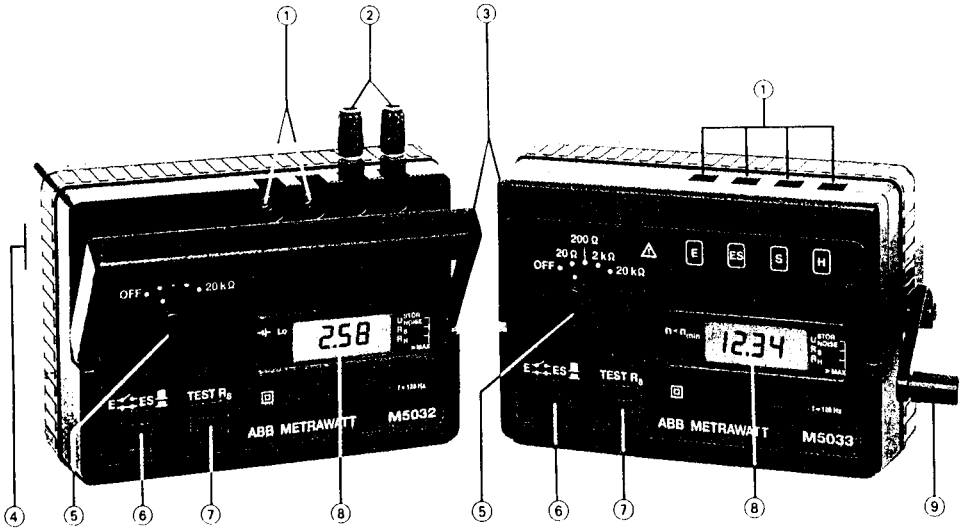
Operating Instructions

GEOHM®33D

Earth Tester

3-348-629-03
2/4.99



(1) Connection sockets for banana plugs

(2) Adapter for connection to cable lugs, bare wire ends or 4mm banana plugs (4 each included with the supply)

(3) Folding carrying handle

(4) Cover of battery compartment (on the bottom of the meter)

(5) Range selector switch, is also the ON OFF switch

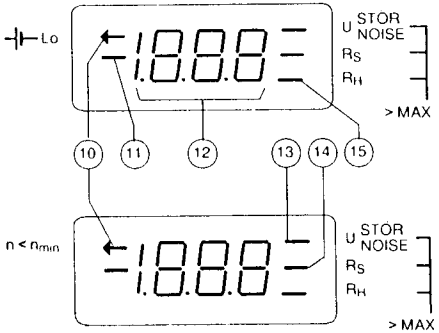
(6) Switch for shorting the connection sockets E and ES

(7) Pushbutton for search electrode resistance test

(8) LCD

(9) Handle for hand generator

Figure 1: Earth testers *M5032* and *M5033*



(10) Symbol for low battery voltage with the *M5032* or low cranking speed with the *M5033*

(11) Minus sign; appears with reversed polarity of search electrode connection with respect to connection of earth electrode and auxiliary earth electrode

(12) Digital display of measured value with 1999 counts

(13) Excessive noise interference symbol

(14) High search electrode resistance symbol

(15) High auxiliary voltage resistance symbol

Figure 2: Display sections on *M5032* (top) and *M5033* (bottom)

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1. Safety precautions

The *M5032* and *M5033* earth testers have been designed and tested to comply with IEC 348 and DIN VDE 0411. When properly used, the safety of both the tester and the user is assured.
To maintain the technically safe and proper condition and to assure a safe use of the tester, it is absolutely necessary to carefully and completely read these operating instructions and to follow them in all respects.

Repair, replacement of parts and calibration.
When opening the tester, live parts may be exposed. The tester must be disconnected from all potential sources prior to repair, replacement of parts or calibration. If repair or calibration can then not be avoided with the tester open and live, **this must only be performed by a qualified person** who understands the danger involved.

Faults and extraordinary stress
When it must be assumed that safe operation is no longer possible, take the tester out of service and secure it against accidental use. It is assumed that safe operation is no longer possible,

- when the tester shows obvious signs of damage,
- when the tester no longer functions correctly,
- after prolonged storage under adverse conditions,
- after severe transport stress.

2. Applications

The *M5032* and *M5033* earth testers serve to measure the earth resistance in electrical systems according to

- DIN VDE 0100 Specifications for erection of power installations with nominal voltages up to 1000V
- DIN VDE 0141 Specifications for earthing installations for rated voltages above 1kV AC
- DIN VDE 0800 Specifications for telecommunications, erection and operation of facilities

and in lightning protection systems according to DIN VDE 0185.

In addition thereto, the testers are suited to determine the soil resistivity which is important when dimensioning earthing systems. Thus, it is advantageous to use these testers for simple geological soil investigations and when planning earthing installations.

Apart from earth resistance measurements, it is also possible to use the testers to measure ohmic resistances, e.g. for resistances of solid and liquid conductors or for internal resistances of galvanic cells, provided these resistances are non-capacitive and non-inductive.

