HIOKI

Instruction Manual

3540

mΩ HiTESTER

HIOKI E. E. CORPORATION

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Contents

Introduction

Thank you for purchasing the HIOKI "3540 mΩ HiTESTER." To obtain maximum performance from the product, please read this manual first, and keep it handy for future reference.

Inspection

When you receive the product, 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 dealer or Hioki representative.

Accessories

9287-10 CLIP TYPE LEAD 1
9451 TEMPERATURE PROBE 1
Instruction Manual 1
R6P manganese batteries (monitor batteries) 6
Spare fuse to protect the circuit
(F1.0 AH/250 V) 1
Ferrite clamp 1
External connector socket (Ver.-01 only) 1

Safety

⚠ WARNING

This product is designed to conform to IEC 61010 Safety Standards, and has been thoroughly tested for safety prior to shipment. However, 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. We disclaim any responsibility for accidents or injuries not resulting directly from product defects.

Safety symbols

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

- The ⚠ symbol printed on the product indicates that the user should refer to a corresponding topic in the manual (marked with the ⚠ symbol) before using the relevant function.
- In the manual, the ⚠ symbol indicates particularly important information that the user should read before

Indicates DC (Direct Current).

Indicates the ON side of the power switch.

Indicates the OFF side of the power switch.

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

⚠ 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 product.
NOTE	Advisory items related to performance or correct operation of the product.

Measurement categories

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

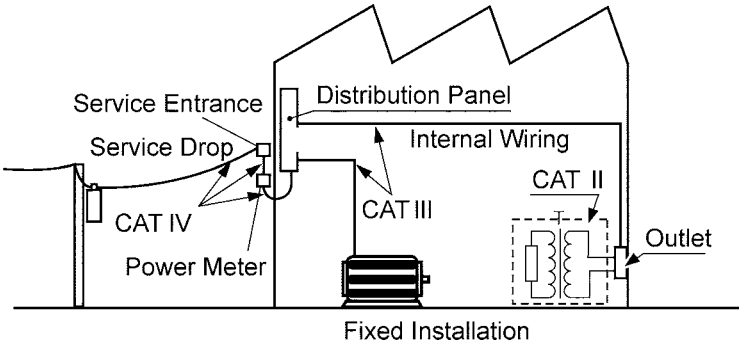
CAT II: Primary electrical circuits in equipment connected to an AC electrical outlet by a power cord (portable tools, household appliances, etc.)
CAT II covers directly measuring electrical outlet receptacles.

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

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

Using a measurement instrument in an environment designated with a higher-numbered category than that for which the instrument is rated could result in a severe accident, and must be carefully avoided.

Use of a measurement instrument that is not CAT-rated in CAT II to CAT IV measurement applications could result in a severe accident, and must be carefully avoided.



Precautions

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

⚠ WARNING **Use either the specified Hioki model 9445-02/03 AC ADAPTER.**

⚠ CAUTION

- Never apply an external voltage to the SENSE and SOURCE terminals of the instrument.
- To properly suppress noise, this product must be set to match the power supply frequency. Before using the product, make sure the power supply frequency selector is set correctly, to avoid erroneous readings.
  (Refer to 4.2.1 Setting the Power Supply Frequency.)
- Do not store or use the product where it could be exposed to direct sunlight, high temperature or humidity, or condensation. Under such conditions, the product may be damaged and insulation may deteriorate so that it no longer meets specifications.
- To avoid damage to the product, protect it from vibration or shock during transport and handling, and be especially careful to avoid dropping.
- The sensor used in the temperature probe is a thin, precision platinum film.
  Please note that excessive voltage pulses or static discharges can destroy the film.
  To avoid damage or malfunction, avoid hitting the tip of the temperature probe and overly bending the leads.
  When measuring high temperatures, do not let the handle of the temperature probe or the compensation lead wire exceed the temperature range.

NOTE

- The battery indicator lights up when the remaining battery capacity is low. In this case, the instrument's reliability is not guaranteed. Replace the battery immediately.
  (Refer to "8.1 Battery Replacement Procedure.")
- Be sure to turn the power switch OFF (○) when not using the instrument.
- Warm up the instrument for at least 30 minutes prior to use, to attain proper measurement accuracy.
- This product should be installed and operated indoors only, between 0 and 40 ℃ and 80 %RH or less.
- A fuse is provided in the current source (SOURCE) to protect the circuit. If the fuse burns out, measurements cannot be made. Refer to "8.2 Fuse Replacement procedure" on how to check for a burned-out fuse.
- This instrument should not be used with relays or other devices that handle small signals, since it may damage their contact coating.
- Do not measure points which have a voltage across them. The main unit of the 3540 will be damaged by an induced voltage if a measurement is made immediately after a temperature rise test or dielectric test of a motor or transformer.
- Accurate measurement may be difficult to obtain if the instrument is used near equipment that generates noise.
  Also, the indicator may sometimes fluctuate if the device-under-test picks up noise. Therefore, do not use the instrument in environments with excessive electrical noise.
- The measurement indication may sometimes fluctuate due to noise pick-up if the temperature probe is touched or held with bare fingers.
- Temperature correction is not possible when the temperature probe is in contact with the surface of the device to be measured. Note that the temperature probe is only designed to measure ambient air temperature.
- Significant measurement error will result if the device to be temperature corrected and the temperature probe are not at the same ambient air temperature.
- Large measurement error will result if the temperature probe is not inserted fully into the tc sensor jack.

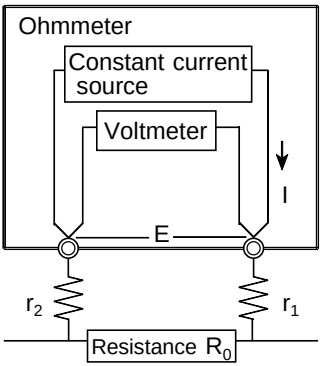
- Make sure the power is turned off before connecting or disconnecting the AC adapter.
- The AC adapter may pick up noise which will affect the measurement. In such a case, operate the instrument from battery power.
- Measurement range , comparator settings and all settings of the 3540 (except for the measured value) are backed up internally, but this backup occurs only after a certain amount of time has elapsed without any operation. Therefore, after changing the settings, wait a few moments (about 5 seconds) before turning off the power.
- Because the 3540 uses direct current to make measurements, thermoelectromotive effects can result in measurement errors. Refer to "1.3 Effects of Thermoelectromotive Force" for details.
- When the one that includes the L component such as the transformer for the power supply a lot is measured a measured value may not stabilize.

Chapter 1
Outline

The 3540 mΩ HiTESTER is an four-terminal method tester designed to accurately measure the coil resistance in motors and transformers, the contact resistance of relays, switches and connectors, and the trace resistance on printed circuit boards. In addition, a temperature correction function, comparator function and data output function are provided, making the 3540 mΩ HiTESTER ideal for use in production and inspection lines and systems.

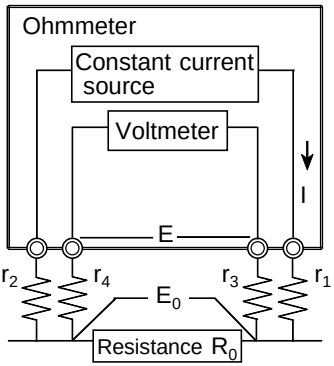
1.1 Four-terminal Method

To obtain accurate results when measuring resistance values that are very small, the Four-terminal method must be used. As shown in figure 1, in the Two-terminal method, the resistance of the test leads adds to the resistance of the device being measured, resulting in an erroneous measurement. However, in the Four-terminal method shown in the Figure 2, the input consists of two current terminals to which a constant current is supplied, and two voltage terminals measured the voltage drop. The voltmeter has a high input impedance so that essentially no current flows through the leads connected between the device-under-test and the voltage terminals. As a result, there is almost no voltage drop across the resistances r_3 and r_4. Thus the voltage drop due to the lead resistances and contact resistances is very small, and these can be canceled out.



The current I flows to the measured resistance R_0 and the wiring resistance r_1 and r_2.
Therefore, the measuring voltage E can be obtained by $E = I (r_1 + R_0 + r_2)$, and it would include the wiring resistance r_1 and r_2.

Figure 1
Measurement Using the 2-terminal Method



All of the current I flows to the measured resistance R_0.
Therefore, the voltage drop of r_3 and r_4 become 0, and voltage E and the voltage drop E_0 of each end of the measured resistance R_0 become equal. Accordingly, the resistance measurement without influence of r_1 to r_4 becomes possible.

Figure 2
Measurement Using the 4-terminal Method

1.2 Temperature Correction Function

The temperature sensor used in the 3540's temperature probe is a thin platinum film whose resistance changes according to temperature. The resistance of the film is detected and converted to a temperature value by the CPU.

This section explains use of the 3540's temperature coefficient correction function.

Since the resistance of copper wire is relatively susceptible to changes in temperature, that fact must be kept in mind when measuring its resistance. Using the temperature probe, the resistance value of copper wire can easily be converted to its 20℃ equivalent for display.

In general, the relationship between the resistance of copper wire and temperature is as indicated by the following expression.

$$R_t = R_{t0} \times \{1 + \alpha_{t0} \times (t - t_0)\} \quad \cdots\cdots (1)$$

Here, α_{t0} is referred to as the temperature coefficient, which is expressed as follows.

$$\alpha_{t0} = 1 / [\{1 / (0.00393 \times \alpha\ \} + (t_0 - 20)] \quad \cdots\cdots (2)$$

Here, σ is the conductivity of copper wire. From expressions (1) and (2), the temperature coefficients of various types of wire with various conductivities can be calculated, and their resistance values at a particular temperature obtained. Table 1 shows the conductivity of various types of copper wire.

Diameter (mm)	Soft copper	Tin-plated soft copper	Hard copper
0.10 to 0.26	0.98	0.93	---
0.26 to 0.29	0.98	0.94	---
0.29 to 0.50	0.993	0.94	---
0.50 to 2.00	1.00	0.96	0.96
2.00 to 8.00	1.00	0.97	0.97

Table 1 Conductivity σ

For 3540 temperature correction, conductivity σ is calculated as 1. Accordingly, when the resistance value R_{20} that is displayed at the time of temperature correction is taken as R_t, the measured resistance at the current ambient temperature is expressed by the following expression. (Temperature coefficient: α_{20} = 3930 ppm, ppm = x 10^{-6})

$$R_{20} = R_t / \{1 + \alpha_{20} \times (t - 20)\} \quad \cdots\cdots (3)$$

Error occurs during temperature correction because the temperature coefficient calculated according to expression (2) differs when the conductivity σ is other than 1.

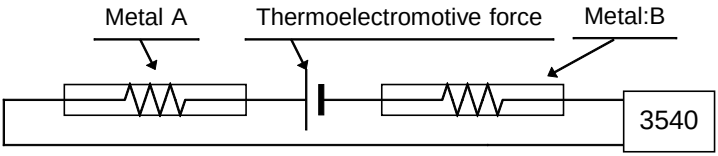
For example, when the tin-plated soft copper wire (diameter 0.10 to 0.26) of Table 1 is measured, σ = 0.93 gives α_{t0} of 3650 ppm, so that the 3540 temperature value contains error.

1.3 Effects of Thermoelectromotive Force

Thermoelectromotive force is the potential difference at the junction of two dissimilar metals. If this emf is large, measurement errors can result. As the 3540 uses constant direct current flowing through the object being measured, readings can be affected by even slight thermoelectromotive force.

Furthermore, the quantity of thermoelectromotive force is dependent upon the temperature of the measurement environment, with the force generally being greater at higher temperature.

Thermoelectromotive force occurs at the junction of dissimilar metals and between the probes of the 3540 and the contacts on the object being measured. The following figure illustrates thermoelectromotive force. The battery symbols represent a junction of dissimilar metals, and the probe symbols represent the thermoelectromotive force.



As an example of the error effects of thermoelectromotive force, if the force is 10 μV and the measured resistance is 3 Ω, the current is 1 mA in the 3 Ω range, so the measured value displayed on the 3540 is actually

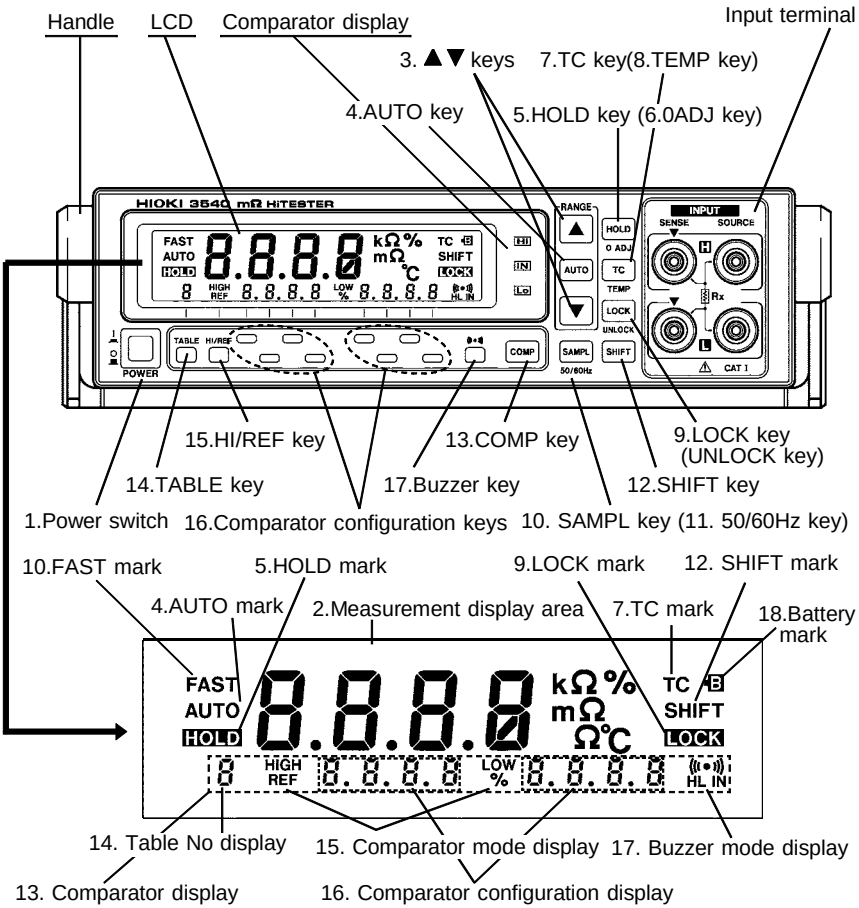
(3 Ω x 1 mA + 10 μV) / 1 mA = 3.010 Ω. In this situation, changing the probe direction to HI-LO leaves the polarity of the thermoelectromotive force unaffected, so the measured value is now (3 Ω X 1 mA - 10 μV) / 1 mA = 2.990 Ω.

