode”.

Accuracy of test current:

6 mA	- 0 % / + 10 %
10 mA	- 10 % / + 0 % (0.5×I∆N) - 0 % / + 10 % (I∆N, ~~2×I∆N~~, 5×I∆N)
30 … 1000 mA	- 5 % / + 0 % (0.5×I∆N) - 0 % / + 5 % (I∆N, 2×I∆N, 5×I∆N)
Input voltage range / frequency	100 … 253 V, 45 … 66 Hz
Fault voltage limit	Selectable 25 V or 50 V, defined in ENVIRONMENTAL TABLE Judgement: UF ≤ LIMIT … result OK
Test current polarity	Selectable POSITIVE or NEGATIVE
Trip-out time limit	See the Table 12 for limit times at 1×, 2× and 5× I∆N
Nominal mains voltage	230 or 120 V, defined in ENVIRONMENTAL TABLE

Fault Voltage U_F mode ("RCD U_F@$I_{\Delta N}$" sub-measurement in RCD function)

Main result Fault Voltage at nominal differential current U_F@$I_{\Delta N}$ (long measurement):

Measuring range	5 … 110 V
Display range	5 … 110 V
Resolution	1 V
Accuracy ($I_{\Delta N}$ = 10 mA)	- 0 / + (10 % rdg + 3 digits)
Accuracy ($I_{\Delta N}$ = 30 … 1000 mA)	- 0 / + (8 % rdg + 3 digits)
Test duration	4 s
Limit value	Selectable 25 V or 50 V (defined in ENVIRONMENTAL TABLE) Judgement: U_F ≤ LIMIT … result OK
Nominal test current $I_{TEST\ NOM}$	0.33 × $I_{\Delta N}$ / 1.41 RMS (0.33 × $I_{\Delta N}$ for 40 ms, 0 mA for the next 40 ms)
Accuracy of test current I_{TEST}	± 10 % of $I_{TEST\ NOM}$
Shape of test current	AC

Sub-result Earth Resistance R_A:

$I_{\Delta N}$ (mA)	Measuring range (Ω)	Display range (Ω)	Resolution (Ω)	Accuracy*
10	500 … 5000	500 … 10000	1	± 8 % rdg
30	150 … 3000	150 … 3000	1	± 5 % rdg
100	50.0 … 1000	50.0 … 99.9	0.1	
		100 … 1000	1	
300	15.0… 300	15.0 … 99.9	0.1	
		100 … 300	1	
500	10.0 … 200	10.0 … 99.9	0.1	
		100 … 200	1	
1000	5.0 … 100.0	5.0 … 100.0	0.1	

* The accuracy may be affected by unstable mains voltage!

Sub-result Voltage $U_{L/PE}$:

See "Sub-result Voltage $U_{L/N}$, $U_{L/PE}$" on page 192.

RCD t (trip-out time) mode ("RCDt" sub-measurement in RCD function)

Main result PASS/FAIL:

Judgement: t ≤ LIM t … result PASS or
t within limit range … result PASS (Selective or G/K type)

Sub-result RCD t (trip-out time):

Test duration in TN/TT/IT system + limits

RCD type	Multiplication 1× /2× /5×	AC test (sinusoidal)	Limit time (ms)			Pulse+ / Pulse- test	Limit time (ms)			DC+ / DC- test	Limit time (ms)			DC+ / DC- test	Limit time (s)
			TN	TT 120 V 230 V	IT		TN	TT 120 V 230 V	IT		TN	TT 120 V 230 V	IT		EV
AC	1×	1× I_{NOM}	0…300	0…300 0…200	0…300	n/a	-	-	-	n/a	-	-	-	n/a	-
	5× (10/30 mA only)	5× I_{NOM}	0…40	0…40	0…40	n/a	-	-	-	n/a	-	-	-	n/a	-
AC[S]	1×	1× I_{NOM}	130…500	130…500 130…200	130…500	n/a	-	-	-	n/a	-	-	-	n/a	-
	2×	2× I_{NOM}	60…200	60…200	60…200	n/a	-	-	-	n/a	-	-	-	n/a	-
AC-G/ AC-K	1×	1× I_{NOM}	10…300	10…300 10…200	10…300	n/a	-	-	-	n/a	-	-	-	n/a	-
	5× (10/30 mA only)	5× I_{NOM}	10…40	10…40	10…40	n/a	-	-	-	n/a	-	-	-	n/a	-
A	1×	1× I_{NOM}	0…300	0…300 0…200	0…300	1× I_{NOM}+/-	0…300	0…300 0…200	0…300	n/a	-	-	-	n/a	-
	5× (10/30 mA only)	5× I_{NOM}	0…40	0…40	0…40	5× I_{NOM}+/-	0…40	0…40	0…40	n/a	-	-	-	n/a	-
A[S]	1×	1× I_{NOM}	130…500	130…200	130…500	1× I_{NOM}	130…500	130…500 130…200	130…500	n/a	-	-	-	n/a	-
	2×	2× I_{NOM}	60…200	60…200	60…200	2× I_{NOM}	60…200	60…200	60…200	n/a	-	-	-	n/a	-
A-G/ A-K	1×	1× I_{NOM}	10…300	10…300 10…200	10…300	1× I_{NOM}+/-	10…300	10…300 10…200	10…300	n/a	-	-	-	n/a	-
	5× (10/30 mA only)	5× I_{NOM}	10…40	10…40	10…40	5× I_{NOM}+/-	10…40	10…40	10…40	n/a	-	-	-	n/a	-
F	1×	1× I_{NOM}	0…300	0…300 0…200	0…300	1× I_{NOM}+/-	0…300	0…300 0…200	0…300	n/a	-	-	-	n/a	-
	5× (10/30 mA only)	5× I_{NOM}	0…40	0…40	0…40	5× I_{NOM}+/-	0…40	0…40	0…40	n/a	-	-	-	n/a	-
A-EV	1×	1× I_{NOM}	0…300	0…300 0…200	0…300	1× I_{NOM}+/-	0…300	0…300 0…200	0…300	n/a	-	-	-	6 mA+/-	0…10
	5× (10/30 mA only)	5× I_{NOM}	0…40	0…40	0…40	5× I_{NOM}+/-	0…40	0…40	0…40	n/a	-	-	-		
F-EV	1×	1× I_{NOM}	0…300	0…300 0…200	0…300	1× I_{NOM}+/-	0…300	0…300 0…200	0…300	n/a	-	-	-	6 mA+/-	0…10
	5× (10/30 mA only)	5× INOM	0…40	0…40	0…40	5× I_{NOM}+/-	0…40	0…40	0…40	n/a	-	-	-		
B/B+	1× (DC: 2×)	1× I_{NOM}	0…300	0…300 0…200	0…300	1× I_{NOM}+/-	0…300	0…300 0…200	0…300	2× I_{NOM}+/-	0…300	0…300 0…200	0…300	n/a	-
	5× (DC: 10×) (10/30 mA only)	5× I_{NOM}	0…40	0…40	0…40	5× I_{NOM}+/-	0…40	0…40	0…40	10× I_{NOM}+/-	0…40	0…40	0…40		
B[S]/ B+[S]	1× (DC: 2×)	1× I_{NOM}	130…500	130…500 130…200	130…500	1× I_{NOM}	130…500	130…200	130…500	2× I_{NOM}+/-	130…500	130…500 130…200	130…500	n/a	-
	2× (DC: 4×)	2× I_{NOM}	60…200	60…200	60…200	2× I_{NOM}	60…200	60…200	60…200	4× I_{NOM}+/-	60…200	60…200	60…200	n/a	-
B-MI/ B+-MI	1× (DC: 2×)	1× I_{NOM}	0…300	0…300 0…200	0…300	1× I_{NOM}+/-	0…300	0…300 0…200	0…300	2× I_{NOM}+/-	0…300	0…300 0…200	0…300	6 mA+/-	0…10
	5× (DC: 10×) (10/30 mA only)	5× I_{NOM}	0…40	0…40	0…40	5× I_{NOM}+/-	0…40	0…40	0…40	10× I_{NOM}+/-	0…40	0…40	0…40		

Table 12: Limit time values for 1×, 2× and 5× $I_{\Delta N}$

Note!

- Shaded fields in above table are valid for AUTO tests in addition (not implemented in Trip-out time measurements).

Measuring range trip-out time t	0 … Limit time (ms)
Display range trip-out time t	0 … Limit time (ms)
Resolution trip-out time t	1 ms (all except EV type), 0.1 s (EV type)
Accuracy trip-out time t	± (2 % rdg + 3 ms) (all except EV type) ± 0.2 s (EV type)
Loading time at 0.5×IΔN	550 ms (in case of no trip-out)
Loading time at 1×IΔN, 2×IΔN, 5×IΔN	
limit time up to including 300 ms	350 ms (in case of no trip-out)
limit time 500 ms	550 ms (in case of no trip-out)
Loading time at 6 mA$_{DC}$ (EV type)	11 s
Accuracy of loading time	See “Accuracy trip-out time t” above
Accuracy of test currents	See the page 203.

Note!

- 30 s pause is involved between each test at Ⓢ types.

Sub-result Fault Voltage at nominal differential current U$_F$@IΔN (quick measurement)
(measured in parallel with trip out time measurement):
This measurement is meant to be indicative, for authoritative U$_F$ value please select “RCD U$_F$@IΔN” sub-measurement, see the page 204.

Measuring range	5 … 110 V
Display range	5 … 110 V
Resolution	1 V
Accuracy	- 0 / + (10 % rdg + 3 digits)*
Needed test duration	At least 40 ms (if RCD trips within 40 ms, U$_F$ will not be displayed)

*Measurement shall last at least 300 ms otherwise the accuracy may be affected, depends on stability of mains voltage!

Note!

- Values of actual DC test currents at B type (1×IΔN, and 5×IΔN) are double with respect to displayed multiplier.

Shapes and values of test current:

AC type	AC
	$I_{TEST\ NOM\ (RMS)} = I\Delta N \times MUL$
A type	Halfwave pulse
	MUL = 0.5, all IΔN:
	$I_{TEST\ NOM\ (RMS/10ms)} = I\Delta N \times 0.35 \times 1.41$
	$I_{TEST\ NOM\ (RMS/20ms)} = I\Delta N \times 0.35$
	MUL = 1, 2, 5, IΔN = 10 mA:
	$I_{TEST\ NOM\ (RMS/10ms)} = I\Delta N \times MUL \times 2 \times 1.41$
	$I_{TEST\ NOM\ (RMS/20ms)} = I\Delta N \times MUL \times 2$
	MUL = 1, 2, 5, IΔN = 30 … 500 mA:
	$I_{TEST\ NOM\ (RMS/10ms)} = I\Delta N \times MUL \times 1.40 \times 1.41$
	$I_{TEST\ NOM\ (RMS/20ms)} = I\Delta N \times MUL \times 1.40$
B type	DC
	$I_{TEST\ NOM\ (RMS)} = I\Delta N \times MUL \times 1$ (MUL = 0.5)
	$I_{TEST\ NOM\ (RMS)} = I\Delta N \times MUL \times 2$ (MUL = 1, 2, 5)

Sub-results Voltage $U_{L/N}$, $U_{L/PE}$, $U_{N/PE}$:
See “Sub-results Voltage $U_{L/N}$, $U_{L/PE}$” on page 192.

Note!

- Voltage $U_{N/PE}$ is displayed only in case B type of RCD is selected (L, N and PE terminals are required to be connected). The same specification is valid as declared for $U_{L/N}$ and $U_{L/PE}$ voltages.

RAMP TEST mode ("RCD IΔ⟋" sub-measurement in RCD function)

Main result PASS/FAIL:

Condition for PASS result	Tripping current IΔ and Trip-out time at tripping current tΔ inside limit values (Fault voltage not judged)

Sub-result Tripping Current IΔ:

AC, AC-K/AC-G types:

Display range	AC shape: 40 % … 120 % of $I_{\Delta N}$, 17 steps (5 % of $I_{\Delta N}$), step time 350 ms, pause time 150 ms, total measuring time 8.35 s
Limit	Fixed 50 % … 100 % of $I_{\Delta N}$

AC Ⓢ type:

Display range	AC shape: 40 % … 120 % of $I_{\Delta N}$, 17 steps (5 % of $I_{\Delta N}$), step time 550 ms, pause time 150 ms, total measuring time 11.75 s
Limit	Fixed 50 % … 100 % of $I_{\Delta N}$

A, A-K/A-G, F types ($I_{\Delta N}$ = 10 mA):

Display range	Halfwave shape: 25 % … 220 % of $I_{\Delta N}$, 40 steps (5 % of $I_{\Delta N}$), step time 350 ms, pause time 150 ms, total measuring time 19.85 s
Limit	Fixed 35 % … 200 % of $I_{\Delta N}$

A, A-K/A-G, F types ($I_{\Delta N} \geq$ 30 mA):

Display range	Halfwave shape: 25 % … 160 % of $I_{\Delta N}$, 28 steps (5 % of $I_{\Delta N}$), step time 350 ms, pause time 150 ms, total measuring time 13.85 s
Limit	Fixed 35 % … 140 % of $I_{\Delta N}$

A Ⓢ type ($I_{\Delta N}$ = 10 mA):

Display range	Halfwave shape: 25 % … 220 % of $I_{\Delta N}$, 40 steps (5 % of $I_{\Delta N}$), step time 550 ms, pause time 150 ms, total measuring time 27.85 s
Limit	Fixed 35 % … 200 % of $I_{\Delta N}$

A Ⓢ type ($I_{\Delta N} \geq$ 30 mA):

Display range	Halfwave shape: 25 % … 160 % of $I_{\Delta N}$, 28 steps (5 % of $I_{\Delta N}$), step time 550 ms, pause time 150 ms, total measuring time 19.45 s
Limit	Fixed 35 % … 140 % of $I_{\Delta N}$

B, B^+ types:

Display range	DC shape: 40 % … 220 % of $I_{\Delta N}$, 37 steps (5 % of $I_{\Delta N}$), step time 350 ms, no pause, total measuring time 12.95 s
Limit	Fixed 50 % … 200 % of $I_{\Delta N}$ AC shape: See AC type above

B Ⓢ, B+ Ⓢ types:

Display range	DC shape: 40 % … 220 % of I∆N, 37 steps (5 % of I∆N), step time 550 ms, no pause, total measuring time 20.35 s
Limit	Fixed 50 % … 200 % of I∆N AC shape: See AC type above
Accuracy (all types)	± 1 step

Notes!