3. Description

General
The *M5032* and *M5033* earth testers comply with DIN VDE 0413, Part 7 "Appliances for testing the protecting devices in power installations, earth testers according to the voltmeter-ammeter method".
They have a measuring span from 0 ... 20kΩ on 4 measuring ranges. The measured result is shown on a 3 1/2digit LCD (maximum reading 1999 digits). Calibration is not required.
The *M5032* is powered by 6 replaceable 1.5V Mignon cells according to IEC LR 6.
The *M5033* is powered by a hand-cranked generator.

Measuring and functional principle

The *M5032* and *M5033* testers measure the earth resistance according to the voltmeter-ammeter method.

The crystal-controlled square-wave generator, fed by the batteries and/or the hand-cranked generator, supplies constant currents of $10mA_{rms}$, $1mA_{rms}$ or $100\mu A_{rms}$ with a frequency of 128Hz for the four measuring ranges 20Ω, 200Ω, 2kΩ and 20kΩ. The constant test current is passed via terminal "E", the earth resistance under test "R_E", the resistance of the auxiliary earth electrode and terminal "H".

The potential drop across the earth resistance "R_E" is first passed to a generator-synchronous, electronic filter and then to a synchronously controlled rectifier to widely eliminate effects caused by polarization voltages and stray AC voltages in the ground. The earth resistance to be measured is proportional to the potential drop. It is shown on the LCD directly in digital form.

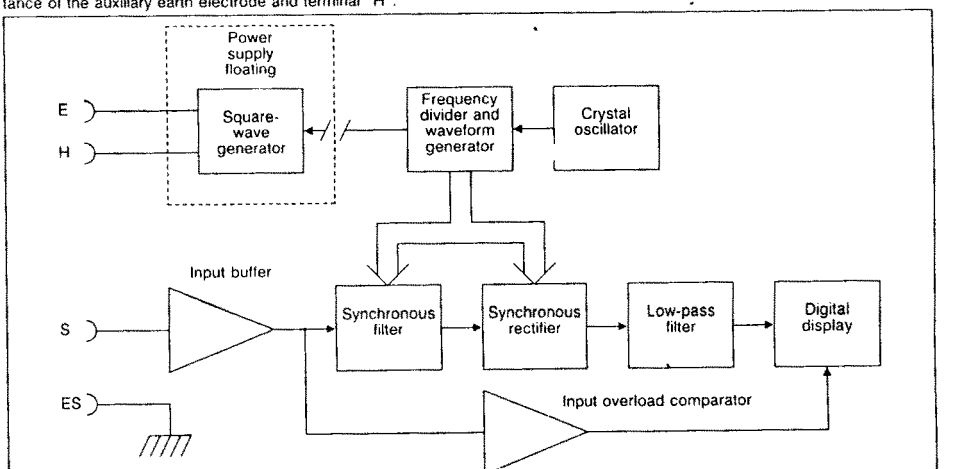


Figure 3: Block diagram of the *M5032* and *M5033* earth testers

4. Specifications

Measuring principle . . . . . Voltmeter-ammeter method according to DIN VDE 0413, Part 7

Measuring ranges

Measuring range	Resolution	Output voltage	Test current (= short circ. current = const.)
0.01 Ω . . . 19.99 Ω	0.01 Ω	max. 50V_{rms}	10mA_{rms}
0.1 Ω . . . 199.9 Ω	0.1 Ω	max. 50V_{rms}	1mA_{rms}
0.001 kΩ . . . 1.999 kΩ	1 Ω	max. 50V_{rms}	100µA_{rms}
0.01 kΩ . . . 19.99 kΩ	10 Ω	max. 50V_{rms}	100µA_{rms}

Measuring range at rated operating conditions to DIN VDE 0413, Part 7 — 5 digits . . . 1999 digits

Accuracy

Intrinsic error . . . . . under reference conditions: ± (2% of reading + 3 digits)

Service error . . . . . on the range 5 digits . . . 1999 digits
under rated operating conditions to DIN VDE 0413, Part 7: ± (5% of rdg. + 3 digits)
under expanded rated operating conditions: ± (5% of rdg. + 3 digits)

Reference conditions

Temperature . . . . . 23°C ± 2K
Position . . . . . any
Interference voltage 0V
Aux. earth electrode resistance . . 0Ω
Search electrode resistance 0Ω
Battery voltage . . . . . 9V DC + 1V / −3V *(for M 5032)*
Generator cranking speed . . . . . ≥ 120RPM *(for M 5033)*

