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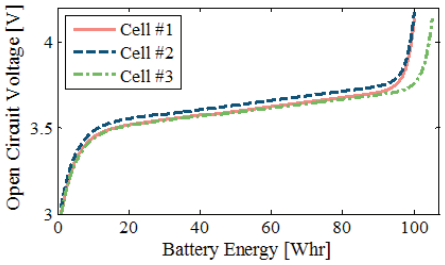
RESEARCH

Active Balancing of Electric Vehicle Battery Cells

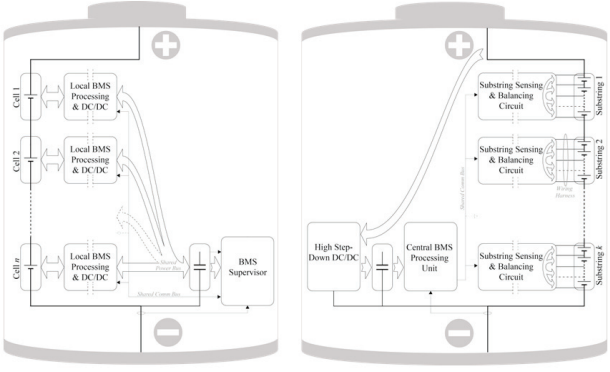
Overview

High-voltage battery packs in electric-drive (HEV, PHEV, EV) vehicles consist of a large number of battery cells connected in series to form a high-voltage DC bus for the propulsion drive train. Cells exhibit beginning-of-life mismatch in capacity, self-discharge rate, capacity, impedance, and temperature characteristics, with further variations leading to differences in the state-of-health over the remaining useful lifetime of the cells. Left unchecked, the cell variations result in accelerated aging of the least healthy cells in the pack, with lifetime of the battery pack tied to the worst performing cells.

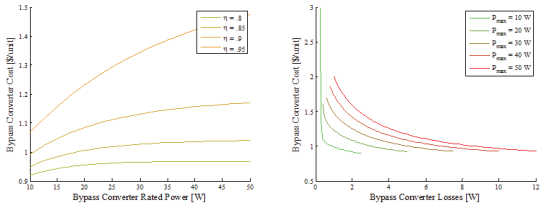


Technology Pathway

To keep the run-time state-of-charge (SOC) of individual cells approximately the same, and to mitigate the impact of cell mismatches over the lifetime of a pack, variosu implementations of battery management systems made up of active or passive balancing circuitry are considered. Options are weighed on cost, complexity, efficiency, and performance.



Cost models are developed for implementations of partial-power processing active balancing cell-to-bus power converters which allow assesment of the tradeoffs between cost and capabilities based on currently available materials and discrete devices.



An electric vehicle design lab was developed and taught to graduate and senior undergraduate students which aloowed the contruction of electric bicycles containing lithium-ion battery packs and front-wheel hub motors. The bicycles, in addition to providing a platform for instruciton on the design and prototyping of power converters, may be used as a small-scale testing platform for active balancing circuits and other EV power electronics research.

Impact

By preferentially steering small amounts of power processing towards healthier cells, effective runtime active balancing systems can reduce variations among cell SOH over the lifetime of the pack, driving the individual cells towards a homogeneous end-of-life. The resulting benefit to pack manufacturers can be selectively implemented as increased lifetime for a given pack size, or smaller pack size for the same lifetime, when compared to passively balanced systems.

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