If the measurement error is large due to the effect of thermoelectromotive force, the following countermeasures can be employed.

(1) Reverse the probes and use the average measured value.
(2) As the thermoelectromotive force is temperature dependent, maintain a constant temperature in the measurement environment.

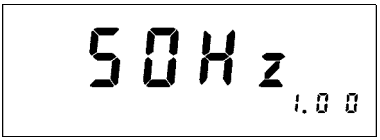
Chapter 2
Name and Functions

2.1 Front Panel



1. **POWER** switch

   On power-up, the LCD and LED's light and the instrument performs an internal check and initialization of internal analog circuits. An error code is displayed if an internal error is detected during the check. (Refer to "8.4 Error Code Table".)
   Upon completion of the internal check, the LCD displays the instruments power supply frequency setting and the 3540 version number.



2. Measurement display area

   Displays the measurement count, decimal point, unit of measurement, and the measurement range.

3. ▲ ▼ keys →Page 26

   The ▲ (up) and ▼ (down) keys are used to select the resistance measurement range.

4. **AUTO** key, **AUTO** mark →Page 26

   Pressing the **AUTO** key turns on automatic range selection, lighting the **AUTO** mark on the LCD. The measurement range for resistance is then automatically selected according to the resistance of the resistor being measured.

5. **HOLD** key, **HOLD** mark →Page 28

   Pressing the **HOLD** key turns on the hold mode, lighting the **HOLD** mark on the LCD and fixing the currently displayed measurement value.

6. **0ADJ** key →Page 27

   To zero-adjust the instrument, short the test leads and press **SHIFT** + **0ADJ** . (Zero adjustment is only possible with a reading of 100 counts or less.)

7. **TC** key, **TC** mark →Page 35

   When the temperature probe is connected, pressing the **TC** key converts the measured resistance value of copper wire to its 20 ℃ equivalent resistance value and displays it.

8. **TEMP** key →Page 36
   Pressing **SHIFT** + **TEMP** with the temperature probe connected selects the temperature measurement mode. Pressing **SHIFT** + **TEMP** a second time returns measurement to the resistance mode.
9. **LOCK** / **UNLOCK** key, **LOCK** mark
   Pressing the **LOCK** key lights the **LOCK** mark on the LCD and locks out key input. With key input locked, all of the keys on the instrument are disabled except for the **POWER** switch and the **SHIFT** key. To unlock the keys, press **SHIFT** + **UNLOCK** .
10. **SAMPL** key, **FAST** mark →Page 28
    Sampling speed is switched using the **SAMPL** key. With fast sampling, FAST is displayed on the LCD and sampling takes place at the rate 16 samples per second. When slow sampling is selected, sampling takes place at the rate of 4 samples per second.
11. **50/60Hz** key →Page 25
    Power supply frequency is selected by pressing **SHIFT** + **50/60Hz** . Select the frequency that matches that of your power supply.
12. **SHIFT** key, **SHIFT** mark
    Pressing the **SHIFT** key lights the **SHIFT** mark on the LCD and puts the keys in the shift mode. In the shift mode, pressing any key activates the function whose name is printed in blue below that key. To cancel the shift mode, press the **SHIFT** key a second time.
13. **COMP** key, comparator display →Page 31
    Pressing the **COMP** key turns on the comparator, lighting the comparator display on the LCD and enabling comparison measurement. To end comparison measurement, press the **COMP** key a second time.
14. **TABLE** key, Table No. display →Page 31
    Pressing the **TABLE** key switches the internal comparator table number. With the 3540, up to seven different comparator configurations can be saved.

15. **HI/REF** key, comparator mode display →Page 31

    The comparator mode is selected with the **HI/REF** key. When the **HIGH** or **LOW** mark is lit on the LCD, the comparator is in the Hi-Lo mode. When the **REF** or **%** mark is lit, it is in the REF-% mode.

16. Comparator configuration keys, comparator configuration display →Page 33

    Upper (HIGH) and lower (LOW) comparator limits and the comparator reference value (REF) and range (%) can be set by pressing keys corresponding to the various digits of the comparator configuration display on the LCD

17. Buzzer key and buzzer mode display →Page 32

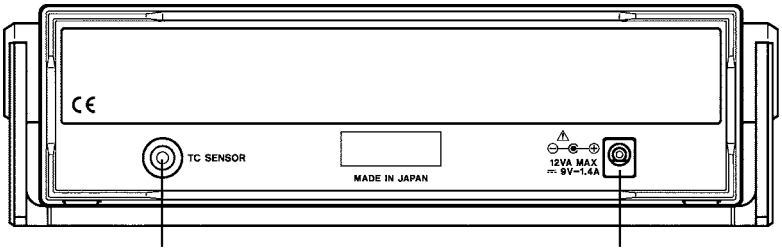
    Pressing the buzzer key switches the buzzer mode that is set dependent upon comparator results. When the HL buzzer mark is lit on the LCD, the buzzer is in the HL mode, and sounds when the comparator result is HIGH or LOW. When the IN buzzer mark is lit on the LCD, the buzzer is in the IN mode, and sounds when the comparator result is IN. When no buzzer mark is lit on the LCD, the buzzer is in the OFF mode, and does not sound.

18. Battery mark →Page 77

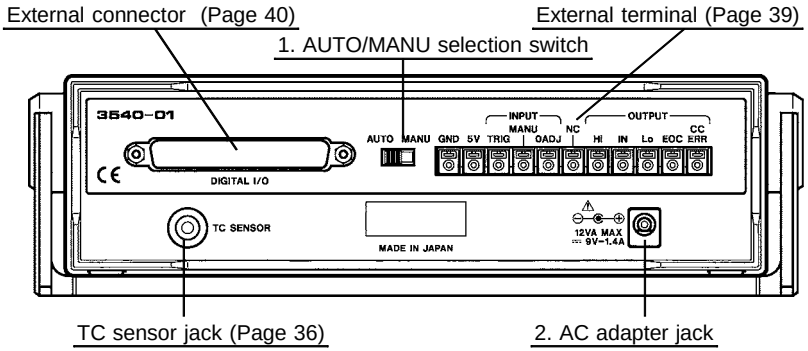
    The battery indicator appears when battery voltage becomes low. Replace the batteries as soon as possible.
    (Refer to "8.1 Battery Replacement Procedure".)

2.2 Rear Panel

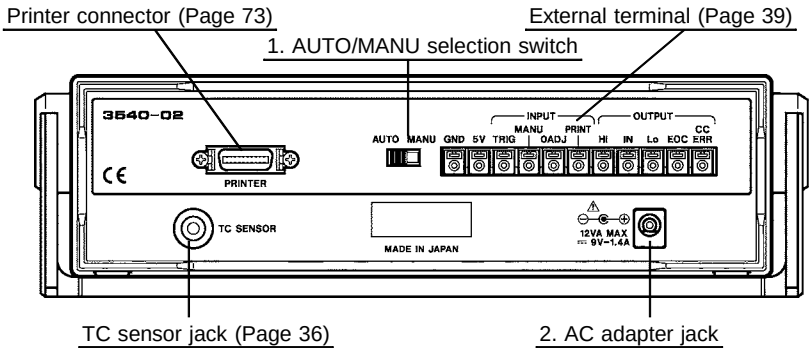
2.2.1 3540



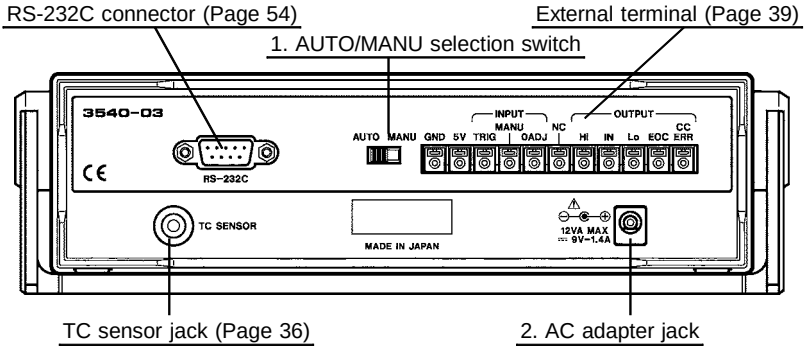
2.2.2 3540-01



2.2.3 3540-02



2.2.4 3540-03



1. AUTO/MANU selection switch →Page 34

Selects the AUTO mode, for continuous comparator output operation("normal" mode), or the MANU mode for comparator output only when the MANU and GND terminals of the external connector on the rear panel are shorted.

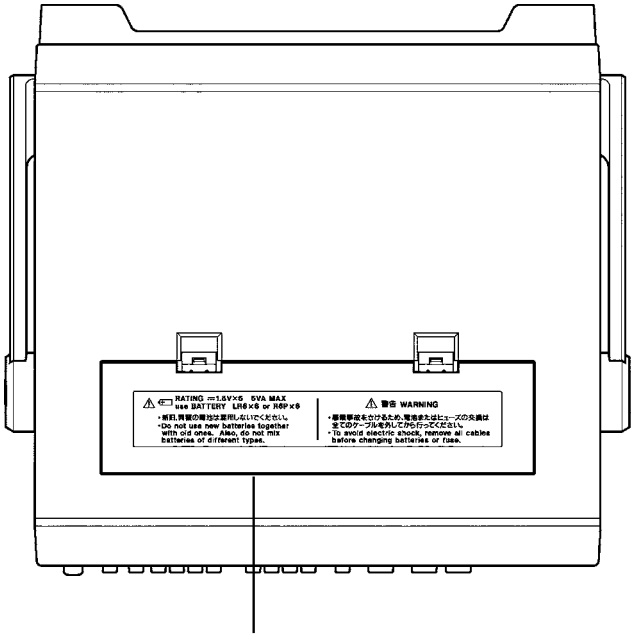
2. AC adapter jack

The 3540 can be operated from an AC power source by connecting an AC adapter.

When using an AC adapter, use only the specified HIOKI model 9445-02, 9445-03 AC ADAPTER.

An AC adapter rated at 9 VDC and 1.4 A to the AC adapter socket. The polarity of socket is center-plus.

