OPERATING MANUAL

Earth Resistance Meter
MRU-21

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Version 1.02, 20.06.2012

The MRU-21 meter is a modern, easy and safe measuring device. Please acquaint yourself with the present manual in order to avoid measuring errors and prevent possible problems related to operation of the meter.

CONTENTS

1 Safety

MRU-21 meter is designed for measuring parameters important for safety of electrical installations. Therefore in order to provide conditions for correct operation and the correctness of the obtained results, the following recommendations must be observed:

- Before you proceed to operate the meter, acquaint yourself thoroughly with this manual and observe the safety regulations and specifications defined by the producer.
- MRU-21 meter is designed to measure earth resistance and the resistance of protective conductors and equipotential bondings. Any application that differs from those specified in the present manual may result in a damage to the device and constitute a source of danger for the user.
- The meter must be operated solely by appropriately qualified personnel members holding required certificates for carrying measurements in electric installations. Unauthorized use of the meter may result in its damage and may seriously endanger unauthorized user.
- The meter must not be used for installations and devices located in facilities where special conditions are present e.g. in places where the danger is related to explosion and fire.
- It is unacceptable to operate the following:
  - ⇒ a damaged meter which is completely or partially out of order,
  - ⇒ a meter with damaged test leads insulation,
  - ⇒ a meter stored for an excessive period of time in disadvantageous conditions (e.g. excessive humidity).**If the meter has been transferred from a cool to a warm environment of a high level of relative humidity, do not carry out measurements until the meter is warmed up to the ambient temperature (approximately 30 minutes).**
- Before commencing measurements, make sure the test leads are connected to the appropriate measurement sockets.
- Do not operate a meter with an open or incorrectly closed battery compartment or power it from sources other than those specified in this manual.
- The inputs of the meter are protected electronically against overload e.g. due to having been connected to a live circuit:

- for all combinations of inputs - up to 276V for 30 seconds.

- Repairs may be carried out only by an authorized service point.
- The device meets the requirements of standards EN 61010-1 and EN 61557-1, -4, -5.

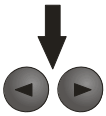
Attention:
The manufacturer reserves the right to introduce changes in appearance, equipment and technical data of the meter.

2 Settings

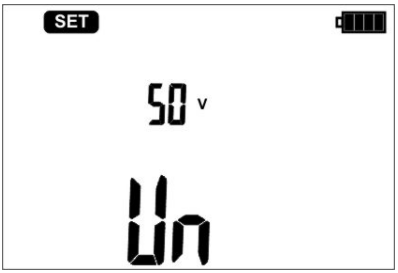
Press the **SET** button to select the test voltage (Un) or power supply source (SuPP). After replacing the batteries, always set the power supply type. The correct charge indication depends on this setting (the discharge characteristics of disposable and rechargeable batteries are different).

1. 

Turn on the meter and press **SET**.

2. 
Use the ◄ and ► buttons to select the parameter: Un or SuPP.

3. 
Use the ▲ and ▼ buttons to change the parameters: Un = 25V or 50V, SuPP = bAt (disposable batteries) or Acc (rechargeable batteries).



4. 

Press **ENTER** to validate the changes and exit the mode, or...

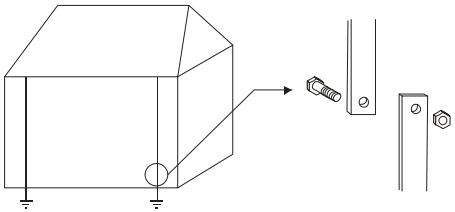
...press **ESC** to exit the setting mode without validating the changes.

3 Measurements

3.1 Earth resistance measurement with the three-lead method

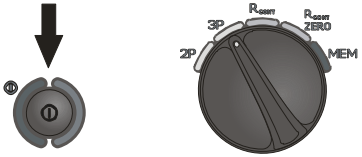
The three-lead measuring method is the basic type of resistance-to-earth measurement.

1



Disconnect the tested earth electrode from the installation of the facility.

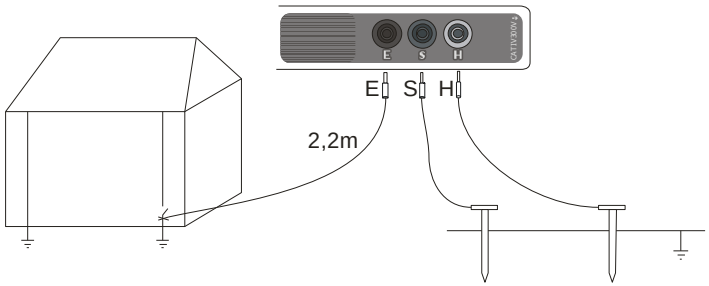
2



Turn on the meter.
Turn the rotary switch to the **R_E 3p** position.

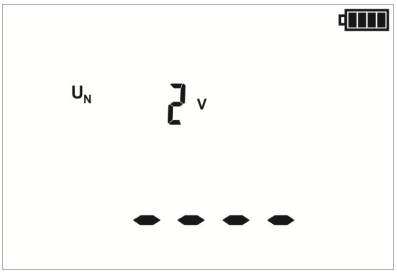
3 If necessary, adjust the voltage measurement according to section 2.

