

Battery measurement methods

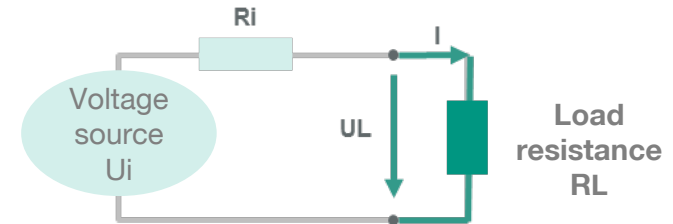
AC/DC internal resistance measurement to ensure the quality and functioning of modern battery systems

Identifying the weakest cell is essential!

AC/DC internal resistance measurement ensures quality and functioning

In e-mobility applications, high quality and safety critical Li-ion battery cells are now used en masse in battery modules or complex systems. Homogeneous, safe and consistent operating behavior of cells in an assembly is required.

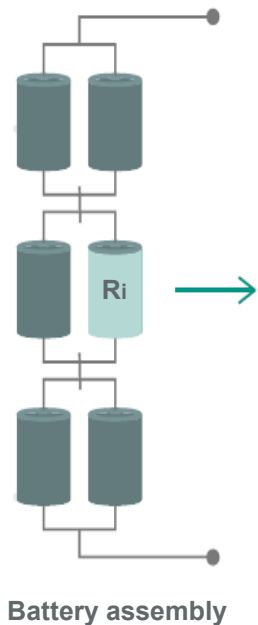
Increased internal resistance of one battery cell in an assembly has **serious effects**.



The AC/DC internal resistance measurement method (two-frequency measurement) used in burster battery measurement systems is ideally suited to seamless fully automated series production, to prevent serious failures in advance.

Goal: Best possible battery balancing within a battery assembly

Influence of the battery's internal resistance



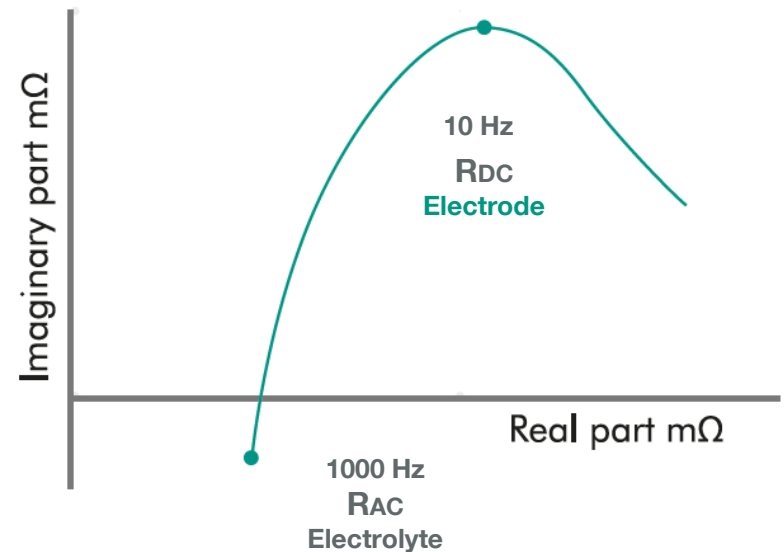
- Greater heating results in acceleration of the aging process ($P = I^2 \times R_i$)
- R_i causes a difference between internal (U_i) and external (U_L) state at $I \neq 0$ and influences the SoC measurement (e.g. charge balancing)
- Internal resistance R_i influences charge/discharge current, and therefore storable energy and deliverable power
- Battery life

Combined AC/DC internal resistance measurement

- The internal resistance of a battery cell is frequency-dependent
- Increasing frequency results in decreasing internal resistance and capacitive/inductive reactive components
- Combined AC and DC resistance measurement at predefined frequencies (typically 1 kHz and 10 Hz) enables precise measurement and evaluation of significant battery parameters in just a few ms

R_{DC} – Internal DC resistance – **Electrode**

R_{AC} – Internal AC resistance – Electrolyte

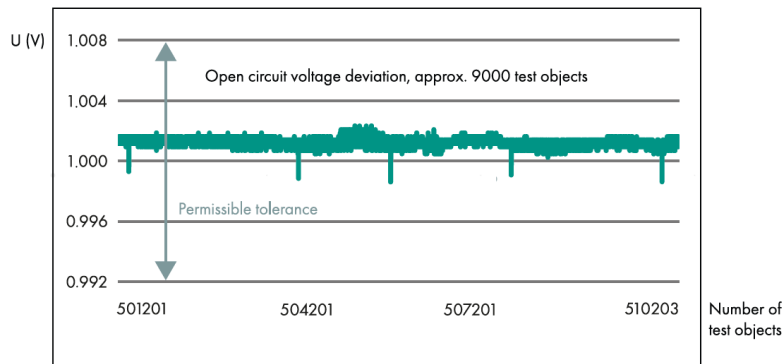


AC and DC internal resistance measurement

Combined AC/DC internal resistance measurement

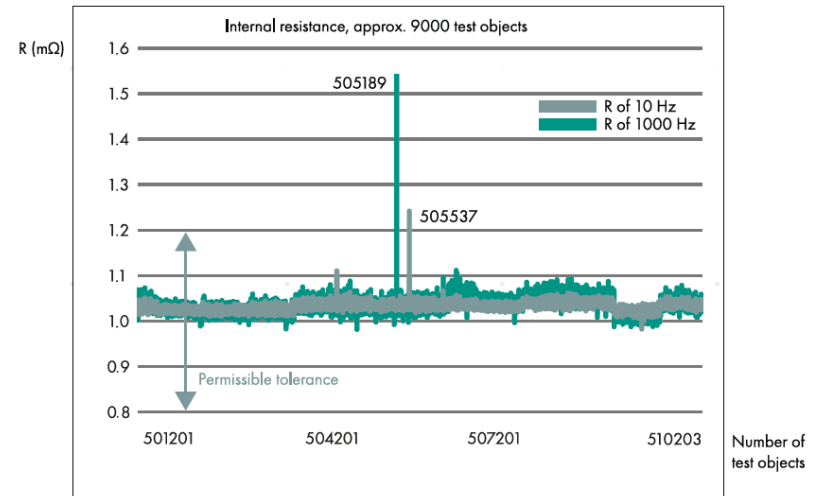
Example: 100% Li-ion round cell testing in mass production

OPEN CIRCUIT VOLTAGE MEASUREMENTS



vs.

AC AND DC INTERNAL RESISTANCE MEASUREMENT



Outlier with major deviations, only both measurements provide information about the battery quality

The comparison shows that with approx. 9,000 test objects, **2 outliers would not have been detected** without the additional AC/DC measurement!

A complex battery assembly is only as strong as **the weakest cell!** Identifying this cell is of **utmost importance for the quality and functioning** of the whole battery pack/module!

Measurement method AC/DC internal resistance measurement

Focus on cost-effectiveness, safety and quality

Possible consequences

- Fire hazard
- Premature aging
- Capacity losses
- Impact on battery life
- Differences in operating performance

Therefore: Quality assurance by identifying weak points

- Check at an **early stage of the process** (BoL, incoming goods inspection)
- General OK/NOK result

How?

- **Internal AC and DC resistance measurement**
 - Additional measurement method for open circuit voltage measurement
 - High-speed multi-channel measurement technology
 - Complete production control

Model 2511

