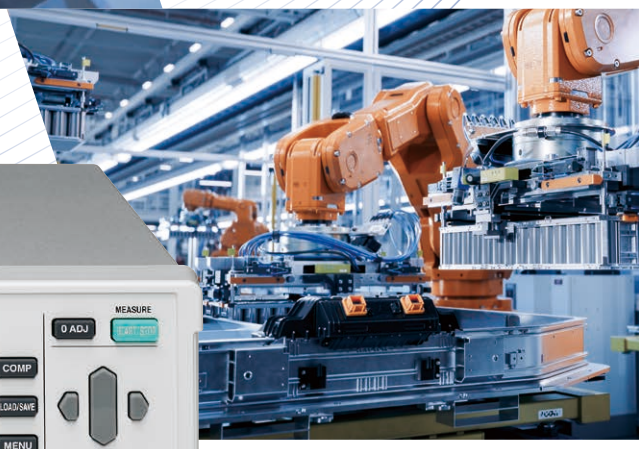
HIOKI

BATTERY IMPEDANCE METER
BT4560-50, BT4560-60

NEW



A new platform for EIS measurement and equivalent circuit analysis

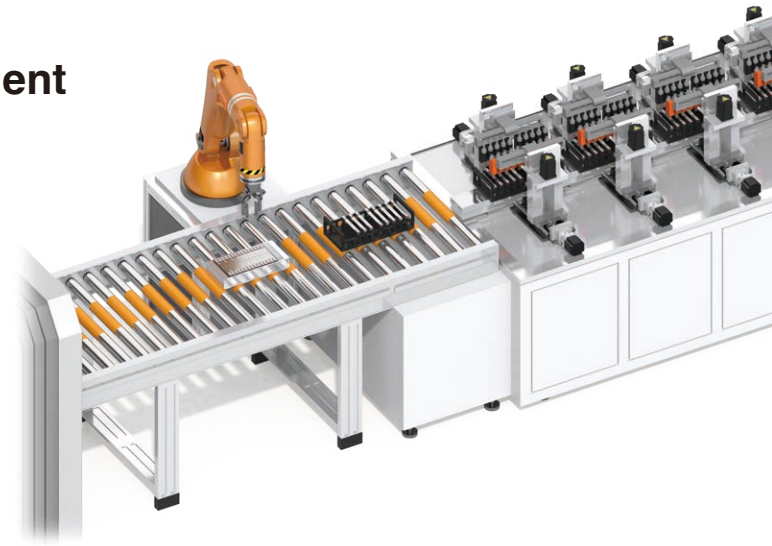
Introducing a measurement solution for R&D and manufacturing of high-capacity batteries for EVs and ESSs

CE 3year Warranty

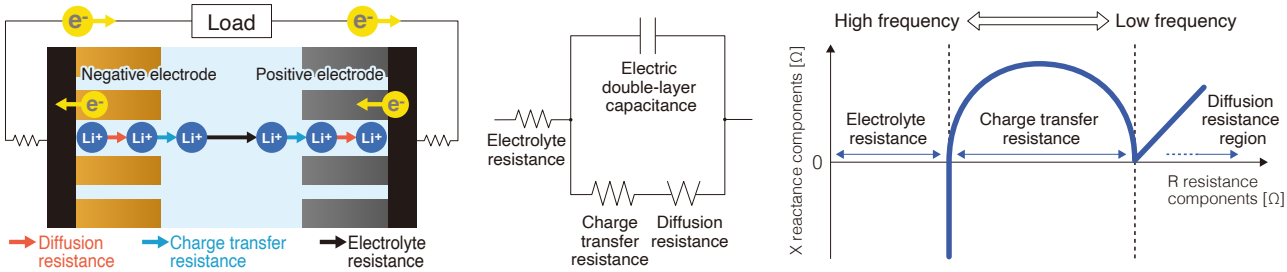
BATTERY IMPEDANCE METER BT4560 series

A reliable EIS measuring instrument for applications ranging from R&D to manufacturing

The Battery Impedance Meter BT4560 series enables quick and easy EIS measurements from R&D to production lines. Furthermore, adding the Switch Mainframe SW1001 or SW1002 seamlessly expands the tester into a multi-channel evaluation system, automating and streamlining evaluation of multiple batteries. The standard LAN interface makes integration into inspection systems straightforward.



What is battery EIS measurement?



