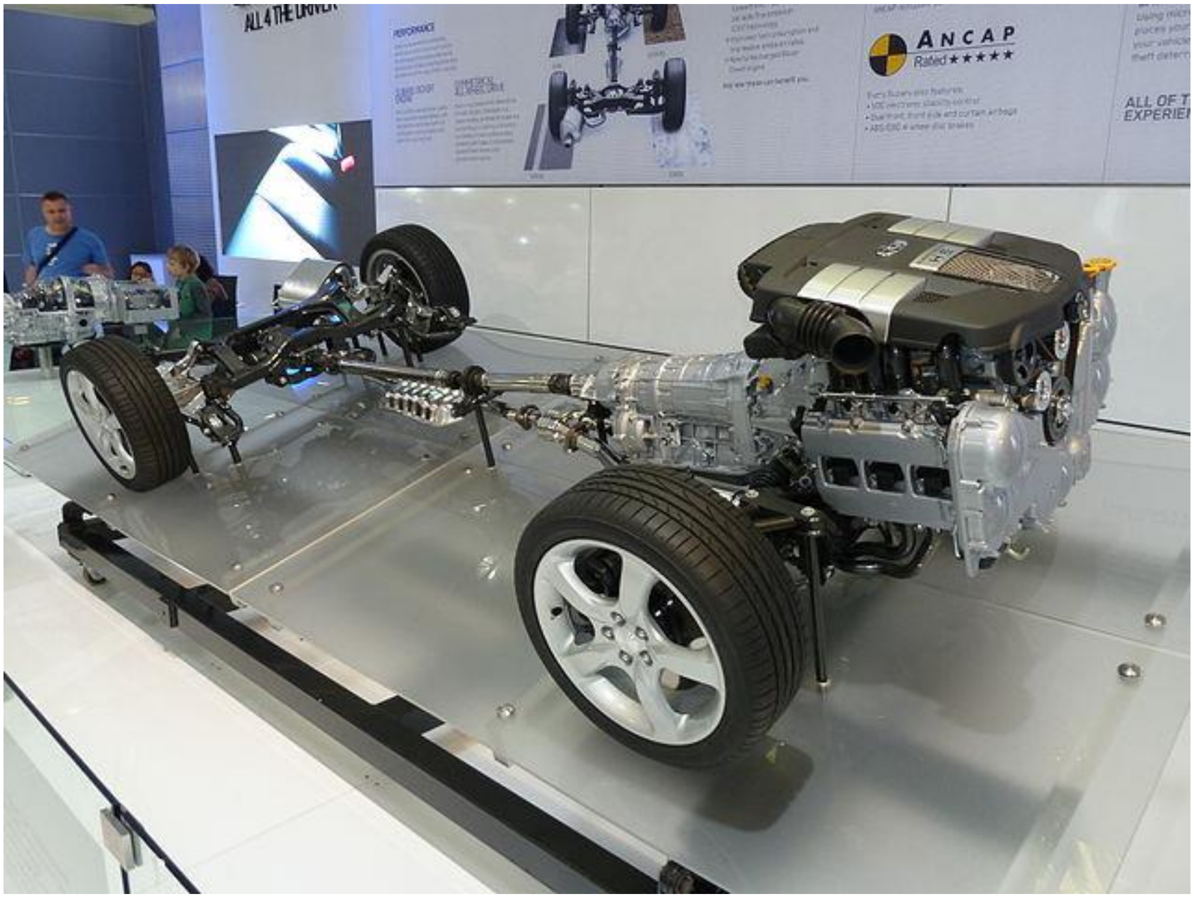
ISIEINDIA Private Limited
E – 210, 2nd Floor, Sector – 63, Noida – 201301
www.isieindia.com | 0120 – 4538457



Program: EV Powertrain Architecture and Energy storage system

Project: Powertrain Efficiency of an Electric Vehicle

Contents

Introduction

Electric vehicles (EVs) are gaining popularity due to their potential for reducing greenhouse gas emissions and dependence on fossil fuels. Achieving optimal efficiency in the power system of an electric vehicle is crucial for maximizing its range and minimizing energy consumption. This report aims to develop a mathematical model to simulate and optimize the efficiency of an electric vehicle's power system.

