

Welcome – we will start the webinar at 10 AM.



Battery Testing in the **Production Line: Do's & Dont's**

WEBINAR

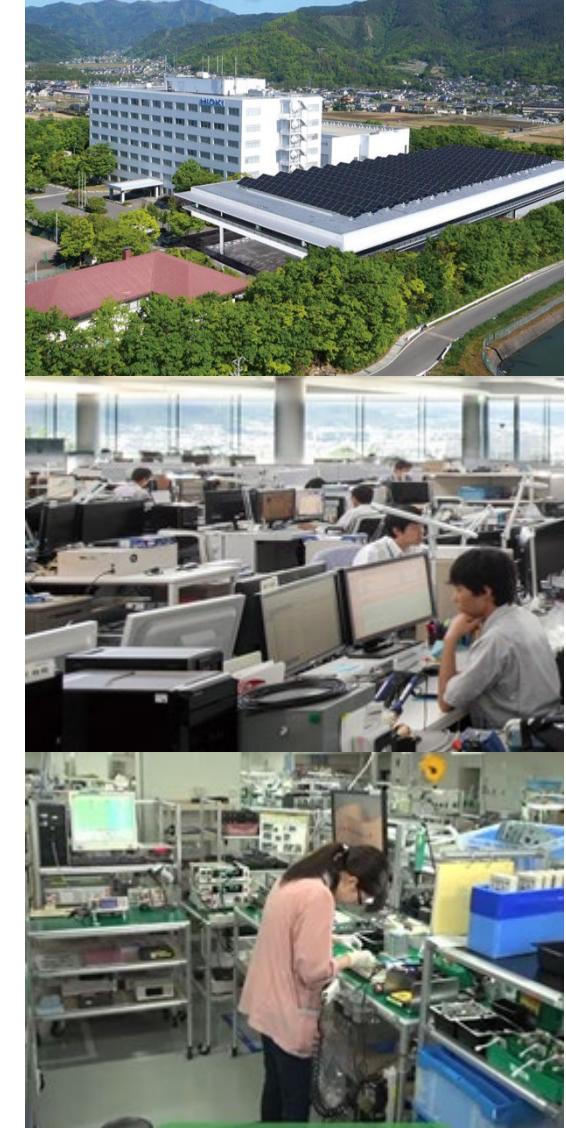
14 FEB 2024, 10:00 AM CET

Roy Hali
HIOKI Europe GmbH

HIOKI

About HIOKI

- Started in 1935 with manufacturing of electrical indicating meters
- Around 1000 employees
- Around 250 MEUR turnover
- Very much driven by engineers
- Made in Japan
- European subsidiary since 2017 -HIOKI EUROPE GmbH



Japanese precision since 1935

Automatic Test Equipment



- [Flying Probe Testers](#)
- [In-Circuit Testers](#)

Professional Measuring Instruments



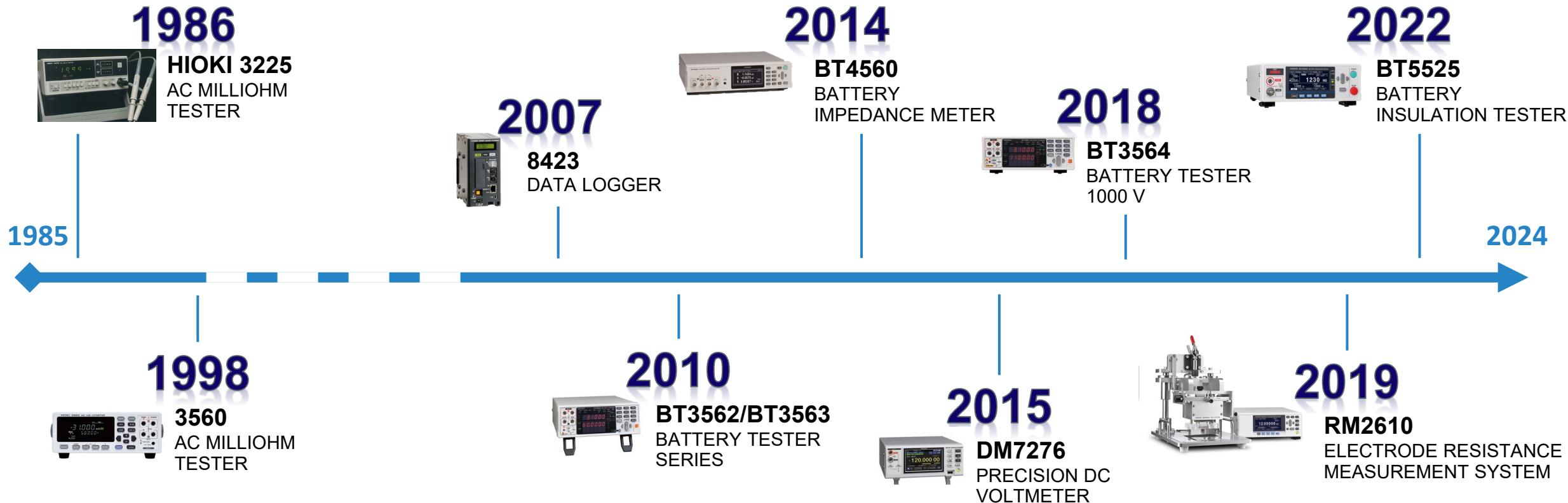
- [Power Analyzers](#)
- [Current Sensors](#)
- [Battery Testers](#)
- [Memory Recorders](#)
- [Data Loggers](#)
- [Resistance Meters](#)
- [Impedance Analyzers](#)
- [Insulation Testers](#)
- [Megaohm Meters](#)
- [Power Quality](#)

Field Measuring Instruments



- [Clamp Meters](#)
- [Digital Multimeters](#)
- [Insulation Testers](#)
- [Battery Testers \(handheld\)](#)

HIOKI's history in Battery Testing: +35 years



[Click here](#) for more information



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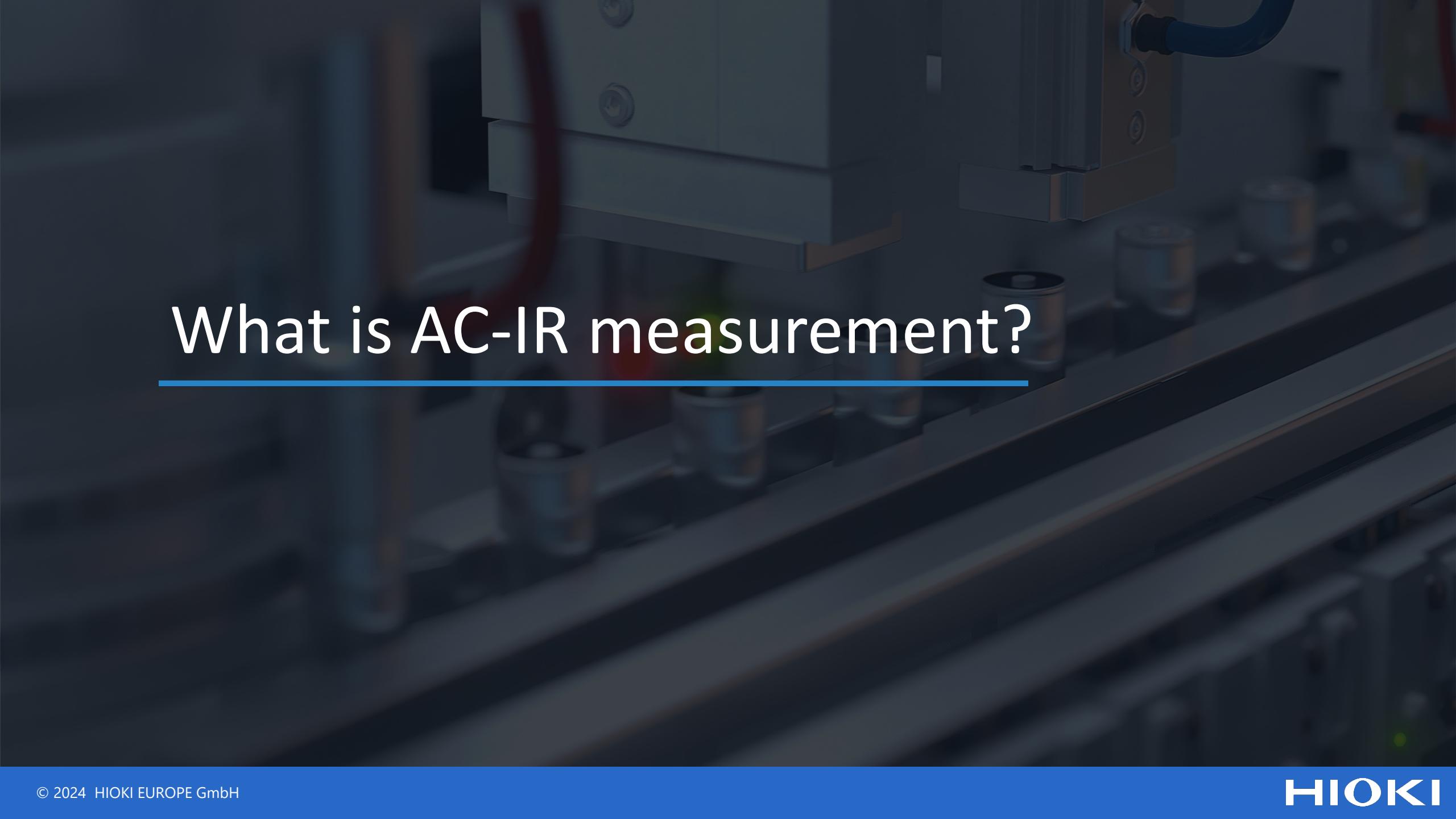
Content

What is AC-IR measurement?

AC-IR measurement in the production line: Do's and Don'ts

Guidelines for trouble shooting

Summary



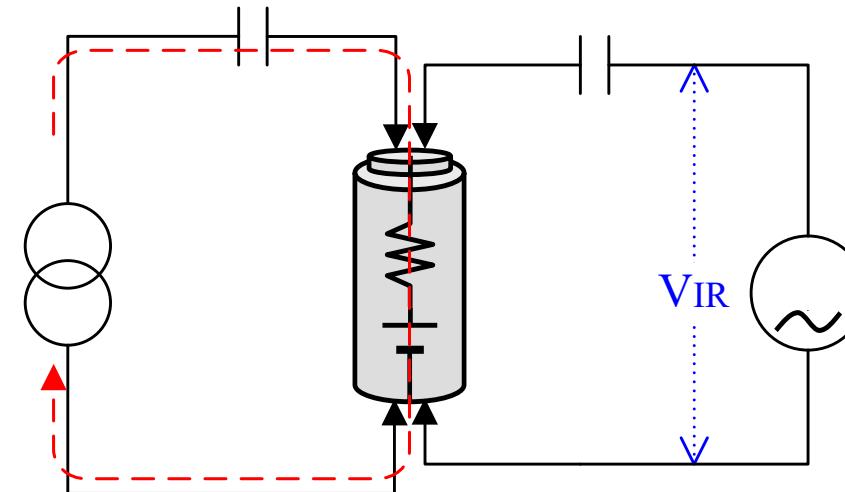
What is AC-IR measurement?

What is AC-IR measurement?

Alternating Current Internal Resistance (AC-IR)

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

A 1kHz AC current is applied to the DUT. The resulting AC voltage is measured, and the internal resistance is calculated.