Rated operating conditions	**to DIN VDE 0413, Part 7**	**expanded**
Temperature	0°C . . . + 30°C	−15°C . . . + 55°C
RH (no dewing)	—	max. 93% at + 40°C
Position		any
Interference voltage	0 ... 5V_{rms}, max. 10% of the meas. volt.	20Ω ...2kΩ range: max. 20 ± 1V_{pp}, 50Hz, sin.
	betw. earth electr. and search electr.	20kΩ range: max. 16 ± 1V_{pp}, 50Hz, sinusoidal
Aux. earth electrode resistance R_H	20Ω range: R_H ≤ 400Ω	20Ω range: R_H ≤ 4.5kΩ
(R_H = resistance of the	200Ω range: R_H ≤ 4kΩ	200Ω range: R_H ≤ 28kΩ
external circuit)	2 and 20kΩ ranges: R_H ≤ 40kΩ	2 and 20kΩ ranges: R_H ≤ 55kΩ
Search electrode resistance R_S . .	20Ω range: R_S ≤ 2kΩ	20Ω range: R_S ≤ 11kΩ
(R_S = resistance of the	200Ω range: R_S ≤ 20kΩ	200Ω range: R_S ≤ 28kΩ
external potential circuit)	2 and 20kΩ ranges: R_S ≤ 50kΩ	2 and 20kΩ ranges: R_S ≤ 110kΩ
Battery voltage	6 . . . 10V DC *(for M 5032)*	
Generator cranking speed	≥ 120 RPM *(for M 5033)*	

Frequency	
of the measuring voltage	128Hz ± 0.5Hz
Temperature ranges	
Operating	–0°C . . . + 55°C
Storage	–40°C . . . + 70°C, *M5032* without batteries
Humidity	
Operating	93% RH max. at + 40°C
Storage	93% RH max. at + 55°C
Digital display	
Type of display	Liquid crystal display (LCD)
Height of numerals	10mm
Number of digits	3 1/2 digits corresp. to 1999 counts
Overrange indication	Only the left digit "1" and the range decimal point are displayed
Power supply	
M 5032	6 each 1.5V Mignon cells to IEC LR 6 (alkaline-manganese cells) Lifespan: With one set of new alkaline-manganese cells 50 x 3 minutes each (until automatically disconnected) or 2.5 hours continuous operation at 0°C: 15 x 3 minutes each or 45 minutes continuous operation Automatic battery check: Dropping of the battery voltage below the lower limit is signalled by a segment on the LCD. In this case the battery holds only enough power for possibly one or two more measurements
M 5033	Internal, hand-cranked generator Minimum cranking speed 120 RPM Automatic speed check: Too low a cranking speed is signalled by a segment on the LCD
Fuse	
Measuring circuit (E - H)	F 100 / 250 to IEC 127 / 1.5ø × 20mm
Electrical safety	
Protection class	III to DIN VDE 0411
Nominal insulation voltage	250V to DIN VDE 0411
Test voltage	3kV AC to DIN VDE 0411
Mechanical configuration	
Protection type	IP 50 to DIN 40 050
Dimensions	*M 5032*: 180mm × 128mm × 125mm *M 5033*: 210mm × 128mm × 125mm
Weight	*M 5032*: 0.82kg *M 5033*: 1.4kg

For a specified maximum earth resistance R_E, the displayed value, taking into account the service error, must not exceed the value given in Table 1. Intermediate values can be interpolated. The values apply to rated operating conditions according to DIN VDE 0413, Part 7.

20Ω range		200Ω range		2kΩ range		20kΩ range	
specified max. R_E Ω	max. display Ω	specified max. R_E Ω	max. display Ω	specified max. R_E kΩ	max. display kΩ	specified max. R_E kΩ	max. display kΩ
0.05	0.02	0.5	0.2	0.005	0.002	0.05	0.02
0.10	0.06	1.0	0.6	0.010	0.006	0.10	0.06
0.20	0.16	2.0	1.6	0.020	0.016	0.20	0.16
0.50	0.44	5.0	4.4	0.050	0.044	0.50	0.44
1.00	0.92	10.0	9.2	0.100	0.092	1.00	0.92
1.50	1.39	15.0	13.9	0.150	0.139	1.50	1.39
2.00	1.87	20.0	18.7	0.200	0.187	2.00	1.87
3.00	2.82	30.0	28.2	0.300	0.282	3.00	2.82
5.00	4.72	50.0	47.2	0.500	0.472	5.00	4.72
7.00	6.62	70.0	66.2	0.700	0.662	7.00	6.62
10.00	9.47	100.0	94.7	1.000	0.947	10.00	9.47
12.00	11.37	120.0	113.7	1.200	1.137	12.00	11.37
15.00	14.22	150.0	142.2	1.500	1.422	15.00	14.22
17.00	16.12	170.0	161.2	1.700	1.612	17.00	16.12
20.00	18.97	200.0	189.7	2.000	1.897	20.00	18.97

Table 1 - according to DIN VDE 0413, part 7, Clause 4.3.4

5. Glossary of terms

To avoid misunderstandings about the terms used, the most important terms are explained below.

Earth is the designation for both the earth as place and as matter, e.g. nature of the soil humus, clay, loam, gravel, rocks.

Reference earth (neutral earth) is the area of the ground, especially the earth's surface away from the influence area of an earth electrode and/or an earthing system in which no noticeable potential caused by the earthing current appears between any two points (Figure 4).

Earth electrode is a conductor imbedded in the ground and conductive to earth, or a conductor imbedded in concrete which is in large-scale contact with the earth (e.g. foundation earth electrode).