Objective

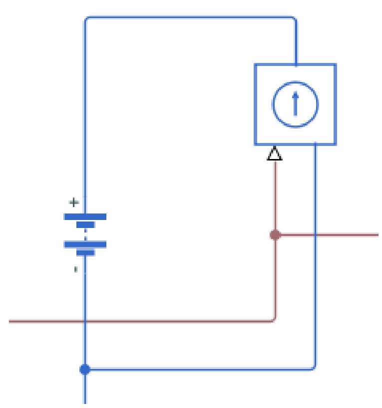
To develop a mathematical model that can simulate and optimize the efficiency of an electric vehicle's power system in terms of energy consumption (Wh/Km). The project aims to achieve the following goals:

- **Mathematical Equation:** Understanding of equation which is being used for calculation purpose.
- Represent Vehicle Dynamic Equations on Excel Sheet
- **Mathematical Model**: Develop a comprehensive mathematical model that accurately represents the energy flow and efficiency of each component in the electric vehicle power system.
- **Simulation**: Implement the mathematical model in MATLAB to simulate the behavior of the power system under different driving conditions and scenarios.

Methodology

BATTERY MODELLING

The battery block in Simscape is typically used as a voltage source in electrical circuits to represent a battery or energy storage device. It can be connected to other electrical components such as resistors, capacitors, or motors to simulate the behavior of a battery-powered system.



Define the parameters

Battery Voltage = 320V

Ah Rating = 94Ah

By configuring the parameters of the battery block, you can simulate different battery characteristics and analyze their impact on the overall system performance, including voltage variations, current limitations, and energy storage capacity.

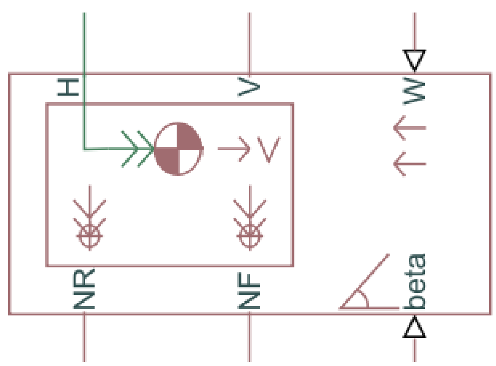
- Select a specific battery chemistry or application of interest for your project, such as lithium-ion batteries for electric vehicles
- Implement the selected battery model in MATLAB Simulink or any other simulation tool.
- Implement Coulomb Counting Method on MATLAB Simulink.

$$SoC(t) = SoC(t_0) + \int \frac{i(t)}{C} dt$$

VEHICLE DYNAMICS

The Vehicle Body block serves as the foundation for building a vehicle dynamics model in Sims cape. By connecting the Vehicle Body block to other mechanical components and applying appropriate forces and constraints, you can simulate the motion, stability, and handling characteristics of the vehicle in various driving scenarios.

It's important to note that the detailed modeling of the vehicle dynamics typically involves additional components and subsystems, such as suspensions, tires, and drivetrain models, which are connected to the Vehicle Body block to create a comprehensive vehicle simulation.



Perform vehicle dynamics analysis using MATLAB Simulink

Define the Parameters

Mass = 1470 kg

Frontal area = 2.91 m^2

Drag co-efficient = 0.15

Air Density = 1.225 kg/m^3

Perform Vehicle Dynamics analysis using MS Excel you can utilize various equations and numerical methods. The equations are:-

Aerodynamic Drag.

Force exerted by air on a moving object as it travels through the atmosphere. It is an important factor in vehicle dynamics, particularly for vehicles moving at higher speeds. To calculate aerodynamic drag, you can use the following equation:

$$F_{ad} = \frac{1}{2} * \rho * C_d * A * v^2$$

F_{ad} Is the drag force

C_d Is the drag coefficient (a dimensionless value that depends on the shape of the object)

ρ (Rho) is the air density

A is the reference area of the object

V is the velocity of the object relative to the air

Rolling Resistance

Force that opposes the motion of a vehicle's tires as they roll on the surface of the road. It occurs due to the deformation and recovery of the tire material and the interaction between the tire and the road surface. To calculate rolling resistance, you can use the following equation:

$$F_{rr} = \mu_{rr} * W$$

F_{rr} Is the rolling resistance force

μ_{rr} Is the rolling resistance coefficient (a dimensionless value)

