Hioki’s Chemical Impedance Analyzer IM3590 is designed to perform impedance (LCR) measurement of electrochemical components and materials. It offers functionality such as Cole-Cole plot generation and equivalent circuit analysis with a broad measurement frequency range of 1 mHz to 200 kHz, measurement speeds as high as 2 ms, and basic accuracy of ±0.05%. With the advanced display and analysis functionality required for research and development work and LCR measurement capability for standard electronic components, the instrument provides a single-device solution for a broad range of measurement applications.
Measure Electrochemical Components and Materials, Batteries, and EDLCs*

Cole-Cole plot

In measurement of electrochemical components and materials, Cole-Cole plots are used to ascertain electrode, electrolyte ion, and other characteristics. The IM3590 can perform frequency sweep measurement using up to 801 points and display the results as a Cole-Cole plot.

- Measurement at low frequencies is necessary in order to measure characteristics such as ion behavior, and the IM3590 can conduct measurements at 1 mHz. The instrument’s upper limit frequency is 200 kHz, allowing it to measure solution resistance.

Temperature measurement and time interval measurement

When used in conjunction with an optional temperature probe, the IM3590 can display graphs that include measured temperatures. By assigning temperature to one axis on the X-Y display, it is possible to display a temperature characteristics graph. The instrument can also perform time interval measurement at up to 801 points, and can display graphs illustrating variation over time, including temperature measurement.

- The temperature sensor (Sheath Type Temperature Probe 9478) has a waterproof sheath, allowing it to be directly inserted into solutions.
- Sheath material: SUS316

Battery measurement function

The IM3590’s battery measurement function simplifies the process of measuring battery impedance characteristics in a no-load state by automatically measuring the battery voltage and superimposing the same voltage from the instrument as DC bias.

- Supported battery specifications
  - Internal impedance: 10 mΩ to 10 Ω
  - Battery voltage: 5 V max

Measurement time and Z repeatability during low-resistance measurement

<table>
<thead>
<tr>
<th>Measurement time [ms]</th>
<th>100</th>
<th>10</th>
<th>1</th>
<th>0.1</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIOKI 3522-50</td>
<td><img src="image1" alt="" /></td>
<td><img src="image2" alt="" /></td>
<td><img src="image3" alt="" /></td>
<td><img src="image4" alt="" /></td>
<td><img src="image5" alt="" /></td>
</tr>
<tr>
<td>IM3590</td>
<td>Improved!</td>
<td><img src="image6" alt="" /></td>
<td><img src="image7" alt="" /></td>
<td><img src="image8" alt="" /></td>
<td><img src="image9" alt="" /></td>
</tr>
</tbody>
</table>

- Measurement accuracy [%]
  - FAST
  - MED
  - SLOW
  - SLOW2

*Electric double-layer capacitors
The ability to measure electrochemical components and materials makes possible evaluation by estimating equivalent circuits, facilitating a deeper understanding of reaction, electrode, and electrolyte characteristics. The IM3590 provides electrochemical component and material equivalent circuit models, allowing evaluation of solution resistance, charge transfer resistance, and electric double-layer capacitance.

**Equivalent circuit analysis result**

**Equivalent circuit model**

---

**Equivalent circuit models and measurement parameters**

- **Unipolar models**
  - Unipolar, or all poles have the same reaction, and the center of the capacitive semicircle lies on the real axis
  - Unipolar, or all poles have the same reaction, and the center of the capacitive semicircle does not lie on the real axis

- **Polar models**
  - Different poles have different reactions, and the center of the capacitive semicircle lies on the real axis
  - Different poles have different reactions, and the center of the capacitive semicircle does not lie on the real axis

**Measurement parameters**

- $R_s$ (Solution resistance)
- $R_1, R_2$ (Charge transfer resistance)
- $C_1, C_2$ (Electric double layer capacitance)
- $CPE_1, CPE_2$ (Constant Phase Element)
- $L_1$ (Inductance)

---

**Internal structure of a standard electrochemical cell**

- $C_1 (CPE_1)$: Electric double layer capacitance
- $R_1$: Charge transfer resistance
- $L_1$: Electrode and wiring inductance
- $C_2 (CPE_2)$: Electric double layer capacitance
- $R_s (R_{sol})$: Solution resistance

**Electronic Components**

(LCR Elements and Piezoelectric and Resonant Elements)

**Sweep function (Frequency and signal level)**

The IM3590 can perform sweep measurement of the frequency characteristics of standard LCR components such as electronic components and piezoelectric elements (resonant components). The ability to display frequency characteristics, admittance circles, and Cole-Cole plots makes it easy to assess characteristics. The instrument can also perform signal level (V/CV/CC) and DC bias voltage sweep operation.

