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Modelling and Simulation of Hybrid Electric Vehicle

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Abstract: *Owing to the concerns about the environmental and energy issues, many research studies have been carried out to enhance the performance of the internal combustion engine vehicles (ICEVs) and launch new-generation vehicles [1]. HEVs (Hybrid Electric Vehicles) is a viable option for improved fuel economy and reduced emissions. HEV architecture are dependent on how much braking energy is regenerated, and how well the regenerated energy is utilized. In this project, we show how model based design can be applied in the development of hybrid electric vehicle system.*

Keywords: Hybrid Electric Vehicles

I. INTRODUCTION

Over the past decade, the lack of petroleum resources and the increased emission rates have stimulated the automotive research all over the world to find more sustainable and clean energy resources. While the limited fossil fuel reserves are being continuously depleted, both the demand and the production rates are growing rapidly [1].

Most of the air pollution takes place due to the burning of fossil fuels such as coal, oil, gasoline to produce energy for electricity or transportation. In which transportation is main reason behind emissions of harmful gases like carbon dioxide.

Vehicle emissions contributes to the formation of ground level ozone (smog), which can trigger health problems such as asthma, reduced lung capacity and increased susceptibility to respiratory illnesses, including pneumonia and bronchi HS and it also effects on environment. hence to overcome this problems researches invented Electric Vehicle.

As there are lots of disadvantages of ICEV's so we are preferring Electric Vehicle. owing to disadvantages of Electric vehicle, there are few problems are occurred in EV. Such as life cycle, charging problem and driving range [4]. The use of EV is difficult in hilly areas as they give less acceleration (due to only use of batteries, torque is less).

In recent years, research in Hybrid Electric Vehicle (HEV) development has focused on various aspects of design. Hybrid Electric Vehicles is combination of two sources fuel and IC engine. Hybrid Electric Vehicles (HEV's) typically use less fuel than similar Electric Vehicle which runs exclusively on electric energy stored in a battery.

II. LITERATURE REVIEW

At least two energy converters, such as Internal Combustion Engines (ICE), electric motors, are combined in a Hybrid Electric Vehicle (HEV). The ultimate aim of the HEV is to have the same power, range and protection as a traditional vehicle while reducing fuel consumption and harmful emissions that are harmful for health.

Hybrid Electric Vehicles (HEVs) combine the benefits of engines and electric motors. They can be designed to meet different goals, such as better fuel economy or more power.[4]

When compared to conventional vehicles, hybrids offer better power and fuel efficiency as they combine the benefits of high fuel efficiency and low emissions. When Hybrid Vehicles are cruising or while braking, the result is excess power which is used to charge the batteries. Improved fuel economy, as well as reduced fuel consumption, is a major benefit of Hybrid Vehicle [4].

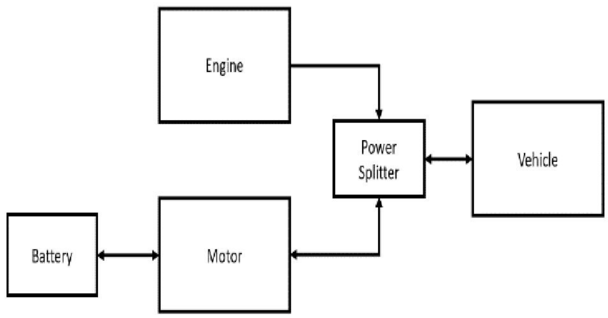
Hybrid vehicle use the electric motor more, they burn less fuel. This causes fewer emissions. It uses electricity, since Hybrid Vehicle partially depend on electricity to run the vehicle, the use of gas is lowered. The main advantages of a hybrid electric motor include comparatively less gas usage and reduced CO2 emission than traditional gas or diesel-engine vehicle.[5]

In an HEV, the extra power provided by the electric motor may allow for a smaller combustion engine. The battery can also power auxiliary loads and reduce engine idling when the vehicle is stopped. Together, these features result in better fuel economy without sacrificing performance. Hybrid Electric Vehicle is beneficial than Conventional vehicles, because they employ electric-drive technologies to boost vehicle efficiency through regenerative braking—recapturing energy otherwise lost during -braking [6].

