Operating Instructions

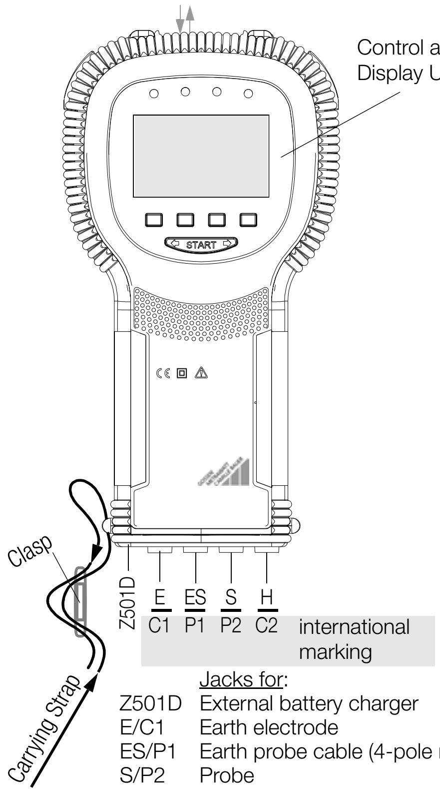
GOSSEN METRAWATT

GEOHM®C-GB int.

Earth Tester

3-349-089-03
4/2.03

GEOHM®C Measuring and Test Instrument

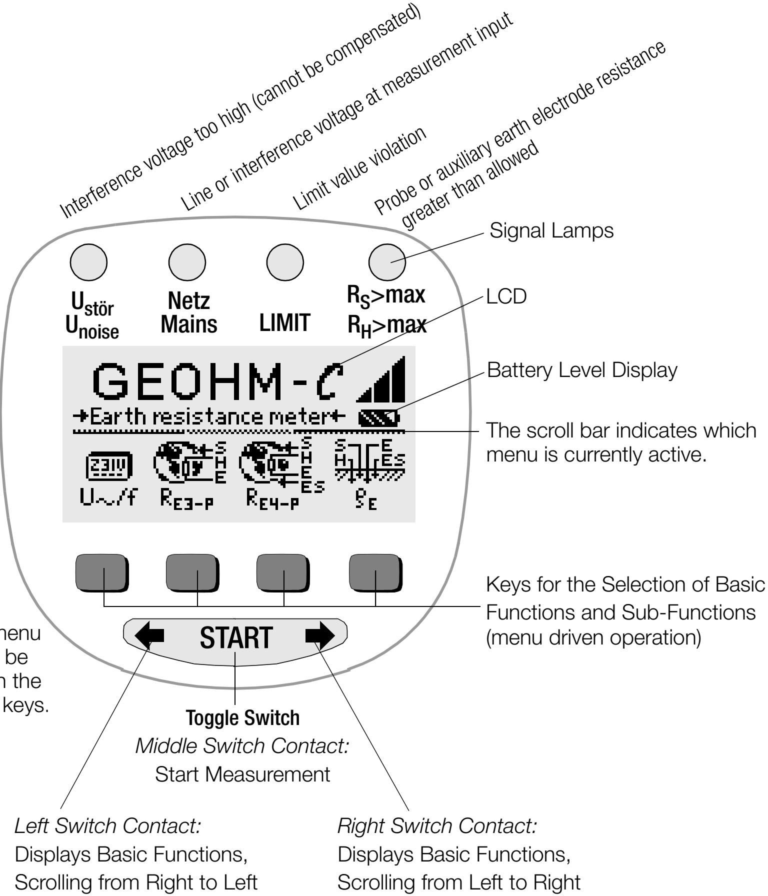


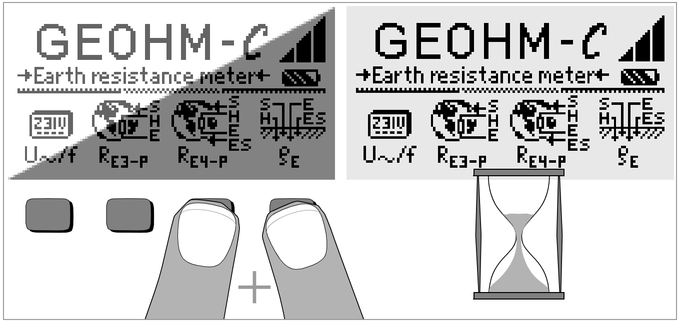
Jacks for:

Z501D	External battery charger
E/C1	Earth electrode
ES/P1	Earth probe cable (4-pole measurement)
S/P2	Probe
H/C2	Auxiliary earth electrode

The desired menu functions can be displayed with the ⬅ and ➡ keys.

GEOHM®C Control and Display Unit





Please proceed as follows if the LCD display is not legible, i.e. too bright or too dark, after switching on the test instrument:

1 Simultaneously press the two right-hand keys to delete the memory which might be faulty.
2 Wait a few seconds to allow the display to be updated.
3 Readjust the contrast if necessary, see page 10.

Contents **Page**

1 Applications

The GEOHM®*C* is a compact instrument for the measurement of earthing resistance in electrical systems in accordance with the following regulations:

DIN VDE 0100	Installation of power systems with nominal voltages of up to 1000 V
DIN VDE 0141	Grounding in AC systems with nominal voltages of greater than 1 kV
DIN VDE 0800	Installation and operation of telecommunications systems including data processing systems: equipotential bonding and grounding
DIN VDE 0185	Lightning protection systems

The instrument is also capable of determining soil resistivity which is essential in calculating dimensions for earthing systems.
It can thus be taken advantage of for simple geological surveys, and for the planning of earthing systems.

Beyond this, ohmic resistance can be measured at both solid and liquid conductors, and internal resistance can be measured at conductive components, as long as these are capacitance and induction-free.

Measured values can be transmitted from the GEOHM®*C* to a PC via the integrated IR interface.

The following quantities can be measured and tested with the GEOHM®*C*:

- Voltage
- Frequency
- Earthing resistance
- Soil resistivity

Correct Positioning of the Earth Electrode

Earth electrodes and earthing systems must always demonstrate the lowest possible overall resistance relative to the ground reference plane in order to assure safe operation of electrical systems, and to fulfill applicable regulations.

This resistance value is influenced by the soil resistivity of the surrounding soil, which depends upon the type of soil, how wet the soil is and the time of year.

Before the location of an earth electrode or an earthing system is finally established, it is advisable to examine prevailing soil characteristics. Soil resistivity can be measured at various depths in different soil layers with the earth tester. The results indicate, for example, whether or not it would be more favorable to drive the earth electrodes deep into the soil, i.e. to use long earth electrodes, or if additional electrodes may be necessary.

Beyond this, different types of earth electrodes are available, for example earth strips, earth rods, mesh earth electrodes and earth plates, each with varying dissipation resistance values (see chapter 5.6.2 on page 19). The earth electrode with the most favorable geometry is selected depending upon soil characteristics.

Earthing System Maintenance

Previously installed earth electrodes and earthing systems can be tested to determine whether or not their resistance values exceed allowable limits, and if so whether ageing of the system and/or changing soil characteristics have contributed to this situation.

Measuring Method and Functional Principle

Earthing resistance is measured with the GEOHM®*C* by means of the ammeter-voltmeter test method.

The battery powered, potential-free constant power source (quartz-controlled square-wave generator) delivers constant current of up to 10 mA at a frequency of 128 Hz to the measuring ranges.

In the interest of safety, maximum test voltage at the terminals is limited to 50 V with reference to earth.

Constant test current travels via terminal **E** through the earth electrode whose resistance R_E is to be measured, through the auxiliary resistor R_H and finally to terminal **H**.

The voltage drop which occurs due to earthing resistance R_E, and which is measured at terminals **ES** or **E** and **S**, is first fed first to an electronic filter which is synchronous to the generator, and then to a synchronously controlled rectifier in order to eliminate influences caused by polarization voltages and stray alternating currents which are present in the soil to the greatest possible extent.

The earthing resistance to be measured is proportional to the voltage drop. It is displayed directly at the LCD in digital format.

Crucial operating conditions are continuously monitored for possible errors. The presence of interference voltage and values in excess of allowable auxiliary earth conductor resistance at the external current circuit are signaled by means of LEDs. Probe resistance at the voltage circuit is measured each time a measurement is started. If the allowable value is exceeded, the appropriate LED lights up.

Excessively low battery voltage and over-ranging are indicated at the LCD.

2 Safety Features and Precautions

The GEOHM®*C* electronic measuring and test instrument has been manufactured and tested in accordance with safety regulations IEC 61010-1/EN 61010-1/VDE 0411-1 and EN 61557.

If used for its intended purpose, safety of the operator and the instrument is assured.

Read the operating instructions carefully and thoroughly before using your instrument, and observe all instructions included therein.

Attention!
Owing to its test voltage of no more than 50 V the tester may not be used in agricultural facilities.

The measuring and test instrument may not be used:

- If the battery compartment cover has been removed
- If external damage is apparent
- With damaged connector cables and measuring adapters
- If it no longer functions flawlessly
- After excessive stress due to transport
- After lengthy periods of storage under unfavorable conditions (e.g. humidity, dust, extreme temperatures)

Meanings of Symbols on the Instrument


Warning concerning a point of danger (Attention: observe documentation!)


