RM3545
RM3545-01
RM3545-02

HIOKI

Instruction Manual

RESISTANCE METER

Video

Scan this code to watch the instructional video(s).
Carrier charges may apply.
Scan this code to watch the instructional video(s).
Carrier charges may apply.

EN

Jan. 2019 Revised edition 4
RM3545A981-04 19-01H

* 6 0 0 4 1 4 1 5 4 *

Using This Instruction Manual

To do this…	Refer to these sections in this manual.
Review important information	Safety Information (p.4) Operating Precautions (p.6)
Start using the instrument right away	Overview (p.19)
Learn more about instrument functions	Search for the function in question in the table of contents (p.i) or the index (p.Index 1).
Learn more about product specifications	Specifications (p. 251)
Troubleshoot a problem	Troubleshooting (p. 286)
Learn more about resistance measurement	Appendix (p. A1)
Learn more about communications commands	Communications Command Instruction Manual (on the application disc)

1
2
3
4

Contents

Chapter 10 External Control (EXT I/O) 177

Chapter 11 Communications (USB/ RS-232C/ GP-IB Interface) 221

Chapter 12 Printing (Using an RS-232C Printer) 239

Chapter 13 Specifications 251

Introduction

Thank you for purchasing the HIOKI Model RM3545/ RM3545-01/ RM3545-02 Resistance Meter. To obtain maximum performance from the instrument, please read this manual first, and keep it handy for future reference.

Model RM3545-01 is the same as the RM3545, but with GP-IB included.
Model RM3545-02 is the same as the RM3545, but Multiplexer Slot included.

Trademarks

- 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 trademark of The Chemours Company FC, LLC

Verifying Package Contents

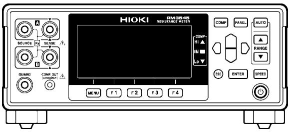
Inspection

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

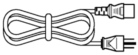
Content confirmation

Confirm that these contents are provided.

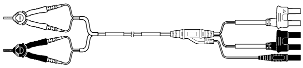
☐ Model RM3545 or
RM3545-01 (with GP-IB included) or
RM3545-02 (with Multiplexer Slot included) .. 1



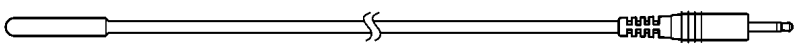
☐ Power Cord (2-line + ground) (p. 35) 1



☐ Model L2101 Clip Type Lead 1

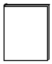


☐ Model Z2001 Temperature Sensor 1

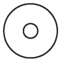


☐ EXT I/O Male Connector (p. 220).................. 1

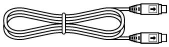
☐ Instruction Manual (This document)... 1



☐ Application disc (CD)* 1
(Communications Command Instruction Manual, USB driver)



☐ USB cable (A-B type)......................... 1



☐ Spare Fuse (F1.6AH/250V) 1

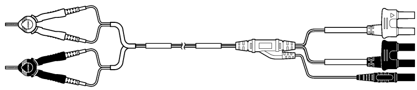
* The latest version of the application disc can be downloaded from the Hioki web site.

Options

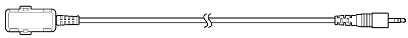
Contact your authorized Hioki distributor or reseller for details.
See: "Appendix 17 Measurement Leads (Options)" (p. A35)

Measurement

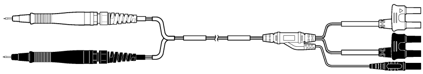
☐ Model L2101 Clip Type Lead



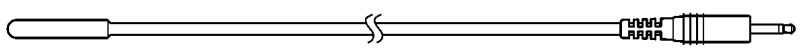
☐ Model L2105 LED Comparator Attachment



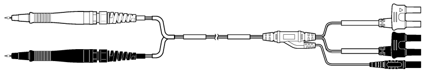
☐ Model L2102 Pin Type Lead



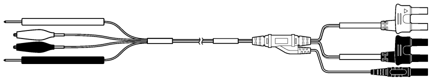
☐ Model Z2001 Temperature Sensor



☐ Model L2103 Pin Type Lead



☐ Model L2104 4-Terminal Lead



Interface Cables

☐ Model 9637 RS-232C Cable (9pin-9pin/ 1.8 m/ crossover cable)
☐ Model 9638 RS-232C Cable (9pin-25pin/ 1.8 m/ crossover cable)
☐ Model 9151-02 GP-IB Connector Cable (2 m)

Multiplexer Unit

☐ Model Z3003 Multiplexer Unit

Safety Information

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

⚠DANGER	**Mishandling during use could result in injury or death, as well as damage to the product. 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 discharge due to short circuits. If persons unfamiliar with electricity measuring instruments are to use the product, another person familiar with such instruments must supervise operations.**

This manual contains information and warnings essential for safe operation of the instrument and for maintaining it in safe operating condition. Before using it, be sure to carefully read the following safety precautions.

Safety Symbols

⚠	In the manual, the ⚠ symbol indicates particularly important information that the user should read before using the instrument. The ⚠ symbol printed on the instrument indicates that the user should refer to a corresponding topic in the manual (marked with the ⚠ symbol) before using the relevant function.
∼	Indicates AC (Alternating Current).
I	Indicates the ON side of the power switch.
○	Indicates the OFF side of the power switch.
⊟	Indicates a fuse.

The following symbols in this manual indicate the relative importance of cautions and warnings.

⚠DANGER	Indicates that incorrect operation presents an extreme hazard that could result in serious injury or death to the user.
⚠WARNING	Indicates that incorrect operation presents a significant hazard that could result in serious injury or death to the user.
⚠CAUTION	Indicates that incorrect operation presents a possibility of injury to the user or damage to the instrument.
NOTE	Indicates advisory items related to performance or correct operation of the instrument.

Symbols for Various Standards

CE	Indicates that the product conforms to regulations set out by the EU Directive.
	WEEE marking: This symbol indicates that the electrical and electronic appliance is put on the EU market after August 13, 2005, and producers of the Member States are required to display it on the appliance under Article 11.2 of Directive 2002/96/EC (WEEE).

Other Symbols

	Indicates the prohibited action.
(p.)	Indicates the location of reference information.
*	Indicates that descriptive information is provided below.
[ ]	Square brackets indicate instrument display labels (such as setting item names).
SET (Bold characters)	Bold characters within the text indicate operating key labels.

Accuracy

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

f.s.	(maximum display value) This is usually the name of the maximum displayable value. For this instrument, it indicates the currently selected range.
rdg.	(reading or displayed value) The value currently being measured and indicated on the measuring instrument.
dgt.	(resolution) The smallest displayable unit on a digital measuring instrument, i.e., the input value that causes the digital display to show a “1” as the least-significant digit.

See: "Example accuracy calculations" (p. 259)

Operating Precautions

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

Preliminary Checks

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

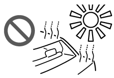
⚠DANGER

Before using the instrument, make sure that the insulation on the power cord, leads or cables is undamaged and that no bare conductors are improperly exposed. Using the instrument in such conditions could cause an electric shock, so contact your authorized Hioki distributor or reseller for replacements.

Instrument Installation

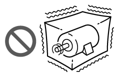
Operating temperature and humidity : 0 to 40°C at 80% RH or less (non-condensating)
Storage temperature and humidity : -10°C to 50°C at 80% RH or less (non-condensating)

Avoid the following locations that could cause an accident or damage to the instrument.

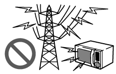

Exposed to direct sunlight
Exposed to high temperature

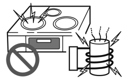
Exposed to water, oil, other chemicals, or solvents
Exposed to high humidity or condensation


Exposed to high levels of particulate dust


Subject to vibration

In the presence of corrosive or explosive gases

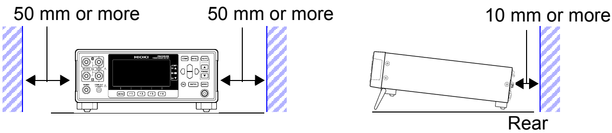

Exposed to strong electromagnetic fields
Near electromagnetic radiators


Near induction heating systems
(e.g., high-frequency induction heating systems and IH cooking utensils)

NOTE Correct measurement may be impossible in the presence of strong magnetic fields, such as near transformers and high-current conductors, or in the presence of strong electromagnetic fields such as near radio transmitters.

Installation Precautions

- The instrument should be operated only with the bottom downwards.
- Do not place the instrument on an unstable or slanted surface.



The instrument can be used with the stand (p. 24).
It can also be rack-mounted. (p. A36).

NOTE Unplugging the power cord kills power to the instrument. Be sure to provide enough unobstructed space to unplug the power cord immediately in an emergency.

Handling the Instrument

⚠WARNING

- **Do not allow the instrument to get wet, and do not take measurements with wet hands. This may cause an electric shock.**
- **Do not attempt to modify, disassemble or repair the instrument; as fire, electric shock and injury could result.**

⚠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.
- To avoid damage to the instrument, do not apply voltage or current to measurement terminals, TEMP.SENSOR jack, TEMP.ANALOG INPUT terminal block, COMP.OUT jack, or D/A OUTPUT terminal block.

NOTE

- 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.
- Use the original packing materials when transporting the instrument, if possible.

Handling the Cords and Leads

⚠DANGER

To avoid electrical shock, be careful to avoid shorting live lines with the test leads.

⚠CAUTION

- Avoid stepping on or pinching cables, which could damage the cable insulation.
- To avoid breaking cables or lead wires, do not bend or pull them.
- To avoid damaging the power cord, grasp the plug, not the cord, when unplugging it from the power outlet.
- To avoid damaging the cable, grasp the connector, not the cable, when unplugging the cable.
- The ends of the pin type lead are sharp. Be careful to avoid injury.
- Keep the cables well away from heat sources, as bare conductors could be exposed if the insulation melts.
- Temperature sensors are precision devices. Be aware that excessive voltage pulses or static discharges can destroy the film.
- Avoid subjecting the temperature sensor tip to physical shock, and avoid sharp bends in the leads. These may damage the probe or break a wire.
- To avoid electric shock, do not exceed the lower of the ratings shown on the instrument and test leads.

NOTE

- Use only the specified cords and leads. Using a non-specified cord or lead may result in incorrect measurements due to poor connection or other reasons.
- If the part of the temperature sensor that connects to the instrument becomes dirty, wipe it clean. The presence of dirt may affect temperature measured values by increasing the contact resistance.
- Exercise care so that the temperature sensor connector does not become disconnected. (If the sensor is disconnected, it will not be possible to perform temperature correction or temperature conversion.)

CD-R disc precautions

⚠CAUTION

- 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.

Before Connecting the Power Cord

⚠WARNING

- **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.**
- **Use only the designated power cord with this instrument. Use of other power cords may cause fire.**
- **Before using the instrument, make sure that the insulation on the power cord is undamaged and that no bare conductors are improperly exposed. Any damage could cause electric shock, so contact your authorized Hioki distributor or reseller.**

⚠CAUTION

To avoid damaging the power cord, grasp the plug, not the cord, when unplugging it from the power outlet.

Before Connecting Measurement Leads

⚠DANGER

To avoid shock and short circuits, turn off all power before connecting measurement leads.

Before Connecting the LED Comparator Attachment

⚠CAUTION

- To keep from damaging the instrument or LED Comparator Attachment, turn off the instrument before connecting the attachment.
- The COMP.OUT jack is provided exclusively for use with the L2105. Do not connect any device other than the L2105.
- The attachment may not fulfill the specifications if the connector is not attached securely.
- Do not over-tighten the cable tie around the measurement leads. Doing so may damage the measurement leads.
- Avoid the following as damage to the cable conductor or insulation may result:
  Twisting or pulling on cables
  Bending cables near the lamp excessively in order to connect them

Before Connecting the Temperature Sensor

⚠WARNING

Failure to fasten the connectors properly may result in sub-specification performance or damage to the equipment.

⚠CAUTION

Note the following precautions to avoid damaging the instrument:
- To keep from damaging the instrument or temperature sensor, turn off the instrument’s main power switch before connecting the sensor.
- Connect the temperature sensor by inserting the plug all the way into the TEMP.SENSOR jack. A loose connection can cause a large error component in measured values.

NOTE

- If the temperature sensor jack becomes dirty, wipe it clean. The presence of dirt will cause an error in temperature measured values.
- When connecting the temperature sensor, do not connect anything to the TEMP.ANALOG INPUT terminal block. Doing so may cause erroneous measured values to be displayed.

Before Connecting the Thermometer

⚠WARNING

- **Note that thermometer circuit is grounded. To avoid electric shock accidents or damage to the instrument, do not connect an analog output thermometer to the TEMP.ANALOG INPUT terminal block that has any potential offset from ground.**
- **Failure to fasten the connectors properly may result in sub-specification performance or damage to the equipment.**

⚠CAUTION

Note the following precautions to avoid damaging the instrument:
- Before connecting a thermometer to the instrument, confirm that any power to the instrument and thermometer is turned OFF.
- Allowable input voltage from an analog thermometer is 0 to 2 V (between terminal contacts). Do not apply voltage exceeding this range.

NOTE

- With thermometers providing 4 to 20 mA output, connect a shunt resistance of about 50 Ω before connecting, and convert the resulting voltage.
- When connecting the thermometer, do not connect anything to the TEMP.SENSOR jack. Doing so may cause erroneous measured values to be displayed.

Before Connecting Data Cables (USB, RS-232C, GP-IB)

CAUTION

Observe the following precautions when connecting the instrument and a controller:

- To avoid faults, do not disconnect or reconnect the USB cable during instrument operation.
- The USB, RS-232C, and GP-IB interfaces are not isolated from the ground circuit. Connect the instrument and the controller to a common earth ground. Using different grounds could result in potential difference between the instrument and the controller. Potential difference on the data cable can result in malfunctions and faults.
- Before connecting or disconnecting the RS-232C Cable and GP-IB Connector Cable, always turn off the instrument and the controller. Failure to do so could result in equipment malfunction or damage.
- After connecting the RS-232C Cable and GP-IB Connector Cable, tighten the screws on the connector securely. Failure to secure the connector could result in equipment malfunction or damage.

Before Connecting the Printer

WARNING

Because electric shock and instrument damage hazards are present, always follow the steps below when connecting the printer.

- **Always turn off the instrument and the printer before connecting.**
- **A serious hazard can occur if a wire becomes dislocated and contacts another conductor during operation. Make certain connections are secure.**

Before Switching between Current Sink (NPN) and Current Source (PNP)

CAUTION

- Configure the NPN/PNP setting to accommodate externally connected equipment.
- Do not operate the NPN/PNP switch while the instrument is on.

Before Connecting EXT I/O

⚠WARNING

To avoid electric shock or damage to the equipment, always observe the following precautions when connecting to the EXT I/O connector.

- **Always turn off the main power switch on the instrument and on any devices to be connected before making connections.**
- **Be careful to avoid exceeding the ratings of external terminals (p. 206).**
- **During operation, a wire becoming dislocated and contacting another conductive object can be serious hazard. Use screws to secure the external connectors.**
- **The ISO_5V pin of the EXT I/O connector is a 5V (NPN)/ -5V (PNP) power output. Do not apply external power to this pin. (External power cannot be supplied to the instrument's EXT I/O connector.)**

⚠CAUTION

To avoid damage to the instrument, observe the following cautions:

- Do not apply voltage or current to the EXT I/O terminals that exceeds their ratings.
- When driving relays, be sure to install diodes to absorb counter-electromotive force.
- Be careful not to short-circuit ISO_5V to ISO_COM.
- Configure the NPN/PNP setting to accommodate externally connected equipment.
- Do not operate the NPN/PNP switch while the instrument is on.

See: "Connector Type and Signal Pinouts" (p. 179)

Before Attaching a Multiplexer Unit
Before Connecting the Multiplexer's Connector

⚠WARNING

- **To avoid electric shock, before removing or replacing a Multiplexer Unit, confirm that the instrument's main power switch is off and that the measurement leads, power cord, and all connectors have been disconnected.**
- **The mounting screws must be firmly tightened or the Multiplexer Unit may not perform to specifications, or may even fail.**
- **Failure to fasten the connectors properly may result in sub-specification performance or damage to the equipment.**
- **When connecting a measurement target with electromotive force (a battery or power supply), take steps to protect against short-circuits.**
- **The Z3003 Multiplexer Unit's maximum allowable voltage for contacts is 30 V RMS/42.4 V peak, or 60 V DC. Do not connect directly to a dielectric strength tester or insulation resistance tester.**
- **To avoid the danger of electric shock, never operate the instrument with a multiplexer unit removed. To use the instrument after removing a multiplexer unit, install a blank panel over the opening of the removed unit.**

⚠CAUTION

- When inserting in the unit, hold the metal plate. Directly touching the board may cause damage of the unit or accuracy deteriorations in the higher resistance ranges due to the influence of static electricity. Taking countermeasures against static electricity (using antistatic devices such as a wrist strap) as well as wearing antistatic gloves are recommended.
- To prevent malfunctions when not using the Multiplexer Unit, store it using the packaging materials in which it was delivered.

Before Using D/A Output

⚠CAUTION

- To avoid electric shock and instrument damage when connecting a device to the instrument's D/A output terminal, turn off main power switch on the instrument and the device being connected and ensure that the measurement leads have been disconnected from the measurement target.
- The maximum output voltage that can be generated from the D/A output is 5 V. If the rated voltage of the device being connected is less than 5.5 V, the connected device could be damaged.
- D/A output is not isolated from the ground circuit. If the device connected to D/A output is not isolated from the ground circuit, the error component in measured values will increase.

Before Turning Power On

⚠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.

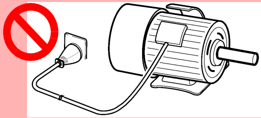
⚠CAUTION

Avoid using an uninterruptible power supply (UPS) or DC/AC inverter with rectangular wave or pseudo-sine-wave output to power the instrument. Doing so may damage the instrument.

Before Measuring

⚠WARNING

- **To avoid electric shock or damage to the instrument, do not apply voltage to the measurement terminals. Also, to avoid electrical accidents, only take measurements after turning off the power to the measurement targets being measured.**

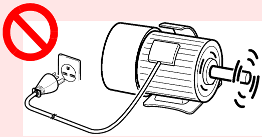


The measurement target is connected to a power supply.

- **Sparks may result at the moment the instrument is connected to, or disconnected from, the measurement target. To avoid fire or bodily injury, avoid use in the presence of explosive gases.**

⚠CAUTION

- Never attempt to measure at a point where voltage is present. Even if the power supply to the motor is turned off, while the motor is rotating inertially, high electromotive power is generated in terminals. When attempting to measure a transformer or motor immediately after voltage withstanding test, induced voltage or residual charge may damage the instrument.



Rotating inertially

- When the RM3545 is used in a way that connects to a withstanding voltage tester via switching relays, construct a testing line bearing the following in mind.

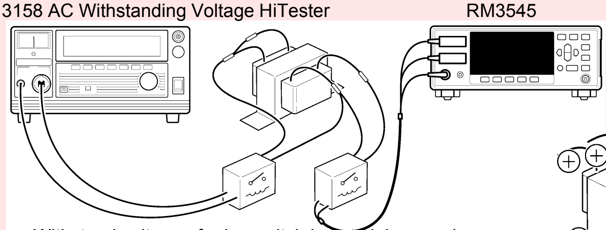
  See: "Appendix 16 Using the Instrument with a Withstanding Voltage Tester" (p. A34)

  (1) The voltage withstanding specification of switching relays should include a safe margin over the withstanding testing voltage.

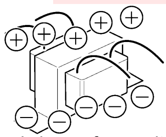
  (2) To protect against damage due to arc discharge in relay contacts, all RM3545 measurement terminals should be grounded during voltage withstanding testing.

  (3) To protect against damage due to residual charge, measure resistance first, and voltage withstanding last.

3158 AC Withstanding Voltage HiTester RM3545



Withstand voltage of relay switch is not high enough.



Residual charge from voltage withstanding test is present.

- Battery internal resistance cannot be measured with this instrument. It will sustain damage. To measure battery internal resistance, we recommend the HIOKI 3555, BT3562, BT3562-01, BT3563, BT3563-01, and 3561 Battery HiTesters ; BT3554, BT3554-01, BT3564, BT3554-10, and BT3554-11 Battery Testers.

NOTE

- To obtain the guaranteed measurement accuracy, allow at least 60 minutes warm-up.
- When measuring devices such as power supply transformers with high inductance or open-type solenoid coils, measured value may be unstable. In such cases, connect a film capacitor of about 1 μF between SOURCE A and SOURCE B.
- Carefully insulate all SOURCE A, SENSE A, SENSE B, and SOURCE B wiring. Proper 4-terminal measurements cannot be performed and an error will occur if core and shield wires touch.
- The SOURCE terminal is protected by a fuse. If the fuse is tripped, the instrument will display "**Blown Fuse.**" and you will not be able to measure resistance values. If the fuse is tripped, replace the fuse.
  See: "14.2 Replacing the Measurement Circuit's Protective Fuse" (p. 302)
- Since the instrument uses DC current for measurement, it may be affected by thermal EMF, resulting in a measurement error. If so, use the Offset Voltage Compensation function (OVC).
  See: "4.8 Compensating for Thermal EMF Offset (Offset Voltage Compensation - OVC)" (p. 82)
  See: "Appendix 10 Effect of Thermal EMF" (p. A24)

When using the temperature sensor

⚠CAUTION

The temperature sensor is not waterproof. Do not submerse it in water or other liquid.

NOTE

- Allow the measurement target for which temperature correction is being performed and the temperature sensor to adjust to the ambient temperature prior to measurement (for more than 10 minutes). Failure to do so will result in a large error component.
- Handling of the temperature sensor with bare hands may cause the sensor to pick up inductive noise, resulting in unstable measured values.
- The temperature sensor is designed for use in applications in which ambient temperature is measured. It is not possible to accurately measure the temperature of the measurement target itself by placing the sensor in contact with the surface of the target. Use of an infrared thermometer to perform correction is appropriate when there is a large temperature difference between the ambient environment and the measurement target.
- Connect the temperature sensor by inserting the plug all the way into the TEMP.SENSOR jack. A loose connection may cause a large error component in measured values.

Overview Chapter 1

1.1 Product Overview and Features

The RM3545 is capable of performing high-speed, high-precision measurement of the winding resistance of components such as motors and transformers, the contact resistance of relays and switches, the pattern resistance of printed circuit boards, and the DC resistance of fuses, resistors, and materials such as conductive rubber using four-terminal measurement. Since the instrument incorporates a temperature correction function, it is particularly well suited to the measurement of targets whose resistance values vary with temperature. It also provides features such as a comparator function, communications, external control, and a multiplexer*, allowing it to be used in a wide range of applications, including in development work and on production lines.

* The multiplexer can be used with the RM3545-02.

High-performance specifications to meet advanced development and production needs

- **Measurement range: 10 mΩ to 1000 MΩ/ Basic accuracy: 0.006%rdg.**
- **Maximum resolution: 10 nΩ**

  Supports low-resistance measurement of current detection resistors, reactors, welds, etc.
- **Up to 1 GΩ range**

  Can be used in open testing of contacts.
- **Discharge voltage of 20 mV or less**

  Low-power measurement can be used in testing under IEC 60512-2 and other contact standards.
- **Accuracy defined without zero-adjustment**

  Conduct measurement with peace of mind, even without performing zero-adjustment.
- **Wiring resistance tolerance in low-resistance range: 1.5 Ω**

  Measurement cables can be extended easily, even when using the 1 A measurement current range.

Easy-to-use functions in research and development, on production lines, or in acceptance inspections

Graphical LCD
Operation is intuitive and easy to learn.

Easy configuration of comparator and panel load operation
Facilitates smooth setup changes on production lines.

Guard terminal
You can reduce the effects of external noise by connecting the guard terminal.

Simple basic settings
Range and measurement speed can be set directly.

LED Comparator Attachment (option)
Streamlines work by eliminating the need to look at the screen.

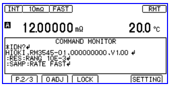
Judgment sounds with user-selectable patterns
Keeps you from mistaking audio from a nearby operator's instrument as your own.

Free power supply (100 to 240 V) with automatic frequency switching
Allows the instrument to be easily moved to overseas production lines.

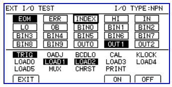
Extensive selection of interfaces
Standard USB, RS-232C, EXT I/O, and D/A output interfaces
(The RM3545-01 also provides a GP-IB interface.)

Support for a variety of temperature sensors
You can connect a radiation thermometer with analog output in addition to the included sensor.

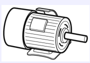
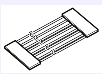
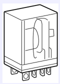
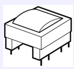
Monitor and test functions
Provides robust support for line development by allowing you to check communications and EXT I/O on the screen.



Example communications monitor screen



Example EXT I/O test screen

1

Multiplexer support to allow multipoint measurement and total judgments (RM3545-02)

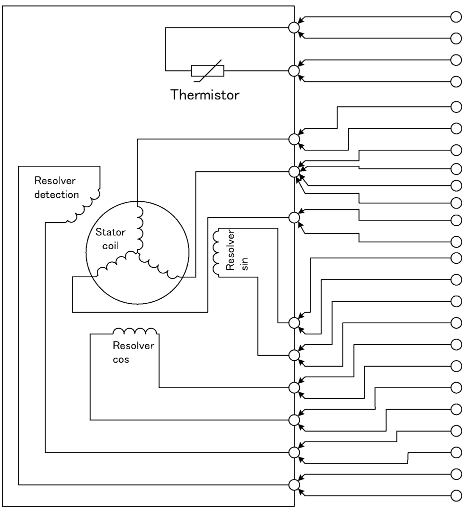
- **Measure up to 20 locations with 4-terminal measurement or 42 locations with 2-terminal measurement (when using two Z3003 units).**
- **Multipoint measurement**

  Allows measurement of network resistors, steering switches, 3-phase motors, etc.
- **Total judgments**

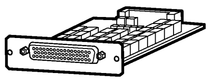
  Outputs total judgment based on measurement results for tested locations.
- **Comparator judgments based on measurement results**

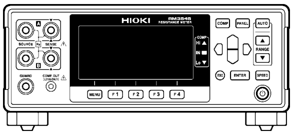
  Allows judgments to be based on comparisons with standard elements for measurement targets such as thermistors that are susceptible to the effects of temperature.
- **External instrument connectivity**

  Allows multipoint measurement, including for external measuring instruments such as LCR meters.



Z3003 Multiplexer Unit





1.2 Names and Functions of Parts

Front Panel

Viewing Measured Values and Settings

Display Screen (Monochrome graphical LCD)

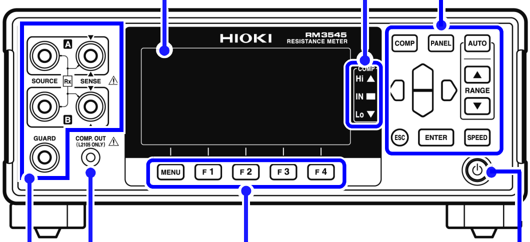
Display of measurements and settings (p. 27)

Viewing Comparator Results

COMP indicator LEDs

Indicate the judgment result of the measured value (p.98).

Hi Measured value is above upper limit
IN Pass (meets criteria)
Lo Measured value is below lower limit



Settings

PANEL key
Saving and loading of panels (p.120)

COMP key
Configuration of comparator settings (p.98)

AUTO, RANGE key
Range switching (p.49)

SPEED key
Measurement speed switching (p.50)

Cursor keys
Selection of settings and digits

ENTER key
Acceptance of settings and manual trigger input

ESC key
Cancellation of operation

MENU key
Switching of F key pages

F keys (F 1 ‥ F 4)
Selection of settings displayed on the screen

Connecting the LED Comparator Attachment

COMP.OUT jack

Connect the L2105 LED Comparator Attachment to view judgment results without needing to refer to the instrument display. (p.107)

Connecting Measurement Leads

Measurement Terminals

Connect measurement leads (p. 36).

- SOURCE A : Current detection terminal
- SOURCE B : Current source terminal
- SENSE A : Voltage detection terminal
- SENSE B : Voltage detection terminal
- GUARD : Guard terminal

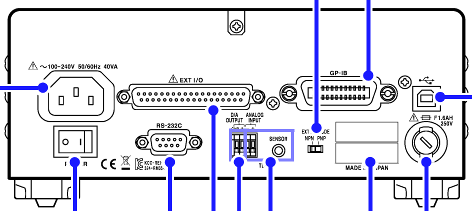
Initiating and Canceling the Standby State

STANDBY Key: Initiates or cancels the standby state. (p. 43).

- Unlit: power off (when no power supplied)
- Red light: Standby State (while power is supplied)
- Green light: power on

Rear Panel

RM3545-01



Switching between NPN and PNP

EXT I/O NPN/PNP switch

Left : Current sink (NPN)
Right: Current source (PNP)

GP-IB Communications

GP-IB Connector (RM3545-01 only)

Connect to a computer, or other device (p.230)

Connecting the Power Cord

Power Inlet

Connect the supplied power cord (p. 35).

Sending and Receiving Data via USB

USB jack

Connect to a computer (p. 223).

Turning the Main Power On and Off

Main power switch (p.43)

○ : Main power off
| : Main power on

Replacing the Measurement Fuse

Fuse holder (p.302)

Manufacturer's Serial No.

Do not remove this label, as it is required for product support.

RS-232C Communications Printer Output

RS-232C connector

- Connect to a computer, PLC, or other device (p.226).
- Connect to a printer (p.239).

Correcting Temperature Converting Temperature

TEMP.SENSOR jack/ TEMP.ANALOG INPUT terminal block

Connect the Z2001 Temperature Sensor or thermometer with analog output when using temperature correction or temperature conversion. (p.37)
Connect the Z2001 to the TEMP.SENSOR jack on the right. Connect analog voltage output from a radiation thermometer or a shunt resistor for analog current output from a radiation thermometer to the TEMP.ANALOG INPUT terminal block.

External Control

EXT I/O connector

Connect when controlling the instrument with a PLC, I/O board, or other equipment to allow measurement to be started and measured values and comparator results to be acquired (p.177).

D/A Output

D/A OUTPUT terminal block

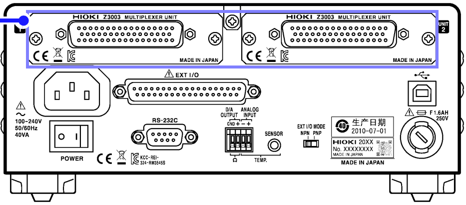
The D/A OUTPUT terminal block outputs resistance values as a voltage signal. (Connect a device that can accept voltage input, for example a Memory HiCorder.) (p.175)

RM3545-02

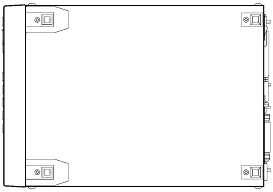
Using the Multiplexer Unit

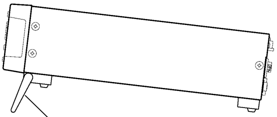
Multiplexer Unit Slot (RM3545-02 only)

Installing the Z3003 Multiplexer Unit (up to 2 units) (p.42)



Bottom Panel





This instrument can be rack mounted.

See: "Appendix 18 Rack Mounting" (p. A36)

Parts removed from this instrument should be stored in a safe place to enable future reuse.

When using the stand

Extend the legs all the way. Do not extend partially.
Make sure to extend both legs of the stand.

Collapsing the stand

Do not collapse the stand partway. Be sure to collapse it all the way.

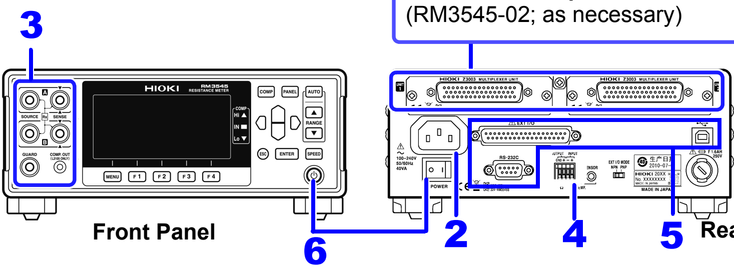
⚠CAUTION

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

1

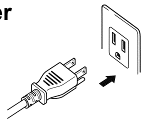
1.3 Measurement Process

Install the Multiplexer Unit
(RM3545-02; as necessary)

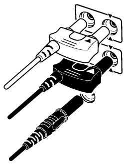


1 **Install this instrument (p. 6)**

2 **Connect the power cord (p.35)**

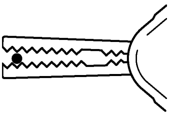


3 **Connect measurement leads (p.36)**

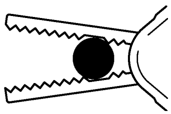


(Connect connectors to the Multiplexer Unit as necessary.)

4 **Connect the temperature sensor or infrared thermometer (p.37)**
(When using the temperature correction function or ΔT)



When clipping a small-gauge wire
(Clip with the tip of the alligator clips.)

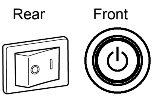


When clipping a large-gauge wire
(Clip with the back of the alligator clips, where there are no teeth.)

5 **Connect the external interface**
(as needed)

- Using the printer (p.239)
- Using the USB, RS-232C or GP-IB interface (p. 221)
- Using the EXT I/O (p. 177)
- Using D/A Output (p. 175)

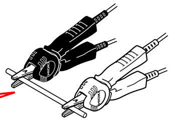
6 **Turn on the instrument and cancel the standby state (p.43)**



7 **Check the measurement target (p.48)**

8 **Make instrument settings** *1

9 **Connect to the test sample (p.51)**



When finished measuring, turn the power off (p.43).

*1 About zero-adjustment

Perform zero-adjustment in the following circumstances:
- The measured value is not cleared due to thermal EMF or other factors.
  → The measured value will be adjusted to zero. (*2)
- Four-terminal connection (called Kelvin connection) is difficult.
  → The residual resistance of the two-terminal connection wires will be canceled.

See: "4.3 Zero Adjustment" (p.68)
"Appendix 6 Zero Adjustment" (p.7)

*2 Accuracy specifications vary when zero-adjustment has not been performed.
For more information, see "Chapter 13 Specifications" (p.251).
Thermal EMF can also be canceled by using OVC.

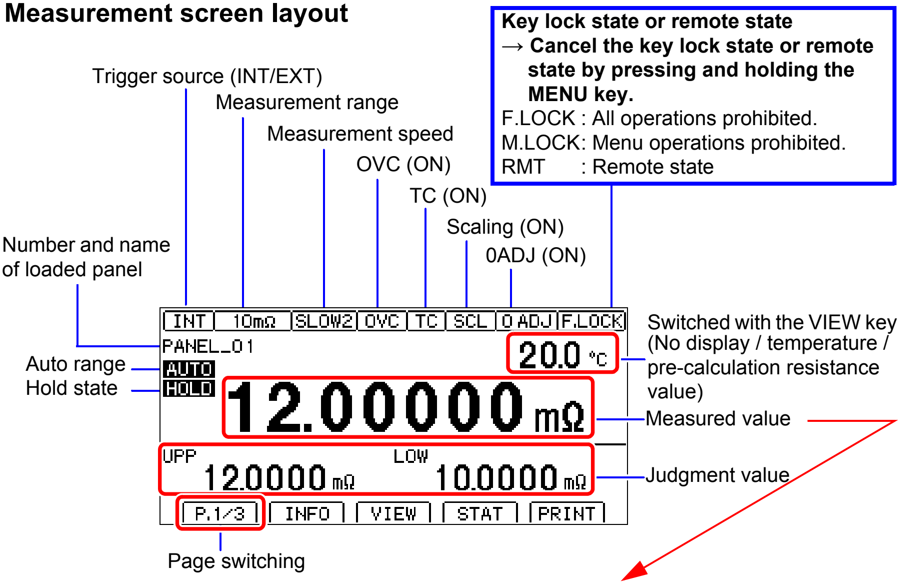
See: "4.8 Compensating for Thermal EMF Offset (Offset Voltage Compensation - OVC)" (p.82)

1

1.4 Screen Organization and Operation Overview

The instrument's screen interface consists of a Measurement screen and various Settings screens.
The screen examples in this guide appear reversed (black on white) for best visibility on the printed page. However, the instrument screens can actually be displayed only as white characters on black background.

Measurement screen layout

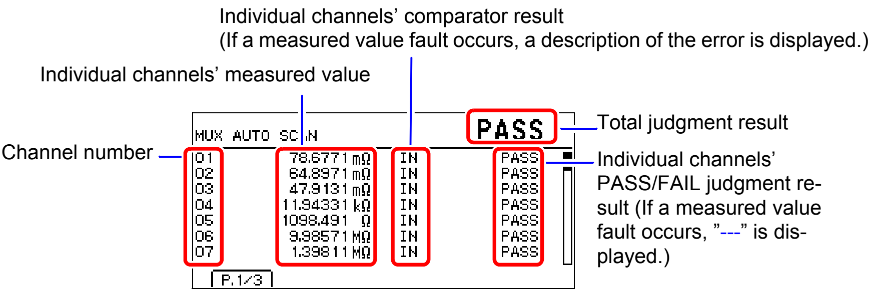


Display of information other than measured values
(For more information, see "Confirming Measurement Faults" (p.55).)

Display	Description
+OvrRng **-OvrRng**	Over-range
CONTACT TERM.A **CONTACT TERM.B**	Contact error
- - - - - - -	Not measured, or broken connection in measurement target *

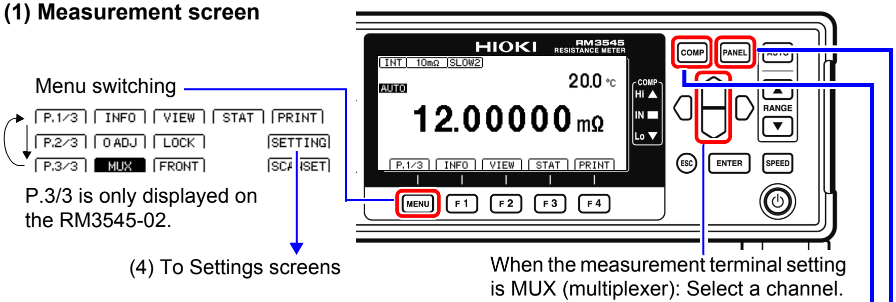
* To treat current faults (when the source wiring is open) as over-range events, change the current fault output mode setting. (p.59)

When the scan function is set to auto or step (RM3545-02 only)



Overview of screen operation

(1) Measurement screen



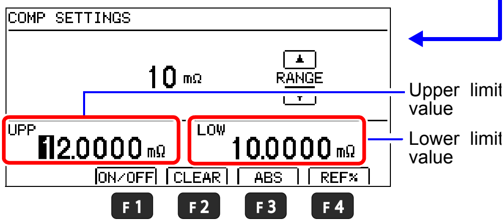
(2) Comparator Settings screen

1 Select the mode with an F key.

2 Change the range with the ▲ and ▼ keys.

3 Move among digits. Change values.

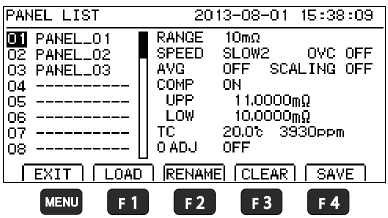
4 Accept the setting with the ENTER key or cancel with the ESC key.



(3) Panel Save/Load screen

1 Select a panel number.

2 Perform action with an F key.



1

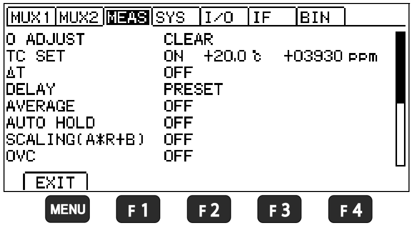
(4) Settings screen

1 Move to the [MEAS], [SYS], [I/O], [IF], [BIN], [MUX1], or [MUX2] tab.*
* MUX1/MUX2 is only displayed on the RM3545-02.

2 Select a setting. Move among settings.

3 Switch functions with an F key or set values.

4 Return to the Measurement screen with the MENU key.

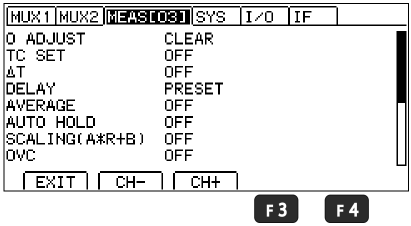


When the measurement terminal setting is MUX (multiplexer)

Set the measurement conditions by channel.

F3 [CH–]: Changes (decreases) the channel.

F4 [CH+]: Changes (increases) the channel.

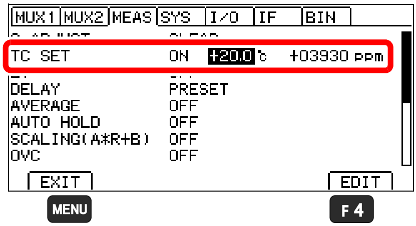


< Setting values >

1 Make the value editable with the F4 key.

2 Move among digits. Change values.

3 Accept the setting with the ENTER key or cancel with the ESC key.



List of settings

Screen		Setting and key	Overview	See
Measurement screen		COMP	Comparator function	(p.100)
		PANEL	Save/load panel	(p.119)
		AUTO	Measurement range	(p.49)
		▲▼ (RANGE)		
		SPEED	Measurement speed	(p.50)
Measurement screen (P.1/2) (For the RM3545-02, P.1/3)		INFO (F1)	Display setting conditions	(p.54)
		VIEW (F2)	Switch measurement screen display	(p.52)
		STAT (F3)	Display statistical calculation results	(p.111)
		STOP (F3) *2	Stop scan	
		PRINT (F4)	Print	(p.241)
Measurement screen (P.2/2) (For the RM3545-02, P.2/3)		0 ADJ (F2)	Zero-adjustment	(p.68)
		LOCK (F3)	Key lock	(p.126)
		SETTING (F4)	Switch to Settings screen	
Measurement screen (P.3/3) *2		FRONT (F1)	Use of the multiplexer	(p.151)
		MUX (F2)	Use the front measurement terminals	
		SCANSET (F3)	Scan function	
Settings screen (SETTING)	Multiplexer Channel Settings screen (MUX1) *2	CH	Use of channels	(p.154)
		TERM	Channel terminals	
		INST	Measuring instruments for each channel	
		0ALL	Scan channels Zero-adjustment settings	(p.164)
		0ADJ	Individual channels' zero-adjustment status	
	Multiplexer Basic Measurement screen (MUX2) *2	SPD	Individual channels' measurement speed	(p.158)
		RANGE	Individual channels' range	
		UPP/REF	Individual channels' comparator settings	
		LOW%		
		PASS	Individual channels' PASS conditions	

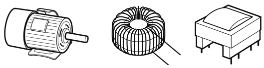
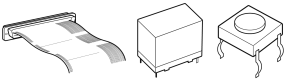
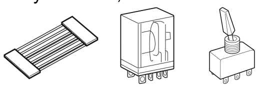
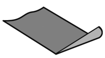
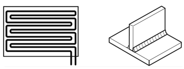
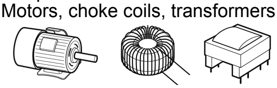
Screen		Setting and key	Overview	See
Settings screen (SETTING)	Measurement Setting screen (MEAS) *3	0 ADJUST	Clear zero-adjustment	(p.71)
		TC SET	Temperature correction	(p.75)
		ΔT	Temperature conversion	(p.116)
		R0, T0		
		k		
		DELAY	Delay	(p.84)
		AVERAGE	Averaging	(p.73)
		AUTO HOLD	Hold measured value	(p.60)
		SCALING(A∗R+B)	Scaling	(p.77)
		A:		
		B:		
		UNIT:		
		OVC	Offset voltage compensation function (OVC)	(p.82)
		LOW POWER	Low-power resistance measurement (LP)	(p.64)
		MEAS CURRENT	Switching measurement currents	(p.66)
		Ω DIGITS	Set the display digits	(p.81)
		CURR ERROR MODE	Current fault output format	(p.59)
		CONTACT CHECK	Contact check function	(p.88)
		CONTACT IMPRV	Contact improver function	(p.90)
		100MΩ PRECISION	100 MΩ high-precision mode	(p.96)

Screen		Setting and key	Overview	See
Settings screen (SETTING)	System Setting screen (SYS)	TERMINAL *2	Measurement terminal settings	(p.148)
		WIRE *2	Multiplexer measurement method	
		SCAN MODE *2	Scan function	
		FAIL STOP *2	Stop at FAIL during scan	
		UNIT TEST *2	Z3003 unit test	(p.167)
		STATISTICS	Statistical calculations function	(p.111)
		TEMP INPUT	Temperature sensor settings	(p.37)
		ANALOG SET1		
		ANALOG SET2		
		CALIBRATION	Self-calibration	(p.92)
		KEY CLICK	Set the operation sound	(p.128)
		COMP BEEP Hi	Set the judgment sound (PASS/FAIL: RM3545-02 only)	(p.105)
		IN		
		Lo		
		PASS		
		FAIL		
		PANEL LOAD 0ADJ	Load zero-adjustment values	(p.122)
		CONTRAST	Set the contrast	(p.131)
		BACK LIGHT	Set the contrast brightness	(p.132)
		POWER FREQ	Set the power frequency	(p.129)
		CLOCK	Clock settings	(p.133)
		RESET	Reset the instrument	(p.134)
		ADJUST	Adjust the instrument	(p.A44)
	EXT I/O Setting screen (I/O)	TRIG SOURCE	Set the trigger source	(p.209)
		TRIG EDGE	Set the trigger signal logic	(p.211)
		TRIG/PRINT FILT	Trigger/print filter function	(p.213)
		EOM MODE	EOM signal setting	(p.215)
		JUDGE/BCD MODE	EXT I/O output mode	(p.217)
		EXT I/O TEST	EXT I/O test	(p.218)
	Communication Interface Setting screen (IF)	INTERFACE	Configure interface settings	(p.223)
		SPEED	Communications	(p.221)
		GP-IB *1		
		DATA OUT		
		CMD MONITOR		
		PRINT INTRVL	Printing	(p.239)
		PRINT COLUMN		
		STAT CLEAR		
	BIN Setting screen (BIN)	BIN	BIN measurement settings	(p.108)

*1 RM3545-01 only
*2 RM3545-02 only
*3 When using the multiplexer, the selected channel number will be displayed next to “MEAS.”

1.5 Checking the Measurement Target

To carry out proper resistance measurement, change the measurement conditions appropriately according to the measurement target. Before starting measurement, use the examples recommended in the following table to configure the instrument.

Measurement target	Recommended settings (Bold indicates a change from the factory default.)				
	Low-Power (p.64)	Measure-ment Current (p.66)	TC/ ΔT (p. 75) (p.116)	OVC (p.82)	Contact check (p.88)
Motors, solenoids, choke coils, transformers 	OFF	High	**TC**	OFF	ON
Signal contact Wire harnesses, connectors, relay contacts, switches 	**ON**	–	**TC**	–	OFF *3
Power contact Wire harnesses, connectors, relay contacts, switches 	OFF	High	**TC**	**ON**	ON
Fuses, resistors 	OFF	**Low** *1	–	**ON**	ON
Conductive paint, Conductive rubber 	OFF	High	–	OFF	**OFF**
Other, Standard resistance measurement Heaters, Electrical wires, Welds 	OFF	High	*2	**ON**	ON
Temperature-rise test Motors, choke coils, transformers 	OFF	High	**ΔT**	OFF	ON

*1: When there is sufficient margin with regard to the rated power, select High.
*2: When the measurement target significantly depends on temperature, use the temperature correction function.
*3: When there is sufficient margin with regard to the allowable applied voltage, select ON.

NOTE
When measuring a commercial power supply transformer using an external trigger, measurement cannot be performed using the delay setting preset. Either make the delay adequately long or measure using the internal trigger (p.84).

Measurement Preparations

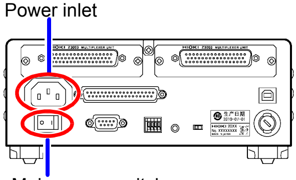
Chapter 2

Be sure to read the "Operating Precautions" (p.6) before installing and connecting this instrument.
Refer to "Appendix 18 Rack Mounting" (p. A36) for rack mounting.

2.1 Connecting the Power Cord

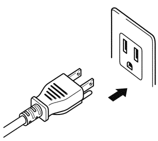
Turn off the power before disconnecting the power cord.

Rear Panel



1 **Confirm that the instrument's Main power switch (rear panel) is OFF(○).**

2 **Confirm that the mains supply voltage matches the instrument, and connect the power cord to the power inlet on the instrument.**



3 **Plug the power cord into the mains outlet.**

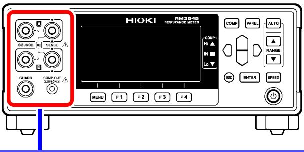
If power to the instrument is cut off with the power switch in the ON position (by a circuit breaker, etc.), the instrument will start up when power is restored, without any need to press the STANDBY key.

2.2 Connecting Measurement Leads

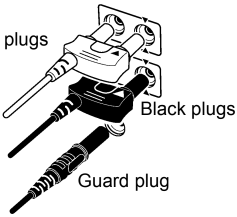
Connect the included or optional Hioki measurement leads to the measurement terminals. Before connecting the measurement leads, read "Operating Precautions" (p.6) carefully. Refer to "Options" (p.3) for details.

NOTE We recommend using optional Hioki measurement leads.

Connection Methods



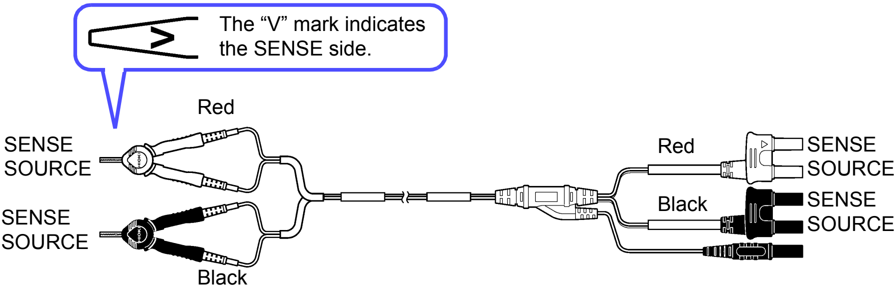
Connecting measurement leads

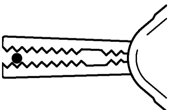


Connect the red plugs to the SOURCE A and SENSE A terminals, the black plugs to the SOURCE B and SENSE B terminals, and the guard plug to the GUARD terminal.

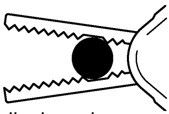
Measurement leads

(Example: When using the L2101 Clip Type Lead)





When clipping a small-gauge wire
(Clip with the tip of the alligator clips.)



When clipping a large-gauge wire
(Clip with the back of the alligator clips, where there are no teeth.)

NOTE When making your own measurement leads or extending a measurement lead, see "Appendix 14 Making Your Own Measurement Leads, Making Connections to the Multiplexer" (p. A30).

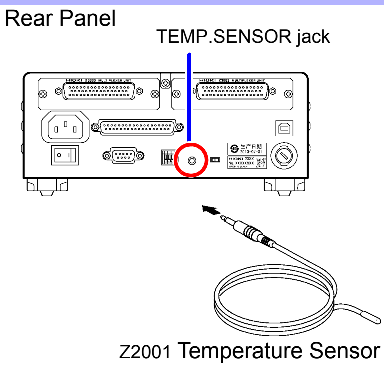
2.3 Connecting Z2001 Temperature Sensor or Thermometer with Analog Output (When using the TC or ΔT)

Connecting the Z2001 Temperature Sensor

Before connecting the temperature sensor, read "Operating Precautions" (p.6) carefully.

Connection Methods

Connecting the Z2001 Temperature Sensor



1 **Confirm that the instrument's Main power switch (rear panel) is OFF(○).**

2 **Connect the Z2001 Temperature Sensor into the TEMP.SENSOR jack on the rear panel.**

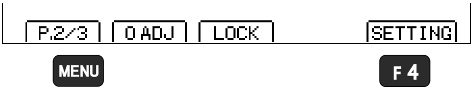
> **Insert the Z2001 securely all the way into the jack.**
> **Do not connect anything to the TEMP.ANALOG INPUT terminal block.**

3 **Place the tip of the temperature sensor near the measurement target.**

4 **Configure temperature measurement.**

After turning on the instrument, check whether the temperature measurement settings are correct. Change if necessary.

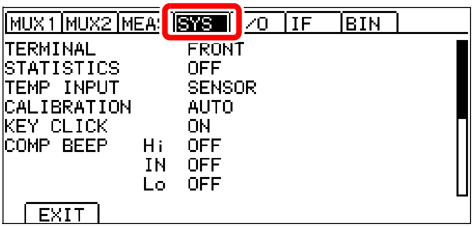
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

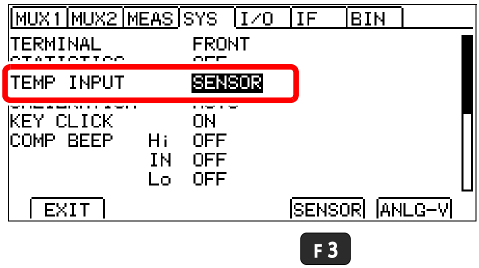
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

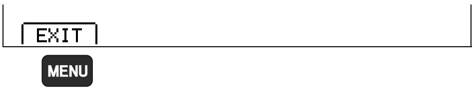
3 Select TEMP INPUT and press F3 (SENSOR).



1 Selection

2 F3 Thermistor sensor (Z2001)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

2

Connecting an Analog Output Thermometer

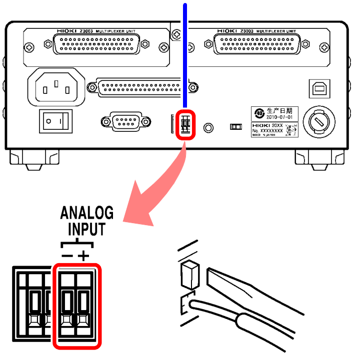
To measure temperature, connect the analog output thermometer to the instrument.
Before connecting the thermometer, read "Operating Precautions" (p.6) carefully.

Connection Methods

Connecting an Analog Output Thermometer

Rear Panel

TEMP.ANALOG INPUT terminal block



1 **Confirm that the instrument's Main power switch (rear panel) is OFF(○).**

2 **Connect the thermometer's analog output connector to the TEMP.ANALOG INPUT terminal block on the rear panel, using a cable.**

Insert the thermometer's analog output connector securely all the way into the terminal block.
Do not connect anything to the TEMP.SENSOR jack.

3 **Configure temperature measurement.**

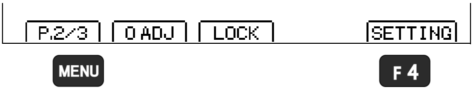
Recommended wire type	:	Single line: AWG22 (0.65 mm diameter) Twisted wire: AWG22 (0.32 mm^2) Diameter of search wire: 0.12 mm or more
Compatible wire types	:	Single line: AWG28 (0.32 mm diameter) to AWG22 (0.65 mm diameter) Twisted wire: AWG28 (0.08 mm^2) to AWG22 (0.32 mm^2) stranded conductor Diameter of search wire: 0.12 mm or more
Standard bare wire length	:	8 mm

NOTE

When using a thermometer that generates 4 to 20 mA output, connect a shunt resistor of about 50 Ω between the positive and negative terminals and convert the output to a voltage prior to input. With a 50 Ω resistor connected, the reference voltage (V_1, V_2) settings are 0.20 V (V_1) and 1.00 V (V_2).

After turning on the instrument, check whether the temperature measurement settings are correct. Change if necessary.

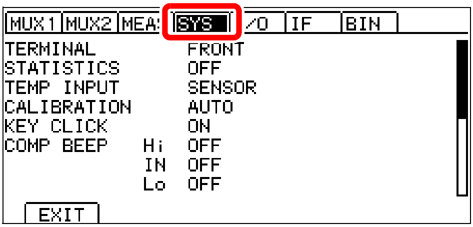
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

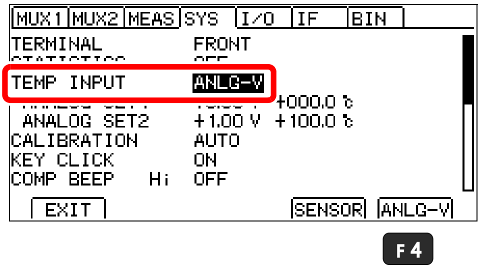
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Select TEMP INPUT and press F4 (ANLG-V).



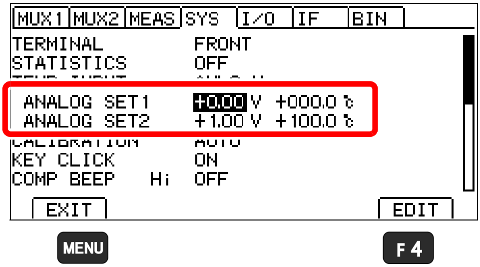
1 Selection

2 F4 Analog input

2

4 Set two reference voltages and the corresponding reference temperatures.

Set reference voltages V_1 and V_2 and reference temperatures T_1 and T_2 by following Steps **1** through **3** for each.



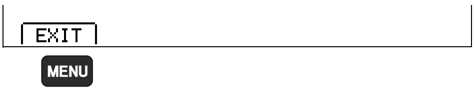
1 Move the cursor to the setting you wish to configure. Make the value editable with the F 4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

Setting range
reference voltage (V_1, V_2): 00.00 to 02.00 V (default V_1: 0 V, V_2: 1 V)
reference temperature (T_1, T_2): -99.9 to 999.9°C (default T_1: 0°C, T_2: 100°C)

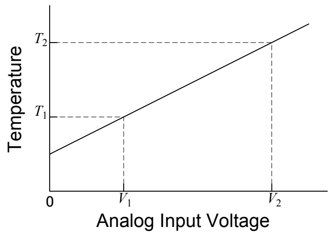
5 Return to the Measurement screen.



MENU Return to the Measurement screen.

The displayed value is calculated by the following expression.

$$\frac{T_2 - T_1}{V_2 - V_1} \cdot \text{(Input Voltage)} + \frac{T_1 V_2 - T_2 V_1}{V_2 - V_1}$$

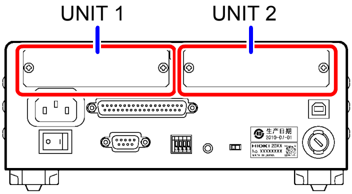


2.4 Installing the Multiplexer Unit

To use multiplexing capability, you must first install the Z3003 Multiplexer Unit.
Before connecting the Multiplexer Unit, read "Operating Precautions" (p.6) carefully.

Installing a Multiplexer Unit

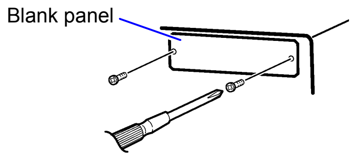
Rear panel



Required item: One Phillips-head screwdriver

1 **Turn off the instrument's main power switch and disconnect the cords and leads.**

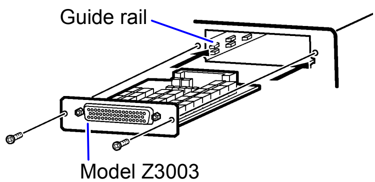
2 **Remove the two screws with a Phillips head screwdriver and remove the blank panel.**



3 **With attention to the orientation of the Multiplexer Unit, insert it firmly all the way in.**

Insert the unit after aligning it with the guide rail.

Taking countermeasures against static electricity (using antistatic devices such as a wrist strap) as well as wearing antistatic gloves are recommended.

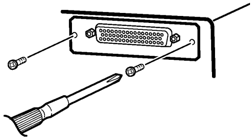


Do not directly touch the board

4 **Using the Phillips screwdriver, tighten the two Multiplexer Unit mounting screws.**

Configure the settings so that they match the unit number used.

See: "Customizing Channel Pin Allocation" (p.152)



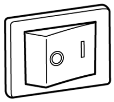
NOTE
When using only one Multiplexer Unit, it can be installed as either UNIT 1 or UNIT 2.

Removing a Multiplexer Unit

After turning off the instrument's main power switch and disconnecting all cords and leads, remove the Multiplexer Unit by reversing the above procedure and then attach the blank panel.

2.5 Turning the Power On and Off

Turning On the Instrument with the Main Power Switch

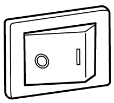


Power ON |

Turn on (|) the main power switch on the rear of the instrument.

If the main power switch was turned off while the instrument was not in the standby state, the standby state will be automatically canceled when the main power switch is turned on.

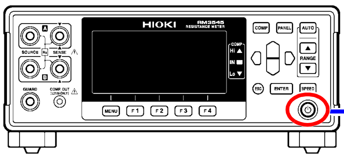
Turning Off the Instrument with the Main Power Switch



Power OFF ○

Turn off (○) the main power switch on the rear of the instrument.

Canceling the Standby State



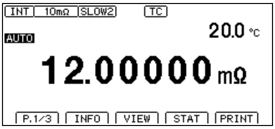
Press the STANDBY key (the STANDBY key will change from red to green).

After the standby state is canceled, a self-test (instrument diagnostic routine) is performed. During the self-test, the following information is displayed while the hardware is verified.

Self-test

The following information is displayed during self-testing:
- Manufacturer and model name
- Firmware versions
- Communication interface setting
- Detected line frequency
- EXT I/O (NPN/PNP) setting
- Self-Calibration setting
- Inserted unit information (RM3545-02 only)

No Errors



Normal display (measurement screen)

Error

Indicates an error (p. 298).

NOTE

The Z3003 Multiplexer Unit test is not performed during the self-test on startup.
See: "8.6 Performing the Multiplexer Unit Test" (p.167)

Before Starting Measurement

To obtain precise measurements, provide about 60 minutes warm-up after turning power on.
The SOURCE terminal is protected by a fuse. If the fuse is tripped, the instrument will display “**Blown FUSE.**” and you will not be able to measure resistance values. In this case, replace the fuse.
See: "14.2 Replacing the Measurement Circuit’s Protective Fuse" (p.302)

Measurement settings are recalled from when the power was previously turned off (settings backup).

Placing the Instrument in the Standby State

Press the Standby key (the Standby key will change from green to red).

Disconnect the power cord from the outlet to extinguish the standby key light.
When power is turned on again, operation resumes with the same state as when last turned off.

If a power outage (e.g., breaker trip) occurs when the instrument is on, it will automatically turn on again when power is restored (without pressing the standby key).

2.6 Pre-Operation Inspection

Before using the instrument for the first time, 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.

1 Peripheral Device Inspection

Is the power cord insulation torn, or is any metal exposed?

Metal Exposed → **Do not use the instrument if damage is found, as electric shock or short-circuit accidents could result. Contact your authorized Hioki distributor or reseller.**

↓ **No Metal Exposed**

Is the insulation on a measurement lead torn, or is any metal exposed?

Metal Exposed → **If there is any damage, measured values may be unstable and measurement errors may occur. Replace the cable with an undamaged one.**

↓ **No Metal Exposed**

2 Instrument Inspection

Is damage to the instrument evident?

Yes → **If damage is evident, request repairs.**

↓ **No**

When turning power on

Is the STANDBY key red or green?

No → **The power cord may be damaged, or the instrument may be damaged internally. Request repairs.**

↓ **Yes**

After the completion of the self-test (when the model number is shown on the screen), is the Measurement screen displayed?

An error indication occurs → **The instrument may be damaged internally. Request repairs.**
See: "14.1 Troubleshooting" (p. 286)
"Error Displays and Remedies" (p.298)

↓ **Yes**

Inspection complete

Basic Measurements
Chapter 3

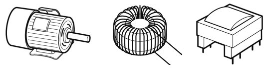
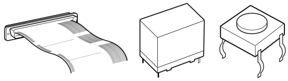
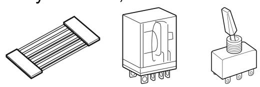
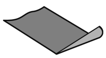
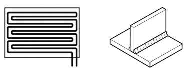
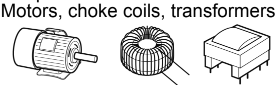
Before making measurements, read "Operating Precautions" (p. 16) carefully.

This chapter explains basic operating procedures for the instrument.

To customize measurement conditions, see "Chapter 4 Customizing Measurement Conditions" (p.63).

3.1 Checking the Measurement Target

To carry out proper resistance measurement, change the measurement conditions appropriately according to the measurement target. Before starting measurement, use the examples recommended in the following table to configure the instrument.

Measurement target	Recommended settings (Bold indicates a change from the factory default.)				
	Low-Power (p.64)	Measure-ment Current (p.66)	TC/ ΔT (p. 75) (p.116)	OVC (p.82)	Contact check (p.88)
Motors, solenoids, choke coils, transformers 	OFF	High	**TC**	OFF	ON
Signal contact Wire harnesses, connectors, relay contacts, switches 	**ON**	–	**TC**	–	OFF *3
Power contact Wire harnesses, connectors, relay contacts, switches 	OFF	High	**TC**	**ON**	ON
Fuses, resistors 	OFF	**Low** *1	–	**ON**	ON
Conductive paint, Conductive rubber 	OFF	High	–	OFF	**OFF**
Other, Standard resistance measurement Heaters, Electrical wires, Welds 	OFF	High	*2	**ON**	ON
Temperature-rise test Motors, choke coils, transformers 	OFF	High	**ΔT**	OFF	ON

*1: When there is sufficient margin with regard to the rated power, select High.
*2: When the measurement target significantly depends on temperature, use the temperature correction function.
*3: When there is sufficient margin with regard to the allowable applied voltage, select ON.

NOTE
When measuring a commercial power supply transformer using an external trigger, measurement cannot be performed using the delay setting preset. Either make the delay adequately long or measure using the internal trigger (p.84).

3.2 Selecting the Measurement Range

The measurement range can be set as follows. Auto-ranging (the AUTO range) can also be selected.

Manual Range Setting

▲ ▼	Select the range to use. (AUTO off) The decimal point location and unit indicator change with each key press.

Auto-Ranging

AUTO	Press this while a manual range is selected. (AUTO lights) The optimum measurement range is automatically selected.

Switching from Autoranging back to Manual range selection

Press AUTO again. The range can now be changed manually.

NOTE

- When the comparator function and BIN measurement function are turned on, the range cannot be changed from fixed (it cannot be switched to auto-ranging). To change the range, turn off the comparator function and BIN measurement function or change the range from within the comparator settings and BIN number settings.
- When measuring certain motor, transformer or coil components, the auto range setting may not stabilize. In such cases, either specify the range manually or lengthen the delay time.
  See: "4.9 Setting Pre-Measurement Delay" (p.84)
- The measurement target power is given by (resistance value × (measurement current)^2) if the measured value is within the measurement range. If the measurement range is exceeded, the power may reach a maximum value that is given by (open voltage × measurement current). Check the measurement range before connecting the measurement target. When using a High measurement current, resistance ranges of 100 Ω and lower may cause a large amount of power to be applied to the measurement target. In particular, a maximum power of about 2 W may be applied to the target at ranges of 100 mΩ and lower (ranges that result in a measurement current of 1 A). Check the measurement range and current switching before connecting the measurement target.
  See: "4.2 Switching Measurement Currents (100 mΩ to 100 Ω)" (p.66)
- When measuring delicate samples, use the Low Power measurement mode.
  See: "4.1 Switching to Low-power Resistance Measurement" (p.64)
- Refer to "Resistance Measurement Accuracy" (p. 252) for information on each range measurement accuracy.
- When using the INT trigger source, current will stop when a contact error occurs (when not connected to the measurement target). By contrast, when using the INT trigger source with the contact check function off, the measurement current is always applied, even when the instrument is not connected to the measurement target. Consequently, a rush current will flow at the moment the instrument is connected to the target (for example, measuring a pure resistance in the 1 A measurement current range will result in a maximum current of 5 A with a convergence time of 0.5 ms). When measuring easily damaged elements, either turn on the contact check or use a range that results in a low measurement current. However, if there is chatter even when the contact check is enabled, it will not be possible to completely prevent a rush current.
- When set to 2-wire with the multiplexer, ranges of 10 Ω and lower cannot be used.

3.3 Setting the Measurement Speed

The measurement speed can be set to FAST, MED (medium), SLOW1, or SLOW2. The MED (medium), SLOW1, and SLOW2 settings offer increased measurement precision compared to the FAST setting as well as greater resistance to the effects of the external environment.
If the setup is excessively susceptible to the effects of the external environment, shield the measurement target and measurement leads adequately and twist the cables together.
See: "Appendix 9 Mitigating Noise" (p. A20)

SPEED	Press this to change the measurement speed.

NOTE
A self-calibration that lasts about 5 ms is performed between measurements. To shorten the measurement interval, set the self-calibration to “manual.”
See: "4.12 Maintaining Measurement Precision (Self-Calibration)" (p.92)

Integration time (Unit: ms) (detected voltage data acquisition time)

LP	Range	FAST		MEDIUM		SLOW1	SLOW2
		50 Hz	60 Hz	50 Hz	60 Hz		
OFF	1000 kΩ or less	0.3*		20.0	16.7	100	200
	10 MΩ or more	20.0	16.7	20.0	16.7	100	200
ON	All ranges	20.0	16.7	40.0	33.3	200	300

When OVC is on, integration is performed twice. When LP is on, OVC is fixed to on.
When using the SLOW2 measurement speed with low-power resistance measurement on, the instrument will performing averaging with two iterations internally even if the averaging function is set to off.
* When using the MUX mesurement terminals, the integration time is 1.0 ms only in the 10 mΩ range.
See: "13.1 Instrument Specifications" (p.251)

Shortest measurement times when using the internal trigger source with continuous measurement on (free-run)

LP OFF (unit: ms), tolerance: ±10%±0.2 ms

Range	FAST		MEDIUM		SLOW1	SLOW2
	50 Hz	60 Hz	50 Hz	60 Hz		
1000 kΩ or lower range	1.0*		20.7	17.4	101	201
10 MΩ or greater range	20.7	17.4	20.7	17.4	101	201

LP ON (unit: ms), tolerance: ±10%±0.2 ms, Only with OVC on

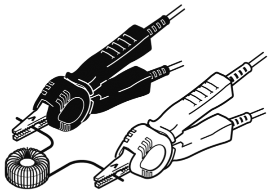
Range	FAST		MEDIUM		SLOW1	SLOW2
	50 Hz	60 Hz	50 Hz	60 Hz		
1000 mΩ	71	65	111	98	431	631
10 Ω	111	105	151	138	471	671
100 Ω	111	105	151	138	471	671
1000 Ω	113	107	153	140	473	673

Shortest conditions
Delay: 0 ms, OVC: OFF, Average: OFF,
Self-Calibration: MANUAL, Contact improver: OFF, Scaling: OFF
Measured value display switching: None
* When using the MUX mesurement terminals, the shortest measurement time is 1.7 ms only in the 10 mΩ range.

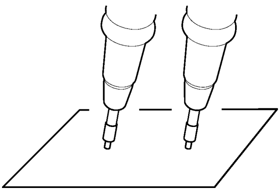
3.4 Connecting Measurement Leads to the Measurement Target

Before making measurements, read "Operating Precautions" (p.6) carefully.

Example with L2101

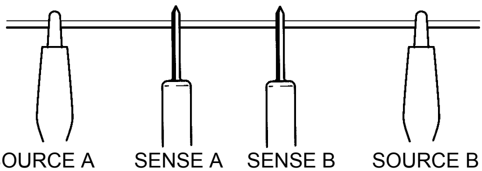


Example with L2102



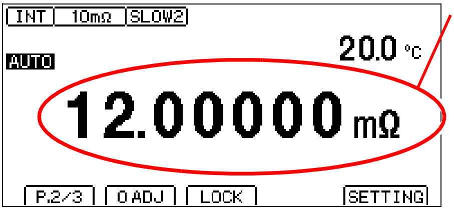
(Place leads in contact with target.)

Example with L2104



The SENSE terminals are placed to the inside of the SOURCE terminals.

3.5 Checking Measured Values



The resistance value will be displayed.

- If the display does not indicate the measured value, see "Confirming Measurement Faults" (p. 55).
- To convert the value into a parameter other than resistance, see below.

See: "5.4 Performing Temperature Rise Test (Temperature Conversion Function (ΔT))" (p.116)

See: "4.6 Correcting Measured Values and Displaying Physical Properties Other than Resistance Values (Scaling Function)" (p.77)

NOTE

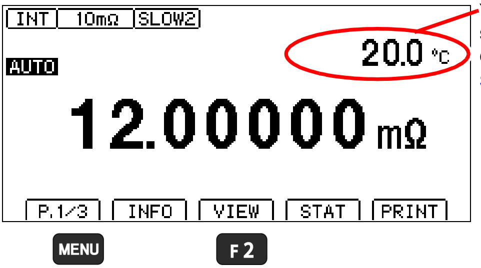
When measuring close to 0 Ω, measured values may turn negative. If measured values turn negative otherwise, check the following:

- Are the SOURCE or SENSE wires connected backwards?
  → Rewire correctly.
- Has the contact resistance decreased since you performed zero-adjustment?
  → Repeat the zero-adjustment process.
- Is the scaling calculation result negative?
  → Change the scaling settings.

Switching the Display

You can change what information is shown on the Measurement screen.

Displaying temperature and pre-calculation measured values



You can switch this part of the display to show nothing, the temperature, or the pre-calculation measured value.

See: "Example displays" (p.53)

1 MENU Switch the function menu to P.1/2.

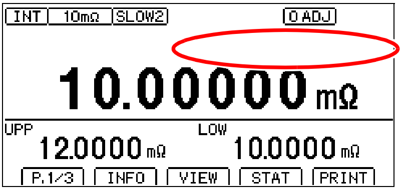
2 F 2 [VIEW]
Switch the Measurement screen.

3

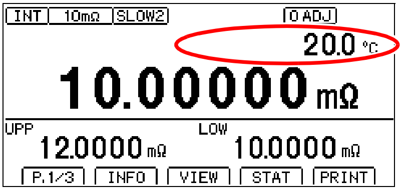
Example displays

Display of pre-calculation measured values varies with the settings.