III. METHODOLOGY

3.1 Block Diagram Of Hybrid Electric Vehicle

The hybrid electric vehicle has characteristics of both the electric vehicle and the ICE (Internal Combustion Engine) vehicle. At low speeds, it operates as an electric vehicle with the battery supplying the drive power

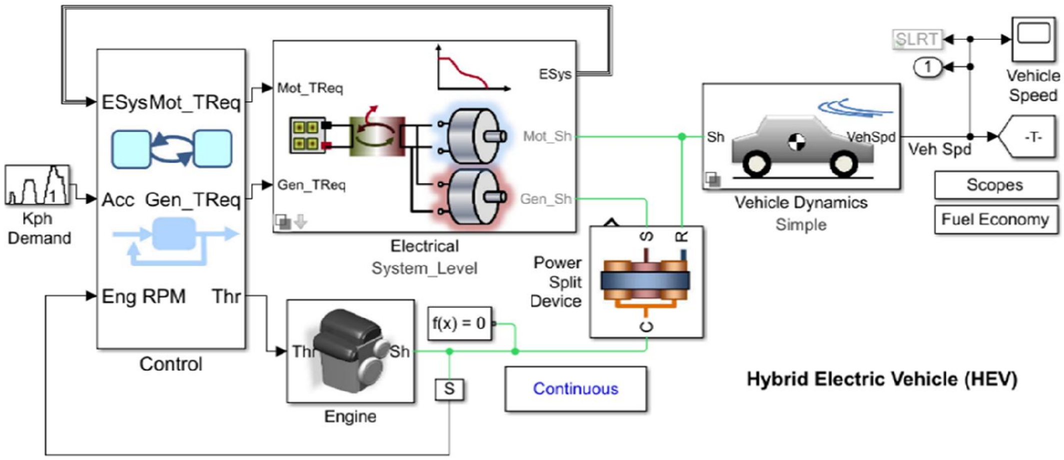


3.2 Design Considerations

Here, we discuss briefly the key aspects of the component design:

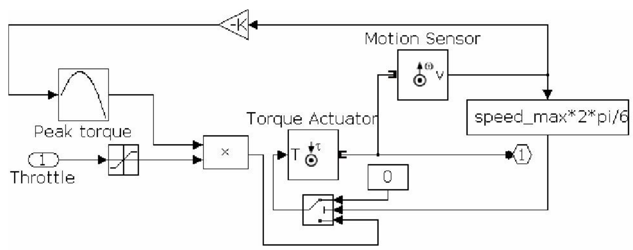
1. **Engine design** - The key elements of engine design are very similar to those of a traditional ICE. Engines used in an HEV are typically smaller than that of a conventional vehicle of the same size and the size selected will depend on the total power needs of the vehicle.
2. **Battery design** - The main considerations in battery design are capacity, discharge characteristics and safety. Traditionally, a higher capacity is associated with increased in size and weight. Discharge characteristics determine the dynamic response of electrical components to extract or supply energy to the battery
3. **Motor** - Motors generally used in HEV systems are DC motors, AC induction motors, or Permanent Magnet Synchronous Motors (PMSM). Each motor has advantages and disadvantages that determine its suitability for a particular application. In this list, the PMSM has the highest power density and the DC motor has the lowest.
4. **Power Splitter** - A planetary gear is an effective power splitter that allows power flows from the two power sources to the driveshaft. The engine is typically connected to the sun gear while the motor is connected to the ring gear.
5. **Vehicle dynamics** - The focus is on friction and aerodynamic drag interactions with weight and gradeability factors accounted for in the equations.
6. **Overall System Design** - The first step in the design process of the hybrid powertrain is to study the maximum torque demand of the vehicle as a function of the vehicle speed. Ratings of the motor and the engine are determined iteratively to satisfy performance criteria and constraints. The acceleration capabilities are determined by the peak power output of the motor while the engine delivers the power for cruising at rated velocity, assuming that the battery energy is limited. Power sources are coupled to supply power by the power-splitter, and the gear ratio of the power-splitter is determined in tandem. The next steps include developing efficient management strategies for these power sources to optimize fuel economy and designing the controllers. The final steps focus on optimizing the performance of this system under a variety of operating conditions.

IV. MODELLING AND SIMULATION



ENGINE

A complete engine model with a full combustion cycle is also too detailed for this application. Instead, we need a simpler



model that provides the torque output for a giventhrottle command. Using Simulink® and SimDriveLine™,we modeled a 57kW engine with maximum power delivery at 523 radians per second.

