SM7110
SM7120

HIOKI

Instruction Manual

SUPER MEGOHM METER

Be sure to read this manual before using the instrument. ▶ p.6, p.9

When using the instrument for the first time

Troubleshooting

EN

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SM7110A961-05 20-09H

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Contents

Introduction

Thank you for purchasing the Hioki SM7110/SM7120 Super Megohm Meter. To obtain maximum performance from the instrument, please read this manual first, and keep it handy for future reference.

Following manuals are provided along with these models. Refer to manuals relevant to your purpose.

Type	Contents	Printed	CD-stored File name
Instruction Manual (This document)	Operating instructions, functions, specifications, etc.	✓	–
Communications Command Instruction Manual	Explanation of communications (including message references and measured value formats)	–	✓ SM7110A964-XX

Trademark

- Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and other countries.
- TEFLON is a registered trademark or a trademark of The Chemours Company FC, LLC.

Notation

*	Additional information is presented below.
SET (Bold character)	Operation keys are displayed in bold.
[ ]	Names on the screen are indicated with brackets **[ ]**.

Accuracy

Hioki expresses accuracy as error limit values specified in terms of percentages of reading, of full scale, and of setting, and digits.

Full scale (Maximum displayable value)	Refers to the maximum displayable value of each measurement range. The instrument has measurement ranges whose values are equal to the maximum displayable values. The limit values of full-scale errors are expressed in percent of full scale (% of full scale. % f.s.).
Reading (Displayed value)	Refers to the displayed value of the measuring instrument. The limit values of reading errors are expressed in percent of reading (% of reading, % rdg).
Digits (Resolution)	Refers to the smallest change in the indication on the digital measuring instrument, i.e., the numeral one in the right most place. The limit values of digit errors are expressed in terms of digits (dgt).
Setting (Set value)	Refers to the set value, such as a voltage value or current value, to be outputted from the instrument. The limit values of setting errors are expressed in percent of setting (% of setting).

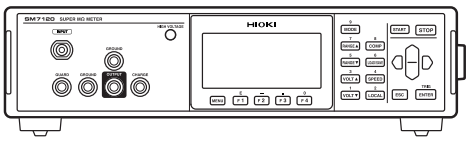
Verifying Package Contents

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

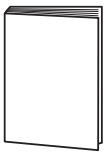
Main unit and accessories

Confirm that these contents are provided.

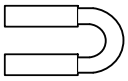
☐ Model SM7110 or SM7120
Super Megohm Meter



☐ Instruction Manual



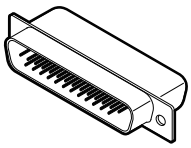
☐ Shorting plug
(For connecting the GROUND terminal with the OUTPUT terminal [or the GUARD terminal])



☐ CD (Communications Command Instruction Manual, USB driver)*

* The latest version can be downloaded from our website.

☐ Male connector for EXT I/O



☐ Power cord

Options

The following options are available for the instrument. Contact your authorized Hioki distributor or reseller when ordering. Options are subject to change. Please check Hioki's website for the latest information. Options are subject to change. Please check Hioki's website for the latest information.

Measurement leads

See p. 11.

☐ **Model L2230 Pin Type Lead (Red)**

Length: 1 m
Terminal shape: Triaxial BNC
Maximum rated voltage: 2000 V
Maximum rated current: 1 A

☐ **Model L2231 Pin Type Lead (Black)**

Length: 1 m
Terminal shape: Banana
Maximum rated voltage: 2000 V
Maximum rated current: 1 A

☐ **Model L2232 Clip Type Lead (Red)**

Length: 1 m
Terminal shape: Triaxial BNC
Maximum rated voltage: 2000 V
Maximum rated current: 1 A

☐ **Model L2233 Clip Type Lead (Black)**

Length: 1 m
Terminal shape: Banana
Maximum rated voltage: 2000 V
Maximum rated current: 1 A

☐ **Model L2234 Open Lead (Red)**

Length: 3 m
Terminal shape: Triaxial BNC
Maximum rated voltage: 2000 V
Maximum rated current: 1 A

☐ **Model L2235 Open Lead (Black)**

Length: 3 m
Terminal shape: Banana
Maximum rated voltage: 2000 V
Maximum rated current: 1 A

Communication cables

☐ **Model 9637 RS-232C Cable (9pin-9pin/1.8m)**

☐ **Model 9638 RS-232C Cable (9pin-25pin/1.8m)**

☐ **Model 9151-02 GP-IB Connector Cable (2 m)**

Electrodes

Conversion of the connectors is required to connect these electrodes. Contact your authorized Hioki distributor or reseller.

☐ **Model SME-8301 Surface Resistance Measurement Electrode**

☐ **Model SME-8302 Electrode for Surface Resistance**

☐ **Model SME-8310 Plate Sample Electrode**

☐ **Model SME-8311 Electrode for Flat Sample**

☐ **Model SME-8320 Weight Electrode**

☐ **Model SME-8330 Liquid Sample Electrode**

☐ **Model SME-8350 Shielding Box**

☐ **Model SME-8360 Electrode for Chip Capacitor**

☐ **Model SM9001 Surface/Volume Resistance Measurement Electrode**

☐ **Model SR-2 Standard Resistor**

Temperature and humidity sensor

☐ **Model Z2011 Humidity Sensor**

Other

☐ **Model DSM8104F Interlock Cable**

Required to use the interlock function in combination with Model SME-8310, SME-8311, or SME-8350.

Measurement Procedure

Be sure to read “Operating Precautions” (p. 9) beforehand.

Installing, connecting, and turning on the instrument

Install the instrument. (p. 10)

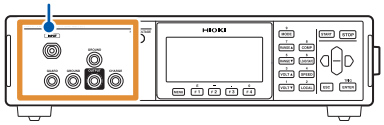
Connect the power cord to the instrument. (p. 29)

Connect the measurement lead, electrode, and the Humidity Sensor to the instrument. (p. 30)

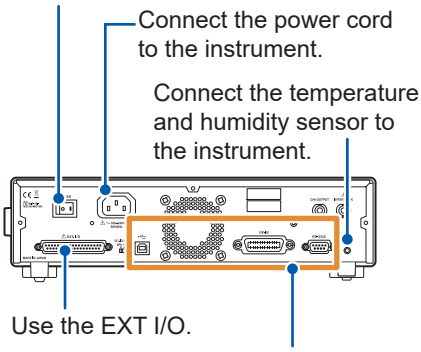
Connect other devices to the instrument via the external interface (as needed).
- Use the EXT I/O. (p. 112)
- Connect a computer to the instrument for communications through USB, RS-232C, or GP-IB. (p. 131)

Turn on the instrument. (p. 37)
(It takes at least 30 minutes to complete a warm-up.)

Connect the measurement lead and electrode to the instrument.



Turn on the instrument.



Setting the instrument (p. 39)

Set the measurement conditions (as needed).
- Basic setting (p. 39)
- Customized setting for measurement conditions (p. 49)
- Setting related to the system (p. 101)
- Default setting table (p. 109)

Starting the measurement

Execute the open correction. (p. 68)

If contact check is set to ON, execute the open correction.

Connect the measurement lead to an object to be measured. (p. 45)

Start the measurement. (p. 46)

Check the measured values. (p. 46)
When the pre-charge function is enabled, the instrument charges the object to be measured through the CHARGE terminal. (p. 64)

Press the STOP key to end the measurement. (p. 46)

If the trigger source setting is set to **[EXTERNAL]**, the measurement automatically stops in completion of each measurement.

Ending

Turn off the instrument. (p. 37)

Safety Information

This instrument is designed to conform to IEC61010 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. If persons unfamiliar with electricity measuring instrument are to use the instrument, another person familiar with such instruments must supervise operations.

Notation

In this manual, 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.

Symbols on the instrument

	Indicates cautions and hazards. When the symbol is printed on the instrument, refer to a corresponding topic in the Instruction Manual.
	Indicates that dangerous voltage may be present at this terminal.
	Indicates the ON side of the power switch.
	Indicates the OFF side of the power switch.
	Indicates a grounding terminal.
	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.

Measurement categories

To ensure safe operation of measuring instruments, IEC61010 establishes safety standards for various electrical environments, categorized as CAT II to CAT IV, and called measurement categories.

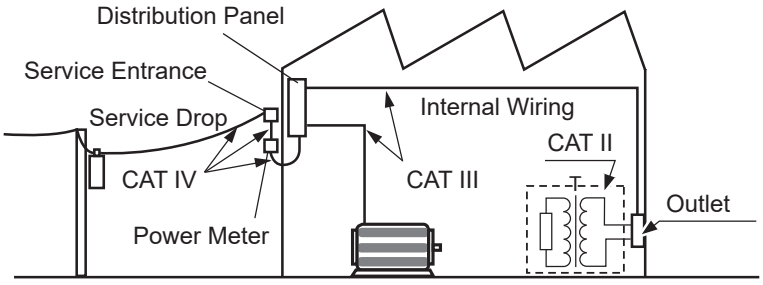
⚠ DANGER

- **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.**

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

Operating Precautions

Follow these precautions to ensure safe operation and to obtain the full benefits of the various functions.

⚠ DANGER

If the measurement lead or the instrument is damaged, there is a risk of electric shock. Before using the instrument, perform the following inspection:

- **Before using the instrument check that the coating of the measurement leads are neither ripped nor torn and that no metal parts are exposed. Using the instrument under such conditions could result in electric shock. Replace the measurement leads with those specified by our company.**
- **Verify that the instrument operates normally to ensure that no damage occurred during storage or shipping. If you find any damage, contact your authorized Hioki distributor or reseller.**

To prevent an electric shock, confirm that the braided conductor for shielding wire is not exposed. If a braided conductor for shielding wire is exposed, do not use the cable.

Instrument installation

⚠ WARNING

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**

⚠ CAUTION

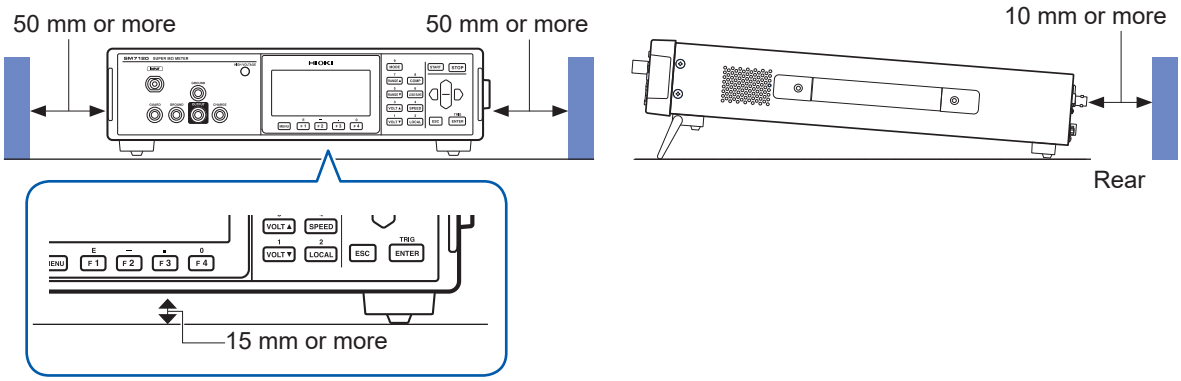
Do not place the instrument on an unstable table or an inclined place. Dropping or knocking down the instrument can cause injury or damage to the instrument.

This instrument is not drip-proof. Water droplets on the connector may result in malfunctions.

Installing the instrument

To prevent overheating, be sure to leave the specified clearances around the instrument.

- Install with the bottom surface facing downward.
- Vents must not be obstructed.



“Extending and retracting the stands” (p. 20)

Handling the instrument

⚠ DANGER

To avoid electric shock, do not remove the instrument’s case. The internal components of the instrument carry high voltages and may become very hot during operation.

⚠ CAUTION

To avoid damage to the instrument, protect it from physical shock when transporting and handling. Be especially careful to avoid physical shock from dropping.

This instrument may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

Before connecting the power cord to the instrument

⚠ DANGER

Use only the designated power cord with this instrument. Use of other power cords may cause fire.

⚠ WARNING

- **Before turning the instrument on, make sure the supply voltage matches that indicated on its power connector. Connection to an improper supply voltage may damage the instrument and present an electrical hazard.**
- **To avoid electrical accidents and to maintain the safety specifications of this instrument, connect the power cord provided only to a 3-contact (two-conductor + ground) outlet.**

⚠ CAUTION

- Do not connect the supply voltage improperly. Doing so may damage the instrument's internal circuitry.
- To avoid damaging the cords, unplug it by grasping the connector, not the cord.

Before connecting the measurement leads and electrode to the instrument

⚠ WARNING

- **Do not use the instrument with circuits that exceed its ratings or specifications. Doing so may damage the instrument or cause it to become hot, resulting in electric shock.**
- **The maximum rated voltage to earth of the input terminal is 1000 V DC for Model SM7110 and 2000 V DC for Model SM7120. Do not apply any higher voltage input to the input terminal.**

- **Use only the specified measurement lead. If using a measurement lead other than the one specified, you cannot perform measurement safely.**
- **To avoid electric shock, do not exceed the lower of the ratings shown on the instrument and test leads.**

Before connecting the Humidity Sensor to the instrument

⚠ CAUTION

- The sensor used in the Humidity Sensor is a thin, precision platinum film. Be aware that excessive voltage pulses or static discharges can destroy the film.
- Avoid subjecting the tip of the Humidity Sensor to physical shock, and avoid sharp bends in the leads. These may damage the probe or break a wire.
- Note that the ambient temperature does not exceed the temperature range specified in Refer to "Specifications of Model Z2011 Humidity Sensor" (p. 146).

Before connecting the measurement leads or electrode to an object to be measured

⚠ WARNING

Between either of the following terminals, a maximum voltage of 1000 V may be generated depending on the measurement voltage settings.

- **Between the OUTPUT terminal and the INPUT terminal**
- **Between the OUTPUT terminal and the GUARD terminal**

To avoid danger, be sure to turn off the instrument before connecting the measured object to the measurement terminal.
If the GUARD terminal and the GROUND terminal are connected with each other, be aware that high voltage is also generated between the OUTPUT terminal and the ground.

Before grounding the instrument

⚠ WARNING

- **During measurements of an object grounded by one wire, if the OUTPUT terminal and the GROUND terminal are connected with each other, a maximum voltage of 2000 V to the earth is applied on the GUARD terminal, INPUT terminal, and an external electrode (the shielding side of measurement lead), according to the measurement voltage settings. Take precautions to avoid an electric shock.**
- **If the GUARD terminal and the GROUND terminal are connected with each other, a maximum voltage of 2000 V is applied between the OUTPUT terminal and the ground (the GROUND terminal is grounded), according to the measurement voltage settings. Take precautions to avoid an electric shock.**

Before performing a measurement

⚠ WARNING

- **While measuring insulation resistance, and when pressing the START key, dangerous voltage is applied to the measurement terminals. To avoid electric shock, do not touch the measurement leads.**
- **Even after the STOP key is pressed, the measurement voltage may remain in the measured object. Because there is a risk of an electric shock, take care to not touch metallic parts to which the voltage is applied until they are fully discharged.**
- **The set voltage is applied to the measured object. Take precautions to avoid an electric shock.**

Before performing an automatic measurement

⚠ CAUTION

To protect the relay contacts, switching the measurement terminals with relays leaving a measurement voltage output requires a protective resistor* inserted in series in the circuit.
Protective resistance value ≥ (Measurement voltage) / (Maximum allowable current)
*** Implements resistance to prevent the current flowing through the contact from exceeding the maximum allowable current of the contact**

Before using the shielding box

⚠ WARNING

A maximum measurement voltage of 2000 V may be generated between the GUARD terminal or the OUTPUT terminal and the GROUND terminal according to a connecting manner of the shorting plug.
Be sure to connect the external case of the shielding box to the GROUND terminal.
To prevent an electric shock, use the interlock function (p. 62).
In addition, take sufficient precautions to avoid an electric shock.

Before removing the measured object

⚠ WARNING

If a high-voltage is used to measure resistance, because measurement voltage may remain in the measured object even after the measurement has ended, there is the risk of an electric shock if you try to immediately remove the object. Set the time in Discharge 2 relatively longer and remove the measured object after the dangerous voltage has been discharged.

Before controlling the instrument externally

Read the following precautions before also using the interlock function.

⚠ WARNING

To avoid electric shock or damage to the equipment, always observe the following precautions when connecting to connectors:
- **Be careful to avoid exceeding the ratings of connectors.**
- **During operation, a wire becoming dislocated and contacting another conductive object can be serious hazard. Use screws to secure the RS-232C connector, GP-IB connector, and EXT I/O terminal.**
- **Ensure that devices and systems to be connected to the RS-232C connector, GP-IB connector, EXT I/O terminal, or INTER LOCK terminal are properly isolated.**

⚠ CAUTION

You must not operate the EXT I/O MODE switch (NPN/PNP) during the instrument turned on.

Select the external I/O mode between NPN and PNP based on devices that are externally connected (p. 112).

Before connecting the communication cable to the instrument

⚠ DANGER

To avoid electrical hazards and damage to the instrument, do not apply voltage exceeding the rated maximum to the EXT I/O terminal.

⚠ CAUTION

- Use a common ground for both the instrument and the computer. Use of different ground circuits will result in a potential difference between the instrument's ground and the computer's ground. If the communications cable is connected while such a potential difference exists, it may result in equipment malfunction or failure.
- Before connecting any communications cable to the instrument or disconnecting any communications cable from the instrument, always turn off the instrument and the computer. Failure to do so could result in equipment malfunction or damage.
- After connecting the communications cable, tighten the screws on the connector securely. Failure to secure the connector could result in equipment malfunction or damage.

Before performing the open correction

⚠ WARNING

If an open correction is carried out, a measurement voltage is instantly output from the measurement terminal.
Before carrying out an open correction (pressing the F2 key [EXEC]), check that no human body is in contact with any jigs or measurement circuits. There is the risk of an electric shock because a maximum voltage of 2000 V is produced.

Before using the instrument as an ammeter

⚠ CAUTION

- To avoid malfunctions of the instrument, insert an adequate protective resistor between the external power supply and the object to be measured. A short-circuit of the terminals of the object causes the instrument to be subject to a voltage output from the external power supply.
- To avoid malfunctions of the instrument, limit the input current at up to 1.8 mA during the testing using a measurement voltage of between 1000 V and 2000 V.

See “Appx. 5 Using Instrument as Ammeter (If Operated in Combination With External Power Supply)” (p. Appx.7).

Precautions during shipment

Store the packaging in which the instrument was delivered, as you will need it when transporting the instrument.

CD precautions

- Exercise care to keep the recorded side of discs free of dirt and scratches. When writing text on a disc's label, use a pen or marker with a soft tip.
- Keep discs inside a protective case and do not expose to direct sunlight, high temperature, or high humidity.
- Hioki is not liable for any issues your computer system experiences in the course of using this disc.

1 Overview

1.1 Product Overview and Features

This instrument is an insulation resistance meter containing a highly sensitive ammeter and a low-noise voltage supply.
Employing the triaxial BNC connector enables the instrument to measure high resistance such as resistance of insulators with no influence of exogenous noise.
The maximum measurement voltages of Model SM7120 and Model SM7110 are 2000 V and 1000 V, respectively.

Stable measurements for a variety of items

- The triaxial BNC connector is used to have external noise resistant structures.
- The maximum measurement voltage is 2000 V, so various objects can be simply measured with a single instrument.
- The instrument has a wide measuring range. (Depends on applied voltage)
- Resistance measuring range: (p. 144); Current measuring range: 0.1 fA to 2 mA
- Because temperature and humidity can be measured simultaneously, change in resistance can be checked against the change in temperature and humidity.
- The contact check function enables you to perform stable measurements even when a voltage applied to measured objects is 2000 V or higher.

Suitable for production lines

- High-speed measurement; it takes only 6.4 ms from input of a trigger to output of the INDEX signal.
- The frequency change function of contact check reduces interference with other devices in the production line.
- It is not necessary to correct cable length even when changing production line construction because the instrument automatically corrects the cable length of contact check.
- Because you can check the control status with the command monitor function and the external I/O monitor function, you can quickly construct a production line.
- Because the external I/O is compatible with both NPN and PNP types, you can immediately use it on your production line.

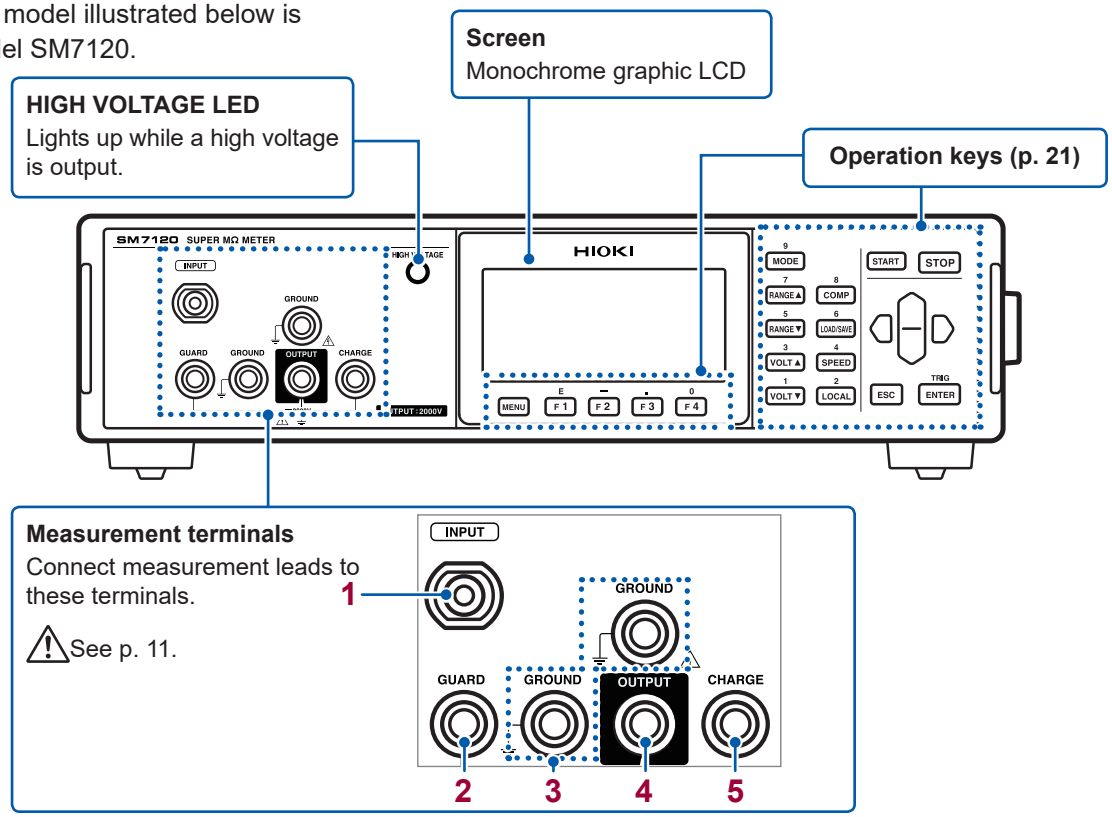
What can be measured

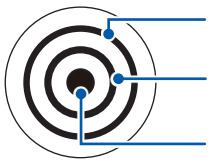
- Insulation resistance between capacitor terminals
- Insulation resistance between a battery terminal and a case
- Insulation resistance between coils of common mode filters
- Checking breakdown voltage
- Surface resistivity and volume resistivity of film, etc.
- Insulation resistance of liquid sample

1.2 Names and Functions of Parts

Front

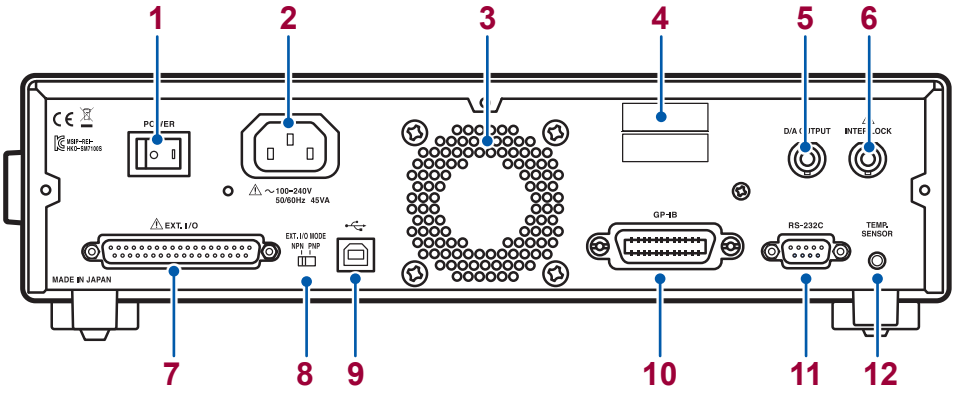
The model illustrated below is Model SM7120.



Measurement terminal		Description
1	INPUT	This is a measurement input terminal. Has triaxial structure. The central conductor is for measurement input. The second-outermost electrode is connected with the GUARD terminal. The second-outermost electrode is connected with the GROUND terminal.  Electromagnetic shielding wire Guard wire for measurement Measurement input wire Additionally installing the shield wires in the measurement line enables the instrument to perform stable measurement with no influence of exogenous noise.
2	GUARD	This is a guard terminal. It is the common side of the ammeter. Used in order to take the guard that cancels the effect of the a leakage current flowing through the retainer, measurement fixture, etc. of the measured object. The GUARD terminal has a negative (−) electrical polarity.
3	GROUND	This is a ground terminal. Used to reduce the effects of noise and minimize the risk of an electric shock. Usually connected to the OUTPUT terminal or the GUARD terminal with the shorting plug.
4	OUTPUT	This is a voltage output terminal. Insulation resistance is measured between this OUTPUT terminal and the INPUT terminal. The electrical polarity of the OUTPUT terminal is positive (+).

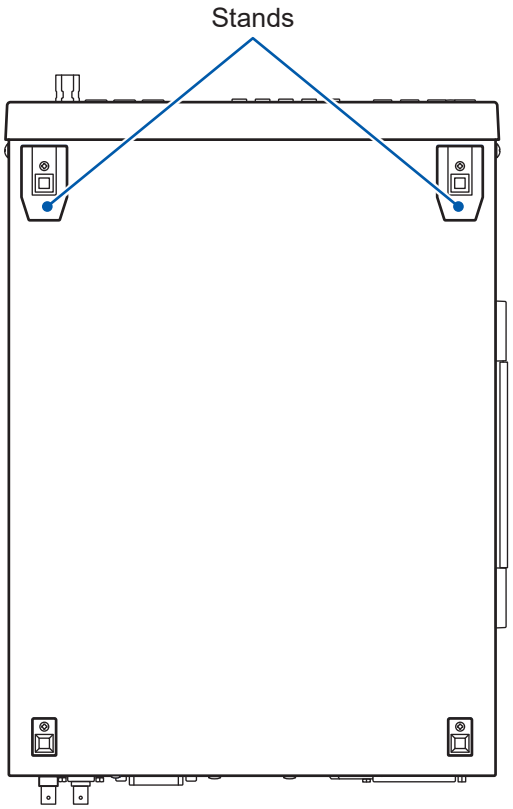
Measurement terminal		Description
5	CHARGE	This is a charge voltage output terminal. Used to pre-charge objects before measurement. The pre-charge voltage is output between the CHARGE terminal and the GROUND terminal. The voltage is same as the measurement voltage. The CHARGE terminal has the same electric potential as the OUTPUT terminal, and its electrical polarity is positive (+).

Rear



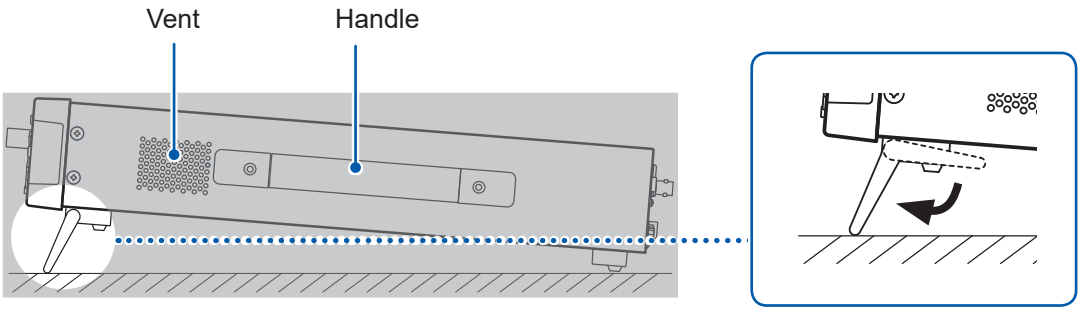
Name		Description
1	Power switch	See p. 37.
2	Power inlet	Connect the accessory power cord to this inlet. (p. 29) ⚠ See p. 11.
3	Vents	Keep the vents clear of obstructions.
4	Serial number	Indicates the serial number. The serial number consists of 9 digits. The first two (from the left) indicate the year of manufacture, and the next two indicate the month of manufacture. Do not remove this label because it is required for product support.
5	D/A OUTPUT terminal	Outputs a voltage proportional to the measured value. (p. 36)
6	INTER LOCK terminal	Used when the interlock function is enabled to prevent an electric shock. (p. 62) ⚠ See p. 13.
7	EXT I/O terminal	Connects an external controller to this connector. (p. 111) ⚠ See p. 13.
8	EXT I/O MODE switch	Left: Current sink (NPN), Right: Current source (PNP) (p. 112)
9	USB connector	Connects a computer to one of these connectors. (p. 131)
10	GP-IB connector	
11	RS-232C connector	
12	TEMP. SENSOR terminal	Connects Model Z2011 Humidity Sensor to this terminal. (p. 32)

Bottom



Right

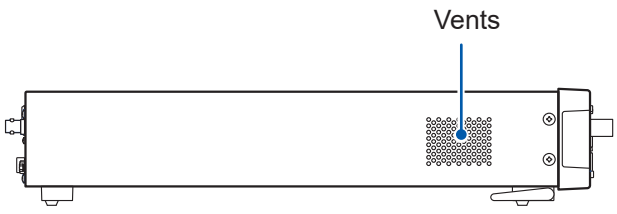
Extending and retracting the stands



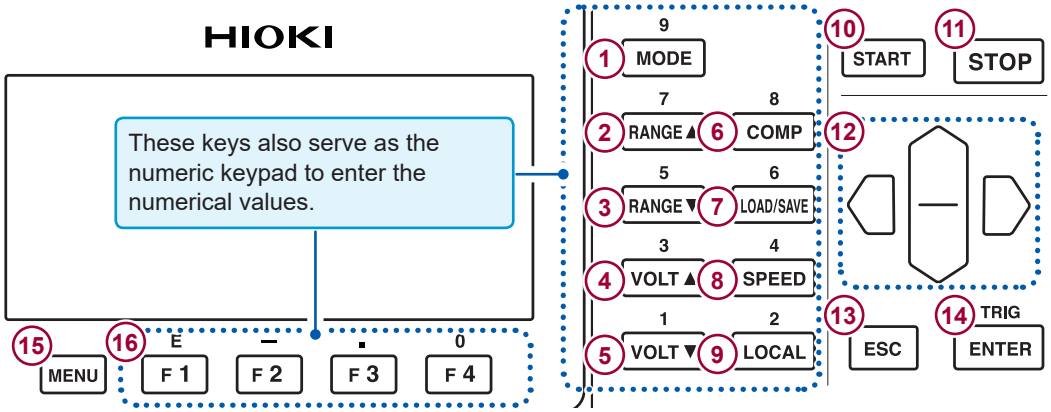
⚠ CAUTION

Do not apply heavy downward pressure with the stand extended. The stand could be damaged.

Left



Operation keys



	Key	Description
1	MODE	Switches the measurement mode. The mode changes every time the key is pressed in the following order: Resistance, Current, Surface resistance, Volume resistance, Liquid volume resistance, and returns back to Resistance.
2	RANGE▲	Switches the present current range to the next upper one. You can change settings on the measurement screen. The range changes every time the key is pressed in the following order: 20 p, 200 p, 2 n, 20 n, 200 n, 2 u, 20 u, 200 u, and 2 m. Some ranges are not available depending on the measurement speed setting.
3	RANGE▼	Switches the present current range to the next lower one. You can change settings on the measurement screen. The range changes every time the key is pressed in the reverse order of the above.
4	VOLT▲	Switches the present measurement voltage to the next upper one. The voltage changes every time the key is pressed in the following order: 0.1, 0.5, 1, 2.5, 5, 10, 25, 50, 100, 250, 500, 1000, (1500, and 2000).
5	VOLT▼	Switches the present measurement voltage to the next lower one. The voltage changes every time the key is pressed in the reverse order of the above.
6	COMP	Displays the comparator settings screen.
7	LOAD/SAVE	Displays the panel load / panel save screen.
8	SPEED	Switches the measurement speed. You can change settings on the measurement screen. The speed changes every time the key is pressed in the following order: FAST, FAST2, MED, SLOW, SLOW2, and returns back to FAST. Some measurement speeds are not available depending on the current range setting.
9	LOCAL	Disables the remote control (communicating with an external device) and enables the key operation.
10	START	Starts measurement.
11	STOP	Stops measurement.
12	◁ – ▷	• Moves the cursor to another setting item or digit. • Changes numerical values.
13	ESC	• Cancels the setting. • Returns to the measurement screen from other screens.

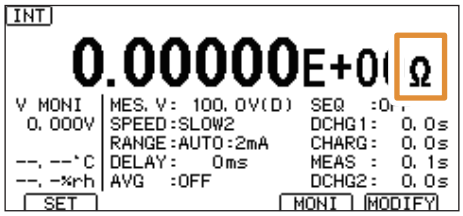
	Key	Description
⑭	TRIG ENTER	Settles the setting. Inputs the trigger if the external trigger setting is used.
⑮	MENU	Moves the screen to another menu settings screen.
⑯	F 1 to F 4	Function keys. Selects item on each settings screen.

1.3 Screen Configuration and Operation

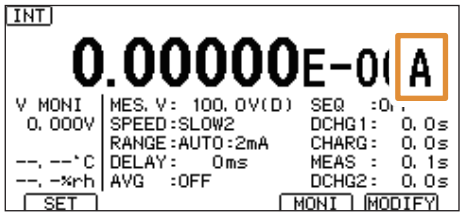
The screens of the instrument consists of the measurement screens and the settings screens.

Measurement screens

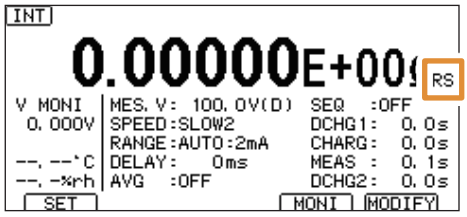
MODE



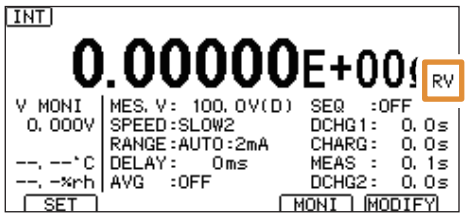
Resistance value measurement mode (initial screen)



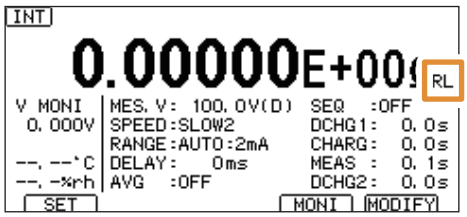
Current value measurement mode



Surface resistivity measurement mode



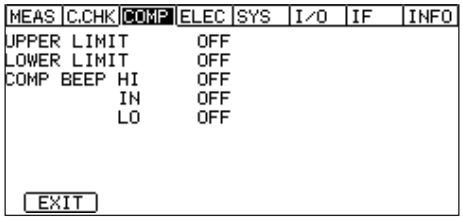
Volume resistivity measurement mode



Liquid volume resistivity measurement mode

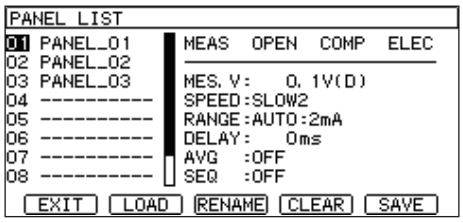
Settings screens

COMP **Comparator settings screen**

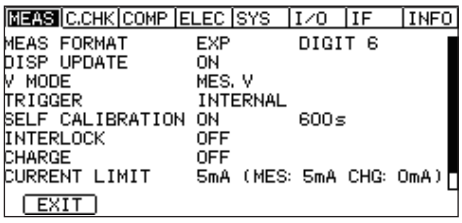


You can also display the screen if you select the **[COMP]** tab on the menu settings screen.

LOAD/SAVE **Panel load / panel save screen**

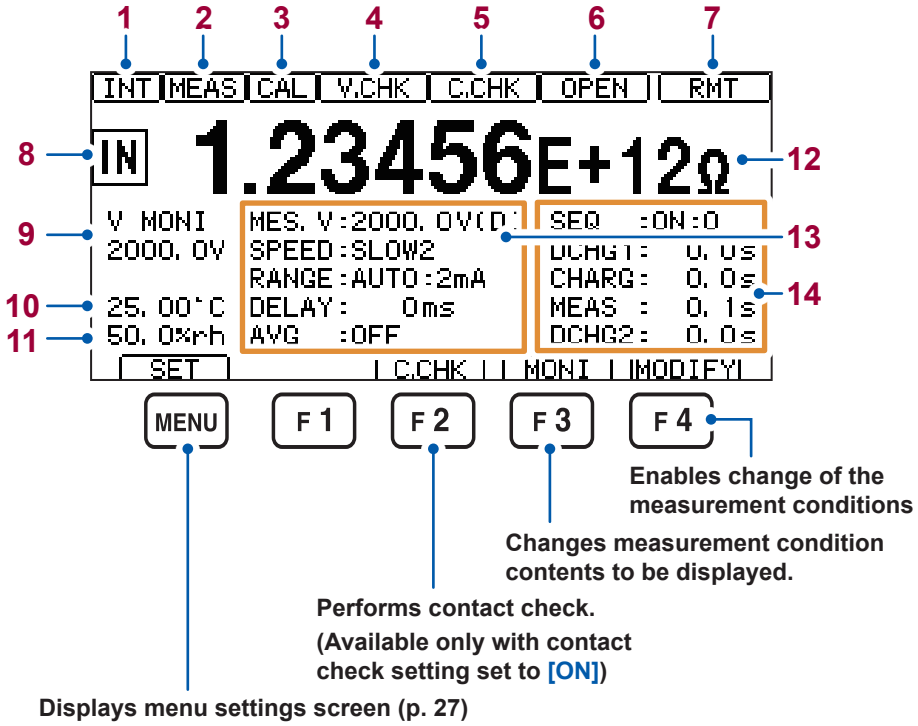


MENU **Menu settings screen**



See “List of menu settings screens” (p. 27).

1.4 Displayed Contents of Measurement Screen



Name		Description	
1	Trigger setting	Displays the presently set trigger.	
		[INT]	Internal trigger
		[EXT]	External trigger
2	Sampling data	Appears during the sampling data.	
3	Self-calibration	Appears during the self-calibration.	
4	Voltage monitor check	Appears when the voltage monitor check function is enabled. Highlighted in reverse video if the voltage is abnormal.	
5	Contact check	Appears when the contact check function is enabled. Highlighted in reverse video if a contact error occurs.	
6	Open correction execution result	Displays the result when the open correction is executed once.	
7	Interlock Key lock	[I.LOCK]	Appears while the interlock function is activated.
		[K.LOCK]	Appears while the key lock function is activated.
		Displays [I.LOCK] while both the interlock and the key lock functions are activated.	
	Remote	[RMT]	Appears while the instrument is placed in the remote status (communicating with an external device). Pressing the LOCAL key disables the remote control.
8	Measurement judgment	Displays the judgment result if the comparator function is enabled.	
9	Voltage monitor value	The voltage produced by the instrument is displayed.	
10	Temperature	Displays temperature and humidity if the Humidity Sensor is connected. Displays an error message if the Humidity Sensor is not connected to the instrument (p. 163). See “2.4 Connecting Humidity Sensor” (p. 32).	
11	Humidity		
12	Measured value	Displays the measured value corresponding to the measured value display mode (p. 39).	

<table>
<tr><th colspan="2">Name</th><th colspan="2">Description</th></tr>
<tr><td rowspan="2">13</td><td rowspan="2">Measurement conditions</td><td>[MES. V]

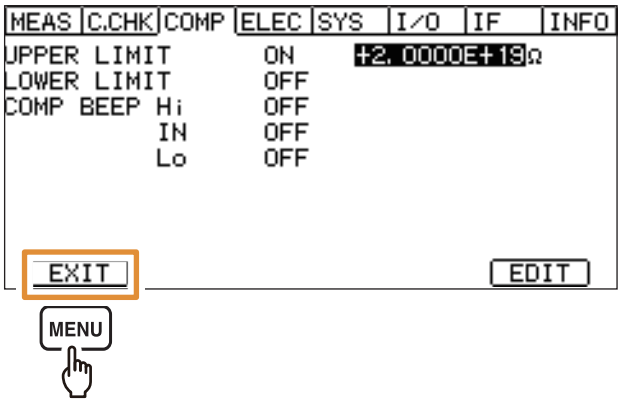
[SPEED]

[RANGE]
[DELAY]
[AVG]</td><td>Applied voltage for measurement (p. 41)
Measurement speed (p. 43)
Current range (p. 44)
Delay function (p. 49)
Average function (p. 50)</td><td rowspan="2">Pressing the F3 key [MONI] changes the contents to be displayed.

MES. V: 100.0V(D) SEQ :OFF
SPEED:SLOW2 DELAY: 0ms
RANGE:AUTO:2mA AVG :OFF</td></tr>
<tr><td>14</td><td>Measurement conditions (Sequence program)</td><td colspan="2">See “4.3 Automatic Inspection (Sequence Program Function)” (p. 52).</td></tr>
</table>

1.5 Basic Key Operation

Displaying measurement screen

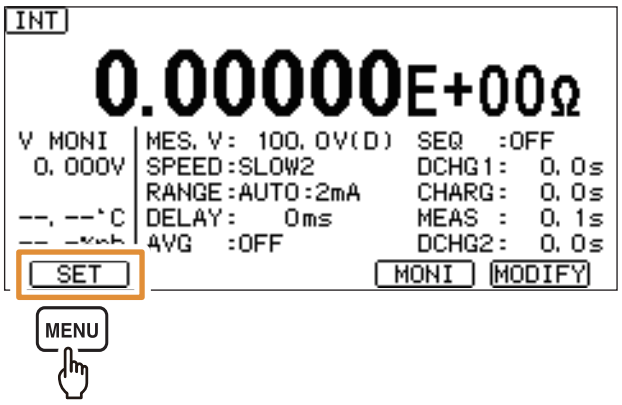


You can also press the **ESC** key to return to the measurement screen.

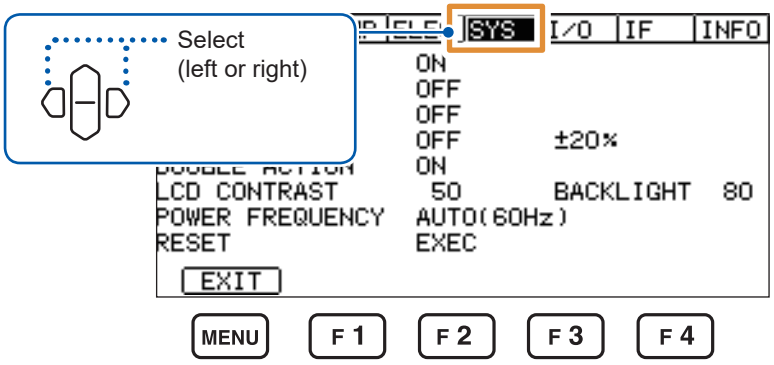
Displaying the various menu settings screens

This section shows an example of switching the measurement screen to the **[SYS]** screen.

1



2

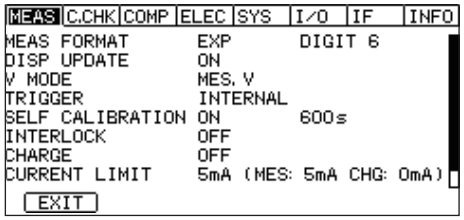


In this manual, the procedure to display the settings screen is described as follows:

Procedure to display the settings screen: (Measurement screen) **MENU** key > ◁▷ **[SYS]** tab

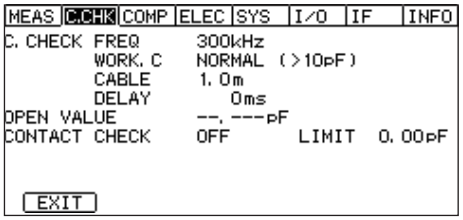
(That is to say, to display the settings screen, on the measurement screen, press the MENU key, and then press the keys ◁ and ▷ to select the **[SYS]** tab.)

List of menu settings screens



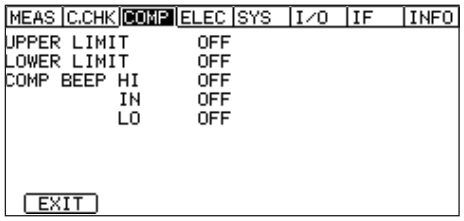
[MEAS] screen

Configuring settings for measurement



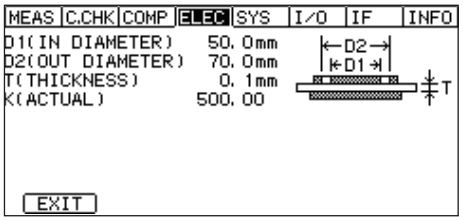
[C.CHK] screen

Configuring settings for open correction and contact check



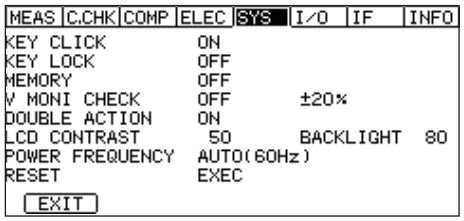
[COMP] screen

Configuring settings for measured value judgment



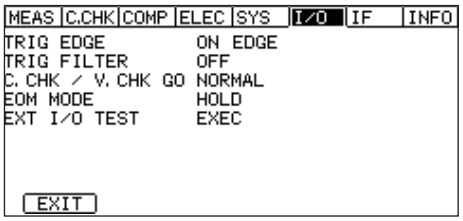
[ELEC] screen

Configuring settings for calculating resistivity



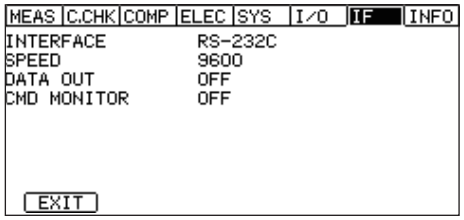
[SYS] screen

Configuring system settings



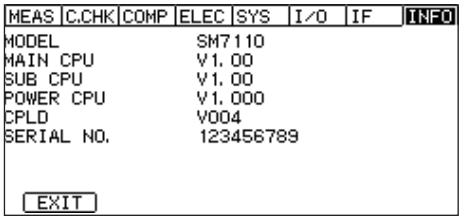
[I/O] screen

Configuring settings for external control



[IF] screen

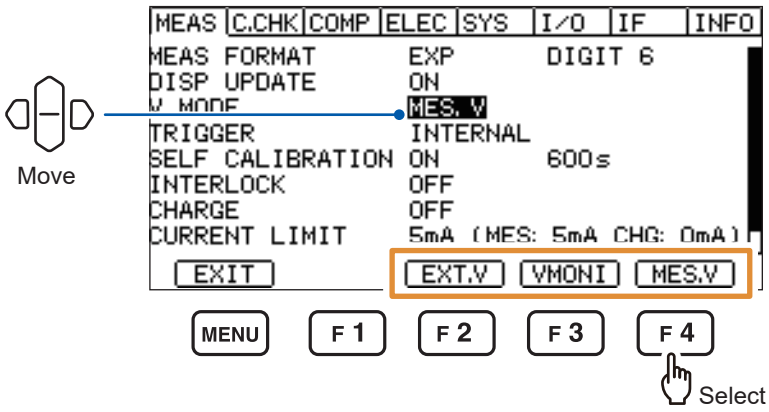
Configuring settings for interface



[INFO] screen

Displays the information of this instrument.

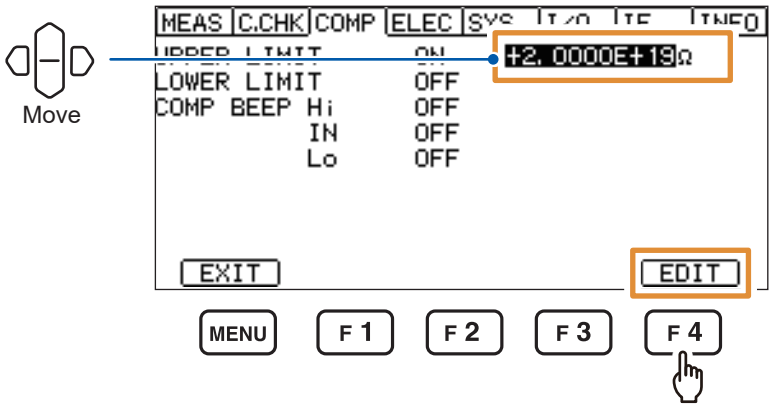
Selecting settings items



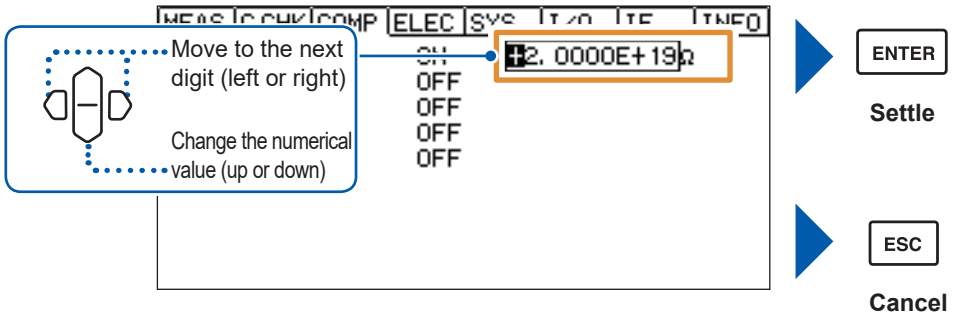
Methods for changing numerical values

The two options are available: using the cursor keys and using the numeric keypad.

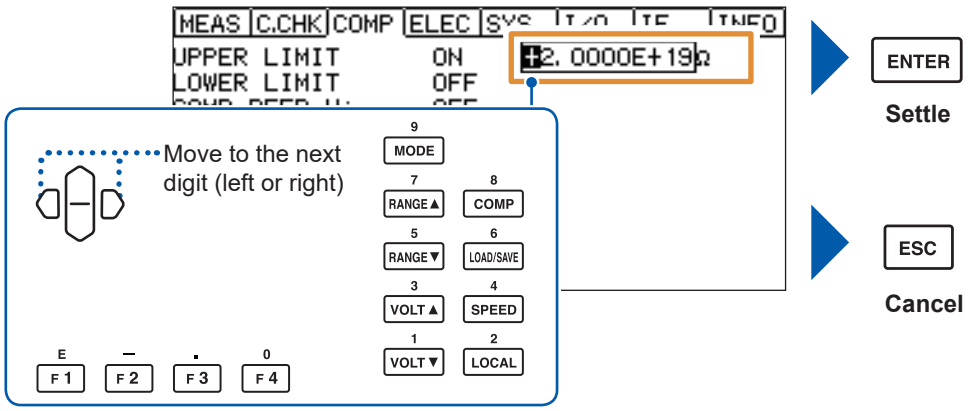
1



2 **(If using the cursor keys)**



(If using the numeric keypad)

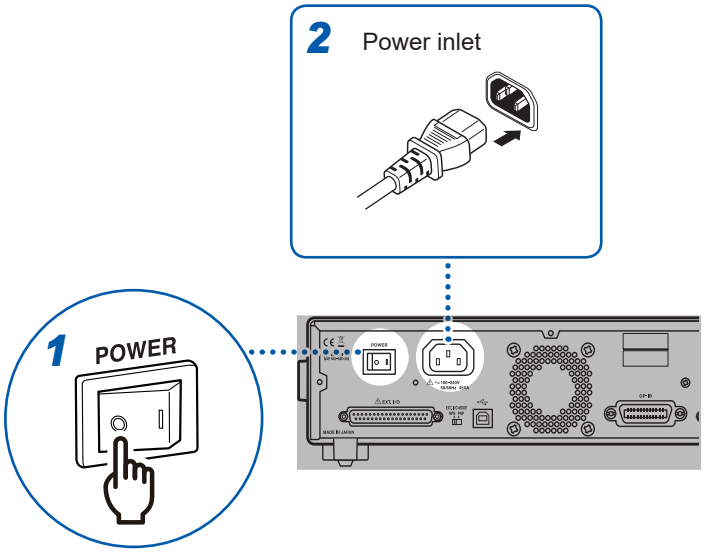


If you press the **ESC** key while changing the numerical value, the numerical value change will be canceled.
If you press the **ENTER** key, the changed content is settled.

2 Preparing for Measurement

2.1 Connecting Power Cord to instrument

Be sure to read “Before connecting the power cord to the instrument” (p. 11) beforehand.

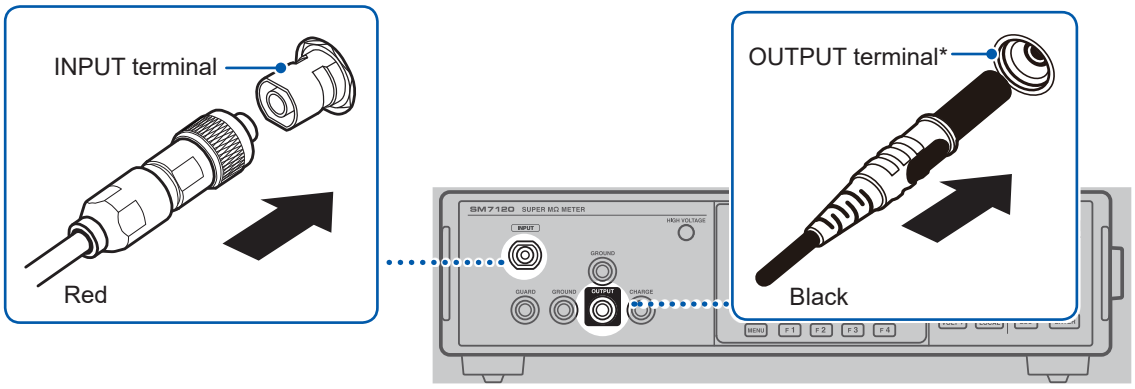


1. **Check that the power switch is in the off position (◯).**
2. **Check that the power voltage is in the range indicated on the rear, and then connect the power cord to the power inlet.**
3. **Connect the plug of the power cord into an outlet.**

2.2 Connecting Measurement Leads to Instrument

Be sure to read “Before connecting the measurement leads and electrode to the instrument” (p. 11) beforehand.

