Why do diverse test methods produce different resistance readings?

Explanation on Battery Resistance Readings

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Measuring internal resistance may provide a rough assessment of a lithium-ion battery, however, a resistance reading is unable to estimate battery capacity, nor can it be used to check the accuracy of a battery analyzer. The battery is a reactive device and each method used provides a different numeric figure. Only a pure resistor would produce the same result.

Example: A18650 lithium-ion cell produces 36 mOhm with a 1000Hz AC signal and 110 mOhm with a DC load. Both reading are correct.

Let's look at the most common resistance measurements.

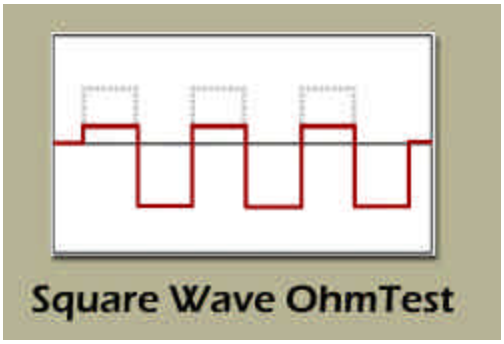
1. Cadex Square-Wave OhmTest

The original OhmTest excites the battery by injecting charge and discharge pulses. The analyzer measures the voltage drop and calculates the internal resistance with the help of Ohm's law.

Advantage: - Quick and easy to apply.

- Provides similar readings to the 1000Hz AC test.

Limitation: - At full charge, the positive excitation pulses are clipped by the limiting circuit of the lithium-ion battery, producing inaccuracies (see figure on right).



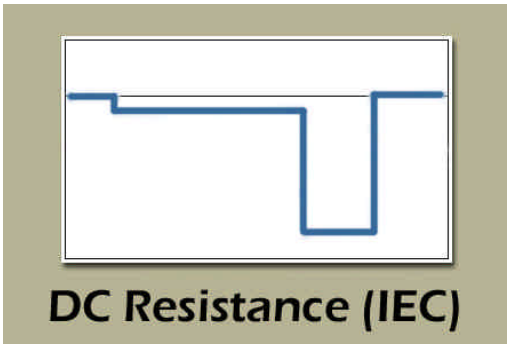
2. Cadex DC OhmTest (C-Series)

This method follows the standard as defined by IEC 60285 and IEC 61436. The battery is discharged for 10 seconds at a low current, followed by a 3 second discharge at a higher current (see figure below). The resistance is calculated using Ohm's law.

Advantage: - Follows IEC standard.

- Life-like test condition for cell phone and other batteries by applying a load.
- Provides good sorting of faulty batteries.

Limitation: - In some cases the resistance readings are higher than the 1000Hz method.



3. The 1000 Hertz Method

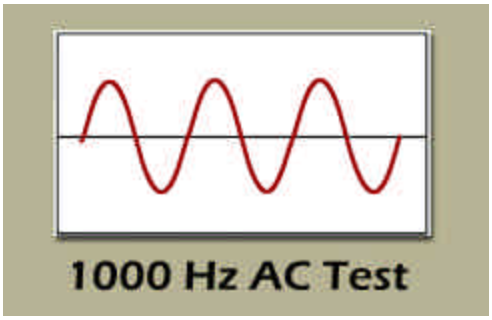
This method is commonly used to obtain a snapshot of the battery resistance. Rather than applying a DC load, the assessment is taken by injecting a 1000Hz signal. Depending on how the calculation is made, this method often results in different resistance values compared to a DC load. Typical applications are the Hioki instrument and the Astratec XpressTEST.

Advantage: - Traditional test method.

- Follows IEC standard

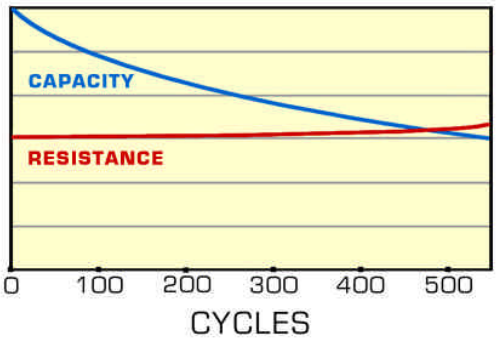
Limitation: - Resistance readings may be subject to battery reactance.

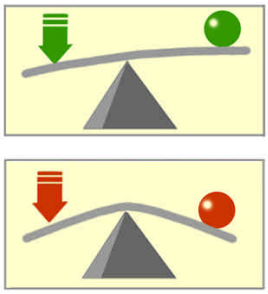
- May not identify all battery problems accurately.



4. Why can internal resistance not be used to check battery performance?

Resistance readings alone are unreliable because some battery types lose capacity while retaining low internal resistance (see chart on right). The Cadex QuickSort™ excludes the internal resistance reading in the inference calculation and only uses the value at the conclusion of the test.





QuickSort™ is based on the *electrochemical dynamic response* of the battery. Like a mechanical arm, a good battery is solid and produces little lag. A weak battery, on the other hand, appears soft and bends and becomes sluggish to the applied force. QuickSort™ looks at the “firmness” of the battery.

5. What truly counts

At the end of the day, the customer wants an accurate assessment of the battery. Since the battery is a reactive device that produces different readings with each method used, the resistance value is only of significance for the internal engine that calculates the end result.

A battery rapid-test system must be designed to replicate the performance as perceived by the customer. With QuickSort™, we achieve this by obtaining a correct prediction 90% of the time. The program uses a generic algorithm that works with all designated lithium-ion batteries. No settings are required and the system functions with cobalt and manganese-based cathodes, fully and partially charged.