4



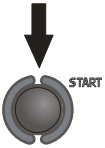
The current electrode (driven into earth) should be connected to **H** socket of the meter.
The voltage electrode (driven into earth) should be connected to **S** socket of the meter.
The tested earth electrode should be connected to **E** socket of the meter.
The tested earth electrode and the current electrode and the voltage electrode should be aligned.

5



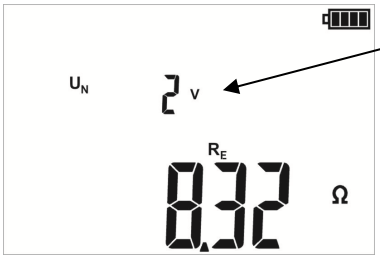
The meter is ready for measurement. Read the interference voltage on the auxiliary display.

6



Press **START**.
Perform the measurement.

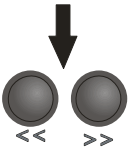
7



Interference voltage.

Read the main measurement result.

Resistance of earth electrode R_E.



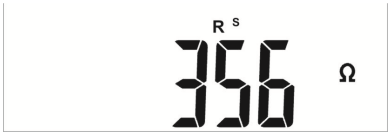
Read the auxiliary results (sequence as below) by pressing **<<** and **>>**.

8

R_H

Resistance of current electrode

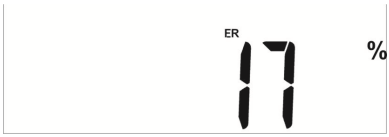
9



R_S

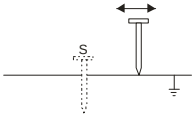
Resistance of voltage electrode

10



Additional uncertainty caused by resistance of the electrodes.

⑪



Repeat the measurements (steps 3-6) after moving the voltage a few meters - placing it farther and closer to the measured earth electrode. If the R_E measurement results differ by more than 3%, the distance of the current electrode from the tested earth electrode should be considerably increased and the measurements should be repeated.

Note:

⚠

The earth resistance measurement can be made when the interference voltage does not exceed 24V. The voltage is measured up to 100V, but above 50V is indicated as dangerous. The meter must not be connected to voltages exceeding 100 V.

- Particular attention should be paid to quality of connection between the tested facility and the test lead – the contact area must be free from paint, rust, etc.

- If resistance of the test probes is too high, R_E earth electrode measurement will include an additional uncertainty. Particularly high measurement uncertainty occurs when a small value of resistance to earth is measured with probes that have a weak contact with earth (such a situation occurs frequently when the earth electrode is well made and the upper soil layer is dry and poorly conductive). In such a case, the ratio of resistance of the probes to resistance of the tested earth electrode is very high and consequently, uncertainty of measurement that depends on this ratio is also very high. Then, you can make a calculation according to the formulas given in item 9 to estimate the influence of measurement conditions, or you can use the graph also included in the appendix. This uncertainty is also displayed in [%] as an additional result. It is calculated on the basis of measured valued. If such additional uncertainty exceeds 30% the Err symbol is displayed You can improve the contact between the probe and soil, for example by dampening with water the place where the probe is driven into earth, driving the probe into earth in a different place, or using a 80 cm-long probe. Check also the test leads for possible insulation damage and for corroded or loosened connection between the banana plug and the test lead. In majority of cases the measurement accuracy achieved is satisfactory. However, one should always be aware of the uncertainty included in the measurement.

- Factory calibration includes the resistance of the 2.2 m test lead (supplied).

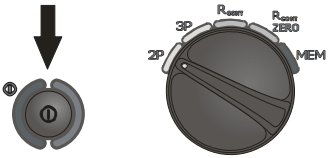
Additional information displayed by the meter

U_N 30 V > 24 V and ⚠	Excessive interference voltage (> 24V). The measurement is not possible. Disconnect the source of interference or try another location of the probes.
U_N 70 V > 50 V and ⚠ and continuous audio signal 🔊	**Interference voltage exceeds 50V!** **Disconnect** the meter immediately! Disconnect the voltage source before you reconnect the meter.

OFL > 50 V and ⚠ and continuous audio signal 🔊	**Interference voltage exceeds 100V!** **Disconnect** the meter immediately! Disconnect the voltage source before you reconnect the meter.
-r- with the electrode (electrodes) name and ⚠	Interruption in measuring circuit or resistance of test probes higher than 60 kΩ. Check connections in the test circuit or reduce the probe resistance by driving it into the soil again.
Er (in the field below Cell) and measurement result and ⚠	Uncertainty of the R_E measurement caused by probes resistance exceeds 30%. Reduce the probe resistance by driving it into the soil again or by dampening the soil in its immediate vicinity.
>1,99kΩ	The R_E measuring range is exceeded.
>50kΩ	Test probes resistance above 50kΩ (but below 60kΩ).
NOISE!	Interference voltage above 10V, or unstable measurement result, or the measured voltages or currents are too low in relation to the noise.
noiS and ⚠ and long audio signal 🔊	Measured voltages or currents are too low in relation to the noise, or highly unstable measurement result. (The noiS symbol is displayed instead of the result).
oL and ⚠	Maximum allowed temperature inside the meter is exceeded.