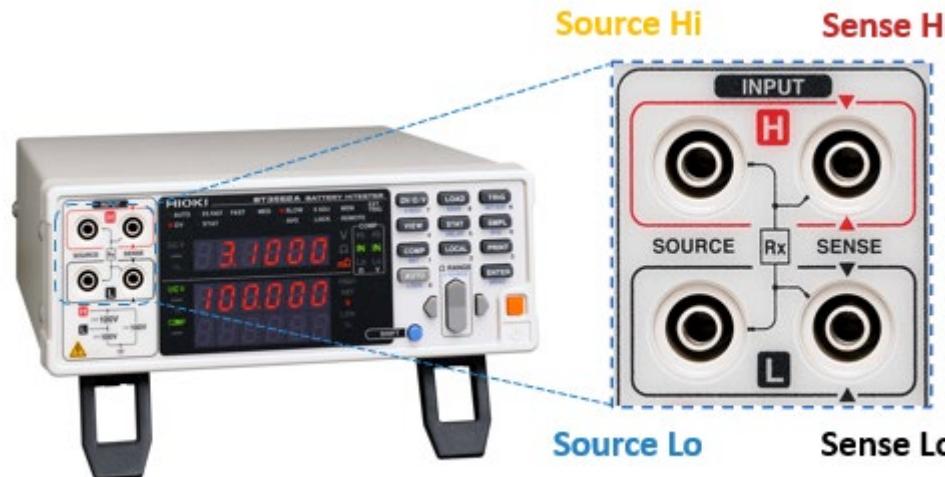


$$IR = V_{IR} / I_{AC}$$

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 resistances of the test leads plus contact resistances.

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

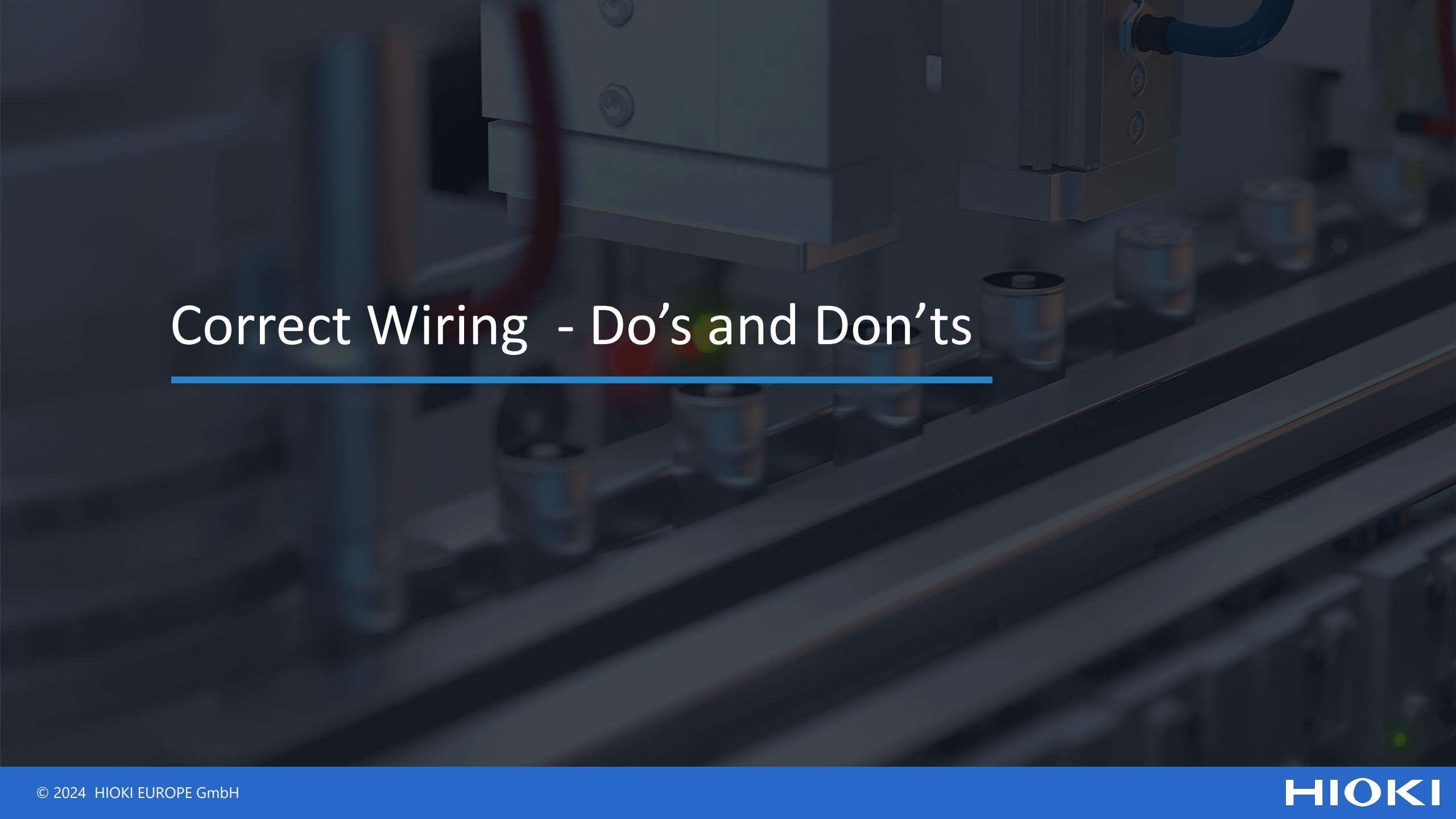


AC-IR measurement in the production line: Do's and Don'ts

AC-IR measurement in the production line: Do's and Don'ts

Factors to achieve reliable quality measurements in the battery production line

- **Correct Wiring**
 - I. Electromagnetic Interference
 - II. Eddy current
 - III. Using multiple measuring instruments
- **Correct Probing**
 - I. Contact resistance
 - II. Contact vs multi contact probing
 - III. Pin positioning and repeatability
- **Using a Multiplexer**
 - I. Multiplexer for AC-IR measurements

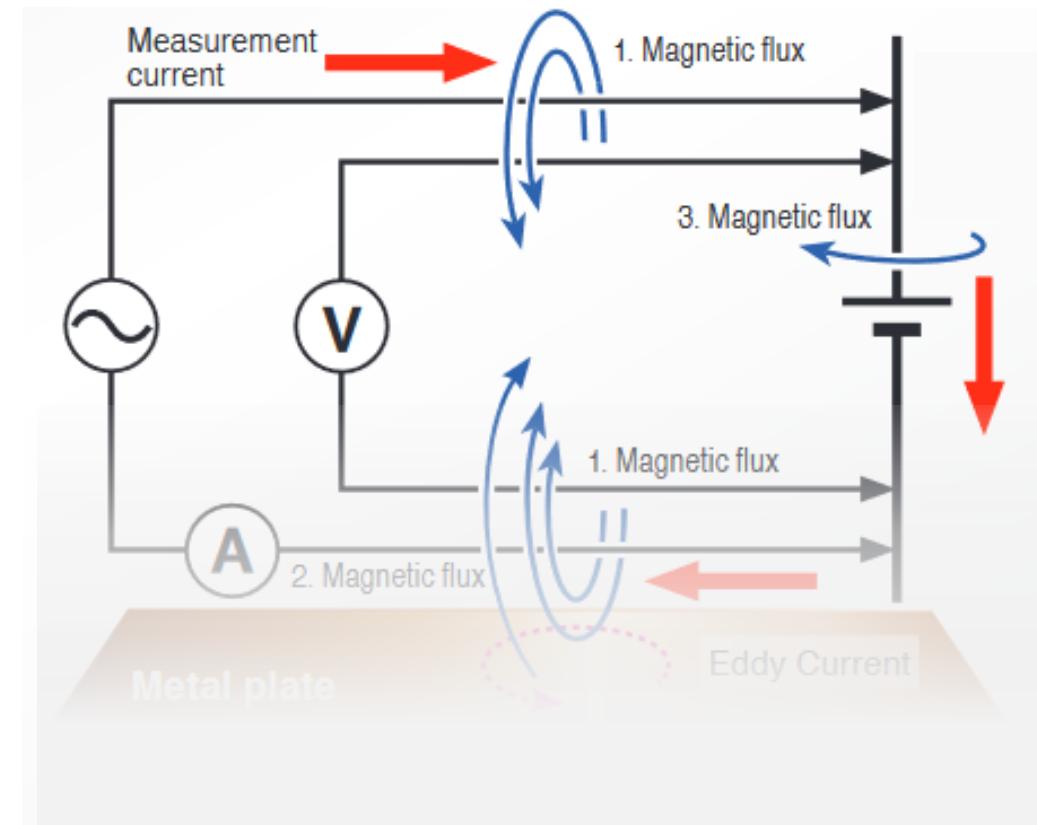


Correct Wiring - Do's and Don'ts

How to eliminate Electromagnetic Induction (1)

What are the sources creating Electromagnetic Interference (EMI)?

- Inverter motor drives for conveyor belts
- Solenoids
- Other measuring instruments

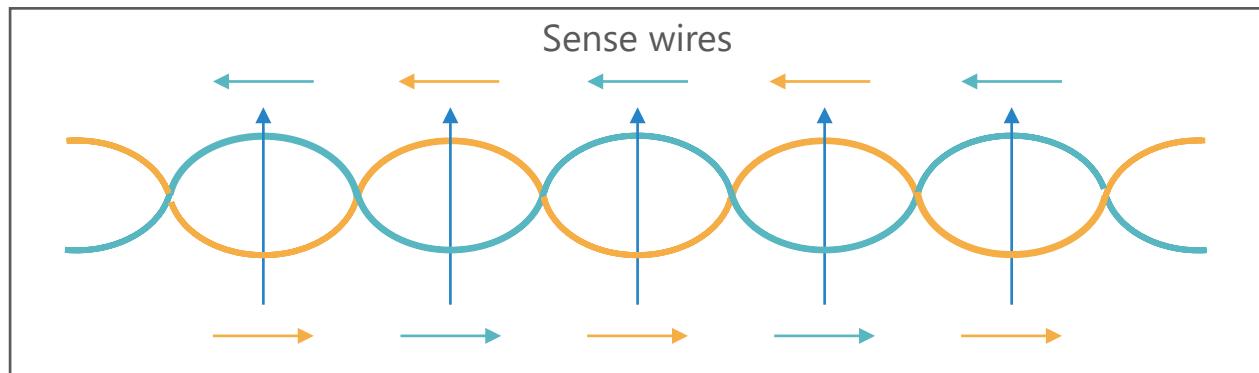
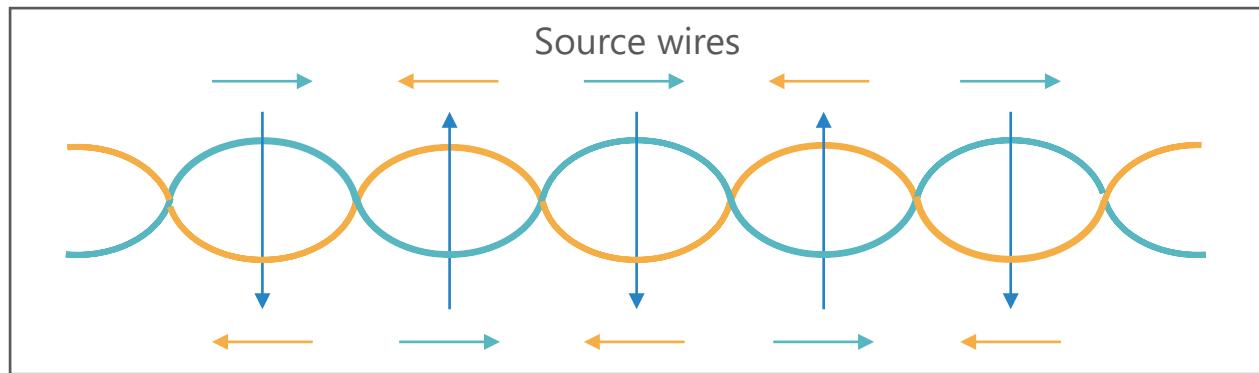


How to eliminate Electromagnetic Induction (2)

Electromagnetic coupling of the measurement current affects the measured value – what to do

Twisting measurement wires reduces the effect of electromagnetic induction.

