HIOKI

FT3151

ANALOG EARTH TESTER

Instruction Manual

Aug. 2017 Revised edition 1 FT3151A980-01

EN

Contents

Introduction

Thank you for purchasing the Hioki FT3151 Analog Earth Tester. To obtain maximum performance from the instrument, please read this manual first, and keep it handy for future reference.

Verifying Package Contents

When you receive the instrument, inspect it carefully to ensure that no damage occurred during shipping. In particular, check the accessories, panel buttons, and connectors. If damage is evident, or if it fails to operate according to the specifications, contact your authorized Hioki distributor or reseller.

Check the package contents as follows.

☐ **FT3151 Analog Earth Tester ×1**

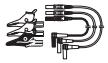
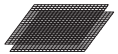
Accessories		
☐ **L9840 ×1**	Auxiliary Earthing Rod (for precise measurement method, 2 pieces set) (ϕ 6 mm, length: 270 mm, straight section: 235 mm, material: stainless steel ISO/TS 15510 L-No. 6)	
☐ **L9841 ×1**	Measurement Cable (for precise measurement method, alligator clip, black, 4 m)	
☐ **L9842-11 ×1**	Measurement Cable (for precise measurement method, yellow, 10 m, equipped with winder)	

☐ **L9842-22 ×1**	Measurement Cable (for precise measurement method, red, 20 m, equipped with winder)	
☐ **C0106 ×1**	Carrying Case	
☐ **Instruction Manual ×1**	This manual	
☐ **AA (LR6) alkaline battery ×6**		

Options (sold separately)

The following options are available for the instrument. Contact your authorized Hioki distributor or reseller when ordering.

L9787	Test Lead (for simplified measurement method, indoor use only, red and black, 1.2 m each) Not classified in accordance with the measurement category.	
L9840	Auxiliary Earthing Rod (for precise measurement method, 2 pieces set) (ϕ 6 mm, length: 270 mm, straight section: 235 mm, material: stainless steel ISO/TS 15510 L-No. 6)	
L9841	Measurement Cable (for precise measurement method, alligator clip, black, 4 m)	
L9842-11	Measurement Cable (for precise measurement method, yellow, 10 m, equipped with winder)	

L9842-22	Measurement Cable (for precise measurement method, red, 20 m, equipped with winder)	
L9843-51	Measurement Cable (for precise measurement method, yellow, 50 m, equipped with flat cable winder)	
L9843-52	Measurement Cable (for precise measurement method, red, 50 m, equipped with flat cable winder)	
L9844	Measurement Cable (for earthing terminal board, alligator clip, 3 cables in 1 set, red, yellow, black, 1.2 m each)	
9050	Earth Nets (2 sheets in 1 set, 300 mm × 300 mm)	
C0106	Carrying Case	
Z5022	Shoulder Strap	

Safety Notes

This instrument is designed to conform to IEC 61010 Safety Standards, and has been thoroughly tested for safety prior to shipment. However, using the instrument in a way not described in this manual may negate the provided safety features.
Before using the instrument, be certain to carefully read the following safety notes:

⚠DANGER

Mishandling during use could result in injury or death, as well as damage to the instrument. Be certain that you understand the instructions and precautions in the manual before use.

⚠WARNING

With regard to the electricity supply, there are risks of electric shock, heat generation, fire, and arc flash due to short circuits. Individuals using an electrical measuring instrument for the first time should be supervised by a technician who has experience in electrical measurement.

Notation

In this document, the risk seriousness and the hazard levels are classified as follows.

⚠ **DANGER**	Indicates an imminently hazardous situation that will result in death or serious injury to the operator.
⚠ **WARNING**	Indicates a potentially hazardous situation that may result in death or serious injury to the operator.
⚠ **CAUTION**	Indicates a potentially hazardous situation that may result in minor or moderate injury to the operator or damage to the instrument or malfunction.
IMPORTANT	Indicates information related to the operation of the instrument or maintenance tasks with which the operators must be fully familiar.
	Indicates a high voltage hazard. If a particular safety check is not performed or the instrument is mishandled, this may give rise to a hazardous situation; the operator may receive an electric shock, may get burnt or may even be fatally injured.
	Indicates prohibited actions.
	Indicates the action which must be performed.
*	Additional information is presented below.

Symbols affixed to the instrument

	Indicates cautions and hazards. When the symbol is printed on the instrument, refer to a corresponding topic in the Instruction Manual.
	Indicates a instrument that has been protected throughout by double insulation or reinforced insulation.
	Indicates DC (Direct Current).
	Indicates AC (Alternating Current).

Symbols for various standards

	Indicates the Waste Electrical and Electronic Equipment Directive (WEEE Directive) in EU member states.
	Indicates that the product conforms to regulations set out by the EU Directive.

Accuracy

We define measurement tolerances in terms of f.s. (full scale), rdg. (reading), dgt. (digit) and setting values, with the following meanings:

f.s.	(Maximum display value) The maximum displayable value.
rdg.	(Reading or displayed value) The value currently being measured and indicated on the measuring instrument.
dgt.	(Resolution) The smallest displayable unit on a digital measuring instrument, i.e., the input value that causes the digital display to show a “1” as the least-significant digit.

Measurement categories

To ensure safe operation of measuring instruments, IEC 61010 establishes safety standards for various electrical environments, categorized as CAT II to CAT IV, and called measurement categories.

⚠DANGER

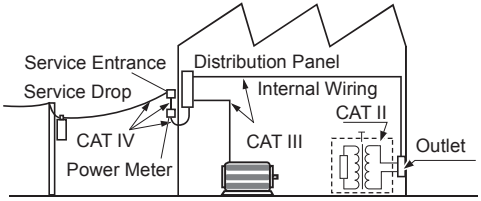
Using a measuring instrument in an environment designated with a higher-numbered category than that for which the instrument is rated could result in a severe accident, and must be carefully avoided. Never use a measuring instrument that lacks category labeling in a CAT II to CAT IV measurement environment. Doing so could result in a serious accident.

This instrument conforms to the safety requirements for CAT II 300 V measuring instruments.

CAT II: When directly measuring the electrical outlet receptacles of the primary electrical circuits in equipment connected to an AC electrical outlet by a power cord (portable tools, household appliances, etc.)

CAT III: When measuring the primary electrical circuits of heavy equipment (fixed installations) connected directly to the distribution panel, and feeders from the distribution panel to outlets

CAT IV: When measuring the circuit from the service drop to the service entrance, and to the power meter and primary overcurrent protection device (distribution panel)



Fixed Installation

Usage Notes

Verifying before usage

Before using the instrument, verify that it operates normally to ensure that no damage occurred during storage or shipping. If you find any damage, contact your authorized Hioki distributor or reseller.

⚠DANGER

Before using the instrument, check that the coating of the test leads and cables are neither ripped nor torn and that no metal parts are exposed. Using the instrument under such conditions could result in an electric shock. Replace the test leads and cables with those specified by our company.

⚠WARNING

Do not short-circuit between two lines to be measured with the metal parts of the test leads. Doing so could result in a serious accident such as a generation of arc.
To avoid an electric shock, do not touch the metal parts of the test leads.
Do not use the instrument with circuits that exceed its ratings or specifications. Doing so may cause it to become hot, resulting in an electric shock.
To avoid an electric shock, be careful to avoid shorting live lines with the test leads.

