

Cell:

A cell is an electrochemical system. It converts stored chemical energy into electrical energy through reactions.

Cell resistance is a dynamic value:

The resistance tells us more about the cell health, performance and safety.

Lithium-ion (Li-ion) battery cells become less efficient over time and with use (degradation).

Increasing load cycles result in higher internal resistance

Cell resistance is dependent on the frequency

- DC (0 Hz)
- Low frequencies 0.01 – 10 Hz most harmful accelerate cell degradation
- Middle frequencies 100 Hz to 10 kHz partially effect dependent on signal amplitude
- High frequencies above 10 kHz almost no harmful effect (can be used to heat up the cell internally).

For good cell analysis a frequency sweep is mandatory.

Cell resistance measurement methods:

DCIR (Ohmic resistance).

Measure resistance by applying current pulses

ACIR (frequency dependent)

Measure resistance by applying 1 kHz AC signal

- Fast
- Production environments
- Not complete picture of cell internal behavior (due to minimal polarization).

EIS (Electrochemical Impedance Spectroscopy)

Measure resistance by applying a range of frequencies (slower than ACIR).

By EIS we capture how the cell responds to an AC signal across a range of frequencies.

Gives us a much better understanding of an electrochemical system (cell) than a simple resistance measurement (DCIR). Basically to analyze the internal condition of batteries without opening them.

LCR meters and impedance analyzers can do this job. Hioki 4560-50 (0.01 Hz to 1050 Hz) or 4560-60 (0.01 Hz to 10 kHz) are special battery impedance meters. To extend the EIS channels Hioki has the SW 1001 or SW 1002 multiplexers to get a multi-channel EIS system.

- Slow
- R&D (also in production more frequently)
- Complete picture of cell internal behavior

Goal:

Chroma DC cyclers together with Hioki impedance meters can be integrated into a system All instruments can be controlled by Chroma LEX (Lab Expert) software. During the cycling of your cell you can perform EIS measurements as a single step.

EIS wiring guidelines to ensure most reliable and accurate measurements:

- 1) Keep the leads as short as possible Best is direct contact of EIS probes onto cell electrodes.
- 2) Twist the AC cables to lower inductance.
- 3) Use four wire (drive pos, drive neg, sense pos, sense neg) to compensate cable resistance
- 4) Keep the distance between EIS electrodes as short as possible to ensure equal power distribution.
- 5) Do not cross DC and AC cables to minimize EMI and noise induction.

FAQ:

- 1) When and why zero adjustment is needed?

Before performing the real EIS measurements, you must perform a zero adjustment. The main purpose of zero-adjustment is to eliminate EMI Electro Magnetic Interference values in the wiring path. Changes in inductance due to different wiring paths can lead to miscalculations in measurement values.

When zeroing adjustment is not or not good executed the final EIS results are not reliable.

- 2) Do you need to perform zero adjustment every time you change the cell for a new cell?

No, when the cell type remains this is not needed.

- 3) Do you need to perform zero adjustment when you want to test a different cell type?

Yes, every cell type had different characteristics which makes zero adjustment mandatory.

4) Can you see the Cole Cole/Nyquist plot in LEX software?

No, we show all data in the Chroma Data Analyzer. By using Hioki software a plot can be generated.

5) Do you need SW 1001 or SW 1002 when you want to control the BT4560-50/60 by Lex software?

Yes, you do need a multiplexer next to the BT4560-50/60 to control it.

6) Is it allowed to move the wiring after zero adjustment has been performed?

No, this is not allowed as it can result in wrong readings.

7) Do you need to use a zero adjustment fixture for zero adjustment?

Yes, you need to make your own zero adjustment fixture based on the cell dimension. It must be made from material with low resistance (preferably smaller than 0.3 mOhm for the needed fixture length).

8) Can you change the speed of EIS measurements?

Yes, the EIS measurement time is dependent on the number of calculations (waves).

9) How many EIS channels is the maximum for SW 1002?

In the SW 1002 we can insert 12 pieces of the SW 9002 cards each 6 channels. This makes maximum 72 EIS channels.

10) Where can you buy the RMK for the Hioki?

The RMK can be ordered at Chroma ATE Europe and are produced in Taiwan.