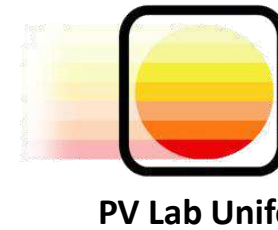




Dipartimento
di Fisica
e Scienze della Terra



WORKSHOP BATTERIE

April 16th 2026
Università degli Studi di Ferrara

GIAKOVA



YOUR TECHNICAL TEAM

COMPANY PROFILE



YOUR TECHNICAL TEAM

Since 1993

SELLING TEST & MEASURING INSTRUMENTS

Giakova, on the market for 30 years, is the Italian distributor specialized in the resale of the best brands of electrical, electronic and thermographic measurement instrumentation.

With its highly qualified technical team, present throughout Italy, it combines sales with a free demo service, an e-commerce portal with over 10,000 products in the catalog and with personalized discounts and consultancy for identifying the best solution in relation to the various areas of application.

DEDICATED SERVICES

- Consultancy service, carried out by our engineers, for choosing the most suitable solution
- Possibility of practical demonstrations of the tools, even at the customer's premises
- Continuous training of all staff
- E-commerce with over 10,000 products in the catalogue
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Sale and rental
measurement instrumentation
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Go to the catalogue



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Giakova is the point of reference in Italy for the supply of measuring instruments, combined with consultancy for the choice of the ideal technological solution for the various fields of application



RF Solution

Specific portfolio of spectrum analyzer for field and R&D application. Cable and antenna testing, complete the wide range of applications we cover in data transmission Rf and cabled.



Low Power

Useful tools for the design or testing of electronic devices for low power consumption applications.



High Power

Specific solutions for the design and functional testing phase of electronic equipment for high power applications.



Hi Sensibility

Specific detection instruments for researchers of innovative materials and laboratory technicians who require very high reliability as they are used for material characterization tests.



Solution for battery testing

Wide range of solutions for the analysis of the various control phases of the battery system, from material verification to the final charge-discharge control of the assembled battery.





Sale and rental
measurement instrumentation
dedicated to Installation and
Maintenance

Go to the catalogue:



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Giakova is the point of reference in Italy for the supply of electrical and electronic measuring instruments.



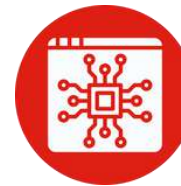
Thermography for Maintenance

Thermal maintenance cameras, almost always portable, are ideal tools for those involved in industrial preventive maintenance programs, electrical inspections or fault finding.



Automation Solutions

Our automation solutions are ideal for process and quality control and monitoring within large companies with production chains.



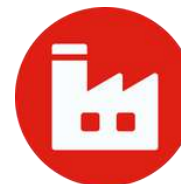
R&D solutions

Our R&D solutions are ideal tools for use in the fields of research, science, engineering and also in some medical fields.



Power Quality Power

Quality tools are typically dedicated to those who deal with the analysis of network quality and the evaluation of consumption to prevent energy waste.



Installation and Maintenance

Tools dedicated to those who install or maintain electrical and mechanical equipment.



Electromedical equipment

Tools dedicated to maintainers and designers of electro-medical equipment.



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Giakova Services



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Calibration services ISO-Accredia



Demo equipment for on-site demonstration



Renting for short & long term period



Organization of technical seminars & Trade Show at customers sites



E-commerce with technical contents, academy section and e-shop capabilities



Weekly newsletter sent to our profiled database with technical info, promos, and whitepapers

Main partners

Tektronix

KEITHLEY
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TDK-Lambda

FLIR

Chroma



Elektro-Automatik

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networks



HIOKI

GW INSTEK

BriPowerTM

IWATSU



E-commerce & website

www.giakova.com

Giakova has a digital portal composed of an information section full of content, technical insights, promotions and news.

Another important section is the catalog with over 20,000 products for sale. Special discounts are reserved for those registered.

The site is visited on average by 2,500 users every month and has a profiled database of 18,000 subscribers who receive our newsletters by area of interest.

GIAKOVA 30
YOUR TECHNICAL TEAM

Home | Applicazioni | Catalogo | Promozioni | Approfondimenti | Eventi e Webinar | Video | News | Chi siamo | Contatti

Ottieni **GRATIS** un Multimetro per ogni Battery Tester BT3554 di Hioki

HIOKI

Giakova è un riferimento in Italia per la vendita di strumenti di misura, abbinata alla consulenza per la scelta della soluzione più adatta nei vari ambiti di applicazione.

I nostri tecnici, con provata esperienza nel mondo della misura elettrica, elettronica e termografica, sono a disposizione per una consulenza nella scelta dello strumento più adatto, tra gli oltre 10.000 disponibili nel nostro e-commerce. Inoltre, scopri i nostri approfondimenti, eventi e video per le più svariate applicazioni.

Catalogo prodotti...
Approfondimenti...
Richiesta demo...

Power RAD → Termografia → RF & Wireless →
Analog & Digital Design → Misure alta sensibilità → Power Quality e Manutenzione →
Fenovario → Elettromedicali → Batterie →

Promozioni in corso
Iniziativa speciale dedicata a "Test & Measurement" e a "Installation & Maintenance"

Scopri →

Oscilloscopi Tektronix Serie MDO3 completi di accessori: sconto del 50%
Promozione Tektronix valida fino al 23 dicembre 2023.

Ottieni gratuitamente un Multimetro per ogni Battery Tester BT3554 di Hioki
Promozione valida fino al 30 settembre 2023.

Termocamere Flir: agevolazioni Industria 4.0
Agevolazioni e benefici Industria 4.0 per termocamere FLIR

Speciale System Integrator
Sconto del 15% riservato ai system integrator

Il programma

Ore 10

Celle agli ioni di litio: fisica, chimica e applicazioni

A cura di UniFE - durata: 1ora

Ore 11

Soluzioni per la misura con la tecnica EIS (Electrochemical Impedance Spectroscopy)

A cura di Giakova - durata: 30 minuti

Ore 11.30

Perché integrare le misure EIS nei ciclatori di celle

A cura di Chroma - durata: 30 minuti

----- LUNCH BREAK -----

Ore 13

Presentazione delle soluzioni di analisi termografica dalla validazione di prodotto allo storage

A cura di Giakova e IMC Service - durata: 30 minuti

Ore 13.30

Test di sicurezza su celle e batterie

A cura di Chroma - durata: 30 minuti

Panoramica safety tester per test isolamento

Ore 14

Q&A e HANDS-ON

A disposizione durante l'intera giornata

Il programma



Postazione EIS

- Impedenza cella litio
- Sistema per cole-cole-plot



Postazione 17010

- Demo Kit simulazione ciclatore con EIS gestito da software



Postazione Infrared

- Termocamere per R&D e monitoraggio dello stoccaggio

Brand presentati

Chroma

FLIR

HIOKI

Con la presenza di:



IMC Service

Battery Testing with EIS

Electrochemical Impedance Spectroscopy (EIS) is a non-destructive electrochemical technique. It applies a small AC signal over a frequency range to measure impedance, revealing processes like charge transfer and diffusion at electrode interfaces.

It can be performed in combination with battery cycling or as an alternative

Sometimes it is mandatory...we cannot make cycling with a primary (non-rechargeable) battery

