Determine Li-ion battery reliability in just 10 seconds

Low-frequency AC-IR measurement without charging/discharging substantially reduces the time needed to inspect the internal resistance of battery cells.
Incomparable Speed
Exceptional Accuracy
Unsurpassed Stability

Fast
Low-frequency AC-IR measurement enables faster measurement

No need to charge/discharge

Traditionally, the internal resistance of battery cells is measured by pre-charging the battery, then passing large currents and measuring the voltage drop (DC-IR measurement). Pre-charging the battery, however, usually takes several minutes to several tens of minutes. The BT4560 eliminates the need for charging or discharging by measuring the internal impedance at a low frequency of 1 Hz or below (AC-IR measurement), enabling significant reduction in the time required for measuring battery cells.

### Difference in speed

<table>
<thead>
<tr>
<th>DC-IR measurement (conventional method)</th>
<th>Requires 20 to 30 minutes to around one hour, including charging/discharging</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-IR measurement (using BT4560)</td>
<td>Requires around 10 seconds*</td>
</tr>
</tbody>
</table>

* When measuring at a frequency of 1 Hz
The BT4560 Battery Impedance Meter substantially reduces the time required for inspecting Li-ion battery cells by measuring at low frequencies, providing a fast and accurate measurement of the battery status.

**Accurate, stable measurements**

**High reliability guaranteed through proven performance**

**Measure very low impedance**

3 mΩ minimum range with high noise suppression

Accuracy: ±0.4% rdg. ±8 dgt.*
Minimum resolution: 0.1 μΩ

* When pure resistance is measured with measurement speed set to [SLOW]

Compared to the current used by traditional battery testers, 0.1A, the BT4560 uses a current 15 times stronger, 1.5 A, which improves the S/N ratio.

Enhanced noise suppression enables the device to provide reliable measurements for low-impedance batteries used for hybrid and plug-in hybrid vehicles.

**Measure DC voltage with high accuracy**

Voltage measurement accuracy comparable to high-end testers

Accuracy: ±0.0035% rdg. ±5 dgt.
Minimum resolution: 10 μV

The BT4560 can measure the voltage much more accurately than traditional resistance meters(±0.01% rdg. ±3 dgt.).

It guarantees highly accurate voltage measurement where greater accuracy than that of previous machines is required.

**Circuit configuration highly tolerant of contact resistance**

The circuit configuration in the BT4560 is not susceptible to contact and wire resistance, enabling stable measurement. Probe cables of up to 4 m are supported, improving the flexibility of cabling in production lines.

**Measure without damaging batteries**

The BT4560 employs AC-IR measurement with a small current load, enabling highly reliable measurement without damaging batteries.

**Two types of dedicated probes for different purposes**

Dedicated probes with four-terminal structure enables stable measurement unaffected by environmental noise or cabling.

**CLIP TYPE PROBE L2002**
For measuring laminated sheet batteries

**PIN TYPE PROBE L2003**
For line-embedded applications and various other types of batteries

* Contact your local Hioki distributor for details of the probe tip shapes.
An alternative measurement method for inspecting charging/discharging output characteristics (DC-IR) [Low-frequency AC-IR measurement]

**Information obtained by low-frequency measurement**

Electrochemical characteristics of a battery and Cole-Cole plot

- **Conceptual diagram of a battery**
  - Positive electrode
  - Negative electrode
  - Ion movement in electrolyte (electrolyte resistance) \( \approx \) approx. 1 kHz
  - Chemical reaction on electrode surface (reaction resistance): approx. 1 Hz
  - Lithium ions move between electrodes through the electrolyte

- **Battery equivalence circuit**
  - Electrolyte resistance
  - Reaction resistance
  - Measurement at low frequency reveals the reaction resistance of the battery

**Cole-Cole Plot**

- High-frequency region
- Low-frequency region
- \( R_1 \) and \( R_2 \)

**Two-point measurement at high and low frequencies**

Traditional battery testers only record the electrolyte resistance of the battery by measuring it at a frequency of 1 kHz. Measurement at a low frequency of around 1 Hz, however, enables the tester to also observe the reaction resistance on the surface of the electrodes.

The BT4560 assures the quality of battery cells by investigating both electrolyte resistance and reaction resistance with a two-point measurement at high and low frequencies. In this way, it helps to improve quality and extend the service life of lithium ion battery modules.