2.3 Top Case



Battery cover (Page 78)

Chapter 3
Specifications

3.1 General Specifications

Measurement method	Four-terminal method
Operating method	Dual integrator circuit
Display	LCD display Resistance measurement 3500 counts Temperature measurement 999 counts
Auto range	Provided (disabled when comparator is on)
Input overflow	"OF" display
Current abnormality	"----" displayed (CCERR: external output*2)
Sampling speed	Resistance measurement "SLOW" 4 samples/sec "FAST" 16 samples/sec Temperature sampling 1 sample/sec
Response time*1	Resistance measurement "SLOW" 300 msec "FAST" 80 msec
Comparator	Table storage of up to 7 configurations (table externally selectable*3) Comparator results displayed by LED and externally output (open collector*2) Comparator modes (Hi-Lo/REF-%), Buzzer mode (HL/IN/OFF)
Temperature correction function	Reference temperature 20ºC (68ºF), copper wire (temperature coefficient: 3930 ppm)
External control*2	TTL output BCD Open collector output EOC, Hi, IN, Lo, CCERR TTL input TRIG, MANU, 0 ADJ, PRINT*4, range control*3, comparator control*3

Interface	RS-232C interface[*5]
Printer	Centronics interface[*4]
Power supply frequency	50/60 Hz, switchable
Overvoltage protection	30 VDC or ACpeak (circuit protection by fuse)
Operating temperature/humidity	0 to 40℃ (32 to 104 ℉), 80 %RH or less (No condensing)
Storage temperature/humidity	-10 to 50℃ (14 to 122 ℉), 80 %RH or less (No condensing)
Operating Environment	Indoor < 2000 m ASL (6566 feet)
Power source	Six LR6 alkaline batteries or six R6P manganese Batteries Rated supply voltage 1.5 VDC x 6
AC adapter (option)	9445-02 AC ADAPTER 9445-03 AC ADAPTER Rated supply voltage of the AC adapter is 100 to 240 VAC. (Voltage fluctuations of 10% from the rated supply voltage are taken into account.) Rated supply frequency is 50/60 Hz.
Maximum rated power	5 VA
Continuous operating time	LR6 Alkaline Batteries Approx.7 hours (30 m, 300 mΩ range, LED and buzzer: ON) Approx.18 hours (other ranges, LED and buzzer: ON) R6P manganese Batteries Approx.1.5 hours (30 m, 300 mΩ range, LED and buzzer: ON) Approx.6 hours (other ranges, LED and buzzer: ON)
Dimensions	Approx. 215W x 61H x 213D mm (8.46"W x 2.40"H x 8.39"D)
Mass	3540 Approx. 900 g (31.7 oz.) 3540-01, 3540-02, 3540-03 Approx. 1,000 g (35.3 oz.) (Except for batteries)

Accessories	9287-10 CLIP TYPE LEAD, 9451 TEMPERATURE PROBE, Instruction Manual, Six R6P manganese batteries, Spare fuse to protect the circuit (F1.0 AH/250 V), Ferrite clamp, External connector socket*3
Options	9445-02 AC ADAPTER, 9445-03 AC ADAPTER, 9452 CLIP TYPE LEAD, 9453 FOUR TERMINAL LEAD, 9455 PIN TYPE LEAD, 9460 CLIP TYPE LEAD WITH TEMPERATURE SENSOR, 9461 PIN TYPE LEAD, 9467 LARGE CLIP TYPE LEAD, 9203 DIGITAL PRINTER, 9425 CONNECTION CABLE, 9233 RECORDING PAPER
Applicable standards	Safety: EN61010 Pollution Degree 2, EMC: EN61326 EN61000-3-2 EN61000-3-3 Effect of radiated radio-frequency electromagnetic field at 3 V/m ±30 dgt max.

*1: Response time varies according to item being measured. Times indicated are for measurement of a reference resistance.

*2: 3540-01, 3540-02, 3540-03 only.

*3: 3540-01 only.

*4: 3540-02 only.

*5: 3540-03 only.

3.2 Measurement Range

Measurement condition	23±5℃ (73 ±9 ℉), 80 %RH or less (No condensing) After zero adjustment When the battery indicator not lighting
Pre-heating period	30 minutes
Effect of radiated radio-frequency electromagnetic field	At 3 V/m ±30 dgt max.

Resistance measurement (with sampling rate set to SLOW)

Range	30 mΩ	300 mΩ	3 Ω	30 Ω	300 Ω	3 kΩ	30 kΩ
Resolution	10 μΩ	100 μΩ	1 mΩ	10 mΩ	100 mΩ	1 Ω	10 Ω
Measurement current	100 mA		1 mA			10 μA	
Max. test voltage	3.5 mV	35 mV	3.5 mV	35 mV	350 mV	35 mV	350 mV
Accuracy 6month	±0.1% rdg. ±6 dgt.	±0.1% rdg. ±4 dgt.	±0.1% rdg. ±6 dgt.	±0.1 %rdg. ±4 dgt.			
Accuracy 1year	±0.15% rdg. ±6 dgt.	±0.15% rdg. ±4 dgt.	±0.15% rdg. ±6 dgt.	±0.15 %rdg. ±4 dgt.			
Temperature coefficient	±0.02% rdg. ±0.5 dgt./℃ (℉)						
Open-terminal voltage	4.0 Vmax.						

* If the sampling rate is set to FAST, add ± 3 dgt. to the digit accuracy error.

Temperature measurement and temperature correction

6month

Temperature range	Temperature measurement accuracy	Temperature correction accuracy (Add the following values to the accuracy specifications of the resistance measurement)
-10.0 to 39.9℃ (14.0 to 103.9℉)	±0.3 %rdg. ±0.5℃	±0.3 %
40.0 to 99.9℃ (104.0 to 211.9℉)	±0.3 %rdg. ±1.0℃	±0.6 %

1year

Temperature range	Temperature measurement accuracy	Temperature correction accuracy (Add the following values to the accuracy specifications of the resistance measurement)
-10.0 to 39.9℃ (14.0 to 103.9℉)	±0.45 %rdg. ±0.8℃	±0.4 %
40.0 to 99.9℃ (104.0 to 211.9℉)	±0.45 %rdg. ±1.5℃	±0.8 %

* For 3540 only, accuracy is ±0.2℃ for 6months (±0.3℃ for 1year) when connected to a manufacturer-recommended temperature sensor (Pt). The temperature-measurement accuracy and temperature-correction accuracy above are those of 3540 combined with the results of the 9541 TEMPERATURE PROBE.

We define measurement tolerances in terms of rdg. (reading) and dgt. (digit) values, with the following meanings:
rdg. (reading or displayed value)
The value currently being measured and indicated on the measuring product/ instrument.
dgt. (resolution)
The smallest displayable unit on a digital measuring product/ instrument, i.e., the input value that causes the digital display to show a "1" as the least-significant digit.

Chapter 4
Operating Procedure

4.1 Preparing Measurement

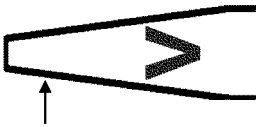
The 3540 works on battery power.
Refer to the section on battery replacement when installing batteries into the battery compartment while.
(Refer to "8.1 Battery Replacement Procedure".)
When connecting the AC adapter, first make sure the POWER switch is OFF, then insert the jack of AC adapter socket, connect the AC adapter body to the AC power source, and finally turn ON the **POWER** switch.

NOTE

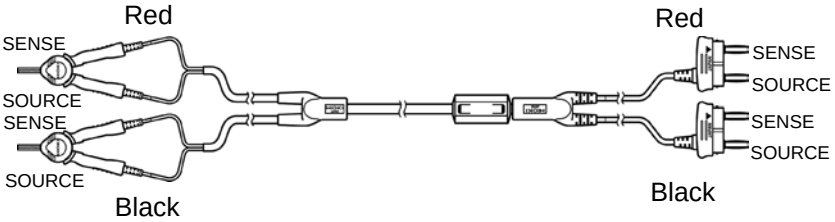
- Since power consumption is high in the case of 3540-01, 3540-02 and 3540-03, batteries will be exhausted quickly.
- For exhausted manganese batteries, the battery voltage fluctuates greatly depending on the current retrieved.
  Therefore, when measuring using manganese batteries, even when the battery voltage is adequately secured at a measurement current of 1 mA, at 100 mA the battery voltage will not be sufficient, causing the power supply to cut off or the LCD to keep repeating a cycle of blinking and disappearing.

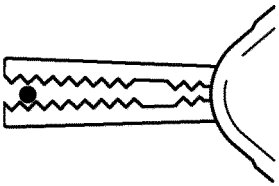
4.1.1 Measurement Leads

Connect the leads as shown in the following figure :

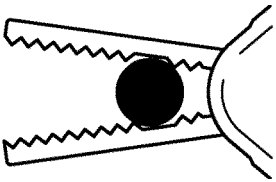


The side with "v" mark is SENSE.





When clipping a thin line
(Clip the line at the tip, serrated part of the jaws.)



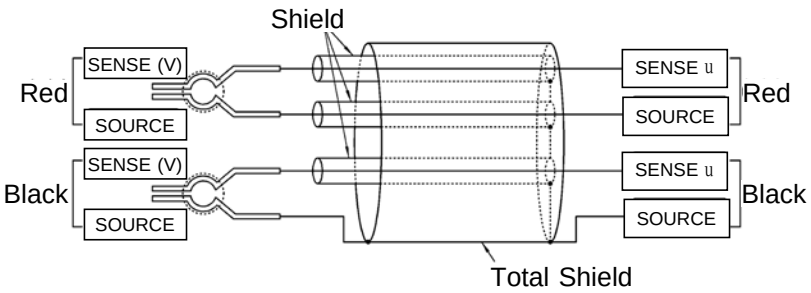
When clipping a thick line
(Clip the line at the deep, non-serrated part of the jaws.)

The cable part of the lead is shielded.

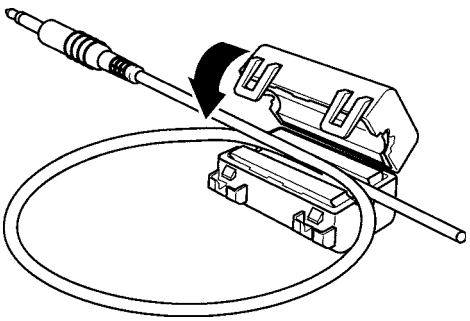
For user-made leads, take the following precautions when the leads :

(1) A shield must be applied. (Refer to the follow figure.)

(2) The cable length must be 5 m or less (The resistance of the wire material should be 100 mΩ/m or less.)



4.1.2 About the Temperature Probe

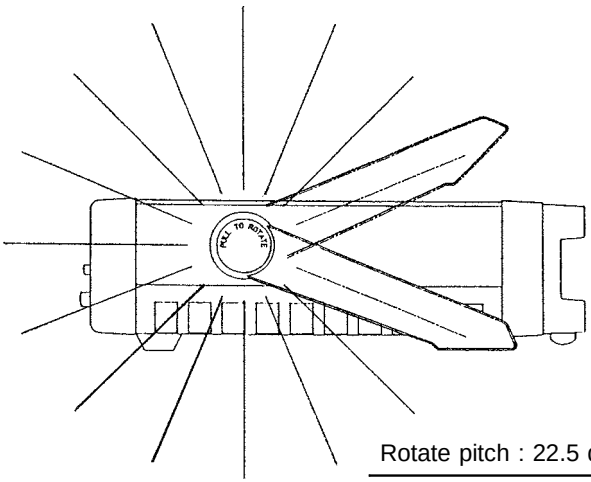


When using the 9451 TEMPERATURE PROBE, loop the probe cable once around the provided ferrite clamp and fasten it as shown in the figure.

4.1.3 Instrument Handle

⚠ CAUTION When using the handle as a stand for the device, do not press down too hard on the device as this can damage the handle.

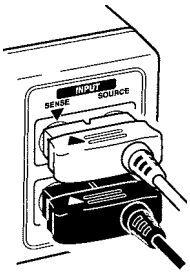
The handle can be used as a stand. Pull both ends of the handle outward to release it and rotate it to the desired position. Then, push the handle inward to lock it in place. The handle can be locked at interval of 22.5 degrees.

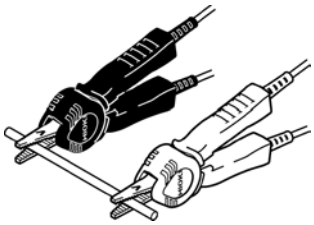


Rotate pitch : 22.5 degrees

4.2 Resistance Measurement

(1) Plug the leads into the input terminals.
Make the connection by mating the red ∇ marks on the leads.
Make the connection by mating the black ∇ marks on the unit and the leads. (See the Figure below.)



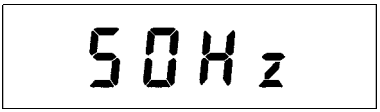


(2) Select the range.
(3) Zero adjust (0 ADJ) the instrument referring to subsection 4.2.3.
(4) Connect the lead clips to the device to be measured, and read the measurement value.

4.2.1 Setting the Power Supply Frequency

⚠ CAUTION To properly suppress noise, this product must be set to match the power supply frequency. Before using the product, make sure the power supply frequency selector is set correctly, to avoid erroneous readings.

First press the **SHIFT** key, then press **50/60Hz**. After a moment, the selected power supply frequency appears on the LCD as shown in the example below.



The power supply setting also appears for a moment after the 3540 is powered up, allowing you to verify the current setting.

4.2.2 Changing the Measurement Range

Manual range

The measurement range is changed by pressing the [▲] or [▼] key.

Pressing the [▲] key cycles the range selection through the sequence from 30 mΩ, to 300 mΩ, and so forth up to 30 kΩ.

Pressing the [▼] key cycles the range selection through the sequence from 30 kΩ, to 3 kΩ, and so forth down to 30 mΩ.

Auto range

Pressing the [AUTO] key toggles auto range selection on or off. When auto range selection is on, the **AUTO** mark lights on the LCD as shown below and the measurement range is selected automatically as appropriate for the value of the resistance being measured.

Auto range selection can be turned off by pressing the [▲] or [▼] keys.

Manual range selection

Auto range selection

NOTE

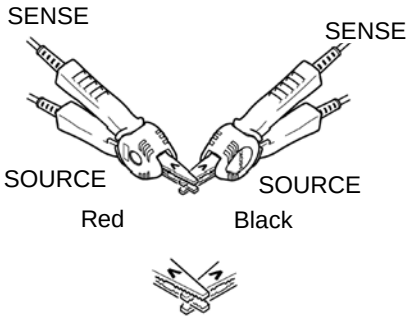
- With the 3540-01, the measurement range can be selected by range control signal through the external connector on the rear panel. However, when the measurement range is selected by range control signal, the setting cannot be changed from the front panel.
- Auto range selection is not possible during comparator operation.