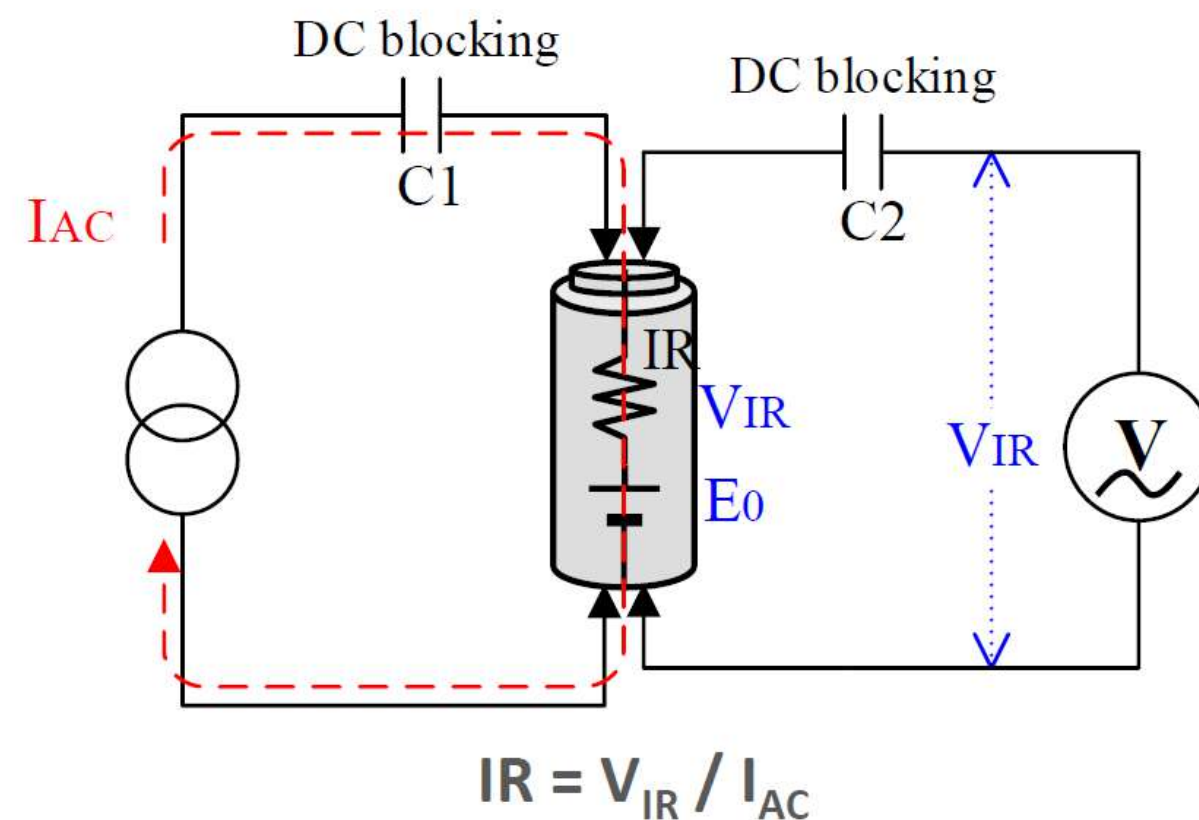
The performance of EIS instruments is very important because parameter variations are very small (especially for Lithium) and the quality of measurements and probes often plays a fundamental role.



What is AC-IR measurement in practice: Alternating Current Internal Resistance (AC-IR)

Measurement method for battery internal resistance defined in the IEC 61960-3:2017 standard.

AC current is applied to the DUT. The resulting AC voltage is measured, and the internal resistance is calculated.



What is AC-IR measurement in practice:

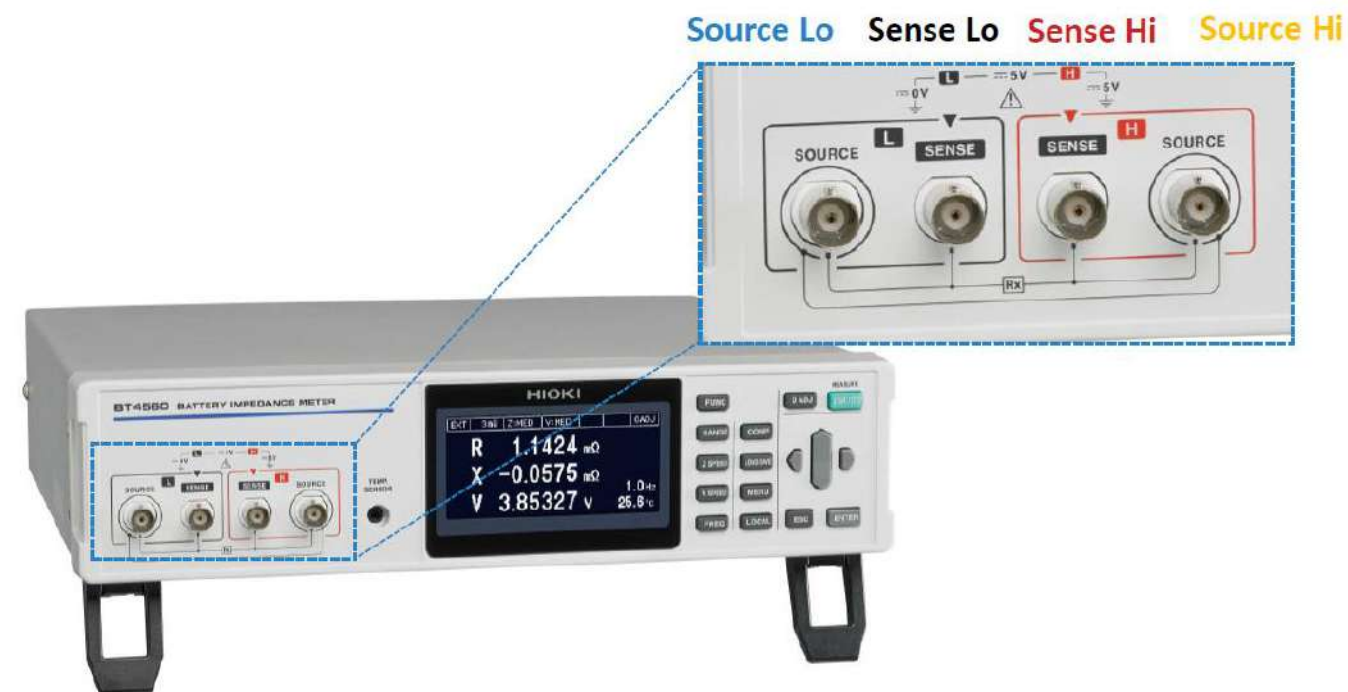
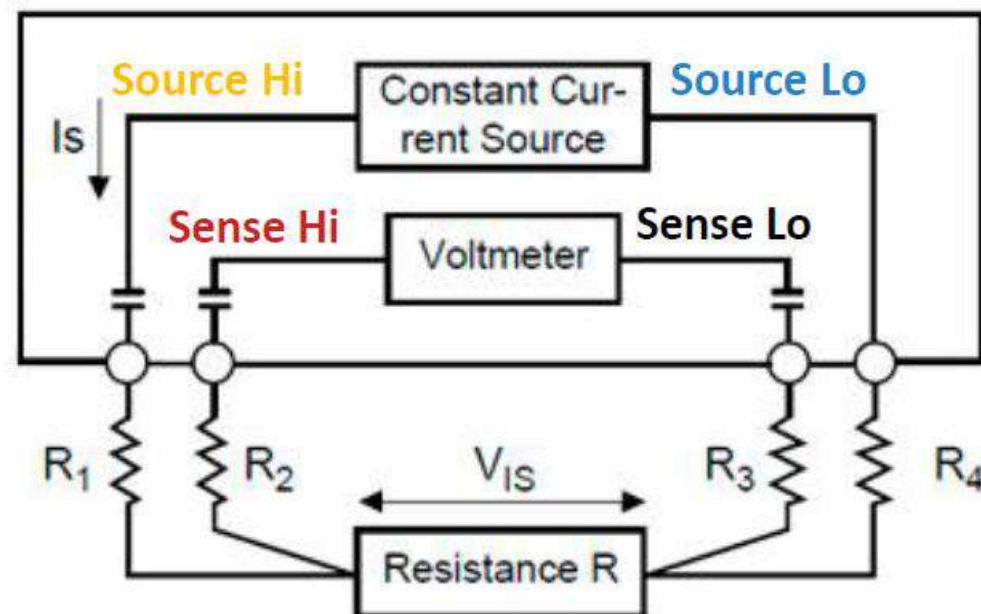
Principle of the 4-wire resistance measurement

Optimum suitability for measuring small resistance.

This method eliminates the influence of wire and contact resistance.

