tinsley
PRECISION INSTRUMENTS

ET-1020KW

Digital Earth Tester

User's guide

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GF-2131

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1. Description

The **ET-1020KW** digital earth tester allows for the measurement of Earth Resistances and Soil Specific Resistivity, and also the spurious voltages caused by parasitic voltages present in the soil.

This equipment is suitable for fast and easy measurement of the grounding resistance in house and industrial buildings, hospital installations, lightning rods, antennas, substations, etc. Soil resistivity measurement allows for soil stratification in order to optimize the most complex grounding systems engineering. Its state-of-the-art system of active and passive filters provides it with high immunity to electric interferences, making it possible to obtain reliable measurements even in the presence of spurious voltages, such as the ones that can be found in some urban areas and near primary substations.

It has an audible signal which advises the operator when the generated current is not enough to carry out reliable measurements. Due to the fact that it may not be noticed, this alarm also prevents further testing.

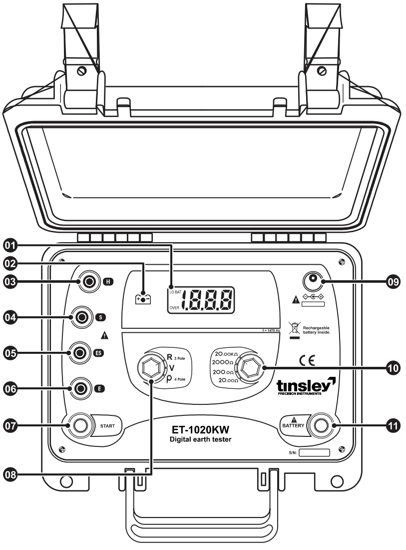
Because of its wide range of measurement (from 0.01 Ω up to 20 kΩ), this equipment allows for reliable testing in all kinds of soils, including those that offer very high resistivity. The use of this instrument is very simple, it has a high-visibility 3½ - digit display with direct readings, even under sunlight.

This earth tester is supplied with a rechargeable internal battery. The smart charger is microprocessor-controlled, and can be powered from a 12 V car battery (or a similar one).

It has a sturdy, easy and safe to carry cabinet, with IP54 protection level. It is suitable to work under adverse geographical and environmental conditions, with extreme temperatures in cold or tropical regions and in high mountain areas, showing a reliable performance in the field.

2. Operating instructions

2.1. Panel controls



❶- 3½ digits display

❷- **Battery Charger Status** LED

❸- Output Terminal **H**

❹- Output Terminal **S**

❺- Output Terminal **ES**

❻- Output Terminal **E**

❼- **START (Pushbutton)**

❽- **FUNCTION SELECTOR (Rotary Switch)**

R (3 poles) = Grounding Resistance

V = AC Voltmeter

ρ **(4 poles)** = Resistivity (4 rods)

❾- DC **Power Input**

❿- **RANGE SELECTOR (Rotary Switch)**

⓫- **BATTERY TEST** (Pushbutton)

2.2. Output Terminals ⚠

Green E Terminal	–	Earth Electrode
Black ES Terminal	–	Voltage Electrode
Blue S Terminal	–	Voltage Electrode
Red H Terminal	–	Current Injection

E - **ES** - **S** - **H:** Standard nomenclature currently recommended by the IEC.

Having the function selector switch in the R position (grounding resistance measurement) the E and ES terminals are internally shorted. The ES terminal is not used for this measurement.

2.3. Internal battery

The **ET-1020KW** has a built-in rechargeable battery. Furthermore, it can be powered by means of an external 12 V battery.

2.4. Battery status check ⚠

Before starting each test, it is recommended to check if the internal battery has enough charge. This can be done by pressing the **Battery Test Pushbutton⓫**. The value shown on the display **must be higher than 1000**. If it is not, the battery needs to be charged. This checking can be repeated during measurements, under the equipment highest consumption conditions.

2.5. Power supply source ⚠

The power supply source provided can be connected to 90-240 V~ mains. It is used to charge the battery.