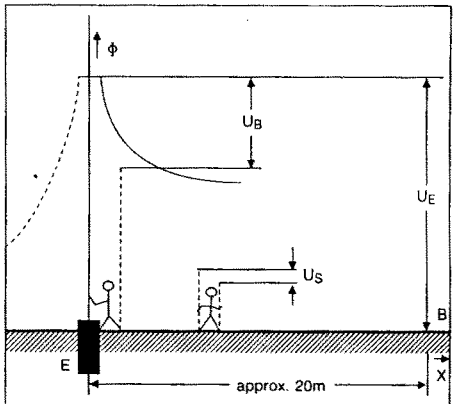
Earth lead is a line which connects a system part to be earthed to an earth electrode provided it is installed above ground or buried insulated in the ground.

Earthing system is a locally limited entirety of earth electrodes which are conductively connected with each other, or metal parts having the same effect (e.g. mast bases, reinforcements, metal sheathing of cables and earthing lines).

To earth means to connect and electrically conductive part to earth via an earthing system.

Earthing is the entirety of all means and measures for connection to earth.

Soil resistivity ρ_E is the specific electrical resistance of the soil. It is normally given in Ωm^2 : m = Ωm and then denotes the resistance of an earth cube having a 1m long edge between two opposed cube planes.



B = Reference earth
E = Earth electrode
U_B = Touch potential
U_E = Earthing potential
U_S = Step potential
X = Distance from earth electrode
ϕ = Potential

Figure 4: Earth's surface potential and potentials with a current-carrying earth electrode

Spreading resistance R_A of an earth electrode is the resistance of the soil between the earth electrode and the reference earth. R_A is practically an effective resistance.

Earthing resistance R_E is the resistance appearing between earthing system and reference earth.

Earthing potential U_E is the potential appearing between the earthing system and the reference earth (Figure 4).

Touch potential U_B is that portion of the earthing potential that can be bridged by a human being (Figure 4), whereby the current path across the human body runs from hand to foot (horizontal distance from the touchable part approximately 1m) or from hand to hand.

Step potential U_S is that portion of the earthing potential that a human being can bridge across a step of 1m in length, whereby the current path across the human body runs from foot to foot (Figure 4). There are no permissible limiting values specified for the magnitude of the step potential.

6. Operation

6.1 Starting

While the *M5033* earth tester with hand generator is always ready for operation, the *M5032* requires the installation of batteries prior to starting.

Installing the batteries (for *M5032*)

CAUTION: Make sure that the tester is completely disconnected from all external circuits prior to opening the battery compartment!

- With a proper equate tool, loosen the slotted screw of the cover of the battery compartment (4) on the bottom of the tester and remove the cover.
- Install 6 each 1.5V Mignon cells according to IEC LR 6 (alkaline-manganese cells) in the battery compartment. Observe correct polarity in line with the given symbols.
- Replace the cover of the battery compartment (4) and tighten it.

Switching the tester on / automatic disconnection (*M5032*)

The tester is switched on when selecting the measuring range. After approximately 3 minutes, the tester disconnects automatically. To switch the tester on again, briefly set the range selector switch to the "OFF" position.

6.2 Measuring

6.2.1 Display of measured value and different symbols in the display section

Digital display of the measured value

The measured value is displayed directly on the 3 1/2digit LCD (12). Refer to the position of the range selector switch (5) for the unit of measurement.

If the measured value is higher than the upper limit of the measuring range selected, only the left digit "1" appears as overrange symbol. The remainder of the display is blanked except for the decimal point. In this case, switch to the next higher range.

Minus sign with reversed polarity

When the polarity of the search electrode connection is reversed with respect to the connection of the earth electrode and the auxiliary earth electrode, the digits are preceded by a minus sign (11). The measured result is still valid but earth electrode, search electrode and auxiliary earth electrode should be connected with correct polarity to remove the minus sign.

Symbol for too low a battery voltage (*M5032*)

When the battery voltage has dropped to such an extent that only a few more measurements can be made, an arrow (10) will appear on the left of the display section. For further measurements, the battery set must be replaced as described in Section "6.1 Starting".

Symbol for too low a cranking speed (*M5033*)

If the generator handle (9) is turned too slow such that the voltage generated is insufficient for a proper measurement, an arrow (10) will appear on the left of the display section. Turn the generator handle faster until the arrow disappears.

Symbol for excessive noise interference
When the interference voltage in the earth to be measured is so high that it cannot be eliminated while measuring, a symbol (13) appears next to the "$U_{NOISE/STOR}$" mark. In this case, the reading is faulty due to excessive noise interference.
If the interference is transient in nature, you should wait until the interference has subsided to obtain a correct result. With a lasting interference, choose a different position for the search electrode and the auxiliary earth.

Symbol for excessive auxiliary earth electrode resistance
If the resistance of the external current circuit (auxiliary earth electrode resistance R_H) is higher than permissible, the symbol (15) appears next to the "R_H" mark when switching on or when measuring. For a valid measurement, the resistance must be reduced until the symbol disappears.
Too high a resistance of the current circuit may, for example, be caused by: poor contact between auxiliary earth electrode and ground, excessive soil resistivity in the vicinity of the auxiliary earth electrode, an open circuit, or a bad connection of the test lead to the auxiliary earth electrode.
A lower auxiliary earth electrode resistance could be obtained by moistening the ground around the auxiliary earth electrode by resiting the spike in a new position, or by using several spikes.

