POWERNET

ADC8000 Intelligent Battery Charger Platform

Battery State of Health (SoH) monitoring

Battery impedance measurement is the best practical method for battery state of health monitoring. The problem lies in ever changing conditions of the use of batteries. Comparable measurements can be accomplished only in equal conditions. The following parameters have effect on battery impedance results:

- Battery Temperature
- Battery state of charge
- Time from latest discharge/charge cycle
- Battery chemistry
- Measurement frequency

When batteries are analyzed with discrete measurement instruments, careful planning is required for accurate results. A battery charger connected permanently to battery can perform all necessary measurement always at equal conditions.

ADC8000 SoH Algorithm

The ADC8000 Battery State of Health monitoring combines input from battery AC impedance monitoring and cumulative temperature data. Based on cumulative and periodic data, alarms are triggered through binary output. Alarm signal is combination of several sources:

- Battery end-of-life
- Battery deep discharged
- Battery midpoint measurement out of range
- Battery overload

When battery alarms occurs, a site visit is needed for detailed information. Using ADC8000 Compatible Software tools, true cause for alarms can be analyzed remotely.

Battery impedance measurement

The battery impedance measurement uses AC/DC converter to generate a variable, small amplitude excitation signal to the battery terminals. The excitation is a high frequency AC signal. Bandpass filtered AC voltage and current signals are sampled by the microprocessor.

The battery impedance is a trend, not single shot measurement. This way we will get a general behaviour of impedance over time. Single shot measurements are dependent on temperature, state of charge and electrical noise. When measurement is done at the same conditions, results are comparable. The ADC8000 calculates long average for impedance measured in different temperature categories. Measurement is compared to initial value for each temperature category. This eliminates impedance

measurement temperature dependency. Impedance measurement is carried only for fully or nearly fully charged battery. This eliminates variations caused by state of charge. Measurement is done with narrow band AC signal with synchronous sampling. This together with long average eliminates all asynchronous noise from measurement leaving clean high sensitivity impedance signal.

Battery lifetime counter

The ADC8000 battery diagnostics predicts remaining battery life time on a months scale. Warnings and alarms are signalled when remaining lifetime reaches customer defined thresholds.

To estimate remaining battery life ADC8000 defines design life for every new battery pack installed according to the New battery commissioning procedure. The design life of battery defines the baseline for battery life expectancy. The battery lifetime counter is a fixed number minute counter that counts down from design life.

Impedance correction for lifetime counter

Counter based battery lifetime does not give accurate picture of abnormal conditions or events that age battery more quickly than temperature alone. Similarly impedance measurement is too sensitive and variable over time that it cannot be used alone for remaining lifetime estimate. Best of both worlds is obtained by combining temperature and impedance trending.

In steady conditions battery impedance change should follow temperature ageing curve. When battery impedance change faster or slower than rate defined by temperature curve, the lifetime counter value is corrected.

Impedance criteria for normal ageing consists of 3 stages, a) for early life, b) for mid life and c) for end-of-life. These three stage represent partially linear approximation of non linear ageing curve. As rate of ageing can change any time, remaining lifetime can be shorted dramatically during EOL phase of battery as impedance reaching 200% will mark end-of-life to battery.

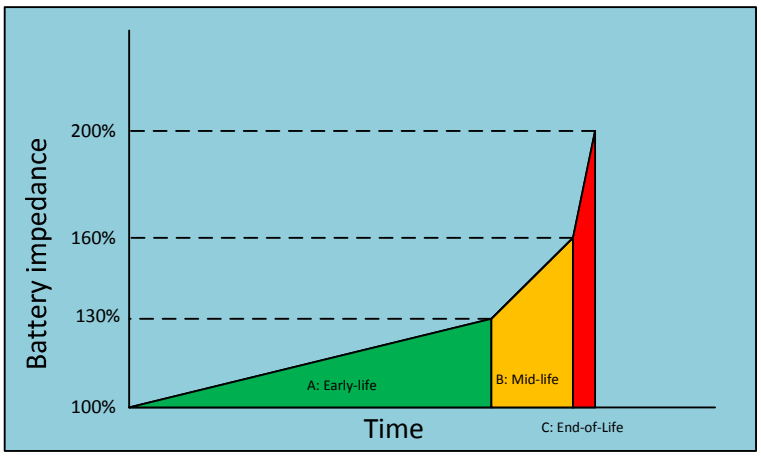

Figure 1: Linear approximation for ageing curve

If the battery impedance increases more than values identified for each stage of life, the lifetime counter is compensated. Due to non-linear nature of ageing, curve correction depends on the stage on ageing.