4.2.3 Zero Adjust Function

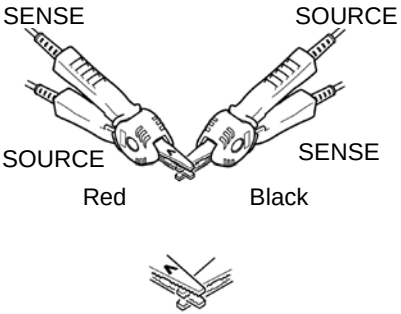
Zero adjustment is performed by shorting the test leads, then pressing first the **SHIFT** key, then the **0ADJ**. (Zero adjustment is only possible with a reading of 100 counts or less.)

Connect the test leads as shown below. The connection must be made exactly as shown; otherwise, altered lead resistance will make it impossible to obtain correct measurement.

With the 3540-01, 3540-02 and 3540-03, zero adjustment can also be performed by shorting the 0 ADJ and GND terminals on the rear panel terminal strip.



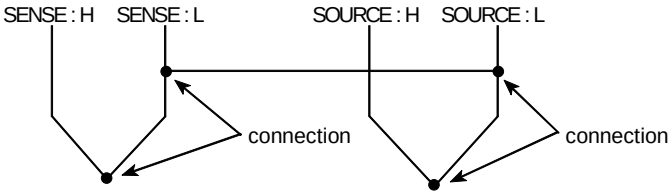
Right connection



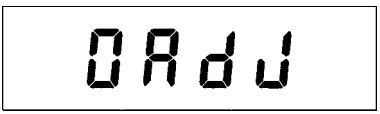
Wrong connection

Bring the "v" marks together at the same position.

NOTE If leads other than the specified ones are used, connect as shown in the following figure.



NOTE The following is displayed on the LCD during 0 ADJ.



NOTE The zero adjust value is maintained internally even when the power is turned off. However, note that zero adjustment must be performed for each measurement range to be used.

4.2.4 Switching the Sampling Speed

Pressing the **SAMPL** key toggles the sampling speed between two settings, FAST and SLOW.

FAST setting

16 samples/sec FAST mark lights on LCD

SLOW setting

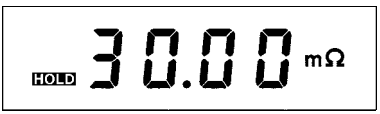
4 samples/sec FAST mark does not light on LCD

FAST setting

SLOW setting

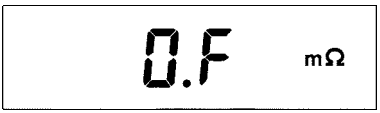
4.2.5 Hold Function

Pressing the **HOLD** key lights the **HOLD** mark on the LCD and holds the current measurement value of the display.
With the 3540-01, 3540-02 and 3540-03, shorting the TRIG and GND terminals on the rear panel terminal strip with display in the hold state results in taking of one measurement, after which display returns to the hold state.
Normal (free-running) measurement resumes when the hold state is canceled.



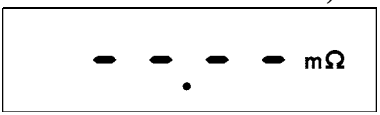
4.2.6 Overload Indicator

If the input overloads, the following mark is displayed on the LCD.



4.2.7 Current Abnormality (CCERR) Detection Function

If any abnormality is detected in the regularity of current in the power supply, the current abnormality detection circuit operates and the symbols indicating CCERR, as shown below, is displayed on the LCD to advise of current abnormality.
With the 3540-01, 3540-02 and 3540-03, the CCERR signal is output from the CCERR terminal on the rear panel. (Refer to "Chapter 5 External Control Features".)



Conditions when current abnormality display

(1) When the resistance being measured is large with respect to the range
   Example: When a 30 Ω resistance is measured in the 30 mΩ range.
(2) When the test leads are shorted (and only SOURCE is detected)
(3) When any of the four terminals on the front panel is not properly connected
(4) When there is an open lead condition
(5) When the fuse is burned out
   (Refer to "8.2 Fuse Replacement Procedure".)

4.3 Comparator Function

The 3540 allows storing of up to 7 comparator configuration tables. Each table can hold the comparator configuration for measurement range, comparator mode, buzzer and mode.
The results of comparison are indicated by buzzer, as well as by lighting of the Hi, IN, and Lo LEDs. With the 3540-01 and 3540-02, results can also be output through the terminal strip on the rear panel by open collector.
Refer to "5.4.2 Outputting Measurement Results" regarding comparator output to the external terminal strip.

NOTE

- Auto range selection is canceled if used together with the comparator.
- Since the measurement range is also saved with the comparator table, switching the comparator table also switches the measurement range.
  If the measurement range is switched during comparator operation, the measurement range information in the corresponding comparator table is also changed.
- With the 3540-01, the comparator table can be controlled with the comparator control signal through the external connector on the rear panel.
  However, when the comparator table is selected by the comparator control signal, the selection cannot be changed with the keys on the front panel.

4.3.1 Using the Comparator

Pressing the **COMP** key lights the comparator display on the LCD and starts the comparator function, allowing you to make comparative measurements
Pressing the **COMP** key a second time turns off the comparator.

4.3.2 Selecting the Comparator Table

The 3540 allows saving up to 7 tables of comparator configurations. The comparator configuration is switched by pressing the **TABLE** key to cycle through the comparator table numbers in the sequence from 1 through 7, then to 1 again.

4.3.3 Selecting the Comparator Mode

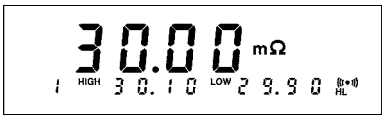
Pressing the **HI/REF** key switches the comparator mode of the currently selected comparator table.
Comparator modes that can be selected are the Hi-Lo mode, in which comparison is done using upper (HIGH) and lower (LOW) limits, and the REF-% mode, in which comparison is based on a reference value (REF) or range (%). With operation in the REF-% mode, the measured value is displayed as a deviation (as a percentage of reference value).

The Hi-Lo mode

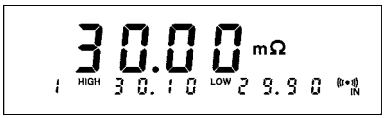
The REF-% mode

4.3.4 Selecting the Buzzer Mode

Pressing the buzzer key switches the buzzer mode of the currently displayed comparator table.
Available buzzer modes are the HL mode, in which the buzzer sounds when comparison results are "Hi" or "Lo"; the IN mode, in which the buzzer sounds when the comparison result is "IN"; and the OFF mode, in which the buzzer never sounds.



The HL mode



The IN mode

The OFF mode

4.3.5 Configuring the Comparison Values

With the Hi-Lo comparator

The upper (HIGH) and lower (LOW) limit values are set using the comparator configuration keys. The configuration range in counts is from 0 to 9999. (A count is the number resulting after any decimal point and unit are eliminated from a numeric value

With the REF-% comparator

The reference value (REF) and range (%) are set using the comparator configuration keys. The configuration range in counts is 0 to 9999 counts for the reference value (REF), and from 0.0% to 999.9% for the range (%).

For the REF-% comparator, the following upper and lower limits are used for comparison.

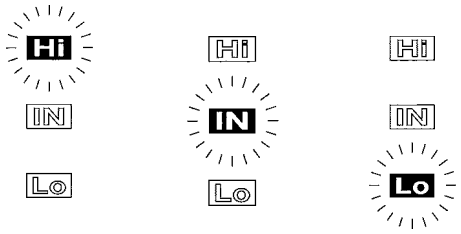
Upper limit = REF + (REF x % / 100)

Lower limit = REF - (REF x % / 100)

The standard for comparator evaluation is as shown below.

Range of measured values	Comparator result
Upper limit < Measured value	Hi
Lower limit ≦ Measured value ≦ Upper limit	IN
Measured value < Lower limit	Lo

LED display for the various comparator results is as follows.



NOTE

- If the value set for the lower limit is greater than that set for the upper limit, the 3540 reverses the values for comparison, taking the lower limit as the upper limit and vice versa.
- If the input limit is exceeded, the comparator result is Hi.
- No comparator result is produced if there is a current abnormality.

4.3.6 Outputting Comparator Results

Comparator results can be output using either of two modes: the auto mode or the manual mode.

With the 3540-01, 3540-02 and 3540-03, the external control mode can be selected using the AUTO/MANU selector switch on the rear panel.

With the 3540, output always uses the auto mode.

Auto mode (AUTO)

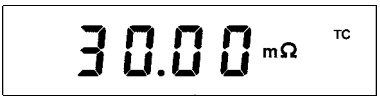
During comparator operation, comparator results are output continuously through the LED, buzzer, and (with the 3540-01, 3540-02 and 3540-03) the comparator result signal terminals (Hi, IN, Lo) on the rear panel.

Manual mode (MANU)

In the manual mode, comparator output to an external source is canceled. Comparison results for any desired period can be obtained by shorting the MANU and GND terminals on the rear panel terminal strip. Output is canceled when the short is broken.

4.4 Temperature Correction Function (TC)

This function uses the principle of temperature correction (refer to "1.2 Temperature Correction Function") to convert the resistance of copper wire to its 20℃ equivalent resistance.
Connect the 9451 TEMPERATURE PROBE to the TC sensor jack on the rear panel. For connection procedures, refer to "4.5 Temperature Measurement".
When the 9451 TEMPERATURE PROBE is connected, pressing the **TC** key lights the **TC** mark on the LCD and performs temperature correction (display as shown below).



If the temperature probe is not connected or is connected incorrectly, when the **TC** key is pressed, and an error message is displayed instead. If temperature correction is not performed as expected, check connection of the temperature probe.
For error messages, refer to "8.4 Error Code Table".

NOTE

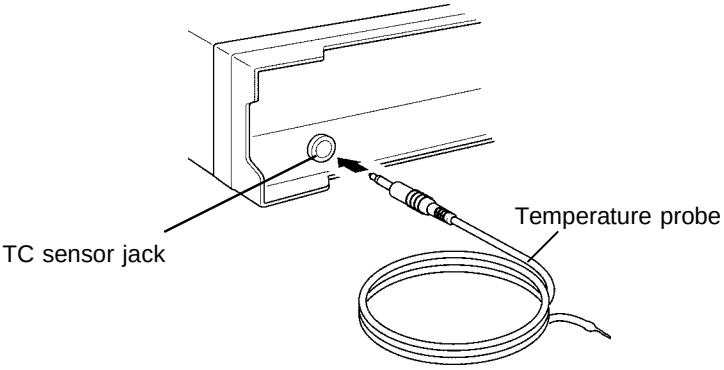
- The temperature probe is not designed to sense surface temperature. It should only be used to sense ambient air temperature.
- Note also that unless both the sample and the probe have completely adjusted to the ambient air temperature, the reading error will be large.

Prior to use, the temperature probe should be connected to the 3540, and both should be allowed to warm up at least 30 minutes.

- The temperature probe should be connected or disconnected with the power of the unit OFF.
- Note also that the temperature probe is not watertight. Therefore, do not allow the instrument to get wet or be immersed in water or any other fluid.
- Large measurement error will result if the temperature probe is not inserted fully into the tc sensor jack.

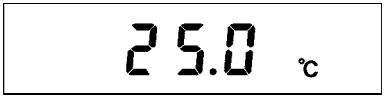
4.5 Temperature Measurement

Turn the power off. And connect the TC adapter as a following this Figure.



Plug into the TC sensor jack on the panel

After turning on the power and pressing **SHIFT** followed by **TEMP**, ambient temperature is sensed by the temperature probe and displayed as follows.



If the temperature probe is not connected or is connected incorrectly, temperature measurement is not performed when the **TEMP** key is pressed, and an "－－－－℃ " is displayed instead. If temperature correction is not performed as expected, check connection of the temperature probe.
For error messages, refer to "8.4 Error Code Table".
After completing the temperature measurement, to proceed to the resistance measurement, press the **SHIFT** key followed by **TEMP** key.

NOTE

- Accurate temperature measurement are not possible if the sheath of the temperature probe is held with bare fingers.
- The temperature probe should be connected or disconnected with the power of the unit OFF.
- Note also that the temperature probe is not watertight. Therefore, do not allow the instrument to get wet or be immersed in water or any other fluid.

Chapter 5
External Control Features

This chapter explains external control features of the 3540-01, 3540-02 and3540-03.

The rear panel of the 3540-01 is equipped with external connectors (for BCD output, range and comparator control, etc.), and an external terminal strip (for trigger input, comparator output, and so forth). The 3540-02 and 3540-03 also has an external terminal strip for functions such as trigger input and comparator output.

5.1 Connectors

The 3540-01, 3540-02 and 3540-03 are equipped with external connectors and/or terminals. Signals assigned to these terminals can be used to control operation of the 3540 or determine its status.

Functions of the various terminals and procedures for using the corresponding signals are described below.

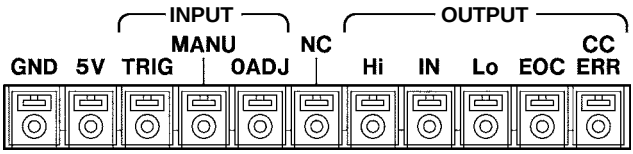
⚠ WARNING

Always observe the following precautions when connecting to an external terminal or external connectors. Failure to do so may result in electric shock or damage to the equipment.