- Values of all actual flowing test currents are TRMS (True Root Mean Square) regardless of selected RCD type (AC, A or B).
- Types A-EV, B/B+-MI and F-EV have no RAMP test.
- 30 s pause is involved between each test at Ⓢ types.

Sub-result Trip-out Time t∆ at tripping current:

See the technical specifications in “RCD t (trip-out time)” on page 205, respect limit trip out times at nominal differential current.

Sub-result Fault Voltage at nominal differential current UF@I∆N:

See “Sub-result Fault Voltage at nominal differential current UF@I∆N (quick measurement)” on page 206.

Sub-results Voltage UL/N, UL/PE, UN/PE:

See “Sub-results Voltage UL/N, UL/PE” on page 192.

Note!

- Voltage UN/PE is displayed only in case B type of RCD is selected (L, N and PE terminals are required to be connected). The same specification is valid as declared for UL/N and UL/PE voltages.

RCD AUTO sequence mode ("RCDAUTO" sub-measurement in RCD function)
Test steps depend on RCD type

Note!

- Values of actual DC test currents at B type (1×, and 5×IΔN) are double with respect to displayed multiplier.

AC, AC-K/AC-G types:
- UF @ IΔN (measurement done in parallel with trip-out time measurement at 0.5 × IΔN AC)
- 0.5 × IΔN: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × IΔN: t @ AC 0° / t @ AC 180°
- 5 × IΔN: t @ AC 0° / t @ AC 180° (10 and 30 mA)

AC S type:
- UF @ IΔN (measurement done in parallel with trip-out time measurement at 0.5 × IΔN AC)
- 0.5 × IΔN: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × IΔN: t @ AC 0° / t @ AC 180°
- 2 × IΔN: t @ AC 0° / t @ AC 180° (10 and 30 mA)

Note!
- 30 s pause is involved between each test.

A, A-K/A-G, F types:
- UF @ IΔN (measurement done in parallel with trip-out time measurement at 0.5 × IΔN pulse)
- 0.5 × IΔN: t @ pulse+ / t @ pulse- (no trip-out)
- 1 × IΔN: t @ pulse+ / t @ pulse-
- 5 × IΔN: t @ pulse+ / t @ pulse- (10 and 30 mA)
- 0.5 × IΔN: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × IΔN: t @ AC 0° / t @ AC 180°
- 5 × IΔN: t @ AC 0° / t @ AC 180° (10 and 30 mA)

A S type:
- UF @ IΔN (measurement done in parallel with trip-out time measurement at 0.5 × IΔN pulse)
- 0.5 × IΔN: t @ pulse+ / t @ pulse- (no trip-out)
- 1 × IΔN: t @ pulse+ / t @ pulse-
- 2 × IΔN: t @ pulse+ / t @ pulse- (10 and 30 mA)
- 0.5 × IΔN: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × IΔN: t @ AC 0° / t @ AC 180°
- 2 × IΔN: t @ AC 0° / t @ AC 180° (10 and 30 mA)

Note!
- 30 s pause is involved between each test.

A-EV, F-EV types:
- U_F @ $I_{\Delta N}$ (measurement done in parallel with trip-out time measurement at 0.5 × $I_{\Delta N}$ pulse)
- 0.5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (no trip-out)
- 1 × $I_{\Delta N}$: t @ pulse+ / t @ pulse-
- 5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180°
- 5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (10 and 30 mA)
- 6 mA: t @ DC+ / t @ DC- (trip-out in 10 s)

B/B^+ type:
- U_F @ $I_{\Delta N}$ (measurement done in parallel with trip-out time measurement at 0.5 × $I_{\Delta N}$ DC)
- 0.5 × $I_{\Delta N}$: t @ DC+ / t @ DC- (no trip-out)
- 1 × $I_{\Delta N}$: t @ DC+ / t @ DC-
- 5 × $I_{\Delta N}$: t @ DC+ / t @ DC- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (no trip-out)
- 1 × $I_{\Delta N}$: t @ pulse+ / t @ pulse-
- 5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180°
- 5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (10 and 30 mA)

B/B^+S type:
- U_F @ $I_{\Delta N}$ (measurement done in parallel with trip-out time measurement at 0.5 × $I_{\Delta N}$ DC)
- 0.5 × $I_{\Delta N}$: t @ DC+ / t @ DC- (no trip-out)
- 1 × $I_{\Delta N}$: t @ DC+ / t @ DC-
- 2 × $I_{\Delta N}$: t @ DC+ / t @ DC- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (no trip-out)
- 1 × $I_{\Delta N}$: t @ pulse+ / t @ pulse-
- 2 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180°
- 2 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (10 and 30 mA)

Note!
- 30 s pause is involved between each test.

B/B+-MI type:
- U_F @ $I_{\Delta N}$ (measurement done in parallel with trip-out time measurement at 0.5 × $I_{\Delta N}$ DC)
- 0.5 × $I_{\Delta N}$: t @ DC+ / t @ DC- (no trip-out)
- 1 × $I_{\Delta N}$: t @ DC+ / t @ DC-
- 5 × $I_{\Delta N}$: t @ DC+ / t @ DC- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (no trip-out)
- 1 × $I_{\Delta N}$: t @ pulse+ / t @ pulse-
- 5 × $I_{\Delta N}$: t @ pulse+ / t @ pulse- (10 and 30 mA)
- 0.5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (no trip-out)
- 1 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180°
- 5 × $I_{\Delta N}$: t @ AC 0° / t @ AC 180° (10 and 30 mA)
- 6 mA: t @ DC+ / t @ DC- (trip-out in 10 s)

Limit trip-out times — See the Table 12 for limit times at 1×, 2× and 5× $I_{\Delta N}$

Sub-result Fault Voltage at nominal differential current U_F@$I_{\Delta N}$:
See “Sub-result Fault Voltage at nominal differential current U_F@$I_{\Delta N}$ (quick measurement)” on page 206.

Sub-results Voltage $U_{L/N}$, $U_{L/PE}$, $U_{N/PE}$:
See “Sub-results Voltage $U_{L/N}$, $U_{L/PE}$” on page 192.

Note!
- Sub-result Voltage $U_{L/PE}$ is displayed regardless of selected RCD type (AC, A or B) while voltages $U_{L/N}$ and $U_{N/PE}$ are displayed only if RCD type B is selected (connection of N conductor is required).

IMD TEST mode (IT systems) ("IMD" sub-measurement in RCD function)

Measurement terminals	L (black), N (blue) and PE (yellow) or COMMANDER, N (blue) and PE (yellow)
Loading Resistor range	5 kΩ up to 750 kΩ (in 64 steps) - 5 … 250 kΩ, step 5 kΩ (50 steps) - 260 … 300 kΩ, step 10 kΩ (5 steps) - 350 … 750 kΩ, step 50 kΩ (9 steps)
Measurement terminals	L (black), N (blue) and PE (yellow) or COMMANDER, N (blue) and PE (yellow)
Start measurement condition	$U_{L1/L2}$ (voltage between L and N test terminals) = 100 … 253 V
$U_{L1/PE}$ max (max allowed voltage between L and PE test terminals or between Commander and PE test terminal during the measurement)	Depends on set resistor R_F, see the table below

R_F value (kΩ)	$U_{L1/PE}$ max (V)
5	120
10	160
15	180
20 … 350	200
400 … 750	253

In case of higher voltage $U_{L1/PE}$ than listed above, message IT INSULATION PROBLEM is displayed and the measurement is stopped.

MAN mode (test with preselected resistor between L and PE, manual stop):

Main result PASS/FAIL:

Result explanation	PASS ⇒ Signalling time at preselected resistor ≤ limit value LIM t FAIL ⇒ Signalling time at preselected resistor > limit value LIM t

Sub-result Signalling Time t:

Measuring range	0.0 … 60.0 s
Display range	0.0 … 60.0 s
Resolution	0.1 s
Accuracy	± 0.2 s
Limit t	Adjustable 0.0 … 10.0 s

Sub-result PE current $I_{L/PE}$:

Calculation	$I_{L/PE} = U_{L/PE}/R_F$
Measuring range	0.00 … 50.00 mA
Display range	0.00 … 50.00 mA
Resolution	0.01 mA
Accuracy	Calculated value, consider accuracy of $U_{L/PE}$ measurement and accuracy of R_F resistor

Sub-result Voltage $U_{L/N}$, $U_{L/PE}$:

Measuring range	10.0 … 280 V
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 280 V)
Input resistance $U_{L/N}$	440 kΩ
Input resistance $U_{L/PE}$	100 MΩ

Sub-result Frequency f:

Measuring range	DC, 45.0 ... 66.0 Hz
Resolution	0.1 Hz
Accuracy	± 0.2 Hz
Minimal voltage $U_{L/N}$	10 V

AUTO mode (test with automatic decreasing of resistor value from set start value R_{START} down to 5 kΩ between L1 and PE, manual stop):

Start Resistor Value R_{START}	5 k … 750 k, see “IMD TEST mode (IT systems)” on page 213.

Main result PASS/FAIL:

Result explanation	PASS ⇒ Resistor ≤ limit value LIM R_F & signalling time at the resistor ≤ limit value LIM t FAIL ⇒ Resistor > limit value LIM R_F or signalling time at the resistor > limit value LIM t

Sub-result Voltage $U_{L/N}$, $U_{L/PE}$:

See “Sub-result Voltage $U_{L/N}$, $U_{L/PE}$” on page 192.

Sub-result Frequency f:

See “Sub-result Frequency f” on page 214.

Sub-result Signalling Time t:

Measuring range	0.0 … set LIM t + 3 s
Display range	0.0 … set LIM t + 3 s
Resolution	0.1 s
Accuracy	± 0.2 s
Limit t	Adjustable 0.0 … 10.0 s

Sub-result Resistor Value R_F:

Resistor values	5 k … 750 k, see “IMD TEST mode (IT systems)” on page 213.
Accuracy	± 5 %
Limit R_F	Adjustable 5 … 750 kΩ, resolution 1 kΩ

Sub-result PE current $I_{L/PE}$:

Calculation	$I_{L/PE} = U_{L/PE}/R_F$
Measuring range	0.00 … 50.00 mA
Display range	0.00 … 50.00 mA
Resolution	0.01 mA
Accuracy	Calculated value, consider accuracy of $U_{L/PE}$ measurement and accuracy of R_F resistor

RCM TEST mode (TT/TN systems) ("RCM" sub-measurement in RCD function)

Nominal differential current $I_{\Delta N}$	Selectable 10, 30, 100, 300 or 500 mA
Accuracy of test current	See "Accuracy of test current" on page 203.
$I_{\Delta N}$ multiplier	×1/2 and ×1
RCD types	A and B
Shape of test current type A	AC (for 11 s)
Shape of test current type B	DC (ramp for 5 s + $I_{\Delta N}$ for 11 s) + AC (for 11 s)

Note!

- Values of actual DC test currents at B type (1× $I_{\Delta N}$) are double with respect to displayed multiplier.

Main result PASS/FAIL:

Result explanation	PASS ⇒ Signalling time ≤ limit value LIM t FAIL ⇒ Signalling time > limit value LIM t

Sub-result Signalling Time t:

Measuring range	0.0 ... 10.0 s
Display range	0.0 ... 10.0 s
Resolution	0.1 s
Accuracy	± 0.2 s

Sub-result Voltage $U_{L/N}$, $U_{L/PE}$, $U_{N/PE}$:
See "Sub-result Voltage $U_{L/N}$, $U_{L/PE}$" on page 192.

Sub-result Fault Voltage at nominal differential current $U_F@I_{\Delta N}$ (quick measurement):
See "Sub-result Fault Voltage at nominal differential current $U_F@I_{\Delta N}$ (quick measurement)" on page 206.

Insulation Resistance RINS MΩ⚠

Measurement terminals	Ω/MΩ (black) and COM (yellow) or COMMANDER and COM (yellow)
Test current	> 1 mA @ 50 kΩ for UN = 50 V @ 100 kΩ for UN = 100 V @ 250 kΩ for UN = 250 V @ 500 kΩ for UN = 500 V @ 1000 kΩ for UN = 1000 V
Short-circuit current	< 2 mA
Detection of external voltage	Yes UEXT higher than 25 V RMS between Ω/MΩ and COM terminals or between COMMANDER and COM terminals before measurement will be detected and measurement disabled

RINS MODE

Main result RINS:

Nominal test voltage UTEST NOM	50, 100, 250, 500 and 1000 VDC or adjustable 50 … 1000 VDC
Test voltage tolerance	(-0 … +25 %) of UTEST NOM
Capacitive load	≤ 2 μF in parallel with RINS - RINS accuracy within technical specifications (RINS up to UTEST NOM / 1 mA) according to standard - RINS accuracy within technical specifications + additional 10% rdg (RINS higher than UTEST NOM / 1 mA) Note! • Result stabilization may last up to 15 s in case of high insulation resistance and high capacitor connected in parallel with the resistance!
Discharge	Internal resistance 360 kΩ (after finishing the measurement) Capacitor is considered to be discharged when the voltage is lower than 25 V
Measuring range	0.12 … 5.00 MΩ (UTEST NOM = 50 … 99 V) 0.12 … 10.0 MΩ (UTEST NOM = 100 … 249 V) 0.12 … 25.0 MΩ (UTEST NOM = 250 … 499 V) 0.12 … 50.0 MΩ (UTEST NOM = 500 … 999 V) 0.12 … 100 MΩ (UTEST NOM = 1000 V)
Display range (test leads)	0.00 … 50.0 MΩ (UTEST NOM = 50 … 99 V) 0.00 … 100 MΩ (UTEST NOM = 100 … 249 V) 0.00 … 250 MΩ (UTEST NOM = 250 … 499 V) 0.00 … 500 MΩ (UTEST NOM = 500 … 999 V) 0.00 … 1000 MΩ (UTEST NOM = 1000 V)

Accuracy	± (5 % rdg + 3 digits) (0.00 … 20.0 MΩ) ± 8 % rdg (20.1 … 50.0 MΩ) ± 15 % rdg (50.1 … 100 MΩ) Indicative measurement (101 … 1000 MΩ)
Limit	Adjustable 0.00 … 50.0 MΩ, standard values 0.25 MΩ, 0.30 MΩ, 1.00 MΩ and 2.00 MΩ, depending on selected standard Judgement: $R_{INS} \geq$ LIMIT … result OK
Measurement duration	Adjustable timer 4 … 300 s, resolution 1 s or continuous

Sub-result Test Voltage U_{TEST}:

Measuring range	0 … 1250 V_{DC}
Resolution	1 V
Accuracy	± (2 % of actual voltage + 2 digits)

Note!

