Ultra High Resistance Meter

Active in chemical and material fields
Suitable for semiconductor evaluation

- High resolution of 5½-digit display
- Micro current measurement: 1fA to 19.9999mA
- High-resistance measurement: $3 \times 10^{17}\Omega$ (current function)
- Voltage source: ±1mV to ±1000V
- High-speed measurement: up to 1000 readings/sec
- Floating measurement of 1000V (5450)
- Temperature and humidity measurement (with the optional accessory)
- Preset function for easy measurement condition setting
- Sequence program for routine measurement

Ultra High Resistance Measurement

$3 \times 10^{17}\Omega$

Maximum

Leak Current Measurement

1 fA

Resolution

High-Speed Measurement

1000

Readings/sec
The 5450/5451 is a state-of-the-art ultra high resistance meter with 5½-digit display that integrates ADC's traditional technologies and new DC amplifier technologies. It was designed for ease of use so that anybody who operates this instrument can get the same measurement results. The 5450/5451 will be the new standard for insulation resistance measurement or micro current measurement of various kinds of insulating materials or semiconductors.

High Performance/High Speed
The 5450/5451 is ten times or more high performance than the conventional models. For example, the current measurement resolution is 1 fA, the high resistance measurement range is $3 \times 10^{17} \Omega$, the voltage to be applied to DUTs is up to ±1000V, the measurement speed is 1000 readings per second and the memory capacity for measurement results is 65000 data. In addition, temperature and humidity can be measured at the same time with insulation resistance by using the optional accessory.

Easy to Use
The 5450/5451 is equipped with the preset function to set measurement conditions separately for each target device, the sequence program to always perform the same measurement, and the graphical display function to measure visually transient current of capacitive DUTs.

Automatic System
The 5450/5451 adopts the GPIB and the USB as standard interface and the BCD output optionally. In addition, the handler interface and the analog output are available to synchronize with other automatic devices. Such a high-performance instrument, 5450/5451 is used in testing of secondary cell and semiconductor materials or testing of electronic parts such as capacitors and print-circuited boards. In addition, it can be used in various usages for insulating materials such as synthetic resins and rubbers from R&D, manufacturing to quality inspection fields. Especially in testing of insulating materials, surface resistivity and volume resistivity measurement conforming to JIS (Japanese Industrial Standards) are available by using the various types of fixtures in combination. For micro current measurement, leak current of a semiconductor device at high-voltage application can be measured with high sensitivity and at high speed. The 5451 is provided with floating measurement capability up to 46 V peak. However, to test securely a DUT that is grounded at one side, the 5450 that is capable of floating measurement up to 1000 V peak is the best.
Flexible High Performance Measurement $3 \times 10^{17} \Omega$ and 1fA, Voltage Source $\pm 1000V$

High-Speed and High-Performance

The 5450/5451 is a high-performance meter capable of measuring micro current from 1fA to 19.9999mA and high resistance up to $3 \times 10^{17} \Omega$ (in current function).

In addition, with its high-speed sampling capability up to 1000 readings per second, the 5450/5451 is suitable for Go/No-Go test in electronic part manufacturing.

Powerful and Flexible Voltage Source

As internal voltage source, a power supply that is capable of current source and sink up to 10W at $\pm 1000V$ was newly developed. This new power supply also applies negative voltage. Thus, the 5450/5451 can not only measure p-channel and n-channel semiconductors or avalanche photo diodes (APD) that operate with reverse bias voltage, but also help capacitors to be charged or discharged quickly.

In addition, by setting the current limit values at will, devices are protected from overcurrent due to breakdown in semiconductor evaluation.

Selectable Ammeter Response

Actual ultra-high resistance measurement or micro current measurement is sometimes difficult to make under the influence of the ambient noise environment. However, a need exists for high-speed measurement in a noise-proof environment.

To satisfy demands for various purposes, the 5450/5451 employs the variable gain feedback system and the response speed of the ammeter is selectable. Consequently, there is a choice between measurement highly durable against disturbance noise and high-speed measurement with quick response depending on the application or required accuracy, thus ensuring highly reliable measurement.

<table>
<thead>
<tr>
<th>Ammeter response</th>
<th>Slow</th>
<th>Med</th>
<th>Fast</th>
<th>ExFast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement speed</td>
<td>Slow</td>
<td>Med</td>
<td>Fast</td>
<td></td>
</tr>
<tr>
<td>Input resistance error</td>
<td>High</td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise immunity</td>
<td>Good</td>
<td></td>
<td>Poor</td>
<td></td>
</tr>
</tbody>
</table>

Stable Measurement of Grounded Sample

The 5450/5451 is capable of floating measurement.