1. Twisting the wiring cancels errors caused by external noise or measurement current
2. The finer the twisting, the more you can reduce the size of the loop where unwanted noise can be picked up.

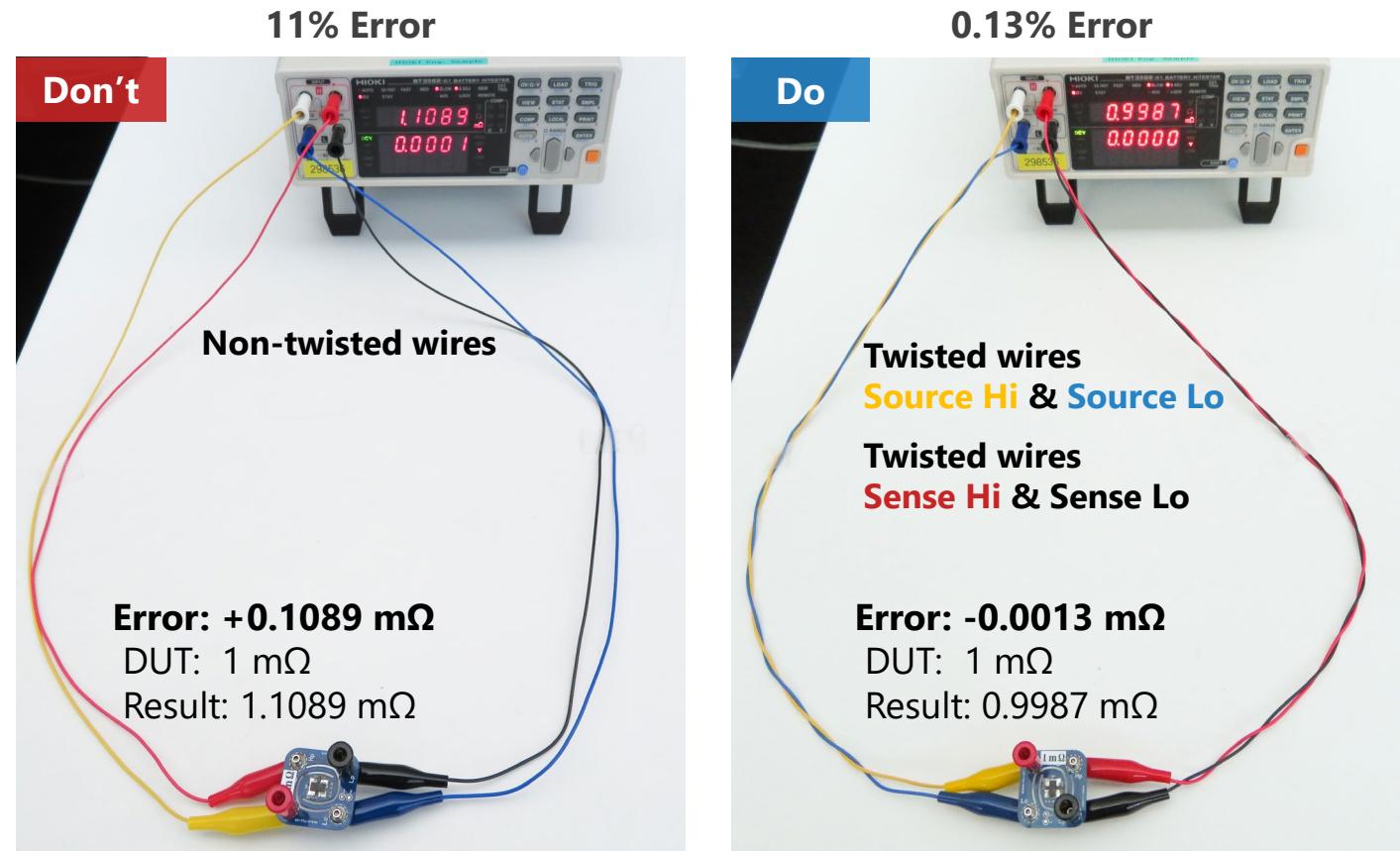


How to eliminate Electromagnetic Induction (3)

Electromagnetic coupling of the measurement current affects the measured value – what to do

Guidelines

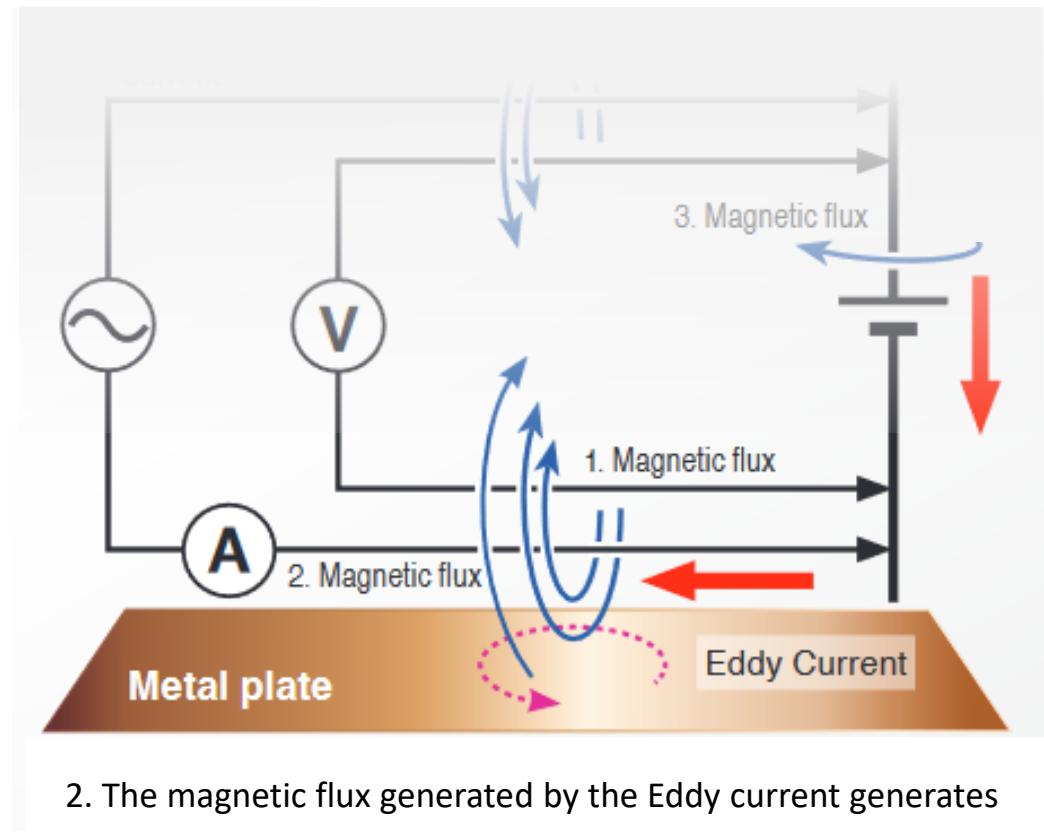
1. Twist the wires for “Sense Hi” and “Sense Lo”, and the wires for “Source Hi” and “Source Lo”.
2. Twist as tight as possible, eliminating the space between the wires.



How to reduce Eddy currents (1)

What is Eddy current?

- Eddy currents are induced nearby metal plates around the source current
- The secondary magnetic field will induce voltage in the Sense signal and effect the measurement
- To reduce the effects of eddy currents, the wiring should be kept away from metal plates.

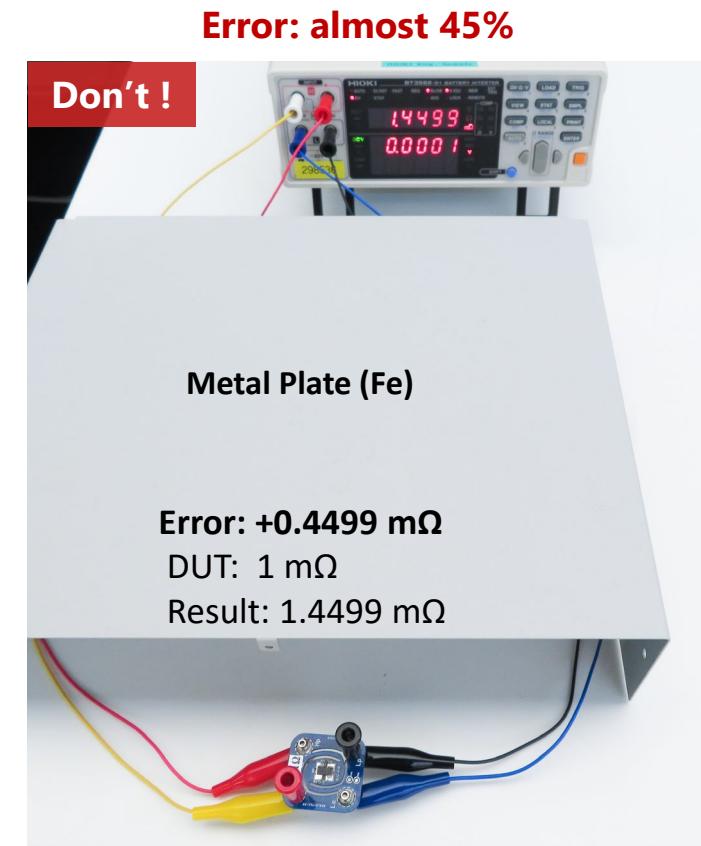
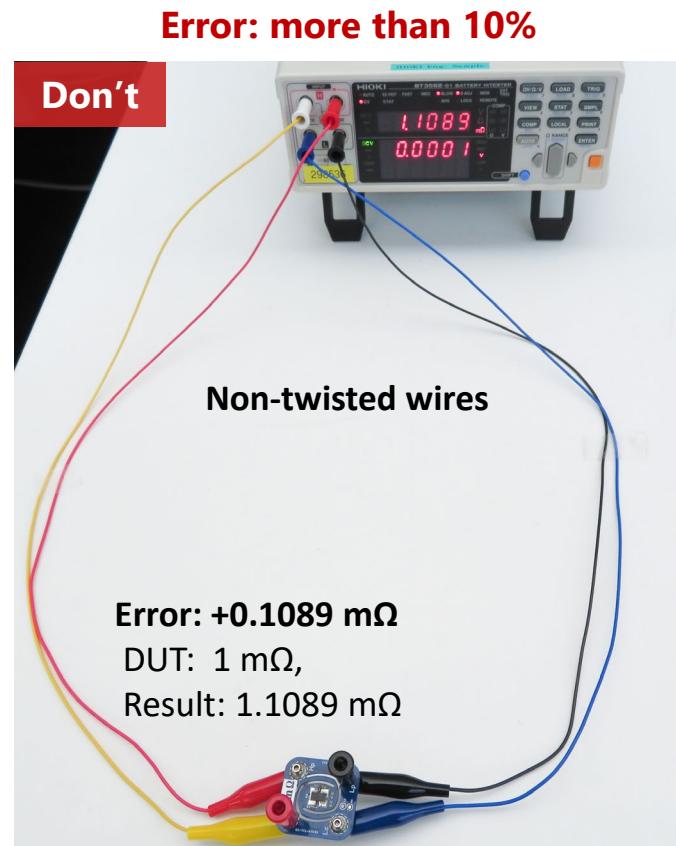


How to reduce Eddy currents (2)

Eddy currents are flowing in nearby metal plates close to the source current

Findings

1. Not twisting source wires result in Eddy current flowing in nearby metal plates.
2. The Eddy current causes magnetic flux that induce voltage in the sense wires if they are not twisted.