- If UUT is grounded, then always connect COM (yellow) test lead to grounded parts of the UUT (never Ω/MΩ (black) test lead). Grounding of Ω/MΩ (black) test lead may influence the test result with parallel connection of 4.4 MΩ as a result of tester's internal resistance.

R_{INS} RAMP MODE

Test voltage starts at 50 V and it is increasing until test current exceeds 1mA or max. up to 1.2 × LIM U_{MAX}. Threshold voltage is displayed as a result.

Main result Threshold Voltage U (voltage @1 mA):

Measuring range	50 … 1200 V_{DC}
Resolution	1 V
Accuracy	± (5 % rdg + 5 digits)
Condition for good result	LIM $U_{MIN} \leq U \leq$ LIM U_{MAX}
LIM U_{MIN}	None or adjustable 50 … 1000 V
LIM U_{MAX}	None or adjustable 50 … 1000 V
	Judgement: LIM $U_{MAX} \geq U \geq$ LIM U_{MIN} … result OK

Notes!

- If UUT is grounded, then always connect COM (yellow) test lead to grounded parts of the UUT (never Ω/MΩ (black) test lead). Grounding of Ω/MΩ (black) test lead may influence the test result with parallel connection of 4.4 MΩ as a result of tester's internal resistance.
- Prior to the measurement make sure to remove possible capacitor connected in parallel with the OUT as the capacitor may cause additional capacitive current shifting the test result.

HV Dielectric Test ⚠HV

See the technical specifications HVA-204 Adapter.

Residual voltage URES, Discharge time TRES U/t

Input voltage	Max. 440 VRMS & 625 VPEAK (measurement can be performed if input voltage is stable inside specified range)
Measurement terminals	L (black) and PE (yellow) or COMMANDER and PE (yellow)
Nominal mains voltage	According to ENVIRONMENT TABLE, parameter NOMINAL VOLTAGE PHASE TO EARTH
Trigger voltage (= START)	- If rectified mean value of input voltage drops down more than by 12 % in a second (rectified mean value measured each 20 ms), then trigger is activated and the measurement starts to run. This will occur for example if AC or DC input voltage starts to decrease. - Momentary value of current half period is compared with momentary value of previous half period (the same polarity). If there is a difference higher than 10 %, then trigger is activated and the measurement starts to run. This condition will occur for example if AC voltage turns to DC. - If peak value of input voltage drops below set limit value (e.g. 60 V). This will occur if peak value of input voltage is just above set limit value when the “START” is pressed and then the voltage slowly decreases. Note! • If peak value of input voltage is lower than set limit value, then the measurement will be done automatically after pressing “START” button and result will be displayed (e.g. “< 60 V” if ULIM = 60 V).
READY condition (green icon)	UIN ≤ 440 VRMS and UIN ≤ 625 VPEAK, stable
Available modes	- STANDARD mode It can be used in any measurement, especially when: - The measurement is to be done on internal accessible test points of the UUT (discharging characteristic not known) and/or - Input voltage is AC non-sinusoidal or DC or AC+DC as in this case LINEAR or NON LINEAR mode cannot be used and/or - High noise is present when the UUT is switched off for measurement purpose as in this case LINEAR or NON LINEAR mode cannot be used and/or - The UUT is using zero-cross switching-off as in this case LINEAR or NON LINEAR mode cannot be used. - LINEAR mode (available in URES function only) It shall be used when: - The measurement is to be done on mains plug where only RC components are involved in measured circuitry causing exponential discharging characteristic and - Input voltage is sinusoidal.

- NON LINEAR mode
  It shall be used when the measurement is to be done on internal accessible parts of the UUT (discharging characteristic not known) but:
  - Input voltage is sinusoidal and
  - Low noise is present when the UUT is switched off for measurement purpose and
  - The UUT is not using zero-cross switching-off.

Connection: 2-wire

Residual Voltage URES ("URES" sub-measurement in U/t function)

Main result Residual Voltage URES

Available modes: STANDARD, LINEAR and NON LINEAR mode

Calculation in STANDARD mode: URES DISP = URES MEAS

Notes!

- In case of AC or AC+DC input voltage, individual test result depends on switching-off moment and may therefore vary within full range from zero to peak value of input voltage. This is why the tester offers more individual measurements to be done and max. value to be taken for documentation. Individual test results are equipped with (INFO) symbol, meaning they may not be considered as final result.
- In case of DC input voltage each individual test result is appropriate for documentation and it is therefore not equipped with (INFO) symbol.
- Input voltage is considered to be pure DC if AC ripple superimposed to DC voltage is lower than 8 % of DC value.

Calculation in LINEAR mode:

- URES DC DISP = URES DC MEAS scaled to UNOM × 1.1 (reason: actual voltage may be 10 % higher than UNOM) × 1.41 V (reason: to be scaled to peak value)
  Condition for UNOM to be recognized:
  USTART RMS = (0.9 … 1.1) × UNOM
- URES DC DISP = URES DC MEAS scaled to USTART RMS × 1.41 V (reason: to be scaled to peak value)
  Condition for UNOM not to be recognized:
  USTART RMS out of (0.9 … 1.1) × UNOM
- URES AC DISP = URES AC MEAS (RMS)

Notes!

- Input voltage is considered to be sinusoidal if:
  - UPEAK/UMEAN (half-wave) = 1.57 ± 20 % and
  - (S_+ - S_-) ≤ 30 % of S_+
    where:
    S_+ … Area of positive half-wave
    S_- … Area of negative half-wave

- Sinusoidal input voltage is a condition for measurement in LINEAR and NON-LINEAR modes. If input voltage is AC non-sinusoidal or DC or DC+AC, then the measurement cannot be done in LINEAR or NON-LINEAR mode and message “ONLY SINUSOIDAL VOLTAGE SUPPORTED! USE STANDARD MODE!” will be displayed after pressing “START” button. Use STANDARD mode in this case.
- There is no need to repeat the measurement several times in LINEAR mode as URES is always scaled to peak value of UNOM × 1.1 (nominal voltage is recognized) or to peak value of input voltage (nominal voltage is not recognized). Each result is appropriate for documentation.

Calculation (NON LINEAR mode)

- URES DC DISP = URES DC MEAS scaled to USTART RMS × 1.41 V (reason: to be scaled to peak value)
- URES AC DISP = URES AC MEAS (RMS)

Notes!

- Sinusoidal input voltage is a condition for measurement in LINEAR and NON-LINEAR mode. If input voltage is AC non-sinusoidal or DC or DC+AC, then the measurement cannot be done in LINEAR or NON-LINEAR mode and message “ONLY SINUSOIDAL VOLTAGE SUPPORTED! USE STANDARD MODE!” will be displayed after pressing the “START” button. Use STANDARD mode in this case.
- The tester requires disconnection of UUT to be done at nearly peak value of input voltage (90 … 100 % of UPEAK). It means the disconnection may be required to be repeated several times until result is displayed. Each displayed result is then appropriate for documentation.

Notes (valid for all three modes)!

- URES may be DC or AC. Condition for URES to be considered as AC is that frequency of the voltage is 45 … 66 Hz. Displayed value is RMS.
- In case of sinusoidal input voltage, sub-result USTART will show RMS value and will be equipped with AC symbol, for example USTART = 236 VAC.
  In case of pure DC input voltage, sub-result USTART will be equipped with DC symbol, for example USTART = 313 VDC.
  In case of any other input voltage (AC non-sinusoidal or DC+AC), sub-result USTART will show RMS value and will be equipped with no symbol, for example USTART = 360 V.

	Expressions explanation: URES DISP = Displayed residual voltage (AC or DC) URES MEAS = Measured residual voltage (AC or DC) URES DC DISP = Displayed DC residual voltage URES DC MEAS = Measured DC residual voltage URES AC DISP = Displayed AC residual voltage URES AC MEAS = Measured AC residual voltage USTART RMS = Input start RMS voltage
Measuring range	10 … 625 V (URES DC) 10 ... 440 VRMS (URES AC)
Display range	10 … 625 V (URES DC) 10 ... 440 VRMS (URES AC)
Resolution	1 V
Accuracy	-0 / +6 V (URES < 60 V) (in order to reach zero negative tolerance, 3 V is added to measured result and then displayed) -0 / +10 % (URES ≥ 60 V) (in order to reach zero negative tolerance, measured result is multiplied by 1.05 and then displayed)
LIM U	60 VRMS or adjustable 25 … 60 VRMS, resolution 1 V
LIM t (= trigger stop)	Selectable 1 s, 5 s or user settable 1 … 300 s, resolution 1 s
Accuracy of LIM t	+0.00 / -0.01 s
Sub-result Start Voltage USTART:	
Measuring range	10.0 ... 440 VRMS
Display range	0.0 ... 99.9, 100 … 490 VRMS
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Frequency range	DC and 45.0 ... 66.0 Hz
Input resistance	>40 MΩ

Discharge time TRES ("TRES" sub-measurement in U/t function)

Main result Discharging Time TRES:

Available modes	STANDARD and NON LINEAR mode
Measuring range	0.3 ... 300.0 s
Display range	0.3 ... 300.0 s
Resolution	0.1 s
Accuracy	± (3 % rdg + 0.3 s)
	Note! • NON LINEAR mode: Correct result would be obtained if measured UUT would be switched-off at peak input voltage. Due to the fact that the UUT may in worst case be switched-off at 90 % of peak value, displayed result may be lower by up to 10 % of correct one. Example how to calculate correct result: Displayed result is 15.4 s. Due to possible switch-off the UUT at 90 % of peak value, correct displayed result could be higher by 10 % of displayed one meaning it could be 16.9 s. Correct result may therefore lay between 14.64 s (take 15.4 s and respect low limit value on bases of given accuracy) and 17.70 s (take 16.9 s and respect high limit value on bases of given accuracy).
LIM U (= trigger stop)	60 VRMS or adjustable 25 … 60 VRMS
LIM t	Selectable 1 s, 5 s or user settable 1 … 300 s, resolution 1 s

Sub-result Start Voltage USTART:

See "Sub-result Start Voltage USTART" under URES measurement above.

CURRENT mA/A

Clamp Load Current RMS ("ILOAD ⊂⊃" sub-measurement in mA/A function)

Clamp type	AC, output 1 mA / A, e.g. CC-204-40A or AC, output 1 mA / A, e.g. CC-204-1000A
Measurement terminals	CLAMP connector
Input resistance	1 Ω max
Input terminal max current	1 A RMS

Main result Load Current ILOAD:

Measuring range	0.1 ... 1000 A (0.1 ... 60.0 A with ALCA-100-EUR clamp)
Display range	0.1 ... 99.9 A, 100 … 1000 A
Resolution	0.1 A, 1 A
Crest factor	3.0 max (please consider also crest factor of used clamp)
Accuracy (without clamp error)	± (3 % rdg + 2 digits)
Limit I	Adjustable 0.1 … 1000 A, standard value 3.5 A Judgement: ILOAD ≤ LIM I … result OK

Sub-result Max Load Current ILOAD MAX:

See "Main result Load Current ILOAD" above.

Sub-result Load Current Total Harmonic Distortion THD:

Minimal current	0.1 A
Measuring range	0.0 ... 150.0 %
Display range	0.0 ... 150.0 %
Resolution	0.1 %
Accuracy	± (3 % rdg + 3 digits)
Limit THD	Adjustable 0.0 ... 15.0 % (2^{nd} … 40^{th} harmonic), standard value 12.0 % (2^{nd} … 30^{th} harmonic) Judgement: THD ≤ LIM THD … result OK
Harmonics measured	1^{st} … 40^{th}

Sub-result Current Frequency f:

Minimal current	0.1 A
Measuring range	45.0 ... 66.0 Hz
Resolution	0.1 Hz
Accuracy	± 0.1 Hz
Limit f	Adjustable ± (0.0 … 10.0 %) of fNOM, standard value ± 1.0 % of fNOM Judgement: (fNOM - set %) ≤ f ≤ (fNOM + set %) … result OK

Load Current RMS ("ILOAD TPA" sub-measurement in mA/A function)

It can be measured in combination with TPA-204-63A* or TPA-204-32A* only, see the technical specifications in User manual TPA-204-63A* / TPA-204-32A*.

Clamp Leakage Current RMS ("I_{LEAK}  " sub-measurement in mA/A function)

Clamp type	AC, output 1 mA / A, e.g. CC-204-40A
Measurement terminals	CLAMP connector
Input resistance	1 Ω max.
Input terminal max current	1 mA RMS

Main result Leakage Current I_{LEAK}:

Measuring range	0.8 ... 1000 mA
Display range	0.5 ... 19.9 mA, 20 ... 1000 mA
Resolution	0.1 mA, 1 mA
Crest factor	3.0 max (please consider also crest factor of used clamp)
Accuracy (without clamp error)	± (3 % rdg + 2 digits) general accuracy ± (5 % rdg + 15 digits) (0.5 … 19.9 mA) @ f = 10 … 100 kHz
Operational error	± 30 % (0.8 … 1000 mA) acc. to EN 61557-1
Operational error	± 15 % (@ 3.5 mA) acc. to EN 61557-16
Frequency range	40 Hz ... 100 kHz (characteristics according to DIN EN 61557-16 Annex A, fig. A.1, A.2)
Limit value	Adjustable 0.5 ... 1000 mA, standard values 3.5 mA and 10.0 mA Judgement: $I_{LEAK} \leq$ LIM … result OK

Sub-result Max Leakage Current $I_{LEAK\ MAX}$:

See "Main result Leakage Current I_{DIFF}" above.