The 5451 has floating measurement capability up to 46 V peak, however the 5450 up to 1000 V peak that enables a DUT grounded at one side to be measured.

Temperature and Humidity Measurement

JIS K6911 and K6723 specify temperature and humidity as test conditions for material resistivity measurement.

The 5450/5451 can measure the ambient temperature and humidity by connecting the recommended temperature/humidity sensor probe.

Interface Selection

In addition to GPIB and USB, the 5450/5451 is equipped with a handler interface that can control the timing with external devices such as a automatic machine in a production line. Moreover, the embedded interlock signal prevents unintended voltage output to help operators perform safety measurement.

Preset Function for Quick Operation

For ultra-high resistance or micro current measurement, the amplifier gain, the integration time and the input resistance need to be set according to its purpose. For surface or volume resistivity measurement, the electrode coefficient needs to be set. Like this, various settings are required before measurement.

The 5450/5451 contains ten types of preset conditions for surface or volume resistivity measurement using the accessory, micro current measurement by pico ammeter, capacitor leak current measurement and other measurements. Thus, such a measurement can be started quickly by just selecting the preset condition without long condition settings.

Of course, user parameter settings are also available.
Sequence Program Function

The order of settings or processes is important in each measurement. The 5450/5451 has a sequence program function to store seven patterns of sequence such as order and conditions of measurements. This function makes it possible to easily measure insulation resistance one minute after voltage application conforming to JIS. In addition, anyone can obtain the same measurement results by using the stored setting conditions.

Much Safer Input Connector

When insulation resistance is measured by using floating measurement, voltage of the reverse polarity to the setting voltage is generated between the input terminal and the driving guard. Conventional triaxial connectors are not necessarily safe because their metal parts are exposed. The 5450/5451 adopts safer triaxial (S-Triax) connectors, securing measurement.
**Graphical Display of Time Course**

When the leak current of a capacitor is measured, right after DC voltage is applied, inrush current that is called charge current corresponding to the capacity flows then it decreases exponentially. This current is called absorption current that is caused by the time change during dielectric polarization inside the sample. A current flowing after the absorption current reaches equilibrium becomes leak current.

Here, the time it takes the absorption current to decrease exponentially and settle into equilibrium varies depending on the dielectric materials, and is sometimes very long. To measure the leak current precisely, it is important to see if the abrupton current settles down.

The 5450/5451 has a function to display the time course of measured values graphically on the dot-matrix LCD display. Thus, the measured values described above can be captured visually.

**Contact Check Function**

The 5450/5451 has a contact check function to detect quickly contact failures between capacitive samples (capacitors) and measurement cables or measurement electrodes. This function is executable when specified or in every measurement. Preceding Open Cal (default value measurement) cancels the capacity of the measurement cables or measurement electrodes, allowing precise contact check.

The judgment results in PASS when the capacity measured by contact check is larger than the capacity measured by Open Cal, or FAIL when it is smaller.

**High-Speed Measurement in Auto Range**

When current function measurement employs an auto range mode, high-speed device measurement is difficult because the switching time between device measurements is required, and it takes long to reach the range for a target value to be measured. Thus, to improve the takt time, a fixed range mode is normally used for measurement.

However, the upper and lower limits of an auto range can be set on the 5450/5451. Consequently, setting the minimum necessary auto range realizes the minimum switching time and improves the takt time significantly.
From Electronic Parts to Sheet, Film, Liquid and More
JIS-Compliant High-Precision Measurement with Accessories

**Condition Setting with One Touch**
To measure the volume or surface resistivity of an insulating material, the electrode size needs to be set according to JIS. The preset function of the 5450/5451 includes the default settings of typical electrode sizes that are widely used, making it simple to set measurement conditions for various insulating materials.

<table>
<thead>
<tr>
<th>JIS number</th>
<th>Electrode size</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>K6911</td>
<td>φ.50</td>
<td>Testing methods for thermosetting plastics</td>
</tr>
<tr>
<td>K6723</td>
<td>φ.70</td>
<td>Plasticized polyvinyl chloride compounds</td>
</tr>
<tr>
<td>C2170</td>
<td>φ.30.5</td>
<td>Methods of test for determining the resistance and resistivity of solid planar materials used to avoid electrostatic charge accumulation</td>
</tr>
</tbody>
</table>

**Measurement with Voltage Source of ±1000V**
JIS K6911 is the measurement standard for the volume or surface resistivity of insulating materials such as plastic. As for the surface resistivity measurement, it specifies that negative voltage should be applied to the ring electrode against the main electrode. As the 5450/5451 is equipped with the bipolar voltage source that outputs both positive and negative voltage up to ±1000V, it can measure precisely the surface resistivity.