Protection class II device


9 V DC charging socket for NA 0100S charging adapter (article no. Z501D)


Indicates EC conformity

CAT II Overvoltage category II device

3 Terminology

In order to assure that the terminology used in these operating instructions is not misunderstood, the most important terms are defined below.

Earth: a term used as a designation for the planet Earth, as well as a connection to ground.

Ground reference plane: the zone in the ground within which no significant voltages occur between any two point as a result of earth current, especially the surface of the earth located outside of the sphere of influence of an earth electrode or earthing system (see also Figure 1 on page 6).

Earth electrode: a conductor which is embedded in, and electrically connected to ground, or a conductor which is embedded in concrete which has a large surface area in contact with the ground (e.g. a foundation)

Earth cable: a cable which is used to connect the system component to be grounded to an earth electrode, and which is laid above ground, or underground if insulated.

Earthing system: a system of electrically connected earth electrodes which is restricted to a specific local area, or other metal objects which have the same function (e.g. tower footings, armoring, metal cable jacketing and earthing blades).

Ground (verb): to connect an electrically conductive object to earth via an earthing system

Earthing: all means and measures in their entirety, which are required to ground an object

Earthing resistance R_E**:** resistance between the earthing system and the ground reference plane

Soil resistivity ρ_E**:** the specific electrical resistance of the soil. Usually defined as Ωm^2: m = Ωm, soil resistivity represents the resistance of a cube of earth along an edge with a length of 1 meter between two opposing surfaces of the cube.

Dissipation resistance R_A**:** earth resistance between the earth electrode and the ground reference plane. For all intense purposes R_A is an equivalent resistance (same as R_E).

Earth potential U_E**:** voltage which occurs between the earthing system and the ground reference plane (see also Figure 1 on page 6)

Contact voltage U_B**:** the portion of earth potential which can be short-circuited by human being (see also Figure 1 on page 6), where the current path over the human body runs from hand to foot (horizontal distance of approximately 1 meter from the accessible part), or from hand to hand.

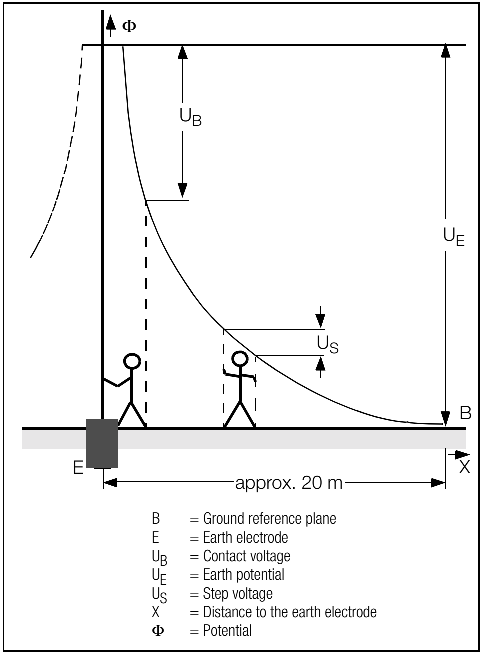
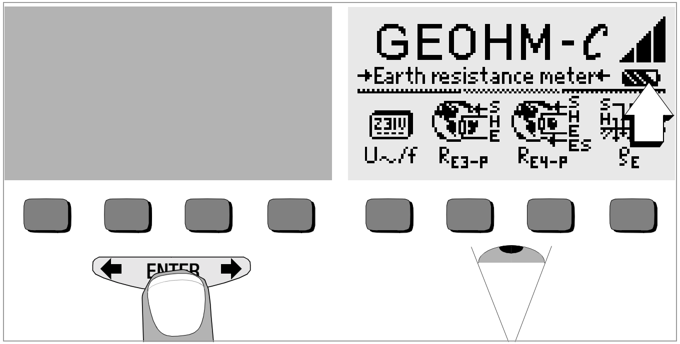


Figure 1 Ground-to-electrode potential and voltages with current carrying earth conductor

Step voltage U_S**:** the portion of earth potential which can be short-circuited by human being over a single step of 1 meter, where the current path over the human body runs from foot to foot (see also Figure 1 on page 6). No allowable limit values have been established for step voltage.

4 Initial Start-Up

4.1 Switching the Instrument On and Off



The instrument can be switched on by pressing any key.

The instrument is switched off manually by simultaneously pressing and holding the two outermost softkeys.

4.2 Battery Test

Five battery symbols ranging from depleted to fully charged continuously indicate the current battery level in the main menu.

4.3 Installing and Replacing Batteries

New batteries must be installed before initial start-up, or when **only one solid segment remains in the battery symbol**.

Attention!
The instrument must be disconnected from the measuring circuit (mains) at all poles before the battery compartment is opened.

Four 1.5 V baby cells in accordance with IEC LR14 are required for operation of the GEOHM®*C*. Use alkaline-manganese batteries only.

Rechargeable NiCd or NiMH batteries may be used as well. Be absolutely sure to refer to chapter 8.2 on page 26 regarding the charging cycle and the charging adapter.

Always replace the batteries in complete sets.

Dispose of batteries in an environmentally sound fashion.

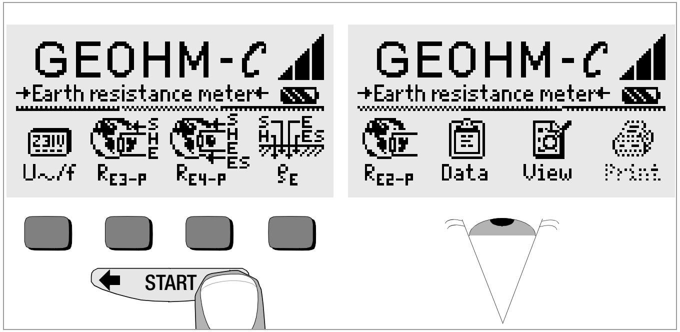
- ➪ Loosen the two slotted screws at the battery compartment cover on the housing rear panel and remove the cover.
- ➪ Insert four 1.5 V baby cells making certain the they are poled in accordance with the symbols. Insert the two batteries which are half covered by the housing first.
- ➪ Replace the cover and retighten the screws.

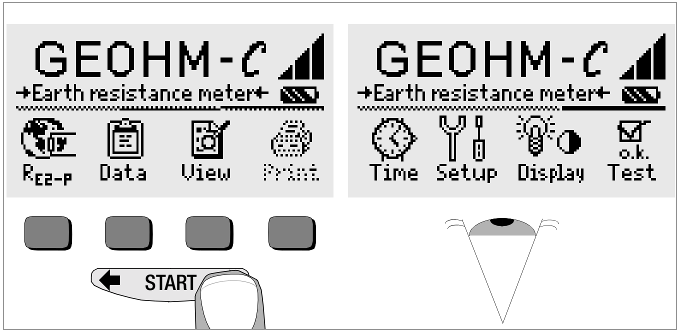
Attention!
The instrument may not be operated if the battery compartment cover has not been installed and properly tightened!

4.4 Additional User Interface Languages

User interface languages other than those included with the instrument can be uploaded with the help of a software update. Please ask for a list of currently available languages.

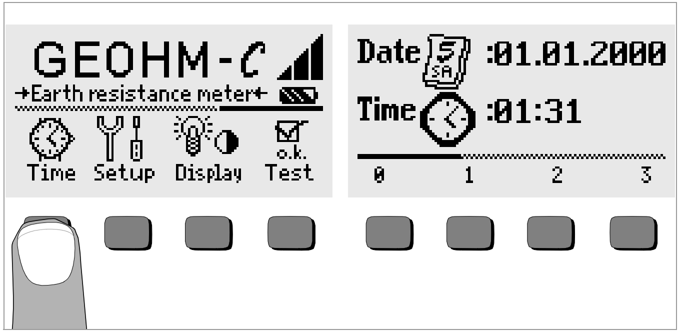
4.5 Selecting Menus and Configuring Basic Settings





Press the ← or the → key in order to display the desired measuring function, the desired device settings or the database functions.

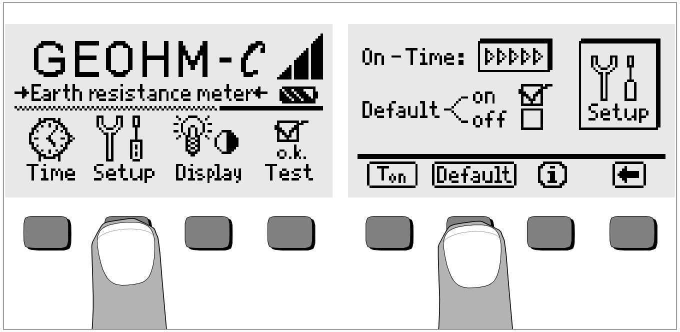
Setting the Clock



- ➪ Activate the Time key.
- ➪ The cursor appears at the first digit in the date. Enter the desired numeral with one of the softkeys.
  Numerals which do not appear can be displayed with the help of the ← or the → key. Each time a numeral is selected, the cursor moves to the next position to the right.
- ➪ Date and time are saved as soon as the last numeral has been entered.
- ➪ The setup mode is exited by pressing the **START** key and the new settings become effective.

Default Settings – Last Used Settings

A selection can be made here as to whether the menus will be displayed according to the default settings, or if the last opened menus should be displayed.



➪ Press the Setup key.