2.6. Battery charge

This equipment has an internal battery charger with a smart, microprocessor-controlled circuit which adjusts the battery charge to the optimized parameters to ensure the maximum service life. It is supplied by an external source for 90-240 V~ (supplied with the equipment) or by a 12 V car battery.

In order to recharge the battery, connect the equipment to the mains supply or to the external battery. After a few seconds, the **BATTERY CHARGER STATUS LED⓬** will flash during one second in green and red alternately. During this period, the charger checks the battery initial status, selecting in this way the charge optimized parameters. After this, the **BATTERY CHARGER STATUS LED⓬** will remain lit in red until the charge is complete, then the led will turn into green and will remain this way until the equipment is disconnected from supply.

If, during the battery charge with 12 V car battery, the equipment is used to perform measurements, the charge will be momentarily interrupted, returning to the charge process once measurements are finished. In the following table we summarised the meaning of the luminous indications of the LED⓬

Alternate green and red lights	Evaluation of the battery initial status when the source is connected, during one second.
Steady red light	Battery under charge.
Flashing red light	The battery was not successfully charged. It denotes some trouble in the battery charging process.
Steady green light	The charge has successfully finished. The battery is OK.

Note: *Under storage, the battery loses part of its charge. Thus, before using the equipment for the first time, or after some time of being out of use, the battery must be recharged. As the kind of rechargeable battery that this equipment uses does not show the "memory effect" and due to the charger intelligent characteristics, there are no restrictions to start charging it as many times as is needed. As soon as the charger detects that the battery is completely charged, it will automatically turn to the Float state (Green indication), protecting it from overcharging.*

2.7. Measurement ranges

The equipment has 4 resistance measurement ranges:

Range	Unit	Reading resolution
0 – 20.00	Ω	0,01
0 – 200.0	Ω	0,1
0 – 2.000	Ω	1
0 – 20	kΩ	0,01

2.8. Grounding resistance measurement

1. Insert in the soil the two auxiliary rods: the **E3** current rod and the **E2** voltage rod. Connect them by means of provided cables to **H**❸ and **S**❹ output terminals, respectively. The **E**❻ terminal must be connected to the grounding system under test (**E1**) using the 5 meters cable (see fig. 01).

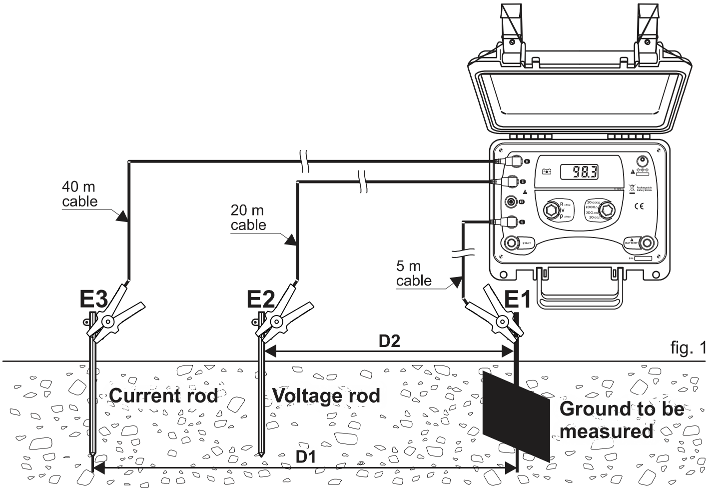


fig. 1

2. Select the **R(3 pole)** position in the **FUNCTION Selector Switch**❽. Select the 20 kΩ range with the **RANGE Selector Switch**❿ and press **the START Pushbutton**❼. If the resistance value is lower than 2 kΩ, select the most adequate, electing the scale from the highest to the lower. If the acoustic alarm bips, this indicates some abnormality in the rods wiring, the reason may be a misconnection or an excessively high

diffusion resistance in the current rod. Check the installation to fix this problem. (See item 5).

If a number 1 appears in the most significant digit position, this means that the measured value is higher than the highest one of the selected range (Overrange). In this case, the immediately higher range must be selected until finding a valid reading value (this will not be possible if the measured resistance is higher than 20 kΩ).