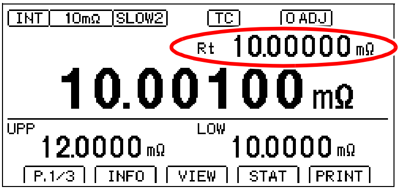
(No display)



(Temperature display)

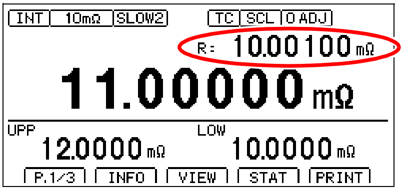


(Value before TC calculation
: With TC ON)



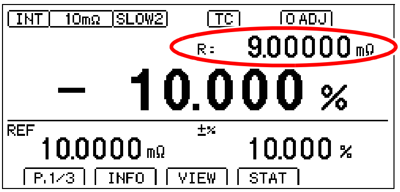
Rt: Resistance measured value
before TC calculation

(Value before scaling calculation
: With scaling ON)



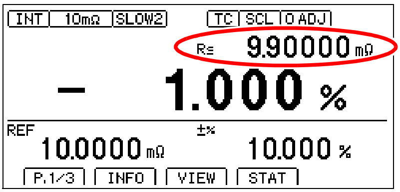
R: Resistance measured value
before scaling

(Value before REF% calculation
: With REF% comparator setting and
scaling OFF)



R: Resistance measured value
(before relative calculation)

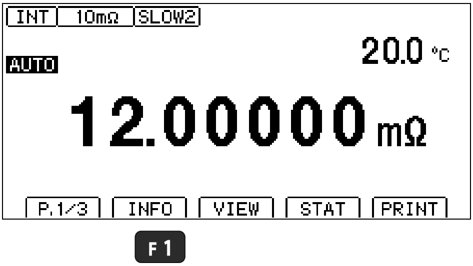
(Value before REF% calculation
: With REF% comparator setting and
scaling ON)



RS: Resistance measured value
after scaling (before relative calculation)

Displaying a list of measurement conditions and settings

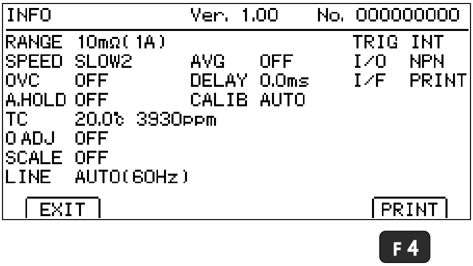
1 **Display the measurement conditions.**



1 MENU Switch the function menu to P.1/2.

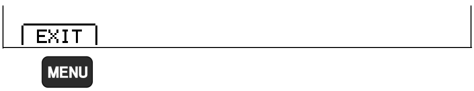
2 F1 [INFO]
Display measurement conditions.

2 **Check the measurement conditions.**



If the interface type has been set to "printer," you can print settings with F4.

3 **Return to the Measurement screen.**



MENU Return to the Measurement screen.

NOTE

When the scan function is set to auto or step, the list of measurement conditions and settings cannot be displayed.

Confirming Measurement Faults

When a measurement is not performed correctly, a measurement fault indicator appears and a ERR signal of the EXT I/O is output (no ERR signal is output for over-range or unmeasured events). Operation when a current fault occurs can be changed with the settings.

See: "Appendix 15 Checking Measurement Faults" (p. A33)

Over-range

Display
+OvrRng
-OvrRng

This fault is displayed in the following two instances.
(1) Appears when the measured value is outside of the measurement or display range. (*1)
(2) Appears when a measurement fault(*2) occurs (when the current fault mode setting is "Over-range").
When no measurement current flows from the SOURCE A terminal to the SOURCE B terminal

Similarly, if the measurement range is exceeded in temperature measurement, **OvrRng** is displayed.
The comparator result is Hi when **+OvrRng** is displayed, and Lo when **-OvrRng** is displayed. No ERR signal is output.

Contact error

See: "Appendix 1 Block Diagram" (p. A1)

Display
CONTACT - - - - - - -
TERM.A/B

(When the scan function is set to auto or step, **CONTACT A** or **CONTACT B** will be displayed. When the communications monitor function is on, **CA** or **CB** will be displayed.)

The resistance between the SENSE A and SOURCE A probe contacts, and between the SENSE B and SOURCE B probe contacts, are measured and an error is displayed if the result is about 50 Ω or greater. If this error persists, probe wear or cable failure may be the cause. When the resistance value between the SENSE and SOURCE is high, for example when the measurement target is conductive paint or conductive rubber, you will not be able to perform measurement due to the continuous error state. In this case, turn off the contact check function.

See: "4.10 Checking for Poor or Improper Contact (Contact Check Function)" (p.88)

Current Fault or measurement not performed

Display
- - - - - - -

This fault is displayed in the following instances. If "**- - - - - - -**" is displayed, a comparator judgment will not be made.
(1) Appears when a measurement fault(*2) occurs (when the current fault mode setting is "Current fault").
When no measurement current flows from the SOURCE A terminal to the SOURCE B terminal
(2) This fault is displayed when no measurement has been performed since the measurement conditions were changed.

Multiplexer channel error

Display
SW.ERR

A multiplexer relay hot-switching prevention function error has occurred. The relay cannot be switched because the current from the measurement target has not decreased. Increase the delay setting since the measurement circuit may be being influenced by back EMF from a transformer or other device. Do not apply any current or voltage to the measurement terminals.

See: "4.9 Setting Pre-Measurement Delay" (p.84)

Display
NO UNIT

No Multiplexer Unit was detected. Verify that the unit has been inserted.
Do not allocate units that have not been inserted to channels.

Temperature sensor not connected

Display	
- - . - °C	Temperature measurement cannot be performed because the temperature sensor has not been connected. There is no need to connect the temperature sensor when not using temperature correction or ΔT. Switch the display if you do not wish to display the temperature. See: "Switching the Display" (p.52)

Example displays: Display and output when the probes are open or when the measurement target is open

Display and output during current fault detection		Current fault mode setting (p. 59): Current fault	Current fault mode setting (p. 59): Over-range
Contact Check Results	Normal (No error)	Display: - - - - - - - COMP indicator: No judgment EXT I/O: ERR signal output	Display: +OvrRng COMP indicator: Hi EXT I/O: No ERR signal output, HI signal output
	Fault (Error)	Display: CONTACT TERM.B/ CONTACT TERM.A COMP indicator: No judgment EXT I/O: ERR signal output	

Measurement Fault Detection Order

Measurement Fault Detection		Display	EXT I/O signal
A Wiring Contact Error	Yes →	CONTACT TERM.A	ERR output
↓ No			
B Wiring Contact Error	Yes →	CONTACT TERM.B	ERR output
↓ No			
Current fault	Yes →	+OvrRng or - - - - - - - (Depends on output format settings)	HI output or ERR output (Depends on output format settings)
↓ No			
Below Lower Limit	Yes →	-OvrRng	LO output
↓ No			
Above Upper Limit	Yes →	+OvrRng	HI output
↓ No			
No Measurement Data	→	- - - - - - -	

NOTE

Measurement fault detection proceeds in the order shown at the left, ending with display of the first detected error.

*1 Over-range Detection Function

Examples of Over-range Faults

Over-range Detection	Measurement Example
The measured value is outside of the measurement range.	Attempting to measure 13 kΩ with the 10 kΩ range selected
The relative tolerance (%) display of the measured value exceeds the display range (999.999%).	Measuring 500 Ω (+2400%) with a reference value of 20 Ω
The zero-adjusted value is outside of the display range.	Performing zero-adjustment after connecting 0.5 Ω with the 1 Ω range →Measuring 0.1 Ω yields a -0.4 Ω reading, exceeding the display range.
While measuring, input voltage exceed the A/D converter input range.	Measuring a large resistance value in an electrically noisy environment
Current did not flow normally to the measurement target. (When the current fault mode setting is set to "Over-range output" only)	When the measurement target yields an open FAIL result When either the SOURCE A or SOURCE B terminal suffers from poor contact. *To display "- - - - - - -" when a current fault occurs, set the current fault mode setting to "Current fault."(p.59)

*2 Current Fault Detection Function

Example of Current Fault

- SOURCE A or SOURCE B probe open
- Broken measurement target (open work)
- SOURCE A or SOURCE B cable break, poor connection

NOTE
SOURCE wiring resistance in excess of the following values may cause a current fault, making measurement impossible. When using measurement current 1 A ranges, keep the wiring resistance as well as the contact resistance between the measurement target and measurement lead low.

LP OFF

Range	100 MΩ range high-precision mode	Current switching	Measurement Current	SOURCE B - SOURCE A (Other than measurement target) *
10 mΩ	–	–	1 A	1.5 Ω
100 mΩ	–	High	1 A	1.5 Ω
100 mΩ	–	Low	100 mA	15 Ω
1000 mΩ	–	High	100 mA	15 Ω
1000 mΩ	–	Low	10 mA	150 Ω
10 Ω	–	High	10 mA	150 Ω
10 Ω	–	Low	1 mA	1 kΩ
100 Ω	–	High	10 mA	100 Ω
100 Ω	–	Low	1 mA	1 kΩ
1000 Ω	–	–	1 mA	1 kΩ
10 kΩ	–	–	1 mA	1 kΩ
100 kΩ	–	–	100 μA	1 kΩ
1000 kΩ	–	–	10 μA	1 kΩ
10 MΩ	–	–	1 μA	1 kΩ
100 MΩ	ON	–	100 nA	1 kΩ
100 MΩ	OFF	–	1 μA or less	1 kΩ
1000 MΩ	OFF	–	1 μA or less	1 kΩ

LP ON

Range	Measurement Current	SOURCE B - SOURCE A (Other than measurement target) *
1000 mΩ	1 mA	2 Ω
10 Ω	500 μA	5 Ω
100 Ω	50 μA	50 Ω
1000 Ω	5 μA	500 Ω

* When using the Z3003 Multiplexer Unit, ensure that the total of the unit's internal wiring resistance (including relays) and the wiring resistance from the connector to the measurement target does not exceed the values in the above table.
You can verify that the unit's internal wiring resistance is 1 Ω or less using the unit test.
See: "8.6 Performing the Multiplexer Unit Test" (p.167)

Setting the measurement method for an open target (current fault mode setting)

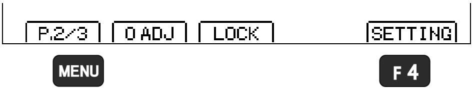
This section describes how to configure instrument operation when current fault output is detected.

When set to current fault, a break in the measurement target wiring is determined to be an error, and no comparator judgment is made. When set to over-range, a break in the measurement lead or other open state is determined to be an over-range event, and a comparator judgment of Hi results. Choose the setting that best suits your application.

NOTE
The current fault mode setting applies to all channels. (RM3545-02 only)

3

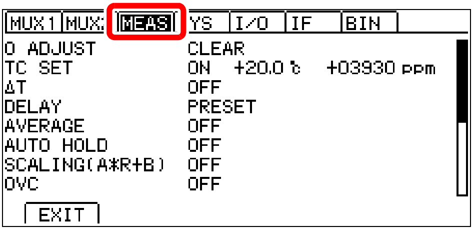
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

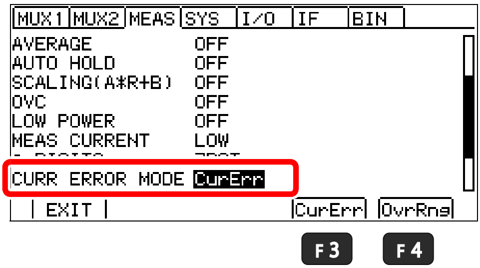
2 F4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Select the desired current fault mode.



1 Selection

2
F3 Current fault (default)
F4 Over-range

4 Return to the Measurement screen.

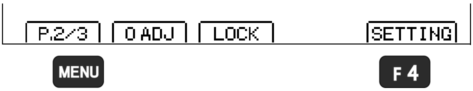
MENU Return to the Measurement screen.

Holding Measured Values

The auto-hold function provides a convenient way to check measured values. Once the measured value stabilizes, the beeper will sound, and the value will be automatically held.

NOTE
The auto-hold function setting applies to all channels. (RM3545-02 only)

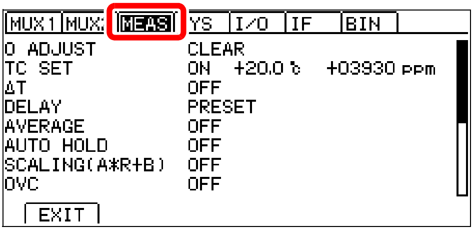
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

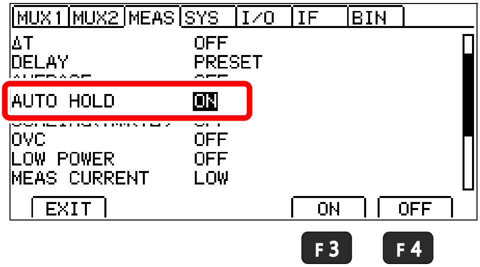
2 F4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

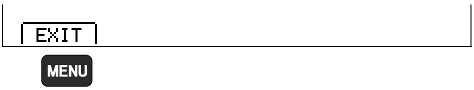
3 Enable the auto-hold function.



1 Selection

2
F3 ON
F4 OFF (default)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

5 While the measured value is being held, the HOLD indicator will light up.

Canceling auto-hold operation

Hold operation is automatically canceled when the measurement leads are removed from the measurement target and then brought into contact with the measurement target again. You can also cancel hold operation by pressing ESC or changing the range and measurement speed. When hold operation is canceled, the HOLD indicator will go out.

Customizing Measurement Conditions Chapter 4

Before making measurements, read "Operating Precautions" (p. 16) carefully.
This chapter explains functionality employed to make more advanced, more accurate measurements.
The following table lists functions and example uses:

Example uses	Function	See
When you wish to convert resistance values based on a reference temperature	Temperature Correction (TC)	p.75
When you wish to increase the measurement precision	Zero Adjustment Offset Voltage Compensation Function (OVC) 100 MΩ range high-precision mode	p.68 p.82 p.96
When you wish to eliminate excess display digits	Zero Adjustment Changing the Number of Measured Value Digits	p.68 p.81
When you wish to cancel surplus resistance from 2-terminal wiring	Zero Adjustment	p.68
When you wish to correct for the effects of thermoelectric force	Zero Adjustment Offset Voltage Compensation Function (OVC)	p.68 p.82
When you wish to correct measured values	Scaling Function	p.77
When you wish to stabilize measurement	Averaging Function Delay Function	p.73 p.84
When you wish to speed up auto-ranging	Delay Function	p.84
When you wish to limit the open voltage	Low-Power Resistance Measurement	p.64
When you wish to limit the current	Low-Power Resistance Measurement Switching Measurement Currents	p.64 p.66
When you wish to perform measurement while minimizing the effect on the contact surface state	Low-Power Resistance Measurement	p.64
When you wish to detect contact defects and measurement cable breaks	Contact Check Function	p.88
When you wish to convert readings into a physical property other than resistance (for example, length)	Scaling Function	p.77
When you wish to improve probe and switching relay contact	Contact Improver Function	p.90
When you wish to perform measurement as quickly as possible and perform self-calibration during instrument downtime	Self-Calibration Function	p.92

4.1 Switching to Low-power Resistance Measurement

In low-power resistance measurement, the open terminal voltage is limited to 20 mV to allow measurement with an extremely low current.

When measuring signal contacts (wire harnesses, connectors, relay contacts, or switches), the low-power resistance measurement function can be used to minimize the effect on the contact state.
When you measure signal contacts with the low-power function off, the oxide film on the contacts is more readily damaged.
If the contact's oxide film is damaged, it will tend to produce lower resistance values.
By contrast, the oxide film on power contacts (high-current contacts) is eliminated during use. When such contacts are measured with the low-power function on, it is not possible to break down the oxide film, resulting in higher measured values.
See: "3.1 Checking the Measurement Target" (p.48)
See: "Appendix 12 Measuring Contact Resistance" (p. A27)

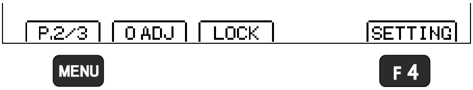
Ranges, measurement currents, and open voltages that can be used with the low-power function on

Range	Max. measurement range	Measurement current	Open voltage
1000 mΩ	1200.00 mΩ	1 mA	20 mV$_{MAX}$
10 Ω	12.0000 Ω	500 μA	
100 Ω	120.000 Ω	50 μA	
1000 Ω	1200.00 Ω	5 μA	

NOTE

- Because the detection voltage decreases when the low-power function is on, measurement is more susceptible to external noise. If measured values fail to stabilize, take steps to address the noise, referring to "Appendix 7 Unstable Measured Values" (p. A12). The following four steps are particularly effective in this situation:
  - Shield the measurement cable (connect the shielding to the instrument's GUARD terminal).
  - Twist the measurement cables together.
  - Shield the measurement target (connect the shielding to the instrument's GUARD terminal).
  - Decrease the measurement speed or use the averaging function.
- Since the effects of thermal EMF are eliminated when the low-power function is on, the instrument will be automatically set to OVC ON. If the measurement target has a large reactance component, it will be necessary to increase the delay.
  See: "4.8 Compensating for Thermal EMF Offset (Offset Voltage Compensation - OVC)" (p.82)
  See: "4.9 Setting Pre-Measurement Delay" (p.84)
- When using the SLOW2 measurement speed with low-power resistance measurement on, the instrument will average measured values twice and display the result, even if the averaging function is set to off. If the averaging function is on, the instrument will perform averaging using the set number of iterations.
- When low power is set to on, the contact improvement function will be set to off.
- When low power is set to on, the contact check default setting is off.

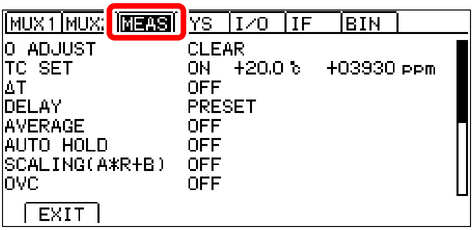
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

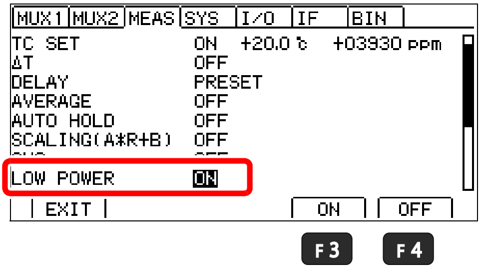
2 F4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Select the low-power mode, as needed.



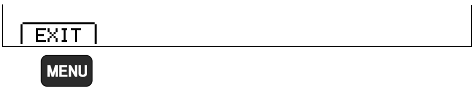
1  Selection

2

F3 Low-power resistance measurement

F4 Normal resistance measurement (default)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

4.2 Switching Measurement Currents (100 mΩ to 100 Ω)

Power equivalent to the resistance value × (measurement current)^2 will be applied to the measurement target. If there are any of the following concerns, depending on the level of the measurement current, set the measurement current to low.

- The measurement target may melt (such as a fuse or inflator).
- The measurement target may heat up, causing a change in resistance.
- The measurement target may be magnetized, causing a change in inductance.

See: "3.1 Checking the Measurement Target" (p.48)

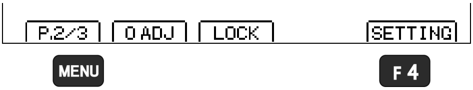
Range	High		Low	
	Measurement current	Maximum power in measurement range	Measurement current	Maximum power in measurement range
10 mΩ	1 A	12 mW	–	
100 mΩ	1 A	120 mW	100 mA	1.2 mW
1000 mΩ	100 mA	12 mW	10 mA	120 μW
10 Ω	10 mA	1.2 mW	1 mA	12 μW
100 Ω	10 mA	12 mW	1 mA	120 μW
1000 Ω	1 mA	1.2 mW	–	
10 kΩ	1 mA	12 mW	–	
100 kΩ	100 μA	1.2 mW	–	
1000 kΩ	10 μA	120 μW	–	
10 MΩ	1 μA	12 μW	–	
100 MΩ (high-precision mode: ON)	100 nA	1.2 μW	–	
100 MΩ, 1000 MΩ (high-precision mode: OFF)	1 μA or less	1.3 μW	–	

NOTE

Because the detection voltage decreases when the measurement current is Low, measurement is more susceptible to external noise. If measured values fail to stabilize, take steps to address the noise, referring to "Appendix 7 Unstable Measured Values" (p. A12). The following four steps are particularly effective in this situation:

- Shield the measurement cable (connect the shielding to the instrument’s GUARD terminal).
- Twist the measurement cables together.
- Shield the measurement target (connect the shielding to the instrument’s GUARD terminal).
- Decrease the measurement speed or use the averaging function.

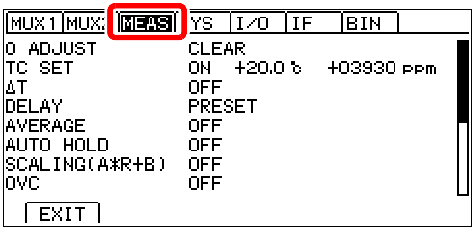
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

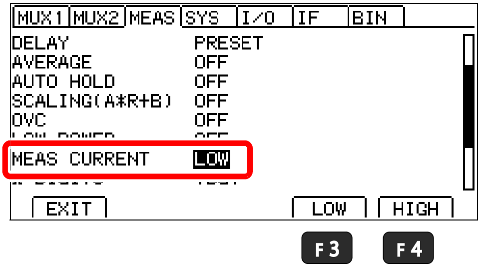
2 F 4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

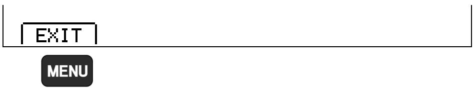
3 Select the 100 mΩ range measurement current.



1 Selection

2
F 3 LOW
F 4 HIGH (default)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

NOTE

- When the measurement current is switched, zero-adjustment will be initialized. Perform zero adjustment again.
- When using the INT trigger source, current will stop when a contact error occurs (when not connected to the measurement target). By contrast, when using the INT trigger source with the contact check function off, the measurement current is always applied, even when the instrument is not connected to the measurement target. Consequently, a rush current will flow at the moment the instrument is connected to the target (for example, measuring a pure resistance in the 1 A measurement current range will result in a maximum current of 5 A with a convergence time of 0.5 ms). When measuring easily damaged elements, either turn on the contact check or use a range that results in a low measurement current. However, if there is chatter even when the contact check is enabled, it will not be possible to completely prevent a rush current.

4.3 Zero Adjustment

Perform zero-adjustment in the following circumstances:

- When you wish to increase the measurement precision
  → For some ranges, there may be a component added to the accuracy if zero-adjustment is not performed.
  See: "Measurement Specifications" (p. 252)
- The measured value is not cleared due to thermal EMF or other factors.
  → The measured value will be adjusted to zero. (*1)
- Four-terminal connection (called Kelvin connection) is difficult.
  → The residual resistance of the two-terminal connection wires will be canceled.

*1 Accuracy specifications vary when zero-adjustment has not been performed.
For more information, see "Chapter 13 Specifications" (p.251).
Thermal EMF can also be canceled by using OVC. (p.82)

For more information about how to perform zero-adjustment properly, see "Appendix 6 Zero Adjustment" (p. A7).

Before Zero Adjustment

- Execute zero adjustment when the ambient temperature has changed, or when a measurement lead is replaced after zero adjustment was performed. However, when performing zero-adjustment is difficult, for example when using the L2102 or L2103 Pin Type Lead, perform zero-adjustment using the standard included L2101 Clip Type Lead or similar lead and then switch to the pin type lead to perform measurement.
- Zero adjustment should be executed in each range to be used. Perform zero-adjustment for the current range only when setting the range manually or for all ranges when using auto-ranging.
- When zero adjustment is executed with auto-ranging, correct zero adjustment may not be possible if the delay time is too short. In this case, execute zero adjustment with a manually set range.
  See: "3.2 Selecting the Measurement Range" (p.49)
  "4.9 Setting Pre-Measurement Delay" (p.84)
- Zero adjustment values are retained internally even when the instrument is turned off. They are also saved with panels. You can also elect not to load zero-adjustment values from panels.
  See: "6.1 Saving Measurement Conditions (Panel Save Function)" (p.120)
  "6.2 Loading Measurement Conditions (Panel Load Function)" (p.121)
- Zero-adjustment can be performed even when the EXT I/O 0ADJ signal is ON (when shorted with the EXT I/O connector’s ISO_COM pin).
- When switching the offset voltage correction (OVC) function, measurement current, or low-power function, zero adjustment will be canceled automatically. If necessary, repeat the zero adjustment process.
- Although resistance of -1%f.s. to 50%f.s. can be canceled in each range, try to keep the canceled resistance to 1%f.s. Zero-adjustment cannot be performed for 100 MΩ and higher ranges.

LP	f.s.
OFF	1,000,000dgt.
ON	100,000dgt.

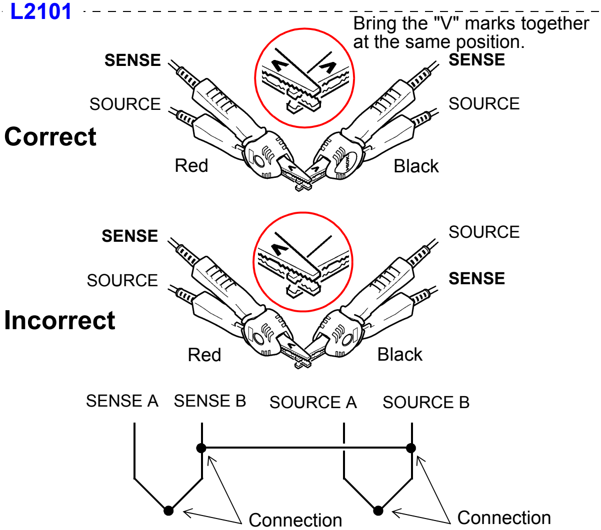
- If a resistance that is smaller than the resistance value when zero-adjustment was performed is measured, the measured value will be negative.
  Example: If you set an offset of 50 mΩ for the 100 mΩ range
  →If you measure 30 mΩ, -20 mΩ will be displayed.
- When using the multiplexer, zero-adjustment can be performed by scanning all channels.
  See: "8.5 Zero Adjustment (When a Multiplexer Unit Has Been Installed)" (p.164)

Allow the instrument to warm up for 60 minutes before performing zero-adjustment.

Performing zero-adjustment

1 **Short the measurement leads together.**

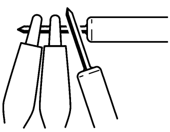
L2101



L2102, L2103 (options)

Since zero-adjustment cannot be performed with the L2102 or L2103, use the L2101 Clip Type Lead or other lead type to perform zero-adjustment.

L2104 (option)

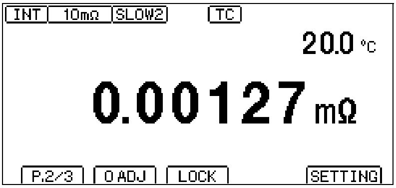


Place the alligator clips on the outside and the lead rods on the inside when performing zero-adjustment.

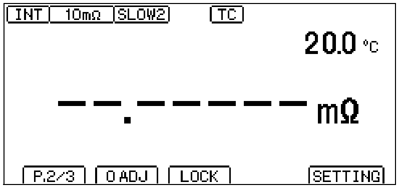
2 **Verify that the measured value is within ±1%f.s. If the measured value is 50%f.s. or less in each range, zero-adjustment can be performed, but a warning will be issued when it is greater than 1%f.s.**

If no measured value is displayed, verify whether the measurement leads have been wired properly.

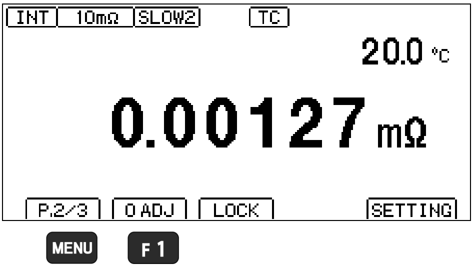
Proper wiring



Improper wiring



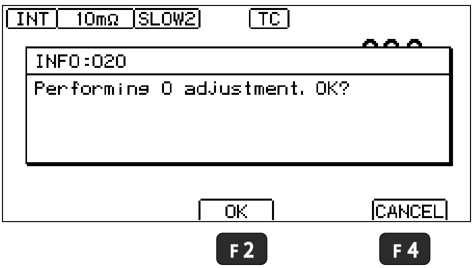
3 **Perform zero-adjustment.**



1 MENU Switch the function menu to P.2/3.

2 F1 [0ADJ]
Perform zero-adjustment.

4 **A confirmation message will be displayed. Confirm and return to the Measurement screen.**

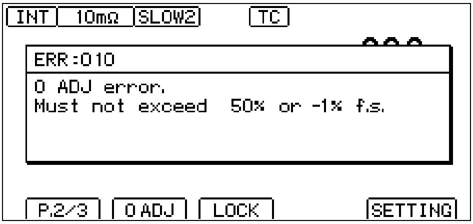


F2 Perform zero-adjustment and return to the Measurement screen.

F4 Cancel the operation and return to the previous screen.

Zero Adjustment Faults

If zero adjustment fails, the following error message appears.



Before attempting zero adjustment again, confirm the following:
- Verify that the measured value is -1%f.s. to 50%f.s. in each range.
- When using measurement leads that you made, reduce the wiring resistance.
- Confirm that the measurement leads connections are correct.

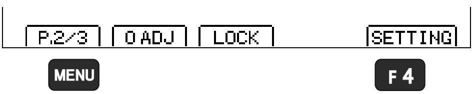
See: "*2 Current Fault Detection Function" (p. 57)

NOTE
- If zero-adjustment fails for auto-ranging, zero-adjustment will be canceled for all ranges.
- If zero-adjustment fails for a manually set range, zero-adjustment will be canceled for the current range.

Canceling zero-adjustment

Cancels zero-adjustment for all ranges.

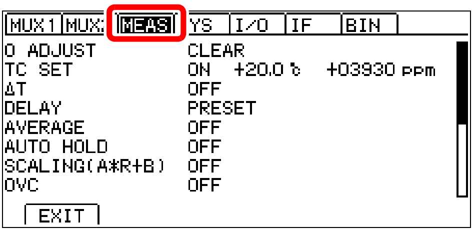
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

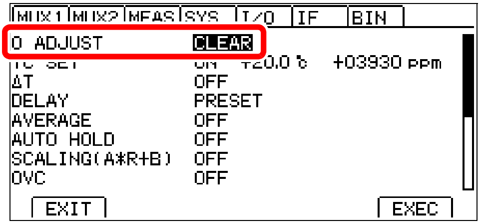
2 F4 The Settings screen appears.

2 **Open the Measurement Setting Screen.**



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Select 0 ADJUST.



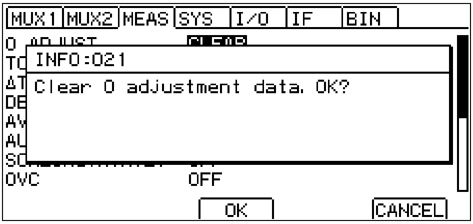
F4

1  Selection

2

F4 Cancel zero-adjustment.

4 A confirmation message will be displayed. Confirm and return to the Measurement screen.



F2 F4

F2 Clear zero-adjustment and return to the Settings screen.

F4 Cancel the operation and return to the previous screen.

5 Return to the Measurement screen.

MENU

MENU Return to the Measurement screen.

4.4 Stabilizing Measured Values (Averaging Function)

The averaging function averages multiple measured values and displays the results. It can be used to reduce variation in measured values.

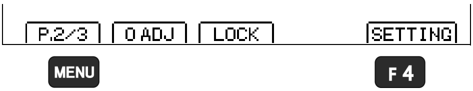
For internal trigger measurement (Free-Run), a moving average is calculated.
For external trigger measurement (and **:READ?** command operation) (Non-Free-Run), a mean average is used.
For more information about communications commands, see the included application disc.

Average (of measurements D1 to D6) with Averaging Samples set to 2.

	1st Sample	2nd Sample	3rd Sample
Free-Run (Moving Avg.)	(D1+D2)/2	(D2+D3)/2	(D3+D4)/2
Non-Free-Run (Mean Avg.)	(D1+D2)/2	(D3+D4)/2	(D5+D6)/2

When using the SLOW2 measurement speed with low-power resistance measurement on, the instrument will performing averaging with two iterations internally even if the averaging function is set to off. If the averaging function is on, the instrument will perform averaging using the set number of iterations.

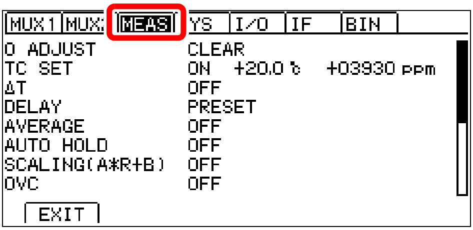
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

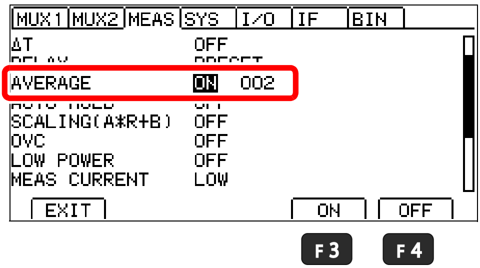
2 F 4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Enable the averaging function.



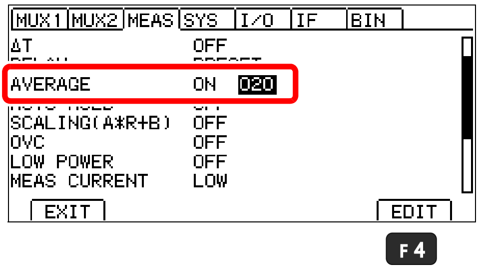
1 Selection

2

F3 Enables the averaging function

F4 Disables the averaging function (default) (go to step 5)

4 Set the number of averaging iterations.



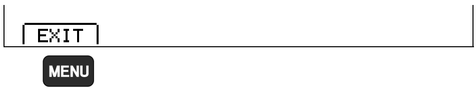
Setting range: 2 to 100 times (default: 2 times)

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

5 Return to the Measurement screen.



MENU Return to the Measurement screen.

4.5 Correcting for the Effects of Temperature (Temperature Correction (TC))

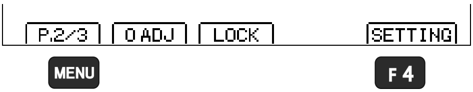
Temperature correction converts resistance values to resistance values at standard temperature and displays the result.

For more information about the principle of temperature correction, see "Appendix 4 Temperature Correction (TC) Function" (p. A4).
To perform temperature correction, connect the temperature sensor or thermometer with analog output to the TEMP. jack on the rear of the instrument.
See: "2.3 Connecting Z2001 Temperature Sensor or Thermometer with Analog Output (When using the TC or ΔT)" (p.37)
See: "3.1 Checking the Measurement Target" (p.48)

4

NOTE
Setting ΔT to on causes TC to be turned off automatically.

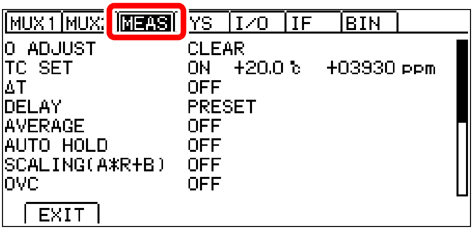
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

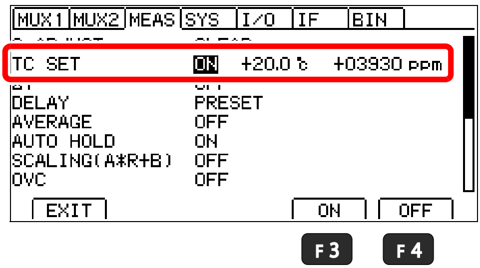
2 F4 The Settings screen appears.

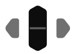
2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Enable the temperature correction function. (TC)



1  Selection

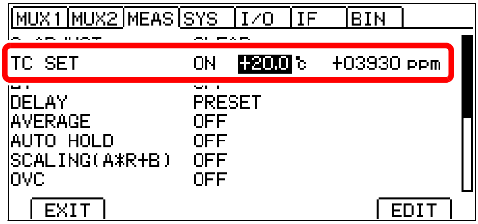
2

F3 Enables the TC function

F4 Disables the TC function (default) (go to step 5)

4 **Set the reference temperature and temperature coefficient.**

(Set the reference temperature and temperature coefficient by following steps **1** through **3** for each.)



F4

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.

Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept

(ESC Cancel)

Setting range
reference temperature : -10.0 to 99.9°C (default: 20°C)
temperature coefficient : -99999 to 99999ppm/°C (default: 3930ppm/°C)

5 **Return to the Measurement screen.**

MENU

MENU Return to the Measurement screen.

4.6 Correcting Measured Values and Displaying Physical Properties Other than Resistance Values (Scaling Function)

This function applies a correction to measured values. It can be used to cancel the effects of the probing position or differences between measuring instruments, or to apply a user-specified offset as an alternative to zero-adjustment. In addition, units can be specified, allowing it to be used to convert measured values to physical properties other than resistance (for example, length).

Scaling is performed by means of the following equations:

$$R_S = A \times R + B$$

R_S : Resistance value after scaling
R : Measured value after zero-adjustment and temperature correction
A : Gain coefficient Setting range: 0.2000×10^{-3} to 1.9999×10^{3}
B : Offset Setting range: 0 to $\pm 9 \times 10^{9}$ (maximum resolution: 1 nΩ)

Displayed and sent/received measured values as well as the printer output format vary with the gain coefficient.

Low-Power: OFF

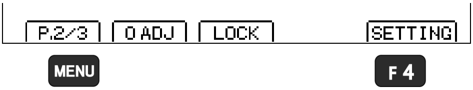
Range	Gain coefficient						
	(0.2000 to 1.9999) $\times 10^{-3}$	(0.2000 to 1.9999) $\times 10^{-2}$	(0.2000 to 1.9999) $\times 10^{-1}$	(0.2000 to 1.9999) $\times 1(10^{0})$	(0.2000 to 1.9999) $\times 10(10^{1})$	(0.2000 to 1.9999) $\times 10^{2}$	(0.2000 to 1.9999) $\times 10^{3}$
10 mΩ	00.000 μ	000.000 μ	0000.000 μ	00.000 00 m	000.000 0 m	0000.000 m	00.000 00
100 mΩ	000.000 μ	0000.000 μ	00.000 00 m	000.000 0 m	0000.000 m	00.000 00	000.000 0
1000 mΩ	0000.000 μ	00.000 00 m	000.000 0 m	0000.000 m	00.000 00	000.000 0	0000.000
10 Ω	00.00 000 m	000.000 0 m	0000.000 m	00.000 00	000.000 0	0000.000	00.000 00 k
100 Ω	000.000 0 m	0000.000 m	00.000 00	000.0000	0000.000	00.000 00 k	000.000 0 k
1000 Ω	0000.000 m	00.000 00	000.000 0	0000.000	00.000 00 k	000.000 0 k	0000.000 k
10 kΩ	00.000 00	000.000 0	0000.000	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M
100 kΩ	000.000 0	0000.000	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M
1000 kΩ	0000.000	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M	0000.000 M
10 MΩ	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M	0000.000 M	00.000 00 G
100 MΩ*	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M	0000.000 M	00.000 00 G	000.000 0 G
1000 MΩ	0000.0 k	00.000 M	000.00 M	0000.0 M	00.000 G	000.00 G	0000.0 G

* When high-precision mode is off in the 100 MΩ range, 5 digits are displayed.

Low-Power: ON

Range	Gain coefficient						
	(0.2000 to 1.9999) $\times 10^{-3}$	(0.2000 to 1.9999) $\times 10^{-2}$	(0.2000 to 1.9999) $\times 10^{-1}$	(0.2000 to 1.9999) $\times 1(10^{0})$	(0.2000 to 1.9999) $\times 10(10^{1})$	(0.2000 to 1.9999) $\times 10^{2}$	(0.2000 to 1.9999) $\times 10^{3}$
1000 mΩ	0000.00 μ	00.000 0 m	000.000 m	0000.00 m	00.000 0	000.000	0000.00
10 Ω	00.000 0 m	000.000 m	0000.00 m	00.000 0	000.000	0000.00	00.000 0 k
100 Ω	000.000 m	0000.00 m	00.000 0	000.000	0000.00	00.000 0 k	000.000 k
1000 Ω	0000.00 m	00.000 0	000.000	0000.00	00.000 0 k	000.000 k	0000.00 k

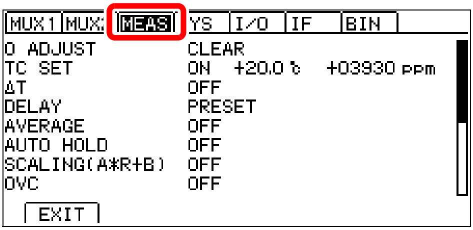
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

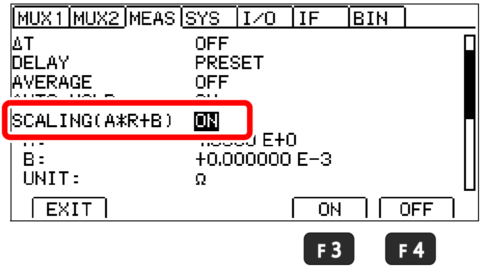
2 F4 The Settings screen appears.

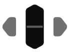
2 **Open the Measurement Setting Screen.**



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 **Enable the scaling function.**



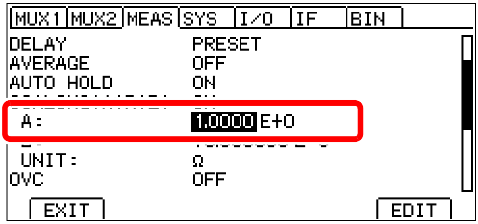
1  Selection

2

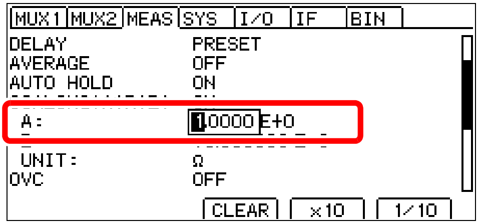
F3 Enables the scaling function

F4 Disables the scaling function (default) (go to step 8)

4 Set the gain coefficient.



F4



F2 F3 F4

Setting range: 0.2000×10^{-3} to 1.9999×10^{3}

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.

Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

F3 Multiply by 10.

F4 Multiply by 1/10.

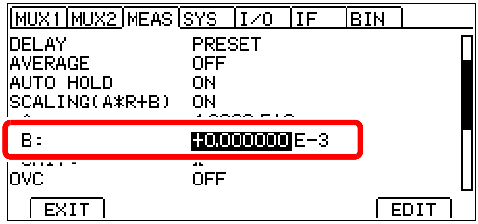
F2 Clear value.

It is not possible to set the exponent (E+3, etc.) directly. Use F3 and F4 to multiply by 10 and 1/10 as necessary.

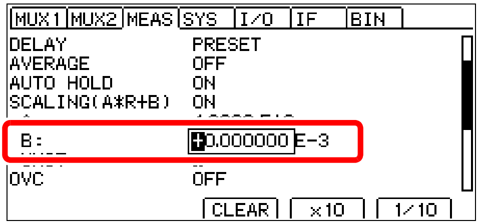
3 ENTER Accept

(ESC Cancel)

5 Set the offset.



F4



F2 F3 F4

Setting range: 0 to $\pm9\times10^{9}$
(maximum resolution: 1 nΩ, default: 0)

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.

Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

F3 Multiply by 10.

F4 Multiply by 1/10.

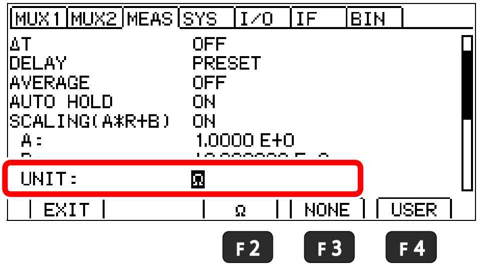
F2 Clear value.

It is not possible to set the exponent (E+3, etc.) directly. Use F3 and F4 to multiply by 10 and 1/10 as necessary.

3 ENTER Accept

(ESC Cancel)

6 Set the units for the displayed measured values.



1 Selection

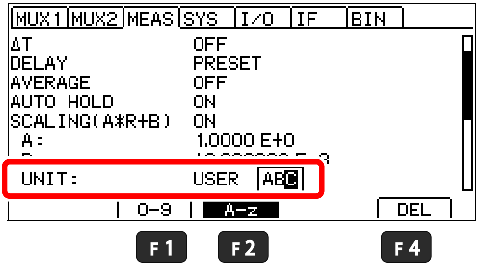
2

F2 Use Ω as the unit. (default) (go to step 8)

F3 Eliminate the unit. (go to step 8)

F4 Use a user-defined unit.

7 Edit the unit as desired.



1 Make the value editable with the F4 key.

Move among digits. Change values.

Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

F1 Enter a number from 0 to 9

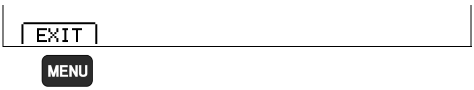
F2 Enter a letter from A to z

F4 Delete 1 character.

2 ENTER Accept

(ESC Cancel)

8 Return to the Measurement screen.



MENU Return to the Measurement screen.

NOTE

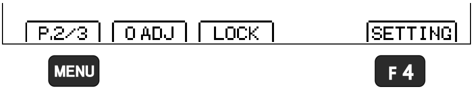
Scaling calculation is performed on measured values after zero-adjustment calculation. Consequently, measured values may not equal zero even after zero adjustment.

- If the calculation result exceeds the display range, the measured value will not be displayed at full scale.
  Example: If you set an offset of 90 Ω for the 10Ω range
  → Values in excess of 10 Ω will be displayed as OvrRng.
- If the calculation result is negative, the displayed value will be negative.
  Example: If you set an offset of -50 mΩ for the 100 mΩ range
  → If you measure 30 mΩ, -20 mΩ will be displayed.

4.7 Changing the Number of Measured Value Digits

NOTE
The number of measured value digits setting applies to all channels. (RM3545-02 only)

1 Open the Settings Screen.

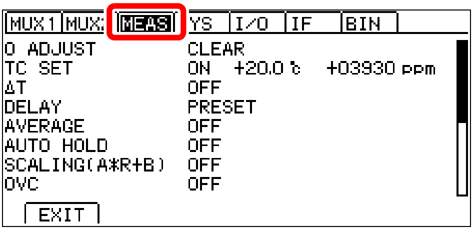


1 MENU Switch the function menu to P.2/3.

2 F4 The Settings screen appears.

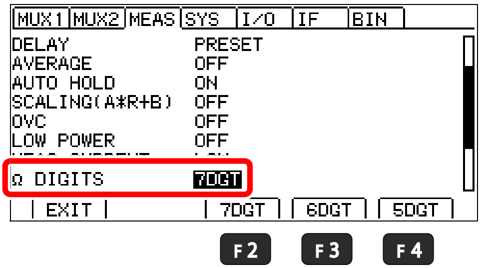
4

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Select the number of measurement digits.



1 Selection

2
F2 7digits (1,000,000dgt.) (default)
F3 6digits (100,000dgt.)
F4 5digits (10,000dgt.)

(If the number of f.s. digits is less than the setting, the number of f.s. digits will be used. For more information about f.s., see "13.1 Instrument Specifications" (p.251).)

4 Return to the Measurement screen.

MENU Return to the Measurement screen.

4.8 Compensating for Thermal EMF Offset (Offset Voltage Compensation - OVC)

This function automatically compensates for offset voltage resulting from thermal emf or internal instrument bias. (OVC: Offset Voltage Compensation)

See: "Appendix 10 Effect of Thermal EMF" (p. A24)
"3.1 Checking the Measurement Target" (p.48)

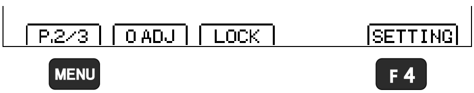
The following value is known to be a true resistance value from R_P , the value measured with current flowing in the positive direction, and R_N , the value measured with current flowing in the negative direction.

$$\frac{R_P - R_N}{2}$$

- When low-power resistance measurement is disabled.
  From the 10 mΩ range to the 1,000 Ω range, the offset voltage correction function can be turned on. From the 10 kΩ range to the 1,000 mΩ range, the OVC function cannot be used.

- When low-power resistance measurement is enabled.
  The offset voltage correction function will be automatically turned on for all ranges. This function cannot be disabled.

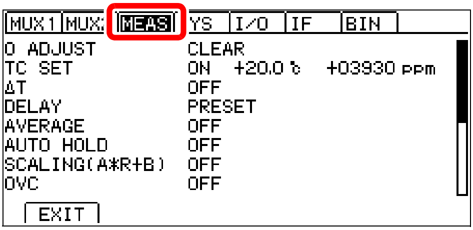
1 Open the Settings Screen.

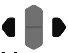


1 MENU Switch the function menu to P.2/3.

2 F 4 The Settings screen appears.

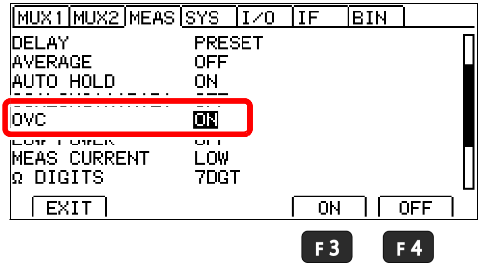
2 Open the Measurement Setting Screen.





Move the cursor to the [MEAS] tab with the left and right cursor keys.

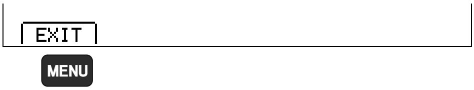
3 Enable the offset voltage compensation (OVC) function.



1 Selection

2
F3 ON
F4 OFF

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

NOTE

- When the measurement target has a high inductance, it is necessary to adjust the delay time. (p.84) To adjust the delay, begin with a longer delay than necessary, then gradually shorten it while watching the measured value.
- If using the zero-adjustment function, execute it after making any changes to Offset Voltage Compensation.
- When Offset Voltage Compensation is enabled (OVC lit) measurement time is increased.

4.9 Setting Pre-Measurement Delay

This function adjusts the time for measurement to stabilize by inserting a waiting period after use of the OVC or the auto range function to change the measurement current. When this function is used, the instrument waits for its internal circuitry to stabilize before starting measurement, even if the measurement target has a high reactance component.

If the measurement target, for example, is an inductor that takes longer to stabilize after applying a measurement current, and it cannot be measured with the initial delay (default), adjust the delay. Set the delay time to approximately ten times the following calculation so that the reactance component (inductance or capacitance) does not affect the measurement.

$$t = -\frac{L}{R}\ln\left(1 - \frac{IR}{V_O}\right)$$

L...... Inductance of measurement target
R...... Resistance of measurement target + test leads + contacts
I....... Measurement current (see “Accuracy” (p.253))
V_O ... Open-terminal voltage (see “Accuracy” (p.253))

The delay setting can be selected from a preset (internal fixed value) or user-set value.

(1) Preset (internal fixed value)

Value depends on the range and offset voltage correction function.

LP OFF (unit: ms)

Range	100 MΩ range high-precision mode	Measure-ment cur-rent	Delay	
			OVC: OFF	OVC: ON
10 mΩ	–	–	75	25
100 mΩ	–	High	250	25
	–	Low	20	2
1000 mΩ	–	High	50	2
	–	Low	5	2
10 Ω	–	High	20	2
	–	Low	5	2
100 Ω	–	High	170	2
	–	Low	20	2
1000 Ω	–	–	170	2
10 kΩ	–	–	180	–
100 kΩ	–	–	95	–
1000 kΩ	–	–	10	–
10 MΩ	–	–	1	–
100 MΩ	ON	–	500	–
100 MΩ	OFF	–	1	–
1000 MΩ	OFF	–	1	–

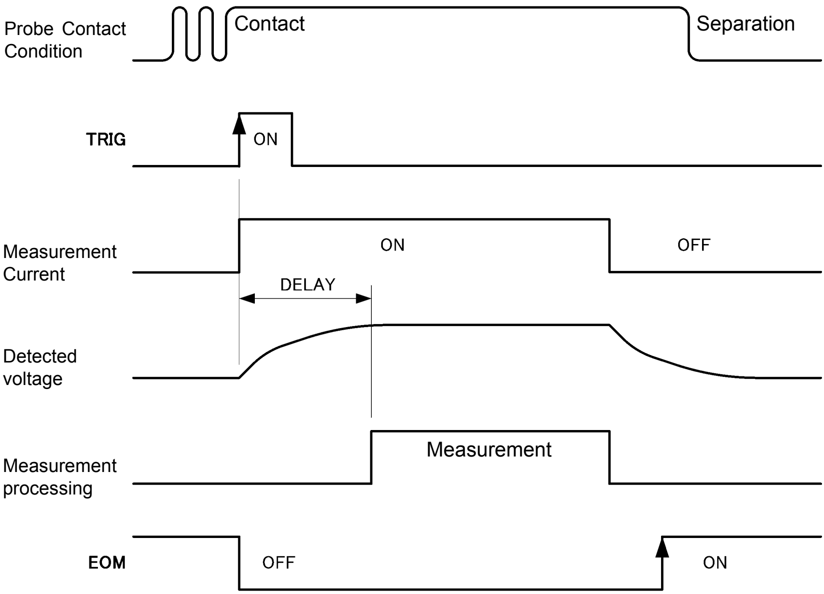
LP ON

Delay
1

(2) User-set value

Setting range: 0 to 9999 ms
The set value is used for all ranges.

Delay Timing Chart



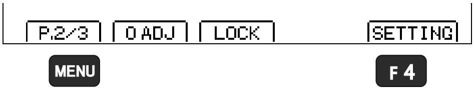
NOTE

- The preset value is set assuming about 10 mH of inductance and varies with each measurement range.
- When using the EXT trigger source, the measurement current will not be stopped for measurement ranges of 10 kΩ and greater (continuous application).

Setting the Delay Time

Set the delay so that reactance component (inductance or capacitance) does not affect measurements.
To fine tune the delay, begin with a longer delay than necessary, then gradually shorten it while watching the measured value.

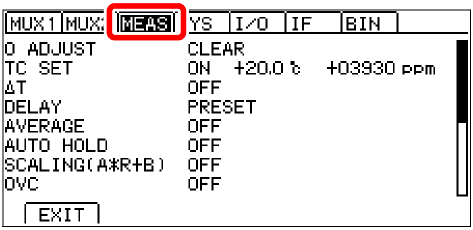
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

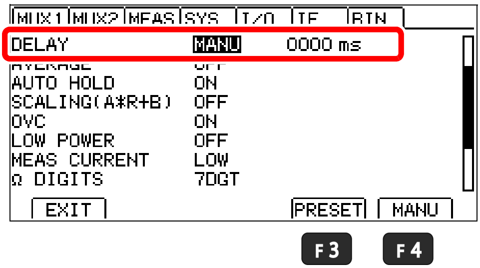
2 F4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Select whether to use the preset (default) or a user-set value.



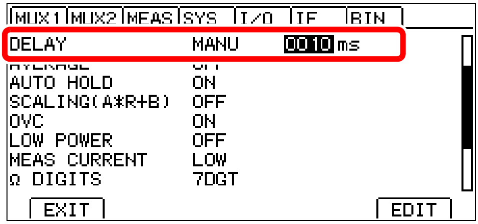
1 ◀ ▶ Selection

2

F3 Preset (internal fixed value) (go to step 5)

F4 User-set

4 Set DELAY.



F4

Setting range: 0 ms (default) to 9999 ms

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

5 Return to the Measurement screen.

MENU

MENU Return to the Measurement screen.

4.10 Checking for Poor or Improper Contact (Contact Check Function)

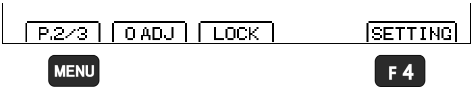
This function detects poor contact between the probes and measurement target, and broken measurement cables.
The instrument continually monitors the resistance between the SOURCE A and SENSE A probes and the SOURCE B and SENSE B probes from the start of integration (including response time) and while measuring. When the resistance is outside of the threshold, a contact error is determined to have occurred.a

When a contact error occurs, **CONTACT TERM.A** or **CONTACT TERM.B** error message appears. No comparator judgment is applied to the measured value. When these error messages appear, check the probe contacts, and check for broken measurement cables.
When the resistance value between the SENSE and SOURCE is high, for example when the measurement target is conductive paint or conductive rubber, you will not be able to perform measurement due to the continuous error state. In this case, turn off the contact check function.
(If the error is not cleared by shorting the tips of a known-good measurement cable, the instrument requires repair.)
See: "3.5 Checking Measured Values" (p.52)
See: "Appendix 15 Checking Measurement Faults" (p. A33)

NOTE

- The contact check threshold is about 50 Ω. Because the threshold depends on the measurement target, connection cables, measurement range, and other factors, it may not reach 50 Ω. Additionally, if the source resistance value alone is large, a current fault may occur without a contact error. (p.55)
- Turning the setting off with the 100 MΩ or greater range will cause the contact check function to operate continuously.
- When set to 2-wire with the multiplexer, the contact check function will be turned off.
- During low-resistance measurement, poor contact of the SOURCE A or SOURCE B probe may be detected as an over-range measurement.
- When contact checking is disabled, measured values may be displayed even when a probe is not contacting the measurement target.
- When the contact check is disabled, the measured value error component may increase when the contact resistance increases.
- When using the INT trigger source, current will stop when a contact error occurs (when not connected to the measurement target). By contrast, when using the INT trigger source with the contact check function off, the measurement current is always applied, even when the instrument is not connected to the measurement target. Consequently, a rush current will flow at the moment the instrument is connected to the target (for example, measuring a pure resistance in the 1 A measurement current range will result in a maximum current of 5 A with a convergence time of 0.5 ms). When measuring easily damaged elements, either turn on the contact check or use a range that results in a low measurement current. However, if there is chatter even when the contact check is enabled, it will not be possible to completely prevent a rush current.
- Routing measurement cables together with power lines, signal lines, or measurement cables for other devices may result in a contact error.
- The contact check function default setting is disabled during low-power resistance measurement. Turning on the contact check function will cause the open terminal voltage to change to 300 mV.

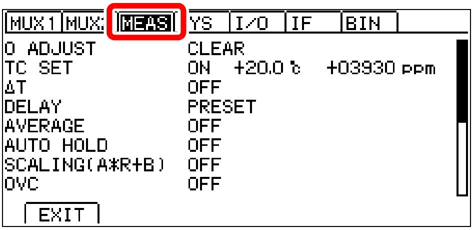
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

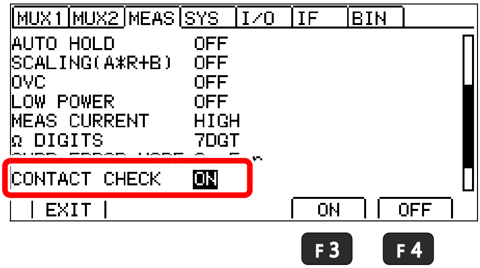
2 F4 The Settings screen appears.

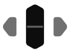
2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Enable the Contact Check function.



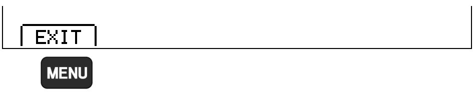
1  Selection

2

F3 Enables the contact check function (default setting when low power is set to off)

F4 Disables the contact check function (default setting when low power is set to on)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

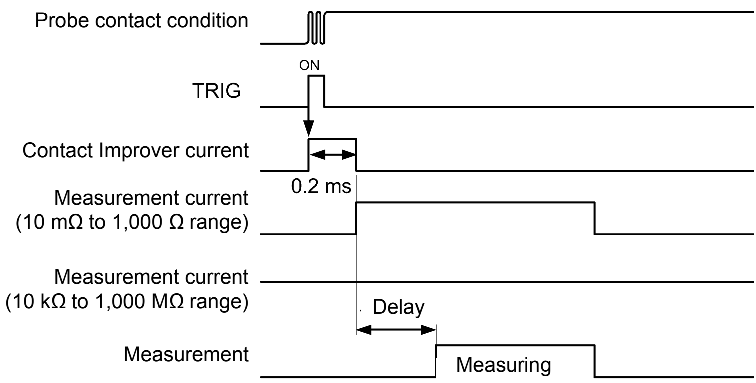
4.11 Improving Probe Contact (Contact Improver Function)

Probe contacts can be improved by applying current from the SENSE A to the SENSE B probes before measuring.

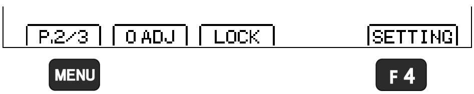
⚠CAUTION The Contact Improver function applies voltage to the sample. Be careful when measuring samples with characteristics (magnetoresistive elements, signal relays, EMI filters, etc.) that may be affected.

The maximum contact improvement current is 10 mA, and the maximum applied voltage is 5 V.
When low power is set to on, the contact improver function is set to off.
Using the contact improver function causes the time until measurement completion to be lengthened by 0.2 ms.

Timing Chart (Contact Improver Function)



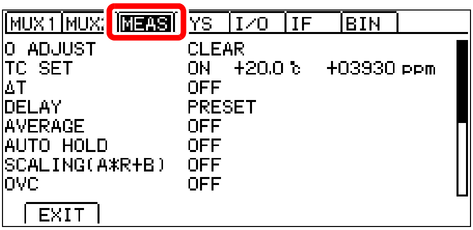
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

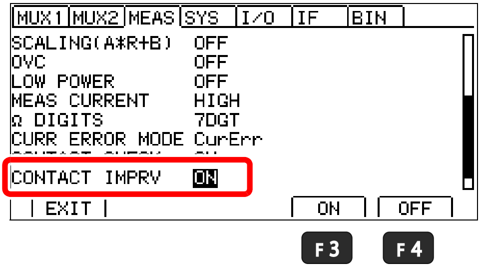
2 F4 The Settings screen appears.

2 **Open the Measurement Setting Screen.**



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 **Enable the Contact Improver function.**



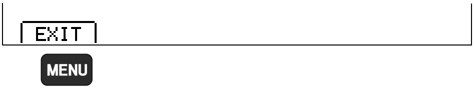
1  Selection

2

F3 Enables the contact improver function

F4 Disables the contact improver (default)

4 **Return to the Measurement screen.**



MENU Return to the Measurement screen.

4.12 Maintaining Measurement Precision (Self-Calibration)

The instrument corrects the circuitry's internal offset voltage and gain drift as a form of self-calibration in order to maintain its measurement precision.

You can select between two self-calibration function execution methods.

Execute automatically. (default) → **Configure automatically.**
A self-calibration that lasts about 5 ms is performed between measurements.

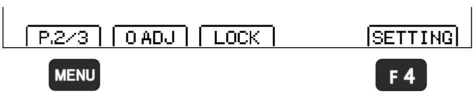
Execute at user-selected timing. → **Configure manually.**
Self-calibration is performed at the user's desired timing using the EXT I/O CAL signal input or a communications command (`:SYSTem:CALibration`). Using this setting prevents self-calibration from being performed automatically at unexpected times.

Self-calibration timing and intervals

Setting	Calibration timing	Measurement hold interval (calibration interval)
Auto *	After measurement	5 ms
Manual	During execution	400 ms

* When using the auto setting
When using the auto setting, self-calibration is performed for 5 ms once every second during TRIG standby operation. In the event the TRIG signal is received during a 5 ms self-calibration, the self-calibration is canceled, and measurement will start after 0.5 ms. If you are concerned about variation in measurement times, please use the manual setting.

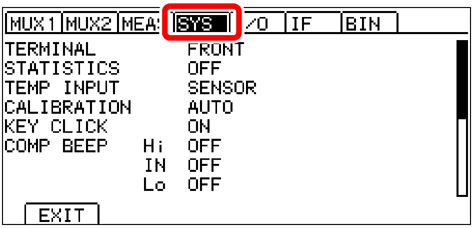
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

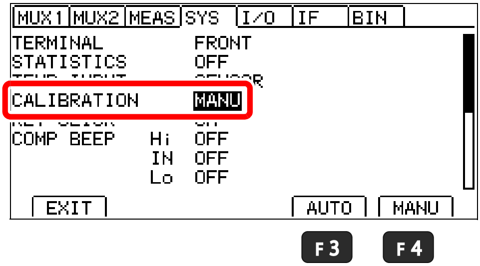
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

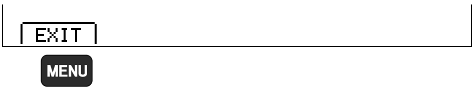
3 Configure self-calibration operation.



1 Selection

2
F3 Configure automatically. (default)
F4 Configure manually.

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

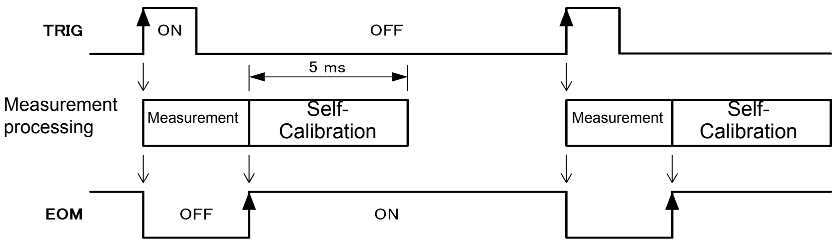
NOTE

When self-calibration operation is set to manual, be sure to perform self-calibration if the temperature of the environment in which the instrument is operating changes by 2 degrees or more. (Accuracy cannot be guaranteed if self-calibration is not performed.)
Even if the temperature variation in the operating environment is less than 2 degrees, self-calibration should be performed at a 30-minute interval.

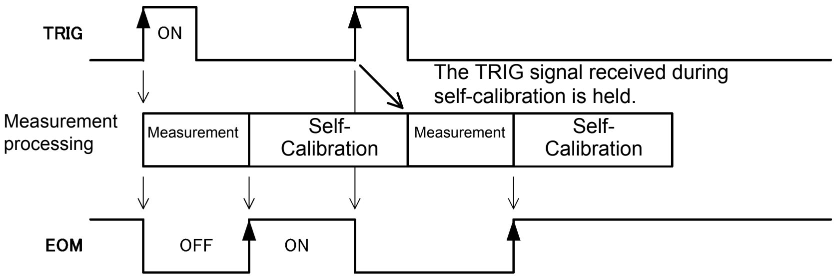
Auto setting operation

Self-calibration starts immediately after measurement completes and is finished in 5 ms. One TRIG signal received during self-calibration is held, and measurement will start after the self-calibration completes.

If there is at least 5 ms of extra time in the measurement interval



If the TRIG signal is received during self-calibration



Additionally, self-calibration is performed once every second during TRIG standby operation. In the event the TRIG signal is received during self-calibration, the self-calibration is canceled, and measurement will start after 0.5 ms.

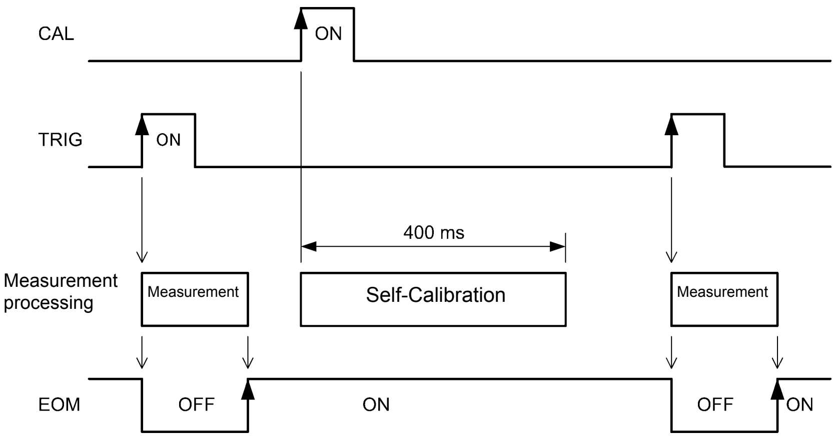
NOTE

- During auto-scan operation, self-calibration starts only after scanning completes. Self-calibration will not be performed after each channel is measured.
- A 400 ms self-calibration is performed immediately after switching from MANUAL to AUTO. Do not input the TRIG signal during that interval.

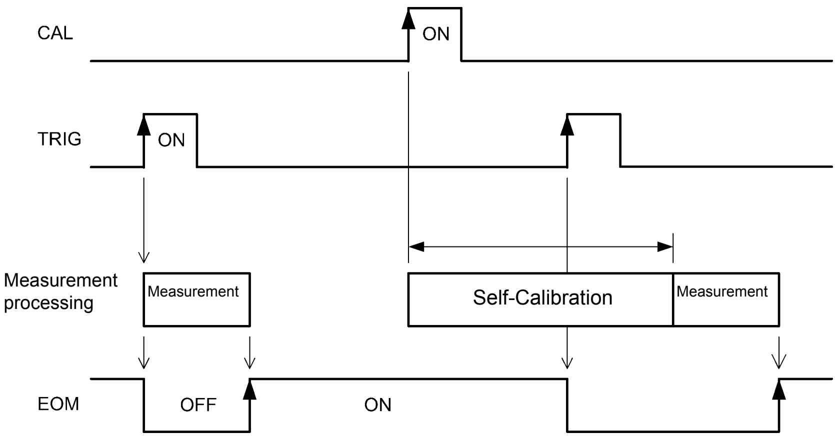
Manual setting operation

Self-calibration starts immediately when the CAL signal is input.
If the TRIG signal is input during self-calibration, self-calibration will continue. In this case, the TRIG signal will be accepted, the EOM signal will turn off, and measurement will start after self-calibration completes.
If the CAL signal is received during measurement, the CAL signal will be accepted, and self-calibration will start after measurement completes.

Method of normal use



If the TRIG signal is received during self-calibration

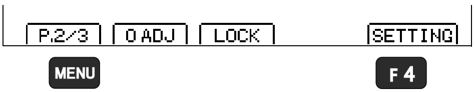


4.13 Increasing the Precision of the 100 MΩ Range (100 MΩ High-precision Mode)

The precision of the 100 MΩ range can be increased.

Turning on high-precision mode has the following effects:
- The 1,000 MΩ range will be unavailable for use.
- More time will be required for measured values to stabilize. To adjust the time required until values stabilize, set a delay.
  See: "4.9 Setting Pre-Measurement Delay" (p.84)

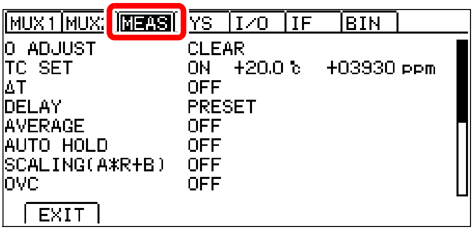
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

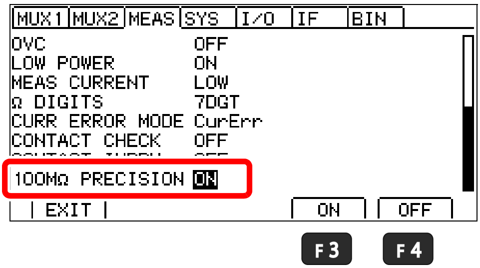
2 F4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Turn on 100 mΩ range high-precision mode.



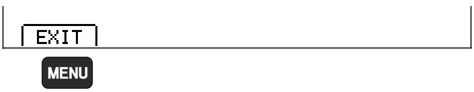
1 Selection

2

F3 Enables the 100 MΩ high-precision mode

F4 Disables the 100 MΩ high-precision mode

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

Judgment, Statistics, and Conversion Functions

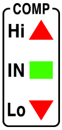
Chapter 5

This chapter explains measured value judgments and conversion functions.

5.1 Judging Measured Values (Comparator Function)

The comparator function provides the following capabilities:

- Displaying information on the instrument (COMP lamp Hi/ IN/ Lo)



Measured value > Upper limit value

Upper limit value ≥ Measured value ≥ Lower limit value

Measured value < Lower limit value

- Sounding the beeper
  (By default, the beeper is disabled.)
  See: "Checking Judgments Using Sound (Judgment Sound Setting Function)"(p.105)

- Displaying data away from the instrument
  The L2105 LED Comparator Attachment is an option.
  See: "Checking Judgments with the L2105 LED Comparator Attachment (Option)"(p.107)

- Outputting judgment results to external equipment
  See: "Chapter 10 External Control (EXT I/O)" (p. 177)

- Making a total judgment
  See: "Total judgments"(p.157)

The comparator judgment mode can be set as one of the following:

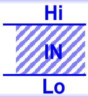
Decide whether a measured value is between specified upper and lower threshold values (absolute values) (p. 101)

→ **Select the ABS (absolute values) judgment mode**

example

100.00 mΩ . upper threshold
80.00 mΩ ... lower threshold

Upper threshold [Ω]
Lower threshold [Ω]



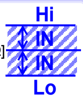
Decide whether a measured value is within specified tolerance limits relative to a specified reference value (p. 103)

→ **Select the REF% (relative values) judgment mode**

example

12.000 kΩ... reference value
±0.08% .... positive/negative tolerance

Positive tolerance [%]
Reference value [Ω]
Negative tolerance [%]



Before Using the Comparator Function

- The comparator judgment indicator will function as follows for over-range events ("**OvrRng**" display) and measurement faults ("**CONTACT TERM**" display or "**- - - - - - -**" display):
  See: "Confirming Measurement Faults"(p.55)

Measured value display	Comparator Judgment Indicator
+OvrRng	**Hi**
-OvrRng	**Lo**
CONTACT TERM or **- - - - - - -**	Off (no judgment)

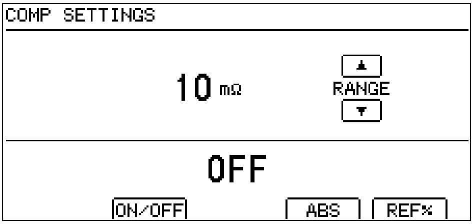
- If power is turned off during comparator setting, changes to settings are lost as they revert to their previous values. To accept the settings, press the ENTER .

5

Enabling and Disabling the Comparator Function

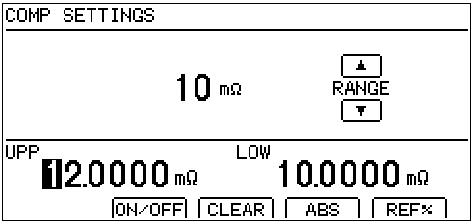
The comparator function is disabled by default.
When the function is disabled, comparator settings are ignored.

1 Open the Comparator Settings screen.



COMP The Comparator Settings screen appears.

2 Enable or disable the comparator function.



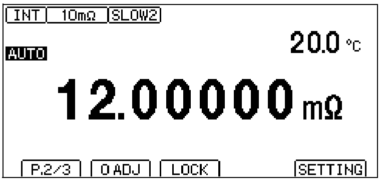
F 1

F 1 Switch the comparator function ON or OFF.

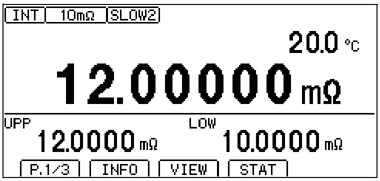
3 Return to the Measurement screen.

ENTER

When the comparator function is OFF



When the comparator function is ON



Comparator judgments are indicated only when the comparator function is enabled.