Differential Current RMS ("IDIFF TPA" sub-measurement in mA/A measurement)
It can be measured in combination with TPA-204-63A* or TPA-204-32A*, see the technical specifications in User manual TPA-204-63A* / TPA-204-32A*.

Welding circuit "Touch Current in Fault Condition" RMS ("ITOUCH WELD FAULT" sub-measurement in mA/A function)
It can be measured in combination with TPA-204-63A* or TPA-204-32A*, see the technical specifications in User manual TPA-204-63A* / TPA-204-32A*.

Welding circuit "Touch Current in Normal Condition" RMS ("ITOUCH WELD NORMAL" sub-measurement in mA/A function)

Measurement terminals	L (black) and PE (yellow) or COMMANDER and PE (yellow)

Main result Welding Touch Current in Normal Conditions (IT WELD NORMAL):

Measuring range	0.12 ... 20.0 mA
Display range	0.02 ... 1.99 mA, 2.0 ... 20.0 mA
Resolution	0.01 mA, 0.1 mA
Accuracy	± (3 % rdg + 2 digits)
Limit value	Adjustable 0.02 ... 20.0 mA, standard value 0.50 mA Judgement: IT WELD NORMAL ≤ LIM … result OK
Frequency range	DC ... 100 kHz (characteristics according to DIN EN 60974-4 / VDE 544-1 Annex N)
Internal resistance	2 kΩ, circuit N.1 EN 60974-1
Measurement method	Acc. to Figure 1 of EN 60974-4:2011 standard
Over-range limit	Yes, the measurement will be automatically interrupted 2 s after exceeding 22 mA or the measurement will be interrupted within 40 ms if input current is higher than 30 mA.

Sub-result Max Current IT WELD NORMAL MAX:
See "Main result Welding Touch Current in Normal Conditions (IT WELD NORMAL)" above.

Touch Current RMS ("I_T" sub-measurement in mA/A function)

Measurement terminals	L (black) and PE (yellow) or COMMANDER and PE (yellow)

Main result Touch Current I_T:

Measuring range	0.12 ... 20.0 mA
Display range	0.02 ... 1.99 mA, 2.0 ... 20.0 mA
Resolution	0.01 mA, 0.1 mA
Accuracy	± (3 % rdg + 2 digits)
Crest factor	3.0 max
Limit value	Adjustable 0.02 ... 20.0 mA, standard value 0.50 mA Judgement: $I_T \leq$ LIM … result OK
Frequency range	DC ... 100 kHz (characteristics according to DIN EN 61557-16 Annex A, fig. A.1, A.2)
Measurement method	Acc. to EN 61557-16 A.1 standard
Internal resistance (via probe)	1 kΩ
Over-range limit	Yes, the measurement will be automatically interrupted 2 s after exceeding 22 mA or the measurement will be interrupted within 40 ms if input current is higher than 30 mA.
Over-voltage limit	Yes, the measurement will not start if input voltage $U_{L/PE}$ could cause touch current higher than 5 mA – possible trip-out of installation RCD. Warning "$U_{L/PE}$ VOLTAGE TOO HIGH, RCD COULD TRIP!" will be displayed in this case.

Sub-result Max Touch Current $I_{T\,MAX}$:

See "Main result Touch Current I_T" above.

VOLTAGE / POWER U/P

UMAINS RMS ("UMAINS" sub-measurement in U/P function)

Connection	L/N (2-wire, $U_{L/N}$) $L_1/L_2/L_3$ (3-wire, $U_{L1/L2}$, $U_{L2/L3}$, $U_{L3/L1}$) $L_1/L_2/L_3$/N (4-wire, $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$)
Measurement terminals	L (black) and N (blue) (2-wire connection) L1 (black), L2 (red) and L3 (yellow) (3-wire connection) L1 (black) L2 (red), L3 (yellow) and N (blue) (4-wire connection)
Nominal mains voltage U_{NOM}	Defined in ENVIRONMENTAL table, parameters U_{NOM} PHASE TO EARTH (L/PE) and U_{NOM} PHASE TO PHASE (L/L)
Nominal frequency f_{NOM}	Defined in ENVIRONMENTAL table, parameter f_{NOM}
Max voltage between N and any other test terminal	280 Vrms & CF2 (both limitations)
Max voltage between any combination of test terminals except N	440 Vrms & CF2 (both limitations)

L/N connection

Main result $U_{L/N}$:

Measuring range	10.0 ... 253 V, 45 … 66 Hz
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 253 V)
Limit U	Adjustable ± (0 … 15 %) of $U_{NOM\ L/PE}$), standard value ± 10 % of $U_{NOM\ L/PE}$ Judgement: U = $U_{NOM\ L/PE}$ ± LIM U … result OK
Input resistance $U_{L/N}$	220 kΩ

Sub-result Voltage Total Harmonic Distortion THD:

Minimal voltage	10.0 V
Measuring range	0.0 ... 150.0 %
Resolution	0.1 %
Accuracy	± (3 % rdg + 3 digits)
Limit THD	Adjustable 0.0 ... 150.0 % (2^{nd} … 40^{th} harmonic), standard value 12.0 % (2^{nd} … 30^{th} harmonic) Judgement: THD ≤ LIM THD … result OK
Harmonics measured	1^{st} … 40^{th}

Sub-result Frequency f:

See "Sub-result Frequency f" on page 214.

Limit f	Adjustable ± (0.0 … 10.0 %) of f_{NOM}, standard value ± 1.0 % of f_{NOM} Judgement: f = f_{NOM} ± LIM f … result OK

$L_1/L_2/L_3$ connection

Main result $U_{L1/L2}$, $U_{L2/L3}$, $U_{L3/L1}$:

Measuring range	10.0 ... 440 V, 45… 66 Hz
Display range	0.0 … 99.9 V, 100 … 490 V
Resolution	0.1, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Limit U	Adjustable ± (0 … 15 %) of $U_{NOM\ L/L}$), standard value ± 10 % of $U_{NOM\ L/L}$ Judgement: U = $U_{NOM\ L/L}$ ± LIM U … result OK
Input resistance $U_{L1/L2}$, $U_{L2/L3}$, $U_{L3/L1}$	381 kΩ

Sub-result Voltage Total Harmonic Distortion THD:

Minimal voltage	17.0 V
Measuring range	0.0 ... 150.0 %
Resolution	0.1 %
Accuracy	± (3 % rdg + 3 digits)
Limit THD	Adjustable 0.0 ... 150.0 % (2^{nd} … 40^{th} harmonic), standard value 12.0 % (2^{nd} … 30^{th} harmonic) Judgement: THD ≤ LIM THD … result OK
Harmonics measured	1^{st} … 40^{th}

Sub-result Frequency f:

Minimal input voltage	17.0 V
Measuring range	45.0 ... 66.0 Hz
Resolution	0.1 Hz
Accuracy	± 0.2 Hz
Limit f	Adjustable ± (0.0 … 10.0 %) of f_{NOM}, standard value ± 1.0 % of f_{NOM} Judgement: f = f_{NOM} ± LIM f … result OK

L1/L2/L3/N connection

Main result $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$:

Measuring range	10.0 ... 253 V, 45 … 66 Hz
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 253 V)
Limit value U	Adjustable ± (0 … 10 %) of U_N, standard value ± 10 % Judgement: U = U_N ± LIMIT … result OK
Limit U	Adjustable ± (0 … 15 %) of $U_{NOM\ L/PE}$, standard value ± 10 % of $U_{NOM\ L/PE}$ Judgement: U = $U_{NOM\ L/PE}$ ± LIM U … result OK

Input resistance $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$	220 kΩ

Sub-result Voltage Total Harmonic Distortion THD:

Minimal voltage	10.0 V
Measuring range	0.0 ... 150.0 %
Resolution	0.1 %
Accuracy	± (3 % rdg + 3 digits)
Limit THD	Adjustable 0.0 ... 150.0 % (2^{nd} … 40^{th} harmonic), standard value 12.0 % (2^{nd} … 30^{th} harmonic) Judgement: THD ≤ LIM THD … result OK
Harmonics measured	1^{st} … 40^{th}

Sub-result Frequency f:

Measured on bases of $U_{L1/N}$ or $U_{L2/N}$ or $U_{L3/N}$ voltage with this order.

See the chapter “Sub-result Frequency f” on page 214.

POWER ("POWER ⊙▭" sub-measurement in U/P function)

POWER 2W for single-phase loads

Voltage measurement terminals	L1 (black) and N (blue)
Current measurement terminal	CLAMP connector

Main result Apparent Power S:

Calculation	$S\ (VA) = U_{L1/N} \times I_{L1}$
Measuring range	1.0 VA ... 253 kVA
Display range	0.0 ... 99.9 VA, 100 ... 999 VA, 1.00 ... 9.99 kVA, 10.0 ... 99.9 kVA, 100 ... 280 kVA
Resolution	0.1 VA (1.0 … 99.9 VA) 1 VA (100 … 999 VA) 0.01 kVA (1.00 … 9.99 kVA) 0.1 kVA (10.0 ... 99.9 kVA) 1 kVA (100 … 280 kVA)
Accuracy	± (5 % rdg + 10 digits) 1.0 ... 100.0 VA ± (5 % rdg + 3 digits) 101 VA ... 253 kVA

Sub-result Active Power P:

Calculation	$P\ (W) = U_{L1/N} \times I_{L1} \times PF$
Measuring range	1.0 W ... 253 kW
Display range	0.0 ... 99.9 W, 100 ... 999 W, 1.00 ... 9.99 kW, 10.0 ... 99.9 kW, 100 ... 280 kW
Resolution	0.1 W (1.0 … 99.9 W) 1 W (100 … 999 W) 0.01 kW (1.00 … 9.99 kW) 0.1 kW (10.0 ... 99.9 kW) 1 kW (100 … 280 kW)
Accuracy	± (7 % rdg + 10 digits) 1.0 ... 100.0 W ± (7 % rdg + 3 digits) 101 W ... 253 kW

Sub-result Reactive Power Q:

Calculation	$Q\ (var) = U_{L1/N} \times I_{L1} \times \frac{\sum_{K=1}^{40} U_K \times I_K \times \sin\varphi_K}{\sqrt{1+(\frac{THD_U}{100})^2} \times \sqrt{1+(\frac{THD_I}{100})^2} \times U_{K=1} \times I_{K=1}}$
Measuring range	1.0 var ... 253 kvar
Display range	0.0 ... 99.9 var, 100 ... 999 var, 1.00 ... 9.99 kvar, 10.0 ... 99.9 kvar, 100 ... 280 kvar
Resolution	0.1 var (1.0 … 99.9 var) 1 var (100 … 999 var) 0.01 kvar (1.00 … 9.99 kvar) 0.1 kvar (10.0 ... 99.9 kvar) 1 kvar (100 … 280 kvar)
Accuracy	± (7 % rdg + 10 digits) 1.0 ... 100.0 var ± (7 % rdg + 3 digits) 101 var ... 253 kvar

Sub-result Voltage $U_{L1/N}$:

See “Main result $U_{L/N}$” on page 192.

Sub-result Current I_{L1}:

See “Main result Load Current I_{LOAD}” on page 224.

Sub-result Power factor PF:

Minimal voltage $U_{L1/N}$	10 V
Minimal current I_{CLAMP}	0.1 A
Calculation	$PF = \frac{\sum_{K=1}^{40} U_K \times I_K \times \cos\varphi_K}{\sqrt{1+(\frac{THD_U}{100})^2} \times \sqrt{1+(\frac{THD_I}{100})^2} \times U_{K=1} \times I_{K=1}}$
Display range	-1.00 ... 1.00
Resolution	0.01
Tolerance	± (5 % rdg + 5 digits)

Sub-result Cos φ:

Minimal voltage $U_{L1/N}$	10 V
Minimal current I_{CLAMP}	0.1 A
Calculation	Cosφ ($U_{K=1}$) – Cosφ ($I_{K=1}$)
Display range	-1.00 ... 1.00
Resolution	0.01
Tolerance	± (5 % rdg + 5 digits)

POWER 3W for three-phase loads

Assumptions	Three-phase load is symmetrical, phase currents are alike
Voltage measurement terminals	L1 (black), L2 (red) and L3 (yellow)
Current measurement terminals	CLAMP connector

Main result Apparent Power S (total apparent power on three phase load):

Calculation	$S\ (VA) = (U_{L1/L2} / 1.73 \times I_{L1}) \times 3$
Measuring range	1.0 VA ... 762 kVA
Display range	0.0 ... 99.9 VA, 100 ... 999 VA, 1.00 ... 9.99 kVA, 10.0 ... 99.9 kVA, 100 ... 840 kVA
Resolution	0.1 VA (1.0 … 99.9 VA) 1 VA (100 … 999 VA) 0.01 kVA (1.00 … 9.99 kVA) 0.1 kVA (10.0 ... 99.9 kVA) 1 kVA (100 … 840 kVA)
Accuracy	± (5 % rdg + 10 digits) 1.0 ... 100.0 VA ± (5 % rdg + 3 digits) 101 VA ... 762 kVA

Sub-result Active Power P (total active power on three phase load):

Calculation	$P\ (W) = (U_{L1/L2} / 1.73 \times I_{L1} \times PF) \times 3$
Measuring range	1.0 W ... 762 kW
Display range	0.0 ... 99.9 W, 100 ... 999 W, 1.00 ... 9.99 kW, 10.0 ... 99.9 kW, 100 ... 840 kW
Resolution	0.1 W (1.0 … 99.9 W) 1 W (100 … 999 W) 0.01 kW (1.00 … 9.99 kW) 0.1 kW (10.0 ... 99.9 kW) 1 kW (100 … 840 kW)
Accuracy	± (7 % rdg + 10 digits) 1.0 ... 100.0 W ± (7 % rdg + 3 digits) 101 W ... 762 kW

Sub-result Reactive Power Q (total reactive power on three phase load):

Calculation	$Q\ (var) = (U_{L1/L2} / 1.73 \times I_{L1} \times \frac{\sum_{K=1}^{40} U_K \times I_K \times \sin\varphi_K}{\sqrt{1+(\frac{THD_U}{100})^2} \times \sqrt{1+(\frac{THD_I}{100})^2} \times U_{K=1} \times I_{K=1}} \times 3$
Measuring range	1.0 var ... 762 kvar
Display range	0.0 ... 99.9 var, 100 ... 999 var, 1.00 ... 9.99 kvar, 10.0 ... 99.9 kvar, 100 ... 840 kvar
Resolution	0.1 var (1.0 … 99.9 var) 1 var (100 … 999 var) 0.01 kvar (1.00 … 9.99 kvar) 0.1 kvar (10.0 ... 99.9 kvar) 1 kvar (100 … 840 kvar)
Accuracy	± (7 % rdg + 10 digits) 1.0 ... 100.0 var ± (7 % rdg + 3 digits) 101 var ... 762 kvar

Sub-results Voltage $U_{L1/L2}$, $U_{L2/L3}$, $U_{L3/L1}$:
See “Main result $U_{L1/L2}$, $U_{L2/L3}$, $U_{L3/L1}$” on page 229.