2.9. Spurious voltages measurement

1. In order to check the existence and to measure the spurious voltages present in the soil, the inserted rods must be kept in place, connected to the equipment as shown in figure 01.
2. Select the V position with the **FUNCTION Selector Switch [08]** and press **the START Push-button [07]**. The display will show the AC voltage between the grounding E1 and the E2 probe, up to 200 V.

2.10. Soil resistivity measurement - Wenner Method

1. Insert four rods (spikes) in the soil, well aligned and with a constant D separation, as shown in fig. 02. When performing this measurement, the distance between the rods is critical as it takes part in the resistance calculation.
2. Select the position ρ **(4 pole)** in the **FUNCTION Selector Switch [08]** and connect the rods, as it is shown in figure 02.

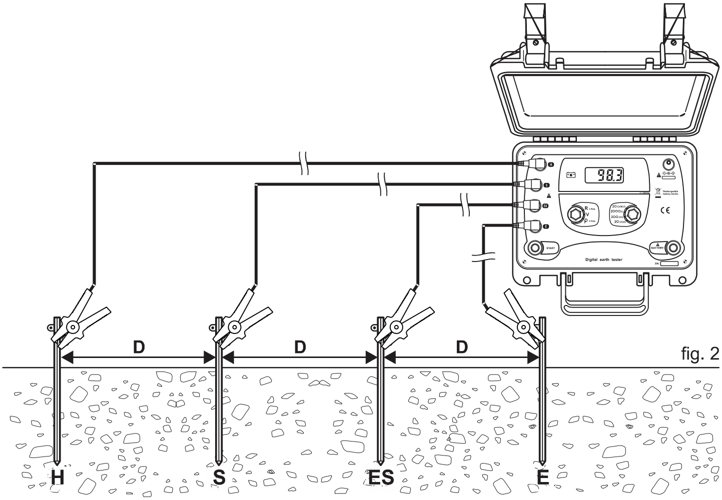


fig. 2

3. Find the most appropriate range and press the **START Pushbutton⓱**.
4. To obtain the soil resistivity value, Wenner's equation should be applied. In its simplified form, this equation is as follows:

$$\rho = 2\pi \, R \, D$$

Where:

- **ρ** = soil resistivity value, expressed in [Ωm]
- π = 3.14159
- **R** = value shown on the display.
- **D** = distance between the rods, expressed in meters.

In this way, mean soil resistivity is obtained from the surface up to a depth equal to the D distance between the rods. The information required to determine the soil stratification by means of a graphic method or by the use of an appropriate software is obtained by performing several measurements with different distances between the rods. The distances which are generally adopted are: 1m, 2m, 4m, 8m, 16 m. In order to carry out measurements with D=16m, cables can be distributed as shown in figure 03, with the instrument near the ES rod.

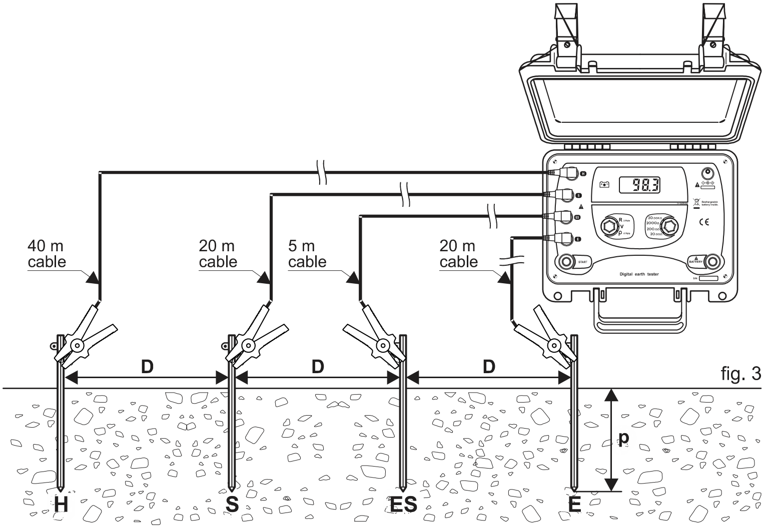


fig. 3

5. Wenner's equation simplified form can be applied whenever the insertion depth of each rod is not significant compared to the D distance. This condition can be difficult to fulfil when D is small, due to the need of ensuring a good contact between the rod and the soil. If this were the case, the full form of the equation must be applied:

$$\rho = \frac{4\pi RD}{1 + \frac{2D}{\sqrt{D^2 + 4p^2}} - \frac{D}{\sqrt{D^2 + p^2}}}$$