NOTE

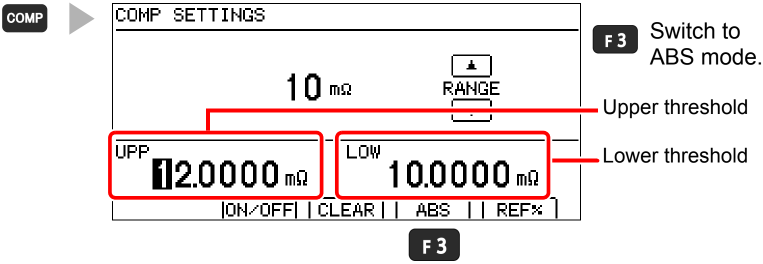
- Turning on the ΔT or BIN measurement function causes the comparator function to automatically turn off.
- The range cannot be changed while using the comparator function. To change the range, do so with the ▲ and ▼ keys on the Comparator Settings screen. To use auto-ranging, turn OFF the comparator function.

Decide According to Upper/Lower Thresholds (ABS Mode)

Setting example: Upper threshold 12 mΩ, lower threshold 10 mΩ

To abort the setting process, press ESC. Settings are abandoned and the display returns to the previous screen.

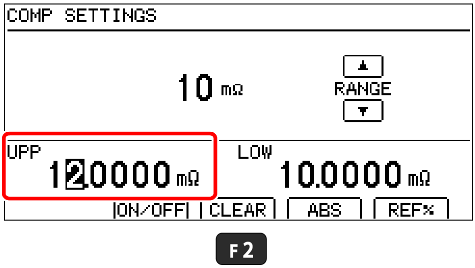
1 **Open the absolute value threshold setting screen.**

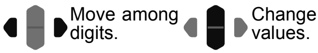


2 **Set the range.**

Select the range you wish to use.
Change the decimal point position and unit (changes each time you press the button).

3 **Set the positive tolerance.**



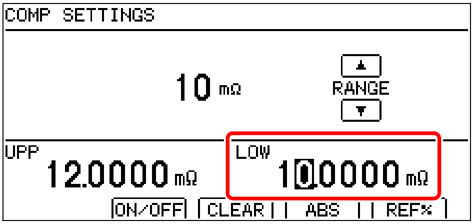


Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

To Reset Numerical Values

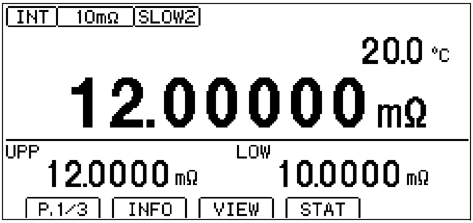
Press F2 to clear the upper limit value. The upper limit value will be reset to 0.

4 Set the negative tolerance in the same way.



5 Accept the settings and return to the Measurement screen.

ENTER



Decide According to Reference Value and Tolerance (REF% Mode)

When REF% mode is enabled, the measured value will be displayed as an absolute value (%).

$$\text{Relative Value (tolerance)} = \left(\frac{\text{Measured Value}}{\text{Reference Value}} - 1\right) \times 100\ [\%]$$

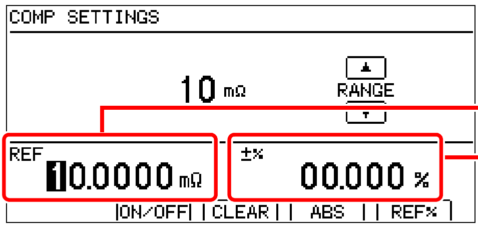
Display range: -999.999% to +99.999%

Example setting: Set a reference value of 10 mΩ with ±1% allowable range.

To abort the setting process, press ESC. Settings are abandoned and the display returns to the previous screen.

1 Open the relative tolerance setting screen.

COMP
F4



F4

Reference value

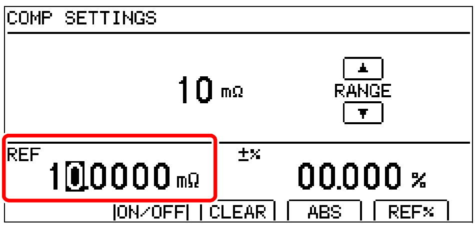
Allowable range (upper and lower limit ranges relative to the reference value)

2 Set the range.

▲ ▼ Select the range you wish to use.
Change the decimal point position and unit (changes each time you press the button).

3 Set the reference value.

Pressing an inoperative key during setting sounds a low-pitch beep (when the key beeper is enabled).



F2

Move among digits. Change values.

Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

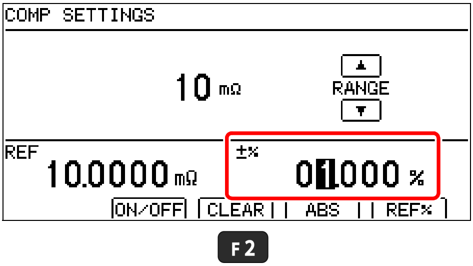
To Reset Numerical Values

Press F2 to clear the reference value. The reference value will be reset to 0.

When using REF% mode and the multiplexer, the CH1 measurement results can be used as the reference value by pressing F2 on MENU P.2/2.

5

4 Set the allowable range (upper and lower limit values).



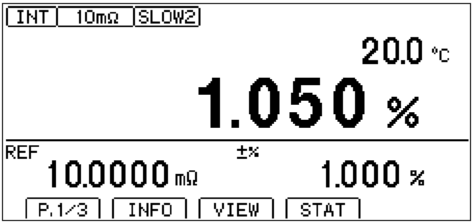
Move among digits. Change values.

Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

To Reset Numerical Values

Press F2 to clear the upper and lower limit values. The upper and lower limit values will be reset to 0.

5 Accept the settings and return to the Measurement screen.

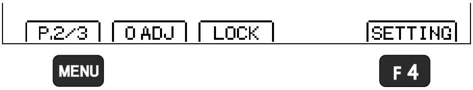


Checking Judgments Using Sound (Judgment Sound Setting Function)

The comparator judgment beeper can be enabled and disabled.
The judgment beeper is disabled (OFF) by default.

Separate judgment tones can be set for Hi, IN, and Lo judgments.
When using the multiplexer, separate judgment tones can be set for PASS and FAIL judgments when the scan function is set to auto or step.

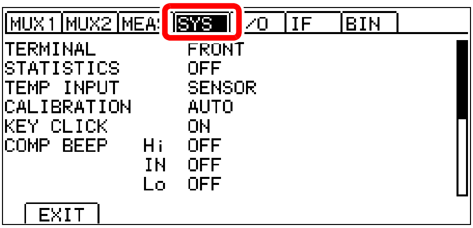
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

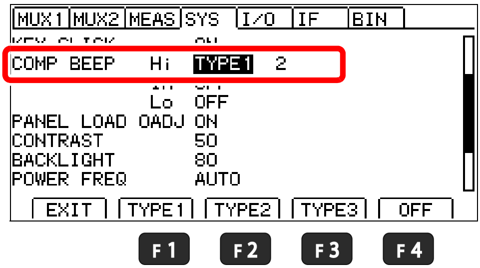
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Select the sound you desire for Hi judgments.

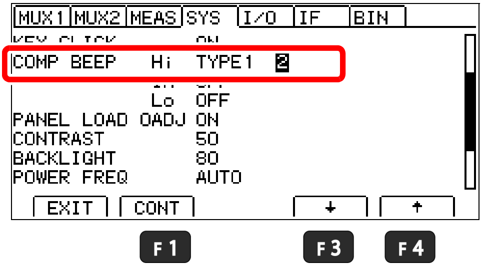


1 Selection

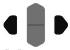
2 F1 to F3
Select the sound you desire.

F4
Disable the beeper. (default) (go to step 5)

4 Select the number of times to sound the beeper for Hi judgments.



Setting range: 1 to 5 times, continuous



Move the cursor to the setting you wish to configure.

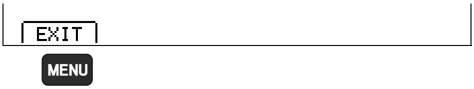
F1 To sound the beeper continuously

To set the number of beeps:

F3 F4 Change the number of beeps.

5 Repeat this process to configure settings for IN and Lo judgments.

6 Return to the Measurement screen.



MENU Return to the Measurement screen.

NOTE

The volume cannot be adjusted.

Checking Judgments with the L2105 LED Comparator Attachment (Option)

By connecting the L2105 LED Comparator Attachment to the COMP.OUT jack, you can check judgment results easily at a distance from the instrument. The indicator will turn green for IN judgments and red for Hi and Lo judgments.

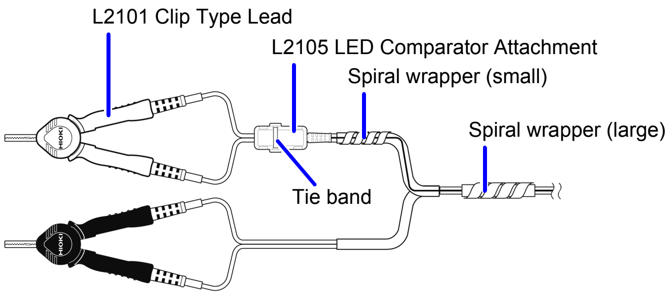
Connection Methods

Before connecting the LED Comparator Attachment, read "Operating Precautions"(p.6) carefully.

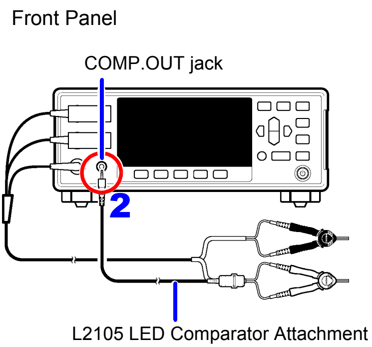
Attaching the LED Comparator Attachment

Position the LED Comparator Attachment where you wish.

Example: Using a tie band and two of the spiral wrappers that came with the L2105, attach the LED Comparator Attachment to a measurement lead.



Connecting the LED Comparator Attachment to the Instrument



1 **Confirm that the instrument's Main power switch (rear panel) is OFF(○).**

2 **Plug the L2105 LED Comparator Attachment into the COMP.OUT jack on the front panel.**

Insert the plug securely all the way into the jack.

5.2 Classifying Measurement Results (BIN Measurement Function)

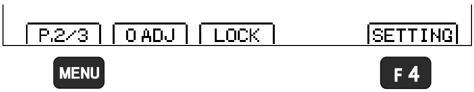
BIN Measurement compares a measured value with up to ten sets of upper and lower thresholds (BIN 0 to BIN 9) in one operation, and display the results. Measured values that do not fall in any BIN are judged to be OB (out-of-bin). Judgment results are output at the EXT I/O connector.

See: "Connector Type and Signal Pinouts" (p. 179)

NOTE

- When the BIN measurement function is on, the comparator cannot be turned on.
- Turning on ΔT or setting the measurement terminal to multiplexer automatically turns off the BIN measurement function.
- The range cannot be changed while using the BIN measurement function. To change the range, do so with the ▲ and ▼ keys on the BIN Number Settings screen.
  Turn off the BIN measurement function when using auto-ranging.

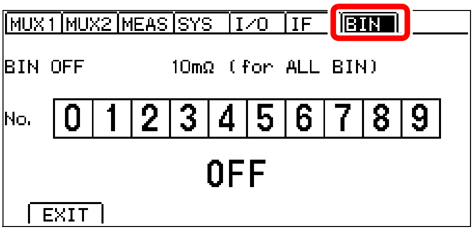
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

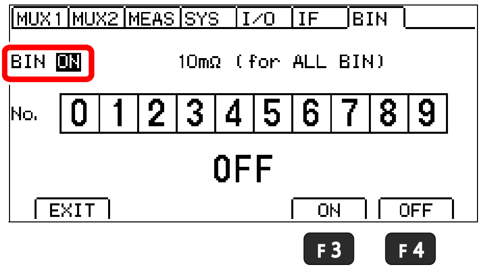
2 F4 The Settings screen appears.

2 Open the BIN Setting Screen.



Move the cursor to the [BIN] tab with the left and right cursor keys.

3 Open the BIN Setting Screen.



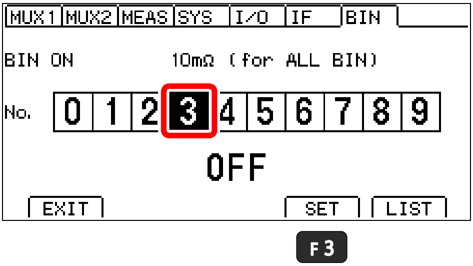
1 Selection

2

F3 Enables the BIN function

F4 Disables the BIN function (default)

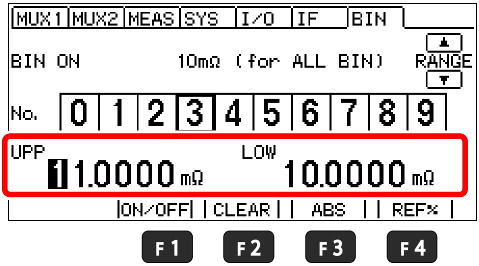
4 Set the BIN number.



1 ◀ ▶ Selection

2 Select a BIN number.

3 F3 Set the BIN numbers.



4 ◀ ▶ Move among digits. ▲ ▼ Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

F1 Switches the function on and off.

F2 Clears the setting for the highlighted parameter.

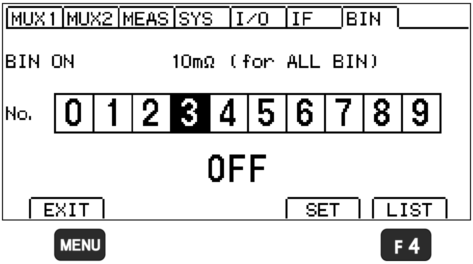
F3 Sets the judgment mode to ABS (UPP, LOW).

F4 Sets the judgment mode to REF%.

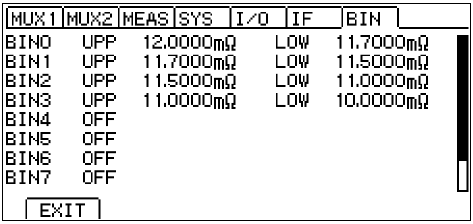
▲ ▼ Range switching
(The range setting applies to all BIN numbers.)

5 ENTER Accept
(ESC Cancel)

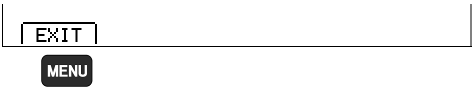
5 You can also display a list of set BIN numbers.



F4 BIN setting list display
MENU Return to the Measurement screen.

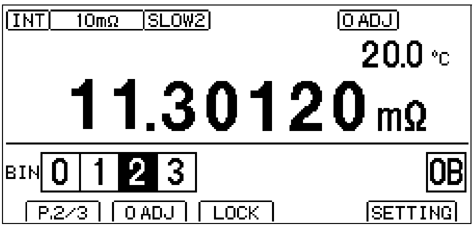


6 Return to the Measurement screen.



MENU Return to the Measurement screen.

When the BIN function is ON



The BIN number with the IN judgment will be shown in reverse video.

5.3 Performing Statistical Calculations on Measured Values

Statistical calculations can be performed on up to 30,000 measured values, with results displayed. Printing is also available (p. 247).
Calculation types: average, maximum and minimum values, population standard deviation, sample standard deviation, process compatibility indices

Maximum value	$Xmax = MAX(x_1, \ldots.., x_n)$
Minimum value	$Xmin = MIN(x_1, \ldots.., x_n)$
Average	$\bar{x} = \dfrac{\sum x}{n}$
Population standard deviation	$\sigma_n = \sqrt{\dfrac{\sum x^2 - n\bar{x}^2}{n}}$
Standard deviation of sample	$\sigma_{n-1} = \sqrt{\dfrac{\sum x^2 - n\bar{x}^2}{n-1}}$
Process capability index (dispersion) *	$Cp = \dfrac{\lvert UPP-LOW \rvert}{6\sigma_{n-1}}$
Process capability index (bias)*	$Cpk = \dfrac{\lvert UPP-LOW \rvert - \lvert UPP+LOW-2\bar{x} \rvert}{6\sigma_{n-1}}$

In these formulas, n represents the number of valid data samples.

*** Process capability index**
- The process capability indices represent the quality achievement capability created by a process, which is the breadth of the dispersion and bias of the process' quality. Generally, depending on the values of Cp and Cpk, process capability is evaluated as follows:
  - Cp, Cpk >1.33 ....Process capability is ideal
  - 1.33 ≥ Cp, Cpk >1.00 .Process capability is adequate
  - 1.00 ≥ Cp, Cpk ....Process capability is inadequate
- UPP and LOW are the upper and lower thresholds of the comparator.
- When the BIN function is on, the process capability index will not be calculated.

NOTE
- Intermally, statistical calicullations are processed by the floating point method, which involves fractional numbers in the displayed digits or below in calculations.
- Internal calculations are performed on floating-point values, and decisions round up any fraction of the least-significant digit.
- When only one valid data sample exists, standard deviation of sample and process capability indices are not displayed.
- When $\sigma_{n-1} = 0$, Cp and Cpk are 99.99.
- The upper limit of Cp and Cpk is 99.99. If Cp or Cpk exceeds 99.99, the value 99.99 is displayed
- Negative values of Cpk are handled as $Cpk = 0$.
- If statistical calculation is turned off and then back on without first clearing calculation results, calculation resumes from the point when it was turned off.
- Measurement speed is restricted when statistical calculation is enabled.
- Turning on ΔT or setting the measurement terminal to multiplexer automatically turns off the statistical calculation function.

Deleting Statistical Calculation Results

Stored data is automatically erased at the following times:
- when changing measurement conditions (low-power, measurement current, OVC, 100 MΩ range high-precision mode, TC, non-offset scaling settings)
- when changing comparator settings (p.98)
- when changing BIN measurement function settings (p.108)
- when printing the statistical calculations (p. 247) (you can select whether to delete results after printing (p.248))
- upon system reset (p. 134)
- when turning off the instrument

Using Statistical Calculations

Turning on the statistical calculation function causes statistics to be calculated based on the EXT I/O TRIG signal. The timing at which statistics are calculated for measured values varies with the trigger source setting.

- With external (EXT) triggering: If the TRIG signal is input, one measurement is performed and subjected to statistical calculation.
- With internal (INT) triggering : If the TRIG signal is input, statistics will be calculated using the last updated measured value. When using the auto-hold function, statistics will be calculated using the held measured value.

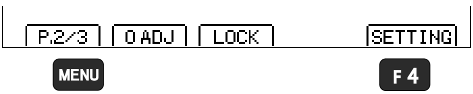
Operation is the same in the following cases (except when using auto-hold):

- when pressing the ENTER
- when a ***TRG** remote control command is received

When the EXT I/O PRINT signal is input, operation varies with the trigger source.

- When using an external trigger [EXT]: The most recent measurement results are printed.
- When using the internal trigger [INT]: Statistics are calculated using the last updated measured value and printed after the PRINT signal is input.
- The same operation can be accomplished by pressing F4 **[PRINT]** on the **MENU P.1/3** display.

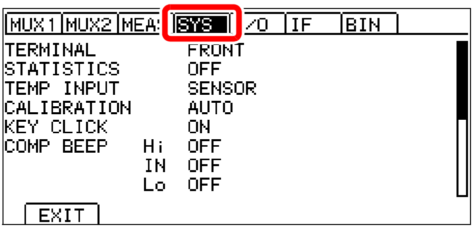
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

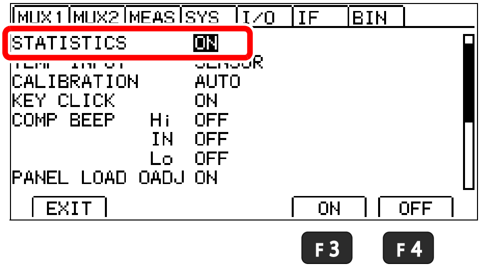
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Enable the statistical calculation function.



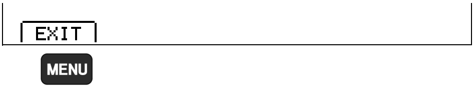
1 Selection

2

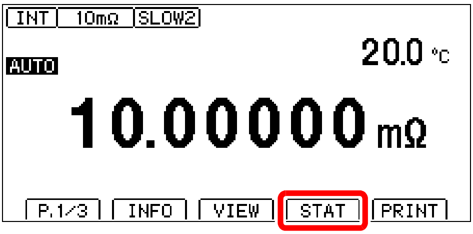
F3 Enable statistical calculation

F4 Disable statistical calculation (default)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.



When statistical calculation is ON, **F3 [STAT]** will be displayed when the **MENU [P.1/3]** display is active.

See: Confirm calculation results (p. 114)

5

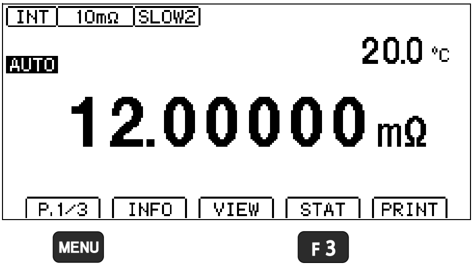
Confirming, Printing, and Erasing Calculation Results

Statistical calculation results are displayed on the screen.
Additionally, results can be printed using an RS-232C printer. Once statistical calculation results have been printed, the data can be automatically deleted.

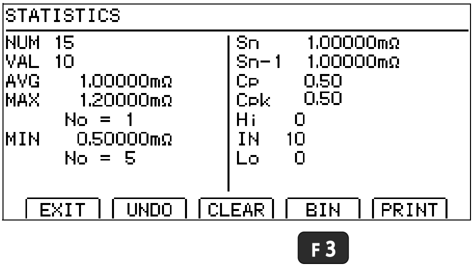
Before printing, select the **[PRINT]** interface setting.
See: "Printing (Using an RS-232C Printer)"(p.239)

The number of valid samples can be confirmed on the Calculation Results screen.
- When the number of valid samples is zero, no calculation results are displayed.
- When only one valid data sample exists, no standard deviation or process capability indices are displayed.

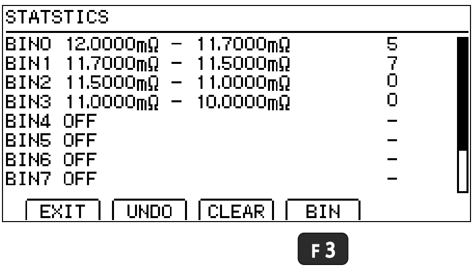
1 Open the Calculation Results screen.



1. MENU Switch the function menu to P.1/3.
2. F3 Displays the Calculation Results screen (if statistical calculation is ON).



Switching between statistical results and BIN results



NUM	Total data count
VAL	Number of valid measured values (error-free data)
AVG	Mean
MAX	Maximum
MIN	Minimum

Sn	Population standard deviation
Sn-1	Standard deviation of sample
Cp	Process capability index (dispersion)
Cpk	Process capability index (bias)

(When the comparator function is ON)

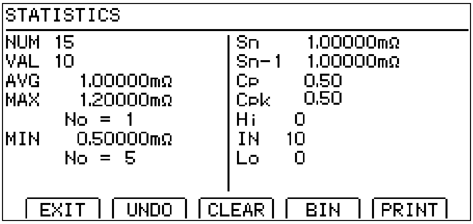
Hi	Number of comparator Hi settings
IN	Number of comparator IN settings
Lo	Number of comparator Lo settings

(When the BIN function is ON)

BIN	BIN setting range and IN judgment count

2 To print

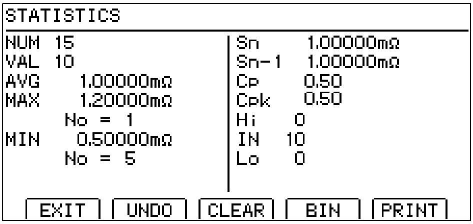
For more information about printing, see "Chapter 12 Printing (Using an RS-232C Printer)" (p.239)



F4

F4 Output to the printer.
"Example Printouts" (p. 249)

To erase



F1 F2

F1 Erases the last measurement and calculation result (executes only once).

F2 Erases all measured values and statistical calculation results.

5.4 Performing Temperature Rise Test (Temperature Conversion Function (ΔT))

The temperature conversion principle is used to derive temperature increase over time. This functionality allows the temperature during normal stops and other data to be estimated.

See: "Appendix 5 Temperature Conversion (ΔT) Function" (p. A6)

To perform temperature conversion, connect the Z2001 Temperature Sensor to the TEMP. jack on the rear of the instrument. Before connecting the sensor, read the following.

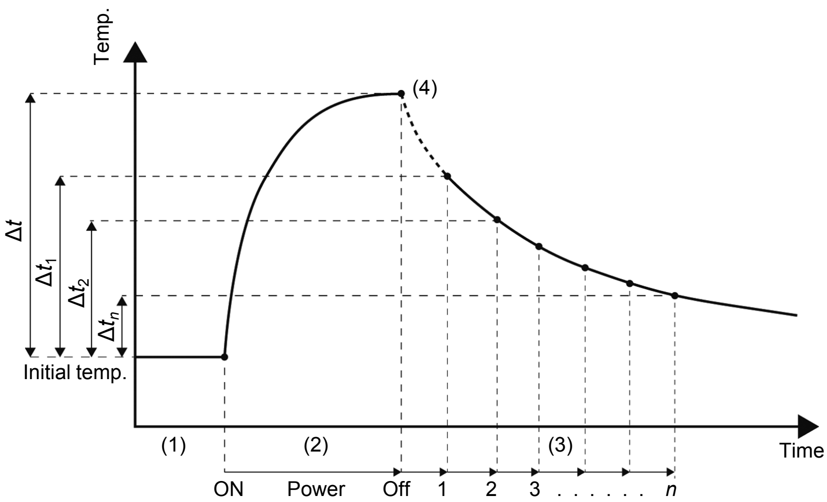
See: "Connecting the Z2001 Temperature Sensor"(p.37)
"Connecting an Analog Output Thermometer"(p.39)
"3.1 Checking the Measurement Target" (p.48)

NOTE

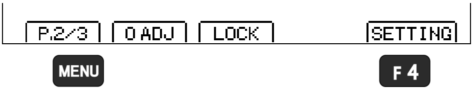
When ΔT is set to ON, the comparator function cannot be turned ON.
When TC, the BIN measurement function, or the statistical calculation function is set to on, ΔT is automatically set to off.

Example temperature rise test

(1) After the motor and coil are stabilized at room temperature, measure the resistance (R_1) and instrument ambient temperature (t_1), and then input these values to the instrument. (p.117)
(2) Disconnect the test lead from the measurement target.
(3) After turning off the power, reconnect the test lead to the measurement target and then measure the temperature rise value (Δt_1 to Δt_n) at the preset intervals.
(4) Draw a line by connecting the collected temperature data (Δt_1 to Δt_n), and estimate the maximum temperature rise value (Δt).



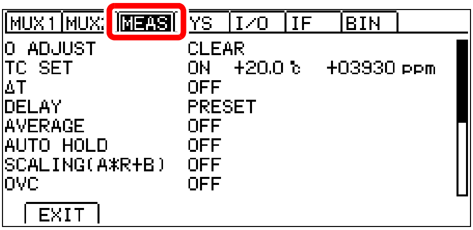
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

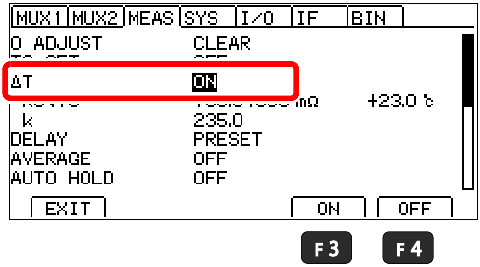
2 F4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Enable the temperature conversion function. (ΔT)

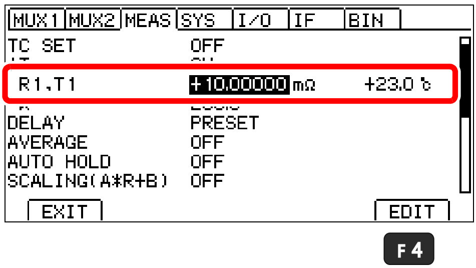


1 Selection

2
F3 Enables the function
F4 Disables the function (default) (go to step 6)

4 Set the initial resistance and initial temperature.

Set the initial resistance and initial temperature in Steps **1** through **3**.



1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

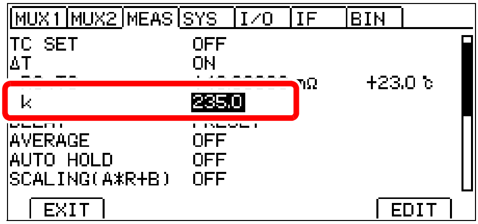
2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

Setting range initial resistance : 0.001 μΩ to 9000.000 MΩ (default: 1.0000 Ω)
initial temperature: -10.0 to 99.9°C (default: 23.0°C)

NOTE The initial resistance value range varies with the scaling setting.

5 Set the reciprocal (*k*) of the temperature coefficient at 0°C.



F4

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

Setting range: -999.9 to 999.9 (default: 235.0)

6 Return to the Measurement screen.

MENU

MENU Return to the Measurement screen.

Guideline for *k*

IEC 60034 recommends the following:
- Copper: *k* = 235
- Aluminum: *k* = 225

See: "Appendix 5 Temperature Conversion (ΔT) Function" (p. A6)

Saving and Loading Panels (Saving and Loading Measurement Conditions) Chapter 6

Current measurement conditions can be saved and loaded using the panel load function from the key operations, communications commands, or EXT-I/O.

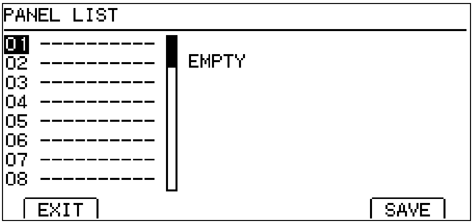
The instrument can save up to 30 sets (panel number: 1 to 30) of measurement conditions when not using the multiplexer or up to 8 sets (panel number: 31 to 38) when using the multiplexer. This data is retained even if the instrument is turned off.

Settings that can be saved with the Panel Save function

- Panel name
- Save time and date
- Resistance range
- 100 MΩ high-precision mode
- Low-Power resistance measurement (LP)
- Switching measurement currents
- Measurement speed
- Zero-adjustment (Loading of these values can be disabled.) (p.122)
- Averaging
- Delay
- Temperature correction (TC)
- Offset voltage compensation (OVC)
- Scaling
- Self-calibration settings
- Contact Improver
- Contact check
- Comparator
- BIN settings
- Judgment beeper
- Auto hold
- Temperature conversion (ΔT)
- Statistical calculations settings
- Multiplexer settings (including channels)

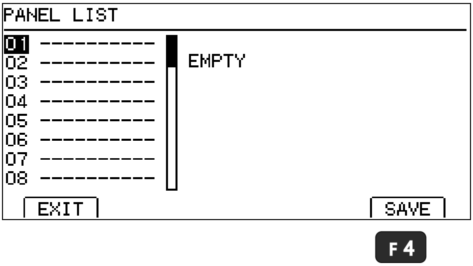
6.1 Saving Measurement Conditions (Panel Save Function)

1 Open the Panel List Screen.



PANEL The Panel List Screen appears.

2 Save the measurement conditions.

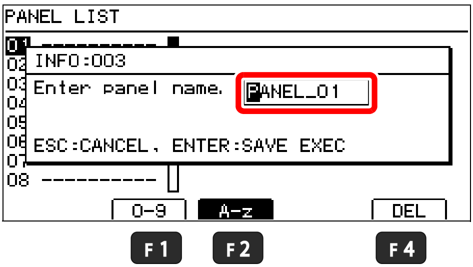


1 Selection

2 F4 Save the conditions.

3 Enter the panel name.

(If you enter the number of a previously saved panel, a warning message will be displayed.)



1 Move among characters. Change characters.

Move the cursor to the character you wish to set with the left and right cursor keys. Change the character with the up and down cursor keys.

F1 Enter a number from 0 to 9

F2 Enter a letter from A to Z, or an underbar character (_).

F4 Delete 1 character.

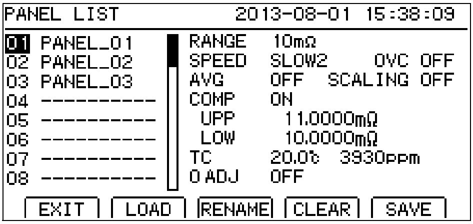
2 ENTER Accept

(ESC Cancel)

6.2 Loading Measurement Conditions (Panel Load Function)

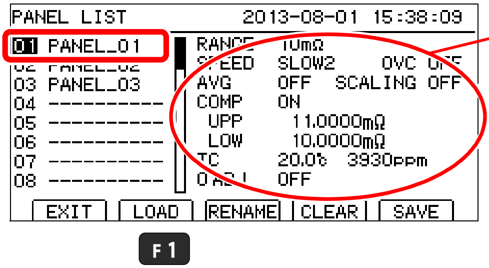
Loads the measurement settings saved by the Panel Save function.
By default, loading a panel causes zero-adjustment values to be loaded. If you do not wish to load zero-adjustment values, see "Preventing Loading of Zero-adjustment Values"(p.122).

1 **Open the Panel List Screen.**



PANEL The Panel List Screen appears.

2 **Select a panel number.**

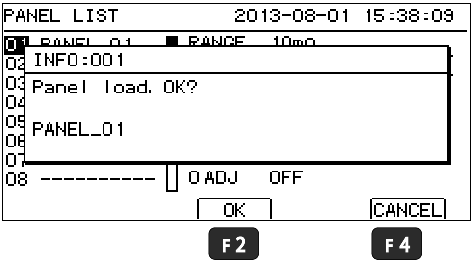


Data saved for selected panel

1 Selection

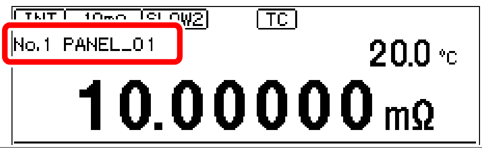
2 F1 Load the panel. (You can also load the panel with the ENTER key.)

3 **Verify that the confirmation message is shown and return to the Measurement screen.**



F2 Load the panel and switch to the Measurement screen (you can also do this with the ENTER key).

F4 Cancel the operation and return to the previous screen. (you can also do this with the ESC key)



The name of the loaded panel will be displayed on the Measurement screen.

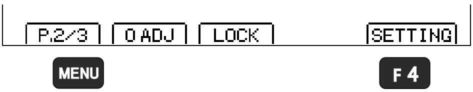
NOTE

- Panels can also be loaded with the EXT I/O LOAD0 to LOAD5 control and communications commands.
  See: "Chapter 10 External Control (EXT I/O)"; "Input Signals" (p. 181)
  For more information about commands, see the included application disc.
- If measurement conditions are changed after being loaded, the panel name will no longer be displayed.

Preventing Loading of Zero-adjustment Values

By default, zero-adjustment values are also loaded along with panel data. The following procedure can be used to prevent loading of zero-adjustment values.

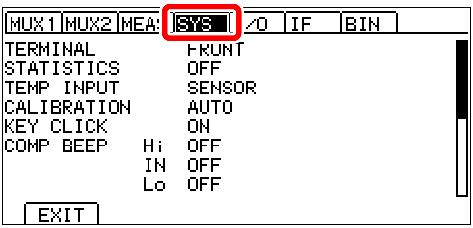
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/2.

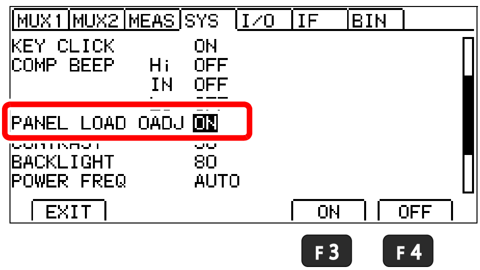
2 F 4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Select whether to load zero-adjustment values.



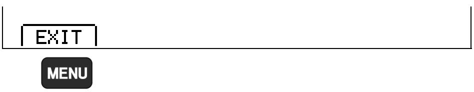
1 Selection

2

F 3 When a panel is loaded, change zero-adjustment values to the values in effect when the panel was saved. (default)

F 4 Do not change zero-adjustment values, even when panel data is loaded.

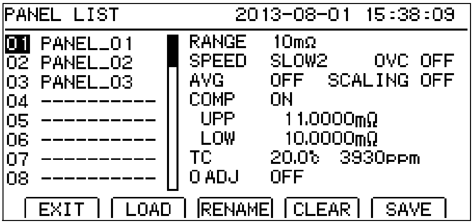
4 Return to the Measurement screen.



MENU Return to the Measurement screen.

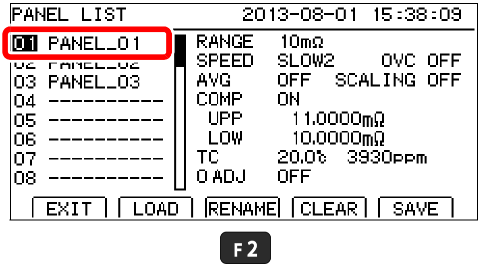
6.3 Changing Panel Names

1 Open the Panel List Screen.



PANEL The Panel List Screen appears.

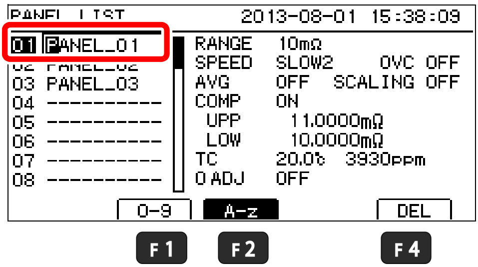
2 Select a panel number.



1 Selection

2 F2 Edit the panel name.

3 Edit the panel name.



1 Move among characters. Change characters.

Move the cursor to the character you wish to set with the left and right cursor keys. Change the character with the up and down cursor keys.

F1 Enter a number from 0 to 9

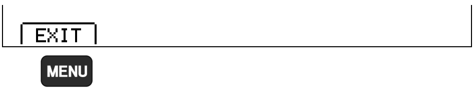
F2 Enter a letter from A to Z, or an underbar character (_).

F4 Delete 1 character.

2 ENTER Accept

(ESC Cancel)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

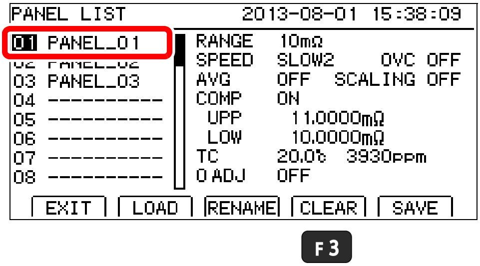
6

6.4 Deleting Panel Data

1 **Open the Panel List Screen.**

PANEL The Panel List Screen appears.

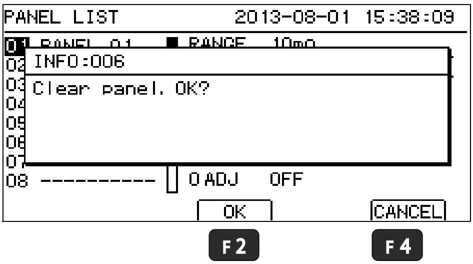
2 **Select a panel number.**



1 Selection

2 F3 Delete the panel.

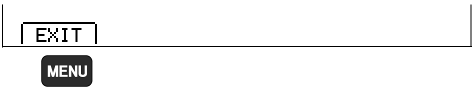
3 **Verify that the confirmation message is shown and return to the Measurement screen.**



F2 Delete the panel and switch to the previous screen (you can also do this with the ENTER key).

F4 Cancel the operation and return to the previous screen. (you can also do this with the ESC key)

4 **Return to the Measurement screen.**



MENU Return to the Measurement screen.

NOTE

Once a panel's data is deleted, it cannot be restored (the delete operation cannot be undone).

System Settings Chapter 7

This chapter describes system settings.

7.1 Disabling and Enabling Key Operations

Disabling Key Operations (Key-Lock Function)

Activate the key-lock function to disable the instrument's front panel key operations.
Three key-lock levels are available to suit specific purposes.

Only basic settings (range, speed, comparator, panel load) are enabled.

Disabling All Except Comparator Settings

Key operations other than **AUTO**, **RANGE ▲▼**, **SPEED**, **COMP**, **PANEL**, **0ADJ**, **PRINT**, **ENTER** (trigger) and **MENU** [UNLOCK] (key-lock cancel) keys are disabled.
To disable key operations: select [MENU]
[M.LOCK] is displayed when returning to the measurement screen.

Key operations to change settings are disabled (although key-lock can be canceled).

Disabling All Key Operations Including Comparator Settings

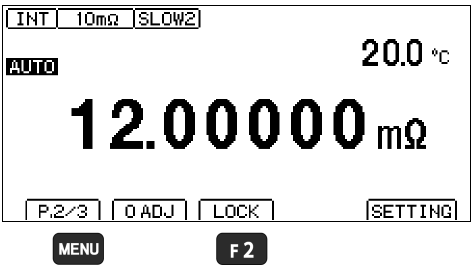
All key operations except **ENTER** (trigger) and **MENU** [UNLOCK] (key-lock cancel) are disabled.
To disable key operations: select [FULL]
[F.LOCK] is displayed when returning to the measurement screen.

All key operations are disabled.

Disabling All Panel Keys

Asserting (ON) the EXT I/O KEY_LOCK signal disables all panel keys, including **MENU** [UNLOCK] (key-lock cancel) and **MENU** [LOCAL] (disables remote control). However, the **ENTER** (trigger) key remains enabled (p.177).
To cancel the key lock state: Turn OFF the EXT I/O KEY_LOCK signal.

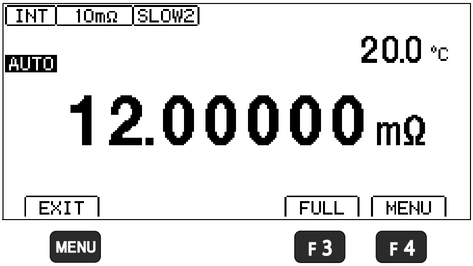
1



1 MENU Switch the function menu to P.2/3.

2 F2 Display the Key Lock Selection screen.

2 Enable or disable key operations.



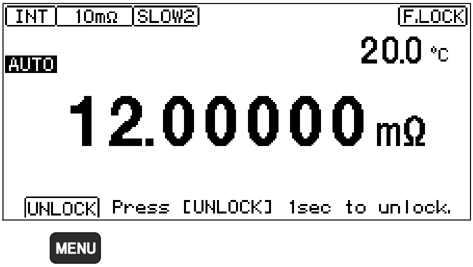
- **F3** Disable all except key-lock cancel and return to the Measurement screen.
- **F4** Disable all except key-lock cancel and basic settings change and return to the Measurement screen.
- **MENU** Return to the Measurement screen.

[UNLOCK] is displayed.
(Key-lock operation triggered by the EXT I/O KEY_LOCK signal is not displayed.)

Re-Enabling Key Operations (Key-Lock Cancel)

Key-lock can be canceled only when **[UNLOCK]** is displayed.

Press and hold MENU [UNLOCK] for one second.



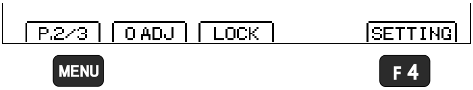
NOTE

If key operations are disabled by the KEY_LOCK signal, de-assert (OFF) the signal to unlock the keys.

7.2 Enabling or Disabling the Key Beeper

The key beeper sound can be enabled and disabled.
The key beeper is enabled (ON) by default.

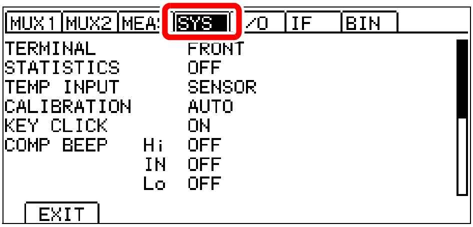
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

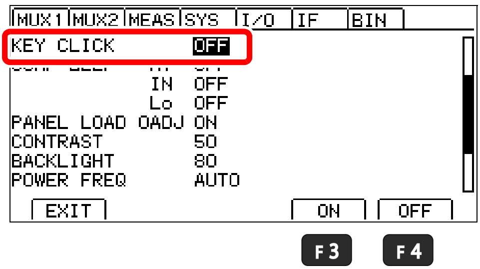
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

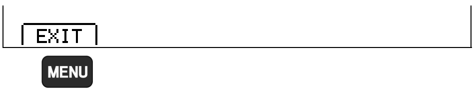
3 Select whether to enable or disable the key beeper.



1 Selection

2
F3 Enables the beeper (default)
F4 Disables the beeper

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

NOTE
(Version 2.00 and later only)
To disable the key beeper, error beep, and auto-hold beep, turn off the instrument and then turn it back on while holding down the **[F1]** and **[ENTER]** keys. "(**ERR,AUTO HOLD**)" will be displayed as the KEY CLICK setting, and the error beep and auto-hold beep will be set to the same setting as the keep deeper.

7.3 Power Line Frequency Manual Setting

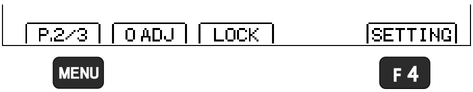
With the default setting (AUTO), the instrument attempts to automatically detect the line frequency, but manual setting is also available.

NOTE

- Unless the line frequency is set correctly, measured values may be unstable.
  An error message appears if line noise is high enough to prevent correct frequency detection (ERR:097 (p.298)). In that case, set the instrument's line frequency manually.
- When the AUTO setting is selected, the line frequency is automatically set to 50 or 60 Hz when the instrument is turned on or reset.
  However, automatic detection is not available when the line frequency changes after turning power on or resetting.
  If the actual line frequency deviates from 50 or 60 Hz, select the closest frequency.

Examples:
If the actual line frequency is 50.8 Hz, select the 50 Hz setting.
If the actual line frequency is 59.3 Hz, select the 60 Hz setting.

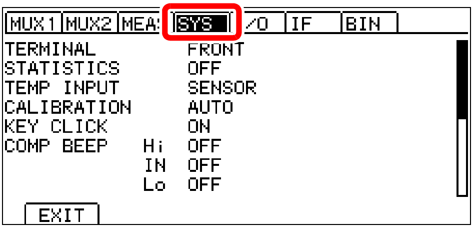
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

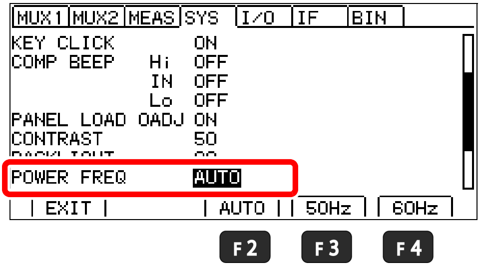
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Select the line frequency being used.



1 Selection

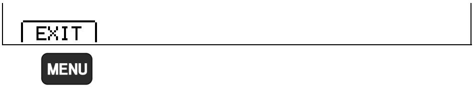
2

F2 Automatically detect local line frequency (default)

F3 When the line frequency is 50 Hz

F4 When the line frequency is 60 Hz

4 Return to the Measurement screen.

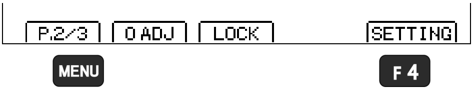


MENU Return to the Measurement screen.

7.4 Adjusting Screen Contrast

The screen may become hard to see when ambient temperature changes. In this case, adjust the contrast.

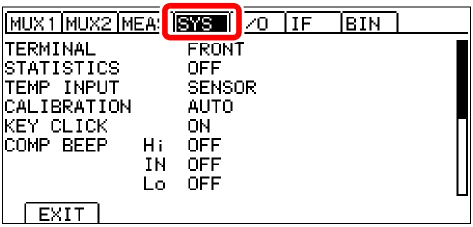
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

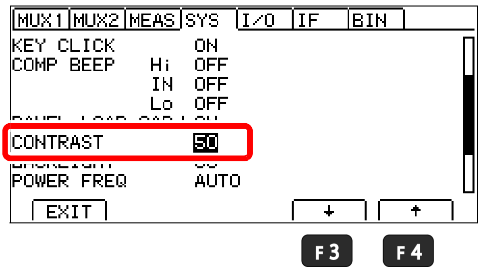
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Adjust the contrast.



1 Selection

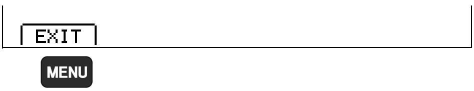
2

F3 Decrease the contrast.

F4 Increase the contrast.

Setting range: 0 to 100%, 5% step
(default: 50%)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

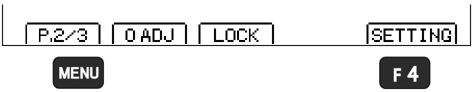
7.5 Adjusting the Backlight

Adjust backlight brightness to suit ambient illumination.

NOTE

- When external (EXT) triggering is selected, backlight brightness is automatically reduced after non-operation for one minute.
- (Version 2.00 and later only)
  To disable the key beeper, error beep, and auto-hold beep, turn off the instrument and then turn it back on while holding down the **[F1]** and **[ENTER]** keys. "(**ERR,AUTO HOLD**)" will be displayed as the KEY CLICK setting, and the error beep and auto-hold beep will be set to the same setting as the keep deeper. (p.128)
- Be aware that the display may be hard to see when brightness is set too low (near 0%).

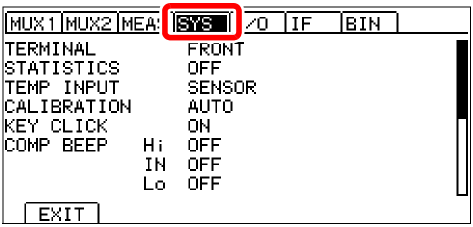
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

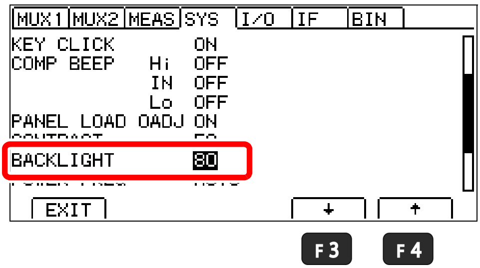
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Adjust the backlight.



1 Selection

2 F3 Decrease the backlight brightness.

F4 Increase the backlight brightness.

Setting range: 0 to 100%, 5% step
(default: 80%)

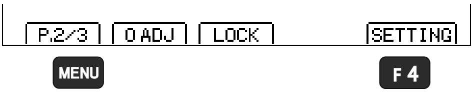
4 Return to the Measurement screen.

MENU Return to the Measurement screen.

7.6 Setting the Clock

To record and print the correct time when using statistical calculations (p.111), the clock needs to be set correctly. The time of printing is also output when printing statistical calculation results.

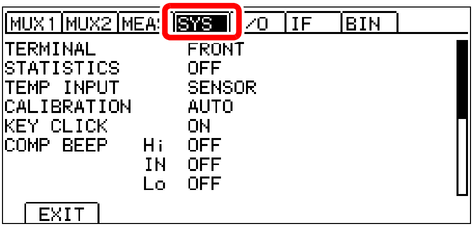
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

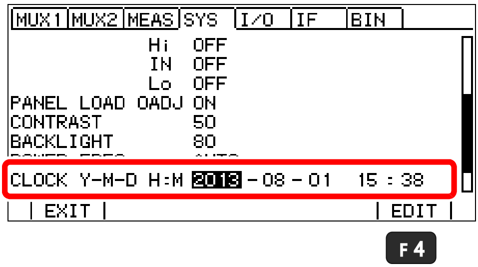
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Set the date and time.



Enter the last two digits of the year, and the month, day, hour and minutes in that order.

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

4 Return to the Measurement screen.

MENU Return to the Measurement screen.

7.7 Initializing (Reset)

Three reset functions are available.
For more information about communications commands, see the included application disc.

Reset: Returns measurement conditions (except the panel data) to factory defaults.

The instrument can be reset by three methods.

- Reset from the System setting screen
- Turn on the instrument while holding down ESC and ENTER .
- Reset by remote control command
  `*RST` command (Interface settings are not initialized.)

System reset: Returns all measurement conditions and the panel save data to factory defaults.

The instrument can be system reset by three methods.

- System reset from the System setting screen
- Turn on the instrument while holding down ESC , ENTER , and ▶ .
- Reset by remote control command
  `:SYSTem:RESet` command (Interface settings are not initialized.)

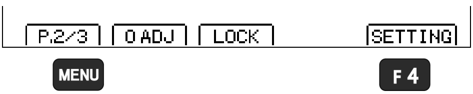
Multiplexer channel reset: Returns the multiplexer channel settings to factory defaults.

The instrument's multiplexer channels can be reset by two methods.

- System reset from the System setting screen
- Reset by remote control command
  `[:SENSe:]CHReset` command

This procedure describes reset from the System setting screen.

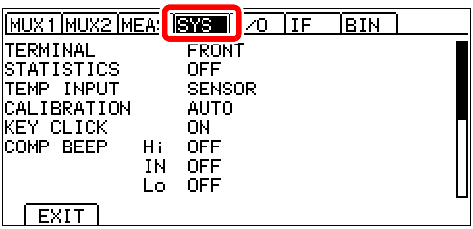
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

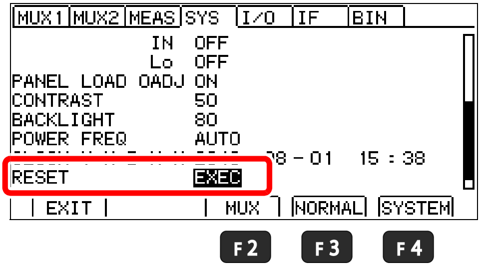
2 F 4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Select RESET.



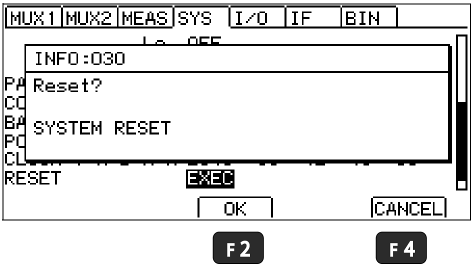
1  Selection

2 F2 Perform a multiplexer channel reset.

F3 Perform a reset.

F4 Perform a system reset.

4 Select whether to initialize the instrument.



F2 Execute

F4 Cancel the operation

The Measurement screen is displayed when system reset finishes.

Default Settings

Screen		Setting and Key	Default Settings	Multiplexer channel reset	See
Measurement screen		COMP	OFF	√	(p.100)
		AUTO	AUTO	√	(p.49)
		▲▼ (RANGE)		√	
		SPEED	SLOW2	√	(p.50)
Measurement screen (P.1/2) (For the RM3545-02, P.1/3)		VIEW (F2)	OFF	–	(p.52)
Measurement screen (P.2/2) (For the RM3545-02, P.2/3)		0 ADJ (F2)	OFF	√	(p.68)
		LOCK (F3)	OFF	–	(p.126)
Measurement Screen (P.3/3) *2		FRONT (F1)	FRONT	–	(p.151)
		MUX (F2)		–	
		SCANSET (F3)	OFF	–	
Setting screen (SETTING)	Multiplexer Channel Settings screen (MUX1) *2	CH	OFF	√	(p.154)
		TERM		√	
		INST	RM3545	√	
		0ALL	ON	√	(p.164)
		0ADJ	-	√	
	Multiplexer Basic Measurement screen (MUX2) *2	SPD	SLOW2	√	(p.158)
		RANGE	AUTO	√	
		UPP/REF	OFF	√	
		LOW%	OFF	√	
		PASS	IN	√	
	Measurement Setting screen (MEAS) *3	TC SET	OFF	√	(p.75)
		ΔT	OFF	√	(p.116)
		DELAY	PRESET	√	(p.84)
		AVERAGE	OFF	√	(p.73)
		AUTO HOLD	OFF	–	(p.60)
		SCALING(A∗R+B)	OFF	√	(p.77)
		OVC	OFF	√	(p.82)
		LOW POWER	OFF	√	(p.64)
		MEAS CURRENT	HIGH	√	(p.66)
		Ω DIGITS	7DGT	–	(p.81)
		CURR ERROR MODE	CurErr	–	(p.59)
		CONTACT CHECK	ON	√	(p.88)
		CONTACT IMPRV	OFF	√	(p.90)
		100MΩ PRECISION	OFF	√	(p.96)

Screen		Setting and Key	Default Settings	Multiplexer channel reset	See
Setting screen (SETTING)	System Setting screen (SYS)	TERMINAL *2	FRONT	–	(p.148)
		STATISTICS	OFF	–	(p.111)
		TEMP INPUT	SENSOR	–	(p.37)
		CALIBRATION	AUTO	–	(p.92)
		KEY CLICK	ON	–	(p.128)
		COMP BEEP Hi	OFF	–	(p.105)
		IN	OFF	–	
		Lo	OFF	–	
		PASS	OFF	–	
		FAIL	OFF	–	
		PANEL LOAD 0ADJ	ON	–	(p.122)
		CONTRAST	50	–	(p.131)
		BACK LIGHT	80	–	(p.132)
		POWER FREQ	AUTO	–	(p.129)
	EXT I/O Setting screen (I/O)	TRIG SOURCE		–	(p.209)
		TRIG EDGE	OFF → ON (ON EDGE)	–	(p.211)
		TRIG/PRINT FILT	OFF	–	(p.213)
		EOM MODE	HOLD	–	(p.215)
		JUDGE/BCD MODE	JUDGE	–	(p.217)
	Communications Interface Setting screen (IF)	INTERFACE	RS232C	–	(p.223)
		SPEED	9600bps	–	(p.226)
		DATA OUT	OFF	–	(p.236)
		CMD MONITOR	OFF	–	(p.233)
	BIN Setting screen (BIN)	BIN	OFF	–	(p.108)

*1 RM3545-01 only
*2 RM3545-02 only
*3 When using the multiplexer, the selected channel number will be displayed next to "MEAS."

Channel default values for the multiplexer are as follows:

4-wire

CH		UNIT	TERM A	TERM B
1	Enabled	1	TERM A1	TERM B1
2	Disabled	1	TERM A2	TERM B2
:	:	:	:	:
10	Disabled	1	TERM A10	TERM B10
11	Disabled	2	TERM A1	TERM B1
12	Disabled	2	TERM A2	TERM B2
:	:	:	:	:
20	Disabled	2	TERM A10	TERM B10
21	Disabled	1	TERM A1	TERM B1
22	Disabled	1	TERM A1	TERM B1
:	:	:	:	:
42	Disabled	1	TERM A1	TERM B1

2-wire

CH		UNIT	TERM A	TERM B
1	Enabled	1	TERM A1	TERM B1
2	Disabled	1	TERM A2	TERM B2
:	:	:	:	:
21	Disabled	1	TERM A21	TERM B21
22	Disabled	2	TERM A1	TERM B1
23	Disabled	2	TERM A2	TERM B2
:	:	:	:	:
42	Disabled	2	TERM A21	TERM B21

Multiplexer Chapter 8

By using the RM3545-02 in combination with the Z3003 Multiplexer Unit, it is possible to conduct measurements by switching among up to 20 locations (4-wire) or up to 42 locations (2-wire).

When installing the multiplexer unit, be sure to read "2.4 Installing the Multiplexer Unit"(p.42).

NOTE

- The Z3003 Multiplexer Unit's contacts use mechanical relays. Since mechanical relays have a finite service life, programs should be created so as to minimize the switching of contacts.
  Particularly when set to 2-wire, the frequency of contact switching when switching from TERM An (TERM Bn) to Am (TERM Bm) can be minimized by switching such that n and m are both odd numbers or both even numbers, rather than switching such that n is odd and m is even, or vice versa.
  For more information about how to reduce 4-wire/2-wire relay switching, see ""8.2 Internal Circuitry"(p.146)
  Examples
  Example 1: TERM A1/B1 → TERM A2/B2 → TERM A3/B3 → TERM A4/B4
  Example 2: TERM A1/B1 → TERM A3/B3 → TERM A2/B2 → TERM A4/B4
  Example 2 requires less contact switching than Example 1.
  Contact service life reference value
  4-wire: 50 million cycles, 2-wire: 5 million cycles
- The unit test function performs short and open tests by shorting the measurement terminals. Short test measures each pin's round-trip wiring resistance in the 2-terminal resistance measurement state and generates a PASS result if the value is 1 Ω or less. When using a measurement current of 1 A, it may not be possible to conduct measurement due to an inability to achieve the 1 A measurement current, even if the unit test yields a PASS result. If you encounter a current fault (**-------** or **OvrRng** display), reduce the wiring resistance and the contact resistance between the measurement target and measurement leads. (p.57)

8.1 About the Multiplexer

Two Z3003 Multiplexer Units can be installed on the RM3545-02.

Number of locations that can be measured

Number of units	2-wire	4-wire
1 unit	21 locations	10 locations
2 units	42 locations	20 locations

Benefits of using the Multiplexer Unit

- Wirings connecting with a variety of measurement targets can be simplified because the A and B terminals of each channel can be individually assigned with user-specified terminals.
  See: "8.7 Example Connections and Settings"(p.169)
  Example: 3-phase motor with ∆ wiring or Y wiring
  Series elements such as a network resistor
  Independent elements

- Different measurement conditions can be set for each channel.
  See: "8.3 Multiplexer Settings"(p.148)

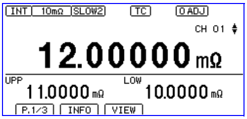
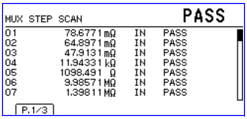
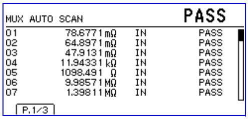
- Batch zero-adjustment can be performed for the desired channels.
  See: "8.5 Zero Adjustment (When a Multiplexer Unit Has Been Installed)"(p.164)

- Judgments can be made using measured values as references.
  See: "Setting Basic Measurement Conditions and Total Judgment Conditions for Individual Channels" (p.157)

- Up to 42 channels can be registered.

- Up to eight setting panels (panel number: 31 to 38) can be saved, apart from measurement conditions for which the multiplexer is not used (when using the measurement terminals on the front of the instrument).

- You can choose from the following three scan methods according to your application:
  (1) Scan function: OFF
  (2) Scan function: Step
  (3) Scan function: Auto

Scan function	OFF	Step	Auto
Overview	The measurement location can be changed freely. Example uses • Using the multiplexer manually • Repeating measurement for particular channels only • Switching channels using external control	The measurement location is switched according to a previously set order. A single TRIG signal causes one channel to be measured. Example uses • Controlling the measurement target during testing, for example with switches • Changing operation based on each channel's measurement results	The measurement location is switched according to a previously set order. A single TRIG signal causes all channels to be measured. Example uses • Performing scanning at the fastest possible speed when controlling the measurement target during testing is not necessary, for example for 3-phase motor windings or network resistors
Measurement screen			
Trigger source	Internal [INT] / External [EXT]	External [EXT] only	External [EXT] only
Channel switching	Up/down cursor operation, commands, LOAD signal	Automatic switching based on the trigger (channel by channel)	Automatic switching based on the trigger (all channels)
TRIG operation	TRIG signal input ↓ Current channel measurement ↓ Judgment, EOM signal ON output	TRIG signal input ↓ CH1 measurement ↓ CH1 judgment, EOM signal ON output ↓ TRIG signal input ↓ CH2 measurement ↓ CH2 judgment, EOM signal ON output ↓ . . . ↓ TRIG signal input ↓ CHn measurement ↓ CHn judgment, Total judgment, EOM signal ON output	TRIG signal input ↓ CH1 measurement ↓ CH2 measurement ↓ . . . ↓ CHn measurement ↓ Total judgment, EOM signal ON output
Acquisition of each channel's measured value and judgment results	Display, Communications commands, EXT I/O	Display, Communications commands, EXT I/O	Display, Communications commands
Total judgment	No	Yes	Yes

Process up to multiplexer use

Advance preparations

1 **Connect the measurement cables to the multiplexer's connector.**

See: "Connector Type and Pinouts" (p.143)

2 **Enable the multiplexer and set the scan function.**

See: "Configuring Multiplexer Settings" (p.148)

3 **Set channel pin allocation.**

See: "Customizing Channel Pin Allocation" (p.152)

4 **Set the measurement conditions for each channel.**

See: "Customizing Measurement Conditions for Individual Channels" (p.161)

Zero Adjustment

5 **Set zero-adjustment.**

See: "8.5 Zero Adjustment (When a Multiplexer Unit Has Been Installed)"(p.164)

6 **Connect each channel to 0 Ω.**

7 **Perform zero-adjustment.**

Measurement

8 **Connect and measure the measurement target.**

See: "8.4 Measuring with the Multiplexer"(p.162)

About multiplexer EXT I/O control, see "Chapter 10 External Control (EXT I/O)"(p.177).
For more information about multiplexer command control, see the Communications Command Instruction Manual on the included application disc.

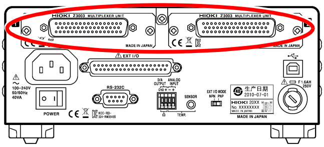
NOTE

Restrictions when using the Multiplexer Unit

- When setting the measurement terminal to MUX (multiplexer)
  The measurement terminals on the front of the instrument will not be available for use, but connected internally to Z3003's switches. Do not connect the measurement leads to the measurement terminals on the front of the instrument. The BIN measurement function and statistical calculation function will be turned off automatically.
  The data memory function cannot be used.
- When the multiplexer's measurement method is set to 2-wire
  Ranges of 10 Ω and lower will not be available for use. The contact check function will be disabled.
- Relay hot switching prevention function
  Because back EMF remains when measuring a target such as a transformer, the relay hot switching prevention function will operate to keep processing from switching to the next channel until the back EMF has decreased.
  See: "3.2 Selecting the Measurement Range"(p.49)
  "4.2 Switching Measurement Currents (100 mΩ to 100 Ω)"(p.66)

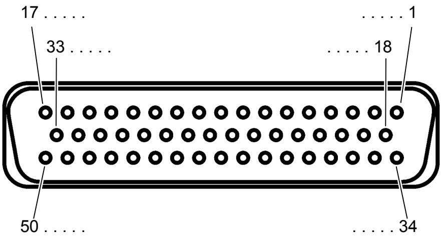
Connector Type and Pinouts

Pinouts (Connector: D-SUB 50pin receptacle)



Connector: (Instrument Side)
- 50-pin D-sub, 3-row type female with #4-40 screws
- Recommended wire (max.)
  Single wire: AWG22 equivalent
  Stranded wire: AWG24 equivalent

  See: "Appendix 14 Making Your Own Measurement Leads, Making Connections to the Multiplexer"(p.30)



Multiplexer Connector (Instrument Side)

Mating Connectors:
- DD-50P-ULR (solder type)
  Japan Aviation Electronics Industry Ltd.

Pin assignments vary with the measurement method (4-wire/2-wire).
See: "Configuring Multiplexer Settings" (p.148)

4-wire

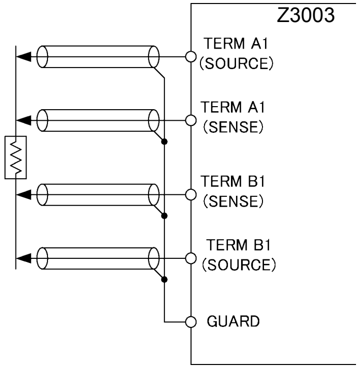
No.	Pin name		No.	Pin name		No.	Pin name	
1	-	-	18	TERM B5	SOURCE	34	TERM B9	SOURCE
2	TERM B1	SOURCE	19		SENSE	35		SENSE
3		SENSE	20	TERM A5	SOURCE	36	TERM A9	SOURCE
4	TERM A1	SOURCE	21		SENSE	37		SENSE
5		SENSE	22	TERM B6	SOURCE	38	TERM B10	SOURCE
6	TERM B2	SOURCE	23		SENSE	39		SENSE
7		SENSE	24	TERM A6	SOURCE	40	TERM A10	SOURCE
8	TERM A2	SOURCE	25		SENSE	41		SENSE
9		SENSE	26	TERM B7	SOURCE	42	-	-
10	TERM B3	SOURCE	27		SENSE	43	GUARD	
11		SENSE	28	TERM A7	SOURCE	44	GUARD	
12	TERM A3	SOURCE	29		SENSE	45	EX SOURCE B (EX Cur Hi)	
13		SENSE	30	TERM B8	SOURCE	46	EX SENSE B (EX Pot Hi)	
14	TERM B4	SOURCE	31		SENSE	47	EX SENSE A (EX Pot Lo)	
15		SENSE	32	TERM A8	SOURCE	48	EX SOURCE A (EX Cur Lo)	
16	TERM A4	SOURCE	33		SENSE	49	EX GUARD	
17		SENSE				50	EARTH	

2-wire

No.	Pin name	No.	Pin name	No.	Pin name
1	TERM A1	18	TERM B9	34	TERM B17
2	TERM B1	19	TERM B10	35	TERM B18
3	TERM B2	20	TERM A10	36	TERM A18
4	TERM A2	21	TERM A11	37	TERM A19
5	TERM A3	22	TERM B11	38	TERM B19
6	TERM B3	23	TERM B12	39	TERM B20
7	TERM B4	24	TERM A12	40	TERM A20
8	TERM A4	25	TERM A13	41	TERM A21
9	TERM A5	26	TERM B13	42	TERM B21
10	TERM B5	27	TERM B14	43	GUARD
11	TERM B6	28	TERM A14	44	GUARD
12	TERM A6	29	TERM A15	45	EX B (EX Hi)
13	TERM A7	30	TERM B15	46	EX B (EX Hi)
14	TERM B7	31	TERM B16	47	EX A (EX Lo)
15	TERM B8	32	TERM A16	48	EX A (EX Lo)
16	TERM A8	33	TERM A17	49	EX GUARD
17	TERM A9			50	EARTH

About multiplexer wiring

- Connect the multiplexer and measurement target as shown in the following diagram.
  See "8.7 Example Connections and Settings"(p.169) for specific examples of connections.



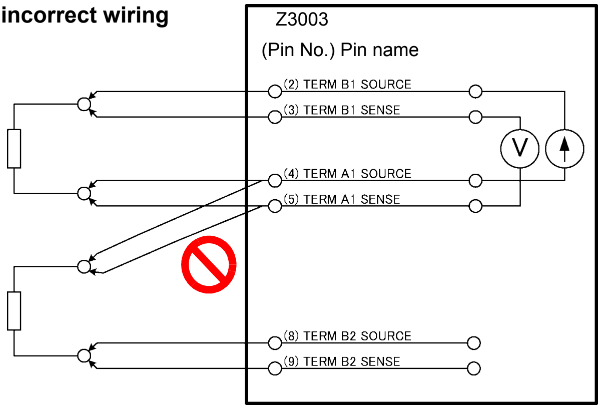
- Use shielded wires in the cables connected to the multiplexer connectors. Failure to do so may cause measured values to be unstable due to the effects of noise.
- Connect cable shielding to the GUARD pin.

See: "Appendix 14 Making Your Own Measurement Leads, Making Connections to the Multiplexer" (p. A30)

NOTE

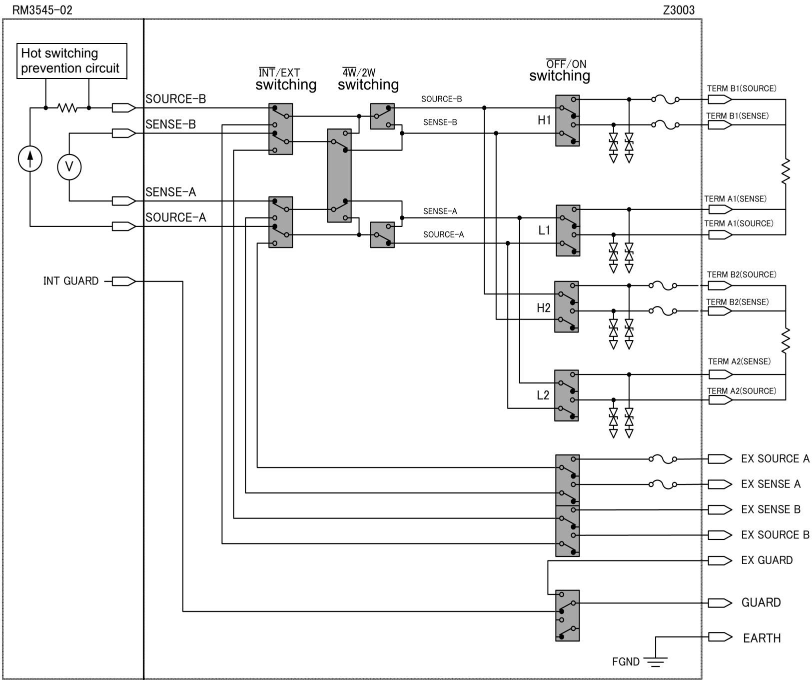
- Connections and measurements cannot span different multiplexer units.
  Example of unsupported measurement
  Between Unit 1 TERM 1 and Unit 2 TERM 2
- If two or more targets are connected simultaneously with one combination of source and sence terminals, 4-terminal measurement will not be performed properly. Connect only one target with one combination of terminals.

Example of incorrect wiring



8.2 Internal Circuitry

- The Z3003 Multiplexer Unit enables the instrument to measure resistances connected with user-specified pins, assigning them to each of the A and B terminals.
- Each measurement terminal has built-in protection against coil back-EMF.
- Each terminal incorporates a built-in, protective fuse (rated current: 1.6 A). (Fuses cannot be replaced by the customer.) If the fuse trips due to over-input, measurement will no longer be possible. If this occurs, have the instrument repaired.
- The Z3003 Multiplexer Unit stores the number of relay switching cycles. This information can be accessed when performing the unit test with key operation or using commands, and it should be used to gauge maintenance timing.
- The unit test function performs short and open tests by shorting the measurement terminals. Short test measures a specific pin's round-trip wiring resistance and generates a PASS result if the value is 1 Ω or less.
- For more information about multiplexer command control, see the Communications Command Instruction Manual on the included application disc.



Electrical Specifications

See: "13.2 Z3003 Multiplexer Unit"(p.280)

(1) Measurement targets (wiring order is user-selected)

4-wire	10 locations (when using two Z3003 units, 20 locations)
2-wire	21 locations (when using two Z3003 units, 42 locations)

(2) Measurable range

Measurement current	Instrument with Z3003: 1 A DC or less Externally connected device: 1 A DC or less, 100 mA AC or less
Measurement frequency	Externally connected device: DC, 10 Hz to 1 kHz

(3) Contact specifications

Contact type	Mechanical relay
Maximum allowable voltage	30 V RMS and 42.4 V peak or 60 V DC
Maximum allowable power	30 W (DC) (Resistance load)
Contact service life	4-wire: 50 million cycles, 2-wire: 5 million cycles (reference value)

8.3 Multiplexer Settings

In addition to instrument key operation and communications commands, a sample application software is available for configuring multiplexer settings.