Electrochemical impedance spectroscopy (EIS) is a type of testing that measures a battery's impedance across a broad frequency range using small AC signals. The technique, which yields detailed insights into characteristics such as a battery's internal resistance and electrode reactions, aids in the understanding of battery behavior and performance, making it useful in R&D and quality control applications.

Why Hioki is entrusted with high-capacity battery EIS Measurement for EV/ESS

Bench-top EIS measurement

Photo: BT4560-60

Battery Impedance Meter BT4560 series

- **A reliable EIS measuring instrument for applications ranging from R&D to manufacturing**
- **Simultaneous measurement of impedance, voltage, and temperature**
- **Convenient evaluation application software for R&D use**
- **Compatibility with third-party equivalent circuit analysis software**

BT4560-50, BT4560-60 basic performance	
Impedance	Maximum resolution: 0.1 μΩ
Voltage range	±5 V, resolution of 10 μV
Measurement current	Max. 1.5 A rms
EIS measurement frequency	BT4560-50: 0.01 Hz to 1050 Hz BT4560-60: 0.01 Hz to 10.00 kHz

Advanced multi-channel solutions Option

SW1001

Switch Mainframe SW1002

- **Reduce measurement error with multiplexer circuitry designed with impedance measurement in mind**
- **Channel switching time: 11 ms**
- **Ideal for shortening test-times and building reliable testing systems**

SW1001 basic performance	
Number of multiplexer slots	3
Channels	Up to 18 (4-terminal-pair measurement)

SW1002 basic performance	
Number of multiplexer slots	12
Channels	Up to 72 (4-terminal-pair measurement)

Measurement setup

Flexible capability to accommodate a variety of EIS measurement situations

Single-channel

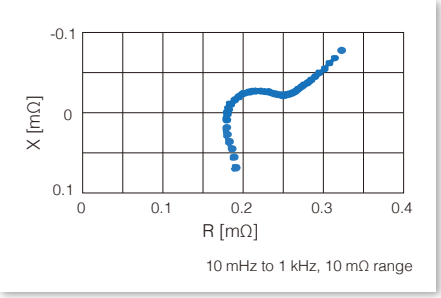
BT4560-60 (1 channel)

Multi-channel

BT4560-60 + SW1001 (6 channels)

High-precision, high-stability measurement performance Ideal for use with the high-capacity batteries used in EVs and ESSs

0.1 μΩ resolution impedance measurement

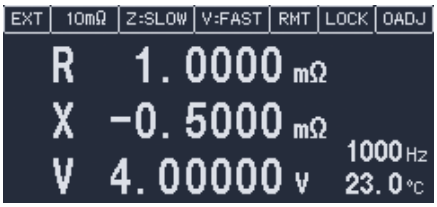


The BT4560 series can accurately measure high-capacity batteries with internal impedance of less than 1 mΩ. It provides reproducible data that boosts the reliability of analysis and evaluation.

High-precision DC voltage measurement

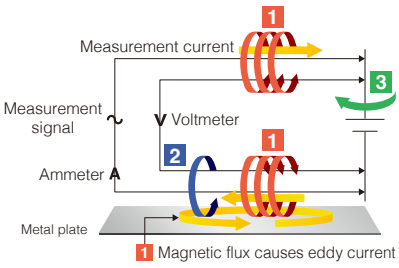
Accuracy: ±0.0035% rdg. ±5 dgt.

Measure a 4 V Li-ion cell with an accuracy of ±190 μV.



This level of precision places the BT4560 series on par with a 6 1/2 digit high-precision voltmeter, realizing simutaneous high-precision measurements of battery voltage and impedance.

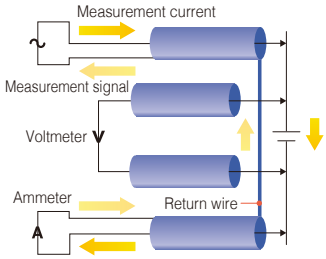
Improve the stability of high-frequency measurement with 4-terminal-pair measurement



Induction fields lead to measurement error

Influences of induction fields on 4-terminal measurement

1. Magnetic flux is caused by measurement current
2. Magnetic flux is caused by eddy current
3. Magnetic flux comes from external sources



BT4560

Reducing effects of induction fields with 4-terminal-pair measurement

Current flows in the opposite direction of the measurement current to limit magnetic flux, reducing the effects of the induction field.