W is the weight or load on the tire

Grading Force

Grade resistance or hill climbing resistance, refers to the force required to overcome the incline or gradient of a road or terrain. When a vehicle travels uphill or downhill, it experiences a gravitational force that needs to be considered in vehicle dynamics analysis. The equation for grading force is as follows:

$$F_{hc} = W * sin(\theta)$$

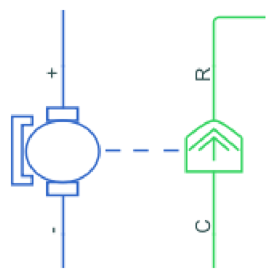
F_{hc} Is the grading force

W is the weight or load on the vehicle

θ is the angle of the incline or gradient

DC MOTOR MODELLING

In the model, use a DC motor due to the fact that a lot of electric vehicles work with DC motors. DC motor torque characteristics are represented by this block.
By configuring the parameters of the DC motor block and connecting it to other components in the Simscape model, you can simulate and analyze the behavior of the DC motor in response to various electrical inputs and mechanical loads.

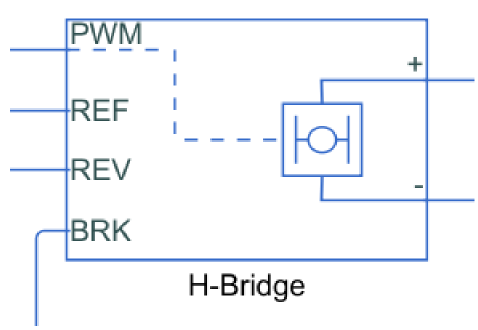


Define the parameter
Rated Voltage= 320V
Rated Load = 84 kW
No-Load Speed = 10000 rpm
Rated Speed = 3796 rpm

CONTROL SYSTEM

H-Bridge

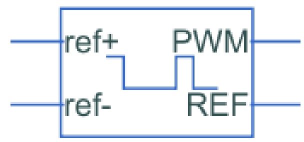
By configuring the H-Bridge circuit using appropriate Sims cape electrical components and providing control inputs, you can simulate and analyze the behavior of the H-Bridge configuration in controlling the DC motor. Note that the specific components and connections required may vary depending on the motor specifications and the desired control strategy.



ISIEINDIA Private Limited
E – 210, 2nd Floor, Sector – 63, Noida – 201301
www.isieindia.com | 0120 – 4538457

Controlled PWM Voltage source

Use the "Controlled PWM Voltage Source" block to generate a controlled PWM (Pulse-Width Modulation) voltage signal. This block allows you to specify the duty cycle and period of the PWM waveform, which can be used to control various systems, including DC motors.



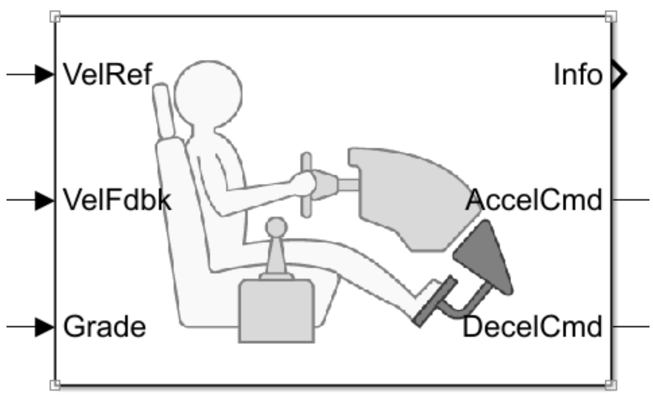
Controlled PWM Voltage

Define the Parameter

PWM Frequency = 4000

Longitudinal Driver Controller

Longitudinal driver control refers to the control of a vehicle's longitudinal (forward and backward) motion. It involves controlling the acceleration or deceleration of the vehicle to achieve desired speed or position tracking. In a vehicle dynamics context, longitudinal driver control is often associated with controlling the throttle and brake inputs to regulate the vehicle's speed and maintain desired behavior.