3.2 Earth resistance measurement with the double-lead method

1

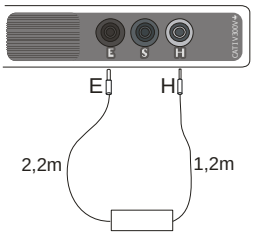


Turn on the meter.
Turn the rotary switch to the **R_E 2p** position.

2

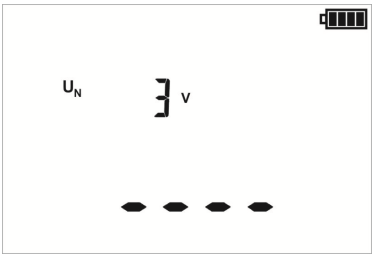
If necessary, adjust the voltage measurement according to section 2.

3



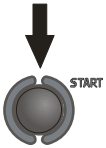
Connect the tested facility to the **E** and **H** terminals.

④



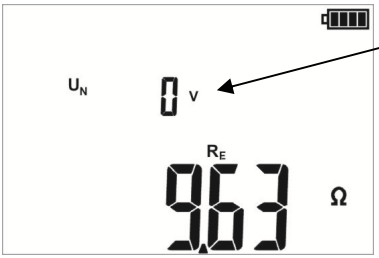
The meter is ready for measurement. Read the interference voltage on the auxiliary display.

⑤



Press **START**.
Perform the measurement.

⑥



Interference voltage.

Read the measurement result.

Measured resistance.

Note:

- Factory calibration includes the resistance of the 1.2 m and 2.2 m test leads (supplied).

Additional information displayed by the meter

U_N 30 V > 24 V and ⚠	Excessive interference voltage (> 24V). The measurement is not possible. Disconnect the source of interference.
U_N 10 V > 50 V and ⚠ and continuous audio signal 🔊	**Interference voltage exceeds 50V!** **Disconnect** the meter immediately! Disconnect the voltage source before you reconnect the meter.
U_N OFL > 50 V and ⚠ and continuous audio signal 🔊	**Interference voltage exceeds 100V!** **Disconnect** the meter immediately! (The OFL symbol is displayed instead of the interference voltage). Disconnect the voltage source before you reconnect the meter.

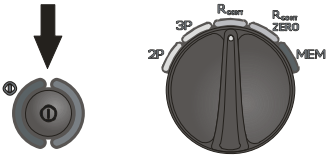
-r- and ⚠	Interruption in the test circuit.
>1,99kΩ	The R_E measuring range is exceeded.
NOISE!	Interference voltage above 10V, or unstable measurement result, or the measured voltages or currents are too low in relation to the noise.
noiS and ⚠ and long audio signal 🔊	Measured voltages or currents are too low in relation to the noise, or highly unstable measurement result. (The noiS symbol is displayed instead of the result).
oL and ⚠	Maximum allowed temperature inside the meter is exceeded.

3.3 Measurement of resistance of protective conductors and equipotential bonding

NOTE

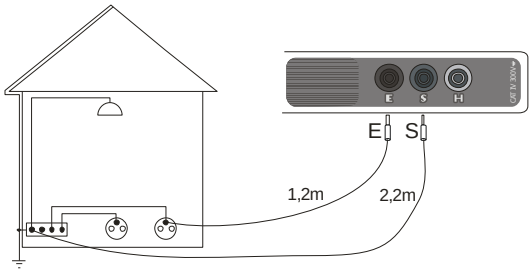
Calibrate the test leads when measuring very small resistance values or when using test leads different than the supplied 1.2 m and 2.2 m.

1



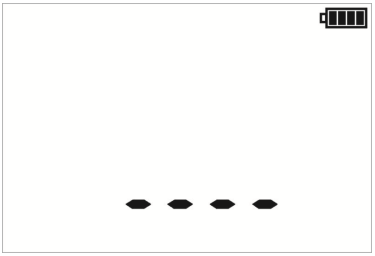
Turn on the meter.
Turn the rotary switch to the **R_{CONT}** position.

2



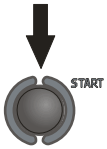
Connect the tested facility to the **S** and **E** terminals.

3



The meter is ready for measurement.

④



Press **START**.
Perform the measurement.

⑤

Read the measurement result.

Note:

- The test current flows in one direction. To obtain the result for both directions, switch the test leads and perform the measurement again, then calculate the arithmetic mean of both results.

Additional information displayed by the meter

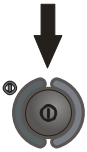
> 3 V and ⚠	Excessive interference voltage (> 3Vrms). The measurement is not possible. Disconnect the source of interference.
> 50 V and ⚠ and continuous audio signal 🔊	**Interference voltage exceeds 50V!** **Disconnect** the meter immediately! Disconnect the voltage source before you reconnect the meter.
> 199Ω	The R_{CONT} measuring range is exceeded.
NOISE!	1..3Vrms interference voltage during the R_{CONT} measurement. Measurement is slightly unstable. The results may include an additional uncertainty.
noi 5 and ⚠ and long audio signal 🔊	Measurement is highly unstable.
oL and ⚠	Maximum allowed temperature inside the meter is exceeded.

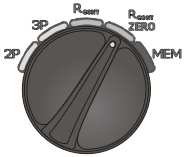
3.4 Calibration of test leads

In order to eliminate the impact of the resistance of test leads on the measurement result, the compensation (autozeroing) of resistance may be performed. This is made with the **AUTOZERO** function in the Rcont measurement.