**Solar Battery Leak Current (PID) Test**
Solar batteries used in “Mega” solar power plants have a problem of output reduction called PID (potential-induced degradation) phenomenon in hot and humid conditions because leak current occurs in the module circuits at high voltage source. The PID phenomenon occurs by interaction among the tempered glass on the surface, cell, back sheet and the aluminum frame of a solar battery. To evaluate this phenomenon, the leak current between the cell and frame needs to be measured. Differently from the cell, negative voltage must be applied to the grounded frame. Thus, the 5450 capable of floating measurement of -1000 V is the best choice.

**Print-Circuited Board Resistance Measurement**
By using the accessory, test lead 12603, the insulation resistance of print-circuited boards can be measured.

**Cable Insulation Resistance Measurement**
The 5450 is capable of floating measurement up to 1000 DCV. Thus, it is suitable for measuring the insulation resistance of grounded cables, transformers and so on.
**Electronic Part Evaluation System**

The 5450/5451 not only performs high-speed measurement of up to 1000 readings per second, but also features the 65,000 data memory and the handler interface. The 5450/5451 shows its excellent performance by connecting with a scanner or a handler via a PC, for example in automatic sorting of semiconductors or electronic parts.

**A Variety of Accessories for Research and Development of New Materials and Polymer Materials**

Using the accessory resistivity chambers makes it easy to measure the volume or surface resistivity of materials. With the sequential program function and the LID signal, the 5450/5451 automatically performs discharge, charged and measurement according to the setting procedure in cover’s open and close timings.

**Pressure Test by Sweep Function of ±1000V**

The 5450/5451 has a sequence program function that can sweep with a 4-digit setting resolution up to ±1000V. Using this function enables precise pressure test of semiconductors.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Model</th>
<th>Exterior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12702A/B</td>
<td>Resistivity chamber</td>
<td>For measurement of the volume or surface resistivity of sheet, filmy and platy samples. The pressure to a sample is adjustable and its thickness is measurable. Thus, it is possible to measure the sample with the electrode firmly fixed by pressure.</td>
</tr>
<tr>
<td></td>
<td>12704A</td>
<td>Resistivity chamber</td>
<td>For measurement of the volume or surface resistivity of sheet, filmy and platy samples. Adhesion with a sample is excellent because all electrodes use conductive rubber. One-touch switching between volume and surface resistivity measurement.</td>
</tr>
<tr>
<td></td>
<td>12708</td>
<td>Resistivity chamber</td>
<td>For measurement of the volume or surface resistivity of sheet, filmy and platy samples. Temperature in the range from normal temperature to +200°C can be applied to a sample.</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>Resistivity chamber</td>
<td>For measurement of the volume or surface resistivity of sheet, filmy and platy samples. For normal usage</td>
</tr>
<tr>
<td></td>
<td>12707</td>
<td>Resistivity chamber for liquid sample</td>
<td>For measurement of the volume resistivity of liquids. It requires only 0.8cc of sample for measurement. The electrodes can be removed and cleaned easily.</td>
</tr>
<tr>
<td></td>
<td>15045 series</td>
<td>Standard resistance box</td>
<td>For inspection of digital electrometers. Five models available: 1×10Ω, 1×10&lt;sup&gt;3&lt;/sup&gt;Ω, 1×10&lt;sup&gt;5&lt;/sup&gt;Ω, 1×10&lt;sup&gt;7&lt;/sup&gt;Ω, 1×10&lt;sup&gt;9&lt;/sup&gt;Ω</td>
</tr>
<tr>
<td></td>
<td>12706A</td>
<td>Test fixture</td>
<td>For insulation measurement or micro current measurement of electronic parts such as capacitors. Its structure takes shielding and isolation into account to allow stable measurement of low current and high resistance.</td>
</tr>
<tr>
<td></td>
<td>12701A</td>
<td>Test fixture</td>
<td>For current measurement of electronic parts such as semiconductor.</td>
</tr>
<tr>
<td></td>
<td>12604</td>
<td>Tweezers probe</td>
<td>For insulation measurement of chip capacitors. With the tweezers-like shape, small chip components can be measured easily and efficiently.</td>
</tr>
<tr>
<td></td>
<td>A08076</td>
<td>Shielded measurement plate</td>
<td>To be used with the 12604. For removing external noise. This measurement plate is shielded with Teflon, allowing measurement with low influence of induction noise.</td>
</tr>
<tr>
<td></td>
<td>12603</td>
<td>Test lead</td>
<td>For insulation resistance measurement and voltage or current measurement between patterns on print-circuited boards. It is suitable for measurement in which the measurement point is changed in succession. An external power supply is required for insulation resistance measurement.</td>
</tr>
</tbody>
</table>

Once the measurement conditions are set, the 5450/5451 always performs the same measurement. It can prevent measurement failures due to operational mistakes to occur. Electrode coefficients necessary for volume or surface resistivity measurement can be set in addition to those of the resistivity chambers.