Sub-result Current I_{L1}:
See “Main result Load Current I_{LOAD}” on page 224.

Sub-result Power factor PF:

Minimal voltage $U_{L1/L2}$	17 V
Minimal current I_{CLAMP}	0.1 A
Calculation	$PF = \frac{\sum_{K=1}^{40} U_K \times I_K \times \cos\varphi_K}{\sqrt{1+(\frac{THD_U}{100})^2} \times \sqrt{1+(\frac{THD_I}{100})^2} \times U_{K=1} \times I_{K=1}}$
Display range	-1.00 ... 1.00
Resolution	0.01
Tolerance	± (5 % rdg + 5 digits)

Sub-result Cos φ:

Minimal voltage $U_{L1/L2}$	17 V
Minimal current I_{CLAMP}	0.1 A
Calculation	Cosφ ($U_{K=1}$) – Cosφ ($I_{K=1}$)
Display range	-1.00 ... 1.00
Resolution	0.01
Tolerance	± (5 % rdg + 5 digits)

POWER 4W for three-phase loads

Assumptions	Three-phase load is symmetrical, phase currents are alike
Voltage measurement terminals	L1 (black), L2 (red), L3 (yellow) and N (blue)
Current measurement terminal	CLAMP connector

Main result Apparent Power S (total apparent power on three phase load):

Calculation	$S\ (VA) = (U_{L1/N} \times I_{L1}) + (U_{L2/N} \times I_{L1}) + (U_{L3/N} \times I_{L1})$
Measuring range	1.0 VA ... 759 kVA
Display range	0.0 ... 99.9 VA, 100 ... 999 VA, 1.00 ... 9.99 kVA, 10.0 ... 99.9 kVA, 100 ... 840 kVA
Resolution	0.1 VA (1.0 … 99.9 VA) 1 VA (100 … 999 VA) 0.01 kVA (1.00 … 9.99 kVA) 0.1 kVA (10.0 ... 99.9 kVA) 1 kVA (100 … 840 kVA)
Accuracy	± (5 % rdg + 10 digits) 1.0 ... 100.0 VA ± (5 % rdg + 3 digits) 101 VA ... 759 kVA

Sub-result Active Power P (total active power on three phase load):

Calculation	P (W) = S × PF
Measuring range	1.0 W ... 759 kW
Display range	0.0 ... 99.9 W, 100 ... 999 W, 1.00 ... 9.99 kW, 10.0 ... 99.9 kW, 100 ... 840 kW
Resolution	0.1 W (1.0 … 99.9 W) 1 W (100 … 999 W) 0.01 kW (1.00 … 9.99 kW) 0.1 kW (10.0 ... 99.9 kW) 1 kW (100 … 840 kW)
Accuracy	± (7 % rdg + 10 digits) 1.0 ... 100.0 W ± (7 % rdg + 3 digits) 101 W ... 759 kW

Sub-result Reactive Power Q (total reactive power on three phase load):

Calculation	$Q\ (var) = S \times \frac{\sum_{K=1}^{40} U_K \times I_K \times \sin\varphi_K}{\sqrt{1+(\frac{THD_U}{100})^2} \times \sqrt{1+(\frac{THD_I}{100})^2} \times U_{K=1} \times I_{K=1}}$
Measuring range	1.0 var ... 759 kvar
Display range	0.0 ... 99.9 var, 100 ... 999 var, 1.00 ... 9.99 kvar, 10.0 ... 99.9 kvar, 100 ... 840 kvar
Resolution	0.1 var (1.0 … 99.9 var) 1 var (100 … 999 var) 0.01 kvar (1.00 … 9.99 kvar) 0.1 kvar (10.0 ... 99.9 kvar) 1 kvar (100 … 840 kvar)
Accuracy	± (7 % rdg + 10 digits) 1.0 ... 100.0 var ± (7 % rdg + 3 digits) 101 var ... 759 kvar

Sub-results Voltage $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$:
See “Main result $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$” on page 230.

Sub-result Current I_{L1}:
See “Main result Load Current I_{LOAD}” on page 224.

Sub-result Power factor PF:

Min. voltage $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$	10 V
Minimal current I_{CLAMP}	0.1 A
Calculation	$PF = \frac{\sum_{K=1}^{40} U_K \times I_K \times \cos\varphi_K}{\sqrt{1+(\frac{THD_U}{100})^2} \times \sqrt{1+(\frac{THD_I}{100})^2} \times U_{K=1} \times I_{K=1}}$
Display range	-1.00 ... 1.00
Resolution	0.01
Tolerance	± (5 % rdg + 5 digits)

Sub-result Cos φ:

Min. voltage $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$	10 V
Minimal current I_{CLAMP}	0.1 A
Calculation	Cosφ ($U_{K=1}$) – Cosφ ($I_{K=1}$)
Display range	-1.00 ... 1.00
Resolution	0.01
Tolerance	± (5 % rdg + 5 digits)

Phase Sequence ("3PROTATION" sub-measurement in U/P function)

Measurement terminals	L1 (black), L2 (red) and L3 (yellow) (3-wire connection) L1 (black), L2 (red), L3 (yellow) and N (blue) (4-wire connection)
Minimal voltage	25 V phase to phase (3-wire connection) 15 V phase to N (4-wire connection)
Frequency range	45.0 ... 66.0 Hz

Main result 3PSEQ:

Display range	RIGHT / LEFT / UNDEFINED

Sub-results Voltage $U_{L1/L2}$, $U_{L2/L3}$, $U_{L3/L1}$ (3-wire connection):

Measuring range	10.0 ... 440 V
Display range	0.0 … 99.9 V, 100 … 490 V
Resolution	0.1, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Input resistance $U_{L1/L2}$, $U_{L2/L3}$ $U_{L3/L1}$	381 kΩ

Sub-results Voltage $U_{L1/N}$, $U_{L2/N}$, $U_{L3/N}$ (4-wire connection):

Measuring range	10.0 ... 280 V
Display range	0.0 ... 99.9 V, 100 … 280 V
Resolution	0.1, 1 V
Accuracy	± (2 % rdg + 3 digits) (10.0 … 99.9 V) ± (2 % rdg) (100 … 280 V)
Input resistance $U_{L1/N}$, $U_{L2/N}$ $U_{L3/N}$	220 kΩ

Sub-result Negative Sequence Voltage NSC, Zero Sequence Voltage ZSC:

Note!

- ZSC measurement is only possible in 4W connection!

Min. voltage 3-wire connection	170 V (phase to phase)
Min. voltage 4-wire connection	100 V (phase to N)
Measuring range	0.0 ... 15.0 %
Display range	0.0 ... 15.0 %
Resolution	0.1 %
Accuracy	± (3 % rdg. + 5 digits)
Limit value	Adjustable 0.0 … 15.0 %, standard value 2.0 % Judgement: NSC, ZSC ≤ LIMIT … result OK

Protective Extra Low Voltage RMS ("PELV" sub-measurement in U/P function)

Measurement terminals	L (black) and PE (yellow)
Frequency range	DC and 45.0 ... 66.0 Hz
Input resistance	220 kΩ
Max input voltage	See the page 228.

Main result $U_{PELV\ AC+DC}$:

Calculation	$U_{PELV\ AC+DC} = U_{TRMS}$
Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)

Sub-result Voltage U_{AC}:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Limit	Adjustable 0.0 ... 440 Vrms, standard values 6.0 V and 25.0 V Judgement: $U_{AC} \leq$ LIMIT … result OK

Sub-result Voltage U_{DC}:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V)* ± (2 % rdg) (100 … 440 V)

* This accuracy is valid if peak value is lower than 120 V.

Limit	Adjustable 0.0 ... 440 V, standard values 15.0 V and 60.0 V Judgement: $U_{DC} \leq$ LIMIT … result OK

Sub-result Frequency f:

See the chapter "Sub-result Frequency f" on page 214.

Safety Extra Low Voltage RMS ("SELV" sub-measurement in U/P function)

Measurement terminals	L (black) and N (blue)
Frequency range f	DC and 45.0 ... 66.0 Hz
Input resistance	440 kΩ
Max input voltage	See the page 228.

Main result $U_{SELV\ AC+DC}$:

Calculation	$U_{SELV\ AC+DC} = U_{TRMS}$
Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)

Sub-result Voltage U_{AC}:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Limit	Adjustable 0.0 ... 440 Vrms, standard values 6.0 V and 25.0 V Judgement: $U_{AC} \leq$ LIMIT … result OK

Sub-result Voltage U_{DC}:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V)* ± (2 % rdg) (100 … 440 V)

* This accuracy is valid if peak value is lower than 120 V.

Limit	Adjustable 0.0 ... 440 V, standard values 15.0 V and 60.0 V Judgement: $U_{DC} \leq$ LIMIT … result OK

Sub-result Frequency f:

See the chapter "Sub-result Frequency f" on page 214.

Control Voltage RMS ("UCONTROL" sub-measurement in U/P function)

Measurement terminals	L (black) and N (blue)
Frequency range f	DC and 45.0 ... 66.0 Hz
Input resistance	440 kΩ
Max input voltage	See the page 228

Main result Control Voltage $U_{CONTROL\ AC+DC}$:

Calculation	$U_{CONTROL\ AC+DC} = U_{TRMS}$
Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)

Sub-result Voltage U_{AC}:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V) ± (2 % rdg) (100 … 440 V)
Limit	Adjustable 0.0 ... 440 Vrms, standard values 230 V (50 Hz) and 227 V (60 Hz) Judgement: $U_{AC} \leq$ LIMIT … result OK

Sub-result Voltage U_{DC}:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg + 3 digits) (0.0 … 99.9 V)* ± (2 % rdg) (100 … 440 V)

* This accuracy is valid if peak value is lower than 120 V.

Limit	Adjustable 0.0 ... 440 V, standard value 220 V Judgement: $U_{DC} \leq$ LIMIT … result OK

Sub-result Frequency f:

See the chapter "Sub-result Frequency f" on page 214.

DC Supply Voltage ("UDC SUPPLY" sub-measurement in U/P function)

Measurement terminals	L (black) and N (blue)
Input resistance	440 kΩ (internal low pass filter in firmware for superposed AC voltage)
Nominal voltage UNOM	10.0 … 100 V
Max input voltage	See the page 228.

Main result DC Supply Voltage UDC SUPPLY:

Measuring range	0.0 ... 440 V
Display range	0.0 ... 99.9 V, 100 ... 490 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg. + 3 digits) (0.0 … 99.9 V)* ± (2 % rdg.) (100 … 440 V)

* This accuracy is valid if peak value is lower than 120 V.

Mode BATTERIES:

Low limit value	Adjustable 0 ... 100 % of UNOM, standard value 85 % of UNOM
High limit value	Adjustable 100 ... 150 % of UNOM, standard value 115 % of UNOM Judgement: UDC = Low LIMIT to High LIMIT … result OK

Mode CAR BATTERIES:

Low limit value	Adjustable 0 ... 100 % of UNOM, standard value 70 % of UNOM
High limit value	Adjustable 100 ... 150 % of UNOM, standard value 120 % of UNOM Judgement: UDC = Low LIMIT … High LIMIT … result OK

Mode DRIVE MODULES:

Low limit value	Adjustable 0 ... 100 % of UNOM, standard value 90 % of UNOM
High limit value	Adjustable 100 ... 150 % of UNOM, standard value 110 % of UNOM Judgement: UDC = Low LIMIT … High LIMIT … result OK
Ripple limit value (peak-peak)	Adjustable 0 ... 50 % of UNOM, standard value 15 % of UNOM Judgement: URIPPLE ≤ LIMIT … result OK

Sub-result ripple peak-peak Voltage URIPPLE @ DRIVE MODULES mode only:

Measuring range	0.0 ... 200 V
Display range	0.0 ... 99.9 V, 100 ... 200 V
Resolution	0.1 V, 1 V
Accuracy	± (2 % rdg. + 3 digits) (0.0 … 99.9 V) ± (2 % rdg.) (100 … 200 V)
Frequency range f	20 ... 200 Hz

Sub-result max. DC Supply Voltage UMAX:

See "Main result DC Supply Voltage UDC SUPPLY" above.

Sub-result min. DC Supply Voltage UMIN:
See “Main result DC Supply Voltage UDC SUPPLY” above.

Welding No-load RMS Voltage (“URMS WELD” sub-measurement in U/P function)
See the technical specifications in User manual TPA-204-63A* / TPA-204-32A*.

Welding Peak Voltage (“UPEAK WELD” sub-measurement in U/P function)
See the technical specifications in User manual TPA-204-63A* / TPA-204-32A*.

Cable Extension Testing (AUTO function)
See the chapter “Cable Extension Testing” in User manual TPA-204-63A* / TPA-204-32A*.