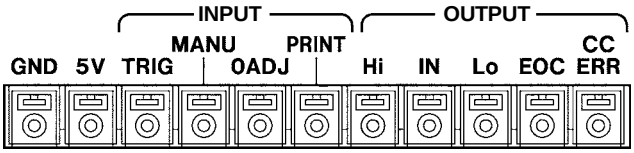
- **Always turn off the power to the unit and to any connected device before making connections.**

5.1.1 The External Terminal

The External Terminal (3540-01 and 3540-03)



The External Terminal (3540-02)



Signals	Input and output	Signals	Input and output
GND	Ground	Hi	Open collector output
5V	Power supply	IN	
TRIG	TTL input	Lo	
MANU		EOC	
0ADJ		CCERR	
PRINT*			

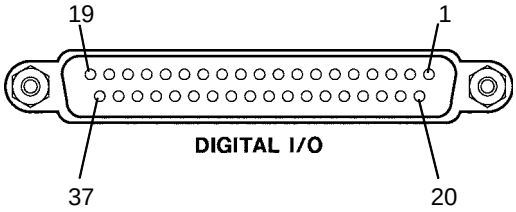
* 3540-02 only

5.1.2 The External Connectors

Using connector: DCLC-J37SAF-13L9 (made by Japan aviation electron) 37 pins receptacle

Adaptive pin: FDCD-37P (made by HIROSE) 37 pins plug

* A plug with FDCD-37P type compatible pins is provided with the 3540-01. For details on the compatible pins and use of the plug, refer to "5.2.2 External Connectors".



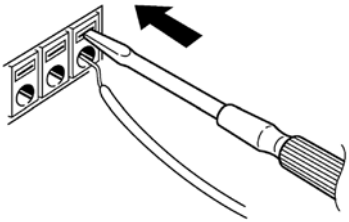
Pin number	Input and output	Signals	Signals	Input and output	Pin number
1	TTL output	BCD(10^3 digit)-bit 3			
2		BCD(10^3 digit)-bit 2	BCD(10^1 digit)-bit 1	TTL output	20
3		BCD(10^3 digit)-bit 1	BCD(10^1 digit)-bit 0		21
4		BCD(10^3 digit)-bit 0	BCD(10^0 digit)-bit 3		22
5		BCD(10^2 digit)-bit 3	BCD(10^0 digit)-bit 2		23
6		BCD(10^2 digit)-bit 2	BCD(10^0 digit)-bit 1		24
7		BCD(10^2 digit)-bit 1	BCD(10^0 digit)-bit 0		25
8		BCD(10^2 digit)-bit 0	CCERR		26
9		BCD(10^1 digit)-bit 3	EOC		27
10		BCD(10^1 digit)-bit 2	GND	Ground	28
11		DP 1	NC	NC	29
12	TTL input	RANGE 0	DP 0	TTL output	30
13		RANGE 1	DP 2		31
14		RANGE 2	COMP 0	TTL input	32
15	power source	5 V	COMP 1		33
16			COMP 2		34
17			GND	Ground	35
18					36
19					37

NC: not connected

5.2 Connections to Terminals

5.2.1 The External Terminal

(1) Use suitable wires bared at their ends for a length of about 10 mm.
(2) As shown in Figure, depress the knob on the terminal with a screwdriver, and push the end of the wire into the connection hole.
(3) Release the screwdriver, and the wires will be locked into place.
(4) Use the same procedure to remove the wires



Recommended wire

Single strand: 1.0 mm dia. (AWG #18)

Multi strand: 0.75 mm^2

Usable limits

Single strand: 0.4 to 1.0 mm dia. (AWG #26 to #18)

Multi strand: 0.3 to 0.75 mm^2 (AWG #22 to #20)

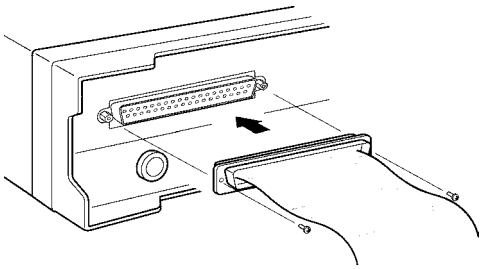
Strand diameter: minimum 0.18 mm

Standard insulation stripping length: 10 mm

Button pressing tool: Blade screwdriver (tip width 2.6 mm)

5.2.2 External Connectors

(1) Make connections to the compatible pins as appropriate for the pin assignments of the external connector.
(2) Plug the connector wired in (1) firmly into the external connector.
(3) Fasten the plug to the external connector with screws (M2.6).



About the accessory plug

The connector plug (FDCD-37P) provided with the 3540-01 is equipped with a flat cable pressure connector. Use the following flat ribbon cable with this connector.

Cable pitch: 1.27 mm or 1.38 mm
Core wire: AWG#26 to #28 (stranded or single core)
Insulation thickness: 0.8 mm to 1 mm

NOTE

- A special tool is required in order to make flat cable pressure connections.
  Consult the connector maker for the tool and how to make connections.
- A wide variety of other connectors are available from various manufacturers which can be used in place of the connector provided. These include solder connection type connectors, pressure fitted connectors, and connectors with various types of covers.
  See the various manufacturers' catalogs for connectors that can be used in place of the one provided.

5.3 Electrical Specification

5.3.1 Power Supply Rating

5 V	Power supply (GND + Approx. 5 V) Approx. 200 mA max.
GND	Ground (0 V)

NOTE

- The maximum capacity of this power supply is about 200 mA. In situations requiring more power, use an external power supply.
- If transitory current is required, insert an electrolytic capacitor between 5 V and GND.
- Since GND is insulated from the measurement circuit, do not connect the measurement system to GND.
- The voltage (5 V) varies a maximum of approximately 20% according to the size of the load current on the power supply. (Approximately 4 V to approximately 6 V) For example, the power supply voltage will fall below 5 V if the load current increases.

5.3.2 Input/output Ratings

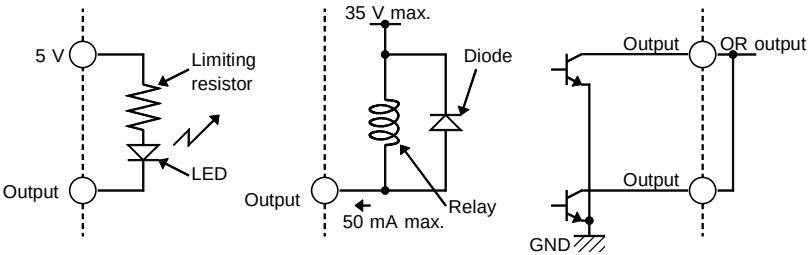
⚠ WARNING

The ratings given here are absolute maximums. This means that exceeding these values, even momentarily, may result in damage to the circuits. Always ensure that applied voltage and current are below the rated values.
However, with TTL output, never apply polarized voltage or current.

Input/output type	Absolute maximum rating	Signal logic	
		Valid	Invalid
TTL input	5 V, 20 mA max.	0 V	5 V
TTL output		5 V	0 V
Open collector output	35 V, 50 mA max.	ON	OFF

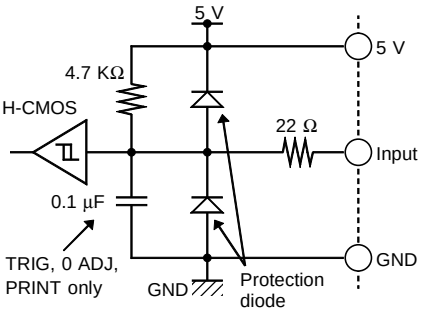
NOTE

- Signal logic refers to the signal state in which the function indicated by the signal is becomes valid.
- With open collector signals, the output transistor acts as a switch between the output signal and GND inside the 3540. When output is "valid", the switch goes ON and current flows inside the 3540 from the output signal to GND.
  Accordingly, this type of output can be used to control connected LEDs or contact relays, provided that such devices operate on less than 35 V, 50 mA. However, if a relay is connected, be sure to insert a diode to absorb counter electromotive force.
- Multiple open collector outputs can be connected together for use. This produces a wired OR configuration in which a "valid" signal any one on the connected outputs will produce a "valid" result. For example, if a "valid" result is desired from the Hi and Lo comparator results, connect the Hi and Lo open collector outputs.

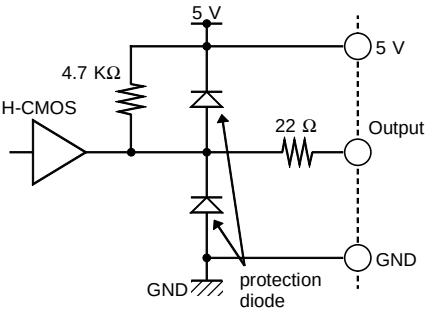


LED connection　　Relay connection　　Wired OR

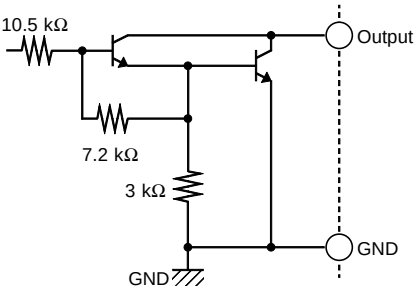
5.3.3 Internal Circuit



TTL input circuit



TTL output circuit



Open corrector output circuit

5.4 Using the Signals

This section explains how to use the 3540's various signals and shows the signals' timing charts.

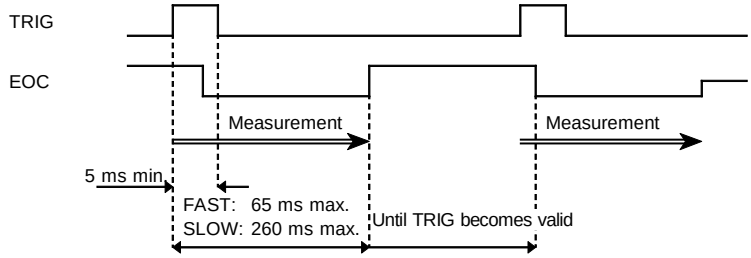
NOTE

- Since the timing charts indicate the logic of the signals, the high line positions are "valid" and the low line positions are "invalid." Note that the positions of the lines are not related to the signal (voltage) levels.
  In the I/O code explanations (for measurement range and comparator), "0" indicates 0 V, and "1" indicates 5 V.
  For an explanation of the signal logic, refer to "5.1 Connectors" and "5.3 Electrical Specifications".
- Refer to "Chapter 4 Operating Procedure" regarding instrument settings such as the comparator configuration.
- The timings shown in the timing charts assume that no key input is taking place.

5.4.1 Measurement Control

With measurement in the hold state

In the hold state, measurement starts when TRIG becomes valid, then EOC becomes valid when measurement ends. EOC then remains valid until the next time TRIG becomes valid.

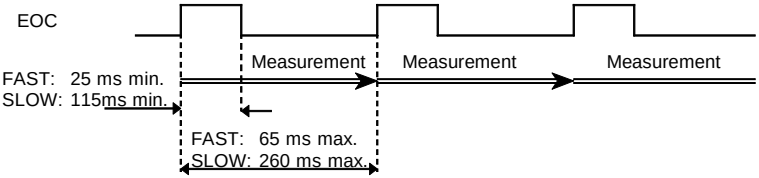


NOTE

- During measurement, EOC is also invalidated when the next TRIG signal is input.

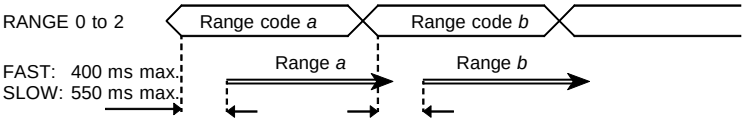
With free-running measurement

With free-running measurement, the 3540 measures repeatedly at the internal sampling rate, with EOC becoming valid each time measurement ends.



Changing the measurement range

The measurement range used by the 3540 change be changed using signals RANGE 0 to RANGE 2.



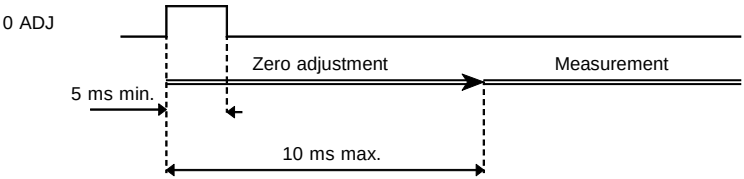
RANGE 2	RANGE 1	RANGE 0	Measurement range
1	1	0	30 mΩ
1	0	1	300 mΩ
1	0	0	3 Ω
0	1	1	30 Ω
0	1	0	300 Ω
0	0	1	3 kΩ
0	0	0	30 kΩ
1	1	1	No range control

NOTE

- After switching range codes, up to 550 ms are required for the internal circuitry to stabilize. Therefore, no measurement should be taken for at least 550 ms after switching range codes.

Zero adjustment

Zero adjustment is possible using 0 ADJ.

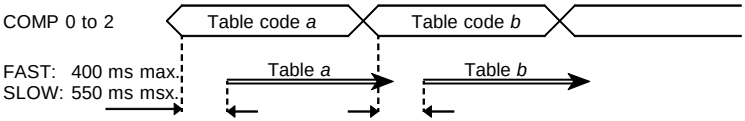


NOTE

- Measurement is not possible during zero adjustment.
- Wait at least 10 ms after completing zero adjustment before taking measurements.

Changing the Comparator Table

The comparator table used by the 3540 can be changed using signals COMP 0 to COMP 2.