Where:
ρ = soil resistivity [Ωm]
D = distance (spacing) between rods [m]
p = insertion depth of the auxiliary rods [m]
R = value shown on the display
When **D >> p**, the simplified form is obtained.

6. In order to properly evaluate soil resistivity, measurements must cover the whole area to be occupied and influenced by the future grounding system. For an area of up to 10,000 m^2, it is recommended resistance

measurements to be performed in at least five points, arranged as shown in figure 04. Two sets of measurements should be needed for the central point (each set of measurements with its corresponding spaces between rods of 1, 2, 4, 8 and 16 m).

Larger areas can be divided in areas of 10,000 m^2 each, and measurements in 5 points can be carried out as shown in figure 04. Besides, in the case of different forms, there will always be the possibility of limiting a rectangle and proceed as in the previous case.

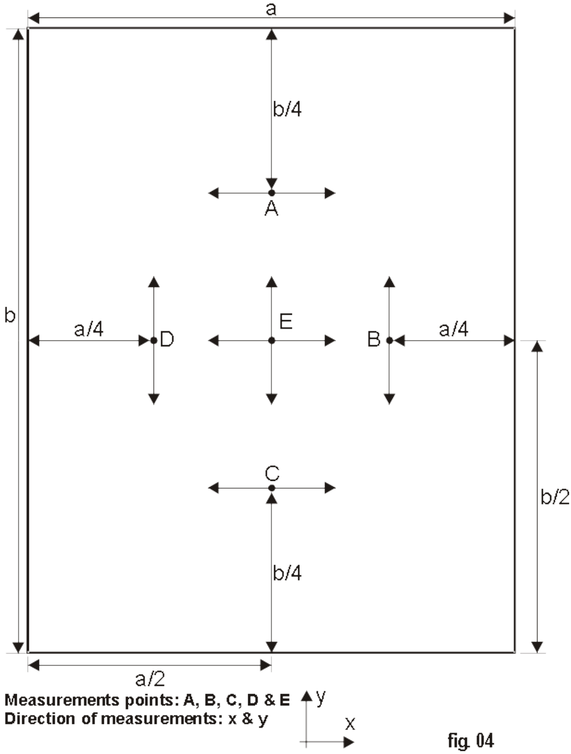


fig. 04

2.11. Audible Alarm

The **ET-1020KW** has an audible alarm circuit to avoid false measurement records. If, due to any reason, the current is lower than the value required to perform reliable measurements, or if there is no current flowing between H and E, the alarm circuit will be activated and will emit an audible intermittent signal. When the operator is in the field during measurement and hears the intermittent "beep" sound, he must check the connections to the rods and to the earth tester terminals, as well as the wires continuity (possibly, a wire may be cut off). If there isn't any abnormality in the connection or in the wires, it is possible that the soil resistance is abnormally high, causing an excessively high diffusion resistance of the auxiliary rods. That resistance could be improved by watering the auxiliary rods, or by inserting several interconnected rods. The battery status must also be checked.

2.12. Influence of grounding resistance of the auxiliary rods

Whenever the probe grounding resistance is lower than 1,000 Ω, the error caused is not significant (less than 5%). The current rod may have a resistance of up to 5,000 Ω, without affecting measurements and without causing significant errors.