Values R1 to R4 are the resistance of the test leads plus contact resistance

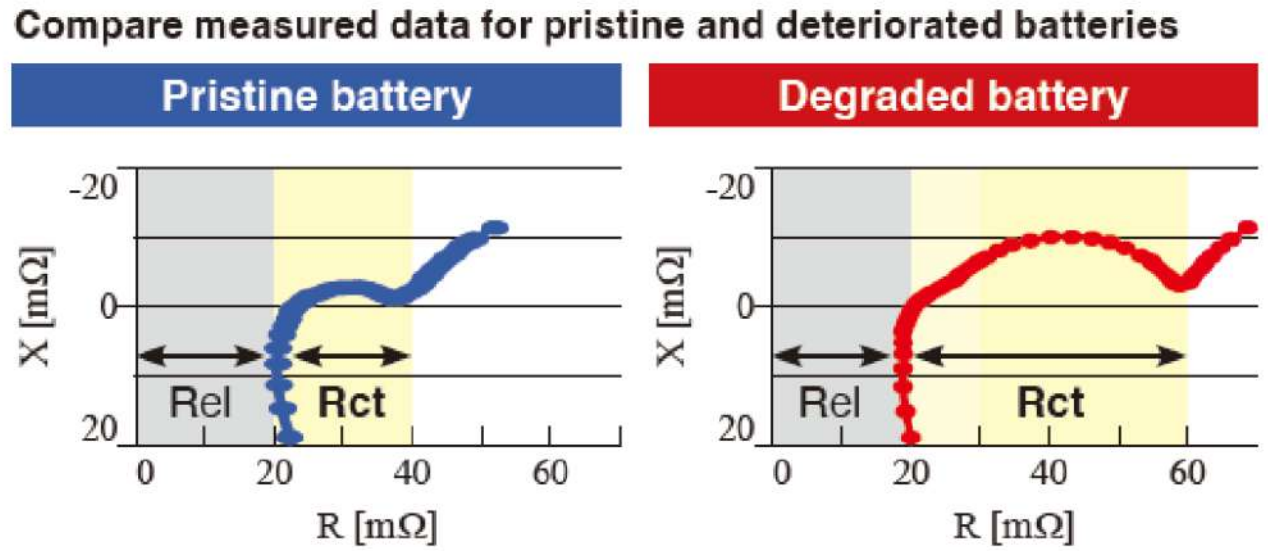
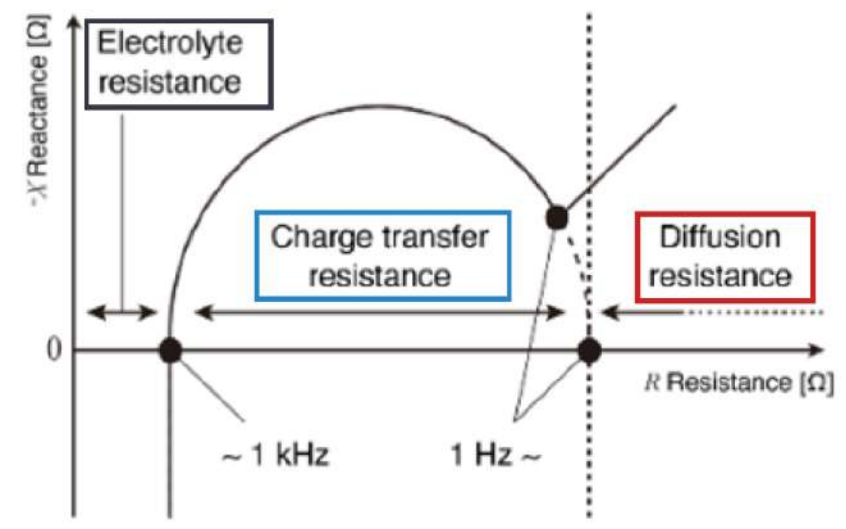
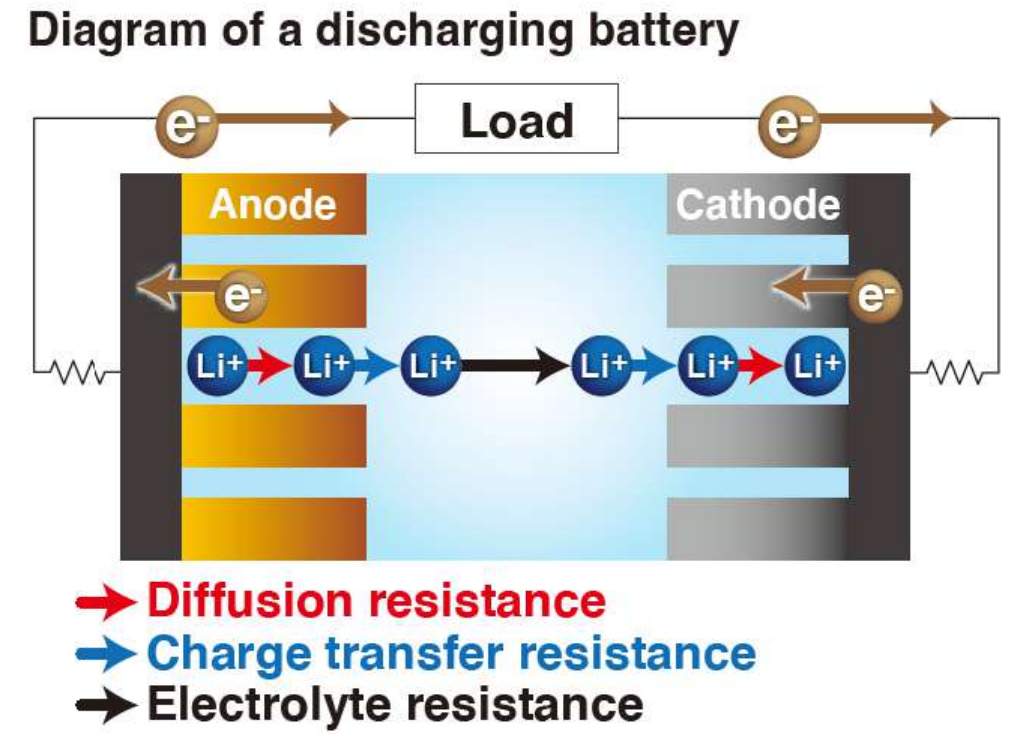
$$R_{DUT} = \frac{V_{IS}}{I_S}$$



What is AC-IR measurement in practice:

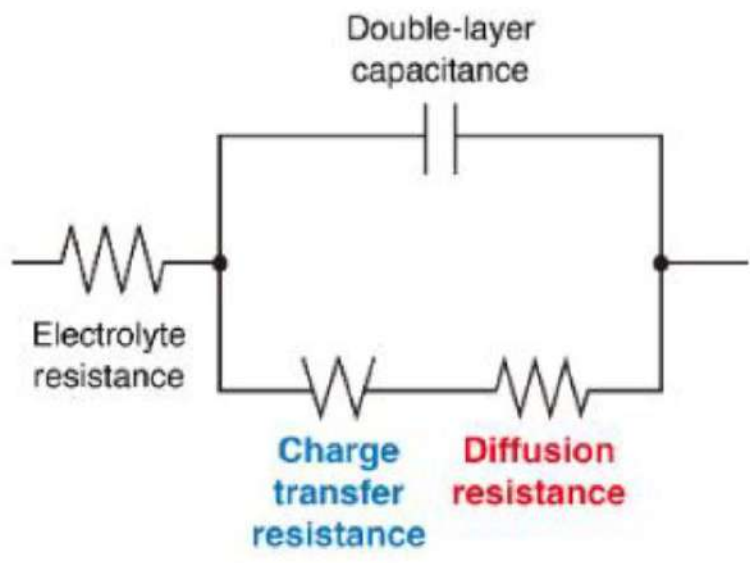
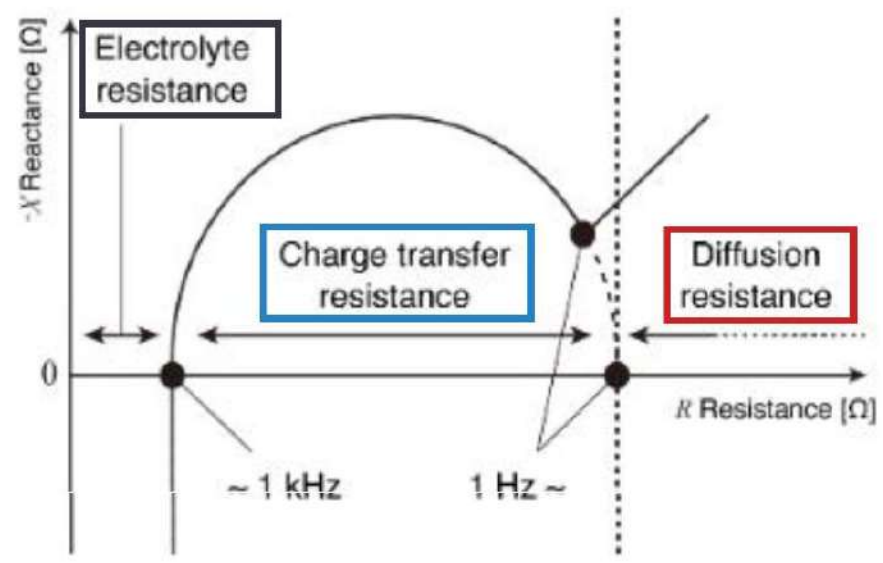
EIS analyze the electrical properties of materials and devices by applying AC signal across a wide frequency range. It provides non-destructive analysis of lithium-ion batteries and deeper insights into performance and degradation.

