Thesis Project Portfolio

Modular Battery Management System (BMS)

(Technical Report)

Challenges in the Auto Industry Paradigm Shift from ICE to Electric

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The history of the electric vehicle is inextricably linked to battery technology. As such, the functionality and safety of the battery system in electric vehicles is critically important to the adoption of electric vehicle technology. The architecture of a battery-electric vehicle (BEV) generally consists of a conglomeration of battery modules that are individually managed by a battery management system (BMS), with each module containing individual battery cells. In addition to the battery modules themselves, the BMS is also a critical component of any battery-electric vehicle design. Modular and scalable BMS designs can help provide flexibility in allowing for different module and cell configurations for different vehicle applications, such as cars, e-bikes, and scooters. The design of such a modular BMS is the focus of the technical portion of the project. The technical project makes use of multiple modular BMS "cell" nodes managing individual sets of two battery cells and a primary main BMS node that manages the individual "cell" nodes.

A BMS is needed in BEVs to prevent the battery from overcharging or drawing too much electrical current, which can reduce battery lifespan. In addition, a BMS can report important battery information such as the state of charge (SOC) and further extend battery lifespan via cell balancing (Brandl et al., 2012). However, many BMSs can only be used for certain battery pack configurations with a maximum number of cells. The technical project is a modular BMS design that can handle many different pack types and sizes, while still providing essential BMS functionality of monitoring, protecting, and efficiently using battery packs in electric vehicles. This modular system is a network of BMS boards that can be used for battery packs of many sizes. The BMS provides charge and discharge protection, displays the state of charge of the battery pack, uses active cell balancing and has a user interface to set parameters and view data. To help reduce the additional space overhead of the BMS, each individual BMS module is

compact enough to directly attach onto 18650 cells, rechargeable lithium-ion cells commonly used in electric vehicles.

Driven by consumer demand and governmental pressure around the world, the automotive industry is making a large-scale transition from internal combustion engine powered vehicles to low or zero-emissions alternatives, such as BEVs. Looking at this transition through the lens of a technological paradigm shift, both the short timeframe within which this shift must happen, as well as its sheer scale, has contributed to significant obstacles and setbacks. The sociotechnical portion of the paper looks at the underlying issues and consequences of different factors in the industry transition. A recent example of the large-scale recall of Chevrolet Bolt BEVs due to battery fires from battery manufacturing defects, is analyzed by examining technological and structural factors in the industry that contributed to these issues.

Overall, this topic is interesting and relevant to me due to my personal and professional interests; I am a car enthusiast and had a summer internship at Rivian, an electric vehicle manufacturer. I believe that it is critical to transition away from dependence on fossil fuels and electric vehicle adoption is an important step in that process. Helping to develop improvements in technology, such as my modular battery management system capstone project, can help to contribute to the transition in a small way. The role of the BMS being a critical part of a battery-electric vehicle that monitors and controls the health and state of the battery pack means that its design can have an outsized impact on the cost and performance of BEVs. The topic of the technological paradigm shift occurring in the automobile industry from internal combustion engine vehicles to electric vehicles therefore ties in closely with my technical capstone project. Working on the two projects has allowed me to gain a better sense of the context in which the technology I developed in the technical portion fits into the industry-wide paradigm shift.