Abstract

Comparative Analysis of Battery Management System Topologies for Electric Vehicles

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Electric vehicles use very large high-energy density Li-ion battery stacks consisting of multiple cells connected in series (Traction Battery). At a high-level of abstraction, this problem assumes that the individual cells (in a stack) undergo charging and discharging independently, resulting in charge mismatch in the cells in every stack. This charge mismatch results in decreased battery operational life and unexpected thermal failures. This research is motivated towards the analysis and development of a battery management systems (BMS) circuit topology and algorithm to address the underlying issue in order to avoid a major failure. Existing BMS topologies, namely Switched Capacitor, and Single Core Multi-Winding and their application algorithms are reviewed and compared. Experimental work involves lifecycle testing performed on Li-ion cells prior to implementation on a forward-flyback converter based BMS board. The algorithm in this experiment focuses on voltage-based highest-average-deviant strategy—an approach in which voltage is balanced in an evenly distributed manner by averaging the sampled cell voltages, finding the difference between the average cell voltage of each cell and applying the balancing current to the cell with the highest difference. Preliminary lifecycle tests to analyze under and over voltage ranges are performed on the 18650 Lithium-Manganese-Cobalt-Oxide (LiNiMnCo or NMC) Li-ion cells using PCBA 5010-4 battery analyzer. Cells are later stacked up to emulate an electric vehicle traction battery for evaluation of the voltage-based strategy algorithm using a forward-flyback converter topology based board. This evaluation set-up consists of multiple 18650 protected NMC Li-ion cells, 12 Volts lead acid battery, Texas Instruments battery management board, Hercules Safety microcontroller (MCU) and a direct current (DC) charger. Standards and regulations like AEC-Q100, ISO 26262, IEEE 1679.1-2017, and IEC 62660-1 have been taken into consideration while performing this experiment. Results are evaluated based on cost, modularity and balancing time and indicate that the BMS topologies play a major role in defining the operational life and selection of Li-Ion cells applicability. An application suggestion for future work is also mentioned.

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