A simple example of how the EIS shows a significant degradation of charge transfer resistance.



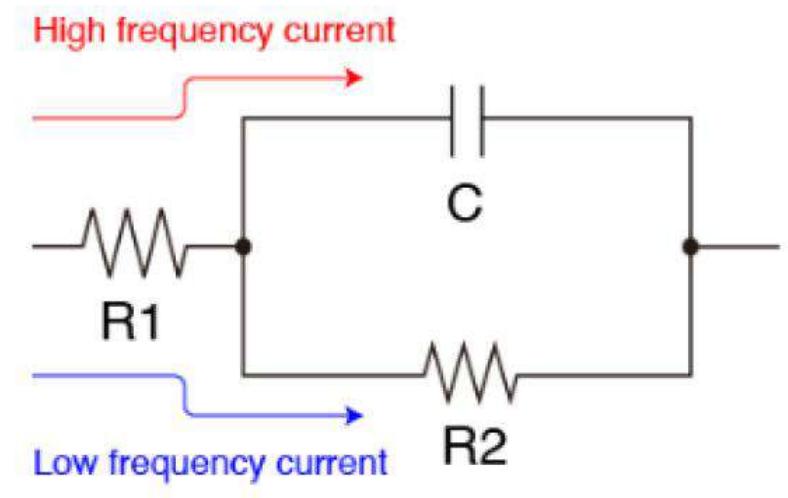
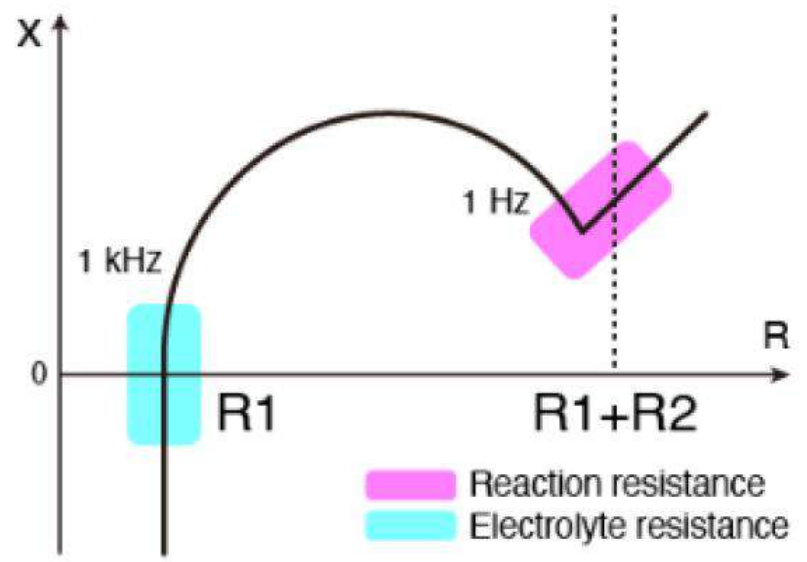
What is AC-IR measurement in practice:

A schematic representation of the "real world" impedance in a Lithium-Ion Battery



- **Less than 1 Hz:**
(Diffusion resistance)
- **1 Hz to several hundred Hz**
(Charge transfer resistance)
- **About 1 kHz**
(Electrolyte resistance)

Battery chemical reactions involve multiple processes, each operating at its unique reaction speed.



What is AC-IR measurement in practice:

Here is the essential summary of the three resistance contributions in a battery

1. Electrolyte Resistance:

The difficulty ions face while moving through the liquid between the two electrodes. It also includes the electrical resistance of metallic components (current collectors) and contacts.

2. Charge Transfer Resistance:

The "effort" required for an ion to cross the electrode surface (overcoming the SEI layer barrier) and transition from a free ion in the liquid to an intercalated ion in the solid.

3. Diffusion Resistance:

The slowness with which ions move inside the solid structure of the electrode to find an available site to settle.

- **Less than 1 Hz:**

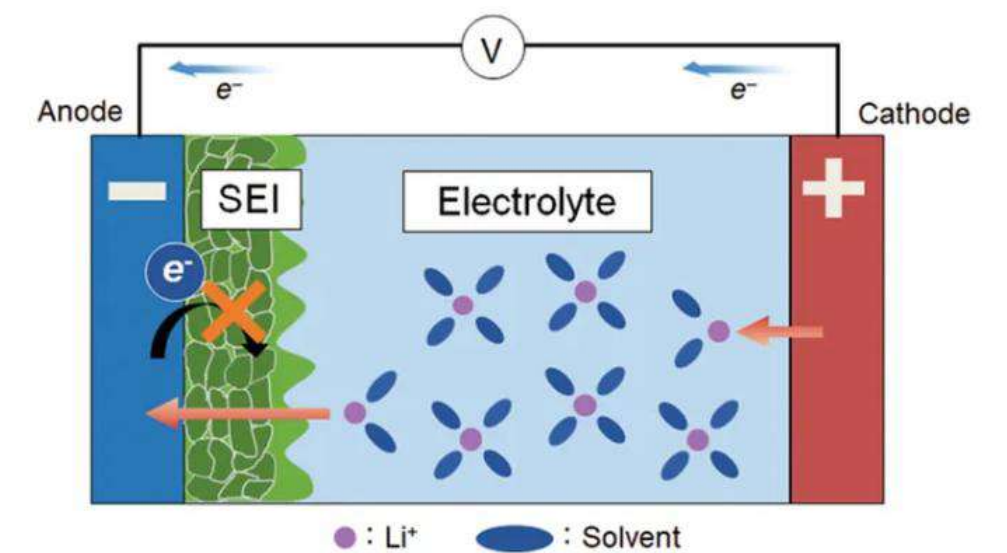
(Diffusion resistance)

- **1 Hz to several hundred Hz**

(Charge transfer resistance)

- **About 1 kHz**

(Electrolyte resistance)



[1] Schematic Diagram Illustrating SEI layer in a Li-Ion Cell

Cell Testing: Analyzing LiB cell defect causes

Identify the causes of battery defects by measuring AC impedance at multiple frequency. Together with the battery impedance meter BT4560 we can also provide a solution with the Chemical impedance analyzer IM3590; it has a battery measurement mode; It measures internal impedance (up to 5V) in a no-load state by generating a matching battery voltage via the HC terminal.

What is difference between BT4560 and IM3590?

BT4560-50 Battery impedance meter



BT4560 basic specification	
Measurement range	3 mΩ / 10 mΩ/ 100mΩ
Voltage range	± 5V, resolution of 10 μV
Measurement current	Max. 1.5 A rms
EIS measurement frequency	10 mHz to 1050 Hz

IM3590 Chemical impedance analyzer



IM3590 basic specification (Battery measurement mode)	
Measurement range	100 mΩ / 1 Ω/ 10 Ω
Voltage range	± 5V, resolution of 1 mV
Measurement current	Max. 50 mA rms
EIS measurement frequency	1 mHz to 200 kHz

NOW AVAILABLE BT4560-60

- Measurement range same as BT4560-50
- Voltage Range same as BT4560-50
- Measurement current same as BT4560-50
- EIS measurement frequency 0.01 Hz to 10 kHz

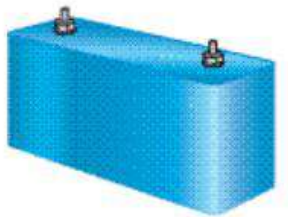
Modules & Packs: defect test

PRODUCTION & INCOMING INSPECTION

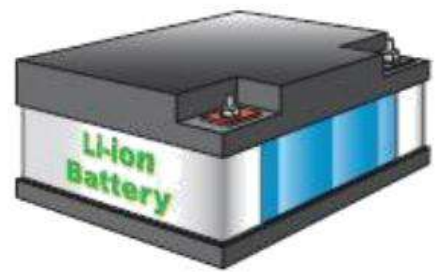
Wide range of products for AC impedance measurement @ 1 kHz frequency. Up to 1000 V





BT356x Battery Testers

Modules



Packs



Model	BT3561A	BT3562A	BT3563A	BT3564
				
	<u>BT3561A</u>	<u>BT3562A</u>	<u>BT3563A</u>	<u>BT3564</u>
Frequency	1 kHz			
Voltage (Ranges)	60 V (2)	100 V (3)	300 V (3)	1000 V (3)
Resistance Ranges	7 ranges: 3 mΩ, 30 mΩ, 300 mΩ, 3 Ω, 30 Ω, 300 Ω, 3 kΩ			
Resistance Resolution	0.1 μΩ, 1 μΩ, 10 μΩ, 100 μΩ, 1 mΩ, 10 mΩ, 100 mΩ (depending on range)			

OCV – Open Circuit Voltage

THE IMPORTANCE OF MEASURING OCV

Another parameter that indicates the battery's quality and state of health is the measurement of open-circuit voltage (OCV). Even stock batteries, not yet used, are subject to an aging process that manifests as the creation of micro-discharges between the positive and negative poles. This phenomenon causes a decrease in open-circuit voltage. This type of phenomenon is not detectable with a simple insulation test.