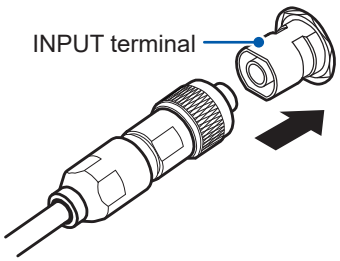
The measurement leads are optional. (p. 3)
Required leads: Measurement lead (red) and measurement lead (black) ×1 each



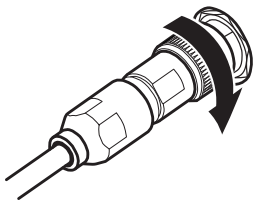
* Connect the black lead to the GROUND terminal if both the GROUND and OUTPUT terminals are grounded.

How to connect measurement lead (red) to the instrument

1 **Attach the connector to the INPUT terminal.**



2 **Tighten the screw by turning it clockwise.**

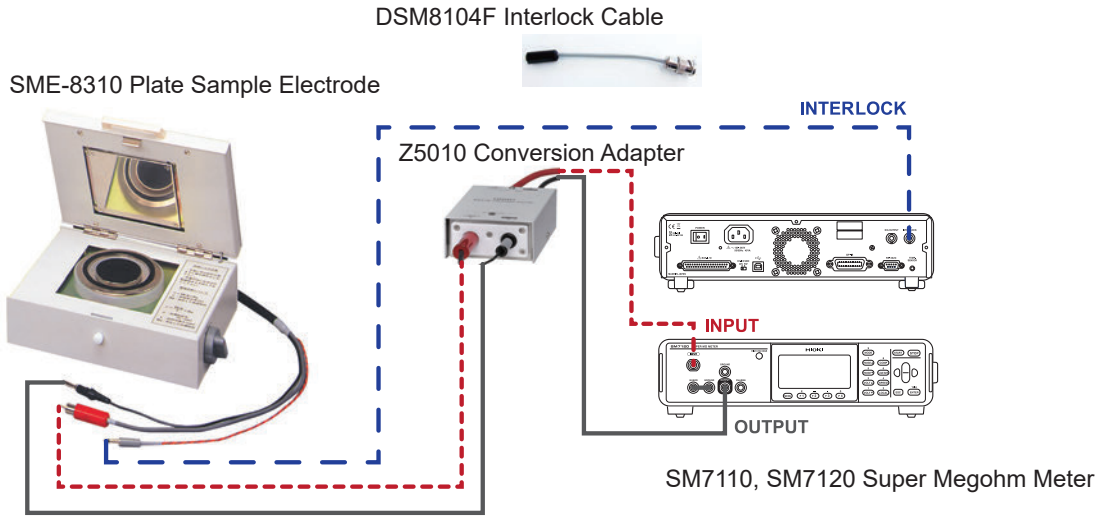


2.3 Connecting Electrode

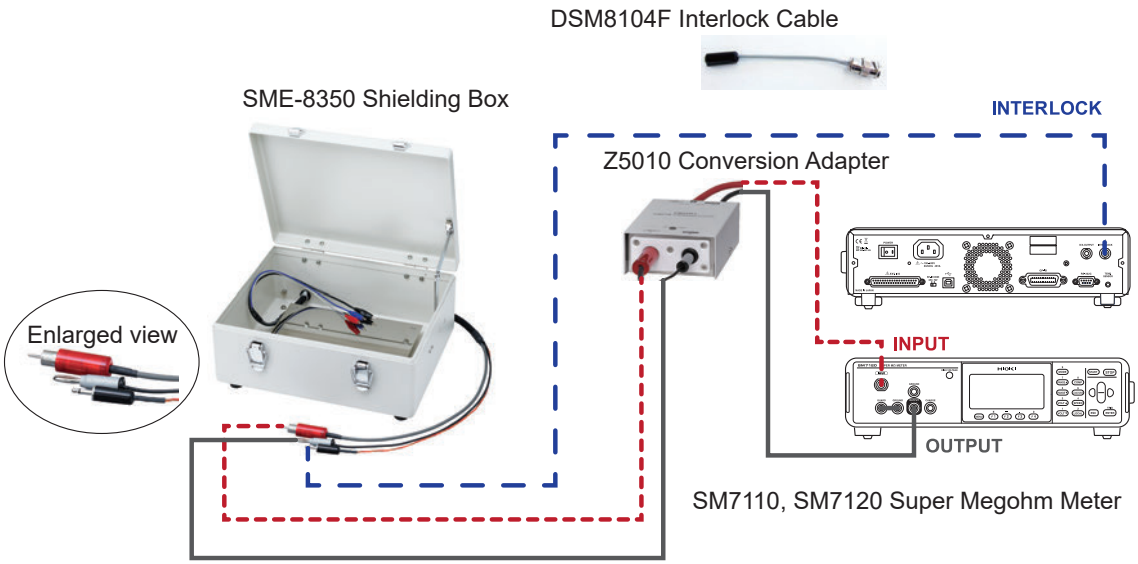
Be sure to read “Before connecting the measurement leads and electrode to the instrument” (p. 11) beforehand.

Electrodes are optional. (p. 4)
To connect a electrode to the instrument, refer to the Instruction Manual that comes with each of the electrode.

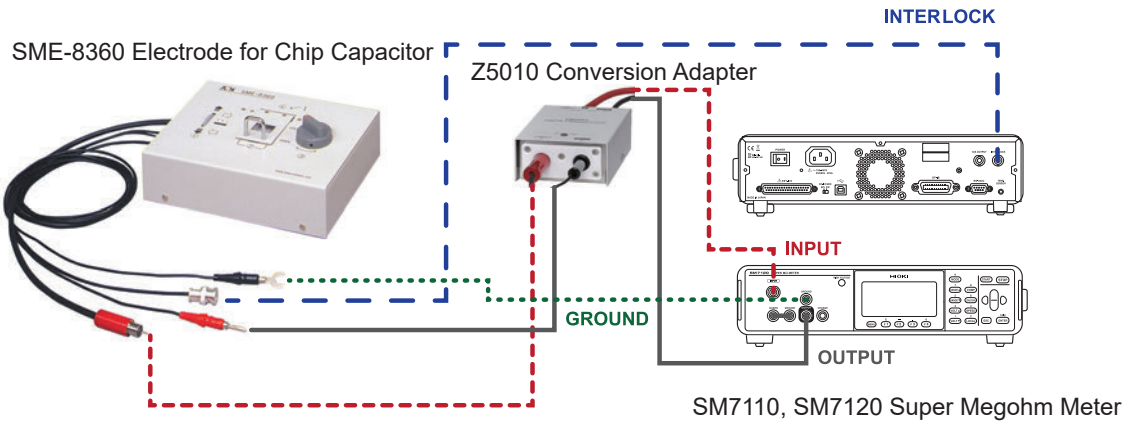
Model SME-8310 Plate Sample Electrode



Model SME-8350 Shielding Box



Model SME-8360 Electrode for Chip Capacitor

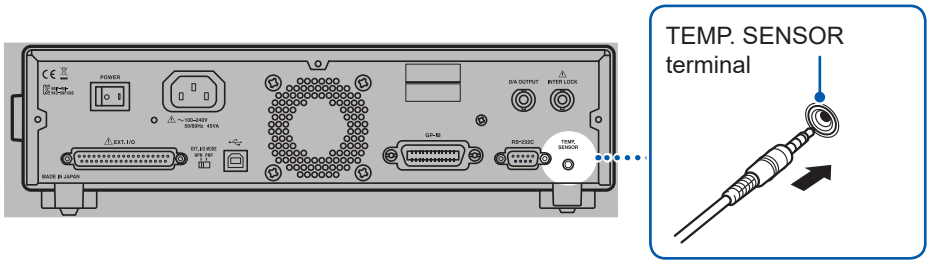


2.4 Connecting Humidity Sensor

Be sure to read “Before connecting the Humidity Sensor to the instrument” (p. 11) beforehand.

The Humidity Sensor is optional. (p. 4)
Required sensor: Model Z2011 Humidity Sensor

Install the Humidity Sensor close to the object to be measured. This enables the environment, temperature and humidity, around the object also to be measured simultaneously.



2.5 Grounding Instrument

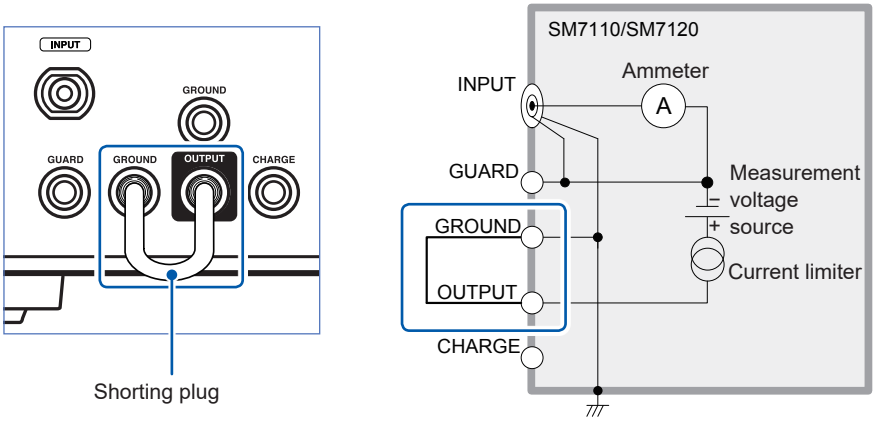
Be sure to read “Before grounding the instrument” (p. 12) beforehand.

Choose between connecting the OUTPUT terminal with the GROUND terminal (ground) and connecting the GUARD terminal with the GUARD terminal using the shorting plug.

(1) If measuring insulation resistance or ground insulation resistance of the measured object * with one line grounded (Grounding the OUTPUT terminal)

Grounding the OUTPUT terminal allows the negative setting voltage to be applied to the GROUND terminal.
To measure an object whose one line is grounded, connect the shorting plug as shown in the figure below. Connect the grounded line of the object with the GROUND terminal (OUTPUT), and the non-grounded line with the INPUT terminal.

If you connect the grounded line of the object with the INPUT terminal, and the non-grounded line with the GROUND terminal, a current will leak to the ground, causing an error of the measured value.

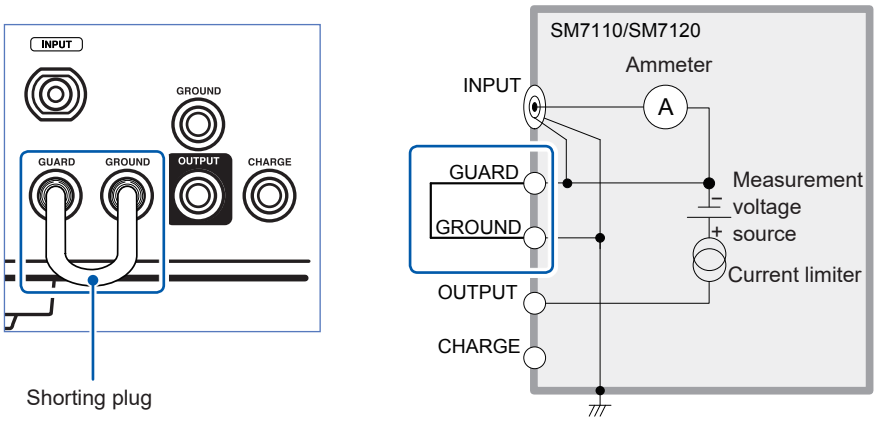


IMPORTANT
Be sure to connect the GROUND terminal to the OUTPUT terminal.
Even when the GROUND terminal is not connected to the OUTPUT terminal, the positive (+) voltage can be applied on the ground side terminal of the measured object if the GROUND terminal is connected to the ground terminal of the object. In that case however, noise can be easily superimposed on the input circuit, resulting in unstable measurement.

* Arrester, transformer, power transmission line, distribution line, etc.

(1) If setting a guard using a retainer, measurement fixture, etc. (Grounding the GUARD terminal)

Connect the GROUND terminal to the GUARD terminal.
Grounding the GUARD terminal allows the positive setting voltage output from the OUTPUT terminal to be applied.
Measurement can be done more safely because the potential of the guard circuit equals to the ground potential. (See the figure below.)



(2) If measured objects are not grounded

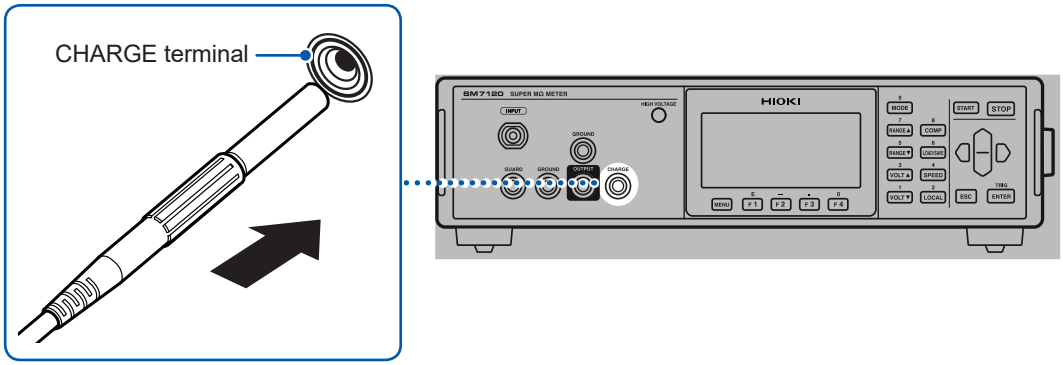
Connect the GROUND terminal to the OUTPUT terminal or the GUARD terminal. Either of them can be connected to.

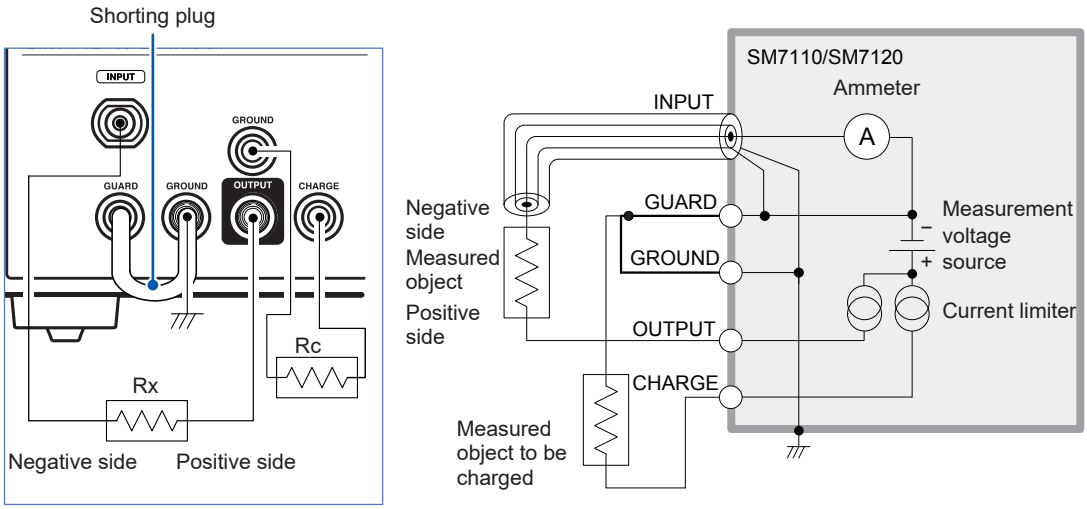
2.6 If Measured Object Is to Be Charged Before Measurement (Pre-charge)

When objects such as capacitors with high electrostatic capacity are measured automatically, the measurement time can be shortened if the measured object is charged prior to measurement (pre-charge).

Set the pre-charge to **[ON]** (charges objects). (p. 64)
See “Measurement without use of a measurement fixture” (p. 81).

Connect Model L2233 Clip Type Lead (Black), etc. to the CHARGE terminal. (See the figure below.)
- In addition to the measurement cables, you will need two black cables for the charge. (Connect to the CHARGE and GROUND terminals)
- A charge is carried out during measurement of the connected object (while the measurement voltage is applied).





Rc is the measured object after measurement of Rx.

Example of connection (grounding an measured object)

When not using the CHARGE terminal, you can charge up the object Rx, which is connected between the OUTPUT side and the INPUT terminal, by applying a measurement voltage for a sufficient period of time before starting a measurement.

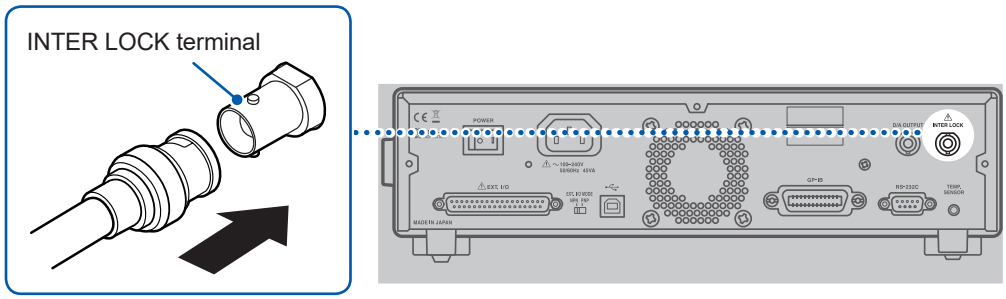
2.7 For Safe Measurement

The INTER LOCK terminal is internally connected to Pin 24 of the EXT I/O terminal.
Read “Before controlling the instrument externally” (p. 13) beforehand.

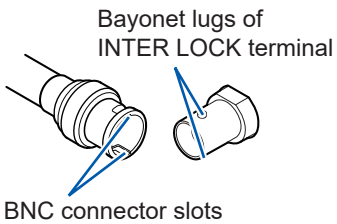
Operating the instrument incorrectly will cause an electric shock because measurement voltage is output when measurement starts.
Use the interlock function to perform measurement safely.
For example, if the signal for the open lid of the shielding box is connected to the INTER LOCK terminal on the back of the instrument, the interlock function is activated when the lid is open.

If the pins of the INTER LOCK terminals are open-circuited with the interlock function set to **[ON]**, the interlock function is activated with the result that the output of measurement voltage and the measurement function are disabled.
See “4.7 Setting Interlock Function” (p. 62).

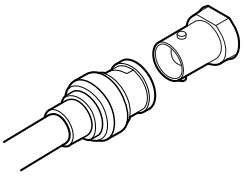
How to connect cable for interlock



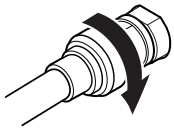
1 **Check the orientation of the slots in the BNC connector and ensure that it fits into the bayonet lugs of the instrument side.**



2 **Align the slots in the BNC connector along the bayonet lugs of the instrument, and insert the BNC connector into the instrument connector.**



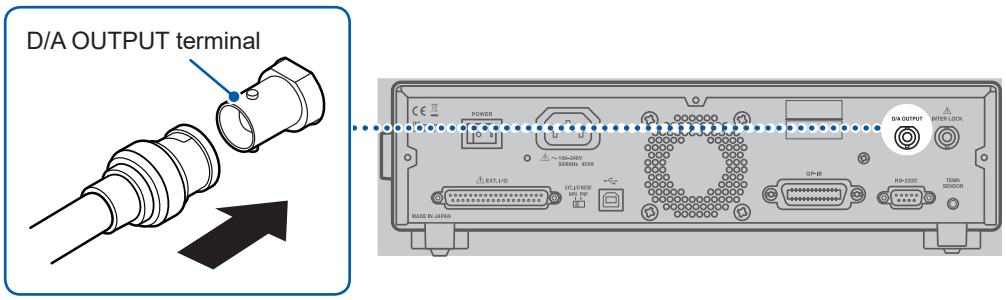
3 **Turn the BNC connector clockwise to lock it.**



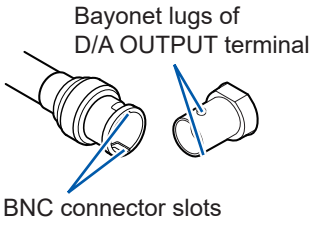
2.8 Outputting Measurement Current Value Converted to Analog Signal

Use the D/A output function to log the output together with the output of other measuring instruments such as recorders.
A voltage of 2.0 V is output if the measured current value reaches the maximum display value of the present current range's scale.
If the measured value is out of the present current range, a voltage of 2.5 V is output.
(Example: With the current range setting set to 20 pA, a voltage of 2.0 V is output when the value "19.9999 pA" is displayed)
No instrument settings are required.

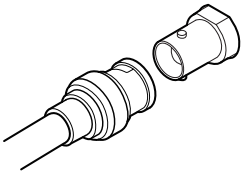
How to connect the output cable to the instrument



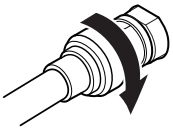
1 **Check the orientation of the slots in the BNC connector and ensure that it fits into the bayonet lugs of the instrument side.**

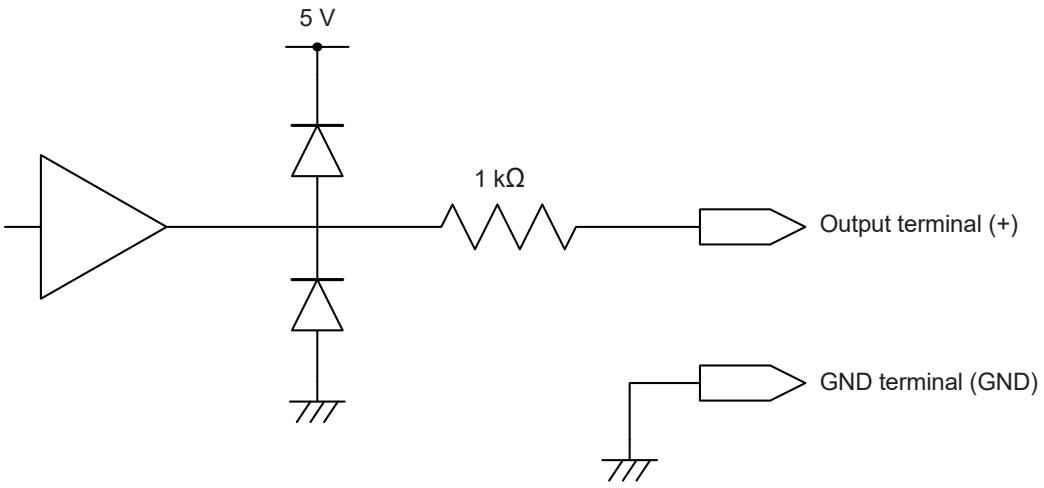


2 **Align the slots in the BNC connector along the bayonet lugs of the instrument, and attach the BNC connector to the instrument connector.**



3 **Turn the BNC connector clockwise to lock it.**

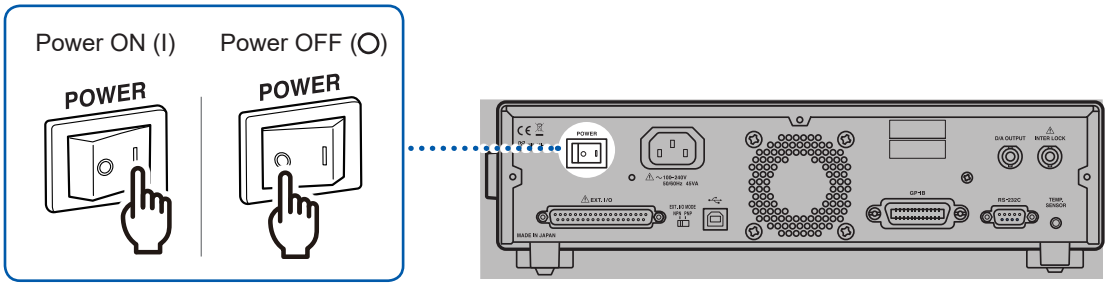




- The GND terminal of D/A output is connected to the ground (case metal part).
- The output impedance is 1 kΩ. Use connected instruments with input impedance of 10 MΩ or more. (The output voltage is divided by the output resistance and the input impedance. For 1 MΩ, it is lower by 0.1%.)
- External noises may be superimposed on an analog signals if cables are connected to the instrument. If necessary, use a band-limiting filter, etc. in the connected instrument.
- The output voltage is updated with each current measurement sampling cycle.
- The recorded wave form will be in a staircase pattern (because the output circuit response is very fast with respect to the update period).
- Output voltage is reduced to 1/10 (or increases by 10 times) even at the same resistance value according to the change of range in auto-range. It is recommended to use the manual range.
- An output is set to 0 V when settings are changed (the range is changed, etc.) or when the instrument is turned off. Moreover, an irregular voltage with an amplitude that is within the maximum output voltage is output at the moment when the power switch on the rear is flipped to the on position.
- Set the measurement speed to **[FAST]** and the self-calibration to **[OFF]** (execute manually) to ensure that the D/A output response time is at its fastest.
  See “3.3 Setting Measurement Speed” (p. 43) and “4.6 Maintaining Measurement Accuracy (Self-Calibration Function)” (p. 60).

2.9 Turning On/Off Instrument

Turn the instrument on or off using the power switch on the rear.
For more accurate measurement, warm up the instrument for 30 minutes or more after turning on the instrument.



The self-test is executed automatically after startup (ROM/RAM check).
If an error is displayed on the LCD screen, the instrument is necessary to be repaired. Please contact your authorized Hioki distributor or reseller.
See “Error display and solution” (p. 162).

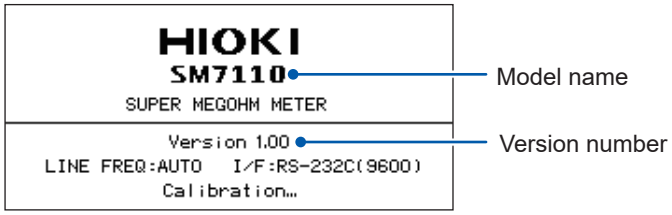
2.10 Inspection Before Use

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.

Verifying the instrument and the peripheral devices

Inspection items	Solution
Is the power cord insulation torn, or is any metal exposed?	Do not use the instrument if damage is found, as an electric shock or short-circuit accidents could result. Contact your authorized Hioki distributor or reseller.
Is the insulation of the connected lead or the connection cords torn, or is any metal exposed?	If any damage is found, it may cause an electrical shock. If this happens, replace the measurement probe or connection cords with ones specified by Hioki.
Is the instrument damaged?	

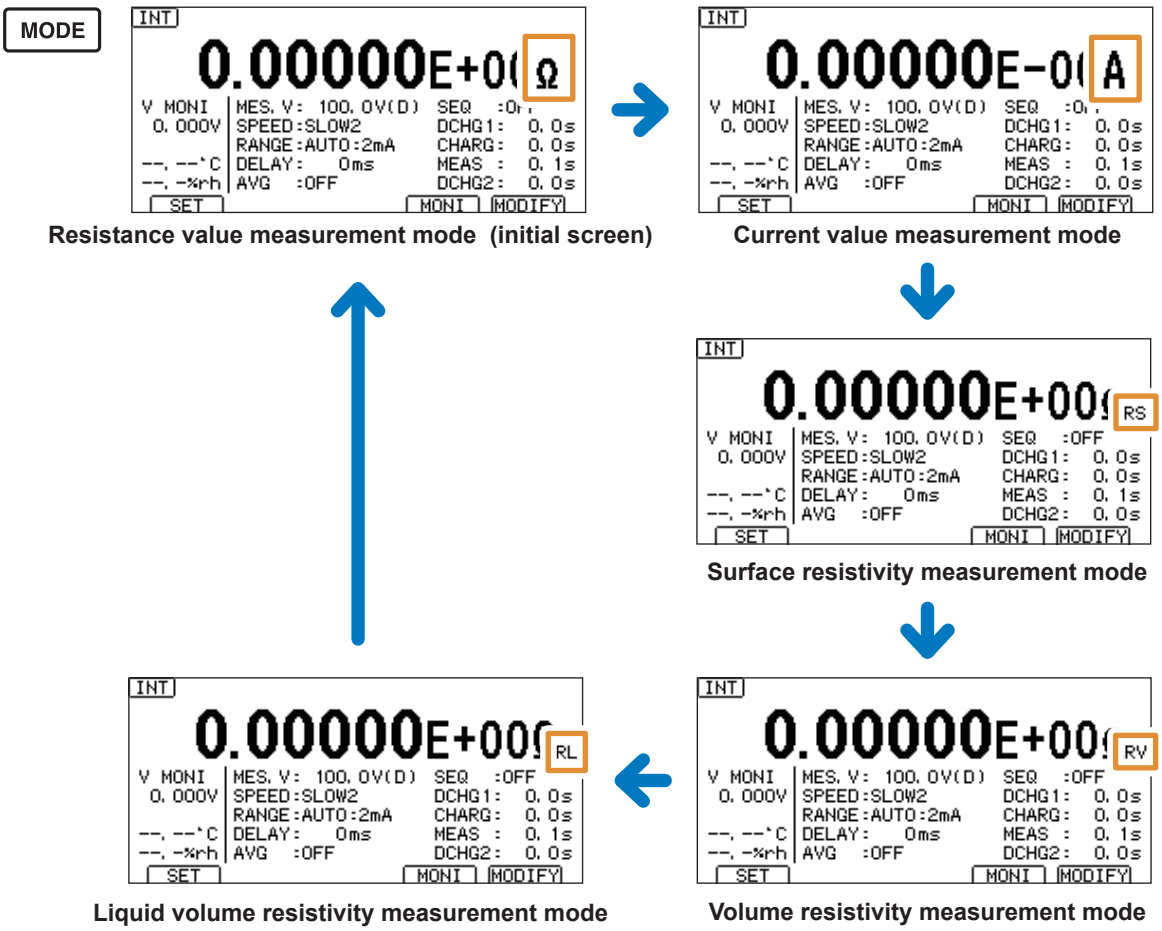
Verifying the instrument on start-up

Inspection items	Solution
Does the fan rotate when the instrument is turned on? Are “Model name” and “Version number” displayed on the screen?	If the fan does not rotate, or if “Model name” and “Version number” are not displayed, the instrument may be malfunctioning. Request repairs. 
Is the measurement screen displayed after the self-test?	If the screen does not display anything, the instrument may be malfunctioning internally. Request repairs.

3 Basic Measurement

3.1 Setting Measured Value Display Mode

Press the **MODE** key to switch the measured value display modes.

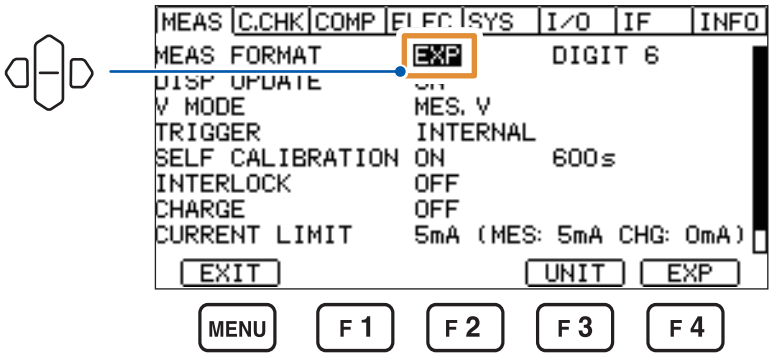


Measurement conditions must be set to measure surface resistivity and volume resistivity.
See “4.14 Setting Resistivity Calculation (Resistivity Measurement Function)” (p. 74).

Changing display notation

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

[EXP]	Exponential notation:	Displays values, expressed in exponential notation, to five decimal places. (Example: 1.00000E+16 Ω) (default setting)
[UNIT]	Decimal notation:	Displays values, expressed in decimal notation, that have six significant figures. (Example: 10.0000 PΩ)

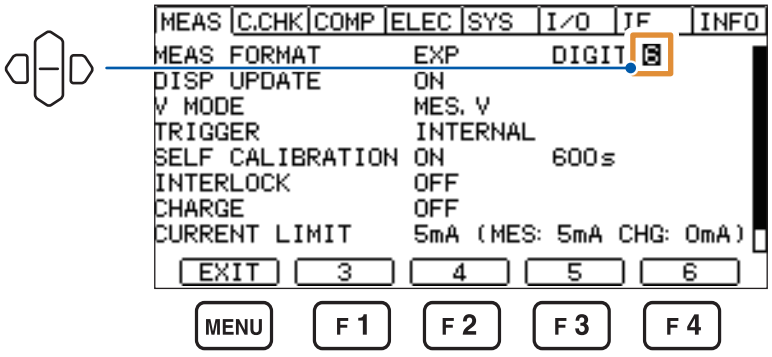


Changing displayed digits

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

Press the **[F1]**, **[F2]**, **[F3]**, or **[F4]** key to change the number of the displayed digits.

3 digits to 6 digits (Default setting: 6 digits)



3.2 Setting Applied Measurement Voltage

If using the internal power supply

Press the **VOLT▲** key or the **VOLT▼** key on the measurement screen to change the applied measurement voltage.
Pressing the **F4** key **[MODIFY]** enables also the function keys to be used to select the voltage.

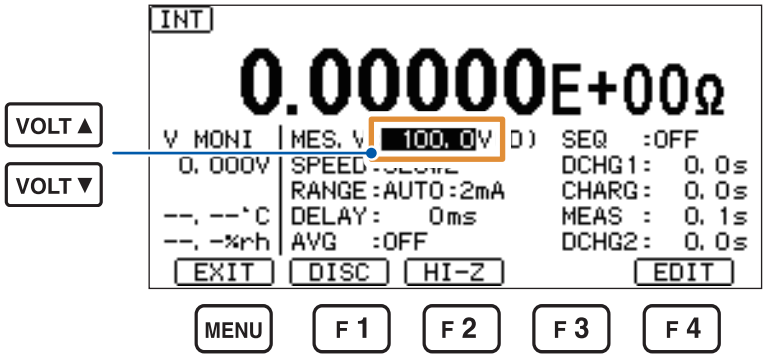
IMPORTANT
If the measurement voltage setting or the charge setting is changed after the current limiter has been set and if the current limiter exceeds the upper limit, the current limiter is set to the largest value among the settable values.

See “4.9 Limiting Current Flowing Through Measured Object (Current Limiter)” (p. 65).

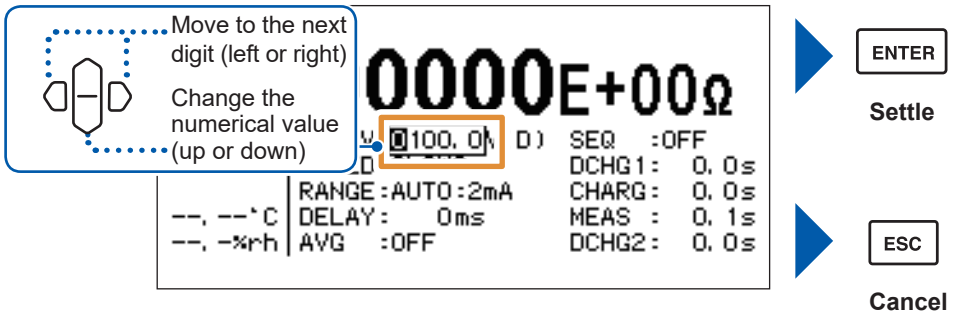
The numerical value can also be changed with the numeric keypad.
See “Methods for changing numerical values” (p. 28).

1 Select the voltage.

0.1, 0.5, 1, 2.5, 5, 10, 25, 50, 100, 250, 500, 1000, 1500*, 2000* (Default setting: 0.1)
* Can be set only for Model SM7120

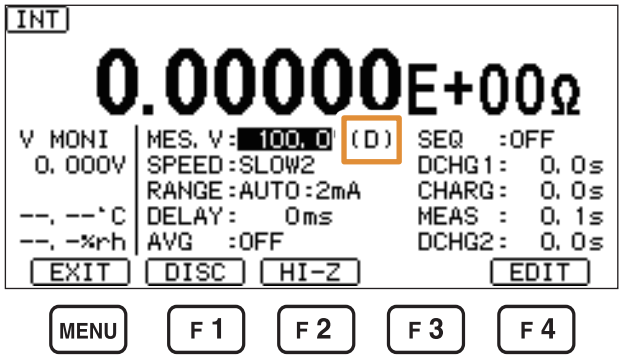


Pressing the **F4** key **[EDIT]** enables the numerical value to be changed in increments of 0.1 V.



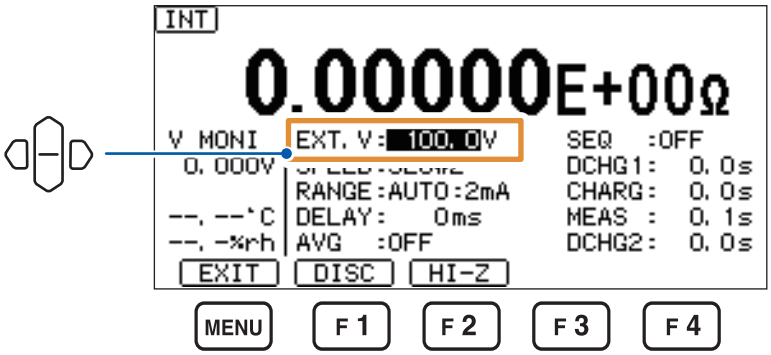
2 **Select a status in which the instrument is placed on completion of the measurement between the electric discharge and the high-impedance.**

[DISC (D)] Sets to the electric discharge status (default setting).
[HI-Z (Z)] Sets to the high-impedance status.



If using the external power supply

Set the voltage value for resistance calculation to [EXT.V].



See “4.4 Setting Voltage Value for Resistance Calculation” (p. 56).

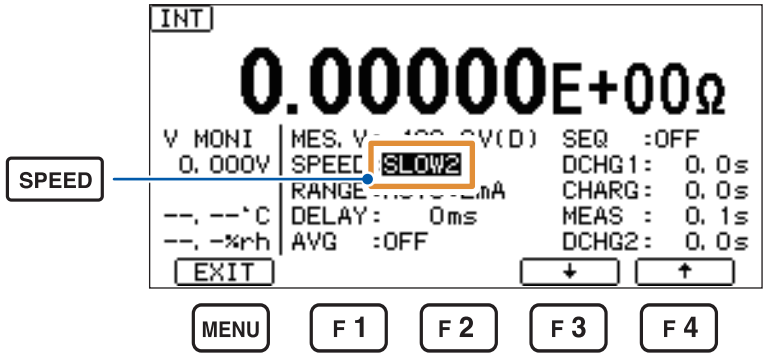
3.3 Setting Measurement Speed

The slower measurements are, the more the accuracy improves.
Pressing the **SPEED** key on the measurement screen changes the measurement speed.
See “Current measurement accuracy” (p. 143).

Some measurement speeds are not available depending on the current range setting. If the measurement speed cannot be changed, check the current range.
See “Available setting depending on current ranges and measurement speed” (p. 43).

Press the SPEED key on the measurement screen.
Pressing the **F4** key **[MODIFY]** enables also the function keys to be used to select the measurement speed.

FAST, FAST2, MED, SLOW, SLOW2 (Default setting: SLOW2)



The measurement speed changes every time the **F3** key **[↓]** is pressed in the following order: FAST, FAST2, MED, SLOW, and SLOW2.
The measurement speed changes every time the **F4** key **[↑]** is pressed in the following order: SLOW2, SLOW, MED, FAST2, and FAST.

Available setting depending on current ranges and measurement speed

✓: Setting available, –: Setting not available

Measurement speed / Range	FAST	FAST2	MED	SLOW	SLOW2
20 pA	–	–	–	✓	✓
200 pA	–	–	✓	✓	✓
2 nA	✓	✓	✓	✓	✓
20 nA	✓	✓	✓	✓	✓
200 nA	✓	✓	✓	✓	✓
2 µA	✓	✓	✓	✓	✓
20 µA	✓	✓	✓	✓	✓
200 µA	✓	✓	✓	✓	✓
2 mA	✓	✓	–	–	–

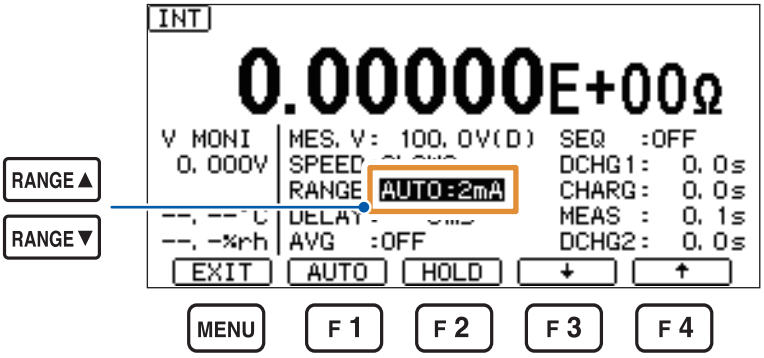
3.4 Changing Current Range

Change the current range if the measured current value or the measured resistance value exceeds the measurable range or if measurement with another measurement accuracy is preferred.
See “Current measurement accuracy” (p. 143).

No setting for resistance range is required (If the current range is set to **[AUTO]**, the resistance range will be automatically selected).
Some ranges are not available depending on the measurement speed setting. If the current range cannot be changed, check the measurement speed.
See “Available setting depending on current ranges and measurement speed” (p. 43).

Press the RANGE▲ key or the RANGE▼ key on the measurement screen.
Pressing the **F4** key **[MODIFY]** enables also the function keys to be used to select the current range.

20 pA, 200 pA, 2 nA, 20 nA, 200 nA, 2 uA, 20 uA, 200 uA, 2 mA, AUTO (Default setting: AUTO)



Pressing the **F1** key **[AUTO]** sets the range to **AUTO** immediately.
Pressing the **F2** key **[HOLD]** fixes the current range on the presently selected range.
Pressing the **F3** key **[↓]** switches the current range to the next upper range.
Pressing the **F4** key **[↑]** switches the current range to the next lower range.

3.5 Connecting Measurement Leads or Electrode to Object to Be Measured

Be sure to read “Before connecting the measurement leads or electrode to an object to be measured” (p. 12) beforehand.

Connect the measurement leads or electrode (both are optional) to the object to be measured.

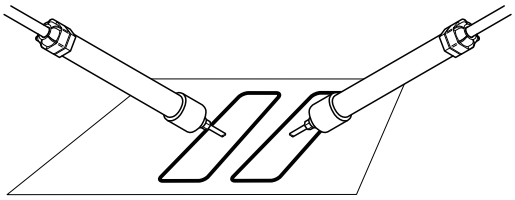
Measurement fixtures can be available depending on the object to be measured.

Using measurement fixtures is recommended	• Objects to be measured (components, circuits, etc.) are the same in form. • Objects to be measured are is extremely small in size. • Large amount of objects are to be measured. • Objects are to be measured using numerous points.
Using a measurement fixture is not recommended (Use measurement leads.)	• Objects to be measured are different in form from each other. • Objects to be measured are large in size. • Objects to be measured are heavy in weight. • Small amount of objects are to be measured.

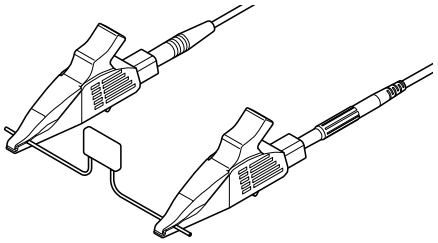
For measurement examples using electrodes and a measurement fixture, see “5 Measurement Methods Suitable for Various Objects to Be Measured” (p. 79).
To connect a electrode to objects to be measured, refer to Instruction Manual that comes with each of the electrodes.

If measuring resistance values and electric currents

Pin type test lead



Clip type test lead



3.6 Starting/Stopping Measurement

Be sure to read “Before performing a measurement” (p. 12) beforehand.

Internal trigger (INT) (default setting)	Pressing the **START** key results in a measurement voltage applied, and then starts a measurement. Pressing the **STOP** key stops applying the voltage and the measurement.
External trigger (EXT)	Pressing the **START** key results in a measurement voltage applied. Inputting a trigger signal starts a measurement. Pressing the **STOP** key stops applying the voltage.

- An measurement voltage is reduced to 0 V when the measurement is stopped. No trigger cannot be accepted.
- A voltage between the OUTPUT terminal and the INPUT terminal is discharged (placed in a discharge state with the current limiter connected). (The output of the CHARGE terminal is basically the same as the OUTPUT terminal. Therefore, the CHARGE terminal is also discharged in a manner similar to the OUTPUT terminal.)

3.7 Confirming Measurement Results

Detecting a measurement abnormality

If the measurement is not correctly performed, an error message appears on the screen, and ERR signal is output from EXT I/O terminal.
See “Measurement errors” (p. 163).

Temperature measurement indication

If the Humidity Sensor is not connected to the instrument (Display: [--.--°C], [--.-%rh])

The Humidity Sensor is not connected to the instrument. Thus, temperature cannot be measured. If the temperature measurement is not necessary, connecting the Humidity Sensor to the instrument is not required.

Out-of-range indication

The out-of-range indication for each of the parameters is displayed due to causes listed below.

Parameters	Out-of-range indication	Cause
Resistance value	**[Current Over Range]**	The measured value exceeds the indication range of the present current range. * This means that the resistance is low.
Current		
Surface resistivity Rs		
Volume resistivity Rv		
Liquid volume resistivity RL		
Temperature	**[+Over°C]**	The measured value is greater than 80.0°C.
	[-Over°C]	The measured value is smaller than -40.0°C.
Humidity	**[Over%rh]**	The measured value is greater than 90%RH.

3.8 Basic Measurement Examples

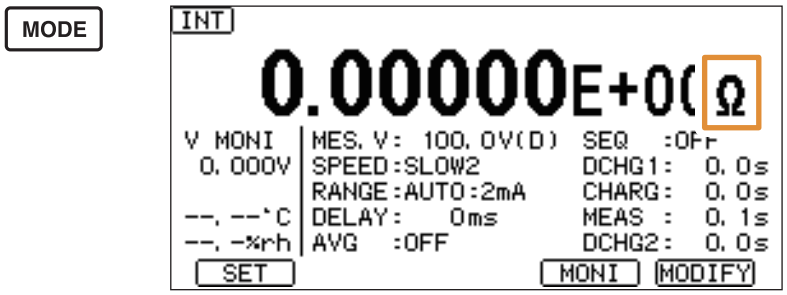
Measurement of the resistance value of a capacitor is explained as an example here.

Examples of setting contents

Measured value display mode	Resistance value measurement mode (initial screen)
Measurement voltage	**[100 V]**
Current range	**[AUTO]**
Measurement speed	**[SLOW2]**

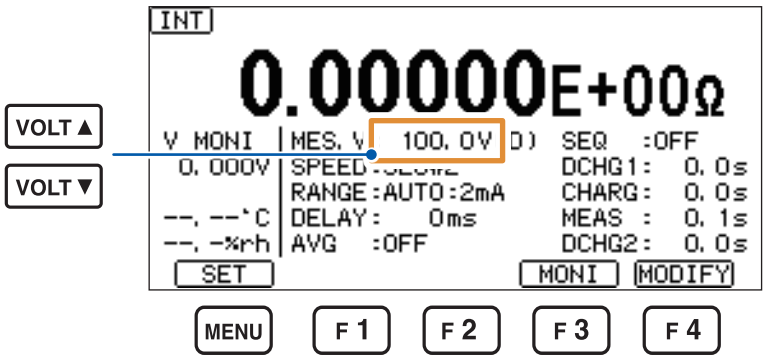
Set the trigger source to the internal trigger (INT).

1 **Press the MODE key to display the Resistance measurement screen. (p. 39)**

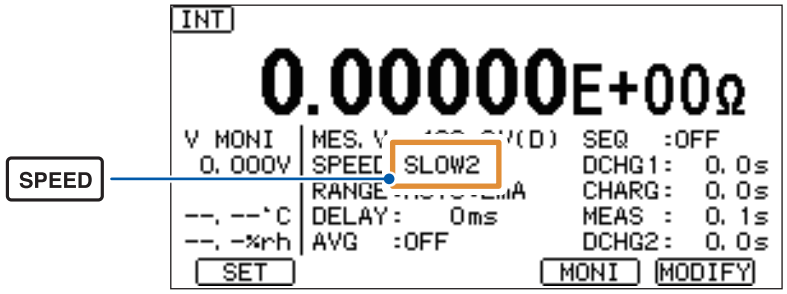


The instrument displays values that include the input resistance of 1kΩ (±10%).

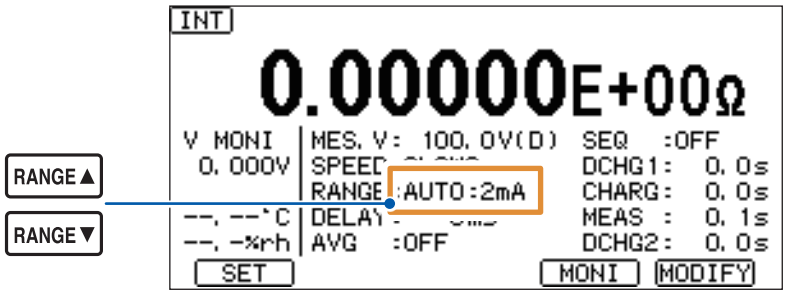
2 **Press the VOLT▲ key or VOLT▼ key to set the measurement voltage to [100 V]. (p. 41)**



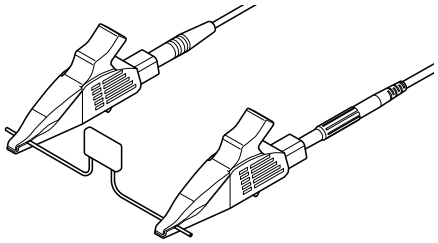
3 **Press the SPEED key to set the measurement speed to [SLOW2]. (p. 43)**



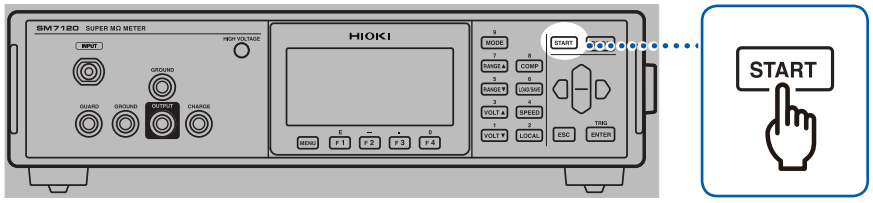
4 **Press the RANGE▲ key or RANGE▼ key to set the range to [AUTO]. (p. 44)**



5 **Connect the clip type test lead to both terminals the of capacitor.**

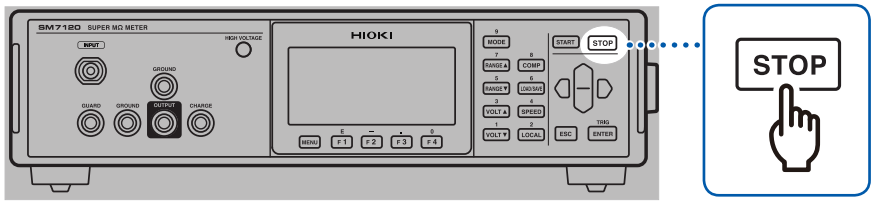


6 **Press the START key to start a measurement.**



A measurement voltage of 100 V is applied on both ends of the capacitor and the resistance value is measured.

7 **Press the STOP key to stop the measurement.**

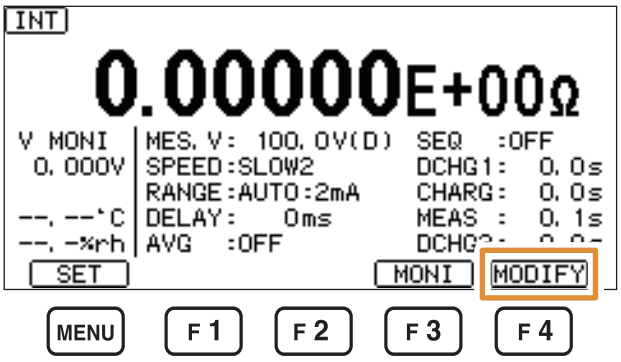


4 Applied Measurement

4.1 Starting Measurement After Measured Value Becomes Stable (Delay Function)

For the case of external trigger (EXT), set the time from when a trigger is input to when a measurement starts. (The delay time elapses after a trigger is input each time.) With the trigger source setting set to the internal trigger (INT), no delay time elapses after the trigger. Set it on the Measurement screen.

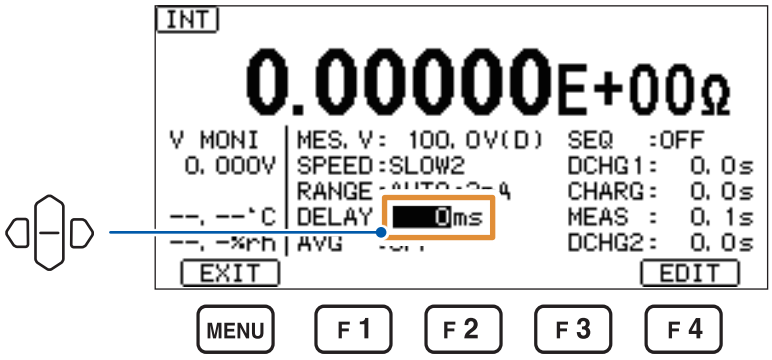
1 Press the F4 key [MODIFY] to enable the measurement conditions to be changed.



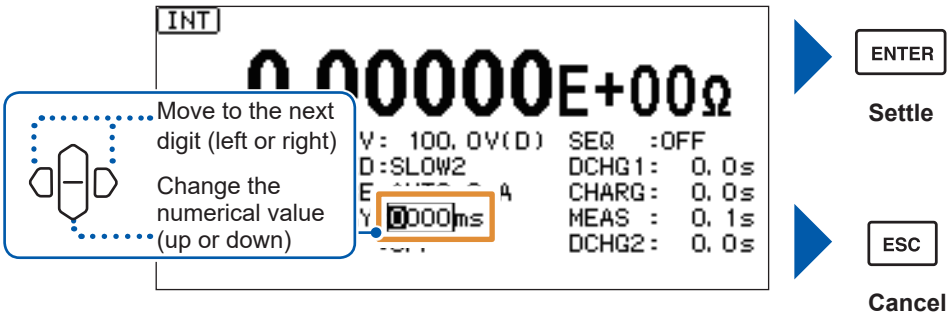
Pressing the **ESC** key cancels the changes of the measurement conditions.

2 Set the delay time.

0 ms to 9999 ms (Default setting: 0 ms)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed in increments of 1 ms.

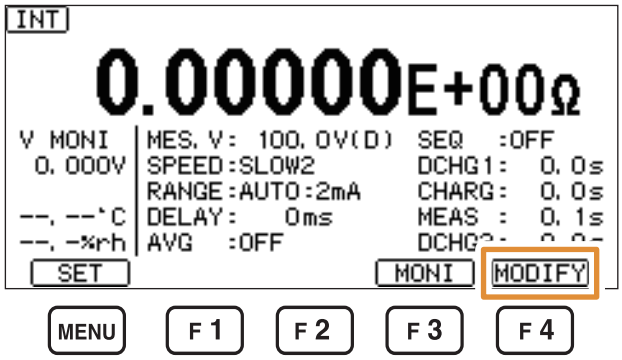


The numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

4.2 Reducing Variation in Measured Values (Average Function)

The average for the set number of measured values will be displayed as the result. This function can reduce the variation in the measured values. Set it on the Measurement screen.