2.13. Special considerations about grounding resistance measurements

By employing the Fall of Potential method, normally used to measure Grounding Diffusion System (GDS) resistance, two rods are used as auxiliary electrodes. In **figure 01**, $\mathbf{D_1}$ is the distance between GDS $\mathbf{E_1}$ and the $\mathbf{E_3}$ current electrode**,** whereas $\mathbf{D_2}$ is the distance between GDS and the $\mathbf{E_2}$ probe. The current generated by the equipment flows through GDS and the current electrode, and the voltage between GDS and the $\mathbf{E_2}$ probe is measured. The R value is obtained as the quotient between the voltage and the current.

In figure 05 the potential profile has been graphically shown relating the GDS in the area between this and the current electrode, assuming that the distance between those points is enough for its corresponding "influence areas" not to be overlapped. An "influence area" is the area close to each electrode where a significant potential gradient is observed. Out of that area, the potential is constant (potential plateau between points A and B - Fig 05).

In order to obtain a valid measurement of the GDS resistances, it is necessary to move the auxiliary current rod away enough to comply with the “no overlap condition” of the areas of influence, and the voltage rod (probe) must be set up in the potential plateau area. The criteria commonly accepted is to consider that the radius of each influence area is three to five times bigger than the electrode dimension.

The appropriate compliance of this condition must be checked by carrying out three successive measurements of GDS resistances, keeping the current rod position but moving the voltage rod about 2 meters between measurements (points L, M, y N). If the three measurements show the same result (within the earth meter specified error) the measurement should be considered correct. Otherwise, the distance to the current rod should be significantly increased and the process, repeated.

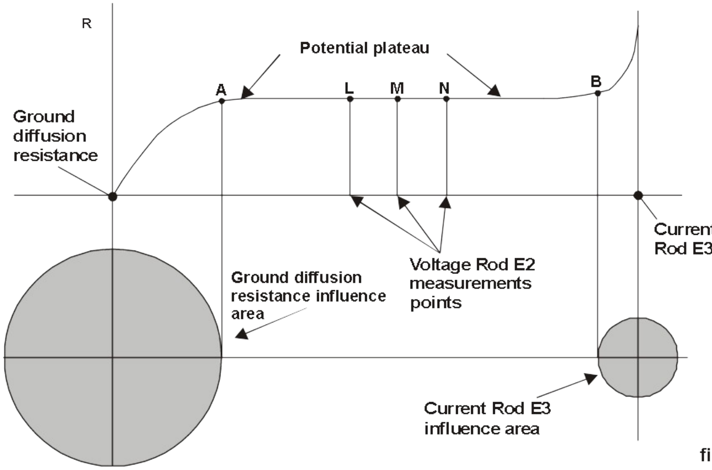


fig. 05

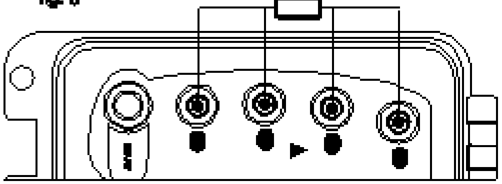
Generally, GDS dimensions are greater than those of the auxiliary current rod, thus its area of influence diameter is also greater. So, in order to comply with the required condition, the probe must be set up closer to the current rod than to the GDS. A distance of 62% is usually adopted as a first try (62% rule). It should be noted that when measuring GDS resistances in large systems (such as a large grid that underlies a substation) distances of hundreds of meters are required to fulfil the condition. Technical literature describes alternative methods that make it possible to reduce those distances with valid results, such the “slope method” developed by Dr. G. Tagg in 1970.

All these considerations refer to physical aspects, essential to the measurement process, thus they are applied to all earth meters, and do not depend on the manufacturer or the technology used.

3. Equipment operation checking

Using a standard resistance (i.e. 10.0 Ω nominal), it's possible to test the equipment calibration. This resistance must be connected to the 4 terminals on the earth meter, as shown in figure 06.

fig. 6



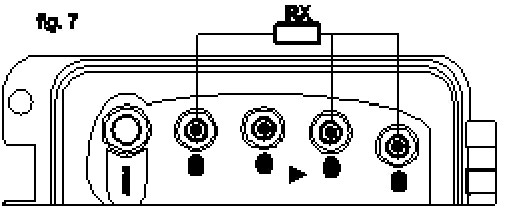
Following this procedure:

- The Function Selector Switch ⓪⑧ must be in the ρ position (4 pole).
- The Range Selector Switch⑩ must select the 20.00 Ω scale.
- Start the equipment.
- Press the **Battery** Test Button⑪ to check the battery charge status. If the display shows a value lower than 1000, the battery should be recharged or external power supply should be used.
- Press the Start Pushbutton ⓪⑦. After 5 seconds, the display should indicate a stable value, close to the nominal value of the standard resistance.
- If this were not the case, the accuracy of the instrument would be out of its specification and it would be necessary to adjust by a qualified laboratory.
- If you want to calibrate the earth meter in other points of the present range or of other ranges, adequate standard resistances must be used. In order to avoid errors by the test leads resistances and their connections, the 4-wire connection is used (fig 06), with the earth meter in its measurement function of ρ (4 pole). According to the scale, the highest acceptable error is:

Range	**Maximum error allowed**
0 – 20.00 kΩ	±(2% of the measured value + 0.2 kΩ)
0 – 2000 Ω	±(2% of the measured value + 20 Ω)
0 – 200 Ω	±(2% of the measured value + 2 Ω)
0 – 20 Ω	±(2% of the measured value + 0.2 Ω)

When using a test resistance higher than 100 Ω, the leads and contacts resistances are not significant, thus figure 07 configuration can be used, with the Function Selector Switch ⓲ in the R position (3 pole).

fig. 7



4. Technical Specifications

Application : Measurement of grounding resistances (3 terminals), soil resistivity (4 terminals) and spurious voltages present in the soil.

Resistance measurement method : The equipment injects an electronically stabilised current in the soil, and measures, with high precision, the voltage developed in the soil by means of that current flowing through grounding diffusion resistances. Display shows the Resistance value.

Immunity to interference : Operation frequency: 1470 Hz
This operation frequency complies with the equation:

$$fg = \frac{2n + 1}{2} \times fi$$

Where:
fg = frequency of the current generated by the earth meter.
n = integer number.
fi = industrial frequency (50 or 60 Hz)

The compliance with this equation implies that the operation frequency will not coincide with any harmonic of the industrial frequency, in order to minimise the effect of parasitic currents present in the surveyed soils, by means of the use of appropriate filters.

Operation as a voltmeter : In the voltmeter function, the equipment operates as a CA conventional voltmeter, making it possible to check the presence and to measure voltages generated by parasitic currents.

Measurement ranges : Resistances: 0-20Ω; 0-200Ω; 0-2,000Ω and 0-20kΩ
Voltage: 0-200V~

Accuracy : **Resistances measurements**: ± (2% of the measured value + 1% of the maximum value of the selected range).
Voltage measurement: ± (2% of the measured value + 1% of end of scale value)

Reading resolution : 0.01Ω in the resistance measurement.
0.1V in the voltage measurement.

Output power and Current : The output power is less than 0.5W, and the output current is limited to less than 15mA (Peak to peak)

Battery status checking	:	It makes it possible to verify the battery charge status under normal use conditions.
Audible alarm	:	It warns the operator in case that there are abnormalities in the current circuit, which make it difficult to obtain a reliable result.
Power supply	:	By means of an internal rechargeable battery or from a 12 V external battery.
Battery charger	:	It is supplied by means of an external power supply for 90-240 V~ (provided with the equipment) or from a 12 V car battery.
Operation temperature	:	-10°C to 50°C
Storage temperature	:	-25°C to 65°C
Humidity	:	95% RH (without condensation)
Equipment weight	:	Approximately 2.4 kg (without accessories)
Dimensions	:	221 x 189 x 99 mm.
Included accessories	:	• Four steel rods. • Connection wire to supply the charger with a 12 V external battery (the car battery). • Battery charger power supply, 90-240 V~ input voltage. • One 40 meters cable in red colour. • Two 20 meters cable in blue and green colour. • One 5 meters cable in black colour. • One 5 meters cable to connect to the grounding system to be measured. • Canvas bag. This User's guide.

Notes