The BT4560 is theoretically capable of also measuring the variation in open-circuit voltage; however, it is recommended to use a voltmeter that offers excellent precision on the order of μV , in order to detect tiny voltage variations, as is the specific case for Lithium-ion batteries.

We recommend **DM7276**



The importance of a good probing

TEST LEADS

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.

Functionality suited to 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.



NPN/PNP switching

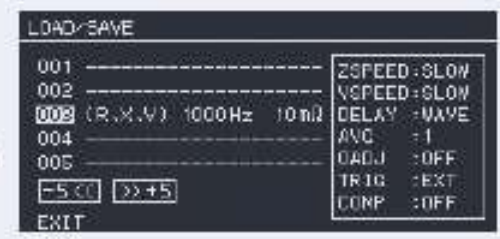
The BT4560 series's EXT. I/O circuit can be switched between current sink output (NPN) and current source output (PNP).

Comparator function

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

Panel save/load function

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



Multi-channel measurement how to choose a multiplexer

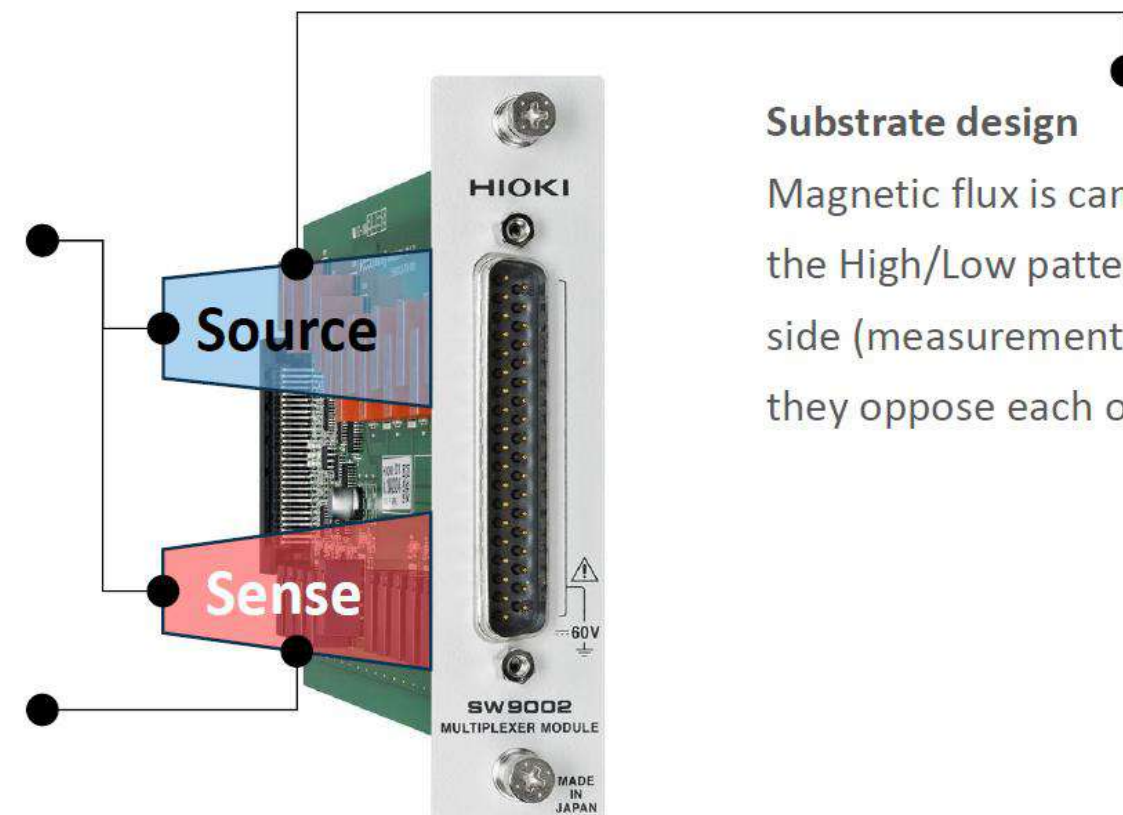
Circuit design: Use a multiplexer module circuitry that is not easily affected by Eddy currents and noise

Suitable modules should be designed to reduce the influence on the measurement signal by canceling the magnetic flux of the measurement current and separating the source side and sense side.

Separation

Sense and source are separated to eliminate any effect on each other

Sense loop area is minimized to reduce the effect of external noise



SW9002 Multiplexer Module

Substrate design

Magnetic flux is cancelled by orienting the High/Low patterns on the Source side (measurement current) so that they oppose each other



SW1002 Switch Mainframe

Correct Wiring

How to eliminate electromagnetic interference

EMI common sources:

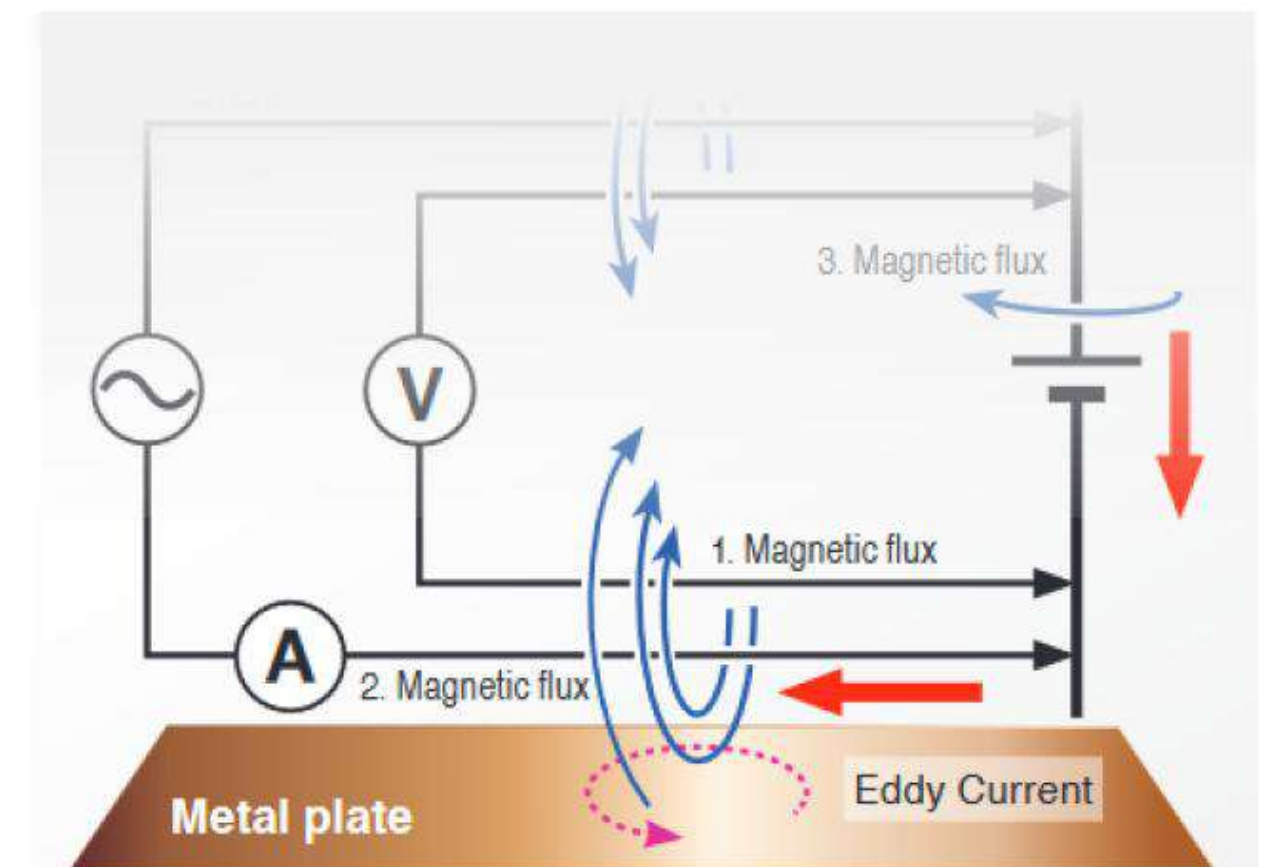
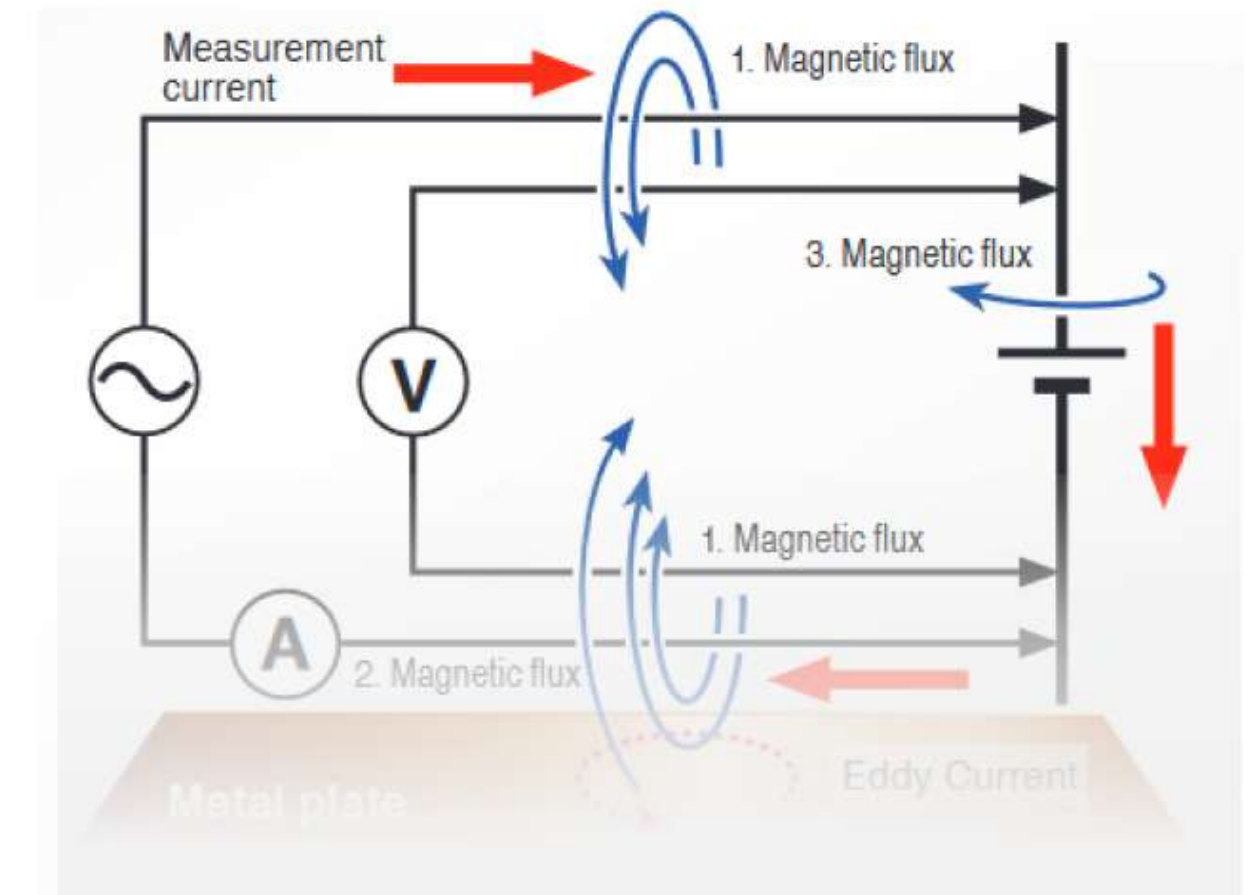
inverter motor drives, solenoides, other measutring instruments

Twisting measurement wires reduces the effect of Electromagnetic induction

How to reduce Eddy current

Eddy current are induced nearby metal plates around
The source current

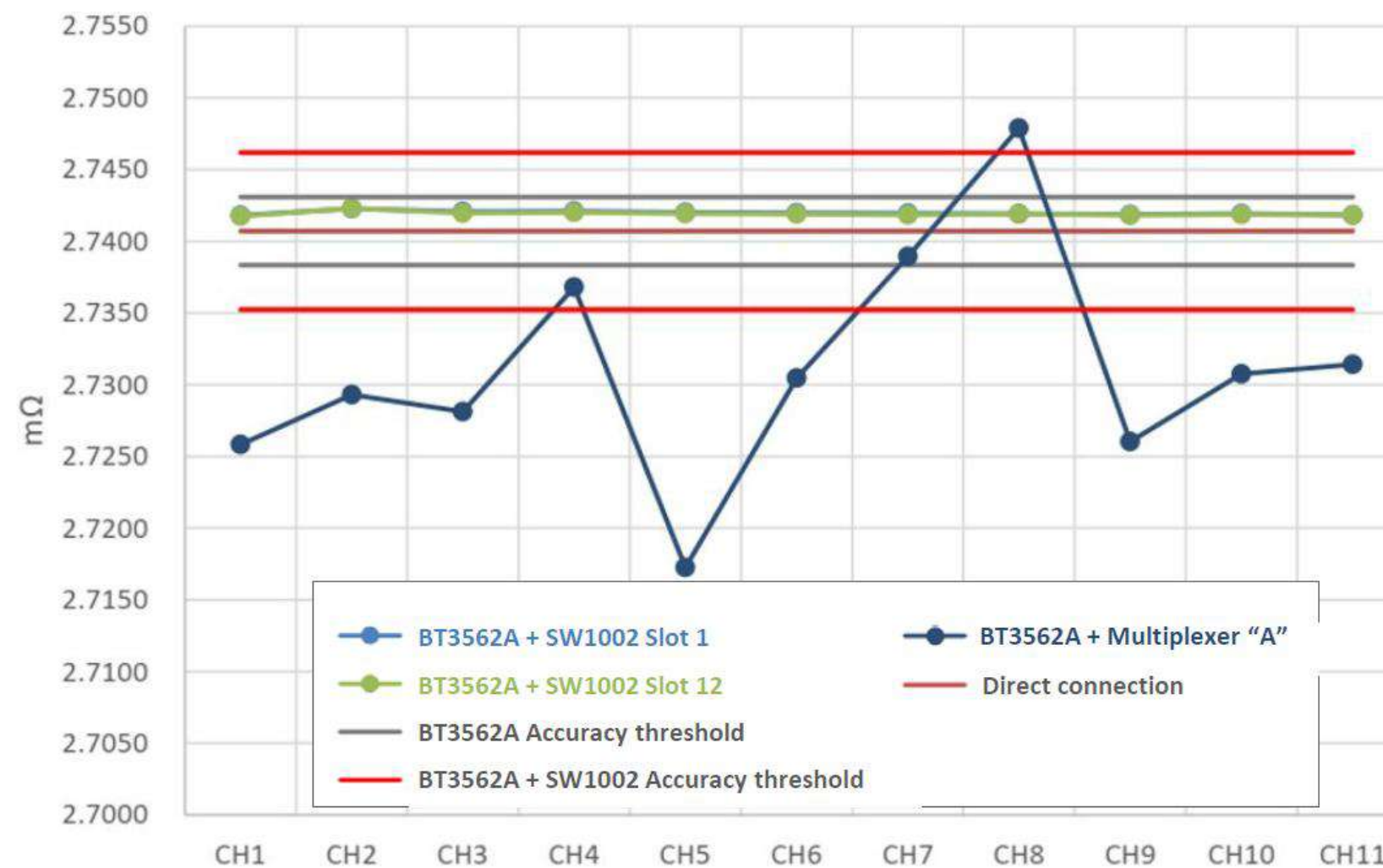
To reduct that effect the wiring must be kept away from
Metal plates or shielded



Multi-channel measurement how to choose a multiplexer

The Multiplexer should be designed to be used for measuring AC-IR

Multiplexers not designed for AC-IR measurements show very bad reproducibility (Multiplexer "A")
SW1001 Switch mainframe and SW9001/SW9002 Multiplexer Modules are designed for AC-IR measurement.