1 **Press the F4 key [MODIFY] to enable the measurement conditions to be changed.**



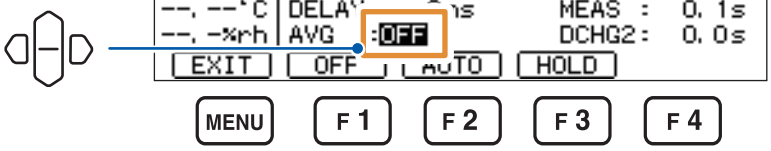
Pressing the **ESC** key cancels the changes of the measurement conditions.

2 **Select whether to perform the average process or not.**

[AUTO] If measured value fluctuates significantly, the instrument discards the internal average value and calculates another average value. Set **[AVG]** to **[HOLD]**, and then set the average frequency.

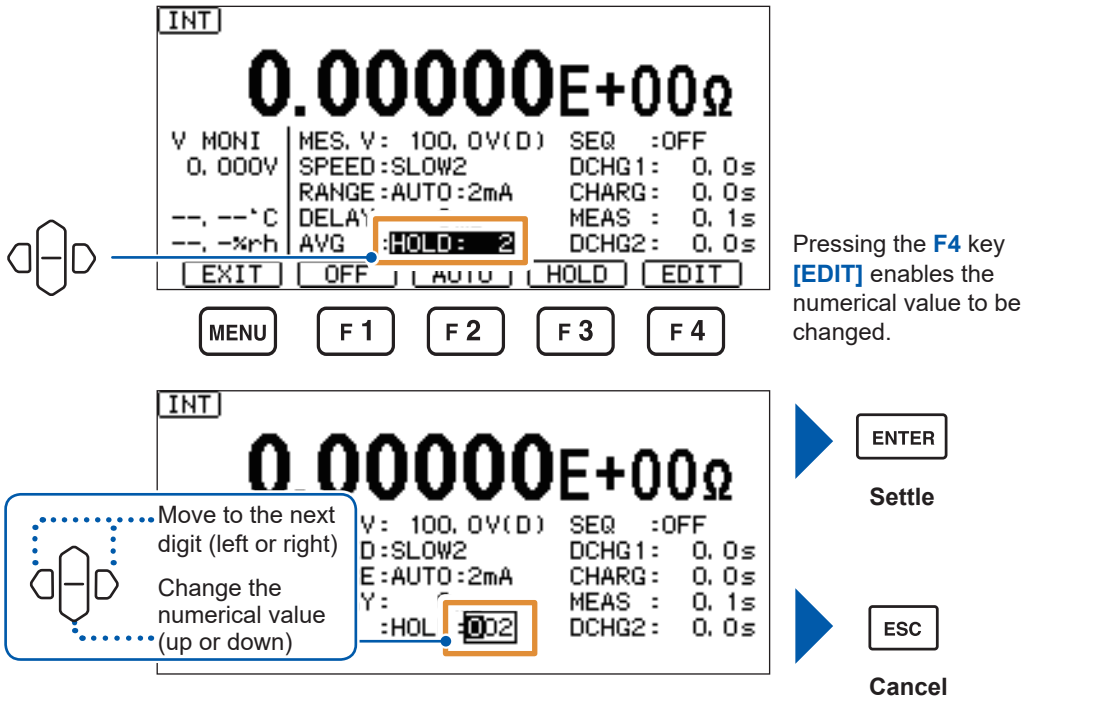
[HOLD] Moving average (However, arithmetic averages are calculated with the trigger source setting set to the external trigger and the sequence measurement set to off.)

[OFF] Does not perform the average process (default setting).



3 If [HOLD] is selected, set the average frequency.

2 to 255 times (default setting: 2 times)



Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

4.3 Automatic Inspection (Sequence Program Function)

Be sure to read “Before removing the measured object” (p. 13) beforehand.

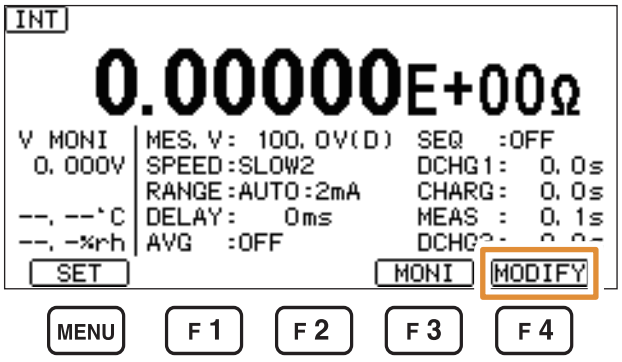
After a test pattern including discharge, charge, measurement and discharge is set, the tests can be executed in sequence (sequence measurement).
Thus, the time of applying the measurement voltage to the object to be measured can be controlled accurately.
The sequence measurement can inspect objects under the equal condition by setting the following items first.

[DCHG1]	Discharge 1	Sets the discharge time before measurements start.
[CHARG]	Charge	Sets the charging (voltage application) time before measurements start.
[MEAS]	Measurement	Sets the measurement time. The measured value is output at this time.
[DCHG2]	Discharge 2	Sets the discharge time after measurements complete.

Set them on the Measurement screen.

1 **Press the F4 key [MODIFY] to enable the measurement conditions to be changed.**

If no items are displayed, press **F3** key **[MONI]** to switch the measurement condition display.

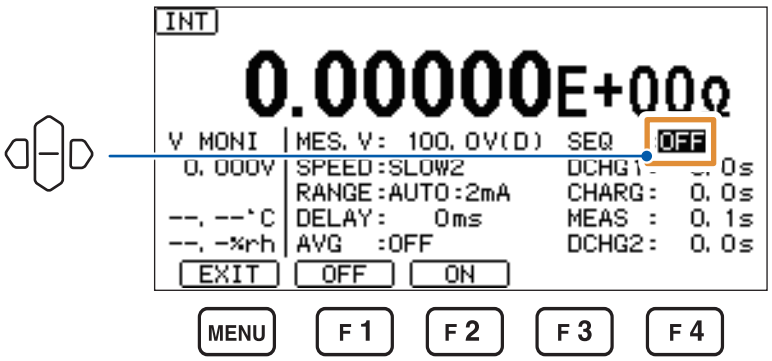


Pressing the **ESC** key cancels the changes of the measurement conditions.

2 **Select whether to perform sequence measurement or not.**

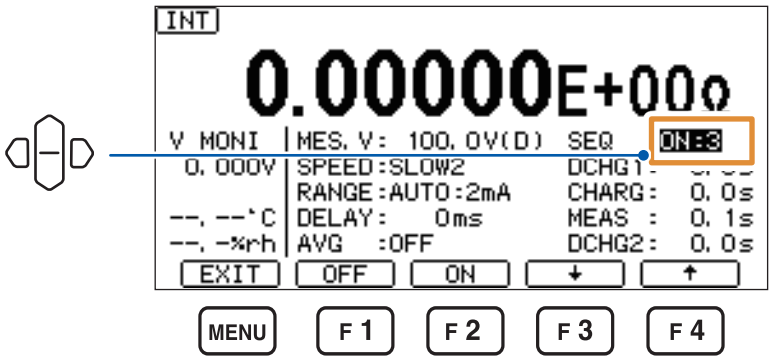
[ON] Yes

[OFF] No (default setting) (Measurement will be done continuously.)



3 If [ON] is selected, set the save number.

0 to 9 (default setting: 0)

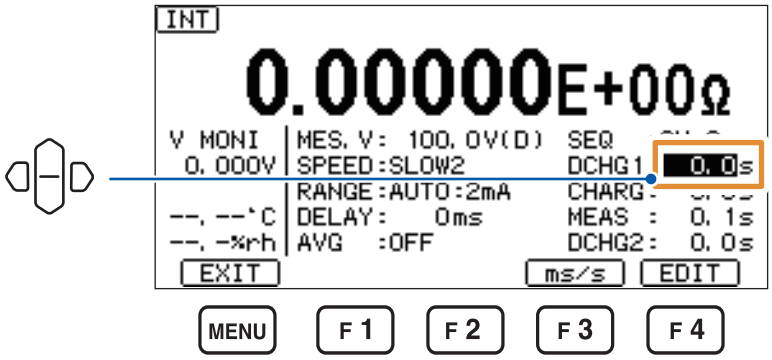


Press the **F3** key **[↓]** or **F4** key **[↑]** to select a number.

4 Set the discharge time before measurements start.

Press **F3** key **[ms/s]** to switch the unit.

0 ms s to 999.9 s (default setting: 0.0 s)



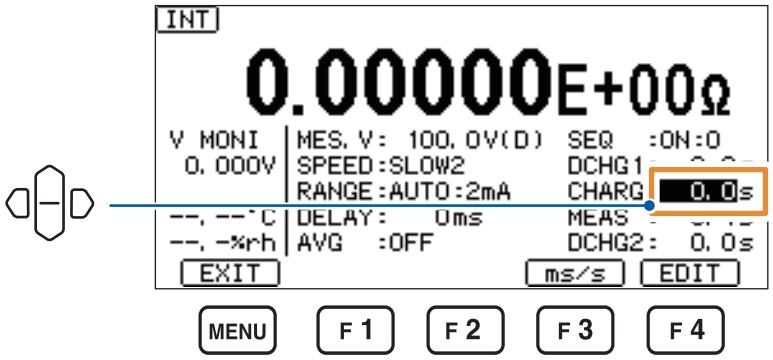
Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.

If the setting of the voltage output function for no voltage output is set to **[DISC (D)]**, the measurement object is discharged while no measurement is performed. The instrument will not discharge voltage if it is disconnected from the measured object by external relays or if the setting of the voltage output function for no voltage output is set to high impedance (**[Hi-Z]**).
In such case, set Discharge 1 (**[DCHG1]**). Also, set the setting to Discharge 1 (**[DCHG1]**) when electric charge is remaining in the measured object due to repeated measurement.

5 **Set the charging (voltage application) time before a measurement starts.**

Press **F3** key **[ms/s]** to switch the unit.

0 ms to 999.9 s (default setting: 0.0 s)

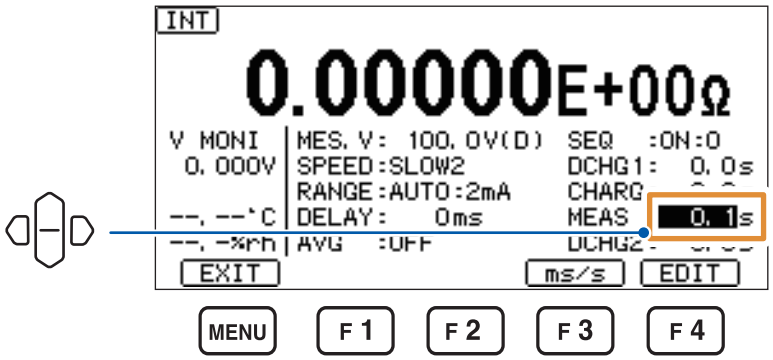


Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.

6 **Set the measurement time.**

Press **F3** key **[ms/s]** to switch the unit.

1 ms to 999.9 s (default setting: 0.1 s)

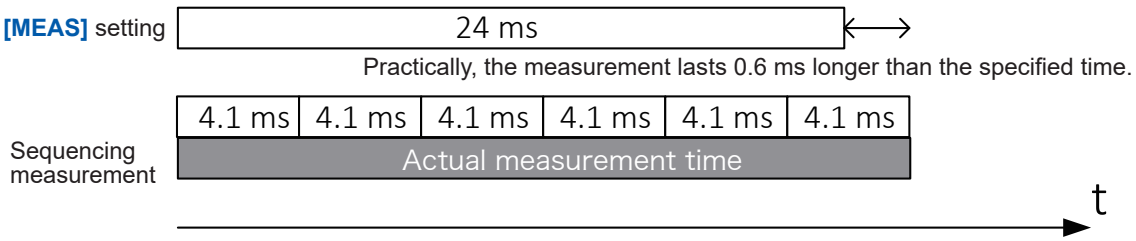


Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.

The time specified for sequencing measurement

For the sequencing measurement, the instrument measures a measuring object repeatedly during the measurement time specified in the **[MEAS]** field at a measurement speed specified in the **[SPEED]** field.

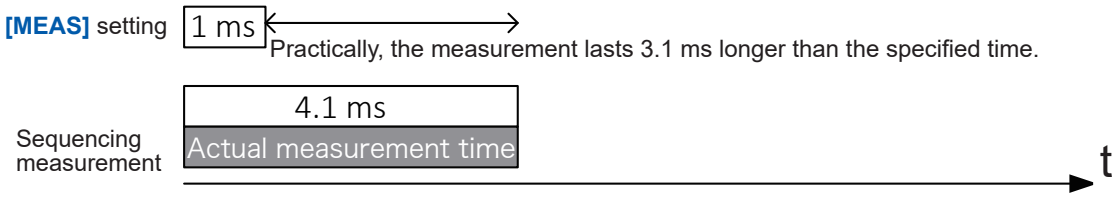
Example: **[SPEED]**=FAST(4.1 ms), **[MEAS]**=24 ms



In the following case, the actual measurement time the sequencing measurement requires becomes longer than the measurement time specified in the **[MEAS]** field.

When the specified time of the sequencing measurement is shorter than the interval calculated from the measurement speed setting specified in the **[SPEED]** field

Example: **[SPEED]**=FAST(4.1 ms), **[MEAS]**=1 ms

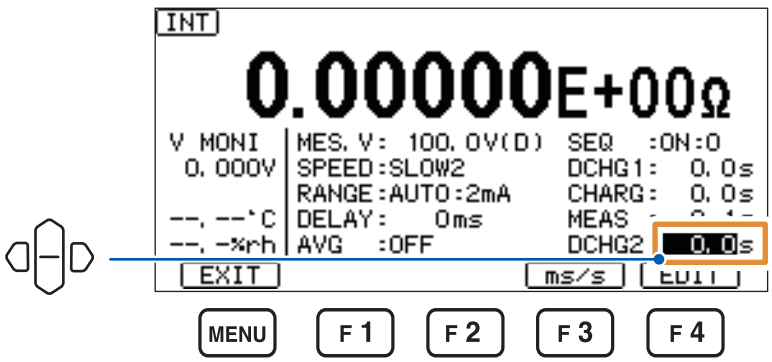


As described above, the overall time of the sequencing measurement becomes longer, which does not affect charging and discharging times.

7 Set the discharge time after measurement completes.

Press **F3** key **[ms/s]** to switch the unit.

0 ms to 999.9 s (default setting: 0.0 s)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.

During discharge states (and also stopped states), the circuit between the measurement input terminal and the OUTPUT terminal is connected to another circuit consisting of the current limiter and the input resistance (approximately 1 kΩ) in the current measurement block that are connected to each other in series.

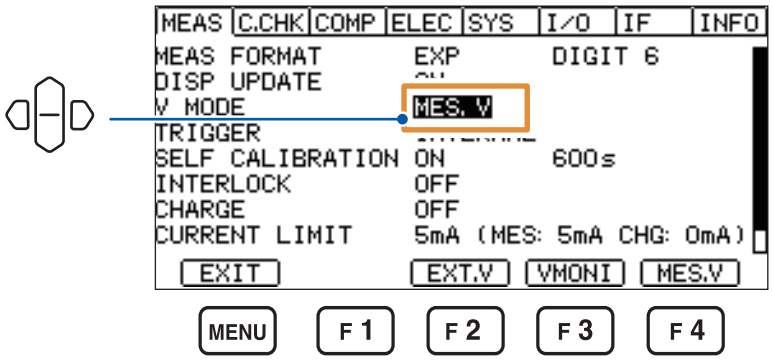
4.4 Setting Voltage Value for Resistance Calculation

Although resistance values are calculated from currents and voltages measured by this instrument, you can also set the voltage to any optional value and enables the instrument to calculate resistance values.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

1 Select the voltage to be used for calculating resistance values.

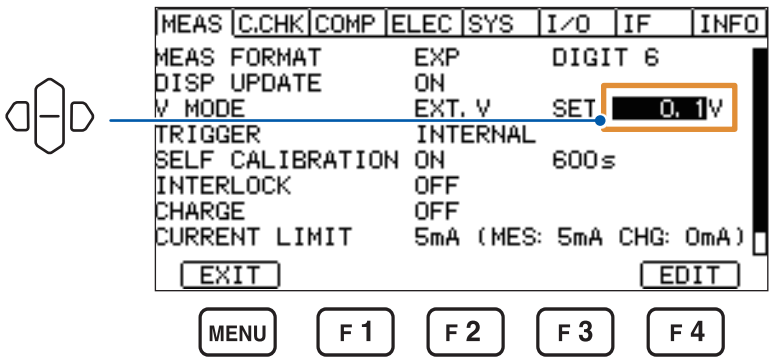
[EXT.V] Use any optional voltage. (when the external power supply is used)
[VMONI] Use the voltage measured by the instrument (voltage monitor value).
[MES.V] Use the voltage set as the applied voltage for measurement (default setting).



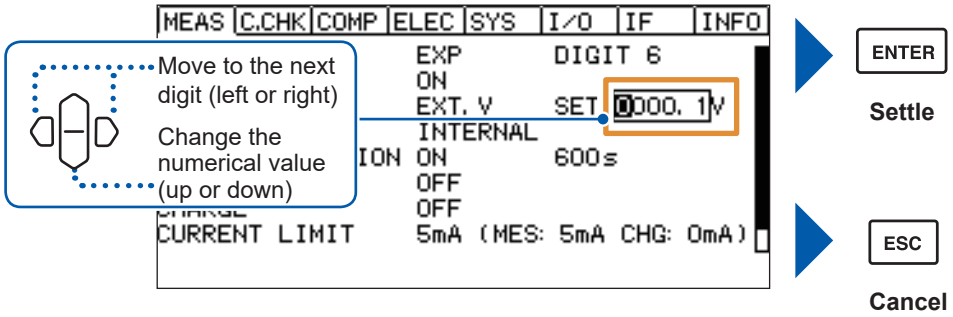
If high-speed measurements are carried out with the V mode set to **[VMONI]**, resistance values can be measured to be lower than actual values because measurements start before measurement voltages sufficiently increase.

2 If [EXT.V] is selected, set the voltage value.

0.1 V to 5000.0 V (default setting: 0.1 V)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.



Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

4.5 Changing Measurement Starting Conditions (Trigger Function)

The following two methods are available to set the measurement starting conditions.

External trigger	After the **START** key is pressed, when the external trigger signal is input, a measurement starts.
Internal trigger	When the **START** key is pressed, the internal triggers are generated automatically and measurements are repeatedly performed.

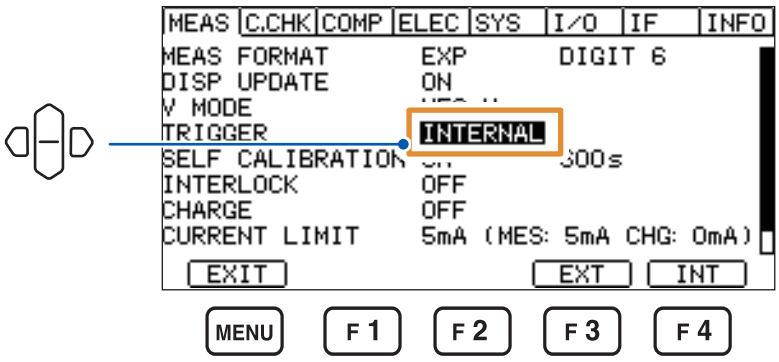
⚠ WARNING

When the START key is pressed, a hazardous voltage is generated at the measurement terminal. To avoid an electric shock, do not touch the tip of the measurement lead.

Setting the trigger mode

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

[EXTERNAL] External trigger
[INTERNAL] Internal trigger (default setting)



Inputting an external trigger

- For inputting triggers using the keys
  After the **START** key is pressed on the Measurement screen, when the **ENTER (TRIG)** key is pressed, a measurement is performed once.
- For inputting triggers to the EXT I/O
  When the TRIG terminal of the EXT I/O terminal on the rear is short-circuited with the ISO_COM terminal, a measurement is performed once. (p. 112)
- For inputting triggers to the communications interface
  When the command **`*TRG`** is sent to the communication interface, a measurement is performed once.

IMPORTANT

- If it is set to the internal trigger, the trigger input to the EXT I/O and the command **`*TRG`** are ignored.
- Measurement can be interrupted in the middle by pressing the **STOP** key.

4.6 Maintaining Measurement Accuracy (Self-Calibration Function)

The self-calibration corrects the offset voltage and the gain drift in the internal circuit.
The default setting is **[ON]**: thus, the self-calibration is executed automatically every time the set interval elapses (default setting: 600 s).
Regardless of whether the self-calibration is set to on or off, the self-calibration is automatically executed once at a startup and five minutes later.

IMPORTANT

- Executing self-calibration is a condition for maintaining the measurement accuracy of the instrument. If this function is set to **[OFF]**, manually calibrate the instrument regularly. Be sure to perform self-calibration manually especially after warming-up the instrument or when the ambient temperature has changed by 2°C or more.
- A trigger generated during self-calibration causes the instrument to suspend an immediate measurement. Once the self-calibration is complete, the instrument starts the measurement, with the result that it takes longer between the trigger input and the end of the measurement.

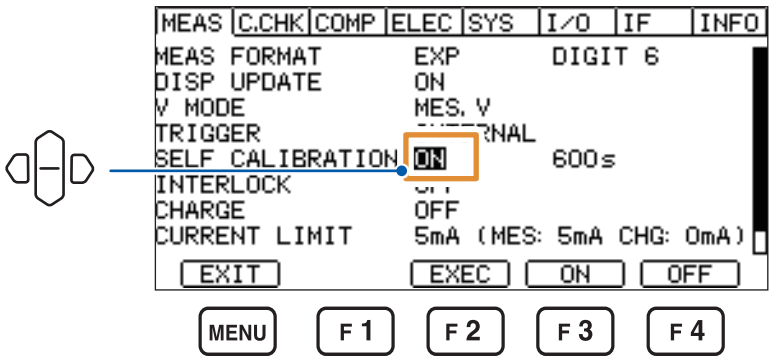
How to execute the self-calibration manually

Pressing the **F2** key **[EXEC]** while the settings screen is displayed executes the self-calibration once.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

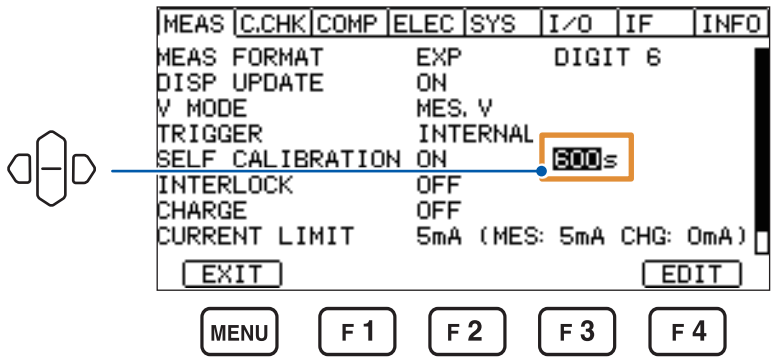
1 **Select whether to perform the self-calibration automatically or not.**

[ON] Yes (default setting)
[OFF] No (It is necessary to execute self-calibration manually at periodic intervals.)

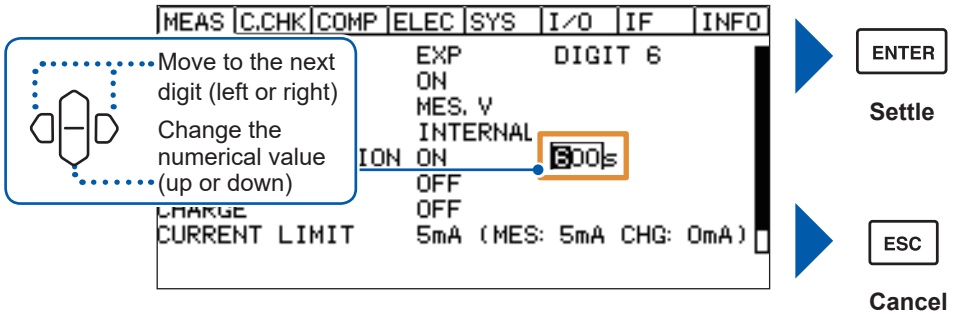


2 If [ON] is selected, set the self-calibration interval.

1 s to 600 s (default setting: 600 s)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.



Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

4.7 Setting Interlock Function

It is considered to be safe to install the interlock on another installation because the measurement voltage is not output when a shielding box lid is open.
Use the interlock function for such a case.
The output of measurement voltage and the measurement function are disabled when the interlock function is activated.
If the interlock setting is set to **[ON]** while the terminals of the INTER LOCK terminal are open, the interlock function is activated and the interlock cannot be set to **[OFF]** on the settings screen.
Either deactivate the interlock (p. 63) or set the interlock setting to **[OFF]** by using the following method.

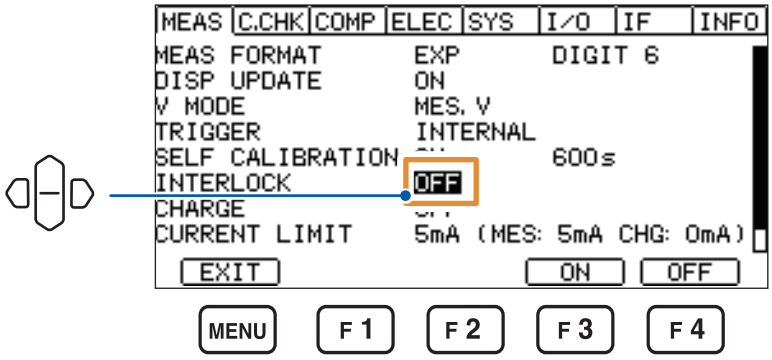
- Turn off the instrument once and then turn on it again while pressing both the **MENU** key and the down cursor key.
- Send the command `:INTerlock OFF` through the USB, the RS-232C, or the GP-IB communication.

First, connect the instrument and the shielding box with each other.
See “2.7 For Safe Measurement” (p. 35).

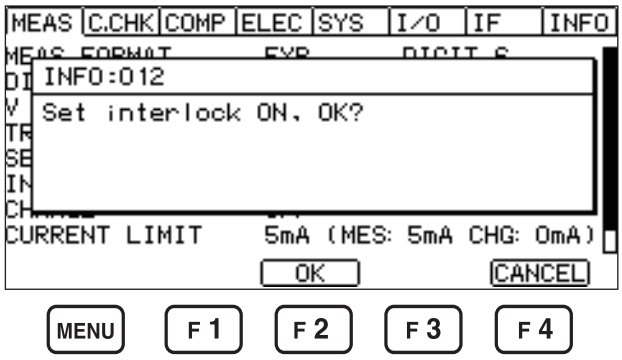
Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

[ON]	Enabled
[OFF]	Disabled (default setting)

1 **Press the F3 key [ON].**



The confirmation dialog box is displayed.



To cancel the settings, press the **F4** key **[CANCEL]** or the **ESC** key.

2 **Press the F2 key [OK].**

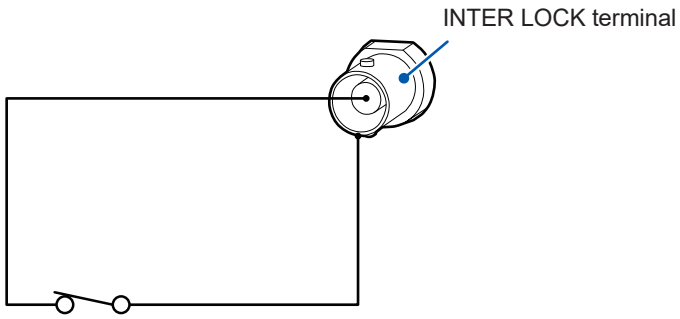
Interlock function is **[ON]** (Enabled).

How to deactivate the interlock

To deactivate the interlock, perform one of the following ways:

- Input 0 V to the INTER LOCK terminal.
- Short-circuit between the INTER LOCK terminal core wire and shield.
- Connect the signals INTERLOCK and ISO_COM in the EXT I/O terminal with each other to short-circuit them.

See “9 External Control (EXT I/O)” (p. |111).



Short-circuit between the terminals to deactivate the interlock.

4.8 Setting Pre-charge

The CHARGE terminal can be used to charge measured objects before measurement (pre-charge). Thus, this setting enables required times for automatic measurements for objects such as capacitors to decrease.

IMPORTANT
If the measurement voltage setting or the charge setting is changed after the current limiter has been set and if the current limiter value exceeds the upper limit, the current limiter is set to the largest value among the settable values.

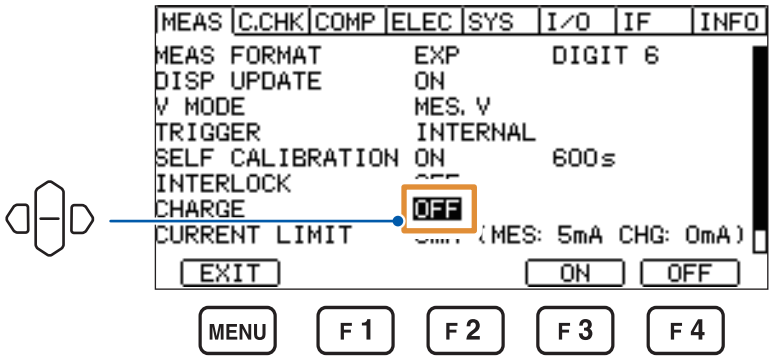
See “4.1 Starting Measurement After Measured Value Becomes Stable (Delay Function)” (p. 49).

To connect objects to the instrument, see “2.6 If Measured Object Is to Be Charged Before Measurement (Pre-charge)” (p. 34).

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

[ON] Charges objects to be measured.

[OFF] Does not charge objects to be measured. (default setting)



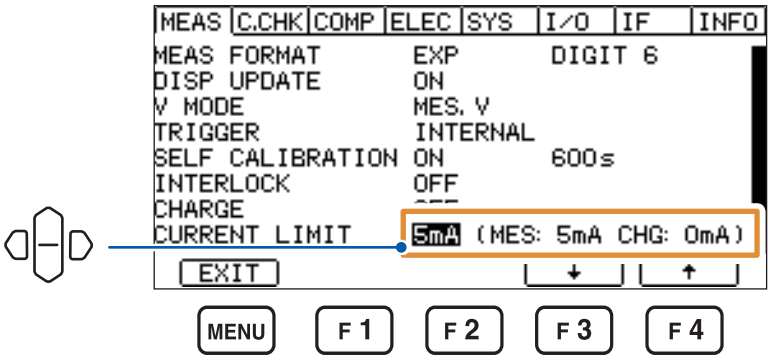
4.9 Limiting Current Flowing Through Measured Object (Current Limiter)

The current limiter can be used to limit currents flowing through measured objects. Thus, the measured objects can be charged faster, and it will also prevent objects from being damaged.
The current in the CHARGE terminal can also be restricted by the current limiter.
The value you can set varies according to the charge setting (p. 64) and the measurement voltage setting (p. 41) (p. 66).

IMPORTANT
If the measurement voltage setting or the charge setting is changed after the current limiter has been set and if the current limiter exceeds the upper limit, the current limiter is set to the largest value among the settable values.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

1.8 mA, 5 mA, 10 mA, 50 mA (default setting: 5 mA)



Press the **F3** key **[↓]** or **F4** key **[↑]** to select a value.

Current limiter set value

Charge setting	Set voltage range	Set value	Total current	Current value	
				Measurement system	Charging system
ON	0.1 V to 250.0 V	50 mA	50 mA	5 mA	45 mA
		10 mA	10 mA	5 mA	5 mA
		5 mA	5 mA	5 mA	0 mA
	250.1 V to 1000.0 V	10 mA	10 mA	5 mA	5 mA
		5 mA	5 mA	5 mA	0 mA
	1000.1 V to 2000.0 V	1.8 mA	1.8 mA	1.8 mA	0 mA
OFF	0.1 V to 250.0 V	50 mA	50 mA	50 mA	0 mA
		10 mA	10 mA	10 mA	0 mA
		5 mA	5 mA	5 mA	0 mA
	250.1 V to 1000.0 V	10 mA	10 mA	10 mA	0 mA
		5 mA	5 mA	5 mA	0 mA
	1000.1 V to 2000.0 V	1.8 mA	1.8 mA	1.8 mA	0 mA

- The set voltage range of 1000.1 V to 2000.0 V is available for Model SM7120 only.
- Limiter accuracy: ±10%
  However, the value is defined only when the output is equal to or greater than the minimum generated voltage (a voltage drop due to the output impedance of the voltage generating circuit and the input impedance of the measurement circuit).

	Limit current	Minimum generated voltage
Measurement system	50 mA	60 V
	10 mA	12 V
	5 mA	6 V
	1.8 mA	2.4 V
Charging system	45 mA	0.9 V
	5 mA	0.1 V

4.10 Auto-Range Timeout Function

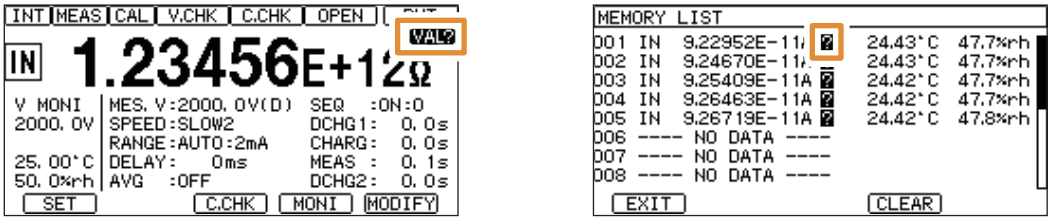
If the guarding and shielding of the instrument and measurement paths are not effective enough, the instrument can be adversely affected by external noises or other factors, resulting in unstable measurement. If you use the auto-range function in such environments, the instrument will repeatedly switch between ranges, causing measurement to continue with a voltage outputted. Using the auto-range timeout function can forcibly stop range switching in order to start measurement once the range switching has repeated four times. The range switching count will be reset at the start of the next measurement.

Activate this function under the following conditions:

- When a measured value is not updated due to repeated range switching
- When a measured value is not updated and the HIGH VOLTAGE LED is steadily on even after the measurement time set in **[MEAS]** has elapsed during auto-testing (sequence program function)

IMPORTANT

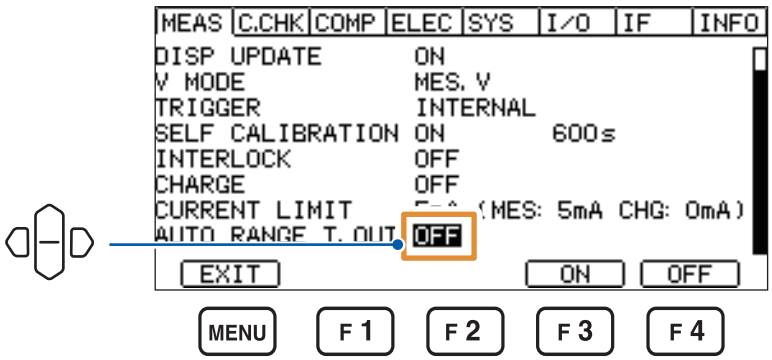
When the auto-range timeout function is activated, the instrument may perform measurement using a range other than the most appropriate one. This will cause a value that falls outside the accuracy guarantee range or the message **[Current Over Range]** to appear. When the displayed value falls outside the accuracy guarantee range, the symbol **[VAL?]** will appear at the top-right of the measurement screen. Please be advised that measured values with the symbol **[VAL?]** may not accurate enough for use. In addition, please recheck the guarding and shielding of the measurement paths for validity. Note that the symbol **[?]** will appear in the list screen of the internal memory.



Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

[ON] Auto-range timeout enabled

[OFF] Auto-range timeout disabled (default setting)



4.11 Contact Check (Various Setting)

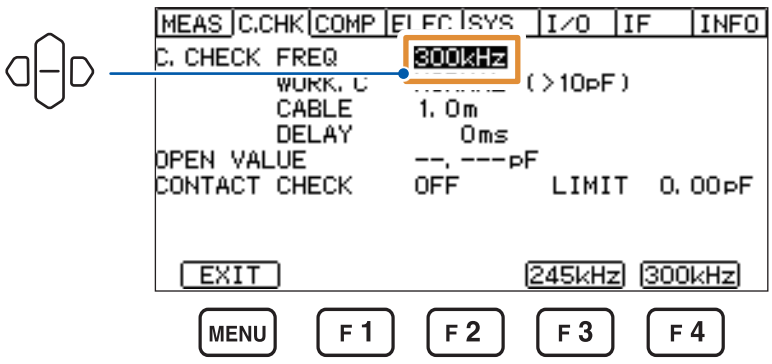
While measuring the insulator, if a measurement fixture of the measurement system is not in contact with the measured object, even defective insulation may be wrongly determined to be pass. To avoid such erroneous judgment, the contact check function is used to check if the measurement fixture is brought into contact with the measured object to be measured.
Moreover, because inaccurate contact checks are performed if the capacitance is changed with the cable length changing, the correction is required depending on the cable length.
Because the instrument can automatically correct the cable length, the auto-correction of the cable length allows the instrument to be used immediately after the cable length is changed.
To perform the contact check accurately, configure the following settings.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[C.CHK]** tab

[FREQ]	Contact check frequency
[WORK.C]	Capacitance of object to be measured
[CABLE]	Length of measurement cable
[DELAY]	Delay time

Setting of [FREQ]

Set the frequency of the signal applied during the open correction or the contact check.
245 kHz, 300 kHz (default setting: 300 kHz)

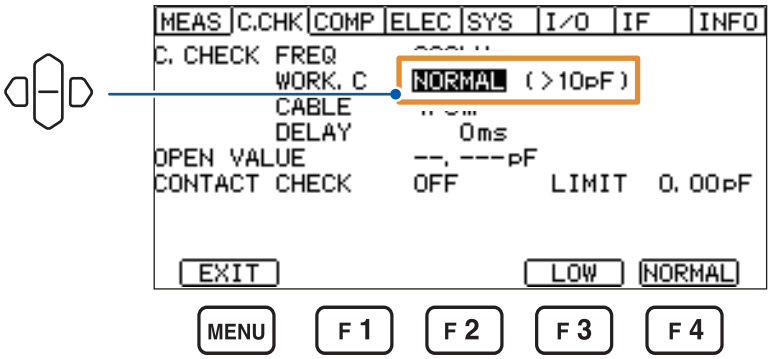


Setting of [WORK.C]

Set the capacitance of the object to be measured.

[LOW] If the capacitance of the objects to be measured is 10 pF or less

[NORMAL] If the capacitance of the objects to be measured exceeds 10 pF (default setting)



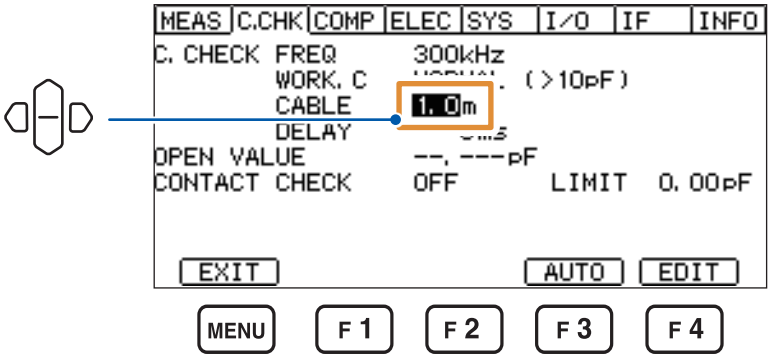
If the capacitance of the object to be measured is unknown, select **[NORMAL]** and then execute the open correction with the object connected to the instrument to obtain its capacitance.
See “4.12 Canceling Capacitance of Measurement Fixture (Fixture Capacitance Open Correction Function)” (p. 71).

Setting of [CABLE]

Set the cable length.

[AUTO] The cable length is automatically detected and set.

[EDIT] Optional numerical values can be set.
0.5 m to 3.0 m (Can be set in increments of 0.1 m, default setting: 1.0 m)

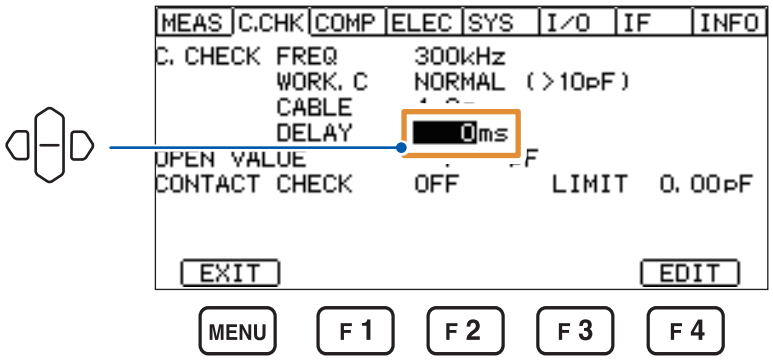


Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.

If using an accessory or an optional cable, press the **F4** key **[EDIT]** to specify its length.
If the cable is modified or extended, it is recommended to press the **F3** key **[AUTO]**.
Pressing the **F3** key **[AUTO]** executes the cable length correction once. If you change the cables, press the **F3** key **[AUTO]** to execute the cable length correction again.

Setting of [DELAY]

Set the wait time from the TRIG input to the start of the contact check
0 ms to 9999 ms (default setting: 0 ms)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.

4.12 Canceling Capacitance of Measurement Fixture (Fixture Capacitance Open Correction Function)

Be sure to read “Before performing the open correction” (p. 14) beforehand.

This function measures the capacitance of a measurement fixture with its terminals open. The fixture capacitance open correction function can reduce the impact of residual impedance of the measurement fixture (such as lead or fixture) and improve the measurement accuracy.

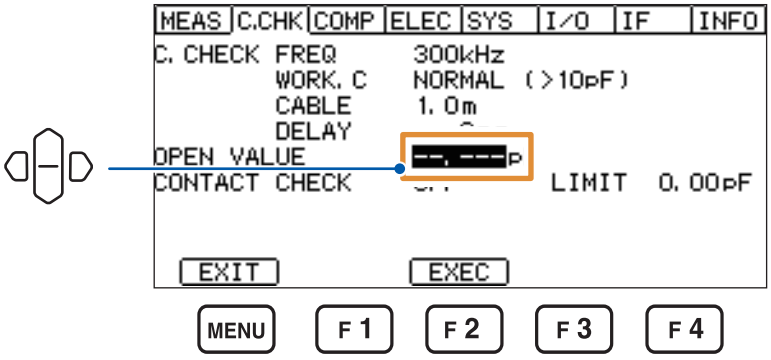
- If the contact check function is set to **[ON]**, always execute “fixture capacitance open correction” before measurement.
- When the open correction is executed once, **[OPEN]** is displayed on the front indicator of the instrument.
- Execute the fixture capacitance correction again after changing any of the contact check settings.

1 **Connect the measurement fixture such as a measurement lead to the instrument.**

Do not connect to any measured object to the measurement fixture.

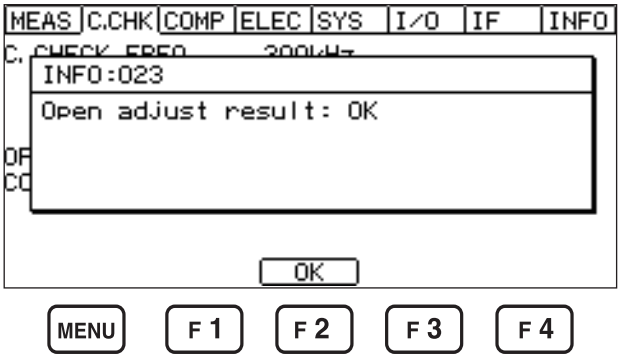
Procedure to display the settings screen: (Measurement screen) **MENU** key > **[C.CHK]** tab

2 **Press the F2 key [EXEC].**



The open correction is executed, acquiring the correction value.
The data acquired by executing “fixture capacitance open correction” is saved even after the instrument is turned off.
A capacitance of between 0.000 pF and 99.999 pF can be corrected.

3 **Press the F2 key [OK].**



A short-circuit between the INPUT and OUTPUT terminals will cause the fixture capacitance open correction to fail, displaying a result “NG.” Check a short-circuit between the terminals.

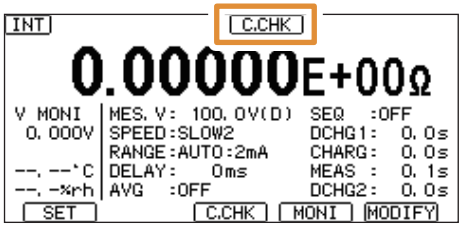
4.13 Contact Check (Executing Contact Check, Setting Reference Value)

Be sure to read “Before performing a measurement” (p. 12) beforehand.

The contact check can be performed with the cable connected to the object to be measured.
The instrument judges the contact check result to be pass or fail by detecting a difference of the capacitance between that obtained when the cable is open and that obtained during the contact check.

Judgment if the contact check function is set to ON

If the contact check function setting set to **[ON]**, the indicator **[C.CHK]** is displayed on the measurement screen.
Pressing the **F2** key **[C.CHK]** on the measurement screen or the **F2** key **[EXEC]** on the contact check setting screen executes the contact check once.
The contact check also starts at the start of measurement.
The contact check measures a capacitance by applying a high-frequency signal and determines the connection condition based on a difference between the measured capacitance and that measured with the terminals open.



Resistance value measurement mode (initial screen)

> If the contact check function is **[ON]**, always execute the fixture capacitance open correction before measurement.

If using an external power supply, set the applied voltage source to **[EXTERNAL]**.
See “3.2 Setting Applied Measurement Voltage” (p. 41).

If the capacitance value of the measurement system is less than the contact check reference value (contact error), **[C.CHK]** highlighted in reverse video (no object is connected to the instrument). In this case, inspect the instrument and the measurement fixture.

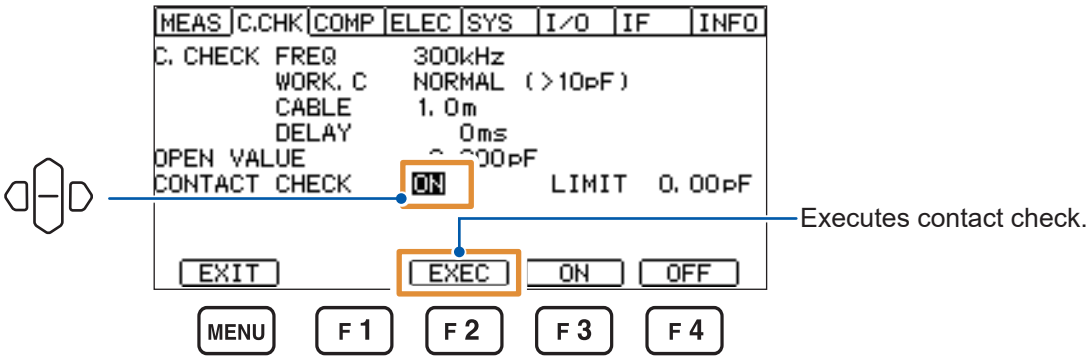
> Measurement is completed and data is output normally even if a contact error occurs.

The instrument uses the system of detecting electrostatic capacitance. Hence it cannot be used for purely resistive objects that have less low capacitance components.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[C.CHK]** tab

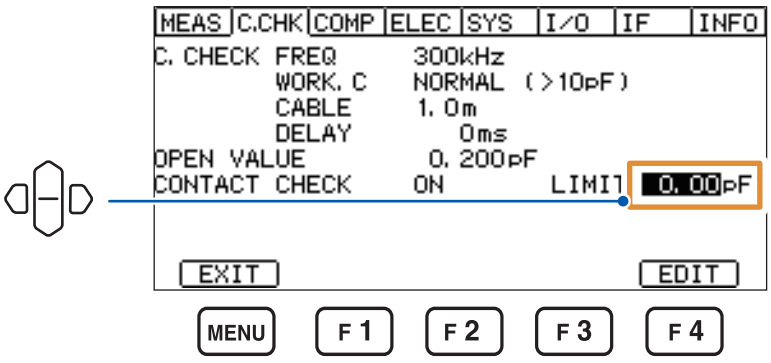
1 Select whether to perform contact check or not.

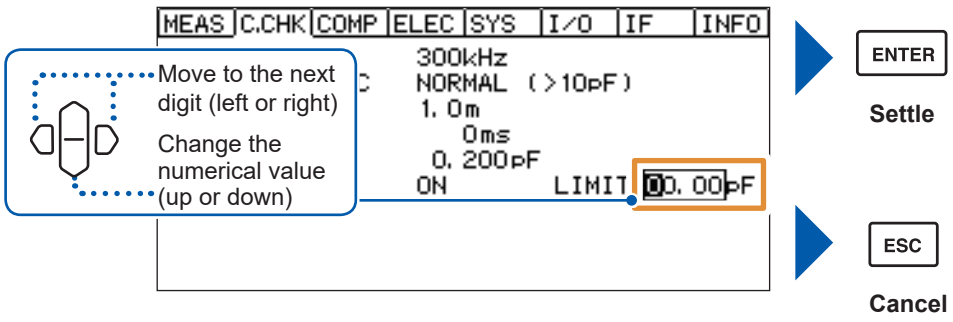
[ON] Enabled (The contact check is executed before starting measurement.)
[OFF] Disabled (default setting)



2 Set the capacitance reference value for judgment.

Set the minimum capacitance value for measurement objects.
Judgments are delivered by comparing measured values to this reference value.
A contact error occurs if the capacitance is less than this value.



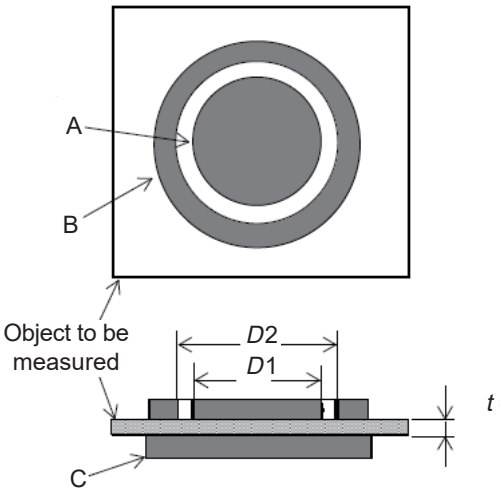


Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

4.14 Setting Resistivity Calculation (Resistivity Measurement Function)

Use of a electrode conforming to JIS or other standards enables the instrument to directly calculate the surface resistivity and volume resistivity from the measured resistance.
Set the measured value display mode to **[RS]** (surface resistivity), **[RV]** (volume resistivity), or **[RL]** (liquid volume resistivity).
See “3.1 Setting Measured Value Display Mode” (p. 39).

Examples of electrodes and connection points for measurement to distinguish between volume resistivity and surface resistivity are given below.



(1) Example of electrodes

	Volume resistivity	Surface resistivity
A	Main electrode	Main electrode
B	Guard electrode	Counter electrode
C	Counter electrode	Guard electrode

(2) Access point

Main electrode:	INPUT terminal
Guard electrode:	GUARD terminal
Counter electrode:	OUTPUT terminal

The product of the measured volume resistance and the electrode constant is called volume resistivity (ρv), while the product of the surface resistance and the electrode constant is called surface resistivity (ρs).

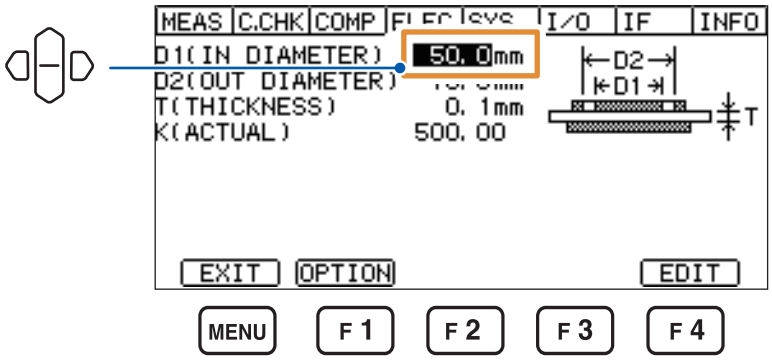
See “Calculation formula” (p. 150) in the specifications about the calculation formulas.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[ELEC]** tab

Select whether to set the model name of the option or to directly enter the electrode constant.

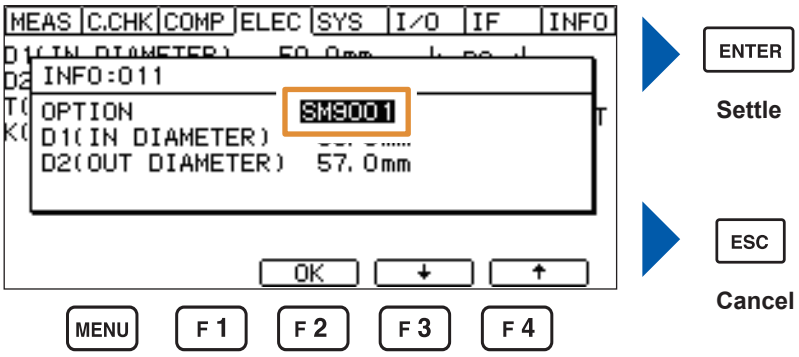
[OPTION] If the option connected to the instrument is selected, the numerical value is set automatically.

[EDIT] Set optional numerical values.



If [OPTION] is selected

Select a model connected to the instrument by pressing the F3 key [↓] or F4 key [↑].



