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.

![Cole-Cole plot](image)

**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.

![X-Y display screen](image)

**Advantage**

**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 of alkaline batteries](image)

**Measurement time and Z repeatability during low-resistance measurement**

(Measurement frequency: 100Hz; Sample: 10mΩ Resistance)

![Measurement time and Z repeatability during low-resistance measurement](image)
Electrochemical equivalent circuit analysis

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

1. Unipolar, or all poles have the same reaction, and the center of the capacitive semicircle lies on the real axis

2. Unipolar, or all poles have the same reaction, and the center of the capacitive semicircle does not lie on the real axis

#### Polar models

3. Different poles have different reactions, and the center of the capacitive semicircle lies on the real axis

4. 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

- **L_1**: Electrode and wiring inductance
- **C_1** (CPE_1): Electric double layer capacitance
- **R_1**: Charge transfer resistance
- **R_s** (R_sol): Solution resistance
- **C_2** (CPE_2): Electric double layer capacitance
- Electrolysis solution
- Electrode
- Electrode
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**
  
  - **Four-element model**
  
  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)
  - $f_n$ (Minimum admittance frequency)
  - $f_1$ (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.
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.)

- 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.

- 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.)

- 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.)

- Wide setting range for measurement frequency

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.

- 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.

- Functions and Features to Simplify the Operation of LCR Measurements

- Measurable parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z (impedance)</td>
<td>(</td>
</tr>
<tr>
<td>Y (admittance)</td>
<td>(</td>
</tr>
<tr>
<td>(\theta) (phase angle)</td>
<td>([°])</td>
</tr>
<tr>
<td>Rs (Equivalent series resistance)</td>
<td>(ESR[Ω])</td>
</tr>
<tr>
<td>Rp (Parallel resistance)</td>
<td>([Ω])</td>
</tr>
<tr>
<td>Rdc (DC resistance)</td>
<td>([Ω])</td>
</tr>
<tr>
<td>X (reluctance)</td>
<td>([Ω])</td>
</tr>
<tr>
<td>G (conductance)</td>
<td>([S])</td>
</tr>
<tr>
<td>B (susceptance)</td>
<td>([S])</td>
</tr>
<tr>
<td>Ls (series inductance)</td>
<td>([H])</td>
</tr>
<tr>
<td>Lp (parallel inductance)</td>
<td>([H])</td>
</tr>
<tr>
<td>Cs (series capacitance)</td>
<td>([F])</td>
</tr>
<tr>
<td>Cp (parallel capacitance)</td>
<td>([F])</td>
</tr>
<tr>
<td>Q (Q factor)</td>
<td>(Q = 1/D)</td>
</tr>
<tr>
<td>D (loss coefficient = tanδ)</td>
<td>(\Omega)</td>
</tr>
<tr>
<td>T (temperature)</td>
<td>(°C)</td>
</tr>
<tr>
<td>(\sigma) (conductivity)</td>
<td>([\text{S/m}])</td>
</tr>
<tr>
<td>(\varepsilon) (dielectric constant)</td>
<td>([\text{F/m}])</td>
</tr>
</tbody>
</table>
## 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 from 0°C to 40°C 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.)
- **B** is the coefficient for the resistance of the sample
- **C** is the coefficient for the impedance of the sample

**Formula:**

\[
\text{Accuracy} = A + B \times \frac{Z}{Z_x} \text{ Range} - 1
\]

Where:
- Zx is the actual impedance measurement value (Z) of the sample.
- A is the accuracy of DC(Rdc) when Rdc (± % rdg.)
- B is the coefficient for the sample impedance, measurement range from the actual measurement value of impedance or the approximate impedance value calculated with the following expression.

\[
\frac{1}{\text{ω}C(F)} = \text{wL(H)} (\theta \approx 90^\circ) \\
\text{w} \times \text{R (Ω)} (\theta \approx 0^\circ) \quad \text{(w: 2 x n x Measurement frequency (Hz))}
\]

*Method for determining basic accuracy*

- Calculate the basic accuracy from the sample impedance, measurement range, and measurement frequency and the corresponding basic accuracy A and coefficient B from the table above.
- The calculation expression to use differs for each of the 1 kΩ range and above and 100 Ω range and below.
- For C and L, obtain basic accuracy A and coefficient B by determining the measurement range from the actual measurement value of impedance or the approximate impedance value calculated with the following expression.

\[
Z = (\theta \approx 0^\circ) \\
\frac{1}{\text{ω}C(F)} \quad \text{wL(H)} (\theta \approx 90^\circ) \\
\text{w} \times \text{R (Ω)} (\theta \approx 0^\circ) \quad \text{(w: 2 x n x Measurement frequency (Hz))}
\]

### Guaranteed accuracy period
1 year

### 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.

\[
Z \text{ basic accuracy} = 0.15 + 0.02 \times \left| \frac{10 \times Zx}{900} - 1 \right| = 0.23 \text{ (±%rdg.)}
\]

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

\[
\theta \text{ basic accuracy} = 0.08 + 0.02 \times \left| \frac{10 \times Zx}{900} - 1 \right| = 0.16 \text{ (±deg.)}
\]
In the 10 MΩ to 1 kΩ range, the guaranteed accuracy range is as follows when measured values (impedance values) exceed the range.