3.4.1 Turning AUTOZERO on

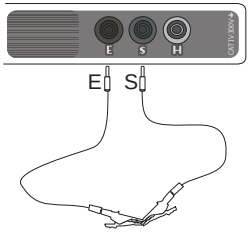
1





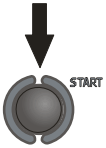
Turn on the meter.
Turn the rotary switch to the the **R_{CONT} ZERO** position.

2



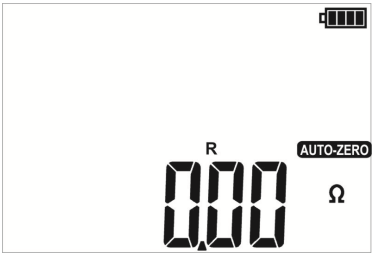
Short the test leads by putting crocodile clips on exposed ends of the test leads.

3



Press **START**.
Perform autozeroing.

4



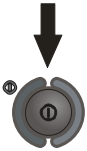
Autozeroing completed.

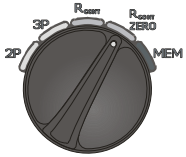
Note:

- Remember that the resistance of crocodile clips and crocodile-banana connections is added to the resistance of the test leads.

3.4.2 Turning AUTOZERO off

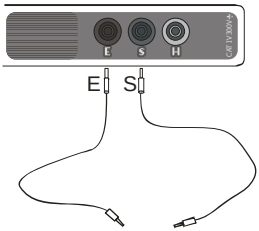
1





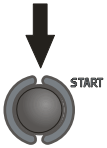
Turn on the meter.
Turn the rotary switch to the the **R_{CONT} ZERO** position.

2



Disconnect the test leads.

3



Press **START**.

4

Autozeroing is off.
During the measurements, the meter will compensate the resistance of the supplied 1.2 m and 2.2 m leads.

NOTE
It suffices when the compensation for given test leads is performed only once. It is remembered when the meter is turned off.

4 Memory

The MRU-21 meters feature memory that can store 990 single measurement results The whole memory is divided into 10 memory banks, with 99 cells in each bank. Each measurement result can be stored in a memory cell marked with a selected number and in a selected memory bank. Thanks to this, the user of the meter can, at his/her option, assign memory cell numbers to individual measurement points and the memory bank numbers to individual facilities. The user can also perform measurements in any sequence and repeat them without losing other data.

Memory of measurement result data **is not deleted** when the meter is switched off. Thanks to this, the data can be later read or sent to a computer. The number of a current memory cell or memory bank is not changed either.

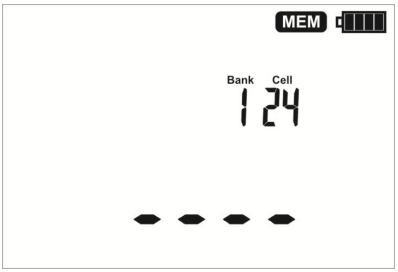
Note:

- One cell can contain the results of a single measurement.
- After each entry of the measurement result to the cell, its number is automatically incremented.
- It is recommended to delete the memory after reading the data or before performing a new series of measurements that may be stored into the same memory cells as the previous ones.

4.1 Storing the measurement result data in the memory

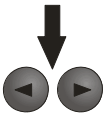
1

Press **ENTER** after completion of the measurement.
The meter is in the memory storing mode.



Cell is empty.

2

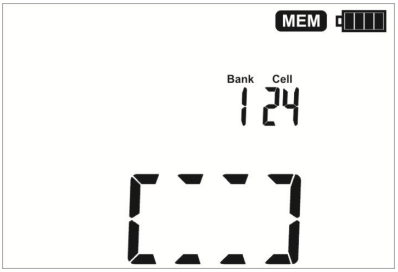


Use the ◄ and ► symbols to select the bank...

or use the ▲ and ▼ symbols to select the cell.

③

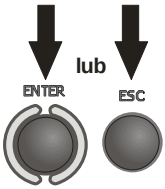
Press **ENTER** again. The screen (shown below) appears for a moment, accompanied by three short beeps, and then the meter returns to display the last result of the measurement.



④

An attempt to overwrite a result causes the warning symbol to appear.

⑤



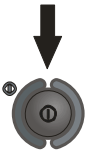
Press **ENTER** to overwrite the result or **ESC** to abort.

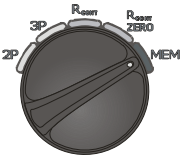
Note:

- Stored in the memory is a complete set of results (main result and supplementary results), as well as the test voltage for R_E.

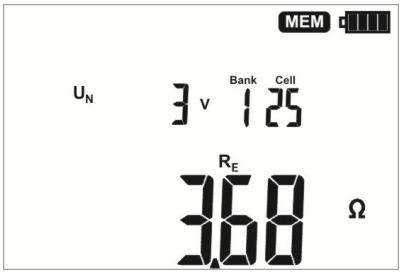
4.2 Viewing memory data

1



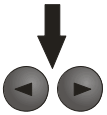


Turn on the meter. Turn the rotary switch to the **MEM** position.



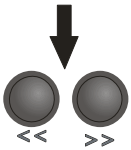
The content of the last saved cell appears.