For cables to connect the 5450/5451 with these accessories, refer to “Connection Cable List” on page 11.
### Specifications

Unless otherwise specified, all accuracies are guaranteed for one year at a temperature of 23°C ±5°C and a relative humidity not exceeding 70%. The temperature coefficient is specified in the range between 0°C to 50°C.

Temperature coefficient: For the 4 ½-digit display, the digit error is reduced to 1/10.

#### DC Current Function (Current Display)

<table>
<thead>
<tr>
<th>Current range</th>
<th>Maximum display</th>
<th>Resolution</th>
<th>5450 Accuracy */2 (% of rdg+digit)</th>
<th>5451 Accuracy */2 (% of rdg+digit)</th>
<th>Temperature coefficient */3 (% of rdg+digit)/°C</th>
<th>Settling time */4</th>
</tr>
</thead>
<tbody>
<tr>
<td>200mA</td>
<td>199.9999mA</td>
<td>1fA</td>
<td>0.3 ± 60 (60fA)</td>
<td>0.7 ± 60 (60fA)</td>
<td>0.035 ± 10 (10fA)</td>
<td>250ms</td>
</tr>
<tr>
<td>2000mA</td>
<td>199.9999mA</td>
<td>10fA</td>
<td>0.25 ± 30 (30fA)</td>
<td>0.7 ± 30 (30fA)</td>
<td>0.02 ± 2 (20fA)</td>
<td>25ms</td>
</tr>
<tr>
<td>20mA</td>
<td>19.9999mA</td>
<td>100fA</td>
<td>0.2 ± 30 (3pA)</td>
<td>0.3 ± 30 (3pA)</td>
<td>0.01 ± 2 (200fA)</td>
<td>5ms</td>
</tr>
<tr>
<td>2000nA</td>
<td>19.9999nA</td>
<td>10pA</td>
<td>0.1 ± 30 (30pA)</td>
<td>0.3 ± 30 (30pA)</td>
<td>0.01 ± 2 (20pA)</td>
<td></td>
</tr>
<tr>
<td>200μA</td>
<td>19.9999μA</td>
<td>100fA</td>
<td>0.1 ± 20 (20nA)</td>
<td>0.15 ± 20 (20nA)</td>
<td>0.005 ± 2 (250pA)</td>
<td>2ms</td>
</tr>
<tr>
<td>20μA</td>
<td>19.9999μA</td>
<td>10nA</td>
<td>0.1 ± 10 (10nA)</td>
<td>0.1 ± 10 (10nA)</td>
<td>0.005 ± 1 (1nA)</td>
<td></td>
</tr>
<tr>
<td>2000pA</td>
<td>19.9999μA</td>
<td>100nA</td>
<td>0.1 ± 10 (1μA)</td>
<td>0.1 ± 10 (1μA)</td>
<td>0.005 ± 1 (100nA)</td>
<td></td>
</tr>
<tr>
<td>200nA</td>
<td>19.9999nA</td>
<td>1nA</td>
<td>0.1 ± 10 (1μA)</td>
<td>0.1 ± 10 (1μA)</td>
<td>0.005 ± 1 (100nA)</td>
<td></td>
</tr>
</tbody>
</table>

1. Integration time: 10 PLC, Display digit: 5½, Auto zero: ON
2. When the advanced setting function “input 1kΩ” is ON, 15 digits are added to the digit error.
3. 20mA/ C is added to the digit error at a temperature from 40°C to 50°C.
4. Time to settle to the final value: 0.1% when the ammeter response is EXFAST. (Range switching time is not included)

#### Additional error depending on the integration time

<table>
<thead>
<tr>
<th>Integration time</th>
<th>Display digit</th>
<th>Additional error ± (digits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50μs</td>
<td>4½ digits</td>
<td>2</td>
</tr>
<tr>
<td>2ms</td>
<td>4½ digits</td>
<td>10</td>
</tr>
<tr>
<td>1PLC</td>
<td>5½ digits</td>
<td>10</td>
</tr>
</tbody>
</table>

Noise rejection ratio (at 50/60 Hz ±0.08%)

<table>
<thead>
<tr>
<th>Integration time</th>
<th>NMRR</th>
<th>Effective CMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>50μs</td>
<td>60dB or more</td>
<td>120dB or more</td>
</tr>
</tbody>
</table>

