INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Development of Robust State of Charge Estimation Algorithms for Lithium-ion Batteries in Electric Vehicles

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SHORT ABSTRACT

With increasing innovation and environmental awareness, electric vehicles (EVs) are becoming more popular than the conventional fuel based vehicles for emission-free future transportation. Lithium-ion battery (LIB) is the most suitable choice of energy storage system that works as the core of an EV. Along with the battery, a micro-controller known as battery management system (BMS) is required for reliable and secure operation of the battery. In BMS, real-time access to the information of one of the most critical battery states, known as state of charge (SOC), is vital as it indicates the remaining capacity of the battery, helps to prevent overcharging and undercharging, increases capacity utilization and lifespan, improves reliability, reduces cost, and ensures safety of the battery and its surroundings. Being an internal state, SOC is not available for direct measurement by any sensor and estimating it accurately for an LIB is non-trivial due to the highly nonlinear nature of the battery and various uncertain operating conditions. The literature reports several different approaches to estimate SOC of an LIB with each having its own advantages and drawbacks. It is important to note that each method of SOC estimation in literature possess some drawbacks either in accuracy or in real-time implementation. Hence, there is a scope for further improvement of these methods to enhance the performance of SOC estimation.

This thesis primarily offers improved solution for estimating SOC under diverse real-time constraints and operating conditions. It carefully focuses on improving various performance parameters of SOC estimation algorithm such as accuracy, robustness, computational time, and convergence speed. It strives to minimize the information requirement to achieve the cost-effective performance of SOC estimation. The algorithms are designed such that they can be implemented on a low cost BMS. For this purpose, four different model based approaches for SOC estimation have been progressively proposed and developed, including modelling of the LIB and its identification techniques. The proposed SOC estimation approaches are based on conventional super twisting algorithm (STA), strict Lyapunov super twisting STA, adaptive Lyapunov STA, and adaptive generalized integral STA. For designing the state estimators, the required battery model parameters are identified using relay feedback, recursive least square with forgetting, and adaptive forgetting factor based recursive least square approaches. The effectiveness of conventional STA along with relay feedback approach for SOC estimation is validated with numerical simulations. The other SOC estimation algorithms are executed on an actual battery using a real-time driving cycle current profile under diverse conditions. The obtained results demonstrate the efficacy of these proposed methods in terms of crucial performance parameters such as accuracy, chattering, robustness, computational complexity, and convergence speed compared to the well-established SOC estimation methods in the current state-of-the art.