2



Use the ◄ and ► symbols to select the bank...

or use the ▲ and ▼ symbols to select the cell.

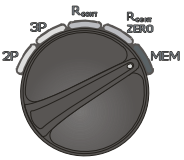


Press **<<** or **>>** to view additional results.

4.3 Deleting memory data

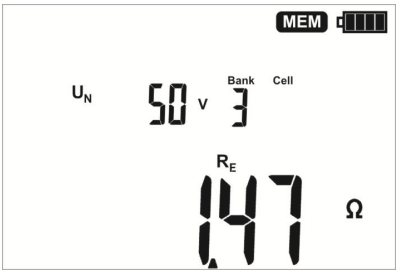
4.3.1 Deleting bank data

1

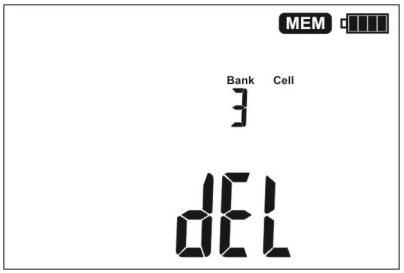


Turn on the meter. Turn the rotary switch to the the **MEM** position.

②



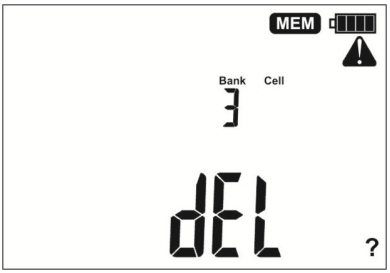
Set the bank number to be deleted.
Set the cell number before “1”...



...the cell number disappears, and appears the symbol dEL indicating the readiness to delete.

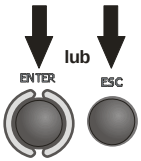
③

Press **ENTER** .

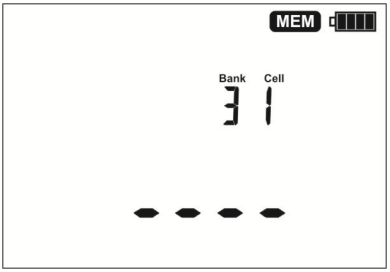


The “?” and ⚠ symbols appear, asking you to confirm deletion.

④



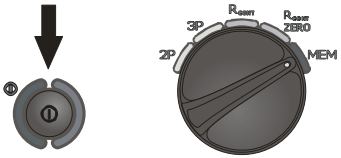
Press **ENTER** to start deleting or **ESC** to abort.



The deletion progress is shown on the display as dashes (each dash means 25%). When deletion is complete, the meter generates three short beeps and sets the cell number to "1".

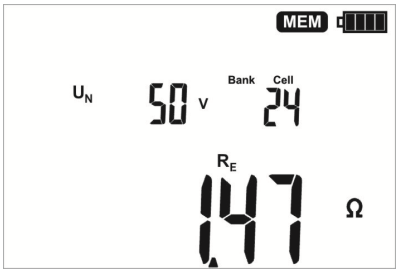
4.3.2 Deleting the whole memory

1

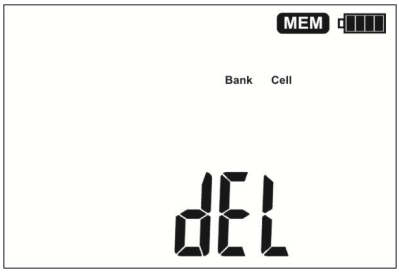


Turn on the meter. Turn the rotary switch to the **MEM** position.

2



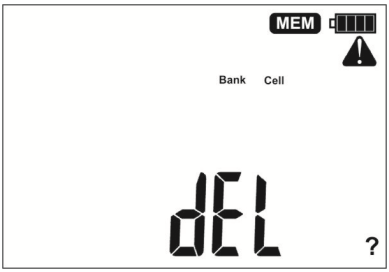
Set the bank number between “0” and “9”...



...the bank number disappears, and appears the symbol dEL, indicating the readiness to delete.

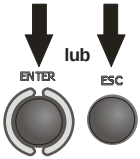
3

Press **ENTER** .



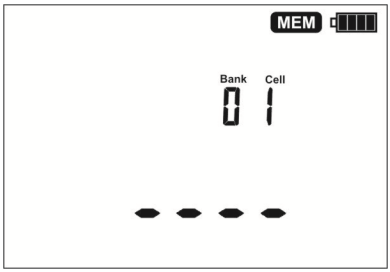
The “?” and ⚠ symbols appear, asking you to confirm deletion.

4



Press **ENTER** to start deleting or **ESC** to abort.

The deletion progress is shown on the display as dashes (each dash means 25%).



When deletion is complete, the meter generates three short beeps and sets the bank number to "0" and the cell number to "1".

4.4 Communication with a computer

4.4.1 Computer connection accessories

What is necessary in order to operate the meter with a computer is additional accessories, namely a cable for serial transmission and appropriate software. If this package has not been purchased along with the meter, it can be bought from the manufacturer or an authorized distributor where detailed software information is also available.

4.4.2 Data transmission

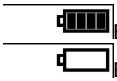
If the rotary switch is in the **MEM** position, after detecting the USB connection with a computer the meter automatically goes to the data transmission mode and displays the following screen.

To transmit data, follow the instructions of the software.