Input Specifications

Input resistance (maximum value) */5

<table>
<thead>
<tr>
<th>Current range</th>
<th>Ammeter response (input amplifier gain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOW (1)</td>
<td>MED (10)</td>
</tr>
<tr>
<td>FAST (100)</td>
<td>EXFAST (1000)</td>
</tr>
<tr>
<td>200pA</td>
<td>11 GΩ, 1.1 GΩ</td>
</tr>
<tr>
<td>2000pA</td>
<td>1 GΩ, 100 MΩ</td>
</tr>
<tr>
<td>20mA</td>
<td>100 MΩ</td>
</tr>
<tr>
<td>200nA</td>
<td>1 MΩ, 100 kΩ</td>
</tr>
<tr>
<td>20μA</td>
<td>100 kΩ</td>
</tr>
<tr>
<td>200μA</td>
<td>11 kΩ, 110 GΩ</td>
</tr>
<tr>
<td>2000μA</td>
<td>1.3 kΩ, 130 Ω</td>
</tr>
<tr>
<td>20mA</td>
<td>180 Ω</td>
</tr>
</tbody>
</table>

1. When “input 1kΩ” is ON, 1.2kΩ is added.

Input voltage drop: ± (measuring current × input resistance + 100μV)

Input bias current: 30 fA or less

#### DC Current Function (Resistance Display)

<table>
<thead>
<tr>
<th>Current range</th>
<th>Maximum display</th>
<th>Measurement range [%]</th>
<th>Accuracy</th>
<th>Temperature coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 pA</td>
<td>1 digit to 5 digits (1 to 9999)</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>⁷ ¹¹</td>
<td>⁸</td>
</tr>
<tr>
<td>2000 pA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>20 nA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>200 nA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>2000 nA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>20 μA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>200 μA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>2000 μA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
<tr>
<td>200 nA</td>
<td>5×10⁻⁴ to 3×10⁻⁹</td>
<td>²²</td>
<td>²²</td>
<td></td>
</tr>
</tbody>
</table>

²² Temperature coefficient: ±[(Temperature coefficient 1 + Temperature coefficient 2) % of rdg]

³³ Temperature coefficient 1 = A + B(Vs-Vi) x 10⁴

²² A: Reading error of accuracy at current range for DC current function (current display) [%]

²² B: Setting error of accuracy at voltage source range for DC voltage source [%]

²² Vs: Voltage source

²² Vi: Input voltage drop

²² Accuracy 2 = A(Vs-Vi)(Rm) + B(Vs) x 10⁴

²² A: Digit error of accuracy at current range for DC current function (current display) [%]

²² B: Digit error of accuracy at voltage source range for DC voltage source [%]

²² Vs: Voltage source

²² Vi: Input voltage drop

²² Rm: Measurement value

¹¹ Temperature coefficient: ±[(Temperature coefficient 1 + Temperature coefficient 2) % of rdg]/°C

²² Temperature coefficient 1 = A + B

²² A: Reading error of temperature coefficient at current range for DC current function (current display) [%/°C]

²² B: Setting error of temperature coefficient at voltage source range for DC voltage source [%/°C]

²² Temperature coefficient 2 = A(Vs-Vi)(Rm) + B(Vs) x 10⁴

²² A: Digit error of temperature coefficient at current range for DC current function (current display) [%/°C]

²² B: Digit error of temperature coefficient at voltage source range for DC voltage source [%/°C]

²² Vs: Voltage source

²² Vi: Input voltage drop

²² Rm: Measurement value

¹¹ When the IV correction (input voltage drop correction) is ON. "Vs(Vs-Vi) x 10⁴” is specified.

¹² When the measurement range is less than 100Ω or input resistance (IV correction: OFF), the accuracy is not guaranteed.

¹² Specified by "Vs(Vs-Vi) x 10⁴" application

¹² For how to calculate the input voltage drop, refer to the input specifications.

