

## Requirements

Qualification tests in development to find out which battery cell is suitable for a use case.

Sample tests in quality assurance to verify battery quality.

To do this, the three battery parameters:

- Voltage U
- Capacity C
- Internal Resistance R

must be determined. Voltage and capacity are measured statically (with DC), the internal resistance is measured dynamically as an AC value.

The internal resistance of a cell consists of ohmic and capacitive elements and is therefore frequency dependent. From the frequency response or the Nyquist plot can be attributed to electrochemical properties. This means that batteries can be inspected for example on production fluctuations. Batteries of different manufacturers or technologies can also be compared.

With the help of reference values (e.g. a new cell), battery conditions (e.g. the ageing state) can be estimated.

## Realization

For the commonly used formats 18650, 21700 and 26650 we offer a complete test system. It consists of:

- cell test adaptor CTA that contacts the cells in four-wire technology
- Measuring instrument BTC1
- PC software for control and evaluation.

For a capacity measurement the cell to be tested must be fully charged. This is normally the case with primary cells, secondary cells (rechargeable batteries) must be charged with an external power supply, which is usually available as an accessory anyway<sup>1</sup>.

After this, the cell is discharged via the BTC1 with an adjustable constant current up to the discharging limit voltage and the charge is measured. The maximum removable charge represents the battery capacity.

The impedance measurement is done in the frequency range between 0, 1Hz to 1kHz, the ohmic fraction (real part) and the capacitive portion (imaginary part) of the impedance are displayed. In spectrum mode, all frequencies are measured consecutively and displayed as Nyquist plot. The equivalent circuit diagram parameters can be calculated on request.



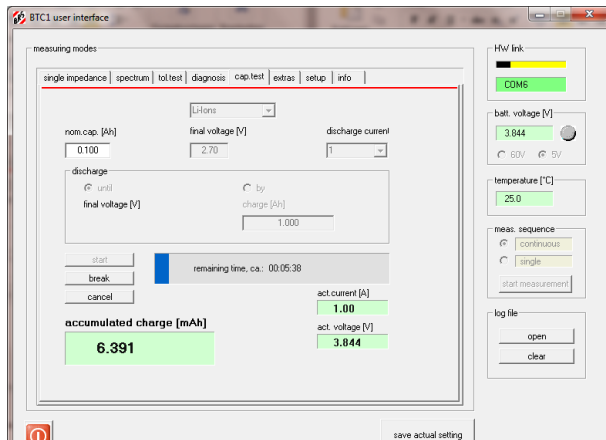
<sup>1</sup> The charging can also be done in the round-cell adaptor.

### Application, Operation

#### Capacity Measurement

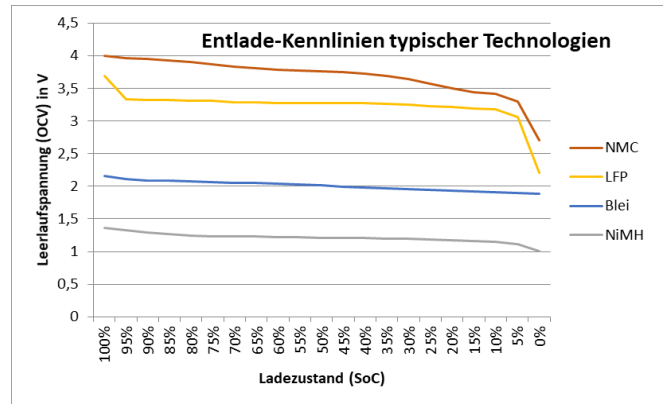
After entering the discharge end voltage, the discharge current and the nominal capacity, the measurement is started. The measurement progress is displayed graphically. After reaching the limit discharge voltage, the measurement is terminated, the charge taken up to that point corresponds to the capacity of the battery.

The entire measurement values are stored in CSV format, from which discharge characteristic can be displayed immediately.



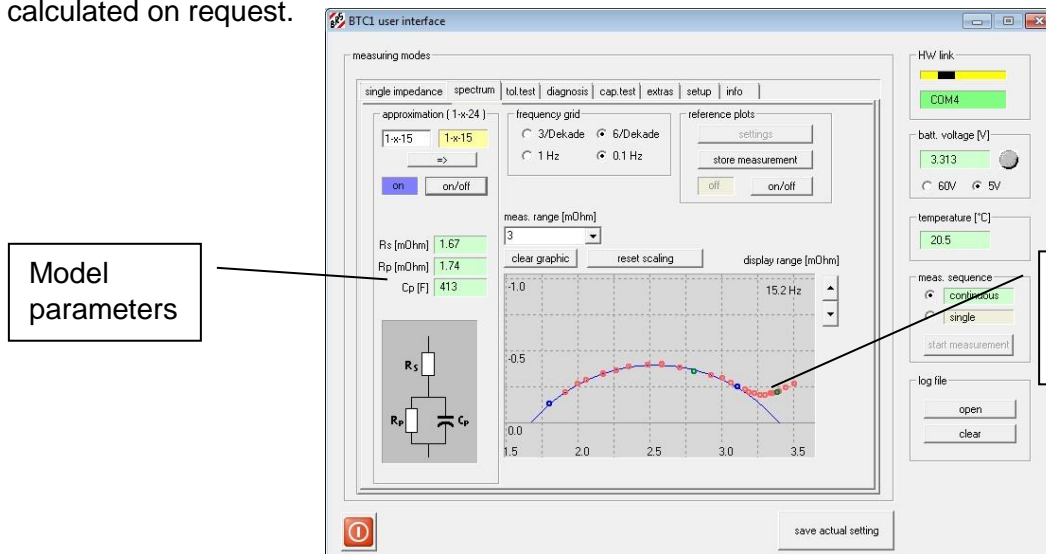
Result:  
Current charge, **Capacity**

Current values: discharge current, battery voltage



#### Spectral Impedanzmessung

It is done in the menu item "Spectrum". The frequency response of the impedance between 1kHz and 0.1Hz in the form of a nyquist plot, i.e. x-axis = ohmic fraction, y-axis = Capacitive part, is displayed. Each point represents a frequency. The model Parameters  $R_s$ ,  $R_p$ ,  $C_p$  can be calculated on request.



Model parameters

Nyquist plot  
1KHz left) to 0.1Hz (right)