The sample application software can be downloaded from the Hioki website (http://www.hioki.com).

Configuring Multiplexer Settings

This section describes how to configure overall multiplexer operation. The measurement terminal and scan function settings can also be configured from the Measurement screen.

See: "When changing the measurement terminal setting or scan function setting on the Measurement screen" (p.151)

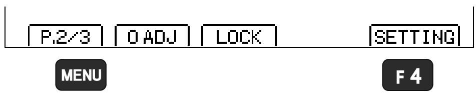
If you wish to initialize the multiplexer channel settings

See: "7.7 Initializing (Reset)"(p.134)

NOTE

- It is not possible to switch to the multiplexer if measurement leads are connected to the measurement terminals on the front of the instrument (ERR:60 will be displayed). To use the multiplexer, be sure to disconnect any measurement leads.
- When switching from the multiplexer to the measurement terminals on the front of the instrument, the channel measurement conditions are retained. However, when switching from the measurement terminals on the front of the instrument to the multiplexer, the channel measurement conditions are switched.

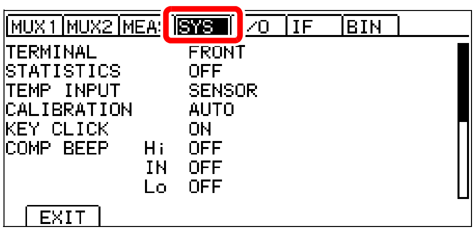
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

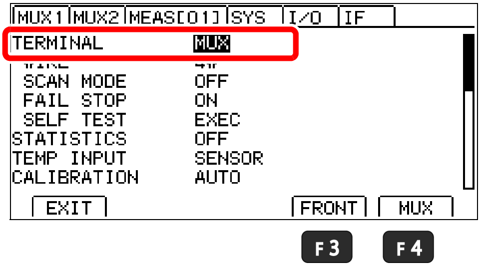
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Set the measurement terminals.



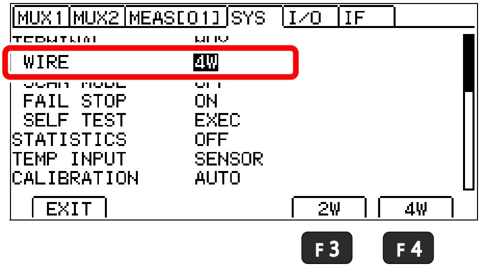
1 Selection

2

F3 Make measurements using the front measurement terminals (do not use the multiplexer). (default)

F4 Use the multiplexer.

4 Select the measurement method.



1 Selection

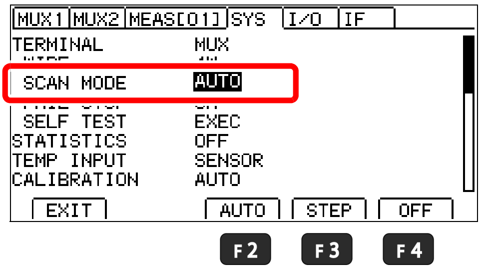
2

F3 2-wire

F4 4-wire (default)

NOTE
When the measurement method is switched, the multiplexer channel settings will be initialized (i.e., a multiplexer channel reset will be performed). Always finalize the measurement method before allocating pins or performing zero-adjustment.

5 Set the scan function.



1 Selection

2

F2 Use auto-scan (measure all channels at each TRIG signal).(default)

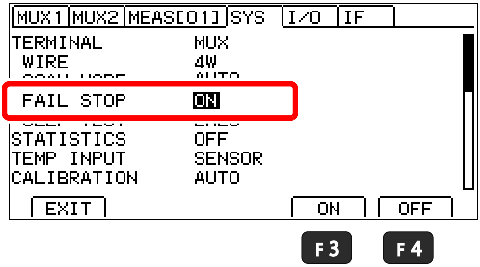
F3 Use step scan (measure 1 channel at each TRIG signal).

F4 Do not scan.

NOTE
When the scan function is set to auto or step, external trigger operation will be used regardless of the trigger source setting.

6 Select FAIL stop operation.

This setting is valid only when the scan function is ON.



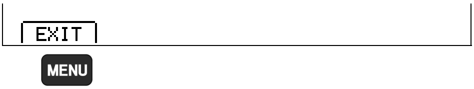
1 Selection

2

F3 Stop scanning when any channel yields a FAIL judgment.

F4 Do not stop scanning even if a channel yields a FAIL judgment. (default)

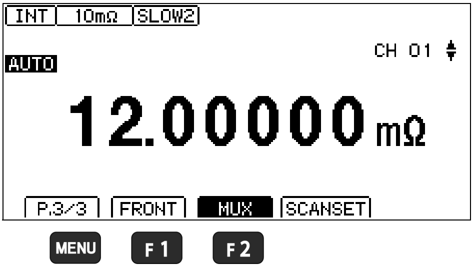
7 Return to the Measurement screen.



MENU Return to the Measurement screen.

When changing the measurement terminal setting or scan function setting on the Measurement screen

1 Set the measurement terminals.

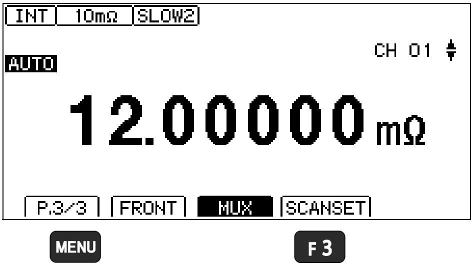


1 MENU Switch the function menu to P.3/3.

2 F1 Make measurements using the front measurement terminals (do not use the multiplexer). (default)

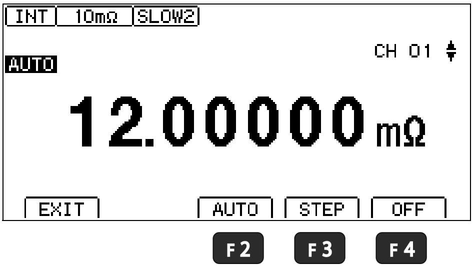
F2 Use the multiplexer.

2 Set the scan function.



1 MENU Switch the function menu to P.3/3.

2 F3 Scan Function Selection screen



F2 Use auto-scan (measure all channels at each TRIG signal).(default)

F3 Use step scan (measure 1 channel at each TRIG signal).

F4 Do not scan.

8

Customizing Channel Pin Allocation

The Multiplexer Unit can measure the resistance between user-specified pin pairs by changing the channel pin allocation. Pin allocation can be set for up to 42 channels.

If you wish to initialize the multiplexer channel settings
See: "7.7 Initializing (Reset)"(p.134)

NOTE

The Z3003 Multiplexer Unit's contacts use mechanical relays. Since mechanical relays have a finite service life, programs should be created so as to minimize the switching of contacts.
Particularly when set to 2-wire, the frequency of contact switching when switching from TERM An (TERM Bn) to Am (TERM Bm) can be minimized by switching such that n and m are both odd numbers or both even numbers, rather than switching such that n is odd and m is even, or vice versa.
For more information about how to reduce 4-wire/2-wire relay switching, see “"8.2 Internal Circuitry"(p.146)

Examples

Example 1: TERM A1/B1 → TERM A2/B2 → TERM A3/B3 → TERM A4/B4
Example 2: TERM A1/B1 → TERM A3/B3 → TERM A2/B2 → TERM A4/B4
Example 2 requires less contact switching than Example 1.

Contact service life reference value

4-wire: 50 million cycles, 2-wire: 5 million cycles

Channel default settings

4-wire

CH		UNIT	TERM A	TERM B
1	Enabled	1	TERM A1	TERM B1
2	Disabled	1	TERM A2	TERM B2
:	:	:	:	:
10	Disabled	1	TERM A10	TERM B10
11	Disabled	2	TERM A1	TERM B1
12	Disabled	2	TERM A2	TERM B2
:	:	:	:	:
20	Disabled	2	TERM A10	TERM B10
21	Disabled	1	TERM A1	TERM B1
22	Disabled	1	TERM A1	TERM B1
:	:	:	:	:
42	Disabled	1	TERM A1	TERM B1

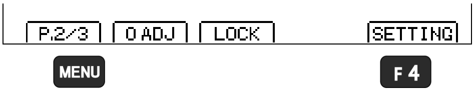
2-wire

CH		UNIT	TERM A	TERM B
1	Enabled	1	TERM A1	TERM B1
2	Disabled	1	TERM A2	TERM B2
:	:	:	:	:
21	Disabled	1	TERM A21	TERM B21
22	Disabled	2	TERM A1	TERM B1
23	Disabled	2	TERM A2	TERM B2
:	:	:	:	:
42	Disabled	2	TERM A21	TERM B21

See: **"8.7 Example Connections and Settings"**(p.169)

Setting the connection and measurement method for individual channels

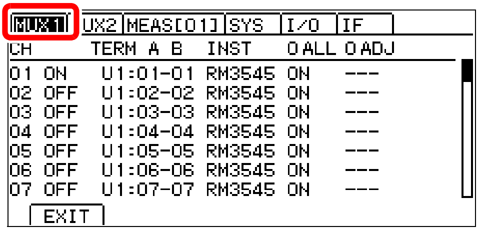
1 Open the Settings Screen.

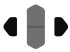


1 MENU Switch the function menu to P.2/3.

2 F4 The Settings screen appears.

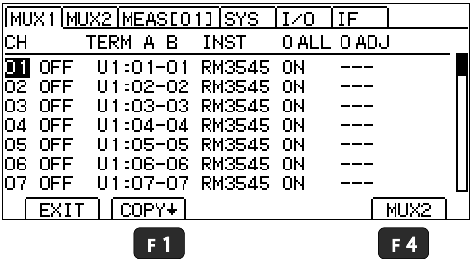
2 Open the Multiplexer Channel Settings screen.

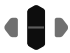




Move the cursor to the [MUX1] tab with the left and right cursor keys.

3 Move to the channel you wish to set.





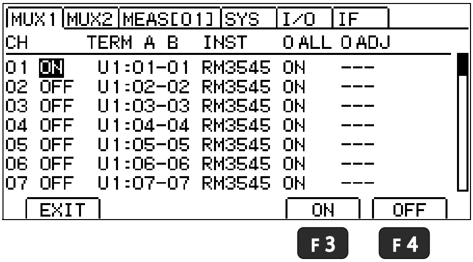
Select the channel to set.

<Hint>

You can copy the settings for the selected channel to the next channel with the F1 key. (Only the settings shown on the screen will be copied. However, unit and pin settings will not be copied.)

You can return to the [MUX2] tab with the F4 key.

4 Set the channels being used to ON.



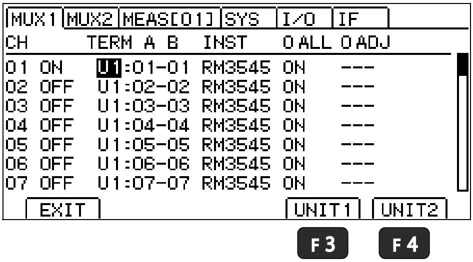
1 Move to the CH settings.

2 F3 Use the channel.

F4 Do not use the channel.

Channels that have been set to OFF cannot be selected on the Measurement screen. Additionally, since channels set to OFF are ignored in scanning, they cannot be measured.

5 Select the unit to which the measurement target will be connected.



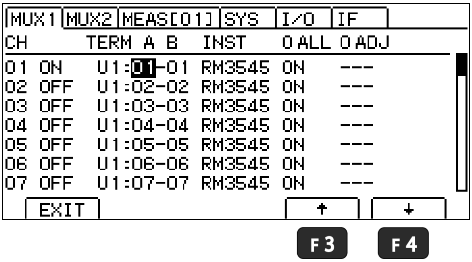
1 Move to unit selection.

2

F3 Multiplexer unit 1

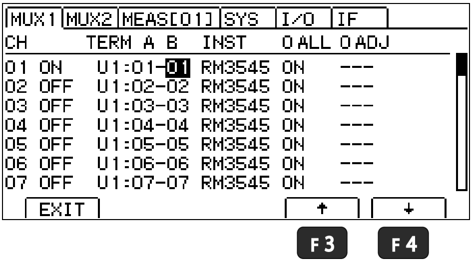
F4 Multiplexer unit 2

6 Select the pin to which the measurement target will be connected.



1 ◀ ▶ Move to TERM A (current detection side) selection.

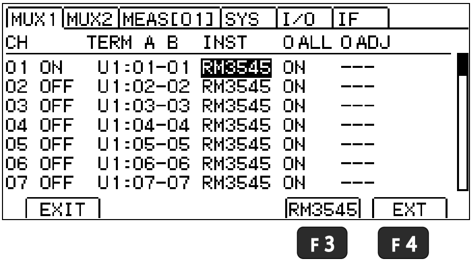
2 F3 F4 Set the terminal number.



1 ◀ ▶ Move to TERM B (current application side) selection.

2 F3 F4 Set the terminal number.

7 Set the measuring instrument for each channel.



1 ◀ ▶ Move to INST selection.

2

F3 Measure resistance with the RM3545.

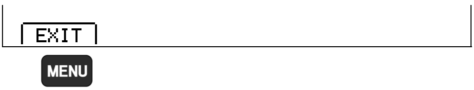
F4 Measure using an externally connected device.

NOTE

When the scan function is set to AUTO, channels that are set to an externally connected device will be ignored.

8 Repeat Steps 3 through 7 above to configure other channels' settings.

9 Return to the Measurement screen.



MENU Return to the Measurement screen.

Setting Basic Measurement Conditions and Total Judgment Conditions for Individual Channels

Basic measurement conditions for individual channels can be set in list form.

Total judgments

After performing scan measurement, a total judgment is made based on the judgment results (comparator judgments) for individual channels. If the judgment results for all channels satisfy the PASS conditions that have been set on a channel-by-channel basis, the total judgment result will be **PASS**, and the EXT I/O output T_PASS signal will turn on. In the event of a measurement fault, a ”**-------**” (judgment not possible) judgment will result, and the EXT I/O T_ERR signal will turn on. A **FAIL** judgment results, and the EXT I/O T_FAIL signal will turn on if the judgment is neither **PASS** nor ”**-------**”.

PASS condition	Description
OFF	Results in an unconditional PASS judgment, even if a measurement fault occurs.
IN	Results in a PASS judgment when the channel’s judgment result is IN. (default)
HI	Results in a PASS judgment when the channel’s judgment result is HI.
LO	Results in a PASS judgment when the channel’s judgment result is LO.
HI/LO	Results in a PASS judgment when the channel’s judgment result is either HI or LO.
ALL	Results in a PASS judgment when the channel’s judgment result is HI, LO, or IN. Does not result in a PASS judgment if a measurement fault occurs.

Total judgment result	Judgment criteria	EXT I/O output
PASS	If all channels’ judgment results satisfy the PASS conditions	T_PASS
FAIL	If even one channel’s judgment result fails to satisfy the PASS conditions	T_FAIL
------- (judgment not possible)	If any of the channels yields a measurement fault or error (takes precedence over FAIL judgments)	T_ERR

NOTE
- Total judgments are not made when scan mode is off.
- Channels for which the measuring instrument is set to EXT (external device) are not included in total judgments.

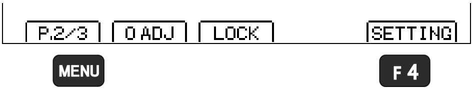
When the comparator judgment method is REF%, the channel 1 measured value can be used as the reference value.

If you wish to initialize the multiplexer channel settings
See: "7.7 Initializing (Reset)"(p.134)

8

Setting basic measurement conditions

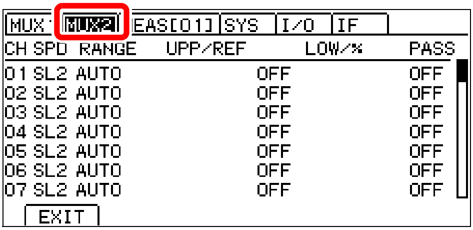
1 Open the Settings Screen.

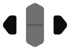


1 MENU Switch the function menu to P.2/3.

2 F4 The Settings screen appears.

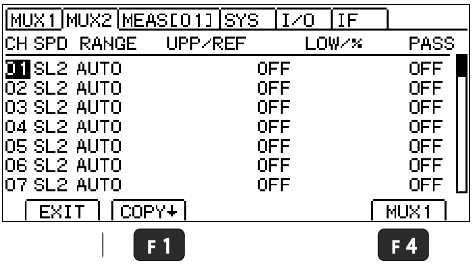
2 Open the Multiplexer Basic Measurement Screen.

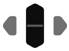




Move the cursor to the [MUX2] tab with the left and right cursor keys.

3 Move to the channel you wish to set.





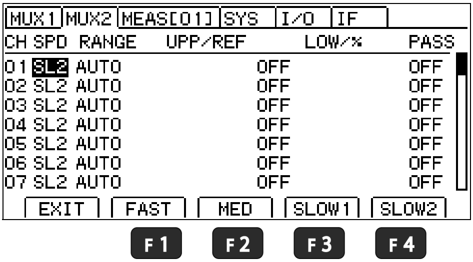
Select the channel to set.

<Hint>

You can copy the settings for the selected channel to the next channel with the F1 key. (All settings shown on the screen as well as those on the [MEAS] tab will be copied.)

You can return to the [MUX1] tab with the F4 key.

4 Set the measurement speed.



1 Move to the SPD (SPEED) parameter.

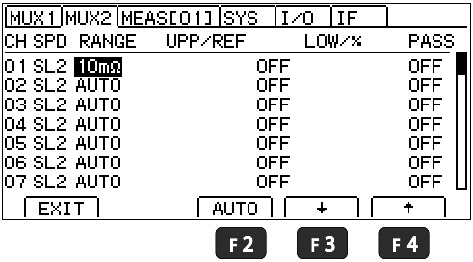
2 F1 Set the measurement speed to FAST.

F2 Set the measurement speed to MEDIUM.

F3 Set the measurement speed to SLOW1.

F4 Set the measurement speed to SLOW2.

5 Set the measurement range.



1 Move to the RANGE parameter.

2

F2 Set to auto-ranging.

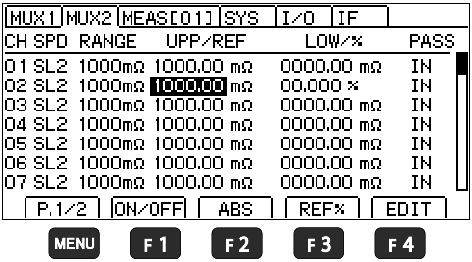
F3 F4 Select the range you wish to use.

NOTE

When auto-ranging is selected, the comparator settings cannot be set to on. To use the comparator, set the measurement range first.

6 Set the comparator.

1. Determine the judgment method.



1 Move to the UPP/REF parameter.

2 F1 Enable or disable comparator.

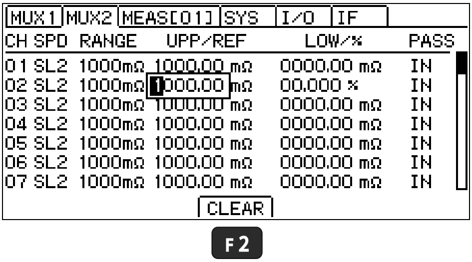
F2 Set the judgment mode to ABS (UPP, LOW).

F3 Set the judgment mode to REF%.

3 F4 Make the value editable.

MENU When using REF% mode and a channel other than CH1, you can use the CH1 measurement results as the reference value by pressing F2 on MENU P.2/2.

2. Set the upper limit value or reference value.



1 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

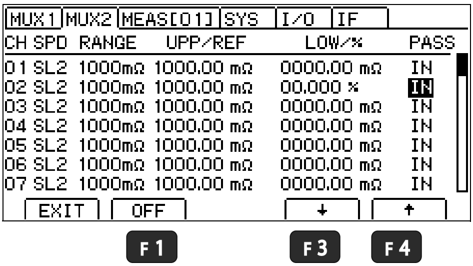
2 ENTER Accept
(ESC Cancel)

To Reset Numerical Values

Press F2 to clear the value. The value will be reset to 0.

3. Set the lower limit value or allowable range.
   Move to the LOW/±% parameter with the left and right cursor keys and set the lower limit value or absolute value in the same manner.

7 Set the PASS condition (when the scan function is set to auto or step only).

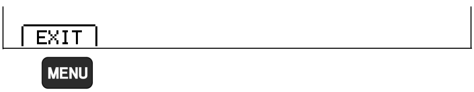


1 Move the cursor to the PASS CONDITION parameter.

2 F1 Set the PASS condition to OFF.

F3 F4 Select the PASS condition.

8 Return to the Measurement screen.



MENU Return to the Measurement screen.

Customizing Measurement Conditions for Individual Channels

Set the measurement conditions for each channel.
See: "Customizing Channel Pin Allocation" (p.152)

If you wish to initialize the multiplexer channel settings
See: "7.7 Initializing (Reset)"(p.134)

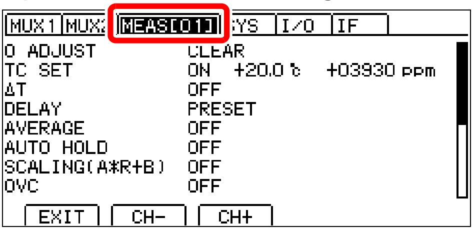
1 Open the Settings Screen.

MENU F 4

1 MENU Switch the function menu to P.2/3.

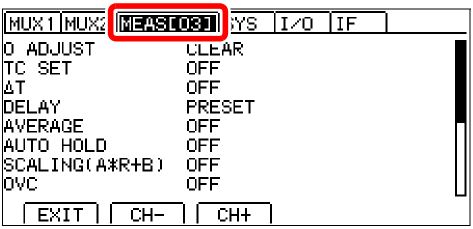
2 F 4 The Settings screen appears.

2 Open the Measurement Setting Screen.



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 Select the channel for which to set measurement conditions.



F 1 F 2

1 F 1 CH– :
Changes (decreases) the channel.

2 F 2 CH+ :
Changes (increases) the channel.

4 Set the measurement conditions.

<Hint>

The channel can be changed for each setting with the ▲ and ▼ keys. (See: p.63)
Measurement conditions can be copied to the next channel. (See: p.158)

5 Return to the Measurement screen.

MENU

MENU Return to the Measurement screen.

8

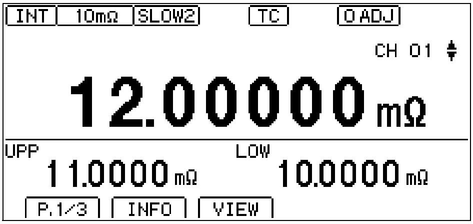
8.4 Measuring with the Multiplexer

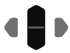
Measuring While Switching Channels Manually

This section describes how to perform measurement while changing channels manually. Before configuring these settings, see "Configuring Multiplexer Settings" (p.148) and "Customizing Measurement Conditions for Individual Channels" (p.161).

1 **Turn off the scan function.**
See: "Configuring Multiplexer Settings" (p.148)

2 **Change channels manually.**
Measurement will be performed after applying the measurement conditions for the selected channel. You can also change the measurement range, speed, and comparator settings directly from the Measurement screen.





Select the channel.

With the exception of channel operations, functionality is the same as measurement using the terminals on the front of the instrument.

Performing Scan Measurement

This section describes how to measure channels in successive order.
Before configuring these settings, see "Configuring Multiplexer Settings" (p.148) and "Customizing Measurement Conditions for Individual Channels" (p.161).

1 **Set the scan function to either auto or step.**

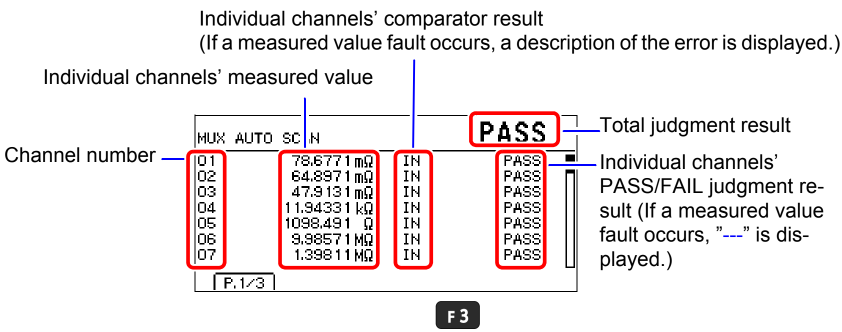
See: "Configuring Multiplexer Settings" (p.148)

> **NOTE**
> When the scan function is set to step, you will need to input the trigger for each channel. When the scan function is set to auto, you can measure all channels with a single trigger input.

2 **Input the external trigger to perform measurement. (trigger input: EXT I/O TRIG signal, ENTER (trigger) key, *TRG command)**

> **NOTE**
> - When the scan function is set to auto or step, the trigger source will be set to an external trigger ([EXT]).
> - When the scan function is auto or step, the range, comparator, and speed cannot be changed on the Measurement screen. Instead, these settings must be changed on the Settings screen.
> - When the scan function is set to AUTO, channels that are set to an externally connected device will be ignored.

The measurement results will be displayed.



Scanning can be stopped by pressing the F3 **[STOP]** key during scanning.

- When the scan function is set to auto
  Scanning will stop midway through the scan.
- When the scan function is set to step
  If there is a scan in progress, it will return to the first channel.

NOTE

During scanning measurement, only the Standby and F3 **[STOP]** keys can be used.

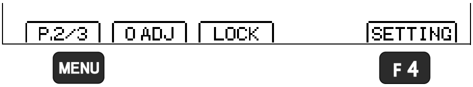
8.5 Zero Adjustment (When a Multiplexer Unit Has Been Installed)

Performing zero-adjustment

Performing scanning zero-adjustment (when the scan function is set to auto or step only)

Zero-adjustment will be performed for all selected channels. If there is a large number of enabled channels, this operation may take several dozens of seconds. However, the measurement time can be shortened by using a manual measurement range.

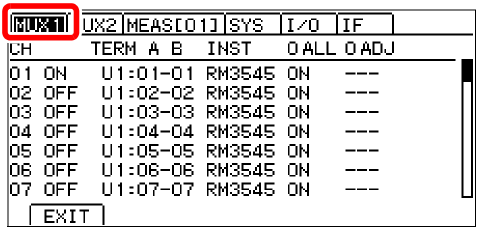
1 Open the Settings Screen.
(If you are already finished configuring settings, proceed to Step 4.)



1 MENU Switch the function menu to P.2/3.

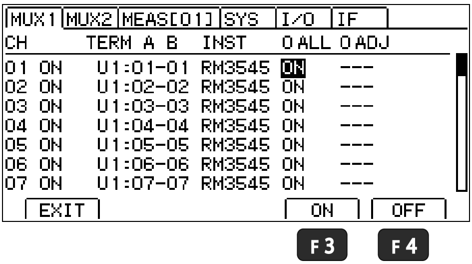
2 F4 The Settings screen appears.

2 Open the Multiplexer Channel Settings screen.



Move the cursor to the [MUX1] tab with the left and right cursor keys.

3 Set the channels for which you wish to perform zero-adjustment.



1 Select the channel to set.

2 Move to the 0ALL parameter.

3 F3 Perform zero-adjustment.

F4 Do not perform zero-adjustment.

The 0ADJ column will indicate "**DONE**" for channels for which zero-adjustment has already been performed.
The 0ADJ column will indicate "**---**" for channels for which zero-adjustment has not yet been performed.

4 Connect each channel to 0 Ω.
See: "Appendix 6 Zero Adjustment" (p. A7)

5 F4 Perform zero-adjustment.
See: "4.3 Zero Adjustment"(p.68)

NOTE

Zero-adjustment cannot be performed for channels for which the measuring instrument is set to an externally connected device.

Canceling zero-adjustment

Zero-adjustment can be canceled from either the Multiplexer Channel Settings screen or the Measurement Settings screen.

Canceling zero-adjustment from the Multiplexer Channel Settings screen

1 **Open the Settings Screen.**

```
P.2/3  0ADJ  LOCK          SETTING
```

MENU F4

1 MENU Switch the function menu to P.2/3.

2 F4 The Settings screen appears.

2 **Open the Multiplexer Channel Setting Screen.**

```
MUX1 UX2 MEAS[01] SYS  I/O  IF
CH      TERM  A  B   INST    0ALL 0ADJ
01  ON    U1:01-01  RM3545  ON    ---
02  OFF   U1:02-02  RM3545  ON    ---
03  OFF   U1:03-03  RM3545  ON    ---
04  OFF   U1:04-04  RM3545  ON    ---
05  OFF   U1:05-05  RM3545  ON    ---
06  OFF   U1:06-06  RM3545  ON    ---
07  OFF   U1:07-07  RM3545  ON    ---
  EXIT
```

Move the cursor to the [MUX1] tab with the left and right cursor keys.

3 **Set the channels for which you wish to cancel zero-adjustment.**

```
MUX1 MUX2 MEAS[01] SYS  I/O  IF
CH      TERM  A  B   INST    0ALL 0ADJ
01  ON    U1:01-01  RM3545  ON    ON
02  ON    U1:02-02  RM3545  ON    ---
03  ON    U1:03-03  RM3545  ON    ---
04  ON    U1:04-04  RM3545  ON    ---
05  ON    U1:05-05  RM3545  ON    ---
06  ON    U1:06-06  RM3545  ON    ---
07  ON    U1:07-07  RM3545  ON    ---
  EXIT  CLEAR
```

F1

1 Select the channel to set.

2 Move to the 0ADJ parameter.

The 0ADJ column will indicate "**DONE**" for channels for which zero-adjustment has already been performed.
The 0ADJ column will indicate "**---**" for channels for which zero-adjustment has not yet been performed.

4 F1 **Select to cancel zero-adjustment.**
When the confirmation message is displayed, select F2 **[OK].**

5 **Return to the Measurement screen.**

```
EXIT
```

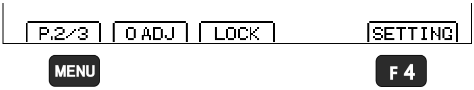
MENU

MENU Return to the Measurement screen.

8

Canceling zero-adjustment from the Measurement Setting screen

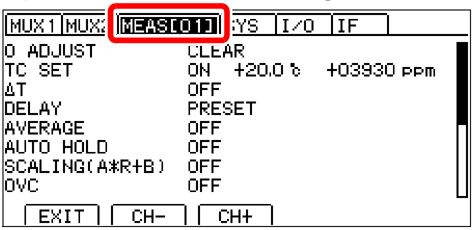
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

2 F4 The Settings screen appears.

2 **Open the Measurement Setting Screen.**



Move the cursor to the [MEAS] tab with the left and right cursor keys.

3 **Select 0 ADJUST.**

1 Selection

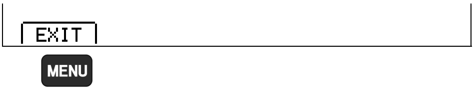
2

F3 Cancel zero-adjustment for all channels.

F4 Cancel zero-adjustment for the selected channel.

4 **When the confirmation message is displayed, select F2 [OK].**

5 **Return to the Measurement screen.**



MENU Return to the Measurement screen.

8.6 Performing the Multiplexer Unit Test

This section describes how to verify proper Multiplexer Unit operation.

NOTE
Do not connect any measurement leads to the measurement terminals on the front of the instrument.

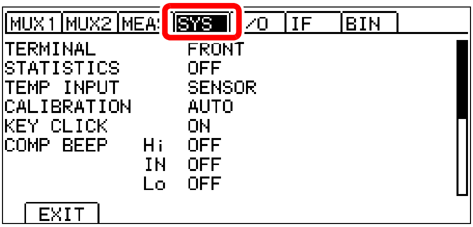
1 Open the Settings Screen.

MENU F4

1 MENU Switch the function menu to P.2/3.

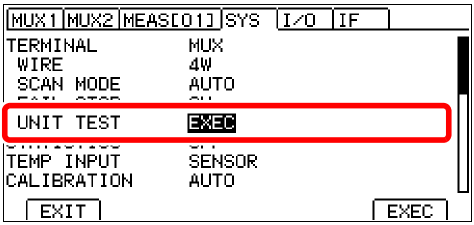
2 F4 The Settings screen appears.

2 Open the System Setting Screen.



Move the cursor to the [SYS] tab with the left and right cursor keys.

3 Perform the unit test.



F4

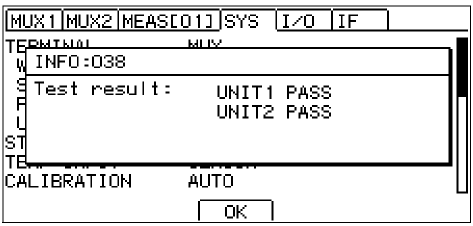
1 Select UNIT TEST.
(UNIT TEST is displayed only when TERMINAL is set to MUX.)

2 Short all the pins numbered 1 to 42.
See: "Connection when performing the unit test" (p.168)

3 F4 Perform the self-test.

After the confrimation message and the number of relay switching cycles are displayed, a short-circuit resistance value check will be performed, and the results will be displayed.

Example test results



If the display shows "**Blown FUSE.**," the measurement circuit's protective fuse has been tripped. Replace the fuse.
See: "14.2 Replacing the Measurement Circuit's Protective Fuse"(p.302)

8

4 **Return to the Measurement screen.**

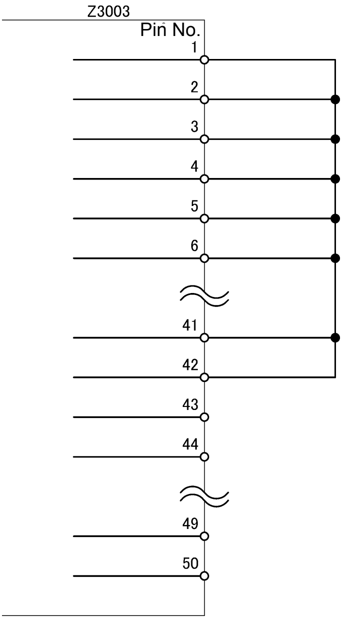
EXIT

MENU

MENU Return to the Measurement screen.

Connection when performing the unit test

When performing the unit test, short all the pins numbered 1 to 42.

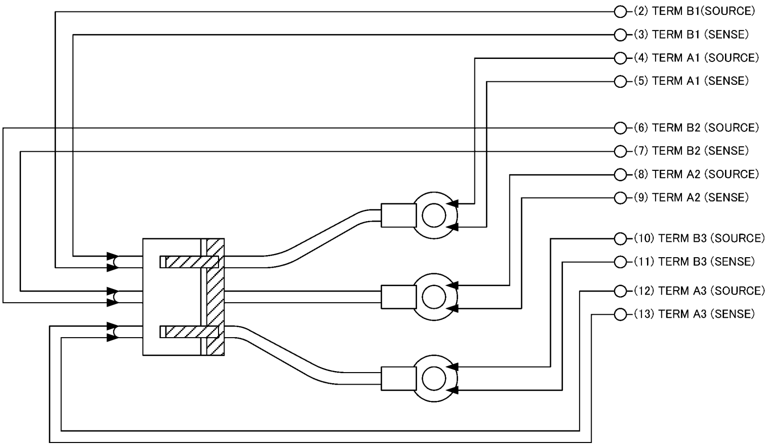


NOTE

- Short wiring resistances are included the round-trip resistance value measured during the test. Short the pins at points that are close to each pin so that wirings are as short as possible.
- Do not short the pins Number 43 and 44 with the others. Since they are the guard terminals, the test will not be performed properly if they are shorted with the others.

8.7 Example Connections and Settings

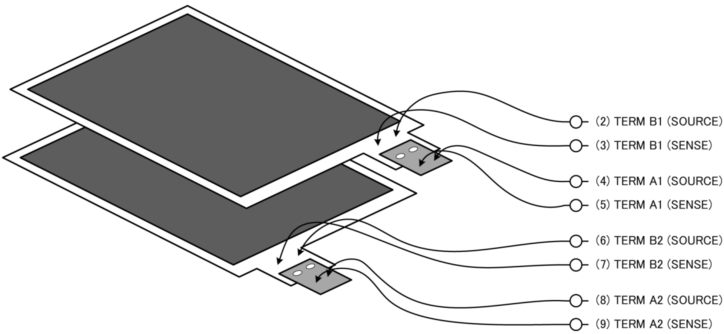
Example cable assembly (wire harness) settings



MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	1	1
2	RM3545	UNIT1	2	2
3	RM3545	UNIT1	3	3

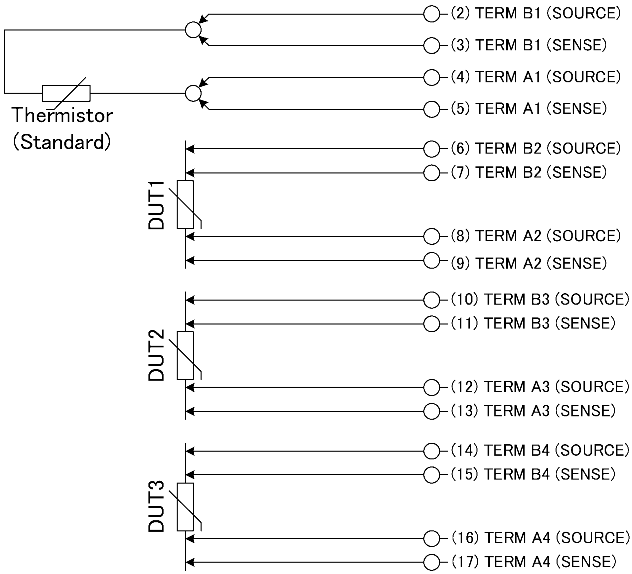
Example battery terminal weld settings



MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	1	1
2	RM3545	UNIT1	2	2

Example settings for a measurement target with high temperature dependence



Using channel 1 (thermistor) measurement results as the comparator reference value

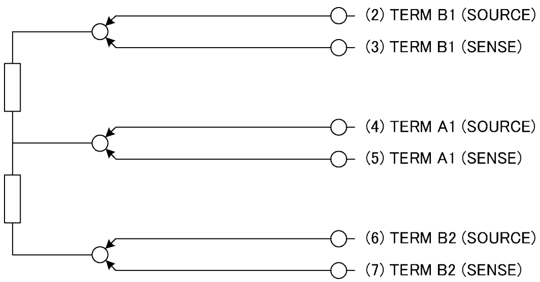
MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	1	1
2	RM3545	UNIT1	2	2
3	RM3545	UNIT1	3	3
4	RM3545	UNIT1	4	4

MEAS settings

MEAS tab	COMP	REF	%
MEAS[01]	OFF		
MEAS[02]	REF%	CH01	5.0
MEAS[03]	REF%	CH01	5.0
MEAS[04]	REF%	CH01	5.0

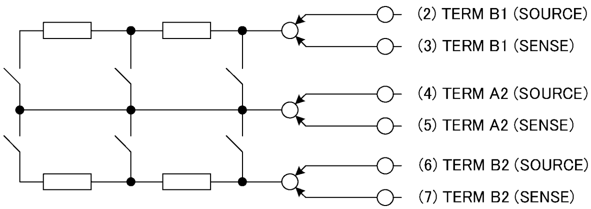
Example network resistor settings



MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	1	1
2	RM3545	UNIT1	1	2

Example steering switch settings

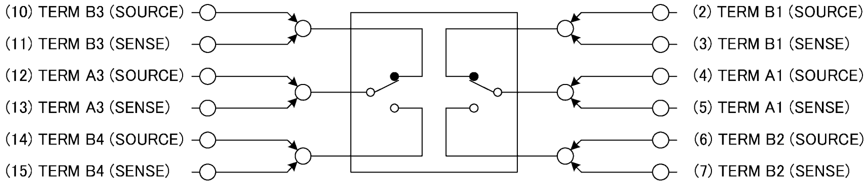


MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	2	1
2	RM3545	UNIT1	2	1
3	RM3545	UNIT1	2	1
4	RM3545	UNIT1	2	2
5	RM3545	UNIT1	2	2
6	RM3545	UNIT1	2	2

(A step scan is used, with switches being toggled on and off between channels.)

Example power switch settings

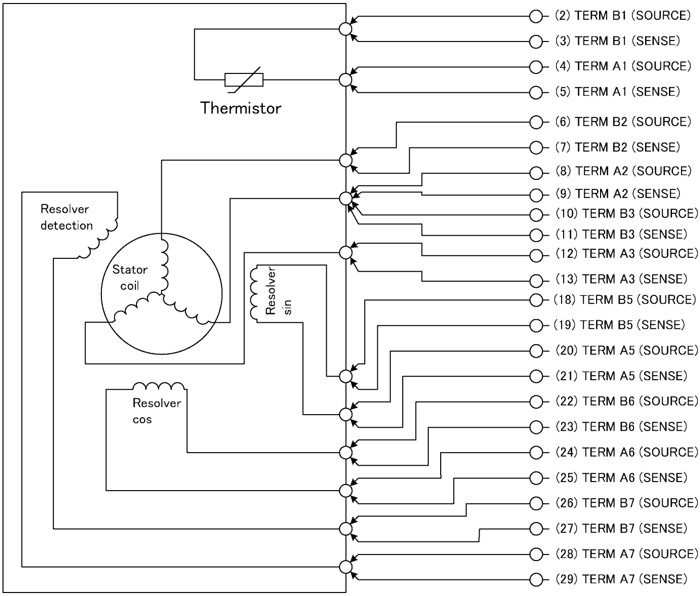


MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	1	1
2	RM3545	UNIT1	1	2
3	RM3545	UNIT1	1	1
4	RM3545	UNIT1	1	2
5	RM3545	UNIT1	3	3
6	RM3545	UNIT1	3	4
7	RM3545	UNIT1	3	3
8	RM3545	UNIT1	3	4

(A step scan is used, with switches being switched between channels 2 and 3 and between channels 6 and 7. Open resistance measurement is performed for channels 2, 3, 6, and 7 using the 1,000 MΩ range.)

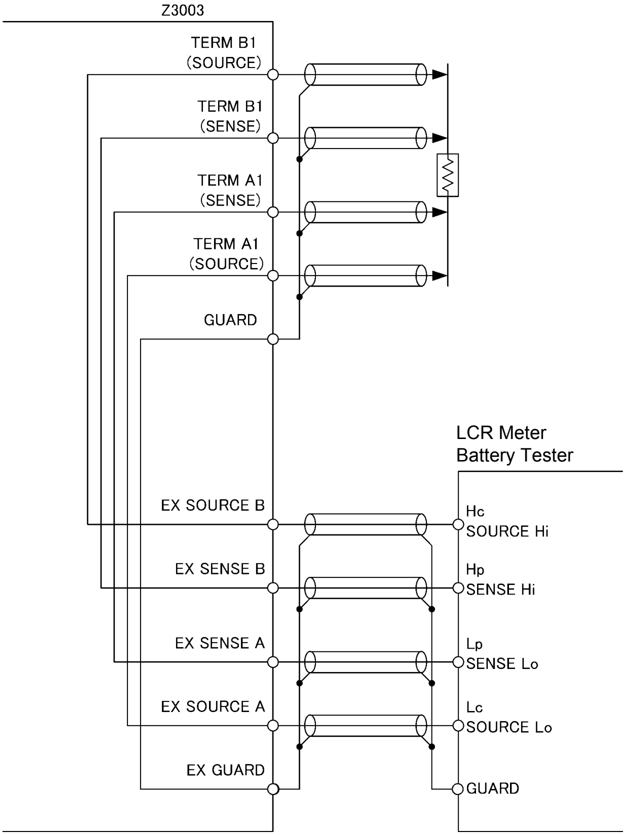
Example motor settings



MUX settings

CH	INST.	UNIT	TERM A	TERM B
1	RM3545	UNIT1	1	1
2	RM3545	UNIT1	2	2
3	RM3545	UNIT1	3	3
4	RM3545	UNIT1	3	2
5	RM3545	UNIT1	5	5
6	RM3545	UNIT1	6	6
7	RM3545	UNIT1	7	7

Connecting an external device



You can switch channels via the front panel, communications, or EXT I/O when using an external device, too.

D/A Output Chapter 9

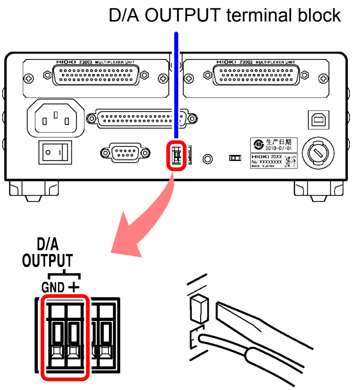
Before using the instrument, read "Before Using D/A Output" (p.14) carefully.

The Model RM3545, RM3545-01 and RM3545-02 are capable of generating D/A output for resistance measured values. By connecting D/A output to a logger or other device, it is possible to easily record variations in resistance values.

9.1 Connecting D/A Output

This section describes how to connect cables to the D/A OUTPUT terminal block on the instrument's rear panel.

Rear Panel



1 Push down on the button with a flat-head screwdriver or similar tool.

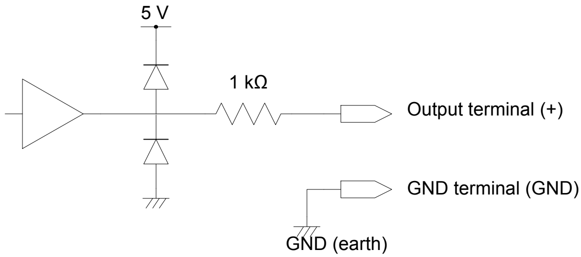
2 Insert the wire into the connection port while holding the button down.

3 Release the button to lock the wire in place. A similar procedure can be used to remove the lead.

Recommended wire type	:	Single line: AWG22 (0.65 mm diameter) Twisted wire: AWG22 (0.32 mm^2) Diameter of search wire: 0.12 mm or more
Compatible wire types	:	Single line: AWG28 (0.32 mm diameter) to AWG22 (0.65 mm diameter) Twisted wire: AWG28 (0.08 mm^2) to AWG22 (0.32 mm^2) stranded conductor Diameter of search wire: 0.12 mm or more
Standard bare wire length	:	8 mm

9.2 D/A Output Specifications

Output	Resistance measured value (display value after zero-adjustment and temperature correction but before scaling and ΔT calculation)
Output voltage	0 V (corresponds to 0 dgt.) to 1.5 V DC* If a measured value fault occurs, 1.5 V; if the measured value is negative, 0 V * For a 1,200,000 dgt. display, corresponds to 1.2 V (1,200,000 dgt.). For a 120,000 dgt. display, corresponds to 1.2 V (120,000 dgt.). For a 12,000 dgt. display, corresponds to 1.2 V (12,000 dgt.). For a display in excess of 1.5 V, fixed at 1.5 V.
Maximum output voltage	5 V
Output impedance	1 kΩ
Number of bits	12bit
Output accuracy	Add ±0.2%f.s. to the resistance measurement accuracy (temperature coefficient: ±0.02%f.s./°C)
Response time	Measurement time + Max. 1 ms Shortest 2.0 ms (tolerance: ±10%±0.2 ms) Shortest conditions INT trigger source, LP: OFF, 1000 kΩ or lower range, Measurement speed: FAST, Delay: 0 ms, Self-Calibration: MANUAL



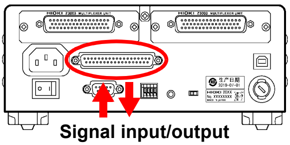
NOTE

- The D/A output's GND pin is connected to the Protected Earth (to the metallic part of the case).
- The instrument has an output impedance of 1 kΩ. Connected devices must have an input impedance of at least 10 MΩ. (The output voltage is divided by the output resistance and input impedance. For instance, an input impedance of 1 MΩ decreases the output voltage by 0.1%.)
- Connecting a cable may result in external noise. Implement a lowpass filter or other measures as needed in the connected device.
- The output voltage is updated at the resistance measurement sampling timing.
- Recorded waveforms are stepped (since the output circuit response is extremely fast compared to the update period).
- When using auto-ranging, the same resistance value may result in 1/10 (or 10 times) the output voltage due to range switching. It is recommend to set the range manually.
- Output is set to 0 V when changing settings (range switching, etc.) and when the instrument is turned off. Additionally, an unstable voltage that is less than or equal to the maximum output voltage is output momentarily when the main power switch on the rear of the instrument is turned on.
- To maximize the D/A output response time, set the measurement speed to FAST and self-calibration to manual. (See: "3.3 Setting the Measurement Speed" (p. 50), "4.12 Maintaining Measurement Precision (Self-Calibration)" (p. 92))

External Control (EXT I/O) Chapter 10

The EXT I/O connector on the rear of the instrument supports external control by providing output of the EOM and comparator judgment signals, and accepting input of TRIG and KEY_LOCK signals. All signals are isolated from the measurement circuit and ground (I/O common pins are shared).
Input circuit can be switched to accommodate either current sink output (NPN) or current source output (PNP).

Confirm input and output ratings, understand the safety precautions for connecting a control system, and use accordingly.



Check the controller's I/O specifications.

↓

Set the instrument's NPN/PNP switch. (p.178)

↓

Connect the instrument's EXT I/O connector to the controller. (p.179)

↓

Make instrument settings. (p.209)

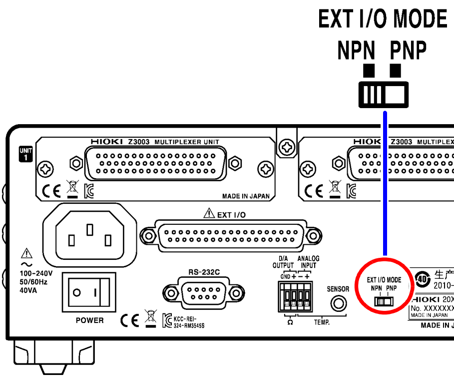
10.1 External Input/Output Connector and Signals

Switching between Current Sink (NPN) and Current Source (PNP)

Before switching, see "Before Switching between Current Sink (NPN) and Current Source (PNP)" (p. 12).

The NPN/PNP switch allows you to change the type of programmable controller that is supported.
The instrument ships with the switch set to the NPN position.
See: "10.3 Internal Circuitry"(p.204)

	NPN/PNP switch setting	
	NPN	PNP
RM3545 input circuit	Supports sink output.	Supports source output.
RM3545 output circuit	Non-polar	Non-polar
ISO_5V output	+5 V output	-5 V output



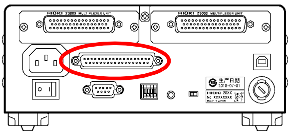
Left: Current sink (NPN)
Right: Current source (PNP)

Connector Type and Signal Pinouts

Before connecting a connector, see "Before Connecting EXT I/O" (p. 13). Use of EXT I/O enables the following control functionality:

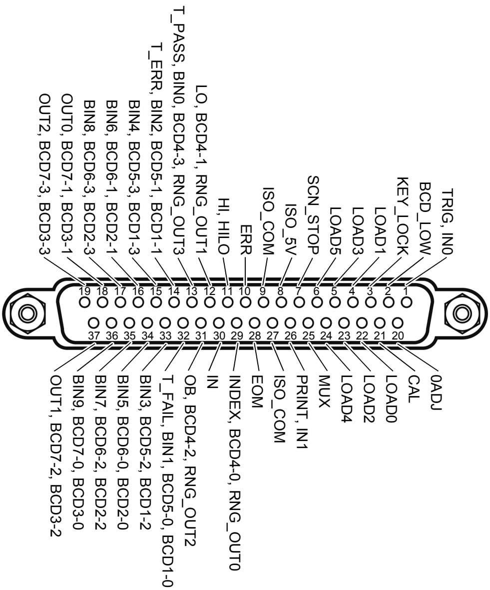
- Measurement start (TRIG) → Measurement end (EOM, INDEX)
  → Acquisition of judgment results
  (HI, IN, LO, ERR, T_ERR, T_PASS, T_FAIL)
  (T_PASS, T_FAIL, and T_ERR are used only when the scan function is set to auto or step.)
- Measurement start (TRIG) → Measurement end (EOM, INDEX)
  → Acquisition of measured values (BCD_LOW, BCDm-n, RNG_OUTn)
- Panel load (LOAD0 to LOAD5, TRIG)
- Multiplexer channel specification (MUX, LOAD0 to 5, TRIG)
- General-purpose I/O (IN0, IN1, OUT0, OUT1, OUT2)

The functionality described in "Performing an I/O Test (EXT I/O Test Function)" (p. 218) provides a convenient way to check external I/O operation.



Connector: (Instrument Side)
37-pin D-sub female with #4-40 screws

Mating Connectors:
DC-37P-ULR (solder type) /
DCSP-JB37PR (pressure weld type)
Japan Aviation Electronics Industry Ltd.



EXT I/O Connector (Instrument Side)

Pin	Signal name	I/O	Function	Logic	Pin	Signal name	I/O	Function	Logic
1	TRIG, IN0	IN	External trigger General-purpose input	Edge	20	0ADJ	IN	Zero adjust	Edge
2	BCD_LOW	IN	BCD Lower byte output	Level	21	CAL	IN	Self-calibration execution	Edge
3	KEY_LOCK	IN	Key-Lock	Level	22	LOAD0	IN	Panel load Channel specification	Level
4	LOAD1	IN	Panel load Channel specification	Level	23	LOAD2	IN	Panel load Channel specification	Level
5	LOAD3	IN	Panel load Channel specification	Level	24	LOAD4	IN	Panel load Channel specification	Level
6	LOAD5	IN	Panel load Channel specification	Level	25	MUX	IN	Multiplexer selection	Level
7	SCN_STOP	IN	Scan stop	Edge	26	PRINT, IN1	IN	Measured value printing General-purpose input	Edge
8	ISO_5V	–	Isolated power supply +5 V (-5 V) output	–	27	ISO_COM	–	Isolated common signal ground	–
9	ISO_COM	–	Isolated common signal ground	–	28	EOM	OUT	End of measurement	Level
10	ERR	OUT	Measurement fault	Level	29	INDEX, BCD4-0, RNG_OUT0	OUT	Analog measurement finished BCD	Level
11	HI, HILO	OUT	Comparator judgment	Level	30	IN	OUT	Comparator judgment	Level
12	LO, BCD4-1, RNG_OUT1	OUT	Comparator judgment BCD	Level	31	OB, BCD4-2, RNG_OUT2	OUT	BIN judgment BCD	Level
13	T_PASS, BIN0, BCD4-3, RNG_OUT3	OUT	Total judgment BIN judgment BCD	Level	32	T_FAIL, BIN1, BCD5-0, BCD1-0	OUT	Total judgment BIN judgment BCD	Level
14	T_ERR, BIN2, BCD5-1, BCD1-1	OUT	Total judgment BIN judgment BCD	Level	33	BIN3, BCD5-2, BCD1-2	OUT	BIN judgment BCD	Level
15	BIN4, BCD5-3, BCD1-3	OUT	BIN judgment BCD	Level	34	BIN5, BCD6-0, BCD2-0	OUT	BIN judgment BCD	Level
16	BIN6, BCD6-1, BCD2-1	OUT	BIN judgment BCD	Level	35	BIN7, BCD6-2, BCD2-2	OUT	BIN judgment BCD	Level
17	BIN8, BCD6-3, BCD2-3	OUT	BIN judgment BCD	Level	36	BIN9, BCD7-0, BCD3-0	OUT	BIN judgment BCD	Level
18	OUT0, BCD7-1, BCD3-1	OUT	General-purpose output BCD	Level	37	OUT1, BCD7-2, BCD3-2	OUT	General-purpose output BCD	Level
19	OUT2, BCD7-3, BCD3-3	OUT	General-purpose output BCD	Level					

NOTE
- Only the RM3545-02 can be used for multiplexer-related control.
- The 0ADJ signal should be asserted (ON) for at least 10 ms.
- The connector's frame is connected to the instrument's rear panel (metal portions) as well as the power inlet's protective ground terminal.
  When switching the panel load or multiplexer channel using a command or key operation, fix pins 4 to 6 and 22 to 24 to on or off.

Signal Descriptions

(1) Isolated power supply

Pin	Signal name	NPN/PNP switch setting	
		NPN	PNP
8	ISO_5V	Isolated power supply +5 V	Isolated power supply -5 V
9, 27	ISO_COM	Isolated common signal ground	

(2) Input Signals

TRIG	The TRIG signal operates at either the ON or OFF edge. ON or OFF edge triggering can be selected on the EXT I/O setting screen (default: ON edge). • When external triggering (EXT) is enabled The TRIG signal causes one measurement to be performed. • When internal triggering (INT) is enabled The TRIG signal does not trigger measurement. A wait is necessary to allow the measured value to stabilize after switching ranges or loading a panel. The wait time varies with the measurement target. After TRIG signal input, statistical calculations for the most recently updated measured value (p.111) and data memory (p.235) are performed. Trigger input can also be performed using the **ENTER** (trigger) key or the ***TRG** command.	p.211 p.84
0ADJ	When the 0ADJ signal is switched from OFF to ON, one zero-adjustment operation will be performed at the signal edge. To avoid malfunction, this signal should be asserted (ON) for at least 10 ms. The ERR signal turns ON when zero-adjustment fails.	p.68
PRINT	Asserting the PRINT signal prints the current measured value.	p.242
CAL	When the CAL signal is changed from off to on while using the manual self-calibration setting, self-calibration will start at that edge. The signal will be disabled when using auto self-calibration. The time required for self calibration is approximately 400 ms. If asserted during measurement, executes after the end of measurement.	p.92

10

KEY_LOCK	While the KEY_LOCK signal is held ON, all front panel keys (except standby key and **ENTER** (trigger) key) are disabled (key unlock and remote control cancellation operations are also disabled).	p.126
MUX	The function of the LOAD signal (pins 4, 5, 6, 22, 23, 24) changes depending on the MUX signal.	p.185
SCN_STOP	Serves as the channel reset signal. This signal is enabled only when the scan function is set to auto or step. When the scan function is set to auto: A scan stop reservation is made when the SCN_STOP signal changes to ON, and scanning is stopped at the completion of measurement. Measurement starts from the initial channel the next time the TRIG signal turns on. To prevent erroneous operation, hold the on state for at least 5 ms. When the scan function is set to step: When the SCN_STOP function changes to on while the instrument is in the TRIG signal standby state, the initial channel is measured the next time the TRIG signal turns on. To prevent erroneous operation, hold the on state for at least 5 ms.	p.148
BCD_LOW	When used with the BCD output setting, turning the BCD_LOW signal OFF causes the higher digits to be output. Turn the BCD_LOW signal ON causes the lower digits and range information to be output.	p.184
LOAD0 to LOAD5	Selecting the panel number to load and the multiplexer channel and then inputting the TRIG signal causes the instrument to load the selected panel and channel number, switch to the channel, and perform measurement. LOAD0 is the LSB, while LOAD5 is the MSB. For more information, see "(4) Signal correspondence chart"(p.185). If LOAD0 to LOAD5 are the same as the previous load operation when the TRIG signal is input, measurement will be performed once if using external triggering, but the panel load operation and channel switching operation will not be performed. If any of the LOAD signals changes to the enabled state and there are no changes for an interval of 10 ms, the panel load operation or channel switching operation will be performed even if the TRIG signal is not input. Do not change the LOAD0 to 5 signals until load operation and channel switching operation are complete. LOAD signals are also enabled when controlling the instrument via communications (remotely). All key operation is disabled when the LOAD signal for a valid panel number and channel number is on. When loading panels or switching channels using commands or key operation, fix pins 4 to 6 as well as 22 to 24 to either ON or OFF. When the scan function is set to auto or step, the channel cannot be changed with the LOAD0 to LOAD5 signals. If you attempt to switch to the multiplexer while measurement leads are connected to the measurement terminals on the front of the instrument, the ERR signal will turn on, and you will not be able to make the switch. Disconnect the measurement leads and switch the LOAD signal again.	p.185
IN0, IN1	The input state can be monitored by using the `:IO:INPut?` command, using these pins as general-purpose input pins. See: Communications Command Instruction Manual on the included application disc.	

(3) Output Signals

EOM	This signal indicates the end of measurement and zero-adjustment. At this point in time, the comparator judgment results and the ERR, BCD and BIN signals have been finalized.	p.215
INDEX	This signal indicates that A/D conversion in the measurement circuit is finished. When the asserted (ON) state occurs, the measurement target can be removed.	
ERR	This signal indicates that a measurement fault has occurred (except out-of-range detection). It is updated simultaneously with the EOM signal. At this time, comparator judgment outputs are all de-asserted (OFF).	p.55
HI, IN, LO	These are the comparator judgment output signals.	
HILO	When using BCD output, pin 11 outputs the result of an OR operation applied to the Hi and Lo judgments.	
T_PASS, T_FAIL, T_ERR	These are the total judgment results. They are valid only when the scan function is set to auto or step.	p.157
BCDm-n	When using BCD output, this signal outputs n bits of digit m. (When BCD1-x is the lowermost digit, BCDX-0 is the LSB.) When the measured value display is "**OvrRng**", "**CONTACT TARM**", or "**- - - - - - -**," all digits of BCD output will be 9. When the measured value display is a negative value, all digits of BCD output will be 0. When the lower limit value has been set to 0 and a negative measured value is encountered, the LO signal will be output in accordance with the display screen result. However, when using the comparator's REF% mode, an unsigned value equivalent to the absolute value being displayed (i.e., an absolute value) will be output.	p.186
OB, BIN0 to BIN9	When BIN output has been configured, the BIN judgment results will be output from pins 13 to 17 and pins 31 to 36. When the results do not correspond to BIN0 to BIN9, OB will turn on.	
OUT0 to OUT2	When the output mode is judgment mode, pins 18, 19 and 37 can be used as general-purpose output pins. The output signals can be controlled with the `:IO:OUTPut` command. See: Communications Command Instruction Manual on the included application disc.	p.217
RNG_OUT0 to RNG_OUT3	When BCD_LOW is turned ON when using BCD output, range information can be acquired from pins 12, 13, 29, and 31.	p.186

NOTE
- When not displaying the Measurement screen and while error messages (except Setting Monitor errors) are being displayed, input signals are disabled.
- EXT I/O input and output signals are not usable while changing measurement settings.

JUDGE mode and BCD mode

Output signals operate under either JUDGE mode or BCD mode. The JUDGE mode output signals vary depending on whether the multiplexer is being used. In BCD mode, signals are used for both the upper and lower digits (and range information).
See: "Switching Output Modes (JUDGE Mode/ BCD Mode)" (p. 217)

Pin functions in JUDGE mode

(When the multiplexer is not being used)

Pin	Function	Pin	Function
9	ISO_COM	28	EOM
10	ERR	29	INDEX
11	HI	30	IN
12	LO	31	OB
13	BIN0	32	BIN1
14	BIN2	33	BIN3
15	BIN4	34	BIN5
16	BIN6	35	BIN7
17	BIN8	36	BIN9
18	OUT0	37	OUT1
19	OUT2		

(When the multiplexer is being used)

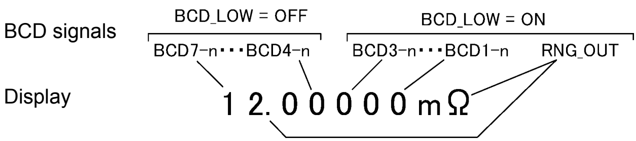
Pin	Function	Pin	Function
9	ISO_COM	28	EOM
10	ERR	29	INDEX
11	HI	30	IN
12	LO	31	–
13	T_PASS	32	T_FAIL
14	T_ERR	33	–
15	–	34	–
16	–	35	–
17	–	36	–
18	OUT0	37	OUT1
19	OUT2		

Pin functions in BCD mode

The BCD upper digits and lower digits (and range information) are switched using the BCD_LOW signal.

Pin	BCD_LOW (2pin)		Pin	BCD_LOW (2pin)	
	OFF	ON		OFF	ON
9	ISO_COM		28	EOM	
10	ERR		29	BCD4-0	RNG_OUT0
11	HILO		30	IN	
12	BCD4-1	RNG_OUT1	31	BCD4-2	RNG_OUT2
13	BCD4-3	RNG_OUT3	32	BCD5-0	BCD1-0
14	BCD5-1	BCD1-1	33	BCD5-2	BCD1-2
15	BCD5-3	BCD1-3	34	BCD6-0	BCD2-0
16	BCD6-1	BCD2-1	35	BCD6-2	BCD2-2
17	BCD6-3	BCD2-3	36	BCD7-0	BCD3-0
18	BCD7-1	BCD3-1	37	BCD7-2	BCD3-2
19	BCD7-3	BCD3-3			

Relation between BCD signals and display



(4) Signal correspondence chart

LOAD0 to LOAD5

LOAD5	LOAD4	LOAD3	LOAD2	LOAD1	LOAD0	MUX signal OFF	MUX signal ON
OFF	OFF	OFF	OFF	OFF	OFF	–	–
OFF	OFF	OFF	OFF	OFF	ON	Panel 1	Channel 1
OFF	OFF	OFF	OFF	ON	OFF	Panel 2	Channel 2
OFF	OFF	OFF	OFF	ON	ON	Panel 3	Channel 3
OFF	OFF	OFF	ON	OFF	OFF	Panel 4	Channel 4
OFF	OFF	OFF	ON	OFF	ON	Panel 5	Channel 5
OFF	OFF	OFF	ON	ON	OFF	Panel 6	Channel 6
OFF	OFF	OFF	ON	ON	ON	Panel 7	Channel 7
OFF	OFF	ON	OFF	ON	OFF	Panel 8	Channel 8
OFF	OFF	ON	OFF	OFF	ON	Panel 9	Channel 9
OFF	OFF	ON	OFF	ON	OFF	Panel 10	Channel 10
OFF	OFF	ON	OFF	ON	ON	Panel 11	Channel 11
OFF	OFF	ON	ON	OFF	OFF	Panel 12	Channel 12
OFF	OFF	ON	ON	OFF	ON	Panel 13	Channel 13
OFF	OFF	ON	ON	ON	OFF	Panel 14	Channel 14
OFF	OFF	ON	ON	ON	ON	Panel 15	Channel 15
OFF	ON	OFF	OFF	OFF	OFF	Panel 16	Channel 16
OFF	ON	OFF	OFF	OFF	ON	Panel 17	Channel 17
OFF	ON	OFF	OFF	ON	OFF	Panel 18	Channel 18
OFF	ON	OFF	OFF	ON	ON	Panel 19	Channel 19
OFF	ON	OFF	ON	OFF	OFF	Panel 20	Channel 20
OFF	ON	OFF	ON	OFF	ON	Panel 21	Channel 21
OFF	ON	OFF	ON	ON	OFF	Panel 22	Channel 22
OFF	ON	OFF	ON	ON	ON	Panel 23	Channel 23
OFF	ON	ON	OFF	OFF	OFF	Panel 24	Channel 24
OFF	ON	ON	OFF	OFF	ON	Panel 25	Channel 25
OFF	ON	ON	OFF	ON	OFF	Panel 26	Channel 26
OFF	ON	ON	OFF	ON	ON	Panel 27	Channel 27
OFF	ON	ON	ON	OFF	OFF	Panel 28	Channel 28
OFF	ON	ON	ON	OFF	ON	Panel 29	Channel 29
OFF	ON	ON	ON	ON	OFF	Panel 30	Channel 30
OFF	ON	ON	ON	ON	ON	–	Channel 31
ON	OFF	OFF	OFF	OFF	OFF	–	Channel 32
ON	OFF	OFF	OFF	OFF	ON	–	Channel 33
ON	OFF	OFF	OFF	ON	OFF	–	Channel 34
ON	OFF	OFF	OFF	ON	ON	–	Channel 35
ON	OFF	OFF	ON	OFF	OFF	–	Channel 36
ON	OFF	OFF	ON	OFF	ON	–	Channel 37
ON	OFF	OFF	ON	ON	OFF	–	Channel 38
ON	OFF	OFF	ON	ON	ON	–	Channel 39
ON	OFF	ON	OFF	OFF	OFF	–	Channel 40
ON	OFF	ON	OFF	OFF	ON	–	Channel 41
ON	OFF	ON	OFF	ON	OFF	–	Channel 42
ON	OFF	ON	OFF	ON	ON	–	–
ON	OFF	ON	ON	OFF	OFF	–	–
ON	OFF	ON	ON	OFF	ON	–	–
ON	OFF	ON	ON	ON	OFF	–	–
ON	OFF	ON	ON	ON	ON	–	–
ON	ON	OFF	OFF	OFF	OFF	–	–
ON	ON	OFF	OFF	OFF	ON	–	Panel 31
ON	ON	OFF	OFF	ON	OFF	–	Panel 32
ON	ON	OFF	OFF	ON	ON	–	Panel 33
ON	ON	OFF	ON	OFF	OFF	–	Panel 34
ON	ON	OFF	ON	OFF	ON	–	Panel 35
ON	ON	OFF	ON	ON	OFF	–	Panel 36
ON	ON	OFF	ON	ON	ON	–	Panel 37
ON	ON	ON	OFF	OFF	OFF	–	Panel 38
ON	ON	ON	OFF	OFF	ON	–	–
ON	ON	ON	OFF	ON	OFF	–	–
ON	ON	ON	OFF	ON	ON	–	–
ON	ON	ON	ON	OFF	OFF	–	–
ON	ON	ON	ON	OFF	ON	–	–
ON	ON	ON	ON	ON	OFF	–	–
ON	ON	ON	ON	ON	ON	–	–

RNG_OUT0 to RNG_OUT3 (when the BCD_LOW signal is ON)

RNG_OUT3	RNG_OUT2	RNG_OUT1	RNG_OUT0	Range
OFF	OFF	OFF	ON	10 mΩ
OFF	OFF	ON	OFF	100 mΩ
OFF	OFF	ON	ON	1000 mΩ
OFF	ON	OFF	OFF	10 Ω
OFF	ON	OFF	ON	100 Ω
OFF	ON	ON	OFF	1000 Ω
OFF	ON	ON	ON	10 kΩ
ON	OFF	OFF	OFF	100 kΩ
ON	OFF	OFF	ON	1000 kΩ
ON	OFF	ON	OFF	10 MΩ
ON	OFF	ON	ON	100 MΩ
ON	ON	OFF	OFF	1000 MΩ

BCDm-0 to BCDm-3

BCDm-3	BCDm-2	BCDm-1	BCDm-0	Measured value
OFF	OFF	OFF	OFF	0
OFF	OFF	OFF	ON	1
OFF	OFF	ON	OFF	2
OFF	OFF	ON	ON	3
OFF	ON	OFF	OFF	4
OFF	ON	OFF	ON	5
OFF	ON	ON	OFF	6
OFF	ON	ON	ON	7
ON	OFF	OFF	OFF	8
ON	OFF	OFF	ON	9

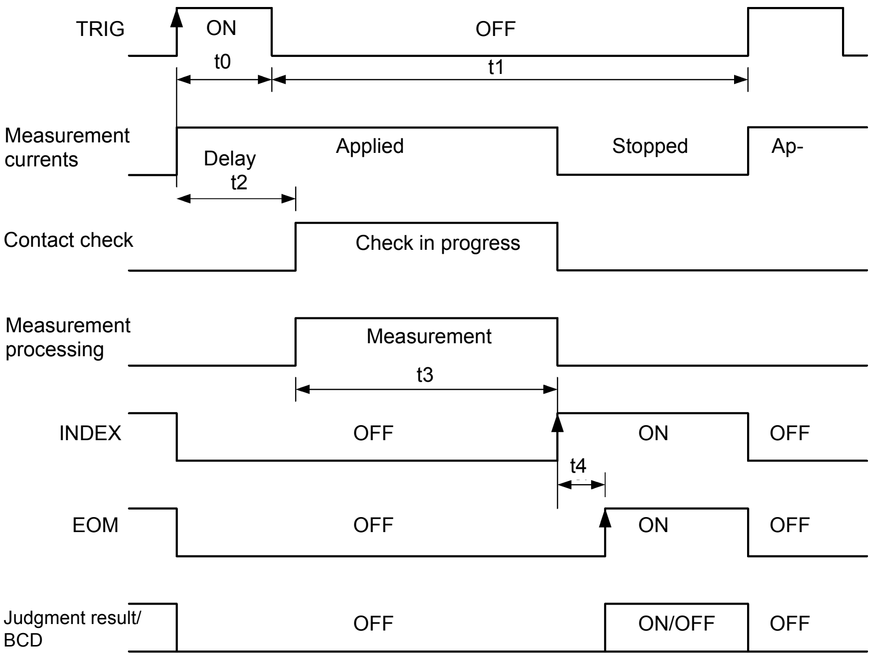
10.2 Timing Chart

Each signal level indicates the ON/OFF state of a contact. When using the current source (PNP) setting, the level is the same as the EXT I/O pin voltage level. When using the current sink (NPN) setting, the high and low voltage levels are reversed.

From Start of Measurement to Acquisition of Judgment Results

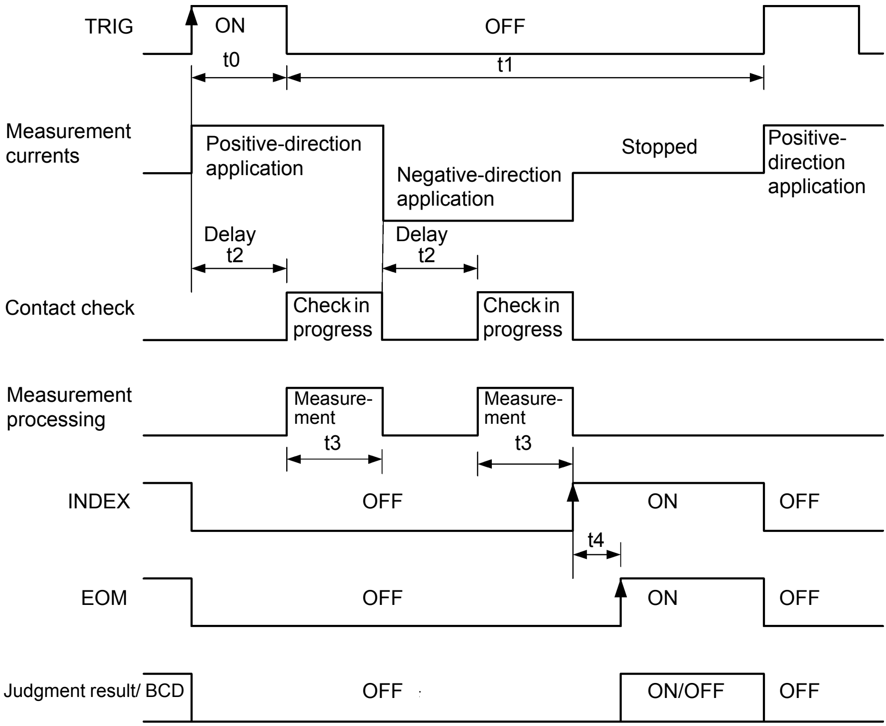
(1) External trigger [EXT] setting (EOM output hold)

When OVC is OFF



Judgment result /BCD: HI, IN, LO, ERR, BCDm-n, RNG_OUT0 to 3

When OVC is ON



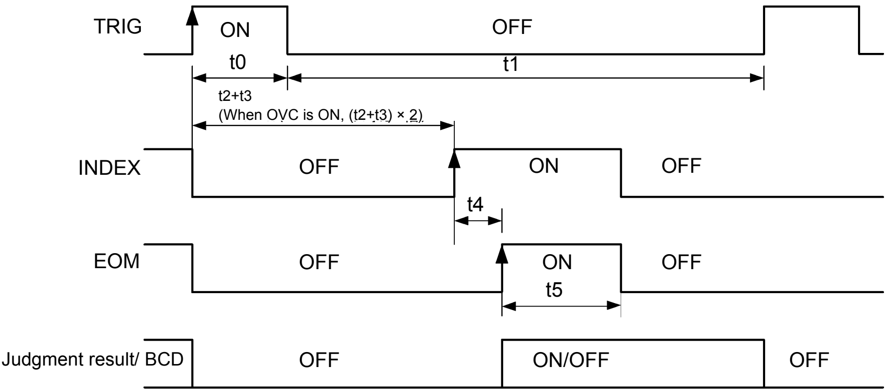
Judgment result/ BCD: HI, IN, LO, ERR, BCDm-n, RNG_OUT0 to 3

NOTE

- The measurement current will not be stopped for measurement ranges of 10 kΩ and greater (continuous application).
- Do not apply a TRIG signal while measuring (when the INDEX signal is OFF) (the signal will be retained only once). The TRIG signal is held during self-calibration.
  See: "Self-calibration timing" (p. 193)
- When changing settings such as measurement range, allow processing time (100 ms) before applying a TRIG signal.
- When not displaying the Measurement screen and while error messages are being displayed, input signals are disabled. However, the PRINT signal is valid on the Statistical Calculation Results screen.
- The judgment result and BCD output are finalized before the EOM signal changes to ON. However, if the controller's input circuit response is slow, it may be necessary to insert wait processing after the EOM signal's changing to ON is detected until the judgment results are acquired.