An example of 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	

Software solutions



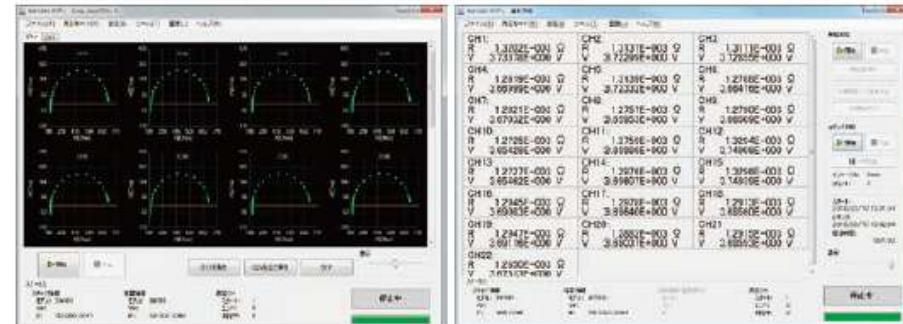
Computer application software

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.

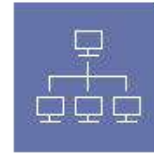
Measure multiple batteries



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.

Hioki free tools

Third-party interactions



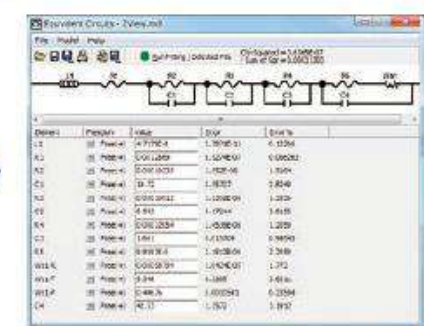
Interoperability with third-party software

Data compatibility with ZView® equivalent circuit analysis software



EIS measurement data

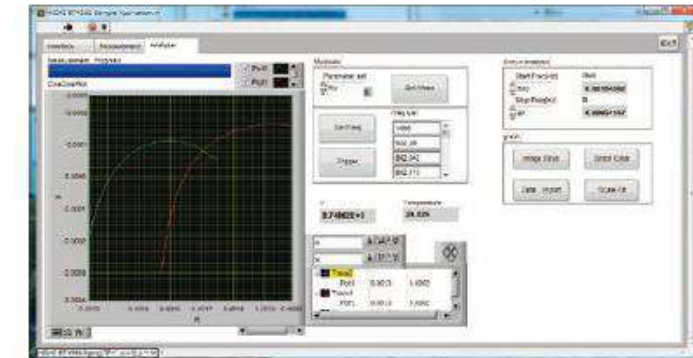
Import



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.

Software solutions

Hioki's Circuit Fitting is a free web app that performs equivalent circuit analysis on EIS data from the BT4560 battery impedance meter. Users upload files to auto-generate Nyquist plots and comparative graphs



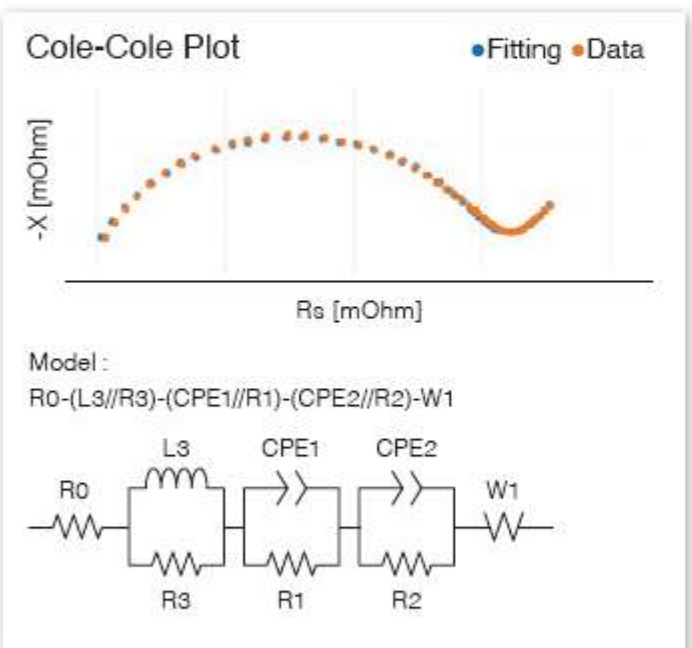
Circuit Fitting: a simple analysis web app

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



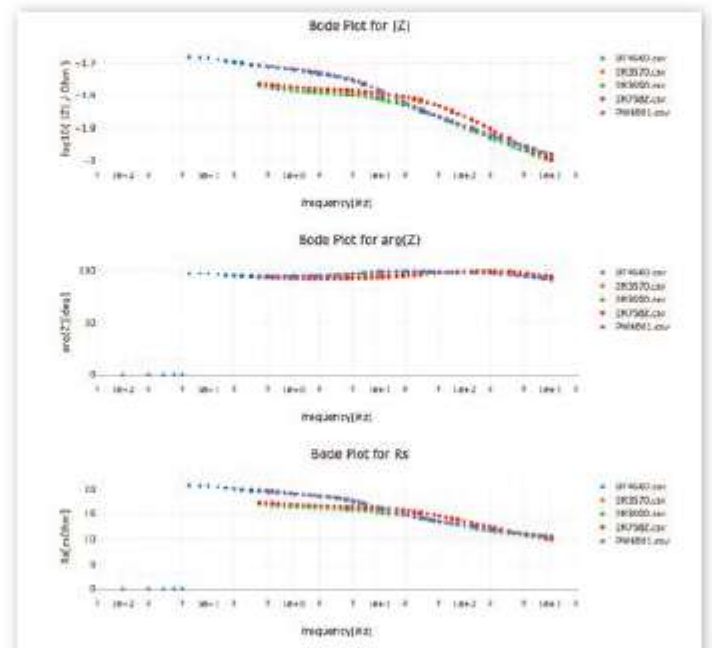
This free web application can perform equivalent circuit analysis and create two- and three-dimensional comparative graphs of Nyquist plots (Cole-Cole plots).

Automatically display equivalent circuit analysis results



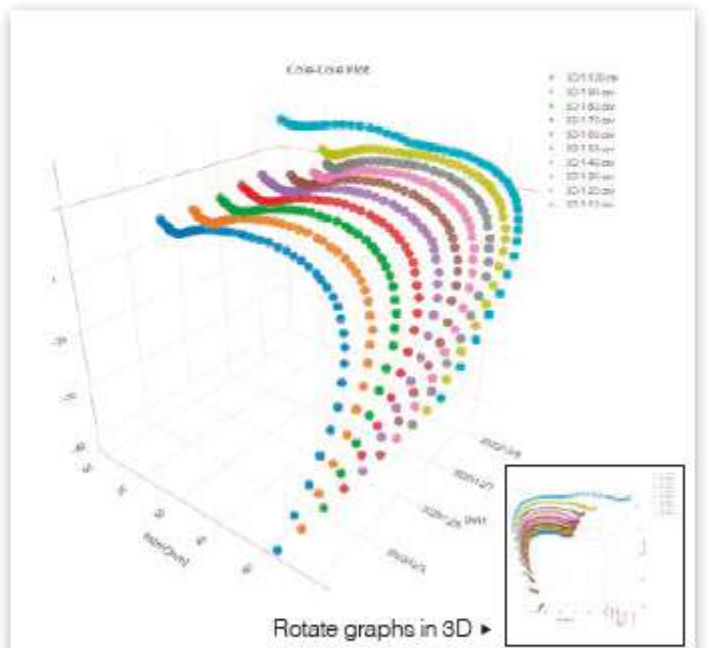
Analyze battery impedance using predefined models. Automatically display analysis results simply by uploading a measurement file.

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.

Third-party interactions

Low Resistance Measurement

Measures Low Resistance with High Precision Using Temperature Noise Compensation

In a high-speed production line, after welding the busbars (typically nickel or aluminum) to the battery cells, the weld point reaches high temperatures (over 100°C), causing temporary variations in the measured resistance due to the material's temperature coefficient (TCR). Without compensation, one would have to wait for natural cooling (10–30 seconds), reducing the production line's performance. RM3546 simultaneously detects temperature and resistance, converting in real time to the equivalent resistance at 20°C (standard reference temperature). This allows for an immediate pass/fail judgment on weld quality (e.g., defects like microfractures or voids), reducing the production cycle by 20–50% and minimizing false rejects.



