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A Review on Performance Analysis of High performance EV Powertrain model

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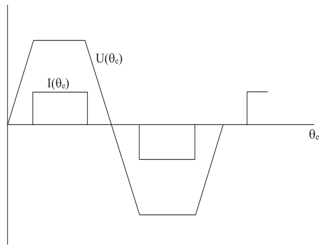
***Abstract* —** The *main goal of this research project is to capture the transient behaviour of the entire powertrain while using true physics-based dynamics rather than conventional charts and maps. A thorough description of the longitudinal car's multi-body model is provided, along with mathematical representations of the vehicle's suspension, aerodynamic behaviour, and continuous variable transmission (CVT). The d q frame models the PMSM and PMSG as well as DC/AC and AC/DC. It is suggested that a novel frictional torque function be used to forecast all mechanical and electrical losses aside from resistance loss. The proposed frictional torque function's findings are in good agreement with those found in empirical sources. To guarantee the simplicity and viability of the simulation in a reasonable amount of time, average models for AC/DC, DC/AC, and DC/DC converters are utilised. To model the transient operation of the series HEV powertrain during various modes of operation, a unique DC-link control technique is presented. The supervisory control is put into place to satisfy the driver's need for traction power while also preventing over-discharging of the battery below a predetermined level and optimising the efficiency of the drive train, fuel consumption, and emissions. The present work proposes a novel "load follower" supervisory control approach based on thermostat control and power follower. The performance of a driver model based on PI controllers appears to be sufficient when tracking the typical NEDC cycle. Energy balance calculations, accessible transient and steady state data points for individual components, as well as the simulation results are used to confirm.*

***Keywords* - Electric Vehicle, powertrain, series hybrid vehicle, series parallel hybrid vehicle, battery.**

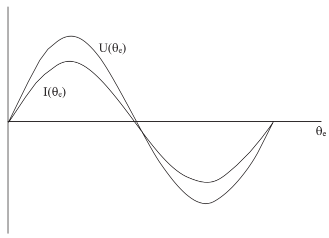
1. INTRODUCTION

Electrical parts such a generator, motor, and converters are included in the hybrid powertrain in addition to the IC engine to control energy flow. A revolving magnetic field in electrical machines is used to transfer energy from the mechanical to the electrical and vice versa. A motor is a device that transforms electrical energy from the input port into magnetic energy during the intermediary stage, and then into mechanical energy at the output port. The device is said to as a generator when the direction of energy flow is exactly reversed. The same machine can function as both a generator and a motor, depending on the flow of energy. The way that they operate and the sorts of energy that they use as input and output can be used to classify electrical machines.

A permanent magnet synchronous machine is one in which permanent magnets are used in place of the synchronous machine's rotor windings (PMSM). Similar to AC synchronous machines, PMSMs have multiphase stators, and the rotor speed is inversely proportional to the electrical frequency of the stator current. It can be made to have input/output characteristics that are very similar to a separately stimulated brush-type DC machine by implementing the proper control. Only the permanent magnet synchronous motor and generator are the subject of the current research.



(a) Brushless dc or trapezoidal flux



(b) Brushless ac or sinusoidal flux

2. OBJECTIVE

The present work is distinctive in that it offers precise dynamic mathematical modelling and simulation capabilities for every vehicle component, in contrast to existing modelling and simulation methodologies. Model-ling loss mechanisms take the place of efficiency maps. For instance, unique mathematical models for frictional losses in these machines are integrated with current electro-mechanical models to more correctly anticipate both dynamic and steady-state performance, as opposed to utilising efficiency maps to characterise the behaviour of generators and motors. In addition to actual relationships, modelling elements based on fundamental physics also capture the dynamics of the system. There are definitely limits to how much of the universe can be modelled entirely by elementary physics.