5 Meter power supply

5.1 Monitoring of the power supply voltage

The charge level of the batteries or rechargeable batteries is indicated by the symbol in the right upper corner of the display on a current basis:


Batteries charged

Batteries discharged

Replace or recharge the batteries!

Note:

- The bAt symbol on the display means insufficient power supply voltage and the need to replace or recharge the batteries.
- Measurements performed with an insufficient supply voltage feature additional errors which the user is unable to evaluate. Consequently, such measurements cannot prove that the tested earthing system is correct.

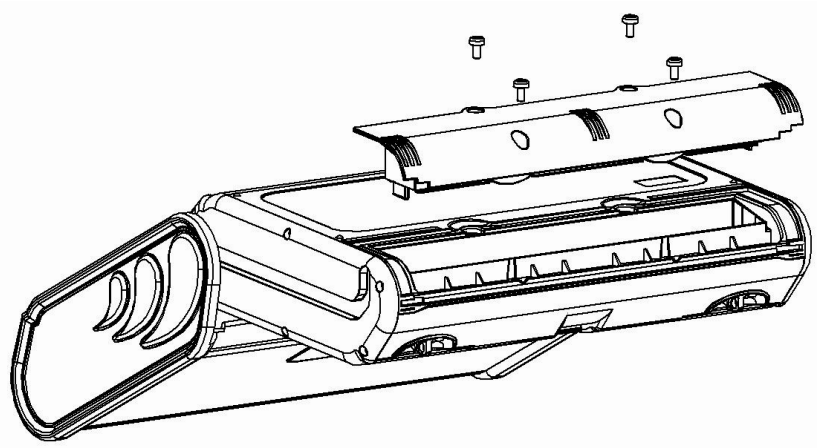
5.2 Replacement of batteries

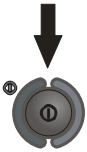
The MRU-21 is powered by four R14 disposable or rechargeable batteries (alkaline batteries are recommended). The disposable or rechargeable batteries are placed in the compartment at the bottom of the enclosure.

WARNING:
Before replacing the batteries, disconnect the test leads from the meter.

To replace the batteries:

- remove all test leads from the sockets and turn the meter off,
- remove the four screws of the battery compartment (in the lower part of the enclosure),
- remove the compartment and take off the lid (use a tool),
- remove and replace all batteries, observing the correct polarity when putting new batteries ("-" on the spring). Reverse polarity will not damage the meter or the batteries, but the meter will not work.
- put on the lid, place the compartment and secure it with 4 screws.



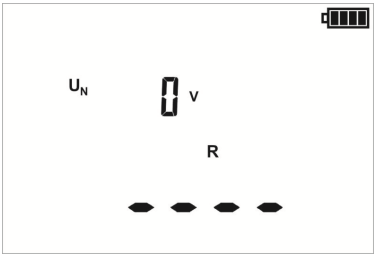


After replacement of batteries, the meter when turned on, starts in the power supply selection mode.

Selected power supply:
rechargeable batteries:

Use the ▲ and ▼ symbols to select the power supply: bAt (disposable batteries) or Acc (rechargeable batteries).

Press **ENTER** to validate the choice
The meter goes to the measurement readiness mode.



NOTE!
After replacing the batteries, always set the power supply type. The correct charge indication depends on this setting (the discharge characteristics of disposable and rechargeable batteries are different).

NOTE!
Have the meter serviced in case of battery leakage inside the compartment.

Batteries must be recharged in an external charger.

6 Cleaning and maintenance

NOTE!
Apply only maintenance methods specified by the manufacturerin this manual.

The casing of the meter and its case may be cleaned with a soft, damp cloth using all-purpose detergents. Do not use any solvents or cleaning agents which might scratch the casing (powders, pastes, etc.).

Clean the probes with water and dry it. Before the probes are stored for a prolonged period of time it is recommended to grease them with any machine lubricant.

The reels and test leads should be cleaned with water and detergents, and then dried.

The electronic system of the meter does not require maintenance.

7 Storage

The following recommendations must be observed to ensure proper storing of the device:

- Disconnect all the test leads from the meter.
- Clean the meter and all its accessories thoroughly.
- Wind the long test leads onto the reels.
- If the meter is to be stored for a prolonged period of time, the batteries must be removed from the device.
- in order to prevent total discharge of the rechargeable batteries during prolonged storage, charge them from time to time.

8 Dismantling and utilization

Worn-out electric and electronic equipment should be collected selectively, i.e. it must not be disposed with waste of another kind.

Worn-out electronic equipment should be sent to a collection point in accordance with regulations related to Waste Electrical and Electronic Equipment.

Before the equipment is sent to a collection point, do not attempt to dismantle any elements.

Observe the local regulations concerning disposal of packages, worn-out batteries and accumulators.

