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Incremental Capacity Analysis of a Lithium-ion Battery Pack for Different Charging Rates

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Motivation
Incremental Capacity Analysis (ICA) is a method used to investigate the capacity State-of-Health (SoH) of battery cells [1]. The aim of this poster is to present the challenges for implementing the ICA technique for battery packs, here consisted of 14 cells, by means of different C-rates (C/10, C/6 and C/5) and for several temperatures. LFP chemistry based cells are connected in series to build the packs, for either 60Ah and 160Ah.

Experimental Setup
14*Winston 160Ah LiFeYPO4 cells at C/6 between 5°C and 30°C
14*CALB 60Ah LiFePo4 cells at C/5 and C/10 charge current rate

Direct & Terminal ICA

Charge Voltages: at C/10 & C/5

Charge Voltages: at C/10 for Charger & BMS

ICA Method

Incremental Capacity Analysis:

\[
IC = \frac{dQ}{dV}
\]

At a chosen ΔV (5-25mV) [2]

Several approaches in literature for wide range of chemistries, capacities and cell designs [3]

For many different C-rates and temperatures [4]

Significance at a battery pack level not yet established

Smoothing of raw data and filtering of charge/discharge capacity curves, to achieve an identifiable and unique IC peak

Results

Direct ICA: Less than 1mV deviation to the averaged cells ICA

Accurate cell capacity SoH estimation based on pack readings

Terminal ICA: Approx. 10mV deviation to the averaged ICA

Terminal ICA sees a higher impedance path compared to direct

Variable temperatures for C/6: For the 160Ah battery pack.
The peak moves to the lower voltage levels due to lower resistance, which is caused by a higher temperature

ICAs influenced from temperature variations on the pack level

160Ah battery pack charged with C/6 at 5°C: spread of the individual cells’ peaks due to inactivity of balancing during charging. Charge is stopped when a cell reaches cut-off limit.

ICAs are influenced from the cell to cell temperature variation

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References


Conclusion & Future Work

The additional Z path, the temperature variations and the C-rates must be considered for ICA on a battery pack.

Terminal ICA is not deriving the actual capacity SoH of the cells.

Outlook: Lifetime experiments at pack level under certain conditions.