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Offline Parameter Identification and State-of-Charge Estimation for Healthy and Aged Electric Vehicle Batteries Based on the Combined Model

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Abstract : Recently, Electric Vehicles (EVs) have received extensive consideration since they offer a more sustainable and greener transportation alternative compared to fossil-fuel propelled vehicles. Lithium-Ion (Li-ion) batteries are increasingly being deployed in EVs because of their high energy density, high cell-level voltage, and low rate of self-discharge. Since Li-ion batteries represent the most expensive component in the EV powertrain, accurate monitoring and control strategies must be executed to ensure their prolonged lifespan. The Battery Management System (BMS) has to accurately estimate parameters such as the battery State-of-Charge (SOC), State-of-Health (SOH), and Remaining Useful Life (RUL). In order for the BMS to estimate these parameters, an accurate and control-oriented battery model has to work collaboratively with a robust state and parameter estimation strategy. Since battery physical parameters, such as the internal resistance and diffusion coefficient change depending on the battery state-of-life (SOL), the BMS has to be adaptive to accommodate for this change. In this paper, an extensive battery aging study has been conducted over 12-months period on 5.4 Ah, 3.7 V Lithium polymer cells. Instead of using fixed charging/discharging aging cycles at fixed C-rate, a set of real-world driving scenarios have been used to age the cells. The test has been interrupted every 5% capacity degradation by a set of reference performance tests to assess the battery degradation and track model parameters. As battery ages, the combined model parameters are optimized and tracked in an offline mode over the entire batteries lifespan. Based on the optimized model, a state and parameter estimation strategy based on the Extended Kalman Filter (EKF) and the relatively new Smooth Variable Structure Filter (SVSF) have been applied to estimate the SOC at various states of life.

Keywords : lithium-ion batteries, genetic algorithm optimization, battery aging test, parameter identification
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