**Correlation between DC-IR measurement and low-frequency AC-IR measurement**

- **DC-IR measurement**
  - Method whereby a DC load is put through the battery, and the resistance is calculated from the voltage variation that occurs.
  - \( E_0 \)
  - \( T \)
  - \( E \)
  - \( Load \)

- **AC-IR measurement**
  - Method whereby an AC signal is applied to the battery to measure its impedance.
  - \( X \)
  - \( R \)
  - \( R_1 \)
  - \( R_1 + R_2 \)

When the correlation between DC-IR and AC-IR measurements is plotted using multiple Li-ion batteries ....

A strong correlation is found between the measured values of DC-IR and low-frequency AC-IR. Useful as an alternative to DC-IR testing.
Characteristics and features of BT4560

All-in-one compact unit
The BT4560 requires no loading devices and provides measurements simply as a stand-alone unit, without having to establish a complicated measurement system.

Simultaneous measurement of impedance and voltage
Reduce tact time by simultaneously providing impedance measurement and highly accurate DC voltage measurement.

Self-calibration
Correct any offset voltage and gain drift that may be present in the circuit to improve the accuracy of voltage measurement.

Simultaneous measurement of impedance and voltage
Reduce tact time by simultaneously providing impedance measurement and highly accurate DC voltage measurement.

Sample delay*
Specify a delay between AC voltage being applied and sampling being started so that measurement can start after the response stabilizes.

Slope correction function*
If measurement signals drift due to the battery characteristics or the input impedance of measurement instrument, the tester applies correction to the linear drift.

Prevent charging or discharging when AC voltage is applied*
To prevent the battery that is being measured from charging or discharging, the battery impedance meter terminates the applied measurement signal when zero is crossed.

Temperature measurement
Reaction resistance measured at low frequency is sensitive to temperature. An optional temperature sensor measures the temperature around the battery and associates the results with data, thereby improving the reliability of the measurements.

*Functions available during impedance measurement

Create Cole-Cole plots using bundled software
The BT4560 comes with a free PC application that can be used for measurement and drawing Cole-Cole plots. You can also select the desired measurement frequency or export the measured values in text format.

Cole-Cole plot drawing screen
Cole-Cole plot data
Measurement screen
Functions suitable for automated machines

Contact check
Monitor the contact resistance of the probe before and after measurement so that the measurement will only start when the measuring electrode on the probe is in contact with the object to be measured.

Comparator
- Simultaneously measure impedance and voltage
- Output overall determination results
- Use the two-tone buzzer to indicate determination results

Panel saving and loading
Store up to 126 sets of measurement conditions in internal memory so that they can be called through EXT. I/O for future measurements.

NPN/PNP switch
Switch the input/output circuits for EXT. I/O according to the type of output: current sink output (NPN) or current source output (PNP).