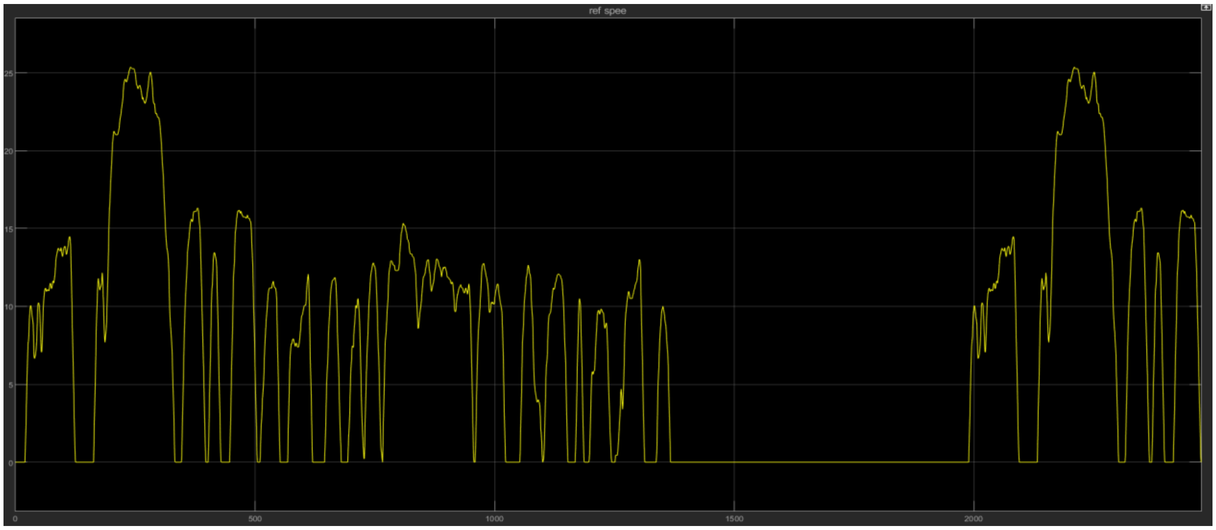


Longitudinal Driver

DRIVE CYCLE

In the context of vehicle testing and simulation, a drive cycle refers to a predefined pattern or sequence of vehicle operating conditions that represents typical driving behavior. Drive cycles are used to assess vehicle performance, fuel economy, emissions, and various other aspects of vehicle behavior under real-world driving conditions.

Drive Cycle Plot



Model Development

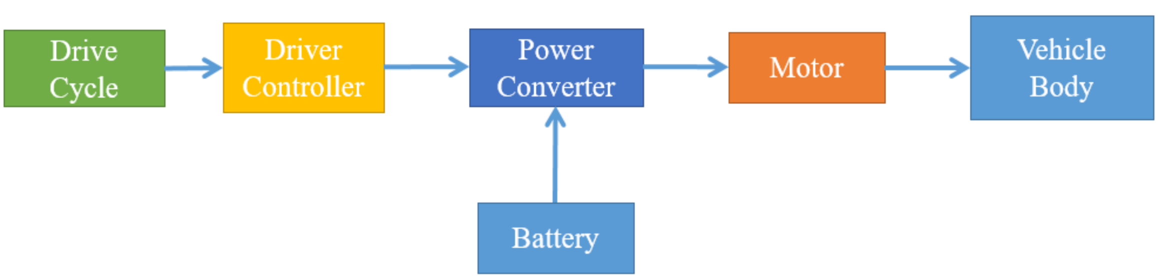
Energy Flow Analysis: Analyze the energy flow, considering input energy from the battery, losses in the power electronics, energy conversion in the motor, and energy consumption by auxiliary systems(if).

System Integration: Combine the individual efficiency models to create an overall efficiency model for the entire Vehicle

Control Strategies: Develop control strategies that optimize the power flow within the system to maximize efficiency. Consider factors such as regenerative braking, optimal power allocation between motor and auxiliary systems, and energy management algorithms for the battery.

Description of the data collection process (e.g., using a test vehicle, simulation data, or real-world data).

Model Block Diagram



Description of the MATLAB model developed for evaluating EV efficiency
Explanation of the model inputs and outputs
Discussion of the assumptions and simplifications made in the model

Results and Discussion

Presentation of the analyzed results using tables, graphs, and figures

Discussion of the factors influencing EV efficiency and their impact on the results

Expected Outcomes:

- Development of a mathematical model representing the electric vehicle powertrain system.
- Simulation results showcasing energy consumption (Wh/km) and system efficiency under various driving conditions.
- Exploration of strategies and modifications to improve the system's efficiency.

Conclusion:

Key factors influencing efficiency include motor efficiency, battery performance, regenerative braking efficiency, and control strategies.
The developed mathematical model provides valuable insights into energy consumption and system efficiency.
The project contributes to enhancing the overall energy efficiency of the electric vehicle powertrain system.