Faster and Better Estimation of Li-Ion Batteries State of Health

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Objectives

- Develop a State of Health (SoH) estimation method for battery management systems.
- Estimate SoH with less than 2% error.
- Major reduction of Electrochemical Impedance Spectroscopy (EIS) testing time.

Background

The range of Battery Electric Vehicles (BEV) is not only affected by the performance of the battery pack, but also by how the battery cells age within the battery pack and by how well the Battery Management System (BMS) can compensate for aging through the tracking of:

- State of Health (SOH)
- State of Charge (SOC)
- State of available Power (SoaP)

These internal states cannot be measured directly but must be estimated.

SoH estimation accuracy impacts the longevity of the overall pack and the accuracy of estimating State of Charge (SoC) and State of available Power (SoaP). If the SoH is known, the operation of the pack and its associated estimation algorithms can be better adjusted to compensate for battery aging effects.

Figure 1: High Level view of the importance of SoH estimation
**Challenge**

- A method is sought that can accurately estimate battery SoH with rapid EIS measurement times utilizing the battery relaxation effect and EIS.
- Electrochemical Impedance Spectroscopy (EIS) measurements are usually done after 1 to 3 hours of rest time to avoid measurement errors caused by battery relaxation effects.
- The relaxation effect has a relationship with SoH, but testing times are usually 1 hour or more.

**Research**

- Our area of research was centered around the battery relaxation effect and its dependence on SoH.
- The battery relaxation effect is known to be SoH dependent, however, research surrounding this topic either requires measurement times of one hour or more, or large datasets to train black box algorithms.

![Graph showing SoH estimation performance](image)

*Figure 2: SoH Estimation Performance*

**Results**

- Our new empirical SOH model based on EIS successfully estimates battery SoH with a maximum error of 1.7% and less than 1% error between 90% and 80% SOH.
- Measurement time was reduced to less than 15 minutes.

**Conclusion**

- The SoH estimation model can be a valuable part of EIS-capable Battery Management Systems.
- The Model will be an important part of rapid testing equipment to classify batteries for second life applications or for quality control.