#### Resistance Function (Resistance Display)

<table>
<thead>
<tr>
<th>Resistance range</th>
<th>Maximum display</th>
<th>Minimum display</th>
<th>Resolution</th>
<th>Setting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 kΩ</td>
<td>109.9 kΩ</td>
<td>5.0 kΩ</td>
<td>0.1 kΩ</td>
<td>500 ms</td>
</tr>
<tr>
<td>1000 kΩ</td>
<td>1099 kΩ</td>
<td>50 kΩ</td>
<td>1 kΩ</td>
<td>5000 ms</td>
</tr>
<tr>
<td>10 MΩ</td>
<td>10.99 MΩ</td>
<td>500 MΩ</td>
<td>0.01 MΩ</td>
<td>100000 ms</td>
</tr>
<tr>
<td>1 kΩ</td>
<td>1099.9 MΩ</td>
<td>500 kΩ</td>
<td>1 MΩ</td>
<td>1000000 ms</td>
</tr>
<tr>
<td>10 GΩ</td>
<td>10.99 GΩ</td>
<td>0.5 GΩ</td>
<td>0.01 GΩ</td>
<td>10000000 ms</td>
</tr>
<tr>
<td>1 MΩ</td>
<td>1099.9 GΩ</td>
<td>50 GΩ</td>
<td>1 GΩ</td>
<td>100000000 ms</td>
</tr>
<tr>
<td>10 TΩ</td>
<td>1099.9 TΩ</td>
<td>0.5 TΩ</td>
<td>0.01 TΩ</td>
<td>1000000000 ms</td>
</tr>
<tr>
<td>100 TΩ</td>
<td>1099.9 TΩ</td>
<td>5.0 TΩ</td>
<td>0.1 TΩ</td>
<td>10000000000 ms</td>
</tr>
<tr>
<td>1000 TΩ</td>
<td>1099.9 TΩ</td>
<td>50 TΩ</td>
<td>1 TΩ</td>
<td>100000000000 ms</td>
</tr>
</tbody>
</table>

* Accuracy 1 = A+B+Vi/(Vs-Vi) = 100˚9

*1 For how to calculate the input voltage drop, refer to the input specifications.
### (Continued from previous page) Resistance Function (Resistance Display)

#### Accuracy/Temperature coefficient

<table>
<thead>
<tr>
<th>Resistance range</th>
<th>Source voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10V</td>
</tr>
<tr>
<td>10kΩ</td>
<td></td>
</tr>
<tr>
<td>Current measure</td>
<td>20mA</td>
</tr>
<tr>
<td>Accuracy</td>
<td>(1.3+0.003)</td>
</tr>
<tr>
<td>Temperature coeff</td>
<td>0.12+0.0003</td>
</tr>
<tr>
<td>100kΩ</td>
<td></td>
</tr>
<tr>
<td>Current measure</td>
<td>2mA</td>
</tr>
<tr>
<td>Accuracy</td>
<td>(1.3+0.003)</td>
</tr>
<tr>
<td>Temperature coeff</td>
<td>0.12+0.0003</td>
</tr>
<tr>
<td>1MΩ</td>
<td></td>
</tr>
<tr>
<td>Current measure</td>
<td>200μA</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1.3+0.003</td>
</tr>
<tr>
<td>Temperature coeff</td>
<td>0.12+0.0003</td>
</tr>
<tr>
<td>100MΩ</td>
<td></td>
</tr>
<tr>
<td>Current measure</td>
<td>2mA</td>
</tr>
<tr>
<td>Accuracy</td>
<td>2.3+0.005</td>
</tr>
<tr>
<td>Temperature coeff</td>
<td>0.27+0.0007</td>
</tr>
<tr>
<td>1000MΩ</td>
<td></td>
</tr>
<tr>
<td>Current measure</td>
<td>2mA</td>
</tr>
<tr>
<td>Accuracy</td>
<td>3.3+0.008</td>
</tr>
<tr>
<td>Temperature coeff</td>
<td>0.22+0.0005</td>
</tr>
</tbody>
</table>

#### DC Voltage Source

<table>
<thead>
<tr>
<th>Voltage range</th>
<th>Source range</th>
<th>Setting resolution</th>
<th>Maximum input</th>
<th>Accuracy (% of setting + digits)</th>
<th>Temperature coefficient (% of setting + digits)/10°C</th>
<th>Output rate (10-500Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10V</td>
<td>0±0.00V</td>
<td>1mV</td>
<td>20mA</td>
<td>0.05 + 5 (5mV)</td>
<td>0.005 + 5 (0.5mV)</td>
<td>1msec-p</td>
</tr>
<tr>
<td>50V</td>
<td>0±0.000V</td>
<td>10mV</td>
<td>20mA</td>
<td>0.05 + 5 (50mV)</td>
<td>0.005 + 5 (0.5mV)</td>
<td>1msec-p</td>
</tr>
<tr>
<td>100V</td>
<td>0±0.000V</td>
<td>50mV</td>
<td>20mA</td>
<td>0.05 + 5 (500mV)</td>
<td>0.005 + 5 (0.5mV)</td>
<td>1msec-p</td>
</tr>
</tbody>
</table>

#### Temperature coefficient

% of reading + % of range, Auto zero: ON

The accuracies in parentheses indicate guaranteed values by the resistance standard. Others are calculated from DC current function (Current Display) accuracies and DC voltage source accuracies.

