MI 3290
Earth Analyser

Earth testers

METREL®

Earth Analyser MI 3290

MI 3290 Earth Analyser is a portable, battery or mains powered test instrument with excellent IP protection (IP 54 open case), intended for measurement of earthing resistance, specific earth resistance and earth potential of various energetic and non-energetic objects.

The user can choose between different methods from classic 3 wire earthing resistance measurement up to one or four clamp method for measurement of pylons. He has a choice of measurement methods with different frequency methods: single frequency or frequency sweep from 55 Hz to 15 kHz, HF method with 25 kHz and pulse method simulating the lightning strike. High electrical noise immunity makes this instrument best suited for industrial environment.

MI 3290 Instrument versions

Earth Analyser MI 3290 is delieverd in 4 different sets.

A set is a selection of measurement functions and accessory

<table>
<tr><th>SET</th><th>MI 3290 GL
Grounding and lightning</th><th>MI 3290 GP
Grounding of pylons</th><th>MI 3290 GF
Grounding and voltage funnel</th><th>MI 3290 GX
all functions</th></tr>
<tr><td>MEASUREMENT FUNCTIONS</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2/3/4 pole</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Specific earth res. Venner/Schlumberger</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>3pole + iron clamp</td><td>✓</td><td></td><td></td><td>✓</td></tr>
<tr><td>stakeless, 2 iron clamp</td><td>✓</td><td></td><td></td><td>✓</td></tr>
<tr><td>High freq. 25 kHz</td><td>✓</td><td></td><td></td><td>✓</td></tr>
<tr><td>Pulse</td><td>✓</td><td></td><td></td><td>✓</td></tr>
<tr><td>RMS Current with iron clamp</td><td>✓</td><td></td><td></td><td>✓</td></tr>
<tr><td>1 - 4 flex clamp active</td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>1 - 4 flex clamp passive</td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>RMS Current with flex clamp</td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Step & Contact</td><td></td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>Earth potential</td><td></td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>Milohm meter7/200 mA DC</td><td></td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>Impedance meter AC</td><td></td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>ACCESSORY</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Licence key - different FW set, same SW set</td><td>GL</td><td>GP</td><td>GF</td><td>GX</td></tr>
<tr><td>TEST LEAD COAXIAL 75M ON REEL + G CLAMP</td><td colspan="3">✓</td><td>✓</td></tr>
<tr><td>3 x TEST LEAD 50M ON CABLE REEL</td><td colspan="3">✓</td><td>✓</td></tr>
<tr><td>2 x TEST LEAD 5M</td><td colspan="3">✓</td><td>✓</td></tr>
<tr><td>PROFESSIONAL EARTH SPIKES 2 x 50cm + 2 x 90 cm</td><td colspan="3">✓</td><td>✓</td></tr>
<tr><td>2 x Current clamp</td><td>✓</td><td></td><td></td><td>✓</td></tr>
<tr><td>FLEXIBLE CURRENT CLAMP 50A 5M</td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Step Contact Meter Set with plates</td><td></td><td></td><td>✓</td><td>✓</td></tr>
</table>

MI 3290 Lockout specification

1**. Multifunctional earth analyser:** A measurement instrument with unique selection of different earthing measurement methods:

- all classic earthing resistance test methods,
- selective methods with one iron clamp or up to four flex clamps simultaneously,
- two clamp (stakeless) method
- with test frequencies up to 25 kHz and frequency sweep
- impulse method,
- Wenner and Schlumberger method,
- potential, step and touch voltage measurements,
- autocheck and other support functions.

2. The only instrument which supports the balancing procedure for the selective methods.

3. HF method is a vectorised measurement

4. A modern user interface

- manipulation with buttons and/or touch screen
- lifelong storage capacity
- multilevel structured memory organisation and predefined tests and autosequences
- user accounts

MI 3290 Measurements

Earthing resistance measurements

- Earthing resistance 2,3,4-pole
- Selective earthing resistance (1x Iron clamp)
- Earthing resistance of multi-leg pylons with up to 4 flex clamps
- Earthing resistance (2x iron clamps)
- HF-Earthing resistance (25 kHz, acc. to IEEE_Std 81)
- Passive Flex clamp

MI 3290 Measurements

Earthing resistance measurements

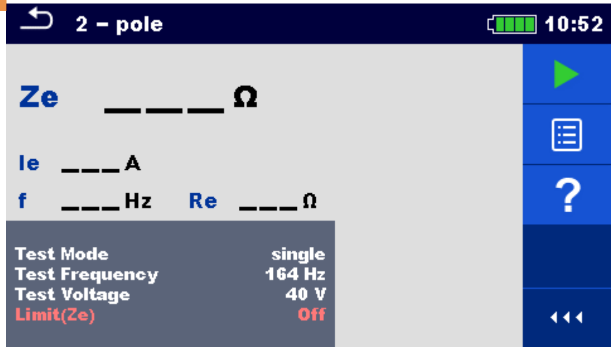
Clasic, well known 2, 3 and 4 pole earthing resistance measurements based on FoP (Fall of Potential) methode.

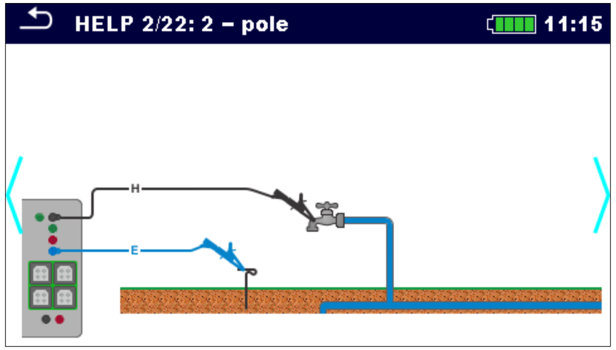
Standard test sscreens

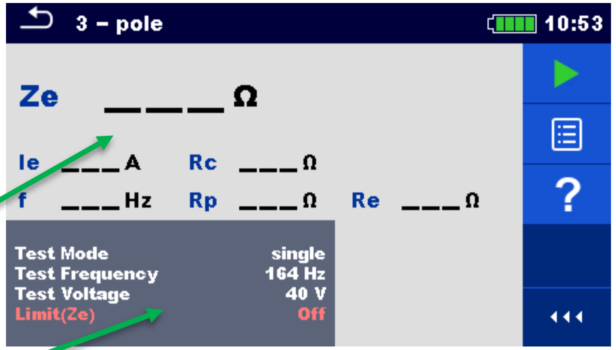
with results field,

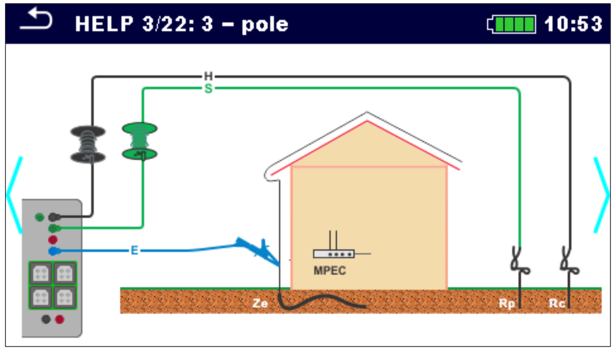
parameters field and

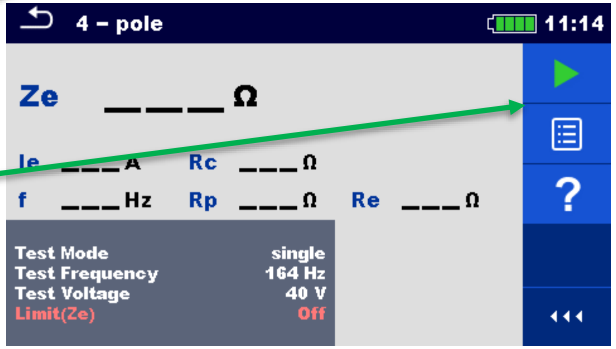
control panel.

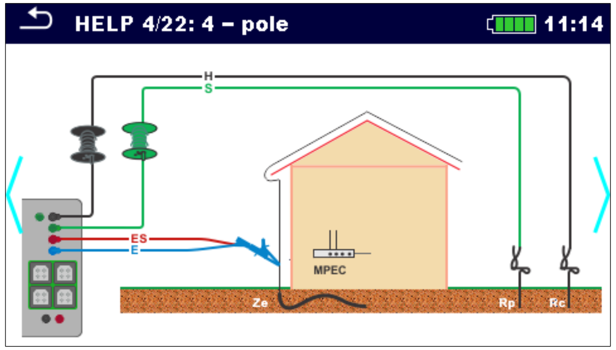








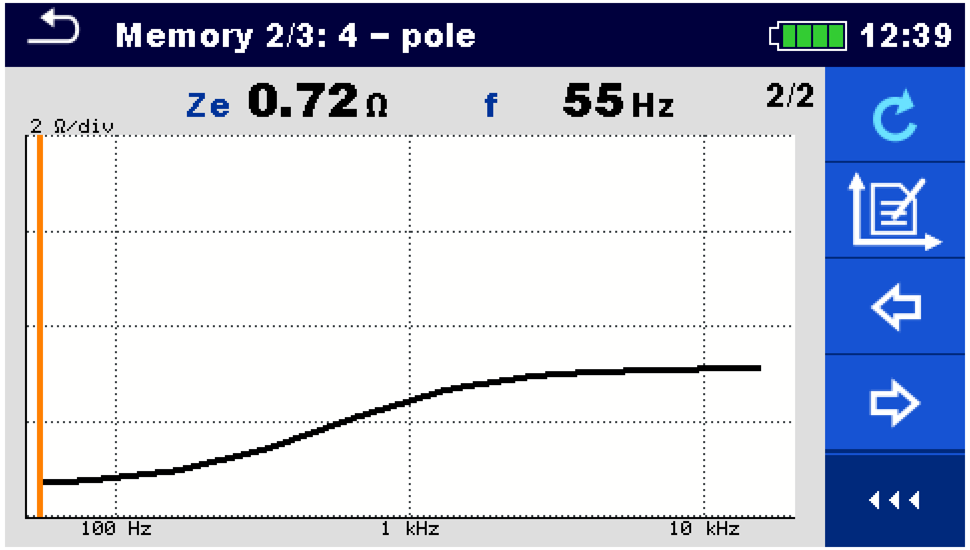


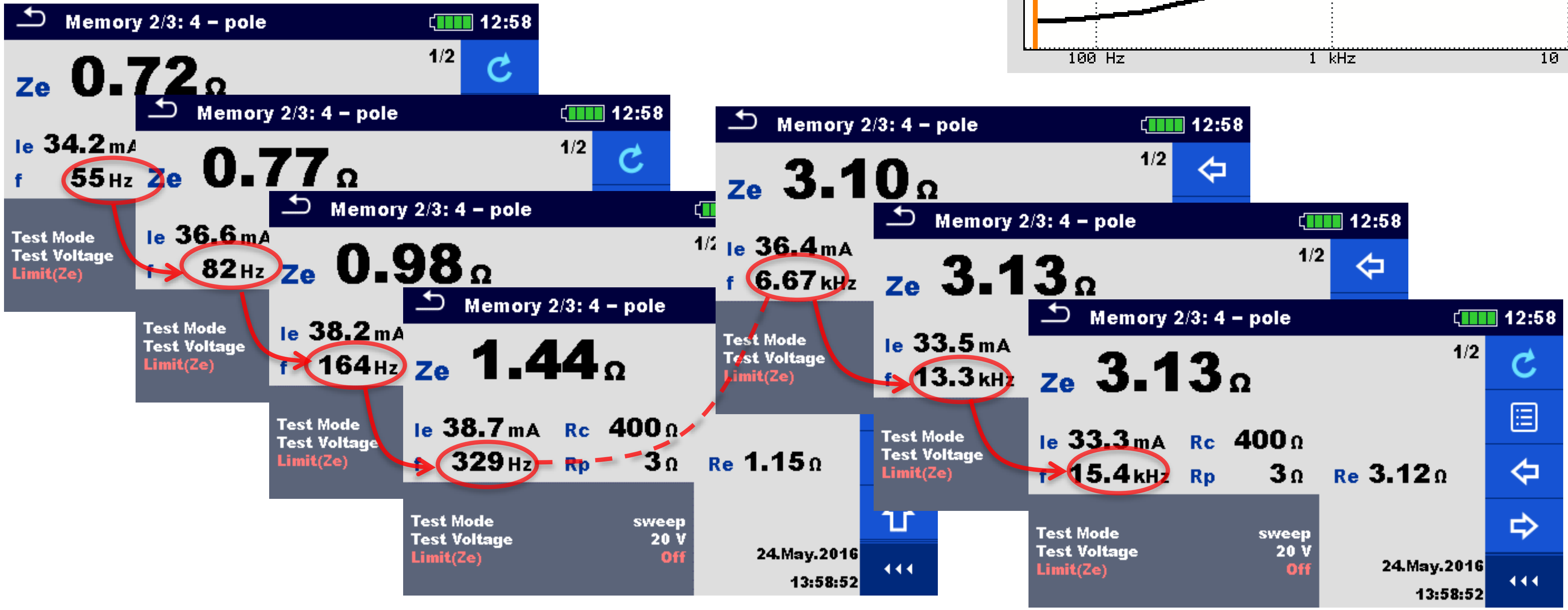


MI 3290 Measurements

Fixed frequency or frequency sweep

If Swep test mode is selected then results can be viewed in numerical or graphical mode