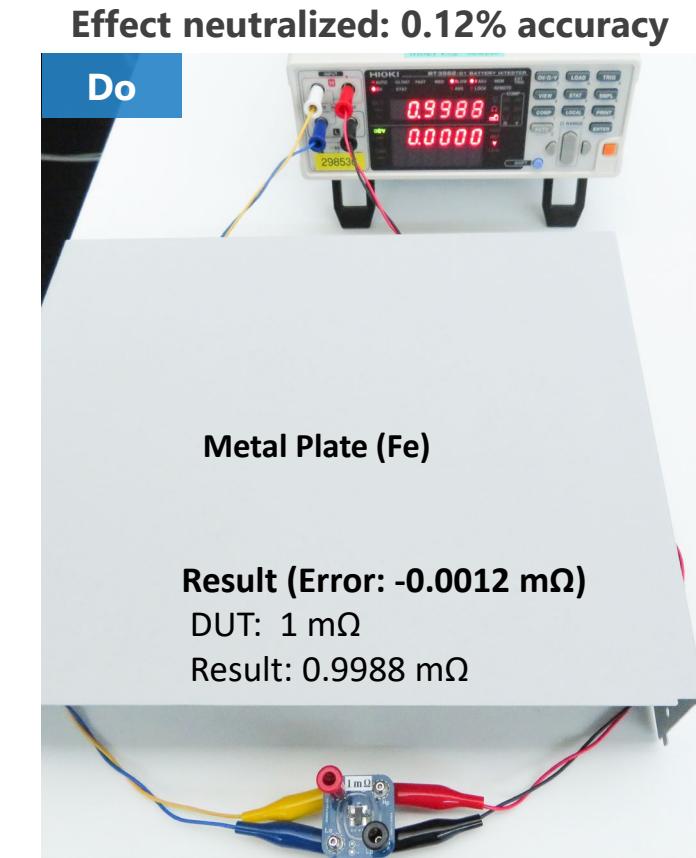
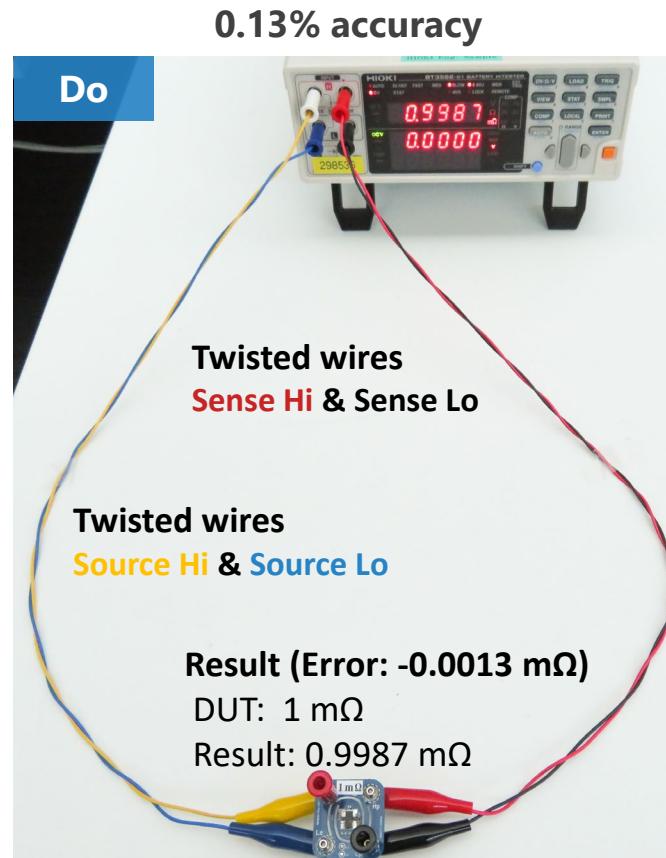


How to reduce Eddy currents (3)

Twisting wires prevents the influence of Eddy current on the measurement

Guidelines

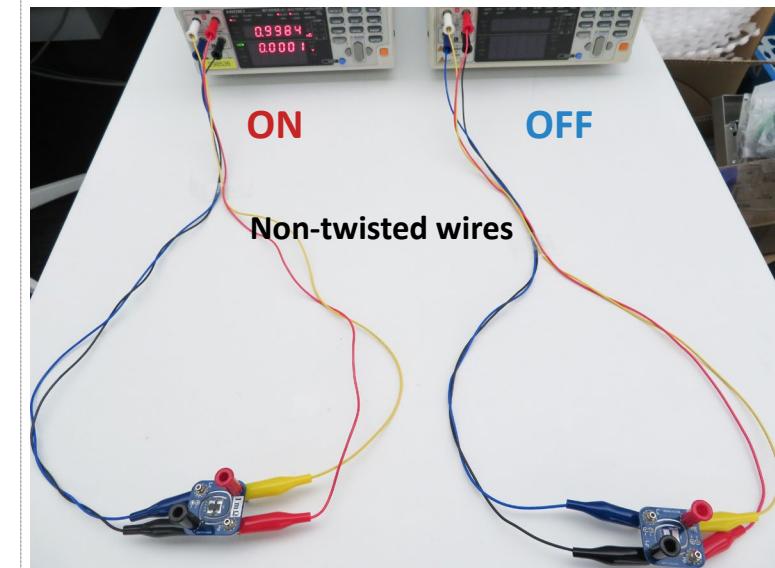
1. Twist the “Sense Hi” and “Sense Lo” measurement wires around each other and twist the “Source Hi” and “Source Lo” wires around each other.
2. Twist the wires as tight as possible, eliminating the space between the wires.
3. Keep the twisting even and consistent.
4. Do not place interfering objects such as metal plates near the measuring wires.



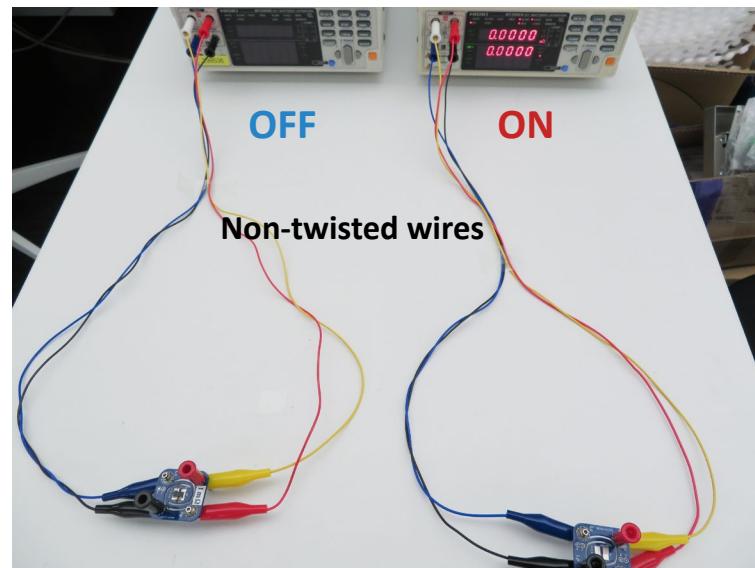
Multiple measuring instruments: avoid interferences (1)

The source currents of measuring instruments can influence each other

Single use: accurate results

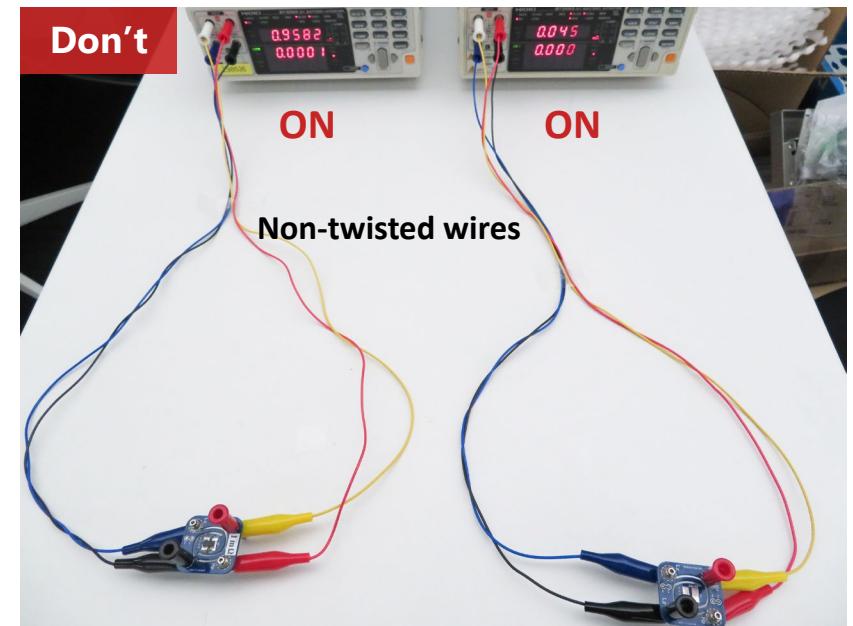


Left instrument:
DUT: 1 mΩ, Result: 0.9984 mΩ
Error: -0.0016 mΩ



Right instrument:
DUT: 0 mΩ, Result: 0.0000 mΩ
Error: 0 mΩ

Instrument interference: unstable results



Left instrument:
DUT: 1 mΩ, Result: 0.9582 mΩ
Error: -0.0418 mΩ

Right instrument:
DUT: 0 mΩ, Result: 0.0450 mΩ
Error: +0.045 mΩ

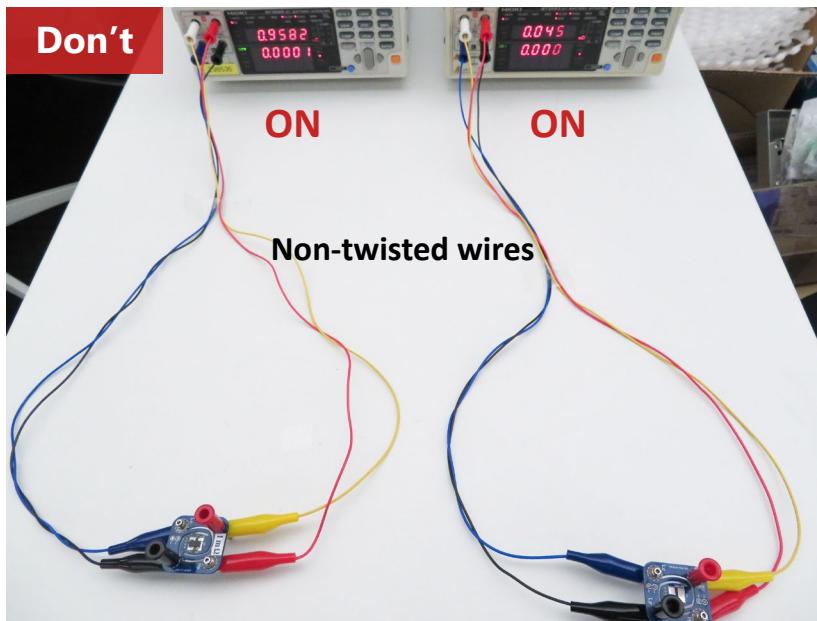
Multiple measuring instruments: avoid interferences (2)

Set up multiple instruments correctly to eliminate electromagnetic interferences.