4-terminal-pair measurement is a method for using a return wire to cancel magnetic flux caused by the measurement current. Nearby metal objects can cause eddy currents, with measurement variation increasing as the distance to the wire decreases. The 4-terminal-pair method cancels the effects of such eddy currents. This significantly reduces variability in measured values when wires move during measurement. As a result, compared to ordinary 4-terminal measurement, 4-terminal-pair measurement excels at high frequencies measurement (generally about 200 Hz or higher).

4-terminal-pair measurement probes

Choose from 2 types depending on the battery's shape

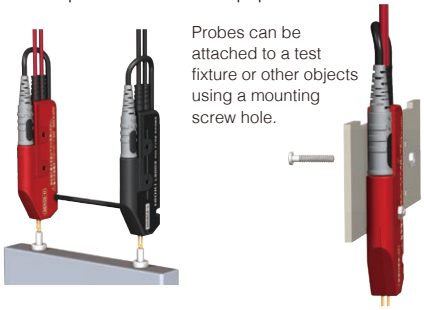
Clip-Type Probe L2002

For measuring laminated batteries

Probes can be adjusted by sliding the stopper to ensure uniform contact position.

Pin-Type Probe L2003

For measuring various types of batteries, for example when the instrument is embedded in production line equipment



Probes can be attached to a test fixture or other objects using a mounting screw hole.

Customers considering embedding the BT4560 in an automated system

Special-order measurement probe cables can be extended to a length of up to 4 m depending on the operating environment. If you need advice concerning system development, for example about topics like fabricating your own probes or wiring, Hioki's global support network can propose solutions quickly and efficiently.

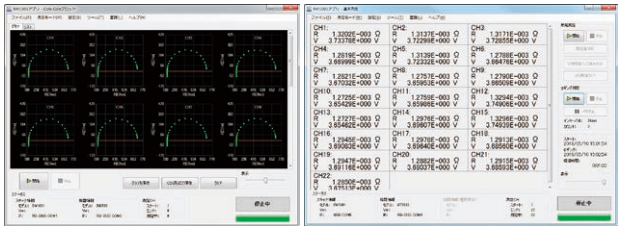
Data acquisition software that's convenient in R&D work

Computer application software

Easily acquire EIS measurement data

You can easily acquire EIS measurement data using the computer application software that comes with the instrument as a standard accessory. The software can also make measurements at a fixed interval, for example to evaluate the correlation between temperature variations and internal impedance.

Measure multiple batteries



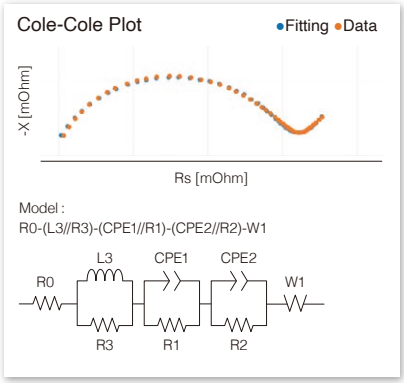
Hioki provides software for controlling the SW1001/SW1002 Switch Mainframe to perform EIS measurement of multiple batteries. This software, a standard accessory to both of the switch mainframes, can perform EIS measurement across up to 72 channels, display Nyquist plots in real time. It supports data logging for EIS and single frequency measurement.

Circuit Fitting: a simple analysis web app

Find the application here:
https://www.circuitfitting.net

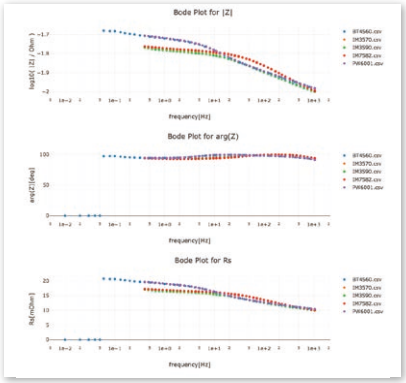
This free web application can perform equivalent circuit analysis and create two- and three-dimensional comparative graphs of Nyquist plots (Cole-Cole plots).

Automatically display equivalent circuit analysis results



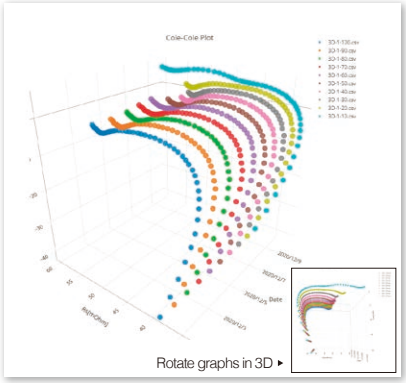
Analyze battery impedance using predefined models. Automatically display analysis results simply by uploading a measurement file.