Temperature coefficient: % of reading + % of range

13 Integration time: 10 PLC or longer, Auto zero: ON

14 The accuracies in the 1000 GΩ or higher range are guaranteed at a temperature of 0°C to 40°C

### DC Voltage Source

<table>
<thead>
<tr>
<th>Voltage range</th>
<th>Source range</th>
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<th>Maximum input</th>
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<td>0.05 + 5 (500mV)</td>
<td>0.005 + 5 (0.5mV)</td>
<td>1msec-p</td>
</tr>
</tbody>
</table>

### Measurement Speed: DC Current Function (Current Display)

<table>
<thead>
<tr>
<th>Integration time</th>
<th>Measurement speed</th>
<th>Display digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>500μsec (burst)</td>
<td>1000 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>500μsec</td>
<td>200 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>2msec</td>
<td>100 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>1PLC</td>
<td>33 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>5PLC</td>
<td>12 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>10PLC</td>
<td>4.6 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>40PLC</td>
<td>0.6 readings/sec</td>
<td>19999</td>
</tr>
<tr>
<td>80PLC</td>
<td>0.3 readings/sec</td>
<td>19999</td>
</tr>
</tbody>
</table>

16 When the data memory store is set to Burst, integration time of 500μs, sampling interval of 1ms, free run, auto range OFF, calculation OFF and measurement display OFF are automatically set, allowing measurement of 1000 reading per second.

### Pure resistive load setting time

<table>
<thead>
<tr>
<th>Voltage range</th>
<th>Current limiter range</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 V</td>
<td>200μA, 2.0mA, 200μA</td>
</tr>
<tr>
<td>200 V</td>
<td>200μA, 2.0mA, 200μA</td>
</tr>
<tr>
<td>1000 V</td>
<td>200μA, 2.0mA, 200μA</td>
</tr>
</tbody>
</table>

15 Time to settle to 1% of the final value when changing the output from zero to full scale

With the maximum setting voltage source value or limit value in each range.
**Advanced Setting Functions**

- **Preset**
  Ten types of parameters are preset for different applications.

- **Integration time and sampling interval**
  There are eight types of integration time for A/D conversion and the sampling interval is set between 1ms and 9999.9s

- **Auto zero**
  Removes the offset errors of the internal measurement circuits.

- **Input amplifier response (Input amplifier gain)**
  Four levels of input amplifier gain adjust the noise immunity and the response.

- **Input resistance 1kΩ**
  The input resistance 1kΩ is set to ON or OFF. Setting to ON is recommended for stable operation for leak current or insulation resistance measurement of capacitors.

- **IV correction (Input voltage drop correction)**
  Measures and corrects the input resistance error in DC current function (resistance display).
  When it is set to ON, corrected voltage is displayed if valid measurement data exists.
  "In resistance function (resistance display) it is always ON.

- **Auto range response**
  Three levels of auto range switching speed
  High-speed response measurement corresponding to the required number of digits is available.

- **Auto range delay**
  Delay time to the next sampling after range change by auto range operation.

- **Range limit**
  Upper and lower limits of the measurement range.
  Limiting the measurement range reduces the measurement delay due to unnecessary range switching.

- **Contact check**
  Function to detect contact failures of measurement samples
  It is necessary for manufacturing capacitive samples such as capacitor.
  Detection range: 0.5pF or more
  Open Cal range: 0.5pF to 50pF

- **Sequence program**
  Seven types of sequence program including JIS-compliant insulation resistance measurement that performs evaluation one minute after voltage application.

**Calculation Function**

- **NULL calculation**
  Displayed value (NULL) = Measured value - NULL constant

- **Smoothing calculation**
  Displayed value (SM) = Moving average of a specified number of times

- **Section average calculation**
  Displayed value (CAVE) = Average of a specified number of times

- **Comparator calculation**
  Judgment (HIGH) = HIGH setting value < Measured value
  Judgment (LOW) = Measured value < LOW setting value
  Display (GO) = LOW setting value ≤ Measured value ≤ HIGH setting value

- **MAX/MIN/AVE calculation**
  Displayed value (MAX) = Maximum measured value after calculation start
  Displayed value (MIN) = Minimum measured value after calculation start
  Average value (AVE) = Average after calculation start
  Displayed value (S) = [Measured current [A] × integral time [S]] of a specified number of times

- **Integral calculation**
  Displayed value (S) = [Measured current [A] × integral time [S]] of a specified number of times

- **Volume resistivity calculation**
  \( \rho V = \frac{(D+d)\pi}{4t} \times Rv \)

- **Surface resistivity calculation**
  \( \rho s = \pi \times \frac{D+d}{D-d} \times Rs \)

**Display Functions**

- **Graph display**
  Displays the time course of measured values on the 240 × 64 dot matrix LCD.
  Charge current response and convergence can be checked visually, helping characteristic analysis of samples.