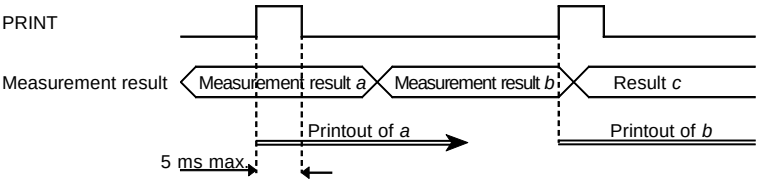
COMP 2	COMP 1	COMP 0	Comparator table
1	1	0	No. 1
1	0	1	No. 2
1	0	0	No. 3
0	1	1	No. 4
0	1	0	No. 5
0	0	1	No. 6
0	0	0	No. 7
1	1	1	No comparator control

NOTE

- After switching comparator table, up to 550 ms are required for the internal circuitry to stabilize. Therefore, no measurement should be taken for at least 550 ms after switching comparator table.

Printing (with the 3540-02 only)

Measurements displayed can be output to a printer connected to the printer connector using the PRINT signal.
Refer to "Chapter 7 Printers".



NOTE

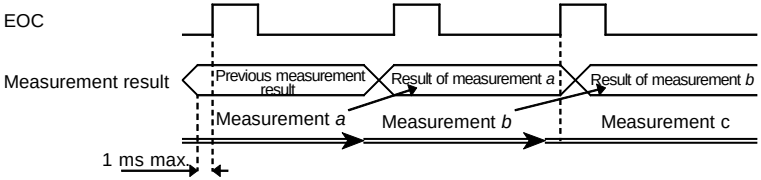
- Output of any previous printout must be completed before printing the next measurement.
  Print time varies according to the speed of the connected printer.
- Printout of the measurement displayed starts when the PRINT signal becomes valid. Before starting printing, check the EOC signal to verify that measurement has been completed.

5.4.2 Outputting Measurement Results

Measurement output in the auto mode (outputting comparator results)

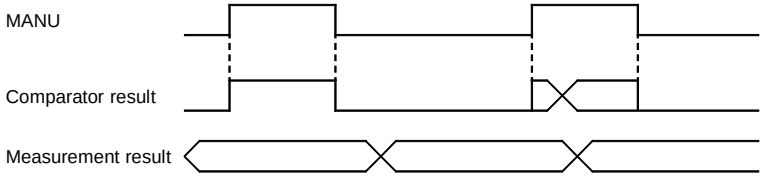
In the auto mode, comparator results (Hi, IN, Lo) and result data of measurements (BCD, DP) are output when EOC becomes valid after measurement is completed.

Comparator results and measurement data should be taken after EOC becomes valid (at the signal's rising edge).



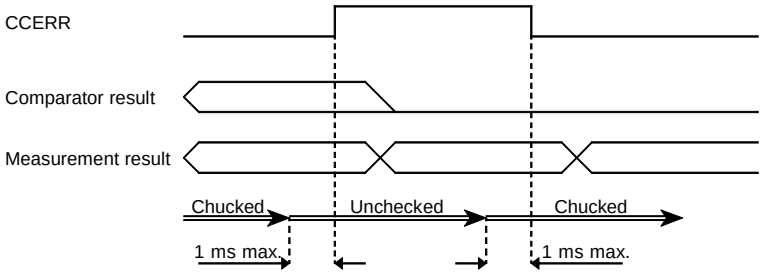
Measurement output in the manual mode (outputting comparator results)

In the manual mode, comparator results (Hi, IN, Lo) are output only when the MANU signal becomes valid. Measurement data (BCD, DP) is output continuously.



Output during current abnormalities

When a current abnormality occurs (when the resistance being measured is unchucked), the CCERR signal becomes valid. When this happens, the all comparator result output becomes invalid.



NOTE

- Comparator results are output even if CCERR becomes valid. However, comparator results are not output if CCERR is valid when measurement starts.

About the measurement data

Measurement data is output as 4 digits (each of which is represented by 4 bits) of BCD data indicating the display count of the measured value, and as a 3-bit DP code indicating the range. Meanings of the BCD and DP output codes are as follows.

BCD bits				Number	BCD bits				Number
3	2	1	0		3	2	1	0	
0	0	0	0	0	0	1	0	1	5
0	0	0	1	1	0	1	1	0	6
0	0	1	0	2	0	1	1	1	7
0	0	1	1	3	1	0	0	0	8
0	1	0	0	4	1	0	0	1	9

Meanings of BCD digit codes

DP 2	DP 1	DP 0	Measurement range	Exponent
0	0	0	30 mΩ	x 10^{-5}
0	0	1	300 mΩ	x 10^{-4}
0	1	0	3 Ω	x 10^{-3}
0	1	1	30 Ω	x 10^{-2}
1	0	0	300 Ω	x 10^{-1}
1	0	1	3 kΩ	x 10^{0}
1	1	0	30 kΩ	x 10^{1}

Meanings of DP codes

Measured values are expressed as follows by the BCD and DP codes.

Measured value = {BCD(10^3digit) x 10^3+BCD(10^2digit) x 10^2+BCD(10^1digit) x 10^1 +BCD(10^0digit) x 10^0} x (exponent indicated by DP code)

For example, when the numbers indicated by BCD digits (10^3) to (10^0) are 0001, 0010, 0011, and 0100 and the DP code is 001, the display count of the measured value is 1234, the measurement range is 300 m, and the exponent is x 10^{-4}, giving a measured value as follows.

Measured value = 1234 x 10^{-4} = 0.1234 (Ω) = 123.4 (mΩ)

NOTE The BCD code "9999" is output with OF or CCERR.

Chapter 6
RS-232C Interface

6.1 Specifications

6.1.1 RS-232C Settings

The RS-232C settings of the 3540-03 are as follows. Since the 3540 settings are fixed and cannot be changed, these settings must be matched on the computer side.

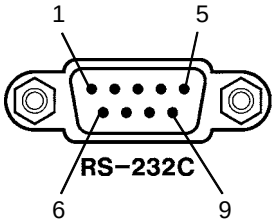
Transmission mode:	Start-stop synchronization, full duplex
Transfer rate:	9600
Data length:	8
Parity:	None
Stop bit:	1
Hand shake:	X flow, hardware flow and none
Delimiter:	CR, CR+LF for reception CR+LF for transmission

6.1.2 Electrical Characteristics

Input voltage level	+5 V to +15 V -15 V to -5 V	ON OFF
Output voltage level (load resistance 3 kΩ to 7 kΩ)	+5 V to +9 V -9 V to -5 V	ON OFF

6.1.3 Connector

Pin arrangement of interface connector (D-sub 9-Pin male)



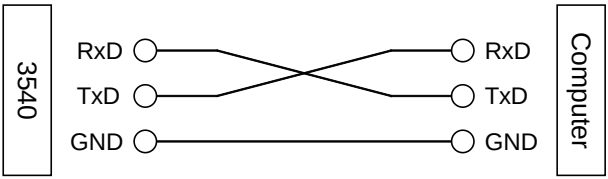
The signal lines of the 3540-03's RS-232C connector are as follows.

Pin number	Signal	I/O	Contents
2	RxD	IN	Incoming data
3	TxD	OUT	Outgoing data
5	GND	GND	Signal ground
Other pins are not used			

6.1.4 Connection Method

Use a cross cable for connecting to the computer.

The outgoing data and the incoming data will cross and there is no need to make other connections provided the signal ground wire is connected.



For the flow control on the computer side, hardware flow must be set to OFF.

Connecting cable

Connector on cable side: D-Sub 9-Pin female

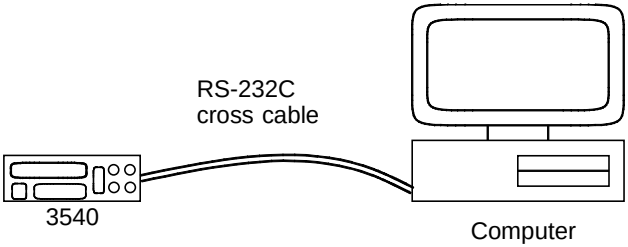
Connection: Reverse connection

Compatible cable for connection to PC/AT compatible PC: 9637 RS-232C CABLE

6.2 Communication Method

6.2.1 Connection to Computer

Connect the 3540-03 to the computer using a cross cable.



Perform the RS-232C settings on the computer side.
For details on how to make the settings, refer to the instruction manual for the computer.

6.2.2 Command Transfer Method

The command is issued from the computer.
When the 3540 receives the incoming command from the computer, it executes the processing specified by the command.
When 3540 has completed processing of the command, it always returns a response to the computer.
When the computer has confirmed the response, it sends the next command.

NOTE Every time the computer has sent a command, a response is always returned.
Make sure that the computer only sends the next command after it has received the response to the previous command issued from the 3540.
If multiple commands are sent consecutively, the 3540 may not execute the commands or command errors may occur.

6.2.3 Command Format

The 3540 commands have the following structure.

Command + parameter + delimiter

The command and the parameter are separated by `" "` (one character space).
If there is no parameter, send the delimiter after the command.
The command may consist of both upper and lower case letters.
Make sure to use one character space as the separator between the command and the parameter.

When the command contains a parameter
In the case of
`"rng 0"` (+ delimiter)
the command format consists of the command `"rng"` followed by the separator `" "`. Then follows the parameter `"0"`. Following the parameter comes the delimiter.

When the command contains no parameter
`"adj"` (+ delimiter)
the command format consists of the command `"adj"` immediately followed by the delimiter.

NOTE The meaning of the delimiter is to separate commands and data. When the 3540 receives the delimiter, it starts analysis of the command.

6.2.4 Response Format

When a command is sent to 3540, 3540 processes the command. When processing is completed, 3540 always returns a response.

When there is no information from 3540,
OK (+ delimiter)

When there is information from 3540 (measurement values, etc.),
Response character string related to the command (+ delimiter)

When the command contained an error,
CMD ERR (+ delimiter): Command error
EXEC ERR (+ delimiter): Execution error

6.2.5 Delimiter

Depending on transmission direction, the delimiter is as follows.
From computer to 3540: CR or CR+LF
From 3540 to computer: CR+LF

6.3 Command

6.3.1 Explanation of Command References

Syntax Describes the syntax of the command.

<data> Explains the parameter data.

Response Explains the received data.

Function Explains the actions specified by the command.

Error Describes errors that may occur when the command is executed.

Example Command execution examples.
PC> denotes command from the computer.
3540> denotes command from 3540.

NOTE The setting conditions and comparator data are written to the non-volatile memory in the 3540 main unit 5 seconds after the settings have been made (no key operations should be performed during this interval).

6.3.2 Command References

RESET

Initializes the settings

Syntax `RESET`

Response `OK` Initialization completed

Function Initializes the settings of the 3540

Measurement mode	Resistance measurement mode
Measurement range	30 mΩ range
Sampling speed	SLOW
Hold function	Free-running (hold state canceled)
Comparator	Comparator not used
Table No.	1
Comparator mode	Hi-Lo comparator
Comparison values	HIGH, LOW, REF, % = [0000]
Buzzer mode	OFF
Temperature correction function (TC)	OFF
Zero adjuster data	0 count reading for entire range.
Power supply frequency	50 Hz

Example Executing initialization.

PC >`RESET` Execute initialization

3540 >`OK` Initialization completed.

RMES

Resistance measurement value

Syntax `RMES`

Response `<rdata>`

<data> `<rdata>`

Resistance measurement value (see "6.3.3 Received Data".)

Function Obtains the latest resistance measurement value and comparator result.

Example Obtaining resistance measurement value.

PC >`RMES` Obtain measurement value.

3540 > `15.72E-03` Measurement value: 15.72 mΩ

TMES

Temperature measurement value

Syntax TMES

Response <tdata>

<data> <tdata>

Temperature measurement value (See "6.3.3 Received Data".)

Function Obtains the latest temperature measurement value

Examples Obtaining temperature measurement values.

PC	>TMES	Obtain measurement value.
3540 >	25.6	Temperature measurement value 25.6℃
PC	>TMES	Obtain measurement value
3540 >	- 5.1	Temperature measurement value -5.1℃

TRG

Trigger measurement

Syntax TRG

Response <rdata>

<data> <rdata>

Resistance measurement value (See "6.3.3 Received Data".)

Function During measurement hold, measurement is performed once and this result is captured.
In the free-running state, the newest resistance measurement value is captured.

Example Obtaining the resistance measurement value.

PC	>TRG	Obtain measurement value
3540 >	15.72E-03	Resistance measurement value 15.72 mΩ

EOC

Resistance measurement end confirmation

Syntax EOC

Response

ON	Resistance measurement completed
OFF	Resistance measurement unfinished

Function Checks whether the resistance measurement is completed.
The condition of the measurement completed is cleared when the data is readout with this command.

Example Checks whether the resistance measurement is completed.

PC	>EOC	Checks whether the resistance measurement is completed.
3540	>ON	Resistance measurement is completed.
PC	>EOC	Checks whether the resistance measurement is completed.
3540	>OFF	Resistance measurement is not completed.

Note The EOC command is ineffective in versions 1.02 or before.
In this case, the command error "CMD ERR" occurs when the EOC command is transmitted.
The version number of 3540 is displayed on the lower right of the LCD, when powering on.

ADJ

Zero-adjust

Syntax `ADJ`

Response

`OK`	Zero adjustment completed
`EXEC ERR`	Zero adjustment execution error

Function Executes zero adjustment

Error When attempts are made to perform zero adjustment with a reading exceeding 100 counts, the zero adjustment error is generated and zero adjustment is prevented. In these cases, the execution error is returned as the response.