Creation of bode plots to ascertain phase characteristics



Create Bode plots and Nyquist plots simultaneously. Bode plots allow you to ascertain phase characteristics.

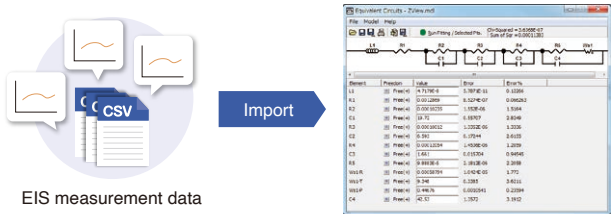
Analyze characteristics using 3D graphs



Create Nyquist and Bode plots using the time or date as a third axis. Rotate 3D graphs in any direction to review them and export bitmap images.

Interoperability with third-party software

Data compatibility with ZView® equivalent circuit analysis software

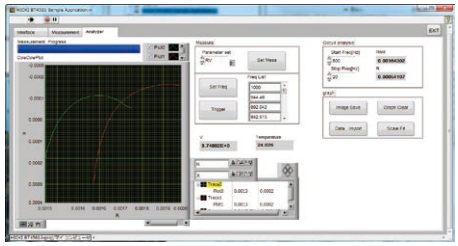


EIS measurement data

Import data acquired with the BT4560 series's standard application software into ZView®*, a third-party equivalent circuit analysis software package to conduct detailed analysis.

*ZView® is a trademark of Scribner Associates Inc.

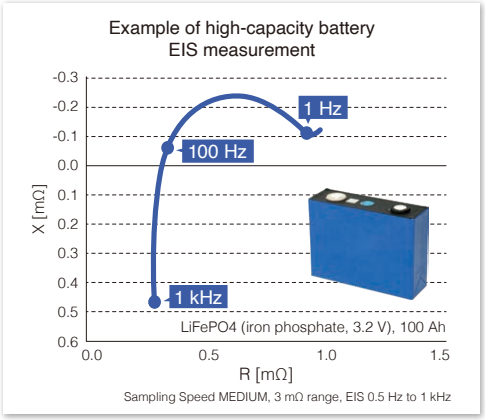
LabVIEW driver for BT4560



Hioki provides a LabVIEW driver to be used when developing evaluation systems integrated with instruments such as thermostatic chambers and charge/discharge testers. The LabVIEW driver is bundled with a sample application software with functionality for overlaying 5 graphs and conducting simple equivalent circuit analysis.

Quality control and inline testing

Perform low-frequency impedance testing to accommodate the characteristics of high-capacity batteries.



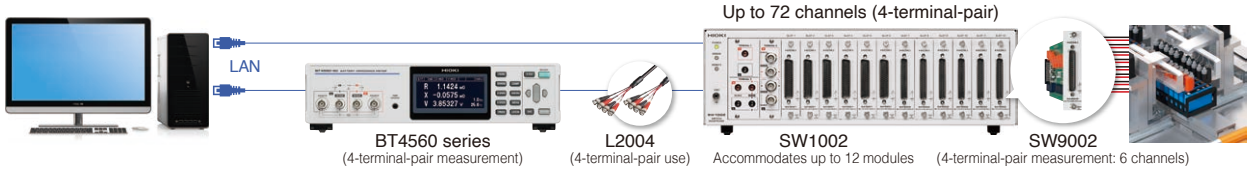
Low-frequency impedance measurement objectives and advantages

- **Perform cell screening using zero-cross points*1**
- **Accumulate data for degradation diagnostics**
- **Analyze the causes of cell and module defects**
- **Improve the reproducibility of testing (using measurement at low frequencies can reduce the effects of eddy currents)**

*1: The frequency point at which X = 0 Ω in a Nyquist plot. In high-capacity batteries, this point tends to shift towards frequencies that are lower than 1 kHz.

Example automatic testing system using a multiplexer

You can use the BT4560 series to build an automatic testing system that can efficiently measure multiple batteries. You can flexibly expand the number of channels to match your desired test-system size by using the 6-channel Multiplexer Module SW9002 (designed for impedance measurement) and the Switch Mainframe SW1001 or SW1002 (which houses multiplexer modules).