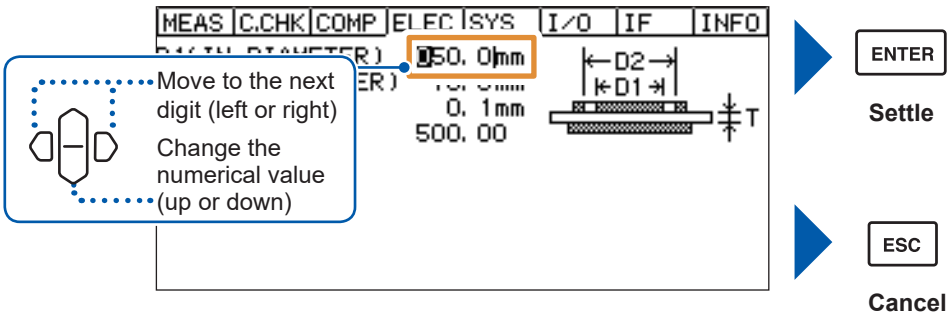
Option	Main electrode (D1)	Counter electrode (D2)
SM9001	ϕ30.5 mm	ϕ57.0 mm
SME-8301	ϕ30.0 mm	ϕ34.0 mm
SME-8310	ϕ50.0 mm	ϕ70.0 mm
SME-8311	ϕ19.6 mm	ϕ24.1 mm
SME-8320	ϕ50.0 mm	ϕ70.0 mm

If [EDIT] is selected

Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

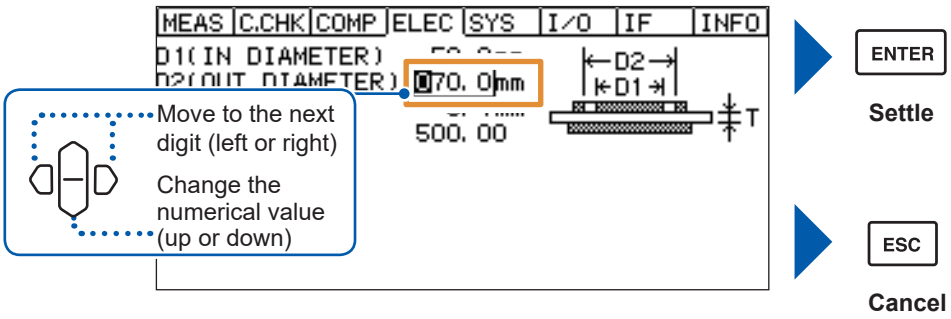
1 Set the diameter of the main electrode (D1).

0.0 mm to 100.0 mm (Can be set in increments of 0.1 mm, default setting: 50.0 mm)



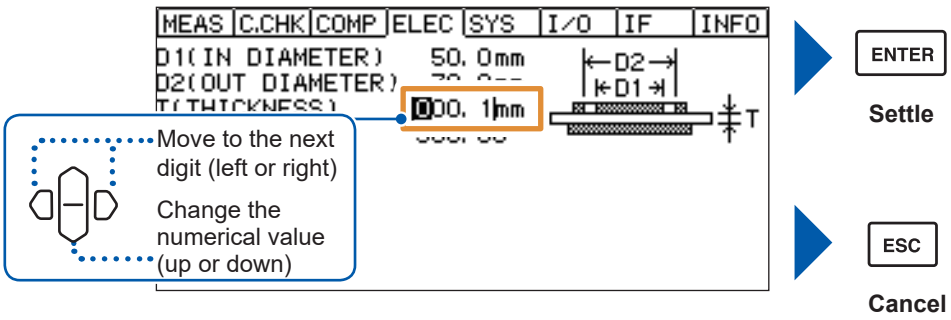
2 Set the inner diameter of the counter electrode (D2).

0.0 mm to 100.0 mm (Can be set in increments of 0.1 mm, default setting: 70.0 mm)



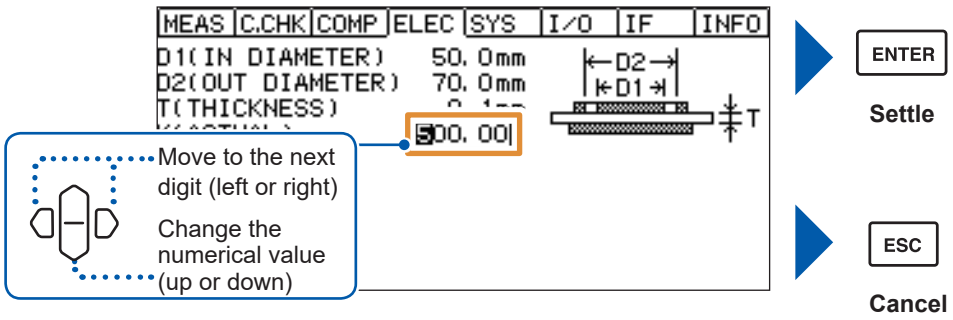
3 Set the thickness (t) of the object to be measured.

0.0 mm to 100.0 mm (Can be set in increments of 0.1 mm, default setting: 0.1 mm)



4 **Set the electrode constant (K).**

0.01 to 999.99 (Can be set in increments of 0.01, default setting: 500.00)
You can enter the electrode constant (K) to calculate liquid volume resistivity (RL).
The electrode constant (K) is listed on the test report of the SME-8330 Liquid Sample Electrode.

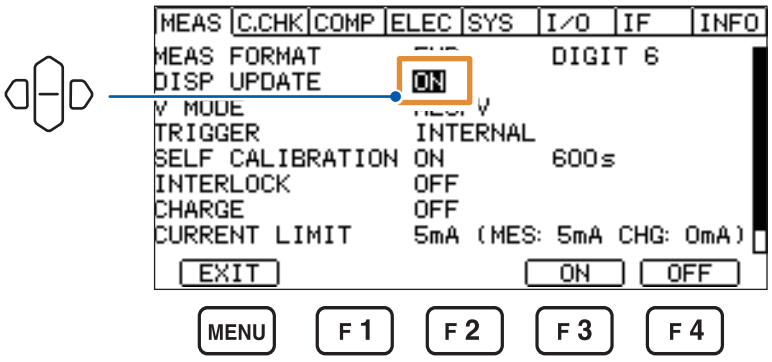


4.15 Further Accelerating Measurement (Function of Updating Drawing During Measurement)

Usually, measured values displayed on the screen are updated every time a measurement completes. In this case, you need to wait until the screen is updated for some time, a period from when a measurement completes (the EOM is output) to when the next TRIG is accepted. Set this function setting to **[OFF]** to accelerate further the measurement by omitting measured value display updating.

Procedure to display the settings screen: (Measurement screen) **MENU** key > **[MEAS]** tab

[ON] Updates the measured value display every measurement (default setting).
[OFF] Does not update the measured value display (Update the display when the setting is changed).



5 Measurement Methods Suitable for Various Objects to Be Measured

Insulation resistance objects to be measured vary in material, shape, electrical characteristics, and other properties, and the suitable insulation resistance measurement method varies depending on the object.
This chapter describes suitable insulation resistance measurement methods for different objects.

5.1 Measuring Components or Circuits

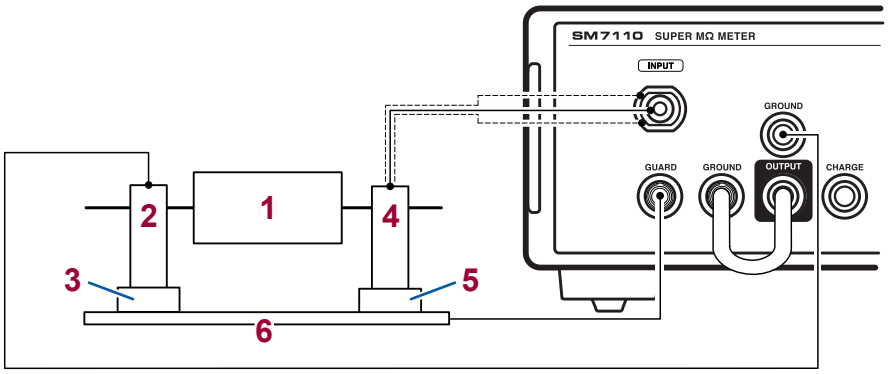
Measurement principle

Generally, insulation resistance is measured by measuring a current that flows from a terminal through a measured object to another terminal, and converting the result into a resistance value.
To measure only the current that flows through the measured object, the current that does not flow through the object (e.g., current that flows through the insulator of the object holder) must be diverted to the GUARD terminal (on the common side of the current measurement block) so that it does not flow into the INPUT terminal. That is, “guarding” is to make the current flowing through the outside of the measured object directly flow to the common side to prevent it from flowing into the INPUT terminal.
If you use a measurement fixture, generally the component holder of the fixture must be guarded. However, measuring the insulation resistance of the fixture in addition to that of the measured object may not be problem if the insulation resistance of the fixture is much, for example, hundredfold or more, higher that of the object.
Although the structure of an actual fixture may vary depending on the shape of the object to be measured, the guard circuit must be configured in such a way that the current not flowing through the object is diverted to the GUARD terminal.

Measurement with use of a measurement fixture

Design the circuit in order that the currents flowing through the outside of all the objects to be measured flow through the guard circuit and connect the guard circuit to the GUARD terminal of the instrument.

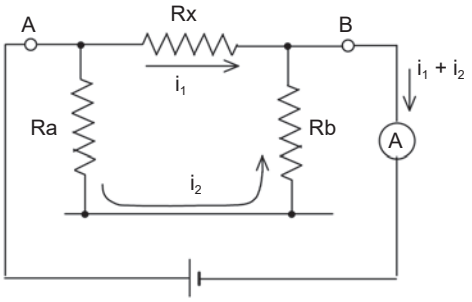
Example of use: (Use a measurement fixture with a guard installed)



1	Sample (Rx)
2	Terminal A
3	Insulator a (Ra)
4	Terminal B
5	Insulator b (Rb)
6	Holding plate (guard)

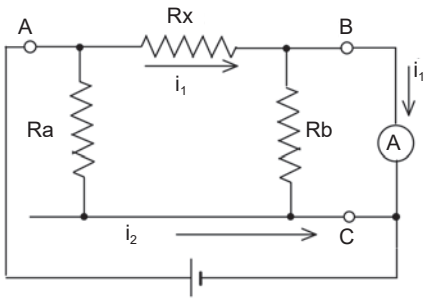
Principle of the guard

(a) Measurement without a guard



Measurement voltage source

(b) Measurement with a guard



Measurement voltage source

The figures “Example of use” and “Principles of the guard” explains the effectiveness of the guard. Considering how the current flows from Terminal A to Terminal B in the “Example of use,” 2 flow channels are found.

- Current pathway passing through the measured object (Rx)
- Current pathway passing through in the following order: Insulator a (Ra), holding plate, Insulator b (Rb), and Terminal B.

Connect Terminal A to the OUTPUT terminal and Terminal B to the INPUT terminal of the instrument, and then start a measurement. Thus, the sum of the insulation resistance (Rx) of the measured object, the current that flows through the insulation resistance Ra of Insulator a, and the current that flows through the insulation resistance Rb of Insulator b is measured. “Principle of the guard” shows the equivalent circuit of this case.

As you can clearly see from the equivalent circuit in “(a) Measurement without a guard,” both the current i_1, which flows through the measured object, and the current i_2, which flows through Insulators a and b, flow into the input circuit through Terminal B.

Next, use a metal plate as the holding plate of the holder, and connect it to the GUARD terminal of the instrument. This ensures that only the current flowing through the measured object flows into the INPUT terminal; the current that flows through Insulators a and b is excluded. (See “(b) Measurement with a guard.”)

This equivalent circuit shows that the current i_2, which flows through Insulator a, does not flow into the input circuit, but directly flows into the common current measurement block, and that only current i_1, which flows through the measured object, flows into the input circuit.

Measurement without use of a measurement fixture

Connect the optional Pin Type Lead or Clip Type Lead to the measured object and perform measurement.
Both the measuring leads do not have a guard on the end connected to the OUTPUT terminal but have a guard on the other end connected to the INPUT terminal.

Pin Type Lead	The structure of the lead is designed to guard also the test rods, so that you can perform measurement while holding the test rods in your hands.
Clip Type Lead	The clip parts have no guard, connect them to the terminals of the object to be measured and perform measurement with your hands kept away from them.

See “2.2 Connecting Measurement Leads to Instrument” (p. 30), and “3.5 Connecting Measurement Leads or Electrode to Object to Be Measured” (p. 45)

The insulation resistance value varies depending on the insulation material. However, the measurement time, measurement voltage, and temperature also have a significant impact on the measured value.

Impact of the measurement time

A circuit of an insulator is schematically considered as a complex circuit in which resistance and capacitance are included serially or parallel; thus, applying a voltage to the insulator results in the dielectric absorption current and leakage current equivalent to the charging current flowing.
The insulation resistance can be obtained by measuring the leakage current and converting it into a resistance value. Generally, the dielectric absorption current is considerably larger than the leakage current, and the time constant may also be very large depending on the type of the insulator. Therefore, in some cases, it may take a long time for the dielectric absorption current to become smaller than the leakage current. If a resistant value of such an insulator is measured, measuring for a short time results in a small insulation resistance value; the longer the measurement time, the higher will be the insulation resistance value.

Impact of measurement voltage

The time constant and insulation resistance value of the dielectric absorption current may considerably vary depending on the voltage applied to the insulator. Generally, the higher the measurement voltage, the lower will be the insulation resistance value.

Impact of temperature

Temperature also has an impact on insulation resistance values. Although they will vary depending on the type of the insulator, generally the higher the temperature, the lower will be the insulation resistance.
Accurate insulation resistance not only it takes time, but also it is difficult to perform measurement.

In some cases, you cannot freely determine the measurement voltage due to the dielectric strength of the object toe be measured. However, a measurement time value of 1 minute is used, and 1-minute insulation resistance value is expressed with the measurement voltage as, for example, “1000 MΩ at a voltage of 500 V DC.”
To compare the insulation resistance, you must determine the measurement voltage and time to perform measurement. However, it may be important to reduce the measurement time (or inspection time) in a production process. In such cases, it is important to determine the time in the range that allows correlation with the 1-minute value.

Automatic measurement

If you have many objects or points to be measured, “automatic measurement” is useful. The function performs measurement by automatically switching objects, measurement fixtures, or measurement terminals to be measured.
For automatic measurement, the switch timing must be aligned with the instrument operation. The following are the 2 methods to align the timing.

When switching objects to be measured according to the INDEX signal output from Pin 29 of the instrument’s EXT I/O terminal	• Set the trigger mode of the instrument to Internal trigger mode or External trigger mode. **Internal trigger mode** • When the **START** key is pressed, measurement starts. **External trigger mode** • After the **START** key is pressed, when a manual trigger is input, measurement starts.

When a trigger pulse is input to Pin 1 of the EXT I/O terminal of the instrument at the timing of switching the objects to be measured	• Set the trigger mode of the instrument to External trigger mode.
	• After the **START** key is pressed, when a trigger pulse is input to Pin 1 of the instrument’s EXT I/O terminal, measurement starts.
	• The conditions of the external trigger signal are as follows:
	  • Pulse width: 200 µs or greater
	  • Drive output: Open collector or TTL output
	  • Drive current: 1 mA or higher sink current

For details, see the following pages:

Trigger mode: “4.5 Changing Measurement Starting Conditions (Trigger Function)” (p. 58)
EXT I/O terminal: “9 External Control (EXT I/O)” (p. 111)

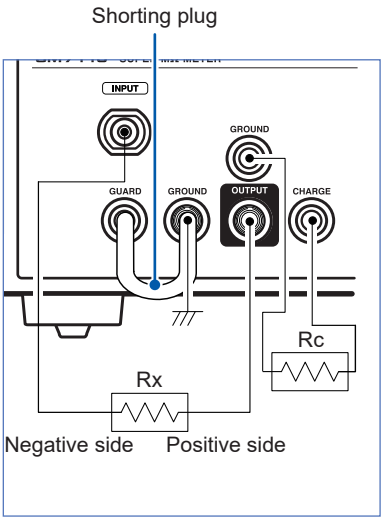
When automatically measuring an object with a large capacitance (such as a capacitor)

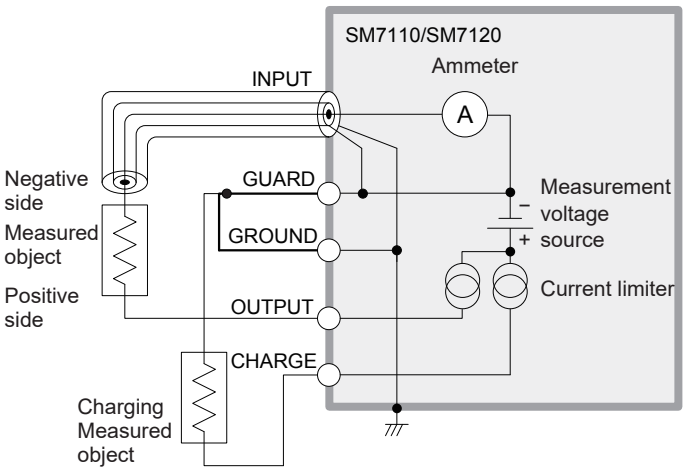
Improving the reliability of insulation resistance measurement

Set the contact check function that checks connections (contacts) in the measurement circuit including the measured object and the measurement fixture.
See “4.13 Contact Check (Executing Contact Check, Setting Reference Value)” (p. 72).

Reducing the measurement time and improving the measurement accuracy

Pre-charge the measured object before measurement.
Connection to the CHARGE terminal (p. 34) and the following settings are required:
See “4.8 Setting Pre-charge” (p. 64) and “4.9 Limiting Current Flowing Through Measured Object (Current Limiter)” (p. 65)





Rc is the measured object after Rx.

Example of CHARGE terminal connection (A grounded measured object)

5.2 Measuring Flat Sample

Measuring insulation resistance of an object with no terminals installed requires something that can function as terminals to be attached on the object.
The measurement method varies depending on the type of the terminal.

What function as terminals
It must be possible to switch the objects to be measured easily. Therefore, items with a structure that allows them to function as terminals just by contacting the object is often used.
The terminals used for measurement must have proper contact with the object to be measured without any loose connection.
For a solid insulation material, the method of bringing terminals (electrode) that have a specific pin shape or those with smooth flat surfaces, which can contact with smooth surfaces of objects to be measured without any space between them, into close contact with the object to be measured is employed to measure insulation resistance. (The shape and structure of the terminals varies depending on the shape and characteristics of the object to be measured.)

Measurement using pin type terminals

Insulation resistance is classified into “volume resistance,” which is the current flowing through the measured object and “surface resistance,” which is the current flowing along the surface of the sample. To measure both of them together, use pin type terminals.

Example of pin creation

Make 2 holes (such as tapered holes) with a predefined diameter at a certain interval on the flat sample. Apply material with relatively low insulation resistance, such as petroleum jelly, to the pins and insert the pins into the holes to use them as terminals for measurement.
These pins are of a simple structure and provide relatively steady contacts, eliminating the need for smoothing the surface of the sample to obtain a flat surface.

Setting the instrument

Press the **MODE** key to switch the measurement mode to resistance value measurement mode, and then perform measurement. (p. 39)

Measurement using an electrode for measuring surface resistance

The electrode for measuring surface resistance is used as terminals for measurement by pressing it on the surface of the object to be measured. It provides an easy method to perform measurement if the objects to be measured are relatively soft.
This electrode cannot exactly separate the volume resistance but can essentially measure the surface resistance because it is generally lower.
In particular, this method is useful for objects to be measured that have been subjected to surface anti-static treatment.

Setting the instrument

Press the **MODE** key to switch the measurement mode to sureface resistivity measurement mode, and then preform measurement. (p. 39)

Measurement using an electrode for a flat sample

The “volume resistance” and “surface resistance” must be measured separately because their properties are different from each other.
To compare different insulating materials in terms of insulation resistance, the insulating material-specific resistance values that are not affected by the shape of the terminal are required. They are considered to be the volume resistivity or surface resistivity. Use an electrode (such as optional Model SME-8310 or SME-8311) to determine the volume resistance value or the surface resistance value. Then, multiply the values by each of the electrode constants to calculate the volume resistance value or the surface resistivity. The instrument can automatically calculate the volume resistivity or the surface resistivity.

Setting the instrument

Settings for calculating the resistivity are required.
See “4.14 Setting Resistivity Calculation (Resistivity Measurement Function)” (p. 74).

Press the **MODE** key to switch the measurement mode to volume resistivity measurement mode, and then perform measurement. (p. 39)

Volume resistance measurement and surface resistivity measurement (the functional role of the guard electrode)

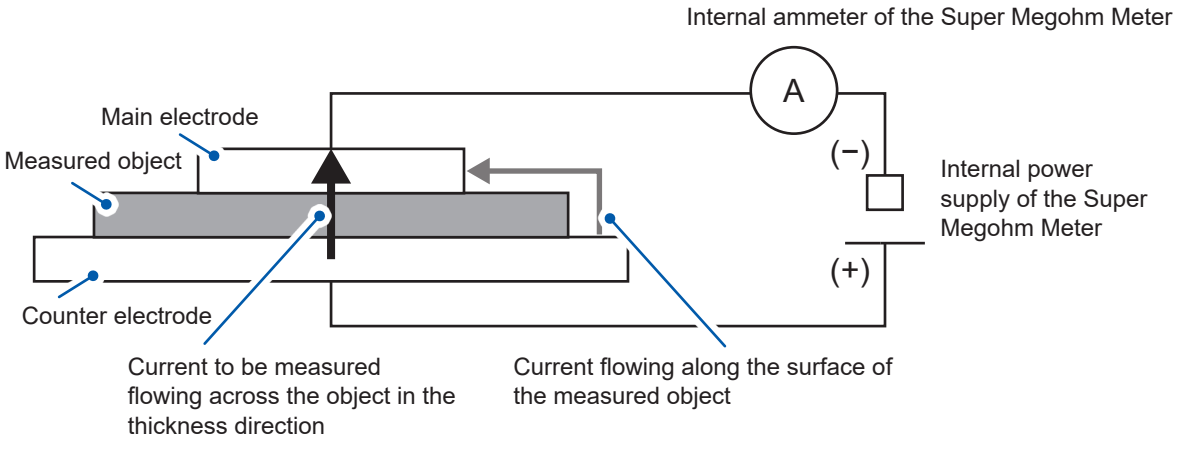
A guard is required for measuring volume resistance and surface resistivity.
Hioki provides Model SME-8310 Plate Sample Electrode and Model SME-8311 Electrode for Flat Sample as options.
Both the devices consists of 3 electrodes: “main electrode,” “counter electrode,” and “guard electrode.”

> Because measurement using Model SME-8301 Surface Resistance Measurement Electrode is equivalent to the measurement described in “Surface resistance measurement (1) Measurement without the guard electrode (p. 86),” it cannot provide accurate surface resistance measurement.

Volume resistance measurement

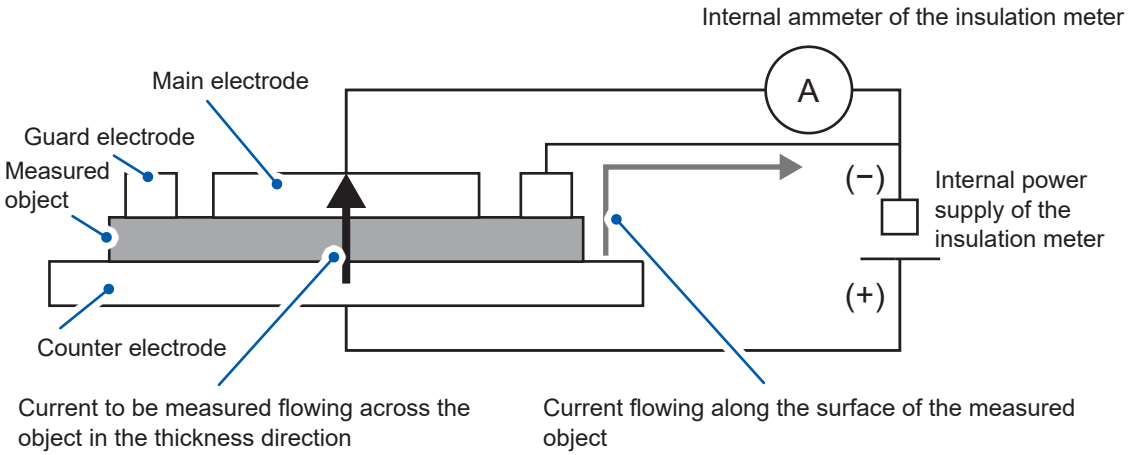
(1) Measurement without the guard electrode

Because the current flowing along the surface of the measured object is also measured unnecessarily, the current flowing across the object in the thickness direction cannot be separately measured.



(2) Measurement with the guard electrode

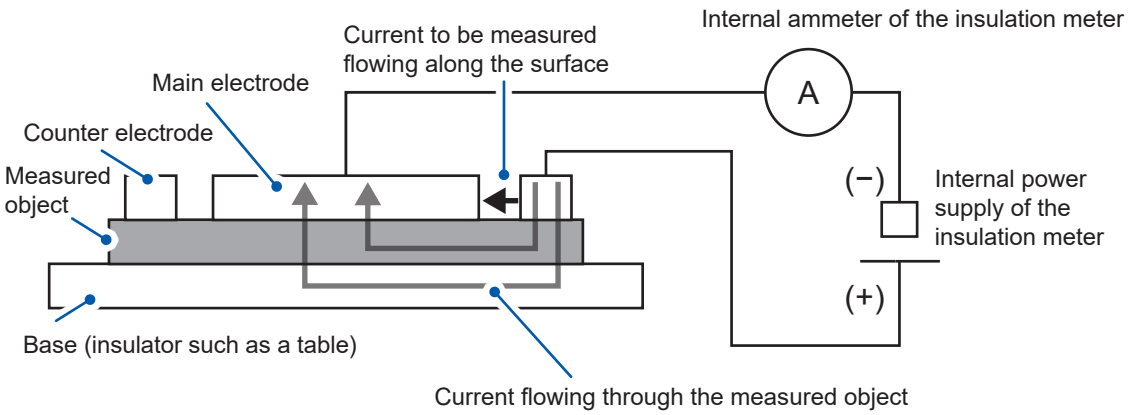
Because the current flowing along the surface of the measured object flows out through the guard electrode to the external power supply, the current flowing across the object in the thickness direction can be separately measured with accuracy.



Surface resistance measurement

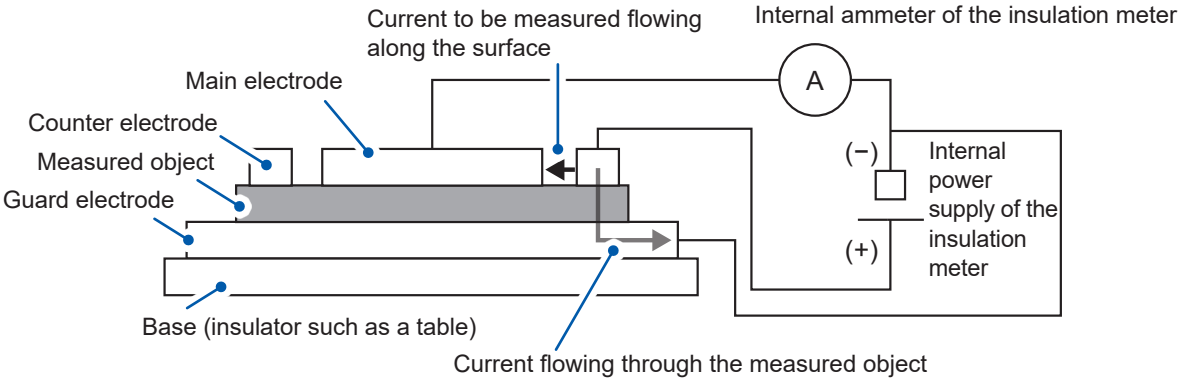
(1) Measurement without the guard electrode (also applicable to measurement with use of Model SME-8301)

Because the current flowing through the measured object and the other current flowing through the base (insulator) are also measured unnecessarily, the current flowing along the surface cannot be separately measured.



(2) Measurement with the guard electrode

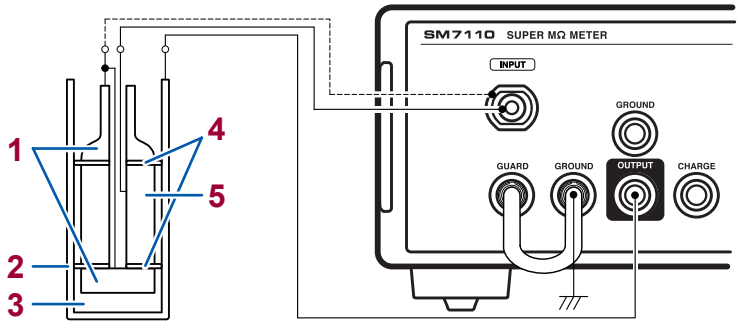
Because the current flowing through the measured object flows out through the guard electrode to the external power supply, the current flowing along the surface of the measured object can be separately measured with accuracy.



5.3 Measuring a Liquid Sample

To measure the volume resistance of a liquid sample, insert an electrode with a fixed shape in the liquid sample or use an electrode that can also function as the container for the liquid sample.

When using an electrode for liquid samples



1	Guard electrode
2	Counter electrode
3	Liquid sample
4	Supporting insulator
5	Main electrode

Example of connection

Setting the instrument

Settings for calculating the resistivity are required.
See “4.14 Setting Resistivity Calculation (Resistivity Measurement Function)” (p. 74).

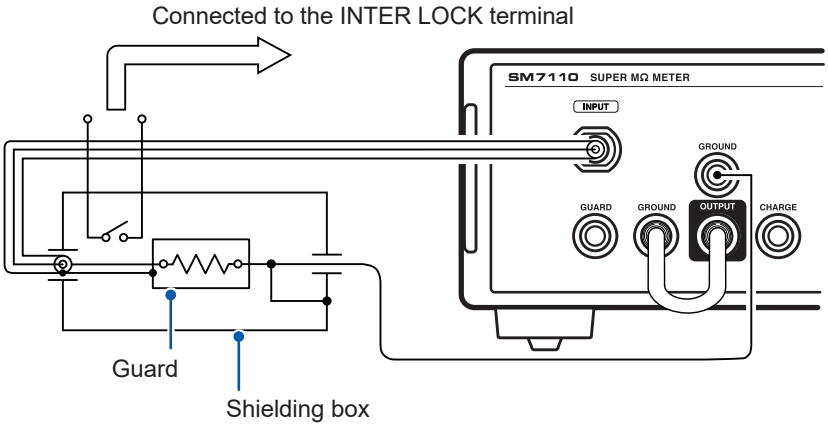
Press the **MODE** key to switch the measurement mode to liquid volume resistivity measurement mode, and then perform measurement. (p. 39)

For the electrode constant, refer to the Instruction Manual of the electrode for liquid samples.

5.4 Measurement With Use of Shielding Box

Be sure to read “Before using the shielding box” (p. 13) beforehand.

Measurement of high insulation resistance, which requires to measure current with high-sensitivity, may be unstable due to ambient noise or inductive current.
Thus, measurement objects to be measured must placed in a shielding box.



Example of connection

Model SME-8350 Shielding Box is provided as an option.

Setting the instrument

For the measurement with use of a shielding box, set the measured value display mode according to the objects to be measured.
See “5.1 Measuring Components or Circuits” (p. 79), “5.3 Measuring a Liquid Sample” (p. 88), and “5.2 Measuring Flat Sample” (p. 84)

5.5 Measuring Current

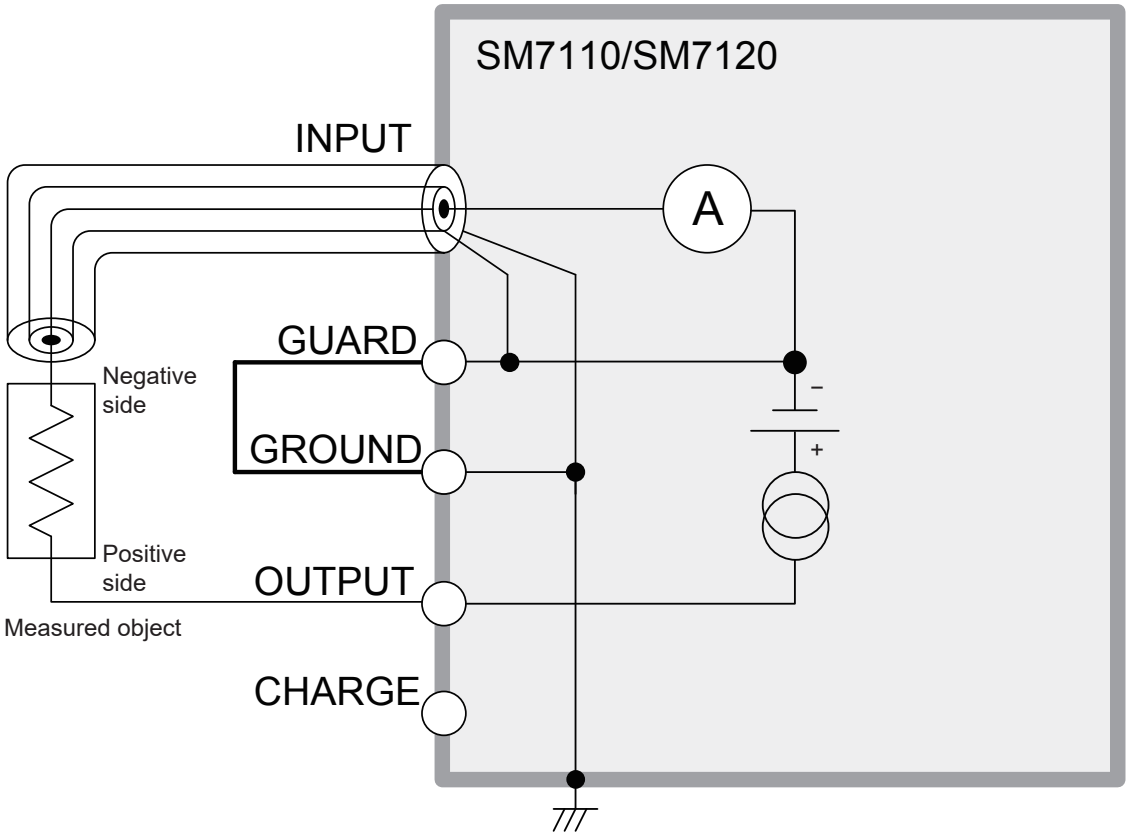
Connection method

1 **Connect the positive side of the object to be measured to the OUTPUT terminal of the instrument.**

2 **Connect the negative side of the object to be measured to the INPUT terminal of the instrument.**

> Use a shielded wire for the measurement lead connected to the INPUT terminal so that it is not affected by inductive interference such as noise.

3 **Connect the GUARD terminal and the GROUND terminal to each other with the shorting plug.**



Setting the instrument

Press the **MODE** key to switch the measurement mode to liquid volume resistivity measurement mode, and then perform measurement. (p. 39)

6 Judging Measured Value (Comparator Function)

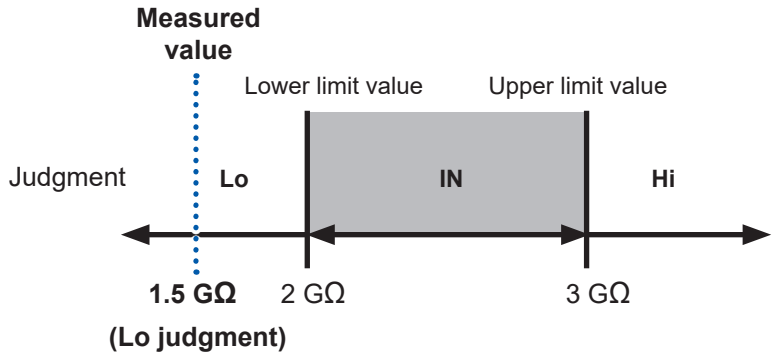
The comparator function judges whether measured values are within or out of a range defined by an upper and lower limits set previously.
A judgment is displayed as follows on the screen.

[Hi]	(Upper limit) < (Measured value)
[IN]	(Lower limit) ≤ (Measured value) ≤ (Upper limit)
[Lo]	(Measured value) < (Lower limit)

Upper and lower limit values

The function judges whether the measured value is higher than the upper limit previously set (Hi), within the range between the lower and upper limits previously set (IN), or lower than the lower limit preciously set (Lo).

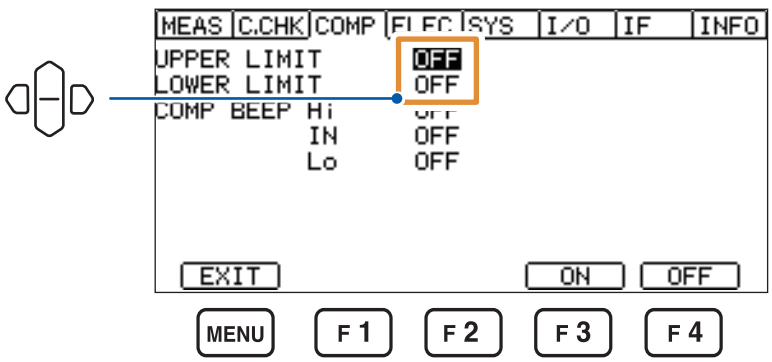
(Example: For upper limit is 3 GΩ, lower limit is 2 GΩ, measured value is 1.5 GΩ)



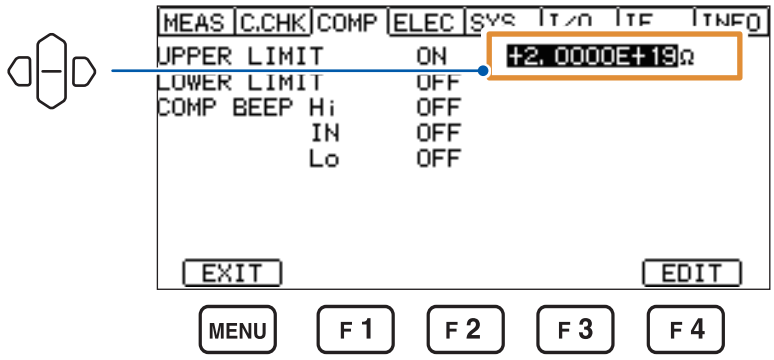
Procedure to display the settings screen: **COMP** key

1 Select whether the measured value is to be judged or not.

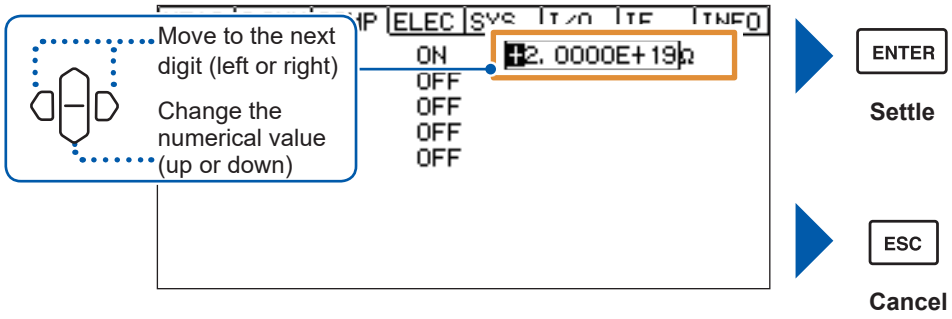
[ON] Yes
[OFF] No (default setting)



2 **If the upper limit and lower limit settings are set to [ON], set the numerical value.**



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.



Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

Settable range

The following ranges are applicable in common to all ranges.

Resistance value measurement mode	2.0000E+19 Ω to 5.0000E+01 Ω
Current value measurement mode	-1.99999E-03 A to 1.99999E-03 A
Surface resistivity measurement mode	2.0000E+21 Ω to 5.0000E+03 Ω
Volume resistivity measurement mode	
Liquid volume resistivity measurement mode	

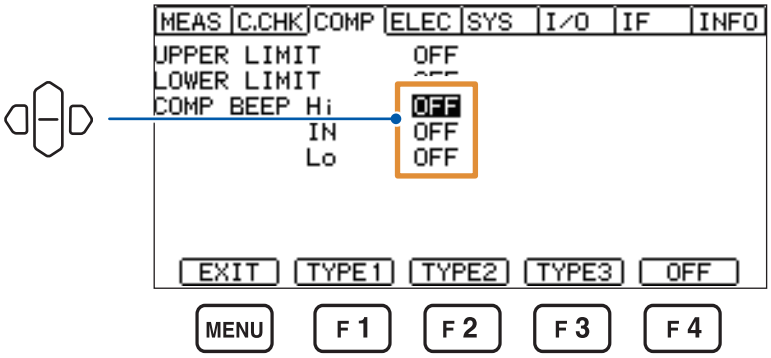
6.1 Setting Judgment Sound

Select whether to use a judgment sound for the measurement results.

Procedure to display the settings screen: **COMP** key

1 **Select the respective buzzer sounds for Hi judgment, IN judgment, and Lo judgment.**

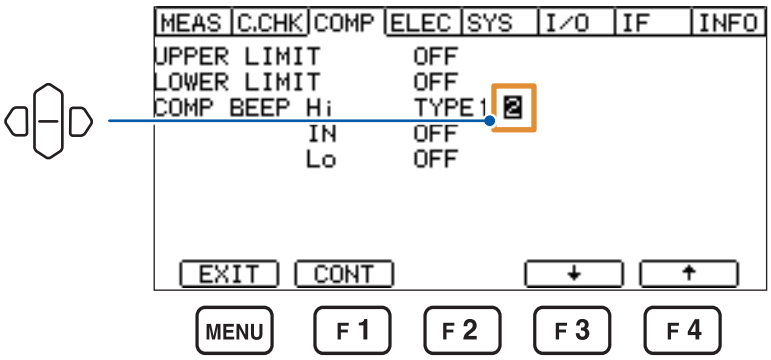
[OFF] (No sound, default setting), **[TYPE1]**, **[TYPE2]**, **[TYPE3]**



Selecting **[TYPE1]**, **[TYPE2]**, or **[TYPE3]** sounds the buzzer in a specific tone for confirmation.

2 **If [COMP BEEP] is set to any one of [TYPE1], [TYPE2], or [TYPE3], set the number of ringing times.**

1 to 5 times, continuous (Default setting: 1 time)

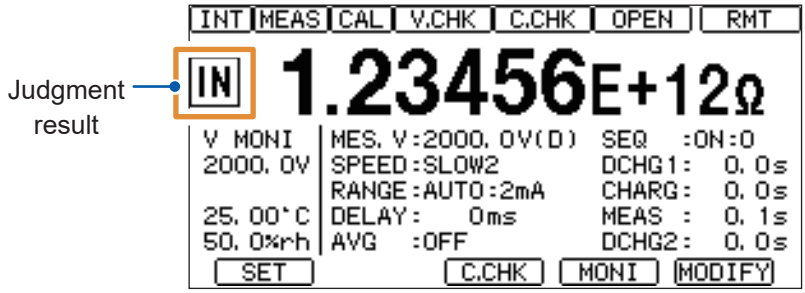


Press the **F3** key **[↓]** or **F4** key **[↑]** to change the number of times.
Press the **F1** key **[CONT]** to use the continuous sound setting.

6.2 Confirming Judgment Results

An indicator appears on the measurement screen according to the judgment results.
The respective parameter judgment result and comprehensive judgment result are output to EXT I/O.
When the measurement is normally completed along with an IN judgment, the On signal is outputted through the PASS terminal.

IN	If the measured value is smaller than the upper limit value but greater than the lower limit value that are previously set
Hi	If the measured value is greater than the upper limit value that is previously set
Lo	If the measured value is smaller than the lower limit value that is previously set



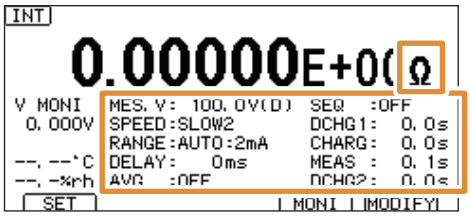
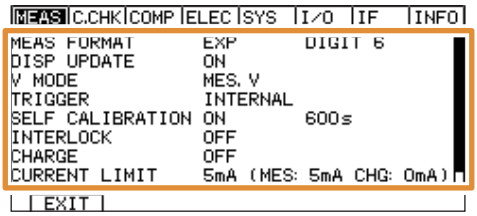
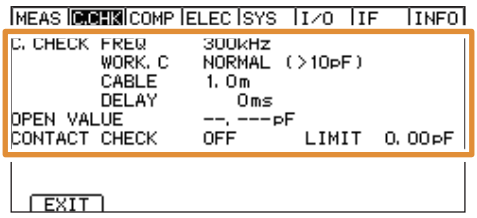
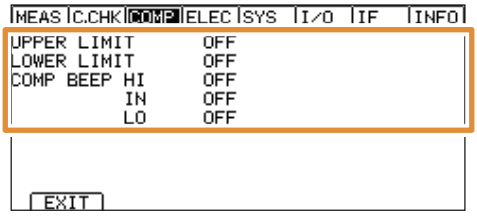
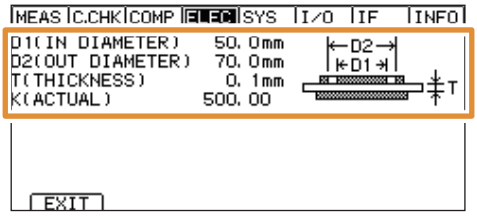
Measurement result	Judgment result	Output of EXT I/O					
		HI	IN	LO	ERR	PASS	FAIL
(Upper limit) < (Measured value)	Hi	on	off	off	off	off	on
(Lower limit) ≤ (Measured value) ≤ (Upper limit)	IN	off	on	off	off	on	off
(Measured value) < (Lower limit)	Lo	off	off	on	off	off	on
Current Over Range	Hi	on	off	off	off	off	on
Measurement error*	No judgment	off	off	off	on	off	off
During interruption of measurement	No judgment	off	off	off	off	off	off

* The following instances result in measurement error:
  - The A/D converter for measurement and that for voltage measurement have overflowed.
  - The contact-check measured value or fixture-capacitance open correction value exceeds 99.999 pF.

7 Saving and Loading Settings (Panel Saving and Loading)

The present settings can be saved to the memory of the instrument (panel saving function).
The saved settings can be loaded from the memory by pressing the keys or sending communication commands (panel loading function).
The instrument can save a maximum of 50 settings. The saved settings are retained even when the instrument is turned off.

Setting items that can be saved with the panel saving

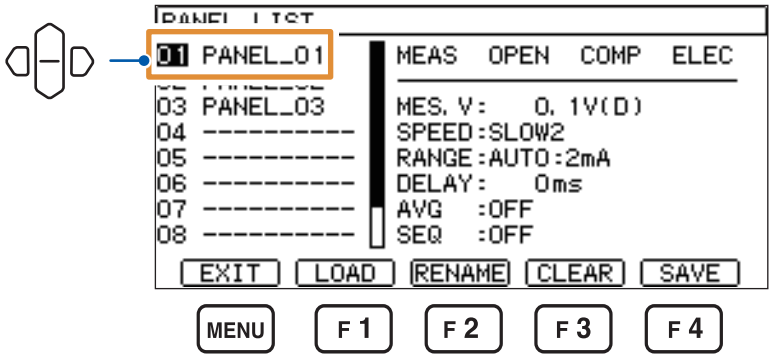
Basic settings		• Measured value display mode • Applied voltage for measurement • Measurement speed • Current range • Delay • Average • Sequence program
[MEAS] settings		• Display range • Displayed digit number • Function of updating and switching drawing during measurement • Voltage value for resistance calculation • Trigger • Self-calibration • Interlock • Current limiter
[C.CHK] settings		• Fixture capacitance open correction • Contact check
[COMP] settings		• Upper and lower limit values of comparator • Judgment sound
[ELEC] settings		• Resistivity measurement settings

7.1 Saving Settings (Panel Saving Function)

This function saves the settings that are currently set.

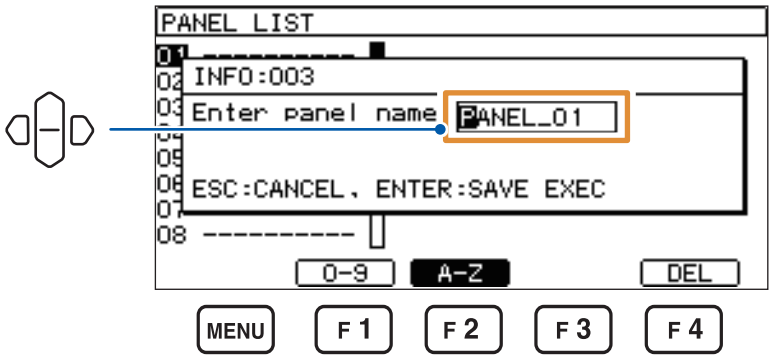
Procedure to display the setting screen: **LOAD/SAVE** key

1 **Select the panel number to be saved, and press the F4 key [SAVE].**

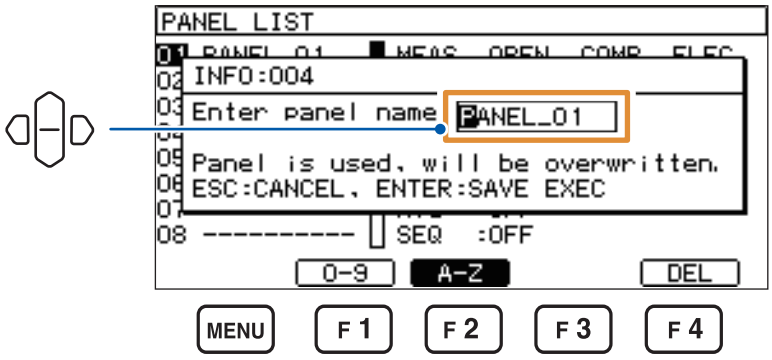


The confirmation dialog box is displayed.

(If saving it as a new one)



(If saving it, replacing the exist one with the new one with the same name)



The panel name can be changed.

F1 key **[0-9]**	Numeric input mode is enabled. (Select a numerical value using the cursor.)
F2 key **[A-Z]**	Alphabetical character input mode is enabled. Underscores (_) can also be entered. (Select a character using the cursor.)
F4 key **[DEL]**	Deletes the characters one by one.

To cancel the save operation, press the **ESC** key.

2 **Press the ENTER key.**

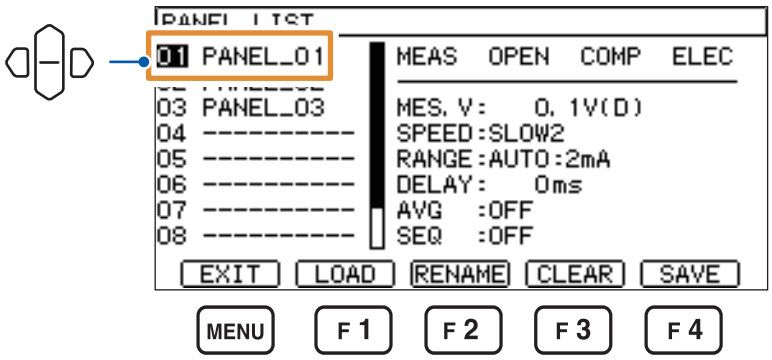
The present settings are saved.

7.2 Loading Settings (Panel Loading Function)

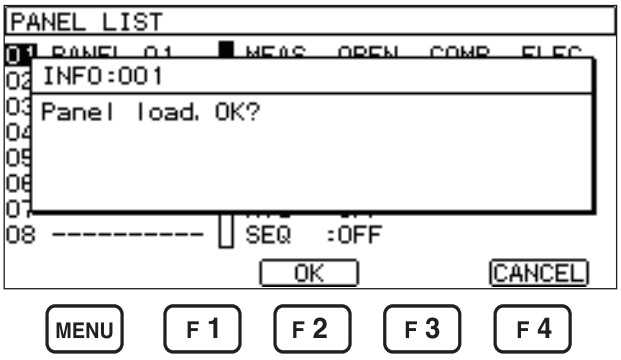
This function loads the settings that are saved.

Procedure to display the setting screen: **LOAD/SAVE** key

1 **Select the panel number to be loaded, and press the F1 key [LOAD] or the ENTER key.**



The confirmation dialog box is displayed.



To cancel the load operation, press the **F4** key **[CANCEL]** or the **ESC** key.

2 **Press the F2 key [OK] or the ENTER key.**

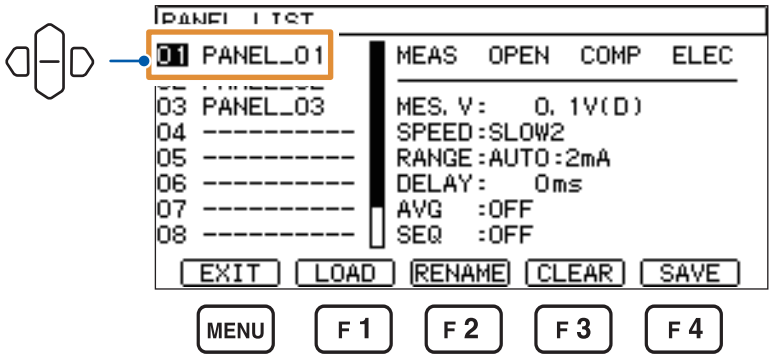
The present settings are replaced with the settings of the selected panel.

7.3 Changing Panel Name

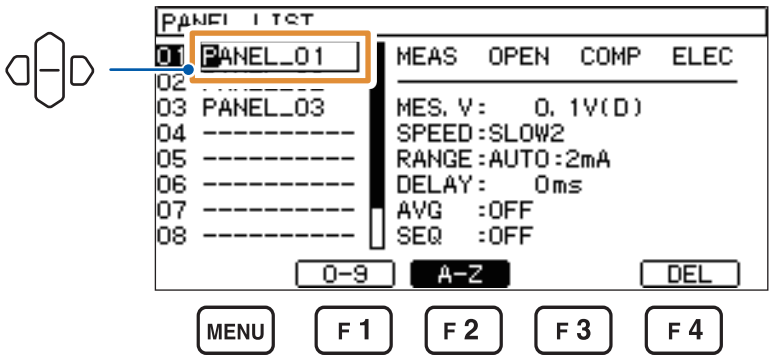
This section describes the procedure for changing the panel name.

Procedure to display the setting screen: **LOAD/SAVE** key

1 **Select the number of the panel whose name you want to change, and press the F2 key [RENAME].**



2 **Change the panel name.**



F1 key **[0-9]**	Numeric input mode is enabled. (Select a numerical value using the cursor.)
F2 key **[A-Z]**	Alphabetical character input mode is enabled. Underscore (_) can also be entered. (Select a character using the cursor.)
F4 key **[DEL]**	Deletes the characters one by one.

To cancel the change operation, press the **ESC** key.

3 **Press the ENTER key.**

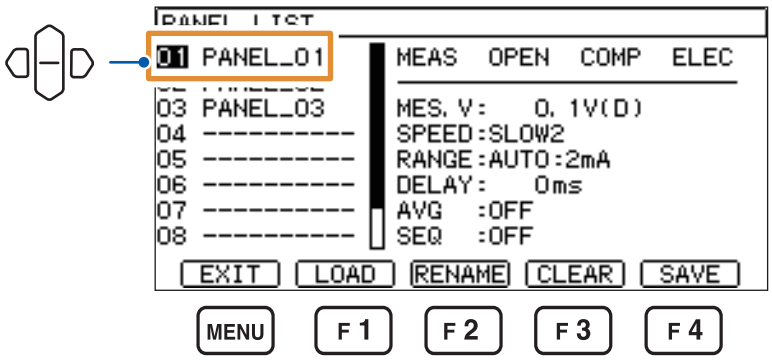
The panel name is settled.