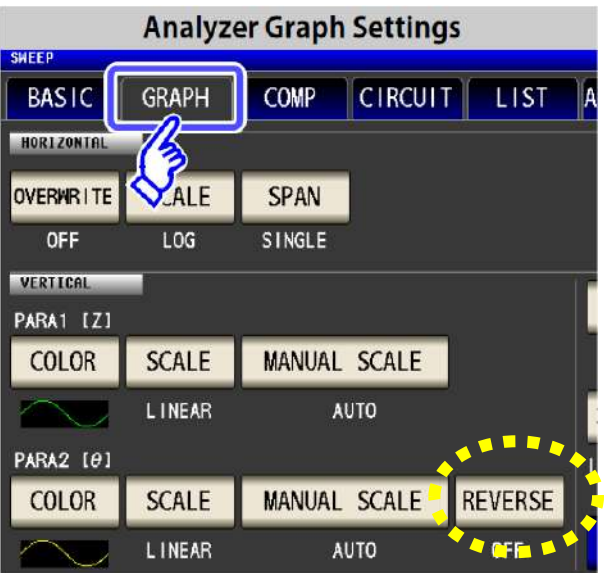
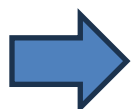
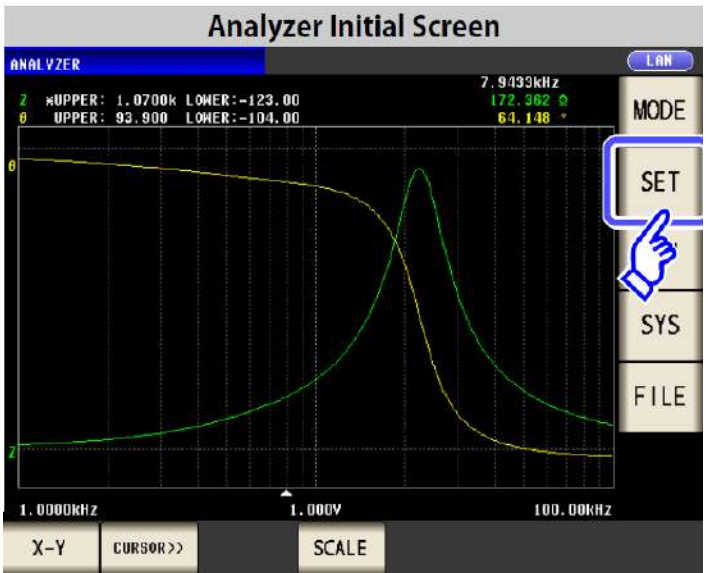
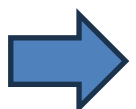
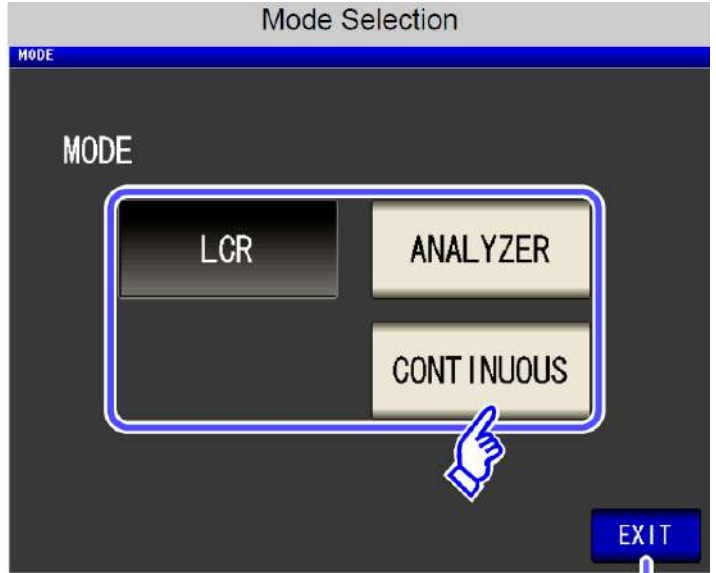
Ideal for battery busbar
weld inspection



Judges connection quality
by measuring resistance

COLE-COLE Plot with IM3590

Mode Selection:
Set Analyzer

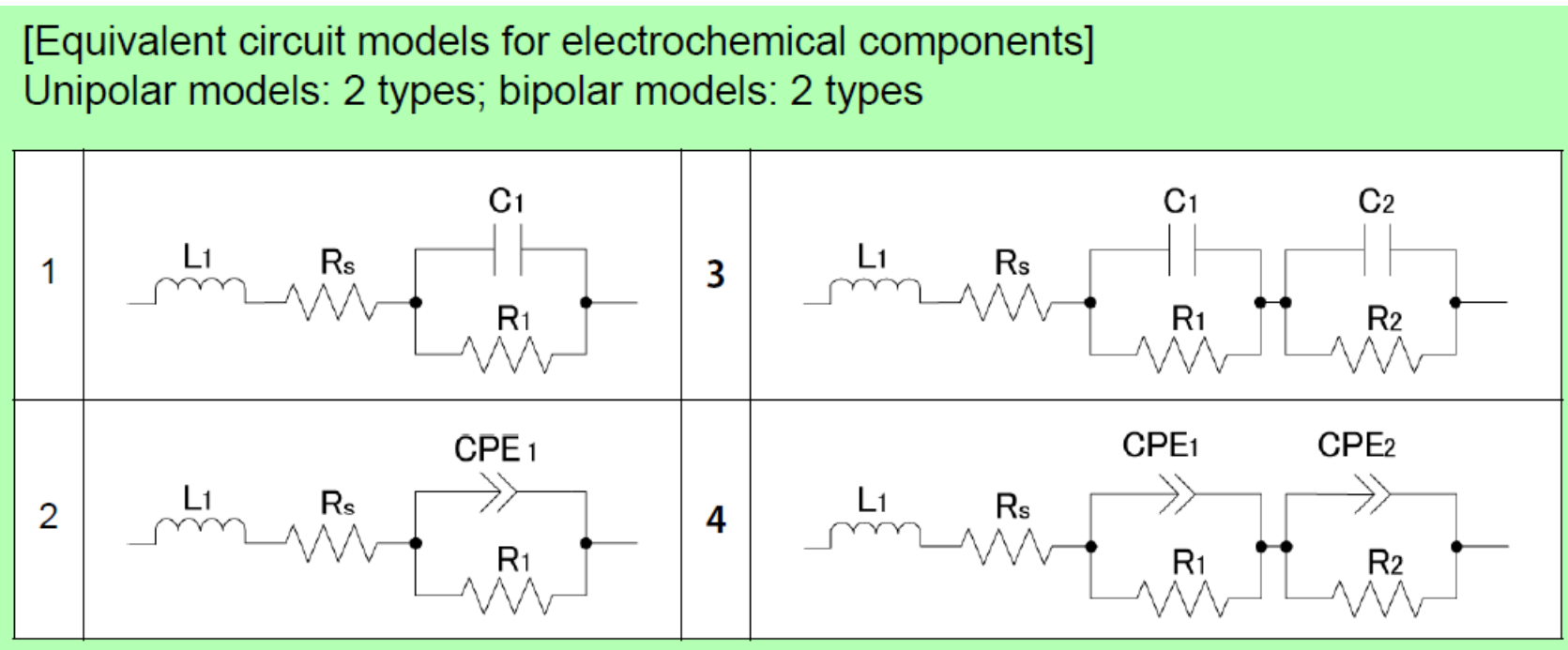


BASIC:
 Sweep Setup → PARA=Rs-X; TRIG: SEQ;
 Sweep Point → Start Freq, Stop Freq, points N, Scale (linear/log)
 Basic Setup → Level (Voltage); Range: AUTO; Speed: FAST (also Med, Slow/Slow2); AWG (num. medie)

GRAPH:
 Orizontal → Log
 Vertical → PARA 1: Rs, PARA2: x (Linear); manual scale: AUTO, PARA2 → set Reverse ON
 Grid → PARA1
 XY Graph → SAME

CIRCUIT:
 Model → CHEMICAL - ELECTRIC

ADVANCED:
Select battery Mode





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