Guidelines

1. Twist the measurement wires "Sense Hi" and "Sense Lo", as well as "Source Hi" and "Source Lo".
2. Make the twist loop as small as possible.
3. Keep the twisting even and consistent

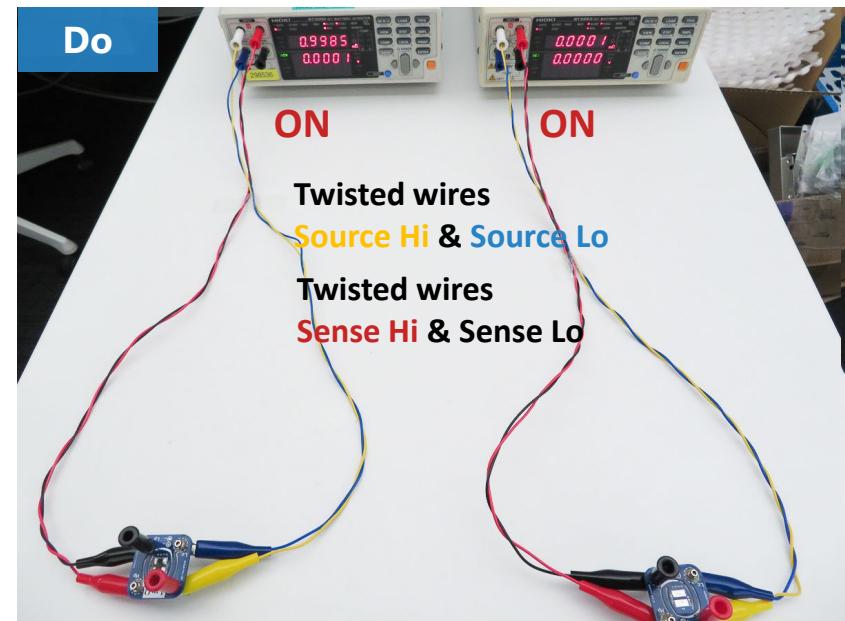
Multiple instruments: increased error



Left instrument:
DUT: 1 mΩ, Result: 0.9582 mΩ
Error: -0.0418 mΩ

Right instrument:
DUT: 0 mΩ, Result: 0.0450 mΩ
Error: +0.045 mΩ

Twisted wires: Interference is eliminated



Left instrument:
DUT: 1 mΩ, Result: 0.9985 mΩ
Error: -0.0015 mΩ

Right instrument:
DUT: 0 mΩ, Result: 0.0001 mΩ
Error: +0.0001 mΩ

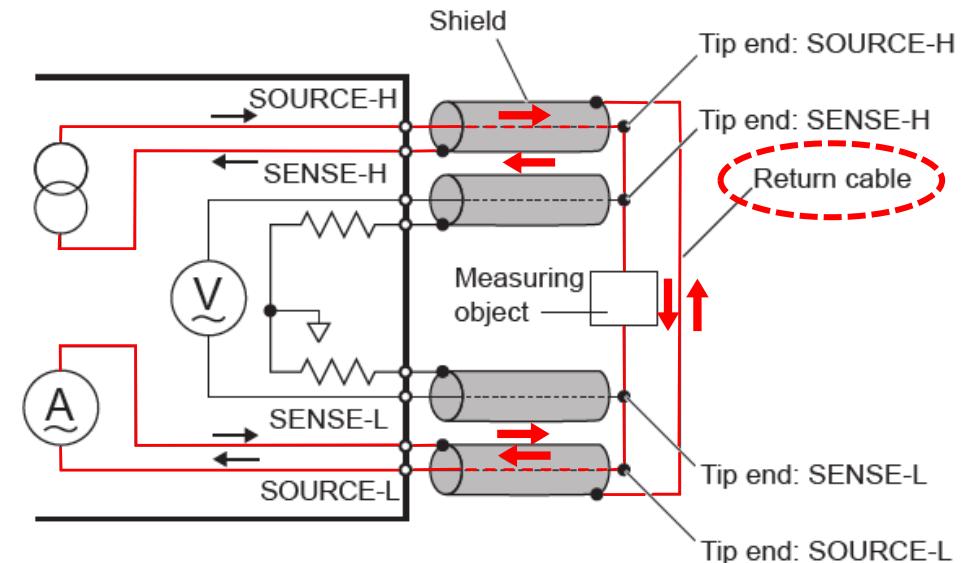
Different wiring method to reduce Eddy current

4-terminal pair wiring method

- Effective method to reduce the influence of Eddy currents and other electromagnetic interference (EMI).
- Source current is lead into the opposite direction through the shielding of the source wire in order to eliminate electromagnetic field.
- BT4560 Battery Impedance Meter is the only instrument that uses the 4-terminal pair method because of high source current.

+ Very effective method to eliminate EMI

- Source current circuit length is twice as long



[BT4560 Battery Impedance Meter](#)



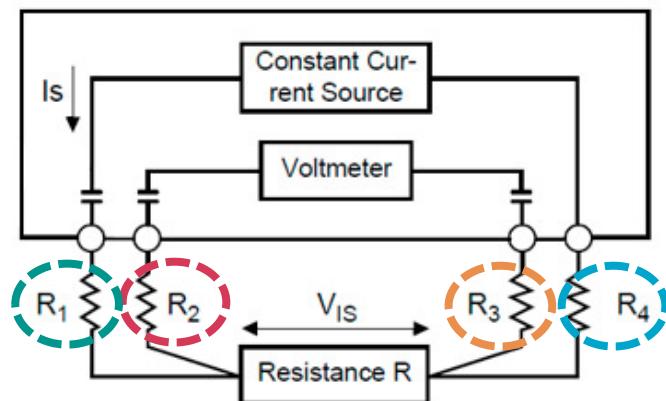
Probing - Do's and Don'ts

Importance of probing resistance and wiring resistance

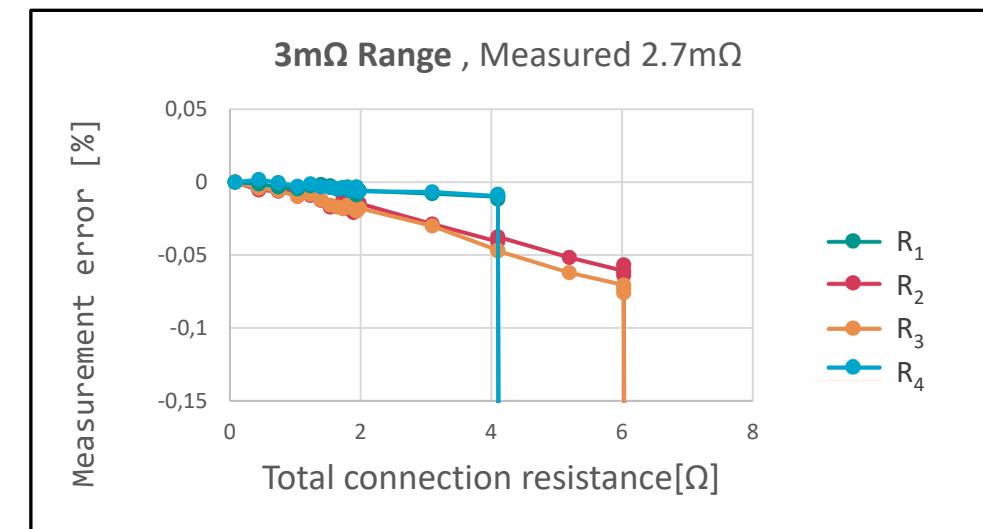
Contact resistance influences the measurement reproducibility

Guidelines

1. Keeping measurement wires as short as possible
2. Make sure the contact pins are in good condition



Values R_1 to R_4 are the resistances of the test leads plus contact resistances.

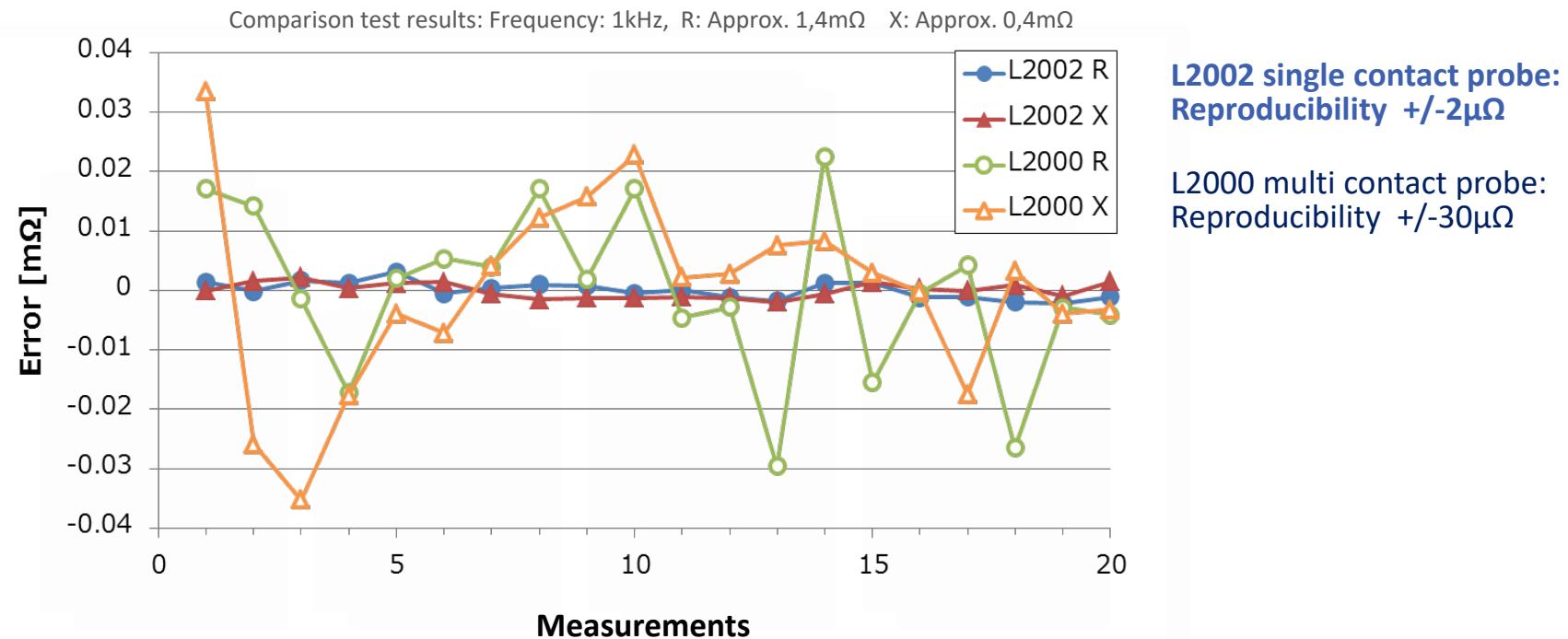


Single contact probes vs. multi-contact probes

For low resistance measurements it is important to make a single contact with the battery