9 Technical specifications

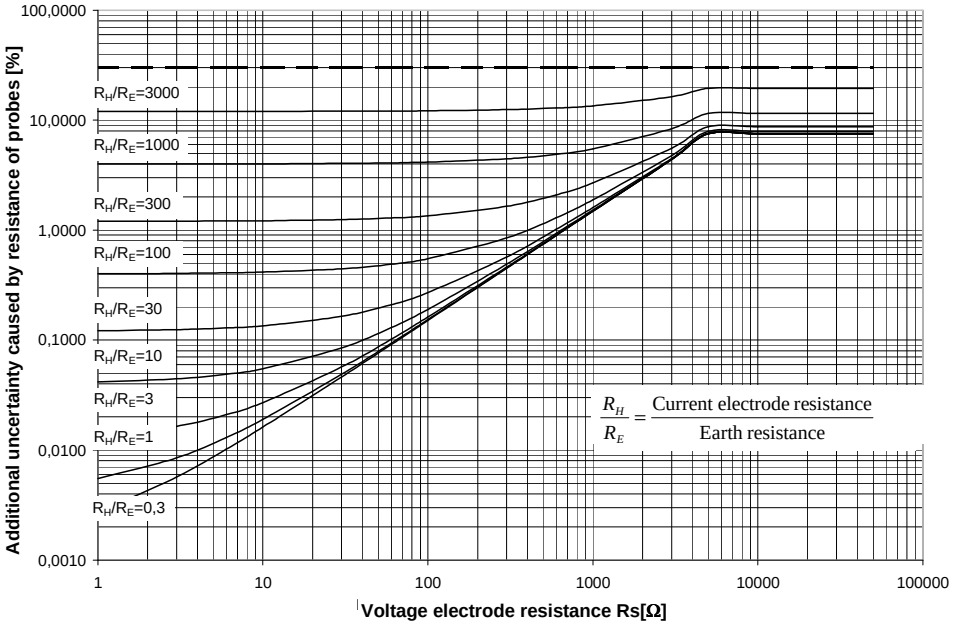
- The specified accuracy relates to the meter terminals.
- "m.v" means a standard measured value.

9.1 Basic data

Measurement of resistance to earth R_E
Measurement method: technical, conforming with IEC 61557-5.
Measuring range acc. to IEC 61557-5: 0.50Ω ... 1.99kΩ for U_n=50V
0.68Ω ... 1.99kΩ for U_n=25V

Display range	Resolution	Basic uncertainty
0.00...9.99Ω	0.01Ω	±(2% m.v. + 3 digits)
10.0...99.9Ω	0.1Ω	
100...999Ω	1Ω	
1.00...1.99kΩ	0.01kΩ	

- In the three-lead method, the meter displays the uncertainty caused by the probes resistance. Such uncertainty can be also evaluated using the following diagram:



Electrodes resistance and measurement uncertainty

Measurement of resistance of auxiliary earth electrodes R_H, R_S

Display range	Resolution	Measurement uncertainty
000...999Ω	1Ω	±(5% (R_S + R_E + R_H) + 3 digits)
1.00...9.99kΩ	0.01kΩ	
10.0...50.0kΩ	0.1kΩ	

Measurement of interference voltages
Internal resistance: about 100kΩ

Display range	Resolution	Measurement uncertainty
0...100V	1V	±(2% m.v. + 3 digits)

R_{CONT} measurement
Measurement method: technical
Measuring range according to IEC 61557-4: Ω

Display range	Resolution	Measurement uncertainty
0.00...9.99Ω	0.01Ω	±(2% m.v. + 3 digits)
10.0...99.9Ω	0.1Ω	
100...199Ω	1Ω	

Note: Guaranteed are only the values with tolerances or limits. Values without tolerances are for information only.

Other technical specification

a) type of insulation .....double, PN-EN 61010-1 and IEC 61557 compliant
b) measurement category.....IV 300V acc. to PN-EN 61010-1
c) degree of protection of enclosure acc. to PN-EN 60529 ..... IP54
d) maximum interference voltage for the R_E measurement 24V
e) maximum interference voltage for the R_{CONT} measurement 3V
f) maximum measured interference voltage 100V
g) R_E test current frequency..... 125 Hz
h) R_E test voltage.....25V or 50V
i) R_E test current 20mA
j) maximum resistance of test electrodes 50kΩ
k) R_{CONT} test current (with shorted terminals for $U_{BAT} \geq 6{,}0V$) 200mA
l) maximum voltage at open terminals for R_{CONT}..... 13V
m) meter power supply ..... R14 alkaline disposable or rechargeable batteries (4 pcs)
n) number of R_E measurements .....> 1000 (5Ω, 2 measurements per minute)
o) dimensions.....288 x 223 x 75 mm
p) weight with batteries..... about 1,4 kg
q) display..... LCD with backlight
r) operating temperature .....-10..+55°C
s) reference temperature.....+23 ± 2°C
t) storage temperature .....-20°C..+70°C
u) humidity.....20...80%
v) reference humidity.....40...60%
w) time to AUTO-OFF ..... 5 minutes
x) the product meets the EMC requirements acc. to PN-EN 61326-1:2006 and PN-EN 61326-2-2:2006
y) quality standard.....development, design and manufacturing are ISO 9001 compliant

9.2 Additional information

Data on additional uncertainties are useful mainly when the meter is used in non-standard conditions and for metrological laboratories for the purpose of calibration.