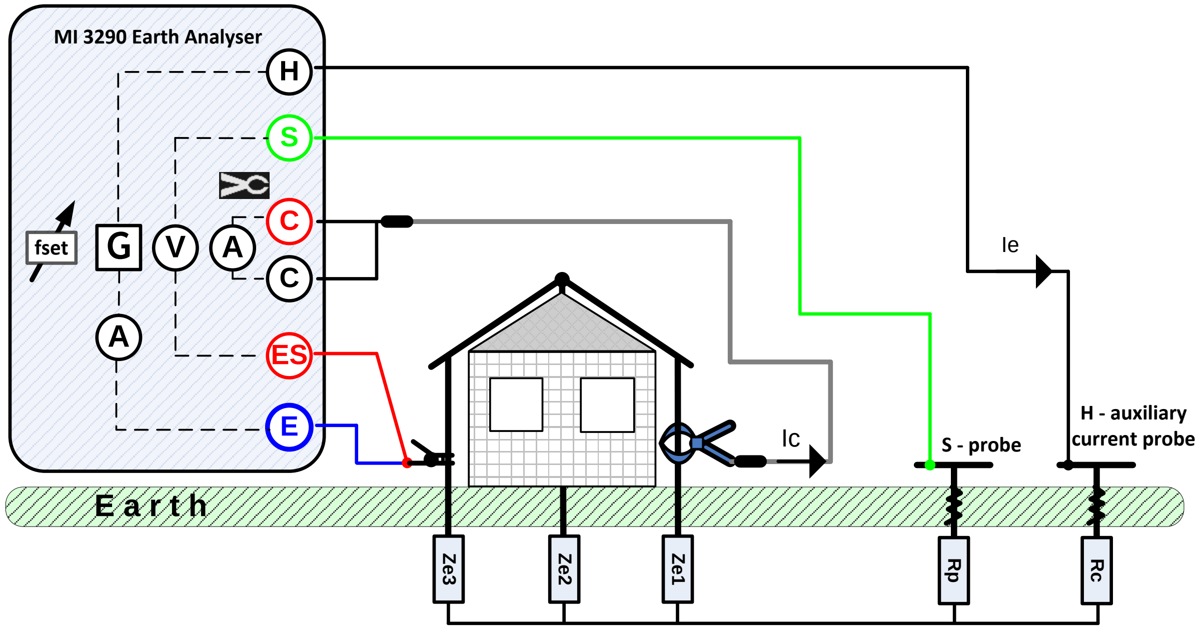
MI 3290 Measurements

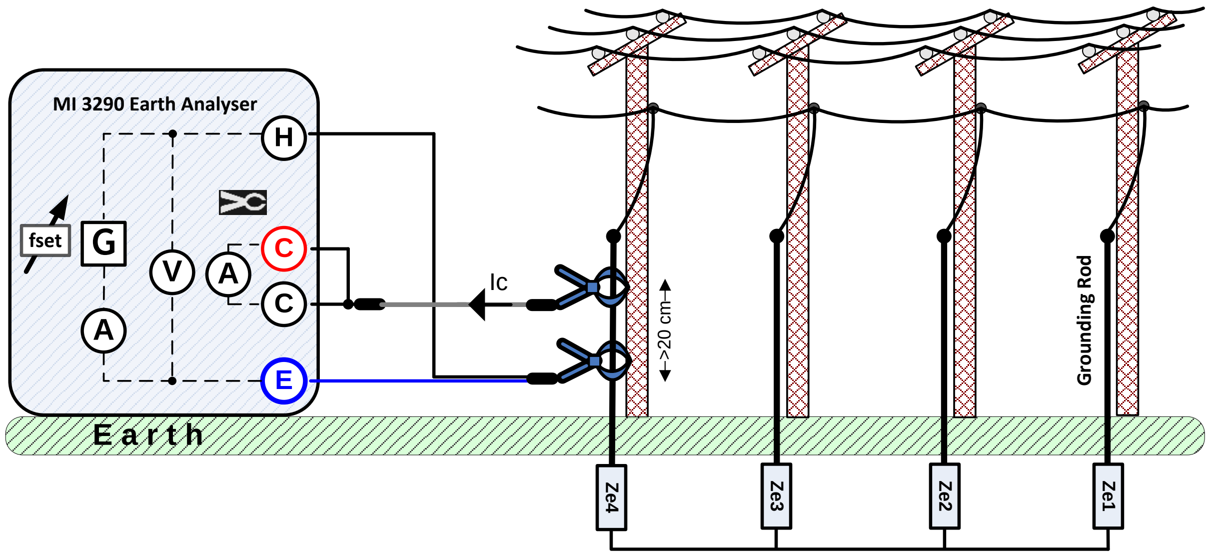
Earthing resistance measurements

- Selective earthing resistance (1x Iron clamp)
- Earthing resistance (2x iron clamps) – stakeless method

The measuring method needs a closed loop to be able to generate the test currents. It is especially suitable for use in urban areas because there is no need to place the test probes.

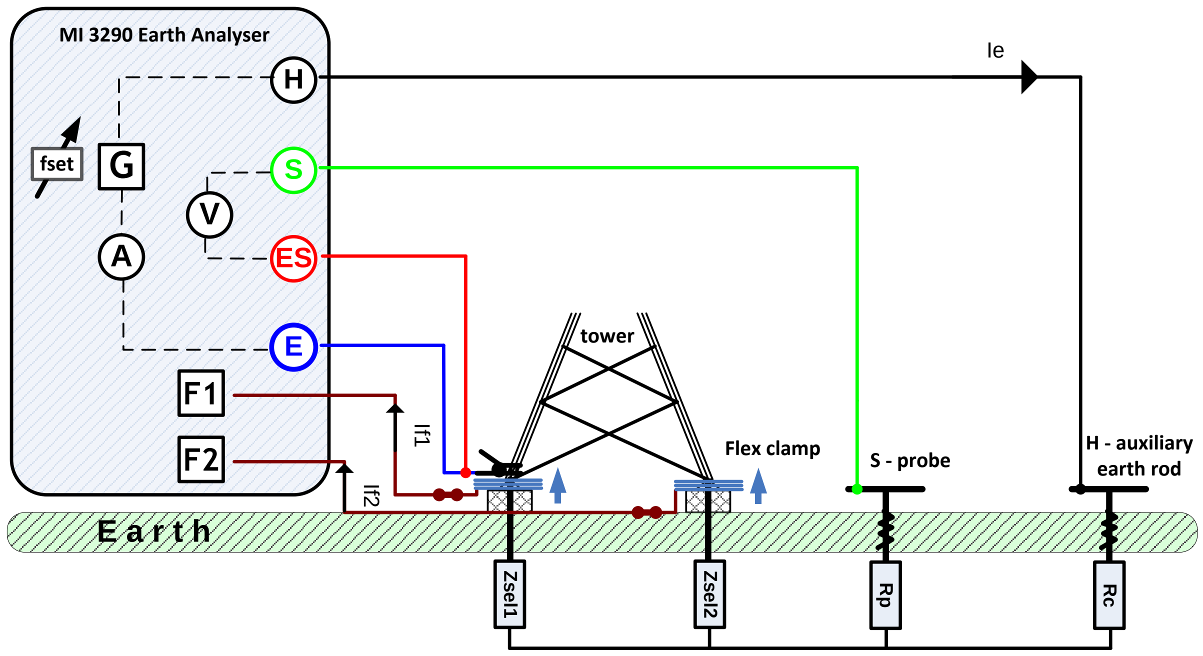
Basically this method returns the value of the loop resistance, not the earthing resistance of the tested rod. But in most cases this value is very close to it.





MI 3290 Measurements

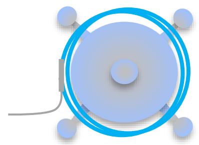
Earthing resistance measurements



Earthing resistance of mono or multi-leg pylons with overhead grounding wire (OHGW) with up to 4 flex clamps :

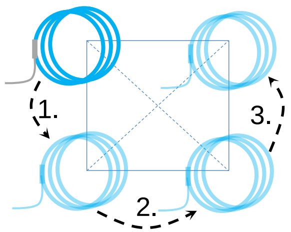
- Active or passive method
  Passive method does not need the H probe
- Different connection possibilities:

Mono tower



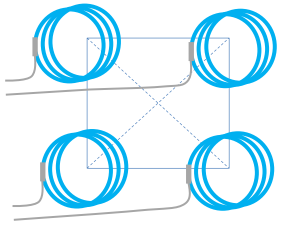
1 flex,
1 measurement
Circumference = 5m or 10m

4 leg tower



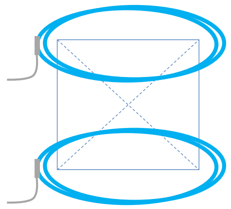
1 flex,
4 measurements
Circumference = 5m

4 leg tower



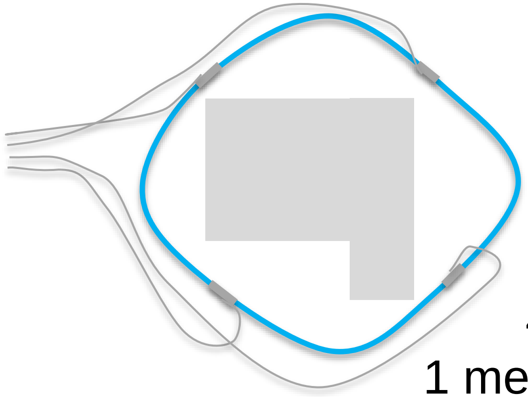
4 flex,
1 measurement
Circumference = 5m

4 leg tower



2 flex,
1 measurement
Circumference = 5m or 10m

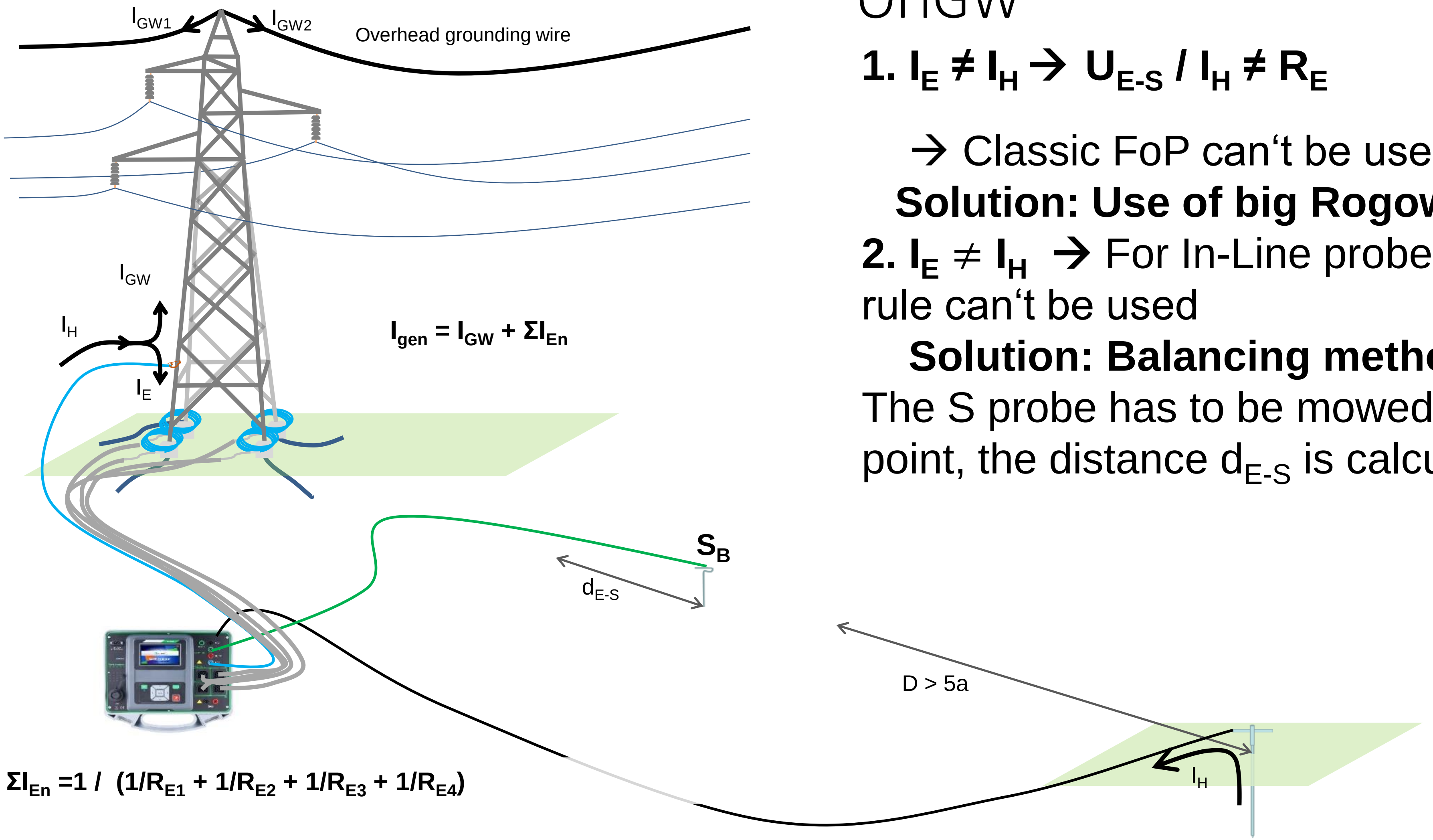
Larger object



4 flex,
1 measurement
Circumference = 4 x 5m = 20m

Balancing method

Earthing resistance measurements



$R_E = U_{E-S} / \Sigma I_{En} = 1 / (1/R_{E1} + 1/R_{E2} + 1/R_{E3} + 1/R_{E4})$

Problem: remote grounding over the OHGW

1. $I_E \neq I_H \rightarrow U_{E-S} / I_H \neq R_E$

→ Classic FoP can‘t be used.