Examples Executing zero adjustment.

PC	`>ADJ`	Execute zero adjustment.
3540	`>OK`	Zero adjustment execution completed.
PC	`>ADJ`	Execute zero adjustment.
3540	`>EXEC ERR`	Zero adjustment execution error

FUNC

Function settings

Syntax `FUNC <func data>`

<data> `<func data>`

`0:` resistance measurement mode

`1:` temperature measurement mode

Response

`OK`	Function switch completed.

Function Sets the measurement mode to resistance measurement or temperature measurement.

Example Setting to temperature measurement mode.

PC	`>FUNC 1`	Set to temperature measurement mode.
3540	`>OK`	Setting completed.

RNG

Range setting

Syntax `RNG <range data>`

<data> `<func data>`

`0:` 30.00 mΩ
`1:` 300.0 mΩ
`2:` 3.000 Ω
`3:` 30.00 Ω
`4:` 300.0 Ω
`5:` 3.000 kΩ
`6:` 30.00 kΩ

Response `OK` Switch of range for resistance measurement completed.

Function Sets the range to the specified resistance measurement range. When the comparator is ON, the comparator data range information is set to this range.

Example Setting the resistance measurement range to the 30 Ω range.

PC >`RNG 3` Set to 30 Ω range.
3540 >`OK` Setting completed.

SMP

Sampling setting

Syntax `SMP <sample data>`

<data> `<func data>`

`0:` SLOW
`1:` FAST

Response `OK` Sampling speed switch completed.

Function Sets the resistance measurement sampling to SLOW or FAST.

Example Setting the sampling to FAST.

PC >`SMP 1` Set to FAST.
3540 >`OK` Setting completed.

HZ

Setting the power supply frequency

Syntax HZ <hz data>

<data> <func data>
0: 50 Hz
1: 60 Hz

Response OK Setting of the power supply frequency completed.

Function Sets the power supply frequency to 50 Hz or 60 Hz.

Example Setting the power supply frequency to 50 Hz.
PC >Hz 0 Set to 50 Hz.
3540 >OK Setting completed.

HOLD

Hold function

Syntax HOLD <on/off>

<data> <on/off>
0: OFF
1: ON

Response OK Hold function setting completed.

Function Toggles the hold function ON/OFF.

Example Turning ON the hold function.
PC >HOLD 1 Set hold to ON.
3540 >OK Setting completed.

AUTO

Auto range

Syntax AUTO <on/off>

<data> <on/off>
0: OFF
1: ON

Response

OK	Auto range setting completed.
EXEC ERR	Auto range setting execution error.

Function Toggles the auto range ON or OFF.

Error While the comparator is ON, auto range cannot be set to ON.
If this is attempted, the response will indicate an execution error.

Examples Setting the auto range to ON

PC	>AUTO 1	Set auto range to ON.
3540	>OK	Setting completed.
PC	>AUTO 1	Set auto range to ON.
3540	>EXEC ERR	Auto range setting execution error.

TC

Temperature correction function

Syntax TC <on/off>

<data> <on/off>
0: OFF
1: ON

Response

OK	Setting of the temperature correction function completed.

Function Toggles the temperature correction function ON or OFF.

Example Setting the temperature correction function to ON.

PC	>TC 1	Set temperature correction function to ON.
3540	>OK	Setting completed.

COMP

Comparator

Syntax COMP <on/off>

<data> <on/off>
0: OFF
1: ON

Response OK Comparator ON/OFF setting completed.

Function Toggles the comparator ON or OFF.

Example Turning ON the comparator.
PC >COMP 1 Set comparator to ON.
3540 >OK Setting completed.

CNO

Comparator table

Syntax CNO <comp no>

<data> <comp no>
1: No. 1
2: No. 2
3: No. 3
4: No. 4
5: No. 5
6: No. 6
7: No. 7

Response OK Comparator table configuration completed.
EXEC ERR Execution error

Function Configures the comparator table to the specified table number.

Error When the comparator is not ON, this setting is not possible.
If attempted, the execution error is generated.

Example To configure the comparator table as No. 7.
PC >CNO 7 Set as table No. 7
3540 >OK Setting completed.

CMD

Comparator mode setting

Syntax CMD <comp mode>

<data> <comp mode>
0: Hi-Lo
1: REF-%

Response

OK	Comparator mode setting completed.
EXEC ERR	Execution error

Function Sets the comparator mode to Hi-Lo or REF-%.

Error When the comparator is not ON, this setting is not possible. If attempted, the execution error is generated.

Example To set the comparator mode to Hi-Lo.

PC	>CMD 0	Set the comparator mode to Hi-Lo.
3540	>OK	Setting completed.

BUZ

Buzzer

Syntax BUZ <comp buzzer>

<data> <comp buzzer>
0: OFF
1: HL
2: IN

Response

OK	Buzzer mode setting completed.
EXEC ERR	Execution error

Function Sets the buzzer mode to OFF, HL or IN.

Error When the comparator is not ON, this setting is not possible. If attempted, the execution error is generated.

Example Setting the buzzer mode to IN.

PC	>BUZ 2	Set the buzzer mode to IN.
3540	>OK	Setting completed.

CHI

Comparator HIGH/REF setting

Syntax `CHI <comp hi data>`

<data> `<comp hi data>`
0 to 9999: Upper limit value (HIGH) or reference value (REF)
(Count value with the decimal point neglected.)

Response

`OK`	Comparator HIGH/REF data setting completed.
`EXEC ERR`	Execution error

Function Sets the comparator HIGH and REF setting values to the specified values.

Error When the comparator is not ON, this setting is not possible.
If attempted, the execution error is generated.

Example Setting the comparison value HIGH to 1000.

PC	>`CHI 1000`	Set to 1000.
3540	>`OK`	Setting completed.

CLO

Comparator LOW/% setting

Syntax `CLO <comp lo data>`

<data> `<comp lo data>`
0 to 9999: Lower limit value (LOW) or range (%)
(Count value with the decimal point neglected.)

Response

`OK`	Comparator LOW/% data setting completed.
`EXEC ERR`	Execution error

Function Sets the comparator LOW and % setting values to the specified values.
For the range (%) setting, 100.0% equals "1000".

Error When the comparator is not ON, this setting is not possible.
If attempted, the execution error is generated.

Example Setting the comparison value LOW to 1000.

PC	>`CLO 1000`	Set to 1000.
3540	>`OK`	Setting completed.

CCC

Constant-current status check

Syntax CCC

Response

CC OK	Constant-current normal
CC ERR	Constant-current abnormality (CCERR)

Function Checks the condition of the current for resistance measurement. Unless the constant-current flows correctly, the resistance value cannot be measured.

Examples Checking the current constant-current status.

PC	>CCC	Find the constant-current status.
3540	>CC ERR	Current abnormality (CCERR)
PC	>CCC	Find the constant-current status.
3540	>CC OK	Current normal.

LOCK

Key lock setting

Syntax LOCK <on/off>

<data> <on/off>

0: OFF

1: ON

Response

OK	Key lock setting completed.

Function Toggles the key lock function ON or OFF.

Example Locking the keys.

PC	>LOCK 1	Turn key lock ON.
3540	>OK	Setting completed.

6.3.3 Received Data

<rdata>

The rdata format of the resistance measurement value data is as follows.

measurement value + "," + comparator results

When the comparator is OFF, the format only consists of the measurement value and the "," + comparator results are not attached.

Format of measurement values

□.□□□E±□□
□□.□□E±□□
□□□.□E±□□

1 2 3

1 Space character
2 Mantissa
3 Exponent. E+Sign of characteristic + 2-digit numerical value
I.e., one of mΩ (E-03), Ω (E+00) or kΩ (E+03).

In the REF-% mode with the comparator ON, it becomes □□□.□ and the exponent is not attached. (4-digit numerical value+decimal point)
The unit is %.

In special cases, the format may be:

"OF":	Overflow
"CC ERR":	Abnormal current
"BAD DATA":	When the TC function is ON, the temperature measurement value exceeded the range or in case of sensor error.

Comparator results
Comparator results are indicated by single digits as follows:
0: Invalid
1: Lo
2: IN
3: Hi

Examples

35.00E-03	→ 35.00 mΩ
3.500E+00	→ 3.500 Ω
35.00E+00,1	→ 35.00 Ω, comparator result = Lo.
3.500E+03,2	→ 3.500 kΩ, comparator result = IN.
100.5,3	→ 100.5 %, comparator result = Hi.

<tdata>

The tdata format of the temperature measurement value data is as follows.
sign + □□.□

Sign
One space character when plus.
"-" when minus.

The measurement value is indicated by 3 digits+decimal point (fixed position) and the unit is℃ .

In special cases, the format may be:

OF:	Overflow
-OF:	Minus overflow
SENS ERR:	Sensor not connected or broken wire.

Example
25.0 → 25.0℃
- 9.5 → -9.5℃

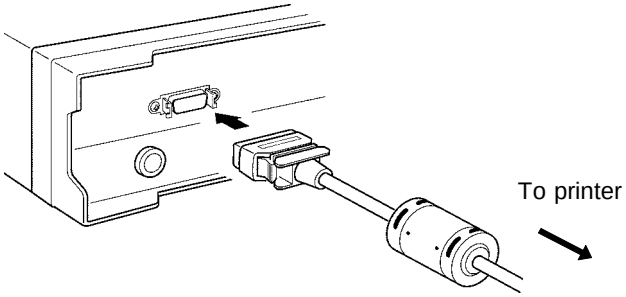
Chapter 7
Printers

This chapter discusses printer output from the 3540-02.
With the 3540-02, measured values can be printed out using the optional 9203 DIGITAL PRINTER or other general purpose Centronics printer.
This instruction manual explains how to print out measured values to a general purpose Centronics printer. For printing using the 9203, refer to the 9203 Instruction Manual.

In order to output measured values to the printer, short the PRINT signal on the rear panel terminal strip to GND.
For printing using the PRINT signal, refer to "5.4.1 Measurement Control".

7.1 Making Connections

Connect the printer to the printer connector on the rear panel using the optional 9425 CONNECTION CABLE as shown below.
The connection cable is equipped with two locking claws. Be sure to press the connector in firmly until these claws click into place.



⚠ WARNING

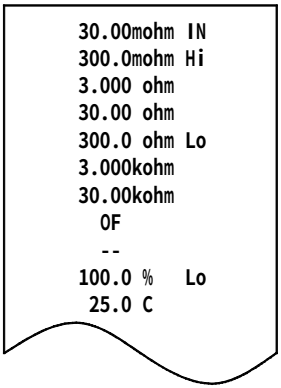
Always observe the following safety precautions when connecting a printer. Failure to observe these safety precautions may result in electrocution or damage to the equipment.

- **Always turn off the product and the printer before making any connections.**
- **Because of the inherent dangers of such situations, be careful to prevent the connections from coming loose or leads from coming into contact with other conductors. Make sure the connections are secure.**

7.2 Printing

This section explains printing to a general purpose Centronics printer. For printing using the 9203, refer to the 9203 Instruction Manual.

A printout example is shown below, along with the meanings of the printed data.



Function	Measurement range	measured value	Comparator
Resistance measurement	30 mΩ	30.00 mΩ	IN
	300 mmΩ	300.0 mmΩ	Hi
	3 Ω	3.000 Ω	Unused
	30 Ω	30.00 Ω	
	300 Ω	300.0 Ω	Lo
	30 kΩ	30.00 kΩ	Unused
	300 kΩ	300.0 kΩ	
Over			
Current Abnormality (CCERR)			
Resistance measurement (Standard deviation)			Lo
Temperature measurement	-	25.0 ℃	-

NOTE

The data outputted from the instrument to printer is ASCII text only and does not include any control command (except for CR+LF).

Only the printer, which can print ASCII text directly, is connectable. (ex. ESC/P printer).

Please be careful that the type of printer, which needs the exclusive commands to print ASCII text, is not connectable.

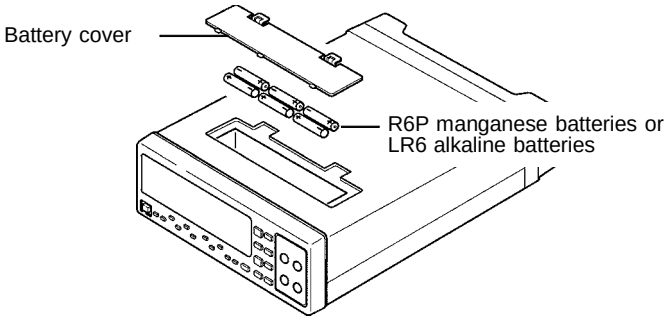
Chapter 8
Maintenance and Service

8.1 Battery Replacement Procedure

- **To avoid electric shock when replacing the batteries first disconnect the AC adapter and leads from the object to be measured. Also, after replacing the batteries always replace the cover before using the unit.**
- **Do not mix old and new batteries, or different types of batteries. Also, be careful to observe battery polarity during installation. Otherwise, poor performance or damage from battery leakage could result.**
- **To avoid the possibility of explosion, do not short circuit, disassemble or incinerate batteries.**
- **Handle and dispose of batteries in accordance with local regulations.**

The battery mark on the LCD lights when the battery is exhausted. When this occurs, change the battery as follows.