(2) External trigger [EXT] setting (EOM output pulse)

The EOM signal turns ON at the end of measurement and then reverts to the OFF state once the time (t5) that has been set as the EOM pulse width elapses.

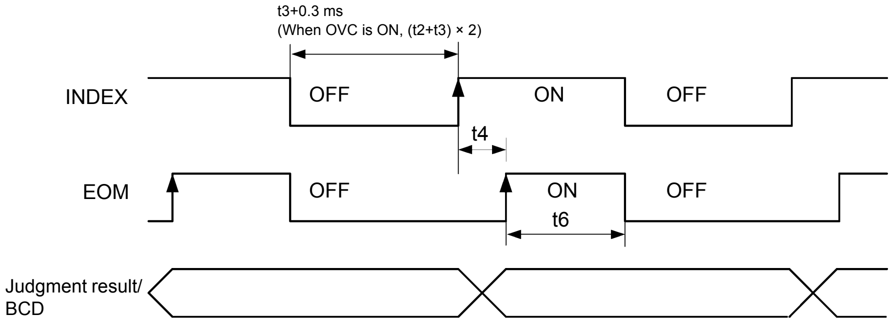


Judgment result/ BCD: HI, IN, LO, ERR, BCDm-n, RNG_OUT0 to 3

See: "Setting EOM Signal" (p. 215)

When the TRIG signal is input while the EOM signal is ON, the EOM signal will turn OFF once measurement processing is started in response to the TRIG signal.

(3) Internal trigger [INT] setting



Judgment result/ BCD: HI, IN, LO, ERR, BCDm-n, RNG_OUT0 to 3

When using the internal trigger [INT] setting, the EOM signal consists of pulse output with a width of 5 ms. However, EOM will be held at ON while ERR is ON. The judgment result and ERR signals do not turn OFF at the start of measurement.

NOTE
Setting self-calibration to MANUAL results in the fastest measurement. The t6 interval will be 0 ms, and the EOM signal will remain off.

Timing Chart Interval Descriptions

Interval	Description	Duration	Remarks
t0	Trigger Pulse Asserted (ON)	0.1 ms or more	ON/ OFF-edge selectable
t1	Trigger Pulse De-asserted (OFF)	1 ms or more	
t2	Delay	0 to 9999 ms	Setting-dependent
t3	Acquisition processing time	Integration time + Internal wait time (see following table)	
t4	Calculation time	0.3 ms	Calculation time is longer when memory storage and statistical calculations are enabled.
t5	EOM pulse width	1 to 100 ms	Setting-dependent
t6	EOM pulse width with internal trigger	5 ms	Cannot be changed.

The measurement time (from trigger input to EOM ON) can be calculated as follows:

- When OVC is OFF
  td+(t2+t3)×na+t4
- When OVC is ON
  td+(t2+t3+t2+t3)×na+t4

td : Trigger detection time (ON edge: max. 0.1 ms; OFF edge: max. 0.3 ms)
na : Number of average iterations (however, during free-run* operation with the INT trigger source, 1 iteration)

Note that when using the SLOW2 measurement speed with low-power resistance measurement on, the instrument will performing averaging with two iterations internally even if the averaging function is set to off. If the averaging function is on, the instrument will perform averaging using the set number of iterations.

*: When not using the `INITiate:CONTinuous OFF` or `:READ?` command
(For more information about commands, see the Communications Command Instruction Manual on the included application disc.)

Measurement times may vary depending on the self-calibration timing.

See: "Self-calibration timing" (p. 193)

Integration time reference values (unit: ms)

LP	Range	FAST		MEDIUM		SLOW1	SLOW2
		50 Hz	60 Hz	50 Hz	60 Hz		
OFF	1 MΩ or less	0.3*		20.0	16.7	100	200
	10 MΩ or more	20.0	16.7	20.0	16.7	100	200
ON	All ranges	20.0	16.7	40.0	33.3	200	300

* When using the MUX mesurement terminals, the integration time is 1.0 ms only in the 10 mΩ range.

Internal wait time (unit: ms) (Processing time before and after integration measurement) reference values

- When the trigger source is set to INT and OVC is OFF

Time
0.4

- Other

LP OFF

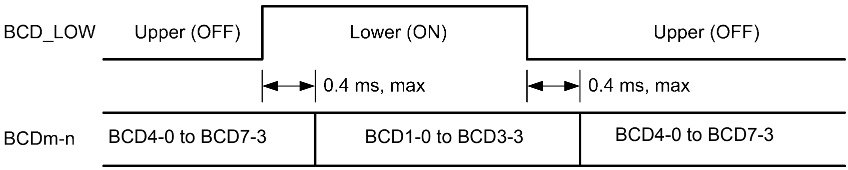
Range	100 MΩ range high-precision mode	Measurement Current	Time
10 mΩ	–	–	40
100 mΩ	–	High	40
	–	Low	1.8
1000 mΩ	–	High	1.5
	–	Low	1.3
10 Ω	–	High	1.5
	–	Low	1.3
100 Ω	–	High	2.1
	–	Low	1.3
1000 Ω	–	–	2.3
10 kΩ	–	–	12
100 kΩ	–	–	20
1000 kΩ	–	–	150
10 MΩ	–	–	570
100 MΩ	ON	–	1300
	OFF	–	300
1000 MΩ	OFF	–	400

LP ON

Range	Time
1000 mΩ	15
10 Ω	35
100 Ω	35
1000 Ω	36

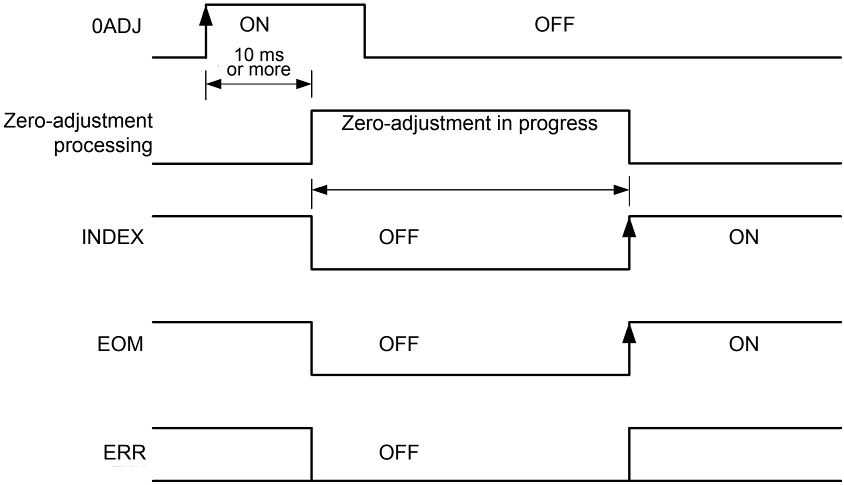
BCD Signal Timing

BCDm-n signal transition time based on the BCD_LOW signal



If the response of the input circuit in the controller is slow, inserting more than 0.4 ms of wait processing may be required after the BCD_LOW signal is controlled.

Zero-adjustment timing



- For pulse EOM output, the EOM signal turns OFF when the pulse width time elapses.
- When using the internal trigger [INT] setting, the EOM signal consists of pulse output with a width of 5 ms. The ERR signals do not turn OFF at the start of measurement. They are updated at the completion of the next measurement.
- When not using the multiplexer, the zero-adjustment time is approximately 600 ms when using a manually set range and approximately 4 s when using auto-ranging. When performing scanning zero-adjustment while using the multiplexer, the zero-adjustment time will elapse for each channel.

Self-calibration timing

For more information about the self-calibration function, see p.92.

To maintain measurement precision, the instrument self-calibrates to compensate for internal circuit offset voltage and gain drift.
You can select between two self-calibration function execution methods.

Execute automatically. (default)

Configure automatically.

A self-configuration that lasts about 5 ms is performed between measurements.

Execute at user-selected timing.

Configure manually.

Self-calibration is performed at the user's desired timing using the EXT I/O CAL signal input or a communications command (`:SYSTem:CALibration`). Using this setting prevents self-calibration from being performed automatically at unexpected times.

Self-Calibration Timing and Interval

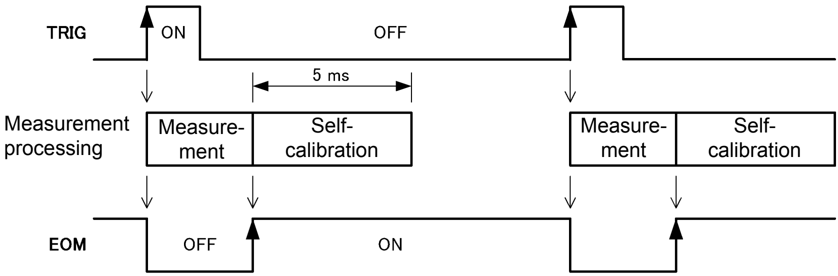
Setting	Calibration timing	Measurement hold interval (calibration interval)
Auto *	After measurement	5 ms
Manual	During execution	400 ms

*When using the auto setting
When using the auto setting, self-calibration is performed for 5 ms once every second during TRIG standby operation. In the event the TRIG signal is received during a 5 ms self-calibration, the self-calibration is canceled, and measurement will start after 0.5 ms. If you are concerned about variation in measurement times, please use the manual setting.

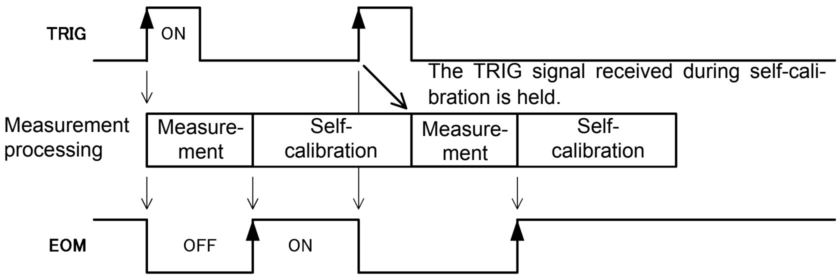
Auto setting operation

Self-calibration starts immediately after measurement completes and is finished in 5 ms. One TRIG signal received during self-calibration is held, and measurement will start after the self-calibration completes.

If there is at least 5 ms of extra time in the measurement interval



If the TRIG signal is received during self-calibration



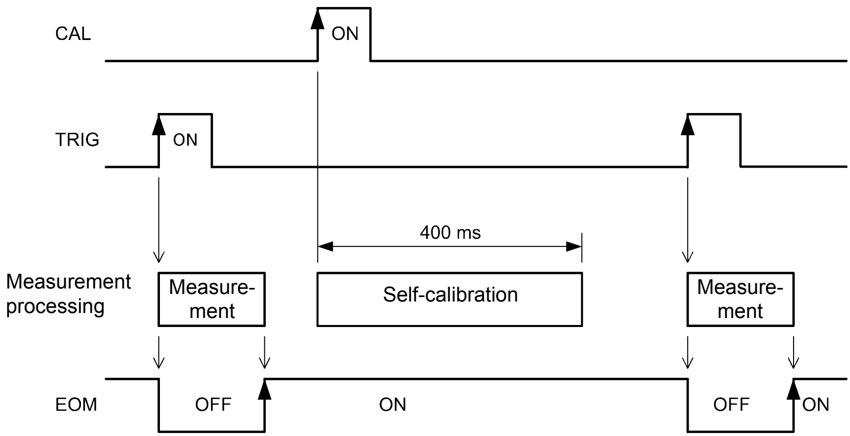
NOTE

- During auto-scan operation, self-calibration starts only after scanning completes. Self-calibration will not be performed after each channel is measured.
- A 400 ms self-calibration is performed immediately after switching from MANUAL to AUTO. Do not input the TRIG signal during that interval.

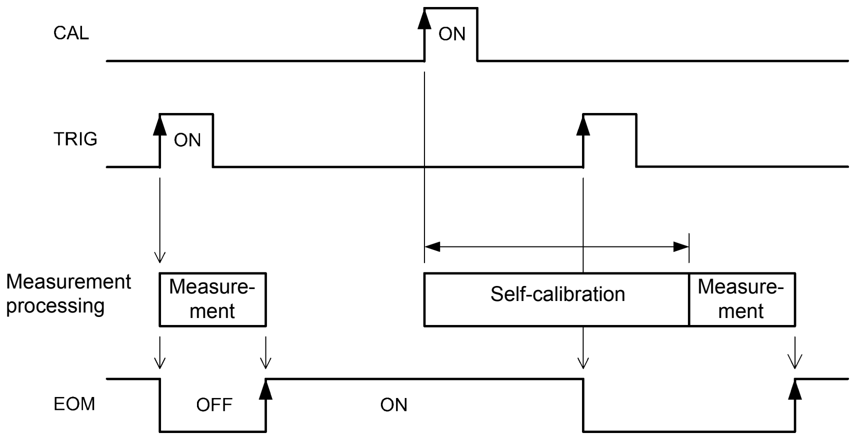
Manual setting operation

Self-calibration starts immediately when the CAL signal is input. If the TRIG signal is input during self-calibration, self-calibration will continue. In this case, the TRIG signal will be accepted, the EOM signal will turn off, and measurement will start after self-calibration completes. If the CAL signal is received during measurement, the CAL signal will be accepted, and self-calibration will start after measurement completes.

Method of normal use



If the TRIG signal is received during self-calibration



Contact improver timing

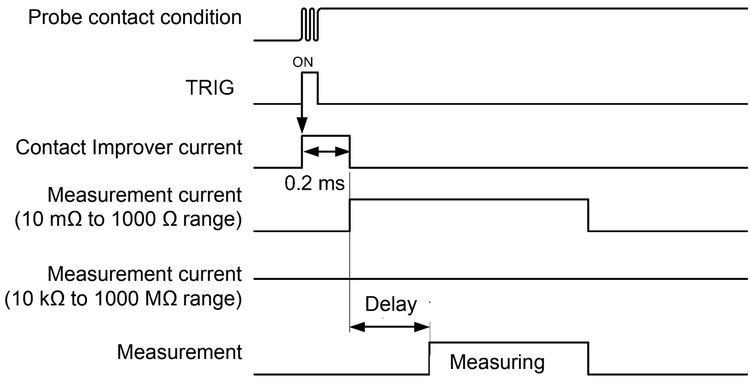
For more information about the contact improver function, see p.90.

Probe contacts can be improved by applying current between the sense terminals before measurement.

CAUTION The Contact Improver function applies voltage to the sample. Be careful when measuring samples with characteristics that may be affected.

The maximum contact improvement current is 10 mA, and the maximum applied voltage is 5 V. When low power is set to on, the contact improver function is set to off. Using the contact improver function causes the time until measurement completion to be lengthened by 2 ms.

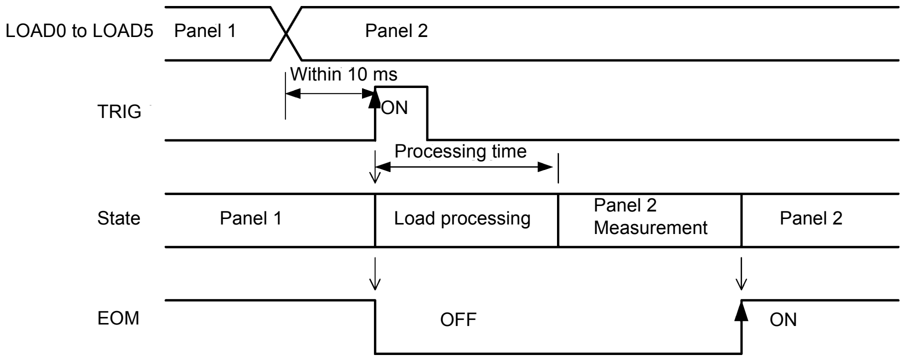
Timing Chart (Contact Improver Function)



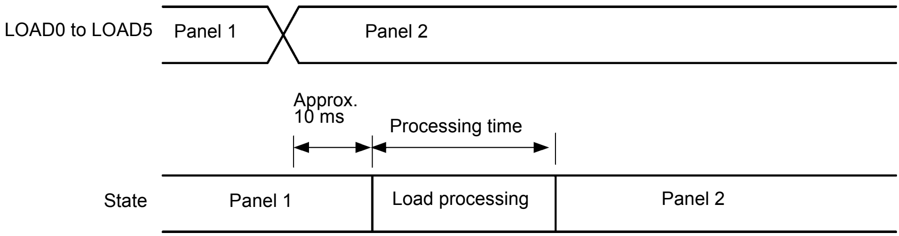
Panel Load Timing

When using the multiplexer, set the MUX signal to ON.

(1) When using the TRIG signal



(2) When not using the TRIG signal



Processing time

Panel 1 to 30	Approx. 100 ms
Panel 31 to 38	Approx. 200 ms

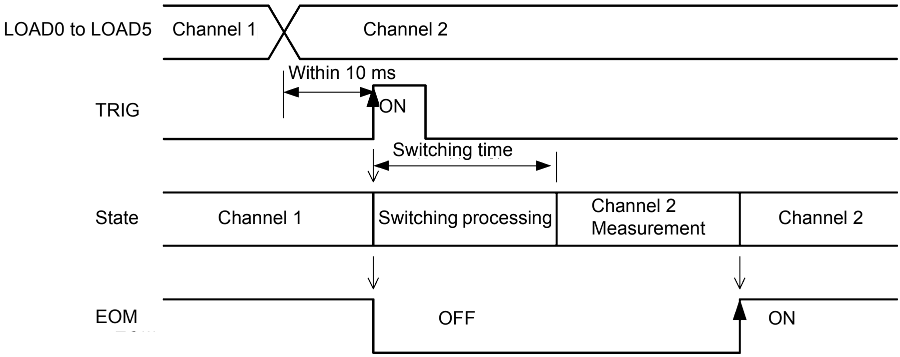
Multiplexer Timing

See: "8.3 Multiplexer Settings"(p.148)

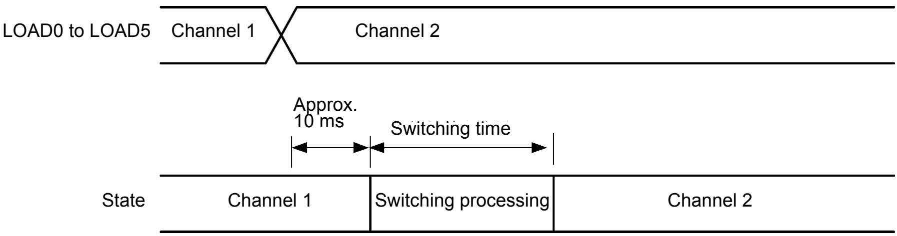
(1) Scan function: OFF

To switch channels, set the MUX signal to ON.

When using the TRIG signal



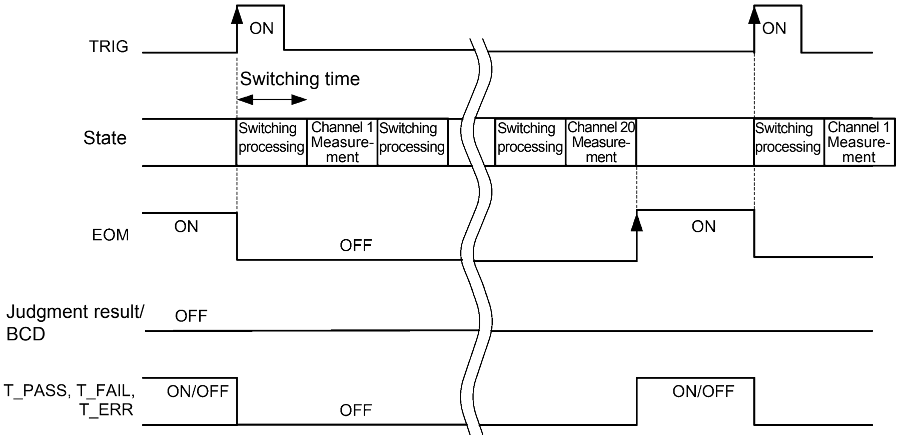
When not using the TRIG signal



NOTE
Channels can be changed when the scan function is OFF. When the scan function is set to auto or step, channels cannot be changed for external input signals.
If you attempt to switch to the multiplexer while measurement leads are connected to the measurement terminals on the front of the instrument, the ERR signal will turn on, and you will not be able to make the switch. Disconnect the measurement leads and switch the LOAD signal again.

(2) Scan function: Auto

Measurement is performed while switching all channels after one trigger input.

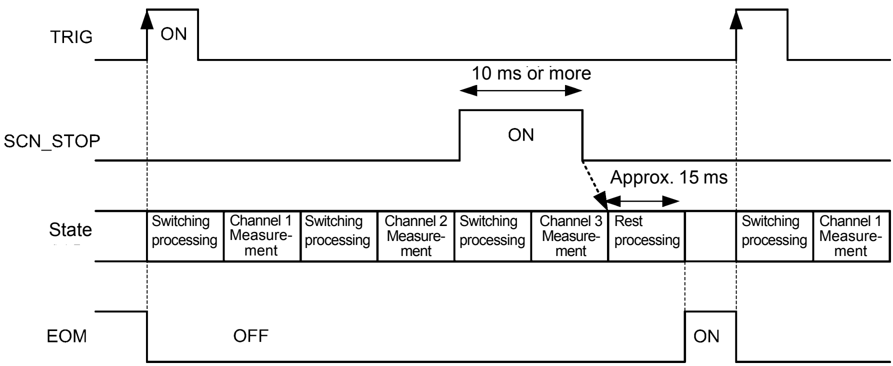


Judgment result/ BCD: HI, IN, LO, ERR, PASS, FAIL, BCDm-n, RNG_OUT0 to 3
In this example, channels 1 through 20 have been set to ON.

NOTE

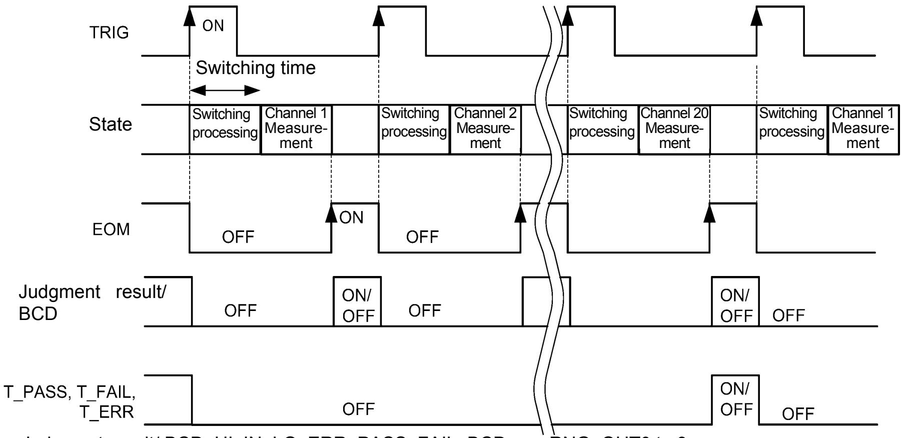
- The channel judgment result (HI, IN, LO, ERR) signals and BCD signal are not output. Only the judgment result (T_PASS, T_FAIL, T_ERR) signals are output.
- The INDEX signal does not turn on for each channel. It turns on after the completion of scanning.
- During scanning, the TRIG, CAL, and 0ADJ signals are ignored without being held.

SCN_STOP operation



(3) Scan function: Step

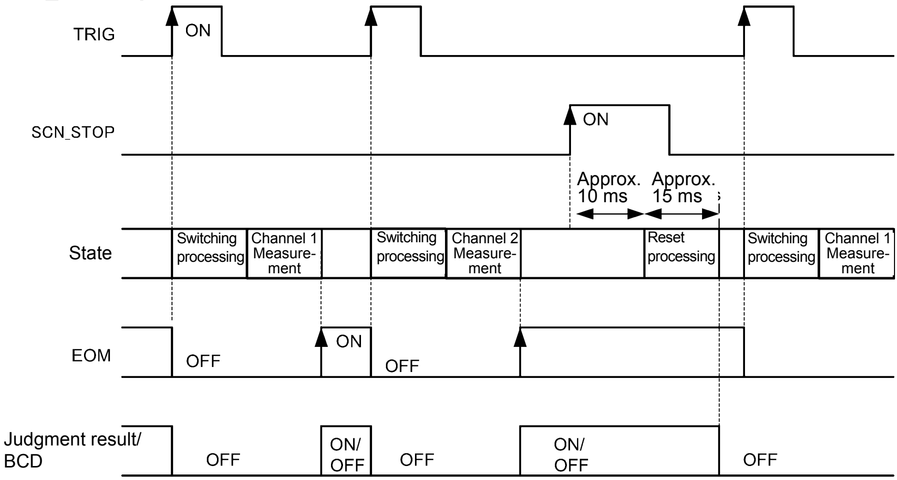
After the trigger, processing switches to the next channel and measurement is performed. The total judgment (T_PASS, T_FAIL, T_ERR) signals are only output once measurement of the last channel is complete.



Judgment result/ BCD: HI, IN, LO, ERR, PASS, FAIL, BCDm-n, RNG_OUT0 to 3
In this example, channels 1 through 20 have been set to ON.

NOTE
- Once the TRIG signal turns on after measurement of all channels is complete, measurement will start again with the first channel.
- During scanning, the TRIG, CAL, and 0ADJ signals are ignored without being held.
- For channels for which an externally connected device is selected, EOM will turn on after switching processing completes.

SCN_STOP operation



Channel switching time

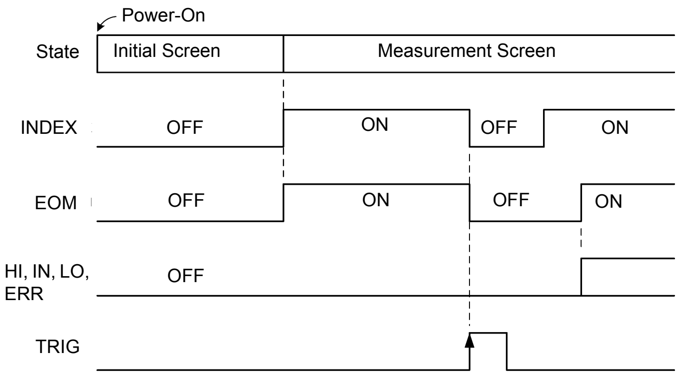
Without range or low-power switching	Approx. 30 ms
With range or low-power switching	Approx. 50 ms

NOTE

When there is back EMF, for example due to a transformer, the relay hot-switching prevention function will increase the duration of switching processing. The hot-switching prevention function will be canceled after the back EMF has dissipated or after a maximum of (1 s + the set delay time) has elapsed. Refer to "From Start of Measurement to Acquisition of Judgment Results" (p. 187) for measurement time.

Output Signal State at Power-On

When transitioning from the Startup screen to the Measurement screen after turning on the instrument's power, the EOM and INDEX signals will turn ON.
When using pulse EOM output, the signals will remain OFF.



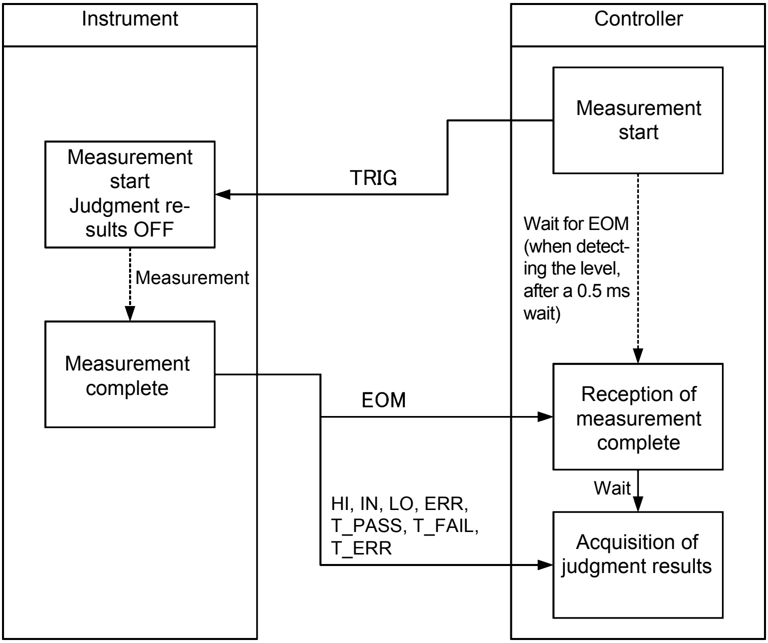
The chart depicts operation when the trigger source is set to EXT while using hold EOM output.

10

Acquisition Process When Using an External Trigger

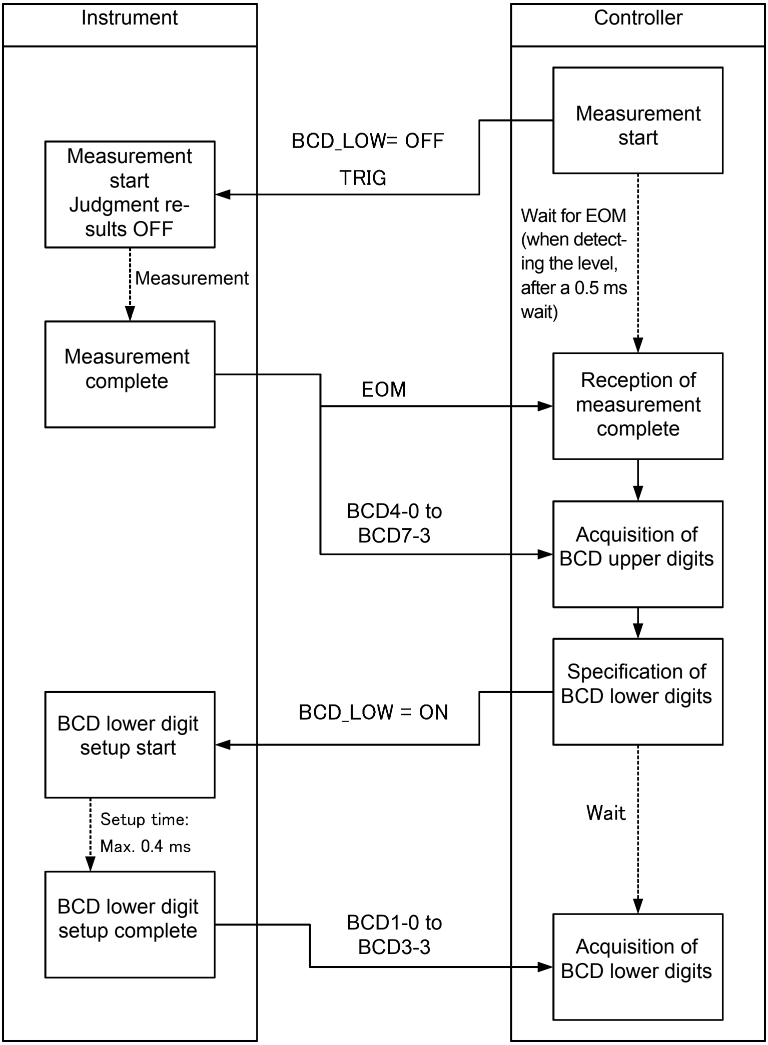
This section describes the process from measurement start to acquisition of judgment results or measured values when using an external trigger.

The instrument outputs the EOM signal immediately once the judgment result (HI, IN, LO, ERR, T_PASS, T_FAIL, T_ERR) has been finalized. If the response of the input circuit in the controller is slow, inserting wait processing may be required after the EOM signal switching to ON is detected until a judgment result is acquired.



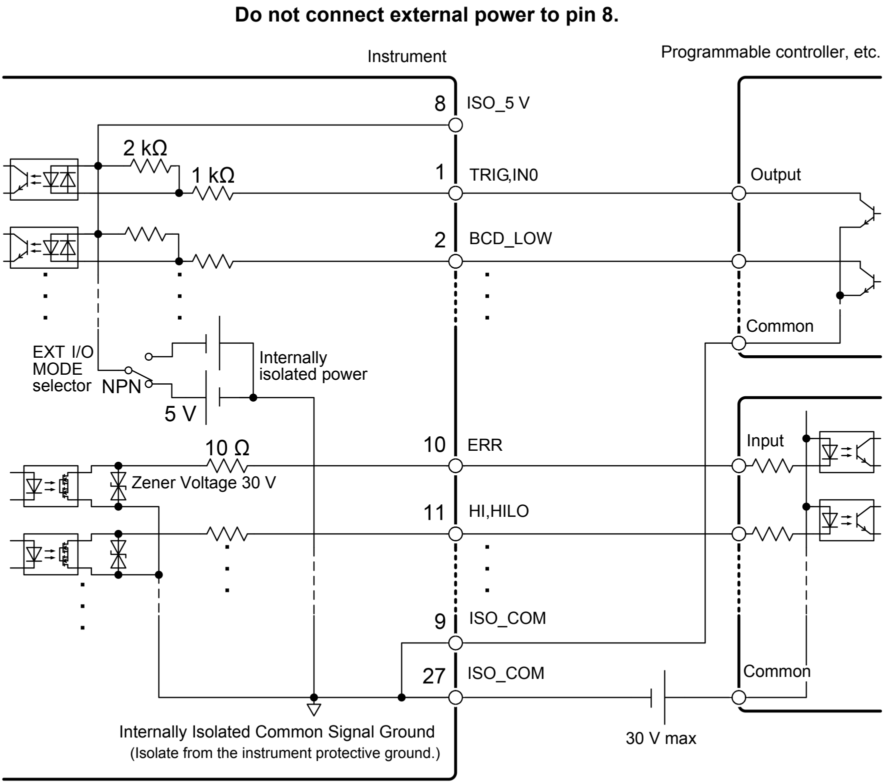
Measured value (BCD) acquisition processing when using an external trigger

For BCD output, the upper and lower digits must be acquired separately. The upper and lower digits can be acquired in any order. In the following example, the upper digits are acquired first. If the response of the input circuit in the controller is slow, inserting wait processing after the EOM signal switching to ON is detected until a measurement value (in the BCD format) is acquired. In addition, inserting more than 0.4 ms of wait processing after the BCD_LOW signal is controlled.



10.3 Internal Circuitry

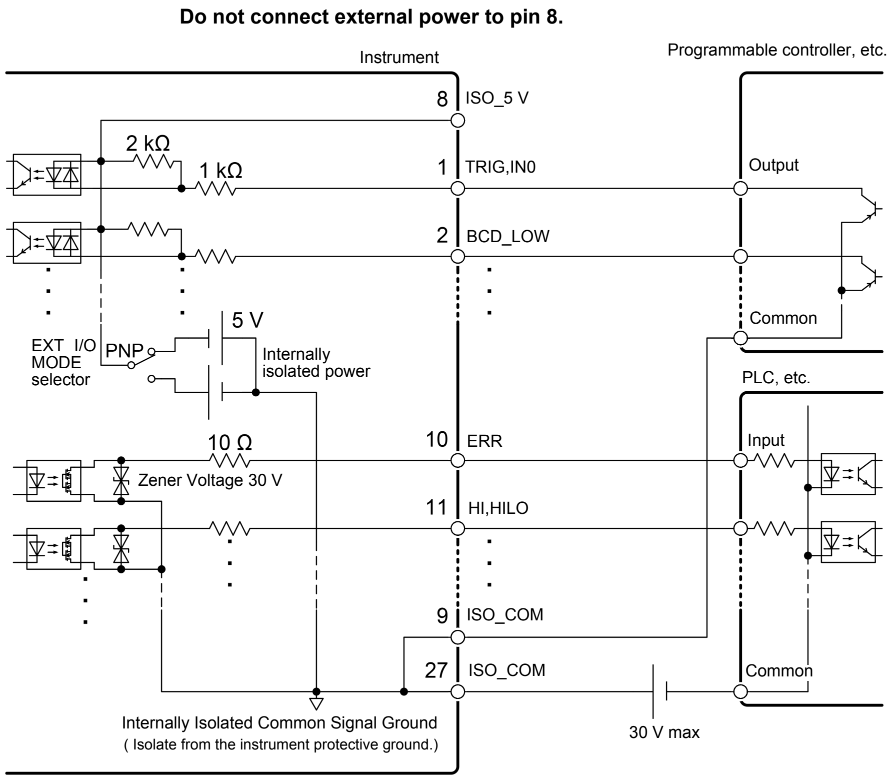
NPN Setting



NOTE

- Use ISO_COM as the common pin for both input and output signals.
- If a high current will flow to common wiring, branch the output signal common wiring and input signal common wiring from a point lying close to the ISO_COM pin.

PNP Setting



NOTE

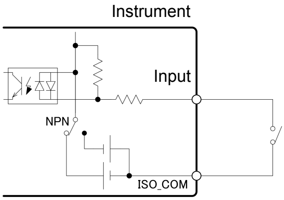
Use ISO_COM as the common pin for both input and output signals.

Electrical Specifications

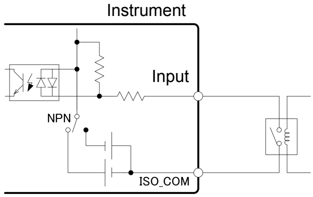
Input Signals	Input type	Optocoupler-isolated, non-voltage contact inputs (Current sink/source output compatible)
	Input asserted (ON)	Residual voltage: 1 V or less (Input ON current: 4 mA (reference value))
	Input de-asserted (OFF)	Open (shutoff current: 100 µA or less)
Output Signals	Output type	Optocoupler-isolated, open drain output (non-polar)
	Maximum load voltage	30 V_{MAX} DC
	Maximum output current	50 mA/ch
	Residual voltage	1 V or less (load current: 50 mA) / 0.5 V or less (load current: 10 mA)
Internally Isolated Power Output	Output Voltage	Sink output: 5.0 V±10% Source output: -5.0 V±10%
	Maximum output current	100 mA
	External power input	none
	Isolation	Floating relative to protective ground potential and measurement circuit
	Insulation rating	Terminal-to-ground voltage of 50 V DC, 30 Vrms AC, 42.4 Vpk AC or less

Connection Examples

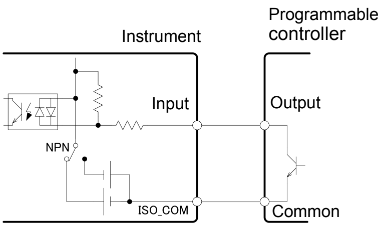
Input Circuit Connection Examples



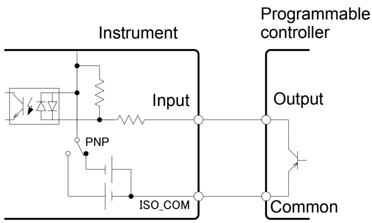
Connection to switch



Connection to relay

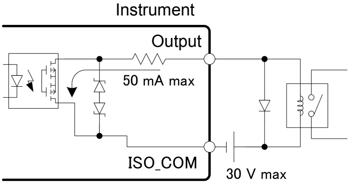


Connection to programmable controller
(negative common output)

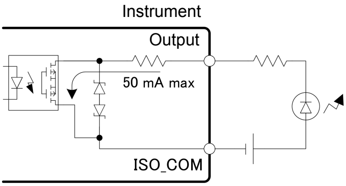


Connection to programmable controller
(positive common output)

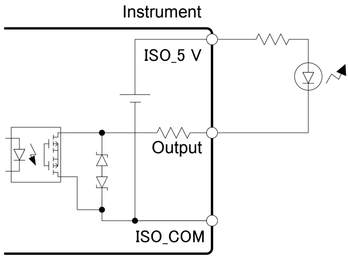
Output Circuit Connection Examples



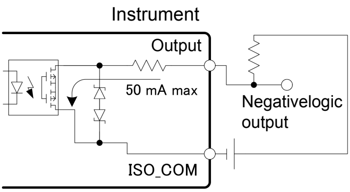
Connection to relay



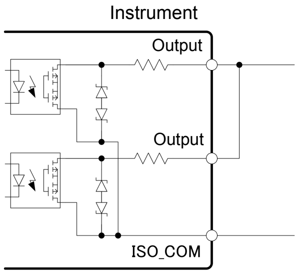
Connection to LED



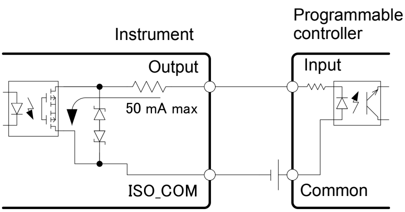
Connection to LED
(using ISO_5 V)



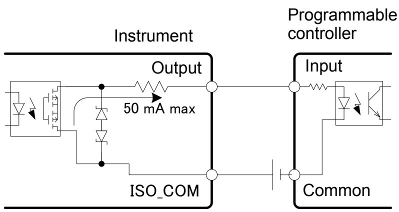
Negative-logic output



Wired or



Connection to programmable controller
(plus common input)



Connection to programmable controller
(negative common input)

10.4 External I/O Settings

The following external I/O settings are provided:

Input settings

- Set the measurement start conditions (trigger source).(p.209)
- Set the TRIG signal logic.(p.211)
- Eliminate TRIG/PRINT signal chatter (filter function).(p.213)

Output settings

- Set the EOM signal.(p.215)
- Switch output modes (judgment mode/BCD mode).(p.217)

Setting Measurement Start Conditions (Trigger Source)

Measurements can be started in two ways.

To measure automatically → **Measure with internal (INT) triggering**

Trigger signals are automatically generated internally for continuous measurement.

To measure at specific times

To hold measured values as desired → **Measure with external (EXT) triggering**

Measurements are triggered by an external signal.
Manual measurement triggering is also available.

- Apply a trigger signal at the EXT I/O connector (p. 177)
- Send the *TRG command by communications interface
- Press ENTER (only when EXT is selected)

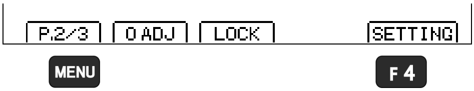
NOTE

- When internal triggering is enabled, the EXT I/O TRIG signal and the *TRG command are ignored (except for memory storage and statistical calculations).
- To measure samples such as inductors that require time to settle, adjust delay time. Start with a long delay, and gradually shorten it while watching for the measured value to settle.
  See: "4.9 Setting Pre-Measurement Delay" (p. 84)

10

Switching the trigger source

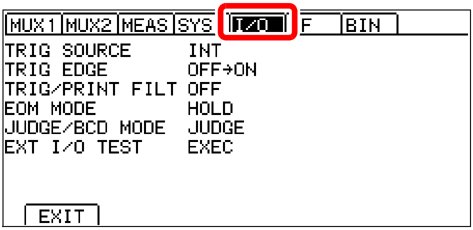
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

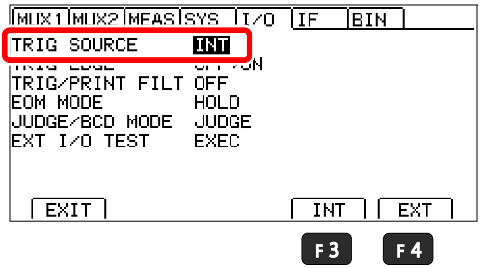
2 F4 The Settings screen appears.

2 Open the EXT I/O Setting Screen.



Move the cursor to the [I/O] tab with the left and right cursor keys.

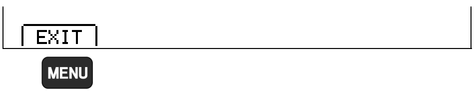
3 Select the trigger source.



1 Selection

2
F3 (INT) Internal trigger (default)
F4 (EXT) External trigger

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

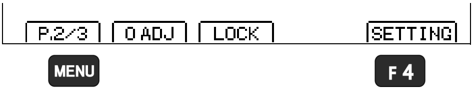
Continuous measurement (**:INITIATE:CONTINUOUS ON**) is the normal trigger state when using key operation from the front panel. Selecting the internal (INT) trigger source activates continuous triggering ("free-run"). When external (EXT) triggering is selected, each external trigger event initiates one measurement. Continuous measurement can be disabled by sending the **:INITIATE:CONTINUOUS OFF** command via RS-232C, USB or GP-IB. When continuous measurement is disabled, trigger acceptance is controlled only by the controller (computer or PLC).

See: For trigger command: See the included application disc.

Setting the TRIG Signal Logic

Select the ON or OFF edge as the logic at which the TRIG signal is enabled. When using the OFF edge, measurement times will be increased by approximately 0.2 ms.

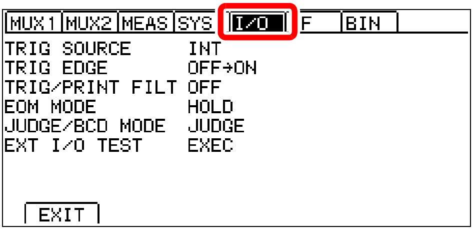
1 Open the Settings Screen.



1 [MENU] Switch the function menu to P.2/3.

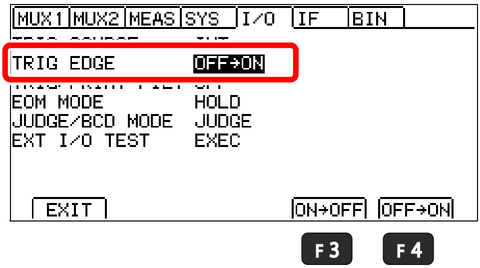
2 [F4] The Settings screen appears.

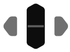
2 Open the EXT I/O Setting Screen.



Move the cursor to the [I/O] tab with the left and right cursor keys.

3 Select the trigger conditions.



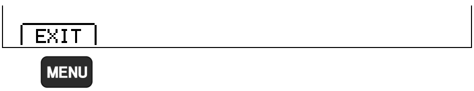
1  Selection

2

[F3] [ON → OFF]
Start measurement at the OFF edge.

[F4] [OFF → ON]
ON edge (default)

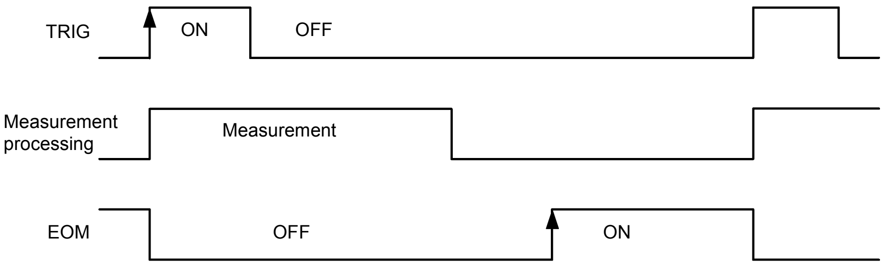
4 Return to the Measurement screen.



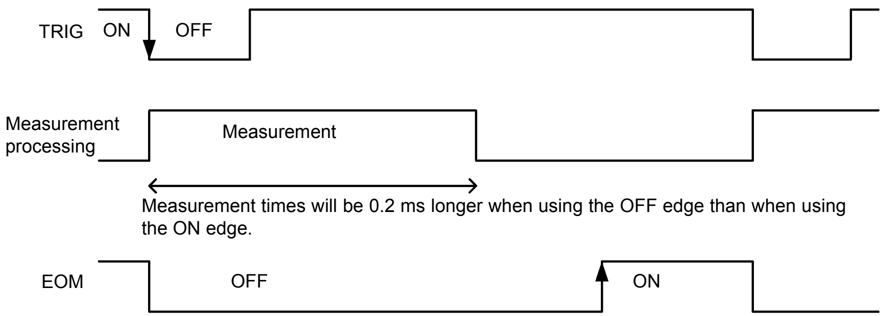
[MENU] Return to the Measurement screen.

ON edge and OFF edge operation

- ON edge



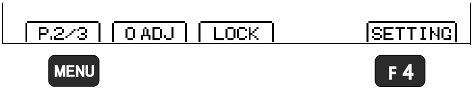
- OFF edge



Eliminating TRIG/PRINT Signal Chatter (Filter Function)

The filter function, which eliminates chatter, is useful when connecting a foot switch or similar device to the TRIG/PRINT signal.

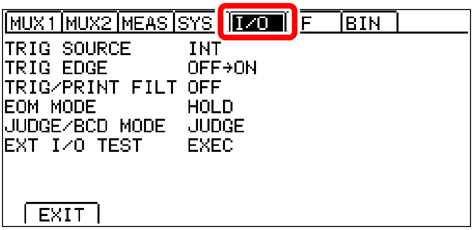
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

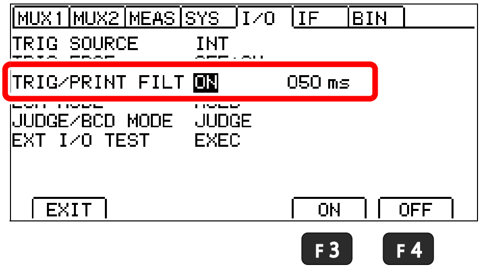
2 F 4 The Settings screen appears.

2 **Open the EXT I/O Setting Screen.**



Move the cursor to the [I/O] tab with the left and right cursor keys.

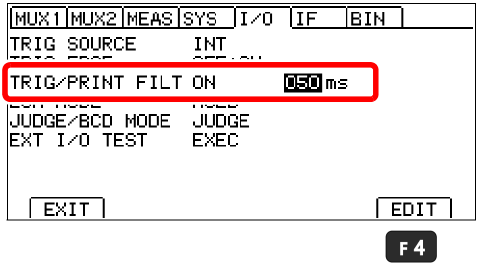
3 **Select the filter function.**



1 Selection

2
F 3 ON
F 4 OFF (default)

4 Set the response time.



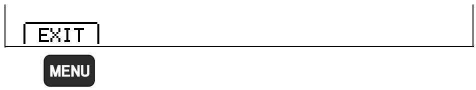
Setting range: 50 ms to 500 ms (default: 50 ms)

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

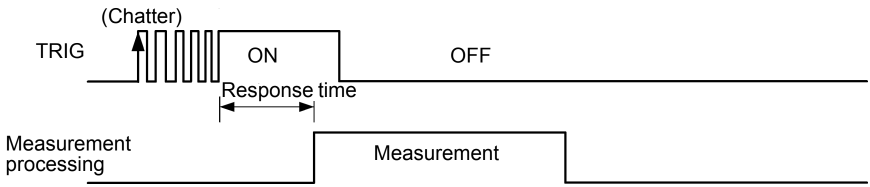
5 Return to the Measurement screen.



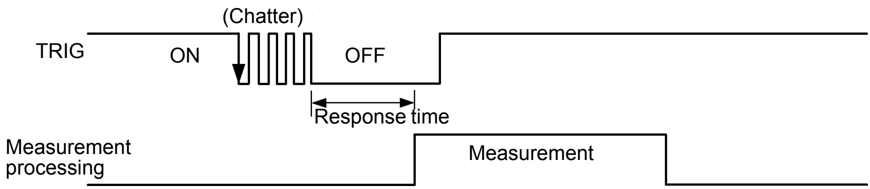
MENU Return to the Measurement screen.

Filter function (TRIG signal example)

- Using the ON edge



- Using the OFF edge



Hold the input signal until the response time elapses.

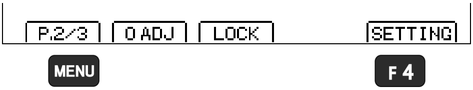
Setting EOM Signal

You can select whether to hold EOM signal output until the next trigger is input or output a user-specified pulse width.

NOTE

When using the internal trigger [INT], the EOM pulse width is fixed at 5 ms, regardless of the settings.

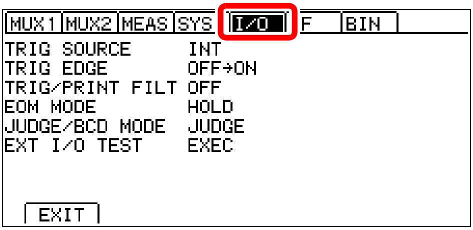
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

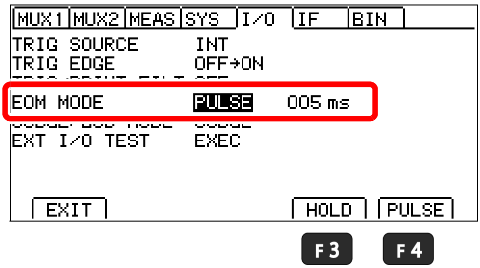
2 F4 The Settings screen appears.

2 Open the EXT I/O Setting Screen.



Move the cursor to the [I/O] tab with the left and right cursor keys.

3 Select the EOM signal output type.



1 Selection

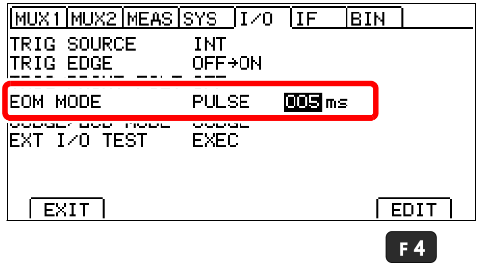
2

F3 The EOM signal remains asserted after end-of-measurement (default) (to step 5).

F4 The specified pulse is output after end-of-measurement.

10

4 **(When PULSE is selected)**
Select the pulse width.



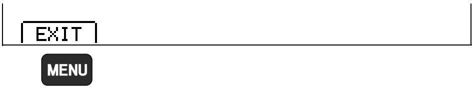
Setting range: 1 ms to 100 ms (default: 5 ms)

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

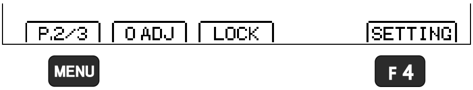
5 **Return to the Measurement screen.**



MENU Return to the Measurement screen.

Switching Output Modes (JUDGE Mode/ BCD Mode)

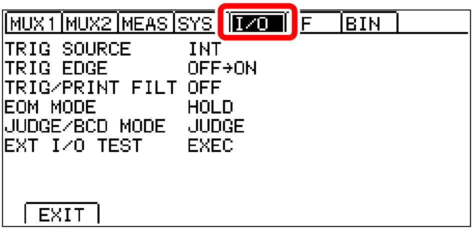
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

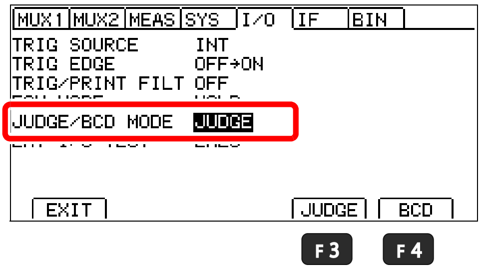
2 F 4 The Settings screen appears.

2 Open the EXT I/O Setting Screen.



Move the cursor to the [I/O] tab with the left and right cursor keys.

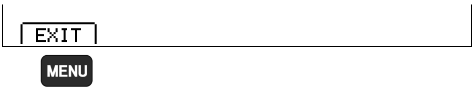
3 Select the output mode.



1 Selection

2
F 3 JUDGE mode (default)
F 4 BCD mode

4 Return to the Measurement screen.



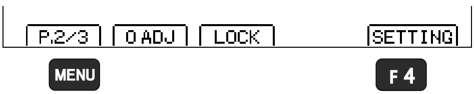
MENU Return to the Measurement screen.

10.5 Checking External Control

Performing an I/O Test (EXT I/O Test Function)

In addition to switching output signals ON and OFF manually, you can view the input signal state on the screen.

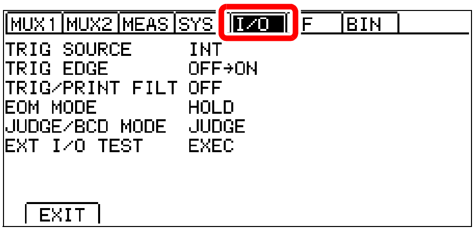
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

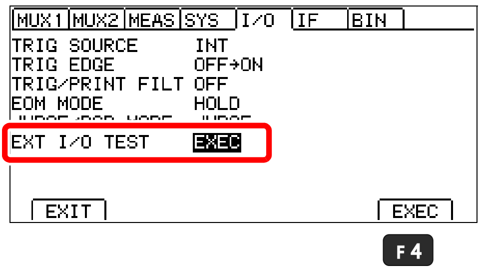
2 F4 The Settings screen appears.

2 Open the EXT I/O Setting Screen.



Move the cursor to the [I/O] tab with the left and right cursor keys.

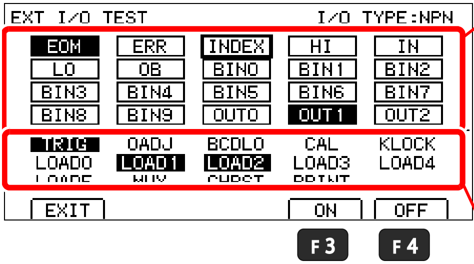
3 Open the EXT I/O Test Screen.



1 Selection

2 F4 Open the Test screen.

4 Perform the EXT I/O test.



Output signals
Allows you to perform signal operations. (ON: Reverse video; OFF: Normal display)

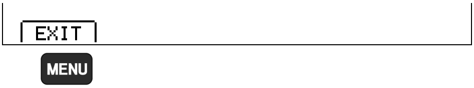
◀ ▶ : Select signal.

F3 : Turn signal ON.

F4 : Turn signal OFF.

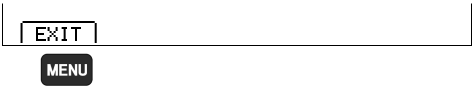
Input signals
Displays the signal state. (ON: Reverse video; OFF: Normal display)

5 Return to the EXT/IO setting screen.



MENU Return to the EXT/IO setting screen.

6 Return to the Measurement screen.



MENU Return to the Measurement screen.

10.6 Supplied Connector Assembly

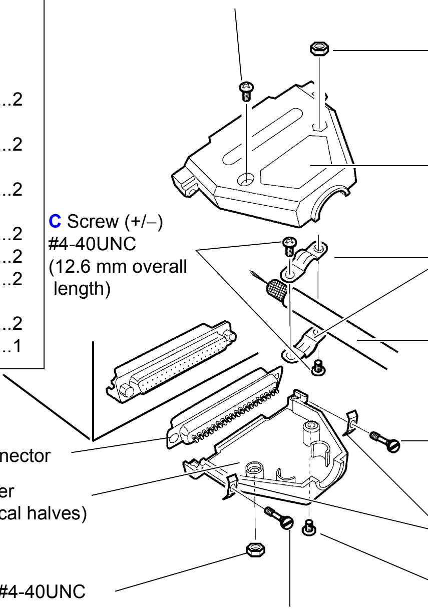
The EXT I/O connector and shell are supplied with the instrument. Assemble as shown below.

NOTE

- Use shielded cables to connect a PLC to the EXT I/O connector. Using non-shielded conductors may result in system errors from electrical noise.
- Connect the shield to the ISO_COM pin of the EXT I/O connector.

Required tools:
- Screwdriver
- Shielded cable
- Soldering iron

Accessories
- **A** Cover 2
- **B** Screws (+/-) #4-40UNC (16.9 mm overall length)...2
- **C** Screws (+/-) #4-40UNC (12.6 mm overall length)...2
- **D** Screws (–) #4-40UNC (15.0 mm overall length)...2
- **E** Nuts #4-40UNC.................2
- **F** Cable Clamps....................2
- **G** Saddle Washers (shell protection)...............2
- **H** Connector 1



Assembly Sequence

1. Solder the (shielded) cable wires to the supplied EXT I/O connector (H) pins.
2. Affix the cable clamps (F) on the cable with screws (C).
3. Position the cable clamps (F) to fit properly inside the cover (A).
4. Insert screws (D) through the saddle washers (G).
5. In one half of cover (A), place connector (H), clamps (F), saddle washers (G) and screws (D).
6. Place the other half of cover (A) on top.
7. Affix the halves of the cover (A) together with screws (B) and nuts (E).

Be careful not to overtighten the screws, which could damage the covers.

Communications (USB/ RS-232C/ GP-IB Interface) Chapter 11

Before connecting data cables, read "Operating Precautions" (p.12) carefully.

11.1 Overview and Features

The instrument’s communications interfaces can be used to control the instrument and acquire data. See the section that’s relevant to your goal.

To control the instrument with commands To create a control program	To acquire measured values without using commands (USB or RS-232C only)*1	To control the instrument in a simple manner without creating a program (using dedicated software*2)
↓	↓	↓
"Using the USB Interface" (p.223) "Using the RS-232C Interface" (p.226) "Using the GP-IB Interface (RM3545-01 only)" (p.230)		
↓	↓	↓
"11.3 Controlling the Instrument with Commands and Acquiring Data" (p.232)	"11.4 Auto-Exporting Measured Values (at End of Measurement) (Data Output Function)" (p.236)	Use the sample application.*2

*1 USB or RS-232C only.
*2 The sample application can be downloaded from the Hioki website (http://www.hioki.com).

Communications times

- There may be a display processing lag depending on the frequency and nature of any communications processing performed.
- Time spent transferring data must be added when communicating with a controller. GP-IB and USB transfer times vary with the controller. RS-232C transfer times can be approximated with the following formula, where the transfer speed (baud rate) is N bps using 1 stop bit, 8 data bits, no parity, and 1 stop bit, for a total of 10 bits:
  Transfer time T [1 character/sec] = Baud rate N [bps] / 10 [bits]
  Since measured values are 11 characters in length, the transfer time for 1 piece of data is 11/T.
  Example: For a 9,600 bps connection, 11 (9,600 / 10) = Approximately 11 ms
- For more information about command execution times, see the Communications Command Instruction Manual on the included application disc.

Specifications

NOTE
You must select one communications interface for use. Communications control using different interfaces cannot be performed simultaneously.

USB Specifications	
Connector	Series B receptacle
Electrical specification	USB2.0 (Full Speed)
Class	CDC Class, HID Class
Message terminator (delimiter)	Receiving: CR+LF, CR Transmitting: CR+LF

RS-232C Specifications	
Transfer method	Communications: Full duplex Synchronization: Start-stop synchronization
Baud rate	9,600 bps/ 19,200 bps/ 38,400 bps/ 115,200 bps
Data length	8bits
Parity	none
Stop bit	1bit
Message terminator (delimiter)	Receiving: CR+LF, CR Transmitting: CR+LF
Flow control	none
Electrical specification	Input voltage levels 5 to 15 V: ON, -15 to -5 V: OFF Output voltage levels 5 to 9 V: ON, -9 to -5 V: OFF
Connector	Interface Connector Pinout (Male 9-pin D-sub, with #4-40 attachment screws) The I/O connector is a DTE (Data Terminal Equipment) configuration Recommended cables: 9637 RS-232C Cable(for PC) 9638 RS-232C Cable(for D-sub25pin connector)

Operating Code: ASCII codes

GP-IB Specifications (Interface Functions) (RM3545-01 only)		
SH1	All Source Handshake functions	●
AH1	All Acceptor Handshake functions	●
T6	Basic talker functions	●
	Serial poll function	●
	Talk-only mode	–
	The talker cancel function with MLA (My Listen Address)	●
L4	Basic listener functions	●
	Listen-only mode	–
	The listener cancel function with MTA (My Talk Address)	●
SR1	All Service Request functions	●
RL1	All Remote/Local functions	●
PP0	Parallel Poll function	–
DC1	All Device Clear functions	●
DT1	All Device Trigger functions	●
C0	Controller functions	–

Operating Code: ASCII codes

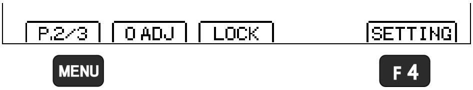
11.2 Preparations before Use (Connections and Settings)

Using the USB Interface

1. Configuring USB Interface Communications

Make these instrument settings.

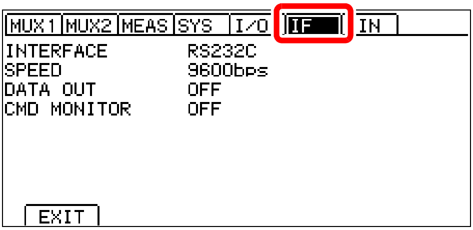
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

2 F 4 The Settings screen appears.

2 **Open the Communications Interface Setting Screen.**



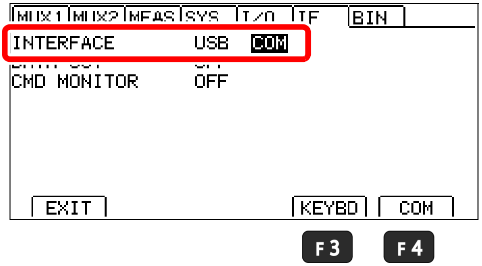
Move the cursor to the [IF] tab with the left and right cursor keys.

3 **Select the interface type.**

1 Selection

2 F 3 USB Interface

4 Select the USB connection mode.



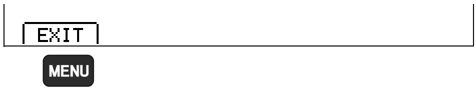
1 Move the cursor to the setting you wish to configure.

2

F3 USB keyboard mode

F4 COM mode (default)

5 Return to the Measurement screen.



MENU Return to the Measurement screen, and enable the communications interface.

NOTE

- USB keyboard mode is provided for data output use only. When using commands, set the connection to COM mode.
- There is no need to install the USB driver in USB keyboard mode.
- Install the USB driver when using COM mode for the first time. (p.224)

2. Install the USB driver. (When COM mode is selected)

When connecting the instrument to the computer for the first time using the COM Class method, you will need a dedicated USB driver. The following procedure need not be followed if the driver has already been installed, for example in the course of using another Hioki product. The USB driver can be found on the included application disc or downloaded from the Hioki website (http://www.hioki.com).
There is no need to install the driver when using the USB keyboard Class method.

Installation procedure

Install the driver before connecting the instrument and computer with a USB cable. If the instrument has already been connected, disconnect the USB cable in order to perform the installation.

1. **Log in to a user account on the computer with administrator privileges (for example, "administrator").**

2. **Before starting the installation, exit all applications running on the computer.**

3. **Launch HiokiUsbCdcDriver.msi. After doing so, follow the instructions on the screen to complete the installation.**

   To run the installer from the included application disc, execute the following file:

   X:\driver\HiokiUsbCdcDriver.msi (**X**: CD-ROM drive)

   In some operating environments, it may take some time for the dialog box to be displayed.

4. **After installing the software, the instrument will be recognized automatically when it is connected to the computer with the USB cable.**

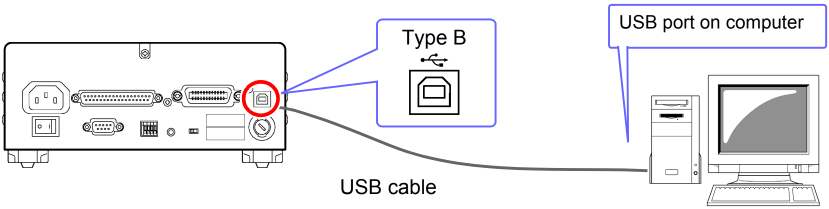
- If the "**Found New Hardware Wizard**" screen is displayed, select "**No, not this time**" when asked whether to connect to Windows Update and then choose "**Install the software automatically**."
- If an instrument with a different serial no. is connected, the computer may recognize it as a new device. Follow the instructions on the screen to install the device driver.
- A warning message will be displayed. Choose "**Continue Anyway**."

Procedure to uninstall the driver (uninstall the driver once it is no longer needed)

Delete the Hioki USB CDC Driver using [Control Panel] - [Add or Remove Programs].

3. Connect the USB cable.

Connect the included USB cable to the instrument's USB jack.

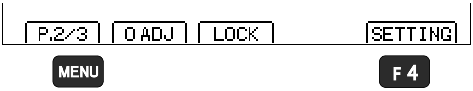


Using the RS-232C Interface

1. Configuring RS-232C Interface Communications

Make these instrument settings.

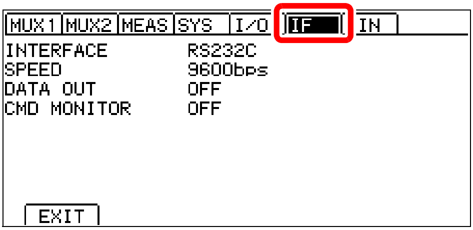
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

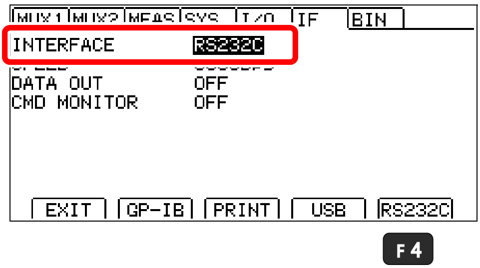
2 F4 The Settings screen appears.

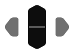
2 **Open the Communications Interface Setting Screen.**



Move the cursor to the [IF] tab with the left and right cursor keys.

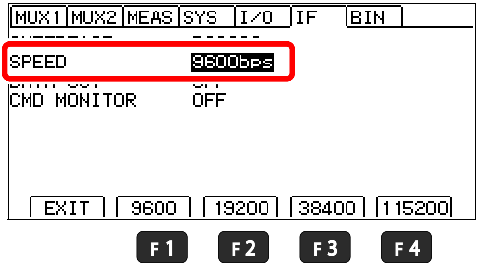
3 **Select the interface type.**



1  Selection

2 F4 RS-232C Interface

4 **Select the interface transfer rate (baud rate).**

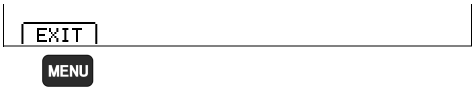


1 Selection

2

- F1 9600 (bps) (default)
- F2 19200 (bps)
- F3 38400 (bps)
- F4 115200 (bps)

5 **Return to the Measurement screen.**



MENU Return to the Measurement screen, and enable the communications interface.

NOTE

Some transmission speed (baud rate) settings may not be usable with some computers due to a large error component. In this case, switch to a slower setting.

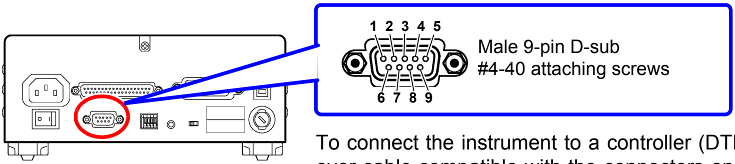
Configure the controller (PC or PLC).

Be sure to make set up the controller as shown below.

- Asynchronous communication
- Transfer rate: 9600bps/ 19200bps/ 38400bps/ 115200bps
  (set to match the instrument setting)
- Stop bit: 1
- Data length: 8
- Parity check: None
- Flow control: None

2. Connect the RS-232C cable.

Connect the RS-232C cable to the RS-232C connector. When connecting the cable, be sure to tighten the connector in place with screws.



Rear Panel

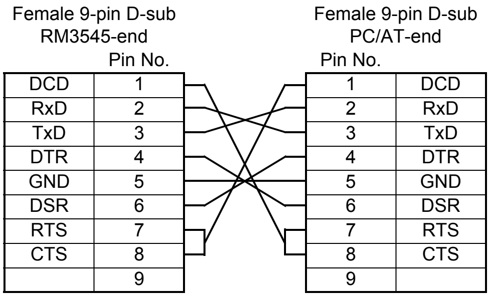
To connect the instrument to a controller (DTE), use a cross-over cable compatible with the connectors on both the instrument and the controller.
The I/O connector is a DTE (Data Terminal Equipment) configuration. This instrument uses only pins 2, 3, and 5. The other pins are unconnected.

Pin No	Signal Name	Code Addr.		Mutual connection circuit name	Remarks
		EIA	JIS		
1	DCD	CF	CD	Carrier Detect	Not used
2	RxD	BB	RD	Receive Data	
3	TxD	BA	SD	Transmit Data	
4	DTR	CD	ER	Data Terminal Ready	Active (ON) level is +5 to +9 V (constant)
5	GND	AB	SG	Signal Ground	
6	DSR	CC	DR	Data Set Ready	Not used
7	RTS	CA	RS	Request to Send	Active (ON) level is +5 to +9 V (constant)
8	CTS	CB	CS	Clear to Send	Not used
9	RI	CE	CI	Ring Indicator	Not used

Connecting a controller with a 9-pin D-sub male port

Use a crossover cable with female 9-pin D-sub connectors.

Crossover Wiring

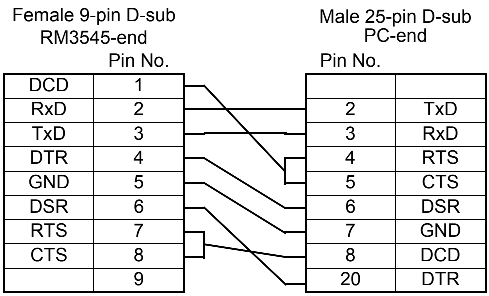


Recommended cable: HIOKI Model 9637 RS-232C Cable (1.8 m)

Connecting a controller with a 25-pin D-sub female port

Use a crossover cable with a female 9-pin D-sub and a male 25-pin D-sub connector.
As the figure shows, RTS and CTS pins are shorted together and crossed to DCD in the other connector.