---

External control input/output terminal (EXT. I/O)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal name</th>
<th>I/O</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>START (TRIG)</td>
<td>IN</td>
<td>Starts measurement (external trigger)</td>
</tr>
<tr>
<td>2</td>
<td>0 ADJ_ALL</td>
<td>IN</td>
<td>All-zero adjustment</td>
</tr>
<tr>
<td>3</td>
<td>STOP</td>
<td>IN</td>
<td>Stops measurement</td>
</tr>
<tr>
<td>4</td>
<td>LOAD 1</td>
<td>IN</td>
<td>Load number bit 1</td>
</tr>
<tr>
<td>5</td>
<td>LOAD 3</td>
<td>IN</td>
<td>Load number bit 3</td>
</tr>
<tr>
<td>6</td>
<td>LOAD 5</td>
<td>IN</td>
<td>Load number bit 5</td>
</tr>
<tr>
<td>7</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>ISO_SV</td>
<td>OUT</td>
<td>Isolated power supply +5 V (-5 V) output</td>
</tr>
<tr>
<td>9</td>
<td>ISO_COM</td>
<td>OUT</td>
<td>Isolated power supply common</td>
</tr>
<tr>
<td>10</td>
<td>ERR</td>
<td>OUT</td>
<td>Measurement error</td>
</tr>
<tr>
<td>11</td>
<td>Roz2_HI</td>
<td>OUT</td>
<td>Resistance determination result is HI, impedance determination result is HI</td>
</tr>
<tr>
<td>12</td>
<td>Roz2_LO</td>
<td>OUT</td>
<td>Resistance determination result is Lo, impedance determination result is Lo</td>
</tr>
<tr>
<td>13</td>
<td>V_In</td>
<td>OUT</td>
<td>Voltage determination result is HI</td>
</tr>
<tr>
<td>14</td>
<td>Xorθ_HI</td>
<td>OUT</td>
<td>Reactance determination result is HI, phase angle determination result is HI</td>
</tr>
<tr>
<td>15</td>
<td>Xorθ_LO</td>
<td>OUT</td>
<td>Reactance determination result is Lo, phase angle determination result is Lo</td>
</tr>
<tr>
<td>16</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>PASS</td>
<td>OUT</td>
<td>The determination result passed</td>
</tr>
<tr>
<td>19</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0 ADJ_SPOT</td>
<td>IN</td>
<td>Spot zero adjustment</td>
</tr>
<tr>
<td>21</td>
<td>CAL</td>
<td>IN</td>
<td>Self-calibration</td>
</tr>
<tr>
<td>22</td>
<td>LOAD 0</td>
<td>IN</td>
<td>Load number bit 0</td>
</tr>
<tr>
<td>23</td>
<td>LOAD 2</td>
<td>IN</td>
<td>Load number bit 2</td>
</tr>
<tr>
<td>24</td>
<td>LOAD 4</td>
<td>IN</td>
<td>Load number bit 4</td>
</tr>
<tr>
<td>25</td>
<td>LOAD 6</td>
<td>IN</td>
<td>Load number bit 6</td>
</tr>
<tr>
<td>26</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>ISO_COM</td>
<td>OUT</td>
<td>Isolated power supply common</td>
</tr>
<tr>
<td>28</td>
<td>EOM</td>
<td>OUT</td>
<td>End of measurement</td>
</tr>
<tr>
<td>29</td>
<td>INDEX</td>
<td>OUT</td>
<td>Measurement reference signal</td>
</tr>
<tr>
<td>30</td>
<td>Roz2_IN</td>
<td>OUT</td>
<td>Resistance determination result is HI, impedance determination result is HI</td>
</tr>
<tr>
<td>31</td>
<td>V_HI</td>
<td>OUT</td>
<td>Voltage determination result is HI</td>
</tr>
<tr>
<td>32</td>
<td>V_LO</td>
<td>OUT</td>
<td>Voltage determination result is Lo</td>
</tr>
<tr>
<td>33</td>
<td>Xorθ_IN</td>
<td>OUT</td>
<td>Reactance determination result is HI, phase angle determination result is HI</td>
</tr>
<tr>
<td>34</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>FAIL</td>
<td>OUT</td>
<td>The determination result failed</td>
</tr>
</tbody>
</table>
Accuracy specifications

**Impedance measurement accuracy**

- **3 mΩ range (0.1 Hz to 100 Hz), 10 mΩ range, 100 mΩ range**
  
  R accuracy = ± (0.004 |R| + 0.0017 |X| ) [mΩ] ± α
  
  X accuracy = ± (0.004 |X| + 0.0017 |R| ) [mΩ] ± α
  
  Z accuracy = ± 0.4% rdg. ± α (|sinθ| + |cosθ|)
  
  θ accuracy = ± 0.1° ± 57.3 θ (|sinθ| + |cosθ|)
  
  (The units of R and X are [mΩ]. α is as shown in the table below.)

- **3 mΩ range (110 Hz to 1050 Hz)**
  
  R accuracy = ± (0.004 |R| + 0.0052 |X| ) [mΩ] ± α
  
  X accuracy = ± (0.004 |X| + 0.0052 |R| ) [mΩ] ± α
  
  Z accuracy = ± 0.4% rdg. ± α (|sinθ| + |cosθ|)
  
  θ accuracy = ± 0.3° ± 57.3 θ (|sinθ| + |cosθ|)
  
  (The units of R and X are [mΩ]. α is as shown in the table below.)

<table>
<thead>
<tr>
<th>α</th>
<th>3 mΩ range</th>
<th>10 mΩ range</th>
<th>100 mΩ range</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAST</td>
<td>25 dgt.</td>
<td>60 dgt.</td>
<td>60 dgt.</td>
</tr>
<tr>
<td>MED</td>
<td>15 dgt.</td>
<td>30 dgt.</td>
<td>30 dgt.</td>
</tr>
<tr>
<td>SLOW</td>
<td>8 dgt.</td>
<td>15 dgt.</td>
<td>15 dgt.</td>
</tr>
</tbody>
</table>

Temperature coefficient

- R: ± R accuracy × 0.1/°C,
- X: ± X accuracy × 0.1/°C,
- Z: ± Z accuracy × 0.1/°C,
- θ: ± θ accuracy × 0.1/°C

(Applied in the ranges of 0°C to 18°C and 28°C to 40°C)

**Voltage measurement accuracy** (when self-calibration is performed)

<table>
<thead>
<tr>
<th>V</th>
<th>Display range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage accuracy</td>
<td>±5.10000 V to 5.10000 V</td>
<td>±0.0035% rdg. ±5 dgt.</td>
</tr>
<tr>
<td>SLOW</td>
<td>±5.10000 V to 5.10000 V</td>
<td>±0.0035% rdg. ±5 dgt.</td>
</tr>
</tbody>
</table>