7.4 Deleting Panel Contents

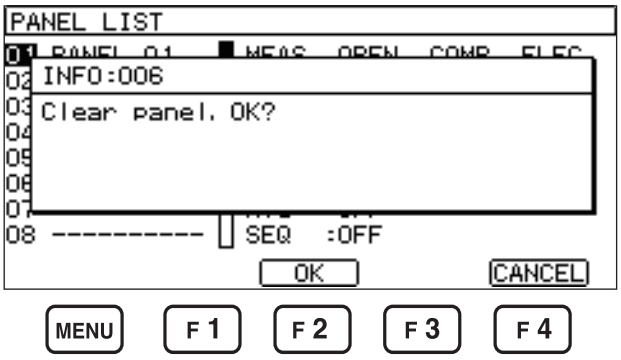
This section describes the procedure for deleting saved settings.

Procedure to display the setting screen: **LOAD/SAVE** key

1 **Select the panel number to be deleted, and press the F3 key [CLEAR].**



The confirmation dialog box is displayed.



To cancel the delete operation, press the **F4** key **[CANCEL]** or the **ESC** key.

2 **Press the F2 key [OK] or the ENTER key.**

The contents of the panel is deleted.

8 System Setting

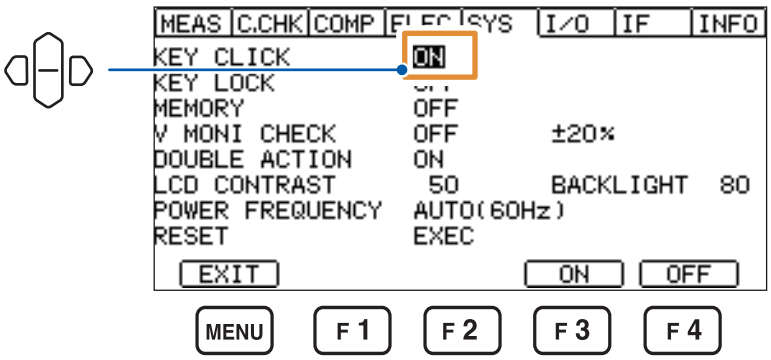
8.1 Setting Sound of Key Operation

You can set the sound setting of key operation to be enabled or disabled.

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

[ON] The operation sound is emitted (default setting).

[OFF] The operation sound is not emitted.



8.2 Disabling Key Operation (Key Lock Function)

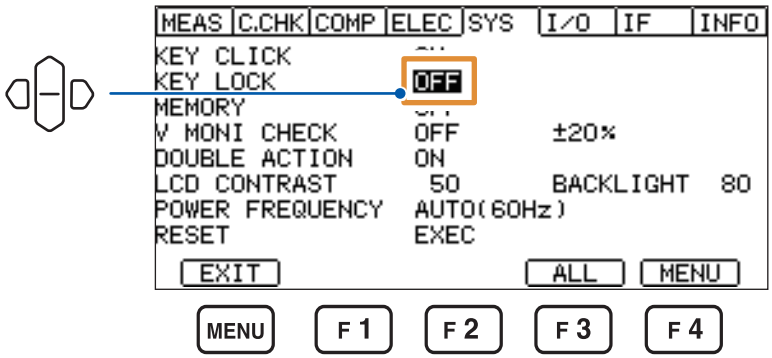
You can disable the key operation.

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

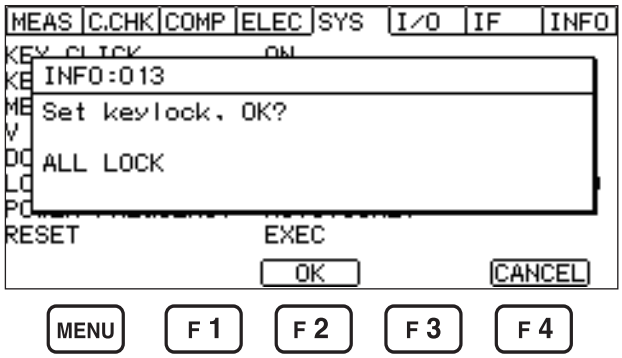
1 **Press [ALL] or [MENU] to disable the key operation (to activate the key lock function).**

[ALL] Disables any key operation except **[UNLOCK]** among the **MENU** keys or the **STOP** key.

[MENU] Disables the following key operation:
COMP, **LOAD/SAVE**, and **MENU**



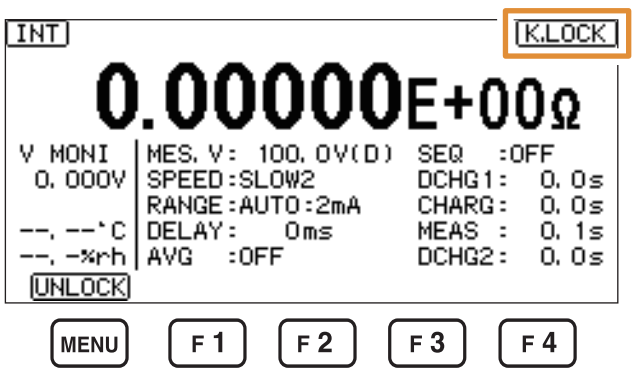
The confirmation dialog box is displayed.



To cancel the key lock function to be activated, press the **F4** key **[CANCEL]** or the **ESC** key.

2 **Press the F2 key [OK].**

[K.LOCK] is displayed on the measurement screen, and the key operation is disabled.



To deactivate the key lock function, hold down the F4 key [UNLOCK] for 1 second or more.

Inputting the KEYLOCK signal disables all the key operation. (The key lock function cannot be deactivated by using any operation keys.)
No key operation is enabled while the KEYLOCK signal state is on.
When the signal switches to the off state, the key lock function is deactivated.

8.3 Browsing, Deleting, and Outputting Internal Memory Data

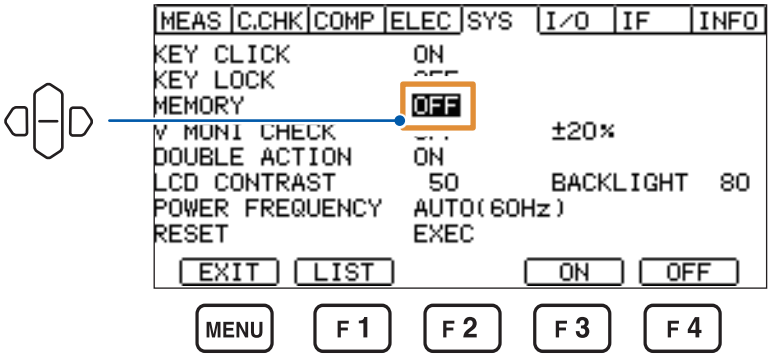
The memory function can automatically store up to 999 measured values in the internal memory of the instrument. The number of stored measured values reaching 999 disables further measured values to be stored.

You can browse the list of saved measured values, delete them, or acquire them by sending the communication command (`:MEMory?`).

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

Select whether to activate the memory function or not.

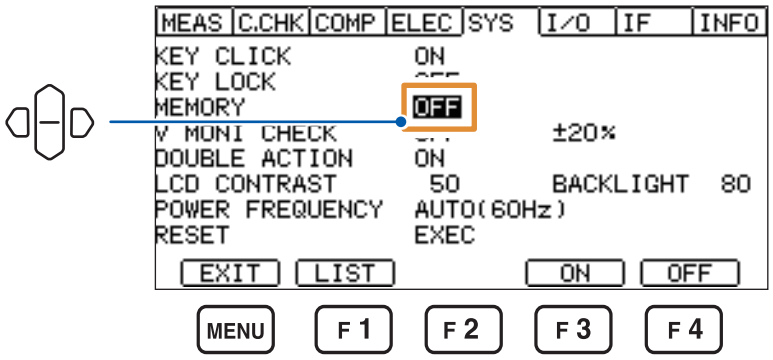
[ON] Activate the memory function.
[OFF] Deactivate the memory function. (default setting)



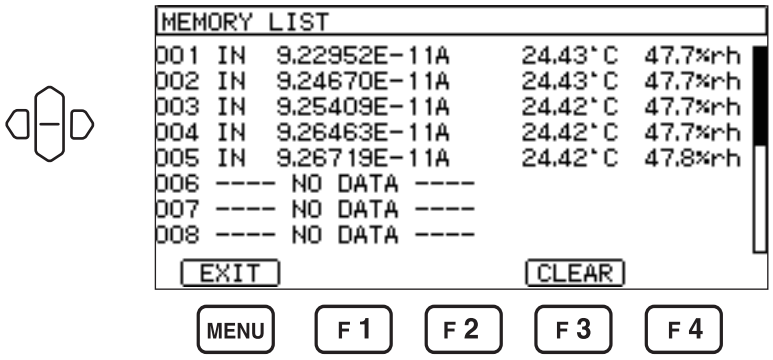
Browsing and deleting data

Procedure to display the screen: (Measurement screen) **MENU** key > ◁▷ **[SYS]** tab

1 Press the F1 key [LIST].



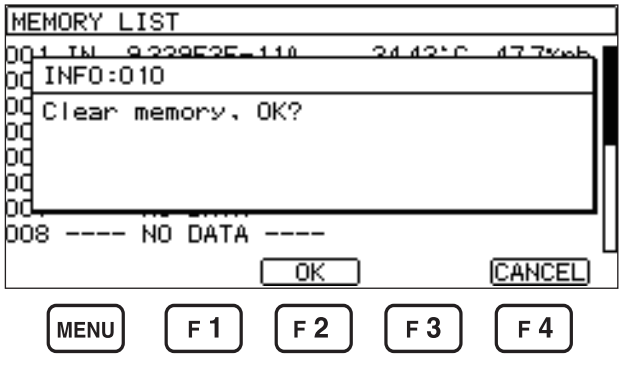
The internal memory list is displayed.



You can scroll the list by pressing the up or down cursor key.
Press the **MODE** key to switch the measurement mode.

2 Press the F3 key [CLEAR].

The confirmation dialog box is displayed.



To cancel the deletion of memory data, press the **F4** key **[CANCEL]** or the **ESC** key.

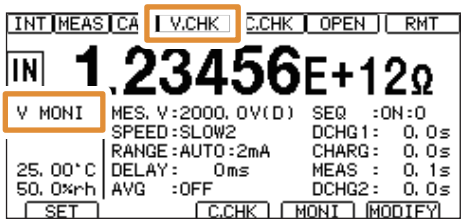
3 Press the F2 key [OK].

The memory data is deleted.

8.4 Checking Voltage Error (Voltage Monitor Check Function)

A warning can be displayed on the screen, if a voltage value measured internally by the instrument becomes abnormal.

Display with the voltage monitor check function set to on



Resistance value measurement mode (initial screen)

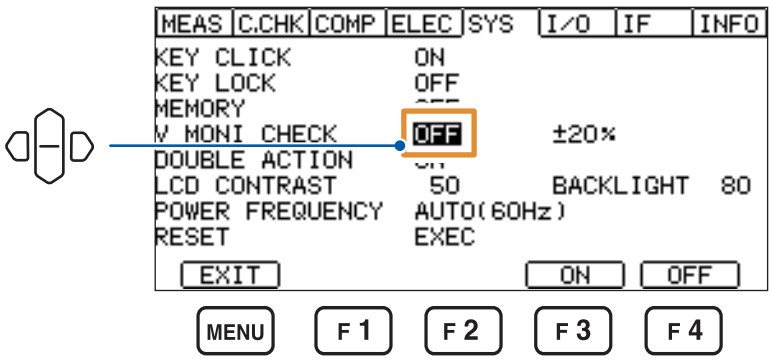
[V.CHK] is displayed on the measurement screen under normal conditions.
If the voltage is outside the set range (error condition), **[V.CHK]** is highlighted in reverse video. Because the measurement was performed before the voltage became stable in this case, increase the delay time or extend the voltage range for the alarm.

Even when the voltage monitor check is activated, the measurement will be completed normally, and the data will be output.

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

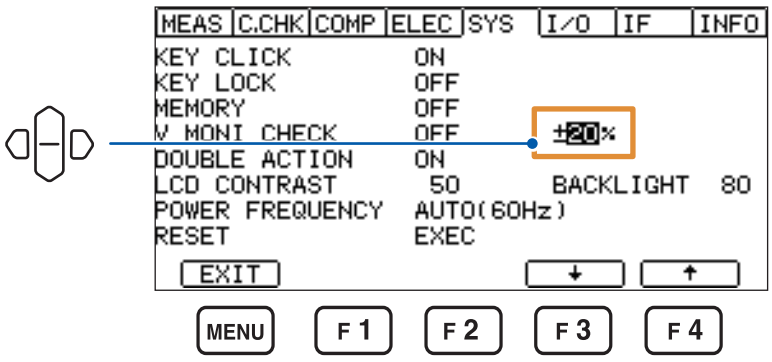
1 Select whether to generate an alarm if a voltage error occurs.

[ON] Enabled
[OFF] Disabled (default setting)



2 If [ON] is select, set the voltage range.

±2% to ±20% (default setting: ±20%)



Press the **F3** key **[↓]** or **F4** key **[↑]** to change the value.

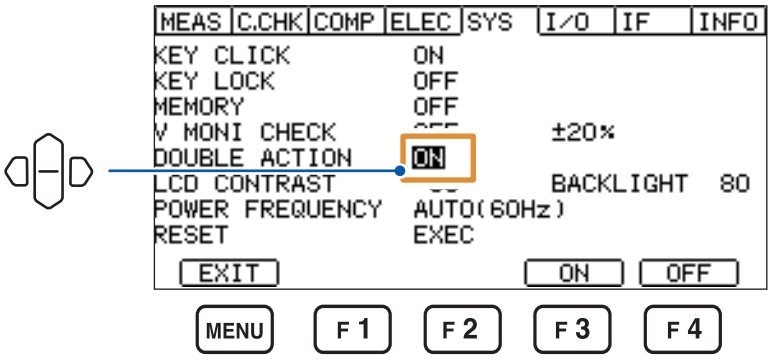
8.5 Preventing Test From Being Incorrectly Started (Double Action Function)

When the double action function is set to **[ON]**, incorrect starts of tests can be prevented, resulting in safety improvement of tests.

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

[ON] To start a measurement, press the **STOP** key, and then, press the **START** key within approximately 1 second (default setting).

[OFF] To start a measurement, press the **START** key.



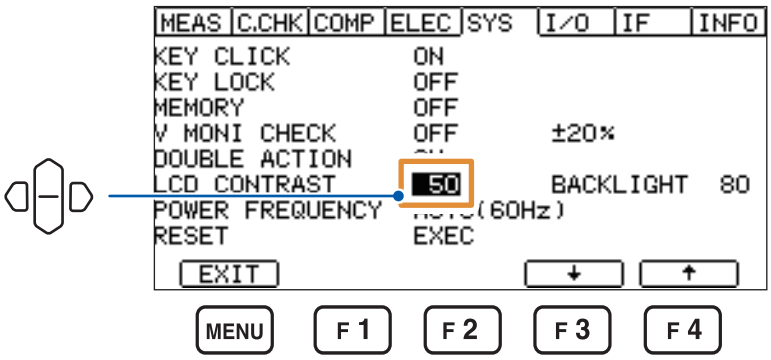
If the double action function is set to **[ON]**, pressing the **START** key without pressing the **STOP** key causes the beep sound to be emitted and an error to appear.

8.6 Adjusting Screen Contrast

The visibility of the screen may not be clear at some ambient temperatures. The visibility of the screen can be adjusted by adjusting the screen contrast.

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

0% to 100%, in increments of 5% (default setting: 50%)



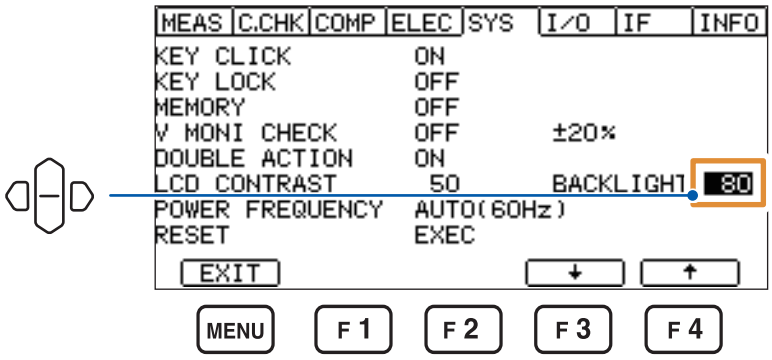
Press the **F3** key **[↓]** or **F4** key **[↑]** to change the value.

8.7 Adjusting Backlight Brightness

The brightness of the backlight can be adjusted for the illumination of the installation location.

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

0% to 100%, in increments of 5% (default setting: 80%)



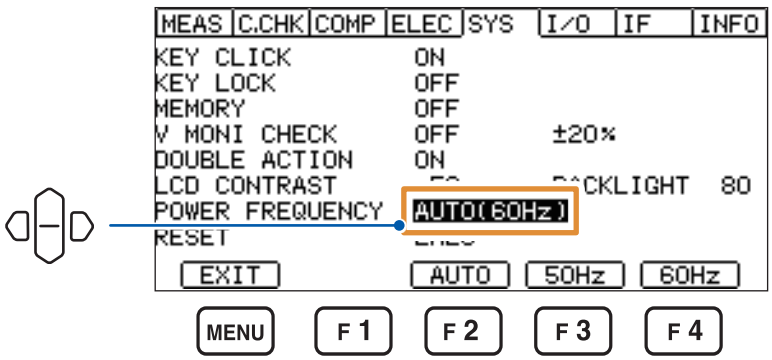
Press the **F3** key **[↓]** or **F4** key **[↑]** to change the value.

8.8 Changing Power Frequency Setting (Power Frequency Setting Function)

You can change the setting for the power frequency. This enables stable measurement without being affected by the power frequency.

Procedure to display the setting screen: **MENU** key > **[SYS]** tab

[AUTO]	Automatically detects either 50 Hz or 60 Hz (default setting).
[50Hz]	50 Hz
[60Hz]	60 Hz



8.9 Initializing Settings (Reset)

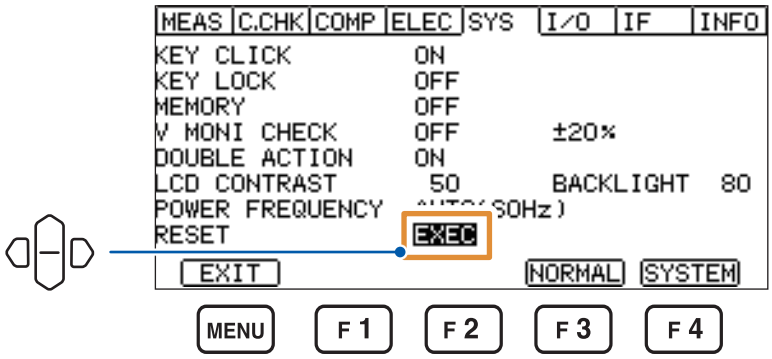
The reset function has 2 methods.
For details of items that are to be reset, see “Default setting list” (p. 109).

Procedure to display the setting screen: (Measurement screen) **MENU** key > **[SYS]** tab

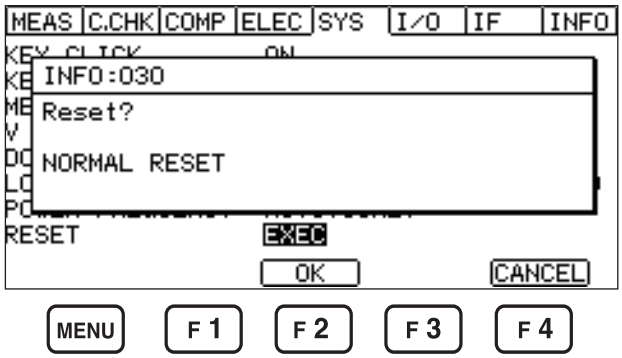
1 Select the reset method.

[NORMAL] Resets the settings to the factory default excluding the panel data (The communication settings are not reset).

[SYSTEM] Resets all the settings to the factory default including the panel data (The communication settings are not reset).



The confirmation dialog box is displayed.



To cancel the reset operation, press the **F4** key **[CANCEL]** or the **ESC** key.

2 Press the F2 key [OK].

The reset operation is executed.

To reset all of the settings including those of the panel data and the communications to the factory default, turn off the instrument, and then turn it on while holding down both the **MENU** key and the **LOAD/SAVE** key.

Default setting list

	Setting		Screen display	Default setting	Reference
Measurement screen	Voltage output function		MES.V	0.1 V (D)	p. 41
	Measurement speed		SPEED	SLOW2	p. 43
	Range		RANGE	AUTO	p. 44
	Delay function		DELAY	0.0 ms	p. 49
	Average function		AVG	OFF	p. 50
	Sequence program function	Setting	SEQ	OFF	p. 52
		Discharge 1	DCHG1	0.0 s	
		Charge	CHARG	0.0 s	
		Measurement	MEAS	0.1 s	
		Discharge 2	DCHG2	0.0 s	
	Measured value display mode		–	Resistance value display	p. 39
MEAS	Measured value display	Mode	MEAS FORMAT	EXP (exponent display)	p. 40
		Displayed digit	DIGIT	6 digits	p. 40
	Updating Drawing During Measurement		DISP UPDATE	ON	p. 77
	Voltage value for resistance calculation	Setting	V MODE	MES.V	p. 56
		Voltage set value	SET	0.1 V	
	Trigger mode		TRIGGER	INTERNAL (internal trigger)	p. 58
	Self-calibration	Setting	SELF CALIBRATION	ON	p. 60
		Setting time	–	600 s	
	Interlock		INTERLOCK	OFF	p. 62
	Current limiter	Charge-system current limit	CHARGE	OFF	p. 64
		Total current limit	CURRENT LIMIT	5 mA (measurement system: 5 mA, charge system: 0 mA)	p. 65
C.CHK	Contact check setting	Frequency	FREQ	300 kHz	p. 68
		Work capacitance	WORK.C	NORMAL	
		Cable length	CABLE	1.0 m	
	Contact check	Setting	CONTACT CHECK	OFF	p. 72
		Judgment reference value	LIMIT	0.00 pF	
COMP	Comparator function (for each measurement mode)	Upper limit value	UPPER LIMIT	OFF	p. 91
		Lower limit value	LOWER LIMIT	OFF	
	Judgment sound (Hi, IN, Lo)	Judgment sound	COMP BEEP	OFF	p. 93
		Number of ringing times for judgment	–	1	
ELEC	Diameter of the main electrode		D1	50.0 mm	p. 74
	Internal diameter of the counter electrode		D2	70.0 mm	
	Thickness of sample		t	0.1 mm	
	Electrode constant		K	500.00	

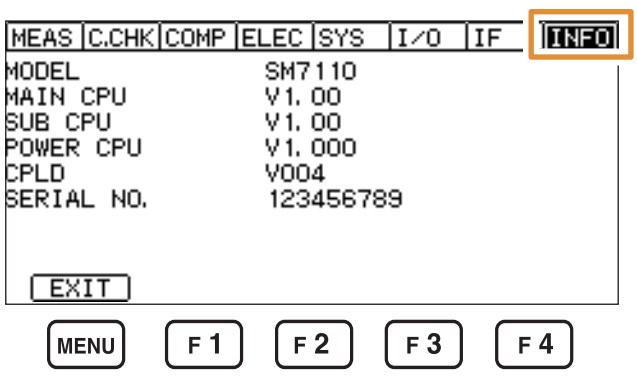
	Setting		Screen display	Default setting	Reference
SYS	Key operation sound		KEY CLICK	ON	p. 101
	Key lock		KEY LOCK	OFF	p. 102
	Memory function		MEMORY	OFF	p. 103
	Voltage monitor check	Setting	V MONI CHECK	OFF	p. 105
		Set value	–	±20%	
	Double action		DOUBLE ACTION	ON	p. 106
	LCD contrast		LCD CONTRAST	50%	p. 106
	LCD brightness		BACKLIGHT	80%	p. 107
	Power frequency		POWER FREQUENCY	AUTO (automatically detects either 50 Hz or 60 Hz)	p. 107
I/O	Trigger logic setting		TRIG EDGE	ON	p. 127
	Trigger filter	Function	TRIG FILTER	OFF	p. 128
		Time	–	1 ms	
	GO-signal outputting logic level		C.CHK / V.VHK GO	NORMAL	p. 129
	EOM output timing	Mode	EOM MODE	HOLD	p. 130
		Time	–	1 ms	
	Output signal setting		–	NPN (switch on rear)	p. 112
IF	Communication Interface		INTERFACE	RS-232C	p. 131
	RS-232C communication speed		SPEED	9600 bps	p. 135
	GP-IB address		ADDRESS	1	p. 136
	GP-IB delimiter		DELIMITER	LF	
	USB mode		USB MODE	COMM	p. 132
	Data output function		DATA OUT	OFF	p. 138
	Communication monitor function		CMD MONITOR	OFF	p. 139

8.10 Checking Instrument Information

You can check the following information:

- Model name of the product
- Version number of the main CPU
- Version number of the sub CPU
- Version number of the power supply CPU
- Version number of the CPLD
- Serial number

Procedure to display the setting screen: (Measurement screen) **MENU** key > ◁▷ **[INFO]** tab



9 External Control (EXT I/O)

Be sure to read “Before controlling the instrument externally” (p. 13) beforehand.

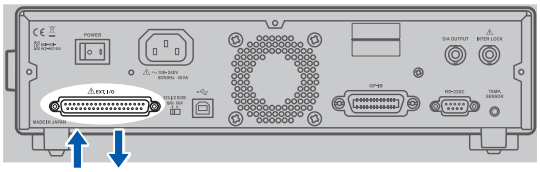
Connecting the instrument to an external device such as a PLC (programmable logic controller) via the EXT I/O terminal on the rear of the instrument enables you to control the instrument in the following ways:

- Output signals from the instrument to the external device (for example, end of measurement and judgment result signals, etc.).
- Input signals from the external device to the instrument (for example, measurement starting signal, etc.).

IMPORTANT
Do not control two or more instruments by sharing a single-line PLC output. Doing so could cause the instruments to malfunction.

All of the signals are isolated from the measurement circuit and the ground. (The ISO-COM terminals are shared by the input and the output.)
The input circuit can be switched so as to correspond to the current sink output (NPN) or the current source output (PNP).

To use the instrument properly, confirm the input/output ratings and the internal circuit configuration, and understand the safety precautions before connecting cables to a control system.



Signal input/output

Rear

Check the input/output specifications of the external device.

↓

Set the NPN/PNP switch of the instrument (p. 112).

↓

Connect the EXT I/O terminal of the instrument to the external device (p. 112).

↓

Test I/O (signal input and output test) (p. 126)

↓

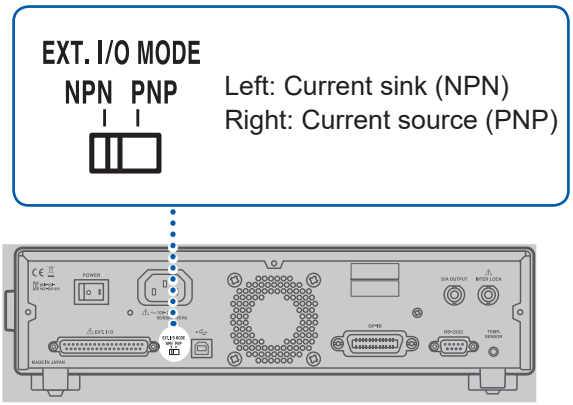
Setting the instrument (p. 127).

9.1 Switching Current Sink (NPN) / Current Source (PNP)

Be sure to read “Before controlling the instrument externally” (p. 13) beforehand.

Use the EXT I/O MODE selector switch to change the type of the PLC that can be supported. By factory default, the external I/O setting is set to NPN.

	NPN/PNP switch setting	
	NPN	PNP
Input circuit of the instrument	Supports sink output	Supports source output
Output circuit of the instrument	Non-polar	Non-polar
ISO_5V output	+5 V output	-5 V output

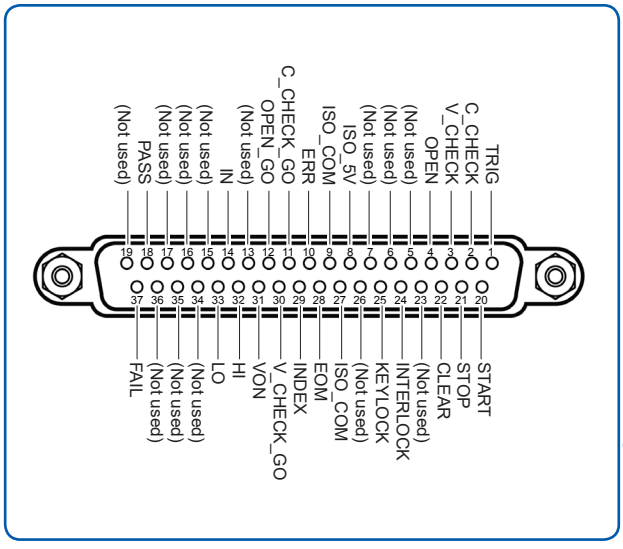


Rear

9.2 External Input/Output Terminals and Signals

Instrument-side connector and mating connectors

Be sure to read “Before controlling the instrument externally” (p. 13) beforehand.

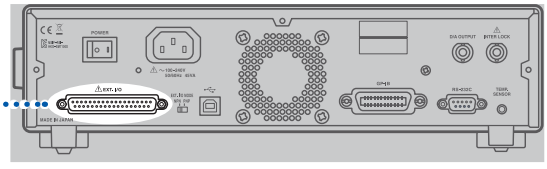


Connectors

- 37-pin D-sub socket contact
  #4-40 inch screws

Mating connectors

- DC-37P-ULR (solder type)
- DCSP-JB37PR (insulation displacement type)
  Manufactured by Japan Aviation Electronics Industry, Ltd.
  Or other equivalent parts



Rear

Instrument-side connector pin assignment

IMPORTANT
The connector shell is connected (allows conduction) to the metallic enclosure and the protective earth pin of the power inlet. Note that it is not isolated from ground.

Pin No.	Signal name	I/O	Function	Operation mode
1	TRIG	IN	Starts measurement.	Edge
2	C_CHECK	IN	Executes contact check.	Edge
3	V_CHECK	IN	Executes voltage error check.	Edge
4	OPEN	IN	Executes open correction.	Edge
5	Not used	IN	(NC)	–
6	Not used	IN	(NC)	–
7	Not used	IN	(NC)	–
8	ISO_5V	–	+5 V (−5 V) output of isolated power supply	–
9	ISO_COM	–	Common terminal of isolated power supply	–
10	ERR	OUT	Measurement error	Level
11	C_CHECK_GO	OUT	Contact check result	Level
12	OPEN_GO	OUT	Open correction result	Level
13	Not used	OUT	(NC)	–
14	IN	OUT	Comparator judgment of IN	Level
15	Not used	OUT	(NC)	–
16	Not used	OUT	(NC)	–
17	Not used	OUT	(NC)	–
18	PASS	OUT	Judgment result of PASS	Level
19	Not used	OUT	(NC)	–
20	START	IN	Starts to output measurement voltage.	Edge
21	STOP	IN	Stops to output measurement voltage.	Edge
22	CLEAR	IN	Clears measured value and judgment result.	Edge
23	Not used	IN	(NC)	–
24	INTERLOCK	IN	Deactivates interlock function.	Level
25	KEYLOCK	IN	Activates/Deactivates key lock.	Level
26	Not used	IN	(NC)	–
27	ISO_COM	–	Common terminal of isolated power supply	–
28	EOM	OUT	End of measurement	Level
29	INDEX	OUT	Measurement reference	Level
30	V_CHECK_GO	OUT	Voltage error check result	Level
31	VON	OUT	Voltage output status	Level
32	HI	OUT	Comparator judgment of Hi	Level

Pin No.	Signal name	I/O	Function	Operation mode
33	LO	OUT	Comparator judgment of Lo	Level
34	Not used	OUT	(NC)	–
35	Not used	OUT	(NC)	–
36	Not used	OUT	(NC)	–
37	FAIL	OUT	Judgment result of FAIL	Level

Function of each of the signals

IMPORTANT
- The EOM and INDEX signals switch to the on state at start-up.
- To avoid misjudgment, determine judgments by checking both the PASS and the FAIL signals.

Input signal

OPEN	Executes an open correction.	Setting the input to the on state executes an open correction.
START	Starts to output a measurement voltage.	Setting the input to the on state allows a measurement voltage to output.
TRIG	Starts a measurement.	Setting the input to the on state starts a measurement.
C_CHECK	Executes a contact check.	Setting the input to the on state executes a contact check.
V_CHECK	Checks voltage for an error.	Setting the input to the on state starts checking voltage for an error.
STOP	Stops to output the measurement voltage.	Setting the input to the on state stops outputting the measurement voltage.
CLEAR	Clears a measured value and judgment result.	After clearing them, the instrument will return a response indicating that no measurement is performed in response to a measured-value query of the communication commands.
INTERLOCK	Deactivates the interlock.	Setting the input to the on state deactivates the interlock function.
KEYLOCK	Activates the key lock.	Setting the input to the on state activates the key lock function. To deactivate the key lock function, input the Off signal.

Output signal

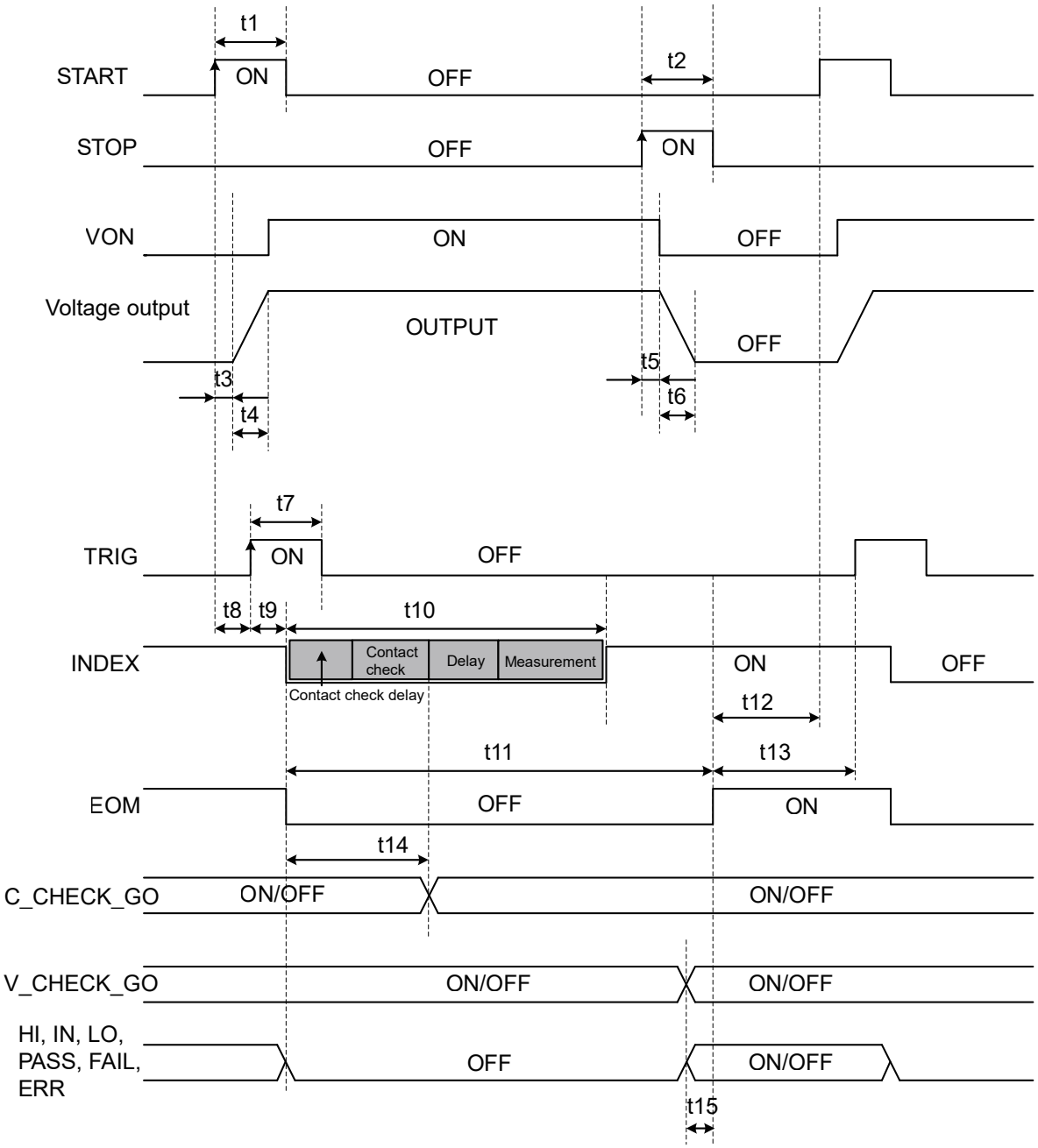
EOM	End of measurement	Outputs the On signal when the measurement and the judgment are completed.
INDEX	Measurement reference	Outputs the On signal when the measurement circuit finishes the A/D acquisition.
ERR	Measurement error	Outpauts the On signal if a measurement error occurs.
	The following instances result in measurement error: • The A/D converter for measurement and voltage measurement has overflowed. • The fixture-capacitance open correction value exceeds 99.999 pF.	
C_CHECK_GO	Contact check result	Outputs the On signal when the contact check gives a pass judgment.
V_CHECK_GO	Voltage error check result	Outputs the On signal when any voltage error was not found.
OPEN_GO	Open correction result	Outputs the On signal when the open correction gives a pass judgment.
VON	Voltage output status	Outputs the On signal while the voltage monitor value is maintained within ±10% of the set voltage value.
HI	Comparator judgment of Hi	Outputs the On signal when the comparator gives a Hi judgment.
IN	Comparator judgment of IN	Outputs the On signal when the comparator gives an IN judgment.
LO	Comparator judgment of LO	Outputs the On signal when the comparator gives a Lo judgment.
PASS	Judgment result of PASS	Outputs the On signal when the comparator gives an IN judgment after the measurement is normally completed.
FAIL	Judgment result of FAIL	Outputs the On signal when the comparator gives a judgment other than IN after the measurement is normally completed.

9.3 Timing Chart

The levels of each signal represent whether the contacts are in the on or the off state.
With the current source (PNP) setting, the voltage level of the corresponding output terminal becomes high when an output state is on, and low when a state is off.
If the output signal setting is set to the current sink (NPN), the voltage levels, high and low are inverted.
Times indicated in the timing charts can be obtained only under no-load conditions.

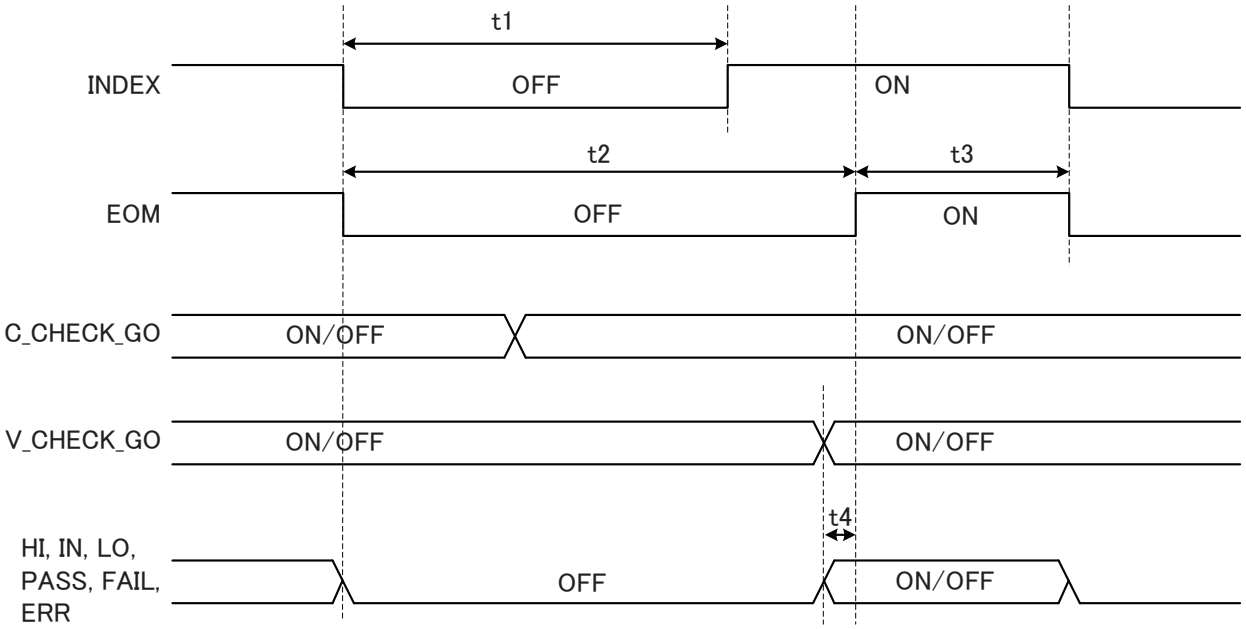
From when measurement starts to when judgment result is acquired

(1) Voltage output, measurement with external trigger setting



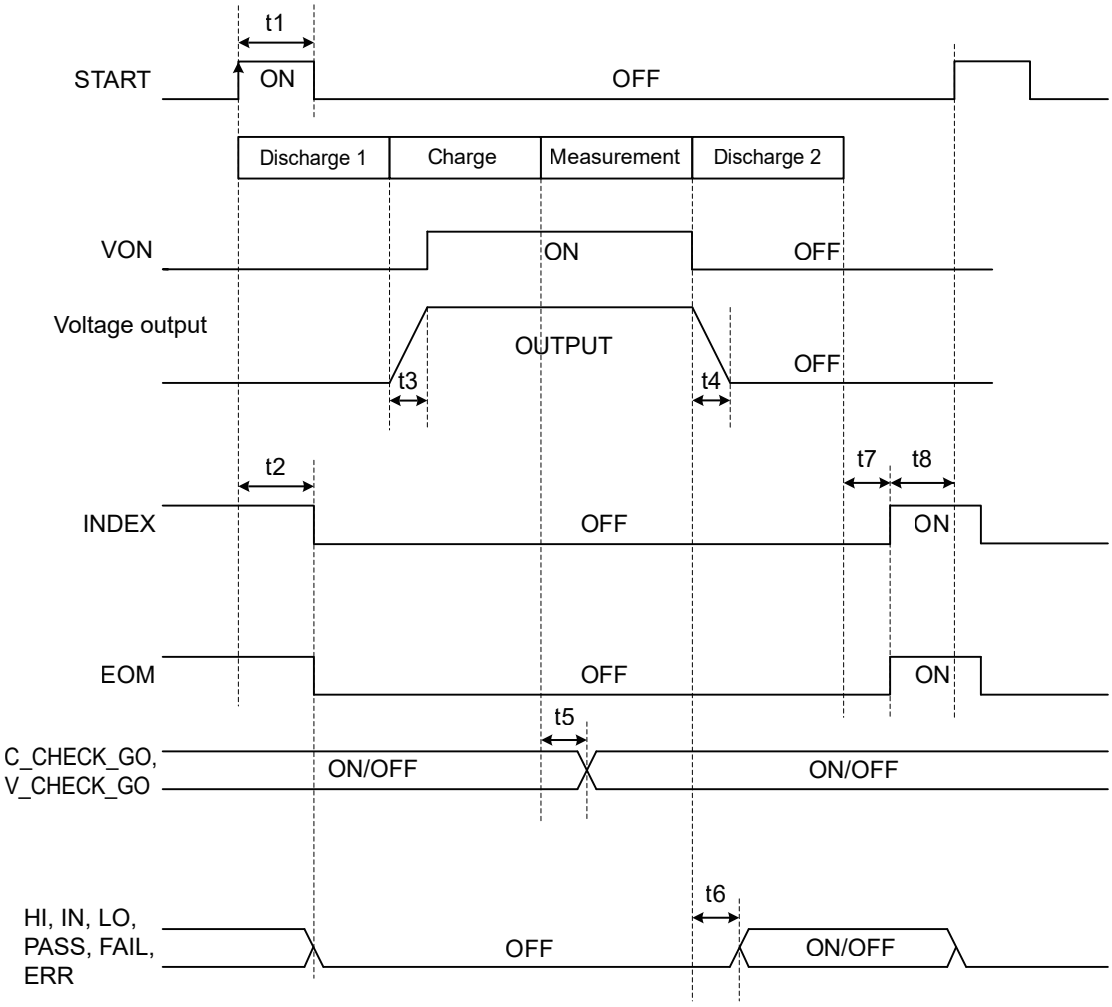
Item	Contents	Time
t1	START pulse width	200 µs or more
t2	STOP pulse width	200 µs or more
t3	Delay time of voltage output start	100 µs or less
t4	Rising time of voltage output	With the discharge setting: 10 ms or less With the high-impedance setting: 1 ms or less
t5	Delay time of voltage output stop	200 µs or less
t6	Falling time of voltage output	With the discharge setting: 10 ms or less With the high-impedance setting: unspecified
t7	TRIG pulse width	200 µs or more
t8	TRIG acceptable time from START (Manually prolonging this time enables to charge objects to be measured.)	0 µs or more
t9	Delay time for INDEX and EOM	200 µs or less
t10	INDEX time	([Contact check delay time] + [Contact-checking time] + [Delay time] + [Measurement time]) or less
t11	EOM time	(INDEX + [Comparator measurement time] + 0.4 ms) or less Add 1.0 ms to calculate a resistance measured value from a voltage measured value
t12	START setup time	Display on: 40 ms or more Display off: 1 ms or more
t13	TRIG setup time	Display on: 40 ms or more Display off: 1 ms or more
t14	Judgment output time for C_CHECK	3 ms or less
t15	Judgment output and Judgment setup time for V_CHECK Time required for the EOM signal to output after output of a judgment signal	70 µs or more

(2) Measurement with internal trigger setting



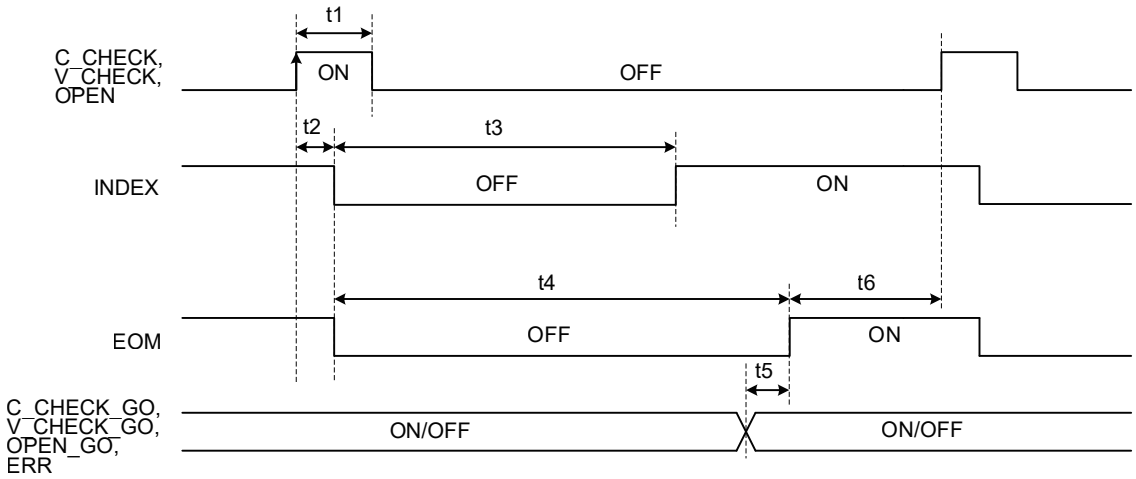
Item	Contents	Time
t1	INDEX time	([Contact checking time] + [Delay time] + [Measurement time]) or less
t2	EOM time	(INDEX + [Comparator measurement time] + 0.4 ms) or less Add 1.0 ms, however, if calculating a resistance measured value from a voltage measured value
t3	Internal TRIG setup time	40 ms ±5 ms
t4	Judgment setup time Time required for the EOM signal to output after output of a judgment signal	70 µs or more

(3) Sequence measurement



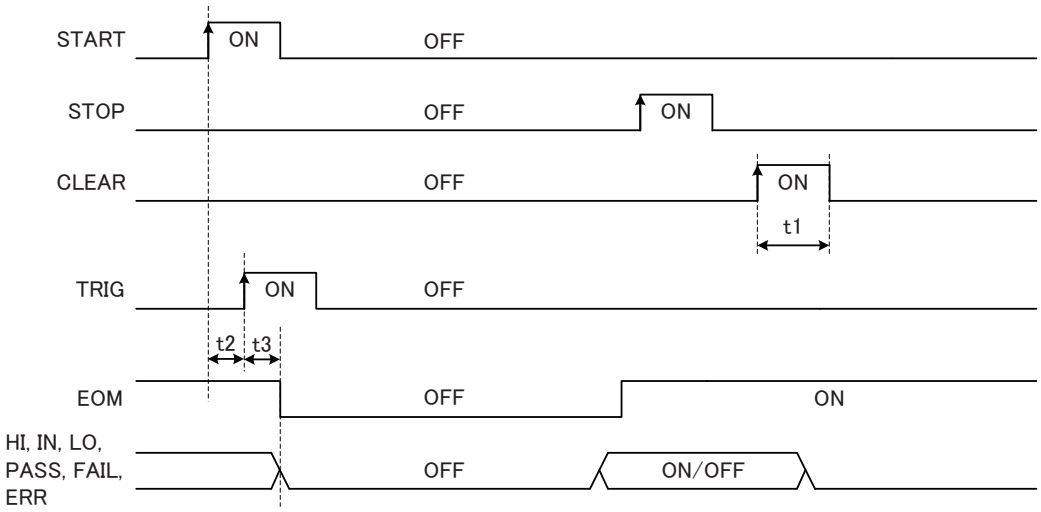
Item	Contents	Time
t1	START pulse width	200 µs or more
t2	Delay time for INDEX and EOM	200 µs or less
t3	Rising time of voltage output	With the discharge setting: 10 ms or less With the high-impedance setting: 1 ms or less
t4	Falling time of voltage output	With the discharge setting: 10 ms or less With the high-impedance setting: not specified
t5	Contact check time	2.3 ms or less
t6	Judgment setup time	100 µs or more
t7	Delay time for INDEX and EOM	200 µs or less
t8	START setup time	Display on: 40 ms or more Display off: 4 ms or more

(4) Contact check, voltage check, or open correction (independent execution)



Item	Contents	Time
t1	Pulse width of C_CHECK, V_CHECK, or OPEN	1 ms or more
t2	Delay time for INDEX and EOM	1.5 ms or less
t3	INDEX time	• Contact-checking time • Voltage-checking time (2 ms) • Open correction time (200 ms) The INDEX time becomes 40 ms longer when one of the operations listed above is executed during halts of voltage output.
t4	EOM time	(INDEX + 1 ms) or less
t5	Time required for the EOM signal to output after output of a judgment signal	100 µs or less
t6	C_CHECK, V_CHECK, OPEN setup time	Display on: 40 ms or more Display off: 4 ms or more

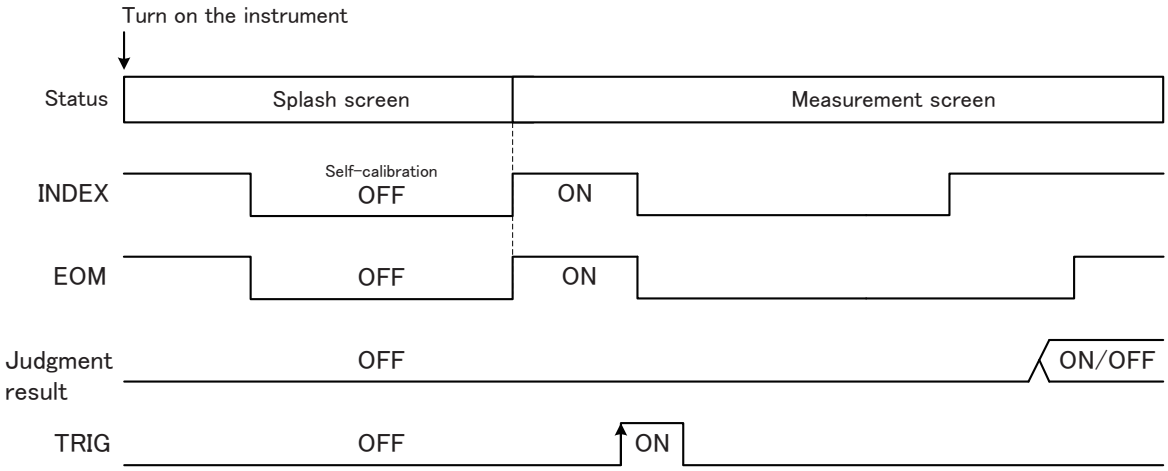
(5) Clears measured value and judgment result.



Item	Contents	Time
t1	CREAR pulse width	1 ms or more
t2	TRIG acceptable time from START	0 µs or more
t3	Delay time for EOM	200 µs or less

Output signal status on start-up

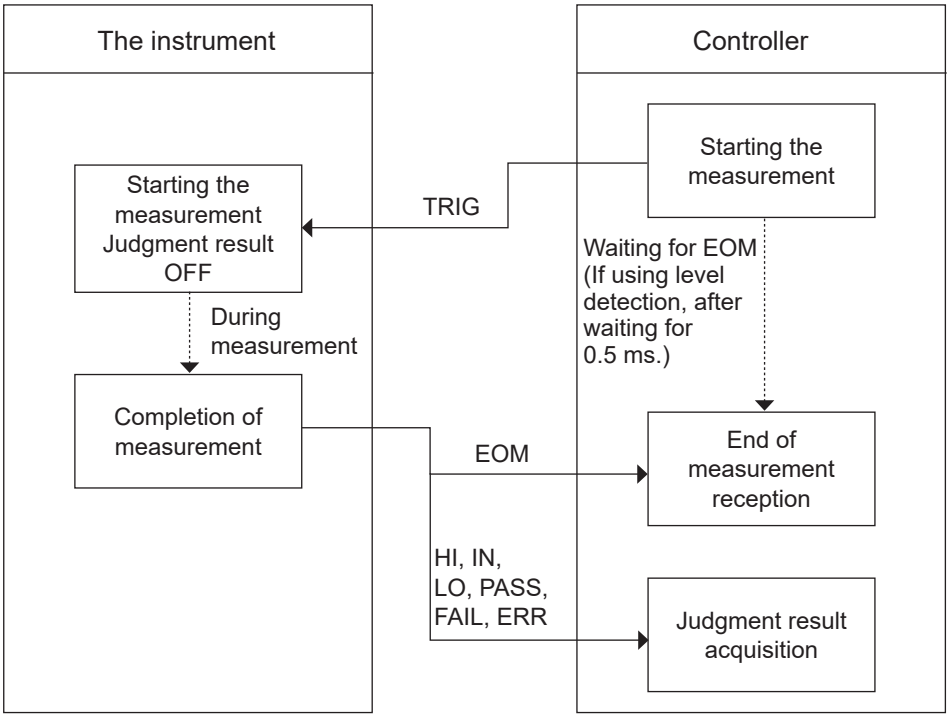
After turning on the instrument, when the screen changes from the start-up screen to the measurement screen, the EOM and INDEX signals change to ON.