Crossover Wiring



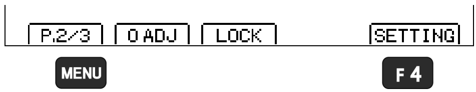
Note that the combination of a dual male 25-pin D-sub cable and a 9- to 25-pin adapter cannot be used.

Recommended cable: HIOKI Model 9638 RS-232C Cable

Using the GP-IB Interface (RM3545-01 only)

1. Configuring GP-IB Interface Communications

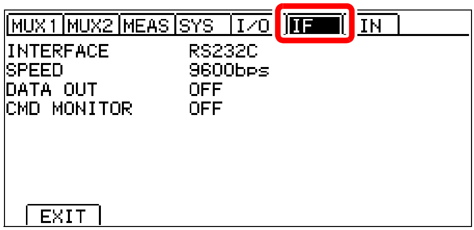
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

2 F 4 The Settings screen appears.

2 **Open the Communications Interface Setting Screen.**



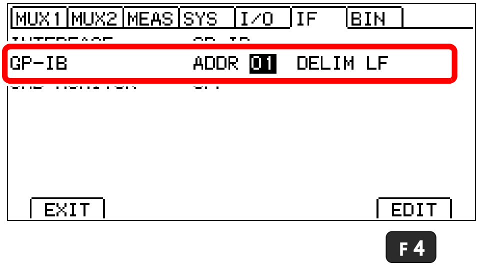
Move the cursor to the [IF] tab with the left and right cursor keys.

3 **Select the interface type.**

1 Selection

2 F 1 GP-IB Interface

4 Select the instrument's address.



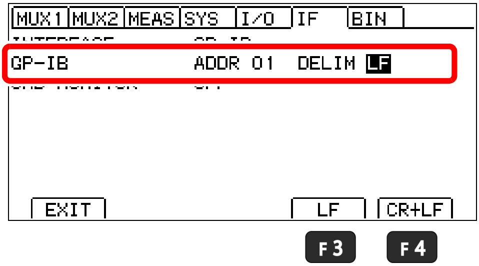
Setting range: 0 to 30 (default: 1)

1 ◀ ▶ Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 ◀ ▶ Move among digits. ▲ ▼ Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

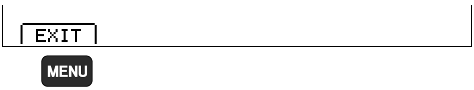
5 Select the interface message terminator.



1 ◀ ▶ Selection

2
F3 LF (default)
F4 CR+LF

6 Return to the Measurement screen.

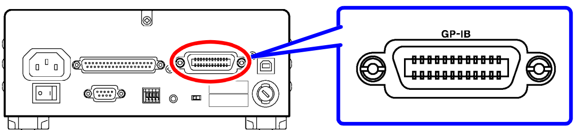


MENU Return to the Measurement screen, and enable the communications interface.

NOTE
"GP-IB" is only displayed on model RM3545-01 (equipped with GP-IB).

2. Connect the GP-IB cable.

Connect the GP-IB cable to the GP-IB connector. When connecting the cable, be sure to tighten the connector in place with screws.



Rear Panel

Recommended cable:
HIOKI Model 9151-02 GP-IB Connector Cable (2 m)

11.3 Controlling the Instrument with Commands and Acquiring Data

For more information about communications commands and query notation (from the communications message reference), see the Communications Command Instruction Manual on the included application disc. When creating programs, the communications monitor function can be used to display commands and their associated responses on the Measurement screen.
IEEE 488.2-1987 standard (essential) commands can be used with the GP-IB interface.

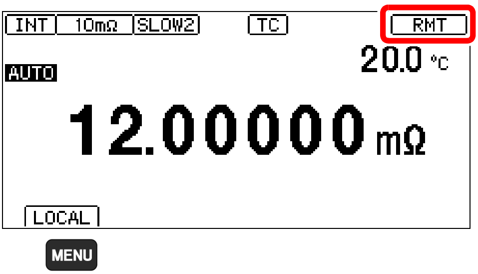
- Applicable standard: IEEE 488.1-1987[*1]
- Reference standard: IEEE 488.2-1987[*2]

NOTE
When the output queue becomes full, a query error will be issued, and the output queue will be cleared. Therefore, clearing the output queue and query error output from the deadlocked condition[*3] as defined in IEEE 488.2 is not supported.
When the interface setting is set to the printer, proper command operation is not guaranteed. Do not send commands.

*1 ANSI/IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation
*2 ANSI/IEEE Standard 488.2-1987, IEEE Standard Codes, Formats, Protocols, and Common Commands
*3 The situation in which the input buffer and the output queue become full, so that processing cannot continue.

Remote and Local States

During remote control operation, **[RMT]** appears on the Measurement screen, and all except the **MENU** key are disabled.
Pressing the MENU **[LOCAL]** disables remote control and re-enables the operating keys.

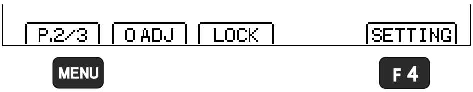


In the local lockout state (GP-IB command LLO: Local Lock Out) selecting **[LOCAL]** on the screen has no effect. In this state, send the `GTL` command, or turn the instrument off and back on to re-establish local control.
If the Setting screen was displayed when remote control was enabled, the instrument returns to the Measurement screen automatically.

Displaying Communications Commands (Communications Monitor Function)

The communications monitor function can be used to display communications commands and query responses on the instrument's screen.

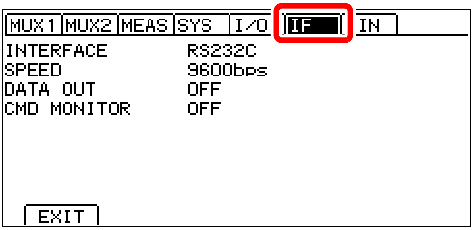
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

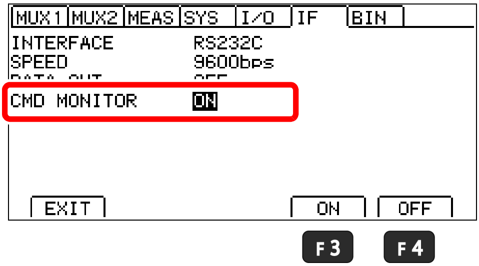
2 F 4 The Settings screen appears.

2 Open the Communications Interface Setting Screen.



Move the cursor to the [IF] tab with the left and right cursor keys.

3 Set the communications monitor to either ON or OFF.

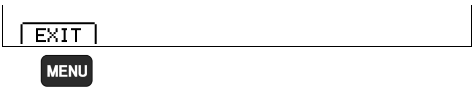


1 Selection

2 F 3 ON

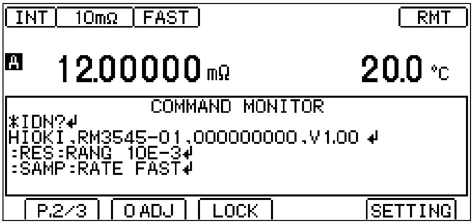
F 4 OFF (default)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

5 **Command and queries will be displayed on the bottom of the Measurement screen.**



Messages displayed in the communications monitor and their meanings

If an error occurs during command execution, the following information will be displayed:
- Command error (improper command, improper argument format, etc.)

> #CMD ERROR

- Argument out of range

> #PARAM ERROR

- Execution error

> #EXE ERROR

The approximately location of the error will also be shown.
- Argument error (-1 is out of range)

> :RES:RANG -1
> #   ^ PARAM ERROR

- Spelling error (for example, using "RENGE" instead of "RANGE")

> :RES:RENGE 100
> #   ^ CMD ERROR

NOTE
- If an illegal character code is received, the character code will be shown in hexadecimal notation enclosed in angle brackets (< >). For example, the character 0xFF would be displayed as <FF>, and 0x00 would be displayed as <00>. If all you see is hexadecimal characters like this when using the RS-232C interface, check the communications conditions or try using a lower communications speed.

- When using the RS-232C interface
  If an RS-232C error occurs, the following information will be displayed:
  Overrun error (signal lost) .... #Overrun Error
  Break signal received.................. #Break Error
  Parity error .... #Parity Error
  Framing error .... #Framing Error
  If any of these messages is displayed, check the communications conditions or try using a lower communications speed.

- The error position may shift, for example when sending a series of consecutive commands.

Acquiring Measured Values at Once (Data Memory Function)

Operation slows when measured values are acquired after each measurement. To avoid this delay, up to 50 measured values can be stored in memory and acquired at once later.

Measured values are stored in memory as follows:

- Every time a measurement is performed by external (EXT) triggering
- When a trigger is applied during internally (INT) triggered measurement

The following three storage methods are available:
- Store upon receiving an EXT I/O TRIG signal (p. 177)
- Store upon receiving a `*TRG` command
- Pressing the ENTER key.

NOTE

- This function can only be enabled by communications command. The data memory function should be enabled by communications command beforehand. This setting is not available from the front panel key operation.
- Stored memory data cannot be viewed on the instrument's screen. Use communications commands to export stored data.
- Once 50 measured values have been stored, new measured values cannot be stored until the memory is cleared.
- When the multiplexer measurement terminals are selected, the data memory function is automatically turned off.

For more information about commands, see the Communications Command Instruction Manual on the included application disc.

Stored data is automatically erased at the following times:

- when changing measurement conditions (range, low-power, measurement current, OVC, 100 MΩ range high-precision mode, TC)
- when changing memory function settings
- when the comparator is set (p. 98)
- when changing BIN measurement function settings (p.108)
- when ΔT is set (p.116)
- upon system reset (p. 134)
- when turning off the instrument

11.4 Auto-Exporting Measured Values (at End of Measurement) (Data Output Function)

Once measurement completes, the instrument can send measured values automatically as data to a computer via its UBS or RS-232C interface.
There are two methods for sending data. For more information about how to switch between the methods, see "Using the USB Interface" (p.223)

(1) COM mode

Data is output to serial communications (COM, RS-232C communication) verification software or to a receiving program created by the user.

(2) USB keyboard mode (available only with the USB interface)

Data is written to a text editor or spreadsheet application as if it were being typed on the keyboard.
When using USB keyboard mode, be sure to launch the text editor or spreadsheet application and position the cursor where you wish the data to be written before outputting the data. Improper placement of the cursor will cause the data to be overwritten at that point. Be sure to set the input mode to single-byte characters.

Output data format

Measured value format when scaling is off
(The measured value format varies depending on scaling. (p.77))
Changing the number of digits in the measured value will not change the format. Undisplayed digits have a value of 0.

- Resistance value (Absolute value display, unit: Ω)

Low-power	Measurement Range	Measured Value	±OvrRng	Measurement Fault
OFF	10 mΩ	±□□.□□□□□E-03	±10.00000E+19	+10.00000E+28
	100 mΩ	±□□□.□□□□E-03	±100.0000E+18	+100.0000E+28
	1000 mΩ	±□□□□.□□□E-03	±1000.000E+17	+1000.000E+27
	10 Ω	±□□.□□□□□E+00	±10.00000E+19	+10.00000E+29
	100 Ω	±□□□.□□□□E+00	±100.0000E+18	+100.0000E+28
	1000 Ω	±□□□□.□□□E+00	±1000.000E+17	+1000.000E+27
	10 kΩ	±□□.□□□□□E+03	±10.00000E+19	+10.00000E+29
	100 kΩ	±□□□.□□□□E+03	±100.0000E+18	+100.0000E+28
	1000 kΩ	±□□□□.□□□E+03	±1000.000E+17	+1000.000E+27
	10 MΩ	±□□.□□□□□E+06	±10.00000E+19	+10.00000E+29
	100 MΩ	±□□□.□□□□E+06	±100.0000E+18	+100.0000E+28
	1000 MΩ	±□□□□.□□□E+06	±1000.000E+17	+1000.000E+27
ON	1000 mΩ	±□□□□.□□E-03	±1000.00E+17	+1000.00E+27
	10 Ω	±□□.□□□□E+00	±10.0000E+19	+10.0000E+29
	100 Ω	±□□□.□□□E+00	±100.000E+18	+100.000E+28
	1000 Ω	±□□□□.□□E+00	±1000.00E+17	+1000.00E+27

- Resistance value (Relative value display, unit: %)

Measured Value	±OvrRng	Measurement Fault
±□□□.□□□E+00	±100.000E+18	+100.000E+28

- Temperature, temperature conversion display (unit: °C)

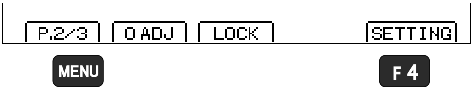
Measured Value	±OvrRng	Measurement Fault
±□□□.□E+00	±100.0E+18	+100.0E+28

For positive measured values, a space (ASCII 20H) represents the “+” sign.
When ±OvrRng is displayed, values are ±1E+20.
When a measured value fault occurs, values are +1E+30.

NOTE

- This function is not applicable to the GP-IB Interface.
- This function cannot be used when the scan function is set to auto or step while using the MUX measurement terminals.
- This function is cannot be used when the outer trigger is set to [EXT] in USB keyboard mode.
- When using the internal trigger [INT], data is automatically sent at TRIG signal input or when the ENTER key is pressed.
- Do not use commands when data output is ON. Doing so may cause measured values to be sent twice or other issues.

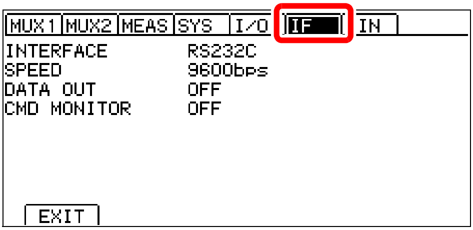
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

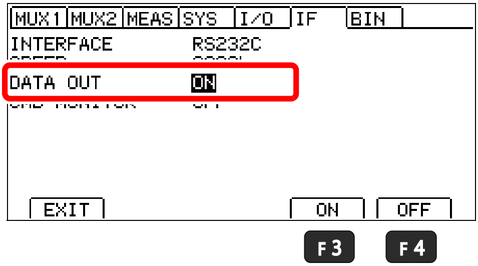
2 F4 The Settings screen appears.

2 Open the Communications Interface Setting Screen.



Move the cursor to the [IF] tab with the left and right cursor keys.

3 Enable or disable auto-exporting (DATA OUT)



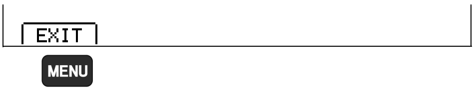
1  Selection

2

F3 Enable auto-exporting

F4 Disable auto-exporting (default)

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

Preparing connected equipment (PC or PLC)

- When outputting data with the COM port
  Place the equipment in the receive standby state. If connecting the instrument to a computer, launch the application software and place it in the receive standby state.
- When outputting data with a virtual keyboard
  Launch the application and position the cursor where you wish to enter the text.

Printing (Using an RS-232C Printer) Chapter 12

Connecting the printer to the instrument → Make instrument settings (p.241) → Make printer settings → Printing (p.242)
- Measured values and comparator judgments
- List of measurement conditions and settings
- Statistical calculation results

12.1 Connecting the Printer to the Instrument

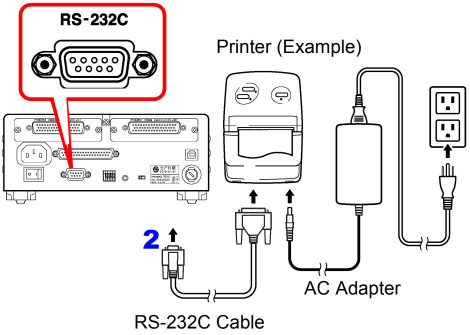
Before connecting a printer, read "Operating Precautions" (p.12) carefully.

Printer

The requirements for a printer to be connected to the instrument are as follows.
Confirm compatibility and make the appropriate settings on the printer before connecting it to the instrument.
See: "Instrument Settings" (p. 241)

- Interface.................................... RS-232C
- Characters per line .... At least 48
- Communication speed .... 9600 bps (default)/ 19,200bps/ 38,400bps/ 115,200bps
- Data bits.................................... 8
- Parity... none
- Stop bits 1
- Flow control .... none
- Control codes............................. Capable of directly printing plain text
- Message terminator (delimiter) .. CR+LF

Connection Methods

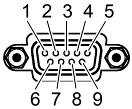


1 **Confirm that the instrument and printer are turned off.**

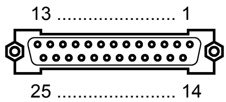
2 **Connect the RS-232C Cable to the RS-232C connectors on the instrument and printer.**

3 **Turn the instrument and printer on.**

Connector Pinouts



RM3545 (9-pin) Connector



Printer (25-pin) Connector (Example)

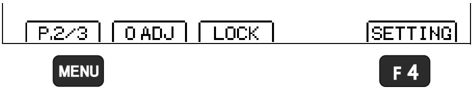
Circuit name	Signal Name	Pin
Receive Data	RxD	2
Transmit Data	TxD	3
Signal or Common Ground	GND	5

Pin	Signal Name	Circuit name
2	TxD	Transmit Data
3	RxD	Receive Data
7	GND	Signal or Common Ground
4	RTS	Request to Send
5	CTS	Clear to Send

Be sure to check the connector pin assignments for the printer being used.

Instrument Settings

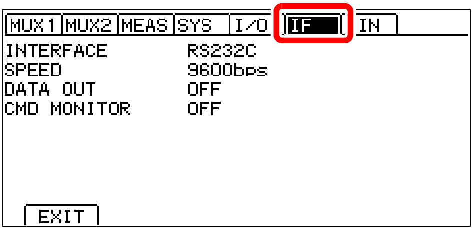
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

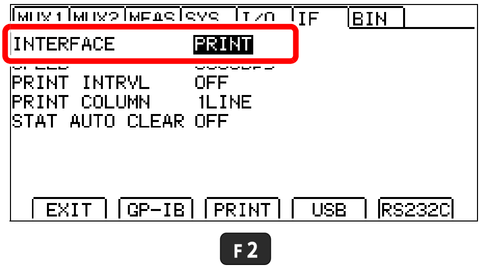
2 F 4 The Settings screen appears.

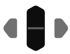
2 Open the Communications Interface Setting Screen.



Move the cursor to the [IF] tab with the left and right cursor keys.

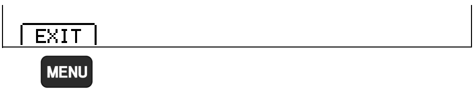
3 Select PRINT as the interface type.



1  Selection

2 F 2 To use the printer

4 Return to the Measurement screen.



MENU Return to the Measurement screen.

12.2 Printing

Before Printing

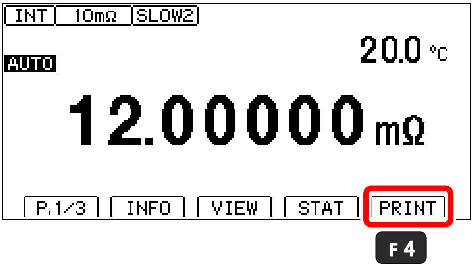
Verify that the instrument settings (p.241) are correct.

Printing Measured Values and Comparator Judgments

Printing by key operation

Pressing F4 **[PRINT]** on Measurement screen P.1/3 causes the current measured value to be printed. When the temperature is not being displayed, only the resistance value will be printed. When the temperature is being displayed, both the resistance value and the temperature will be printed.

See: "Switching the Display" (p.52)



Printing by external control

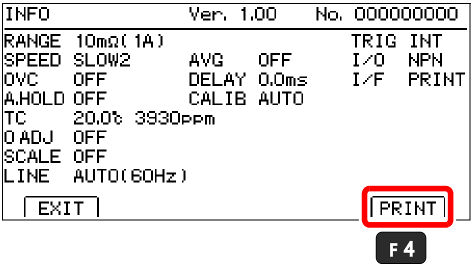
When the instrument's EXT I/O connector's PRINT signal is turned ON (by shorting it with the EXT I/O connector's ISO_COM pin), you can print measured values and judgment results.

- To print continuously for each measurement, connect the EOM signal to the PRINT signal and set the instrument to use the internal trigger.
- To print after the completion of trigger-based measurement using an external trigger, connect the external I/O EOM signal to the PRINT signal.
- When using the internal trigger setting with the statistical calculation function ON, statistical calculation will be performed with the latest updated measured value when the PRINT signal is turned ON.

Printing List of Measurement Conditions and Settings

Pressing F4 after pressing F1 **[INFO]** on Measurement screen P.1/3 to display a list of settings prints a list of measurement conditions and settings.

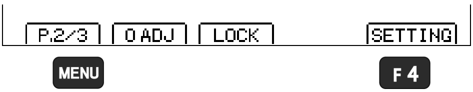
See: "Displaying a list of measurement conditions and settings" (p.54)



Changing the number of columns printed per row

Normally a row consists of one column, but you can also print three columns per row. When printing three columns per row, the temperature and interval time are not printed.

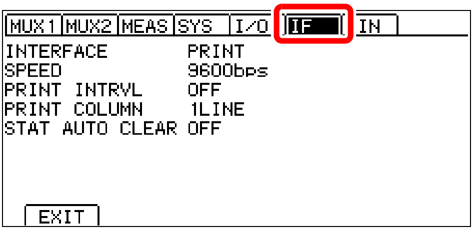
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

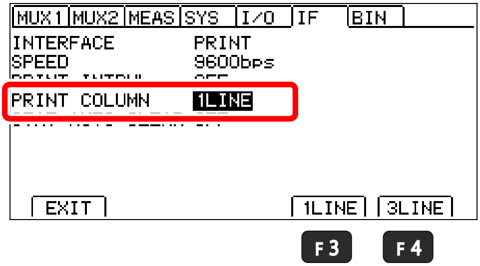
2 F4 The Settings screen appears.

2 **Open the Communications Interface Setting Screen.**



Move the cursor to the [IF] tab with the left and right cursor keys.

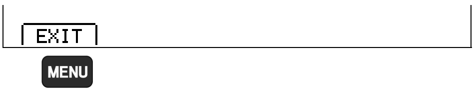
3 Select the number of print columns.



1 Selection

2 F3 1 column (default)
F4 3 columns

4 Return to the Measurement screen.

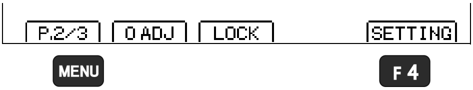


MENU Return to the Measurement screen.

Interval printing

You can automatically print measured values at a fixed time interval.

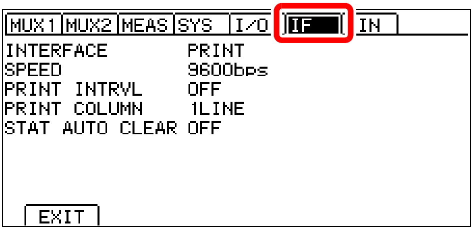
1 Open the Settings Screen.



1 MENU Switch the function menu to P.2/3.

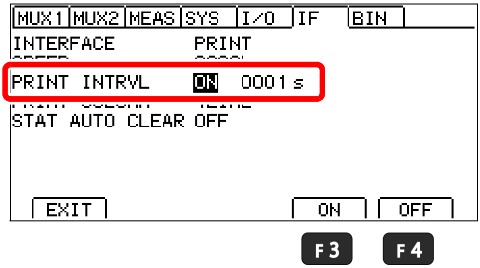
2 F4 The Settings screen appears.

2 Open the Communications Interface Setting Screen.



Move the cursor to the [IF] tab with the left and right cursor keys.

3 Turn ON the interval function.

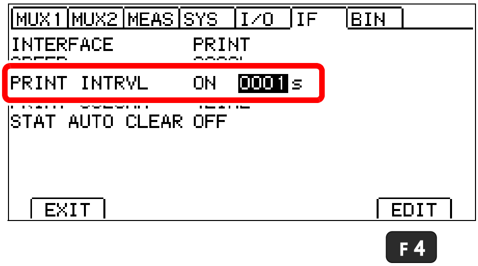


1 Selection

2 F3 ON

F4 OFF (default)

4 **Set the interval.**



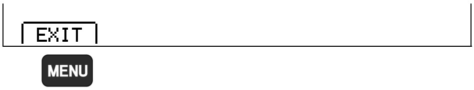
Setting range: 0 to 3600 seconds
(Using a setting of 0 sec. disables automatic printing.)

1 Move the cursor to the setting you wish to configure. Make the value editable with the F4 key.

2 Move among digits. Change values.
Move the cursor to the digit you wish to set with the left and right cursor keys. Change the value with the up and down cursor keys.

3 ENTER Accept
(ESC Cancel)

5 **Return to the Measurement screen.**



MENU Return to the Measurement screen.

Interval printing operation

1 **Interval printing starts with F4 [PRINT] key or EXT I/O PRINT signal input.**

2 **Every time the set interval elapses, the elapsed time (in hours:minutes:seconds format)*1 and measured value are printed.**

Note that when the ENTER or EXT I/O TRIG signal is input, the elapsed time and measured value at that point in time are displayed.

3 **Interval printing stops when F4 [PRINT] key or PRINT signal input is received again.**

*1 When the elapsed time reaches 100 hours, it is reset to 00:00:00 and starts counting from 0 again.

Example: 99 hours 59 minutes 50 seconds elapsed: 99:59:50
100 hours 2 minutes 30 seconds elapsed: 00:02:30

NOTE
- Since measurement conditions and measured values will be mixed together when measurement conditions are printed during interval printing, avoid printing settings while interval printing is in progress.
- Interval printing cannot be used when the multiplexer's scan function is set to auto or step.

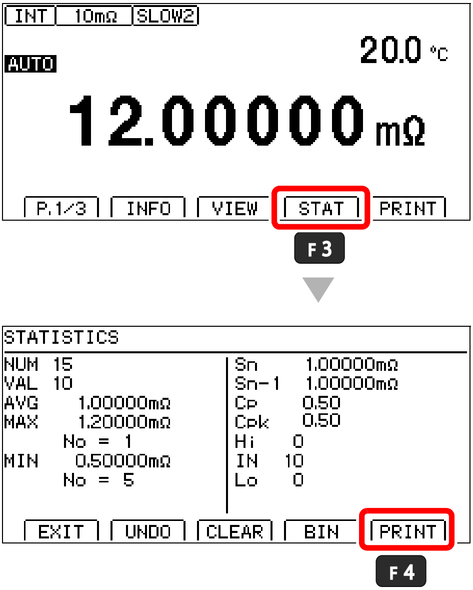
Printing Statistical Calculation Results

Statistical calculation results can be printed when statistical calculation is enabled (ON). To print, select PRINT on the screen or turn ON the instrument's EXT I/O connector's PRINT signal (short it with the ISO_COM pin).

To enable statistical calculation:

See: "5.3 Performing Statistical Calculations on Measured Values" (p. 111)

(When statistical calculation is enabled)



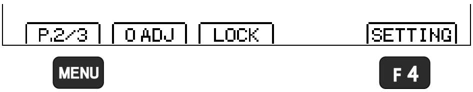
If no valid data exists, only the data count is printed. When only one valid data sample exists, standard deviation of sample and process capability indices cannot be printed.

12

Clearing statistical calculation results after each is printed

You can clear statistical calculation results automatically after each is printed.

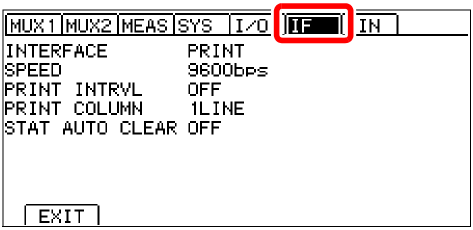
1 **Open the Settings Screen.**



1 MENU Switch the function menu to P.2/3.

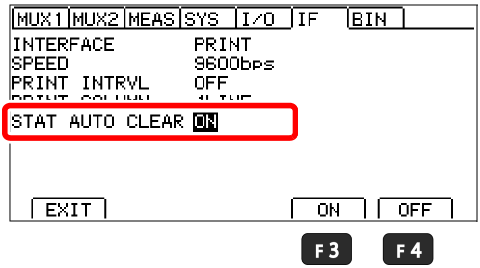
2 F 4 The Settings screen appears.

2 **Open the Communications Interface Setting Screen.**



Move the cursor to the [IF] tab with the left and right cursor keys.

3 **Turn ON the statistical calculation clear function.**



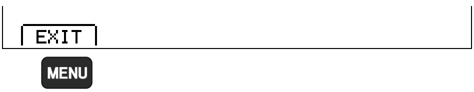
1 Selection

2

F 3 Turn ON the statistical calculation clear function.

F 4 Turn OFF the statistical calculation clear function. (default)

4 **Return to the Measurement screen.**



MENU Return to the Measurement screen, and enable the communications interface.

Example Printouts

♦ Resistance measured value, relative value, and temperature measured value (printing one column per row)

- Resistance measured value and temperature measured value

```
2013-07-31 14:24:02   99.9758mOhm
2013-07-31 14:25:54    9.9756mOhm
2013-07-31 14:27:02   -0.0058mOhm,  ----
2013-07-31 14:28:02   99.9758kOhm,  25.0 C
2013-07-31 14:29:02   99.9758MOhm, +OvrRng
2013-07-31 14:30:02   +OvrRng
2022-07-31 14:48:40   -------
```

- Comparator (ABS)

```
2013-07-31 14:49:02   99.9758mOhm Hi ,   25.0 C
2013-07-31 14:50:02   10.9008mOhm IN
2013-07-31 14:51:02    9.9758mOhm Lo
```

- Comparator (REF%)

```
2013-07-31 14:52:11   10.000  %    Hi
2013-07-31 14:53:11   -0.010  %    IN
2013-07-31 14:55:11 -100.000  %    Lo
```

- BIN ON

```
2013-07-31 14:56:31    5.0007mOhm 01
2013-07-31 14:57:25   10.0005mOhm             OB
```

- ΔT ON

```
2013-07-31 14:58:52  175.6    C
```

♦ Resistance measured value (printing three columns per row)

```
10.0004mOhm,  10.0006mOhm,   0.0004mOhm
```

♦ Interval printing

```
00:00:00     10.0004mOhm
00:00:01     10.0011mOhm
00:00:02     10.0001mOhm
00:00:03     10.0005mOhm
00:00:04     10.0000mOhm
00:00:05     10.0005mOhm
```

♦ Multiplexer scan results (RM3545-02 only)

```
2013-07-31 14:00:11 Total judge FAIL
CH01    99.9758MOhm Hi FAIL
CH02     9.9758MOhm IN PASS
CH03  100.9758MOhm Lo PASS
```

Do not print results during scanning.

♦ List of measurement conditions and settings

```
MODEL   RM3545-02
NO.     000000000
VER.    1.00
RANGE   10mOhm(1A)
SPEED   FAST
AVG     10
OVC     ON
DELAY   10ms
A.HOLD  OFF
CALIB   AUTO
TC      OFF
0 ADJ   OFF
SCALE   OFF
LINE    AUTO(60Hz)
TRIG    INT
I/O     NPN
I/F     PRINT
```

♦ Statistical calculation results

```
DATE - TIME  2013-07-31 14:01:11
NUMBER    11
VALID     10
AVERAGE   1200.160mOhm
MAX       1200.200mOhm (No = 9)
MIN       1200.130mOhm (No = 1)
Sn        0.00020mOhm
Sn-1      0.00028mOhm
Cp        0.19
Cpk       0.03
COMP Hi   4
COMP IN   6
COMP Lo   0
BIN0  10.000mOhm -   0.000mOhm   3
BIN1  20.000mOhm -  10.000mOhm   1
BIN2  30.000mOhm -  20.000mOhm   3
BIN3  40.000mOhm -  30.000mOhm   2
BIN4  50.000mOhm -  40.000mOhm   3
BIN5  60.000mOhm -  50.000mOhm  10
BIN6  70.000mOhm -  60.000mOhm   2
BIN7  80.000mOhm -  70.000mOhm   2
BIN8  90.000mOhm -  80.000mOhm   3
BIN9 100.000mOhm -  90.000mOhm   3
Out of BIN                       5
```

The “Valid” statistical calculation result indicates the number (count) of data samples not subject to errors such as measurement faults.

Specifications Chapter 13

13.1 Instrument Specifications

Measurement Ranges

LP	100 MΩ range high-precision	Measurement range and f.s.	Number of ranges
OFF	OFF	0.000 00 mΩ (10 mΩ range) to 1200.0 MΩ (1000 MΩ range) 10 MΩ or lower range: f.s.=1,000,000dgt. 100 MΩ or greater range: f.s.=10,000dgt.	12
	ON	0.000 00 mΩ (10 mΩ range) to 120.000 0 MΩ (100 MΩ range) f.s.=1,000,000dgt.	11
ON	–	0.00 mΩ (1000 mΩ range) to 1200.00 Ω (1000 Ω range) f.s.=100,000dgt.	4

Measurement Method

Measurement signal	Constant current
Measurement method	Four-terminal
Measurement terminals	Banana terminals SOURCE A Current detection terminal SOURCE B Current sourcing terminal SENSE A Voltage detection terminal SENSE B Voltage detection terminal GUARD Guard terminal

Measurement Specifications

(1) Resistance Measurement Accuracy

Conditions of guaranteed accuracy	
Warm-up time	At least 60 minutes (When the instrument warms up for less than 60 minutes, measurement accuracy will be twice the value indicated in the accuracy table.)
Temperature and humidity range for guaranteed accuracy	23°C±5°C (73°F±9°F), 80%RH or less
Accuracy specifications conditions	Self-calibration function set to AUTO (Self-calibration function set to MANUAL, temperature fluctuations after self-calibration within ±2°C and interval within 30 min.)
Temperature coefficient	Add (±1/10th of measurement accuracy per °C) from 0 to 18°C and from 28 to 40°C.

13

■ Low Power: OFF

Range	100MΩ range high-precision mode	Max. measurement range *1	Measurement Accuracy *2 ±(%rdg.+%f.s.) FAST	MED	SLOW1	SLOW2	Measurement Current Switching	*3	Additional accuracy without 0ADJ ±(%f.s.) *2	Max. open-terminal voltage
10 mΩ	–	12.000 00 mΩ	0.060+0.050 (0.060+0.015)	0.060+0.020 (0.060+0.002)		0.060+0.020 (0.060+0.001)	–	1 A	0.020 (-)	5.5 V *4
100 mΩ		120.000 0 mΩ	0.060+0.010 (0.060+0.003)	0.060+0.010 (0.060+0.001)		0.060+0.010 (0.060+0.001)	High	1 A	0.002 (-)	
			0.014+0.050 (0.014+0.015)	0.014+0.020 (0.014+0.002)		0.014+0.020 (0.014+0.001)	Low	100 mA	0.020 (-)	
1000 mΩ		1200.000 mΩ	0.012+0.010 (0.012+0.003)	0.012+0.008 (0.012+0.001)			High	100 mA	0.002 (-)	
			0.008+0.050 (0.008+0.015)	0.008+0.020 (0.008+0.002)			Low	10 mA	0.020 (-)	
10 Ω		12.000 00 Ω	0.008+0.010 (0.008+0.003)	0.008+0.008 (0.008+0.001)			High	10 mA	0.002 (-)	
			0.008+0.050 (0.008+0.015)	0.008+0.020 (0.008+0.002)			Low	1 mA	0.020 (-)	
100 Ω		120.000 0 Ω	0.007+0.005 (0.007+0.005)	0.007+0.002 (0.007+0.001)	0.007+0.001 (0.007+0.001)		High	10 mA	– (-)	
			0.008+0.010 (0.008+0.003)	0.008+0.010 (0.008+0.001)			Low	1 mA	0.002 (-)	
1000 Ω		1200.000 Ω	0.007+0.005 (0.007+0.005)	0.006+0.002 (0.006+0.001)	0.006+0.001 (0.006+0.001)		–	1 mA	– (-)	
10 kΩ		12.000 00 kΩ	0.008+0.005	0.007+0.002	0.007+0.001			1 mA	–	20 V
100 kΩ		120.000 0 kΩ	0.008+0.005	0.007+0.002	0.007+0.001			100 µA		
1000 kΩ		1200.000 kΩ	0.015+0.005	0.008+0.002	0.008+0.001			10 µA		
10 MΩ		12.000 00 MΩ	0.030+0.005	0.030+0.002	0.030+0.001			1 µA		
100 MΩ	ON	120.000 0 MΩ	0.200+0.005	0.200+0.002	0.200+0.001			100 nA		
	OFF	120.00 MΩ	10.00 MΩ or less: 0.50 + 0.02 10.01 MΩ or more: 1.00 + 0.02					1 µA or less		
1000 MΩ	OFF	1200.0 MΩ	100.0 MΩ or less: 1.00 + 0.02 100.1 MΩ or more: 10.00 + 0.02							

■ Low Power: ON

Range	Max. measurement range *1	Measurement Accuracy *2 ±(%rdg.+%f.s.) FAST	MED	SLOW1	SLOW2	Measurement Current *3	Max. open-terminal voltage
1000 mΩ	1200.00 Ω	0.200+0.100	0.200+0.010	0.200+0.005	0.200+0.003	1mA	20 mV *5
10 Ω	12.000 0 Ω	0.200+0.050	0.200+0.005	0.200+0.003	0.200+0.002	500 µA	
100 Ω	120.000 Ω	0.200+0.050	0.200+0.005	0.200+0.003	0.200+0.002	50 µA	
1000 Ω	1200.00 Ω	0.200+0.050	0.200+0.005	0.200+0.003	0.200+0.002	5 µA	

*1 Negative values can be up to -10% full scale.
The maximum display range is 9,999,999 dgt. or 9 GΩ.
(If the maximum measurement range is exceeded, the over-range display will be shown even if the value is less than or equal to the maximum display range.)

*2
- When LP: OFF, 0.001% f.s. = 10 dgt. However, when using the 100 MΩ range or greater with the 100 MΩ range high-precision setting off, 0.01% f.s. = 1 dgt. With LP: ON, 0.001% f.s. = 1 dgt.
- Measurement accuracy is the accuracy after zero-adjustment. When not performing zero-adjustment, the value indicated under [Additional accuracy without 0ADJ] is added.
- Values in parentheses on the second row apply when OVC is on. Only OVC on values are provided in the "Low Power: ON" table.
- During temperature correction, the following value is added to the resistance measurement accuracy rdg. error:

$$\frac{-\alpha_{t0}\Delta t}{1+\alpha_{t0}\times(t+\Delta t-t_0)}\times 100\ [\%]$$

t_0 : Standard temperature [°C]
t : Current ambient temperature [°C]
Δt : Temperature measurement accuracy
α_{t0} : Temperature coefficient [1/°C] at t_0

*3 Measurement current accuracy is ±5%
When using the 1,000 Ω range or lower with an external trigger source or with continuous measurement off (non-free-run), the measurement current is only applied from the start of measurement (TRIG = ON) to the end of measurement (INDEX = ON). The measurement current is stopped at all other times. When using the internal trigger source with continuous measurement on (free-run), the measurement current is stopped while the contact check indicates an error.

*4 When using an external trigger source or when continuous measurement is off (non-free-run), the open voltage is limited to 20 mV or less from 1 ms after the completion of measurement (INDEX = ON) until the start of the next measurement (TRIG = ON).

*5 When the contact check function is off (when the contact check function is on, 300 mV)

■ Measurement time (unit: ms) tolerance: ±10%±0.2 ms

When using the internal trigger source with continuous measurement on (free-run): Time of 1 measurement in the measurement target connected state

OVC *1	Measurement time
OFF	$(D+E1)\times N+F+G$
ON	$(C+D+E2)\times 2\times N+F+G$

When using an external trigger source or with continuous measurement off (non-free-run): From trigger input until EOM turns on

OVC *1	Measurement time
OFF	$A+B+(C+D+E2)\times N+F$
ON	$A+B+(C+D+E2)\times 2\times N+F$

A: Trigger detection time (unit: ms)

TRIG logic setting	Time
ON edge	0.1
OFF edge	0.3

B: Contact improvement time (unit: ms)

Contact improver function	Time
OFF	0.0
ON	0.2

C: Delay setting (unit: ms)

Time
Varies with setting.

D: Integration time (unit: ms) (detected voltage data acquisition time)

LP	Range	FAST		MEDIUM		SLOW1	SLOW2
		50 Hz	60 Hz	50 Hz	60 Hz		
OFF	1000 kΩ or less	0.3*		20.0	16.7	100	200
	10 MΩ or more	20.0	16.7	20.0	16.7	100	200
ON	All ranges	20.0	16.7	40.0	33.3	200	300

* When using the MUX mesurement terminals, the integration time is 1.0 ms only in the 10 mΩ range.

$E1$: Internal wait time 1 (unit: ms) (Processing time before and after integration measurement)

Time
0.4

$E2$: Internal wait time 2 (unit: ms) (Processing time before and after integration measurement)
LP OFF

Range	100 MΩ range high-precision mode	Measurement Current	Time
10 mΩ	–	–	40
100 mΩ	–	High	40
	–	Low	1.8
1000 mΩ	–	High	1.5
	–	Low	1.3
10 Ω	–	High	1.5
	–	Low	1.3
100 Ω	–	High	2.1
	–	Low	1.3
1000 Ω	–	–	2.3
10 kΩ	–	–	12
100 kΩ	–	–	20
1000 kΩ	–	–	150
10 MΩ	–	–	570
100 MΩ	ON	–	1300
	OFF	–	300
1000 MΩ	OFF	–	400

LP ON

Range	Time
1000 mΩ	15
10 Ω	35
100 Ω	35
1000 Ω	36

F: Calculation time (unit: ms)

Setting	Time
Statistical calculation: OFF Scaling: OFF Measured value display switching: None	0.3

G: Self-calibration time (unit: ms)

Self-calibration setting	Time
Auto	5.0
Manual	0.0

N: Number of average iterations (unit: iterations)

Trigger source, continuous measurement	Number of iterations
When using the internal trigger source with continuous measurement on (free-run)	1 (Moving Avg.)
When using an external trigger source or with continuous measurement off (non-free-run)	Varies with setting. *2

*1 When LP is on, OVC is fixed to on.
*2 When using the SLOW2 measurement speed with low-power resistance measurement on, the instrument will performing averaging with two iterations internally even if the averaging function is set to off.

Shortest measurement times when using the internal trigger source with continuous measurement on (free-run)

LP OFF (unit: ms), tolerance: ±10%±0.2 ms

Range	FAST		MEDIUM		SLOW1	SLOW2
	50 Hz	60 Hz	50 Hz	60 Hz		
1000 kΩ or lower range	1.0*		20.7	17.4	101	201
10 MΩ or greater range	20.7	17.4	20.7	17.4	101	201

LP ON (unit: ms), tolerance: ±10%±0.2 ms, Only with OVC on

Range	FAST		MEDIUM		SLOW1	SLOW2
	50 Hz	60 Hz	50 Hz	60 Hz		
1000 mΩ	71	65	111	98	431	631
10 Ω	111	105	151	138	471	671
100 Ω	111	105	151	138	471	671
1000 Ω	113	107	153	140	473	673

Shortest conditions
Delay: 0 ms, OVC: OFF, Average: OFF,
Self-Calibration: MANUAL, Contact improver: OFF, Scaling: OFF
Measured value display switching: None

* When using the MUX mesurement terminals, the shortest measurement time is 1.7 ms only in the 10 mΩ range.

13

Shortest measurement times when using the external trigger source or when continuous measurement off (non-free-run)

LP OFF (unit: ms), tolerance: ±10%±0.2 ms, Values in parentheses on the second row apply when OVC is on.

<table>
<tr><th rowspan="2">Range</th><th rowspan="2">100 MΩ range high-precision mode</th><th rowspan="2">Measurement Current</th><th colspan="2">FAST</th><th colspan="2">MEDIUM</th><th rowspan="2">SLOW1</th><th rowspan="2">SLOW2</th></tr>
<tr><th>50 Hz</th><th>60 Hz</th><th>50 Hz</th><th>60 Hz</th></tr>
<tr><td>10 mΩ</td><td>–</td><td>–</td><td colspan="2">41
(82)</td><td>61
(121)</td><td>58
(115)</td><td>141
(281)</td><td>241
(481)</td></tr>
<tr><td rowspan="2">100 mΩ</td><td>–</td><td>High</td><td colspan="2">41
(82)</td><td>61
(121)</td><td>58
(115)</td><td>141
(281)</td><td>241
(481)</td></tr>
<tr><td>–</td><td>Low</td><td colspan="2">2.5
(4.6)</td><td>23
(44)</td><td>19
(38)</td><td>103
(204)</td><td>203
(404)</td></tr>
<tr><td rowspan="2">1000 mΩ</td><td>–</td><td>High</td><td colspan="2">2.2
(4.0)</td><td>22
(44)</td><td>19
(37)</td><td>102
(204)</td><td>202
(404)</td></tr>
<tr><td>–</td><td>Low</td><td colspan="2">2.0
(3.6)</td><td>22
(43)</td><td>19
(37)</td><td>102
(203)</td><td>202
(403)</td></tr>
<tr><td rowspan="2">10 Ω</td><td>–</td><td>High</td><td colspan="2">2.2
(4.0)</td><td>22
(44)</td><td>19
(37)</td><td>102
(204)</td><td>202
(404)</td></tr>
<tr><td>–</td><td>Low</td><td colspan="2">2.0
(3.6)</td><td>22
(43)</td><td>19
(37)</td><td>102
(203)</td><td>202
(403)</td></tr>
<tr><td rowspan="2">100 Ω</td><td>–</td><td>High</td><td colspan="2">2.8
(5.2)</td><td>23
(45)</td><td>20
(38)</td><td>103
(205)</td><td>203
(405)</td></tr>
<tr><td>–</td><td>Low</td><td colspan="2">2.0
(3.6)</td><td>22
(43)</td><td>19
(37)</td><td>102
(203)</td><td>202
(403)</td></tr>
<tr><td>1000 Ω</td><td>–</td><td>–</td><td colspan="2">3.0
(5.6)</td><td>23
(45)</td><td>19
(38)</td><td>103
(205)</td><td>203
(405)</td></tr>
<tr><td>10 kΩ</td><td>–</td><td>–</td><td colspan="2">13</td><td>33</td><td>30</td><td>113</td><td>213</td></tr>
<tr><td>100 kΩ</td><td>–</td><td>–</td><td colspan="2">21</td><td>41</td><td>38</td><td>121</td><td>221</td></tr>
<tr><td>1000 kΩ</td><td>–</td><td>–</td><td colspan="2">151</td><td>171</td><td>168</td><td>251</td><td>351</td></tr>
<tr><td>10 MΩ</td><td>–</td><td>–</td><td>591</td><td>588</td><td>591</td><td>588</td><td>671</td><td>771</td></tr>
<tr><td rowspan="2">100 MΩ</td><td>ON</td><td>–</td><td>1321</td><td>1318</td><td>1321</td><td>1318</td><td>1401</td><td>1501</td></tr>
<tr><td>OFF</td><td>–</td><td>321</td><td>318</td><td>321</td><td>318</td><td>401</td><td>501</td></tr>
<tr><td>1000 MΩ</td><td>OFF</td><td>–</td><td>421</td><td>418</td><td>421</td><td>418</td><td>501</td><td>601</td></tr>
</table>

LP ON (unit: ms), Tolerance: ±10%±0.2 ms, Only with OVC on

Range	FAST		MEDIUM		SLOW1	SLOW2
	50 Hz	60 Hz	50 Hz	60 Hz		
1000 mΩ	71	65	111	98	431	1262
10 Ω	111	105	151	138	471	1342
100 Ω	111	105	151	138	471	1342
1000 Ω	113	107	153	140	473	1346

Shortest conditions
Delay: 0 ms, Average: OFF, TRIG logic setting: ON,
Self-Calibration: MANUAL, Contact improver: OFF, Scaling: OFF,
Measured value display switching: None (With LP: ON, OVC is fixed to on. With LP: ON and measurement speed: SLOW2, the number of average iterations is fixed to 2.

(2) Resistance D/A output accuracy

Output accuracy	Resistance measurement accuracy ±0.2%f.s. (temperature coefficient ±0.02%f.s./°C)
Response time	Measurement time + Max. 1 ms Shortest: 2.0 ms (tolerance: ±10%±0.2 ms) Shortest conditions: INT trigger source, LP: OFF, 1000 kΩ or lower range, Measurement speed: FAST, Delay: 0 ms, Self-Calibration: MANUAL

(3) Temperature measurement accuracy (Thermistor sensor)

Measurement range	-10.0 to 99.9°C
Measurement period (speed)	2 ± 0.2 s
Period of guaranteed accuracy	1 year

Combined accuracy with Model Z2001 Temperature Sensor

Accuracy	Temperature range
±(0.55 + 0.009×|*t* -10|)°C	-10.0°C to 9.9°C
± 0.50°C	10.0°C to 30.0°C
±(0.55 + 0.012×|*t* -30|)°C	30.1°C to 59.9°C
±(0.92 + 0.021×|*t* -60|)°C	60.0°C to 99.9°C

t : measurement temperature (°C)
Accuracy of instrument alone: ±0.2°C

(4) Temperature measurement accuracy (Analog Input)

Guaranteed accuracy range	0 to 2 V
Maximum allowable voltage	2.5 V
Detected resolution	1 mV or less
Display range	-99.9 to 999.9°C
Measurement period (speed)	50±5 ms, no moving average
Period of guaranteed accuracy	1 year
Accuracy	±1%rdg. ±3 mV Temperature accuracy conversion method 1% × ($T_R - T_{0V}$) + 0.3% × ($T_{1V} - T_{0V}$) T_{1V} : temperature @ 1-V input T_{0V} : temperature @ 0-V input T_R : current temperature Add temperature coefficient (±0.1%rdg. ±0.3 mV)/°C to above accuracy for ambient temperature ranges 0 to 18 and 28 to 40°C.

(5) Calculation order

1. Zero-adjustment 2. Temperature correction 3. Scaling

About Instrument Accuracy

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

f.s.	(maximum display value) This is usually the name of the maximum displayable value. For this instrument, it indicates the currently selected range.
rdg.	(reading or displayed value) The value currently being measured and indicated on the measuring instrument.
dgt.	(resolution) The smallest displayable unit on a digital measuring instrument, i.e., the input value that causes the digital display to show a “1” as the least-significant digit.

Example accuracy calculations

(Digits in excess of display range are truncated.)

- **Resistance measurement accuracy**

Measurement conditions: 100 mΩ range, low current, OVC OFF, no zero-adjustment, SLOW1, 30 mΩ measurement target
Resistance measurement accuracy: ±(0.014%rdg. + 0.020%f.s.),
Additional accuracy without 0ADJ: ±0.020%f.s.

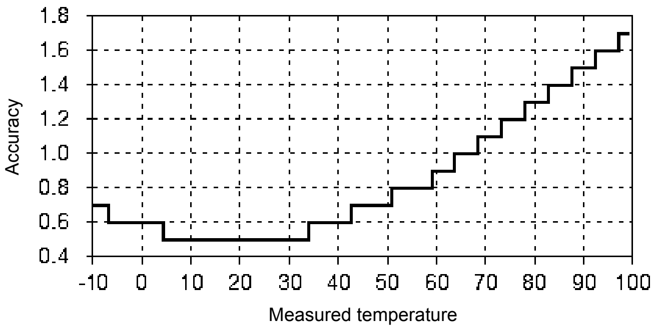
±(0.014%×30 mΩ + (0.02%+0.02%) × 100 mΩ) = **±0.0442 mΩ**

- **Temperature measurement accuracy**

Measurement conditions: Thermistor temperature sensor, measurement temperature of 35°C
Temperature measurement accuracy: ±(0.55+0.012×|t-30|)

±(0.55+0.012×|35-30|) = **±0.610°C**

(Truncate digits in excess of display range: 0.6°C)



- **Temperature correction additional accuracy**

Measurement conditions: Temperature coefficient of 3,930 ppm/°C, standard temperature of 20°C, measurement temperature of 35°C

Additional error $\frac{-\alpha_{t0}\Delta t}{1+\alpha_{t0}\times(t+\Delta t-t_0)}\times 100$ [%]

$$\frac{-0.393\%\times(\pm 0.6)}{1+0.393\%\times(35\pm 0.6-20)} = \mathbf{+0.222\%rdg., -0.223\%rdg.}$$

Functions

(1) Resistance range switching function

Mode	AUTO/ MANUAL (Automatically set to manual if the comparator or BIN function is turned on.)
Measurement Ranges	LP OFF: 10 mΩ/ 100 mΩ/ 1000 mΩ/ 10 Ω/ 100 Ω/ 1000 Ω/ 10 kΩ/ 100 kΩ/ 1000 kΩ/ 10 MΩ/ 100 MΩ/ 1000 MΩ LP ON: 1000 mΩ/ 10 Ω/ 100 Ω/ 1000 Ω (With the 100 MΩ range high-precision setting on, the 1,000 MΩ range cannot be used. When using the MUX measurement terminal setting with the 2-wire measurement method, the 10 Ω and lower ranges cannot be used.)
Default setting	Mode: AUTO, Measurement Range: 1000 MΩ

(2) 100 MΩ range high-precision function

Setting	ON/ OFF
Default setting	OFF

(3) Number of measurement digits selection function

Number of measurement digits selection	7digits/ 6digits/ 5digits (If the number of f.s. digits is less than the setting, the number of f.s. digits will be used.)
Default setting	7digits

(4) Low-Power Resistance Measurement function (LP)

Operation	Low-power measurement is performed by limiting the measurement current and open voltage. (1000 mΩ to 1000 Ω range)
Setting	ON/ OFF (With OVC on when LP is on and the contact improvement function fixed to off)
Default setting	OFF

(5) Measurement Current Switching

Operation	The measurement current is limited during measurement. (100 mΩ to 100 Ω range)
Measurement current	High/ Low

Range	Measurement current	
	High	Low
100 mΩ	1 A	100 mA
1000 mΩ	100 mA	10 mA
10 Ω	10 mA	1 mA
100 Ω	10 mA	1 mA

Default setting	High

(6) Measurement Speed

Setting	FAST/ MED/ SLOW1/ SLOW2
Default setting	SLOW2

(7) Power Line Frequency Setting

Operation	Selects the line voltage frequency
Setting	AUTO (50 or 60 Hz, auto-detect)/ 50 Hz / 60 Hz
Default setting	AUTO (auto-detect upon power on and resetting)

(8) Zero Adjustment

Operation	Cancels the internal offset voltage and the surplus resistance.
Setting	ON/ OFF (clear): for each range Scan zero adjustment ON/ OFF: Set by channel. (RM3545-02 only)
Adjustment range	Within ±50%f.s. for each range (warning message displayed when in excess of ±1%f.s. for each range) Zero-adjustment cannot be used at 100 MΩ or above (it is forcibly turned off).
Default setting	Zero adjustment: OFF, Scan zero adjustment: ON

(9) Averaging function

Operation	A moving average is used when using the internal trigger source with continuous measurement on (free-run). A mean average is used when using an external trigger source or with continuous measurement off (non-free-run). Moving average: $R_{avg(n)} = \frac{1}{A}\sum_{k=n}^{n+A-1} R_k$ Mean average: $R_{avg(n)} = \frac{1}{A}\sum_{k=(n-1)A+1}^{nA} R_k$ R_{avg} : Average, A : Number of averaging iterations, n : Number of measurements, R_k : Measured value No. k
Setting	ON/ OFF (When using the SLOW2 measurement speed with low-power resistance measurement on, the instrument will performing averaging with two iterations internally even if the averaging function is set to off.)
Number of averaging iterations	2 to 100 times
Default setting	OFF, Number of averaging iterations: 2 times

(10)Delay Setting

Operation	Adjusts the time for measurement to stabilize by inserting a waiting period after using the OVC or the auto-range function to change the measurement current or after the TRIG signal. Preset: Integration starts after the factory-default time (which varies with the range) elapses. User-set: Integration starts after the specified time elapses (for all ranges).
Setting	Preset (internal fixed value)/ user-set (set value)
Delay setting range	0 ms to 9999 ms
Default setting	Preset/ 0 ms

Preset delay value (internal fixed) (unit: ms)

LP OFF

Range	100 MΩ range high-precision mode	Measurement current	Delay	
			OVC: OFF	OVC: ON
10 mΩ	–	–	75	25
100 mΩ	–	High	250	25
	–	Low	20	2
1000 mΩ	–	High	50	2
	–	Low	5	2
10 Ω	–	High	20	2
	–	Low	5	2
100 Ω	–	High	170	2
	–	Low	20	2
1000 Ω	–	–	170	2
10 kΩ	–	–	180	–
100 kΩ	–	–	95	–
1000 kΩ	–	–	10	–
10 MΩ	–	–	1	–
100 MΩ	ON	–	500	–
100 MΩ	OFF	–	1	–
1000 MΩ	OFF	–	1	–

LP ON

Delay
1

(11)Temperature measurement settings

Temperature sensor types	Thermistor sensor/ Analog input
Analog input Formula	$t = \frac{T_2 - T_1}{V_2 - V_1} v + \frac{T_1 V_2 - T_2 V_1}{V_2 - V_1}$ t : Displayed value (°C) v : Input voltage (V) V_1 : Reference voltage 1 (V) Setting range: 0.00 to 2.00 V T_1 : Reference temperature 1 (°C) Setting range: -99.9 to 999.9°C V_2 : Reference voltage 2 (V) Setting range: 0.00 to 2.00 V T_2 : Reference temperature 2 (°C) Setting range: -99.9 to 999.9°C
Default setting	Sensor type: Thermistor sensor, V_1: 0 V, T_1: 0°C, V_2: 1 V, T_2: 100°C

(12)Temperature Correction Function (TC)

Operation	Temperature correction converts resistance values to resistance values at standard temperature and displays the result. (When ΔT is on, TC is automatically turned off.)
Formula	$R_{t0} = \frac{R_t}{1 + \alpha_{t0}(t - t_0)}$ R_t : Measured resistance value (Ω) R_{t0} : Corrected resistance value (Ω) t_0 : Standard temperature (°C) Setting range: -10.0 to 99.9°C t : Current ambient temperature (°C) α_{t0} : Temperature coefficient (1/°C) at t_0 Setting range: -99,999 to 99,999ppm/°C
Setting	ON/ OFF (When ΔT is on, TC is automatically turned off.)
Default setting	OFF, t_0 : 20°C, α_{t0} : 3,930ppm/°C

(13)Offset Voltage Compensation Function (OVC)

Operation	Reverses measurement current polarity to eliminate offset voltage effects
Applicable ranges	Low-Power OFF : 0 mΩ range to 1000 Ω range Low-Power ON : All ranges
Setting	ON/ OFF (When low-power is on, OVC is fixed to on.)
Default setting	OFF

13

(14)Scaling Function

Operation	Measured values are corrected with the linear function $R_S = A \times R + B$ R_S : Value after scaling A : Gain coefficient Setting range: 0.200 0 × 10^{-3} to 1.999 9 × 10^{3} R : Measured value after zero-adjustment and temperature correction B : Offset Setting range: 0 to ±9 × 10^{9} (maximum resolution: 1 nΩ)
Setting	ON/ OFF
Display format	See below. (When 9 G is exceeded, the over-range display is shown.)

■ Low-Power: OFF

Range	Gain coefficient						
	(0.2000 to 1.9999) ×10^{-3}	(0.2000 to 1.9999) ×10^{-2}	(0.2000 to 1.9999) ×10^{-1}	(0.2000 to 1.9999) ×1(10^{0})	(0.2000 to 1.9999) ×10(10^{1})	(0.2000 to 1.9999) ×10^{2}	(0.2000 to 1.9999) ×10^{3}
10 mΩ	00.000 μ	000.000 μ	0000.000 μ	00.000 00 m	000.000 0 m	0000.000 m	00.000 00
100 mΩ	000.000 μ	0000.000 μ	00.000 00 m	000.000 0 m	0000.000 m	00.000 00	000.000 0
1000 mΩ	0000.000 μ	00.000 00 m	000.000 0 m	0000.000 m	00.000 00	000.000 0	0000.000
10 Ω	00.00 000 m	000.000 0 m	0000.000 m	00.000 00	000.000 0	0000.000	00.000 00 k
100 Ω	000.000 0 m	0000.000 m	00.000 00	000.000 0	0000.000	00.000 00 k	000.000 0 k
1000 Ω	0000.000 m	00.000 00	000.000 0	0000.000	00.000 00 k	000.000 0 k	0000.000 k
10 kΩ	00.000 00	000.000 0	0000.000	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M
100 kΩ	000.000 0	0000.000	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M
1000 kΩ	0000.000	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M	0000.000 M
10 MΩ	00.000 00 k	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M	0000.000 M	00.000 00 G
100 MΩ*	000.000 0 k	0000.000 k	00.000 00 M	000.000 0 M	0000.000 M	00.000 00 G	000.000 0 G
1000 MΩ	0000.0 k	00.000 M	000.00 M	0000.0 M	00.000 G	000.00 G	0000.0 G

* When high-precision mode is off in the 100 MΩ range, 5 digits are displayed.

■ Low-Power: ON

Range	Gain coefficient						
	(0.2000 to 1.9999) ×10^{-3}	(0.2000 to 1.9999) ×10^{-2}	(0.2000 to 1.9999) ×10^{-1}	(0.2000 to 1.9999) ×1(10^{0})	(0.2000 to 1.9999) ×10(10^{1})	(0.2000 to 1.9999) ×10^{2}	(0.2000 to 1.9999) ×10^{3}
1000 mΩ	0000.00 μ	00.000 0 m	000.000 m	0000.00 m	00.000 0	000.000	0000.00
10 Ω	00.000 0 m	000.000 m	0000.00 m	00.000 0	000.000	0000.00	00.000 0 k
100 Ω	000.000 m	0000.00 m	00.000 0	000.000	0000.00	00.000 0 k	000.000 k
1000 Ω	0000.00 m	00.000 0	000.000	0000.00	00.000 0 k	000.000 k	0000.00 k

Unit	Ω/ none/ user-selected 3 characters (Except SI prefix)
Default setting	OFF, A: 1.0000 ×1, B: 0, Unit: Ω

(15)Self-Calibration Function

Operation	Compensates for offset voltage and gain of measurement circuit
Setting	AUTO/ MANUAL
Compensation timing	AUTO : At power-on, after measured value, during TRIG standby (every 1 s) MANUAL: During EXT I/O CAL signal input, when executing the calibration command
Self-calibration time	At power-on, when switching to auto and during manual execution: 400 ms Auto: 5 ms (moving average)
Default setting	AUTO

(16)Contact Improvement Function

Operation	A voltage is applied between the SENSE A and SENSE B terminals after TRIG signal input, and a contact improvement current is allowed to flow for 0.2 ms.
Setting	OFF/ ON (When LP is on, the contact improvement function is fixed to off.)
Default setting	OFF
Applied voltage	Max. 5 V
Contact improvement current	Max. 10 mA (flowing to the measurement target)

(17)Faulty Measurement Detection

■ Over Detection Function

Operation	Indicates under- or over-range values in the following conditions: • Measured value is outside of the measurement range • Measured value is outside of the A/D converter input range • Calculation result exceeded the number of display digits

■ Contact Check Function

Operation	Checks the connections between SOURCE A and SENSE A, and between SOURCE B and SENSE B terminals
Setting	ON/ OFF (When using the MUX measurement terminal setting with the 2-wire measurement method, fixed to off. When using the 100 MΩ or greater range, the setting is fixed to ON.)
Threshold	50 Ω (reference value)
Default setting	ON (When LP is off), OFF (When LP is on)

Current fault detection function

Operation	Detects faults in which the stipulated measurement current cannot be applied. No cancelation function.
Current fault mode setting	Current fault (ERR signal output) / over-range (HI signal output)

Display and output during current fault detection

		Current fault mode setting	
		Current fault	Over-range
Contact Check	Normal (No error)	Current fault display ERR signal output	Over-range display HI signal output
	Fault (Error)	Contact error display ERR signal output	

Default setting	Current fault (ERR signal output)

Reference values for wiring resistance and contact resistance that will result in a current fault

LP OFF

Range	100 MΩ range high-precision mode	Current switching	Measurement Current	SOURCE B - SOURCE A (Other than measurement target)
10 mΩ	–	–	1 A	1.5 Ω
100 mΩ	–	High	1 A	1.5 Ω
100 mΩ	–	Low	100 mA	15 Ω
1000 mΩ	–	High	100 mA	15 Ω
1000 mΩ	–	Low	10 mA	150 Ω
10 Ω	–	High	10 mA	150 Ω
10 Ω	–	Low	1 mA	1 kΩ
100 Ω	–	High	10 mA	100 Ω
100 Ω	–	Low	1 mA	1 kΩ
1000 Ω	–	–	1 mA	1 kΩ
10 kΩ	–	–	1 mA	1 kΩ
100 kΩ	–	–	100 μA	1 kΩ
1000 kΩ	–	–	10 μA	1 kΩ
10 MΩ	–	–	1 μA	1 kΩ
100 MΩ	ON	–	100 nA	1 kΩ
100 MΩ	OFF	–	1 μA or less	1 kΩ
1000 MΩ	OFF	–	1 μA or less	1 kΩ

LP ON

Range	Measurement Current	SOURCE B - SOURCE A (Other than measurement target)
1000 mΩ	1 mA	2 Ω
10 Ω	500 μA	5 Ω
100 Ω	50 μA	50 Ω
1000 Ω	5 μA	500 Ω

(18)Comparator Function

Operation	Compares setting and measured values
Setting	ON/OFF (fixed range when the comparator function is on; the comparator function is automatically turned off when the ΔT and BIN functions are on)
Comparator mode	ABS mode/ REF% mode
Default state	OFF, ABS mode
Judgment	Hi Measured value > Upper limit value IN Upper limit value ≥ measured value ≥ Lower limit value Lo Lower limit value > measured value
Total judgment function (RM3545-02 only)	
Operation	When using the MUX measurement terminal setting with the scan function set to AUTO or STEP, a PASS/FAIL judgment is made for each channel, and a total judgment is determined.
PASS/FAIL judgment (for each scan channel)	PASS When the comparator judgment satisfies the PASS conditions FAIL When the comparator judgment does not satisfy the PASS conditions
Total judgment	PASS When all channels are PASS or when the PASS condition is OFF FAIL When any channel is FAIL
PASS conditions	OFF/ Hi/ IN/ Lo/ Hi or Lo/ ALL (for each scan channel)
Default setting	IN

■ ABS Mode

Upper/Lower limit ranges	0.000 0 mΩ to 9000.00 MΩ *
Default setting	0.000 0 mΩ

■ REF% Mode

Display	Absolute value display and Relative value display $(\text{Relative value}) = \left\{\frac{(\text{Measured value})}{(\text{Reference value})} - 1\right\} \times 100\ [\%]$
Relative value display range	-999.999% to 999.999%
Reference value range	0.000 1 mΩ to 9000.00 MΩ * When using the MUX measurement terminal setting, the measurement results for scan channel 1 can be used as the reference value. (RM3545-02 only)
Upper/ Lower limit ranges	0.000% to ±99.999%
Default setting	Reference value: 0.000 1 mΩ, Upper/ Lower limit ranges: 0.000%

* When set using the instrument's keys, the input range will reflect the range and scaling coefficient with a maximum resolution of 1 nΩ and a maximum value of 9 GΩ.

(19)BIN Function

Operation	Compares setting and measured values and displays the result.
Setting	ON/ OFF (When the BIN function is on, the range and comparator functions are fixed to off. When ΔT is on while using the MUX measurement terminal setting, the BIN function is automatically turned off.)
Comparator mode	ABS mode/ REF% mode
Display	Absolute value (resistance value) display only
BIN number	0 to 9
Default state	OFF
Judgment	Hi Measured value > Upper limit value IN Upper limit value ≥ measured value ≥ Lower limit value Lo Lower limit value > measured value

■ ABS Mode

Upper/Lower limit ranges	0.000 0 mΩ to 9000.00 MΩ *
Default setting	0.000 0 mΩ

■ REF% Mode

Reference value range	0.000 1 mΩ to 9000.00 MΩ *
Upper/ Lower limit ranges	0.000% to ±99.999%
Default setting	Reference value: 0.000 1 mΩ, Upper/ Lower limit ranges: 0.000%

* When set using the instrument’s keys, the input range will reflect the range and scaling coefficient with a maximum resolution of 1 nΩ and a maximum value of 9 GΩ.

(20)Comparator Beeper Setting

Operation	Sounds a beeper based on the comparator judgment result or total judgment. (Set separately for Hi/ IN/ Lo and for PASS/ FAIL when using the MUX measurement terminals.)
Operation settings and tones	type 1/ type 2/ type 3/ OFF
Number of beeps	1 to 5 times / continuous
Default setting	OFF, 2times

(21)Auto Hold Function

Operation	Holds measured values automatically (only when using the measurement terminals on the front of the instrument with the internal trigger source and continuous measurement on [free-run]). The hold is canceled when the measurement leads are removed from the target and the next measurement performed, or when the ESC key is pressed.
Operation setting	ON/ OFF
Default setting	OFF

(22)Temperature Conversion Function (ΔT)

Operation	Utilizing the temperature-dependent nature of resistance, the temperature conversion function converts resistance measurements for display as temperatures.

Formula

$$\Delta t = \frac{R_2}{R_1}(k + t_1) - (k + t_2)$$

Δt : Temperature increase (°C)
t_1 : Winding temp. (°C, cool state) when measuring initial resistance R_1
Setting range: -10.0 to 99.9°C
t_2 : Ambient temp. (°C) at final measurement
R_1 : Winding resistance (Ω) at temp. t_1 (cool state) Setting range: 0.001 μΩ to 9000.000 MΩ *
R_2 : Winding resistance (Ω) at final measurement
k : Reciprocal (°C) of temp. coefficient of conductor material at 0°C
Setting range: -999.9 to 999.9

* When set using the instrument's keys, the input range will reflect the range and scaling coefficient with a maximum resolution of 1 nΩ and a maximum value of 9 GΩ.

ΔT display range	-9999.9 to 9999.9°C
Setting	ON/ OFF (When the ΔT function is on, the comparator functions are fixed to off. ; ΔT is automatically turned off when TC, the statistical calculation function, and the BIN function are on.)
Default setting	OFF, t_1: 23.0°C, R_1: 1.000 0 Ω, k : 235.0

(23)Statistical Calculations

Operation	Statistical calculations are performed on measured values.
Setting	ON/ OFF (The statistical calculation function is automatically turned off when ΔT is on while using the MUX measurement terminal setting.)
Maximum number of data points	30,000
Calculations	Total data count, Number of valid data samples, Mean, Minimum value (index no.), Maximum value (index no.), Standard deviation of sample, Population standard deviation • When the comparator function is ON Count for each comparator judgment, Process capability indices (dispersion, bias) • When the BIN function is ON Count for each BIN number, OUT (Hi or Lo) count for all BIN numbers, invalid BIN count
Clearing calculations	Clear all data / clear 1 data point (to revert to data immediately before measurement)
Default setting	OFF

(24)Panel Save, Panel Load

Operation	Saves and loads measurement conditions using user-specified panel numbers.
Number of panels	When using the measurement terminals on the front of the instrument: 30; when using the MUX measurement terminal setting: 8
Panel names	10 characters (letters or numbers)
Saved data	Save time and date, resistance range, 100 MΩ high-precision mode, Low-Power resistance measurement (LP), switching measurement currents, measurement speed, zero-adjustment, average, delay, temperature correction (TC), offset voltage compensation (OVC), scaling, self-calibration setting, contact improver, contact check, comparator, BIN setting, judgment sound, Auto Hold, temperature conversion (ΔT), statistical calculations setting, multiplexer setting (including channels)
Loading of zero-adjustment values	ON/ OFF
Default setting	ON

(25)Clock

Auto calendar, auto leap year, 24-hour clock	
Accuracy	Approx. ±4 minutes/ month
Default setting	01/01/2013, 00:00
Backup battery life	Approx. 10 years (23°C reference value)

(26)Reset Functions

■ Reset

Operation	Resets settings (except panel data) to factory defaults

■ System reset

Operation	Reverts all settings, including panel data, to their default values.

■ Multiplexer channel reset (RM3545-02 only)

Operation	Returns the multiplexer channel settings to the factory defaults.

(27)Self-Test

■ Self-test at startup

Operation	ROM/RAM check, measurement circuit protective fuse check

■ Z3003 unit test (RM3545-02 only)

Operation	Each pin's round-trip wiring resistance value is measured with all the A and B terminals shorted while in the 2-terminal resistance measurement state, and the number of contacts is displayed.
Judgment criterion	Short test: FAIL when the resistance measurement is 1 Ω or more in the shorted state Open test: FAIL when no measurement fault is detected in the open state

Interface

(1) Display

LCD type	Monochrome graphical LCD 240 × 110
Backlight	White LED Brightness adjustment range: 0 to 100% (5% increments), Default setting: 80% When using EXT trigger source, brightness is automatically reduced when keys are not used. Brightness recovers upon front panel key operation.
Contrast	Adjustment range: 0 to 100% (5% increments), Default setting: 50%
Measured value display switching	In addition to normal measured values, the following are displayed: No display/ temperature/ pre-calculation resistance value (TC, scaling, REF%, ΔT)

(2) Keys

COMP, PANEL, ▼, ▲, ▶, ◀, MENU, F1, F2, F3, F4, ESC, ENTER, AUTO, ▼, ▲ (RANGE), ⏻ (Standby), SPEED

Key-Lock Functions

Operation	Disables operation of unneeded keys. Can also be canceled using a communication command.
Setting	OFF/menu lock/all-key lock Menu lock : Disables all keys other than direct keys (below) and the cancel key. COMP, PANEL, AUTO, ▼, ▲ (RANGE), SPEED, 0ADJ, PRINT, STAT, STOP All-key lock: Disables all except the cancel key. All front panel keys are disabled when the KEY_LOCK signal is received.
Default setting	OFF

Key-Press Beeper Setting

Setting	ON/ OFF
Default setting	ON

(3) Communications interfaces

Interface types	GP-IB/ RS-232C/ PRINTER/ USB
Default setting	RS-232C

■ RS-232C and printer communications settings

Communication contents	Remote control, measured value output (export)
Transfer method	Asynchronous, Full duplex
Transmission speed	9,600bps (default setting)/ 19,200bps/ 38,400bps/ 115,200bps
Data length	8 bit
Stop bit	1
Parity	none
Delimiter	Transmit: CR+LF, Receive: CR or CR+LF
Handshaking	No X-flow, no hardware flow
Protocol	Non-procedure
Connector	Male 9-pin D-sub, with #4-40 attachment screws

■ USB

Communication contents	Remote control, measured value output (export)
Connector	Series B receptacle
Electrical specifications	USB2.0 (Full Speed)
Class (mode)	CDC Class (COM mode), HID Class (USB keyboard mode)
Default setting	COM mode

■ Printer

Operation	Prints data when the PRINT signal is input or when the print key is pressed.
Compatible printers	Interface: RS-232C, no. of characters per line: 48 (single-byte) or more Communication speed: 9,600bps/ 19,200bps/ 38,400bps/ 115,200bps Data length: 8bit, Parity: none, Stop bit: 1bit, Flow control: none, Message terminator (delimiter): CR+LF Control codes: Must be able to print plain text directly.
Printing Contents	Resistance measured values, temperature measured values, judgment results, measurement conditions, statistical results
Interval	ON/ OFF
Interval time	0 to 3,600 s
Statistical calculations clear	ON/ OFF
Number of columns printed per row	1 column/ 3 columns
Default setting	Interval: OFF, interval time: 1 s, statistical calculations clear: OFF, number of columns printed per row: 1 column

■ GP-IB interface (RM3545-01 only)

Communication contents	Remote control
Device address	0 to 31
Delimiter	LF/ CR+LF
Default setting	Device address: 1, Delimiter: LF
Miscellaneous	Conforms to IEEE 488.2
Interface Functions	SH1 All Source Handshake functions are supported. AH1 All Acceptor Handshake functions are supported. T6 Basic talker functions are supported. Serial poll function are supported. No talk-only mode. The talker cancel function with MLA (My Listen Address) is supported. L4 Basic listener functions are supported. No listen-only mode. The listener cancel function with MTA (My Talk Address) is supported. SR1 All Service Request functions are supported. RL1 All Remote/Local functions are supported. PP0 No Parallel Poll function. DC1 All Device Clear functions are supported. DT1 All Device Trigger functions are supported. C0 No Controller functions are supported.