**Equivalent circuit analysis of electronic components**

The IM3590 offers five equivalent analysis circuits for circuit components, allowing the instrument to be used to estimate and evaluate standard LCR components such as electronic components and piezoelectric elements (resonant components).

#### Equivalent Circuit Model and Measurement Items

**Three-element model**

![Circuit Diagram](chart1)

- **Measurement items**
  - $L_1$ (Inductance)
  - $C_1$ (Capacitance)
  - $R_1$ (Resistance)
  - $Q_m$ (Resonance sharpness or mechanical quality coefficient)

  The following measurement items can be captured via PC communication.
  - $f_r$ (Resonance frequency)
  - $f_{a}$ (Anti-resonance frequency)

**Four-element model**

![Circuit Diagram](chart2)

- **Measurement items**
  - $L_1$ (Inductance)
  - $C_1$ (Capacitance)
  - $R_1$ (Resistance)
  - $C_0$ (Parallel capacitance)
  - $Q_m$ (Resonance sharpness or mechanical quality coefficient)

  The following measurement items can be captured via PC communication.
  - $f_r$ (Resonance frequency)
  - $f_{a}$ (Anti-resonance frequency)
  - $f_s$ (Series resonance frequency)
  - $f_{p}$ (Parallel resonance frequency)
  - $f_{m}$ (Maximum admittance frequency)
  - $f_{f}$ (Minimum admittance frequency)
  - $f_{2}$ (Maximum susceptance frequency)
  - $f_{2}$ (Minimum susceptance frequency)

**Saving and reading data via front-loading USB port**

Measurement results and settings can be saved to a commercially available USB flash drive connected to the front panel.

(The USB port on the front panel is specifically for a USB flash drive. Batch save all measurement results to a USB flash drive after saving them to the internal memory of IM3590. Some USB flash drives may not be supported due to incompatibility issues.)

**Connecting to a PC or PLC via RS-232C, LAN, or GP-IB (select one option) connection**

Users can also select an optional RS-232C, LAN, or GP-IB interface if needed. IM3590 functions can be controlled from a PLC or computer, and measurement results can be downloaded. (Certain functions, including instrument power on/off and interface configuration, cannot be controlled remotely.)

Download the LabView driver from the HIOKI website at http://www.hioki.com.

External I/O can be used to output measurement complete and judgment result signals and to receive measurement trigger and other signals in order to facilitate control of the instrument.
High-speed, High-precision, Easy-to-use Operation

Basic performance

- **Wide setting range for measurement frequency**
  IM3590 allows DC or a frequency band within the range of 1 mHz to 200 kHz to be set with five-digit resolution (testing at less than 100 Hz has a 1 mHz resolution). This enables the measurement of resonance frequency and measurement and evaluation in a state close to that of actual operating conditions.
  The IM3590’s frequency range extends from the low frequencies that are required for electrochemical impedance measurement in order to assess phenomena such as ion behavior to high frequencies that allow measurement of solution resistance.

- **Wide setting range for measurement voltage and current**
  In addition to normal open-loop signal generation, this instrument enables measurement considering voltage/current dependence in constant voltage and constant current modes. The signal levels can be set over wide ranges, from 5 mV to 5 V, and from 10 μA to 50 mA. (The setting range of measurement signal levels differs depending on the frequency and measurement mode.)

- **Measurement times as short as 2 ms**
  The IM3590 can perform measurements in as little as 2 ms using the FAST measurement speed setting with a measurement frequency of 1 kHz.

- **Basic accuracy of ±0.05%**
  Thanks to Z basic accuracy of ±0.05%, the IM3590 offers a level of accuracy that is ideal for use in applications ranging from component testing to research and development.

- **Guaranteed accuracy at measurement cable lengths of up to 4 m**
  A 4-terminal pair configuration reduces the influence of measurement cables, allowing accuracy to be guaranteed to a length of 4 m and simplifying connections to large samples as well as wiring of automated equipment. (The frequency range over which accuracy is guaranteed varies with the cable length.)

- **Measure 18 parameters, including dielectric constant and conductivity**
  In addition to Z, Y, θ, Rs (ESR), Rp, Rdc (DC resistance), X, G, B, Ls, Lp, Cs, Cp, D (tan δ), Q, and T, the IM3590 can measure the dielectric constant (ε) and conductivity (σ). Parameters can be captured by computer as required.