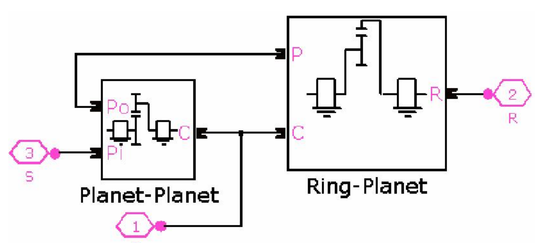
Engine modeled using blocks from theSimDriveline™ library

Synchronous Motor/Generator

The synchronous motor and generator present an interesting example of electromechanical system modeling. Standard techniques for modelingsynchronous machines typically require complex analysis of equations involving electrical and mechanicaldomains. Because the input source to this machinedrive is a DC battery and the output is AC, this would require the creation of complex machine drive and controller designs – often a significant challenge at this stage.

An averaged model that mathematically relates the control voltage input with the output torque and resulting speed is a useful alternative. This simplification allowsus to focus on the overall behavior of this subsystem without having to worry about the inner workings. Furthermore, we can eliminate the machine drive bysimply feeding the DC voltage directly to this subsystem.

Power-Splitter



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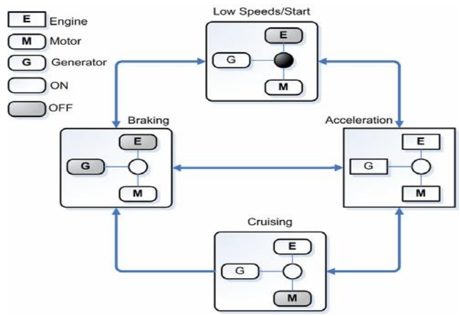
The power-splitter component is modeled as a simpleplanetary gear, as shown in Figure 6. With these building blocks, more complex gear topologies can easily be constructed and tested within the overall system model.



Power-splitter modeled as a planetary gearwith connections

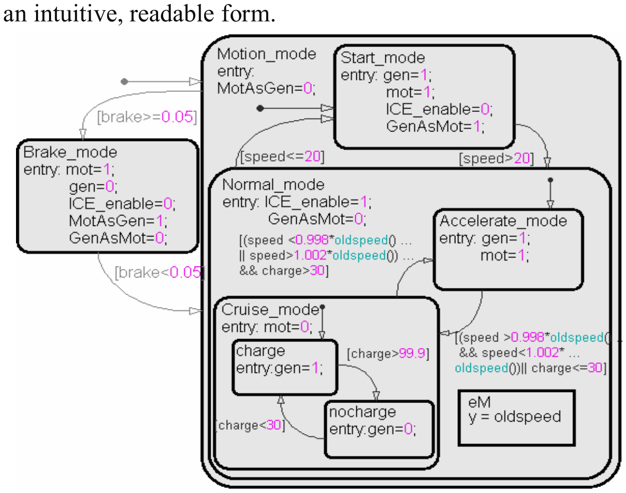
Mode Logic

For efficient power management, an understanding of the economics of managing the power flow in the systemis required. For example, during deceleration, the kinetic energy of the wheels can be partially converted to electrical energy and stored in the batteries. This impliesthat the system must be able to operate in differentmodes to allow the most efficient use of the power sources.

We used the conceptual framework shown in Figure 7 tovisualize the various power management modes.

Algorithm design starts with a broad understanding of the various possible operating modes of the system. In our example, we identified four modes—low speed/start, acceleration, cruising, and braking modes. For each of these modes, we determined which of the power sources should be on and which should be off.

The conceptual framework of the mode logic is easily implemented as statechart. Statecharts enable thealgorithm designer to communicate the logic in an intuitive, readable form.



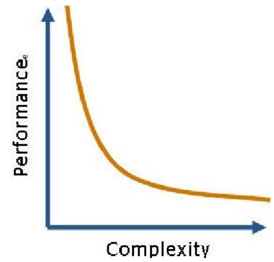
Mode logic modeled with Stateflow

, the Stateflow chart has two notable differences. The "acceleration"and "cruise" states have been grouped to form the "normal" superstate, and the "low speed/start" and "normal" states have been grouped together to form the "motion" superstate. This grouping helps organize the mode logic into a hierarchical structure that is simpler to visualize and debug.

Simulation Performance

The final system-level model of the HEV will containdetailed lower-level models of the various components. As model complexity increases, it will take longer tosimulate the model in the software environment. This behavior is expected because the model contains more variables, equations, and added components which incur an additional computational cost. Intuitively, this can be visualized as an inverse relationship between simulation performance and complexity of the model.

Running the simulations in a high-performance computing environment can offset the increase insimulation times that comes with increased complexity. . With the advent of faster, multicore processors, it is possible to run large simulations without having to investin supercomputer technology.



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