PRCD Testing (AUTO function)
See the chapter “Cable Extension Testing” in User manual TPA-204-63A* / TPA-204-32A*.

***** In development

28. LIMITED WARRANTY AND LIMITATION LIABILITY

It is guaranteed that this MI SPEKTER product is free of material and manufacturing damages for the time period of 24 months starting from the date of purchase. This warranty does not include fuse malfunctions as well as damages caused by accidents, negligence, misusage, unauthorised modifications, abnormal operating conditions or improper handling. The sales offices do not have the right to extend the warranty on behalf of MI SPEKTER.

29. LIST OF USED ABBREVIATIONS

PC I..... Protection Class I (appliances with PE conductor)
UUT..... Unit Under Test
RCD ..... Residual Current Device
RCM ..... Residual Current Monitor
IMD ..... Insulation Monitor Device
PRCD ..... Portable Residual Current Device
TRMS ..... True Root Mean Square
LCD ..... Liquid Crystal Display
PELV..... Protective Extra Low Voltage
SELV ..... Safety Extra Low Voltage
TPA-204-32A* ..... 32 A Three Phase Adapter
TPA-204-63A* ..... 63 A Three Phase Adapter
HVA-204 ..... High-Voltage Adapter
MPCB … ..... Motor Protection Circuit Breaker
I_{PEFC} ..... Prospective Earth Fault Current
I_{PSC} ..... Prospective Short-circuit Current

***** In development

HVA-204

High-Voltage Adapter

User Manual

2025 MI SPEKTER

Table of Contents HVA-204 High-Voltage Adapter:

1. SAFETY INFORMATION, WARNINGS

Measurements of dielectric strength by using the HVA-204 Adapter in combination with MST-204 MachinerySwitchgear Tester should only be carried out by properly trained and competent personnel!
Carefully read the safety information before using the HVA-204 Adapter.

A **Warning** identifies conditions and procedures that are dangerous to the user.
A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.
A **Note** gives a general information on conditions and procedures.

Symbols used on the adapter or in this User Manual:

	**Warning of a potential danger, comply with the User Manual.**
	**Reference, please pay utmost attention.**
	**Earth (ground) terminal**
	**Do not touch, hazardous voltage, risk of electric shock.**
	**Read the User Manual.**
	**Symbol for marking of electrical and electronic equipment (WEEE Directive).**
	**Conformity symbol, confirms compliance with the applicable European directives. The requirements of the EMC Directive and the Low Voltage Directive with the relevant regulations Standards are also fulfilled.**

 WARNINGS

- ☞ **This User Manual contains information and references, necessary for safe operation and maintenance of the adapter. Prior to using the adapter, the user is kindly requested to thoroughly read the User Manual and comply with it in all sections. Please comply also with User Manual MST-204 MachinerySwitchgear Tester while using the HV adapter.**
- ☞ **If the adapter is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.**
- ☞ **Failure to read the User Manual or to comply with the warnings and references contained herein can result in serious bodily injury or adapter damage.**
- ☞ **Please check for local/national safety advices/requirements from health & safety board like EN 50191.**

2. INTRODUCTION

You have acquired a high-quality measurement adapter manufactured by MI SPEKTER, which will enable you to perform repeatable measurements for a very long period of time.

The HVA-204 High-Voltage Adapter is a high-voltage adapter which can be used in combination with MST-204 MachinerySwitchgear Tester only. It is intended to be used for testing the effectiveness of protective measures of electrical equipment on various single-phase and three-phase objects like:

- Machines
- Switchgears
- Low-voltage transformers
- Etc.

Testing complies with the standards EN 60204-1 (Machines), EN 61439-1 (Low-voltage switchgears), EN 61180 (High-voltage test techniques for low-voltage equipment), EN 50191 (Erection and operation of electrical test equipment).

Available measurements, product description:

- High-voltage dielectric test, test voltage adjustable from 250 up to 5100 VAC, trip out current adjustable from 1 up to 100 mA.
- Two standards:
  - MACHINES
  - Low-voltage SWITCHGEARS
- Three basic measurements:
  - NO RAMP
  - RAMP ⌐ (RAMP UP)
  - RAMP ⌐\ (RAMP UP/DOWN)
- Four modes:
  - TRIP OUT
  - TRIP ×mA
  - BURN
  - ⚡ TRIP

3. SCOPE OF SUPPLY

1 pc HVA-204 High-Voltage Adapter with 1.8 m fixed mains/communication cable to be connected to MST-204 Tester (connector “OUTPUT to ADAPTER”)
2 pcs SP02 HV Test Gun without “START” switch, with 2 m cable (HVA-204 PLUS version only)
1 pc Pedal P-204 with 3 m cable
1 pc Soft accessory bag
1 pc Safety instruction HVA-204 High-Voltage Adapter in English

4. AVAILABLE OPTIONAL ACCESSORIES

2 pcs SP02
HV Test Gun without “START” switch, with 2 m cable
1 pc WL-204
Warning Lamp red/green 24 VDC with 0.2 m cable
1 pc WLC-204
Warning Lamp Connector (male) for warning lamp (M12 / 5-pole), e.g. type T4111001051-000 produced by TE Connectivity
1 pc RACK-204
19-inch Rack Panel
1 pc SP03
HV Test Gun with “START” switch, with 2 m cable
1 pc TLS-204-HVA
Test Lead Set for HVA-204 Adapter to be used in combination with safety cage containing:
- 2x HV test cable 2 m with HV connector on one end and open other end
- 2x 2P Safety circuit cable connector (male)
- 1x 9P D-sub connector (male) for example for PEDAL (see all functions in chapter “PEDAL, CONTROL INPUT-OUTPUT SOCKET” on page 259)
1 pc SP02 CABLE
2x HV test cable 2 m with HV connector on one end and open other end

5. TRANSPORT AND STORAGE

Please keep the original packaging for potential later transport, e. g. for calibration. Any transport damage due to faulty packaging will be excluded from warranty claims.

The adapter must be stored in a dry and closed area. In case of the adapter being transported in extreme ambient conditions, a recovery time of minimum 2 hours is required prior to any operation.

6. SAFETY MEASURES

The HVA-204 Adapter has been built and tested in compliance with valid safety regulations and left the factory in safe and perfect condition. In order to maintain this condition and to ensure safe adapter's operation the user must pay attention to the references and warnings contained within this User Manual and the User Manual MST-204 MachinerySwitchgear Tester.

WARNING, DANGER OF ELECTRICAL SHOCK

- ☞ **The HVA-204 Adapter supplies high voltage of a dangerous power. According to EN 50191 guideline the following precautionary measures must be taken prior to a test:**
  - ☞ **Block access to a danger area!**
  - ☞ **Put up warning signs (Attention! High voltage, danger to life!)!**
  - ☞ **Install warning lamp (red/green) to be easily visible!**
  - ☞ **Install EMERGENCY-OFF switch into the mains installation outside the dangerous area!**
- ☞ **Properly trained personnel may only do the tests under supervision of specialist staff and have to be trained regularly.**
- ☞ **Use only supplied HV probes (standard set or optional accessories). Always hold only one gun in one hand.**
- ☞ **Connecting one test terminal to the UUT and working with one probe or holding both probes in one hand is prohibited.**
- ☞ **It is prohibited to touch any part of the UUT during the test. If needed, additional measures must be taken (e. g. cover made of insulating mats) to protect the person performing the test against inadvertent contact with the test object.**
- ☞ **Testing may commence only after all safety measures have been taken.**
- ☞ **Carry out the self-test of HV test circuitry whenever required by the MST-204 MachinerySwitchgear Tester and stop further testing in case of FAILED result, see the instructions in User manual MST-204 MachinerySwitchgear Tester, chapter "SELF-TEST" on page 98.**
- ☞ **Check wear of test leads any time before starting the test, see the instructions in chapter "CHECK WEAR OF HV TEST LEADS" on page 256.**

WARNING, DANGER OF ELECTRICAL SHOCK

- ☞ **In order to avoid electrical shock, the valid safety and national regulations regarding excessive contact voltages must receive utmost attention when working with voltages exceeding 120 VDC or 50 VAC.**
- ☞ **The respective accident prevention regulations established by the national health & safety board for electrical systems and equipment must be strictly met at all times.**
- ☞ **Prior to any operation, ensure that the adapter, HV probes, mains/communication cable and accessories are in perfect condition.**
- ☞ **The adapter may only be connected to MST-204 MachinerySwitchgear Tester as indicated in technical specification section.**
- ☞ **The MST-204 MachinerySwitchgear Tester and therefore HVA-204 Adapter must obligatory be connected to and supplied by properly wired mains socket (PE terminal must be earthed) prior to connecting any HV probe to any test socket and/or prior to connecting any HV gun to a UUT! This is to assure the adapter to be grounded before any further use, otherwise the situation may be hazardous!**

- ☞ **The adapter may only be used within the operating ranges as specified in the technical specification section.**
- ☞ **Only touch HV guns at hand-held area, never directly touch live HV terminals.**
- ☞ **The adapter may only be used in dry and clean environments. Dirt and humidity reduce insulation resistance and may lead to electrical shock, in particular for high voltages.**
- ☞ **Never use the adapter in precipitation such as dew or rain. In case of condensation due to temperature jumps, the adapter may not be used.**
- ☞ **Perfect measurement values may only be ensured within the temperature range from 0 to 40 °C.**
- ☞ **The adapter may only be opened by an authorized service technician. Before opening the HVA-204 Adapter, the adapter must be disconnected from MST-204 MachinerySwitchgear Tester and any electrical circuit.**
- ☞ **There are no user-replaceable components inside the adapter.**
- ☞ **If the operator's safety is no longer guaranteed, the adapter is to be put out of service and protected against use. The safety can no longer be guaranteed if the adapter (or any HV probe):**
  – shows obvious damage
  – does not carry out the desired measurements
  – has been stored for too long under unfavorable conditions
  – has been subjected to mechanical stress during transport
- ☞ **Start any test series by visual inspection.**

7. APPROPRIATE USAGE

WARNINGS

- ☞ **The adapter may only be used under conditions and for the purposes for which it was conceived. For this reason, and particular the safety references, the technical data including environmental conditions and the usage in dry environments must be followed.**
- ☞ **When modifying the adapter, the operational safety is no longer ensured.**
- ☞ **Before commencing the HV tests, you are strongly requested to make reference to the local regulations and standards for safety at works, regulations and any relevant publications from the Health and Safety Executive.**
- ☞ **The UUT must be switched on (mains switch) and disconnected from mains voltage during the HV test. Disconnect also all other potential equipment (e.g. printer, PC, ethernet etc.) that may be connected to the UUT as all connected parts may also carry hazard voltage during the HV test.**
- ☞ **The tests should only be performed by competent personnel who are familiar with the requirements of the type of tests to be conducted.**
- ☞ **It is potentially hazardous for both, user and the UUT if wrong type of test is undertaken or if testing is carried out in an incorrect sequence.**
- ☞ **It is important the operator to fully understand various tests required and how they should be performed.**

8. DESCRIPTION OF WARNING SYMBOLS

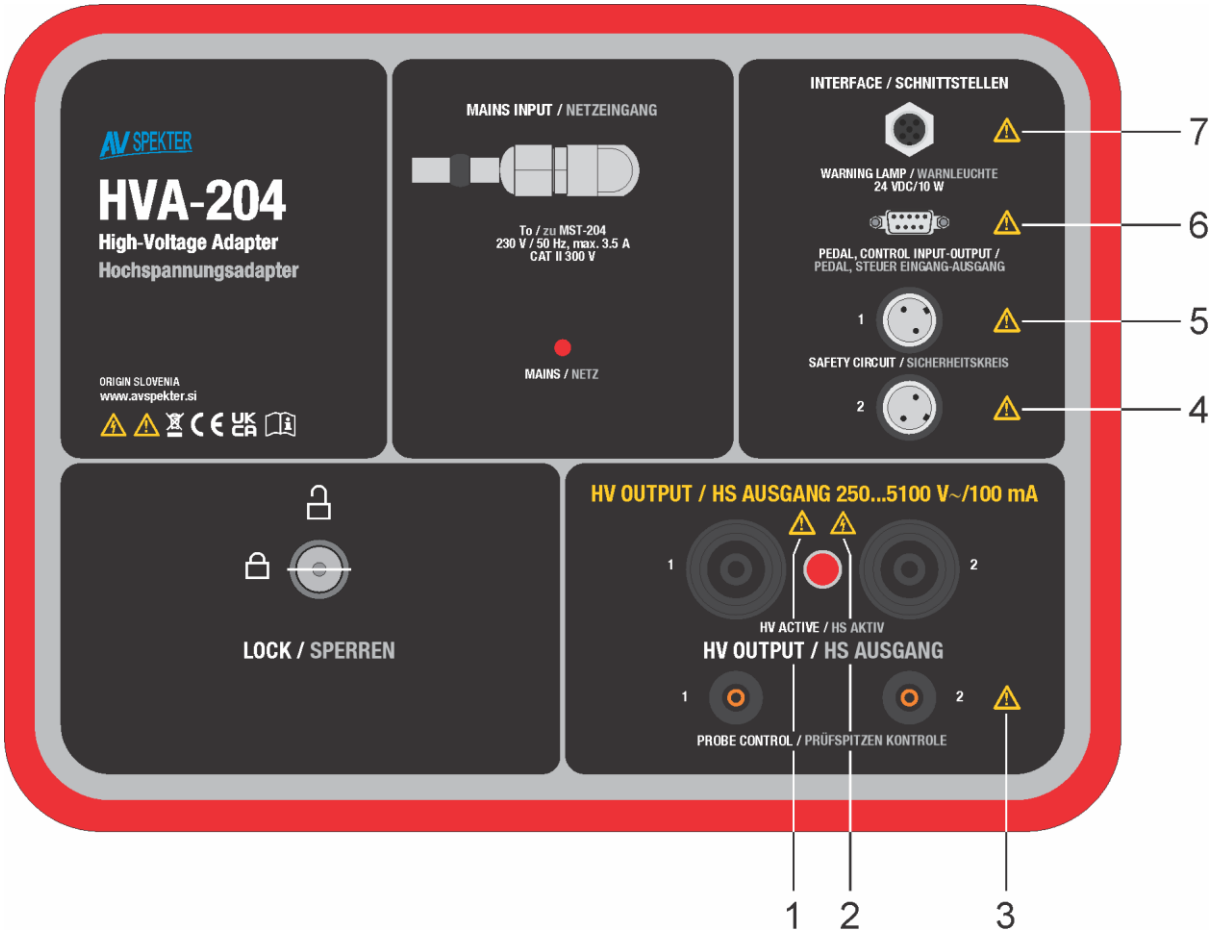

Figure 1: Explanation of warning symbols

Warning 1:
Use HV OUTPUT test sockets for connection of original test guns only!