### Measurable parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>impedance ([Ω])</td>
</tr>
<tr>
<td>Y</td>
<td>admittance ([S])</td>
</tr>
<tr>
<td>θ</td>
<td>phase angle ([°])</td>
</tr>
<tr>
<td>Rs</td>
<td>Equivalent series resistance = ESR ([Ω])</td>
</tr>
<tr>
<td>Rp</td>
<td>Parallel resistance ([Ω])</td>
</tr>
<tr>
<td>Rdc</td>
<td>DC resistance ([Ω])</td>
</tr>
<tr>
<td>X</td>
<td>reluctance ([Ω])</td>
</tr>
<tr>
<td>G</td>
<td>conductance ([S])</td>
</tr>
<tr>
<td>B</td>
<td>susceptance ([S])</td>
</tr>
<tr>
<td>Ls</td>
<td>series inductance ([H])</td>
</tr>
<tr>
<td>Lp</td>
<td>parallel inductance ([H])</td>
</tr>
<tr>
<td>Cs</td>
<td>series capacitance ([F])</td>
</tr>
<tr>
<td>Cp</td>
<td>parallel capacitance ([F])</td>
</tr>
<tr>
<td>Q</td>
<td>Q factor (Q = 1/D)</td>
</tr>
<tr>
<td>D</td>
<td>loss coefficient (tan δ)</td>
</tr>
<tr>
<td>T</td>
<td>temperature ([℃])</td>
</tr>
<tr>
<td>σ</td>
<td>conductivity ([S/m])</td>
</tr>
<tr>
<td>ε</td>
<td>dielectric constant ([F/m])</td>
</tr>
</tbody>
</table>

Functions and Features to Simplify the Operation of LCR Measurements

- **Intuitive operation with touch panel**
  A touch panel display with intuitive operation is inherited from previous models. Furthermore, the incorporation of a color LCD means the display is easy to view, and outstanding operability which ensures you intuitively know what to do helps improve work efficiency.

- **Simultaneous display of four parameters (during normal measurement)**
  The IM3590 can display four parameters simultaneously during normal measurement, making it easy to check among parameters.

- **Measurement screen (Analyzer mode)**

- **Measurement parameter input screen**

- **Setting items of basic measurement conditions**

- **Frequency setting (numeric keypad input)**

- **Measurement times as short as 2 ms**

- **Basic accuracy of ±0.05%**

- **Guaranteed accuracy at measurement cable lengths of up to 4 m**
### IM3590 measurement accuracy

**Conditions**
At least 60 minutes after power-on, after performing open and short compensation, with a temperature and humidity range of 23°C ±5°C and relative humidity of 80% or less (non-condensing) (Outside the range of 23˚C ±5˚C, accuracy can be calculated by multiplying the basic accuracy by the temperature coefficient G.)

**Basic accuracy (Z, θ) calculation expression**

- **Top A:** Basic accuracy of Z (± % rdg.)
- **Bottom A:** Basic accuracy of θ (± % deg.)
- **A** is the accuracy of DC(Rdc) when Rdc (± % rdg.)
- **B** is the coefficient for the resistance of the sample

\[ Zx = A + B \times Z - 1 \]

When temperature compensation is performed during Rdc measurement, add the following value to the calculation expression of basic accuracy:

\[ -100 \times (1 + \alpha \times (1 + 2\alpha \times 10^{-3})) \text{ [%]} \]

\[ \alpha = \frac{t - t_0}{t_0} \]

\[ t_0 \text{: Reference temperature [˚C]} \]

\[ t \text{: Current ambient temperature [˚C]} \]

\[ \Delta t \text{: Temperature measurement accuracy} \]

\[ \theta \text{: Temperature coefficient for } t \text{ [˚C]} \]

\[ Zx \text{: The actual impedance measurement value (Z) of the sample.} \]

**Range Guaranteed accuracy period: 1 year**
When all coefficients by which the basic accuracy is multiplied (signal level of 1 V or Rdc measurement, measurement speed of SLOW2, measurement cable length of 0 m [when using Test Fixture 9262 or similar], DC bias setting of OFF, and operating temperature of 23˚C ±5˚C) are 1, the basic accuracy is the measurement accuracy.