Temperature coefficient

±0.0005% rdg. ±1 dgt. /°C (applied in the ranges of 0°C to 18°C and 28°C to 40°C)

**Temperature measurement accuracy**

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>±0.5°C (measurement temperature: 10.0°C to 40.0°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>±1.0°C (measurement temperature: -10.0°C to 9.9°C, 40.1°C to 60.0°C)</td>
</tr>
</tbody>
</table>

Temperature coefficient: ±0.01°C/°C (applied in the ranges of 0°C to 18°C and 28°C to 40°C)
**BT4560 specifications**  
(Guaranteed accuracy period: 1 year)

### Measured signals
- Impedance, voltage, temperature

### Impedance measurement
- **Measurement parameters**: R resistance, X reactance, Z impedance, θ phase angle
- **Measurement frequency**: 0.1 Hz to 1050 Hz
- **Frequency setting resolution**:
  - 0.10 Hz to 0.99 Hz in 0.01-Hz increments
  - 1.0 Hz to 9.9 Hz in 0.1-Hz increments
  - 10 Hz to 99 Hz in 1-Hz increments
  - 100 Hz to 1050 Hz in 10-Hz increments
- **Measurement ranges**: 3.0000 mΩ, 10.0000 mΩ, 100.000 mΩ

### Measurement current/DC load
- **Current values**:
  - 1.5 Arms ±10%
  - 500 mArms ±10%
  - 50 mArms ±10%
- **DC load current**:
  - 1 mA or less, 0.35 mA or less, 0.035 mA or less

### Measurement wave number
- **Wave ranges**:
  - 0.10 Hz to 66 Hz: 1 wave, 2 waves, 8 waves
  - 67 Hz to 250 Hz: 2 waves, 8 waves, 32 waves
  - 260 Hz to 1050 Hz: 8 waves, 32 waves, 128 waves

### Voltage measurement
- **Measurement range**: 5.00000 V (single range)
- **Resolution**: 10 μV
- **Measurement time**:
  - **FAST**: 0.1 s
  - **MED**: 0.4 s
  - **SLOW**: 1.0 s

### Temperature measurement
- **Display range**: -10.0 °C to 60.0 °C
- **Resolution**: 0.1 °C
- **Measurement time**: 2.3 s

### Measurement functions
- (R, X, V, T) / (Z, θ, V, T) / (R, X, T) / (Z, θ, T) / (V, T)
- **Function**:
  - Comparator, self-calibration, sample delay, average, voltage limit, potential gradient compensation for impedance measurement, charge/discharge prevention during AC signal application, key lock, system test, panel saving and loading (up to 126 condition sets)

### Measurement error detection
- Contact check, measurement current error, voltage drift on measured object, overvoltage input, voltage limit

### Interface
- **EXT. I/O**: TRIG, LOAD, Hi, IN, Lo, and others
- **Transmission speed**: 9,600 bps/19,200 bps/38,400 bps

### Power supplies
- Rated supply voltage: 100 to 240 VAC
- Rated supply frequency: 50/60 Hz
- Rated power: 80 VA

### Dielectric strength
- 1.62 kVAC, 1 min, cutoff current 10 mA
- (Between power supply terminal lump and protective ground)

### Applicable standards
- Safety: EN61010
- EMC: EN61326, EN61000-3-2, EN61000-3-3

### Dimensions and mass
- **Approx.**: 330W × 80H × 293D mm (12.99W × 3.15H × 11.54D in), **Approx.**: 3.7 kg (130.5 oz)

### Accessories
- Power cord ×1, Instruction manual ×1, Zero-adjustment board ×1, USB cable (A-B type) ×1, CD-R (communication instruction manual, PC application software, USB driver) ×1
- **Note**: Company names and product names appearing in this catalog are trademarks or registered trademarks of various companies.

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**Options**

### CLIP TYPE PROBE L2002
- **Cable length**: 1.5 m

### PIN TYPE PROBE L2003
- **Cable length**: 1.5 m

### TEMPERATURE SENSOR Z2005
- **Cable length**: 1 m

### RS-232C CABLE 9637
- **Cable length**: 1.8 m

---

**Instrument**

**BATTERY IMPEDANCE METER BT4560**

**Standard accessories**
- Power cord, Instruction manual,
- Zero-adjustment board, USB cable, CD-R

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**DISTRIBUTED BY**

**Test Equipment Depot**

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Toll Free 1-800-517-8431

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All information correct as of Nov. 17, 2014. All specifications are subject to change without notice.

BT4560E1-4YM Printed in Japan