Scanning measurement times (reference values)

Number of channels	Measurement frequency	Measurement speed mode	Total time (all channels)	Conditions
6	1 kHz	FAST	0.75 s, approx. 123 ms/ch	SW1001 + SW9002 RX measurement function Sample delay: 0 ms (0 waves) LAN communication
6	1 kHz	MEDIUM	0.95 s, approx. 158 ms/ch	
6	100 Hz	FAST	0.84 s, approx. 140 ms/ch	
6	100 Hz	MEDIUM	1.25 s, approx. 208 ms/ch	
6	1 Hz	FAST	7.50 s, approx. 1250 ms/ch	
6	1 Hz	MEDIUM	13.54 s, approx. 2257 ms/ch	

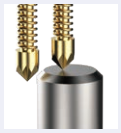
Functionality and interfaces

Functionality suited to automatic testing

The BT4560 series provides LAN, RS-232C, and USB communication interfaces along with a range of judgment/data output features needed for automatic testing.

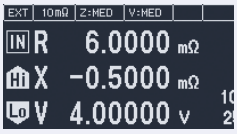
Contact check function

By monitoring probes' contact resistance before and after measurement, the instrument can verify that probes have made proper contact with the circuit under measurement.



Comparator function

- Simultaneous judgment of impedance and voltage
- Overall judgment result output
- Two-tone buzzer for checking judgments

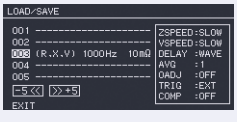


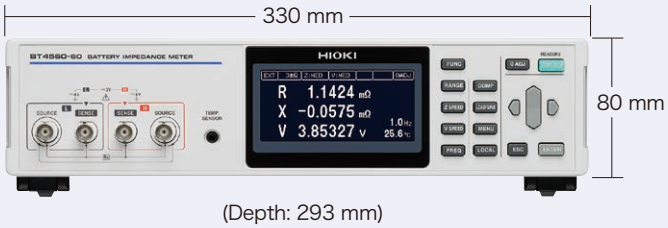
NPN/PNP switching

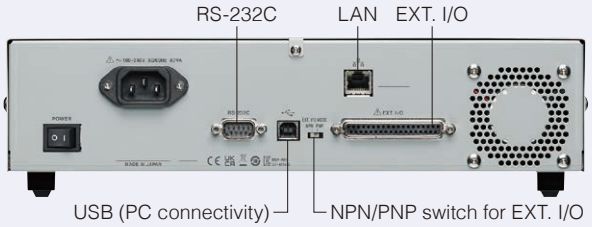
The BT4560 series's EXT. I/O circuit can be switched between current sink output (NPN) and current source output (PNP).

Panel save/load function

Save up to 126 sets of measurement conditions and load them from the EXT. I/O interface.







BT4560-50, BT4560-60 Specifications

Accuracy specifications

Impedance measurement accuracy (α is as shown in the table below.)

■ 3 mΩ range (0.01 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
(The units of R and X are [mΩ]. α is as shown in the table below.)
Z accuracy = ± 0.4% rdg. ± α (|sinθ| + |cosθ|)
θ accuracy = ± 0.1°± 57.3 $\frac{\alpha}{Z}$ (|sinθ| + |cosθ|)

■ 3 mΩ range (110 Hz to 1050 Hz)

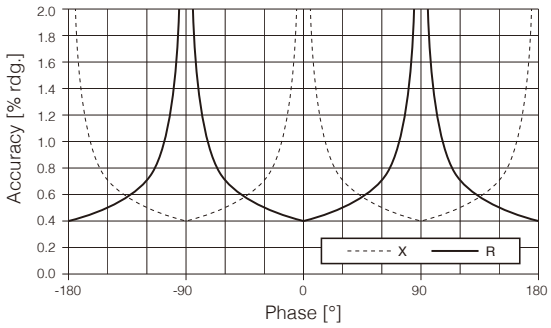
R accuracy = ± (0.004 |R| + 0.0052 |X|) [mΩ] ± α
X accuracy = ± (0.004 |X| + 0.0052 |R|) [mΩ] ± α
(The units of R and X are [mΩ]. α is as shown in the table below.)
Z accuracy = ± 0.4% rdg. ± α (|sinθ| + |cosθ|)
θ accuracy = ± 0.3°± 57.3 $\frac{\alpha}{Z}$ (|sinθ| + |cosθ|)

	Sampling speed	3 mΩ range	10 mΩ range	100 mΩ range
α	FAST	25 dgt.	60 dgt.	60 dgt.
	MED	15 dgt.	30 dgt.	30 dgt.
	SLOW	8 dgt.	15 dgt.	15 dgt.
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)		

*For 1.06 kHz to 10 kHz, values below 1 mΩ are not guaranteed for the 3 mΩ and 10 mΩ ranges.
For the 100 mΩ range, values below 10 mΩ are not guaranteed. See the instruction manual for details.