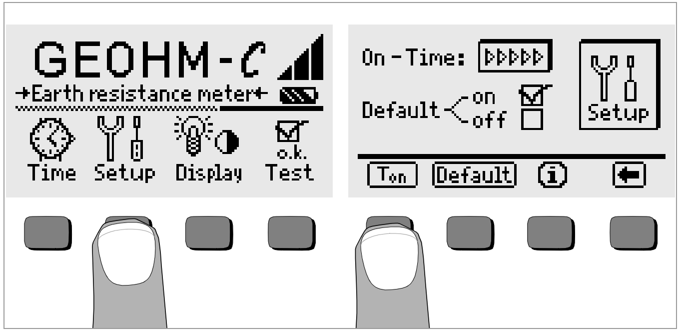
➪ Press the Default key if necessary:

on ✓ Settings such as T_{on} (20 sec.) are reset to the default settings when the instrument is switched on.

off ✓ The last used settings remain effective when the instrument is switched on.

➪ Exit the setup menu by pressing the ← key.

Setting On-Time, Manual Shutdown

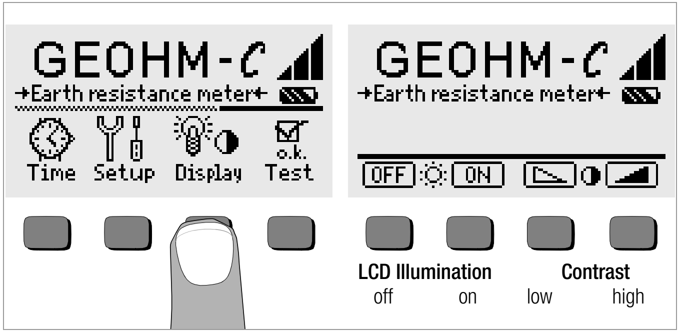


➪ Press the Setup key.

➪ Press the T_{on} key and then the 10sec, 20sec, 30sec or 60sec key depending upon the desired duration after which the test instrument should switch off automatically. Additional setting options can be displayed by activating the scroll bar with the ← or the → key.
If the “>>>>>” setting is selected, no automatic shutdown occurs.
The selected setting has a substantial influence on battery service life.

➪ Exit the setup menu by pressing the ← key.

Background Illumination and Contrast

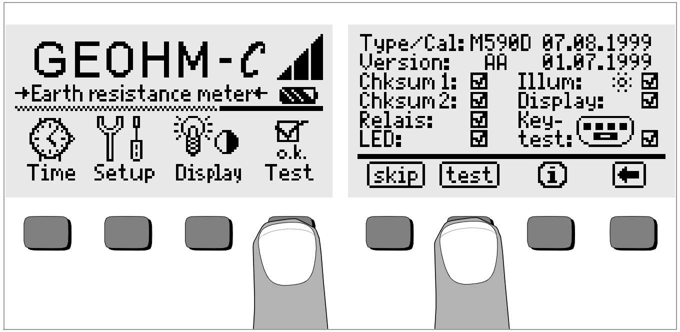


- ➪ Press the Display key.
- ➪ In order to extend battery service life, display illumination can be switched off entirely.
  Press the corresponding softkey to this end.

If LCD illumination is activated (ON), it is automatically switched off several seconds after the last key has been activated in order to extend battery service life. As soon as a key is activated again, illumination is switched back on.

- ➪ Contrast can be optimized with the two keys at the far right.
- ➪ The setup menu is exited by pressing the **START** key, and the selected settings become effective.

Self-Test



- ➪ The self-test is started from the main menu with the Test key. The test has a duration of several minutes.

The following information is displayed in the two headers:

Type/Cal: Device type / date of last calibration (balancing)
Version: Software version and issue date

Self-tests for items Chksum through LED are performed automatically, one after the other, and are checked off or marked with a horizontal dash if they are not passed.

Chksum1/2: Status display for internal testing (each test must be completed with a check mark). If not, the measuring and test instrument may no longer be used. Please contact our service center in this case.
Relays: Each relay is switched twice.
LED: The RH/RS and LIMIT LEDs each blink twice in red, and the Netz/Mains LED blinks twice in green and twice in red. The U_{noise} lamp blinks twice in red.

As soon as the tests in the left-hand column have been completed, the following tests must be started manually.

➪ **Illum:** Press the Test key twice in order to activate and deactivate display illumination.

➪ **Display:** Press the Test key after each test pattern has been displayed in order test the display elements.

➪ **Keytest:** Perform the key test by pressing each of the softkeys once, and by pressing the start key once in each of its three positions. The keys appear filled in at the key pictograph after they have been tested.

Individual tests can be skipped by pressing the skip key before starting the respective test. These tests are then identified with a horizontal dash, as is also the case for tests which have not been passed.

5 Operation

5.1 Display Functions

The following items are displayed at the LCD:

- Measured values with abbreviated designations and units of measure
- The selected function
- Error messages

During measuring sequences which are executed automatically, measured values are saved and displayed in digital format until the next measuring sequence is started, or until the instrument is shut down automatically.
If the upper measuring range limit is exceeded, the upper limit appears in the display preceded by the “>” symbol (greater than) in order to indicate over-ranging.

Attention!
Earthing resistance measurements are not valid if any of the following displays indicate the occurrence of an error before or during measurement, or if low battery voltage is indicated.

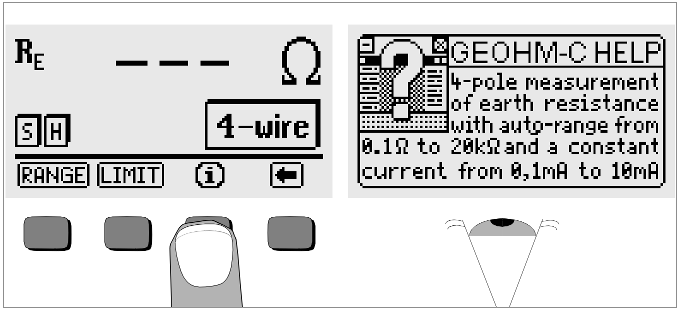
LED Functions

LED lights up red	Measuring Function	Significance	Remedy
$U_{Stör}/U_{noise}$	Interference voltage	Interference voltage in the soil to be measured exceeds the maximum value which can be compensated for by the earth tester.	Wait until the interference voltage clears on its own, or insert the test spike at a different location.
Netz/Mains	Voltage	Line voltage is present.	
LIMIT	Earthing resistance	R_E is greater than the selected limit value.	Check the limit value, improve earthing.
R_S > max	Probe resistance during power-up	Resistance exceeded at the external current circuit. Cause: open circuit, poor connection between test cable and auxiliary earth electrode or high resistance in the ground in proximity to the auxiliary earth electrode	– Reposition the spike – Moisten the soil around the auxiliary earth electrode – Use an auxiliary spike
R_H > max	Auxiliary earth electrode resistance		

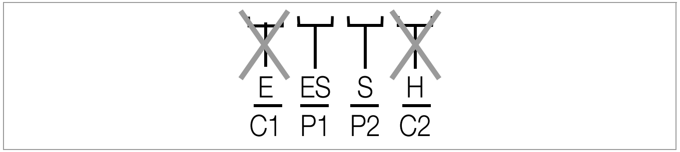
5.2 Online Help

Appropriate online help texts can be displayed at the LCD for each of the basic functions and sub-functions, **after the respective function has been selected in the corresponding menu**.

➪ Press the (i) key to query online help.
Press any key to exit the help function.

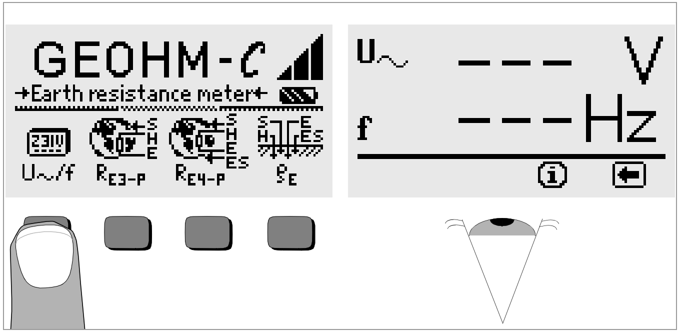


5.3 Voltage Measurement



Attention!
During voltage measurement no device may be connected to jacks E and H (or C1 and C2, respectively).

Voltage measurement between the **S** and **E/S** jacks is started automatically as soon as the voltage measuring function has been selected. Switch-over between AC and DC is performed automatically. The same applies to the polarity indication for direct voltage.

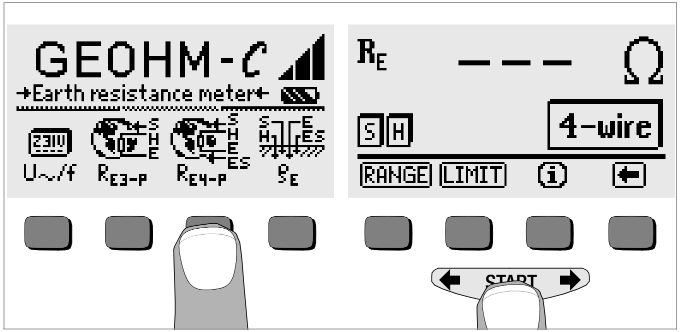


➪ Press the ⬅ key in order to return to the main menu.