(1) Remove the battery cover
(2) Replace the batteries with new ones, observing the correct polarity.
(3) Replace the battery cover.



NOTE

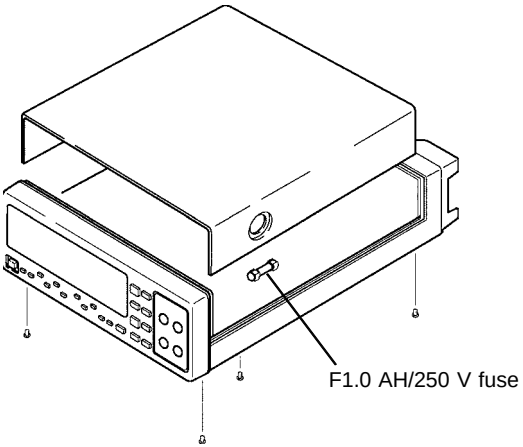
For exhausted manganese batteries, the battery voltage fluctuates greatly depending on the current retrieved.
Therefore, when measuring using manganese batteries, even when the battery voltage is adequately secured at a measurement current of 1 mA, at 100 mA the battery voltage will not be sufficient, causing the power supply to cut off or the LCD to keep repeating a cycle of blinking and disappearing.

8.2 Fuse Replacement Procedure

⚠ WARNING

- **To avoid danger of electrical shock when changing the fuse, disconnect the AC adapter and all test leads and other wiring from the 3540 before making replacement.**
  After replacing the fuse, be sure to close the case before using the instrument.
- **Replace the fuse only with one of the specified characteristics and voltage and current ratings. Using a non-specified fuse or shorting the fuse holder may cause a life-threatening hazard.**
  Fuse type: F1.0 AH/250 V 20x5 mm dia.

To check whether the fuse is burned out set the instrument to the resistance measurement mode. If **NG** is displayed on the LCD when the leads are shorted, the fuse is burned out. The fuse is mounted on the printed circuit board of the main unit. To access the fuse, remove the screws on the bottom of the case and remove the upper part of the case. Then, replace the fuse with the spare fuse in the battery compartment.



8.3 Troubleshooting

When the instrument does not work normally, check the following items :

Symptom	Cause/remedy
LCD does not light when **POWER** switch pressed.	Is the correct AC adaptor being used, and is it properly connected? • Refer to "4.1 Preparing Measurement".
LED is blinking.	Is the battery exhausted? • Refer to "8.1 Battery Replacement Procedure".
LCD disappears when object to be measured is connected	Is the battery exhausted? • Refer to "8.1 Battery Replacement Procedure".
" Err2 " is displayed and the measurement is not available.	Is the temperature probe connected? • Refer to "4.4 Temperature Correction Function (TC)".
Resistances cannot be measured.	Is the instrument in the abnormal current state? • Refer to "4.2.7 Current Abnormality (CCERR) Detection Function". Is the fuse blown? • Refer to "8.2 Fuse Replacement Procedure".
Cannot change measurement range.	Is the measurement range under external control? • Refer to "Chapter 5 External Control Features".
Auto ranging is canceled.	The auto range and comparator functions cannot be used simultaneously. • Refer to "4.2.2 Changing the Measurement Range" and "4.3 Comparator Function".
Measurements fluctuate widely.	Does the power supply frequency setting of the 3540 match the frequency of the AC power supply being used? • Refer to "4.2.1 Setting the Power Supply Frequency".
Cannot measure temperature.	Is the temperature probe connected? • Refer to "4.5 Temperature Measurement".
Temperature correction is not possible.	Is the temperature probe connected? • Refer to "4.4 Temperature Correction Function (TC)".
Comparator does not operate.	Is the AUTO/MANU selector switch set to MANU? • Refer to "4.3.6 Outputting Comparator Results".

Symptom	Cause/remedy
Cannot change comparator tables.	Is comparator table selection being controlled externally? • Refer to "Chapter 5 External Control Features".
External control is not possible.	Are connections wired properly? • Refer to "Chapter 5 External Control Features".
Cannot output to printer.	Is the PRINT signal wired properly? • Refer to "Chapter 5 External Control Features". Is the printer properly connected? • Refer to "Chapter 7 Printers".
RS-232C communication not possible.	Has the RS-232C cable been connected correctly? Are the settings on the computer correct? • Refer to "Chapter 6 RS-232C Interface".

8.4 Error Code Table

An error code is displayed on the LCD when particular errors occur.

Example :

Error code	Meaning
1	Zero-adjust range (within 100 display counts) exceeded
2	Temperature probe not properly connected while using temperature correction functions.
5	Attempted to print while printer not properly connected.
8	During the power-on check, it was found that the backup data such as the comparator configuration or zero-adjustment data was corrupted. Corrupted data is restored to the factory defaults.
9	A fatal error was detected during the power-on check. If this error recurs, contact your nearest sales representative for assistance.

When shipped from the factory, all item are set to the initial state.

Items	Setting contents
Measurement mode	Resistance measurement mode
Measurement range	300 mΩ range
Sampling rate	SLOW mode
Measurement holding	Free-running
Comparator Table No. Comparator mode Buzzer mode Comparison Values	Comparator table are unused. 1 Hi-Lo comparator OFF HIGH, LOW, REF, % = 0000
Temperature correction function (TC)	OFF
Power supply frequency	50 Hz

8.5 Service

- If damage is suspected, check the "Troubleshooting" section before contacting your dealer or Hioki representative.
- When sending the product for repair, remove the batteries and pack carefully to prevent damage in transit. Include cushioning material so the instrument cannot move within the package. Be sure to include details of the problem. Hioki cannot be responsible for damage that occurs during shipment.

8.6 Cleaning

- To clean the product, wipe it gently with a soft cloth moistened with water or mild detergent. Never use solvents such as benzene, alcohol, acetone, ether, ketones, thinners or gasoline, as they can deform and discolor the case.
- Wipe the LCD gently with a soft, dry cloth.

Appendix

Zero Adjustment

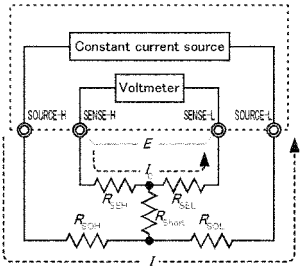
Zero adjustment is a function which adjusts the zero point by deducting the residual value obtained during 0 Ω measurement. For this reason, zero adjustment must be performed when connection is made to 0 Ω. However, connecting a sample with no resistance is difficult and therefore is not practical.
In 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-H and SENSE-L becomes 0 V according to the Ohm's Law of $E = I \times R$. In other words, if you set the voltage between SENSE-H and SENSE-L 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 the four measurement terminals. For this reason, when performing zero adjustment, you need to make connections between the terminals appropriately in advance (Figure 1).
First, short between SENSE-H and SENSE-L to set the voltage between SENSE-H and SENSE-L to 0 V. If lead resistances R_{SEH} and R_{SEL} 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 $E = I_0 \times (R_{SEH} + R_{SEL})$ formula, $I_0 \approx 0$ is achieved; if lead resistances R_{SEH} and R_{SEL} are less than few Ω, voltage between SENSE-H and SENSE-L will become almost zero.
Next, make connection between SOURCE-H and SOURCE-L. This is to avoid display of error when no measurement current flows through. Lead resistances R_{SOH} and R_{SOL} of the cable must be less than the resistance for flowing measurement current.



$E = (I_0 \times R_{SEL}) + (I_0 \times R_{SEH})$
$= (0 \times R_{SEL}) + (0 \times R_{SEH})$
$= 0$ [V]

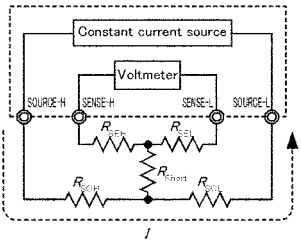
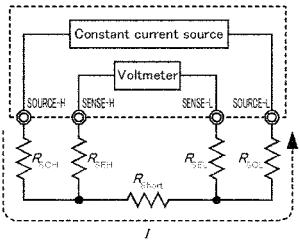
Figure 1 Pseudo connection to 0 Ω

Furthermore, if you also monitor 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-H will go to SOURCE-L but not to the lead of SENSE-H or SENSE-L. This enables the voltage between SENSE-H and SENSE-L 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-H and SENSE-L as well as SOURCE-H and SOURCE-L respectively, and use one path to make connection between SENSE and SOURCE, no potential difference occurs between SENSE-H and SENSE-L, and 0 V is input. This enables zero adjustment to be carried out correctly.
In (b), on the other hand, if you connect SENSE-H and SOURCE-H as well as SENSE-L and SOURCE-L respectively, and use one path to make connection between Hi and Lo, $I \times R_{Short}$ voltage occurs between SENSE-H and SENSE-L. For this reason, the pseudo 0 Ω connection state cannot be achieved and zero adjustment cannot be carried out correctly.

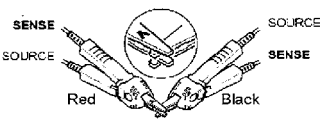
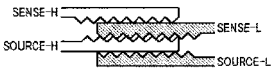
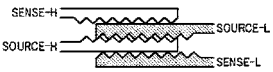
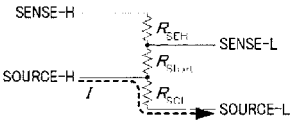
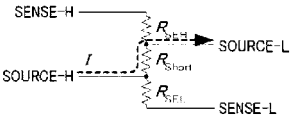
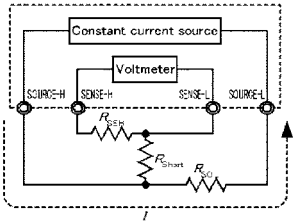
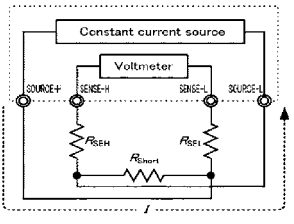
Table 1: Connection methods

Connection methods	 (a) Use one point each between SENSE and SOURCE for connection	 (b) Use one point each between Hi and Lo for connection
Resistance between SENSE-H and SENSE-L	$R_{SEH} + R_{SEL}$	$R_{SEH} + R_{Short} + R_{SEL}$
Measurement current *I*'s flow path	$R_{SOH} \rightarrow R_{SOL}$	$R_{SOH} \rightarrow R_{Short} \rightarrow R_{SOL}$
Voltage occurring between SENSE-H and SENSE-L	0	$I \times R_{Short}$
As connection method for zero adjustment	Correct	Wrong

To perform zero adjustment using a probe

When you actually perform zero adjustment using a probe, 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, 9287-10 CLIP TYPE LEAD as mentioned in "4.2.3 Zero Adjust Function" 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-H and SENSE-L. However, Table 1 (b) is the wrong connection method, so that 0 V is not obtained between SENSE-H and SENSE-L.

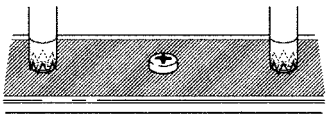
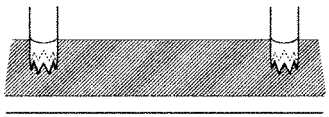
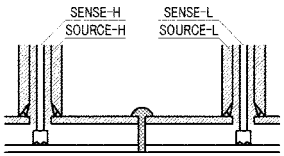
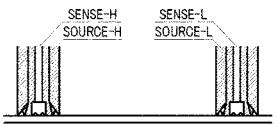
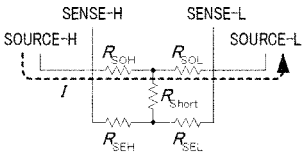
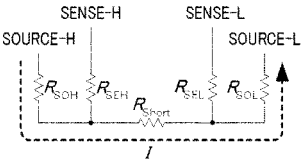
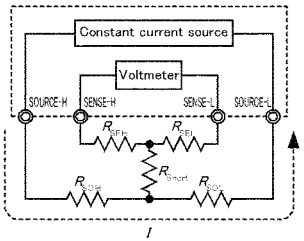
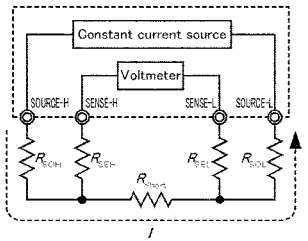
Table 2: Clip type lead connection methods used during zero adjustment

	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-H and SENSE-L. However, Table 1 (b) is the connection using a metal board or similar object, so that 0 V is not obtained between SENSE-H SENSE-L.

Table 3: Pin type lead connection methods in zero adjustment

Connection method	 If connection is made using 9454 ZERO ADJUSTMENT BOARD	 If connection is made using metal board or similar object
Tip of lead		
Equivalent circuit		
Deformed equivalent circuit		
As connection method for zero adjustment	Correct	Wrong

If zero adjustment is difficult when using self-made probe to measure

When you perform zero adjustment using a self-made probe to do measurement, connect the tip of the self-made probe 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 probe. Therefore, after using the standard probe to make the connection shown in Table 1 (a) and performing zero adjustment, you can replace it with a self-made probe to measure with offset removed from the measurement instrument.

If AC resistance meter is used

In addition to removing offset of the measurement instrument, another main purpose of performing zero adjustment is to remove influence of the probe shape. For this reason, when performing zero adjustment, try as much as possible to set the form of the self-made probe close to the 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.

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- In the interests of product development, the contents of this manual are subject to revision without prior notice.
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