Warning 2:
Dangerous voltage 250 up to 5100 VAC may be present at HV OUTPUT 1 and/or HV OUTPUT 2 outputs.

Warning 3:
Use PROBE CONTROL sockets for connection of control connectors of HV test guns only (type SP03)! Do not apply any external voltage to any terminal of the connectors.

Warning 4:
Use SAFETY CIRCUIT 2 sockets for connection of safety switch only! Do not apply any external voltage to any terminal of the connector.

Warning 5:
Use SAFETY CIRCUIT 1 sockets for connection of safety switch only! Do not apply any external voltage to any terminal of the connector.

Warning 6:
Use PEDAL, CONTROL INPUT-OUTPUT socket for connection of original pedal and other accessories according to this User manual only!

Warning 7:
Use WARNING LAMP socket for connection of original warning lamp only! Do not apply any external voltage to any terminal of the socket!

9. DESCRIPTION OF OPERATIONAL ELEMENTS AND CONNECTORS

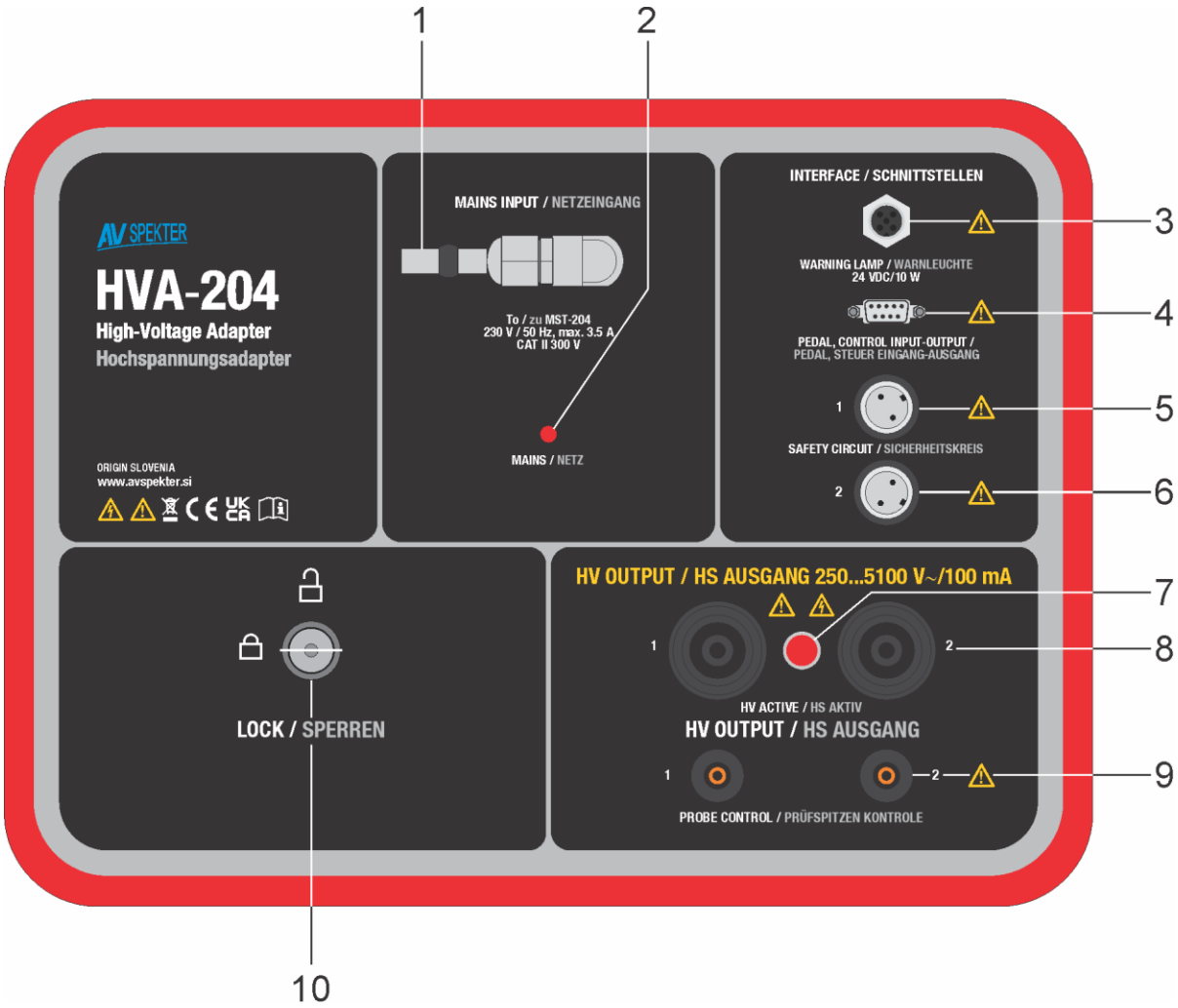

Figure 2: Operational elements and connectors on HVA-204 Adapter

1 ..... Mains/communication cable, to be connected to MST-204 MachinerySwitchgear Tester.
2 ..... MAINS on pilot lamp, to indicate presence of mains voltage in the adapter.
3 ..... Red/green WARNING LAMP socket acc. to EN 50191.
4 ..... PEDAL, CONTROL INPUT-OUTPUT connector, see the explanation in chapter “PEDAL, CONTROL INPUT-OUTPUT SOCKET” on page 258.
5 ..... SAFETY CIRCUIT 1 socket, see the explanation in chapter “SAFETY CIRCUIT 1 & 2 SOCKETS” on page 259.
6 ..... SAFETY CIRCUIT 2 socket, see the explanation in chapter “SAFETY CIRCUIT 1 & 2 SOCKETS” on page 259.
7 ..... HV ACTIVE pilot lamp, to indicate presence of dangerous test voltage at HV test terminals.
8 ..... HV OUTPUT 1 and HV OUTPUT 2 sockets! Use original test guns only to be connected to these sockets.
9 ..... PROBE CONTROL 1 and PROBE CONTROL 2 sockets. Use HV test guns with START SWITCH (type SP03) only to be connected to these sockets. Test guns type SP03 can be supplied optionally.
10 ..... LOCK key, to disable the HV operation against using it by an unauthorized person (while the key is removed).

10. CONNECTION DIAGRAMS AND QUICK INSTRUCTION CARD

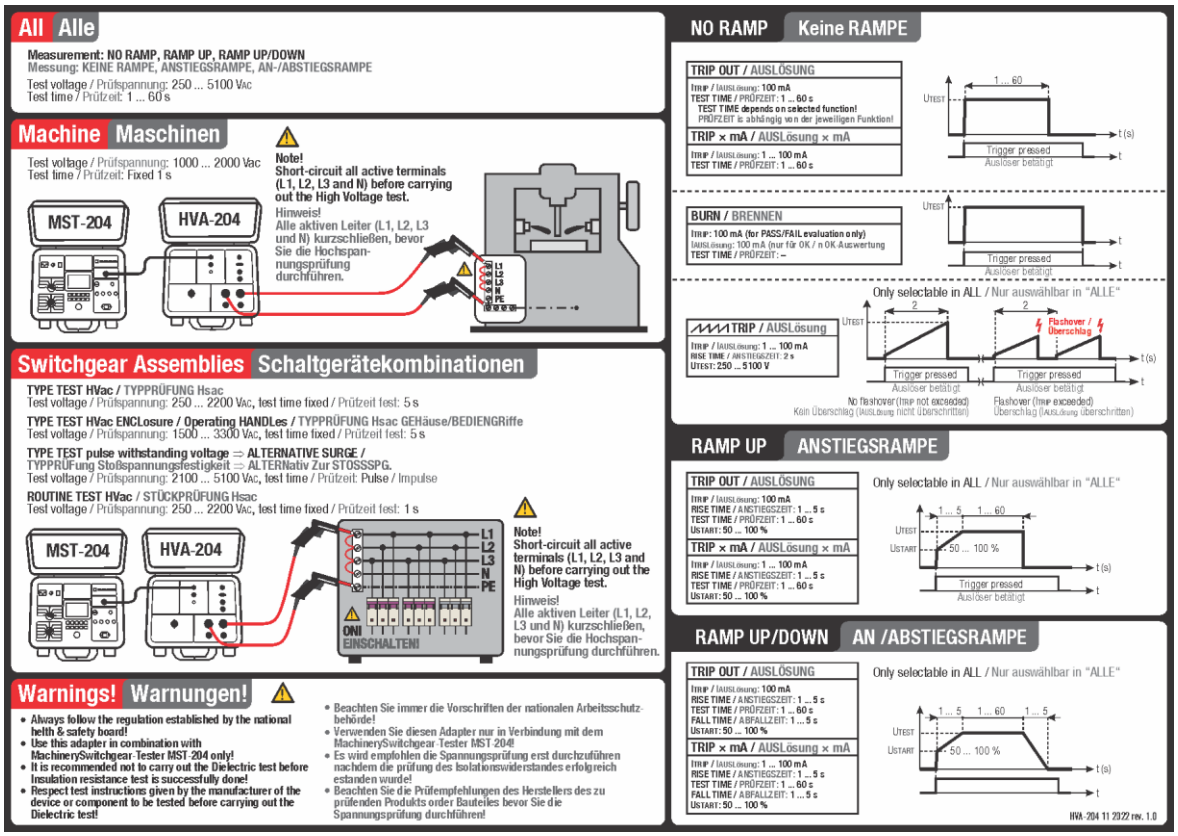

Figure 3: Brief connection diagrams (inside plastic case cover)

11. PREPARATION OF THE HVA-204 ADAPTER

Turning on the HVA-204 Adapter:
Mains/control cord of the adapter may only be connected to “OUTPUT to ADAPTER” supply/communication socket of the MST-204 MachinerySwitchgear Tester as indicated in technical specification section!

Procedure:
1) Connect HVA-204 Adapter to MST-204 Tester, socket “OUTPUT to ADAPTER”.
2) Connect two HV test guns to HVA-204 Adapter, sockets HV OUTPUT 1 and PROBE CONTROL 1 (SP03 only) respectively HV OUTPUT 2 and PROBE CONTROL 2 (SP03 only).
3) Select standard (UUT family) on MST-204 by setting rotary switch #1 to position 1, 2 or 3.
3) Select HV test function on MST-204 MachinerySwitchgear Tester by setting rotary switch #2 to position 7.
4) The HVA-204 Adapter is energized when red MAINS pilot lamp is ON (figure 2, detail 2).

Note!
- Do not connect PC to MST-204 Tester via USB 1 connector while HV measurements are carrying out, USB connection might be disturbed by high test voltage.

12. TEST GUN DESCRIPTION

Type SP02, without "START" switch (included in HVA-204 PLUS version only)**:**

There are two identical test guns in standard set to be used for dielectric test. Use the guns in combination with PEDAL P-204 to carry out the test.

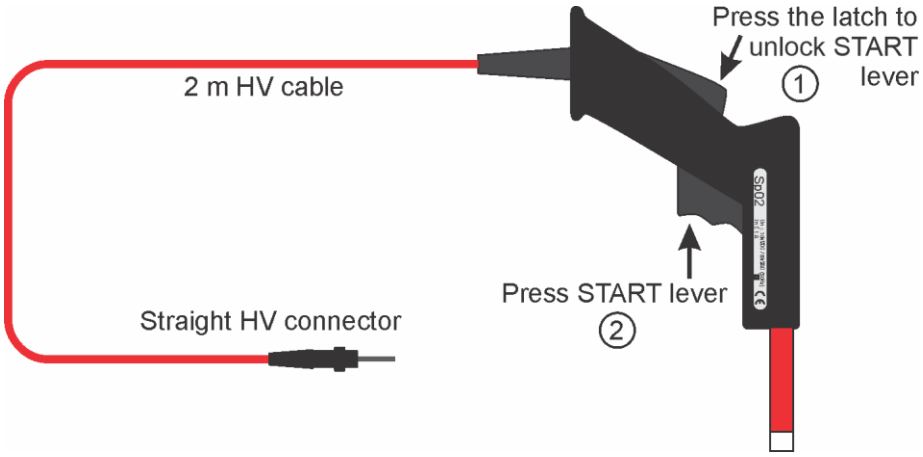

Figure 4: HV test gun type SP02

Type SP03, with "START" switch (optional accessory)**:**

The gun can be supplied upon request (optional accessory). It is a welcome test accessory for comfortable use as there is no need to use it in combination with PEDAL.

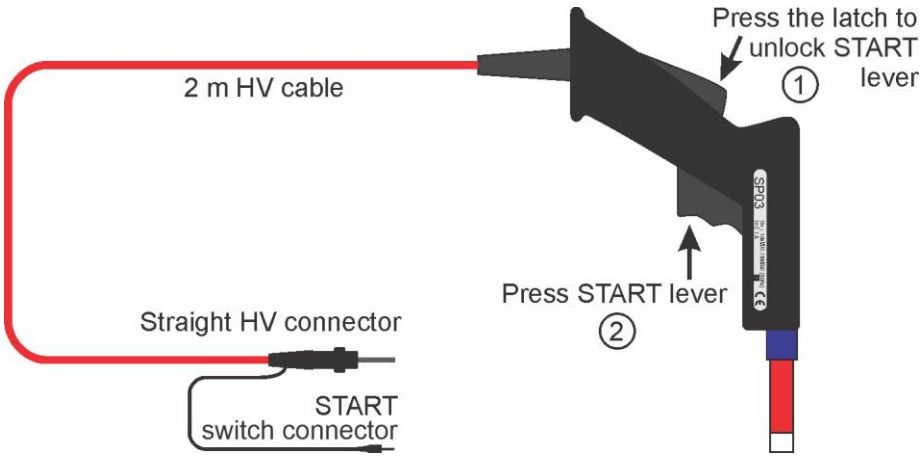

Figure 5: HV test gun type SP03

13. PEDAL DESCRIPTION

The Pedal P-204 is used to run HV test when standard HV guns type SP02 (without “START” switch) are used. HV test is enabled until the Pedal is pressed.
If optional HV guns type SP03 (with “START” switch) are used, the Pedal is not needed as it is replaced with “START” switches on SP03.
Connect the Pedal to PEDAL, CONTROL INPUT-OUTPUT connector on HVA-204.