A supervisory controller is required because a hybrid powertrain uses various power sources, allowing for the best possible distribution of power between them. In the literature, numerous supervisory controllers with varying degrees of complexity have been presented. The majority of the sophisticated supervisory controllers based on optimization that are suggested in the literature are implemented on approximate steady state models of HEV powertrains. Implementing multiple supervisory controllers on more precise models with real-time component controllers and transient dynamics will be quite fascinating. These implementations will provide more precise and realistic predictions about how supervisory controls affect the vehicle's performance metrics.

2.1 Types of Hybrid Powertrain

Vehicles powered by IC engines have a power source with a very high energy density that can be quickly refuelled with liquid fuel. However, the engines in these cars frequently run very inefficiently (particularly at low speeds and torque), losing a lot of energy in the form of harmful pollutants and various inevitable losses. Except during strong acceleration, when a considerable amount of current is pulled from the battery, EVs experience very little loss in operation across the whole speed and torque range. However, the batteries used in EVs have a low energy density and are slow to recharge. As a result, both types of vehicles have some benefits and drawbacks.

2.1.1 Series hybrid powertrain

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Driver power Electric power

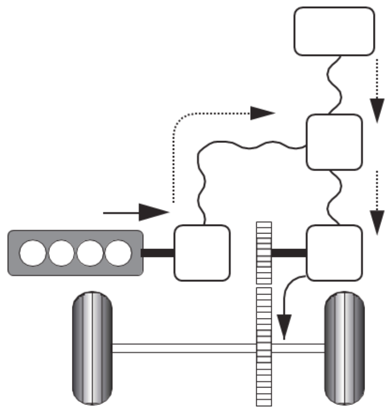

Figure 2.1: Schematic diagram of the Series Hybrid Electric Vehicle

2.1.2 Parallel hybrid powertrain

Both the IC-engine and the motor are connected to the transmission in a parallel hybrid powertrain. Both the motor and the IC-engine may simultaneously power the wheels in this system. The overall power flow travels along a parallel path from the power sources (the IC-engine and battery) to the wheels. This architecture has the advantage of allowing the engine size to be decreased and eliminating the requirement for a generator to power the vehicle. However, this architecture's primary flaw is that the battery can only be charged through regenerative braking, in which case the motor serves as the generator. This construction may be highly lightweight and compact in terms of the powertrain.

Driver power Electric power

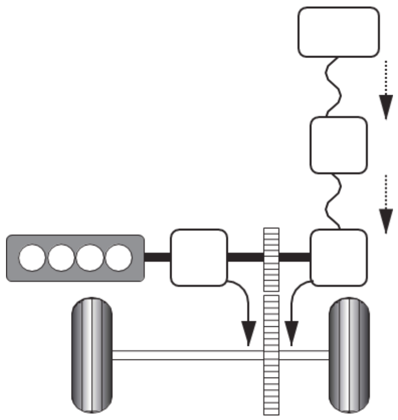

Figure 2.2: Schematic diagram of the Parallel Hybrid Electric Vehicle

2.1.3 Series-parallel hybrid powertrain

The advantages and drawbacks of series and parallel hybrid powertrains are discussed above; a series-parallel hybrid powertrain combines the advantages of both of these systems.

Two electric machines make up the powertrain in the series-parallel architecture, one of which serves as a motor to move the wheels and the other as a generator to charge the battery and start the engine. In order to provide the highest possible efficiency at all times, there is a power splitting device that determines the best power distribution for each power source. The schematic architecture of the series-parallel hybrid powertrain, also referred to as the power-split hybrid powertrain, is shown in Figure 2.3.