IMPORTANT
Use only the specified measurement cables or test leads. Using a non-specified cable may prevent safe measurement.

Use environment of the instrument

See “3.1 General Specifications” (p. 45) about the operating temperature and humidity.

⚠ CAUTION

- Installing the instrument in inappropriate locations may cause a malfunction of instrument or may give rise to an accident. Avoid the following locations:
  - Exposed to direct sunlight or high temperature
  - Exposed to corrosive or combustible gases
  - Exposed to a strong electromagnetic field or electrostatic charge
  - Near induction heating systems (such as high-frequency induction heating systems and IH cooking equipment)
  - Susceptible to vibration
  - Exposed to water, oil, chemicals, or solvents
  - Exposed to high humidity or condensation
  - Exposed to high quantities of dust particles
- To avoid damage to the instrument, protect it from physical shock when transporting and handling. Be especially careful to avoid physical shock from dropping.
- Do not place the instrument on an unstable table or an inclined place. Dropping or knocking down the instrument can cause injury or damage to the instrument.

Handling the cables

⚠ CAUTION

- To prevent cable damage, do not step on cables or pinch them between other objects. Do not bend or pull on cables at their base.
- The tips of the L9787 Test Lead and L9840 Auxiliary Earthing Rod are sharp. Be careful to avoid injury.

Precautions during measurement

⚠ WARNING

Use only the specified measurement cables or test leads. Using a non-specified cable may prevent safe measurement.
If the instrument is used in locations where the rating indicated on the instrument or cords is exceeded, the instrument may be damaged resulting in personal injury. Do not use the instrument in such locations. See “Measurement categories” (p. 7).

Precautions during shipment

⚠ CAUTION

- During shipment of the instrument, handle it carefully so that it is not damaged due to a vibration or shock.
- To avoid damage to the instrument, be sure to remove the accessories and options before shipping.

1 Overview

1.1 Overview

This instrument is an earth tester that is fully functional for measuring earth resistance for grounding works.
This instrument uses the AC phase differential system to measure earth resistance. This assures accurate measurements unaffected by earth voltage and auxiliary earth resistance.

1.2 Features

(1) High performance

Performance of this instrument surpasses the requirements of the Japanese standard JIS C1304 (2002) as well as complies with EN 61557 and the safety standard IEC 61010.

(2) Wide measurement range

The earth resistance measurement ranges are extended to 115% of each of the measurement ranges. This is useful especially for evaluation of resistances of approximately 10 Ω and 100 Ω that are important for earthing evaluation during electrical installation work.

(3) Auxiliary earth resistance check function

Auxiliary earth resistance, which causes measurement errors, can be checked with respect to each of the auxiliary earth poles.

(4) Switchable measurement frequency

Measurement frequency can be switched to minimize the influence of harmonic earth voltage and to assure stable measurement.

(5) Simplified measurement function

Earth resistance can be measured easily using a low-resistance grounding such as the earth of a commercial power supply.

(6) Over-voltage protection and warning buzzer

If a voltage is input by mistake during simplified measurement using a commercial power supply, the internal circuit is protected and the improper connection is warned by sounding the buzzer.

(7) Semi-dust-proof construction

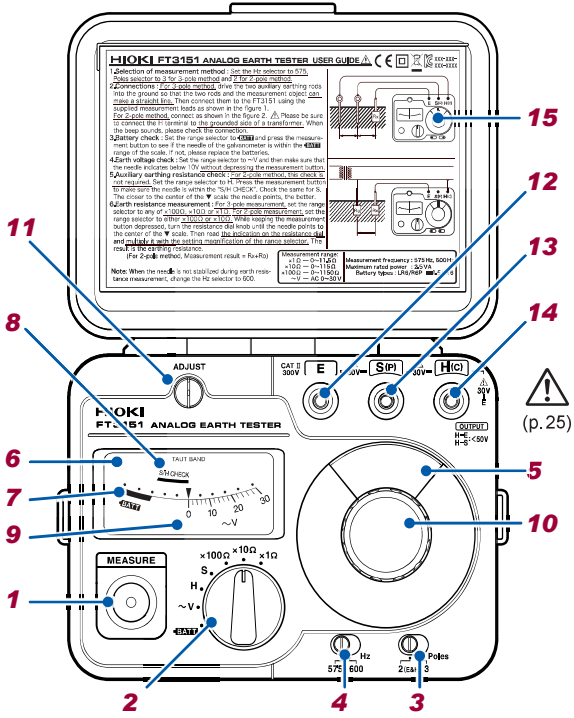
The moving parts such as **MEASURE** button, switches, resistance dial, etc. are dust-proofed simply.

(8) Supplied with winders

The instrument is supplied with useful winders so that the measurement cords can be easily prepared and packed up before/ after measurement.

1.3 Parts Names and Functions

Front

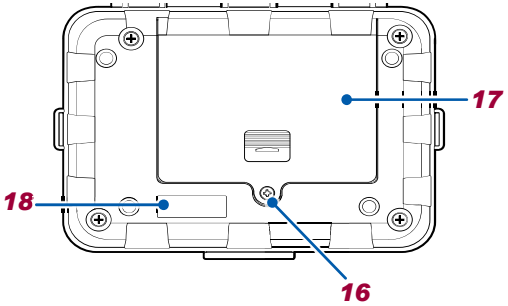


Do not press the button of the instrument with a sharp object. Doing so may damage the button.

1	MEASURE button	Starts the earth resistance measurement, auxiliary earth resistance check, or battery check.
2	Range selector	Switches the function among the battery check, earth voltage measurement, auxiliary earth resistance check, and earth resistance measurement.
3	Poles selector	Switches the measurement method between 2-pole method (simplified measurement) and 3-pole method (precise measurement).
4	Hz selector	Switches the measurement frequency between 575 Hz and 600 Hz to reduce effects of harmonic earth voltage.
5	Resistance dial	Allows the operator to read the measured resistance value.
6	Galvanometer	Displays the value of current that flows through the galvanometer during earth resistance measurement.
7	Battery effective range	Allows the operator to check if the battery voltage is sufficient.
8	Auxiliary earth resistance effective range	Allows the operator to check if the auxiliary earth voltage is favorable.
9	Earth voltage scale	Allows the operator to read the earth voltage value.
10	Dial knob	Allows the operator to adjust the current value flowing through the galvanometer during earth resistance measurement.
11	ADJUST	Allows the operator to perform the zero adjustment for the galvanometer
12	Measurement terminal E	Connect the black cable.
13	Measurement terminal S(P)	Connect the yellow cable.

14	Measurement terminal H(C)	Connect red cable.
15	Explanation label	Contains brief instructions and the instrument's specifications.