5.4 Earth Resistance Measurements in General

Perform measurements as follows after setting up the measuring circuit as described in the following sections:

➪ In order to select the desired measurement type, press the **R_{E3-P}** key for 3-pole, or the **R_{E4-P}** key for 4-pole earth resistance measurement in accordance with the measuring circuit setup.



➪ Press the **START** key in order to start the measurement.

➪ Read the measured value.

➪ Check to see whether or not any errors have been indicated by means of the display functions described above.

➪ Eliminate any indicated errors and start the measurement again.

5.4.1 Configuring the Measuring Range – RANGE Function

Automatic Measuring Range Selection

If automatic measuring range selection is used, the instrument selects the highest possible current it is capable of transmitting from the earth electrode to the auxiliary earth electrode. This is a constant current with a square-wave frequency of 128 Hz. The following current values and resistance measuring values are possible:

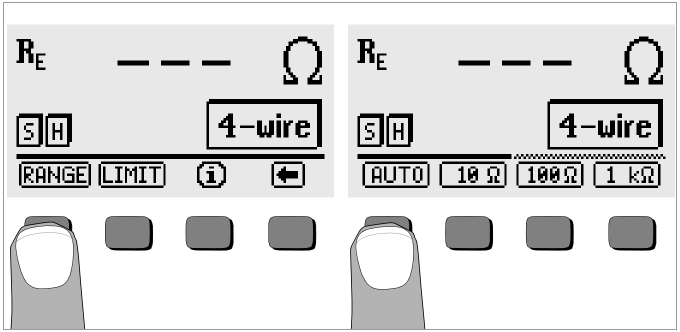
Constant Current	Resistance Measuring Range
10 mA	0.01 ... 19.99 Ω
1 mA	0.1 ... 199.9 Ω
100 µA	1 Ω ... 1.999 kΩ
100 µA	10 Ω ... 19.99 kΩ

Note

If a resolution of only 1 Ω occurs with an earthing resistance value of, for example, 1 Ω, resistance between the earth electrode and the auxiliary earth electrode is so great that a measuring current of only 100 µA is possible. Remedy: Drive the auxiliary earth electrode deeper into the ground or pour a bucket of saltwater over the auxiliary earth electrode (only effective if the soil is dry). The auxiliary earth electrode becomes less resistive as a result and is capable of conducting a larger test current. Probe resistance is less critical, although a bucket of water may also be helpful if the soil is dry. Earthing resistance is not influenced by these measures. However, the earth electrode may not be artificially watered, because this would simulate optimized conditions for the measurement.

Manual Measuring Range Selection

As a rule, you will not need to use manual measuring range selection unless no measurement value is displayed, or if greatly fluctuating measurement values occur with automatic range selection. In extreme cases, superimposed interference voltages may make it impossible for the automatic range selection function to find a suitable measuring range, and may result in continuous error messages. A suitable measuring range can be selected manually in such cases. However, extreme fluctuations in earthing resistance can only be eliminated by moving the measuring point to a different location.



- Press the RANGE key.
- Select a suitable measuring range.
- Start the measurement as described above.

Note

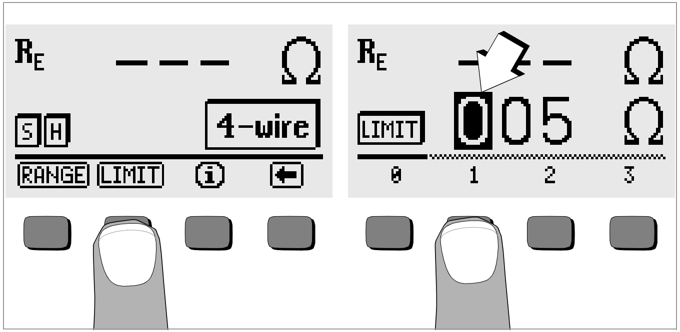
When the measuring range is selected manually, it must be kept in mind that the specified accuracy values are only valid as of measured values of at least 5% of the upper range limit (except in the 10 Ω range: separate specification for small values).

The measuring range can be set as high as 50 kΩ by means of manual measuring range selection.

5.4.2 Setting a Limit Value – LIMIT Function

If required, an earthing resistance limit value R_E can be selected by pressing the LIMIT key. If measured values in excess of this limit value occur, the red LIMIT LED lights up.

Activate the limit value menu. **Set the limit value.**



Setting the Limit Value:
Display the desired numeric value and a decimal point if required with the help of the ⬅ and the ➡ keys, and select the value with the corresponding softkey. The cursor moves one place to the right after each selection has been made. After entries have been made for a maximum of 3 places, and after either Ω or kΩ has been selected, the entry window is exited automatically. The cursor can be moved one place to the right or the entry window can be exited during data entry by pressing the → softkey. The selected limit value is automatically saved to memory when the entry window is exited.

5.5 Measuring Earthing Resistance

5.5.1 Measuring Circuit Setup, Measuring Instructions

3-Wire Connection

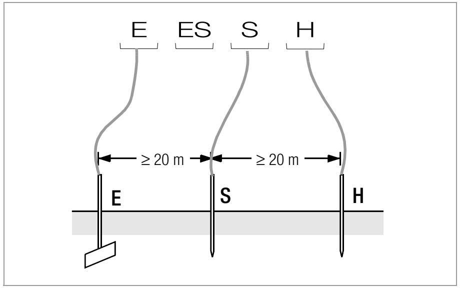


Figure 2 Measuring Earthing Resistance with a 3-Wire Test Setup

- ➪ Position the probe at least 20 meters, and the auxiliary earth electrode at least 40 meters from the earth electrode (see also Figure 2 on page 14).
- ➪ Make sure that contact resistance between the probe and the soil is not too great.
- ➪ If a 3-wire test setup is utilized, the earth electrode is connected to jack "**E**" at the test instrument with a measurement cable, the probe is connected to jack "**S**" and the auxiliary earth electrode is connected to jack "**H**".
- ➪ Press the $\mathbf{R_{E3\text{-}P}}$ key in order to select 3-wire connection.

Resistance of the cable from the earth electrode to the instrument has a direct influence on measuring results.

In order to minimize error caused by measurement cable resistance, a short cable with a large cross section should be used to connect the earth electrode to jack "**E**" for measurements performed with a 3-wire setup.

Connector cable resistance can be measured with the 2-wire method (see chapter 5.7 on page 20).

Note
Measurement cables must be well insulated in order to avoid shunting. In order to reduce coupling influence to a minimum, measurement cables should neither cross one another, nor should they run parallel to each other over long distances.

Measurement is performed as described in chapter 5.4 on page 12.

4-Wire Connection

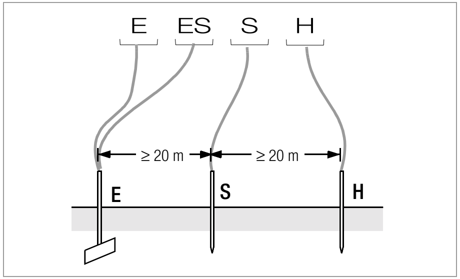


Figure 3 Measuring Earthing Resistance with a 4-Wire Test Setup

4-wire connection is used in the event of excessive cable resistance between the earth electrode and the test instrument.

- ➪ Position the probe at least 20 meters, and the auxiliary earth electrode at least 40 meters from the earth electrode (see also Figure 3 on page 15).
- ➪ Make sure that contact resistance between the probe and the soil is not too great.
- ➪ The earth electrode is connected to jacks "**E**" and "**ES**" with separate cables for 4-wire connection, the probe is connected to jack "**S**" and the auxiliary earth electrode is connected to jack "**H**".
- ➪ Press the R_{E4-P} key in order to select 4-wire connection.

Cable resistance from the earth electrode to jack "**E**" at the instrument is not included in the measurement with this test setup.

Note
Measurement cables must be well insulated in order to avoid shunting. In order to reduce coupling influence to a minimum, measurement cables should neither cross one another, nor should they run parallel to each other over long distances.

Measurement is performed as described in chapter 5.4 on page 12.

Potential Gradient

Suitable positioning of the probe and the auxiliary earth electrode can be determined by observing voltage characteristics and dissipation resistance in the ground.

The test current which is generated by the test instrument and conducted through the earth electrode and the auxiliary earth electrode causes voltage distribution around the earth electrode and the auxiliary earth electrode in the form of a potential gradient (see also Figure 5 on page 16). Resistance distribution is analog to voltage distribution.

Earth electrode and auxiliary earth electrode dissipation resistance are generally different. For this reason, the two potential gradients are not symmetrical.

Dissipation Resistance of Earth Electrodes with Minimal Spread

Positioning of the probe and the auxiliary earth electrode is extremely important for correct determination of earth electrode dissipation resistance. The probe must be positioned between the earth electrode and the auxiliary earth electrode in the so-called ground reference plane (see also Figure 4 on page 16).

The characteristic resistance curve is thus practically horizontal within the ground reference plane.

Proceed as follows in order to select suitable probe and auxiliary earth electrode resistances:

- ➪ Position the auxiliary earth electrode approximately 40 meters from the earth electrode.
- ➪ Position the probe halfway between the earth electrode and the auxiliary earth electrode and measure earthing resistance.
- ➪ Move the probe from its original position 2 to 3 meters closer to the earth electrode, and then 2 to 3 meters closer to the auxiliary earth electrode, and measure earthing resistance at each position.

If the same measured value results from all 3 measurements, the correct earthing resistance value has been obtained and the probe is in the ground reference plane.
However, if these 3 measured values differ from one another, either the probe is not in the ground reference plane, or the characteristic resistance curve is not horizontal at the point at which the probe has been driven into the ground.

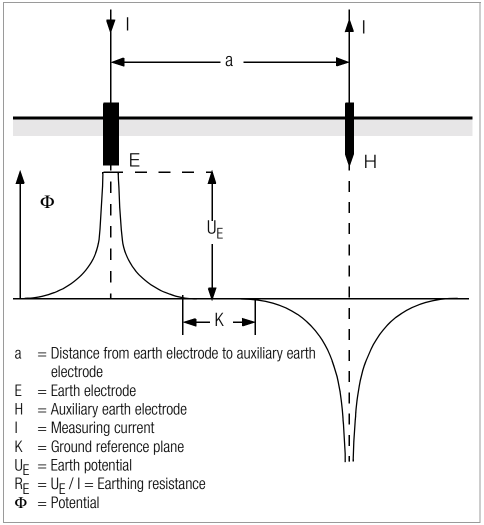
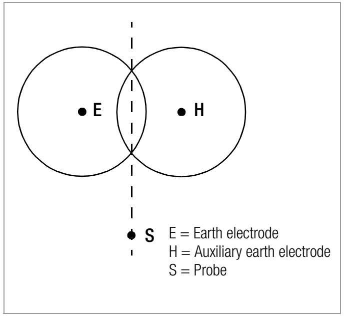


Figure 4 Characteristic Voltage Curve in Homogenous Soil between Earth Electrode E and Auxiliary Earth Electrode H



In such cases, correct measurement results can be obtained either by increasing the distance between the earth electrode and the auxiliary earth electrode, or by moving the probe along the vertical line between the earth electrode and the auxiliary earth electrode (see also Figure 5 on page 16). Moving the probe along this vertical line removes it from the zones of influence of the earth electrode and the auxiliary earth electrode.

Figure 5 Probe S lies outside of the overlapping potential gradients on a vertical line between earth electrode E and auxiliary earth electrode H.

Dissipation Resistance of Earth Electrodes with Large Spread

Significantly greater distances to the probe and the auxiliary earth electrode are required for measurements performed at larger earthing systems. Distances of 2.5 and 5 times the largest diagonal included in the earthing system are used.
It is especially important to position the probe within the ground reference plane for measurements at large earthing systems, because they frequently demonstrate dissipation resistances of only a few ohms or less. The probe and the auxiliary earth electrode should be positioned at a right angle to the largest longitudinal extension of the earthing system. Dissipation resistance must be kept to a minimum, and several earth spikes should be used if necessary and connected to each other (at a distance of 1 to 2 meters from one another).
However, larger distances to the probe are frequently impossible in practice due to physical obstacles.
If this is the case, proceed as shown in Figure 6 on page 17.

- ➭ Auxiliary earth electrode H is positioned as far as possible from the earthing system.
- ➭ The area between the earth electrode and the auxiliary earth electrode is measured at equidistant points (in steps of approx. 5 meters).

➭ Measured resistance values are subsequently displayed as a table, and then as a graphic representation (curve I in Figure 6 on page 17).

If a parallel line is drawn through inflection point S1 to the abscissa, the resistance curve is divided into two parts by this line.
Measured from the ordinate, the bottom portion results in the sought after dissemination resistance of the earth electrode $R_{A/E}$. The upper value represents dissemination resistance of the auxiliary earth electrode $R_{A/H}$. The dissemination resistance of the auxiliary earth electrode should be less than 100 times the dissemination resistance of the earth electrode with a test setup of this type.
If the characteristic resistance curve does not include a well defined horizontal section, measurement should also be performed after changing the position of the auxiliary earth electrode. The new characteristic resistance curve must then be entered to the first diagram and the abscissa scale must be changed such that both auxiliary earth electrode positions are identical. The originally determined dissemination resistance value can be double-checked with deflection point S2 (see also Figure 6 on page 17).

Instructions for Measurements on Unfavorable Terrain

In the event of extremely unfavorable terrain (e.g. sandy ground after a lengthy dry period), auxiliary earth electrode and probe resistance values can be reduced to allowable values by watering the ground around the auxiliary earth electrode and the probe.
If this watering is not sufficient, several earth spikes can be connected to the auxiliary earth electrode in parallel.
In mountainous terrain or if the ground is quite rocky and spikes cannot be driven into the earth, a wire mesh with a mesh size of 1 cm and a surface area of approximately 2 square meters can be used. The wire mesh must be laid flat onto the ground and doused with soda water or saltwater, and may also be weighted down with sacks full of moist soil.

Curve I (CI)		Curve II (CII)	
m	Ω	m	Ω
5	0.9	10	0.8
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	200	100

S1, S2 = Inflection point
CI = Curve I
CII = Curve II

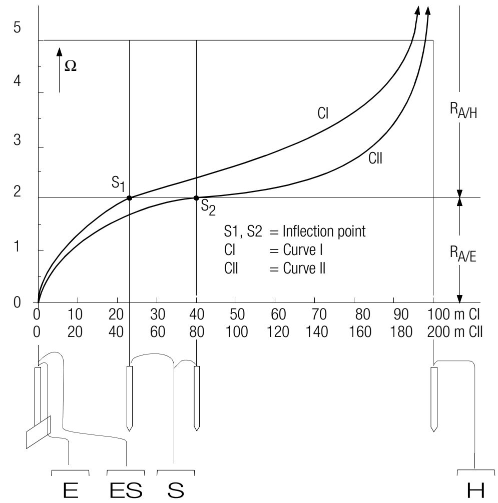


Figure 6 Measuring Earthing Resistance at a Large Earthing System

5.6 Measuring Soil Resistivity

The dissemination resistance value of a given earth electrode is dependent upon soil resistivity. Soil resistivity must be known in order to allow for advance calculation of dissemination resistance for the design of earthing systems.

Soil resistivity ρ_E (see also chapter 3 on page 6) can be measured with the GEOHM®*C* earth tester in accordance with the Wenner method.

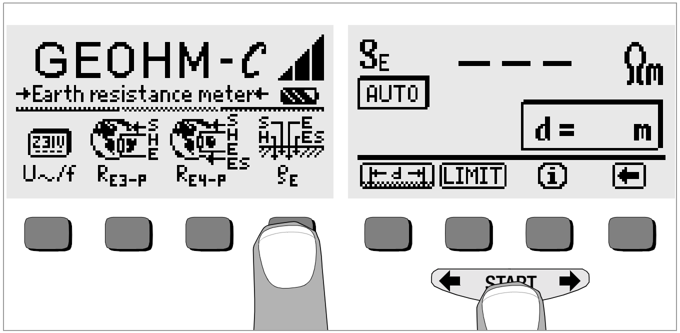
Four earth spikes of greatest possible length are driven into the ground in a straight line separated from one another by distance a, and are connected to the test instrument (see Figure 7).

The earth spikes are usually 30 to 50 cm long. Longer earth spikes can be used in poorly conducting soils (sandy soil etc.). The depth to which the earth spikes are driven into the ground may not exceed 1/20 of distance a.

Note

Erroneous measurement results may occur if pipes, cables or other metallic underground lines run parallel to the measuring circuit.

Measurement is performed as described in chapter 5.4 on page 12. Enter distance a, and soil resistivity is displayed.



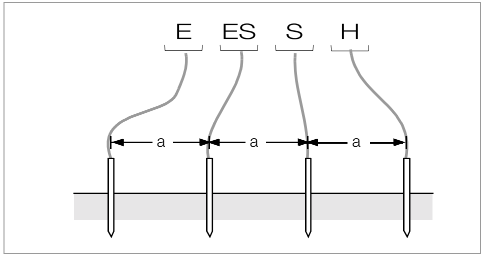


Figure 7 Measuring Soil Resistivity

Soil resistivity is calculated in accordance with the following formula:

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

where:

π = 3.1416

a = distance between earth spikes in meters

R = calculated resistance value in Ω (this value corresponds to R_E as determined by means of the 4-wire measurement setup)

5.6.1 Geologic Surveys

Except in extreme cases, soil is measured to a depth which is approximately equivalent to distance a between the earth spikes.

It is thus possible to draw conclusions concerning various layers within the ground by varying the distance between the earth spikes. Highly conductive layers (water table) within which earth electrodes are best positioned can thus be located within otherwise poorly conducting surroundings.

Soil resistivity is subject to great fluctuation which may result from various conditions such as porosity, moistness, concentration of salts dissolved in ground water and climatic fluctuations.

Soil resistivity ρ_E characteristics as influenced by season (ground temperature and negative temperature coefficient of the ground) closely resemble a sine wave.

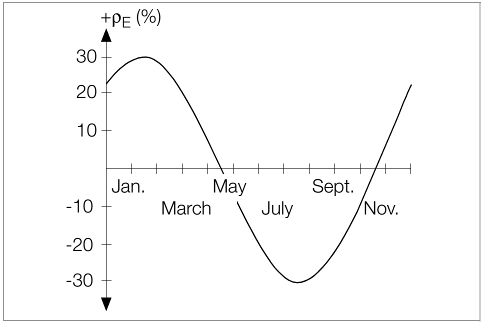


Figure 8 Soil resistivity ρE in as influenced by season without taking precipitation into consideration (earth spike depth < 1.5 m)

The following table shows typical soil resistivity for several types of soil.

Type of Soil	Soil Resistivity ρ_E [Ωm]
Wet bog soil	8 … 60
Arable fields, loam and clay, moist gravel	20 … 300
Moist, sandy soil	200 … 600
Dry sandy soil, dry gravel	200 … 2000
Rocky ground	300 … 8000
Bedrock	10^4 … 10^{10}

Table 1 Soil Resistivity ρ_E for Various Types of Soil

5.6.2 Calculating Dissemination Resistance

The following table includes formulas for calculating dissemination resistance for various types of earth electrodes.
These rule-of-thumb formulas are entirely adequate for practical application.

Number	Earth Electrode Type	Formula	Auxiliary Information
1	Earth strip (crow's foot earth electrode)	$R_A = \frac{2 \cdot \rho_E}{l}$	—
2	Earth rod	$R_A = \frac{\rho_E}{l}$	—
3	Ring earth electrode	$R_A = \frac{2 \cdot \rho_E}{3D}$	$D = 1.13 \cdot \sqrt[2]{F}$
4	Mesh earth electrode	$R_A = \frac{2 \cdot \rho_E}{2D}$	$D = 1.13 \cdot \sqrt[2]{F}$
5	Earth plate	$R_A = \frac{2 \cdot \rho_E}{4{,}5 \cdot a}$	—
6	Hemispherical earth electrode	$R_A = \frac{\rho_E}{\pi \cdot D}$	$D = 1.57 \cdot \sqrt[3]{J}$

Table 2 Formulas for the Calculation of Dissemination Resistance R_A for Various Types of Earth Electrodes

R_A = Dissemination resistance (Ω)
ρ_E = Soil resistivity (Ωm)
l = Earth electrode length (m)
D = Ring earth electrode diameter, diameter of the equivalent circular area of a mesh earth electrode or diameter of a hemispherical earth electrode (m)
F = Surface area (square meters) enclosed by a ring or a mesh earth electrode
a = Edge length (m) of a rectangular earth plate, a is defined as follows for rectangular earth plates: $\sqrt{b \times c}$, where b and c are the two sides of the rectangle.
J = Volume (cubic meters) of an individual foundation

5.7 Measuring Ohmic Resistance

The resistance of liquid and solid conductors can be measured with the GEOHM®C earth tester, as long as they are capacitance and induction-free.

5.7.1 2-Wire Connection

➩ Connect the resistance to be measured R_X between jacks **E** and **H**.

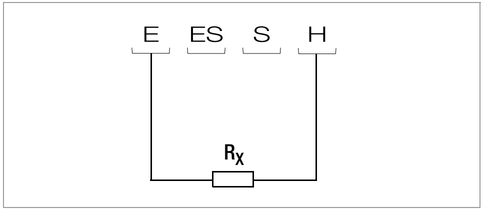
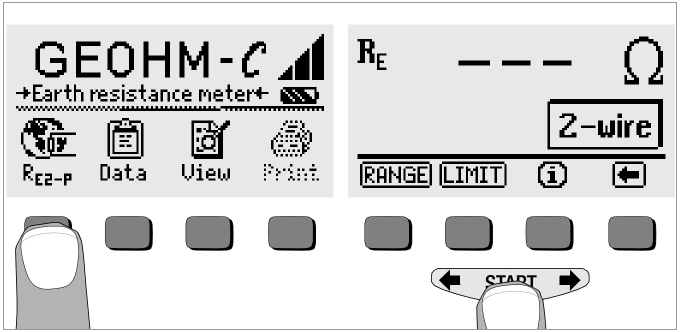


Figure 9 Measuring Ohmic Resistance with a 2-Wire Test Setup



> **Note**
> Cable resistance can be measured with this test setup.

5.7.2 4-Wire Connection

➩ Use 4-wire connection if cable resistance is not to be included in the measurement results.

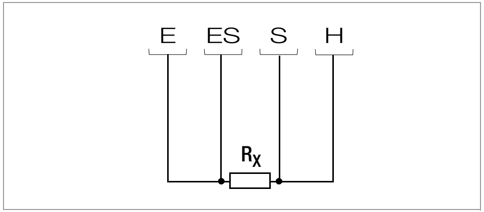
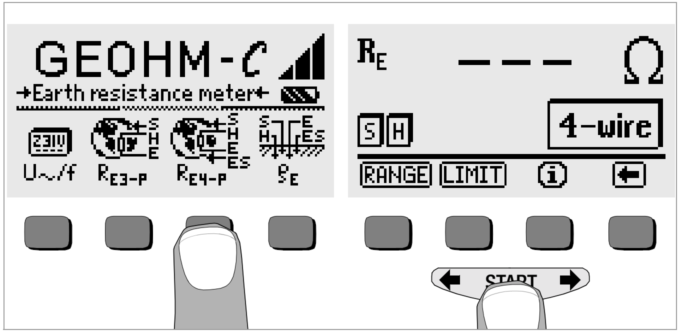


Figure 10 Measuring Ohmic Resistance with a 4-Wire Test Setup

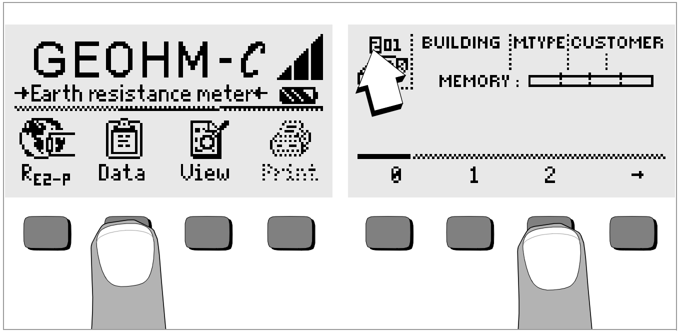


6 Database Function

Displayed measurement data can be saved individually for each measurement to the internal database either with or without a comment. In order to assign the individual measured values to various buildings, customers etc., a data record must first be created with its own memory address.

6.1 Creating a Data Record – Data Function

➪ Press the data softkey.



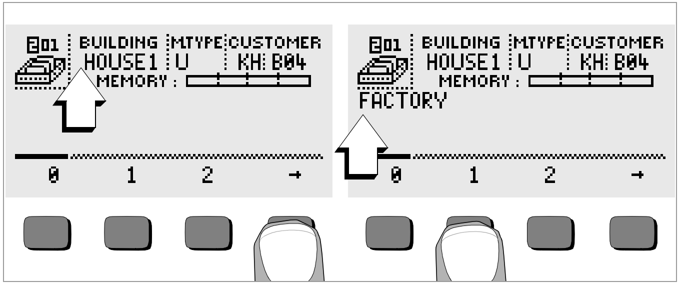
➪ First, enter the desired memory address with the softkeys. After acknowledging this entry with the **START** key (press at center), the cursor appears at the first entry position (BUILDING).

No entry is required for the customer ID field, as long as measurements are only performed for a single company.

The M-TYPE field (measurement type) is used to designate what kind of measurement is involved. This entry is required in order to generate a report with PS3 test instrument software for lightning protection systems.

M-TYPE Setting	Significance
D	Continuity to metallic installations
DG	Continuity to metallic gas lines
DW	Continuity to metallic water lines
DL	Continuity to metallic ventilation systems
D1, D2, D3, D4	Continuity to other, user-defined types of metallic systems
U	Contact resistance measurement at all measuring points in order to determine continuity of all conductors. The number assigned to the measurement designates resistance between specific test joints, e.g. measurement number 1 indicates resistance between test joints 1 and 2, measurement 2 between test joints 2 and 3 etc.
E	Measurement of earth dissemination resistance from individual earth electrodes with open test joints
!	Measurement of earth dissemination resistance for the entire system with closed test joints

➪ Entries can be made to the BUILDING, M-TYPE and CUSTOMER ID fields one after the other, and a building designation can be entered with the help of the softkeys.



Data Entry:
The desired alphanumeric characters can be displayed with the help of the ⬅ and ➡ keys, and then selected with the appropriate softkey.
Control characters are entered in the same way and have the following functions:
←: Move cursor to the left (without deleting characters)
→: Move cursor to the right (without deleting characters)
↲: Same function as the **START** key

After a character has been selected, the cursor moves one place to the right. If the ↲ character is entered or the **START** key is pressed (press at center), the cursor moves to the next field. After the BUILDING, M-TYPE and CUSTOMER-ID fields have been completed and entries have been acknowledged with the ↲ command, they are highlighted at the display. After acknowledging once more with the ↲ character, a designation for the currently selected building can be entered.

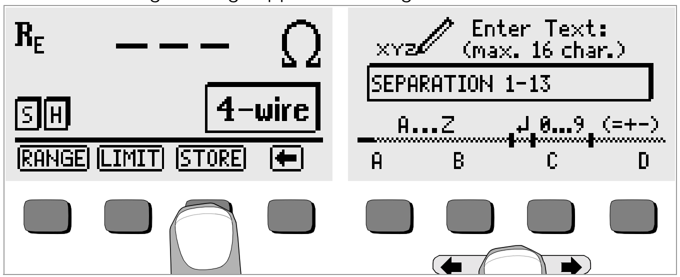
Note
This information is required by the PC software in order to enter measured values to the database, as well as for automatic generation of reports.

6.2 Saving Measured Values to Memory – STORE Function

➪ Start the desired measurement. The STORE softkey is displayed after the measurement instead of the INFO key.
The STORE key is not displayed until after a given amount of time has elapsed for measurements which are performed without the **START** key, so that the operator can first query the help text with the INFO key.

➪ The displayed measurement values are stored to the currently selected database memory address by briefly acknowledging with the STORE key. The key is briefly displayed as an inverse image during storage to memory.

➪ Pressing and holding the STORE key allows for the entry of a comment, and storage of the current measurement.
Entering a Comment:
Display the desired alphanumeric character with the ⬅ or the ➡ key and select the desired character with the corresponding softkey.
Control characters are displayed in the same way and have the following functions:
←: Backspace and delete
↲: Same function as the **START** key
After each character has been selected, the cursor moves one place to the right. Already entered characters can be deleted in reverse by pressing and holding any softkey (except for ↲).
After entry of up to 15 characters, save the measurement values and the comment by acknowledging with the **START** key (press at center) .
The following message appears: “Saving data”.

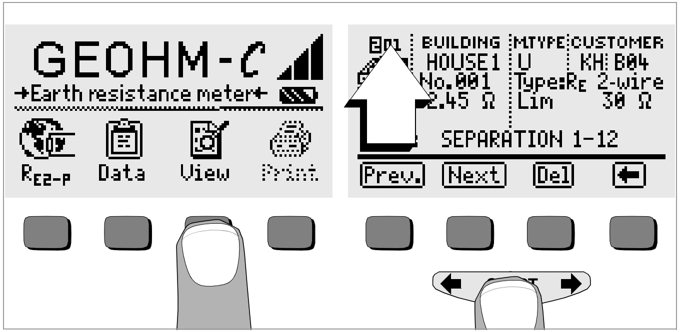


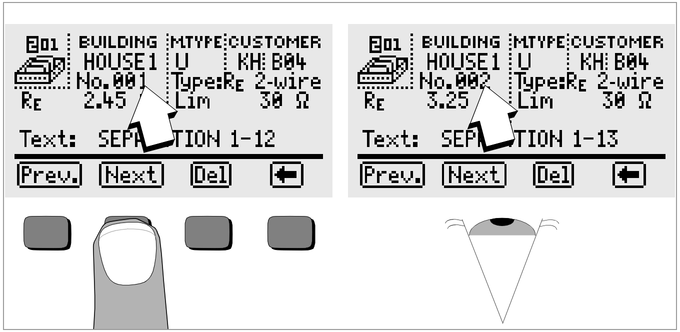
6.3 Querying Data Records – View Function

➪ Press the View key.

➪ You can scroll forward through the memory addresses with the ➡ key, or backwards with the ⬅ key.

➪ After the memory address has been opened, the individual data records which have been stored to memory along with consecutive numbers can be queried with the Prev. and Next softkeys.

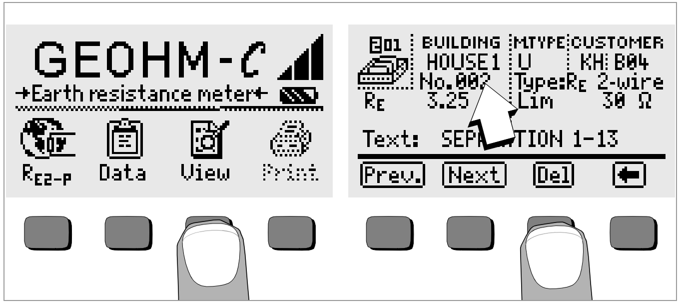




If you discover that a measurement value for the currently selected earthing system is missing, the required measurement can be performed immediately.

6.3.1 Deleting a Data Record from within a Memory Address – View Function

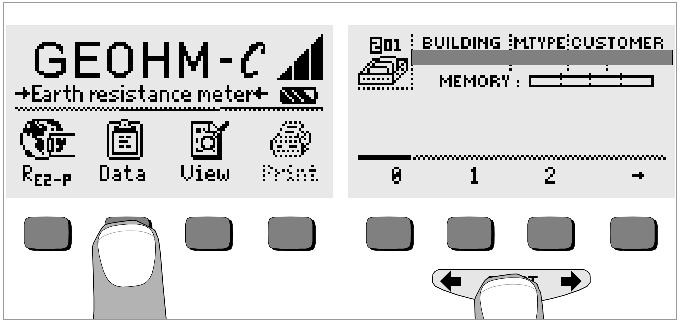
➪ Press the Del key. No security requests appear.
Data record numbering is changed as soon as an individual data record is deleted.



6.3.2 Deleting a Memory Address – Data Function

➪ Press the Data key.

➪ Enter blanks to the data fields BUIDLING, M-TYPE and CUSTOMER ID. After these fields have been entirely overwritten with blanks, they are displayed as inverse images.

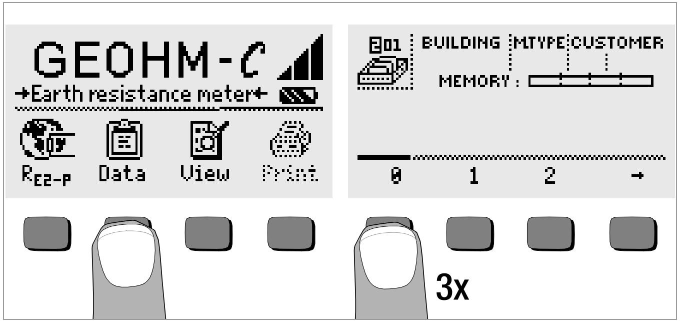


➪ Acknowledge with the **START** key (press at center). All data from the selected memory address are deleted.

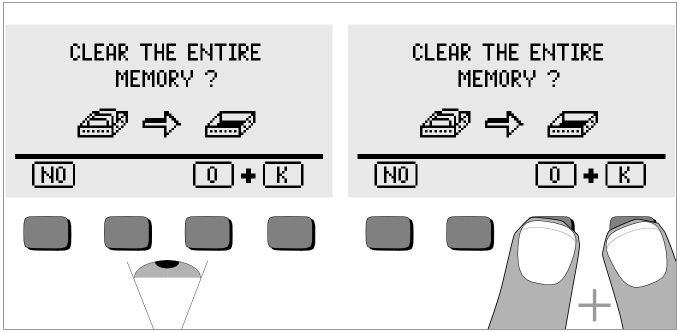
6.3.3 Delete All Memory Addresses – Data Function

Up to 250 data records can be stored to memory. The memory is full when the triangle to the right of the "MEMORY:" parameter is entirely filled in. The entire memory, i.e. all data records from all memory addresses, can be deleted at once. We recommend uploading and saving your data to a PC before deletion.

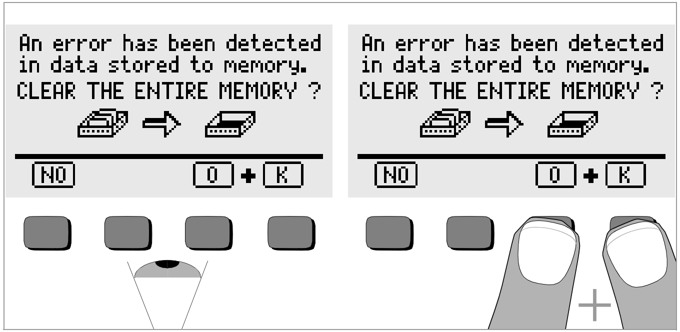
➩ Press the Data key.



➩ Enter memory address "000". A security request appears after acknowledgement with the **START** key (press at center).



➩ Acknowledge by simultaneously pressing O and K to delete all data from memory. The indicator to the right of the "MEMORY:" parameter appears empty. Memory address "001" is displayed at the left. New data can now be entered for this address, or the database can be exited (press ↵ or **START** 9 times).



If the message shown above appears when the test instrument is switched on, you are provided with the opportunity of uploading and saving all data to a PC before deleting the memory in order to correct the error.

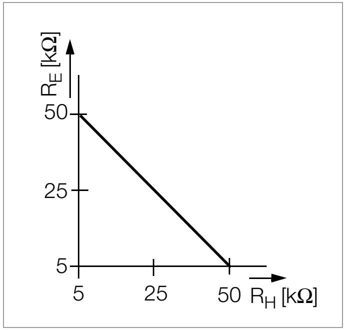
6.4 Print Function

Functions whose symbols appear in gray or which are displayed faintly, will not be available until after the next software update.

7 Characteristic Values

Meas. Qty.	Display range	Measuring Range	Impedance, Test Current	Intrinsic Error	Measuring Error
R_E	0.01 ... 20 Ω 0.1 ... 200 Ω 1 Ω ... 2 kΩ 10 Ω ... 20 kΩ 10 Ω ... 50 kΩ	1.0 ... 20 Ω 5 ... 200 Ω 50 Ω ... 2 kΩ 500 Ω ... 20 kΩ 500 Ω ... 50 kΩ [1]	10 mA 1 mA 100 µA 100 µA 100 µA	±(3%rdg.+6d)	±(10% rdg. + 6d) ±(10% rdg. + 6d) ±(10% rdg. + 6d) ±(10% rdg. + 6d) ±(16% rdg. + 10d)
U⎓ [2]	1.0 ... 99.9 V 100 ... 250 V	10 ... 250 V	500 kΩ	±(2%rdg.+2d)	±(4% rdg. + 3d)
U~ [3]	0 ... 99.9 V 100 ... 300 V				
f [3]	15 ... 99.9 Hz 100 ... 400 Hz	45 ... 200 Hz	500 kΩ	±(0.1%rdg.+1d)	±(0.2% rdg. + 1d)

[1] Manual measuring range selection only, for resistance measurements see chapter 5.7
[2] as from software version AD
[3] For sinusoidal measured quantities only



Output Voltage max. 50 V_{TRMS} at 128 Hz ±0.5 Hz

Reference Conditions

Ambient Temperature	23 °C ±2 K
Relative Humidity	40% … 60%
Battery Voltage	5.5 V ±1%
Line Frequency	50 Hz ±0.2 Hz
Line Voltage Waveshape	sine (deviation between effective and rectified value < 1%)

Nominal Conditions of Use

Series Mode Interference Voltage	< 3 V AC DC
Additional Error due to Probe and Aux. Earth Electrode Resistance	< 5% pf (R_E+R_H+R_S)
Max. Probe Resistance	< 70 kΩ
Max. Auxiliary Earth Electrode Resistance	< 50 kΩ
Max. Earth and Auxiliary Earth Electrode Resistance	≤ 50 kΩ, see graph R_E as a function of R_H

Ambient Conditions

Nominal Range of Use	0 °C … +40 °C
Operating Temperature	–10 °C … +50 °C
Storage Temperature	–20 °C … +60 °C (without batteries)
Relative Humidity	max. 75%, no condensation allowed
Elevation	to 2000 m

Power Supply

Batteries	4 ea. 1.5 V baby cell (4 x C-size) (alkaline manganese per IEC LR14)
Battery Voltage	4.6 … 6.5 V
Battery Service Life	30 hours or 1000 measurements at R_E (with 10 s on-time and automatic device shutdown after each measurement, without display illumination)
Rechargeable Batteries	NiCd or NiMH
Battery Charger (not included)	NA 0100S (article no. Z501D), 3.5 mm jack plug
Charging Voltage / Time	9 V / approx. 14 hours

Due to their reduced charging capacity, fewer measurements can be performed with rechargeable batteries than with normal batteries as a rule.

Electrical Safety

Safety Class	II per IEC 61010-1
Operating Voltage	300 V
Test Voltage	2.3 kV
Overvoltage Category	II
Fouling Factor	2
Fuse	F0.1H250V
Electromagnetic Compatibility (EMC)	IEC 61326/EN 61326

Data Interface

Type	infrared interface (SIR/IrDa) bidirectional, half-duplex
Format	9600 baud, 1 start bit, 1 stop bit, 8 data bits, no parity, no handshake
Range	max. 10 cm, recommended distance: < 4 cm

Mechanical Design

Display	dot matrix: 64 x 128 pixels, illuminated
Protection	housing: IP 54 per EN 60529
Dimensions	275 mm x 140 mm x 65 mm (without measurement cables)
Weight	approx. 1.2 kg with batteries

Display Values including Allowances for Measuring Error

Table for the determination of maximum display values for low earth resistances by making allowances for the tester's measuring error:

Limit Value	Maximum Display Value	Limit Value	Maximum Display Value
1.00 Ω	0.84 Ω	50.0 Ω	44.4 Ω
2.00 Ω	1.74 Ω	100 Ω	89.4 Ω
5.00 Ω	4.44 Ω	500 Ω	444 Ω
10.0 Ω	8.94 Ω	1.00 kΩ	894 Ω
20.0 Ω	17.4 Ω	5.00 kΩ	4.44 kΩ

8 Maintenance

8.1 Housing

No special maintenance is required for the housing. Keep outside surfaces clean. Use a slightly dampened cloth and/or a special purifier for synthetic material for cleaning. Avoid the use of cleansers, abrasives and solvents.

Attention!
For the following reasons, the housing may not be opened by the operator:
– Unexpected problems may occur during reassembly.
– Sealing requirements are no longer fulfilled.

8.2 Battery Operation

When only one solid segment remains in the battery symbol, the batteries must be replaced, or recharged if rechargeable batteries are used.

Attention!
Before opening, the instrument must be completely disconnected from all external electrical circuits!

Check the batteries at short, regular intervals or after lengthy periods of storage to make sure no leakage has occurred. If leakage has occurred, the electrolyte must be carefully and completely removed from the instrument with a damp cloth before new batteries are installed.

Charging the Batteries

Attention!
Use only the Z501D battery charger with safe electrical isolation and a nominal secondary voltage of 9 V DC to recharge the batteries.
Before connecting the battery charger to the charging socket at the instrument, make sure of the following points:
– **Rechargeable batteries have been installed (not normal batteries).**
– The instrument has been disconnected from the measuring circuit at all poles.
– The voltage selector at the charger has been set to 9 V.

Connect the Z501D battery charger to the charging socket with the 3.5 mm jack plug. Set the voltage selector switch at the Z501D to 9 V. Switch the test instrument on.

The test instrument recognizes the fact that a battery charger has been connected and starts the charging cycle. The 5 segments of the battery symbol are continuously displayed in a sweeping pattern from left to right for the entire duration of the charging cycle.

Depleted batteries require a charging cycle of approximately 14 hours. If the batteries are exhausted to a great enough extent, the test instrument can no longer be switched on. If this is the case, leave the test instrument connected to the activated battery charger for about 30 minutes, and then proceed as described above.

Storing the Rechargeable Battery Pack

1 year	at –20 … +35 °C
3 months	at –20 … +45 °C
1 month	at –20 … +55 °C

Replacing the Rechargeable Battery Pack

- ➪ Loosen the two slotted screws at the battery compartment cover on the housing rear panel and remove the cover.
- ➪ Insert the rechargeable battery pack making certain it is poled in accordance with the symbols.
- ➪ Replace the cover and retighten the screws.

Attention!
The instrument may not be operated if the battery compartment cover has not been installed and properly tightened!

Battery Disposal

Dispose of depleted batteries in an environmentally sound fashion, i.e. bring them to an official collection center.

8.3 Fuses

If the fuse has blown due to an overload, an appropriate error message appears at the LCD (R_H > max). However, the instrument's voltage measuring range is still functional.

Replacing the Fuse

The fuse can be accessed easily from the outside of the instrument, and is located to the left of the charging socket.

- ➪ Remove the threaded fuse cap with the help of a suitable tool (e.g. a screwdriver) by pressing and turning counterclockwise.

Attention!
Incorrect fuses may cause severe damage to the test instrument.
Only original fuses from GOSSEN METRAWATT GMBH assure the required protection by means of suitable breaking characteristics (article no. 3-578-235-01).
Bridging or repairing fuses is prohibited!
The instrument may be damaged if fuses with other current ratings, blowing or breaking characteristics are used!

- ➪ Remove the defective fuse and replace it with a new replacement fuse. Replacement fuses are located in the battery compartment.
- ➪ Insert the new fuse and the cap together, and lock into place by turning clockwise.
- ➪ Replace the battery compartment cover and secure with the screws.

9 Repair and Replacement Parts Service, DKD Calibration Lab* and Rental Instrument Service

If required please contact:

GOSSEN METRAWATT GMBH
Service Center
Thomas-Mann-Str. 20
90471 Nürnberg, Germany
Phone: +49 911 86 02 - 410 / 256
Fax +49 911 86 02 - 2 53
E-mail: service@gmc-instruments.com

This address is only valid in Germany.

Please contact our representatives or subsidiaries for service in other countries.

* **DKD Calibration Laboratory for Electrical Quantities DKD–K–19701 accredited per DIN EN ISO/IEC 17025**

Accredited measured quantities: direct voltage, direct current values, DC resistance, alternating voltage, alternating current values, AC active power, AC apparent power, DC power, capacitance and frequency

Competent Partner

GOSSEN METRAWATT GMBH is certified in accordance with DIN EN ISO 9001:2000.

Our DKD calibration laboratory is accredited by the Physikalisch Technische Bundesanstalt *(German Federal Institute of Physics and Metrology)* and the Deutscher Kalibrierdienst *(German Calibration Service)* in accordance with DIN EN ISO/IEC 17025 by under registration number DKD–K–19701.

We offer a complete range of expertise in the field of metrology: from **test reports** and **proprietary calibration certificates** right on up to **DKD calibration certificates**.

Our spectrum of offerings is rounded out with free **test equipment management**.

An **on-site DKD calibration station** is an integral part of our service department. If errors are discovered during calibration, our specialized personnel are capable of completing repairs using original replacement parts.
As a full service calibration laboratory, we can calibrate instruments from other manufacturers as well.

10 Product Support

If required please contact:

GOSSEN METRAWATT GMBH
Product Support Hotline
Phone: +49 911 86 02 - 112
Fax +49 911 86 02 - 709
E-Mail support@gmc-instruments.com

GOSSEN METRAWATT GMBH
Thomas-Mann-Str. 16-20
90471 Nürnberg • Germany
Member of GMC Instruments Group

Phone +49-(0)-911-8602-0
Fax +49-(0)-911-8602-669
E-Mail info@gmc-instruments.com
www.gmc-instruments.com

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