**Interface Function**

- **Remote command**
  Compliant to the ADC command system and the 8340A commands.

- **GPIB**
  \( \text{Standard IEEE488.2} \)
  \( \text{Connector Amphenol 24 pins} \)
  \( \text{Interface functions} \)
  \( \text{SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT1, CO, E2} \)
  \( \text{Output format ASCII} \)
  \( \text{Addressing 31 types of Talker and Listener addresses.} \)

- **USB**
  \( \text{Standard USB2.0 Full-Speed} \)
  \( \text{Connector Type B} \)
  \( \text{Handler interface} \)
  \( \text{Function Input and output of synchronization signals with external devices such as auto handler} \)
  \( \text{Connector Amphenol 24 pins} \)
  \( \text{Input signal External trigger, contact check start, LID.} \)
  \( \text{Output signal Complete output, comparator calculation result, contact check judgment result, measurement end, calculation end, alarm} \)
  \( \text{Signal level Input: TTL, falling edge detection} \)
  \( \text{Output: TTL, negative pulse (open collector)} \)

- **External trigger input**
  \( \text{Connector BNC} \)
  \( \text{Signal level TTL, falling edge detection} \)
  \( \text{Pulse width 100μs or more} \)

- **Interlock/LID input**
  \( \text{Connector BNC} \)
  \( \text{Signal level TTL, rising edge and falling edge detection} \)

- **Complete output**
  \( \text{Connector BNC} \)
  \( \text{Signal level TTL, negative pulse (open collector)} \)
  \( \text{Sink current 5mA or less} \)
  \( \text{Pulse width Selectable between approx. 100μs and 500μs} \)

- **D/A output**
  \( \text{Function Converts any 2- or 3-digit display data to analog form and outputs them.} \)
  \( \text{Outputs any voltage in a range of ±1V (resolution of 1mV) (Remote only)} \)
  \( \text{Connector BNC} \)
  \( \text{Output voltage ±1V} \)
  \( \text{Accuracy ±(0.2% + 2digit)} \)
  \( \text{Output resistance 10Ω or less} \)
  \( \text{Maximum load current ±0.5mA} \)
  \( \text{Maximum allowable input voltage ±5V} \)

- **BCD output**
  \( \text{(factory option)} \)
  \( \text{Function Parallel output of displayed data in the BCD or binary code} \)
  \( \text{OFF (all High) is selectable. Digital output of Hi and Lo of any pins (in remote only)} \)
  \( \text{Connector Amphenol 50 pins} \)
  \( \text{Signal level TTL positive logic} \)

- **Temperature and humidity sensor input**
  \( \text{Temperature measurement range: -50°C to +100°C} \)
  \( \text{Humidity measurement range: 0 to 100% RH (with the recommended temperature and humidity probe with output cable)} \)

**General Specification**

**Operating environment:**
- Temperature 0°C to +50°C
- Relative humidity 85% or less without condensation
Maximum allowable input current: 50mApeak

Storage environment: Temperature: -25°C to +70°C
Relative humidity: 85% or less
without condensation

Warm-up time: 60 minutes or longer

Display: 240 × 64 dot matrix LCD

Range switching: Auto or manual
Input method: Floating
Measurement method: Integration
Over input display: OL display
Memory: Data memory: Up to 65,000 data items
Condition setting memory: 4

Memory: 4

Over input display: OL display

Line frequency: 50Hz/60Hz
Power consumption: 80VA or below
Dimensions: Approx. 424 (W) x 88 (H) x 350 (D) mm
Mass: 9.5kg or less

Safety: IEC61010-1, Measurement category II
EMC: EN61326 class B

Voltage: 50Vdc 1000Vpeak
Guards: 1000Vpeak

GUARD (blue safety socket)

V SOURCE (red safety socket)

GUARD (blue safety socket, terminal block)

GND (terminal block)

Input terminal: INPUT (5450: S.TRIAX, 5451: TRIAX)

Output terminal: VSOURCE (red safety socket)

Connection Cable List

Accessory

Model | Quantity | Name
--- | --- | ---
AC01004-100 | 1 | Power cable
AC01006 | 1 | Input cable (S.TRIAX-safety)
AC01007 | 1 | Input cable (TRIAX-alligator)
AC01008 | 1 | Output cable (safety-safety)
AC01009 | 1 | Alligator clip
AC01010 | 1 | Short plug

Option Number Standard OPT. 32 OPT. 42 OPT. 44

Recommended product

Model | Name
--- | ---
HC2-S-E2ACT-ADC | Temperature and humidity probe with output cable

*Please read through the operation manual carefully before using the products.
*All specifications are subject to change without notice.