Symbol for excessive search electrode resistance
To test the resistance of the external potential circuit (search electrode resistance R_S), press the "TEST R_S" pushbutton (7). If the search electrode resistance R_S is higher than permissible, the symbol (14) appears next to the "R_S" mark. To obtain a valid measurement, the resistance must be reduced until the symbol (14) does no longer appear when pressing the pushbutton (6).
The reasons may be the same as for the excessive auxiliary earth electrode resistance.

Note: Operating the "TEST R_S" pushbutton (7) will cause the display to go blank. Only the decimal point and, when relevant, the excessive search electrode resistance symbol (14) will be shown.

6.2.2 Performing the measurement
After setting-up the measuring circuitry as described in the following sections, perform the measurement as follows:
- For connection of the measuring leads to the tester use the four adapters supplied. They have screw terminals and sockets for connection to cable lugs, bare wire ends or 4mm banana plugs.
- With the range selector switch (5), select the proper range. If the magnitude of the measured value is unknown, first set the switch to the lowest range. If the overrange symbol appears, switch to the next higher range.
- *M5032*: Selection of the measuring range at the same time turns on the tester.
  M5033: Turn the generator handle (9) so fast that the symbol (10) for too low a cranking speed will not appear and/or will disappear.
- Check whether one of the above symbols that signal a faulty measured result is automatically shown and, when relevant, eliminate the cause of the fault as described in the above section.
- Press the "TEST R_S" pushbutton (7) to test the search electrode resistance. This blanks the display. If the symbol (14) appears, the cause of the fault must be eliminated as described in the above section.

The reading is only valid when none of the above mentioned symbols is displayed!

6.3 Measuring the earth resistance
6.3.1 Measuring set-up, notes on measurements

6.3.1.1 Four-wire method

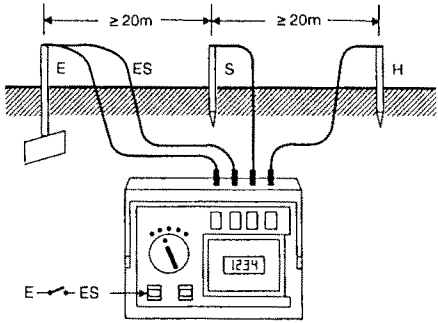


Figure 5: Measuring the earth resistance according to the four-wire method

- Site the spikes for search electrode and auxiliary earth electrode as shown in Figure 5 and as described in the following sections.
- Connect the earth electrode to terminals "E" and "ES" of the tester via two separate measuring leads and connect the search electrode to terminal "S" and the auxiliary earth electrode to terminal "H".
- Place the E/ES switch (6) into an "open" state (pushbutton not depressed).
- Measure the earth resistance as described in Section 6.2 and observe the notes on measurements given in the following sections.

The resistance of the measuring lead between earth electrode and tester terminal "E" is not included in the measurement with this measuring set-up.

Note: The measuring leads must be well insulated to avoid sneak paths. The measuring leads should not cross or run in parallel with each other over long distances to minimize the effect of mutual inductance.

6.3.1.2 Three-wire method

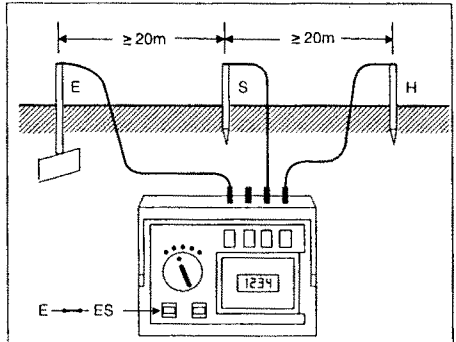


Figure 6: Measuring the earth resistance according to the three-wire method

With the three-wire method, the earth electrode is connected to terminal "E" of the tester with only one measuring lead, and terminals "E" and "ES" are shorted by means of the E/ES switch (6) (pushbutton in depressed position). The resistance of the measuring lead to the earth electrode is directly entered into the measured result.

To keep the error caused by the measuring lead as small as possible when using this measuring method, use a short connection lead with large cross section between earth electrode and terminal "E". You can measure the lead resistance with this earth tester as described in Section 6.5.1. The note with respect to the measuring leads given under the four-wire method applies here as well.

6.3.1.3 Voltage funnel

You will find the proper position for search electrode and auxiliary earth electrode when you observe the voltage trend and/or the spreading resistance in the ground. The measuring current passed by the earth tester across the earth electrode and the auxiliary earth electrode causes a potential distribution in the form of a voltage funnel around the earth electrode. The resistance distribution is analogous to the potential distribution. The resistance areas of earth electrode and auxiliary earth electrode normally differ. The two voltage and/or resistance funnels are thus not symmetric.