Judgment results: HI, IN, LO, PASS, FAIL, ERR
The above chart indicates the operation when the trigger source is set to the EXT.

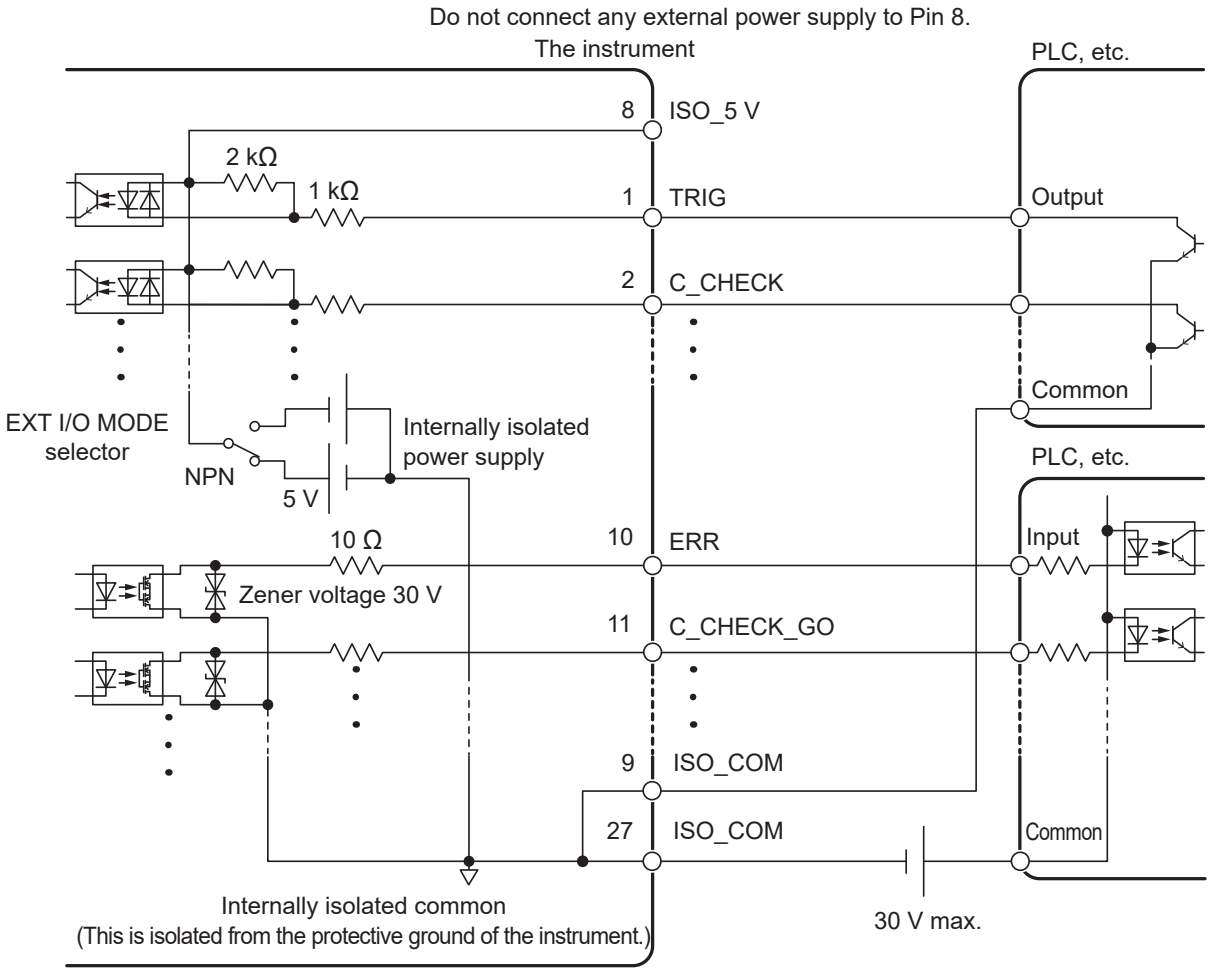
Flowchart for acquiring a judgment result or a measured value with the external trigger setting

The flowchart indicates the procedure with the external trigger setting from the start of the measurement to the acquisition of a judgment result or a measured value. The instrument outputs the EOM signal immediately after the judgment results (HI, IN, LO, PASS, FAIL, ERR) have been determined. If the response of the controller's input circuit is relatively slow, a waiting time is necessary from between the detection of the EOM signal switching to on and the acquisition of the judgment results.

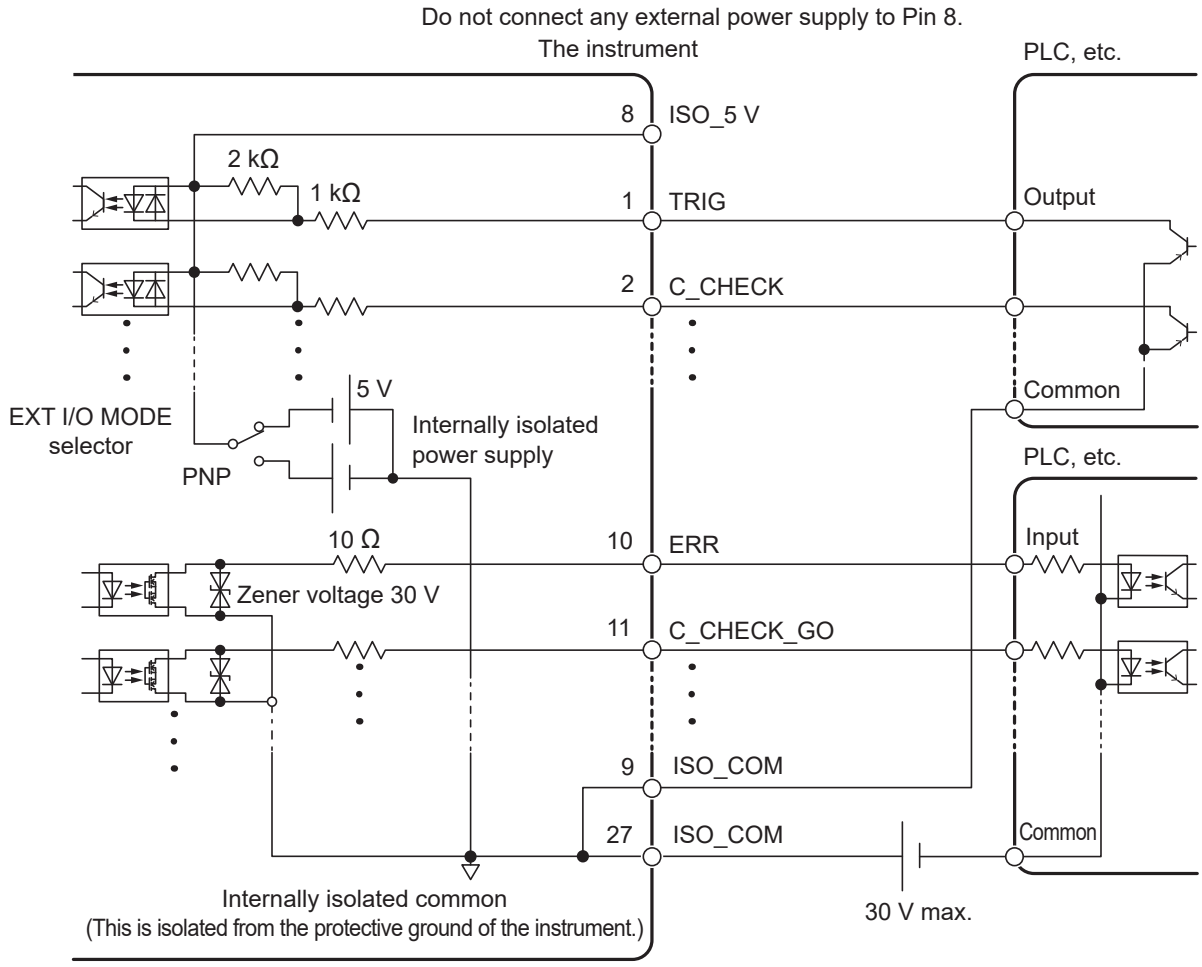


9.4 Internal Circuit Configuration

NPN setting



PNP setting



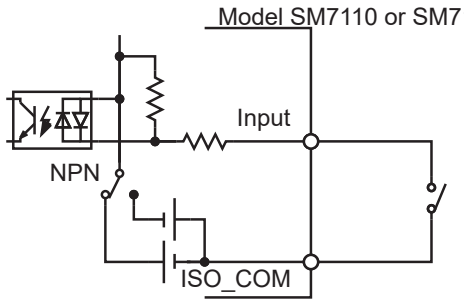
Share the ISO_COM for the common terminals of the input and the output signals.

Electrical Specifications

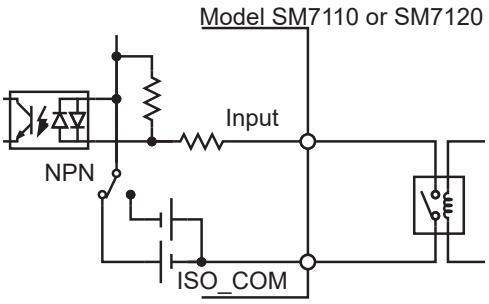
Input signal	Input type	Photo-coupler-isolated, non-voltage contact inputs (supporting current sink and current source outputs)
	Input on	Residual voltage 1V or less (Input on current 4 mA [value for reference])
	Input off	Open-circuit (Breaking current: 100 µA or less)
Output signal	Output type	Photo-coupler-isolated open drain output (non-polar)
	Maximum load voltage	30 V DC
	Maximum output current	50 mA/channel
	Residual voltage	1V or less (Load current: 50 mA) / 0.5 V or less (Load current: 10 mA)
Internally Isolated power supply	Output voltage	For sink output: +5.0 V ±10% For source output: -5.0 V ±10%
	Maximum output current	100 mA
	External power input	None
	Isolation	Floating from the protective ground potential and the measurement circuit
	Insulation rating	Voltage to ground 50 V DC, 30 V rms AC, 42.4 V peak AC or less

Examples of connection

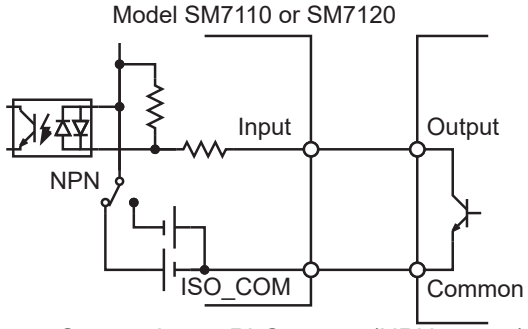
Examples of input circuit connection



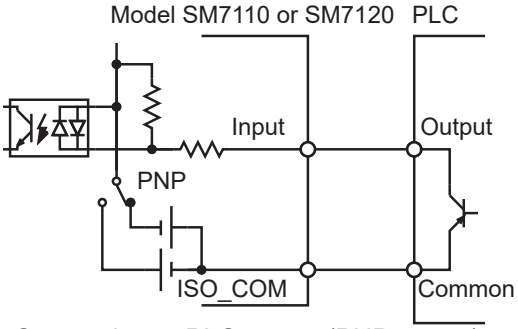
Connection to switch



Connection to relay

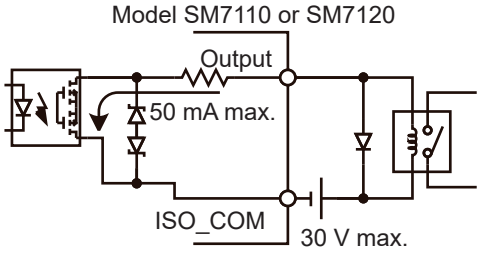


Connection to PLC output (NPN output)

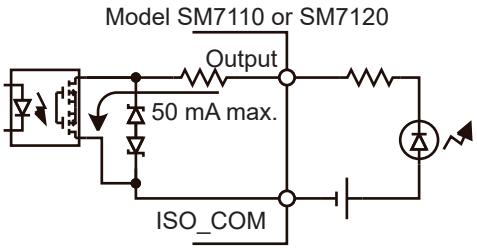


Connection to PLC output (PNP output)

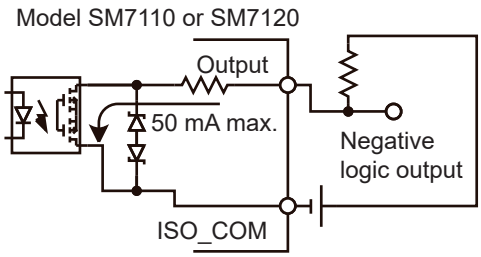
Examples of output circuit connection



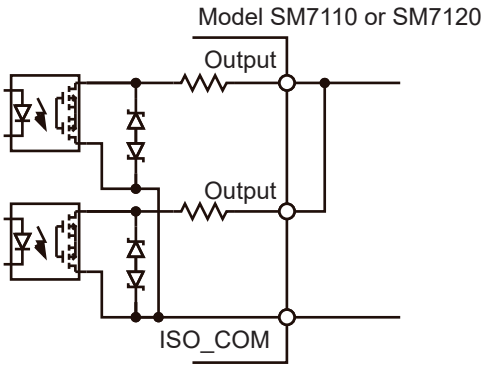
Connection to relay



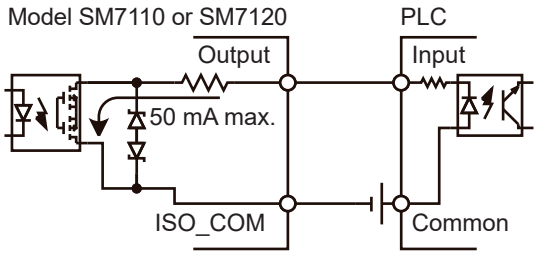
Connection to LED



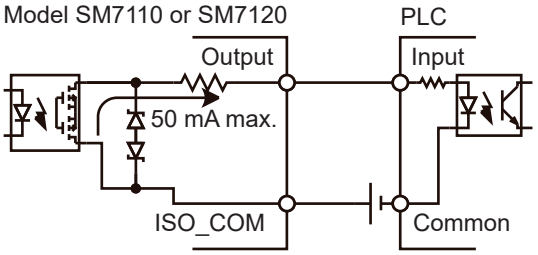
Negative logic output



Wired OR



Connection to PLC input (positive common input)



Connection to PLC input (negative common input)

9.5 Assembling Male Connector for EXT I/O (Accessory)

The male connector for the EXT I/O is supplied along with the instrument. Assemble the connector, referring to the figure below.

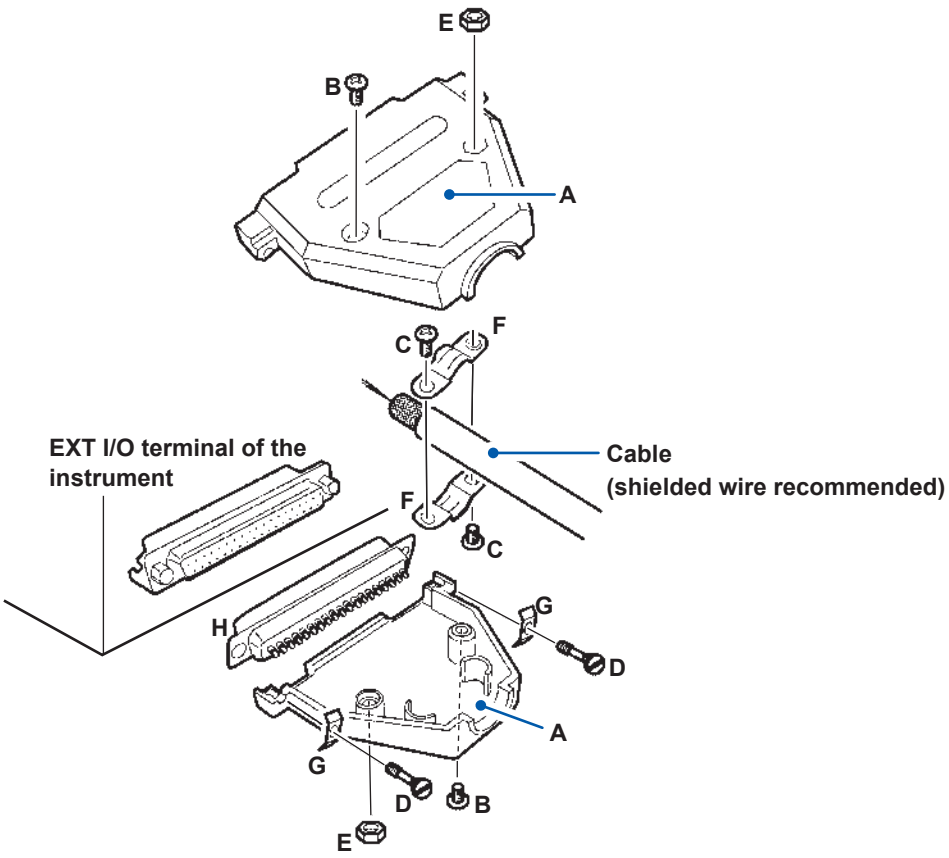
- Use a shielded wire for the cable that connects the EXT I/O connector to a device, such as PLC. Otherwise, the system may malfunction due to noise.
- Connect the shield of the wire to the ISO_COM terminal of the EXT I/O connector.

Required items:

- Screwdriver
- Cable (shielded wire recommended)
- Soldering iron
- Male connector for EXT I/O (accessory)
  - **A**: Hood (The upper and lower hoods have the same shape).....×2
  - **B**: Screw (Phillips slot combination) #4-40UNC (total length: 16.9 mm).....×2
  - **C**: Screw (Phillips slot combination) #4-40UNC (total length: 12.6 mm).....×2
  - **D**: Screw (slotted) #4-40UNC (total length: 15.0 mm).....×2
  - **E**: Nut #4-40UNC .....×2
  - **F**: Fastener (for cable) .....×2
  - **G**: Fastener (case protection).....×2
  - **H**: Connector .....×1

1. **Solder the cable to the connector (H).**
2. **Attach the fasteners (F) to the cable with the screws (C).**
3. **Set the fasteners (F) in the predetermined position on one of the hoods (A).**
4. **Insert the screws (D) into the fasteners (G).**
5. **Set the connector (H), fasteners (G), and screws (D) in the predetermined position on the hood (A) described in step 3.**
6. **Place the other hood (A) from above.**
7. **Secure the hoods (A) with each other with the screws (B) and the nuts (E).**

Do not tighten the screws more than required, because doing so may damage the hoods.

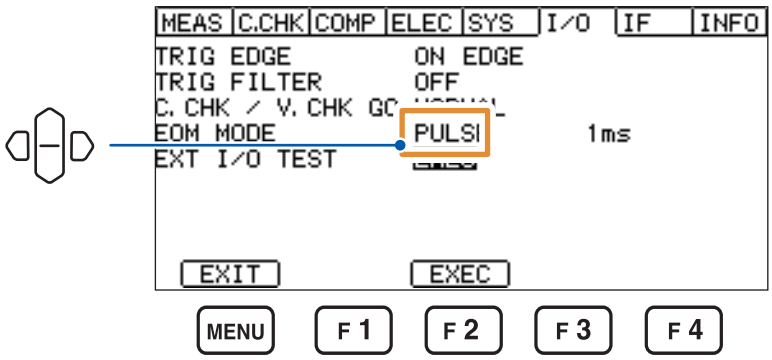


9.6 EXT I/O Terminal Input and Output Testing

The output signal can be switched on and off manually. In addition, the condition of the input signal can be monitored on the screen. (EXT I/O test function)

Procedure to display the setting screen: **MENU** key > **[I/O]** tab

1 **Press the F2 key [EXEC].**

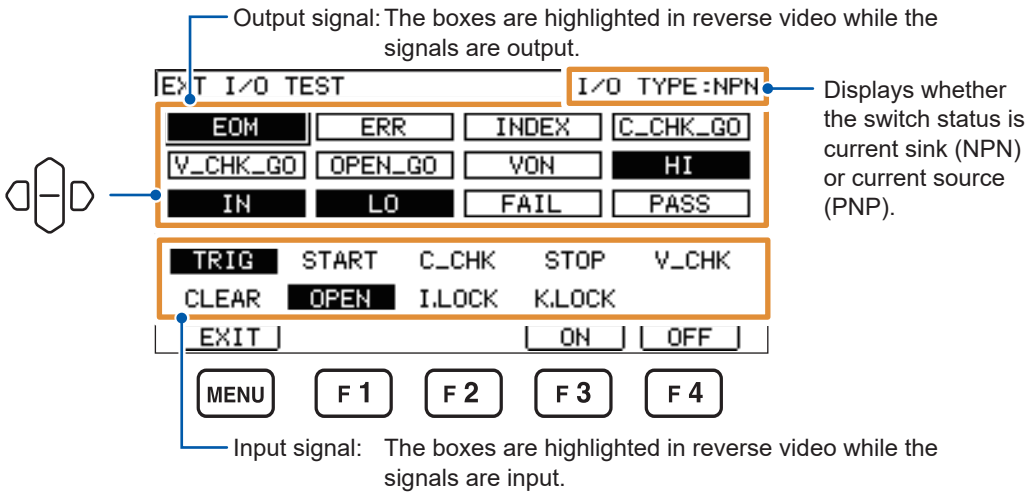


2

Output test	Input test
Select a signal, and press the F3 key [ON]. The signal outputs.	**Input a signal to the instrument.** The boxed signal name for which a signal is input is highlighted in reverse video.
Press the F4 key [OFF]. The signal stops outputting.	

For any of the tests, if the boxes are not highlighted in reverse video, then the instrument and the external device have not been connected with each other. Check the connection between them.

(Both commands and queries via communications could not be accepted during the I/O testing.)



9.7 Settings for External Input and Output

The following items for the external input and output can be set.

Setting	Description	Reference
Trigger logic	An effective edge can be selected for the TRIG signal.	p. 127
Trigger filter	This setting can be used to accept the TRIG signal from the EXT I/O terminal only if the TRIG signal remains in the on state during the set response time.	p. 128
GO-signal outputting logic level	This setting can be used to specify the outputting logic level for the C_CHECK_GO and V_CHECK_GO signals, which are used with the contact check and voltage monitor on, respectively	p. 129
EOM signal output mode	This setting can be used to specify the output method for the EOM (end of measurement) signal.	p. 130

Trigger logic

An effective edge can be selected for the TRIG signal. The logic of the on and the off edges changes depending on the NPN/PNP setting.

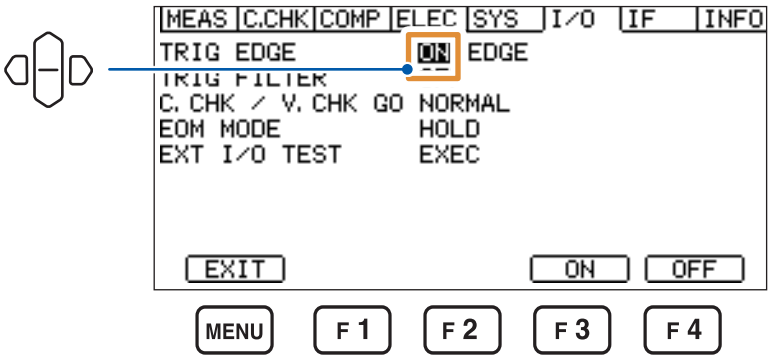
[ON EDGE] PNP setting: Rising, NPN setting: Falling

[OFF EDGE] PNP setting: Falling, NPN setting: Rising

Procedure to display the setting screen: **MENU** key > **[I/O]** tab

[ON] Measurement starts at an on edge (default setting)

[OFF] Measurement starts at an off edge



Trigger filter

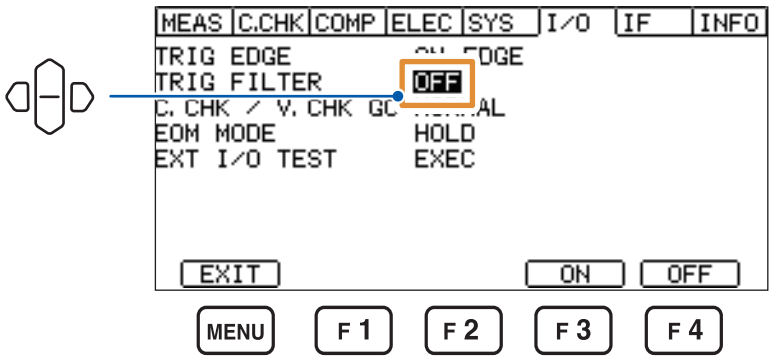
This setting can be used to accept the TRIG signal from the EXT I/O terminal only if the TRIG signal remains in the on state during the set response time.

Procedure to display the setting screen: **MENU** key > **[I/O]** tab

1 Select whether to activate the trigger filter or not.

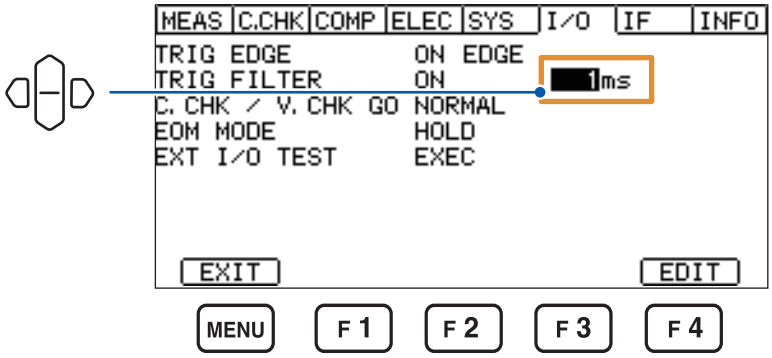
[ON] Activate the trigger filter.

[OFF] Deactivate the trigger filter (default setting).

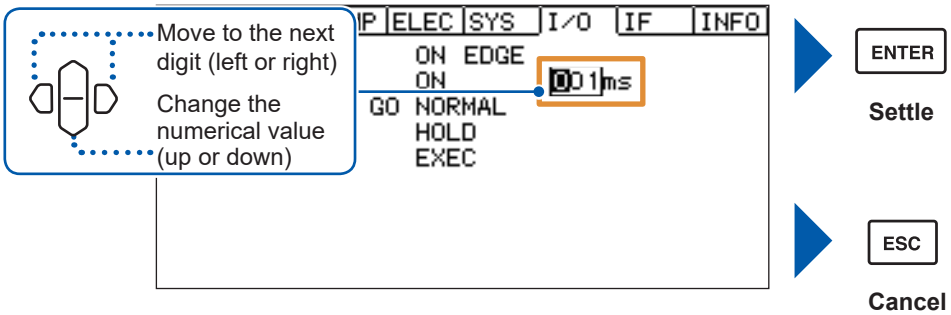


2 If [ON] is selected, set the response time (time during which the TRIG signal remains in the on state).

1 ms to 500 ms (default setting: 1 ms)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.



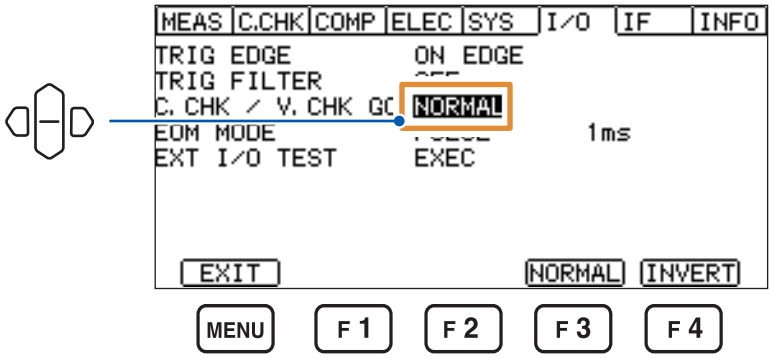
Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

GO-signal outputting logic level

This setting can specify the outputting logic level for the C_CHECK_GO and V_CHECK_GO signals, which are used with the contact check and voltage monitor on, respectively (No logic level of the OPEN_GO signal is inverted).

1 Logic level to be outputted with the NORMAL setting

Procedure to display the setting screen: **MENU** key > **[I/O]** tab

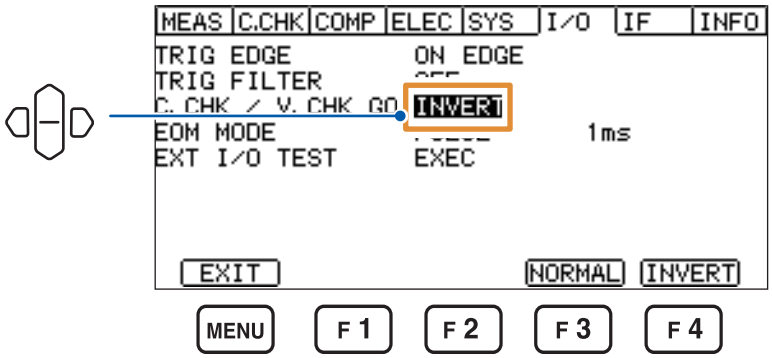


[NORMAL] When a pass judgment is given for the contact check or voltage monitor check: Outputs the On signal.

When a fail judgment is given for the contact check or voltage monitor check: Outputs the Off signal.

2 Logic level to be outputted with the INVERT setting

Procedure to display the setting screen: **MENU** key > **[I/O]** tab



[INVERT] When a pass judgment is given for the contact check or voltage monitor check: Outputs the Off signal.

When a fail judgment is given for the contact check or voltage monitor check: Outputs the On signal.

When the contact check or voltage monitor is disabled, the instrument always gives fail judgments and thus outputs the Off signal.

EOM signal output mode

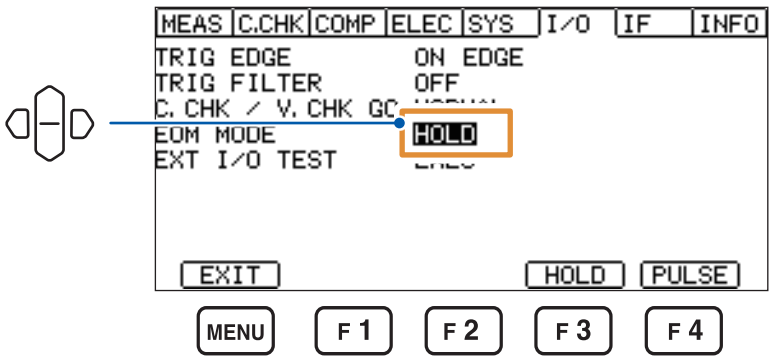
This setting can be used to specify the output method for the EOM (end of measurement) signal.

Procedure to display the setting screen: **MENU** key > ◁▷ **[I/O]** tab

1 Select whether to maintain the EOM signal in the on state or to switch it to the off state after the set time has elapsed.

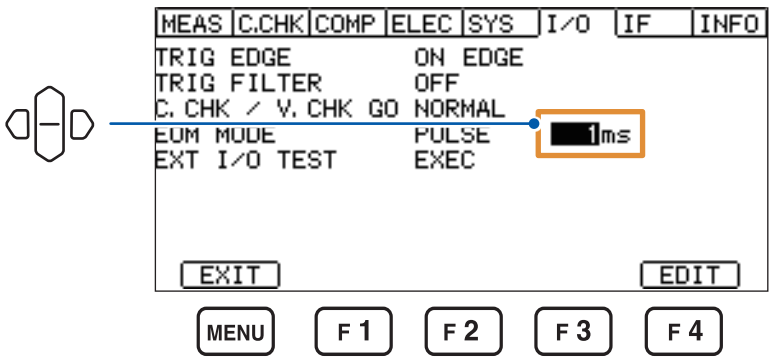
[HOLD] The EOM signal output remains in the on state until the next TRIG signal is input (default setting).

[PULSE] The EOM signal output remains in the off state after the set pulse width has elapsed.

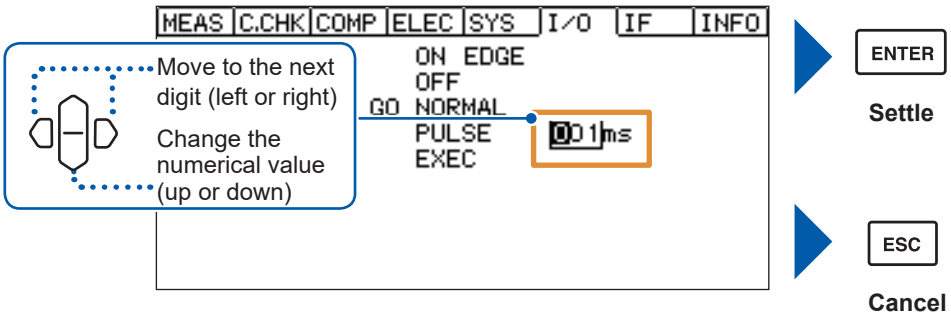


2 If [PULSE] is selected, set the pulse width.

1 ms to 100 ms (default setting: 1 ms)



Pressing the **F4** key **[EDIT]** enables the numerical value to be changed.



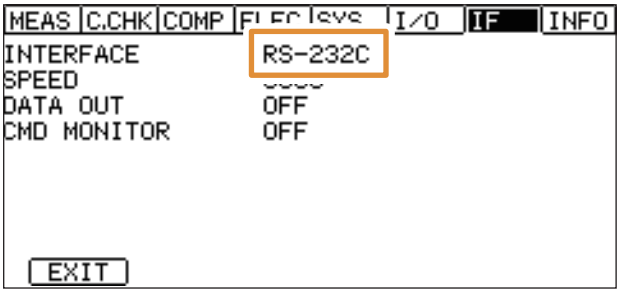
Numerical value can also be changed with the numeric keypad. See “Methods for changing numerical values” (p. 28).

10 Communications (USB, RS-232C, GP-IB)

10.1 Summary and Features of Interface

The instrument can be controlled and data can be acquired through communication commands by using the communication interface.

Multiple interfaces cannot be used simultaneously on the instrument.
The interface set on the **[IF]** screen is enabled.



For details about the communication commands, refer to Communication Command Instruction Manual included in the accompanying CD.
They can also be downloaded from the Hioki website.

For the specifications, see “11.4 Interface Specifications” (p. 154).

10.2 USB Interface

Installing the USB driver

When the instrument is first connected to a computer, it is necessary to install the dedicated USB driver. If the driver has already been installed, skip the following procedure. The accompanying CD contains the USB driver. It can also be downloaded from the Hioki website.

Installation procedure

Install the USB driver before connecting the instrument to a computer with a USB cable. If the USB cable has been already connected to the computer, unplug it.

1. **Log into the computer with administrative privileges such as “administrator.”**
2. **Exit all applications that are running on the computer.**
3. **Open [X:\USB Driver] from the accompanying CD, and run [HiokiUsbCdcDriver.msi] (driver installer) (The drive name “X:” represents the CD-ROM drive).**

   It may take some time for the dialog box is displayed, depending on the system environment. Wait for the dialog box to be displayed.
4. **After the installation is completed, connect the instrument and the computer with a USB cable.**

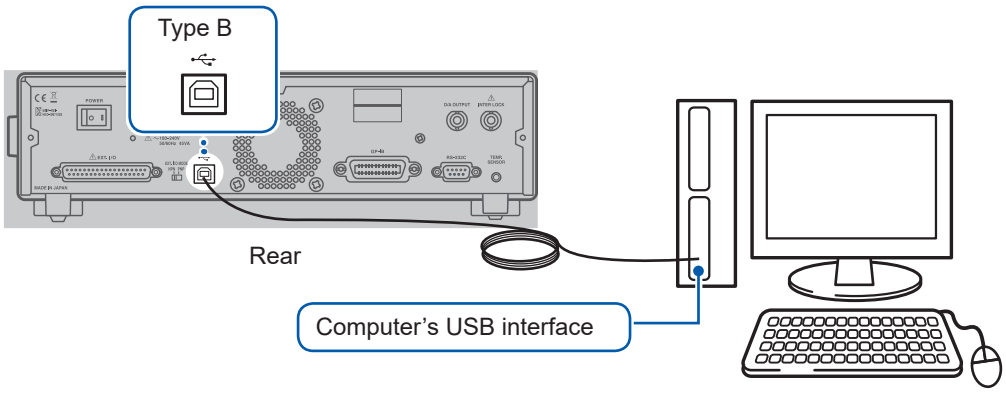
   The instrument is now recognized.
   - If the Hardware Wizard window for new hardware is displayed, select **[No, not this time]** for the Windows Update connection prompt, and then select **[Install the software automatically]**.
   - If an instrument with a different serial number is connected, you may be notified that a new device has been detected. If this happens, install the USB driver, following the instructions on the screen.

Uninstallation procedure

Uninstall the driver if you no longer need it.
On the **[Control Panel]**, click **[Add or Remove Programs]**, and then uninstall **[HOIKI USB CDC Driver]**.

Connecting the USB cable

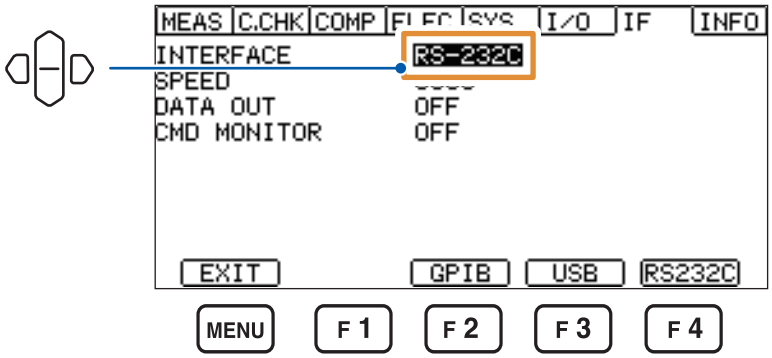
Be sure to read “Before connecting the communication cable to the instrument” (p. 14) beforehand.
The USB cable shall have length of 3 m or less.



Setting the instrument

Procedure to display the setting screen: **MENU** key > [IF] tab

1 **Press the F3 key [USB].**

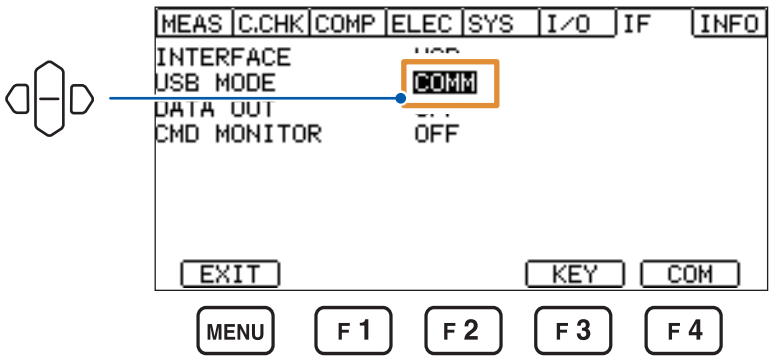


2 **Set the USB mode.**

[KEYBOARD] Outputs measured values through the USB cable connected to the computer. Measured values are output to a text editor or spreadsheet in the same way as data is entered with a keyboard.
For the external trigger setting:
The measurement value is output when the TRIG signal is input or the **ENTER** key is pressed.
For the internal trigger setting
The updated measured value is automatically output on completion of each measurement.
When USB mode is set to **[KEYBOARD]**, measurement value contents are outputted in the order of a measurement value and then a comparator result. You cannot change the output format.

For information about the output formats of measured values and comparator results, see descriptions of “Query Measurement value” and “Query Judgment of Measured Value” in the “Device-Specific Commands” section in the Communications Command Instruction Manual.

[COMM] Controls the instrument with commands through the USB cable connected to the computer (default setting).

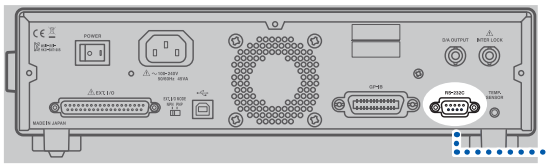


10.3 RS-232C Interface

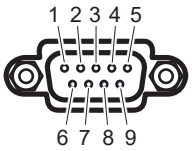
Connecting the RS-232C cable

Be sure to read “Before connecting the communication cable to the instrument” (p. 14) beforehand.

Connect the RS-232C cable to the RS-232C connector. After connecting the cable to the instrument and another device, be sure to fasten the screws.



Rear



D-sub, 9 pins, pin contact
Mating fixed base screw #4-40

For connection with a data terminal equipment (DTE)

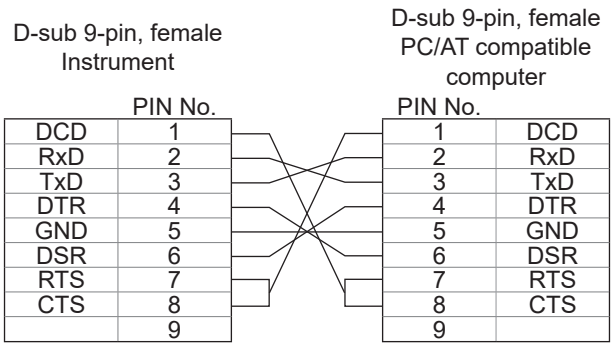
Prepare a cross cable that meets the specifications of the instrument and DTE connectors. The input/output connector conforms to DTE specifications. The instrument uses Pins 2, 3, and 5. The other pins are not used.

Pin no.	Signal name			Signal	Remarks
	Common	EIA	JIS		
1	DCD	CF	CD	Carrier detection	Unconnected
2	RxD	BB	RD	Receive data	
3	TxD	BA	SD	Transmit data	
4	DTR	CD	ER	Data terminal ready	Fixed at on level (+5 V to +9 V)
5	GND	AB	SG	Ground for signal	
6	DSR	CC	DR	Data set ready	Unconnected
7	RTS	CA	RS	Request to send	Fixed at on level (+5 V to +9 V)
8	CTS	CB	CS	Clear to send	Unconnected
9	RI	CE	CI	Calling indicator	Unconnected

When connecting instrument to computer

Use a cross cable with 9-pin female D-sub connectors installed at both ends.

Cross connection

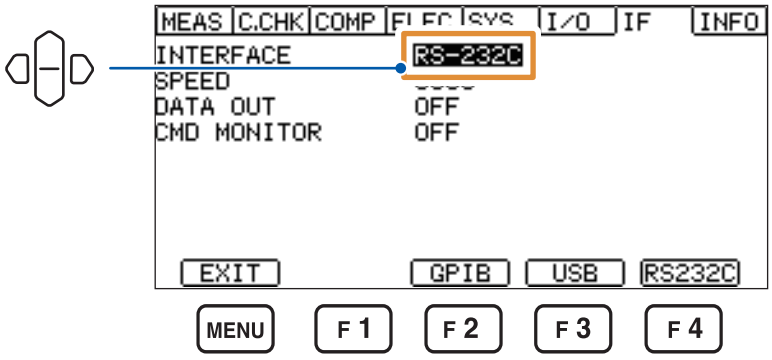


Recommended cable: Hioki Model 9637 RS-232C Cable (1.8 m)

Setting the instrument

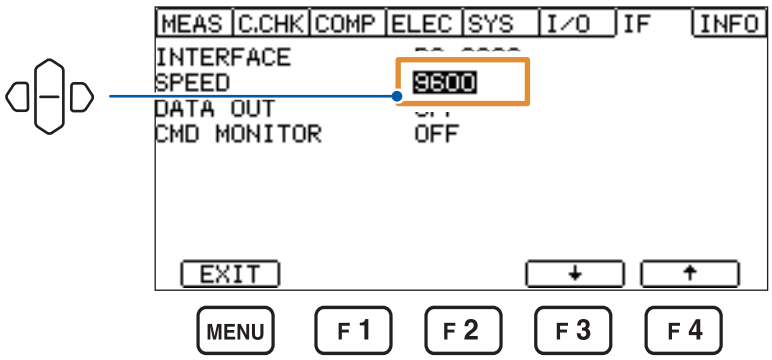
Procedure to display the setting screen: **MENU** key > **[IF]** tab

1 **Press the F4 key [RS232C].**



2 **Set a transmission speed (baud rate).**

4800 bps, 9600 bps, 19200 bps, 38400 bps, 115200 bps (default value: 9600 bps)



Press the **F3** key **[↓]** or **F4** key **[↑]** to select a value.

Setting the controller (Computer or PLC)

Change the controller settings as follows:

- Start-stop synchronization
- Transmission speed — 4800 bps, 9600 bps, 19200 bps, 38400 bps, and 115200 bps (Adjust the speed same as the instrument's setting.)
- Stop bit — 1
- Data length — 8
- Parity check — Not provided
- Flow control — Not provided

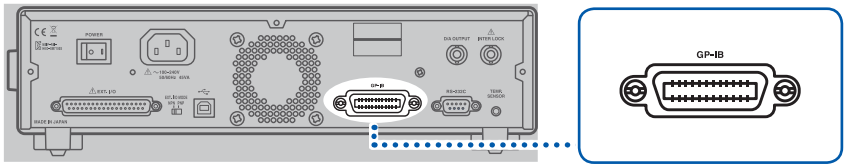
IMPORTANT
It may not be possible to use the fast transmission speed (baud rate) due to significant errors caused by some computers. In such cases, use a lower transmission speed.

10.4 GP-IB Interface

Connecting the GP-IB cable

Be sure to read “Before connecting the communication cable to the instrument” (p. 14) beforehand.

Connect the GP-IB cable to the GP-IB Connector. After connecting the cable to the instrument and another device, be sure to fasten the screws.
Recommended cable: Model 9151-02 GP-IB Connector Cable (2 m)

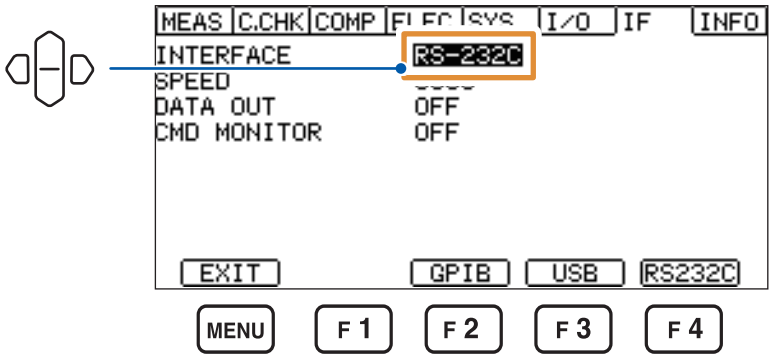


Rear

Setting the instrument

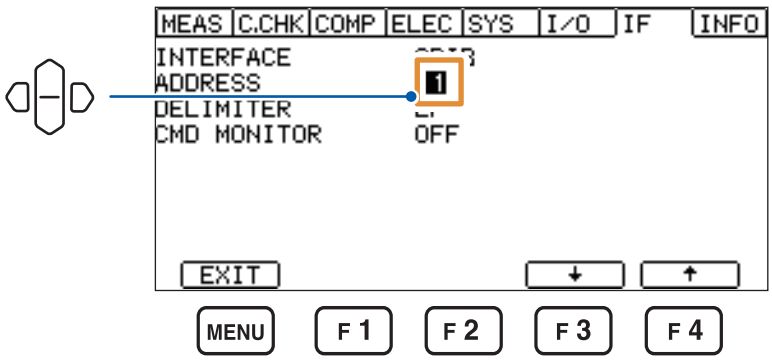
Procedure to display the setting screen: **MENU** key > **[IF]** tab

1 **Press the F2 key [GPIB].**



2 **Set the device address.**

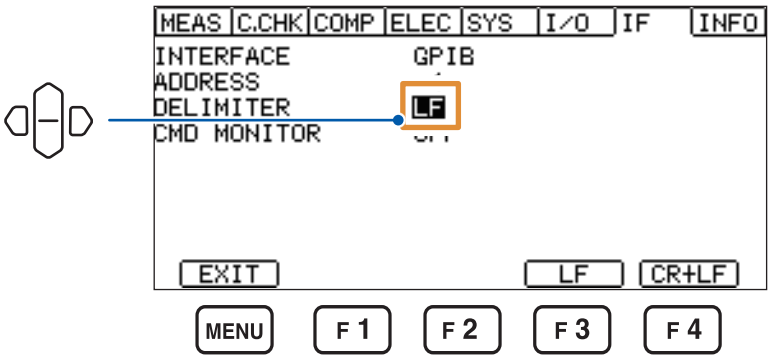
0 to 30 (default setting: 1)



Press the **F3** key **[↓]** or **F4** key **[↑]** to select a value.

3 Set a delimiter.

LF, CR+LF (default setting: LF)



10.5 Settings Common to Interfaces

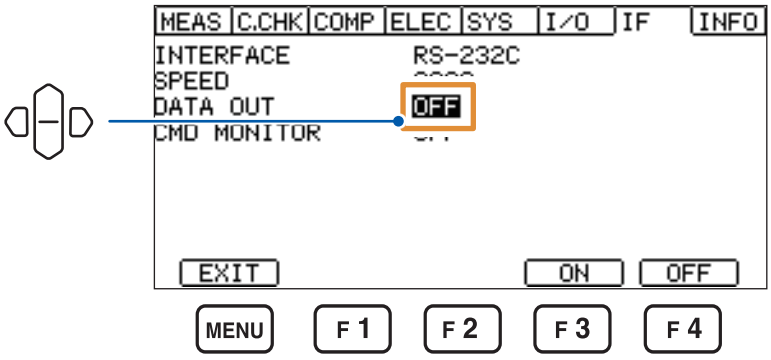
Outputting measured values (data output function) (RS-232C and USB only)

Select whether to output the measured values automatically via each of the interfaces.
Setting this function to **[ON]** disables the communication commands to control the instrument because the data output exclusively uses the interface.

Procedure to display the setting screen: **MENU** key > **[IF]** tab

[ON] Outputs measured values.

[OFF] Does not output any measured values. (default setting)



For the external trigger setting:

Measured values are output when the TRIG signal is input to the instrument or when the **ENTER (TRIG)** key is pressed.

For the internal trigger setting:

Latest measured values are automatically output every time the measurement is completed.

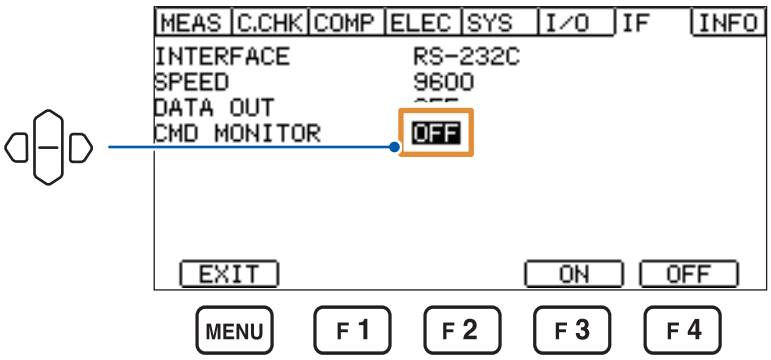
Displaying communication commands (communication monitor function)

The send and receive state of commands and queries can be checked on the screen.

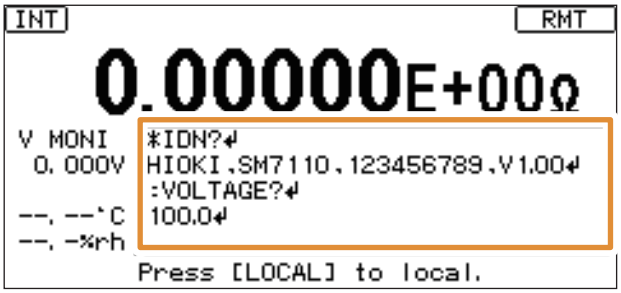
Procedure to display the setting screen: **MENU** key > **[IF]** tab

[ON] Displays commands.

[OFF] Does not display any commands. (default setting)



The communication monitor is displayed on the measurement screen when communication starts.



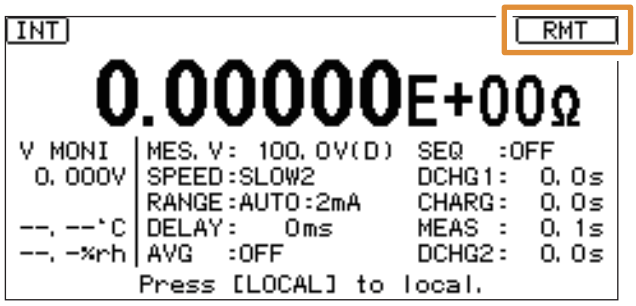
10.6 Control by Using Commands

For the description (communication message reference) of the communication commands and queries, refer to the Communication Command Instruction Manual, which is included in the accompanying CD.

Remote state

The instrument is placed in the remote state during the USB, RS-232C, or GP-IB communication, displaying **[RMT]** on the setting screen.
All the operation keys are disabled except the **LOCAL** key.

When the instrument changes to the remote state while the menu settings screen is displayed, the screen automatically switched to the measurement screen.



Local state

The following operation deactivates the remote control and enables the key operation.

- Press the **LOCAL** key.
- Turn off the instrument and turn it on again.
- Send the command `:SYSTem:LOCal` to the instrument via USB, RS-232C, or GP-IB.
- Send the command `GTL` from GP-IB via the instrument.

11 Specifications

11.1 General Specifications

Operating environment	Indoors, Pollution Degree 2, altitude up to 2000 m (6562 ft.)
Operating temperature and humidity	Temperature 0°C to 40°C (32°F to 104°F) Humidity 80% RH or less (no condensation)
Storage temperature and humidity	Temperature -10°C to 50°C (14°F to 122°F) Humidity 80% RH or less (no condensation)
Standards	Safety EN61010 EMC EN61326 Class A
Dielectric strength	4000 V AC (current sensitivity: 10 mA) Between bundle of power terminals and each of protective ground, interface, and measurement terminal
Power	Commercial power Rated supply voltage: 100 V AC to 240 V AC (A supply voltage can fluctuate from the rated supply voltage within a band of plus or minus 10%.) Rated supply frequency: 50 Hz / 60 Hz Anticipated transient overvoltage: 2500 V Maximum rated power: 45 VA
Interface	USB, RS-232C, GP-IB
Dimensions	Approx. 330W × 80H × 450D mm (12.99"W × 3.15"H × 17.72"D) (excluding protrusions)
Mass	Approx. 5.9 kg (208.1 oz.)
Product warranty period	3 years Connector, cable, etc.: Not covered by the warranty
Accessories	See “Verifying Package Contents” (p. 2).
Options	See “Options” (p. 3).

11.2 Input/Output/Measurement Specifications

The underlined values are the default settings. The set values are retained even after the instrument is turned OFF.

