Implementing State of Power algorithms into BMS edge for chemistry agnostic battery system

Degree programme: BSc in Electrical Engineering and Information Technology
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The integration of second-life batteries is challenging due to the different aging of each cell. These applications require a battery management system (BMS) that parameterize each cell individually. Therefore, it requires live adaptive algorithms which calculate and provide important metrics such as state of charge (SoC), state of health (SoH) and state of power (SoP) based on an equivalent circuit model (ECM).

Initial Situation

This work is part of the BigLeap project which aims to develop next generation battery management systems (BMS) that enable better integration of second-life batteries. This Thesis is based on an adaptive ECM estimation and SoP algorithm developed in Python. These algorithms had to be converted into the C11 programming language and adapted to the real-time operating system (RTOS) of the BMS.

Theory

An ECM uses RC elements to model the dynamic behaviour of the cell in response to a change in current. The accuracy of the ECM is very important as the parameters have a significant impact on the depending algorithms and are a significant source of potential error. The left part of Figure 1 shows the sequence of the algorithms and how they interact.

- To characterise the cell, a general ECM is first loaded which describes the cell parameters. These are used to determine the current SoC using the SoC algorithm
- The predicted SoC is then used to re-estimate the actual ECM parameters based on the measured voltage, the difference from the estimated voltage and current
- The SoP algorithm then uses these ECM updated parameters to predict the available positive and negative power of the cell for a given time

Methodology

The calculation of the actual ECM works as follows: First, the ECM parameters that match the actual SoC and current are loaded. The cell voltage is estimated based on the ECM values, the current and the open circuit voltage (OCV) of the cell. The difference to the measured voltage is used as input for the extended Kalman filter, which statistically weights the calculated values. This makes the ECM more accurate.
The SoP algorithm calculates the voltage and current development for various power over a given period. A table is then created which shows how long the cell can deliver or absorb the power without reaching safety limits. This table is then used to estimate the available power for a requested time by interpolation.

Results

- The converted algorithms run successfully in real time with the limited computing resources
- The ECM parameters are estimated in real time, the predicted voltage gets more accurate over time. The main concern remains the accuracy
- The SoP prediction shows a comparable accuracy to the original implementation
- Future work will focus on optimising the algorithms in terms of accuracy, reliability and robustness for a wide range of second-life cells and operating conditions

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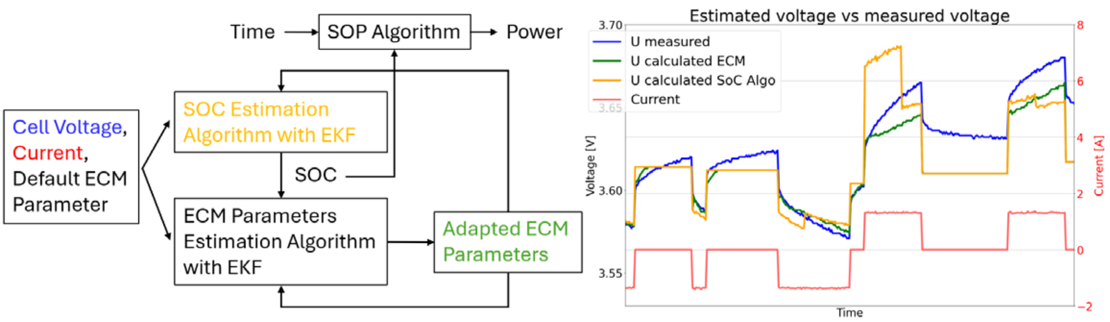

Figure 1: (left) Context diagram of the algorithm and (right) voltage estimation results