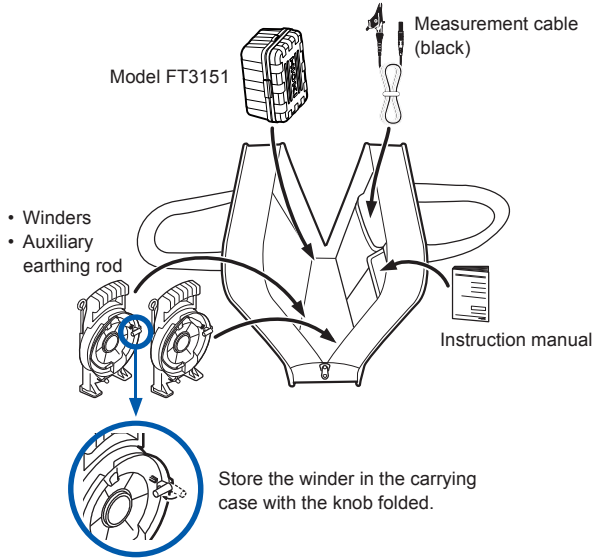
Back



16	Battery cover screw	Binding head screw M3×6
17	Battery cover	Remove this cover for replacing the batteries.
18	Serial number label	Do not remove the label as it is needed for product control such as product warranty etc.

1.4 How to Use Carrying Case

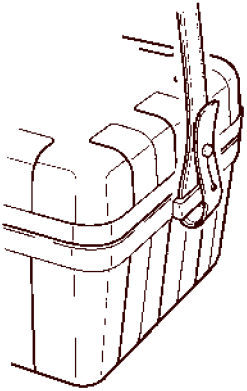
Store the instrument, winders, and other accessories/options into the C0106 Carrying Case as shown in the figure below.



Do not store commercially available pegs in this carrying case because they have sharp tips. Doing so may damage the case.
Do not wash the carrying case.

1.5 Attaching Model Z5022 Shoulder Strap

The optional Z5022 Shoulder Strap is useful for taking the instrument out of the carrying case and for carrying the instrument.



2 Measurement Procedure

Before using the instrument, be sure to read “Verifying before usage” (p. 9).

⚠ DANGER

- **Connect the instrument only to the secondary side of a breaker. The breaker can prevent an accident if a short circuit occurs. Do not connect the instrument to the primary side of a breaker. Doing so can cause a short circuit, which allows large current to flow, causing a serious accident.**
- **Connect the test lead to the instrument first, and then to the active lines to be measured. To avoid an electric shock and short circuits, do not short-circuit two wires to be measured by bringing the metal part of the test lead’s clip into contact with them. Never touch the metal end of the clip.**

⚠ WARNING

To avoid an electric shock, observe the following precautions:

- **Prior to measurement, please make sure that the earthing electrode has been disconnected from the distribution system. The measurement cables L9841, L9842-11, L9842-22, L9843-51, and L9843-52 are measurement cables with the maximum rated voltage of 50 V (between input terminals and the ground) and are designed to measure the earth resistance of an earthing electrode disconnected from the distribution system.**
- **Turn off the instrument before connecting cables and test leads.**
- **Connect measurement cords or test leads to the terminals securely. If a terminal is loose, the contact resistance will increase, resulting in overheating, equipment burnout, or a fire.**

⚠ WARNING

To prevent an electric shock, confirm that the white or red portion (insulation layer) inside the cable of L9787 Test Lead and L9844 Measurement Cable are not exposed. If a color inside the cable is exposed, do not use the cable.

⚠ CAUTION

- If the batteries are exhausted, the warning tone will not sound even if a voltage is applied due to a wrong connection. Always check the batteries before starting to use the instrument.
- To avoid damaging the cables and test leads, grasp the connector, not the cable, to detach the cable.

2.1 Inspection Before Use

Verify that it operates normally to ensure that no damage occurred during storage or shipping. If you find any damage, contact your authorized Hioki distributor or reseller.

Check items	Solution
Is the battery level sufficient?	Perform a battery check to verify that the batteries are still good. (p.29), (p.36)
Is there any damage or crack in the instrument?	Conduct visual checking. Do not use the instrument if damage is found. Doing so will cause an electric shock. Send the instrument for repair.
Is there any foreign material (sand etc.) inside the measurement terminals?	Remove all foreign materials if any. If it cannot be removed, the instrument needs to be repaired.
Does the needle of the galvanometer rest on the mark ▼?	Keeping the instrument horizontal, check if the needle rests on the mark. If the needle does not rest on the mark, have the needle rest on the mark ▼ by turning the zero adjust screw (ADJUST) with a flat-blade screwdriver without pressing the **MEASURE** button.
Are the coating of the test leads neither ripped nor torn and no internal white parts or metal parts exposed?	Do not use any damaged cables and leads. Doing so may cause an electric shock. Replace them with new ones.

Check items	Solution
Check for measurement cables and test leads for a break in the following method: 1. • For the 3-pole method: Set the **Poles** selector to 3. • For the 2-pole method: Set the **Poles** selector to 2. 2. Connect measurement cables or test leads to the instrument and short-circuit their tips. 3. Press **MEASURE** button to check that the measured value is approximately 0 Ω.	If the measured value is not approximately 0 Ω: • The measurement cables or test leads have not been fully inserted. Fully insert the leads. • The measurement cables or test leads may have a break. Replace it with another lead that is specified by Hioki. If the symptom persists even after the measurement cables or test leads are replaced, the instrument may have a failure. The instrument needs to be repaired.

2.2 Measuring Earth Resistance Precisely (Precise Measurement, 3-Pole Measurement Method)

⚠ WARNING

This instrument can output a voltage of approx. 50 V. The instrument must always be dried before using it for measurement to avoid an electric shock.

⚠ CAUTION

Do not connect the test leads if any foreign material remains inside. It may cause failure.

There are two types of measurement method for earth resistance: precision measurement method (3-pole method) and simplified measurement method (2-pole method). The precision measurement method (3-pole method) is the basic measurement method for earth resistance.
The simplified measurement method is used when measurement cannot be performed by the precision measurement method.
The precision measurement is performed by inserting two auxiliary earthing rods into the ground as shown in the figure on p.28.

Measurement of large-scale earthing electrodes

When measuring a large-scale earthing electrode such as a mesh earthing electrode, ring earthing electrode, or earthing electrode provided by a large building structure, it cannot be accurately measured because the H(C) electrode and S(P) electrode come inside the earth resistance area of E electrode.

If long cables are used to avoid the H(C) electrode and S(P) electrode getting inside the earth resistance area, accurate measurement cannot be carried out because it is significantly affected by noise.

In general, measurement of large-scale earthing electrode requires a large measurement current of approximately 20 A. Use measuring instrument designed for measuring large-scale earthing electrodes for this measurement. (No measuring instrument is available for this purpose from Hioki)

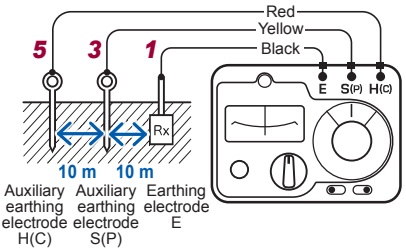
Connecting measurement cables

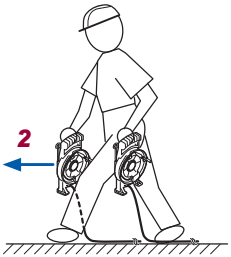
⚠ WARNING

- **The maximum rated voltage between input terminals and the ground is as follows:**
  (CAT II): 300 V rms
  Attempting to measure voltages exceeding this level with respect to ground could damage the instrument and result in personal injury.
- **To avoid an electric shock, do not short-circuit live lines with each other by contacting the test leads to them.**

⚠CAUTION

- To prevent cable damage, do not step on cables or pinch them between other objects. Do not bend or pull on cables at their base.
- The tips of the auxiliary earthing rods are sharp. Be careful to avoid injury.
- To ensure safe operation, use only the accessory cables.
- The cables are hardened in freezing temperatures. Do not bend or pull them to avoid tearing those shield or cutting cables.
- If the cable melts, the metal part may be exposed and can pose a hazard. Do not touch the area that is generating heat.