**Calculation example**
Impedance Zx of sample: 500 Ω (actual measurement value)
Measurement conditions: When frequency 10 kHz and range 1 kΩ
Insert coefficient A = 0.15 and coefficient B = 0.02 for the Z basic accuracy from the table above into the expression.

\[ Z \text{ basic accuracy} = 0.15 + 0.02 \times \left| \frac{10 \times 500}{10} \right| = 0.23 (\pm \% \text{rdg.}) \]

Similarly, insert coefficient A = 0.08 and coefficient B = 0.02 for the θ basic accuracy, as follows:

\[ \theta \text{ basic accuracy} = 0.08 + 0.02 \times \left| \frac{10 \times 500}{10} \right| = 0.16 (\text{deg.}) \]
## IM3590 measurement accuracy

### Guaranteed accuracy range (measurement signal level)

The guaranteed accuracy range differs depending on the measurement frequency, measurement signal level, and measurement range.

<table>
<thead>
<tr>
<th>Range</th>
<th>Guaranteed accuracy range (measurement signal level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100MΩ</td>
<td>0.010% to 5 V when DC bias.</td>
</tr>
<tr>
<td>10MΩ</td>
<td>0.050% to 5 V when DC bias.</td>
</tr>
<tr>
<td>1MΩ</td>
<td>0.050% to 5 V when DC bias.</td>
</tr>
<tr>
<td>10kΩ, 1kΩ, 100Ω</td>
<td>0.005% to 5 V when DC bias.</td>
</tr>
<tr>
<td>1Ω</td>
<td>0.050% to 5 V when DC bias.</td>
</tr>
<tr>
<td>100mΩ</td>
<td>0.501% to 5 V when DC bias.</td>
</tr>
</tbody>
</table>

The above voltages are the voltage setting values corresponding to when in V mode.

### Specifications

**Product warranty:** 1 year

**DC bias measurement**
- **Normal mode:** -5.00 V to 5.00 VDC (10 mV steps)
- **Low impedance high accuracy mode:** -2.50 V to 2.50 V (10 mV steps)

**Rdc (DC resistance) measurement**
- **Temperature measurement function:** Fixed to 2 V
- **Temperature compensation function:** Converted reference temperature is displayed
- **Reference temperature setting range:** -10°C to 99.9°C
- **Temperature coefficient setting range:** -99.99°C/°C to +99.99°C/°C

**Temperature measurement range**
- **Temperature Probe:** Sheath Type Temperature Probe 9478 (option)
- **Measurement range:** -10°C to 99.9°C
- **Sampling cycle:** 640 ms

**Comparator**
- LCR mode: Hi/IN/Lo for 2 parameters

**BiN measurement**
- 10 classifications and out of range for 2 parameters

**Compensation**
- Open/short/load/correlation compensation
- Cable length: 0, 1, 2, and 4 m

**Residual charge protection function**
- **V0:** $\sqrt{10V}$
- **(C: Capacitance [F] of test sample, V = max. 400 V)**

**Trigger synchronous output function**
- Applies a measurement signal during analog measurement only

**Averaging**
- 1 to 256

**Panel loading/saving**
- LCR mode: 60; Analyzer mode: 2
- Compensation value: 128

**Memory function**
- Stores 32,000 data items to the memory of the instrument

**Interfaces**
- EXT I/O (handler), USB (Hi-Speed), USB flash drive
- Option: RS-232C, GP-IB, LAN (10BASE-T/100BASE-TX), Only 1 Optional Interface can be installed at any one time

**Operating temperature and humidity ranges**
- 0°C (32°F) to 40°C (104°F)
- 80% RH or less, no condensation

**Storage temperature and humidity ranges**
- -10°C (14°F) to 55°C (131°F)
- 80% RH or less, no condensation

**Power supply**
- 100 to 240 V AC, 50/60 Hz, 50 VA max.

**Dimensions and mass**
- Approx. 300 W x 119 H x 168 D mm
- Approx. 3.1 kg

**Accessories**
- Power Cord x 1, Instruction Manual x 1, CD-R (Communication Instruction Manual and Sample Software [Communications Control, Accuracy Calculation, and Screen Capture Functionality]) x 1

**Applicable standards**
- EN61326-1, EN61000-3-2, EN61000-3-3
- Safety standard: EN61010

**Memory function**
- Stores 32,000 data items to the memory of the instrument

**Interfaces**
- EXT I/O (handler), USB (Hi-Speed), USB flash drive
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- EN61326-1, EN61000-3-2, EN61000-3-3
- Safety standard: EN61010
Model: CHEMICAL IMPEDANCE ANALYZER IM3590

<table>
<thead>
<tr>
<th>Model No. (Order Code) (Note)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM3590</td>
</tr>
</tbody>
</table>

(For electrochemical components)


Test fixtures are not supplied with the unit. Select an optional test fixture or probe when ordering. Probes are constructed with a coaxial cable with 50Ω impedance characteristics.