Guidelines

1. Choose single contact probing for low resistance measurements.
2. Always probe the battery at the exact same spot.



L2002 single contact probe:
Reproducibility +/- $2\mu\Omega$

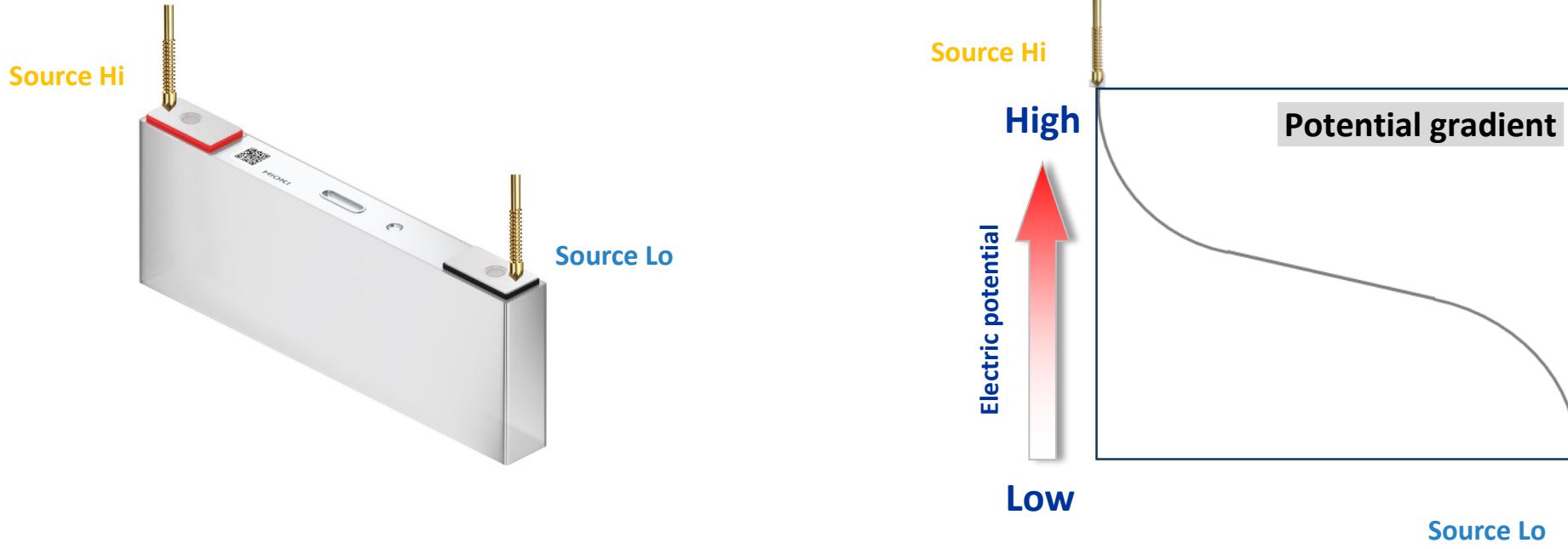
L2000 multi contact probe:
Reproducibility +/- $30\mu\Omega$

Single contact and multi-point contact probe tips examples:



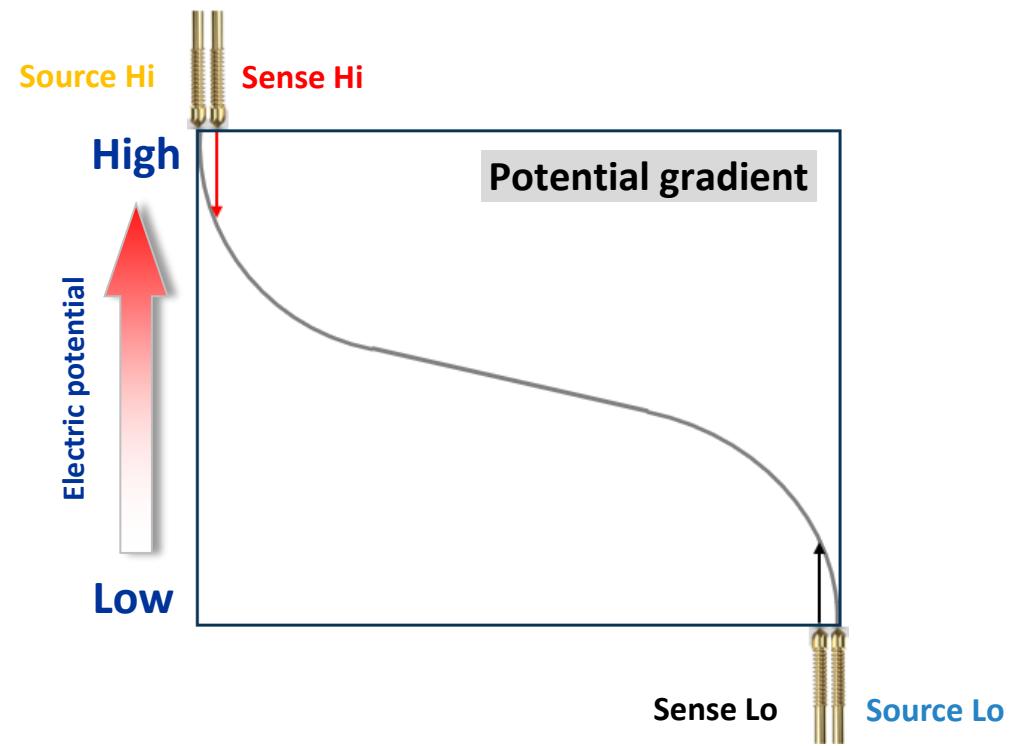
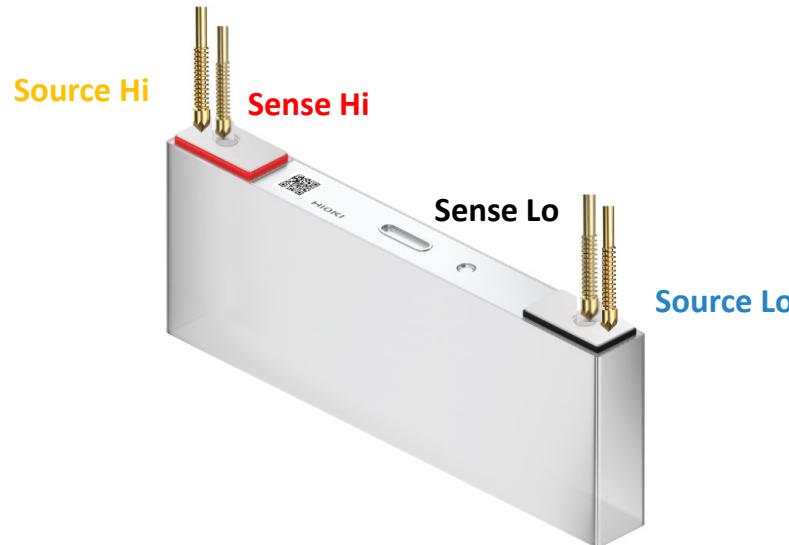
Relation between pin spacing and reproducibility (1)

The contact position of the pins is important for reproducible measurements



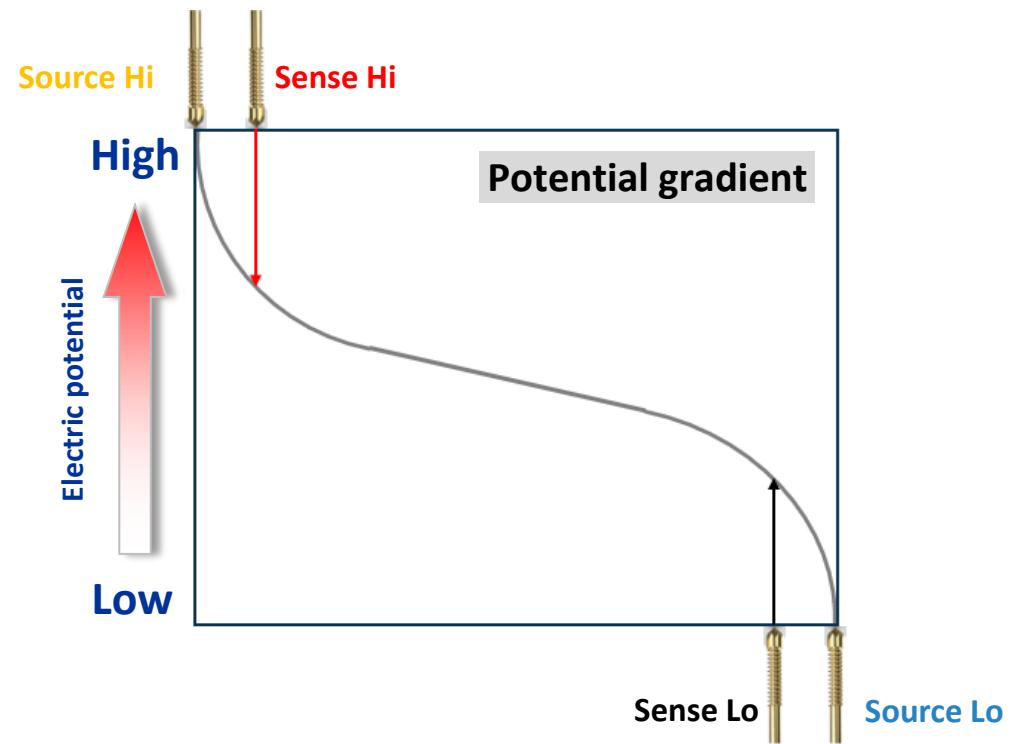
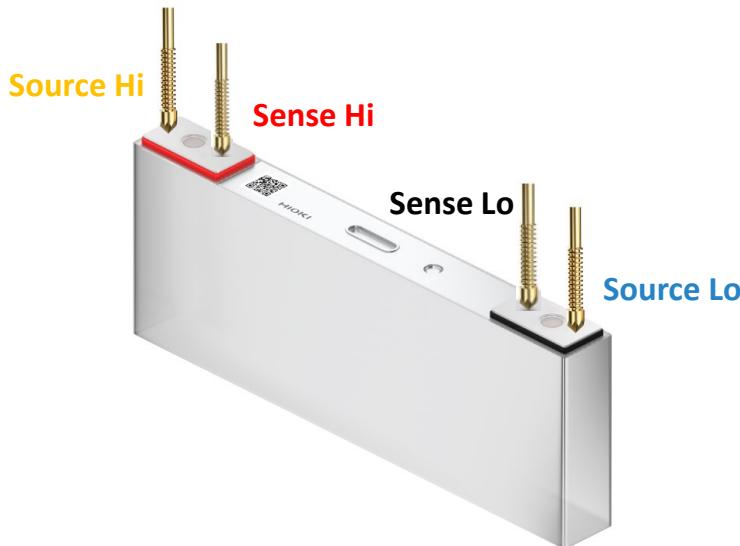
Relation between pin spacing and reproducibility (2)

Too narrow spacing between Source and Sense pins can lead to poor repeatability of the measurement



Relation between pin spacing and reproducibility (3)

Achieve a high measurement repeatability with sufficient spacing between Source and Sense pins



Using a Multiplexer

Using a Multiplexer (1)

Should I use a multiplexer or not? Take this in consideration:

Advantages

- Reduction of number of battery testers
- Lower initial investment
- Improved scalability

Disadvantages

- Longer measurement time
- More complex wiring between multiplexer and battery
- Zero adjustment is more complicated



[SW1002 Switch Mainframe](#)

Using a Multiplexer (2)

