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Forecasting of Li-ion Battery Pack Ageing under User-Specified Drive Cycle with AutoLion-ST™

Introduction

For an electric powertrain, interaction of Li-ion battery pack with other system components including system-level controllers needs to be efficient under real-world conditions. For instance, an electric vehicle running in two significantly different environmental conditions (hot weather of Phoenix, AZ vs. cold weather of Portland, ME) needs to ensure a robust thermal management that can maintain pack temperature within a certain range so that desired electric range can be achieved without sacrificing pack life. Recent news of substantially accelerated battery pack aging for Nissan Leaf in hot climate [1] highlights the importance of battery pack-to-system interaction.

Problem Definition

Evaluate Li-ion battery pack aging with US06 drive cycle when driven in hot environment (Phoenix, AZ) and in cold environment (Portland, ME).

Technology Used

AutoLion-ST™

Setup

- Cell/pack design and operating condition set up with AutoLion-ST™. State.dat file used for power fade and capacity fade characterization.
- NCM/graphite cell chemistry (15 Ah materials capacity) is used with in-built material database
- Pack configuration: 96S,3P (96 cells in series and 3 in parallel)
- Phoenix, AZ and Portland, ME are represented by their yearly average temperature of 35°C and 10°C, respectively
- Thermal management logic is to allow no more than 5°C temperature rise from ambient conditions. Air cooling is used. For simplicity, control is put on heat transfer coefficient between air coolant and battery pack
- Two back-to-back US06 drive cycle (max power demand of 75kW) before pack is charged back through CCCV profile
- This example case file and workspace is provided to the user by EC Power.
- Capacity and power characterization for both aged packs is performed at 25°C.

Results

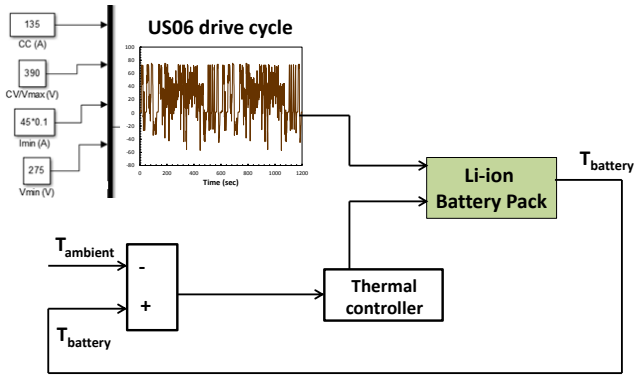

Figure 1: System block diagram with US06 drive cycle and control logic on battery pack temperature.

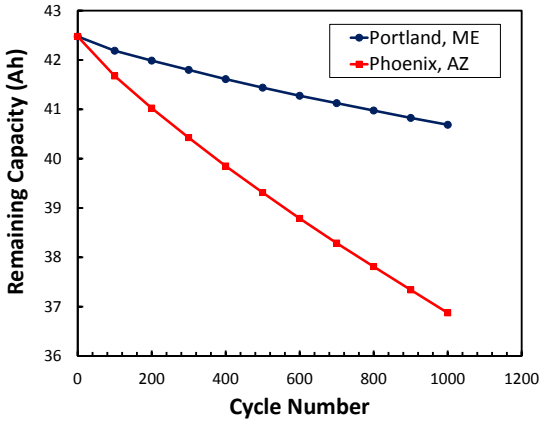

Figure 2: Capacity fade as a function of cycle number for hot (Phoenix, AZ) and cold (Portland, ME) environment with US06 drive cycle.

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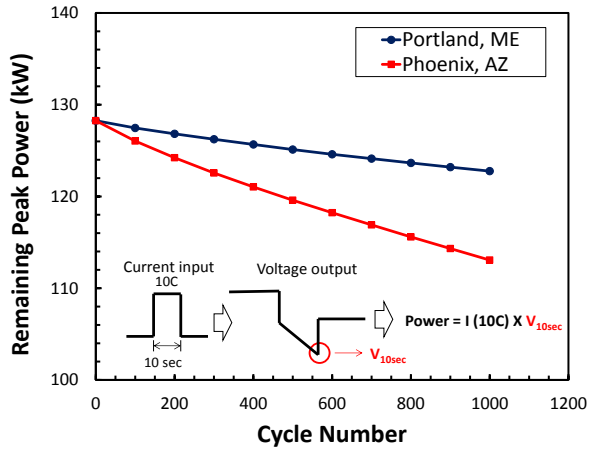

Figure 3: Power fade as a function of cycle number for hot (Phoenix, AZ) and cold (Portland, ME) environment. Power is characterized at 40% SOC for a 10 sec 10C-rate pulse at 25°C.

Benefits

- AutoLion-ST™ is the only system simulation tool that enables users to evaluate pack-to-system interactions and controls as a function of Li-ion battery pack aging.
- AutoLion-ST™ with its physics-based degradation modeling capabilities allows rapid forecasting of system operating strategy on capacity and power fade enabling life-cost optimization based on thermal management control logic.
- AutoLion-ST™ can be incorporated in any system configuration. This coupled with AL-ST™ capability of changing battery chemistry and design without needing any lookup table or refitting RC elements provides unprecedented flexibility to system engineers in system design selection and optimization.

References

1. *http://www.greencarreports.com/news/1079244_independent-tests-show-nissan-leaf-electric-cars-lost-range-in-hot-climates*