Options

**INTERFACE UNIT (Only 1 can be installed at any one time)**

- **GP-IB INTERFACE Z3000**
- **RS-232C INTERFACE Z3001**
- **LAN INTERFACE Z3002**

*R-S-232C cable

For RS-232C cable, a crossover cable for interconnection can be used. The RS-232C cable 9637 (9-pin to 9-pin, crossed cable) cannot be used for applications involving the flow control of hardware.

**DC Bias Unit**

- **DC BIAS VOLTAGE UNIT 9268-11**
- **DC BIAS CURRENT UNIT 9269-10**

Direct connection type, 40 Hz to 8 MHz, maximum applied voltage of DC ±40 V.

When using the 9268-11 or 9269-10, external constant-voltage and constant-current sources are required.

**TEMPERATURE PROBE**

<table>
<thead>
<tr>
<th>SHEATH TYPE TEMPERATURE PROBE 9478</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt100, tip ø2.3 mm (0.09 in), cond length 1 m (3.28 ft), water-proof structure, water-proof property: EN60529:1991, IP67</td>
</tr>
</tbody>
</table>

**Probes and Test Fixtures for Lead Components**

- **FOUR-TERMINAL PROBE L2000-10**
- **TEST FIXTURE L2000**

Cable length 1 m (3.28 ft), DC to 8 MHz, impedance characteristics of 50 Ω, 4-terminal pair configuration, measurable conductor diameter: ø0.3 mm (0.01 in) to 2 mm (0.08 in)

- **FOUR-TERMINAL PROBE 9140-10**
- **TEST FIXTURE 9262**

Cable length 1 m (3.28 ft), DC to 200 kHz, impedance characteristics of 50 Ω, 4-terminal pair configuration, measurable conductor diameter: ø0.3 mm (0.01 in) to 3 mm (0.12 in)

**Test Fixtures for SMD**

<table>
<thead>
<tr>
<th>SMD TEST FIXTURE IM9110</th>
<th>SMD TEST FIXTURE IM9100</th>
<th>SMD TEST FIXTURE 9263</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurable range: DC to 1 MHz, For SMD with electrodes on side, Measurable sample sizes: 00801 (EIA), 0201 (JIS), Please contact HIOKI for information about other sizes, Direct connection type</td>
<td>Measurable range: DC to 8 MHz, For SMD with electrodes on bottom, Measurable sample sizes: 01005 to 0402 (EIA) 0402 to 1005 (JIS), Direct connection type</td>
<td>Direct connection type, Electrodes on side for SMD, DC to 120 MHz, Test sample dimensions: 3.5 mm ±0.5 mm (0.14 in ±0.02 in)</td>
</tr>
</tbody>
</table>

Direct connection type, Electrodes on bottom for SMD, DC to 120 MHz, Test sample dimensions: 1 mm (0.04 in) to 10 mm (0.39 in)

**FOUR-TERMINAL PROBE 9699**

Direct connection type, Electrodes on side for SMD, DC to 8 MHz, Test sample dimensions: 1 mm (0.04 in) to 10 mm (0.39 in)

**PINCHER PROBE L2001**

Cable length 750 mm (2.46 ft), DC to 8 MHz, characteristic impedance of 50 Ω, 4-terminal pair design, 2-terminal electrode, tip electrode spacing of 0.3 to approx. 6 mm (0.01 in to approx. 0.24 in)

Options for L2001

- **CONTACT TIPS IM9901**
- **CONTACT TIPS IM9902**

Compatible chip sizes: 0805 to 5750 (JIS)

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**For Electrochemical Measurement**

**FOUR-TERMINAL PROBE 9500-10**

Cable length 1 m (3.28 ft), DC to 200 kHz, impedance characteristics of 50 Ω, 4-terminal pair configuration, measurable conductor diameter: ø0.3 mm (0.01 in) to 2 mm (0.08 in)

**TEMPERATURE PROBE**

**SHEATH TYPE TEMPERATURE PROBE 9478**

Pt100, tip ø2.3 mm (0.09 in), cond length 1 m (3.28 ft), water-proof structure, water-proof property: EN60529:1991, IP67

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