■ Communications functionality

Remote function	During remote operation by USB, RS-232C or GP-IB, all front panel key operations are disabled. Remote operation is canceled as follows: • LOCAL key, Reset, At power-on • By USB, RS-232C or GP-IB **:SYSTem:LOCal** command • By GP-IB **GTL** command
Communications monitor function	Displays the send/receive status of commands and queries. Setting: ON/ OFF
Data output function	During INT trigger source operation, measured values are output at TRIG signal or **ENTER** key input. During EXT trigger source operation, measured values are automatically output each time measurement completes. (USB keyboard mode is available during INT trigger source use only.) ON/ OFF
Memory function	Measured values stored in the instrument's memory are sent at once. (The memory function is automatically turned off when using the MUX measurement terminal setting.) No. of memory: 50 (volatile memory, no backup) ON/ OFF
Default setting	Communications monitor function: OFF, Data output: OFF, Memory function: OFF

(4) EXT I/O

Input Signals	TRIG (IN0), CAL, KEY_LOCK, 0ADJ, PRINT (IN1), MUX, SCN_STOP, LOAD0 to LOAD5 Valid only with BCD mode output: BCD_LOW Optocoupler-isolated : no-voltage contact inputs (current sink/source output compatible) Input ON : Residual voltage; 1 V or less (Input ON current: 4 mA (reference value)) Input OFF : OPEN (shutoff current: 100 µA or less) Response time : ON edge; Max. 0.1 ms, OFF edge; Max. 1.0 ms
Output Signals	Output mode switching: JUDGE mode/ BCD mode 1. JUDGE mode: EOM, ERR, INDEX, HI, IN, LO, T_ERR, T_PASS, T_FAIL, BIN0 to BIN9, OB, OUT0 to OUT2 2. BCD mode: EOM, ERR, IN, HILO When BCD_LOW is ON : BCD1 to BCD3 × 4 digits, RNG_OUT0 to RNG_OUT3 When BCD_LOW is OFF: BCD4 to BCD7 × 4 digits Optocoupler-isolated : 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/ch Default setting : JUDGE mode

■ Trigger Source Setting

Setting	INT (Internal)/ EXT (External) (when using the MUX measurement terminals with the scan function set to AUTO or STEP, fixed to EXT)
Default setting	INT (Internal)

■ TRIG/PRINT filter function

Setting	ON/ OFF
Operation	During the response time, signal processing is performed only while the input signal is held in the on state.
Response time	50 to 500 ms
Default setting	OFF, 50 ms

■ TRIG Logic Setting

Setting	OFF edge/ ON edge
Default setting	ON edge

■ EOM output timing setting

Setting	HOLD/ PULSE
Operation	When using an external trigger source with the HOLD setting, the on state is held until the next TRIG signal or 0ADJ signal is input. When using an external trigger source with the PULSE setting, the off state is held after the pulse width setting has elapsed. When using the internal trigger source, EOM output is fixed to pulse output with a width of 5 ms (when using auto self-calibration) or no EOM output is generated (when using manual self-calibration), regardless of the EOM output timing setting.
Pulse width	1 ms to 100 ms
Default setting	HOLD, 5 ms

■ EXT I/O test function

Operation	Displays the EXT I/O input signal state and generates output signals as desired.

■ External power output

Output voltage	Sink output: 5.0 V ±10%, source output: -5.0 V ±10%, 100 mA max.
Isolation	Floating from protective ground potential and measurement circuit
Insulation rating	Terminal to ground voltage: Not more than 50 VDC, 30 Vrms AC, and 42.4 Vpk AC

(5) Multiplexer (RM3545-02 only)

(For more information about the Z3003 Multiplexer Unit, see page 139.)

Number of installed units	Max. 2
Measurement terminal settings	Front terminals/ MUX (multiplexer) (When using the MUX measurement terminals, the memory function is fixed to off. If the statistical calculation function or BIN function is set to on, the measurement terminal setting will be automatically set to the front terminals.) When using the MUX setting, the measurement leads cannot be connected to the front measurement terminals.
Supported unit	Z3003
Z3003 control specifications	
Measurement method	2-wire/ 4-wire (When using 2-wire, the minimum measurement range is the 100 Ω range, and the contact check is fixed to the OFF setting.)
Scan function	OFF/ Auto (measure all channels at each TRIG signal)/ Step (measure 1 channel at each TRIG signal) (When the scan function is set to auto or step, the trigger source is fixed to EXT.) FAIL stop ON/ OFF
Channel settings	The A and B terminals of each channel can be individually assigned to user-specified terminals. The measurement current will flow from the B terminal to the A terminal. Channel: Enable/ disable A terminal : 10 terminals (4-wire) or 21 terminals (2-wire) per unit as specified by the user B terminal : 10 terminals (4-wire) or 21 terminals (2-wire) per unit as specified by the user Measuring instrument selection: Instrument measurement / external device measurement The following measurement conditions can be set by channel. resistance range, 100 mΩ range high-precision mode, Low-Power resistance measurement (LP), switching measurement currents, measurement speed, zero-adjustment, average, delay, temperature correction (TC), offset voltage compensation (OVC), scaling, contact improver, contact check, comparator, temperature conversion (ΔT)
Relay hot switching prevention function	The current between current-generating terminals (between SOURCE terminals) is monitored and relay switching is controlled so that it does not occur until the current falls below a certain level.
Contact cycle count recording function	Recorded contacts All Maximum recordable number 999,999,999 contacts
Number of channels that can be set	42
Switching time	30 ms (reference value, not including measurement time and range switching time)

Default setting

Measurement method: 4-wire, Scan function: Auto, FAIL stop: OFF, channel default settings as follows (default measurement conditions)

4-wire

Channel no.	Channel	Unit	A terminal	B terminal
1	Enabled	1	TERM A1	TERM B1
2 to 10	Disabled	1	TERM A2 to TERM A10	TERM B2 to TERM B10
11 to 20	Disabled	2	TERM A1 to TERM A10	TERM B1 to TERM B10
21 to 42	Disabled	1	TERM A1	TERM B1

2-wire

Channel no.	Channel	Unit	A terminal	B terminal
1	Enabled	1	TERM A1	TERM B1
2 to 21	Disabled	1	TERM A2 to TERM A21	TERM B2 to TERM B21
22 to 42	Disabled	2	TERM A1 to TERM A21	TERM B1 to TERM B21

(6) D/A Output

Output	Resistance measured value (display value after zero-adjustment and temperature correction but before scaling and ΔT calculation)
Output voltage	0 V (corresponds to 0 dgt.) to 1.5 V DC* If a measured value fault occurs, 1.5 V; if the measured value is negative, 0 V * For a 1,200,000 dgt. display, corresponds to 1.2 V (1,200,000 dgt.). For a 120,000 dgt. display, corresponds to 1.2 V (120,000 dgt.). For a 12,000 dgt. display, corresponds to 1.2 V (12,000 dgt.). For a display in excess of 1.5 V, fixed at 1.5 V.
Maximum output voltage	5 V
Output impedance	1 kΩ
Number of bits	12bit

(7) L2105 LED Comparator Attachment output

Output	Comparator judgment output (two outputs: Hi and Lo/IN)
Output jack	3-pole earphone jack (ϕ2.5 mm)
Output voltage	5 V±0.2 V DC, 20 mA

Environment and Safety Specifications

Operating environment	Indoors, Pollution degree 2, up to 2000 m (6562-ft.) ASL
Storage temperature and humidity	-10°C to 50°C (14 to 122°F), 80%RH or less (non-condensating)
Operating temperature and humidity	0°C to 40°C (32 to 104°F), 80%RH or less (non-condensating)
Dielectric strength	1.62 kV AC for 1 min, Cutoff current 10 mA, between all power terminals and protective ground, interfaces, and measurement terminals
Applicable Standards **Safety** **EMC**	 EN61010 EN61326 Class A Effect of radiated radio-frequency electromagnetic field: 3%f.s. at 10V/m Effect of conducted radio-frequency electromagnetic field: 2%f.s. at 3 V
Power source	Rated supply voltage: 100 to 240 VAC (Voltage fluctuations of ±10% from the rated supply voltage are taken into account) Rated supply frequency: 50/60 Hz Anticipated transient overvoltage: 2,500 V
Maximum rated power	40 VA
Dimensions	Approx. 215W × 80H × 306.5D mm (8.46"W × 3.15"H × 12.07"D)
Mass	Approx. 2.5 kg (88.2 oz.) (RM3545, RM3545-01) Approx. 3.2 kg (112.9 oz.) (RM3545-02)
Product warranty period	3 years

Accessories

- Power Cord (2-line + ground) (1)
- Model L2101 Clip Type Lead (1)
- Model Z2001 Temperature Sensor (1)
- EXT I/O Male Connector (1)
- Instruction Manual (1)
- Application disc (1)
- USB cable (A - B type) (1)
- Spare Fuse (F1.6AH/250V) (1)

Options

- Model L2101 Clip Type Lead
- Model L2102 Pin Type Lead
- Model L2103 Pin Type Lead
- Model L2104 4-Terminal Lead
- Model L2105 LED Comparator Attachment
- Model Z2001 Temperature Sensor
- Model Z3003 Multiplexer Unit
- Model 9637 RS-232C Cable
(9pin-9pin/ 1.8 m/ crossover cable)
- Model 9638 RS-232C Cable
(9pin-25pin/ 1.8 m/ crossover cable)
- Model 9151-02 GP-IB Connector Cable (2 m)

13.2 Z3003 Multiplexer Unit

General Specifications

(1) Measurement targets (wiring order is user-selected)

4-wire	10 locations (when using two Z3003 units, 20 locations)
2-wire	21 locations (when using two Z3003 units, 42 locations)

(2) Multiplexer I/O (direction of current application is fixed)

Measurement Terminals (4-wire)	TERM A1 to TERM A10 terminal, TERM B1 to TERM B10 terminal (TERM terminal: combinations of the following terminals SOURCE terminal: Current source terminal, SENSE terminal: Voltage detection terminal) EX SOURCE A, EX SOURCE B: External device connection terminal (current) EX SENSE A, EX SENSE B : External device connection terminal (voltage)
Measurement Terminals (2-wire)	TERM A1 to TERM A21 terminal, TERM B1 to TERM B21 terminal EX A, EX B: External device connection terminal
Shielding terminal	GUARD : Guard terminal EARTH : Function ground terminal EX GUARD : External device guard terminal
Connector	D-SUB 50pin receptacle

(3) Pinouts

4-wire

No.	Pin name		No.	Pin name		No.	Pin name	
1	-	-	18	TERM B5	SOURCE	34	TERM B9	SOURCE
2	TERM B1	SOURCE	19		SENSE	35		SENSE
3		SENSE	20	TERM A5	SOURCE	36	TERM A9	SOURCE
4	TERM A1	SOURCE	21		SENSE	37		SENSE
5		SENSE	22	TERM B6	SOURCE	38	TERM B10	SOURCE
6	TERM B2	SOURCE	23		SENSE	39		SENSE
7		SENSE	24	TERM A6	SOURCE	40	TERM A10	SOURCE
8	TERM A2	SOURCE	25		SENSE	41		SENSE
9		SENSE	26	TERM B7	SOURCE	42	-	-
10	TERM B3	SOURCE	27		SENSE	43	GUARD	
11		SENSE	28	TERM A7	SOURCE	44	GUARD	
12	TERM A3	SOURCE	29		SENSE	45	EX SOURCE B (EX Cur Hi)	
13		SENSE	30	TERM B8	SOURCE	46	EX SENSE B (EX Pot Hi)	
14	TERM B4	SOURCE	31		SENSE	47	EX SENSE A (EX Pot Lo)	
15		SENSE	32	TERM A8	SOURCE	48	EX SOURCE A (EX Cur Lo)	
16	TERM A4	SOURCE	33		SENSE	49	EX GUARD	
17		SENSE				50	EARTH	

2-wire

No.	Pin name	No.	Pin name	No.	Pin name
1	TERM A1	18	TERM B9	34	TERM B17
2	TERM B1	19	TERM B10	35	TERM B18
3	TERM B2	20	TERM A10	36	TERM A18
4	TERM A2	21	TERM A11	37	TERM A19
5	TERM A3	22	TERM B11	38	TERM B19
6	TERM B3	23	TERM B12	39	TERM B20
7	TERM B4	24	TERM A12	40	TERM A20
8	TERM A4	25	TERM A13	41	TERM A21
9	TERM A5	26	TERM B13	42	TERM B21
10	TERM B5	27	TERM B14	43	GUARD
11	TERM B6	28	TERM A14	44	GUARD
12	TERM A6	29	TERM A15	45	EX B (EX Hi)
13	TERM A7	30	TERM B15	46	EX B (EX Hi)
14	TERM B7	31	TERM B16	47	EX A (EX Lo)
15	TERM B8	32	TERM A16	48	EX A (EX Lo)
16	TERM A8	33	TERM A17	49	EX GUARD
17	TERM A9			50	EARTH

(4) Measurable range

Measurement current	Instrument with Z3003: 1 A DC or less Externally connected device: 1 A DC or less, 100 mA AC or less
Measurement frequency	Externally connected device: DC, 10 Hz to 1 kHz

(5) Contact specifications

Contact type	Mechanical relay
Maximum allowable voltage	30 V RMS and 42.4 V peak or 60 V DC
Maximum allowable power	30 W (DC) (Resistance load)
Contact service life	4-wire: 50 million cycles, 2-wire: 5 million cycles (reference value)

Measurement Specifications

(1) Conditions of guaranteed accuracy

Warm-up time	Same as instrument with the Z3003.
Temperature and humidity range for guaranteed accuracy	23°C±5°C (73°F±9°F), 80%RH or less
Period of guaranteed accuracy	1 year
Accuracy specifications conditions	When using a 2-wire setup, accuracy is guaranteed only after zero-adjustment.
Temperature coefficient	From 0°C to 18°C and 28°C to 40°C, add a temperature coefficient of ±(1/10 of additional accuracy)/°C.

(2) Additional accuracy (Add the following error components to the instrument's measurement accuracy.)

Effects of leak current	Add a reading error as follows depending on the measurement current (when using guarding) (With humidity of less than 70% RH. If the humidity is greater than or equal to 70% RH, add the following rdg. error × 5.): $\frac{1 \times 10^{-9}\ [\mathrm{A}]}{I_{\mathrm{MEAS}}\ [\mathrm{A}]} \times 100\ [\%\mathrm{rdg.}]$ I_{MEAS} : Measurement current
Effect of measurement speed	Add the f.s. error component as follows when the integration time is not a whole-number multiple of the power supply cycle: $A_{\mathrm{fs}} \times 0.5\ [\%\mathrm{f.s.}]$ A_{fs} : f.s. error component for instrument with the Z3003
Effect of offset voltage	Add the following resistance to the error when OVC is OFF $\frac{10 \times 10^{-6}\ [\mathrm{V}]}{I_{\mathrm{MEAS}}\ [\mathrm{A}]}\ [\Omega]$ I_{MEAS} : Measurement current
Effect of offset resistance fluctuations	When using a 2-wire setup, add the following wiring resistance to the error component. 0.1 [Ω]

(3) Internal offset resistance

Internal measurement circuit resistance value	0.5 Ω (default)

About Instrument Accuracy

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

f.s.	(maximum display value) This is usually the name of the maximum displayable value. For this instrument, it indicates the currently selected range.
rdg.	(reading or displayed value) The value currently being measured and indicated on the measuring instrument.
dgt.	(resolution) The smallest displayable unit on a digital measuring instrument, i.e., the input value that causes the digital display to show a “1” as the least-significant digit.

Example accuracy calculations

(Digits in excess of display range are truncated.)

- **Resistance measurement accuracy when using the Z3003**

RM3545 measurement conditions: 100 kΩ range, measurement current of 100 μA, OVC off, 0ADJ on, FAST, measurement target of 30 kΩ
Resistance measurement accuracy ±(0.008%rdg.+0.005%f.s.)

The accuracy error component is calculated first, and then the total error component is calculated.

(1) Calculating the accuracy error component

- Effects of leak current
  The effects of leak current are determined based on the ratio of leak current to measurement current. The result is added to the reading error (rdg.).

  Additional error : $A = (1\times10^{-9}) / (100\times10^{-6})\times100 = 0.001$%rdg.

- Effect of measurement speed (During FAST measurement, the integration time is not a whole-number multiple of the power supply cycle.)
  If the integration time is not a whole-number multiple of the power supply cycle, the effects of commercial power noise will be more pronounced.

  Additional error : $B = 0.005\times0.5 = 0.0025$ [%f.s.]

- Effect of offset voltage
  The relay and connector thermoelectric force is observed as a measured value offset. When using with OVC on, there is no need to add this.

  Additional error : $C = (10\times10^{-6}) / (100\times10^{-6}) = 0.1\ \Omega$

- Effect of offset resistance fluctuations
  During 2-wire operation, results are affected by fluctuations in the internal offset resistance.

  Additional error : $D = +0.1\ \Omega$

(2) Calculating the total error component

4-wire: $E = \pm((0.008+A)\%\times30\ \text{k}\Omega+(0.005+B)\%\times100\ \text{k}\Omega+C) = \pm10.3\ \Omega$
2-wire: $E + D = +10.4\ \Omega, -10.3\ \Omega$

Functions

(1) Contact cycle count recording function

A contact cycle count of up to 999,999,999 can be recorded using control from the instrument with the Z3003.

(2) Unit Test

By shortting all the pins numbered 1 to 42, each measurement pin's round-trip wiring resistance value in the 2-terminal resistance measurement state can be checked using control from the instrument with the Z3003.

(3) Relay hot switching prevention function

The current flowing between the current generation terminals (SOURCE terminals) can be monitored using control from the instrument with the Z3003.

Environment and Safety Specifications

Operating environment	Indoors, Pollution degree 2, up to 2000 m (6562-ft.) ASL
Storage temperature and humidity	-10°C to 50°C (14 to 122°F), 80%RH or less (non-condensating)
Operating temperature and humidity	0°C to 40°C (32 to 104°F), 80%RH or less (non-condensating)
Applicable Standards	
Safety	EN61010
EMC	EN61326 Class A Effect of radiated radio-frequency electromagnetic field: 5%f.s. at 10V/m (added to the effect on the instrument with the Z3003) Effect of conducted radio-frequency electromagnetic field: 5%f.s. at 3 V (added to the effect on the instrument with the Z3003)
Dimensions	Approx. 92W × 24.5H × 182D mm (3.62"W × 0.96"H × 7.17"D) (excluding protrusions)
Mass	Approx. 180 g (6.3 oz.)
Product warranty period	3 years Relays: Not covered by the warranty

Accessories

Instruction Manual	1
D-SUB 50-pin connector	1 (pin header, solder cup)

Maintenance and Service

Chapter 14

Calibrations

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

The calibration frequency varies depending on the status of the instrument or installation environment. We recommend that the calibration frequency is determined in accordance with the status of the instrument or installation environment and that you request that calibration be performed periodically.

NOTE

If damage is suspected, check the "Q&A (Frequently Asked Questions)" (p.286) section before contact your authorized Hioki distributor or reseller.

Transporting

- Use the original packing materials when transporting the instrument, if possible.
- Pack the instrument so that it will not sustain damage during shipping, and include a description of existing damage. We do not take any responsibility for damage incurred during shipping.

Cleaning

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

IMPORTANT
Never use solvents such as benzene, alcohol, acetone, ether, ketones, thinners or gasoline, as they can deform and discolor the case.

14.1 Troubleshooting

Q&A (Frequently Asked Questions)

The following tables provide information about general issues. For more information about issues related to measured values, the multiplexer, or the instrument's external interfaces, see the following pages.

If you are unable to find information about a particular issue, please contact your distributor.

1. General issues

No	Issue	Items to check		Possible causes → Solutions	See
1-1	The instrument cannot be turned on. (The display shows nothing.)	Color of the STANDBY key	Green	The display settings have not been configured correctly. →Adjust the backlight brightness and contrast.	p.132 p.131
			Red	The instrument is in the standby state. →Press the STANDBY key.	p.43
			None (Off)	The instrument is not receiving power. →Check the continuity of the power cord. →Verify that a circuit breaker has not been tripped. →Turn on the main power switch (on the back of the instrument).	p.43
				The supply voltage or frequency is incorrect. →Check the power supply ratings (100 to 240 V, 50/60 Hz).	
1-2	The keys are unresponsive.	Display	LOCK is shown.	The key lock function is active. →Cancel the key lock function. →Turn OFF the EXT I/O KEY_LOCK signal.	p.127
			RMT is shown.	The instrument is in the remote state. →Cancel the remote state.	p.232
			Panel name is shown.	A panel load operation has been triggered by the EXT I/O. →Turn off the EXT I/O's LOAD signal.	p.89
			Neither LOCK nor RMT and panel name is shown.	Certain functions cannot be used simultaneously. →See the list of functional limitations.	p.296
1-3	The instrument's comparator lamp will not turn on.	Measured values	Displayed	The comparator function is OFF. →Turn ON the function.	p.100
			Not displayed (Display other than value)	If the measured value is not being displayed, no judgment will be made, and the lamp will not turn on.	–

No	Issue	Items to check		Possible causes → Solutions	See
1-4	The LED Comparator Attachment will not turn on.	Instrument's comparator lamp	On	The attachment is not properly connected. →Connect the LED Comparator Attachment properly to the COMP.OUT jack.	p.107
				There is a broken connection. →Replace the LED Comparator Attachment.	–
			Off	See No. 1-3 above, "The instrument's comparator lamp will not turn on."	p.286
1-5	The beeper is not audible.	Key operation sound setting	OFF	The function is OFF. →Turn ON the function.	p.128
		Judgment sound setting	OFF	The function is OFF. →Turn ON the function.	p.105
1-6	You wish to change the beeper volume.	The instrument's beeper volume cannot be changed.		–	–

2. Measurement issues

No	Issue	Items to check		Possible causes → Solutions	See
2-1	Measured values are unstable.	Effects of noise	Susceptibility to noise	See Appendix 9(1)(2).	p.A20 p.A22
		Measurement leads	Clip-type leads	See Appendix 7(3).	p.A13
			Wiring becomes two-terminal wiring in middle.	See Appendix 7(12).	p.A18
		Measurement target	Wide or thick	See Appendix 7(4).	p.A14
			Temperature is unstable (just manufactured, just opened, being held by hand, etc.).	See Appendix 7(5).	p.A14
			Low heat capacity	See Appendix 7(6).	p.A15
			Transformer, motor, choke coil, solenoid	See Appendix 7(9)(10), Appendix 9(1).	p.A16 p.A16 p.A20

No	Issue	Items to check		Possible causes → Solutions	See
2-1	Measured values are unstable.	TC	ON	The temperature sensor is not appropriately positioned. →Move the temperature sensor closer to the measurement target. →Position the temperature sensor so that it is not exposed to wind. →If the response to the measurement target's temperature change is slower than the temperature sensor's response, increase the response time by covering the temperature sensor with something. The temperature sensor's response time is about 10 minutes (reference value).	p.17
			OFF	The measurement target's resistance value is changing due to the temperature, for example because the room temperature has not stabilized. →Turn ON temperature correction (TC).	p.75
		OVC	OFF	The measurement is affected by thermal EMF. →Turn ON the OVC function.	p.82
2-2	Measured values differ from expected values. (A negative value is shown.)	Zero-adjustment	ON	Zero-adjustment is not accurate. →Perform zero-adjustment again.	p.68 p.52
			OFF	Values are being affected by wiring resistance or thermoelectric power due to two-terminal measurement. →Perform zero-adjustment.	p.68
		Scaling function	ON	The offset setting is incorrect. →Turn scaling OFF, or reconfigure the setting properly.	p.77 p.52
				The measurement leads are not connected properly. →Check the connections.	p.51 p.52
		Other: See No. 2-1 above.			p.287

No	Issue	Items to check		Possible causes → Solutions	See
2-3	No measured value is displayed. (Concerning the display of measured value faults, see also p.55.)	Measured values	- - - - - - - -	There is a break in the measurement leads. →Replace the measurement leads.	p.36
				The contact resistance is too high (for user-made leads). →Increase the contact pressure. →Clean or replace the probe tips. →Use a range with a low measurement current or set the measurement current to low.	p.57 p.66
				The wiring resistance is too high (for user-made leads). →Make the wiring thicker and shorter. →Use a range with a low measurement current or set the measurement current to low.	p.57 p.66
			CONTACT TERM.A, **CONTACT TERM.B**	The probe is worn. There is a break in the measurement leads. →Replace the measurement leads.	p.36
				The probe is not coming into contact with the measurement target. →Place the probe in proper contact with the target.	–
				The resistance value between the SENSE and SOURCE is high because the measurement target is conductive paint, conductive rubber, or a similar material. →Turn the contact check function off.	p.88
			OvrRng	The measurement range is low. →Select a high-resistance range or use auto-ranging.	p.49
			SW.ERR **ERR:061**	A multiplexer relay hot-switching prevention function error has occurred. →The relay cannot be switched because the current from the measurement target has not decreased. Increase the delay setting since the measurement circuit may be being influenced by back EMF from a transformer or other device. Do not apply any current or voltage to the measurement terminals.	p.55
			NO UNIT	No multiplexer unit has been inserted. →Insert the unit properly. Do not allocate units that have not been inserted to channels.	p.42

No	Issue	Items to check		Possible causes → Solutions	See
2-3	No measured value is displayed.	Measured values	Nothing is shown.	Auto-ranging is not selecting a range. →See No. 2-4 below.	p.290
			No measured value is shown, even if the measurement leads are shorted.	The fuse may have tripped. →Cycle the instrument's power and perform the self-test to check whether the fuse has tripped. →When using the multiplexer, if the measured value is not displayed after replacing the measurement fuse, the multiplexer unit's fuse may have tripped. Have the Z3003 repaired. The measurement and guard terminals can short each other. →Check whether the measurement leads are damaged.	p.44
2-4	Auto-ranging is not selecting a range. (The range is not appropriate.)	Measurement target	Transformer, motor	Auto-ranging is not able to select a range for measurement targets that have high inductance. →Use a fixed range.	p.49
		Noise may be affecting measurement.		See Appendix 9(1)(2).	p.A20
2-5	It is impossible to perform zero-adjustment.	Measured values before zero-adjustment exceed -1% to 50% of each range full-scale, or a measurement fault has occurred.		There is a problem with the wiring. →Repeat zero-adjustment with the correct wiring. Since zero-adjustment cannot be performed if the resistance value is too high, for example with a user-made cable, work to minimize the wiring resistance.	p.A7
2-6	The auto-hold function is not working (hold operation is not being canceled).	Measured values	Are unstable.	See No. 2-1 above, “Measured values are unstable.”	p.287
			Do not change.	An appropriate range has not been selected. →Select an appropriate range or use auto-ranging.	p.49
2-7	Measured temperature is displayed incorrectly.			The temperature sensor or thermometer is not properly connected. →Connect the temperature sensor by inserting the plug all the way. The settings have been improperly configured. →Check the settings. A temperature sensor other than that specified is used. →Model 9451 Temperature Probe is not supported.	p.37 p.39

3. EXT I/O issues

The EXT I/O test (p.218) function can be used to more easily check operation.

No	Issue	Items to check	Possible causes→Solutions	See
3-1	The instrument is not operating at all.	The IN and OUT values displayed on the instrument's EXT I/O test do not agree with the controller.	The wiring is incorrect. →Check EXT I/O (p.177) again. • A connector is disconnected. • A pin number is incorrect. • ISO-COM pin wiring • NPN/PNP setting • Contact (or open collector) control (voltage does not provide control) • Supply of power to the controller (power cannot be supplied to the instrument)	p.177
3-2	The TRIG signal is not working.	The trigger source is set to the internal trigger (INT).	If the internal trigger setting is being used, the TRIG signal will not serve as a trigger. →Select the external trigger setting.	p.209
		The TRIG ON time is less than 0.1 ms.	The TRIG ON time is too short. →Ensure that the ON time is at least 0.1 ms.	
		The TRIG OFF time is shorter than 1 ms.	The TRIG OFF time is too short. →Ensure that the OFF time is at least 1 ms.	
		The TRIG/PRINT signal filter function is ON.	A longer signal control time is required. →Increase the signal ON time. →Turn OFF the filter function.	p.213
		The **:INIT:CONT** (command) is OFF.	The instrument is not in the trigger wait state. →Send the **:INIT** or **:READ?** command.	
3-3	The instrument will not print.	The interface setting is not set to the printer.	The setting must be configured. →Set the interface to the printer.	p.241
		The TRIG/PRINT signal filter function is ON.	A longer signal control time is required. →Turn OFF the function.	p.213
3-4	The instrument will not load panel data.	No panel has been saved using the panel number that you are trying to load.	The instrument cannot load a panel that has not been saved. →Change the LOAD signal or re-save the panel before the LOAD signal is asserted.	
3-5	The channels cannot be switched with the LOAD signal.	The channel numbers have not been set. The channels have been disabled. The scan function has been turned off.	The scan settings have been improperly configured. →Check the scan settings.	p.148

No	Issue	Items to check		Possible causes→Solutions	See
3-6	EOM is not being output.	The measured value is not being updated.		See No. 3-2 above.	p.291
		EOM signal logic		(The EOM signal turns ON when measurement completes.)	–
		EOM signal setting	Pulse	The pulse width is too narrow, and the EOM signal is not being read while it is on. →Increase the EOM signal's pulse width setting or set the EOM signal setting to "hold."	p.215
			Hold	The measurement time is too short, and the interval during which the EOM signal is OFF cannot be detected. →Change the EOM signal setting to "pulse."	p.215
3-7	The Hi, IN and Lo signals are not being output.	The instrument's comparator lamp is off.		See No. 1-3 above.	p.286
		The output mode is set to BCD.		Change to judgment mode (in BCD mode, the result of a logical OR operation applied to Hi and Lo is output from one signal line).	p.217
3-8	T_PASS, T_FAIL and T_ERR signals are not being output.	The scan function is off. Measurement of all channels has not completed.		The scan settings have been improperly configured. →Check the scan settings.	p.148
3-9	The BCD signal is not being output.	The output mode is judgment mode.		Change to BCD mode.	p.217
		The BCD_LOW signal is not being controlled.		Control the BCD_LOW signal (failure to do so will cause only the upper digits to be output).	p.182
3-10	The RANGE_OUT signal is not being output.	The BCD_LOW signal is not being controlled.		Control the BCD_LOW signal (failure to do so will cause the range_out signal not to be output).	p.182
3-11	The multiplexer channels cannot be switched with the LOAD signal.	The MUX signal is not on.		Turn on the MUX signal.	p.182

4. Communications issues

The communications monitor (p.233) function can be used to more easily check operation.

No	Issue	Items to check		Possible causes→Solutions	See
4-1	The instrument is not responding at all.	Display	**RMT** is not being displayed.	No connection has been established. →Check whether the connector has been connected. →Check whether the interface settings have been configured properly. →(USB) Install the driver on the control device. →(RS-232C) Use a cross cable. →(USB, RS-232C) Check the COM port number on the control device. →(RS-232C) Use the same communications speed for the instrument and the control device.	p.223
			RMT is being displayed.	Commands are not being accepted. →Check the software delimiter. →(GP-IB) Check the message terminator setting. →(GP-IB) Check whether the address setting has been configured properly.	p.231
4-2	An error is being encountered.	Display	Command error	The command isn't being recognized as a valid instruction. →Check the spelling of the command (space: x20H). →Do not append a question mark to commands that are not queries. →(RS-232C) Use the same communications speed for the instrument and the control device.	
				The input buffer (256 bytes) is full. →Insert a dummy query after sending several lines of commands. Example: Send `*OPC?` → Receive `1`	
			Execution error	The command string is correct, but the instrument is not able to execute it. Examples: • When set during scanning • The data portion was spelled incorrectly. `:SAMP:RATE SLOW3` →Check the specifications of the command(s) in question.	
				The input buffer (256 bytes) is full. →Insert a dummy query after sending several lines of commands. Example: Send `*OPC?` → Receive `1`	
4-3	The instrument fails to respond to queries.	Communications monitor	No response	The `:TRIG:SOUR EXT` setting is being used, and the instrument is waiting for the trigger after `:READ?` transmission. →Check the command specifications.	
			Response	There is a mistake in the program. →Check the receive portion of the program.	
4-4	The instrument cannot switch to multiplexer channels or load the multiplexer.	Front measurement terminals	Measurement leads are connected	Measurement leads are connected to the measurement terminals on the front of the instrument. →Do not connect measurement leads to the measurement terminals on the front of the instrument when using the multiplexer.	

5. Printer issues

No	Issue	Items to check	Possible causes→Solutions	See
5-1	No data is being printed.		The printer is not connected. →Check whether the connector has been connected. →Check whether the interface setting is correct. If using the PRINT signal, see No. 3-3 above.	p.239 p.291
5-2	Printed text is garbled		The printer and instrument settings do not match. →Check the printer settings again.	

6. Multiplexer issues

No	Issue	Items to check		Possible causes→Solutions	See
6-1	It is not possible to switch to the multiplexer inputs.	Display	**ERR:60**	Measurement leads are connected to the measurement terminals on the front of the instrument. →Do not connect any measurement leads to the measurement terminals on the front of the instrument. If **ERR:60** is displayed even though no measurement leads are connected, turn off the instrument and remove the Z3003. If **ERR:60** is no longer displayed after removing the Z3003, the Z3003 may be broken. Have it repaired.	p.148
6-2	Channels cannot be switched by operating the instrument's keys.		**CH** is not being displayed.	The front terminals are being used as the measurement terminals. →Set the measurement terminals to MUX.	p.148
			Scan display (set to list display)	The scan function is set to auto or step. →Set the scan function to OFF in order to switch channels with key operation.	p.148
				The set unit number and the unit number in which the Z3003 is installed differ. →Check the settings and the unit on the back of the instrument.	p.148 p.42
			RMT is being displayed.	The instrument is in remote mode, in which it is controlled by communications functionality. →Operate the instrument after canceling remote mode.	p.232
6-3	Channels cannot be switched with EXT I/O.			The MUX signal is not on. →Turn on the MUX signal.	p.182

No	Issue	Items to check		Possible causes→Solutions	See
6-4	Measured values are unstable.			See No. 2-1 above.	p.287
6-5	The measured value differs from the expected resistance value.			The wrong channel is being measured. →Check the current channel and the channel setting.	p.152
				The wiring is shorted. →Check the wiring.	
				The wiring resistance is high. →For 2-wire connection, the wiring resistance affects the measured value as-is. Perform zero-adjustment.	p.164
				Measurement leads are connected to the measurement terminals on the front of the instrument. →Do not connect measurement leads to the measurement terminals on the front of the instrument when using the multiplexer.	p.142
6-6	No measured value is displayed.			The wrong channel is being measured. →Check the current channel and the channel setting.	p.152
		Display	**NO UNIT**	The set unit number and the unit number in which the Z3003 is installed differ. →Check the settings and rear of the unit.	p.148 p.42
				The connected device is set to an external device. →Set the connected device to the RM3545.	p.156
				The relays are worn. →Perform the Multiplexer Unit test. If it yields a FAIL result, have the Z3003 repaired.	p.167 p.303
				The wiring is shorted. →Check the wiring.	
				→See No. 2-3 above.	p.289
				Fuse blown →Check the wiring. If you are still unable to perform measurement, the internal protective fuse may have blown. Have the Z3003 repaired.	p.146

No	Issue	Items to check	Possible causes→Solutions	See
6-7	Zero-adjustment values are not being applied.	Check whether zero-adjustment has been performed for each channel on the Multiplexer Basic Measurement screen.	→Zero-adjustment is performed separately for the front terminals and for each channel, so you will need to perform it for each channel (scanning zero-adjustment can also be performed).	p.164
6-8	Zero-adjustment cannot be performed.	Measured values before zero-adjustment exceed -1% to 50% of each range full-scale, or a measurement fault has occurred.	The wiring resistance is too high. →Zero-adjustment cannot be performed when the wiring resistance is too high. Modify your setup so that the wiring resistance is less than 50% of the measurement target.	p.A7
		The connected device is set to an external device.	Zero-adjustment cannot be performed for channels whose connected device is an external device. →Set the connected device to the RM3545.	
6-9	The unit test generates a FAIL result.		The relays are worn. The fuse in the unit is blown out. →Have the Z3003 repaired.	p.303
6-10	Switching is too slow.		The relay hot switching prevention function is being triggered because back EMF is remaining when measuring a transformer. →Use a high-resistance range or lower the measurement current, for example by using the low current switching setting.	p.142

Function limitations (√: Compatible, –: Incompatible)

	COMP	TC	ΔT	BIN	MUX	STAT	AUTO RANGE, RANGE change
COMP		√	–	–	√	√	–
TC	√		–	√	√	√	√
ΔT	–	–		–	√	–	√
BIN	–	√	–		–	√	–
MUX	√	√	√	–		–	√
STAT	√	√	–	√	–		√
AUTO RANGE, RANGE change	–	√	√	–	√	√	

- When low-power resistance measurement is on, OVC will be fixed to on and contact improvement will be fixed to off. During SLOW2 operation, two-iteration averaging is used even if the averaging function is off.
- When the multiplex scan function is set to auto or step, the trigger source is automatically set to EXT, and the communications function’s memory function will not be available for use.
- When using the multiplexer in 2-wire mode, neither the contact check function nor ranges of less than 1000 mΩ will be available for use.

External Control (EXT I/O) Q&A

Common Questions	Answers
How do I connect external trigger input?	Connect the TRIG signal to an ISO_COM pin using a switch or open-collector output.
Which pins are common ground for input and output signals?	The ISO_COM pins.
Are the common (signal ground) pins shared by both inputs and outputs?	Use ISO_COM as the common pin for input and output signals. The ISO_COM pin serves as the shared common pin.
How do I confirm output signals?	Confirm voltage waveforms with an oscilloscope. To do this, the output pins such as EOM and comparator judgment outputs need to be pulled up (through several kΩ).
How do I troubleshoot input (control) signal issues?	For example, if TRIG signal does not operate properly, bypass the PLC and short the TRIG pin directly to an ISO_COM pin. Be careful to avoid power shorts.
Are the comparator judgment signals retained during measurement (or can they be off)?	When using the external trigger [EXT] setting, the state is determined at the end of measurement, and is off once at the start of measurement. When using the internal trigger [INT] setting, judgment results are held during measurement.
What situations cause measurement faults to occur?	An error is displayed in the following cases: • A probe is not connected • A contact is unstable • A probe or measurement target is dirty or corroded • Measurement target resistance is much higher than the measurement range
Is a connector or flat cable for connection provided?	A solder-type connector is supplied. The cable must be prepared at the user's side.
Is direct connection to a PLC possible?	If the PLC's outputs are relays or open collectors and the PLC's input circuit supports contact input, it can be connected directly. (Before connecting, confirm that voltage and current ratings will not be exceeded.)
Can external I/O be used at the same time as RS-232C or other communications?	After setting up communications, it is possible to control measurement with the TRIG signal while acquiring measurement data via a communications interface.
How should external power be connected?	The instrument's external I/O input and output signals all operate from an internal isolated power source, so power must not be supplied from the PLC side. (Supplying power into the ISO_5V terminal is prohibited.)
Can free-running measured values be acquired using a footswitch?	Measured values can be acquired using the sample application. The sample application can be downloaded from the Hioki website (http://www.hioki.com).

Error Displays and Remedies

The following messages are displayed when the instrument detects an error or abnormal measurement setting. If repair is necessary, contact your authorized Hioki distributor or reseller.

- If damage is suspected, check the "Q&A (Frequently Asked Questions)" (p.286) section before contact your authorized Hioki distributor or reseller.
- If an error is shown on the LCD and the instrument needs to be repaired, please contact your authorized Hioki distributor or reseller.

Display		Description	Remedy
+OvrRng-OvrRng		Over-range (p. 55)	Select the appropriate range.
CONTACT TERM.A (CONTACT A, CA)		Measurement terminal A-side wiring contact error (p. 55)	Check for cable breakage and worn out probes.
CONTACT TERM.B (CONTACT B, CB)		Measurement terminal B-side wiring contact error (p. 55)	Check for cable breakage and worn out probes.
SW.ERR		See ERR:061 (p.299)	
NO UNIT		No multiplexer unit has been inserted.	Insert the unit properly. Do not allocate units that have not been inserted to channels.
ERR:001	**LOW limit is higher than UPP limit.**	Cannot set because the lower limit value is larger than the upper limit value.	Set an upper limit value that is larger than the lower limit value. (p.101)
ERR:002	**REF setting is zero.**	Cannot set because the reference value setting is zero.	Set a reference value that is larger than zero. (p.103)
ERR:003	**Cannot enable while comparator or bin is ON.**	Cannot switch ranges when the comparator is ON.	Set the range after turning the comparator OFF or select the range to use on the Comparator Settings screen. (p.98)
ERR:004	**Cannot enable while comparator or bin is ON.**	Cannot turn auto-ranging ON while the comparator is ON.	Use with the comparator set to OFF.(p.100)
ERR:010	**0 ADJ error. Must not exceed 50% or -1% f.s.**	Out of zero-adjust range. The reading must be within 50% of range full-scale.	Check the zero-adjustment procedure (p. 68).
ERR:011	**Temp. sensor error. Cannot calculate.**	Cannot perform calculations due to a temperature sensor or thermometer error.	Check the temperature sensor or thermometer.
ERR:012	**Comparator is invalid. (Delta T or BIN is ON)**	The comparator cannot be turned on while the ΔT or BIN function is on.	Turn off the ΔT and BIN functions.
ERR:013	**0 ADJ is invalid. (Must be lower than 10MΩ range)**	Zero-adjustment can be performed only for the 10 MΩ or lower ranges.	(Zero-adjustment cannot be performed for 100 MΩ and higher ranges.)
ERR:020	**Undo not available.**	Statistics functions allow only one undo operation.	–
ERR:030	**Command error.**	Command Error.	Check for incorrect commands (Included application disk).

Display		Description	Remedy
ERR:031	**Execution error. (Parameter error)**	Execution Error. The parameter value is out of range.	Check whether the parameter range is correct.
ERR:032	**Execution error.**	Execution Error.	Check whether any command has resulted in execution error conditions.
ERR:060	**Cannot enable MUX function. Disconnect cable from front terminal.**	When using MUX, disconnect the measurement leads from the terminals on the front of the instrument.	When using MUX, disconnect the measurement leads from the terminals on the front of the instrument.
ERR:061	**MUX switching error.**	A multiplexer relay hot-switching prevention function error has occurred.	The relay cannot be switched because the current from the measurement target has not decreased. Increase the delay setting since the measurement circuit may be being influenced by back EMF from a transformer or other device. Do not apply any current or voltage to the measurement terminals.
ERR:090	**ROM check sum error.**	Program ROM checksum error	The instrument is malfunctioning. Request repairs.
ERR:091	**RAM error.**	CPU RAM error	The instrument is malfunctioning. Request repairs.
ERR:092	**Memory access failed. Main power off, restart after 10s.**	A communications error occurred while attempting to access the memory.	Turn off the main power switch, wait at least 10 seconds, and turn it back on.
ERR:093	**Memory read/write error.**	Memory read/write test error	The instrument is malfunctioning. Request repairs.
ERR:095	**Adjustment data error.**	Adjustment data error	The instrument is malfunctioning. Request repairs.
ERR:096	**Backup data error.**	Settings backup error	Settings were reinitialized. Reconfigure measurement conditions and other settings.
ERR:097	**Power line detection error. Select power line cycle.**	Power frequency detection error	Set the frequency to match that of the power being supplied to the instrument.
ERR:098	**Blown FUSE. Or measurement lead is broken.**	The fuse has been tripped.	Replace the fuse. If the fuse is not blown out, the measurement and guard terminals can short each other. Check whether the measurement leads are damaged.
ERR:099	**Clock is not set. Reset? (13-01-01 00:00:00) Press F2"**	The clock is not set, so pressing **F2 [OK]** displays the initialized time 13-01-01 00:00:00.	The backup battery needs to be replaced. Contact your authorized Hioki distributor or reseller.
ERR:100	**MUX unit error.**	The MUX unit experienced an error.	The instrument is malfunctioning. Request a repair to the main unit.

Display		Description	Remedy
INFO:001	**Panel load. OK?**	Panel data will be loaded. Continue?	–
INFO:002	**Panel loading...**	Panel data is being loaded.	–
INFO:003	**Enter panel name. ESC: CANCEL, ENTER: SAVE EXEC**	Enter a name for the panel being saved. Cancel the save operation with the **ESC** key or save the panel with the **ENTER** key.	–
INFO:004	**Enter panel name. Panel is used, will be overwritten. ESC: CANCEL, ENTER: SAVE EXEC**	Enter a name for the panel being saved. The specified name already exists and will be overwritten if you proceed. Cancel the save operation with the **ESC** key or save the panel with the **ENTER** key.	–
INFO:005	**Panel saving...**	Panel data is being saved.	–
INFO:006	**Clear panel. OK?**	Panel data will be cleared. Continue?	–
INFO:007	**Panel clearing...**	Panel data is being cleared.	–
INFO:008	**Printing...**	Printing in progress.	–
INFO:010	**Start interval print.**	Interval printing started.	–
INFO:011	**Stop interval print.**	Interval printing stopped.	–
INFO:020	**Performing 0 adjustment. OK?**	Zero-adjustment will be performed. Continue?	–
INFO:021	**Clear 0 adjustment data. OK?**	Zero-adjustment values will be cleared. Continue?	–
INFO:022	**Cleared 0 adjustment data.**	Zero-adjustment data was cleared.	–
INFO:023	**0 ADJ warning. Adjust within 1% f.s.**	Zero-adjustment data values are large. (Warning)	It is recommended that values be within 1% of range full-scale.
INFO:025	**Undo statistical calculations.**	One statistical calculation was undone.	–
INFO:026	**Self-calibrating...**	Self-calibration measurement in progress.	–
INFO:030	**Reset? NORMAL RESET (without panel clear)/ SYSTEM RESET (with panel clear) / MUX RESET (only CH settings)**	The instrument will be initialized.	–
INFO:035	**MUX CH settings will be reset. Change setting?**	The MUX channel settings will be initialized when switching between 4-terminal and 2-terminal measurement.	–
INFO:036	**0 adjusting...**	Zero-adjustment is being performed with MUX scanning.	–
INFO:037	**Short-circuit pin No.1 to No.42, OK?**	To perform the unit test, short all the pins numbered 1 to 42.	–

Display		Description	Remedy
INFO:038	**Testing MUX units...**	The Multiplexer Unit test is being performed.	The results will be displayed after the test is complete.
INFO:040	**Enter password for Adjustment Mode.**	Enter the password for adjustment mode.	The Adjustment screen is used in repairs and adjustment carried out by HIOKI. It is not available for use by end-users.
INFO:080	**Self-calibration is set to "manual".**	Self-calibration measurement is set to MANU.	–

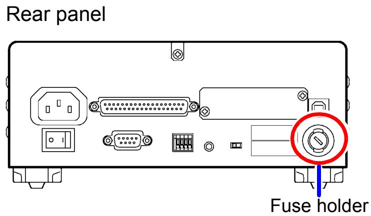
14.2 Replacing the Measurement Circuit's Protective Fuse

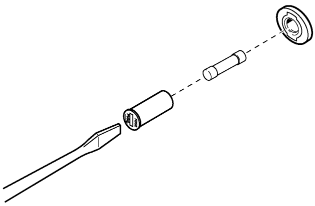
⚠WARNING

- **Replace the fuse only with one of the specified type, characteristics, rated current, and rated voltage.**
  Do not use fuses other than those specified (especially, do not use a fuse with higher-rated current) or do not short circuit and use the fuse holder. Doing so may damage the instrument and result in personal injury.
  Fuse type: F1.6AH/250V (non-arcing) 20 mm × 5 mm dia.
- **To avoid electric shock, turn off the main power switch and disconnect the cords and leads before replacing the fuse.**

NOTE

Inserting the fuse holder without first placing a replacement fuse into it may make it difficult to remove the fuse holder. Be sure to load a replacement fuse before inserting the holder.





1 **Confirm that the instrument's Main power switch (rear panel) is OFF(○), and disconnect the power cord.**

2 **Unlock the fastener on the fuse holder on the rear panel using a slotted screwdriver, and remove the fuse holder.**

3 **Replace the fuse with a rated fuse. (The replacement method may differ depending on the shape of the fuse holder.)**

4 **Reset the fuse holder.**

14.3 Inspection and Repair

⚠WARNING **Do not attempt to modify, disassemble or repair the instrument; as fire, electric shock and injury could result.**

Replaceable Parts and Operating Lifetimes

Properties of some parts used in the instrument may deteriorate after a long-term use.
The regular replacement of those parts is recommended to use the instrument properly for a long time.
For the replacement of the parts, please contact your authorized Hioki distributor or reseller.
The useful lives of the parts depend on the operating environment and frequency of use.
Operation cannot necessarily be guaranteed for the following recommended replacement period of each part.

Parts Name	Recommended Replacement Period	Note and Condition
Electrolytic Capacitors	Approx. 10 years	A PCB on which a part concerned is mounted must be replaced.
Backlight of LCD (Half-life of Brightness)	Approx. 50,000 hours	
Battery for Memory Backup	Approx. 10 years	When turning on the instrument, if the date or time is not substantially accurate, the battery should be replaced.
Relay	Approx. 50 million cycles	
Relay (Z3003 Multiplexer Unit)	Approx. 50 million cycles	4-wire
	Approx. 5 million cycles	2-wire

14.4 Disposing of the Instrument

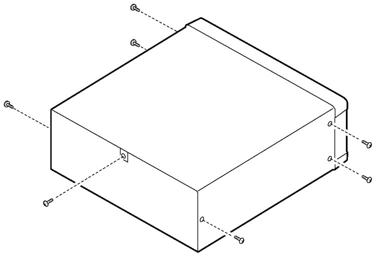
The instrument uses a lithium battery for back-up power to the clock.
When disposing of this instrument, remove the lithium battery and dispose of battery and instrument in accordance with local regulations.

Removing the Lithium Battery

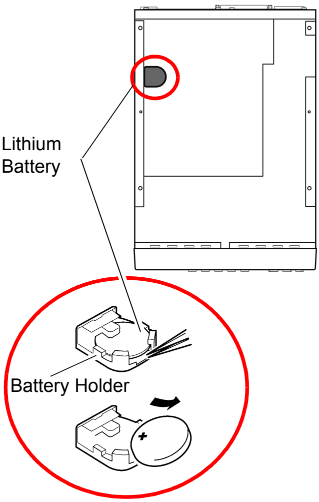
⚠WARNING **To avoid electric shock, turn off the main power button and disconnect the power cord and measurement leads before removing the lithium battery.**

Required tools:
- One Phillips screwdriver (No.1)
- One wire cutter (to remove the lithium battery)

RM3545, RM3545-01



(Overhead View)



1 **Verify that the power is off, and remove the connection cables and power cord.**

2 **Remove the six screws from the sides and one screw from the rear.**

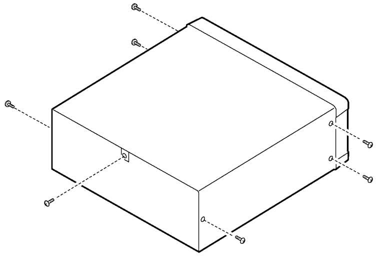
3 **Remove the cover.**

4 **Insert the tweezers between the battery and battery holder as shown in the diagram below and lift up the battery.**

⚠CAUTION
Take care not to short the + and -. Doing so may cause sparks.

CALIFORNIA, USA ONLY
Perchlorate Material - special handling may apply.
See www.dtsc.ca.gov/hazardouswaste/perchlorate

RM3545-02

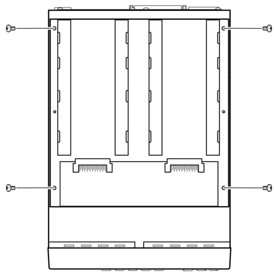


1 **Verify that the power is off, and remove the Multiplexer Unit, connection cables and power cord.**

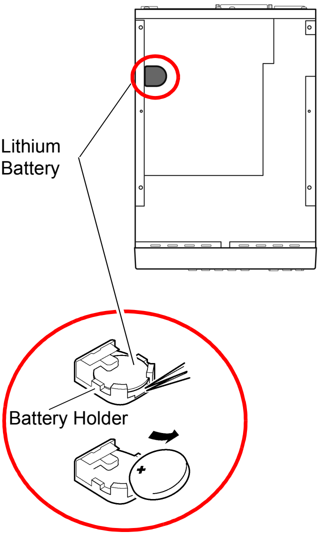
2 **Remove the six screws from the sides and one screw from the rear.**

3 **Remove the cover.**

(Overhead View)



4 **Remove the four screws and then remove the Multiplexer Unit frame.**



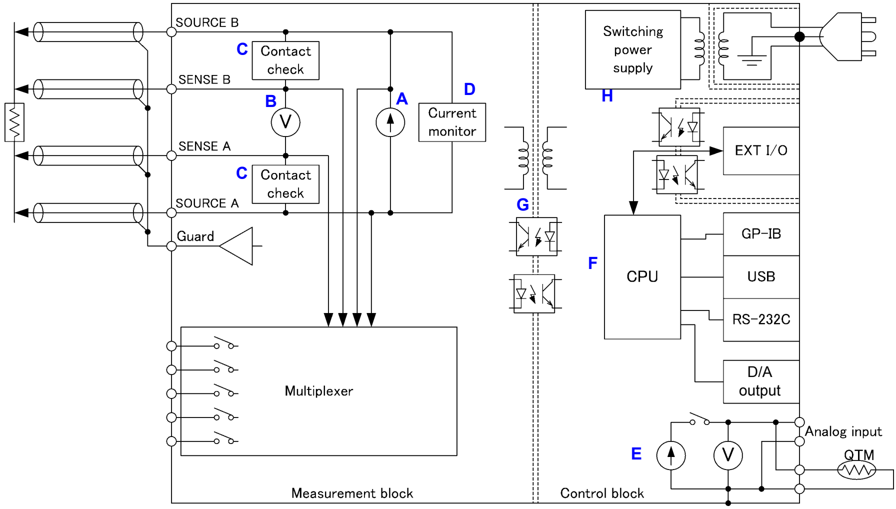
5 **Insert the tweezers between the battery and battery holder as shown in the diagram below and lift up the battery.**

> ⚠CAUTION
> **Take care not to short the + and -. Doing so may cause sparks.**

CALIFORNIA, USA ONLY
Perchlorate Material - special handling may apply.
See www.dtsc.ca.gov/hazardouswaste/perchlorate

Appendix

Appendix 1 Block Diagram

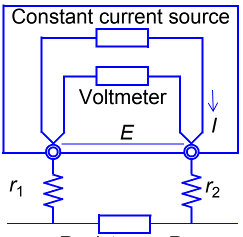


- Constant current (determined by the measurement range) is applied between the SOURCE B and SOURCE A terminals while voltage is measured between the SENSE B and SENSE A terminals. The resistance value is obtained by dividing the measured voltage (**B**) by the constant current flow (**A**).
- The effects of large offset voltages such as from thermal EMF can be reduced by current flowing in the positive and negative directions (**A**).
- The low-noise voltmeter can perform stable measurement, even with an integration time of 0.3 ms (**B**).
- When measurement starts, the contact check circuit (**C**) and constant current monitor (**D**) are activated to monitor for fault conditions while measuring.
- The instrument incorporates a built-in temperature measurement circuit that can be used to correct resistance measured values according to the temperature when measuring a target that exhibits a high level of temperature dependence.
  By separating the temperature measurement circuit from the constant current source, it is possible to connect thermometers with analog output (**E**).
- The high-speed CPU (**F**) provides ultra-high-speed measurements and fast system response.
- Immunity from electrical noise is provided by isolation between the Measurement and Control blocks (**G**).
- The auto-ranging 100-to-240 V switching power supply (**H**) can provide stable measurements even in poor power quality environments.

Appendix 2 Four-Terminal (Voltage-Drop) Method

The resistance of the wiring connecting the measuring instrument and probes and the contact resistance that occurs between probes and the measurement target may prevent low resistance values from being measured at a high level of precision.
Wiring resistance varies greatly depending on the thickness and length of the wire. Cables used in resistance measurement may, for example, exhibit resistance of 90 mΩ/m (for No. 24 AWG [0.2 sq] wiring) or 24 mΩ/m (for No. 18 AWG [0.75 sq] wiring).
Contact resistance varies with probe wear, contact pressure, and measurement current. With good contact, resistance values are generally on the order of several milliohms but may reach as high as several ohms on occasion.
The four-terminal method is used to facilitate reliable measurement of low resistance values.
With two-terminal measurements (Fig. 1), the resistance of the test leads is included in the measurement target's resistance, resulting in measurement errors.
The four-terminal method (Fig. 2) consists of current source terminals (SOURCE A, SOURCE B) to provide constant current, and voltage detection terminals (SENSE A, SENSE B) to detect voltage drop.
Little current flows to the voltage detection terminal lead lines that are connected to the measurement target due to the voltmeter's high input impedance. Consequently, measurement can be performed accurately without being affected by the measurement lead resistance or contact resistance.
*RM3545 voltmeter's input impedance: 10 GΩ or more (reference value)

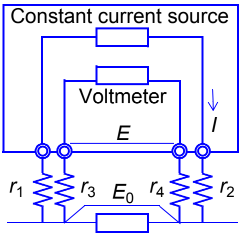
Two-Terminal Measurement Method



Resistance R_0
Figure 1.

Measurement current I flows through measurement target resistance R_0 as well as lead resistances r_1 and r_2.
The voltage to be measured is obtained by $E = I\,(r_1 + R_0 + r_2)$, which includes lead resistances r_1 and r_2.

Four-Terminal Measurement Method



Resistance R_0
Figure 2.

Current I flows from r_2 through measurement target resistance R_0 and through r_1. The high input impedance of the voltmeter allows only negligible current flow through r_3 and r_4.
So the voltage drop across r_3 and r_4 is practically nil, and voltage E across the measurement terminals and voltage E_0 across measurement target resistance R_0 are essentially equal, allowing measurement target resistance to be measured without being affected by r_1 to r_4.

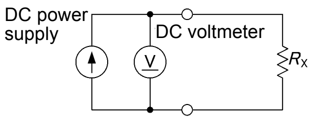
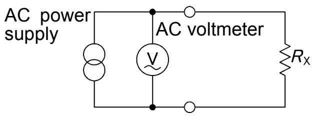
Appendix 3 DC and AC Measurement

Resistance (impedance) measurement can be performed using the DC or AC method.

- DC method
  RM3542, RM3543, RM3544, RM3545, RM3548 resistance meters
  Standard digital multimeters
  Standard insulation resistance meters
- AC method
  3561, BT3562, BT3562-01, BT3563, BT3563-01 Battery HiTesters
  BT3554, BT3554-01 Battery Testers
  Standard LCR meters

The DC measurement method is used widely in applications such as measurement of general-purpose resistors, winding resistance, contact resistance, and insulation resistance. In the DC method, the measurement setup consists of a DC power supply and a DC voltmeter. While its simple circuitry makes it easier to increase accuracy, it is prone to measurement errors due to electromotive force that may be present in the measurement path.
See: "Appendix 10 Effect of Thermal EMF" (p.A24)

The AC method is used when it is not possible to measure using DC, for example in impedance measurement of inductors, capacitors, or batteries. Since an AC ohmmeter consists of an AC power supply and an AC voltmeter, it is not affected by DC electromotive force. On the other hand, caution is necessary since results differ from those obtained using DC measurement, for example due to components such as core loss in coils' series equivalent resistance.

	DC ohmmeter	AC ohmmeter
Measurement signal Detection voltage	DC  	AC 
Advantages	High-precision measurement is possible.	Not affected by electromotive force. Reactance measurement is possible.
Disadvantages	Affected by electromotive force since not capable of performing DC superimposed measurement. (Thermal EMFs can be corrected by the OVC function.)	Difficult to increase precision.
Applications	DC resistance of windings such as transformers and motors, contact resistance, insulation resistance, PCB wiring resistance	Battery impedance, inductors, capacitors, electrochemical measurement
Measurement range	10^{-8} to 10^{16}	10^{-3} to 10^{8}
Hioki instruments	Ohmmeters : RM3542 to RM3548 DMMs : 3237 to 3238 Insulation resistance meters : IR4000 series, DSM series	Battery HiTesters : 3561, BT3562, BT3563 LCR meters : 3570, IM3533, IM3523, etc.

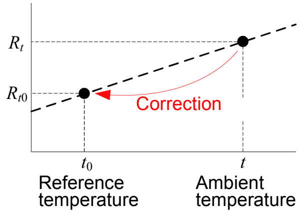
Appendix 4 Temperature Correction (TC) Function

The temperature correction function converts the resistance values of temperature-dependent measurement targets such as copper wire into resistance values at a specific temperature (known as the standard temperature) and displays the results.

Resistances R_t and R_{t0} below are the resistance values of the measurement target (having resistance temperature coefficient at t_0°C of α_{t0}) at t°C and t_0°C.

$$R_t = R_{t0} \times \{ 1 + \alpha_{t0} \times (t - t_0) \}$$

R_t	Actual measured resistance [Ω]
R_{t0}	Corrected resistance [Ω]
t_0	Reference temperature [°C]
t	Ambient temperature [°C]
α_{t0}	Temperature coefficient at t_0 [1/°C]



Example

If a copper measurement target (with resistance temperature coefficient of 3930 ppm/°C at 20°C) measures 100 Ω at 30°C, its resistance at 20°C is calculated as follows:

$$R_{t0} = \frac{R_t}{1 + \alpha_{t0} \times (t - t_0)}$$

$$= \frac{100}{1 + (3930 \times 10^{-6}) \times (30 - 20)}$$

$$= 96.22\ \Omega$$

Refer to the following for temperature correction settings and execution method:

See: "4.5 Correcting for the Effects of Temperature (Temperature Correction (TC))" (p.75)
See: "5.4 Performing Temperature Rise Test (Temperature Conversion Function (ΔT))" (p.116)

NOTE

- The temperature sensor detects only ambient temperature; not surface temperature.
- Allow the instrument to warm up before making measurements. Place the temperature sensor near the measurement target and allow both the sensor and the target to adequately adjust to the ambient temperature prior to use (for more than 10 minutes).

Reference

Conductive Properties of Metals and Alloys

Material	Content [%]	Density (x10^3) [kg/m^3]	Conductivity	Temp. Coeff. (20°C) [ppm/°C]
Annealed copper wire	Cu>99.9	8.89	1.00 to 1.02	3810 to 3970
Hard-drawn copper wire	Cu>99.9	8.89	0.96 to 0.98	3770 to 3850
Cadmium copper wire	Cd 0.7 to 1.2	8.94	0.85 to 0.88	3340 to 3460
Silver copper	Ag 0.03 to 0.1	8.89	0.96 to 0.98	3930
Chrome copper	Cr 0.4 to 0.8	8.89	0.40 to 0.50 0.80 to 0.85	2000 3000
Carlson alloy wire	Ni 2.5 to 4.0 Si 0.5 to 1.0		0.25 to 0.45	980 to 1770
Annealed aluminum wire	Al>99.5	2.7	0.63 to 0.64	4200
Hard-drawn aluminum wire	Al>99.5	2.7	0.60 to 0.62	4000
Aldrey wire	Si 0.4 to 0.6 Mg 0.4 to 0.5 Al remaining portion		0.50 to 0.55	3600

Copper Wire Conductivity

Diameter [mm]	Annealed copper wire	Tinned annealed copper wire	Hard-drawn copper wire
0.01 to less than 0.26	0.98	0.93	–
0.26 to less than 0.29	0.98	0.94	–
0.29 to less than 0.50	0.993	0.94	–
0.50 to less than 2.00	1.00	0.96	0.96
2.00 to less than 8.00	1.00	0.97	0.97

The temperature coefficient changes according to temperature and conductivity If the temperature coefficient at 20°C is α_{20} and the temperature coefficient for conductivity C at t°C is α_{ct}, α_{ct} is determined as follows near ambient temperature.

$$\alpha_{Ct} = \frac{1}{\dfrac{1}{\alpha_{20} \times C} + (t - 20)}$$

For example, the temperature coefficient of international standard annealed copper is 3930 ppm/°C at 20°C. For tinned annealed copper wire (with diameter from 0.10 to less than 0.26 mm), the temperature coefficient α_{20} at 20°C is calculated as follows:

$$\alpha_{20} = \frac{1}{\dfrac{1}{0.00393 \times 0.93} + (20 - 20)} \approx 3650 \text{ ppm/°C}$$

Reference documentation: Handbook for Electronics, Information and Communication Engineers, Volume 1, published by the Institute of Electronics, Information and Communication Engineers

Appendix 5 Temperature Conversion (ΔT) Function

Utilizing the temperature-dependent nature of resistance, the temperature conversion function converts resistance measurements for display as temperatures. This method of temperature conversion is described here.
According to IEC 60034, the resistance law may be applied to determine temperature increase as follows:

$$\Delta t = \frac{R_2}{R_1}(k + t_1) - (k + t_a)$$

Δt	Temperature increase [°C]
t_1	Winding temp. [°C, cool state] when measuring initial resistance R_1
t_a	Ambient temp. [°C] at final measurement
R_1	Winding resistance [Ω] at temp. t_1 (cool state)
R_2	Winding resistance [Ω] at final measurement
k	Reciprocal [°C] of temp. coefficient of conductor material at 0°C

Example

With initial resistance R_1 of 200 mΩ at initial temperature t_1 of 20°C, and final resistance R_2 of 210 mΩ at current ambient temperature t_a of 25°C, the temperature increase value is calculated as follows:

$$\Delta t = \frac{R_2}{R_1}(k + t_1) - (k + t_a)$$

$$= \frac{210 \times 10^{-3}}{200 \times 10^{-3}}(235 + 20) - (235 + 25)$$

$$= 7.75°C$$

Therefore, the current temperature t_R of the resistive body can be calculated as follows:

$$t_R = t_a + \Delta t = 25 + 7.75 = 32.75°C$$

For a measurement target that is not copper or aluminum with a temperature coefficient of α_{t0}, the constant *k* can be calculated using the formula shown for the temperature correction function and the above formula, as follows:

$$k = \frac{1}{\alpha_{t0}} - t_0$$

For example, the temperature coefficient of copper at 20°C is 3930 ppm/°C, so the constant *k* in this case is as follows, which shows almost the same value as the constant for copper 235 defined by the IEC standard.

$$k = \frac{1}{3930 \times 10^{-6}} - 20 = 234.5$$

Appendix 6 Zero Adjustment

Zero adjustment is a function which adjusts the zero point by deducting the residual value obtained during 0 Ω measurement. For this reason, zero adjustment must be performed when connection is made to 0 Ω. However, connecting a sample with no resistance is difficult and therefore is not practical.
In this respect, when performing the actual zero adjustment, create a pseudo connection to 0 Ω and then adjust the zero point.

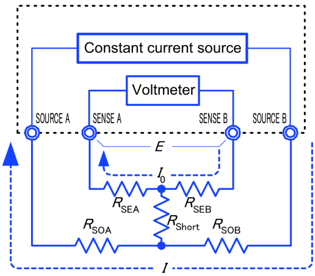
To create 0 Ω connection state

If an ideal 0 Ω connection is made, the voltage between SENSE A and SENSE B becomes 0 V according to the Ohm's Law of $E = I \times R$. In other words, if you set the voltage between SENSE A and SENSE B to 0 V, this gives you the same state of 0 Ω connection.

To perform zero adjustment using the instrument

The instrument uses a measurement fault detection function to monitor the state of connection between measurement terminals. For this reason, when performing zero adjustment, you need to make connections between the terminals appropriately in advance (Fig. 1).

First, short between SENSE A and SENSE B to set the voltage between SENSE A and SENSE B to 0 V. If lead resistances R_{SEA} and R_{SEB} of the cable are less than few Ω, there will be no problem. Because the SENSE terminal is a voltage measurement terminal, almost no current I_0 flows. Therefore, in the $E = I_0 \times (R_{SEA} + R_{SEB})$ formula, $I_0 \approx 0$ is achieved; if lead resistances R_{SEA} and R_{SEB} are less than few Ω, voltage between SENSE A and SENSE B will become almost zero.
Next, make connection between SOURCE A and SOURCE B. This is to avoid display of error when no measurement current flows through. Lead resistances R_{SOA} and R_{SOB} of the cable must be less than the resistance for flowing measurement current.



$$E = (I_0 \times R_{SEB}) + (I_0 \times R_{SEA})$$
$$= (0 \times R_{SEB}) + (0 \times R_{SEA})$$
$$= 0\ [\mathrm{V}]$$

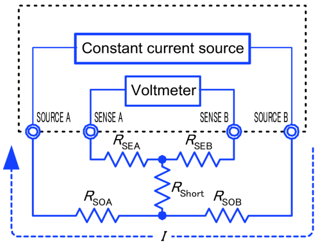
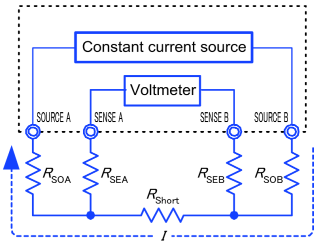
Figure 1.
Pseudo connection to 0 Ω

Furthermore, if the instrument also monitors the connection between SENSE and SOURCE, you need to make connection between SENSE and SOURCE. If lead resistance R_{Short} of the cable has only few Ω, there will be no problem.
If you wire in the way described above, measurement current I flowing out from SOURCE B will go to SOURCE A but not to the lead of SENSE A or SENSE B. This enables the voltage between SENSE A and SENSE B to be kept accurately at 0 V, and appropriate zero adjustment becomes possible.

To perform zero adjustment appropriately

Table 1 shows the correct and wrong connections. The resistances in the figure indicate lead resistances; there will be no problem if they are less than few Ω respectively
In (a), if you connect SENSE A and SENSE B as well as SOURCE A and SOURCE B respectively, and use one path to make connection between SENSE and SOURCE, no potential difference occurs between SENSE A and SENSE B, and 0 V is input. This enables zero adjustment to be carried out correctly.
In (b), on the other hand, if you connect SENSE A and SOURCE A as well as SENSE B and SOURCE B respectively, and use one path to make connection between A and B, $I \times R_{Short}$ voltage occurs between SENSE A and SENSE B. For this reason, the pseudo 0 Ω connection state cannot be achieved and zero adjustment cannot be carried out correctly.

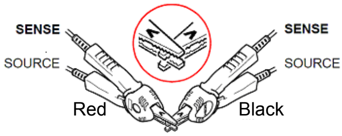
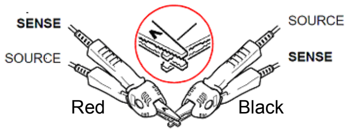
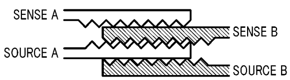
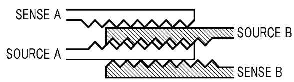
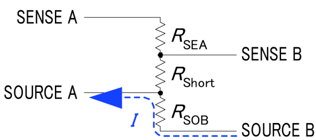
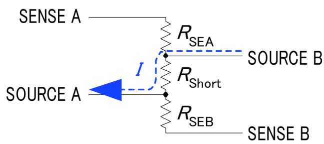
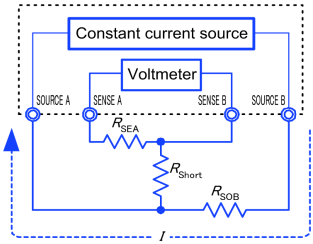
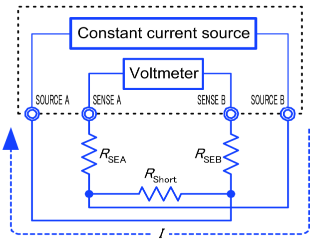
Table 1: Connection methods

Connection methods	 (a) Use one point each between SENSE and SOURCE for connection	 (b) Use one point each between A and B for connection
Resistance between SENSE A and SENSE B	$R_{SEA} + R_{SEB}$	$R_{SEA} + R_{Short} + R_{SEB}$
Measurement current I's flow path	$R_{SOB} \rightarrow R_{SOA}$	$R_{SOB} \rightarrow R_{Short} \rightarrow R_{SOA}$
Voltage occurring between SENSE A and SENSE B	0	$I \times R_{Short}$
As connection method for zero adjustment	Correct	Wrong

To perform zero adjustment using measurement leads

When you actually perform zero adjustment using measurement leads, you may unexpectedly make the connection shown in Table 1 (b). Therefore, when performing zero adjustment, you need to pay sufficient attention to the connection state of each terminal.
Here, L2101 Clip Type Lead is used as an example for the connection explanation. Table 2 shows the connection state of the tip of the lead and equivalent circuit in the respective correct and wrong connections. Table 1 (a) indicates the correct connection method, resulting in 0 V between SENSE A and SENSE B. However, Table 1 (b) is the wrong connection method, so that 0 V is not obtained between SENSE A and SENSE B.