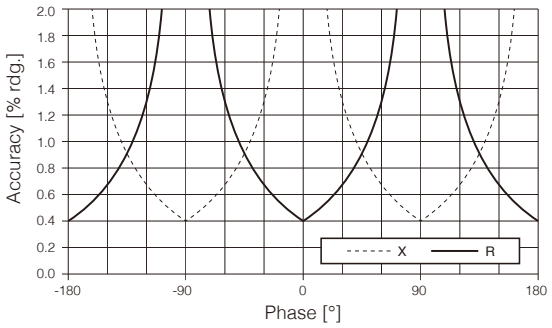
Accuracy graph

■ 3 mΩ range (0.01 Hz to 100 Hz), 10 mΩ range, 100 mΩ range



Impedance accuracy excluding α (0.004 |R| + 0.0017 |X|, 0.004 |X| + 0.0017 |R|)

■ 3 mΩ range (110 Hz to 1050 Hz)



Impedance accuracy excluding α (0.004 |R| + 0.0052 |X|, 0.004 |X| + 0.0052 |R|)

Voltage measurement accuracy (when self-calibration is performed)

Voltage	Display range	–5.10000 V to 5.10000 V
	Resolution	10 µV
Voltage accuracy	FAST/MED/SLOW	±0.0035% rdg. ±5 dgt.
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 (BT4560 series + Z2005 temperature sensor)

Accuracy	±0.5°C (measurement temperature: 10.0°C to 40.0°C) ±1.0°C (measurement temperature: -10.0°C to 9.9°C, 40.1°C to 60.0°C)
Temperature coefficient	Temperature coefficient: ±0.01°C / °C (applied in the ranges of 0°C to 18°C and 28°C to 40°C)

General Specifications (accuracy guaranteed for 1 year)

Measured items	Impedance, voltage, temperature

Impedance measurement

Measurement parameters	R resistance, X reactance, Z impedance, θ phase angle
Measurement frequency	0.01 Hz to 1050 Hz (BT4560-50), 0.01 Hz to 10.00 kHz (BT4560-60)
Frequency setting resolution	0.01 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 (BT4560-60) 100 Hz to 10.00 kHz in 10 Hz increments (BT4560-60)
Measurement ranges	3.0000 mΩ, 10.0000 mΩ, 100.000 mΩ
Allowable input voltage	Up to 5 V

Measurement/DC-load currents

(DC load: offset current applied to measured object during impedance measurement)

	3 mΩ range	10 mΩ range	100 mΩ range
Measurement current	1.5 A rms ±10%	500 mA rms ±10%	50 mA rms ±10%
DC load current	1 mA or less	0.35 mA or less	0.035 mA or less

Number of measurement current waves

	FAST	MED	SLOW	Remarks
0.01 Hz to 66 Hz	1	2	8	BT4560-50 and BT4560-60
67 Hz to 250 Hz	2	8	32	
260 Hz to 1050 Hz	8	32	128	BT4560-50 only
260 Hz to 1.00 kHz	8	32	128	BT4560-60 only
1.01 kHz to 2.00 kHz	128	128	128	
2.01 kHz to 4.00 kHz	256	256	256	
4.01 kHz to 8.00 kHz	512	512	512	
8.01 kHz to 10.00 kHz	1024	1024	1024	

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 (When self-calibration is performed, 0.21 s is added to the measurement time.)