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

Guaranteed accuracy range (measurement signal level)
The above voltages are the voltage setting values correspond to when in V mode.

Measurement speed
- FAST/MED/SLOW/SLOW2

Number of display digits
- Setting: normal sweep or segment sweep,
  Display: List display or graph display

measurement parameters
- Z, Y, O, Rx(ESR), Rp, Rdc(DC resistance), X, G, B, Cs, Cn, Lp, Ls, I, T, n

Maximum/Minimum/Average: 10, 100, 1000 at any one time

Measurement accuracy
- Guaranteed accuracy of 0.501 V to 5 V when DC bias.

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

Specifications
Product warranty: 3 year

measurement modes
- LCR mode: Measurement with single condition
- Analyzer mode: Measurement with two sets
- Measurement method: normal sweep or segment sweep,

measurement range
- Z, Y, O, Rx(ESR), Rp, Rdc(DC resistance), X, G, B, Cs, Cn, Lp, Ls, I, T, n

measurement signal level
- Normal mode: V = \sqrt{I^2 + \text{Re}(Z)^2}

output impedance
- Low impedance high accuracy mode: 25 Ω

display
- 5.7-inch color TFT, display can be set to ON/OFF

measurement time
- 2 ms (1 kHz, FAST, display OFF, representative value)

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: EN61010-1
- EMC: EN55011, EN55022

accessories
- Sample Software: Communications Control, Accuracy Calculation, and Screen Capture Functionality

enables 32,000 data items to the memory of the instrument

memory function
- Optional: RS-232C, GP-IB, LAN (10BASE-T/100BASE-TX), USB (Hi-Speed), USB flash drive

power supply
- 100 to 240 V AC, 50/60 Hz, 50 VA max

dimensions and mass
- Approx. 330 W
- Dimensions: 4.69" H x 80" W x 4.69" D, approx. 109 oz.

power consumption
- Approx. 24 W
- 119 H x 80" W x 4.69" D, approx. 109 oz.
Options

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

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

*RS-232C cable*

For RS-232C, 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.

**GP-IB CONNECTION CABLE** 9151-02
2 m (6.56 ft)

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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)

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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)

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**Test Fixtures for SMD**

- **SMD TEST FIXTURE IM9110**
  - Measurable range: DC to 1 MHz, For SMD with electrodes on side. Measurable sample sizes: 080504 (EA), 0201 (3JS). Please contact HIOKI for information about other sizes. Direct connection type.

- **SMD TEST FIXTURE IM9010**
  - Measurable range: DC to 8 MHz, For SMD with electrodes on bottom. Measurable sample sizes: 0805 to 0402 (EA)/0402 to 1005 (3JS). Direct connection type.

- **SMD TEST FIXTURE 9699**
  - Direct connection type, Electrodes on bottom for SMD, DC to 120 MHz, Test sample dimensions: 1.0 mm (0.04 in) to 4.0 mm (0.16 in) wide, maximum 1.5 mm (0.06 in) high

- **SMD TEST FIXTURE 9263**
  - Direct connection type, DC to 8 MHz, Test sample dimensions: 1 mm (0.04 in) to 10 mm (0.39 in)

- **SMD TEST FIXTURE 9267**
  - 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)

- **PINCHER PROBE L2001**
  - *Ships standard with one set of EN8996
  - Compatible chip sizes: 0603 to 0805 (3JS), 0402 to 1005 (3JS)
  - Reversible contact tips
  - Options for L2001
    - CONTACT TIPS IM9901
      - Compatible chip sizes: 0603 to 0805 (3JS)
    - CONTACT TIPS IM9902
      - Compatible chip sizes: 0603 to 0805 (3JS)

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**DC Bias Unit**

- **DC BIAS VOLTAGE UNIT 9268-10**
  - Direct connection type, 40 Hz to 8 MHz, maximum applied voltage of DC ±40 V.

- **DC BIAS CURRENT UNIT 9269-10**
  - Direct connection type, 40 Hz to 2 MHz, maximum applied current of DC ±4 A (maximum applied voltage of DC ±40 V).

*An internal 300μH inductance is connected in parallel to the DUT.*

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

**Test Fixtures for SMD**

- **SHEATH TYPE TEMPERATURE PROBE 9478**
  - Pt100, tip ø2.3 mm (0.09 in), cord length 1 m (3.28 ft), water-proof structure, water-proof property: EN60529:1991, IP67

**Probes and Test Fixtures for Lead Components**

- **FOUR-TERMINAL PROBE IM9100**
  - 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 5 mm (0.20 in)

- **TEST FIXTURE 92001-10**
  - 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 1.5 mm (0.06 in)

- **FOUR-TERMINAL PROBE 9140-10**
  - 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 5 mm (0.20 in)

- **TEST FIXTURE 9262**
  - Direct connection type, DC to 8 MHz, measurable conductor diameter: ø0.3 mm (0.01 in) to 2 mm (0.08 in)

**Note:** Company names and product names appearing in this catalog are trademarks or registered trademarks of various companies.

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**Model: CHEMICAL IMPEDANCE ANALYZER IM3590**

**Model No. (Order Code) (Note)**

- IM3590 (For electrochemical components)

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

**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.**

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HIOKI E.E. CORPORATION

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https://www.hioki.com/

Scan for all regional contact information

All information correct as of Sept. 20, 2019. All specifications are subject to change without notice.

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