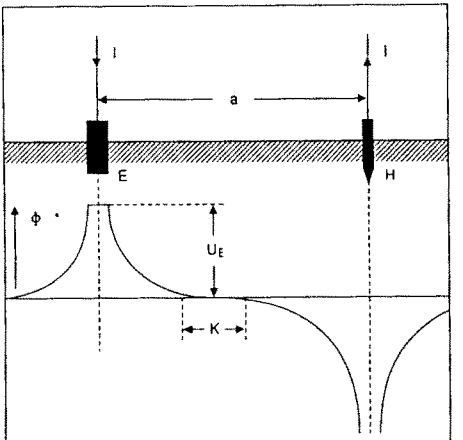
6.3.1.4 Spreading resistance of small earth electrodes

For correct detection of the spreading resistance of small earth electrodes, siting of search electrode and auxiliary earth electrode is very important. The search electrode must be sited between earth electrode and auxiliary earth electrode in the so-called neutral zone (reference earth) (Figure 7). The potential and/or resistance curve is nearly horizontal in the neutral zone.

To choose the proper search electrode and auxiliary earth electrode resistances, proceed as follows:

- Hammer the auxiliary earth electrode into the ground approximately 40m away from the earth electrode.
- Site the search electrode in the center of the connection line earth electrode - auxiliary earth electrode and measure the earth resistance with the *M5032* or the *M5033*.
- Move the search electrode 2 ... 3m towards the earth electrode, then 2 ... 3m towards the auxiliary earth electrode with respect to its original position and measure the earth resistance.

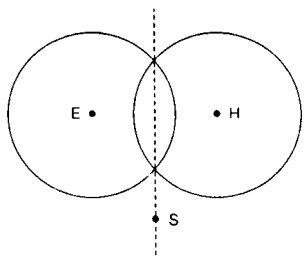
If the three measurements yield the same value, this value then is the searched earth resistance. The search electrode is located in the neutral zone.



a = Distance earth electrode - auxiliary earth electrode
E = Earth electrode
H = Auxiliary earth electrode
I = Measuring current
K = Neutral zone (reference earth)
U_E = Earthing voltage
R_E = U_E / I = earth resistance
ϕ = Potential

Figure 7: Voltage trend in homogenous soil between earth electrode E and auxiliary earth electrode H

If, however, the three measured values for the earth resistance differ, then the search electrode is either not located in the neutral zone, or the voltage and/or resistance curve is not horizontal at the point of insertion of the search electrode. In such cases, correct measured results can be obtained by increasing the distance auxiliary earth electrode - earth electrode, or by moving the search electrode on the mid-vertical between auxiliary earth electrode and earth electrode (Figure 8). When moving the search electrode on the mid-vertical, the search electrode point moves out of the influence area of the two voltage funnels of earth electrode and auxiliary earth electrode.



E = Location of earth electrode
H = Location of auxiliary earth electrode
S = Location of search electrode

Figure 8: Location of search electrode S beyond the overlapping voltage funnels on the mid-vertical between earth electrode E and auxiliary earth electrode H

6.3.1.5 Spreading resistance of larger earthing systems

For the measurement of large earthing systems, much greater distances to search electrode and auxiliary earth electrode are required; here, the 2.5- and/or 5-fold value of the largest diagonal of the earthing system is used for calculation. Such large earthing systems often have spreading resistances of some Ohms only, so that it is particularly important to site the search electrode in the neutral zone. Choose the direction for search electrode and auxiliary earth electrode to make a right angle with the largest extension of the earthing system. Keep the spreading resistance small; eventually use several spikes (distance 1 ... 2m) and connect them with each other.

In practice, however, large measuring distances can often not be realized due to difficult terrain. In this case, proceed as shown in Figure 9.

Place the auxiliary earth electrode at the maximum possible distance from the earthing system. With the search electrode, scan the area between earth electrode and auxiliary earth electrode in steps of equal length (length of step 5m approx.). Note the measured resistances in tabular form and then plot them graphically (curve I) as shown in Figure 9. When drawing a parallel through the point of inflection S_1 to the abscissa, then this line divides the resistance curve into two parts. The lower part, measured at the ordinate, yields the searched spreading resistance of the earth electrode $R_{A/E}$; the upper value is the spreading resistance of the auxiliary earth electrode $R_{A/H}$. With such a measuring set-up, the spreading resistance of the auxiliary earth electrode shall be smaller than 100 times the spreading resistance of the earth electrode.

With resistance curve without distinct horizontal area, the measurement should be checked with a changed position of the auxiliary earth electrode. Draw this additional resistance curve into the first diagram with a changed abscissa scale in such a way that both positions of the auxiliary earth electrode will coincide. The spreading resistance determined at first can be checked by means of the point of inflection S_2 (Figure 9).