Solution: Use of big Rogowsky coil

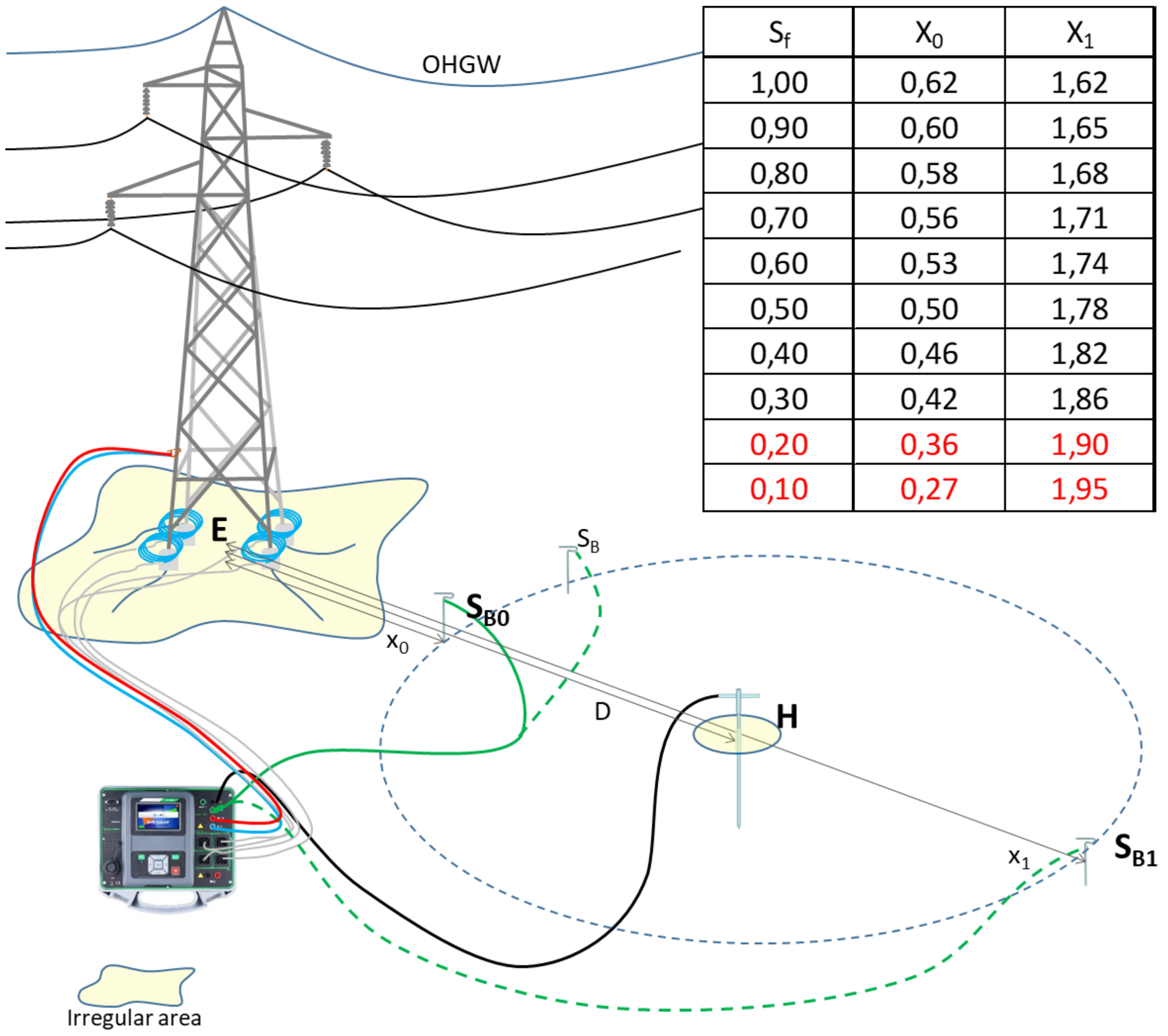
2. $I_E \neq I_H$ → For In-Line probe set-up the 62% rule can‘t be used

Solution: Balancing method

The S probe has to be mowed towards the E point, the distance d_{E-S} is calculated by MI 3290

Balancing method

Earthing resistance measurements



S_f	X_0	X_1
1,00	0,62	1,62
0,90	0,60	1,65
0,80	0,58	1,68
0,70	0,56	1,71
0,60	0,53	1,74
0,50	0,50	1,78
0,40	0,46	1,82
0,30	0,42	1,86
0,20	0,36	1,90
0,10	0,27	1,95

Determination of the balanced position of the S probe for in-line probe set-up:

1. After selecting the 4 Flex measurement the user has to enter the E – H distance and then starts the balancing procedure
2. The instrument measures the currents and then calculates the split factor and distances to S_{B1} and S_{B2} probe
3. User puts the S probe to SB1 or SB2 position and starts the measurement

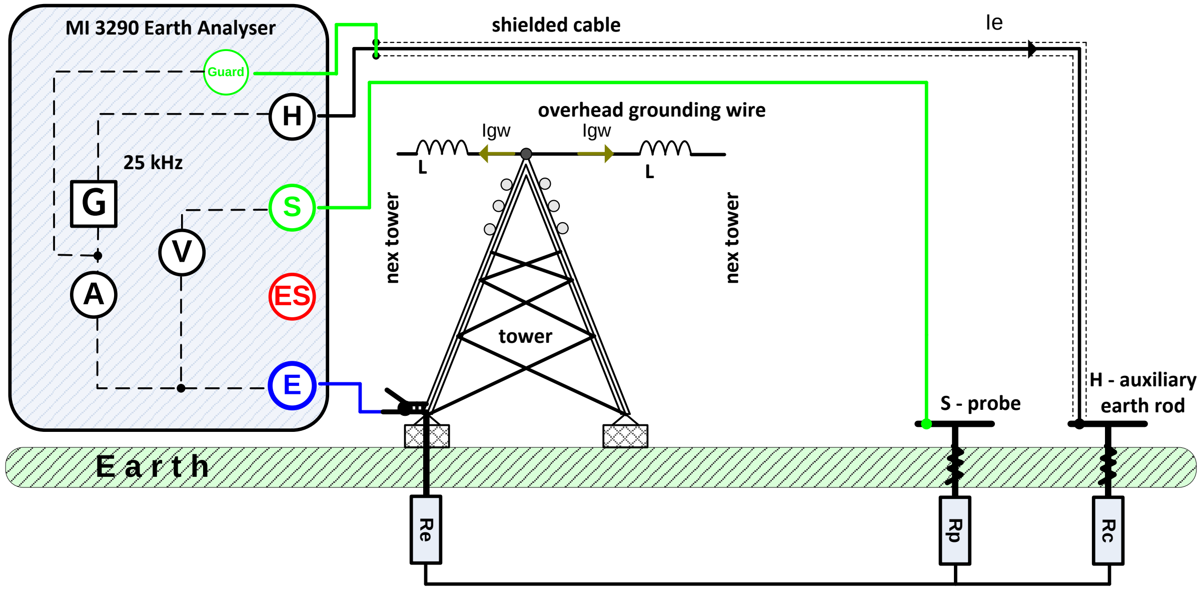
MI 3290 Measurements

Earthing resistance measurements

- **High frquency (25 kHz) method**

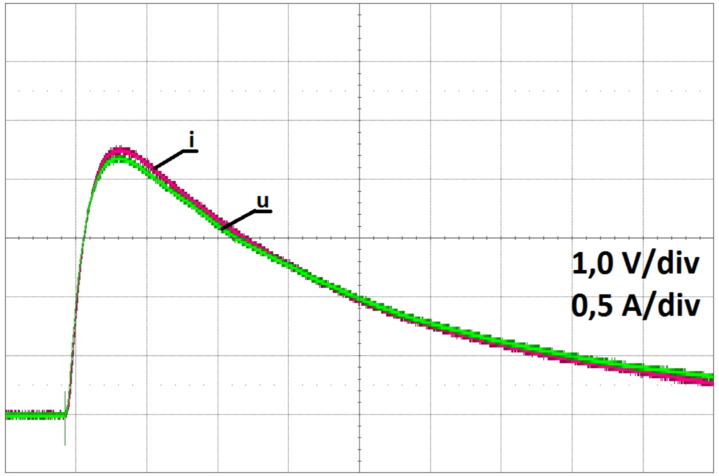
  $I_{gw}(25\ kHz) << I_{Re}$ → $I_e = I_{Re}$

  → clasic 3 pole methode can be used



- **Pulse method**

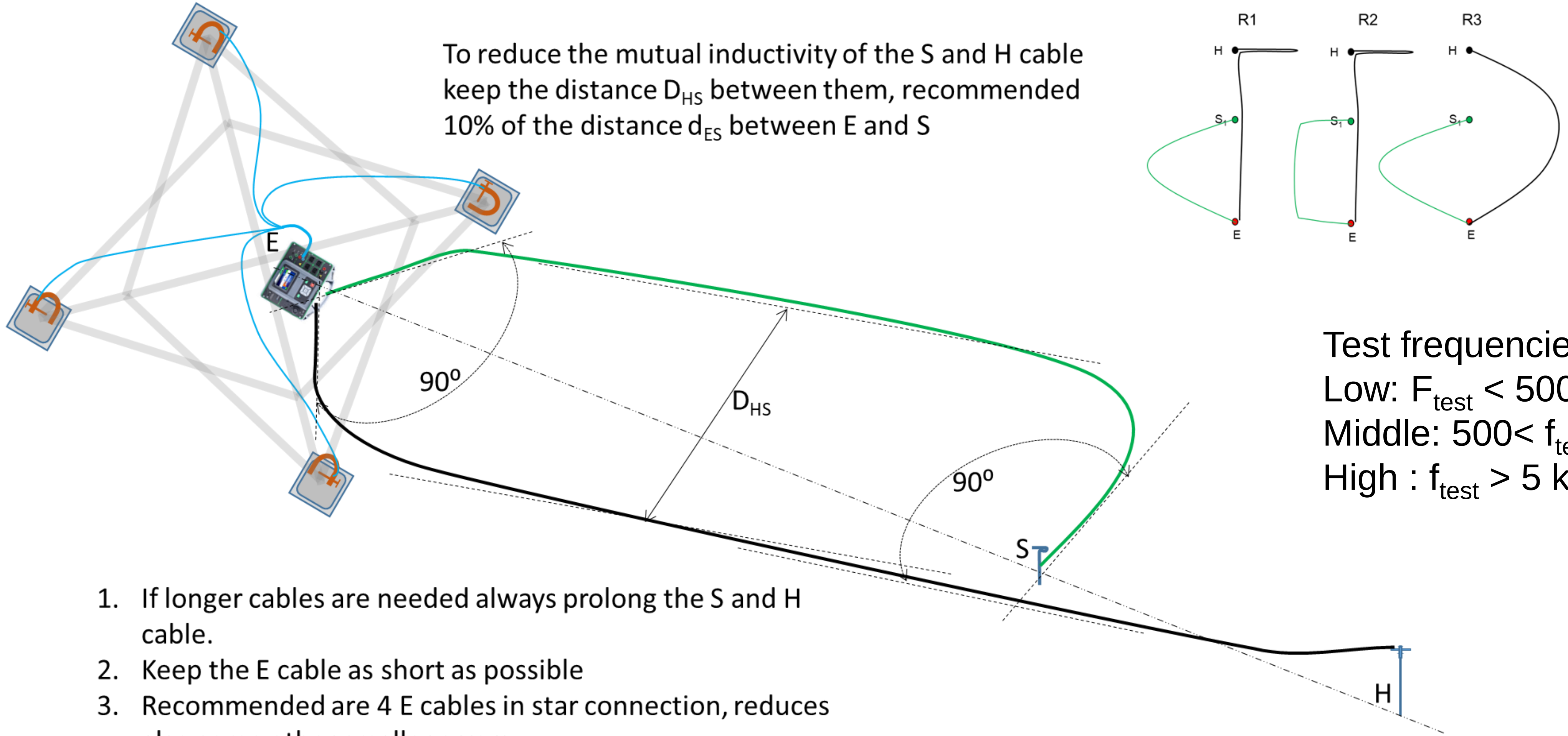
  Impulse 10/350µs: a typicall shape of the lightning strike



This are two further methodes for measuring the pylons with OHGW

Cable positioning when using higher test frequencies

To reduce the mutual inductivity of the S and H cable keep the distance D_{HS} between them, recommended 10% of the distance d_{ES} between E and S



Test frequencies
Low: F_{test} < 500 Hz
Middle: 500< f_{test} <5 kHz
High : f_{test} > 5 kHz

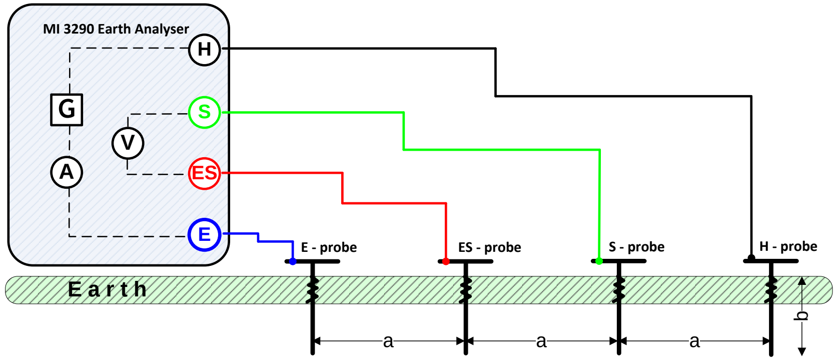
1. If longer cables are needed always prolong the S and H cable.
2. Keep the E cable as short as possible
3. Recommended are 4 E cables in star connection, reduces also some other smaller errors
4. Use G-clamps to reach the minimum contact resistivity
5. Take care that the E and S cable are not to close together