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)
Functions	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 functions	Contact check, measurement current error, voltage drift on measured object, overvoltage input, voltage limit
Interfaces	LAN (TCP/IP, 10BASE-T/100BASE-TX) RS-232C (transmission speed: 9,600 bps/19,200 bps/38,400 bps) USB (pseudo COM port)
EXT. I/O	TRIG, LOAD, Hi, IN, Lo, and others (NPN/PNP can be switched)
Operating temperature and humidity range	0°C to 40°C (32°F to 104°F), 80% RH or less (no condensation)
Storage temperature and humidity range	-10°C to 50°C (14°F to 122°F), 80% RH or less (no condensation)
Operating environment	Indoor, pollution degree 2, altitude up to 2,000 m
Power supplies	Rated supply voltage: 100 to 240 V AC Rated supply frequency: 50/60 Hz
Rated power	80 VA
Dielectric strength	1.62 kV AC, 1 min., cutoff current 10 mA (between all power supply terminals and protective ground)
Applicable standards	Safety: EN61010, EMC EN61326 Class A
Dimensions and weight	Approx. 330W × 80H × 293D mm (12.99W × 3.15H × 11.54D in.), approx. 3.8 kg (134.0 oz.)
Included accessories	Power cord × 1, instruction manual × 1, zero-adjustment board × 1, USB cable (A-B type) × 1

Multiplexer specifications

Switch Mainframe SW1001/SW1002

Number of slots	3 slots (SW1001), 12 slots (SW1002)
Supported BT4560 module	Multiplexer Module SW9002 (4-terminal-pair, 2-wire)
Max. input voltage	60 V DC, 30 V AC rms, 42.4 V peak
Interfaces	LAB, USB, RS-232C (host), RS-232C (command transfer function)
EXT. I/O	SCAN input, SCAN_RESET input, CLOSE output (scan control)

Multiplexer Module SW9002

Wiring method	4-terminal-pair (6-wire) or 2-wire
Number of channels	6 channels (4-terminal-pair, 2-wire)
Contact method	Mechanical relays
Channel switching time	11 ms (not including measurement time)
Maximum allowable voltage	60 V DC, 30 V AC rms, 42.4 V peak
Maximum allowable current	Source: Between HIGH and LOW 2 A DC, 2 A AC rms Sense: Between HIGH and LOW 1 A DC, 1 A AC rms
Connectors used	D-sub 37-pin pin header

Effect on accuracy of using the instrument with the SW9002[*1]

BT4560-50, BT4560-60 (connected via L2004)					
Range		Effect			Conditions, remarks
		Frequency range 0.1 Hz to 100 Hz	Frequency range 110 Hz to 1050 Hz	Frequency range 1060 Hz to 10.00 kHz	
3 mΩ	R	±0.05% f.s.	±0.1% f.s.	(Measurement Accuracy of This Instrument) ×1	1060 Hz to 10.00 kHz: applicable to BT4560-60
	X	±0.1% f.s.	±1.0% f.s.		
10 mΩ	R	±0.015% f.s.	±0.03% f.s.		
	X	±0.03% f.s.	±0.3% f.s.		
100 mΩ	R	±0.01% f.s.	±0.01% f.s.		
	X	±0.015% f.s.	±0.03% f.s.		
All V ranges		±5 μV (After operating environment temperature has stabilized within 1 min. after contacts closed)			

*1: Effect before zero adjustment.

SW1001

SW1002

SW9002

Connection Cable L2004
BNC, 0.91 m (2.99 ft.)

Product

Photo: BT4560-60

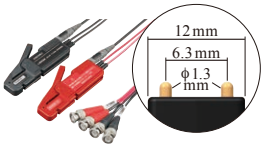
Model: BATTERY IMPEDANCE METER

Model no. (order code): BT4560-50
BT4560-60

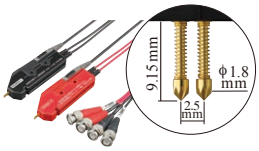
Measurement probes are not included with this product. Please separately select and purchase the measurement probe options appropriate for your application.

Options

Probes and sensors



CLIP TYPE PROBE L2002
Cable length: 1.5 m (4.92 ft.)



PIN TYPE PROBE L2003
Cable length: 1.5 m (4.92 ft.)

TIP PIN 9772-90
For replacing the tip of Pin Type Probe L2003 (one piece)

TEMPERATURE SENSOR Z2005
Cable length: 1 m (3.28 ft.)

4-TERMINAL PROBE L2000
Ideal for clipping to screw terminal, cable length of 1 m (3.28 ft.), cannot be used with 3 mΩ range when connected to BT4560, no combined accuracy defined

PC connectivity

LAN CABLE 9642
Straight,
cross conversion connector included,
cable length: 5 m (16.40 ft.)

RS-232C CABLE 9637
For a PC,
9-pin to 9-pin connectors,
cross cable,
cable length: 1.8 m (5.91 ft.)

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