Curve I (KI)		Curve II (KII)	
m	Ω	m	Ω
5	0.90	10	0.80
10	1.28	20	0.98
15	1.62	40	1.60
20	1.82	60	1.82
25	1.99	80	2.00
30	2.12	100	2.05
40	2.36	120	2.13
60	2.84	140	2.44
80	3.68	160	2.80
100	200.00	200	100.00

S1, S2 = Points of inflection
KI = Curve I
KII = Curve II

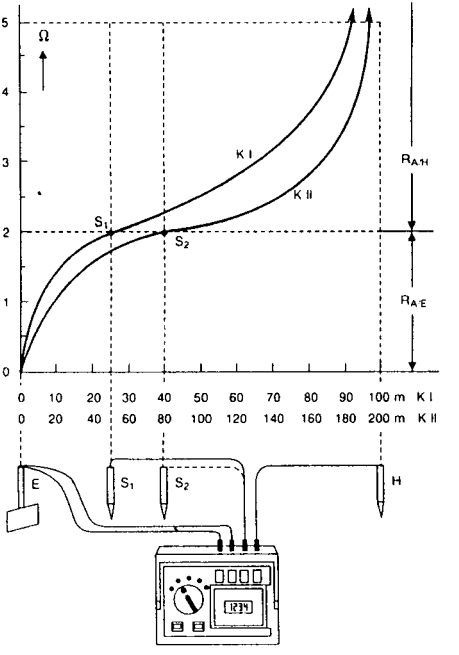


Figure 9: Measuring the earth resistance of a large earthing system

6.3.1.6 Notes on measurements in unfavorable terrain

The resistances of search electrode and auxiliary earth electrode must not exceed the values given under "4. Specifications". Reversing the connection of auxiliary earth electrode and earth electrode allows for determination of the auxiliary earth electrode resistance, if it is smaller than 20kΩ. It can be concluded from the auxiliary earth electrode resistance that the search electrode resistance has about the same value ($R_S \approx R_H$).

In very unfavorable terrain (e.g. sandy soil after extended dry periods), it is possible to reduce the resistance of the auxiliary earth electrode and the search electrode to permissible values by moistening the ground around the auxiliary earth electrode and the search electrode with soda water or salt water. If this is still insufficient, several test spikes can be sited in parallel with the auxiliary earth electrode.

In mountain regions, or with very stony subsoil where it is impossible to hammer test spikes into the ground, wire grids sized approximately 2m² and having a mesh size of about 1cm can be used. Place these grids flat onto the ground, moisten them with soda water or salt water and eventually weight with moist, soil-filled sacks.

6.4 Measuring the soil resistivity

The soil resistivity is a decisive factor for the magnitude of the spreading resistance of an earth electrode. When planning earthing systems, the soil resistivity must be known for predetermination of the spreading resistance.

The *M5032* / *M5033* testers allow for the measurement of the soil resistivity ρ_E (see Section 5.) according to Wenner's method (Figure 10):

Four spikes are driven into the ground in a straight line at a distance a and connected to the earth tester as shown in Figure 10. The measurement is made as described in 6.2.2. The soil resistivity is calculated from the formula

$$\rho_E = 2 \pi a R$$

where π = 3.1416
a = spacing between two spikes
R = measured value obtained with the earth tester

The depth of the driven-in spikes shall not be more than 1:20 of the distance a.

There is the risk of faulty measurements, when piping, cables or other underground metallic lines run in parallel to the measuring set-up!

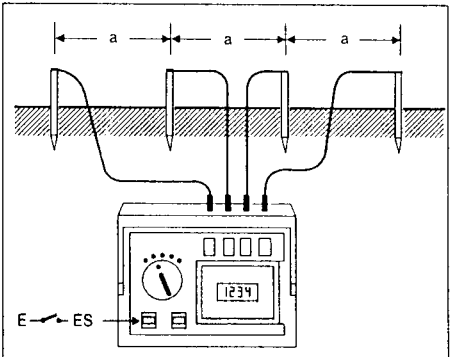


Figure 10: Measuring the soil resistivity according to WENNER's method

6.4.1 Geological evaluation

Apart from extreme cases, the measurement of the soil to be investigated extends to a depth which is about equal to the spike spacing a. Thus, it is possible to gain knowledge on the stratification of the soil by varying the spacing of the spikes. Well conducting stratification (ground-water table) into which earth electrodes are to be inserted can thus be found in a badly conducting environment.

Soil resistivities are subjected to great variations the reasons for which are diversified, e.g. porosity, moisture content, solution strength of salts in the ground-water and climatic variations. The trend of the soil resistivity ρ_E as a function of the season (ground temperature) can be presented with rather good approximation by means of a sine curve (Figure 11).

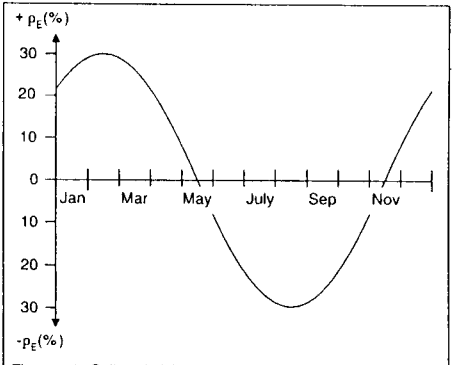


Figure 11: Soil resistivity as a function of the season without the influence of rainfall (earth electrode driven-in to a depth of < 1.5m)

Table 2 below gives a summary of some typical resistivities for different soils.

Type of soil	Soil resistivity ρ_E Ω m
Wet peat	8 .. 60
Arable soil, loam and clay soil wet gravel	20 .. 300
Wet sandy soil	200 .. 600
Dry sandy soil, dry gravel	200 .. 2000
Stony soil	300 .. 8000
Rocks	10^4 .. 10^{10}

Table 2: Soil resistivity ρ_E with different types of soil

6.4.2 Predetermination of spreading resistances

Table 3 gives the formulas for calculation of the spreading resistances for the commonly used types of earth electrodes. In practice, these thumb rules will be quite sufficient.

No.	Earth electrode	Thumb rule	Aux. quantity
1	Strip earth electrode (crow-foot earth electrode)	$R_A = \frac{2 \cdot \rho_E}{l}$	–
2	Earth rod electrode (depth earth electrode)	$R_A = \frac{\rho_E}{l}$	–
3	Ring earth electrode	$R_A = \frac{2 \cdot \rho_E}{3\,D}$	$D = 1{,}13 \cdot \sqrt[2]{F}$
4	Grid earth electrode	$R_A = \frac{\rho_E}{2\,D}$	$D = 1{,}13 \cdot \sqrt[2]{F}$
5	Plate earth electrode	$R_A = \frac{\rho_E}{4{,}5\,a}$	–
6	Hemispherical earth electrode	$R_A = \frac{\rho_E}{\pi \cdot D}$	$D = 1{,}57 \cdot \sqrt[3]{J}$

R_A = Spreading resistance (Ω)
ρE = Soil resistivity (Ωm)
l = Length of earth electrode (m)
D = Diameter of a ring earth electrode, diameter of the substitute circular area of a grid earth electrode or the diameter of a hemispherical earth electrode (m)
F = Area (m^2) of the enclosed area of a ring earth electrode or grid earth electrode
a = Edge length (m) of a square plate earth electrode; with rectangular plates insert for a: $\sqrt{b \cdot c}$, where b and c are the two sides of the rectangle.
J = Contents (m^3) of a single foundation

Table 3: Formulas for calculation of the spreading resistance R_A for different earth electrodes

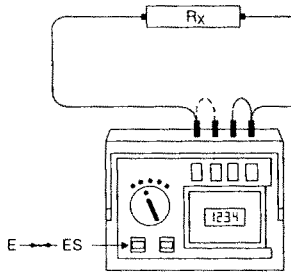


Figure 12: Measuring ohmic resistances according to the two-wire method

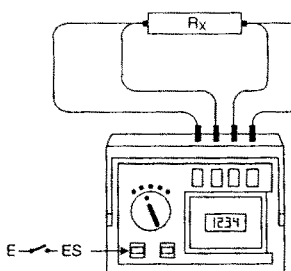


Figure 13: Measuring ohmic resistances according to the four-wire method

6.5 Measuring ohmic resistances

The *M5032* and *M5033* earth testers can also be used to measure the resistance of liquid and solid conductors provided they are nearly non-capacitive and non-inductive.

6.5.1 Two-wire method

Set the E/ES switch (6) to the "closed" position (pushbutton depressed).
With this set-up (Figure 12), the lead resistances enter into the measurement.

6.5.2 Four-wire method

Select the four-wire set-up to prevent the lead resistances to enter into the measured result. This requires that you set the E/ES switch (6) into the "open" position (pushbutton not depressed).

7. Maintenance

Caution: Completely disconnect the tester from all external circuits prior to changing batteries or fuses!

7.1. Batteries *(M5032 only)*

Check in regular, short intervals that the batteries of your tester are not leaking. With leaking batteries, completely remove the battery electrolyte and install new batteries.

When the symbol for low battery voltage (10) appears in the display section, or when the display remains blanked after turn-on, replace the batteries with new one. Proceed as described in Section 6.1.
The tester operates with 6 each 1.5V Mignon cells (alakaline-manganese cells) according to IEC LR 6.
Always replace the complete battery set!

7.2 Fuse

Both testers *(M5032 and M5033)* are fitted with a fuse F 100 / 250 according to IEC 127 / 1 to protect the measuring circuit from overload caused by voltages at the E - H terminals. The fuse is located in a holder in the bottom of the case.

When a fuse blows, replace the G-type fuse as follows:

– Disconnect the tester from the measuring circuit.
– Use a proper tool to unscrew the cap of the fuseholder.
– Remove the fuse and replace it with a new one.

Caution: Absolutely verify that only the specified fuse F 100/250 according to IEC 127 / 1 is installed. If a fuse of other cut-out characteristics, other nominal current or other switching capacity is used, there is danger of damaging components!

– Replace the G-type cap together with the new fuse.

8 Repair and Replacement Parts Service

DKD Calibration Lab and Rental Instrument Service

When you need service, please contact:

GOSSEN-METRAWATT GMBH
Service-Center
Thomas-Mann-Strasse 20
90471 Nürnberg, Germany
Phone +49 911 86 02 - 410 / 256
Fax +49 911 86 02 - 2 53
e-mail fr1.info@gmc-instruments.com

This address is for Germany only. Abroad, our representatives or establishments are at your disposal.

Product Support

When you need service, please contact:

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Product Support Hotline
Phone +49 911 86 02 - 112
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