Figure 6: Pedal P-204

14. CHECK WEAR OF HV TEST LEADS

HV test leads are made of white insulation material covered by a red layer. In case the red layer is worn, white insulation will be clearly visible. So check the HV test leads before using them and put them out of service in case white insulation can be seen – danger to live!

15. WARNING LAMP SOCKET (figure 2, detail 3)

According to EN 50191 the highest level of safety must be undertaken when working with high voltages like used in HV test. For this purpose the HVA-204 Adapter offers an output to drive the WARNING lamp. Use only the lamp listed in chapter “AVAILABLE OPTIONAL ACCESSORIES” on page 248.

Figure 7: Warning lamp socket (left figure, view from front) and Warning Lamp WL-204 (optional accessory)

Socket type (installed on front panel of HVA-204): M12 / 5-pole female
Pin 1: Cathode of green LED
Pin 2: Cathode of red LED
Pin 3: Anode of green and red LED (+24 V DC / 0.5 A max.)

Meaning of switched ON green lamp:
While green lamp is ON the HV Aadapter is safe (not in “READY” mode). Test voltage is not present at test guns and Pedal (or “START” switches on HV guns) is not active.

Meaning of switched ON red lamp:
While red lamp is ON the HV Adapter is in “READY” mode meaning it is ready to carry out HV test. Red lamp is ON after pressing “START” button on MST-204 for 2 seconds. In this case step on the PEDAL (SP02 test guns without “START” switch are used) or press “START” switches on both HV test guns (SP03 test guns with “START” switch are used) to run the test.

Meaning of blinking red lamp:
While red lamp is blinking the HV test is running.

WARNING!

☞ **This is most dangerous situation, do not touch any live part of HV test guns or any part of the UUT!**

16. PEDAL, CONTROL INPUT-OUTPUT SOCKET (figure 2, detail 4)

The following input-output signals are available at the socket:

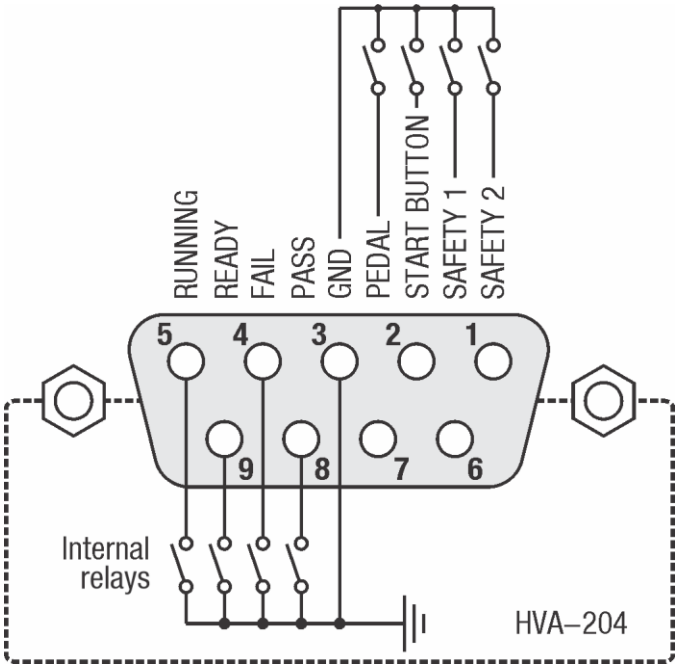

Figure 8: CONTROL INPUT-OUTPUT socket (view from front)

Socket type: D-sub 9-pole female (connect D-sub 9-pole male)

Signals:

Pin 1 ..... Input “SAFETY 2” (the same function as SAFETY CIRCUIT 2 input on HVA-204 Adapter). Pin 1 must be grounded (connected to pin 3) to enable the HVA-204 Adapter operation.

Pin 2 ..... Input “START BUTTON” (the same function as “START” button on MST-204). Pin 2 must be grounded (connected to pin 3) to activate start function.

Pin 3 ..... Ground GND.

Pin 4 ..... Output “FAIL” (the FAIL terminal is grounded via internal relay until failed (red) result is displayed, meaning internal relay is closed).

Pin 5 ..... Output “RUNNING” (the RUNNING terminal is grounded via internal relay until the HV test is running, meaning internal relay is closed).

Pin 6 ..... Input “SAFETY 1” (the same function as SAFETY CIRCUIT 1 input on HVA-204 Adapter). Pin 6 must be grounded (connected to pin 3) to enable the HVA-204 Adapter operation.

Pin 7 ..... Input “PEDAL” (the same function as PEDAL or START switches on HV guns). Pin 7 must be grounded (connected to pin 3) to activate pedal operation.

Pin 8 ..... Output “PASS” (the PASS terminal is grounded via internal relay until passed or conditionally passed (green or yellow) result is displayed, meaning internal relay is closed).

Pin 9 ..... Output “READY” (the READY terminal is grounded via internal relay until the HV tester is in READY mode, meaning internal relay is closed).

Caution!

☞ Do not apply any external voltage to any pin of CONTROL INPUT-OUTPUT socket.

Note!

- All above listed inputs and outputs are active in HV function only.

17. SAFETY CIRCUIT 1 & 2 SOCKETS (figure 2, details 5 and 6)

In order to reach higher safety level, two SAFETY CIRCUIT connectors are installed. Safety switch of a mechanical barrier or safety door can be connected there in order to disable DIELECTRIC function in case the safety switch is open. For these purposes select SAFETY INPUT enabled mode on MST-204 in the menu as follows:
"MENU" hard key F8 → "HV SAFETY" menu key → "SAFETY CIRCUIT 1" (or 2) menu key → "ENABLE" menu key.

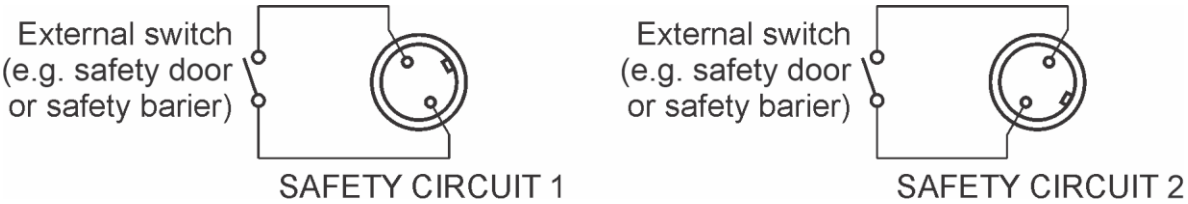

Figure 9: SAFETY CIRCUIT 1 & 2 sockets (view from front)

Connector type: BINDER - 680 09 0304 00 02 – PANEL MOUNT RECEPTACLE/SOCKET, 2-pole female

Please connect 90° plug type BINDER - 682 09 013370 02 – CABLE MOUNT PLUG, 2-pole male.

There are two equivalent SAFETY CIRCUIT sockets available. Both of them shall be connected according to above drawing and the switch shall be closed enabling the tester to operate.

In case the operator wishes to disable operation of SAFETY CIRCUIT 1 and/or SAFETY CIRCUIT 2 inputs, it can be done in MENU/HV SAFETY/SAFETY CIRCUIT 1 (or 2).

Cautions!
☞ **Do not apply any external voltage to SAFETY inputs.**
☞ **Current / voltage rating of used external switches shall be at least 0.1 A / 30 V.**

18. TECHNICAL SPECIFICATIONS OF HVA-204 ADAPTER

18.1. General Features

Standards used	EN 61180 (High-voltage test techniques for low-voltage equipment) EN 50191 (Erection and operation of electrical test equipment)
CE directives	Low Voltage Directive LVD 2014/35/EU Electromagnetic Compatibility EMC 2014/30/EU
Safety standards	EN / IEC 61010-1:2010 (Third edition) (Safety requirements for electrical equipment for measurement, control and laboratory use – General requirements) EN / IEC 61010-2-034:2017 and 61010-2-034: 2021
EMC standard	EN 61326-1:2013 (industrial environment)
Input mains voltage (via MST-204 only!)	230 V +10%/-15% or 240 V +6%/-10%, 50 Hz, CAT II 300 V
Max. current at mains plug	3.5 A
Max. inter. power consumption	800 VA
Protection against HV socket overload	Electronically limited
HV OUTPUT sockets	2 × special HV socket
PROBE CONTROL sockets	2 × 4-pole 3.5 mm socket (for 4-pole 3,5 mm jack) (START and recognition of connected HV guns type SP03 with “START” switch)
Dimensions (W × L × H)	405 x 330 x 180 mm
Weight (without accessories)	13.1 kg
IP protection class	IP65 (closed case cover) IP40 (open case cover, connectors excluded) IP20 (connectors)
Position	Front panel 0° (basic horizontal position) up to 90°
Reference temperature range	+23 °C ± 5 °C
Reference humidity range	10 ... 60 % relative humidity w/o condensation
Working temperature range	0 ... +40 °C
Working humidity range	10 ... 85 % relative humidity w/o condensation
Storage temperature range	-10 ... +60 °C
Storage humidity range	< 85 % relative humidity w/o condensation
Pollution degree	2
Protection class	I
Altitude above sea level	2000 m max.

18.2. Functions

High-Voltage Dielectric Test

Output test voltage	Adjustable 250 ... 5100 VAC, floating - Machines with rated voltage up to 1000 V; Test voltage 1000 ... 2000 VAC - Switchgears up to CAT III 600V or CAT IV 300 V; Test voltage 250 ... 5100 VAC	
Output power	> 500 VA	
Test voltage accuracy	± 3 % of reference value (reference value measured with reference V-meter having an accuracy better than ± 2 %, acc. to EN 61180-2, clause 6.2 and 10.2)	
Voltage measuring range	240 … 5200 VAC	
Voltage resolution	1 V	
Voltage accuracy	± 3 % rdg.	
Short-circuit current	200 … 250 mA	
Trip out current	Fixed acc. to standard	100 mA
	Adjustable	1 … 100 mA
	Burn	No trip
Current measuring range	0 ... 200 mA	
Current resolution	1 mA	
Current accuracy	± (3 % rdg. + 2 mA)	
Capacitive load	100 nF max.	
Test duration	Test duration is not limited until the leakage current is lower than or equal to 60 mA. If the current is higher than 60 mA, the intermittent use should be respected. Max. ratio (current on time) / (current off time) = 1 /10, max. current on time = 1 min.	
Crest factor	1,414 ± 5 %	
Trip out time	< 30 ms after reaching set limit value	
Timer accuracy	± 3 % of set value	
Available test measurements	NO RAMP RAMP ⎍ (RAMP UP) RAMP ⎍ (RAMP UP/DOWN)	
Available test modes	TRIP OUT BURN TRIP ×mA ⩘ TRIP	

18.3. Test Gun Specifications

Standards used	EN / IEC 61010-031:2018
Type	SP02 without “START” switch (included in HVA-204 PLUS version only) SP03 with “START” switch (optional accessory)
Voltage/current rating	10 kV$_{DC}$ / 8 kV$_{AC}$ (50 Hz), max. 1 A
Wear indicator	Red plastic layer around white basic insulation
Pollution degree	2
Protection class	II (double/reinforced insulation)
Altitude above sea level	2000 m max.
Working temperature range	0 ... +40 °C
Working humidity range	10 ... 85 % relative humidity w/o condensation
Storage temperature range	-10 ... +60 °C
Storage humidity range	< 85 % relative humidity w/o condensation

19. MAINTENANCE

When using the Adapter in compliance with this User Manual, no special maintenance is required. However, should functional errors occur during normal operation, our after sales service will repair your adapter without delay.

19.1. Cleaning

If the Adapter is needed to be cleaned after daily usage, it is advisable to use a wet cloth and a mild household detergent.

Prior to cleaning disconnect the HVA-204 Adapter from all measurement circuits and from MST-204 Tester.

Never use acid-based detergents or dissolvent liquids for cleaning.

After cleaning it, do not use the adapter until it is completely dried up.

19.2. Calibration Interval

We suggest a calibration interval of one year. If the adapter is rarely used, the calibration interval can be extended on to 3 years.

19.3. Fuse Replacement

There are no fuses in the HVA-204 Adapter, the adapter is protected by the fuse in MST-204 MachinerySwitchgear Tester.

20. LIMITED WARRANTY AND LIMITATION OF LIABILITY

It is guaranteed that this MI SPEKTER product is free of material and manufacturing damages for the time period of 24 months starting from the date of purchase. This warranty does not include fuse malfunctions, as well as damages caused by accidents, negligence, misusage, unauthorized modifications, abnormal operating conditions or improper handling. The sales offices do not have the right to extend the warranty on behalf of MI SPEKTER.

21. SERVICE

All instruments that are sent in for repair or calibration within or beyond the warranty period must contain the following data: Name of the client, name of the company, address, contact telephone number and a proof of purchase. Please enclose also the test leads and a short description (or a service form) of the problem detected or of desired maintenance.

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22. LIST OF ABBREVIATIONS

UUT..... Unit Under Test
MST-204 ..... Type of Machinery Switchgear Tester
WEEE ..... Waste Electrical and Electronic Equipment recycling
EMC ..... Electromagnetic Compatibility
CE ..... Communauté Européenne

Notes:

Notes: