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Powertrain System Design for an Ultra-light Electric Vehicle

Maximizing energy efficiency without compromising performance is a fundamental goal in electric vehicle design. This project addresses this challenge by optimizing the LEVKART's powertrain using a dynamic Simulink model that provides a detailed simulation of the vehicle's performance.

The transportation sector is shifting rapidly from traditional internal combustion engines (ICE) to electric vehicles (EV) across a range of sizes and purposes, from ultra-light to heavy-duty. Despite their differences, they share a common goal of achieving maximum efficiency. Reducing energy consumption and extending range while minimizing cost and maintaining performance is a core engineering challenge in electric vehicle design.

The main task of this study was to optimize the LEVKART's powertrain, specifically targeting the battery voltage. A dynamic Simulink model was developed to simulate the performance of the vehicle with different battery packs to determine their effects on energy consumption, range, and performance indicators like speed and acceleration. Three voltage levels were simulated, 43.2 V, 39.6 V, and 36 V.

The Simulink model used in this project was adapted from an existing model originally designed for cars and larger electric vehicles and used in the course Electric and Electric Hybrid Vehicle Technology (EIEN41). Adapting this model to the LEVKART required significant modifications to ensure that it was suitable for this type of vehicle.

A key step was to specify parameters for the specific power electronic components used in the LEVKART. This was made to simulate realistic efficiency for the power electronics, aligning the model with the actual performance of the vehicle. Additionally, tests were conducted on the electric machine used in the LEVKART, gathering essential parameters needed to calculate a realistic efficiency for the motor during different operating conditions.

Figure 1: Measurement of the electric machine

Battery performance was another important part. Discharge curves were generated for each one of the battery packs. These curves were used during the simulations to reflect how the battery voltage declines as the state of charge decreases.

Since the LEVKART is a unique vehicle with specific operation requirements, no existing drive cycles were available that could accurately represent the vehicle's usage patterns. New drive cycles were designed based on estimates of how the LEVKART would be used in real-world scenarios.

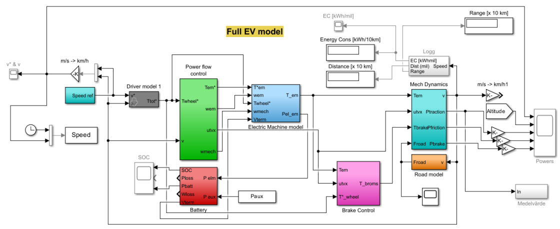

Figure 2: Powertrain system model in Simulink

The simulations showed that switching from the current 43.2 V battery to a lower voltage offered no significant improvements in range. The 43.2 V battery pack that is in use today remains the best choice among the three simulated batteries.

Although further refinements could enhance the model's accuracy, it already shows potential as a valuable tool for future powertrain design. Beyond comparing battery packs, the model could also be applied to evaluate different powertrain components, such as electric machines and power electronics, to optimize the vehicle even further. Additionally, the simulation model could be used to estimate the anticipated vehicle range under various conditions, asses whether the LEVKART can achieve specific performance requirements, such as top speed and acceleration, or verify its ability to follow a specific drive cycle. It could also offer insights into the maximum load the vehicle can handle, providing a comprehensive tool for predicting and optimizing the vehicle's operational capabilities.