9.2.1 R_E measurement

9.2.1.1 Additional uncertainty caused by resistance of auxiliary earth electrodes:

0%	R_H and $R_S \le 100\Omega$
7.5%	($R_H \ge 5k\Omega$ or $R_S \ge 5k\Omega$) and $R_E \ge 500\Omega$
$\delta_{dod} = \pm\left(7{,}5 + \frac{R_H \cdot 0{,}004}{R_E} + 1{,}5 \cdot 10^{-8} \cdot R_H^2\right)$ [%]	$R_S \ge 5k\Omega$ and $R_E \le 500\Omega$
$\delta_{dod} = \pm\left(\frac{R_S}{100000 + R_S} \cdot 150 + \frac{R_H \cdot 0{,}004}{R_E} + 1{,}5 \cdot 10^{-8} \cdot R_H^2\right)$ [%]	remaining cases

The meter displays R_E, R_H and R_S in [Ω]. This uncertainty is calculated by the meter and displayed as **ER**.

9.2.1.2 Additional uncertainty caused by serial interference voltage

R_E	U_{wy}	Additional uncertainty [Ω]
0.00…9.99Ω	25V	$\pm(0.01R_E + 0.012)U_z \pm 0.007U_z^2$
	50V	$\pm(0.01R_E + 0.012)U_z \pm 0.003U_z^2$
10.0…99.9Ω	25V. 50V	$\pm(0.001R_E + 0.05)U_z \pm 0.001U_z^2$
100Ω…1.99kΩ		$\pm(0.001R_E + 0.5)U_z \pm 0.001U_z^2$

9.2.1.3 Additional uncertainty caused by ambient temperature

± 0.25 digit/℃ for Uwy = 50V, ± 0.33 digit/℃ for Uwy = 25V

9.2.1.4 Additional uncertainties according to IEC 61557-5

Working uncertainty or influencing factors	Reference conditions or operating range	Designation	Additional uncertainty
Position	Reference position ±90°	E_1	0
Power supply voltage	$U_{nom} \div U_{min}$	E_2	0
Storage temperature	0 ÷ 35℃	E_3	acc. to formula from 9.2.1.3
Serial interference voltage	3V	E_4	acc. to formula from 9.2.1.2
Resistance of probes and auxiliary earth electrodes	From 0 to 100R_E, but ≤ 50kΩ	E_5	acc. to formula from 9.2.1.1
Working uncertainty	$B = \pm\left(\lvert A \rvert + 1{,}15\sqrt{E_1^2 + E_2^2 + E_3^2 + E_4^2 + E_5^2}\right)$ where A = measurement uncertainty		

9.2.2 R_{CONT} measurement

9.2.2.1 Additional uncertainty caused by ambient temperature

±0.15%/℃

9.2.2.2 Additional uncertainties according to IEC 61557-4

Working uncertainty or influencing factors	Reference conditions or operating range	Designation	Additional uncertainty
Position	Reference position ±90°	E_1	0
Power supply voltage	$U_{nom} \div U_{min}$	E_2	0
Storage temperature	0 ÷ 35℃	E_3	±0.15%/℃
Working uncertainty	$B = \pm\left(\lvert A \rvert + 1{,}15\sqrt{E_1^2 + E_2^2 + E_3^2}\right)$ where A = measurement uncertainty		

10 Equipment

10.1 Standard equipment

Standard set of equipment supplied by the manufacturer includes:

- MRU-21 meter – **WMPLMRU21**,
- set of test leads:
  - 30m lead on the reel (red) with banana plugs – **WAPRZ030REBBSZ**,
  - 15m lead on the reel (blue) with banana plugs – **WAPRZ015BUBBSZ**,
  - 2.2m lead (black) with banana plugs– **WAPRZ2X2BLBB**,
  - 1.2m lead (blue) with banana plugs – **WAPRZ1X2BUBB**,
  - K01 crocodile clip, black – **WAKROBL20K01**,
  - K02 crocodile clip, blue – **WAKROBU20K02**,
- 30cm test probe (2 pcs.) – **WASONG30**,
- carrying case for the meter and accessories ,
- harness (2 pcs, long and short) -**WAPOZSZEKPL**,
- USB cable – **WAPRZUSB**,
- LR14 batteries, (4 pcs),
- SONEL CD,
- operating manual,
- warranty card,
- calibration certificate

10.2 Optional accessories

Additionally, the following items that are not included in the scope of standard equipment can be purchased from the manufacturer or the distributors:

WAPRZ025BUBBSZ

- *25m test lead (blue)*

WAPRZ050YEBBSZ

- *50m test lead*

WAZACIMA1

- *vise*

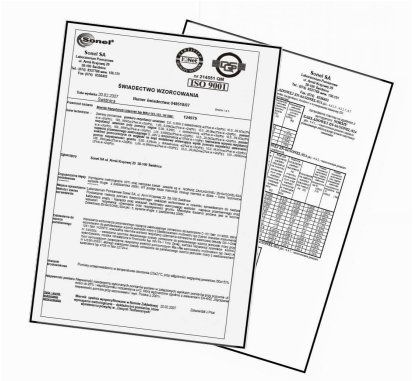
LSWPLMRU21

WASONG80

- *80cm test probe*

WAFUTL3

- *cover for the 80cm test probe*



- *calibration certificate*

11 Manufacturer

The manufacturer of the device and provider of warranty and post-warranty service:

SONEL S.A.
ul. Wokulskiego 11
58-100 Świdnica
Poland
tel. +48 74 858 38 60
fax +48 74 858 38 09
E-mail: export@sonel.pl
Web page: www.sonel.pl

NOTE
Service repairs must be performed solely by the manufacturer.