Basic specifications

Number of channels	1 channel		
Measurement method	The current is measured by applying a constant voltage to the measured object.		
Applied voltage	Model SM7110	0.1 V to 1000 V	
	Model SM7120	0.1 V to 2000 V	
Maximum rated voltage to earth	2000 V DC		
Ammeter input resistance	1 kΩ ±10%		
Input/output terminals	Current input terminal	Triaxial BNC connector (Current input, internal guard, external shield)	
	Voltage output terminal	Banana terminal	
	Charge voltage output terminal	Banana terminal	
	GUARD terminal	Banana terminal	
	GROUND terminal	Banana terminal	
Maximum input voltage	Current input terminal	2000 V (between internal guard and external shield)	
Liquid crystal display	LCD type	Monochrome graphic LCD 240 × 110	
	Backlight	White LED Brightness adjustment range: 0% to 100%, default: <u>80%</u> (in increments of 5%)	
	Contrast adjustment range	0% to 100%, default: <u>50%</u> (in increments of 5%)	
Display update	When settings are changed or when a measurement starts		
Warning	Red LED lights up if the voltage monitor value reaches approx. 30 V or higher.		
Keys	Key types	MODE, RANGE▲, RANGE▼, VOLT▲, VOLT▼, COMP, LOAD/SAVE, SPEED, LOCAL, START, STOP, ↑, ↓, ←, →, ESC, ENTER, MENU, F1, F2, F3, F4	
	Key lock function	Operation details	Disables the operation of keys. Communication commands can also enables the key operation.
		Setting	<u>OFF</u>, MENU, ALL
		MENU	Disables the operation of the following keys: COMP, LOAD/SAVE, and MENU
		ALL	Disables the operation of all keys excluding the **MENU** key **[UNLOCK],** and **STOP** key. Inputting the KEYLOCK signal disables all of the operation performed on the front panel.
	Key operation tone setting function	Setting	<u>ON</u>/OFF

Accuracy specifications

Conditions of guaranteed accuracy	Guaranteed accuracy period	1 year
	Guaranteed accuracy period from adjustments made by Hioki	1 year
	Temperature and humidity for guaranteed accuracy	23°C±5°C (73°F±9°F), 80% RH or less
	Warm-up time	At least 30 minutes
	Power frequency range	50 Hz / 60 Hz ±2 Hz
	Temperature coefficient	In temperature ranges of between 0°C and 18°C and between 28°C and 40°C, ±(measurement accuracy × 1/10)/°C is added.
Effect of radiated radio-frequency electromagnetic field	15% f.s. at 10 V/m	
Effect of conducted radio-frequency electromagnetic field	5% f.s. at 10 V	
Effect of commercial power frequency electromagnetic field	±5 pA are added to the products specifications at 30 A/V.	

Current measurement accuracy

The accuracy listed in the following table is specified after calibration.
Neglecting calibration reduces the accuracy, adding 50 dgt. to the following specifications.
Guaranteed accuracy range: 5% to 100% of each range

Range	Maximum display	Resolution	Current measurement accuracy (±% rdg. ±dgt.)			
			FAST/FAST2	MED	SLOW	SLOW2
20 pA	19.9999 pA	0.1 fA	-	-	2.0 + 450	2.0 + 30
200 pA	199.999 pA	1 fA	-	1.0 + 600	1.0 + 45	1.0 + 30
2 nA	1.99999 nA	10 fA	0.5 + 600	0.5 + 40	0.5 + 30	0.5 + 20
20 nA	19.9999 nA	100 fA	0.5 + 30	0.5 + 20	0.5 + 15	0.5 + 10
200 nA	199.999 nA	1 pA	0.5 + 30	0.5 + 20	0.5 + 15	0.5 + 10
2 µA	1.99999 µA	10 pA	0.5 + 30	0.5 + 20	0.5 + 15	0.5 + 10
20 µA	19.9999 µA	100 pA	0.5 + 30	0.5 + 20	0.5 + 15	0.5 + 10
200 µA	199.999 µA	1 nA	0.5 + 30	0.5 + 20	0.5 + 15	0.5 + 10
2 mA	1.99999 mA	10 nA	0.5 + 30	-	-	-

Voltage measurement accuracy

Range	Maximum display	Resolution	Voltage measurement accuracy (±% rdg. ±dgt.)
10 V	10.000 V	0.001 V	0.03 + 2
100 V	100.00 V	0.01 V	0.03 + 2
1000 V	1000.0 V	0.1 V	0.03 + 2
2000 V *	2000.0 V	0.1 V	0.2 + 2

* The 2000 V range applies only to Model SM7120.

Voltage generation accuracy

Range	Set voltage range	Voltage generation accuracy (±% of setting ±% f.s.)	Time from the START signal to voltage output
10 V	0.1 V to 10.0 V	0.1 + 0.05	0.1 ms max.
100 V	10.1 V to 100.0 V	0.1 + 0.05	0.1 ms max.
1000 V	100.1 V to 1000.0 V	0.1 + 0.05	0.1 ms max.
2000 V *	1000.1 V to 2000.0 V	0.2 + 0.10	0.1 ms max.

* The 2000 V range applies only to Model SM7120.

Voltage generation current limiter

See “4.9 Limiting Current Flowing Through Measured Object (Current Limiter)” (p. 65).

Resistance measurement accuracy

(Resistance measurement accuracy) = (Current measurement accuracy) + (Voltage generation/measurement accuracy)
The measured or set voltage is used as the voltage for resistance measurement.
If a calculation set voltage is used, the resistance measurement accuracy shall be considered as a reference and is not guaranteed.

Resistance value display range

Exponential notation

		Applied voltage				
Range	Resolution	0.1 V	10 V	100 V	1000 V	2000 V
20 pA	0.1 fA	5E+9 Ω to 1E+15 Ω	500E+9 Ω to 100E+15 Ω	5E+12 Ω to 1E+18 Ω	50E+12 Ω to 10E+18 Ω	100E+12 Ω to 20E+18 Ω
200 pA	1 fA	500E+6 Ω to 100E+12 Ω	50E+9 Ω to 10E+15 Ω	500E+9 Ω to 100E+15 Ω	5E+12 Ω to 1E+18 Ω	10E+12 Ω to 2E+18 Ω
2 nA	10 fA	50E+6 Ω to 10E+12 Ω	5E+9 Ω to 1E+15 Ω	50E+9 Ω to 10E+15 Ω	500E+9 Ω to 100E+15 Ω	1E+12 Ω to 200E+15 Ω
20 nA	100 fA	5E+6 Ω to 1E+12 Ω	500E+6 Ω to 100E+12 Ω	5E+9 Ω to 1E+15 Ω	50E+9 Ω to 10E+15 Ω	100E+9 Ω to 20E+15 Ω
200 nA	1 pA	500E+3 Ω to 100E+9 Ω	50E+6 Ω to 10E+12 Ω	500E+6 Ω to 100E+12 Ω	5E+9 Ω to 1E+15 Ω	10E+9 Ω to 2E+15 Ω
2 µA	10 pA	50E+3 Ω to 10E+9 Ω	5E+6 Ω to 1E+12 Ω	50E+6 Ω to 10E+12 Ω	500E+6 Ω to 100E+12 Ω	1E+9 Ω to 200E+12 Ω
20 µA	100 pA	5E+3 Ω to 1E+9 Ω	500E+3 Ω to 100E+9 Ω	5E+6 Ω to 1E+12 Ω	50E+6 Ω to 10E+12 Ω	100E+6 Ω to 20E+12 Ω
200 µA	1 nA	1E+3 Ω to 100E+6 Ω	50E+3 Ω to 10E+9 Ω	500E+3 Ω to 100E+9 Ω	5E+6 Ω to 1E+12 Ω	10E+6 Ω to 2E+12 Ω
2 mA	10 nA	1E+3 Ω to 10E+6 Ω	5E+3 Ω to 1E+9 Ω	50E+3 Ω to 10E+9 Ω	500E+3 Ω to 100E+9 Ω	1E+6 Ω to 200E+9 Ω

The instrument displays values that include the input resistance of 1kΩ (±10%).

Decimal notation with unit prefix

		Applied voltage				
Range	Resolution	0.1 V	10 V	100 V	1000 V	2000 V
20 pA	0.1 fA	5 GΩ to 1 PΩ	500 GΩ to 100 PΩ	5 TΩ to 1000 PΩ	50 TΩ to 10000 PΩ	100 TΩ to 20000 PΩ
200 pA	1 fA	500 MΩ to 100 TΩ	50 GΩ to 10 PΩ	500 GΩ to 100 PΩ	5 TΩ to 1000 PΩ	10 TΩ to 2000 PΩ
2 nA	10 fA	50 MΩ to 10 TΩ	5 GΩ to 1 PΩ	50 GΩ to 10 PΩ	500 GΩ to 100 PΩ	1 TΩ to 200 PΩ
20 nA	100 fA	5 MΩ to 1 TΩ	500 MΩ to 100 TΩ	5 GΩ to 1 PΩ	50 GΩ to 10 PΩ	100 GΩ to 20 PΩ
200 nA	1 pA	500 kΩ to 100 GΩ	50 MΩ to 10 TΩ	500 MΩ to 100 TΩ	5 GΩ to 1 PΩ	10 GΩ to 2 PΩ
2 µA	10 pA	50 kΩ to 10 GΩ	5 MΩ to 1 TΩ	50 MΩ to 10 TΩ	500 MΩ to 100 TΩ	1 GΩ to 200 TΩ
20 µA	100 pA	5 kΩ to 1 GΩ	500 kΩ to 100 GΩ	5 MΩ to 1 TΩ	50 MΩ to 10 TΩ	100 MΩ to 20 TΩ
200 µA	1 nA	1 kΩ to 100 MΩ	50 kΩ to 10 GΩ	500 kΩ to 100 GΩ	5 MΩ to 1 TΩ	10 MΩ to 2 TΩ
2 mA	10 nA	1 kΩ to 10 MΩ	5 kΩ to 1 GΩ	50 kΩ to 10 GΩ	500 kΩ to 100 GΩ	1 MΩ to 200 GΩ

The instrument displays values that include the input resistance of 1kΩ (±10%).

Measurement time

Settings of contact check function and comparator function	ON	OFF
Contact-checking time	2.3 ms	0.0 ms
Comparator measurement time	0.2 ms	0.0 ms

Setting of measurement speed	50 Hz	60 Hz	Internal integration time
FAST	4.1 ms	4.1 ms	2 ms
FAST2	13.7 ms	12.7 ms	0.5 PLC
MED	23.7 ms	20.7 ms	1 PLC
SLOW	109 ms	93 ms	4 PLC
SLOW2	320 ms	320 ms	13 PLC

• Using the external control (EXT I/O) extends the INDEX and the EOM times as follows:

INDEX time (Contact check delay time) + (Contact-checking time) + (Delay time) + (Measurement time)
EOM time INDEX + (Comparator measurement time) + 0.4 ms
To obtain the calculated resistance value based on the measured voltage, add 1.0 ms.

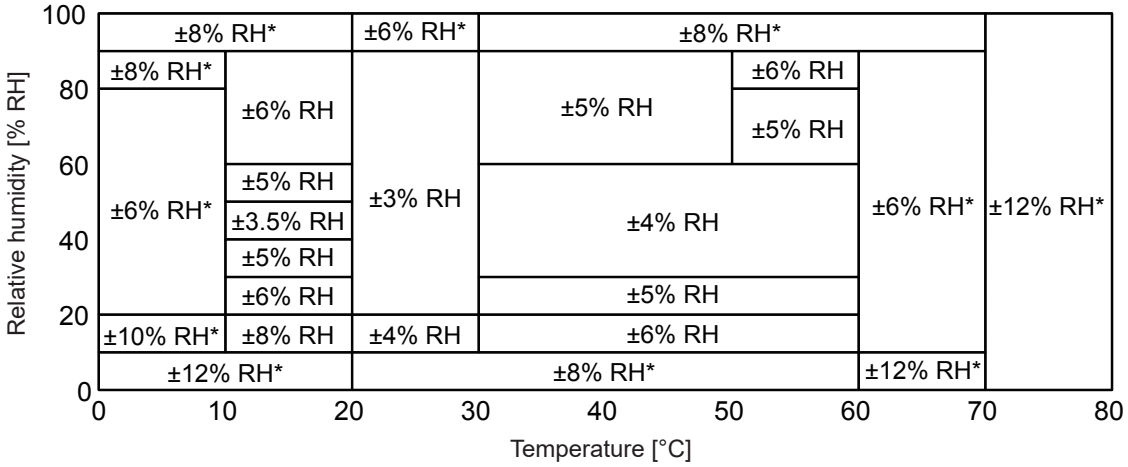
• Self-calibration time: 5 s or less

Measurement time examples (With the measurement speed set to FAST)

Contact check	Comparator measurement	Power frequency: 50 Hz		Power frequency: 60 Hz	
		INDEX	EOM	INDEX	EOM
OFF	OFF	4.1 ms	4.5 ms	4.1 ms	4.5 ms
OFF	ON	4.1 ms	4.7 ms	4.1 ms	4.7 ms
ON	OFF	6.4 ms	6.8 ms	6.4 ms	6.8 ms
ON	ON	6.4 ms	7.0 ms	6.4 ms	7.0 ms

Temperature measurement accuracy	Display range	-40.00°C to 80.00°C Displays **[--.--°C]** with a temperature sensor not connected.
	Accuracy range	-40.00°C to 80.00°C
	Measurement accuracy	See “Specifications of Model Z2011 Humidity Sensor” (p. 146).
	Measurement period	2 s ±0.2 s
Humidity measurement accuracy	Display range	0.0% RH to 90.0% RH Displays **[--.-%rh]** with a humidity sensor not connected.
	Accuracy range	20.0% RH to 80.0% RH
	Measurement accuracy	See “Specifications of Model Z2011 Humidity Sensor” (p. 146).
	Measurement period	2 s ±0.2 s
D/A output accuracy	Output accuracy	(Current measurement accuracy) ±0.2% f.s.
	Temperature coefficient	±0.02% f.s./°C
	Response time	(Measurement time) + 1 ms at a maximum

Specifications of Model Z2011 Humidity Sensor

Temperature measurement accuracy	±0.5°C (10°C to 60°C) Measuring temperature exceeding the range enclosed in parentheses above reduces this accuracy as follows: Add 0.015°C/°C (from −40°C inclusive to 10°C exclusive) Add 0.02°C/°C (from 60°C exclusive to 80°C inclusive)
Humidity measurement accuracy	±3% RH (20°C to 30°C, 20% RH to 90% RH) Measuring humidity exceeding the range enclosed in parentheses above reduces this accuracy as the following table. Values marked with an asterisk (*) are out of the guaranteed accuracy range (values used as reference).  Hysteresis: ±1% RH
Response time	Approx. 300 s (Temperature: 90 percentile response time during a temperature change from 0°C to 60°C or from 60°C to 0°C [used as reference]) (Humidity: 90 percentile response time during a humidity change from 10% RH to 80% RH or from 80% RH to 10% RH [used as reference])

11.3 Function specifications

The underlined values are the default settings. The set values are retained even after the instrument is turned off.

Measured value display mode	Displayed item	Display 1 An item to be displayed can be selected between the following: resistance, current, surface resistivity, volume resistivity, and liquid volume resistivity. Display 2 Displays the measurement voltage. (Displays the character string **[----]** with the voltage value for resistance calculation set to **[EXT.V]**.)
	Display format	EXP/UNIT EXP Exponential notation: Displays values, expressed in exponential notation, to five decimal places. (Example: 1.00000E + 16 Ω). UNIT Decimal notation: Displays values, expressed in decimal notation, that have six significant figures. (Example: 10.0000 PΩ).
	Function to set the number of display digits	The number of display digits can be set in the range from 3 to 6.
	Resistance value	Calculated from the measured current value and the measured voltage value (otherwise, the measured current value and the voltage setting value).
	Resistivity	Calculated from the measured current value, the measured voltage value, and the electrode constant (otherwise, the measured current value, the voltage setting value, and the electrode constant).
Function of drawing update during measurement	Operation method	Changes the timing of updating the measured value display.
	Setting	ON/OFF ON: Updates the measured value display for each measurement. OFF: Does not update the measured value display (The value of VMONI will be updated regardless of this setting).
Voltage output function	Operation method	Sink and source (Supports charge and discharge)
	Current limitation direction	Current can be limited in both directions.
	Voltage output value setting	0.1 V to 1000.0 V (Setting can be changed in increments of 0.1 V) 0.1 V to 2000.0 V (the SM7120 only)
	Setting for output set to OFF	Discharge (D) or high impedance (Z)
	Voltage output time	Time from the START signal input to set voltage stabilization With the discharge setting: 10 ms With the high-impedance setting: 1 ms When the generated voltage is changed during voltage generation: 10 ms
Setting of voltage value for resistance calculation	Operation details	Selects the voltage value used for resistance calculation.
	Function setting	VMONI (measured voltage value), MES.V (applied voltage set value), EXT.V (voltage set value for calculation)
	Voltage setting range	0.1 V to 5000.0 V Available only when the function setting is “EXT.V” (voltage set value for calculation).

Measurement speed	Operation details	Sets the sampling time.
	Setting	FAST/FAST2/MED/SLOW/SLOW2
Range switching function	Current measurement	AUTO/MANUAL
	Resistance measurement	No setting (The current measurement set to AUTO will set the resistance measurement to AUTO.)
Trigger mode	Operation details	Sets a trigger for starting measurement.
	Setting	INTERNAL/EXTERNAL INTERNAL Internal trigger EXTERNAL External trigger Pressing the **TRIG** key samples a datum once.
Delay function	Operation details	Sets the duration from when the **START** key is pressed or the TRIG signal is input until the start of measurement.
	Setting range	0 ms to 9999 ms (in increments of 1 ms)
Contact check delay function	Operation details	Sets the duration before starting contact check
	Setting range	0 ms to 9999 ms (in increments of 1 ms)
Average function	Operation details	Averages measured values.
	Setting	OFF/ON (HOLD)/ON (AUTO)
	Number of averaging with averaging set to ON	2 to 255 times (Any value in this range can be set.)
	Averaging method	HOLD Moving average (However, arithmetic averages are calculated with the trigger source set to the external trigger and the sequence measurement set to off) AUTO The number of times of averaging is automatically changed based on the variation of the measured values.
Power frequency setting	Operation details	Sets the power voltage frequency.
	Setting	AUTO (Automatically detects whether the frequency is 50 Hz or 60 Hz)/50 Hz/60 Hz
Cable length correction function	Operation details	The predetermined length of the cable to be used corrects the fixture capacitance open value and the contact check value. Automatically detected length and user-defined length can be used.
	Correctable range	0.5 m to 3.0 m, default: 1.0 m (Can be set in increments of 0.1 m)
Fixture capacitance open correction function	Operation details	Measures the capacity when the fixture is open. Required to be executed prior to executing the contact check function. The acquired data is retained even when the instrument is turned off.
	Display range	0.000 pF to 99.999 pF

Contact check function	Operation details	Judges the contact condition by comparing a measured value with the judgment reference value.
	Operation method	Capacity measurement method by applying a high frequency signal
	Automatic execution	ON/OFF
	Capacity measurement accuracy range	0.200 pF to 95.000 pF (However, the capacity of the object to be measured shall be equal to or greater than 1/10 of the fixture capacitance.)
	Capacity measurement accuracy	±(20% of the read value ±0.1 pF)
	Judgment reference value input range	0.00 pF to 99.99 pF
	Judgment	GO: (Measured capacity value) > (Judgment reference value) NG: (Judgment reference value) ≥ (Measured capacity value)
	Variable frequency	300 kHz / 245 kHz
	Frequency accuracy	±20%
	Capacitance setting of objects to be measured	LOW/NORMAL
Self-calibration function	Operation details	Corrects the offset voltage and the gain of the measurement circuit.
	Setting	ON/OFF
	Setting time	1 s to 600 s
	Others	Automatically executes the correction once when the instrument is turned on and 5 minutes later regardless of whether the setting is ON or OFF. The correction can be manually executed once from the ON/OFF settings screen. The self-calibration can be executed by sending the command even when the setting is OFF.

Resistivity measurement function	Operation details	Calculates the surface resistivity and the volume resistivity from the predetermined electrode constant.
	Setting Items	Surface resistivity (Diameter of the main electrode)/ (Internal diameter of the counter electrode) Flat sample volume resistivity (Diameter of the main electrode)/ (Thickness of sample) Liquid sample volume resistivity Randomly determined electrode constant Electrode name specification Automatically sets the electrode constant based on the selected electrode.
	Setting range	Diameter of the main electrode (D1) 0.0 mm to 100.0 mm, default: <u>50.0 mm</u> (in increments of 0.1 mm) Internal diameter of the counter electrode (D2) 0.0 mm to 100.0 mm, default: <u>70 mm</u> (in increments of 0.1 mm) Thickness of sample (t) 0.0 mm to 100.0 mm, default: <u>0.1 mm</u> (in increments of 0.1 mm) Electrode constant (K) 0.01 to 999.99, default: <u>500.00</u> (in increments of 0.1 mm)
	Calculation formula	Surface resistivity: $\rho s = \frac{\pi \cdot (D2 + D1)}{D2 - D1} \times$ (Measured value) Flat sample volume resistivity: $\rho v = \frac{\pi \cdot D1^2}{4t} \times \frac{\text{(Measured value)}}{10}$ Liquid sample volume resistivity: $\rho l = K \times$ (Measured value) ρs: Surface resistivity Unit [Ω] ρv, ρl: Volume resistivity Unit [Ω·cm] π: Circular constant = 3.14 $D1$: Diameter of the main electrode Unit [mm] $D2$: Internal diameter of the counter electrode Unit [mm] t: Thickness of sample Unit [mm] K: Electrode constant Unit [cm]
Comparator function	Operation details	Compares the set value and measured values, making judgments.
	Setting	ON/<u>OFF</u>
	Judgment	Judgments are made based on the value internally calculated. Hi (Measured value) > (Upper limit value) IN (Upper limit value) ≥ (Measured value) ≥ (Lower limit value) Lo (Lower limit value) > (Measured value)
Judgment sound setting function	Operation details	Beeps based on the comparator judgment results. (for each of Hi, IN, and Lo).
	Operation setting, tone color	<u>OFF</u>, Type 1, Type 2, Type 3
	Number of beeps	<u>1</u> to 5, Continuous

Interlock function	Operation details	Disables output of measurement voltage and measurement using an external input signal. When the setting is enabled, the interlock is deactivated by inputting the On signal or connecting the terminals with each other. If the interlock function is activated during a measurement, the measurement stops. Measurement cannot be performed by either the keys or communication in the interlocked state.
	Setting	ON (enable)/OFF (disable)
	Input terminal	BNC (Internally in parallel with external I/O)
Sequence program function	Operation details	Sets the sequence of discharge, charge, measurement, and discharge and executes it.
	Setting	ON/OFF (If OFF is set, continuous measurement is executed.)
	Save number	0 to 9
	Allowable time setting range for each pattern (The setting unit can be switched between milliseconds and seconds.)	Measurement: 1 ms to 999.9 s, default: 0.1 s Other than measurement: 0 ms to 999.9 s
	Resolution	In milliseconds: 1 ms In seconds: 0.1 s If the unit is changed from milliseconds to seconds, rounded-off values are displayed.
Panel saving, panel loading	Operation details	Saves and loads the measurement conditions specified by the panel number.
	Numbers of panels	50
	Panel name	10 characters (Alphabets or numbers)
	Saved contents	Measured value display mode, voltage output set value, setting of voltage set value for resistance calculation, measurement speed, range, trigger mode, delay, average, contact check, self-calibration setting, resistivity measurement settings, comparator, judgment sound, interlock, sequence, fixture capacitance open correction value

Voltage monitor check	Operation details	When a monitored voltage value falls within the specified range, the V_CHECK_GO signal switches to the on state.
	Setting	ON/OFF
	Settable range	±2% to ±20% (Resolution: 1%)
	Display	ON: **[V.CHK]** is displayed during normal operation. **[V.CHK]** is displayed during erroneous operation, highlighted in reverse video OFF: Non-displayed
	Voltage monitor range for measured voltage	

SM7120

MES.V	**Voltage monitor** range	Display range of voltage monitor
0.1 V to 9 V	10.000 V	10.000 V
9.1 V to 90 V	100.00 V	100.00 V
90.1 V to 900 V	1000.0 V	1000.0 V
900.1 V to 2000 V	2000.0 V	2000.0 V

SM7110

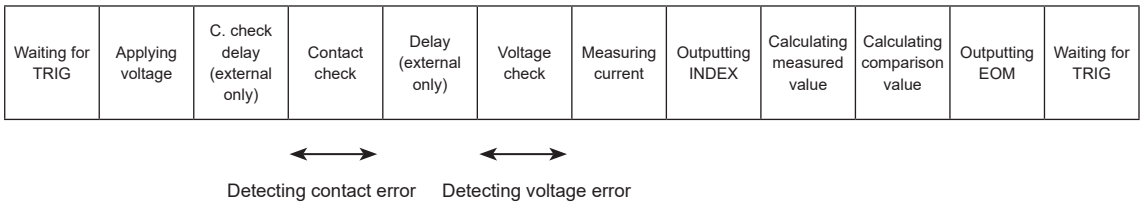
MES.V	**Voltage monitor** range	Display range of voltage monitor
0.1 V to 9 V	10.000 V	10.000 V
9.1 V to 90 V	100.00 V	100.00 V
90.1V to 1000 V	1000.0 V	1000.0 V

DA output function	Operation details	Outputs a voltage corresponding to the measured current. Even when a resistance value is displayed, outputs a voltage corresponding to the measurement current.
	Output voltage	0 V DC to 2 V DC (Outputs 2.0 V at the maximum display value of the current range) An error or Current Over Range (out-of-range) results in a voltage of 2.5 V outputting.
	Maximum output voltage	5 V DC
	Output impedance	1 kΩ
	Number of bits	12 bits
	Output terminal	BNC terminal
Double action function	Operation details	After the **STOP** key is pressed, the **START** key is enabled for only 1 second.
	Setting	ON / OFF
Reset function	Reset	Resets the settings excluding the panel data to the factory default.
	System reset	Resets all the settings including the panel data to the factory default.
Self-test function	Self-test on start-up	Executes the ROM/RAM check.
Error display	See “Error display and solution” (p. 162).	

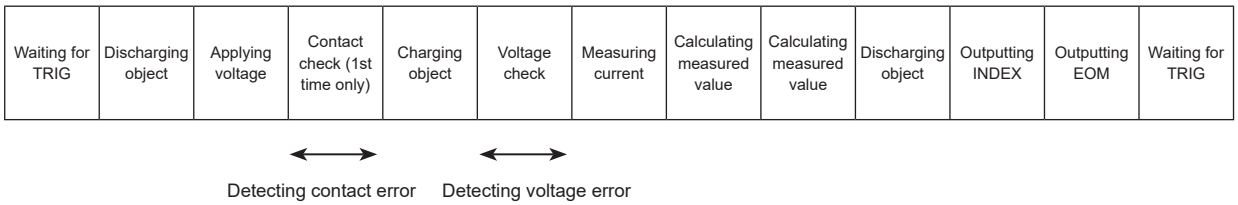
GO signal logic-level inverting function	Operation	When a monitored voltage value falls within the specified range, the V_CHECK_GO signal switches to the on state. When the contact check is set ON Outputs the On signal for a pass judgment with the **[NORMAL]** setting. Outputs the Off signal for a pass judgment with the **[INVERT]** setting. With the voltage monitor check enabled Outputs the On signal for a pass judgment with the **[NORMAL]** setting; outputs the Off signal for a pass judgment with the **[INVERT]** setting. With the contact check and monitor check disabled Always gives fail judgments and thus outputs the Off signal.
	Setting	NORMAL/INVERT

Measurement timing

Trigger measurement



Sequence measurement



- If a contact error occurs, the subsequent process continues.
- Even if a voltage error is detected, the subsequent process continues.

11.4 Interface Specifications

The underlined values are the default settings. The set values are retained even after the instrument is turned off.

USB	Communication contents	Remote control, measured value output
	Connector	Series B receptacle
	Electrical specifications	USB2.0 (Full Speed)
	Class (mode)	CDC class (COM mode) HID class (USB keyboard mode)
RS-232C	Communication contents	Remote control, measured value output
	Transmission method	Start-stop synchronization system, full duplex
	Transmission speed	4800 bps/9600 bps/19200 bps/38400 bps/115200 bps
	Data bit length	8 bits
	Stop bit	1
	Parity bit	None
	Delimiter	Sending: CR + LF; Receiving: CR, CR + LF
	Handshake	X flow: Not provided, Hardware flow: Not provided
	Protocol	Non-procedure system
	Connector	D-sub 9 pins, male, mating fixed base screw #4-40
GP-IB	Communication contents	Remote control
	Device address	0 to 30, default: 1
	Delimiter	LF/CR + LF
	Other	IEEE488.2 compliant
	Interface functions SH1 Provides all source handshake functions. AH1 Provides all acceptor handshake functions. T6 Provides a basic talker function. Provides a serial poll function. Does not provide talk-only mode. Provides a function to release the talker using the MLA (My Listen Address). L4 Provides a basic listener function. Does not provide a listen-only mode function. Provides a function to release the listener using the MTA (My Talk Address). SR1 Provides all service request functions. RL1 Provides all remote/local functions. PP0 Does not provide parallel poll functions. DC1 Provides all device clear functions. DT1 Provides all device trigger functions. C0 Does not provide a controller function.	

Remote functions	Operation details	If communications are performed through RS-232C, USB, or GP-IB, the function changes the instrument status to remote and disables any key operation other than the STOP key. To deactivate the remote control, follow the ways listed below: • Press the **LOCAL** key. • Turn off the instrument and turn it on again. • Execute the command `:SYSTem:LOCal` through RS-232C or GP-IB. • Execute the command `GTL` through GP-IB.
Communication monitor function	Operation details	Displays the sending and receiving status of commands and queries.
	Setting	ON/OFF
Data output function	Operation details	With the trigger mode set to EXT: Outputs measured values when the TRIG signal is input or the **ENTER (TRIG)** key is pressed. With the trigger mode is INT: Automatically outputs measured values every time measurement is completed.
	Setting	ON/OFF (Can be configured using the panel or through communications)
Memory function	Operation details	Stores the measured data in the memory. Collectively sends the saved measured values.
	Number of memories	999 (volatile memories without backup)
	Setting	ON/OFF

11.5 External I/O Specifications

The underlined values are the default settings. The set values are retained even after the instrument is turned off.

Input signal	Signal type	TRIG, V_CHECK, C_CHECK, OPEN, START, STOP, CLEAR, INTERLOCK, KEYLOCK
	Photo-coupler isolation	Non-voltage contact inputs (Supports current sink/source output)
	Input on	Residual voltage: 1 V or less (Input on current 4 mA [value for reference])
	Input off	Open-circuit (Breaking current: 100 µA or less)
	Response time	On edge: 0.1 ms at a maximum, off edge: 1.0 ms at a maximum
Output signal	Signal type	EOM, INDEX, VON, V_CHECK_GO, C_CHECK_GO, OPEN_GO, HI, IN, LO, PASS, FAIL, ERR
	Photo-coupler isolation	Open drain output (Non-polar)
	Maximum load voltage	30 V DC Residual voltage: 1 V or less (load current: 50 mA) / 0.5 V or less (load current: 10 mA)
	Maximum output current	50 mA/channel
Output signal setting	Operation details	Sets the output of EXT I/O to current sink (NPN) or current source (PNP).
	Setting	NPN/PNP
	Setting method	Switches the setting using the rear switch. (Commands cannot be used for switching the setting.)
TRIG filter function	Operation details	Processes signals only when the input signal remains in the on state during the response time.
	Setting	ON/OFF
	Response time	1 ms to 500 ms
TRIG logic setting	Operation details	Sets the start edge for the TRIG signal.
	Setting	ON edge/OFF edge
EOM output timing setting	Operation details	Setting the output mode to HOLD leaves the EOM signal outputting in the on state until the next TRIG signal. Setting the output mode to PULSE leaves the EOM signal outputting in the off state after the period of the set pulse width has elapsed.
	Setting	HOLD/PULSE
	Pulse width	1 ms to 100 ms (Accuracy: ±1%)
EXT I/O test function	Operation details	Displays the input signal status of EXT I/O, and optionally outputs an output signal.
Service power supply output	Output voltage	Sink output: 5.0 V±10% Source output: -5.0 V±10%, 100 mA at a maximum
	Insulation	Floated from the protective ground potential and the measurement circuit
	Insulation rating	Voltage to ground 50 V DC, 30 V rms AC, 42.4 V peak AC or less
Connectors	D-sub 37 pins, female, mating fixed base screw #4-40	
Pin assignment	See “Instrument-side connector pin assignment” (p. 113).	

Functions of input signal	TRIG	Measurement starting input Setting the input to the on state starts a measurement.
	C_CHECK	Contact check execution input Setting the input to the on state executes a contact check.
	V_CHECK	Voltage check execution input Setting the input to the on state executes a voltage check.
	OPEN	Open correction execution input Setting the input to the on state executes an open correction.
	START	Measurement-voltage output starting signal
	STOP	Measurement-voltage output stopping signal
	CLEAR	Value-and-judgment clearing input When the On signal is inputted while the instrument does not perform any measurement, the measured value and judgment result are cleared. After clearing them, the instrument will return a response indicating that no measurement is performed in response to a measured-value query of the communication commands.
	INTERLOCK	Interlock deactivating input
	KEYLOCK	Key lock input

Functions of output signal	EOM	End-of-measurement signal Outputs the On signal when the measurement and the judgment are completed.
	INDEX	Measurement reference output Outputs the On signal when the measurement circuit finishes the A/D acquisition.
	ERR	Measurement error output Outputs the On signal if a measurement error occurs. The following instances results in a measurement error: • The A/D for measurement and voltage measurement has overflowed. • The fixture-capacitance open correction value exceeds 99.999 pF.
	C_CHECK_GO	Contact-check result output When the contact check gives a pass judgment, outputs the On signal with the **[NORMAL]** setting, or the Off signal with the **[INVERT]** setting.
	V_CHECK_GO	Voltage-error-check result output When the voltage error check gives a pass judgment, outputs the On signal with the **[NORMAL]** setting, or the Off signal with the **[INVERT]** setting.
	OPEN_GO	Open correction result output Outputs the On signal when the open correction gives a pass judgment.
	VON	Voltage output status signal Outputs the On signal while outputting a voltage.
	HI	Output for a HI comparator judgment Outputs the On signal when the comparator gives a Hi judgment.
	IN	Output for an IN comparator judgment Outputs the On signal when the comparator gives an IN judgment.
	LO	Output for a LO comparator judgment Outputs the On signal when the comparator gives a Lo judgment.
	PASS	Output for a PASS judgment result Outputs the On signal when the comparator gives an IN judgment after the measurement is normally completed.
	FAIL	Output for a FAIL judgment result Outputs the On signal when the comparator gives a judgment other than IN after the measurement is normally completed.

12 Maintenance and Service

12.1 Troubleshooting

If damage is suspected, check the “Q&A (Frequently Asked Questions)” section before contacting your authorized Hioki distributor or reseller.

Q&A (Frequently Asked Questions)

General items

No.	Trouble	Confirm		Possible causes, solution	Reference
1-1	The instrument cannot be turned on (nothing is displayed).	Power switch (rear)	OFF	The power is not supplied. → Flip the power switch (rear).	p. 37
			ON	The power is not supplied. → Check the conduction of the power cables. → Check if the breaker for the equipment is switched on.	p. 37
				The power voltage or frequency is different. → Check the power rating. (100 V to 240 V, 50 Hz / 60 Hz)	–
				The screen is dark. → Adjust the backlight brightness and contrast.	p. 106
1-2	The keys cannot be operated.	Display	**[K.LOCK]** is displayed.	The keys are locked. → Deactivate the key lock.	p. 102
			[I.LOCK] is displayed.	The instrument is placed in the interlock state. → Deactivate the interlock.	p. 62
			[RMT] is displayed.	The instrument is placed in the remote state. → Deactivate the remote control.	p. 140
1-3	Judgment results are not displayed.	Measured values	are displayed.	The comparator function is set to OFF. → Set the function to ON.	p. 91
			are not displayed. (Non-values are displayed)	If measured values are not displayed, judgment is not done and the indicator is not displayed.	–
1-4	Buzzer cannot be heard.	Key operation tone setting	OFF	The key operation tone is set to OFF. → Set the function to ON.	p. 101
		Judgment sound setting	OFF	The judgment sound is set to OFF. → Set the function to ON.	p. 93
1-5	I want to adjust the buzzer volume.	The buzzer volume cannot be adjusted for this instrument.			–
1-6	The measured values are not displayed.	Run self-calibration. If an error is displayed, internal damage may have occurred. Contact your authorized Hioki distributor or reseller.			p. 60

Measurement items

No.	Trouble	Confirm		Possible causes → Solution	Reference
2-1	Measured values are not stable.	Measurement lead	Self-fabricated	Electromagnetic induction affects the measured values. → Guard the cable, including its end as close to the measured object as possible.	p. Appx.12
		Measured object	Temperature has not been stabilized.	Characteristics have changed depending on the temperature. → Perform measurements after the fluctuation in temperature becomes moderate.	–
		Temperature sensor	Not inserted all the way in.	The Humidity Sensor is not correctly connected. → Insert the Humidity Sensor all the way in.	p. 32

EXT I/O items

No.	Trouble	Confirm	Possible causes → Solution	Reference
3-1	The instrument does not operate at all.	Does the EXT I/O test result, which is the status of the input and the output displayed on the instrument, match with that of the controller?	Wiring etc. is incorrect. → Check the EXT I/O in terms of the following: • Loose connection of the connectors • Pin numbers • Wiring of the ISO_COM terminals • NPN/PNP settings • Contact (or open collector) control (Not controlled by voltage) • Power supply to the controller (Power to the instrument is not required.)	p. 112
3-2	Trigger is not applied.	Trigger source	The trigger mode is set to the internal trigger. → Set it to the external trigger.	p. 58
		Is the on-state time of TRIG more than 0.1 ms?	The on-state time of TRIG is insufficient. → Ensure an on-state time of 0.1 ms or more.	–
3-3	EOM is not output.	Are the measured values updated?	Check Q&A in 3-2.	–
		EOM signal logic	The EOM signal will be in the on state once the measurement is completed.	p. 115
3-4	HI, IN, and LO signals are not output.	Are the judgment results displayed on the instrument screen?	Check Q&A in 1-3.	p. 159

Communication items

The operation can be checked smoothly by using the communication monitor (p. 138).

No.	Trouble	Confirm		Possible causes → Solution	Reference
4-1	The instrument refuses to respond.	Display	**[RMT]** is not displayed.	Connection cannot be established. → Check the connector insertions. → Check that the settings of the interfaces are correct. → Before using the USB, install drivers in the control instruments. → Use the cross cable when RS-232C is used. → Check the COM port number of the control instrument. → Confirm the communication speeds of the instrument to that of the control instrument.	p. 131
			[RMT] is displayed.	Commands are not accepted. → Check the delimiter of the software.	p. 131
4-2	Results in an error.	Display	Results in a command error.	Commands are incorrect. → Check the spelling of the commands. (A space is represented as the numeric character reference x20H.) → Eliminate question marks (?) from commands with no query. → Confirm the communication speeds of the instrument to that of the control instrument.	*1
				The input buffer (256 bytes) overflows. → Wait until the received character strings are processed. Example: Insert dummy queries, e.g., sending `*OPC?` and receiving “1,” every time several lines of commands are sent. Insert a dummy query for sending several lines of commands such as Send `*OPC?` > Receive “1”	
			Results in an execution error.	The command string is correct, but the instrument is not in a state to execute. Example: When sending an unsettable command during **START**. → Check each command specification.	
				The input buffer (256 bytes) overflows. → Wait until the received character string is processed. Example: Insert dummy queries, e.g., sending `*OPC?` and receiving “1,” every time several lines of commands are sent.	
4-3	An response to the query is not returned.	On the communication monitor	There is a response.	The program is not correct. → The instrument returned the query. Check the receiving part of the program.	

*1: For details, refer to the Communication Command Instruction Manual on the accompanying CD.

Error display and solution

System errors (requiring repair)

Error No.	Display	Cause	Solution
ERR:001	Backup data error	Backup data error	Malfunctions occur in the instrument. Request repairs.
ERR:002	RAM error	CPU RAM error	
ERR:003	Memory read/write error	Memory read/write error	
ERR:004	Calibration error	Calibration error in the current measurement block	
ERR:005	A/D communication error	A/D communication error	
ERR:006	Measurement function error	Error in the internal communications with the measurement block	
ERR:007	Power function error	Error in the internal communications with the voltage output block	
ERR:009	Power line detection error	Power frequency detection error	
ERR:011	Over current error	Over-current error	
ERR:012	Adjustment data error	Adjustment data error	
ERR:013	ROM check sum error	Program ROM check sum error	
ERR:014	Fan stop error	Fan stop error	

Function errors

Error No.	Display	Cause	Solution
ERR:101	Command error	The command is not correct.	Check an incorrect command. Refer to Communication Command Instruction Manual in the accompanying CD.
ERR:102	Execution error	The command cannot be executed.	
ERR:103	Parameter error	The parameter part of the command is not correct.	Check an incorrect parameter. Refer to Communication Command Instruction Manual in the accompanying CD.
ERR:110	LOW LIMIT is higher than UPP LIMIT.	The lower limit value is greater than the upper limit value in the comparator setting.	Check an incorrect comparator setting. See “6 Judging Measured Value (Comparator Function)” (p. 91).
ERR:111	Keylocked. Press [UNLOCK] 1 sec to unlock.	The key lock is activated.	Press and hold the **MENU** key for more than 1 second to deactivate the key lock.
ERR:112	Double action is ON. Press [STOP] first and press [START] within 1 sec to start.	The double action function is set to ON.	To start measurement, press the **STOP** key, and then press the **START** key within 1 second. See “8.5 Preventing Test From Being Incorrectly Started (Double Action Function)” (p. 106).

Error No.	Display	Cause	Solution
ERR:113	Can not set this speed. Please change valid range.	The specified measurement speed cannot be set with the present range setting.	Change the range to another, and then change the measurement speed. See “Current measurement accuracy” (p. 143).
ERR:114	Can not set this range. Please change valid speed.	The specified range cannot be set with the present measurement speed setting.	Change the measurement speed to another, and then change the range. See “Current measurement accuracy” (p. 143).

Measurement errors

Error No.	Display	Cause	Solution
None	Current Over Range	The measured value exceeds the current measuring range.	Set the correct range.
None	+Over°C	The measured value exceeds the temperature measuring range. The measuring range is from −40.0°C to 80.0°C.	The temperature is too high to be measured with this instrument.
None	-Over°C	The measured value is lower than the temperature measuring range. The measuring range is from −40.0°C to 80.0°C.	The temperature is too low to be measured with this instrument.
None	Over%rh	The humidity value exceeds the humidity measuring range. The measuring range is from 0.0%RH to 90.0%RH.	The relative humidity is too high to be measured with this instrument.

Other errors

Error No.	Display	Cause	Solution
None	--.--°C	The Humidity Sensor is not connected.	Connect the Humidity Sensor sensor to the instrument.
None	--.-%rh	The Humidity Sensor is not connected.	Connect the Humidity Sensor to the instrument.

12.2 Inspection, Repair and Cleaning

⚠ WARNING

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

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. Please contact your Hioki distributor to have your instrument periodically calibrated.

Backing up the data

The instrument may be initialized (The factory default settings may be restored) when it is repaired or calibrated.
Before you ask for repair or calibration, it is recommended to back up (save or record) the measurement conditions and measured data.
For information about how to back up data, see the abridged manual that accompanies the SM Sample Application Manual, which can be downloaded from Hioki's website.

Replaceable parts and service life

The characteristics of some of the parts used in the product may deteriorate when used for a long time. To ensure the product can be used over the long term, it is recommended to replace these parts on a periodic basis.
When replacing parts, please contact your authorized Hioki distributor or reseller. The service life of parts varies with the operating environment and frequency of use. Parts are not guaranteed to operate throughout the recommended replacement cycle.

Part name	Recommended replacement cycle	Remarks/conditions
Electrolytic capacitors	Approx. 3 years	The circuit board on which the corresponding part is mounted will be replaced.
LCD backlight (Brightness half-life)	Approx. 10 years	When the backlight is used for 24/7 × 365 days
Fan motor	Approx. 7 years	When the backlight is used for 24/7 × 365 days
Relay	Approx. 3 years	When the range is switched 30 times/h

Cleaning

⚠ CAUTION

Clean the vents periodically to avoid blockage.
If a vent becomes clogged, the instrument's internal cooling is impeded, and damage may result

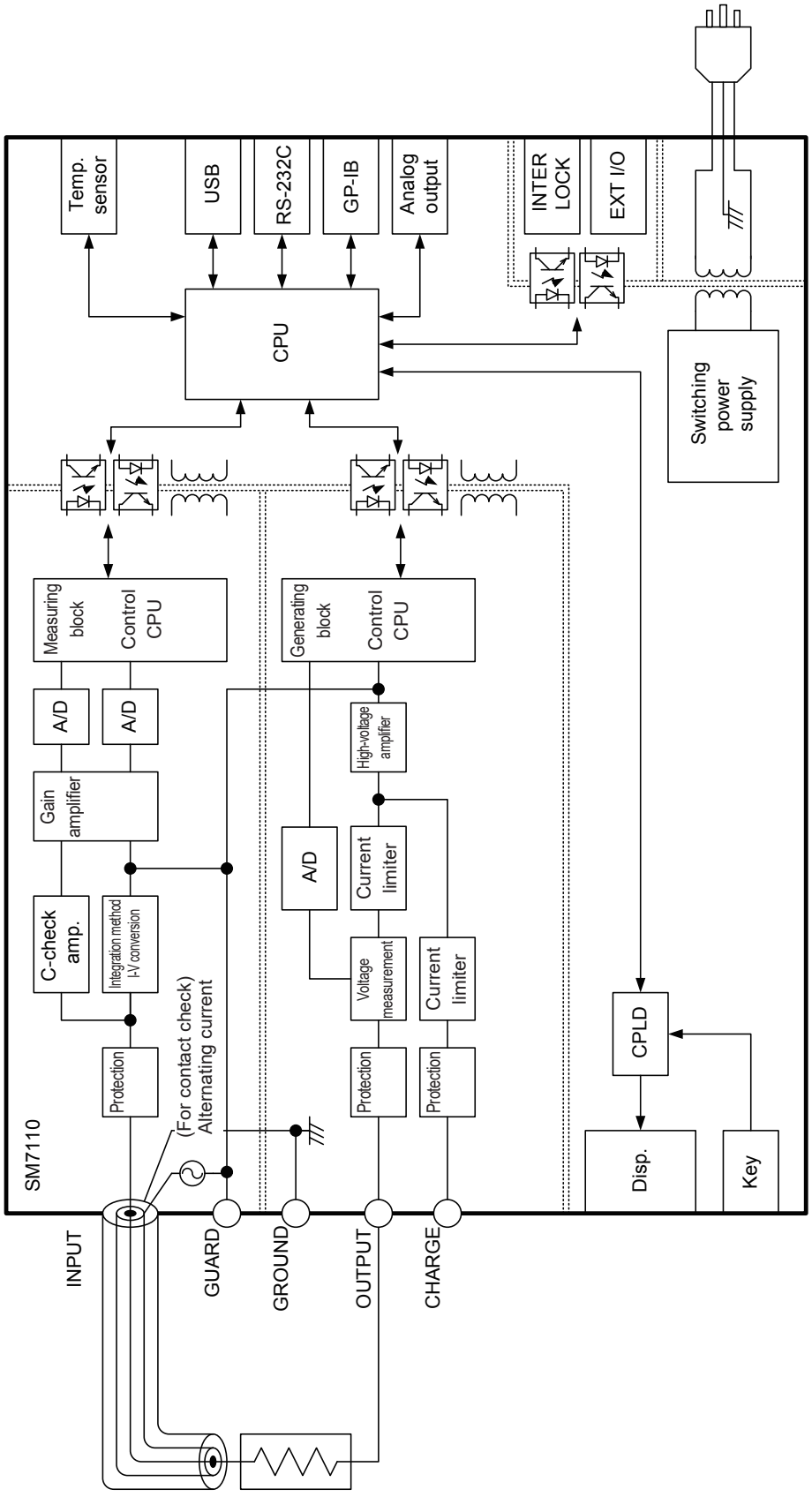
- To clean the instrument, wipe it gently with a soft cloth moistened with water or mild detergent.
- Wipe the LCD gently with a soft, dry cloth.

Disposal

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

Appendix

Appx. 1 Internal Circuits



Appx. 2 Changes in Current Running through Insulator

When measuring insulation resistance, a large current flows as a voltage is applied, and gradually the current becomes smaller, not reaching a constant value.
This is caused by charge current, absorption current, and leak current, and is generally called dielectric absorption. The equivalent circuit of an insulator is shown in Figure 1. In this figure, applying a voltage generates charge currents flowing through the capacitance C_0, C_1, C_2, . . . , C_n. First, these currents charge C_0, and then C_1, C_2, . . . , C_n in order. As the charging progressed, the currents become smaller, resulting in only a leak current flowing through R0 remaining. (See Figure 2.)

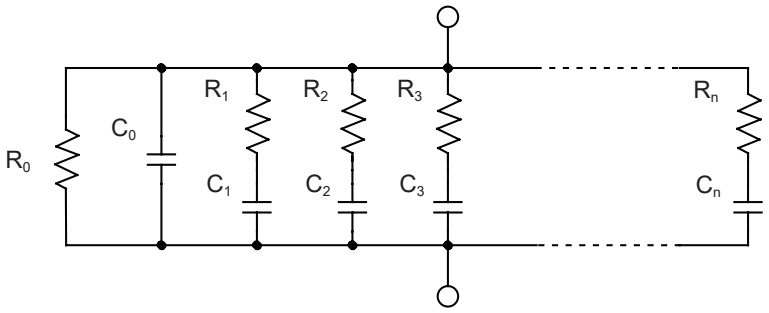


Figure 1 Equivalent Circuit of the Insulator

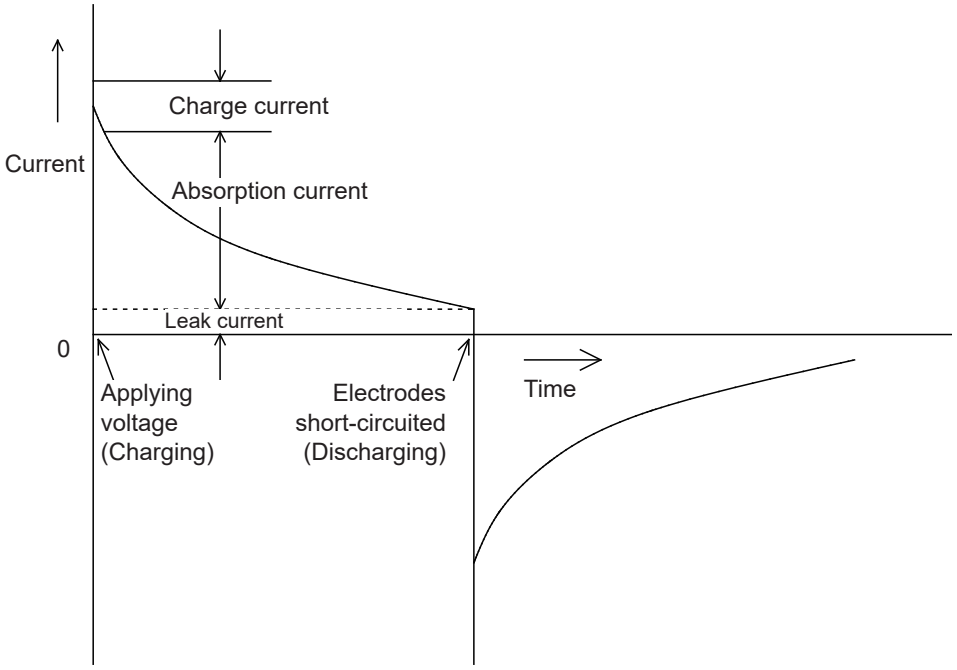


Figure 2 Dielectric Absorption

R_0 is the insulation resistance. Because the high resistance R_1, R_2, . . . , R_n are connected in series respectively with C_1, C_2 , . . . , and C_n, it is difficult to measure only R_0 separately.
It is generally said that the time until convergence can be several hours to several days. Therefore, the resistance 1 minute after applying voltage is considered as the insulation resistance. It is called 1-minute insulation resistance, and is widely used in standards.
When measuring the 1-minute insulation resistance, the first value differs from the second or third consecutively measured values, so be sure to discharge the object with a voltage applied before a measurement.
It also depends on the amount of voltage across C_0 shown in Figure 1; however, discharging the capacitance generally requires a period 5 to 6 times as long as the voltage-applying time during the measurement.

Appx. 3 Sample calculation of resistance measuring accuracy (SM7110)

1. Measure a current value flowing through the measuring object (monitor a current value using current measuring mode) and calculate the resistance of the measuring object. Assuming that the current value stands at 1.00000 nA, the resistance value is found from the following formula.

$$R = \frac{V}{I} = \frac{100.0\ [\mathrm{V}]}{1.00000\ [\mathrm{nA}]} = 100.000\ [\mathrm{G\Omega}]$$

R: Resistance of measuring object
V: Measuring voltage
I : Current value flowing through measuring object

2. Calculate current measuring accuracy

$$\pm(\underbrace{1.00000\ [\mathrm{nA}]\times 0.5\ [\%]}_{\text{Calculation of reading error}}+\underbrace{0.00001\ [\mathrm{nA}]\times 20\ [\mathrm{dgt}]}_{\text{Calculation of full-scale error}} = \pm 0.00520\ [\mathrm{nA}]$$

$$\pm\left(\frac{0.00520\ [\mathrm{nA}]}{1.00000\ [\mathrm{nA}]}\times 100\right) = \pm 0.52\ [\%]$$

3. Calculate voltage generating accuracy.

$$\pm(100.0\ [\mathrm{V}]\times 0.1\ [\%]+100.0\ [\mathrm{V}]\times 0.05\ [\%] = \pm 0.15\ [\mathrm{V}]$$

$$\pm\left(\frac{0.15\ [\mathrm{V}]}{100.0\ [\mathrm{V}]}\times 100\right) = \pm 0.15\ [\%]$$

4. Calculate insulation resistance measuring accuracy.

$$\pm(0.52\ [\%]+0.15\ [\%]) = \pm 0.67\ [\%]$$

$$\pm(100.000\ [\mathrm{G\Omega}]\times 0.67\ [\%]) = \pm 0.670\ [\mathrm{G\Omega}]$$

Appx. 4 Countermeasures Against Noise

(1) Effects of induction noise

A lot of noise is generated from power cords, fluorescent lights, solenoid valves, and computer displays. Below are noise sources that may affect resistance measurement.

1. Electrostatic coupling between a high-voltage line and a measurement lead
2. Magnetic coupling between a high-current line and a measurement lead

Electrostatic coupling between a high-voltage line and a measurement lead

Current that flows in from a high-voltage line is controlled by electrostatic capacitance coupled with a measurement lead.
For example, if a 100 V commercial power line and a resistance measurement lead are electrostatically coupled with a capacitance of 1 pF, a current of approximately 38 nA is induced.

$$I = \frac{V}{Z} = 2\pi \cdot 60 \cdot 1\,\mathrm{pF} \cdot 100\,\mathrm{V_{RMS}} = 38\,\mathrm{nA_{RMS}}$$

If a 1 Ω resistor is measured with a measurement current of 100 mA, the effect reaches to only 0.4 ppm of the measured value and may be ignored. If a resistance of 1 MΩ is measured with a measurement current of 10 μA, the effect is only 0.38% to the measured value. For high resistance measurement, care against electrostatic coupling between a high-voltage line and a measurement lead should be exercised. Shielding measurement leads and objects to be measured electrostatically is effective (Figure 1).

