Abstract

Today's energy economy holds efficiency at a premium. As engineers it is our job to find and eliminate inefficiencies no matter how big or small— whether a major change to an engine design or a small tweak to a shift schedule is required. Because of the ever-increasing need for these efficiency gains, system-level design is a crucial step in the hybrid vehicle development process. There exist several tools to simulate the behavior and performance of hybrid vehicles, but many of these are prohibitively expensive, too complex for engineers (particularly students) to learn from, or unable to support custom or unusual driveline configurations.

This thesis will discuss the development of a simple and extensible Simulink toolset which models hybrid vehicle systems and controls. The forward-looking modeling approach was chosen to not only accommodate the possibility of control optimization, but also to provide for ease of extensibility and the possibility of future real-time control with hardware-in-the-loop simulation.

The design of each vehicle subsystem in Simulink is first presented. A combination of physics-based and data-based modeling approaches is used to maintain the model's simplicity and accuracy. The subsystem models developed include DC traction motors, brake and regenerative braking systems, battery and power transmission, internal combustion engine, electric generator, vehicle dynamics, and a driver model that are combined to compare system level efficiency and performance. The subsystems will be combined to model a series hybrid sedan in a use case scenario. The toolset's results will be validated by comparison to hand calculations and an AVL ADVISOR simulation. Finally, a single-variable optimization study to evaluate the effects of engine displacement on fuel consumption for the FTP-75 driving cycle is presented.