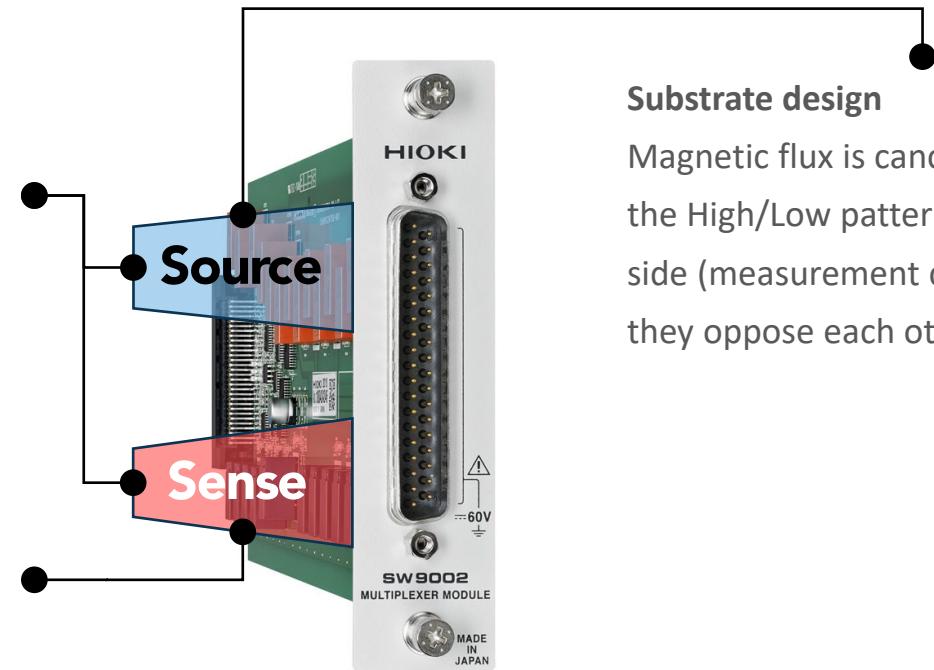
Circuit design: Use a multiplexer module circuitry that is not easily affected by Eddy currents and noise

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

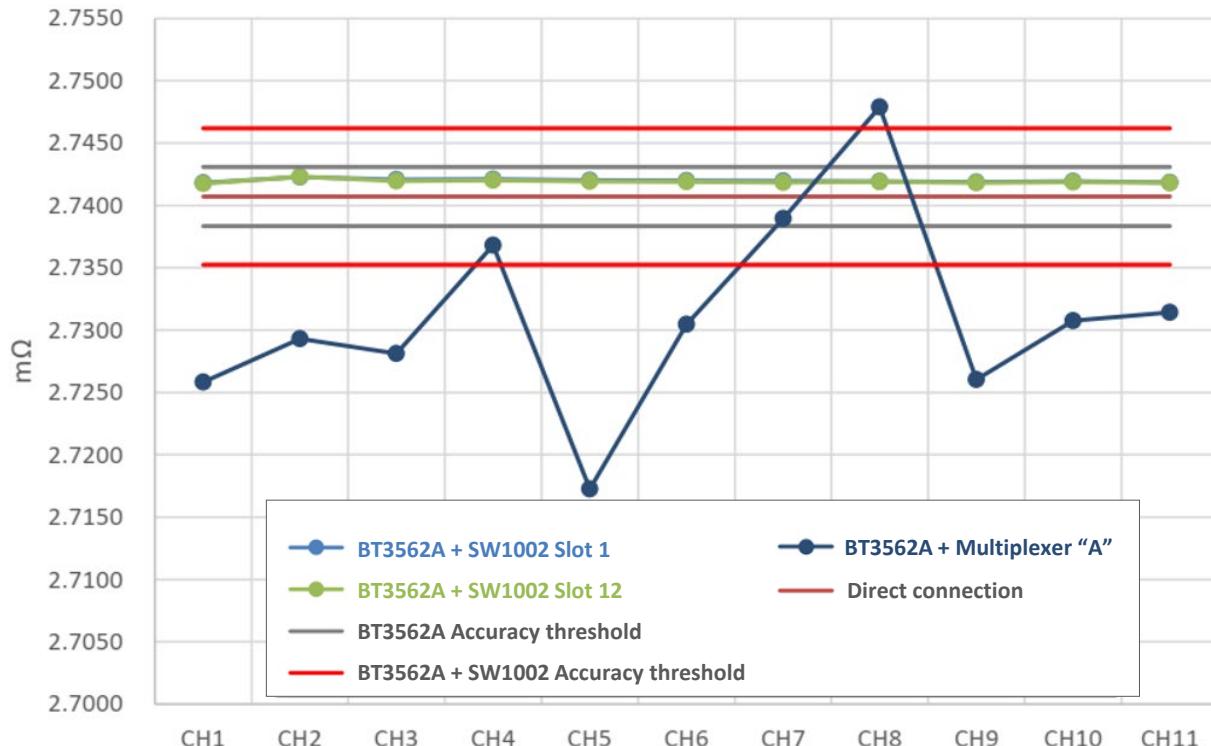
Magnetic flux is cancelled by orienting the High/Low patterns on the Source side (measurement current) so that they oppose each other



[SW1002 Switch Mainframe](#)

Using a Multiplexer (2)

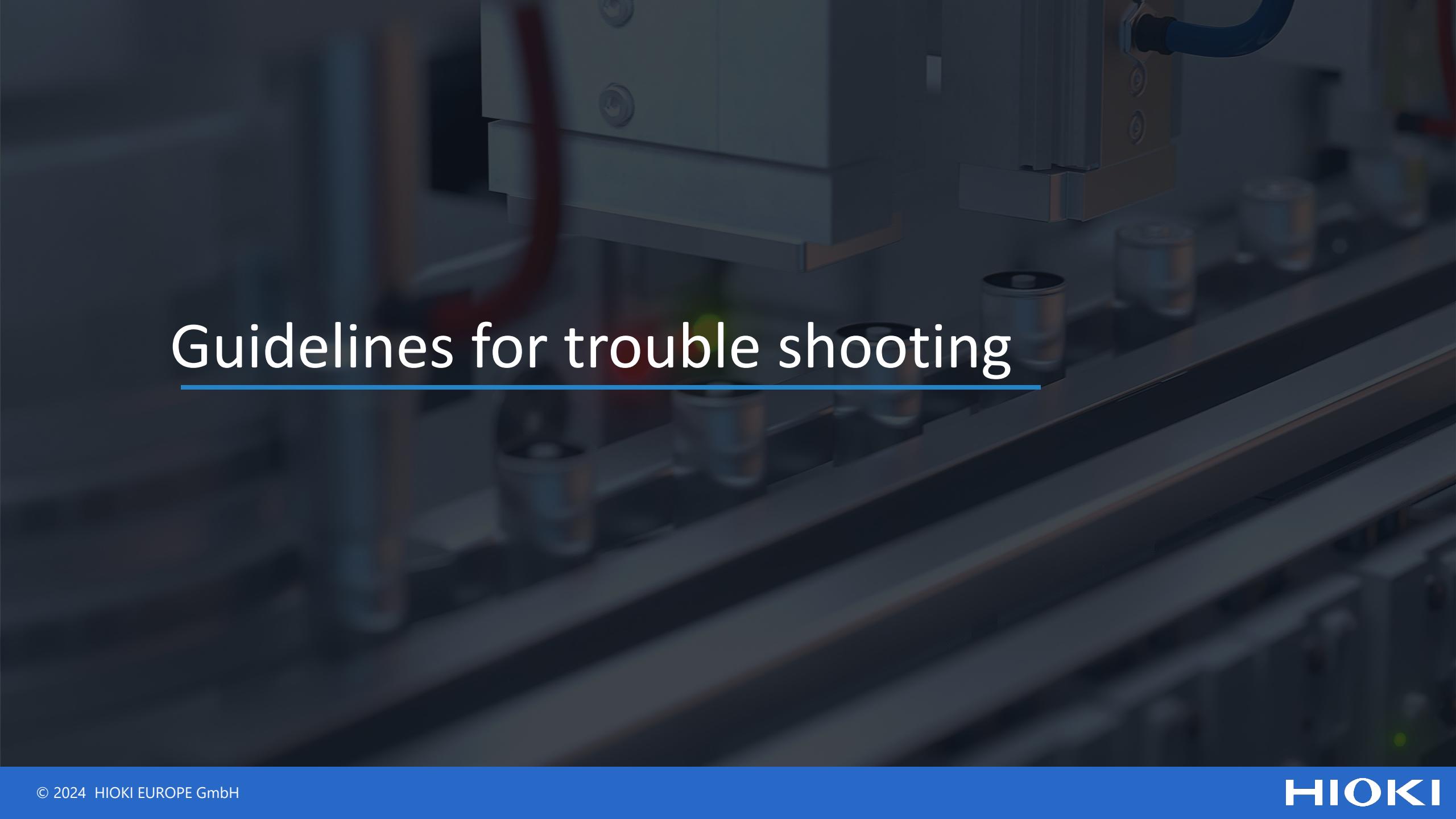
The Multiplexer should be designed to be used for measuring AC-IR



- 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.



[SW1002 Switch Mainframe](#)



Guidelines for trouble shooting

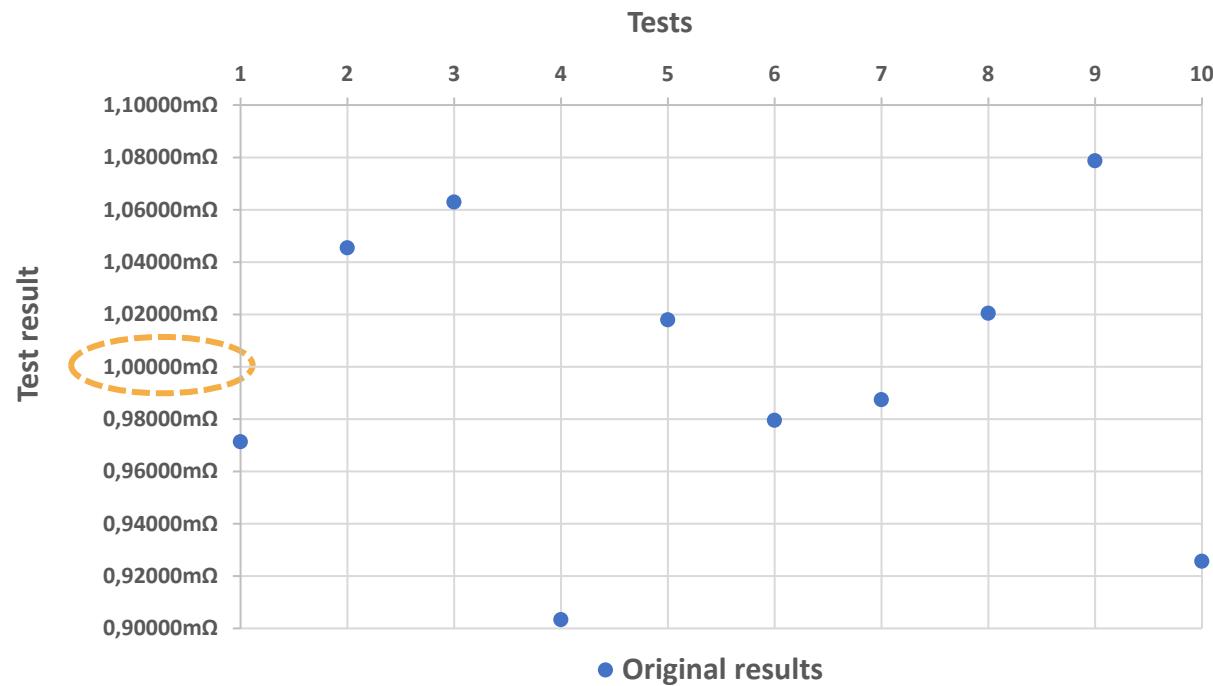
Guidelines for trouble shooting

Step-by step troubleshooting

- To identify the source of the problem, evaluate the influence of individual conditions one by one
 - ✓ Temperature fluctuations
 - ✓ Humidity
 - ✓ Electrical noise
 - ✓ Power supply quality
 - ✓ Wire routing
 - ✓ Battery positioning
 - ✓ Contact positioning
 - ✓ etc.