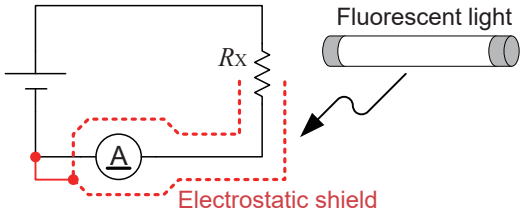


Figure 1 Electrostatic shield close to high-voltage wiring

Magnetic coupling between a high-current line and a measurement lead

A magnetic field is generated from a high-current line. An even larger magnetic field is emitted from transformers and choke coils with a lot of turns. A voltage induced by the magnet field is affected by distance and surface area. A loop with a area of 10 cm^2 placed 10 cm away from a commercial power line carrying a current of 1A generates a voltage of 0.75 μV.

$$v = \frac{d\phi}{dt} = \frac{d}{dt}\left(\frac{\mu_0 IS}{2\pi r}\right) = \frac{4\pi \cdot 10^{-7} \cdot fI}{r}$$

$$= \frac{4\pi \cdot 10^{-7} \cdot 60\,\mathrm{Hz} \cdot 0.001\,\mathrm{m^2} \cdot 1\mathrm{A_{RMS}}}{0.1\,\mathrm{m}} = 0.75\,\mu\mathrm{V_{RMS}}$$

If a 1 mΩ resistor is measured with a measurement current of 1 A, the effect is 0.07% of the measured value. With high resistance measurements, there is no issue because the detection voltage can be increased easily.

Twisting each pair of voltage detection leads, which are for resistance measurement, and noise generating lines in addition to separating the pairs from each other will effectively decrease the impact of magnetic coupling (Figure 2).

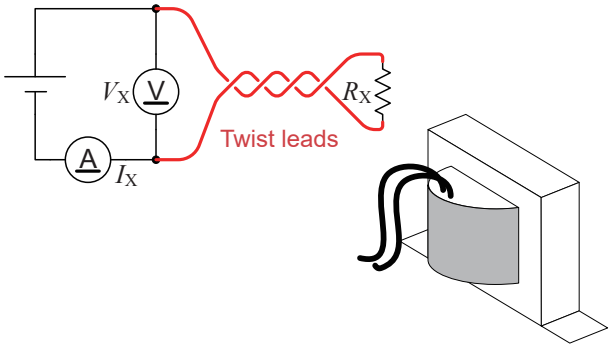


Figure 2 Twist leads close to a high-current line

Countermeasures for the instrument against induction noise

Attaching a ferrite core around a measurement lead as shown in Figure 3 is effective.

In addition to taking the countermeasure on the instrument the instrument, twisting the surrounding noise-generating large current wires and shielding the high-voltage wires are even more effective.

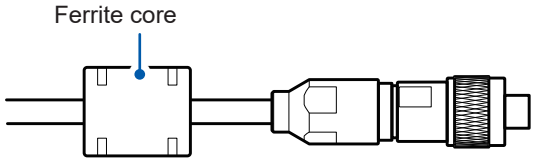


Figure 3 Ferrite core

If the induction noise is caused by a commercial power

Induction noise caused by a commercial power is not only generated from commercial power lines and power outlets, but also fluorescent lights and household electronics. Noise caused by the commercial power depends on the frequency of the commercial power, and is generated at a frequency of 50 Hz or 60 Hz.
To reduce the effect of noise caused by this commercial power, generally the reset time is set to an integral multiple of the power cycle (Figure 4).

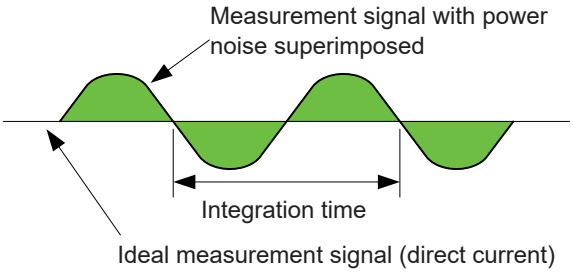


Figure 4 Noise caused by the commercial power

The measurement speed of the instrument has the following five options: FAST, FAST2, MED, SLOW, and SLOW2. For high resistance and low resistance measurement, measured values may not be stable. In that case, you should reduce the measurement speed or take actions against the noise.
If the instrument is operated on AC with a frequency of 50 Hz while the power frequency setting is set to 60 Hz, the reset time will not be synchronized with the power cycle, and the measured values will be fluctuated. Check the power frequency settings.

(2) Effects of conductive noise

Aside from induction noise superimposed on a measured object or measurement leads, conductive noise can invade via another path. Conductive noise refers to noise superimposed on control lines such as power lines and USB cables.
Various equipment is connected to a power line such as motors, welding machines, inverters, etc.
While this equipment is running, or when it is turned on or off, a significant spike will flow through the power line. Due to this spike current and impedance of the power line, a large spike voltage can be generated in the power line and ground line of the power, resulting in effects on the measurement instrument.
Similarly, noise may also be injected from control lines of the controller. Noise that penetrated from the power of the controller, or was generated from a DC-DC converter installed the controller, penetrates the measurement instrument through a USB cable or EXT I/O wire (Figure 5).

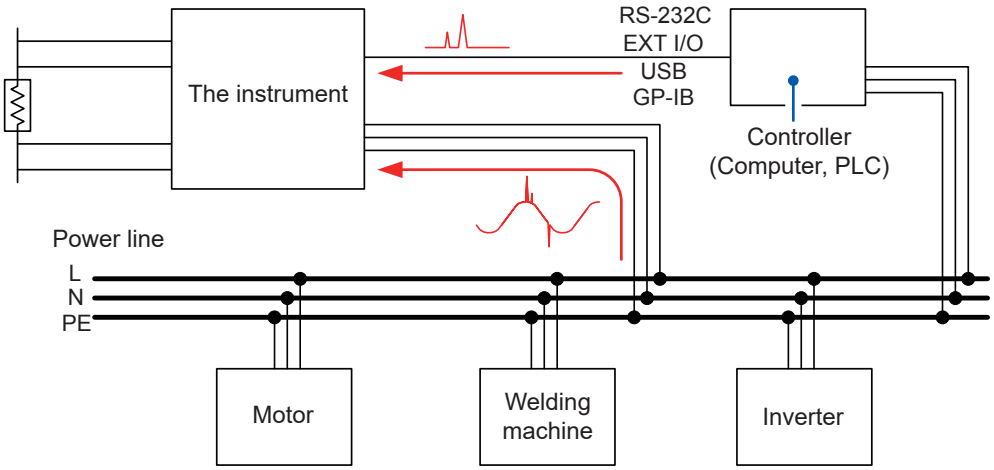


Figure 5 Conductive Noise Penetration

Conductive noise can be monitored with the Hioki 3145 Noise HiLogger while measures are taken. If the penetration path has been specified, follow the measures shown in Figure 6.

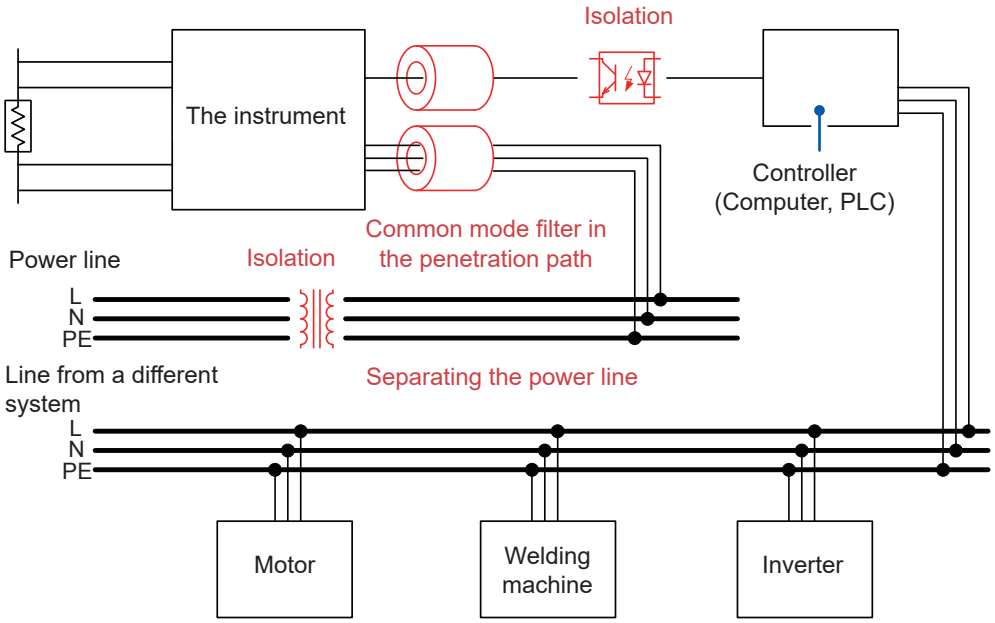


Figure 6 Conductive Noise Countermeasures

Separating the power line

It is best to connect power systems and welding machines to a power from a different system than the instrument.

Install the common mode filter (EMI choke) to the penetration path.

Common mode filters are more effective if you choose ones with high-impedance and install several of them.

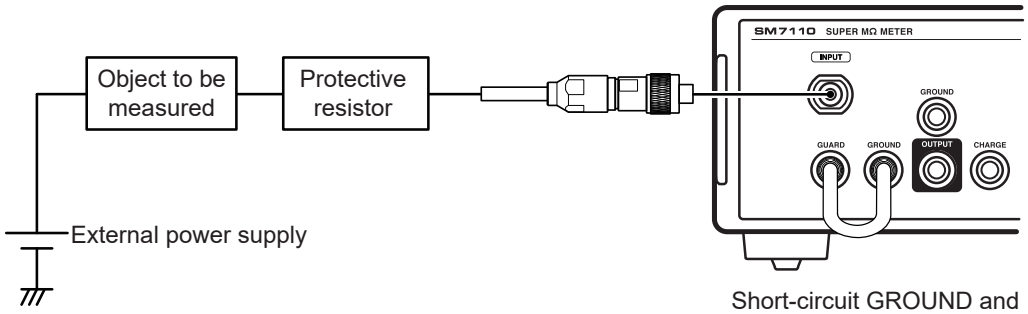
Insulation

Optically isolating the control line will improve the susceptibility to noise.
In Addition, optically isolating the power line with a noise-cut transformer will improve the susceptibility to noise improves.
However, keep in mind that if the ground line is shared by the source side wiring of the transformer and the load side wiring of it, the effect may be diminished.

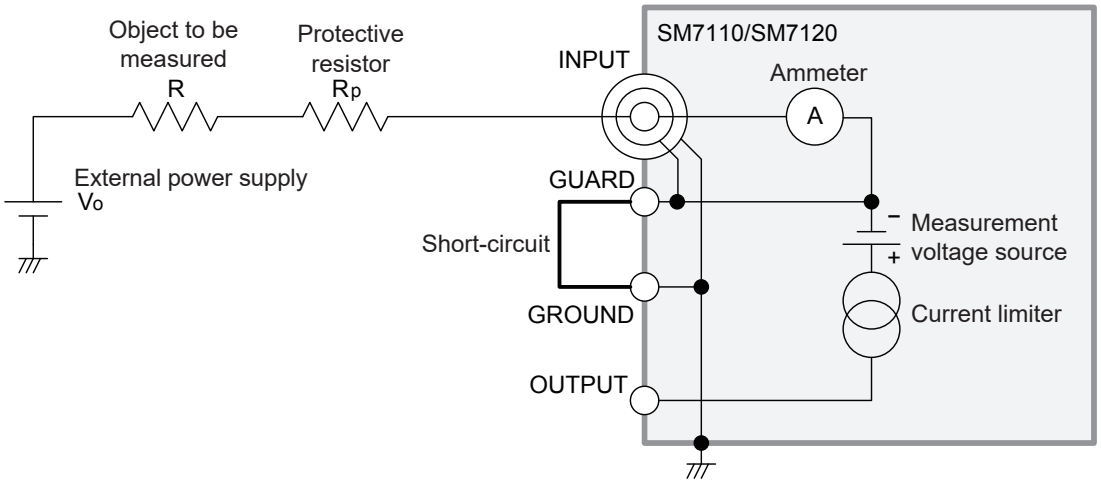
Appx. 5 Using Instrument as Ammeter (If Operated in Combination With External Power Supply)

Be sure to read “Before using the instrument as an ammeter” (p. 14) beforehand.

1 Connect the object to be measured and the other devices to the instrument as follows.



Short-circuit GROUND and GUARD with shorting plug



When using the external power supply, insert a protective resistor so that a current flowing through the instrument is reduced to the current rating or less even if the terminals of the object to be measured are short-circuited with each other.
Test using a measurement voltage of 1000 V or less: 50 mA or less
Test using a measurement voltage exceeding 1000 V: 1.8 mA or less

2 Configure the instrument setting as follows:

Trigger: Internal trigger (INT) (p. 58)
Setting of voltage value for resistance calculation: voltage set value (set value is external power supply output value) (p. 56)

3 Turn on the external power supply.

4 Connect the measurement leads to the object to be measured.

5 Apply the voltage from the external power supply.

6 Press the START key.

A measurement starts.

Determining protective resistance

See “Current-limiting resistor” (p. Appx.11).

Appx. 6 Assembling Switching Unit for Objects to be Measured

To improve the operating efficiency of the insulation resistance measurement, you can assemble a switching device for the following cases:

- Measuring multiple objects in series, selecting a object to be measured with relays
- Measuring a objects that has multiple measurement points with respect to any two of the points in series, selecting measurement points with relays

To measure objects precisely, consider various factors when assembling the switching device.

This chapter describes the following contents.

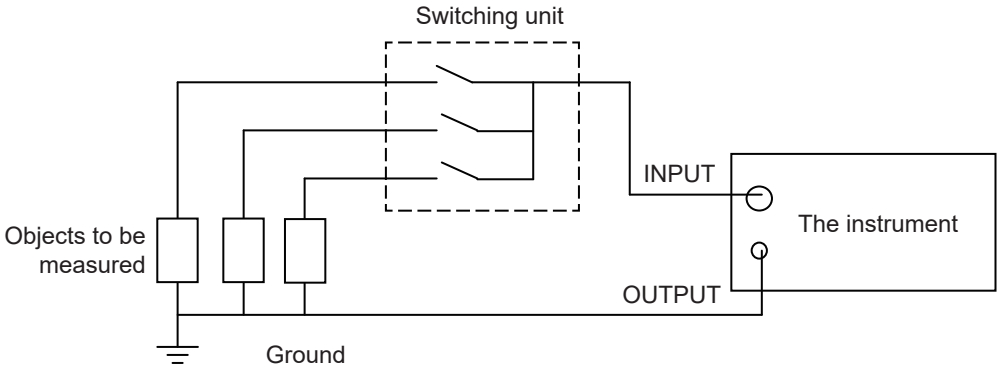
- Procedure for connecting objects to be measured and switching units to the instrument
- Precautions for selecting relays that are to be installed in the switching unit
- Circuit diagram of the switching unit
- Procedure for assembling the switching unit

Connecting objects to be measured and the switching unit to the instrument

Two methods are available depending on the status of the objects to be measured.

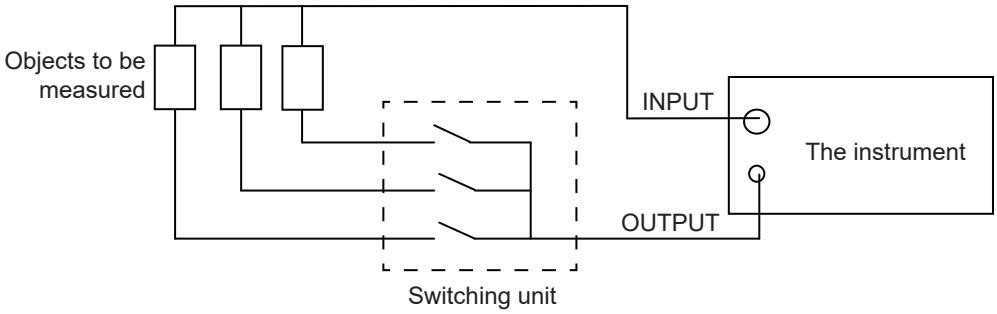
If the objects to be measured are grounded

Because the OUTPUT terminal of the instrument is grounded, connect the switching unit to the INPUT terminal.



If the objects to be measured are not grounded

Measurement can be performed using the same method given in “If the objects to be measured are grounded,” but you can also measure objects with the switching unit connected to the OUTPUT terminal as follows.



Selecting relays to be installed in the switching unit

Important specifications for relays

Switching voltage and dielectric strength

"Maximum switching voltage" and "dielectric strength between contacts and between a contact and a coil" must be sufficiently high with respect to the instrument's set voltage.

Switching current

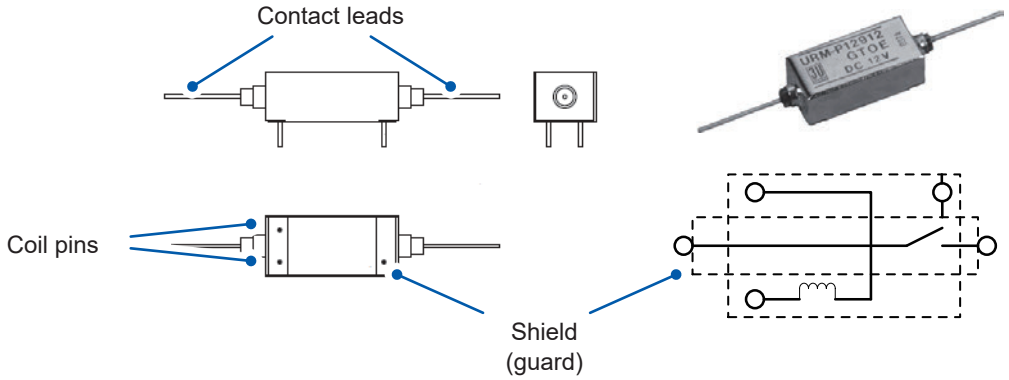
Select relays with switching currents that are high enough relative to a current flowing even if the terminals of a measured object are short-circuited with each other.
In addition, the rated maximum current of the relays must be higher than a transient surge current, which is generated at the moments when contacts become closed and open.
Thus, generally you should include a resistor that limits the current in series with the relay as close to as possible.

Insulation resistance

An insulation resistance between contacts and that between a contact and a coil must be high enough to be negligible with respect to a insulation resistance of a an object to be measured (1000 times greater or more). For example, if the insulation resistance of the object to be measured is 100 MΩ, use a relay with an insulation resistance 100 times greater or more (10,000 MΩ or more) than the insulation resistance of the object to be measured. (If 100 times greater, the error from connecting the switching device to the instrument will be 1% of a measured value; and 1000 times, 0.1%.)

Shape, structure

An ideal structure of a relay is such that its contacts are pulled out with a lead wire, and the contacts and coil are shielded with each other.
For a plug-in type relay, an insulation resistance between pins installed in a relay socket themselves are included in parallel with a space between contacts in the relay, resulting in the negative effect that measured insulation resistance values are lower than expected.
In addition, for the plug-in type relay, long-term use leads to the socket being covered with dirt due to the dust attraction effect of high voltage, and causes insulation deterioration.

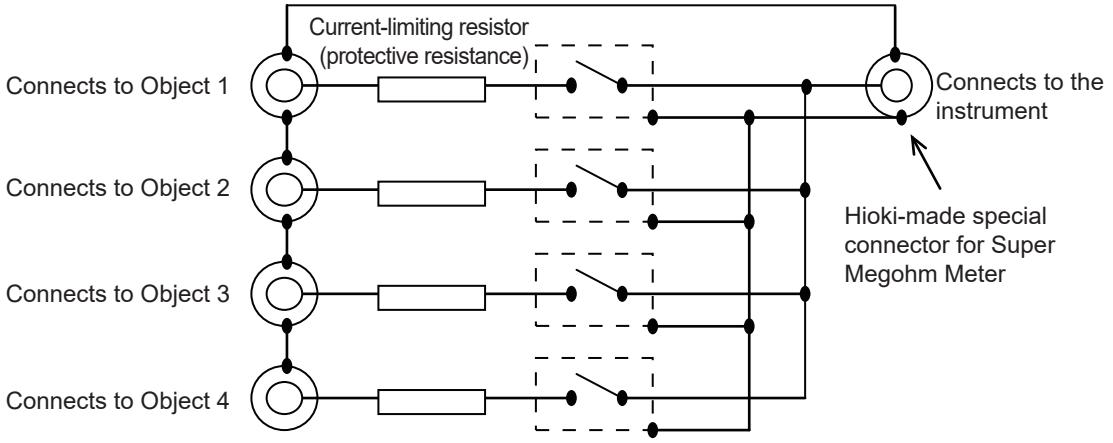


Example (measurement voltage is 350 V or less)

Manufacturer:	Sanyu Electric, Inc.
Model:	URM series
Maximum switching voltage:	350 V
Maximum switching current:	0.5 A
Insulation resistance between contacts:	10^{13} Ω or 10^{14} Ω can be specified
Between contact and guard:	Same as above
Between coil and guard:	10^{11} Ω

Circuit diagram of the switching unit

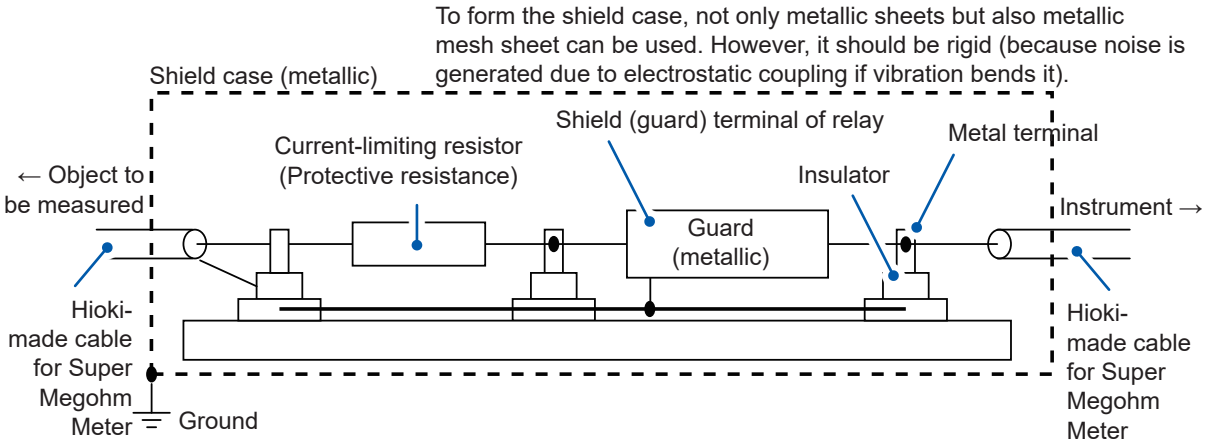
To connect between the measurement leads and the instrument or between the leads and objects to be measured, employ the connectors that are custom-made by Hioki for use with the Super Megohm Meter.
In addition, as for the cables between the instrument and the switching unit and between the switching unit and objects to be measured, employ the cables that are custom-made by Hioki for use with the Super Megohm Meter.



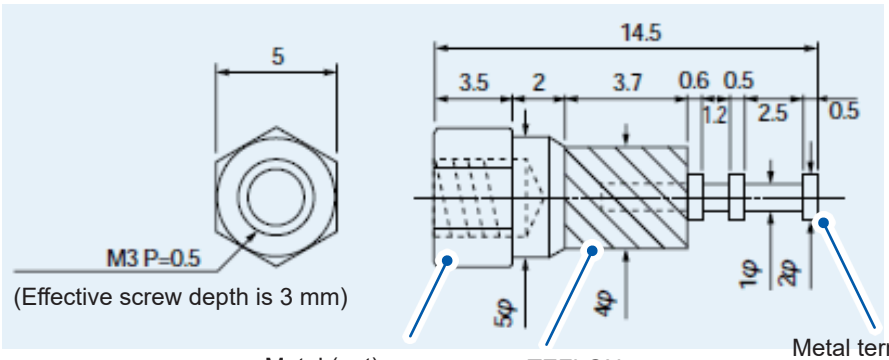
Including current-limiting resistor (protective resistance) and relay

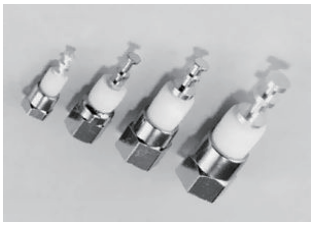
Guard and shield

When connecting a relay and a current-limiting resistor (protective resistance) to the instrument, pay attention to the guard and shield.
See the following example (The guard prevents DC interfering currents from flowing, whereas the shield prevents AC interfering currents from flowing).



Example of terminal for adding relay and resistor





Thread mount TEFLON terminal block FN-1-1 manufactured by Mac-Eight

Metal (nut)
(Used as guard shown in figure on previous page)

TEFLON
(Insulator)

Metal terminal
(Used as metal terminal shown in figure above)

Current-limiting resistor

Resistance value

Decide resistance values of current-limiting resistor as follows, the resistance value can be determined in the following manner:

(1) Resistors shall be low enough to be negligible relative to the insulation resistance of objects to be measured; however, be as high as possible.

(2) The value equivalent to 20 times the time constant with respect to the electrostatic capacity component of objects to be measured shall be short enough relative to the measurement time.

For example, if you want to measure a insulation resistance of 10,000 MΩ with a electrostatic capacitance of 1,000 pF for 5 sec

Considering Item (1), the current limit resistance is calculated from the following expression:

10000×106 ÷ 1000 = Approximately 10 MΩ

The measurement time is calculated, as described in Item (2), from the following expression:

10 MΩ × 1,000 pF × 20 = 0.02 sec

Because this time is considered to be short enough compared to 5 seconds, a resistance of 10 MΩ is acceptable as the current-limiting resistance.

Selecting resistor

Refer to the specifications of current limiting-resistors to check if the maximum working voltages of them are higher that a set voltage of the instrument.

In addition, resistances with power ratings that are high enough relative to a current flowing even if the terminals of an object to be measured is short-circuited with each other.

For example, for a 10 MΩ current-limiting resistor and a set voltage of 250 V, if the terminals of the object to be measured are short-circuited with each other, the load power is calculated from the following expression:

250 V × 250 V ÷ 10 MΩ = 0.00625 W

Considering heat generated by resistance, in general, power ratings 5 times or more, ideally 10 times of the load power is required.

(Example: KOA high voltage high resistance thick film resistor GS1/2 10 MΩ)

Determine a current-limiting resistor so as to limit the current flowing into the instrument to the current rating.

Test using a measurement voltage of 1000 V or less: 50 mA or less

Test using a measurement voltage exceeding 1000 V: 1.8 mA of less

The current is calculated from the following expression:

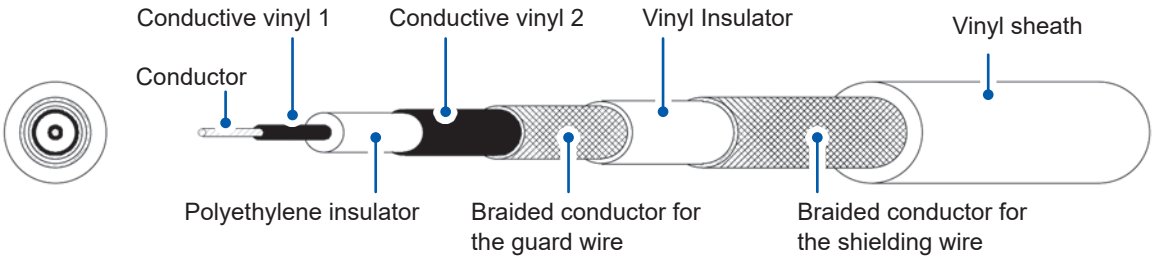
250 V ÷ 10 MΩ = 25 μA

The resistance value, which meets the condition above, is proved to be acceptable.

Appx. 7 Modifying Measurement Lead

When modifying the tip of the Hioki-made measurement lead, follow the procedure below:
When stripping off the jacket or braided conductor, take care not to break the wires or short-circuit them with each other.
We will not guarantee the accuracy of measured values obtained using measurement leads modified by users.

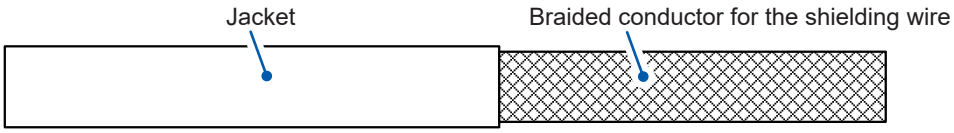
Structure of shielding wire of Hioki-made measurement leads



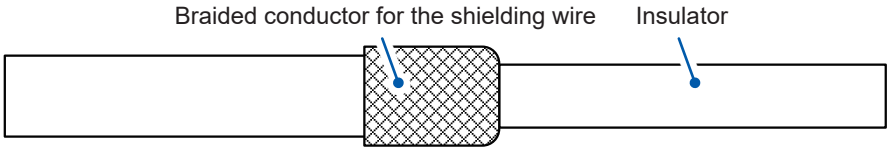
Item	Thickness (Approx.)	Diameter (Approx.)	
Conductor	–	0.54 mm	
Conductive vinyl 1	0.23 mm	1.00 mm	
Polyethylene insulator	0.85 mm	2.70 mm	
Conductive vinyl 2	0.22 mm	3.15 mm	
Braided conductor for the guard wire	0.25 mm	3.65 mm	
Vinyl Insulator	0.35 mm	4.35 mm	
Braided conductor for the shielding wire	0.25 mm	4.85 mm	
Vinyl sheath	1.05 mm	7.00 mm	+0.0 mm -0.2 mm

Modifying the tip of measurement leads

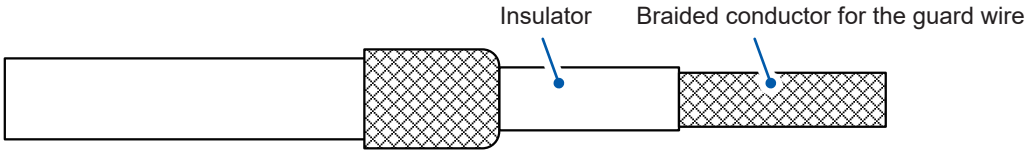
1 **Strip off the jacket from with a knife, etc.**



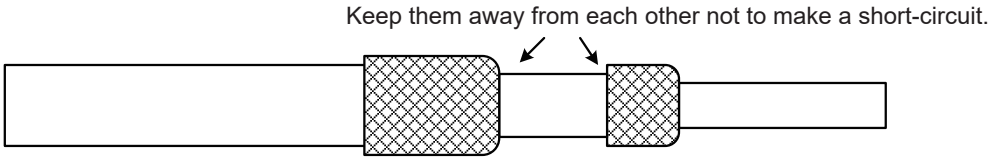
2 **Turn the braided conductor for the shielding wire inside out.**



3 **Strip off the insulator with a knife, etc.**

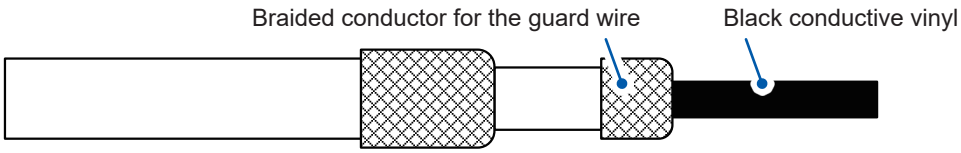


4 **Turn the braided conductor for the guard wire inside out.**

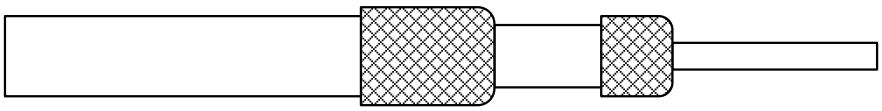


Take care not to short-circuit the shielding wire and the guard wire with each other.

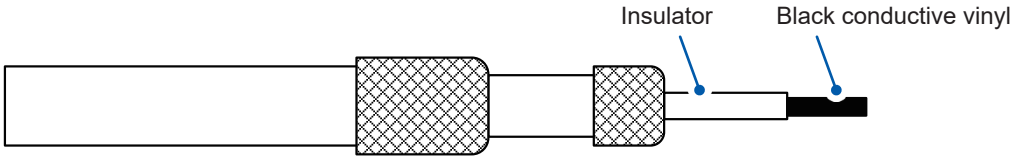
5 **Strip off the insulation with a knife, etc.**



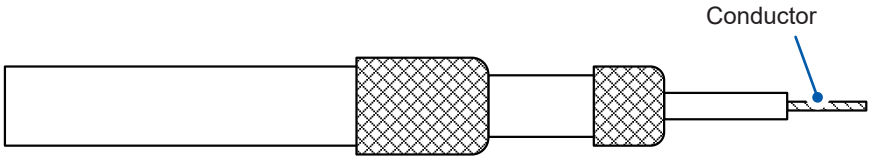
6 **Completely remove the conducting vinyl.**



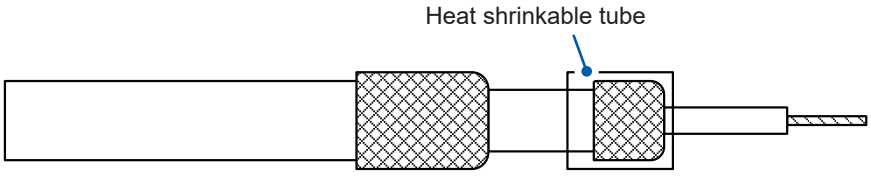
7 **Strip off the insulation with a knife, etc.**



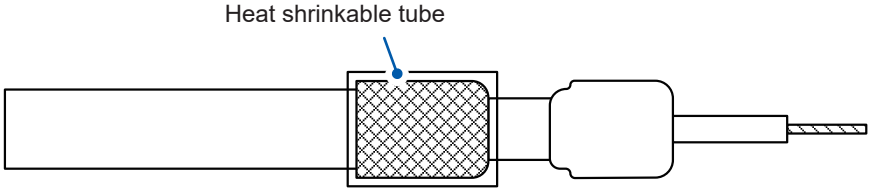
8 **Completely remove the conducting vinyl.**



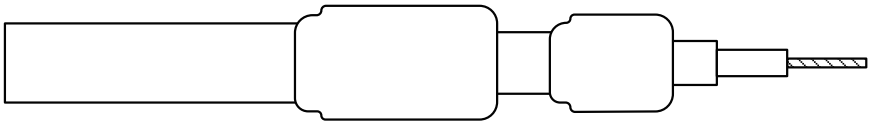
9 **Cover the guard wire with a heat shrinkable tube and make it shrink.**



10 **Cover the shielding wire with a heat shrinkable tube and make it shrink.**



Completed



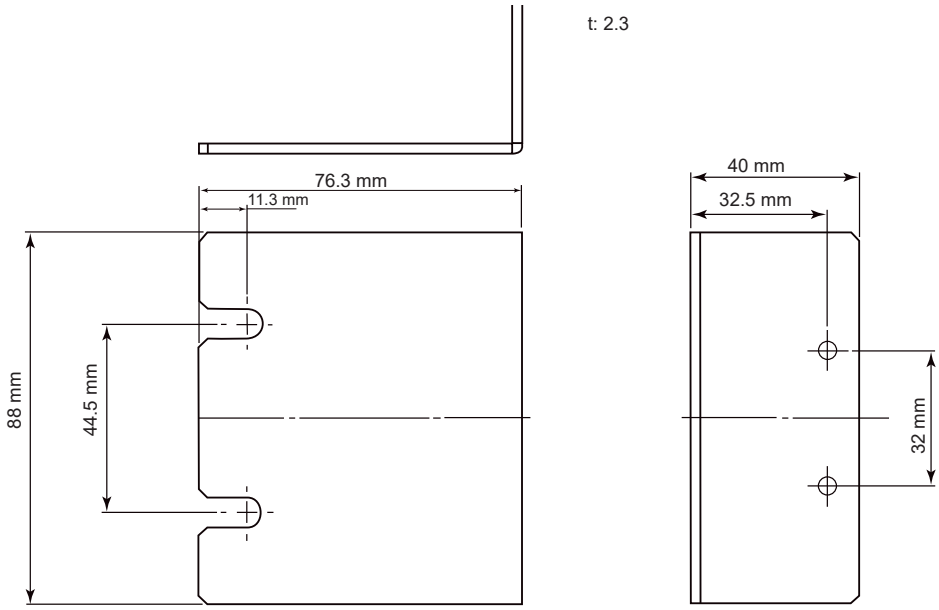
Appx. 8 Mounting Instrument in Rack

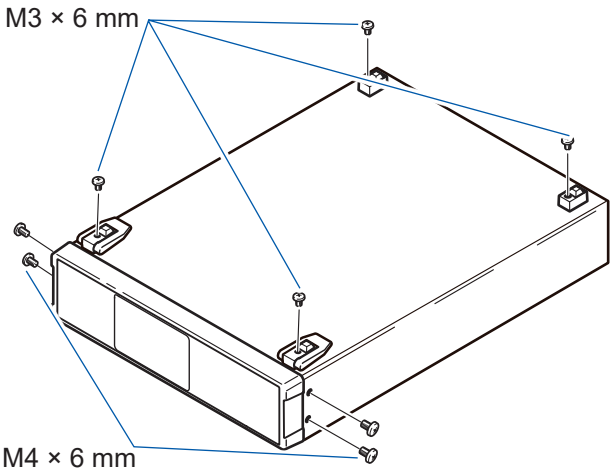
By using the internal threads on the sides, a rack mounting plate can be attached on the instrument.

⚠ WARNING

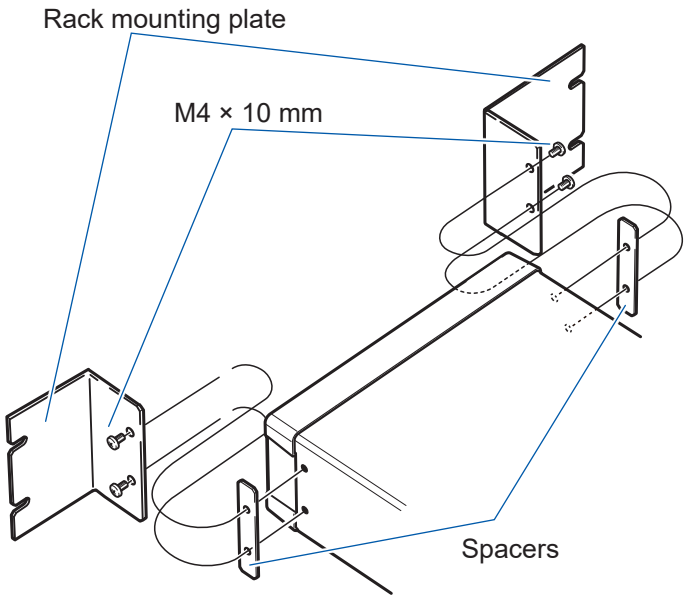
To prevent instrument damage or an electric shock, use only the screws that originally secure the stands and the cover. (Stands: M3 × 6 mm, sides: M4 × 6 mm, when attaching a rack mounting plate: M4 × 10 mm)
If you lost any screws or find that any screws are damaged, please contact your Hioki distributor for a replacement.

Rack mounting plate (EIA)





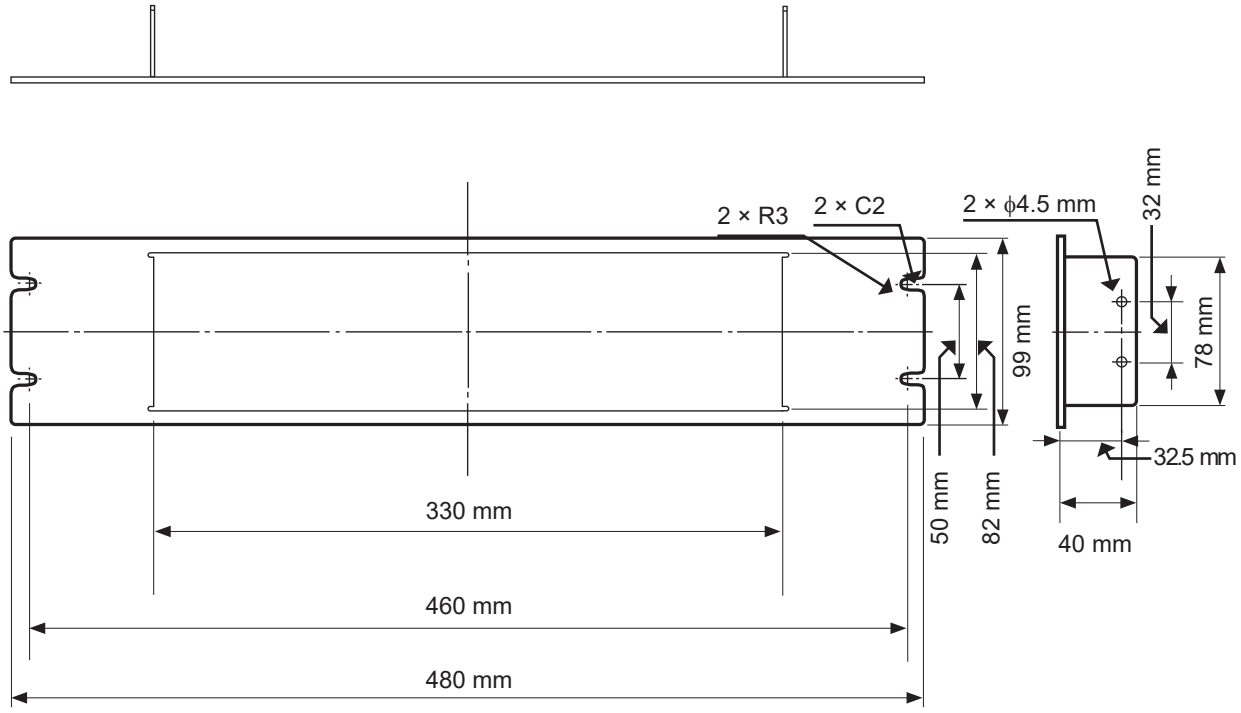
1 **Remove the stands from the bottom of the instrument, and the screws from the sides (4 near the front).**

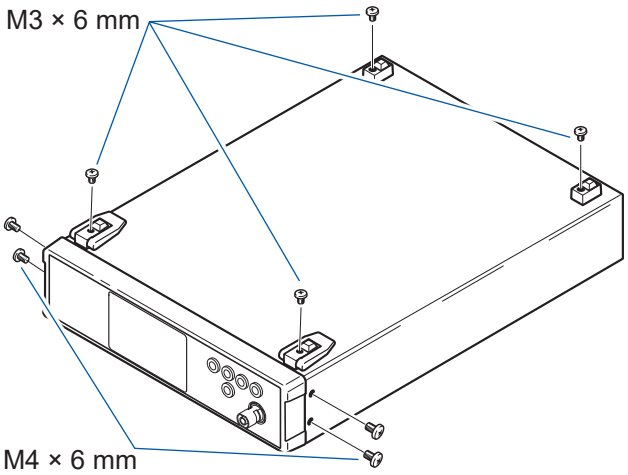


2 **Install the spacers on both sides of the instrument, secure the rack mounting plate with the M4 × 10 screws.**

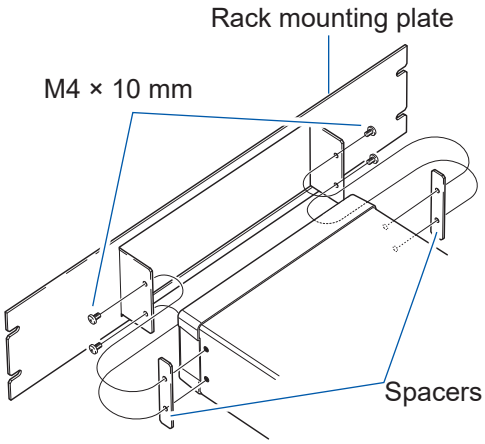
- When installing the instrument into the rack, support the instrument with a commercially available support stand.
- Ensure that the vents on the sides and rear are not blocked.

Rack mounting plate (JIS)





1 **Remove the stands from the bottom of the instrument, and the screws from the sides (4 near the front).**

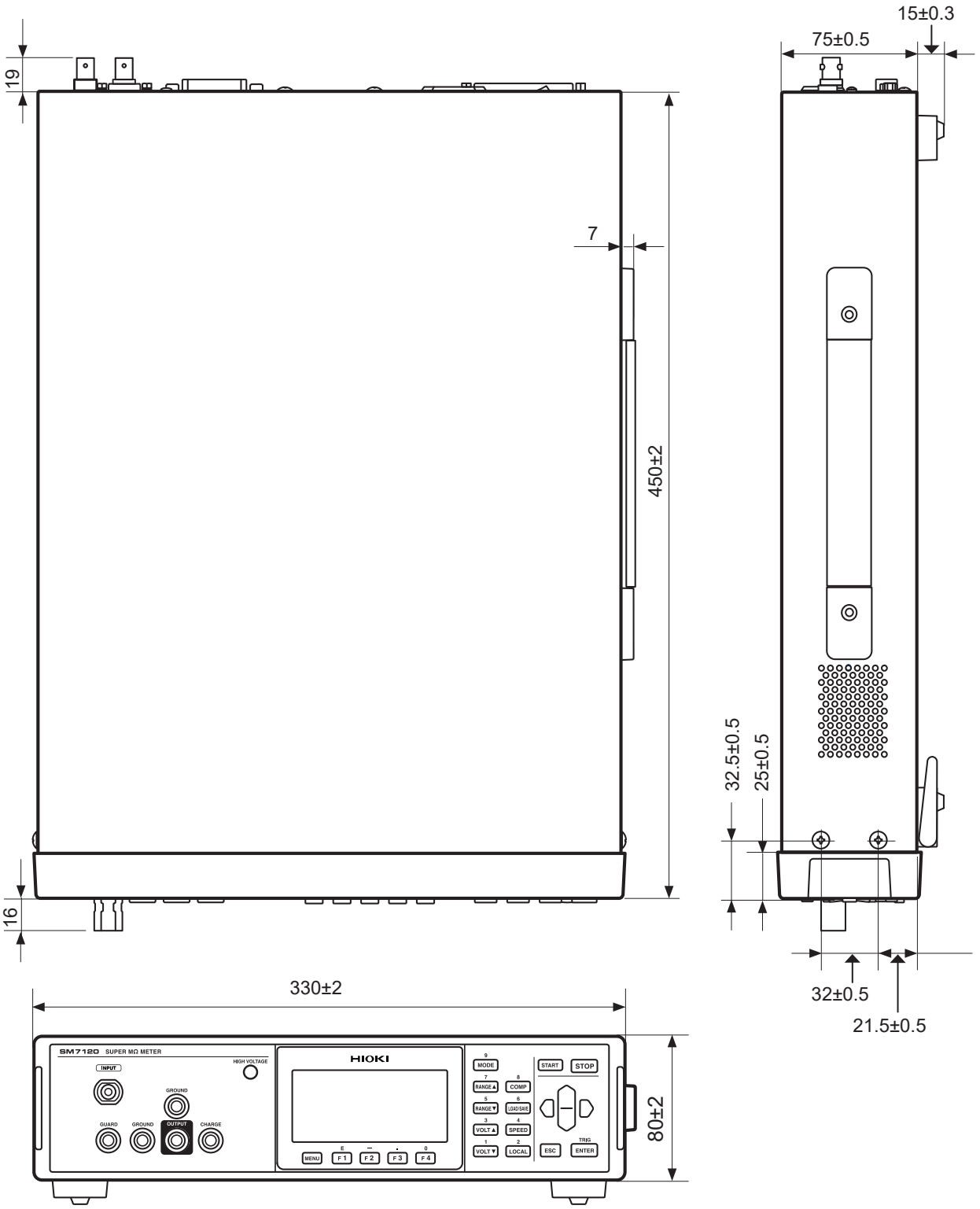


2 **Install the spacers on both sides of the instrument, secure the rack mounting plate with the M4 × 10 screws.**

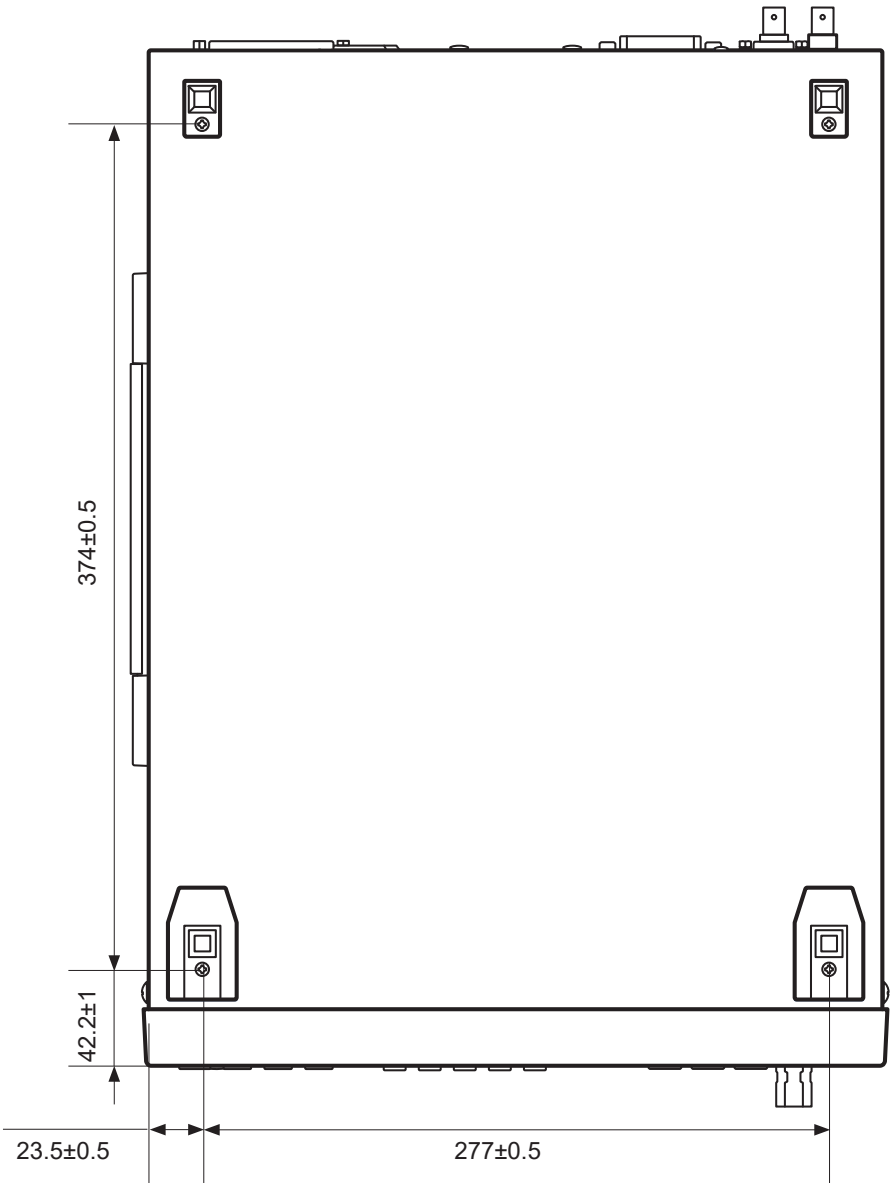
- When installing the instrument into the rack, support the instrument with a commercially available support stand.
- Ensure that the vents on the sides and rear are not blocked.

Appx. 9 Dimensional Diagram

Unit: mm



Unit: mm



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Warranty Certificate

HIOKI

Model	Serial number	Warranty period Three (3) years from date of purchase (___ / ___)

Customer name: _____

Customer address: _____

Important

- Please retain this warranty certificate. Duplicates cannot be reissued.
- Complete the certificate with the model number, serial number, and date of purchase, along with your name and address. The personal information you provide on this form will only be used to provide repair service and information about Hioki products and services.

This document certifies that the product has been inspected and verified to conform to Hioki's standards.
Please contact the place of purchase in the event of a malfunction and provide this document, in which case Hioki will repair or replace the product subject to the warranty terms described below.

Warranty terms

1. The product is guaranteed to operate properly during the warranty period (three [3] years from the date of purchase). If the date of purchase is unknown, the warranty period is defined as three (3) years from the date (month and year) of manufacture (as indicated by the first four digits of the serial number in YYMM format).
2. If the product came with an AC adapter, the adapter is warrantied for one (1) year from the date of purchase.
3. The accuracy of measured values and other data generated by the product is guaranteed as described in the product specifications.
4. In the event that the product or AC adapter malfunctions during its respective warranty period due to a defect of workmanship or materials, Hioki will repair or replace the product or AC adapter free of charge.
5. The following malfunctions and issues are not covered by the warranty and as such are not subject to free repair or replacement:
   -1. Malfunctions or damage of consumables, parts with a defined service life, etc.
   -2. Malfunctions or damage of connectors, cables, etc.
   -3. Malfunctions or damage caused by shipment, dropping, relocation, etc., after purchase of the product
   -4. Malfunctions or damage caused by inappropriate handling that violates information found in the instruction manual or on precautionary labeling on the product itself
   -5. Malfunctions or damage caused by a failure to perform maintenance or inspections as required by law or recommended in the instruction manual
   -6. Malfunctions or damage caused by fire, storms or flooding, earthquakes, lightning, power anomalies (involving voltage, frequency, etc.), war or unrest, contamination with radiation, or other acts of God
   -7. Damage that is limited to the product's appearance (cosmetic blemishes, deformation of enclosure shape, fading of color, etc.)
   -8. Other malfunctions or damage for which Hioki is not responsible
6. The warranty will be considered invalidated in the following circumstances, in which case Hioki will be unable to perform service such as repair or calibration:
   -1. If the product has been repaired or modified by a company, entity, or individual other than Hioki
   -2. If the product has been embedded in another piece of equipment for use in a special application (aerospace, nuclear power, medical use, vehicle control, etc.) without Hioki's having received prior notice
7. If you experience a loss caused by use of the product and Hioki determines that it is responsible for the underlying issue, Hioki will provide compensation in an amount not to exceed the purchase price, with the following exceptions:
   -1. Secondary damage arising from damage to a measured device or component that was caused by use of the product
   -2. Damage arising from measurement results provided by the product
   -3. Damage to a device other than the product that was sustained when connecting the device to the product (including via network connections)
8. Hioki reserves the right to decline to perform repair, calibration, or other service for products for which a certain amount of time has passed since their manufacture, products whose parts have been discontinued, and products that cannot be repaired due to unforeseen circumstances.

HIOKI E.E. CORPORATION
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HIOKI

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