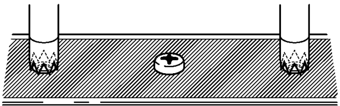
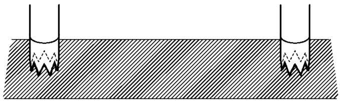
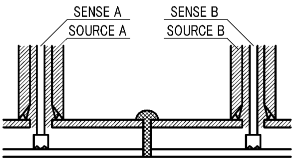
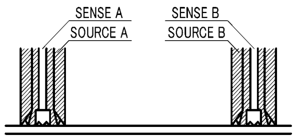
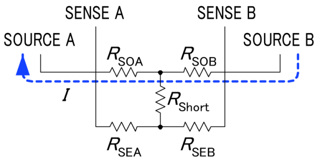
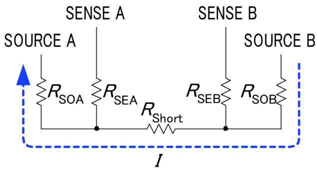
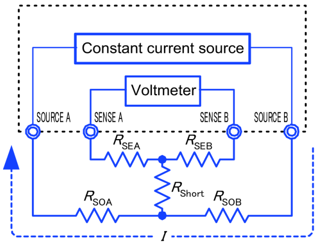
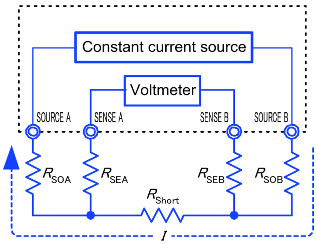
Table 2: Clip type lead connection methods used during zero adjustment

	Correct	Wrong
Connection method		
Tip of lead		
Equivalent circuit		
Deformed equivalent circuit		
As connection method for zero adjustment	Correct	Wrong

To perform zero adjustment using 9454 Zero Adjustment Board

When performing zero adjustment, you cannot use a metal board or similar object to replace 9454 Zero Adjustment Board.
9454 Zero Adjustment Board is not just a metal board. Its structure consists of two layers of metal boards screwed at one point. The zero adjustment board is used when performing zero adjustment of 9465 Pin Type Lead.
Table 3 shows cross sectional diagrams and equivalent circuits of the two connection methods: connecting Pin Type Lead to zero adjustment board, and connecting that to a metal board or similar object. Table 1 (a) indicates the connection using zero adjustment board, resulting in 0 V between SENSE A and SENSE B. However, Table 1 (b) is the connection using a metal board or similar object, so that 0 V is not obtained between SENSE A and SENSE B.

Table 3: Pin type lead connection methods in zero adjustment

<table>
<tr><td>Connection method</td><td>
If connection is made using 9454 Zero Adjustment Board</td><td>
If connection is made using metal board or similar object</td></tr>
<tr><td>Tip of lead</td><td>
</td><td>
</td></tr>
<tr><td>Equivalent circuit</td><td>
</td><td>
</td></tr>
<tr><td>Deformed equivalent circuit</td><td>
</td><td>
</td></tr>
<tr><td>As connection method for zero adjustment</td><td>Correct</td><td>Wrong</td></tr>
</table>

If zero adjustment is difficult when using self-made measurement lead to measure

When you perform zero adjustment using a self-made measurement lead to do measurement, connect the tip of the self-made measurement lead as shown in Table 1 (a). However, if such connection is difficult, you can try the following methods.

If DC resistance meter is used

The main purpose of performing zero adjustment is to remove offset of the measurement instrument. For this reason, the value to be deducted as a result of zero adjustment almost does not depend on the measurement lead. Therefore, after using the standard measurement lead to make the connection shown in Table 1 (a) and performing zero adjustment, you can replace it with a self-made measurement lead to measure with offset removed from the measurement instrument.

If AC resistance meter is used (HIOKI 3561, BT3562, BT3563, etc.)

In addition to removing offset of the measurement instrument, another main purpose of performing zero adjustment is to remove influence of the measurement lead shape. For this reason, when performing zero adjustment, try as much as possible to set the form of the self-made measurement lead close to the actual measurement state. Then, you need to make the connection as shown in Table 1 (a) and perform zero adjustment.
However, if a HIOKI product is used, even in AC resistance measurement, if the required resolution exceeds 100 μΩ, the same zero adjustment method used in DC resistance meter may be sufficient.

Appendix 7 Unstable Measured Values

If the measured value is unstable, verify the following.

(1) Non-Four-Terminal Measurements

The four-terminal method requires that four probes be connected to the measurement target.
By measuring as shown in Fig.1, the measured resistance includes that of the contacts between the probes and measurement target. Typical contact resistance is several milliohm with gold plating, and several tens of milliohm with nickel plating. With measured values of several kΩ this would not seem to be a problem, but if a probe tip is oxidized or dirty, contact resistance on the order of a kΩ is not unusual.

To maximize the opportunity for accurate measurement, separate the four probes so that they make contact with the measurement target as shown in Fig. 2.

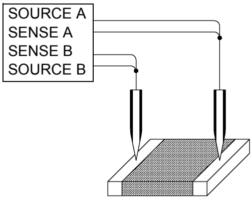


Figure 1. Two-Terminal Measurement

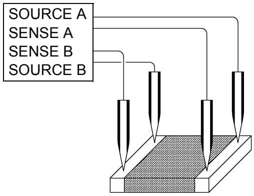


Figure 2. Four-Terminal Measurement

(2) Effects of external noise

Noise affecting the measurement target, measurement cable, power cord, communications lines, and other wires can cause measured values to become unstable. Noise can take the form of:

- Inductive noise from high-voltage or high-current circuits
- Conductive noise from power lines or other sources

Solutions vary with the source of the noise.
For more information, see "Appendix 9 Mitigating Noise" (p.A20)

(3) Multi-Point Contacts with Clip Leads

The ideal conditions for four-terminal measurements are shown in Fig. 3: current flows from the far probe and voltage is detected with uniform current distribution.

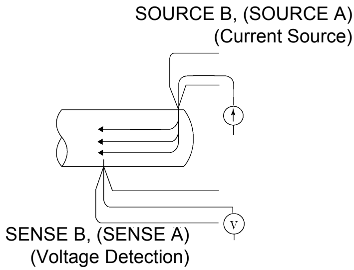


Figure 3. Ideal Four-Terminal Method

To facilitate measurement, the tips of the Model L2101 Clip Type Lead are jagged.
When a clip is opened as shown in Fig. 4, measurement current flows from multiple points, and voltage is detected at multiple points. In such cases, the measured value varies according to the total contact area.

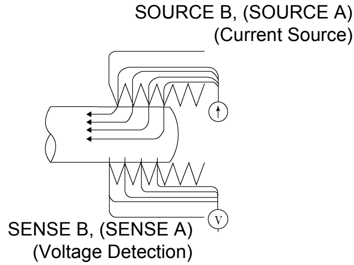


Figure 4. Measurement with Model L2101 Clip Type Lead

Additionally, as shown in Fig. 5, when measuring the resistance of a 100 mm length of wire, the length between the nearest edges of the clips is 100 mm, but the length between the farthest edges of the clips is 110 mm, so the actual measurement length (and value) has an uncertainty of 10 mm (10%).
If measured values are unstable for any of these reasons, maximize stability by measuring with point contacts as far as possible.

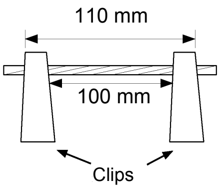


Figure 5. Measuring the resistance of a 100 mm length of wire

(4) Wider/Thicker measurement targets

When the measurement target is wide or thick like a board or block, or when using a current sensing resistor (shunt resistor) of less than 100 mΩ, it will be difficult to measure accurately using Pin Type Leads or Clip Type Leads. By using such measurement probes, there may be considerable fluctuation of the measured value due to contact pressure or contact angle. For example, when measuring a W300 × L370 × t0.4 mm metal board, the measured values are fairly different, even if measuring the same points, as shown below:

- 0.2mm pitch Pin type lead: 1.1 mΩ
- 0.5mm pitch Pin type lead: 0.92 to 0.97 mΩ
- Model L2101 Clip Type Lead: 0.85 to 0.95 mΩ

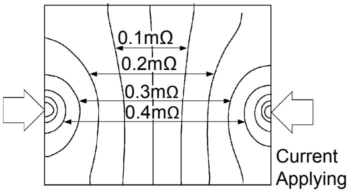


Figure 6. Equipotential lines on a metal board (W300 × L370 × t0.4 mm)

* Applying 1 A current on points on edges and plotting equivalent electric potential lines at each 50 μV level

Additionally, since the resistance values of current sensing resistors assume mounting on a printed circuit board, the desired resistance value cannot be obtained if the resistor's terminals are measured using a pin-type lead.
This does not depend on the contact resistance between probes and the measurement target, but on the current distribution on the measurement target.
Fig. 6 is an example of plotting equivalent electric potential lines of a metal board. Similar to the relation between atmospheric pressure distribution and wind on a weather forecast diagram, current density is higher in locations where the equivalent electric potential lines are narrowly spaced, and lower in locations where they are widely spaced. Through this example, it is shown that the electric potential slope is larger around current applying points. This phenomenon is caused by high current density while current expands on the metal board. Due to this phenomenon, measured values should be rather different, even if the connected position difference is quite slight, in case connecting voltage detection terminals (of measurement probes) near current applying points.
It is known that such effects can be minimized by detecting the voltage within the space between the current contact points.
Generally, if the probes are inside by a margin that is at least three times the measurement target's width (*W*) or thickness (*t*), current distribution may be considered uniform.
As shown in Fig. 7, SENSE leads should be 3*W* or 3*t* mm or more inside from the SOURCE leads.

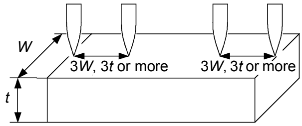


Figure 7. Probe Positions on Wider/Thicker measurement target

(5) Unstable Temperature of the measurement target

Copper wire resistance has a temperature coefficient of about 0.4%/°C. Just holding a copper wire in the hand raises its temperature, causing its resistance to be increased as well. When the hand is removed from the wire, temperature and resistance decrease.
Windings are more susceptible to temperature increase immediately after treatment with varnish, so the resistance tends to be relatively high.
When the temperature of the measurement target and probe differ, thermal EMFs will be generated, causing an error. Allow the measurement target to adjust to room temperature as much as possible prior to measurement.

(6) Measurement target Becomes Warm

The maximum applied power to a measurement target by this instrument is determined as follows. The resistance of samples with small thermal capacity can change due to heating. In such cases, enable low-power measurement.

- Low-power: OFF

Range	High		Low	
	Measurement current	Maximum power in measurement range	Measurement current	Maximum power in measurement range
10 mΩ	1 A	12 mW	–	
100 mΩ	1 A	120 mW	100 mA	1.2 mW
1000 mΩ	100 mA	12 mW	10 mA	120 μW
10 Ω	10 mA	1.2 mW	1 mA	12 μW
100 Ω	10 mA	12 mW	1 mA	120 μW
1000 Ω	1 mA	1.2 mW	–	
10 kΩ	1 mA	12 mW	–	
100 kΩ	100 μA	1.2 mW	–	
1000 kΩ	10 μA	120 μW	–	
10 MΩ	1 μA	12 μW	–	
100 MΩ (precision mode: ON)	100 nA	1.2 μW	–	
100 MΩ, 1000 MΩ (precision mode: OFF)	1 μA or less	1.3 μW	–	

- Low-power: ON

Range	Measurement current	Maximum Applied Power = (Measured Resistance) × (Measurement Current)^2
1000 mΩ	10 mA	120 μW
10 Ω	1 mA	12 μW
100 Ω	1 mA	120 μW
1000 Ω	100 μA	12 μW

(7) Effects of thermal EMF

When there is a junction between different metals and a temperature difference between the junction and the area being observed, thermal EMF occurs. In light of use of copper measurement leads, nickel-plated connectors, and solder containing tin, it is not practical to ensure that only the same metals are used in connections. For more information about how to deal with errors caused by thermal EMF, see "Appendix 10 Effect of Thermal EMF" (p.A24).

(8) Using Low-Power Resistance Measurement

Low-power resistance measurement employs a smaller measurement current than normal measurements. Therefore, measurements are more susceptible to the effects of external electrical noise and thermal EMF.

Measurement should be conducted as far as possible from devices emitting electric or magnetic fields such as power cords, fluorescent lights, solenoid valves and PC displays. If electrical noise ingress is a problem, see "Appendix 9 Mitigating Noise" (p.A20).
If thermal EMF is a problem, use the RM3545's OVC function. If OVC cannot be used for reasons such as tact time limitations, use a low-thermal EMF material such as copper for wiring, and protect against airflow on connecting parts (measurement target or connectors).

(9) Measuring Transformers and Motors

If noise enters an unconnected terminal of a transformer or if motor rotor moves, measurements may be unstable due to induced voltage on the measured winding.
The effects of noise can be reduced by shorting transformers' empty terminals. Exercise care not to induce motor oscillation.

(10)Measuring Large Transformers

When measuring measurement targets with a large inductance component and a high Q value, such as large transformers, measured values may be unstable.
The RM3545 depends on constant current flow through the measurement target. To obtain stability in a constant-current source with a large inductance, response time is sacrificed. If you find that resistance values are scattered when measuring large transformers, please consider the above or contact your local Hioki distributor for further assistance.

(11)Effects of cable configuration

To cancel thermal EMF, the RM3545 periodically reverses the polarity of the measurement current (via its OVC function). Additionally, it only applies the current during measurement to limit heat generation. Rapid fluctuations in this measurement current trigger corresponding fluctuations in the magnetic field, inducing the following voltage in the voltage detection line between SENSE A and SENSE B:

$$v = \frac{\mathrm{d}\phi}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\left(\mu S \frac{I}{l}\right) = \frac{\mu S}{l} \cdot \frac{\mathrm{d}I}{\mathrm{d}t}$$

To avoid the effects of this voltage, the RM3545 waits for a fixed period of time after the measurement current changes before acquiring the voltage between SENSE A and SENSE B.

It is necessary to exercise caution when there are metallic objects present near the measurement cable or measurement target. When the measurement current fluctuates, an eddy current will be induced in such objects (see Fig. 8). This induced current is characterized by a sawtooth-shaped waveform and affects the voltage detection line between SENSE A and SENSE B for an extended period of time (see Fig. 9-b). The eddy current gradually decays due to the resistance of the metal plate, so its effect is more pronounced the faster the measurement speed.

The following five methods may be used to counteract this issue:

1. Move the metallic object father away.

2. Twist the SENSE A and SENSE B lines together.
   Doing so will make the lines more resistant to the effects of the eddy current.

3. Twist the SOURCE A and SOURCE B lines together.
   Doing so will inhibit the generation of an eddy current.

4. Increase the delay setting.
   Doing so will delay the start of measurement until the eddy current has dissipated.

5. Reduce the measurement speed.
   Averaging data from the start of measurement, when the effects of the eddy current are more pronounced, can reduce those effects.

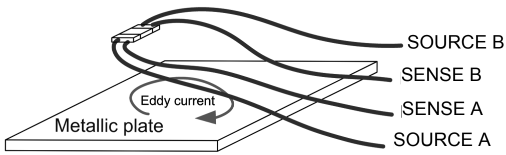
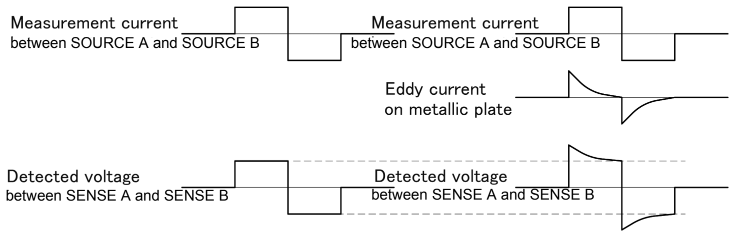


Figure. 8 Generation of an eddy current



a. When Affected by an Eddy Current   b. When Not Affected by an Eddy Current

Figure. 9 Variations in the Detected Voltage Due to Eddy Currents

(12) Measurement of current sensing resistors (shunt resistors)

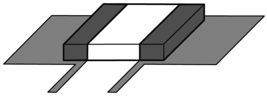


Figure. 10A Current Sensing Resistor mounted on a Printed Circuit Board

When mounting a two-terminal type current sensing resistor on a printed circuit board, separate the current and voltage detection wires as shown in Fig. 10 in order to avoid the effects of wiring resistance. To ensure that the current will flow evenly to the sensing resistor, it is necessary to use the same width for the current wire as the electrode and to avoid bending the wire near the electrode (see Fig. 11). When testing the current sensing resistor, wire probes are generally used (see Fig. 12). In this case, the measurement current will gradually expand inside the current sensing resistor from the point of application (SOURCE B) and flow back again to the probe point (SOURCE A) (see Fig. 13). Current density is high at the current application points (SOURCE A, SOURCE B), and placing the voltage terminals (SENSE A, SENSE B) near them will yield resistance values that tend to be higher than the actual mounted value (see Fig. 14).

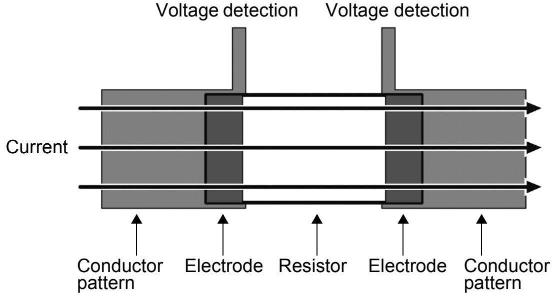


Figure. 11 Current Flow in the Mounted State

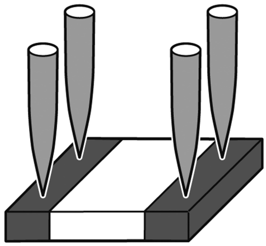


Figure. 12 Probing in the Test State

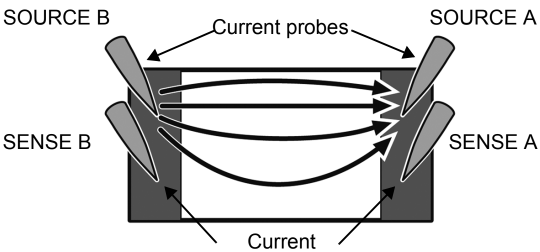


Figure. 13 Flow of Current in the Test State

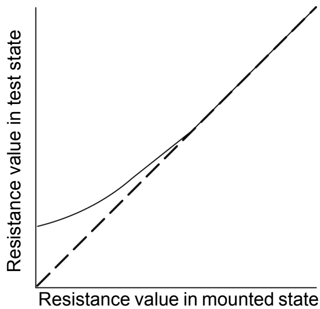


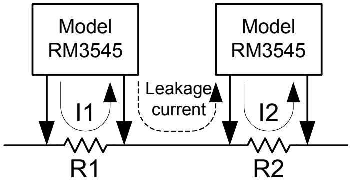
Figure. 14 Difference between Mounted State and Test State

Appendix 8 Using Multiple RM3545s

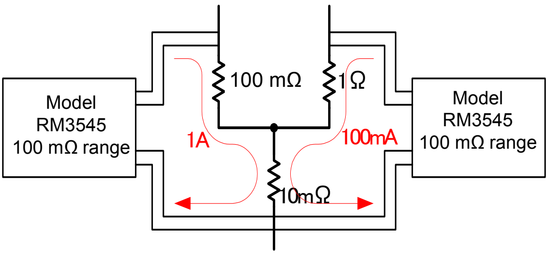
This section describes how to measure multiple locations such as rotary switches using multiple RM3545s to which two measurement targets are connected.

The RM3545 measures resistance by applying a constant current to the sample under measurement. However, when multiple probes are placed in contact with a single point, the measurement current from one RM3545 may be superposed with the measurement current from the other RM3545, preventing accurate measurement.

For example, if measuring two resistance values using two RM3545s as shown in the figure to the right, current I1 will flow to R1, and current I2 will flow to R2. However, a minuscule current may also flow from one RM3545 to the other, preventing accurate measurement.



As shown in the figure below, the measurement currents from the two instruments will flow in common relative to the 10 mΩ resistance, resulting in an error.



In this case, the RM3545 on the left will measure the following resistance value:

$$\frac{(100\text{m}\Omega \times 1\text{A} + 10\text{m}\Omega \times 1.1\text{A})}{1\text{A}} = 111\text{m}\Omega$$

In this case, the RM3545 on the right will measure the following resistance value:

$$\frac{(1\Omega \times 100\text{mA} + 10\text{m}\Omega \times 1100\text{mA})}{100\text{mA}} = 1.11\Omega$$

Appendix 9 Mitigating Noise

(1) Effects of induced noise

Power cords, fluorescent lights, solenoid valves, computer displays, and other devices emit large amounts of noise. Two sources of noise with the potential to affect resistance measurement are:

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

Capacitive coupling from high-voltage lines

Current flowing from a high-voltage line is dominated by the coupled capacitance. As an example, if a 100 V commercial power line and a wire used in resistance measurement are subject to capacitive coupling of 1 pF, a current of about 38 nA will be induced.

$$I = \frac{V}{Z} = 2\pi \cdot 60 \cdot 1\text{pF} \cdot 100\text{V}_{\text{RMS}} = 38\text{nA}_{\text{RMS}}$$

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).

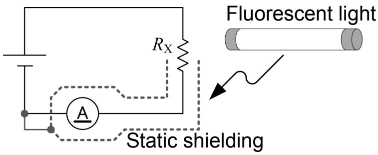


Figure 1. Static Shielding near High-voltage Wires

Electromagnetic coupling from high-current lines

High-current lines emit a magnetic field. Transformers and choke coils with a large number of turns emit an even stronger magnetic field. The voltage induced by the magnetic field is affected by the distance and area. A loop of 10 cm^2 located 10 cm from a 1 A commercial power line will generate a voltage of about 0.75 μV.

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

$$= \frac{4\pi \cdot 10^{-7} \cdot 60\text{Hz} \cdot 0.001\text{m}^2 \cdot 1\text{A}_{\text{RMS}}}{0.1\text{m}} = 0.75\ \mu\text{V}_{\text{RMS}}$$

When measuring a 1 mΩ resistor with 1 A, the effect measures 0.07%. Since the detection voltage can easily be increased for high-resistance measurement, this effect does not pose a significant problem.
The influence of electromagnetic coupling can be reduced by keeping the noise generating line away from the voltage detection line and twisting the cables for each (see Fig. 2).

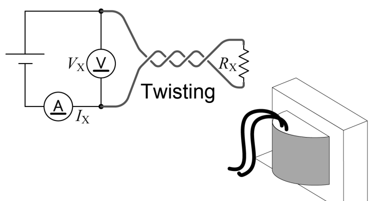


Figure 2. Twisting near High-current Wires

Induced noise countermeasures at the instrument

To counteract noise, it is effective to attach a ferrite core to the measurement leads, as shown in Fig. 3-1, or to twist the four shielded wires and to shield the measurement target with the guard potential, as shown in Fig. 3-2.
It is important to take similar precautions not only for the instrument, but also for the noise source. It is effective to twist nearby high-current wires that may serve as noise sources and to shield high-voltage wires.

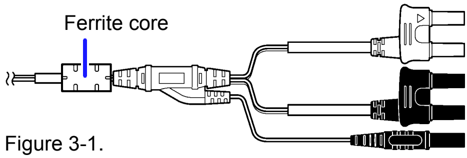


Figure 3-1.

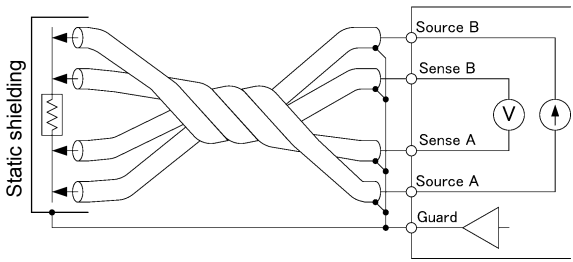


Figure 3-2. Noise Countermeasures at the Instrument

When induced noise is caused by a commercial power supply

Induced noise caused by commercial power supplies is emitted not only by commercial power lines and power outlets, but also from fluorescent lights and household electronics. Noise caused by commercial power supplies occurs at frequencies of 50 Hz and 60 Hz, depending on the frequency of the power supply in use.
To mitigate the effects of noise caused by commercial power supplies, it is standard practice to use a whole-number multiple of the power supply period as the integration time (see Fig. 4).

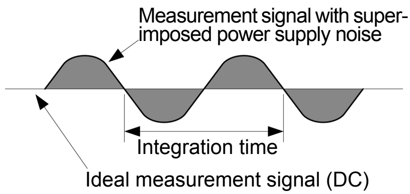


Figure 4. Noise Caused by a Commercial Power Supply

The instrument offers four measurement speeds: FAST, MED, SLOW1, and SLOW2. Measured values may fail to stabilize during either high-resistance or low-resistance measurement. If this occurs, either decrease the measurement speed or implement adequate noise countermeasures.
If the line frequency setting is left at 60 Hz while the instrument is used in a region with a 50 Hz line frequency, measured values will fluctuate, even if the measurement speed is set such that the integration time is equal to the integral multiple of the line frequency. Check the instrument's line frequency setting.

(2) Effects of conductive noise

Conductive noise is distinct from induced noise, which is superimposed on measurement targets and measurement leads. Conductive noise is noise that is superimposed on power lines and control lines such as USB.
A variety of devices, including motors, welders, and inverters, can be connected to power supply lines. A large spike current flows to the power supply while this equipment is operating and each time it starts and stops. Due to this spike current and the power supply line's wiring impedance, a large spike voltage occurs in the power supply line and the power supply ground line, and these spikes may affect measuring instruments.
Similarly, noise may be introduced from the controller's control lines. Noise from the controller's power supply and noise from sources such as DC-DC converters in the controller may reach measuring instruments via USB and EXT I/O wires (see Fig. 5).

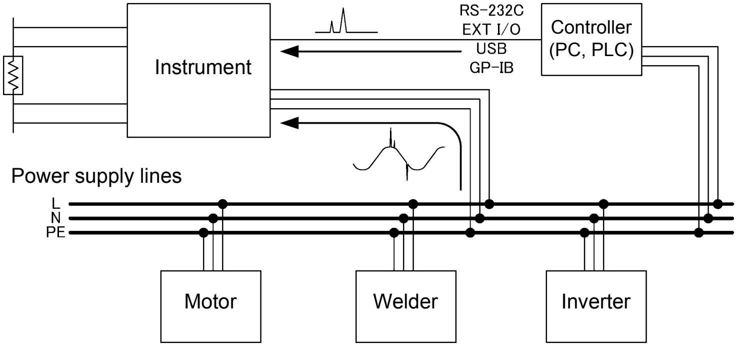


Figure 5. Susceptibility to Conductive Noise

An effective approach is to monitor conductive noise with an instrument such as the HIOKI 3145 Noise HiLogger and implement countermeasures as appropriate. Once the path along which the noise is traveling has been identified, the countermeasures show in Fig. 6 are effective.

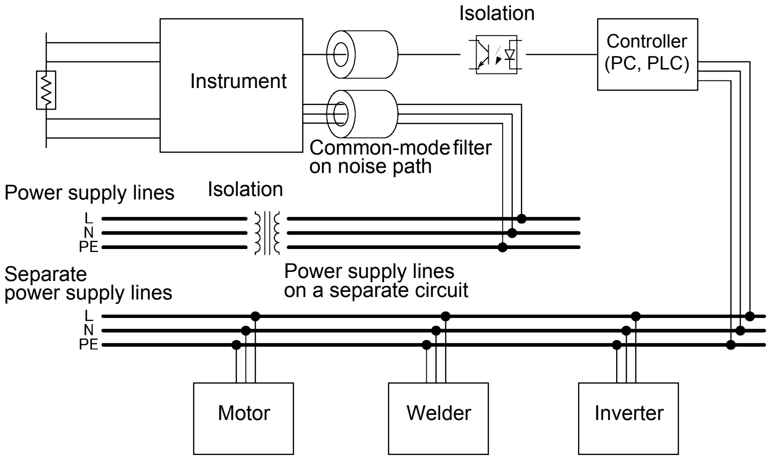


Figure 6. Conductive Noise Countermeasures

Using separate power supply lines

It is preferable to place power circuits, welders, and other equipment on a separate power supply from the instrument.

Adding a common-mode filter (EMI choke) to the noise path

Choose common mode filters with as high an impedance as possible and use multiple filters for increased effectiveness.

Isolating lines

It is highly effective to optically isolate control lines. It is also effective to isolate power supply lines using a noise-cutting transformer. However, note that shared ground lines before or after the isolation can make this approach less effective.

Appendix 10 Effect of Thermal EMF

Thermoelectromotive force (thermal EMF) is the potential difference that occurs at the junction of two dissimilar metals, including between the probe tips and the lead wire of the measurement target. If the difference is sufficiently large, it can cause erroneous measurements. (Fig. 1). The amplitude of thermal EMF depends on the temperature of the measurement environment, with the force generally being greater at higher temperature.

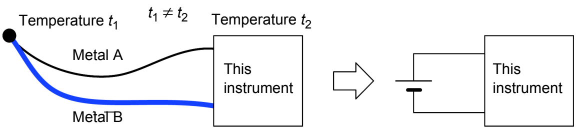


Figure 1. Thermal EMF generation

Increasing thermal EMF examples

- The measurement target is a fuse, thermal fuse, thermistor, bimetal, or thermostat.
- The voltage detection lines incorporate a single stable relay as a contact.
- An alligator clip is used as a voltage detection terminal.
- A voltage detection terminal is held by hand.
- There is a large temperature difference between the measurement target and the instrument.
- Wire materials differ between the SENSE A and SENSE B.

In a resistance measurement, measurement current I_M is applied to measurement target R_X to detect voltage drop $R_X I_M$ across the target. In a low resistance measurement, the voltage $R_X I_M$ to be detected is naturally lower due to the low R_X. When the detected voltage is low, the measurement will be affected by thermal EMF that is generated between the measurement target and probes, and between the cables and the instrument, as well as the voltmeter offset voltage V_{EMF} (Fig. 2). If a measurement target is held by hand, the target will be warmed. A probe will also be warmed by holding it by hand. For these reasons, even if every care is taken, it will be difficult to control thermal EMF so that it does not exceed 1 μV.

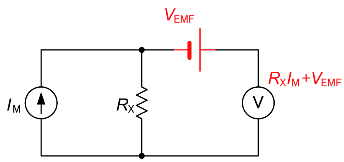


Figure 2. Thermal EMF generation

As an example, if a measurement target with an actual resistance of 1mΩ is measured with a measurement current of 100 mA in an environment with an thermal EMF of 10 μV, the instrument will indicate the following measured value. This is a significant error of 1% higher than the actual resistance.

$$\frac{1\ \text{m}\Omega \times 1\ \text{A} + 10\ \mu\text{V}}{1\ \text{A}} = 1.01\ \text{m}\Omega$$

The voltmeter offset voltage will also be very large, ranging between 1 μV and 10 mV.
This will cause a large low resistance measurement error.
To reduce the effects of thermal EMF, the following actions are possible:

1. Increasing the detection voltage by increasing the measurement current
2. Using zero-adjustment to cancel thermal EMF
3. Changing the detection signal to AC

1. Increasing the detection voltage by increasing the measurement current

   In the above thermal EMF example, assume that the measurement current is increased from 1 A to 100 A. The error will be reduced to 0.01%.

$$\frac{1\ \text{m}\Omega \times 100\ \text{A} + 10\ \mu\text{V}}{100\ \text{A}} = 1.0001\ \text{m}\Omega$$

   However, it is important to note that RI^2 power is applied.

2. Using zero adjustment to cancel thermal EMF

   If current is blocked from being applied to measurement target R_X, the voltmeter will only be supplied with thermal EMF V_{EMF}. However, if the SOURCE terminals are made open-circuit, a current fault will be detected and a measured value will not be displayed. Thus, thermal EMF can be canceled by shorting the SOURCE lines to block current flow to R_X and performing zero adjustment. (Fig. 3).

   See: "3.5 Checking Measured Values" (p.52)
   See: "Appendix 6 Zero Adjustment" (p.A7)

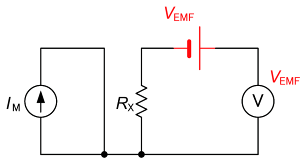


Figure 3. Using zero adjustment to block current flow to R_X

3. Changing the detection signal to AC

   Changing the detection signal to AC is a fundamental solution. Both the thermal EMF and voltmeter offset voltage can be treated as stable DC voltages as they are viewed for a short period of time in seconds. This allows frequency domain separation by changing the detection signal to AC. The Offset Voltage Compensation (OVC) function uses a pulse wave as a measurement current to eliminate thermal EMF (Fig. 4). Specifically, a resistance value that is not affected by thermal EMF is obtained by subtracting the voltage detected when the measurement current is applied in the negative direction from that detected when the current is applied in the positive direction.

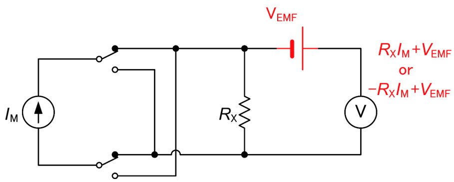


Figure 4. EMF cancelation by current reversal

$$\frac{(R_X I_M + V_{EMF}) - (-R_X I_M + V_{EMF})}{2 I_M} = R_X$$

   When the measurement target is inductive, some delay must be set (p.84) to allow adequate current flow before starting measurement.
   Set the delay so that inductance does not affect measurements.
   To fine tune the delay, begin with a longer delay than necessary, then gradually shorten it while watching the measured value.

Appendix 11 Detecting the Location of a Short on a Printed Circuit Board

Comparing the resistance values at multiple locations provides a useful way to infer the location of a short on an unpopulated printed circuit board. Short patterns X and Y as described below:

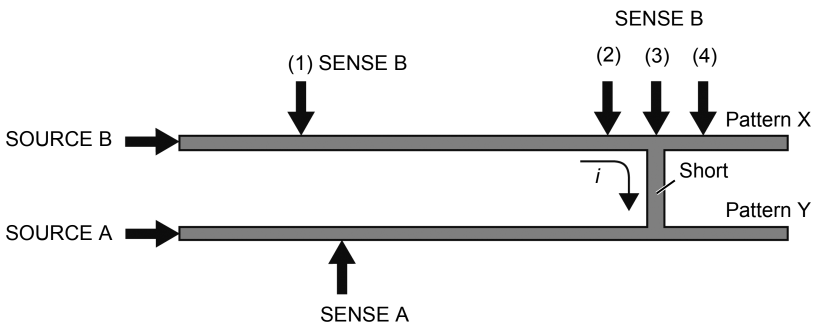
1. **Connect SOURCE A and SOURCE B to their respective patterns.**

2. **Connect SENSE A to a point near SOURCE A, and SENSE B to location (1).**

3. **Observe the measured values as you move SENSE B from (1) to (2), (3), and (4). Higher resistance values indicate greater distance from the short location. Narrow down the short location by moving the SOURCE B and SENSE B terminals.**

Example
(1) 20 mΩ
(2) 11 mΩ
(3) 10 mΩ
(4) 10 mΩ

Based on the above measured values, the short can be inferred to be near (3).



Appendix 12 Measuring Contact Resistance

(1) Types of contacts

Switches, relays, and connector contacts can be broadly classified as either of two types:
Power contacts
Signal contacts

- Power contacts

Lines carrying currents of several dozens of amperes consume power measured in watts, even if they have a resistance of 1 mΩ. Consequently, switch contacts on high-current lines such as circuit breakers have resistance values that are far below 1 mΩ. Power relays, circuit breakers, and other components are designed based on the assumption that they will be used with high-current lines. Consequently, use of low currents (on the order of microamperes) requires caution since gradual corrosion of the contacts will eventually compromise their conductivity.

- Signal contacts

Since switches and connectors used in standard electronic circuits typically carry currents of 1 A or less, their contact resistance is on the order of several dozens of milliohms. These contacts are usually gold-plated so that stable contact can be achieved even with microampere-level currents. Switches that use conductive rubber exhibit resistance values that vary dramatically with the pressure placed on them. They have a high contact resistance of around 1 kΩ, but they are characterized by an extremely high level of durability.

(2) Measuring contact resistance

- Power contacts

Unless otherwise defined, measurement can be accomplished at an adequate level of resolution by using a current of about 1 A. However, if there are local areas of high contact resistance, it is necessary to observe heat generation at the contact while using a current that approaches the conditions under which the contact will be used. Power contacts are typically used at a relatively high voltage of at least 5 V. When measured with an ohmmeter with a low open voltage, the current may be unable to pass through contaminants (oxide film or dirt) on the contact that do not pose an issue during normal use, triggering a judgment of poor contact. For this reason, it is not desirable to measure power contacts with low-power ohmmeters.

- Signal contacts

Most signal contacts are connected to IC input terminals, and it is not unusual for them to carry currents of less than 1 μA. As the contact is repeatedly opened and closed, vibrations cause the plating on the contact surface to flake off, triggering rapid corrosion of the contact (oxidation and sulfuration).
When contacts become corroded so that their contact resistance increases, measurement at high currents such as 1 A may trigger a process by which the contact resistance gradually recovers. Measuring contacts with more advanced corrosion with an ohmmeter with a high open voltage may allow the current to pass through the corrosion, leading to a judgment of good contact.
For this reason, when measuring signal contacts, the open voltage should be limited to the extent possible, and measurement should be carried out using an extremely low current (dry-circuit testing). The instrument can be used to perform dry-circuit testing by enabling the low-power setting.

(3) Resistance in the open state

Generally, contacts have a resistance value of at least 10 MΩ when in the open state. The initial insulation resistance varies greatly with the insulating properties of the enclosure and tends to decline due to dirt on the contacts and nearby dust. To ascertain the resistance in the open state, it is necessary to measure the resistance value with the maximum voltage that could be applied to the open contacts. Consequently, insulation resistance testers that are used to inspect power distribution equipment are designed so that they can apply high voltages ranging from 25 V to 5 kV.

(4) Standards related to contact resistance

Below is a list of some representative standards relating to the measurement of resistance. Please see individual standards for more information about their specific provisions.

JIS C 2525	Testing method for conductor-resistance and resistivity of metallic resistance materials
JIS C 3001	Resistance of Copper Materials for Electrical Purposes
JIS C 3002	Testing methods of electrical copper and aluminium wires
JIS C 3005	Test methods for rubber or plastic insulated wires and cables
JIS C 3101	Hard-drawn copper wires for electrical purposes
JIS C 3102	Annealed Copper Wires for Electrical Purposes
JIS C 3152	Tin Coated Annealed Copper Wires
JIS C 4034	Rotating electrical machines
JIS C 5012	Test methods for printed wiring boards
JIS C 5402	Connectors for electronic equipment
JIS C 5442	Test methods of low power electromagnetic relays for industrial control circuits
JIS C 8306	Testing methods for wiring devices
JIS H 0505	Measuring Methods for Electrical Resistivity and Conductivity of Non-Ferrous Materials
JIS K 7194	Testing method for resistivity of conductive plastics with a four-point probe array

Reference URL http://www.jisc.go.jp/eng/

Appendix 13 JEC 2137 Induction Machine-compliant Resistance Measurement

Standard JEC 2137 specifies the determination of resistance values according to the following formula:

$$R_{t\mathrm{R}} = R_{t\mathrm{T}} \times \frac{t_{\mathrm{R}} + k}{t_{\mathrm{T}} + k} \quad \text{.. Formula 1}$$

$R_{t\mathrm{R}}$	Winding resistance at reference temperature t_{R}
$R_{t\mathrm{T}}$	Measured value of winding resistance at t_{T}
t_{R}	Reference temperature [°C]
t_{T}	Temperature of winding during measurement [°C]
k	Constant (235 for copper wire)

Transforming Formula 1 provides the following:

$$\frac{R_{t\mathrm{R}}}{R_{t\mathrm{T}}} = \frac{t_{\mathrm{R}} + k}{t_{\mathrm{T}} + k} = \frac{1}{1 + \frac{1}{t_{\mathrm{R}} + k}(t_{\mathrm{T}} - t_{\mathrm{R}})} \quad \text{............. Formula 2}$$

On the other hand, Formula 3 shows the temperature correction process with the RM3545. So the temperature coefficient to be set is determined as shown in Formula 4.

$$R_{t\mathrm{R}} = \frac{R_{t\mathrm{T}}}{1 + \alpha_{t\mathrm{R}} \times (t_{\mathrm{T}} - t_{\mathrm{R}})} \quad \text{............................... Formula 3}$$

$$\alpha_{t\mathrm{R}} = \frac{1}{t_{\mathrm{R}} + k} \quad \text{.. Formula 4}$$

For example, if the reference temperature is 20°C, set the temperature coefficient for the instrument as follows.

$$\alpha_{t\mathrm{R}} = \frac{1}{t_{\mathrm{R}} + k} = \frac{1}{20 + 235} = 3922\ [\mathrm{ppm/°C}]$$

Appendix 14 Making Your Own Measurement Leads, Making Connections to the Multiplexer

Recommended Measurement Lead Specifications

Conductor resistance	500 mΩ/m or less
Capacitance	150 pF/m or less
Cable dielectric material	Polyethylene (PE), TEFLON* (TFE), polyethylene foam (PEF) Insulation resistance at least 100 GΩ (Performance value)

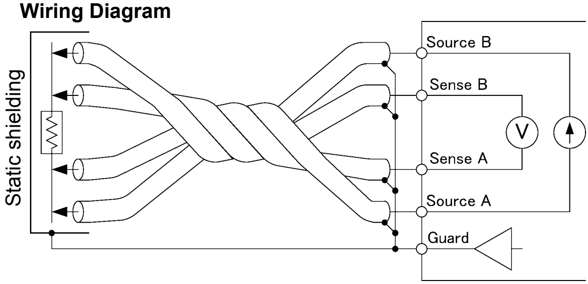
Example: UL1354, UL1631, UL1691

Before Wiring

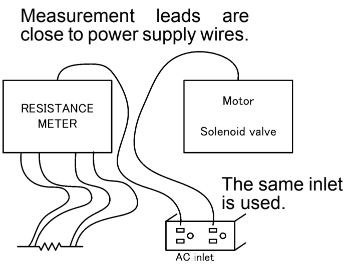
See: "Appendix 7 Unstable Measured Values" (p. A12)

- Use shielded wiring for measurement leads and connect the shield potential to the instrument's GUARD terminal. Use the GUARD potential to shield probes and near the measurement target.
  Twist the four wires together and keep loop area small.

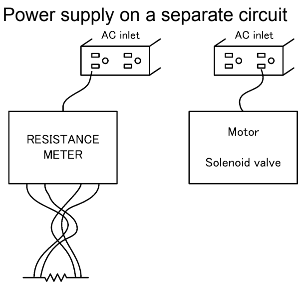
Wiring Diagram



- Keep measurement leads and the measurement target away from high-current, high-voltage, and high-frequency wires (withstanding voltage testers, power cords, motors, solenoid valves).



Poor example



Good example

The phenomenon of induction becomes pronounced in the 10 mΩ and 100 mΩ ranges (when the measurement current is set to 1 A). Variations in lead position or shape may cause measured values to vary. Exercise care to prevent positions and shapes from changing. Additionally, measurement leads and measurement targets should be kept as far as possible from metallic objects.
- When using two or more RM3545 units, do not group the wires from multiple instruments together. Induction phenomena may cause measured values to become unstable or the contact check circuit to generate erroneous results.

- Refer to the block diagram (p. A1) for internal circuit details.
- Wiring resistance in excess of the values listed in the table below may cause a current fault, making measurement impossible. When using measurement current 1 A ranges, keep the wiring resistance (cable line resistance, relay on-resistance) as well as the contact resistance between the measurement targets and probe low.

LP OFF

Range	100 MΩ range high-precision mode	Current switching	Measurement Current	SOURCE B - SOURCE A (Other than measurement target) *
10 mΩ	–	–	1 A	1.5 Ω
100 mΩ	–	High	1 A	1.5 Ω
100 mΩ	–	Low	100 mA	15 Ω
1000 mΩ	–	High	100 mA	15 Ω
1000 mΩ	–	Low	10 mA	150 Ω
10 Ω	–	High	10 mA	150 Ω
10 Ω	–	Low	1 mA	1 kΩ
100 Ω	–	High	10 mA	100 Ω
100 Ω	–	Low	1 mA	1 kΩ
1000 Ω	–	–	1 mA	1 kΩ
10 kΩ	–	–	1 mA	1 kΩ
100 kΩ	–	–	100 μA	1 kΩ
1000 kΩ	–	–	10 μA	1 kΩ
10 MΩ	–	–	1 μA	1 kΩ
100 MΩ	ON	–	100 nA	1 kΩ
100 MΩ	OFF	–	1 μA or less	1 kΩ
1000 MΩ	OFF	–	1 μA or less	1 kΩ

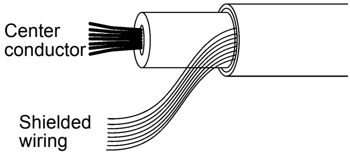
LP ON

Range	Measurement Current	SOURCE B - SOURCE A (Other than measurement target) *
1000 mΩ	1 mA	2 Ω
10 Ω	500 μA	5 Ω
100 Ω	50 μA	50 Ω
1000 Ω	5 μA	500 Ω

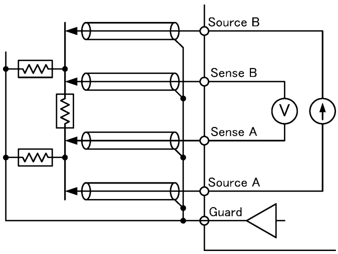
* When using the Z3003 Multiplexer Unit, the unit's internal wiring resistance (including relays) is included. The unit test function can be used to verify that the unit's internal wiring resistance is 1 Ω or below.

See: "8.6 Performing the Multiplexer Unit Test" (p.167)

- Since the voltage detection circuit’s input resistance is sufficiently large, the SENSE line wiring resistance can be as high as 1 kΩ without affecting measured values. However, the wiring resistance should be minimized due to susceptibility to noise. If an excessively high wiring resistance causes the contact check to generate an error, decrease the wiring resistance or disable the contact check function.
- Long wires are susceptible to noise, and measured values may be unstable.
- Extensions should maintain the four-terminal structure. If converted to a two-terminal circuit in the wiring, correct measurement may not be possible due to the effects of wiring and contact resistance.
  Example that would result in error:
  Four-terminal wiring from the instrument to the relay, but two-terminal wiring from the relay.
- After extending measurement leads, confirm operation and accuracy ("Measurement Specifications" (p.252)).
- If cutting the ends off of Hioki measurement leads, make sure that the shield does not touch the center conductor of the SOURCE A, SENSE A, SENSE B and SOURCE B leads. Correct measurement is not possible with a shorted lead.



- Do not connect the end of the shielding wire to a ground or other terminal. Doing so will create a ground loop, making the instrument more susceptible to noise. Keeping the shielding wire away from the center conductor, process the ends of the leads so that they do not come into contact with nearby metal objects.
- Do not apply a current of 1 mA or more to the GUARD terminal. This terminal is not for guarding network resistance measurements.

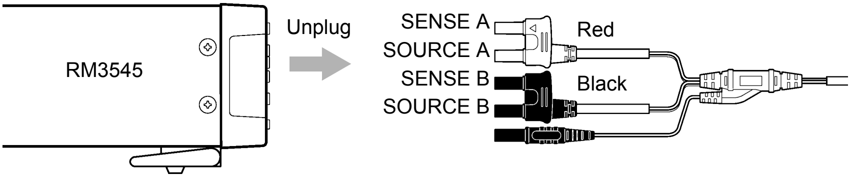


Example of defeated guard measurement

Appendix 15 Checking Measurement Faults

The instrument monitors the connection status of SOURCE A, SOURCE B, SENSE A, and SENSE B. If you experience an unexpected measurement fault, check the following.

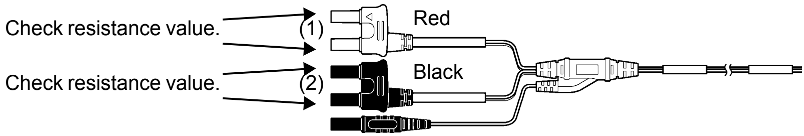
1 **Disconnect the measurement lead plugs from the instrument while keeping the probes in contact with the measurement target.**



2 **Check the resistance between SOURCE A and SENSE A with a tester or other instrument. See (1) below.**

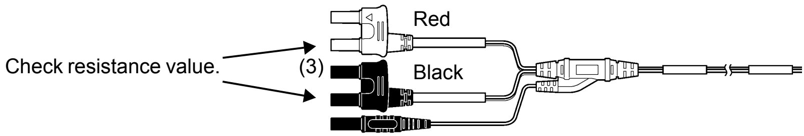
Check the resistance between SOURCE B and SENSE B with a tester or other instrument. See (2) below.

If good contact has been established, the resistance should be 1 Ω or less.



3 **Check the resistance between SOURCE A and SOURCE B with a tester or other instrument. See (3) below.**

If good contact has been established, the resistance should be the sum of the measurement target resistance value and the wiring resistance.



If the above resistance values are too high, check the following:

- Is the probe dirty or worn?
- Is the probe's contact pressure too low?
- Is a power relay being used to switch the wiring (in particular, the sense wiring)?
  Use of power relay contacts without applying current will cause the contact resistance to increase gradually over time.
- Is the wiring too small?
  Particularly if using a 1 A measurement current, keep the round-trip wiring resistance within 1.5 Ω.
  See: p.57
- Is there a break in a measurement lead?
  Switch the lead with another lead or jiggle the wiring and check the resistance value.

Appendix 16 Using the Instrument with a Withstanding Voltage Tester

The instrument can also be used in conjunction with a withstanding voltage tester to test windings. When used with a withstanding voltage tester, the charge stored in the winding may flow into the instrument at the moment it is connected, damaging it. When using the instrument in this manner, take the following into account during the production line design process:

(1) Ensure the contact withstanding voltage of the relays used for switching has a sufficient safety margin relative to the withstanding test voltage (at a minimum, it should be twice the peak voltage).

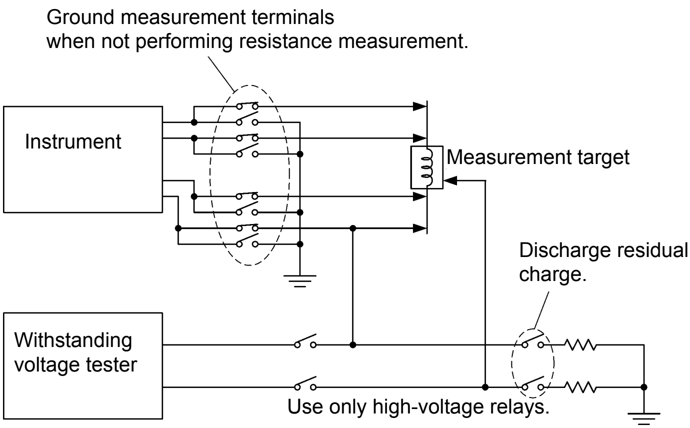
Example high-voltage relays

Okita Works	LRL-101-50PC (5 kV DC between contacts)
	LRL-101-100PC (10 kV DC between contacts)
Sanyu Switch	USM-11524 (5 kV DC between contacts)
	USM-13624SB (10 kV DC between contacts)

(2) During withstanding voltage testing, ground all of the instrument's terminals.

(3) Perform resistance measurement first and the withstanding voltage test last.

If you must perform the withstanding voltage test before resistance measurement, ground both of the measurement target's terminals after the withstanding voltage test to discharge any charge accumulated during the test. Then perform resistance measurement.



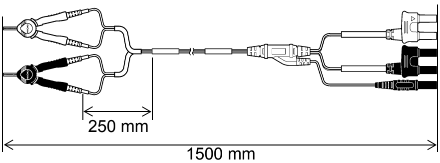
Using the instrument with a withstanding voltage tester

Appendix 17 Measurement Leads (Options)

To purchase any of the options, contact your authorized Hioki distributor or reseller.

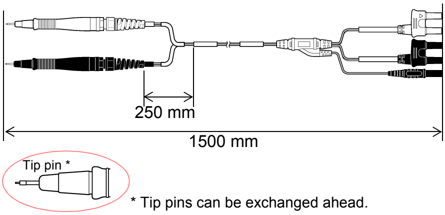
Model L2101 Clip Type Lead

These leads have clip tips. Four-terminal measurements are provided just by clipping on to the measurement target.
Overall length: approx. 1500 mm
Bifurcation-to-lead length: approx. 250 mm
Clippable diameter: ϕ 0.3 to 5.0 mm



Model L2102 Pin Type Lead

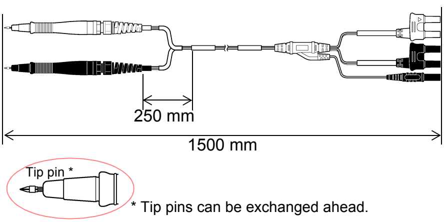
Even on flat contact points that cannot be clipped to, or on measurement targets with small contacts such as relay terminals or connectors, four-terminal measurements are available by just pressing.
Overall length: approx. 1500 mm
Bifurcation-to-lead length: approx. 250 mm
Pin base: ϕ 1.8 mm
Initial contact pressure: approx. 70 g
Total compression pressure: approx. 100 g
(Stroke: approx. 2 mm)



* Tip pins can be exchanged ahead.

Model L2103 Pin Type Lead

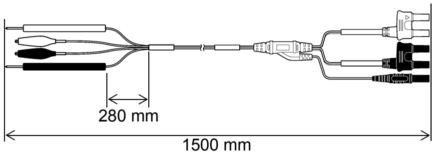
The tips have a four-terminal design developed for floating-foot testing of ICs mounted on boards. Resistance can be correctly measured even with small measurement targets.
Overall length: approx. 1500 mm
Bifurcation-to-lead length: approx. 250 mm
Between pin bases: 0.2 mm
Initial contact pressure: approx. 60 g
Total compression pressure: approx. 140 g
(Stroke: approx. 1.3 mm)



* Tip pins can be exchanged ahead.

Model L2104 4-Terminal Lead

The SOURCE leads of this four-terminal lead set have covered alligator clips, and the SENSE leads have standard test probes. Use for measuring printed circuit board pattern resistance, and where SOURCE and SENSE leads need to be connected separately.
Overall length: approx. 1500 mm
Bifurcation-to-lead length: approx. 280 mm



Appendix 18 Rack Mounting

By removing the screws on the sides, this instrument can be installed in a rack mounting plate.

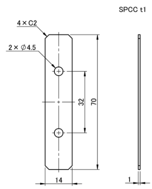
⚠WARNING

Observe the following precautions regarding the mounting screws to avoid instrument damage and electric shock accidents.

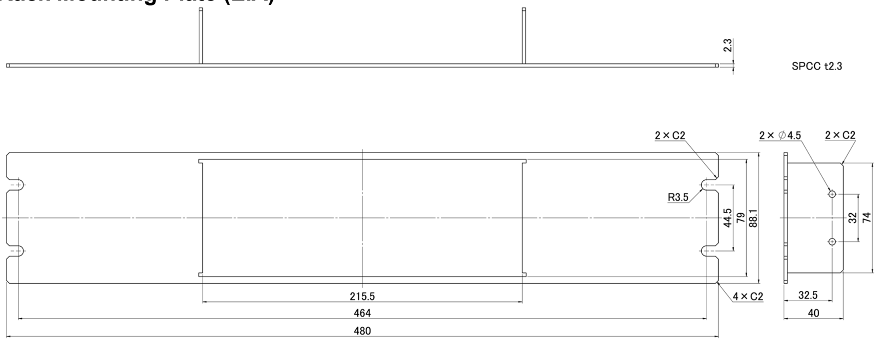
- **When installing the Rack Mounting Plate, the screws must not intrude more than 3.5 mm into either side of the instrument.**
- **When removing the Rack Mounting Plate to return the instrument to stand-alone use, replace the same screws that were installed originally. (Feet: M3 x 6 mm, Sides: M4 x 6 mm)**

Rack Mounting Plate Template Diagram and Installation Procedure

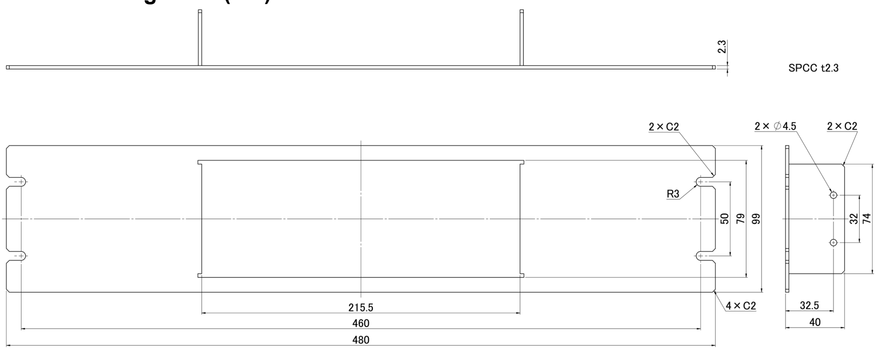
Spacer (Two Required)

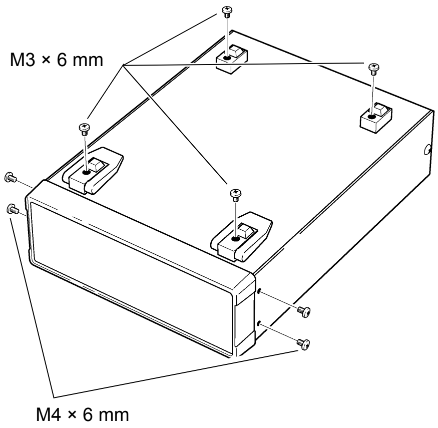


Rack Mounting Plate (EIA)

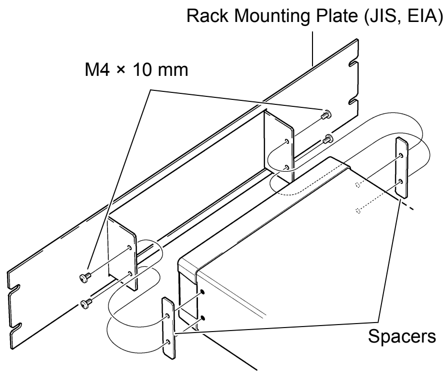


Rack Mounting Plate (JIS)





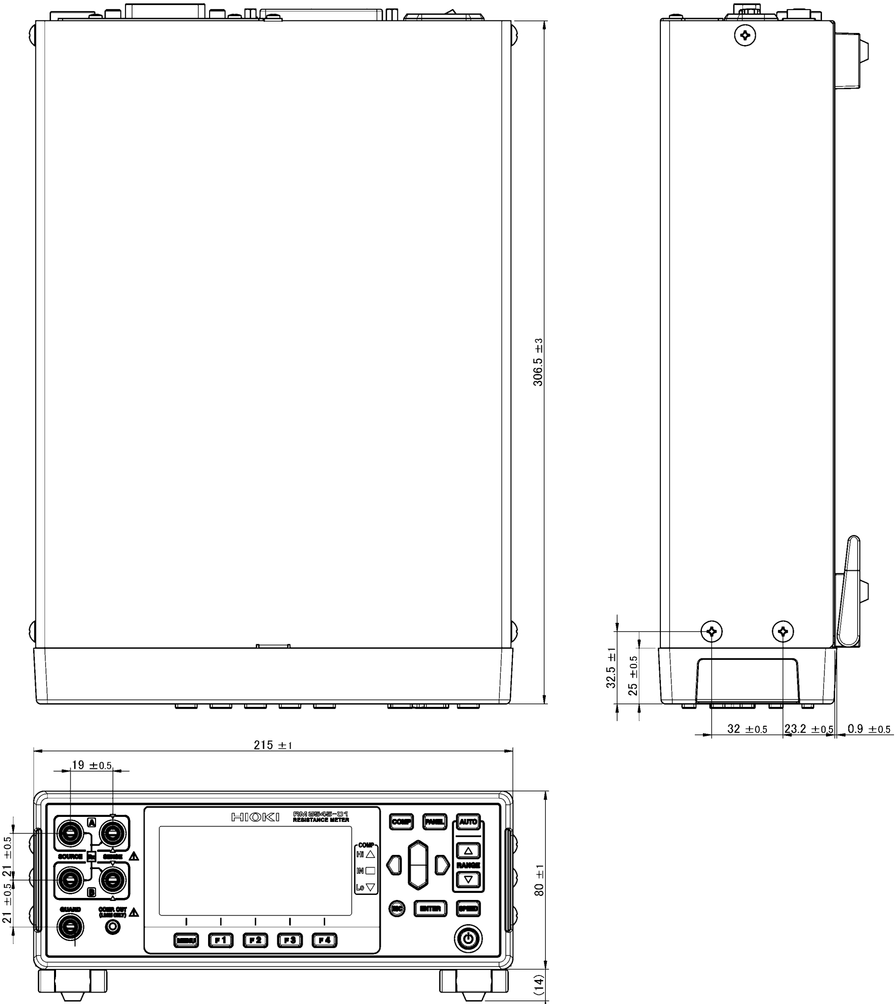
1 **Remove the feed from the bottom of the instrument, and the screws from the sides (four near the front).**



2 **Installing the spacers on both sides of the instrument, affix the Rack Mounting Plate with the M4 × 10 mm screws.**

When installing into the rack, reinforce the installation with a commercially available support stand.

Appendix 19 Outline Drawing



Appendix 20 Calibration

Calibration Conditions

- Ambient temperature and humidity 23±5°C, 80%RH or less
- Warm-up time 60 minutes
- Power supply 100 to 240 V±10%, 50/60 Hz, distortion rate of 5% or less
- External magnetic field Environment close to the Earth's magnetic field
- Initialize settings by resetting the instrument.

Calibration equipment

Please use the following for calibration equipment.

Resistance measurement function

Equipment	Calibration point	Manufacturer	Standard model
Standard resistor	1 GΩ	JAPAN FINECHEM	RH1/2HV (1 GΩ)
Standard resistor	10 Ω to 100 MΩ	Fluke	Equivalent to 5700A
Standard resistor	1 Ω	Alpha Electronics	Equivalent to CSR-1R0
Standard resistor	100 mΩ	Alpha Electronics	Equivalent to CSR-R10
Standard resistor	10 mΩ	Alpha Electronics	Equivalent to CSR-10N
Resistance measurement leads		HIOKI	L2104 4-Terminal Lead

If the FLUKE 5700A cannot be used, please use the following equipment.

Alpha Electronics

CSR-100 (10 Ω)	CSR-104 (100 kΩ)
CSR-101 (100 Ω)	CSR-105 (1 MΩ)
CSR-102 (1 kΩ)	CSR-106 (10 MΩ)
CSR-103 (10 kΩ)	CSR-107 (100 MΩ)

Temperature measurement (Thermistor)

Equipment	Calibration point	Manufacturer	Standard model
Multi-product calibrator	25°C, 2186.0 Ω	FLUKE	Equivalent to 5520A

Temperature (Analog input)

Equipment	Calibration point	Manufacturer	Standard model
Generator	10°C: 0.1 V 100°C: 1 V	HIOKI	Equivalent to SS7012
Temperature measurement cable			Wire resistance: 500 mΩ or less (circuit resistance)

D/A output

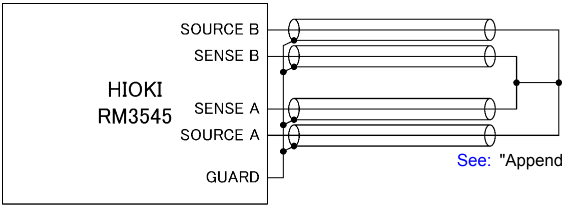
Equipment	Calibration point	Manufacturer	Standard model
Voltmeter	0 Ω: 0 V 1 Ω: 1 V	HIOKI	Equivalent to 3237
Output cable			Wiring resistance: 500 mΩ or less (circuit resistance)

Calibration points

	Range	Calibration point	OVC	Measure ment Current	100 MΩ range high-precision mode	0ADJ
Resistance measurement (Low Power: OFF)	10 mΩ	0 Ω, 10 mΩ	ON, OFF	-	-	With or without*1
	100 mΩ	0 Ω, 100 mΩ	ON, OFF	High, Low	-	With or without*1
	1 Ω	0 Ω, 1 Ω	ON, OFF	High, Low	-	With or without*1
	10 Ω	0 Ω, 10 Ω	ON, OFF	High, Low	-	With or without*1
	100 Ω	0 Ω, 100 Ω	ON, OFF	High, Low	-	With or without*1
	1000 Ω	0 Ω, 1 kΩ	ON, OFF	-	-	With or without*1
	10 kΩ	0 Ω, 10 kΩ	OFF	-	-	-
	100 kΩ	0 Ω, 100 kΩ	OFF	-	-	-
	1000 kΩ	0 Ω, 1 MΩ	OFF	-	-	-
	10 MΩ	0 Ω, 10 MΩ	OFF	-	-	-
	100 MΩ	0 Ω, 100 MΩ	OFF	-	ON, OFF	-
	1000 MΩ	0 Ω, 1000 MΩ	OFF	-	OFF	-
Resistance measurement (Low Power: ON)	1000 mΩ	0 Ω, 1 Ω	ON	-	-	-
	10 Ω	0 Ω, 10 Ω	ON	-	-	-
	100 Ω	0 Ω, 100 Ω	ON	-	-	-
	1000 Ω	0 Ω, 1 kΩ	ON	-	-	-
Temperature (thermistor)		25°C: 2186.0 Ω input				
Temperature (analog input)		10°C: 0.1 V input 100°C: 1 V input				
D/A output	1 Ω	0 Ω: 0 V input 1 Ω: 1 V input				

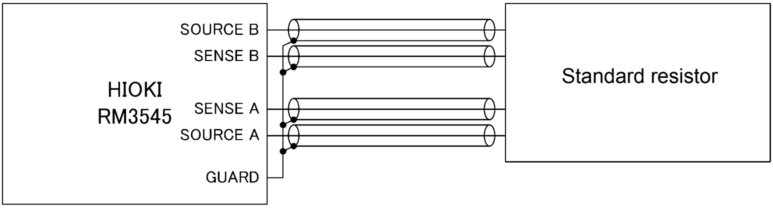
*1 Without 0ADJ: Only with OVC off

Connection Methods

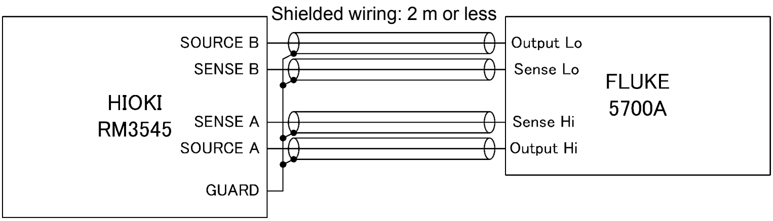


See: "Appendix 6 Zero Adjustment" (p.A7)

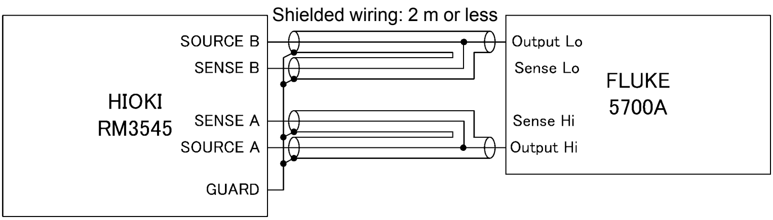
0-Ω calibration



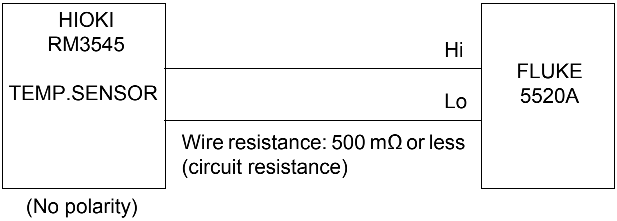
Connection with standard resistor



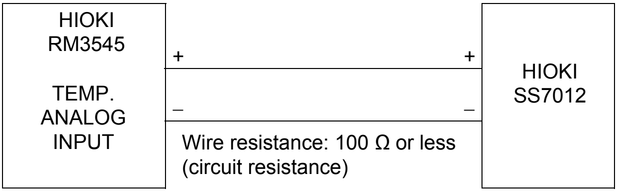
Connection with FLUKE 5700A (10 Ω range to 100 MΩ range)



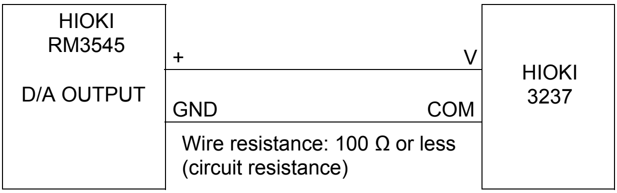
Connection with FLUKE 5700A (100 MΩ range)



Temperature measurement (Thermistor)



Temperature (Analog input)



D/A output

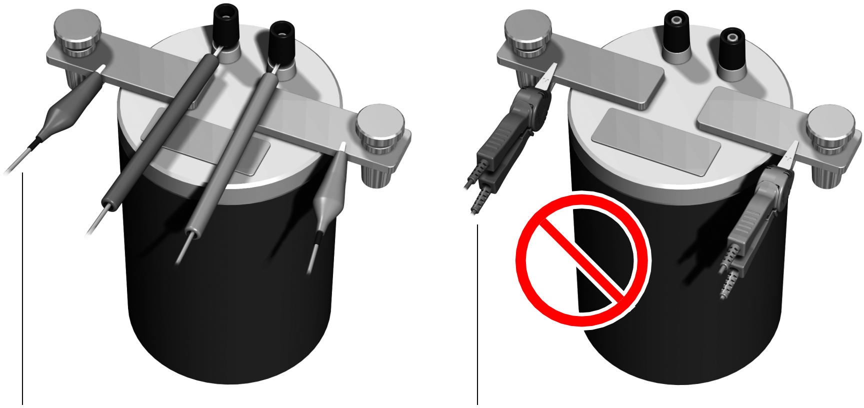
NOTE

- For more information about 0 Ω calibration connections, see "Appendix 6 Zero Adjustment" (p.A7).
- Adequate noise countermeasures must be implemented during high-resistance and low-resistance measurement, when using the low measurement current setting, and during low-power resistance measurement.
  In a highly noisy environment, the measured value may become unstable or inaccurate. In addition, the measurement error detection function may react and no measured value may be displayed. Connect the metal exterior of standard resistors and dial resistors to the instrument's GUARD potential.
  See: "Appendix 7 Unstable Measured Values" (p.A12)
- Do not use alligator clips with the voltage detection terminals. Thermal EMFs may cause measured values to diverge.

When using the YOKOGAWA 2792 to calibration

Use the 4-terminal Lead from Hioki. Note that connection cannot be made with the Clip Type Lead.

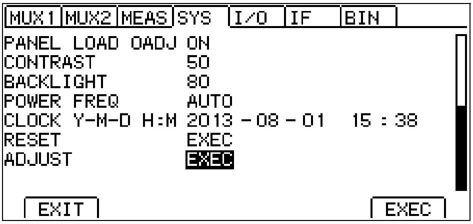
Correct **Wrong**



4-terminal Lead Clip Type Lead

Appendix 21 Adjustment Procedure

The System Settings screen includes an adjustment screen.
The Adjustment screen is used in repairs and adjustment carried out by Hioki. It is not available for use by end-users.



F4 Do not press.

Appendix 22 Instrument Settings (Memo)

When you return your instrument to be calibrated or repaired, its settings will be reset to their default values.
It is recommended to make note of the instrument's settings using the following table before sending it to be calibrated or repaired. Settings can also be saved to a computer by using the sample application software.
The sample application can be downloaded from the Hioki website (http://www.hioki.com).

<table>
<tr><th colspan="2">Screen</th><th>Setting and Key</th><th>Setting</th></tr>
<tr><td colspan="2" rowspan="5">Measurement screen</td><td>COMP</td><td></td></tr>
<tr><td>PANEL</td><td></td></tr>
<tr><td>AUTO</td><td></td></tr>
<tr><td>▲▼ (RANGE)</td><td></td></tr>
<tr><td>SPEED</td><td></td></tr>
<tr><td colspan="2">Measurement screen
(P.1/2) (For the RM3545-02, P.1/3)</td><td>VIEW (F2)</td><td></td></tr>
<tr><td colspan="2" rowspan="2">Measurement screen
(P.2/2) (For the RM3545-02, P.2/3)</td><td>0 ADJ (F2)</td><td></td></tr>
<tr><td>LOCK (F3)</td><td></td></tr>
<tr><td colspan="2" rowspan="3">Measurement Screen
(P.3/3) *2</td><td>FRONT (F1)</td><td></td></tr>
<tr><td>MUX (F2)</td><td></td></tr>
<tr><td>SCANSET (F3)</td><td></td></tr>
<tr><td rowspan="10">Setting screen (SETTING)</td><td rowspan="5">Multiplexer Channel Settings screen (MUX1) *2</td><td>CH</td><td></td></tr>
<tr><td>TERM</td><td></td></tr>
<tr><td>INST</td><td></td></tr>
<tr><td>0ALL</td><td></td></tr>
<tr><td>0ADJ</td><td></td></tr>
<tr><td rowspan="5">Multiplexer Basic Measurement screen (MUX2) *2</td><td>SPD</td><td></td></tr>
<tr><td>RANGE</td><td></td></tr>
<tr><td>UPP/REF</td><td></td></tr>
<tr><td>LOW%</td><td></td></tr>
<tr><td>PASS</td><td></td></tr>
</table>

Screen		Setting and Key	Setting
Setting screen (SETTING)	Measurement Setting screen (MEAS)	TC SET	
		ΔT	
		DELAY	
		AVERAGE	
		AUTO HOLD	
		SCALING(A∗R+B)	
		OVC	
		LOW POWER	
		MEAS CURRENT	
		Ω DIGITS	
		CURR ERROR MODE	
		CONTACT CHECK	
		CONTACT IMPRV	
		100MΩ PRECISION	
	System Setting screen (SYS)	TERMINAL *2	
		STATISTICS	
		TEMP INPUT	
		CALIBRATION	
		KEY CLICK	
		COMP BEEP Hi	
		IN	
		Lo	
		PASS	
		FAIL	
		PANEL LOAD 0ADJ	
		CONTRAST	
		BACK LIGHT	
		POWER FREQ	

Screen		Setting and Key	Setting
Setting screen (SETTING)	EXT I/O Setting screen (I/O)	TRIG SOURCE	
		TRIG EDGE	
		TRIG/PRINT FILT	
		EOM MODE	
		JUDGE/BCD MODE	
	Communications Interface Setting screen (IF)	INTERFACE	
		SPEED	
		GP-IB *1	
		DATA OUT	
		CMD MONITOR	
		PRINT INTRVL	
		PRINT COLUMN	
		STAT CLEAR	
	BIN Setting screen (BIN)	BIN	

*1 RM3545-01 only
*2 RM3545-02 only

Index

Index

Q

R

S

T

U

V

W

Z

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

http://www.hioki.com

18-07 EN-3

HIOKI

http://www.hioki.com

Our regional contact information

HEADQUARTERS
81 Koizumi
Ueda, Nagano 386-1192 Japan

HIOKI EUROPE GmbH
Rudolf-Diesel-Strasse 5
65760 Eschborn, Germany
hioki@hioki.eu

1808EN

Edited and published by HIOKI E.E. CORPORATION Printed in Japan