Guidelines for trouble shooting

Example: The measurement results are unstable



Guidelines for trouble shooting

Example: The measurement results are unstable

→ Action: Perform these 2 tests to identify the cause of the problem

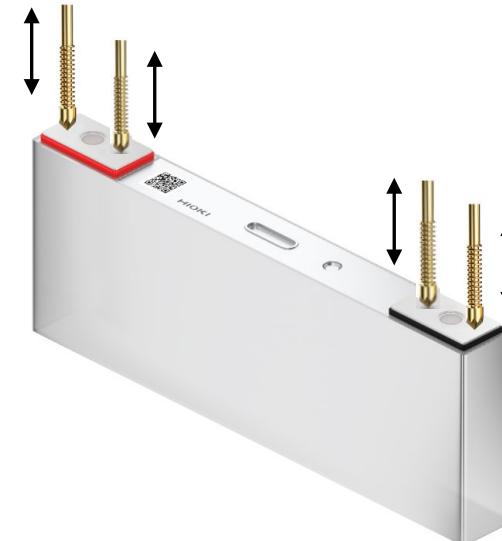
Test 1:

Measure 10 times while keeping the battery connected



Test 2:

Measure 10 times disconnecting the battery between each measurement



Guidelines for trouble shooting

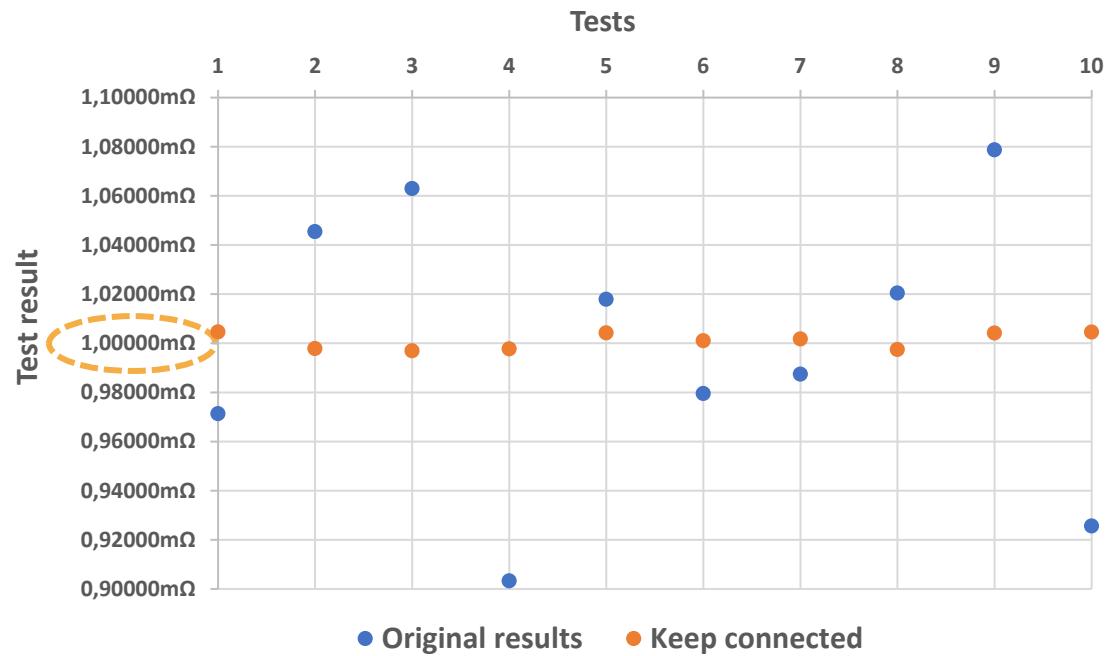
Example: The measurement results are unstable

Test 1:

Measure 10 times keeping the battery connected

Test 2:

Measure 10 times disconnecting the battery between each measurement



Guidelines for trouble shooting

Example: The measurement results are unstable

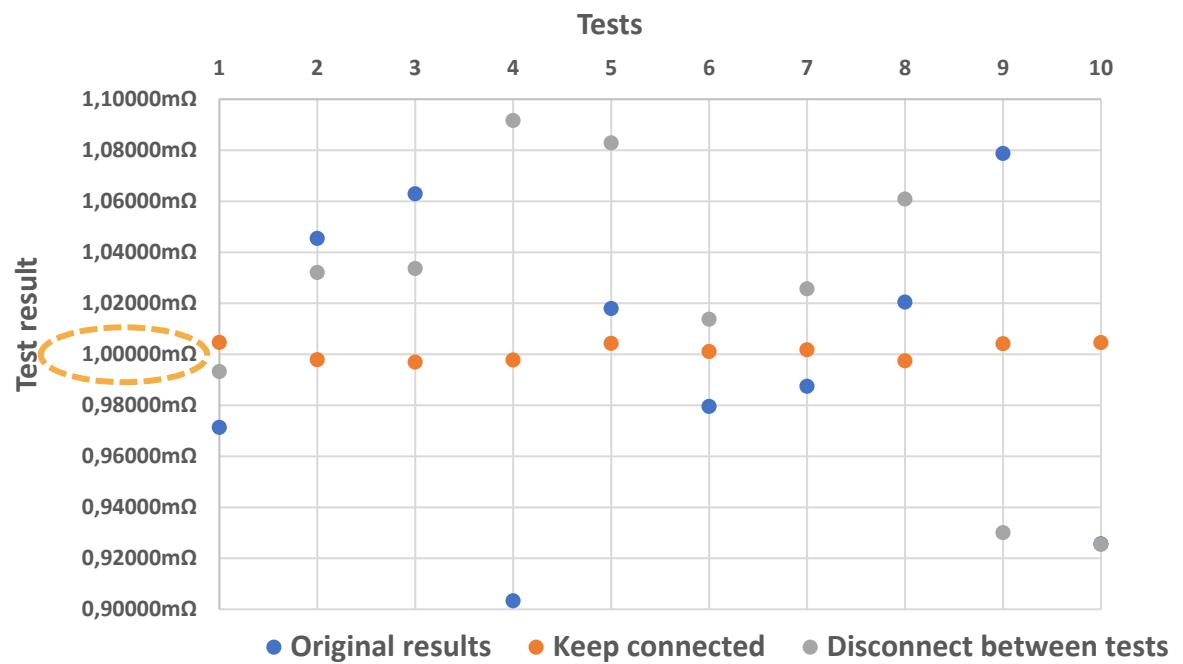
Test 1:

Measure 10 times keeping the battery connected

Test 2:

Measure 10 times disconnecting the battery between each measurement

- The unstable results are caused by probing issues
- You need to check the probe pins and battery fixing to solve the matter



Summary

Summary

Tips to help you to get accurate and reliable results:

- Correct wiring
 - Keep the connection between the battery and the measuring instrument as short as possible
 - Always twist the **Source High** and **Source Low** wires when using 4-wire measurement
 - Always twist the **Sense High** and **Sense Low** wires when using 4-wire measurement
 - Keep the wires as far as possible from metal parts and plates

Summary

Tips to help you to get accurate and reliable results:

- Using a Multiplexer
 - Only use multiplexers that are designed for AC-IR measurement
 - Keep the wires between the Multiplexer and the batteries as short as possible
 - Always twist the **Source High** and **Source Low** wires when using 4-wire measurement
 - Always twist the **Sense High** and **Sense Low** wires when using 4-wire measurement
- Trouble shooting
 - Evaluate the influence of individual conditions one by one

Summary

Tips to help you to get accurate and reliable results:

- Correct Probing
 - Use single contact pins to probe the battery
 - Avoid using metal parts for the probing fixture
- General
 - Already consider the electrical testing at the beginning of the design of the production line
 - Check background information in the Appendix of the Instruction Manual

Q&A

Contact us

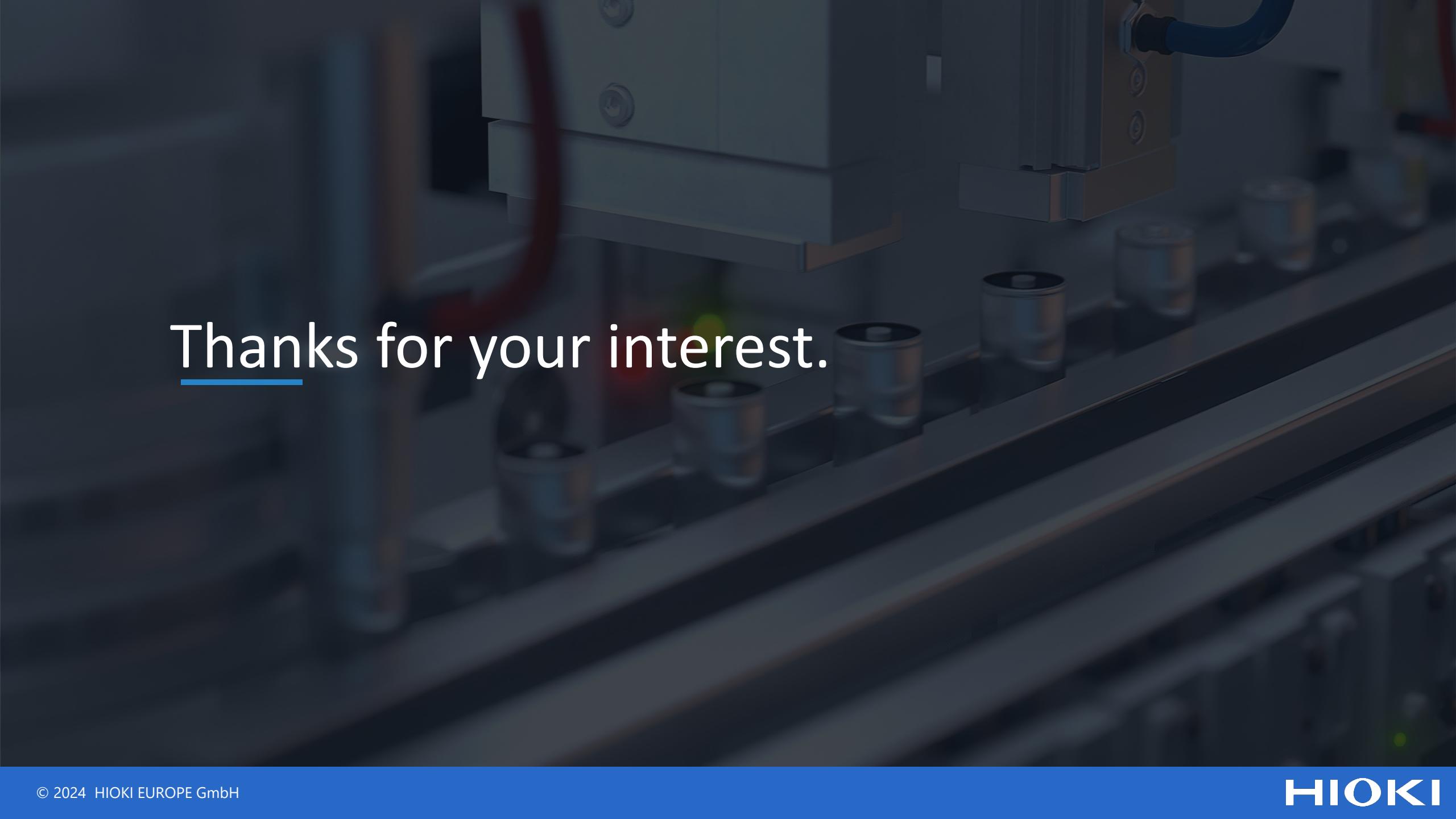
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Thanks for your interest.