1 **Connect the earthing electrode and the terminal E with each other using the measurement cable (black).**

2 **Carry two winders along to the measuring location while pulling out the measurement cables.**

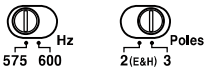
3 **At the location where the measurement cable (yellow) has been fully pulled out, insert the auxiliary earthing rod into the ground and connect the measurement cable (yellow).**

4 **Carry the winder (measurement cable: red) along the straight line through the earthing electrode E and auxiliary earthing electrode S(P) while pulling out the measurement cable.**

5 **At the location where the measurement cable (red) has been fully pulled out, insert the auxiliary earthing rod into the ground and connect the measurement cable (red).**

Insert the auxiliary earthing rods into a moist layer in the ground. Because this instrument can accept a large resistance of auxiliary earthing electrode, the auxiliary earthing rods do not need to be inserted unnecessarily deep into the ground.
For accurate measurement, the distances between earthing electrodes E, S(P), and H(C) need to be approximately 5 m. The measurement cables (yellow) and (red) should be positioned approximately 100 mm away from each other not to tangle or overlap together.

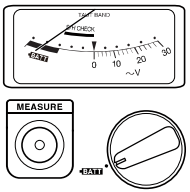
Settings for 3-pole measurement



Set the **Poles** selector to 3.

Setting the measurement frequency
Select the measurement frequency between 575 Hz and 600 Hz by switching the Hz selector. Usually, set the frequency to 575. If the needle of the galvanometer fluctuates during measurement, set the frequency to 600. Switching the measurement frequency enables the instrument to be less affected by a harmonic earth voltage.

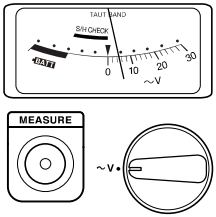
Battery check



Set the range selector to the mark BATT, press the **MEASURE** button, and check if the needle of the galvanometer rests within the range of the mark BATT. Perform this check in the actual measurement condition with the measurement leads already connected.

If the needle of the galvanometer does not reach the range of the mark BATT, replace the batteries with fresh ones. See “4.2 Inserting/Replacing Batteries” (p. 52).

Earth voltage check



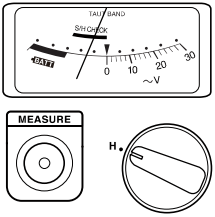
Set the range selector to **~V** to check an earth voltage. Do not press the **MEASURE** button at this time.

⚠CAUTION

- If the **MEASURE** button is pressed, no earth voltage can be measured. Although the needle of the galvanometer may move or go off-scale high, this is not a defect.
- If the earth voltage is 10 V or more, measure the the earth voltage separating the earthing body from the electrical installation or switching the power line off to minimize the earth voltage. Also, if the earth voltage is high, take care that a risk of an electric shock exists.

Auxiliary earth resistance check

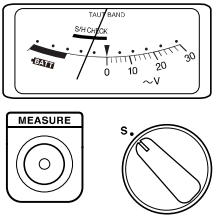
The FT3151 has a function for checking the auxiliary earth resistance. Be sure to perform this check before measuring earth resistance. The check result should be evaluated as follows:
The more the needle of the galvanometer deflects to the left, the higher is the auxiliary earth resistance. (If the needle remains in the vicinity of the zero point, auxiliary earth resistance poses no problem.)



1 **Checking earthing condition of auxiliary earthing rod H(C)**

Set the range selector to H and press the **MEASURE** button.

Verify that the needle of the galvanometer rests within the green range of the S/H CHECK mark.

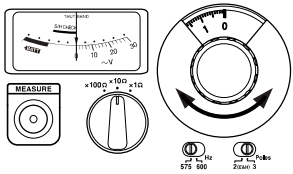


2 **Checking earthing condition of auxiliary earthing rod S(P)**

Set the range selector to S and press the **MEASURE** button.

Verify that the needle of the galvanometer rests within the green range of the S/H CHECK mark.

Earth resistance measurement



Select the range selector to the suitable resistance range from ×1 Ω, ×10 Ω, and ×100 Ω, and have the needle of the galvanometer points to the center of the mark ▼ by turning the dial knob while pressing the **MEASURE** button. Read the indication on the resistance dial and multiply it with the setting of the range selector. The result is the earth resistance.

In general, perform measurement using ×100 Ω range first, and then select the lower range as necessary.
Setting the **Poles** selector 2 will cause an incorrect measured value.
As shown in “3.3 Measuring Range and Tolerances” (p. 48), each influence creates error. The total value of intrinsic uncertainty and influence quantity will be ±17.8% f.s. This indicates that the error will be ±17.8% f.s. at a maximum (±1.78 Ω for ×1 Ω range) depending on conditions. If an earth resistance of 1.78 Ω or less is measured with the range ×1 Ω set, the galvanometer may be balanced with the resistance dial pointing to in the right side of zero (the negative side) owing to such an error. In this case, the earthing resistance is considered to be 1.78 Ω or less. However, the needle of galvanometer does not move correspondingly to the resistance dial adjustment pointing to in the right side of zero, the measurement is invalid.

2.3 Measuring Earth Resistance Simply (Simplified Measurement, 2-Pole Measurement Method)

⚠ DANGER

When using the grounded side of a commercial power supply for simplified measurement, check the outlet first, to determine the grounded side. Use a suitable checker (electroscope or similar) for this purpose.
Take proper precautions against electric shock. If the FT3151 is connected by mistake to the live part of a power supply and a voltage of 85 V or more is applied to the input, a warning tone (beep) will sound. In this case, immediately disconnect the leads and check the outlet again.
This instrument can output a voltage of approximately 50 V. Dry the instrument before using it for measurement so as to avoid an electric shock.

⚠ WARNING

Connect terminal E first. The warning will not sound if the earthing body is not connected to terminal E. When the connection is made by mistake on the power line with the leakage current circuit breaker installed, the breaker may be tripped before the beep sounds.
This instrument can be connected only to the neutral side of an outlet with a voltage-to-ground of 300 V or less. Do not connect with anything other than those specified above. It can be hazardous.

⚠CAUTION

Use the optional L9787 Test Lead for simplified measurement for safety. Connecting the L9841, L9842-11, L9842-22, L9843-51 and L9843-52 Measurement Cable to a commercial power supply may cause electric shock.

What is simplified measurement method (2-pole method)?

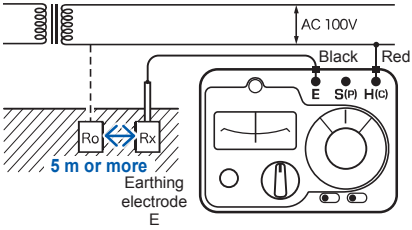
Simplified measurement method (2-pole method) is a measurement method to check the earth resistance of the equipment earthing with an earth system called TT method.
If auxiliary earthing rods cannot be inserted, the earth resistance is obtained with use of an existing low earthing resistor as an auxiliary electrode.
In this method, the measured value is the sum of the earth resistances of the measuring object and existing earthing resistor (Rx+Ro), according to the measurement principle. Thus, the earth resistance of the existing earthing resistor needs to be lower than that of the earthing electrode of the measuring object.

When using the simplified measurement method, the resistance of the existing earthing body is added to the measurement result.
Apply the 3-pole method to measure an earth resistance of 10 Ω or less.

Connecting test leads

"Connection diagram for 2-pole measurement method" shows connection for a simplified measurement using the grounded side of a commercial power supply. Connect the supplied measurement cables to the terminals of the instrument as shown below. Set the range selector to the mark BATT or ~V, connect terminal E to the measurement object E, and then, connect terminal H(C) to the grounded side of a commercial power supply.

Measurement terminal	Measuring cable	Object to be connected
E	Black	Measurement object E
S(P)		Not connected
H(C)	Red or yellow	Ground line (Ro)



Connection diagram for 2-pole measurement method

A metal water pipe or similar can also be used as existing earthing body for simplified measurement.
The distance between the existing earthing body and the measurement object must be at least 5 meters. If the distance is less, correct results will not be obtained.

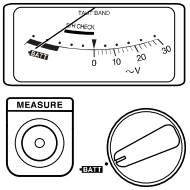
Settings for 2-pole measurement

Set the **Poles** selector to 2.

Setting the measurement frequency

Select the measurement frequency between 575 Hz and 600 Hz by switching the Hz selector. Usually, set the frequency to 575. If the needle of the galvanometer fluctuates during measurement, set the frequency to 600. Switching the measurement frequency enables the instrument to be less affected by a harmonic earth voltage.

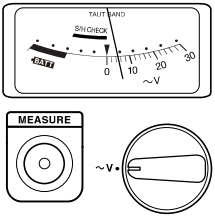
Battery check



Set the range selector to the mark BATT, press the **MEASURE** button, and check if the needle of the galvanometer rests within the range of the mark BATT. Perform this check in the actual measurement condition with the measurement leads already connected.

If the needle of the galvanometer does not reach the range of the mark BATT, replace the batteries with fresh ones. See “4.2 Inserting/Replacing Batteries” (p. 52).

Earth voltage check



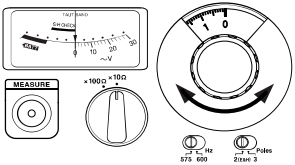
Set the range selector to **~V** to check an earth voltage. Do not press the **MEASURE** button at this time.

Auxiliary earth resistance check

Auxiliary earth resistance check is not required.

When the range selector is set to H or S, and the **MEASURE** button is pressed, the needle of the galvanometer may move or go off-scale high; however, this is not a defect. The check operation is invalid.

Earth resistance measurement



Select the suitable range between ×10 Ω or ×100 Ω and have the needle of the galvanometer points to the center of the mark ▼ by turning the dial knob while pressing the **MEASURE** button.

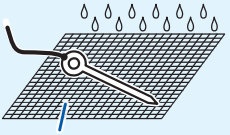
2.4 Using the Earthing Net

If auxiliary earthing rods cannot be driven into the ground, such as on rock, gravel, or concrete, use the earthing net available as an option.

1. **Place the earthing net on the ground, and pour a sufficient amount of water on it.**
   Take some time until the water penetrate the ground sufficiently.
2. **Connect the measurement cables as shown in the illustration, using the clip to connect the lead directly to the earthing net or placing the auxiliary earthing rod on the earthing net.**
3. **Set the range selector to the H and S range.**
4. **Verify that the grid has good contact, and then, perform the measurement.**

Measurement on concrete surface

Because concrete is conductive, auxiliary earthing electrodes can be installed on a concrete surface.
Place an auxiliary earthing rod on the concrete surface and pour water over it, or cover the auxiliary earthing rod with a wet cloth to form an auxiliary earthing electrode.



Model 9050 Earth Nets

If the earth resistance of the auxiliary earthing electrode is not reduced by the above methods, place the optional 9050 Earth Nets on the concrete surface and then position the auxiliary earthing rod on the earth net and pour water over it. Before measurement, allow some time for the water to well soak into the concrete.
As an alternative to the earth net, a metal plate or aluminum foil may be used. However, the earth net will provide better reduction in the earth resistance of auxiliary earthing electrode.
Because asphalt is insulator, it is generally not possible to install the auxiliary earthing electrode on an asphalt surface. However, measurement may be possible on the asphalt surface that has water permeability.
If the earthing net is not available or if it is significantly small, a metal plate or other conducting object can be used as a substitute, provided that it is watered sufficiently.

2.5 Measurement Precautions and Tips

Using the auxiliary earthing rods

For 3-pole measurement, two auxiliary earthing rods are required. Be sure to drive the rods well into the ground to assure correct measurement results.

Earth resistance of auxiliary earthing rods

When the earth resistance of the auxiliary earthing rods is not higher than about 10 kΩ, the FT3151 can carry out correct measurement. However, especially when relatively low earth resistance values are measured, high earth resistance of the auxiliary earthing rods can impair measurement sensitivity.
To assure correct measurement results, be sure to check the earth resistance of the auxiliary earthing rods by setting the range selector to H and S. If the needle of the galvanometer rests within the green band of the scale, the auxiliary earth resistance is within 7 kΩ.

If check results are unsatisfactory:

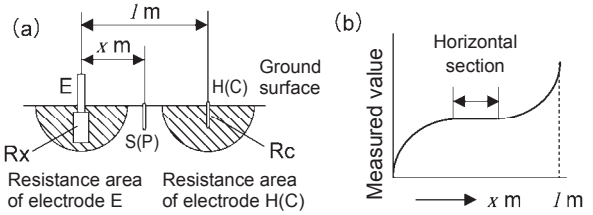
- Drive the auxiliary earthing rods deeply into the ground and water the entire area with a sufficient amount of water. In particular, watering is usually effective in reducing the contact resistance.
- Change the location of the auxiliary earthing rods. Choose a location with high humidity.

If the ground is volcanic rock or sand, the supplied auxiliary earthing rods cannot lower the auxiliary earth resistance sufficiently. In such a case, use a metal pipe or other conductive object with a large surface and bury it as deep as possible in the ground.

Distance between earthing electrodes

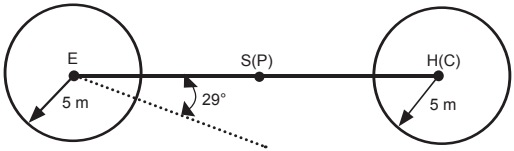
As shown in the figure (a) on the next page, the distance between E and H(C) is given by l m; and the distance between the E and S(P), by x m. If the resistance of the earthing body E is measured while x is being varied, the result will be as shown in the figure (b).
Thus, the measurement errors become larger as the auxiliary

earthing rod S(P) is positioned closer to the earthing body E or the auxiliary earthing rod H(C).
Besides, when the electrodes E and H(C) are positioned close to each other, the earth resistance of the measurement object (Rx) and the earth resistance of the auxiliary earthing rods (Rc) cannot be separated, leading to a measurement error.
In the case of an architectural structure that is grounded over a large area, the resistance range of the earth resistance (Rx) in the figure (a) becomes very wide.
This means that it is necessary to position the auxiliary earthing rods S(P) and H(C) at a sufficiently large distance from the earthing body E.
To determine the proper distance, perform measurement at several points, bringing the auxiliary earthing rod S(P) closer to the auxiliary earthing rod H(C). Check whether there is an area where the measured resistance remains approximately constant although the position of the auxiliary earthing rod S(P) is changed. This corresponds to the horizontal section in the figure (b).
If such area cannot be found, the measurement distance is not sufficient. Move the auxiliary earthing rods S(P) and H(C) farther away from the measurement object.



Position relationship of auxiliary earthing rods

The auxiliary earthing rod S(P) should normally be positioned halfway on a straight line between the earthing body E and the auxiliary earthing rod H(C).
If this is not possible due to obstacles or the like, the auxiliary earthing rod S(P) should be positioned on the area between the two lines: one drawn connecting the earthing body E and the auxiliary earthing rod H(C), and the other drawn from the earthing body E at 29° or less to the first line, with the exception of the areas within a 5-m radius of the earthing body E and the auxiliary earthing rod H(C). This will help to reduce measurement errors.



How to insert / pull out the auxiliary earthing rods

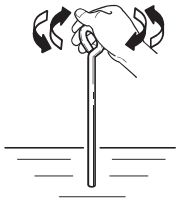
How to insert the auxiliary earthing rods

The accessory auxiliary earthing rods are suitable for providing auxiliary earthing electrodes and are designed for thickness and hardness that allow insertion into a general ground by hand. Because they are thinner than conventional models, they can be inserted into a small gap.
Insert the rods perpendicular to the ground surface by the gloved hands.

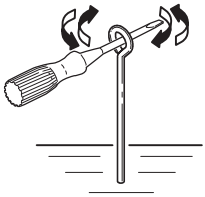
If the ground is too hard to insert the rods by hand, hammer them perpendicularly into the ground. Hammering them excessively hard may result in bending them. If the ground surface is too hard to hemmer the rods with weak force, use the optional Model 9050 Earth Nets for measurement.

How to pull out the auxiliary earthing rod

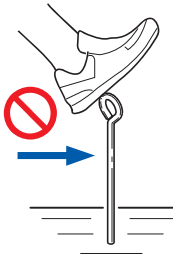
- Hold the loop part of the auxiliary earthing rod and pull it out while turning it.



- If it does not come out by hand, put a hard metal bar etc. (other than the auxiliary earthing rod) through the loop part of the auxiliary earthing rod and pull the auxiliary earthing rod while turning it.
  Pulling the auxiliary earthing rod with another auxiliary earthing rod putting through the loop causes it to be bent.



- Do not subject the auxiliary earthing rod to radial force. Doing so may cause it to be bent.



Influence of earth voltage

Due to the presence of leakage current from electrical equipment connected to the earthing body or of earth current, a voltage may exist at the earthing body.
If the voltage is less than about 10 V, it will normally not affect the earth resistance measurement; however, if the earth voltage is distorted, it may cause measurement errors even at lower voltage levels below 10 V. For this reason, if an earth voltage of more than about 5 V is detected, another electrical equipment should be turned off or the equipment should be disconnected to eliminate the influence of earth voltage on the measurement.
During simplified measurement, harmonic leakage current in the ground line can cause the galvanometer to fluctuate. In such a case, switch the Hz selector from 575 to 600, allowing stable measurement.
If earth voltage is high, the insulation of the electrical path or electrical equipment may have deteriorated. Check the insulation and perform a leakage current test.

3 Specifications

3.1 General Specifications

Product warranty period	3 years
Operating environment (Applicable field)	Altitude up to 2000 m (6562 ft.), pollution degree 2 Designed for earth resistance measurements in locations except farms* *According to the requirements regarding the regulations for open-circuit voltage in EN61557-5
Operating temperature and humidity	0°C to 40°C (32°F to 104°F), 80% RH or less (no condensation)
Storage temperature and humidity	−10°C to 50°C (14°F to 122°F), 80% RH or less (no condensation)
Dust-proofness, Water-proofness	IP40 (EN60529)
Power supply	AA (LR6) alkaline battery Rated supply voltage: 1.5 V DC ×6 Maximum rated power: 2.5 VA
Battery voltage effective range	6.0 V to 10.0 V ±0.5 V
Dimensions	Approx. 164W × 119H × 88D mm (6.46″W × 4.69″H × 3.46″D) (excluding protrusions)
Mass	Approx. 760 g (26.8 oz.) (main unit only)

Standards	Earth resistance meter: EN 61557-1, EN 61557-5 Safety: EN 61010 Measurement circuitry: EN 61010 Probe: EN 61010 EMC: EN 61326
Conforming standard	JIS C 1304:2002 (abolished)
Accessories	See “Verifying Package Contents” (p. 1)
Options	See “Options (sold separately)” (p. 2)

3.2 Basic Specifications

Measurement item	Earth resistance, earth voltage
Measuring range	Earth resistance: 0 Ω to 1150 Ω Earth voltage: 0 V to 30 V
Output voltage	AC without DC component overlapped (less than or equal to 1% of AC RMS component)
Open circuit voltage	Less than 50 V AC rms
Measurement current	Less than 15 mA AC rms (When the 2-pole method is used: less than 3 mA AC rms)
Measurement frequency	575 Hz / 600 Hz Tolerance: ±10%
Measurement method	3-pole method / 2-pole method AC potentiometer
Display method	Resistance indication on meter with linear scale dial, galvanometer
Terminals for measuring voltage	3-pole method: between Terminals S(P) (+) and E (–) 2-pole method: between Terminals H(C) (+) and E (–)

Maximum rated voltage to earth	300 V AC (measurement category II) Anticipated transient overvoltage: 2500 V
Overvoltage protection	250 V AC for 1 min. (between terminals E and S(P) and terminals E and H(C))
Operable number of times	1100 times Measurement condition: 30-second measurement / 30-second pause cycle, 3-pole method, 575Hz, earth resistance of the auxiliary earthing rod is 100 Ω, measurement of 10 Ω using ×1 Ω range
Function	Auxiliary earth resistance check function, overvoltage protection and alarm function (Buzzer sounds if a voltage of 85 V AC or more is input)

3.3 Measuring Range and Tolerances

Conditions of guaranteed accuracy	Guaranteed accuracy period: 1 year Guaranteed accuracy period from adjustment made by Hioki: 1 year Temperature and humidity for guaranteed accuracy: 23°C±5°C (73°F±9°F), 80% RH or less

Earth resistance	Range selector	×1 Ω	×10 Ω	×100 Ω
	Measurement range	10 Ω	100 Ω	1000 Ω
	Display range	0 Ω to 11.5 Ω	0 Ω to 115 Ω	0 Ω to 1150 Ω
	Fiducial value	10 Ω	100 Ω	1000 Ω
	Tolerance (intrinsic uncertainty A)	±0.25 Ω (±2.5% f.s.)	±2.5 Ω (±2.5% f.s.)	±25 Ω (±2.5% f.s.)
	For 2-pole measurement method, only 100 Ω and 1000 Ω ranges are applicable.			
Effect of position (E_1)	Horizontal ±90°		Tolerance × 1.0	
Effect of supplied voltage (E_2)	6 V to 10 V DC		Tolerance × 0.5 but within the measurement accuracy	
Effect of temperature (E_3)	0°C to 40°C		Tolerance × 1.0	

Effect of earth voltage (V_E) (E_4)	50 Hz, 60 Hz	0 V < V_E ≤ 5 V	Tolerance × 1.0
		5 V < V_E ≤ 10 V	Tolerance × 2.0
	DC,16 2/3 (sixteen and two-thirds) Hz, 400 Hz	0 V < V_E ≤ 3 V	Tolerance × 1.0
	For measurement of a resistance of 1 Ω using ×1 Ω range while affected by an earth voltage with a frequency of 400 Hz		Tolerance × 5.0
Effect of auxiliary earth resistance (E_5)	Exceeding 0 Ω to (100 × R_A) but less than or equal to 5 kΩ By S-H check		Tolerance × 1.0
	R_A: Total earth resistance value (between main ground terminal and the earth)		
Effect of system frequency (E_6)	N/A		
Effect of system voltage (E_7)	N/A		
Effect of external magnetic field (E_8)	In a magnetic field of 400 A/m DC or AC with a frequency of 50 Hz or 60 Hz		Tolerance × 0.5
Operating uncertainty (B)	$(B) = \pm\left(\|A\| + 1.15\sqrt{E_1^2 + E_2^2 + E_3^2 + E_4^2 + E_5^2 + E_7^2 + E_8^2}\right)$ ±17.8% f.s. at a maximum		

Earth voltage	Range selector	~V
	Measurement range	30 V
	Measuring range	0 V to 30 V
	Tolerance	±3.0% f.s.
	Effect of temperature	Tolerance × 1.0 (0°C to 40°C)

4 Maintenance and Service

4.1 Repair, Check Up, Cleaning

⚠ DANGER

Touching any of the high-voltage points inside the instrument is very dangerous.
Customers are not allowed to modify, disassemble, or repair the instrument.
Doing so may cause fire, electric shock, or injury.

IMPORTANT
Periodic calibration is necessary in order to ensure that the instrument provides correct measurement results of the specified accuracy.

Calibrations

The calibration period varies depending on the status of the instrument or installation environment. We recommend that the calibration period be determined in accordance with the status of the instrument or installation environment. Contact your Hioki distributor to have your instrument periodically calibrated.

Disposal

Handle and dispose of the instrument in accordance with local regulations.

4.2 Inserting/Replacing Batteries

Before using the instrument first time, insert 6 LR6 alkaline batteries.
Before measurements, check that the battery level is sufficient.
When the battery charge is low, replace the batteries.

⚠ WARNING

- **To avoid an electric shock, turn off the power and disconnect the cables and test leads before replacing the batteries.**
- **To prevent instrument damage or an electric shock, use only the screws for securing the battery cover in place that shipped with the product.**
  If you have lost any screws or find that any screws are damaged, please contact your authorized Hioki distributor or reseller for a replacement.

- **Battery may explode if mistreated. Do not short-circuit, disassemble or dispose of in fire. Do not recharge alkaline batteries. Handle and dispose of batteries in accordance with local regulations.**

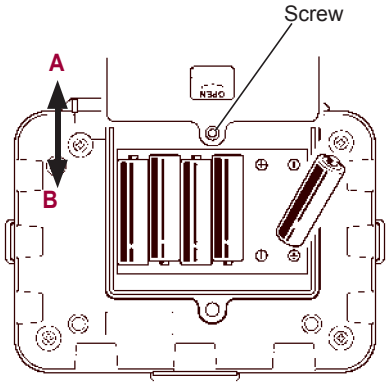
- **After replacing the batteries, replace the cover and secure the screws before using the instrument.**

⚠CAUTION

Poor performance or damage from battery leakage could result. Observe the cautions listed below.

- Do not mix new and old batteries, or different types of batteries.
- Be careful to observe the battery polarity during installation.
- Do not use batteries after their recommended expiry date.
- Do not leave depleted batteries inside the instrument.

- To avoid corrosion and damage to the instrument from battery leakage, remove the batteries from the instrument if it is to be stored for a long time.



1. **Disconnect the measurement leads from the instrument.**
2. **Remove the screw.**
3. **Remove the cover of the battery compartment sliding it in direction A, as shown in the illustration.**
4. **Replace all of the six batteries with fresh ones.**
5. **Reattach the cover of the battery compartment sliding in direction B, as shown in the illustration.**
6. **Fasten the screw to fix the battery compartment cover to the instrument.**

4.3 Cleaning the Unit

- After use, wipe the auxiliary earthing rods to remove mud and other contamination. Otherwise the rods may rust.
- To clean the instrument, wipe it gently with a soft cloth moistened with water or mild detergent.
- Wipe the display gently with a soft, dry cloth.

4.4 Service

- If damage is suspected, check “4.5 Before Returning for Repair” (p. 56) before contacting your authorized Hioki distributor or reseller.
- When transporting the instrument, be sure to observe the following precautions:
  To avoid damage to the instrument, remove the batteries and optional equipment from the instrument. Moreover, be sure to pack in a double carton. Damage occurring during transportation is not covered by the warranty.
- When sending the instrument for repair, be sure to include details of the problem.

4.5 Before Returning for Repair

Symptom	Checkpoint
When the **MEASURE** button is pressed while nothing is connected to the measurement terminals, the galvanometer may register to the end of the scale.	This is not a defect.
When the **MEASURE** button is operated, a high-pitched tone from the inside of the instrument will be heard.	This is not a defect.
Even when the resistance dial is turned, the needle of the galvanometer deflects to the left side of zero.	The earth resistance is higher than the measurement range. Check the earthing condition of the earth electrode.
The needle of the galvanometer goes off scale to the left.	The measurement leads may be broken or the ground line may not be connected to the ground. Check the continuity of the measurement leads using circuit tester. (check of disconnection)
The needle of the galvanometer is fluctuating.	A high-voltage has maybe been generated or the earth resistance of the auxiliary earthing rods may be high. Check the earth voltage and the auxiliary earth resistance.
The measurement with the earthing net placed over the asphalt surface is not possible.	Because asphalt is a non-conductor of electricity, the measurement is not possible even when the earthing net is used.

Symptom	Checkpoint
The S or H check does not enable the needle to rest on the green range.	The earth resistance of the auxiliary earthing rod pole is too high. Change the position of the rod, and/or pour water over the rods.
When measurement is performed with the E, C, and P terminals short-circuited with each other, the measurement result is 0 Ω.	This is not a defect. Check a break in the measurement cable and the earthing condition of the earth electrode.
The 2-pole measurement method cannot be carried out for the newly-built house.	Measurement cannot be performed in the absence of electric power distributed by a power company.
The result measured with the 2-pole measurement method is larger than the expected resistance value.	As for the 2-pole measurement method of the FT3151, the accuracy of the ×1 Ω range is not guaranteed. So the measurements of a low earth resistance (10 Ω or lower) is not accurate.
The measurement result obtained by using the existing auxiliary measurement electrodes is 0 Ω.	The earth electrode may be connected to the auxiliary measurement electrodes through concrete. Do not use the auxiliary measurement electrodes. Instead, drive the auxiliary earthing rods into the ground and measure it with using them.
The battery voltage check does not enable the needle to move even after the batteries are replaced with fresh ones.	The instrument has been damaged. Contact your authorized Hioki distributor or reseller.

Appendix

Appx. 1 Earth resistance

The resistance between an earthing electrode and the ground is usually called the earth resistance. To be exact, it is the sum of the resistance of the earthing conductor, the contact resistance between the earthing conductor and the ground, and the resistance of the ground.
Earth resistance measurement differs from ordinary resistance measurements, due to the factors described below.

- **Polarization action**
  Because the ground has characteristics just like electrolyte, it has the polarizing action: if DC current flows through the ground, an electromotive force occurs in the opposite direction to the current, interfering with correct measurement. Thus, a rectangular wave or a sine wave with a frequency of between several tens heltzes and 1 kHz is usually used to measure the earth resistance.
- **Special conditions**
  Earth resistance is resistance between an earthing electrode and the ground. It is not possible to take it out from the ground and measure it.
  Since the resistance of the ground is relatively high, a voltage drop occurs near the electrode through which the current to be measured flows. Thus, each of the electrodes, which consist of electrode E, electrode S(P), and electrode H(C), needs to be away from each other to approximately 10 m to accurately measure the resistance of earthing electrode.

- **Presence of disturbance factors**
  There are disturbance factors such as effects from earth voltage and an auxiliary earthing electrode in the measurement of earth resistance.
  The earth voltage caused by a leakage current from an instrument that has been connected to the earthing electrode superimposes over the signal to be detected by the earth tester, affecting measured values. In addition, if the earth resistance of the auxiliary earthing electrode is high, the measurement current is reduced, making the instrument susceptible to noise such as earth voltage.
  This instrument employs a system that is less susceptible to these disturbances and allows accurate measurement under adverse conditions.

Appx. 2 Measurement Principle

(1) 3-pole method (precise measurement)

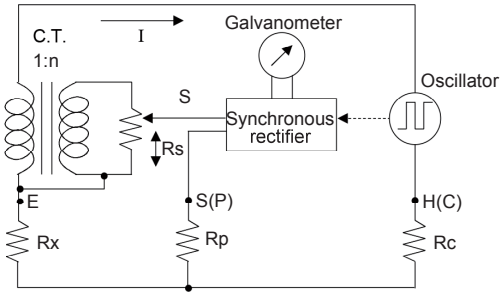
The figure below shows the basic circuit principle for earth resistance measurement.
The measurement current I, driven by the oscillating voltage of the oscillator, flows through the loop formed in the following order: the oscillator, Rc, Rx, and C.T.
Where the voltage between the measurement terminals E and S(P) is given by Ex; the resistance between the measurement terminal E and the slider S of the variable resistor, by Rs; and the voltage drop at the variable resistor, by Es, if the galvanometer is balanced, the following equations then apply:

Ex = IRx
Es = IRs/n (n: C.T. winding ratio)
Ex = Es

Hence

Rx = Rs/n

Then, if the dial connected directly to the sliding resistor has a scale of 1/n for Rs, the dial reading corresponds to the earth resistance Rx.



Measurement principle diagram (3-pole measurement)

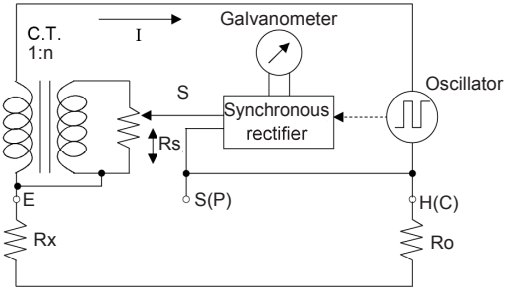
(2) 2-pole method (simplified measurement)

The figure below shows the basic circuit principle for a simplified earth resistance measurement using an existing earthing body. Where the earth resistance of the existing earthing body is given by Ro; and the earth resistance of the measurement object, by Rx, the same equation as for the 3-pole method applies:

Rx + Ro = Rs/n

Thus, the earth resistance can be found by adding the earth resistance of the existing earthing body (Ro) to the earth resistance of the measurement object (Rx).

In addition, the FT3151 uses a significantly low measurement current, in order that the leakage current circuit breaker of a commercial power supply does not be tripped when the grounded side of an AC outlet is used as existing earthing body.



Measurement principle diagram (2-pole measurement)

Warranty Certificate

HIOKI

Model	Serial No.	Warranty period Three (3) years from date of purchase (___ / ___)

This product passed a rigorous inspection process at Hioki before being shipped.

In the unlikely event that you experience an issue during use, please contact the distributor from which you purchased the product, which will be repaired free of charge subject to the provisions of this Warranty Certificate. This warranty is valid for a period of three (3) years from the date of purchase. If the date of purchase is unknown, the warranty is considered valid for a period of three (3) years from the product's date of manufacture. Please present this Warranty Certificate when contacting the distributor. Accuracy is guaranteed for the duration of the separately indicated guaranteed accuracy period.

1. Malfunctions occurring during the warranty period under conditions of normal use in conformity with the Instruction Manual, product labeling (including stamped markings), and other precautionary information will be repaired free of charge, up to the original purchase price. Hioki reserves the right to decline to offer repair, calibration, and other services for reasons that include, but are not limited to, passage of time since the product's manufacture, discontinuation of production of parts, or unforeseen circumstances.
2. Malfunctions that are determined by Hioki to have occurred under one or more of the following conditions are considered to be outside the scope of warranty coverage, even if the event in question occurs during the warranty period:
   a. Damage to objects under measurement or other secondary or tertiary damage caused by use of the product or its measurement results
   b. Malfunctions caused by improper handling or use of the product in a manner that does not conform with the provisions of the Instruction Manual
   c. Malfunctions or damage caused by repair, adjustment, or modification of the product by a company, organization, or individual not approved by Hioki
   d. Consumption of product parts, including as described in the Instruction Manual
   e. Malfunctions or damage caused by transport, dropping, or other handling of the product after purchase
   f. Changes in the product's appearance (scratches on its enclosure, etc.)
   g. Malfunctions or damage caused by fire, wind or flood damage, earthquakes, lightning, power supply anomalies (including voltage, frequency, etc.), war or civil disturbances, radioactive contamination, or other acts of God
   h. Damage caused by connecting the product to a network
   i. Failure to present this Warranty Certificate
   j. Failure to notify Hioki in advance if used in special embedded applications (space equipment, aviation equipment, nuclear power equipment, life-critical medical equipment or vehicle control equipment, etc.)
   k. Other malfunctions for which Hioki is not deemed to be responsible

*Requests
- Hioki is not able to reissue this Warranty Certificate, so please store it carefully.
- Please fill in the model, serial number, and date of purchase on this form.

16-01 EN

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- Please visit our website at www.hioki.com for the following:
  - ■ Regional contact information
  - ■ The latest revisions of instruction manuals and manuals in other languages.
  - ■ Declarations of Conformity for instruments that comply with CE mark requirements.
- All reasonable care has been taken in the production of this manual, but if you find any points which are unclear or in error, please contact your supplier or the International Sales and Marketing Department at Hioki headquarters.
- In the interests of product development, the contents of this manual are subject to revision without prior notice.
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