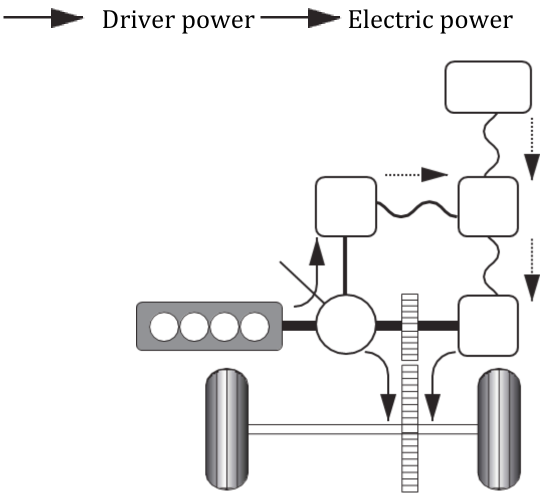

Figure 2.3: Schematic diagram of the Series-Parallel Hybrid Electric Vehicle

2.2 Advantages and disadvantages of using series hybrid powertrain

The benefits listed below are obvious in a series hybrid car. The engine is connected to the PMSG rather than being mechanically attached to the wheels. As a result, while driving, the engine is not exposed to severe transients. In comparison to typical steady state driving settings, transient driving conditions result in very high emissions and fuel consumption [24]. With a series hybrid powertrain, the engine can always operate safely in the best possible region depending on the demands and requirements of the driving environment. Designing an appropriate control architecture for engine running in a very small zone due to decoupling from the gearbox can further cut emissions. The transmission is substantially streamlined because the traction motor drives the wheels.

Due to its various energy conversion steps, the series arrangement has drawbacks when used for highway driving (long distance travel at high speeds on freeways) (i.e., from chemical to mechanical to electrical and then again to mechanical). The car may run in pure electric mode the most of the time and only use the engine when cruising or when more power is required, making it efficient for city travel. If the component efficiencies are increased such that the conversion losses are reduced, the series architecture can be even more beneficial.

2.3 Components of the HEV Powertrain

The primary goal of the current effort is to dynamically model the entire powertrain by combining dynamic models of each component. The present work will give comparable types of analysis utilising dynamic modelling in the next chapters. Analysis of energy losses, fuel consumption, efficiency, and performance with steady state models has already been reported in the literature. The goal is to simulate the system's transient reaction while maintaining its simplicity and viability in a reasonable time frame.

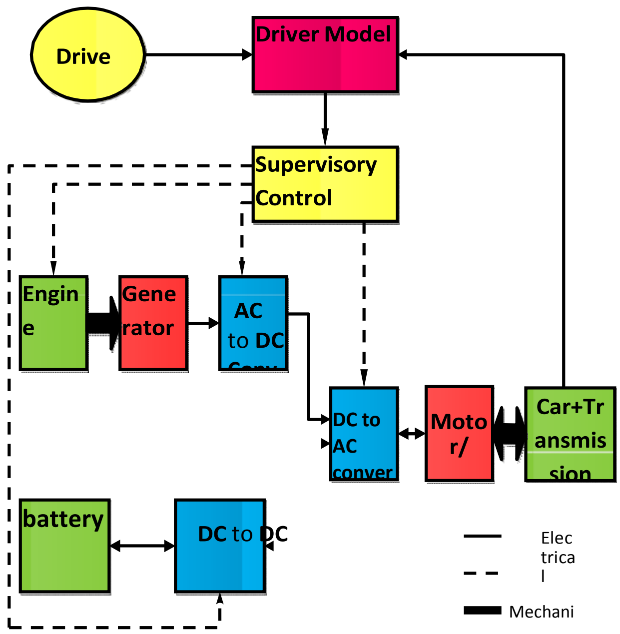

Figure 2.4: Complete structure of series hybrid vehicle powertrain

3. CONCLUSION

This research work focus on the performance analysis of the battery electric vehicle which monitors mechanical as well as electrical parameter of the powertrain with help of Simulink model. The simulated model was analyzed for highest %DOD and ECE cycle for highways drive cycle. It was observed after analyzing for urban and highway drive cycles we got minimum %DOD for urban where the efficiency remained nearly same for all drive cycles. However with the help of regenerative breaking BEV is able to work safe in all operating conditions which can increase its life. It can be concluded that it would be convenient to drive BEV at highways.

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