MI 3290 Measurements

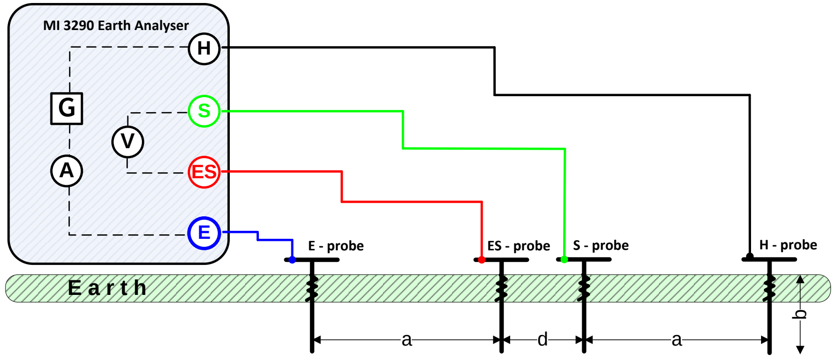
Specific earth resistance measurements

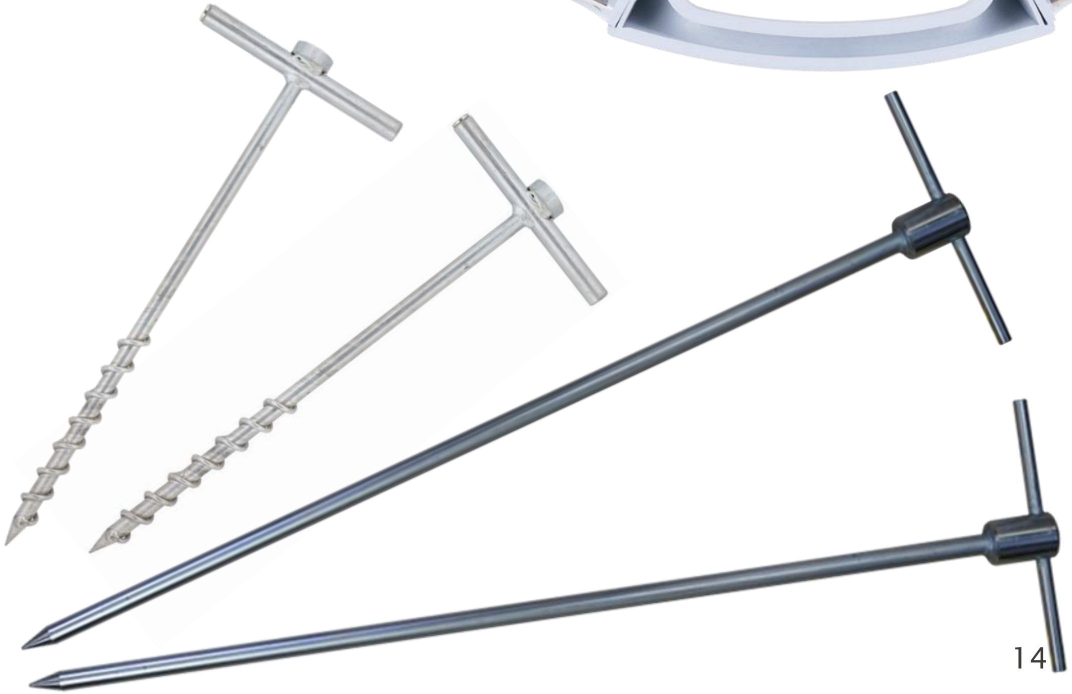
Supported methods:

- Wenner: a = a = a



- Schlumberger: a ≠ d ≠ a

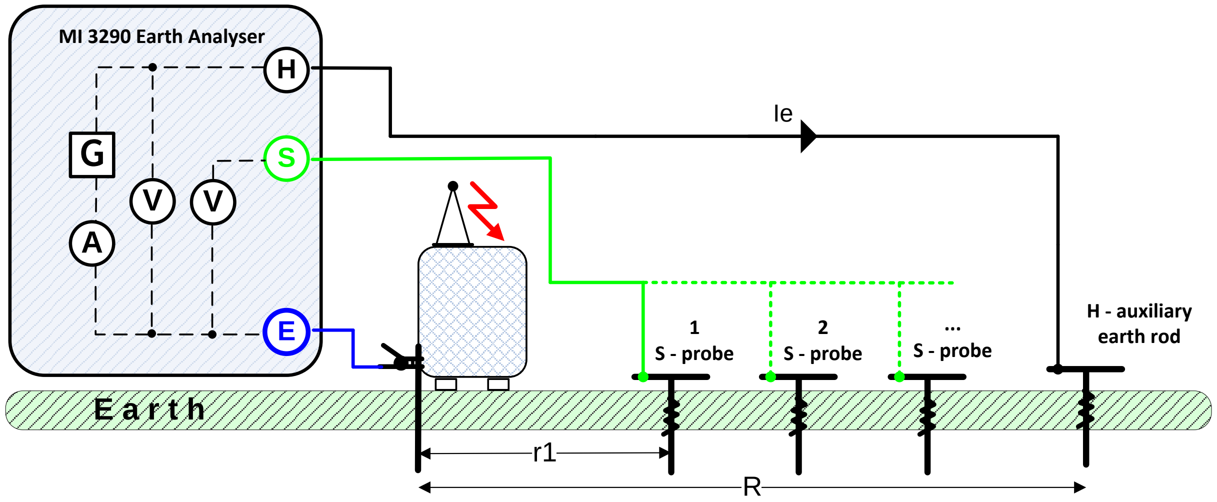




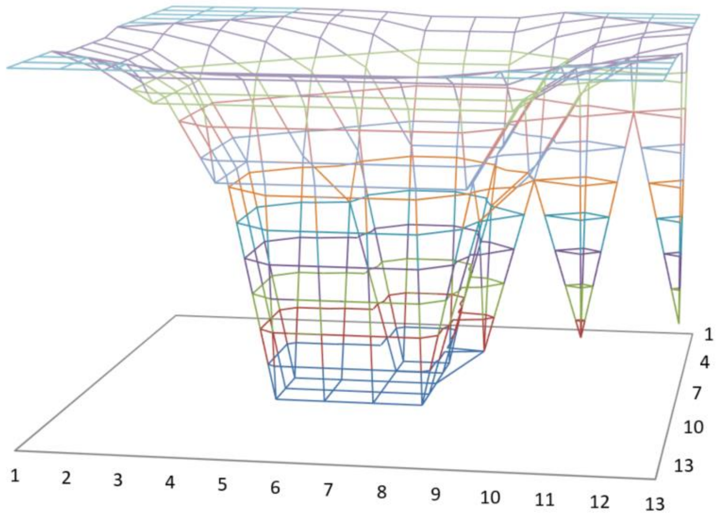
MI 3290 Measurements

Earth potential measurements

The earthing resistance (R_e) is not concentrated in one point but is distributed around the electrode.
In case of fault (lightening strike or short circuit to ground) the voltage drop on R_e is distributed around the grounded object.



A typical voltage distribution occurs around the electrode (the "voltage funnel").



MI 3290 Measurements

Step and contact voltage measurements

Step Voltage

The measurement is performed between two ground points at a distance of 1 m.

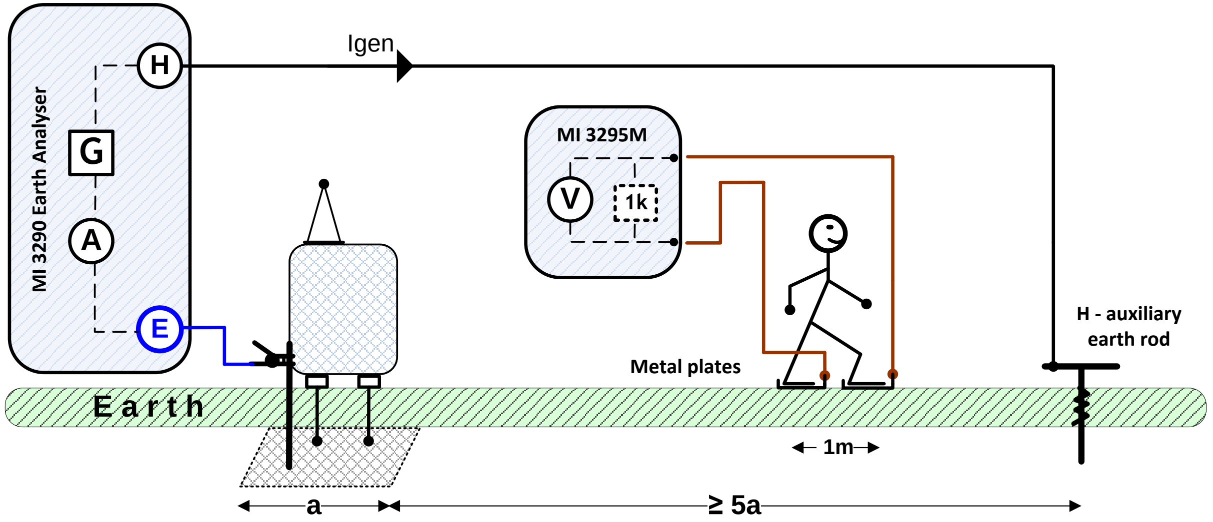
The voltage is measured with a voltmeter (MI 3295M) with an internal resistance of 1kΩ that simulates the body resistance

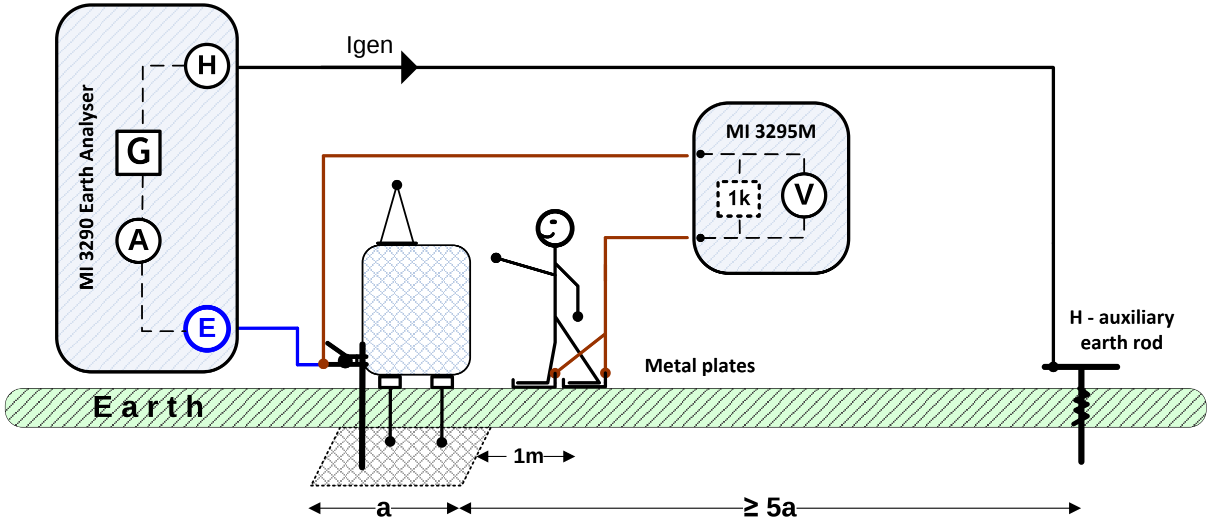
Touch Voltage

The measurement is performed between an earthed accessible metal part and ground 1 m apart.

The measured voltages are up scaled according to following equation:

$$U_{s,t} = U_m(\text{MI 3295M}) \cdot \frac{I_{fault}}{I_{gen}(\text{MI 3290})}$$

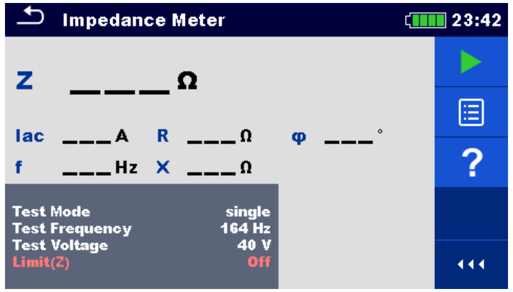


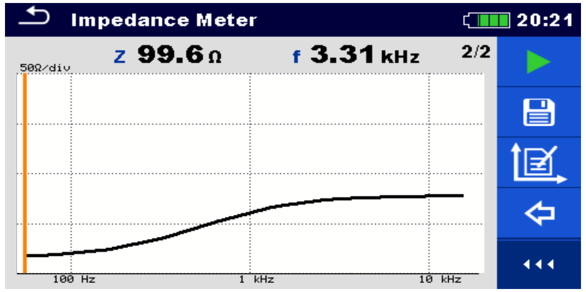


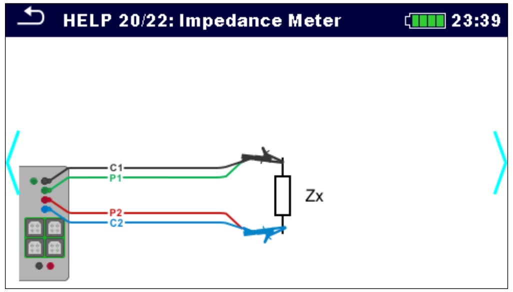
MI 3290 Measurements

Impedance measurement (AC)

Test method: single or sweep
Measurement range: 0 … 20 kΩ





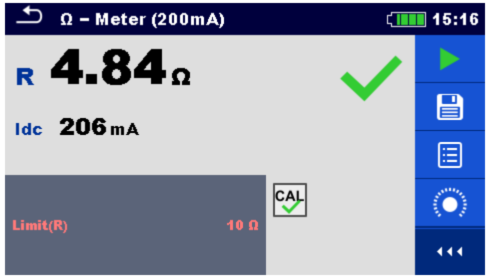


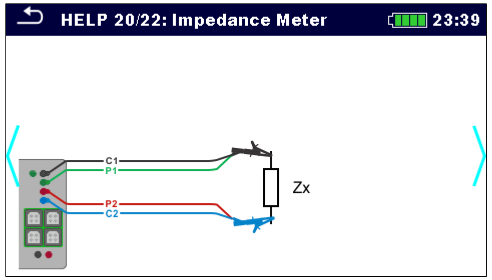
Resistance measurement (200 mA DC)

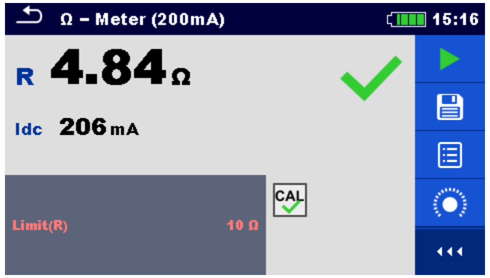
Test method: unidirectional
Measurement range: 0 … 2 kΩ

Resistance measurement (7mA DC)

Test method: unidirectional
Measurement range: 0 … 2 kΩ



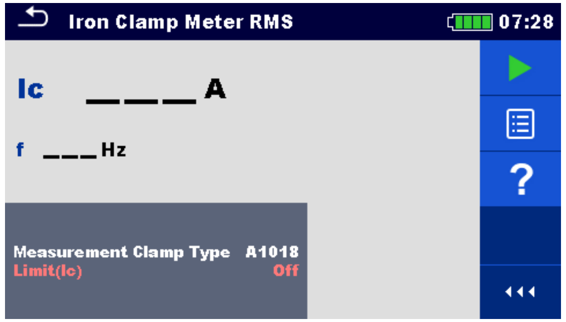


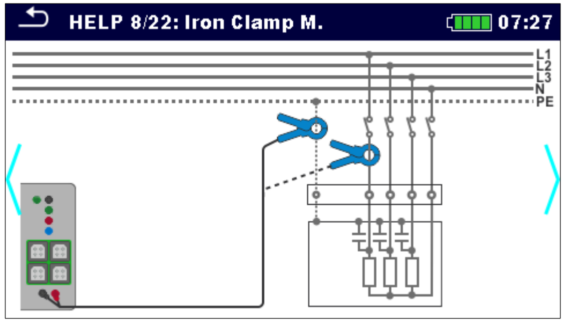


MI 3290 Measurements

Current measurement (Iron clamp)

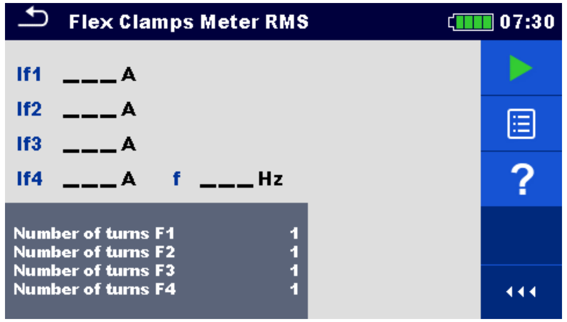
Test method: single or sweep
Measurement range: 1 mA … 8 A

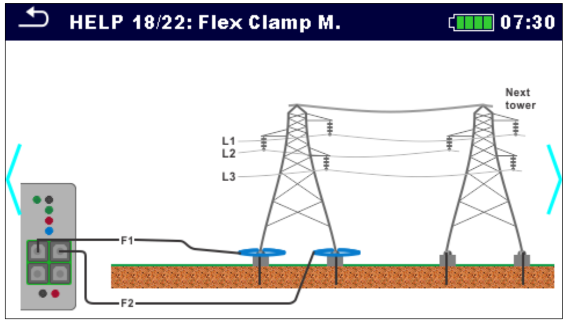




Current measurement (Flex clamp)

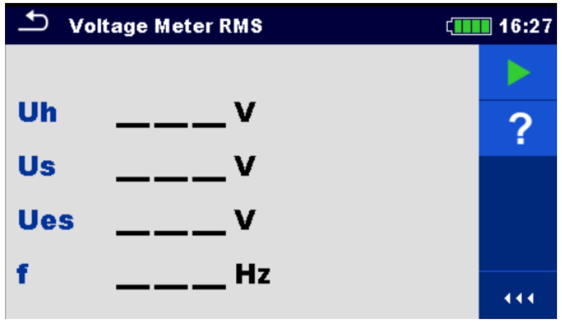
Test method: continuous
Measurement range: 10 mA … 50 A





Voltage measurement

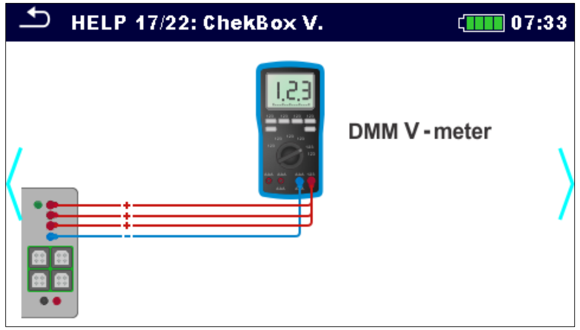
For measurement of voltage noise on H, S, ES to E connection terminals.

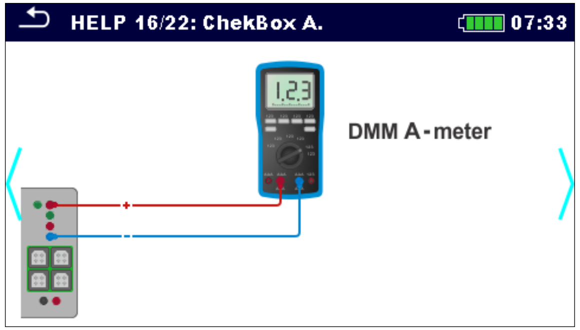


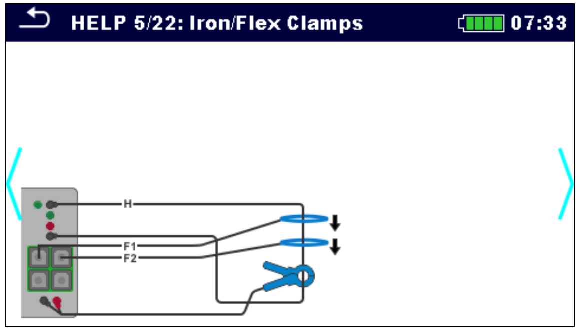
MI 3290 Measurements

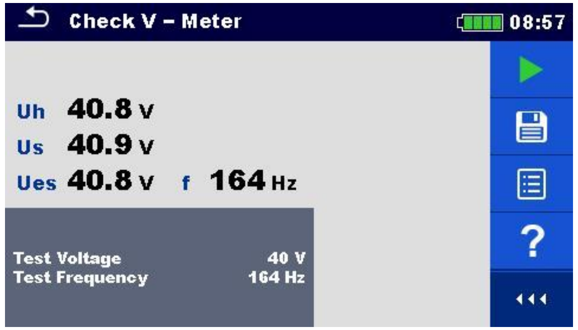
Checkbox

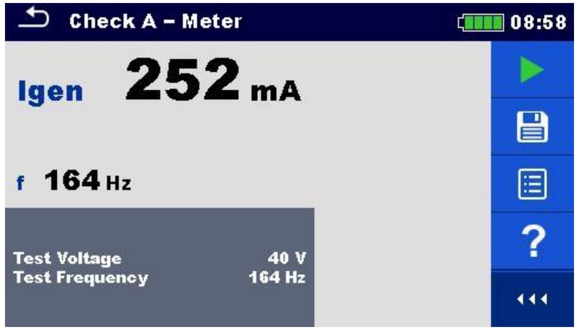
The Checkbox feature should be used to ensure that the meter is reading correctly between calibrations but should not be regarded as a substitute for a full manufacturer’s calibration on the unit.







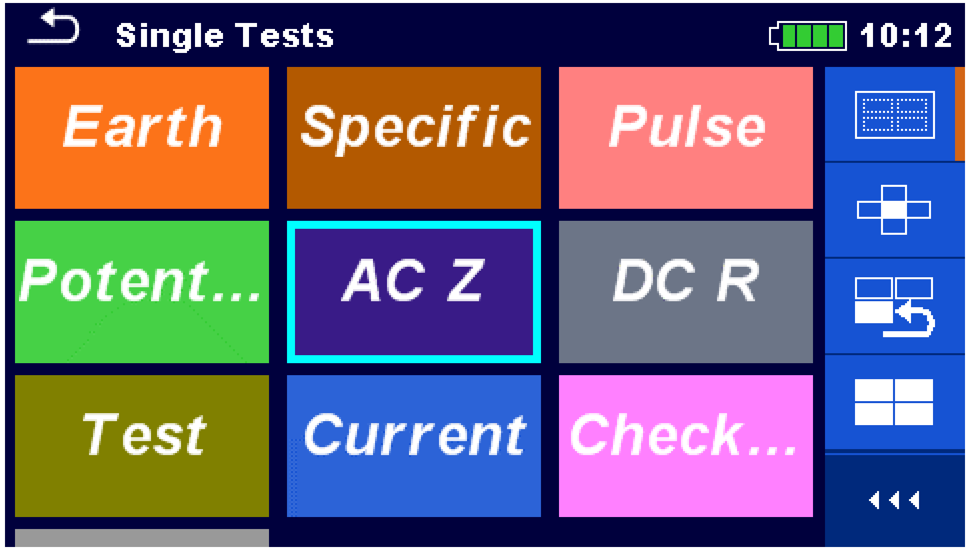


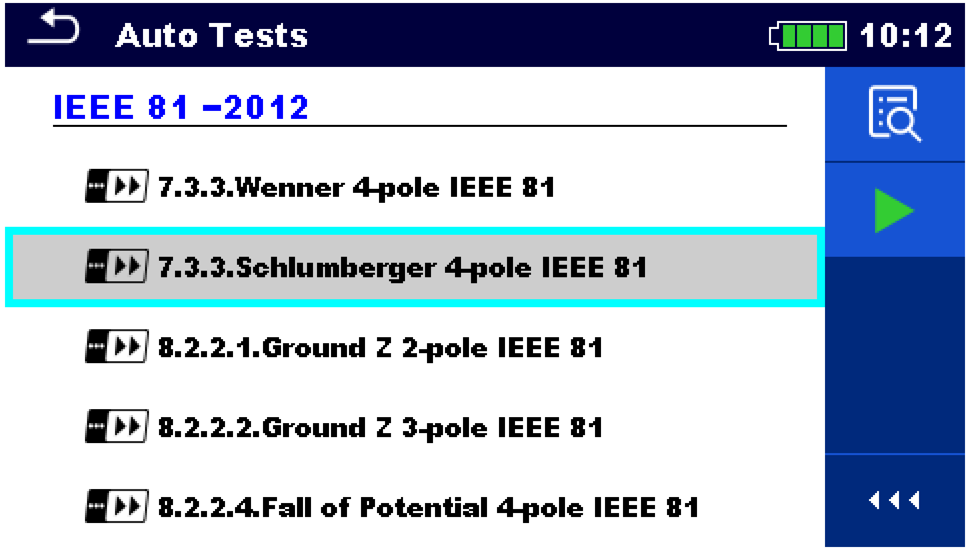


MI 3290 Single tests and Auto tests

User can perform single tests one after other. But if sequence is always the same, he can put that sequence of single test into one auto test and additionally equip with comprehensive instructions which can contain text and pictures.

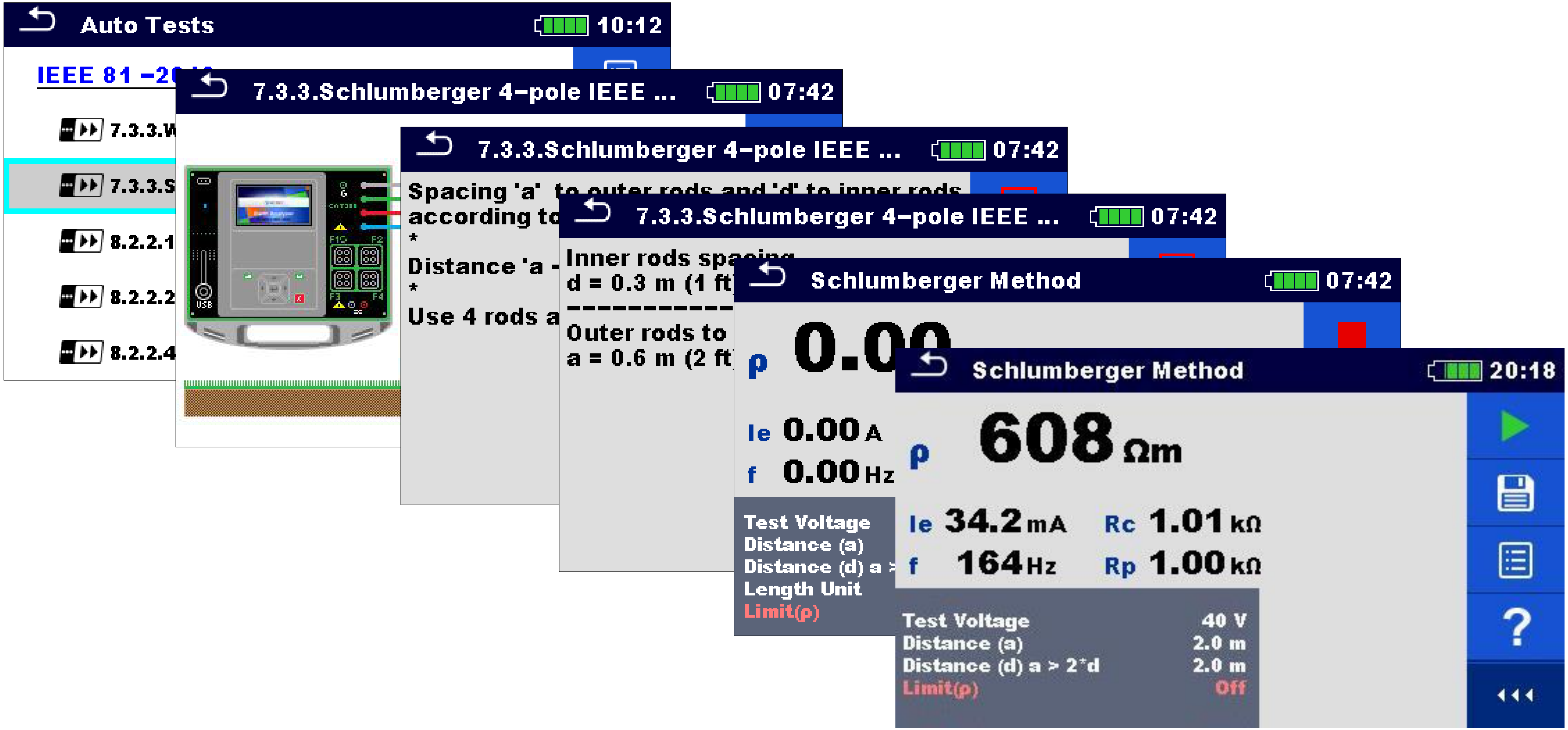
Auto tests can be defined and edited with the help of PC SW Metrel ES Manager (MESM).





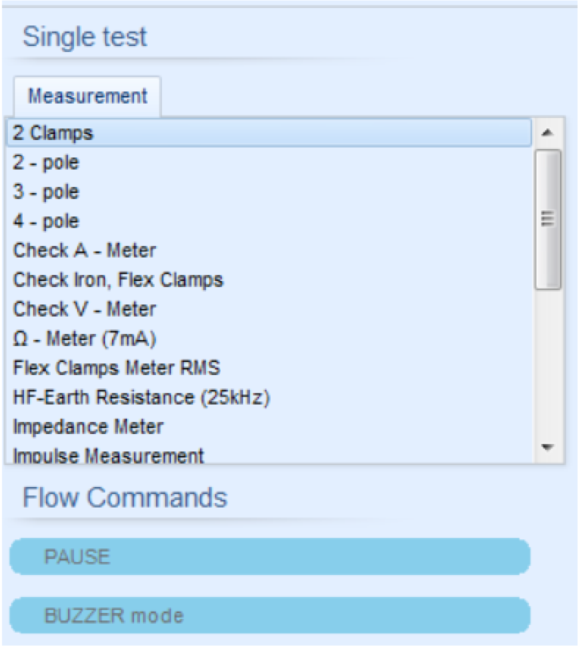
MI 3290 Single tests and Auto tests

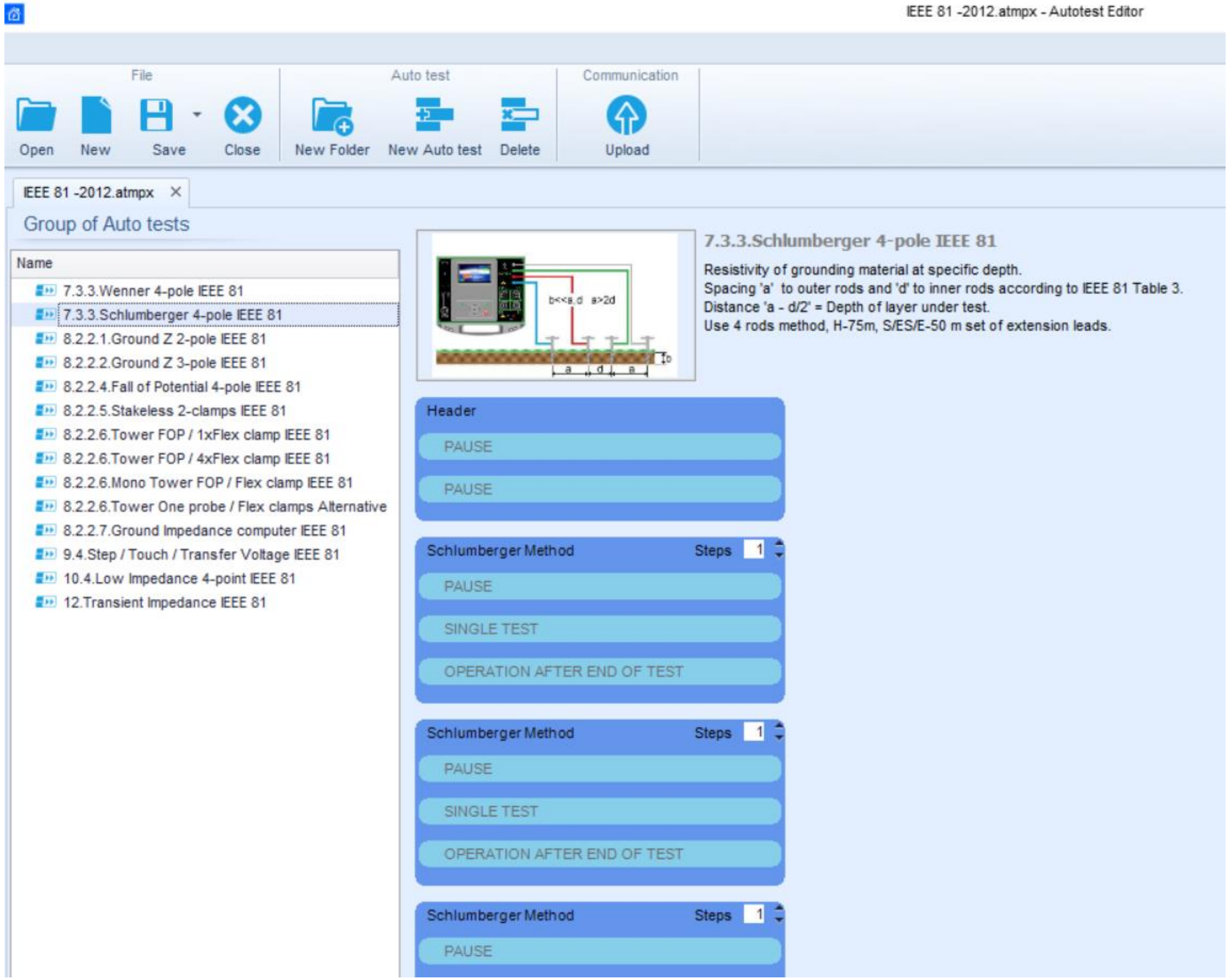
A typical auto test flow:



MI 3290 Single tests and Auto tests

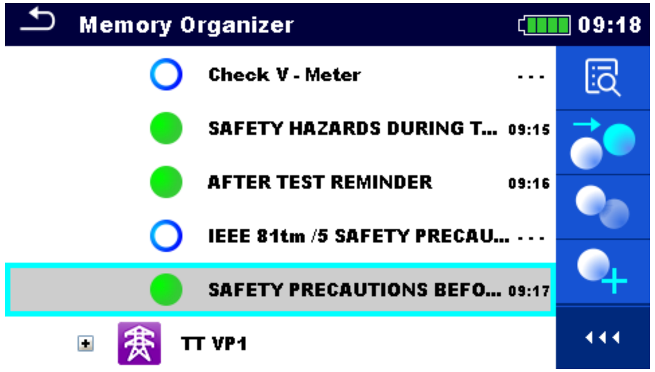
Auto test is a sequence of flow commands and single tests:

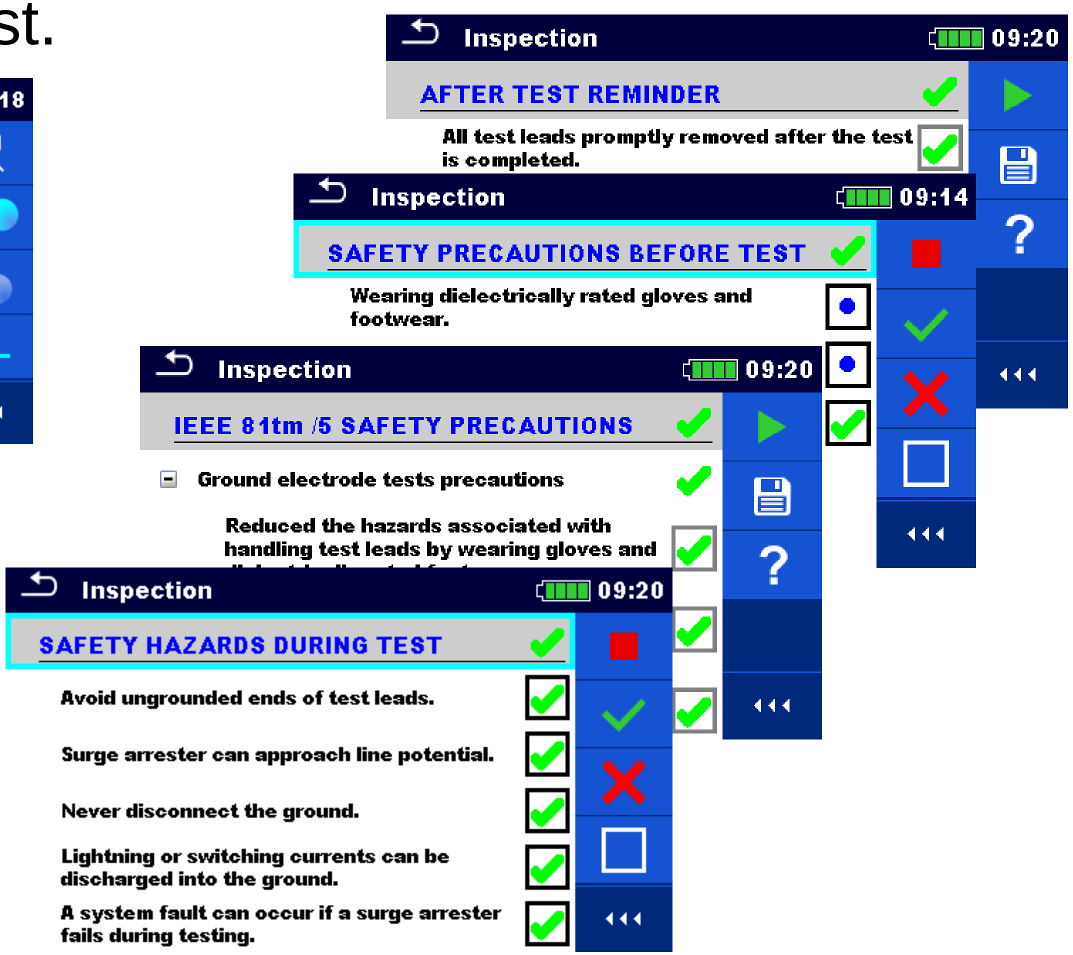




MI 3290 Visual inspection

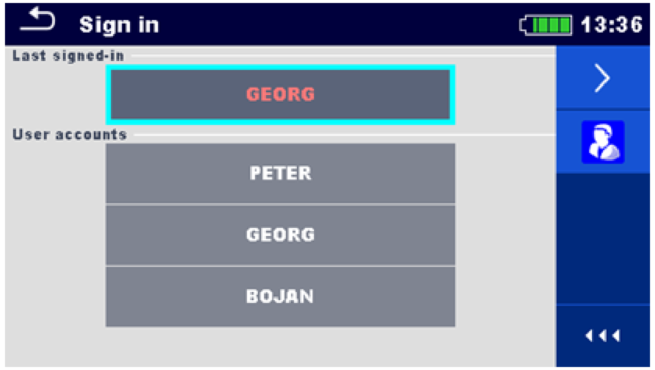
Visual inspections are added to enable the tester to put into protokol all the needed safety activities before and after test.





User accounts

To prevent unauthorized work with the instrument and to have an evidence who has performed specific test.



Earthing resistance measurement methods

There are different measurement methods for measurement of earthing resistance

The methods are changing dependant on the available technology.

Which method is selected depends on the type of the tested object, its size and the surrounding conditions.

Methods are described in different standards like EN 50522-2011 or IEEE 81-2012

Earth resistance measurements

Today‘s standard method for measuring the earthing (grounding) resistance $\mathbf{R_E}$ is the Fall of Potential (FoP) method with a test signal of a specific frequency which is different from the operating frequency of the energetic system.

The resulted ground potential rise (GPR) as a consequence of the test signal is then measured with a sensitive and selective voltmeters.

The advantages of such method are:

- Les power is needed for the test signal – instruments can be battery powered
- The whole test equipment is lightweight and therefore portable

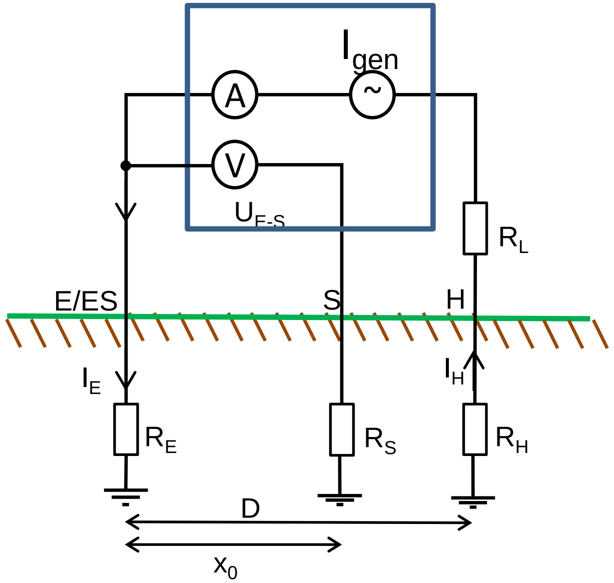
FoP: Basics

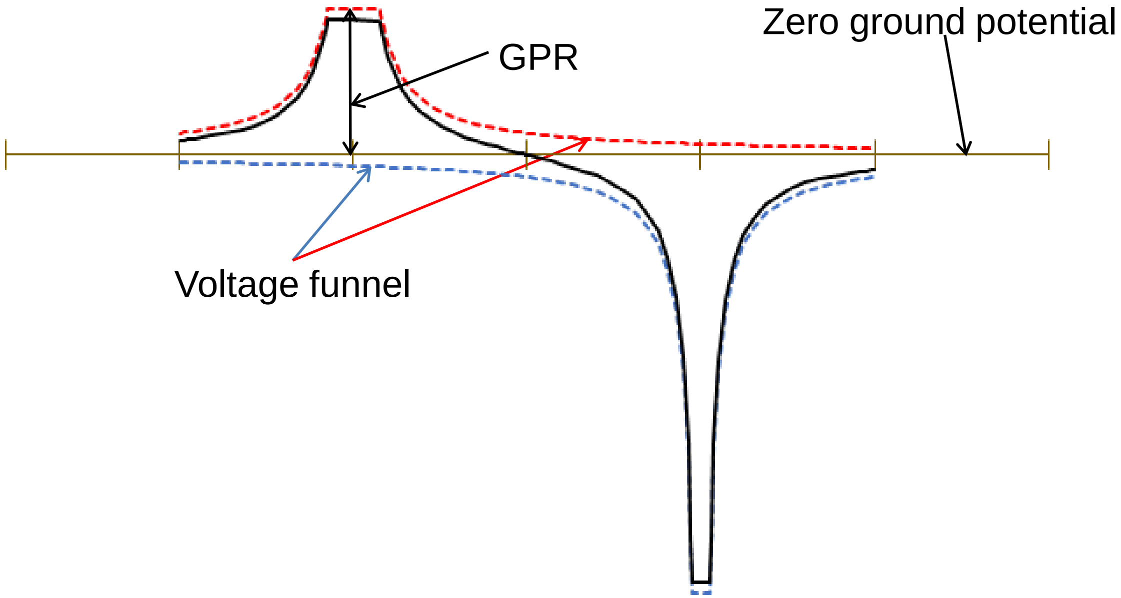
GPR – Ground Potential Rise
If current is injected into earthing system (E) or measurement probe (H), then the potential of this points compared to the zero ground will rise.

Voltage funnel is the graphical representation of the GPR around the earthing system or measurement probe.

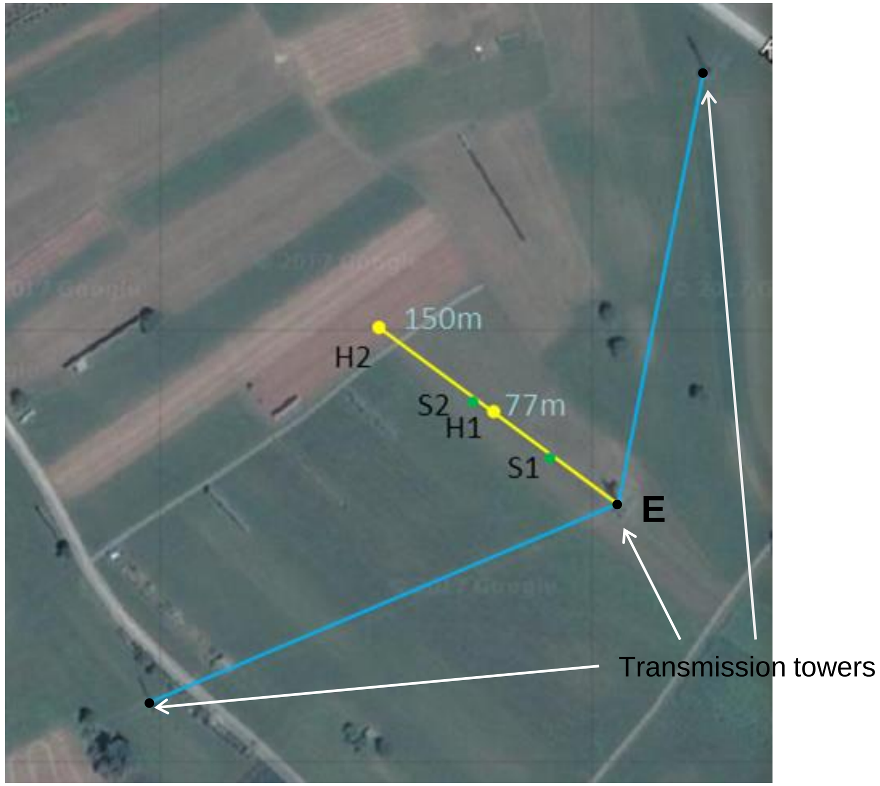
$$R_E = U_{E\text{-}S} / I_E = U_{E\text{-}S} / I_{gen}$$

$$\rightarrow I_E = I_{gen} = I_H$$

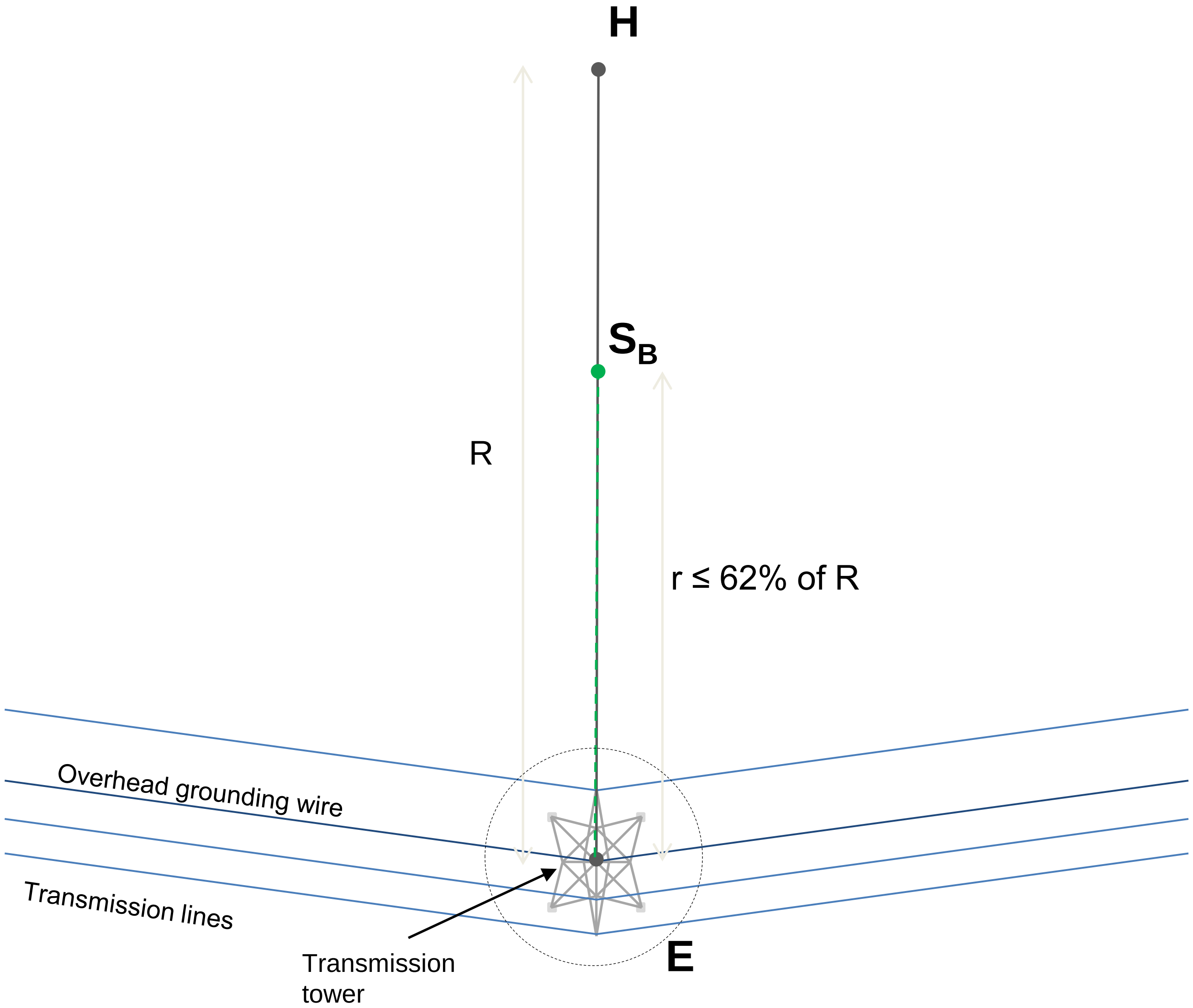




Practical examples:
In-line probe set-up of the measurement points

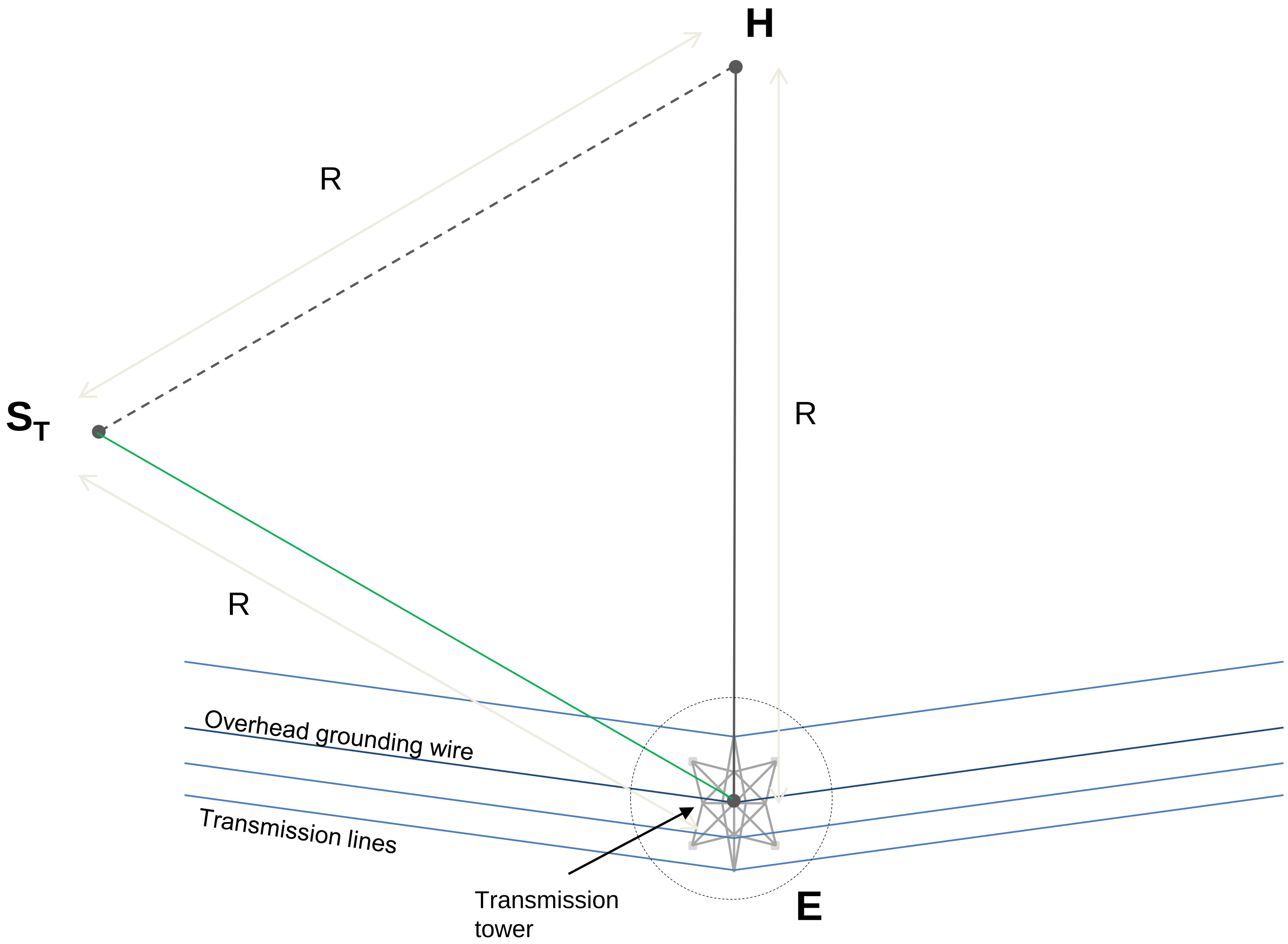


Top (satelite) view



Practical examples:
Triangle probe set-up of the measurement points

Top (satelite) view



Terminology:

- Earth resistance, specific earth resistance, soil resistivity [Ωm]
- Earthing – Grounding
- Earthing resistance or impedance [Ω]
- Earthing system (E) – Grounding system (G)
- Auxiliary probe (H) – Current probe (C)
- Measurement probe: Sense probe (S) – Potential probe (P)
- Probe set-up: In-line, Mirror, Triangle

Probe set-up

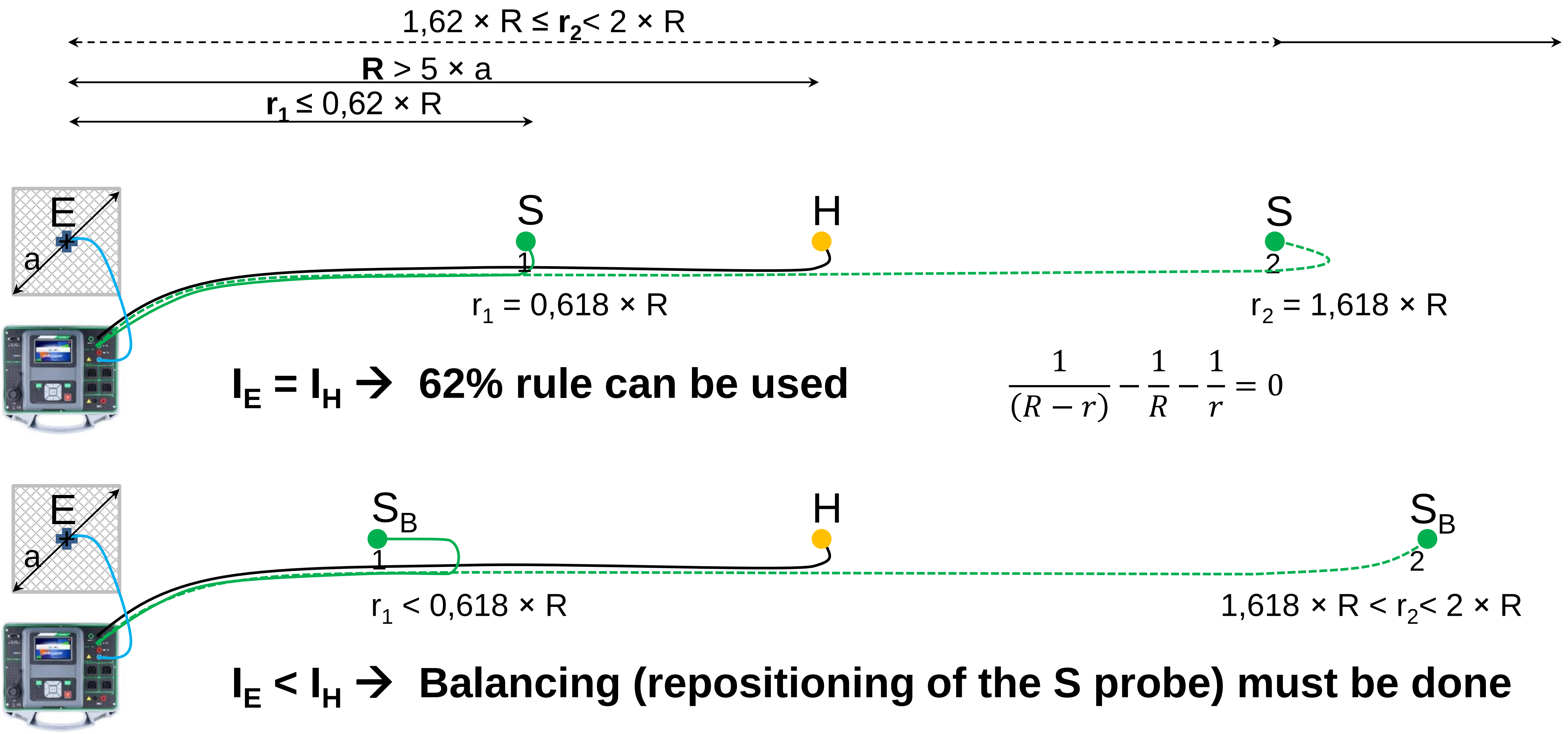
Different probe set-ups are possible. Decision has to be taken based on many parameters:

- Type, size and shape of the tested object
- The configuration of the surrounded terrain
- Close infrastructure objects, especially electro energetic objects
- Available type of measurement equipment
- Requested accuracy, available time

Possible probe set-ups:

- **In-line**: probes are in-line, the probe order is E – S – H or E – H – S, the distances E-S and E-H are variable but correlated
- **Mirror**: probes are in-line, the probe order is S – E – H, the distances S-E and E-H are equal
- **Triangle** (delta): the position of the E, S and H probes are corners of a equilateral triangle.

In-Line probe set-up



In-Line probe set-up
Pro and con

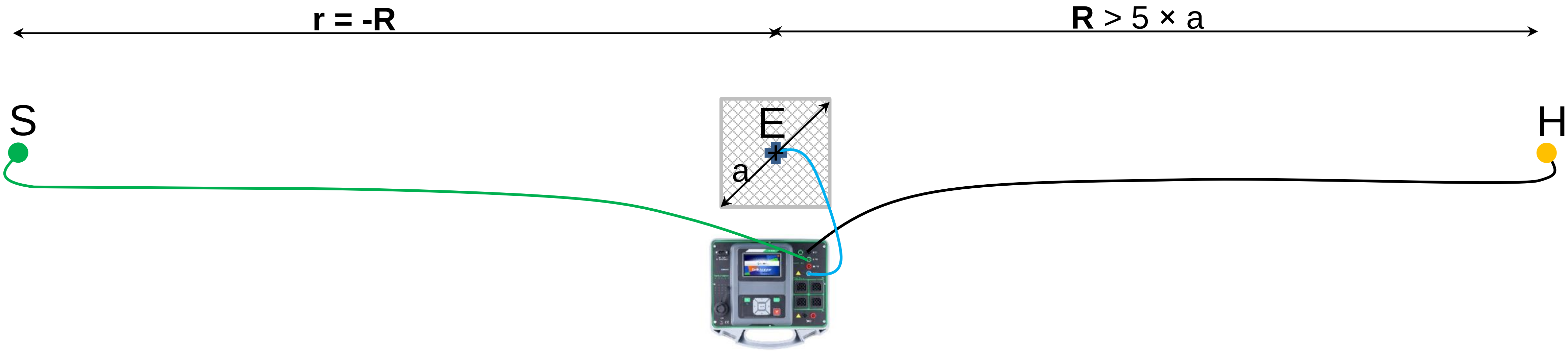
Pro:

- The only probe set-up where (theoretically) the influence of the voltage funnels is nulled → **systematic error = 0**
- Only one measurement is needed (if high accuracy is requested still multiple measurements and averaging of results are recommended)

Con:

- Precise work is needed
- When testing with high frequency test signal the mutual positioning of the measurement cables can influence the results.

Mirror probe set-up



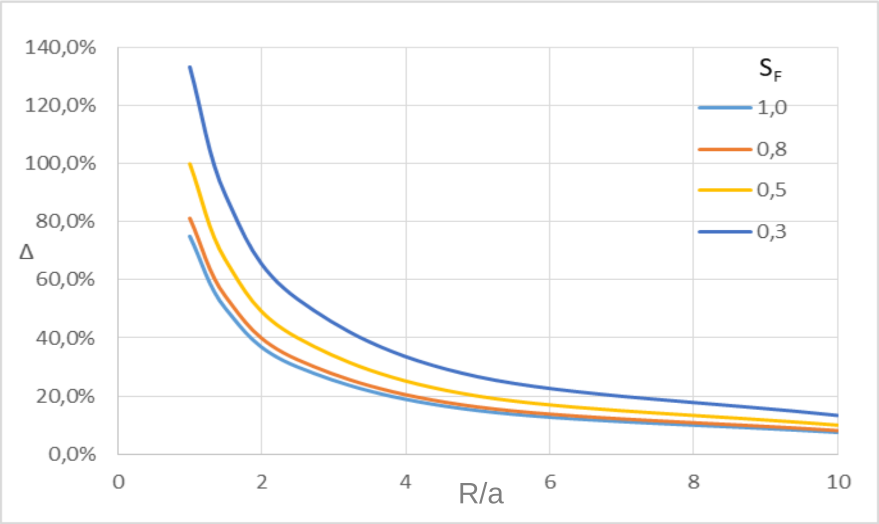
Mirror probe set-up
Pro and con

Pro:

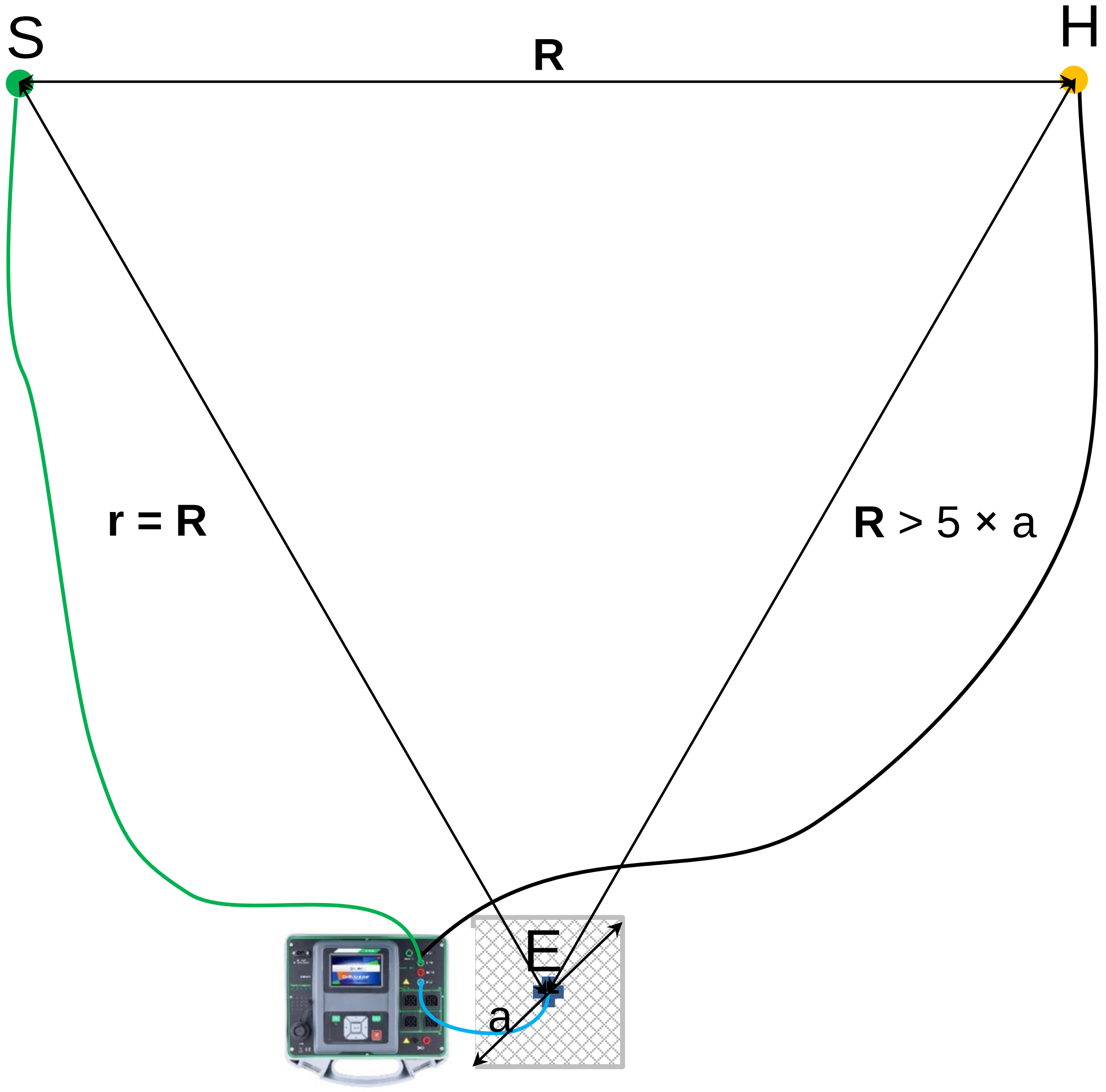
- Simple probe set-up but needs more space
- Only one measurement is needed (if high accuracy is requested still multiple measurements and averaging of results are recommended)
- When testing with high frequency test signal the mutual positioning of the measurement cables has no influence on the results

Con:

- It has **systematic error** (see the graph below) . In the interpretation phase corrections of the measured result are needed



Triangle (delta) probe set-up



Triangle probe set-up
Pro and con

Pro:

- needs more space
- Only one measurement is needed (if high accuracy is requested still multiple measurements and averaging of results are recommended)
- When testing with high frequency test signal the mutual positioning of the measurement cables has very low influence on the results

Con:

- In the interpretation phase corrections of the measured result are needed. The systematic error depends on S_f and the R/a ratio