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Design and simulation of Battery electric vehicle using MATLAB Simulink

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ABSTRACT:

More and more researchers are focusing on the modeling of electric vehicles. One of the most important problems the world's ecosystems are currently confronting is the decrease of greenhouse gas emissions and energy consumption. Even if the actual trajectory of energy is uncertain, we believe that transportation will play a critical role in maintaining it. This study used the MATLAB-Simulink platform to simulate a BEV model and evaluated the various components of the BEV system. MATLAB-Simulink is utilized in this project to develop the BEV components and integrate the entire system. The outputs of this design are the voltage, current, and state of charge values. The car will describe how much energy is discharged when it is traveling and provide information about current and voltage in this project, which is based on voltage, current, and state of charge bases. It was also utilized to simulate the BEV model and related formulas. The required electrical system parts were also identified, along with the corresponding equations for validation. In order to reduce greenhouse gas emissions, we suggested in this project to model the demand for BEVs in the transportation sector going forward. The first step in modeling this is to understand the properties of the parameters and select the appropriate ones for MATLAB simulation of each component. We are also modeling a single app.

Keywords: - Battery Electric Vehicle, MATLAB-Simulink, Simulation, Energy consumption

Introduction :

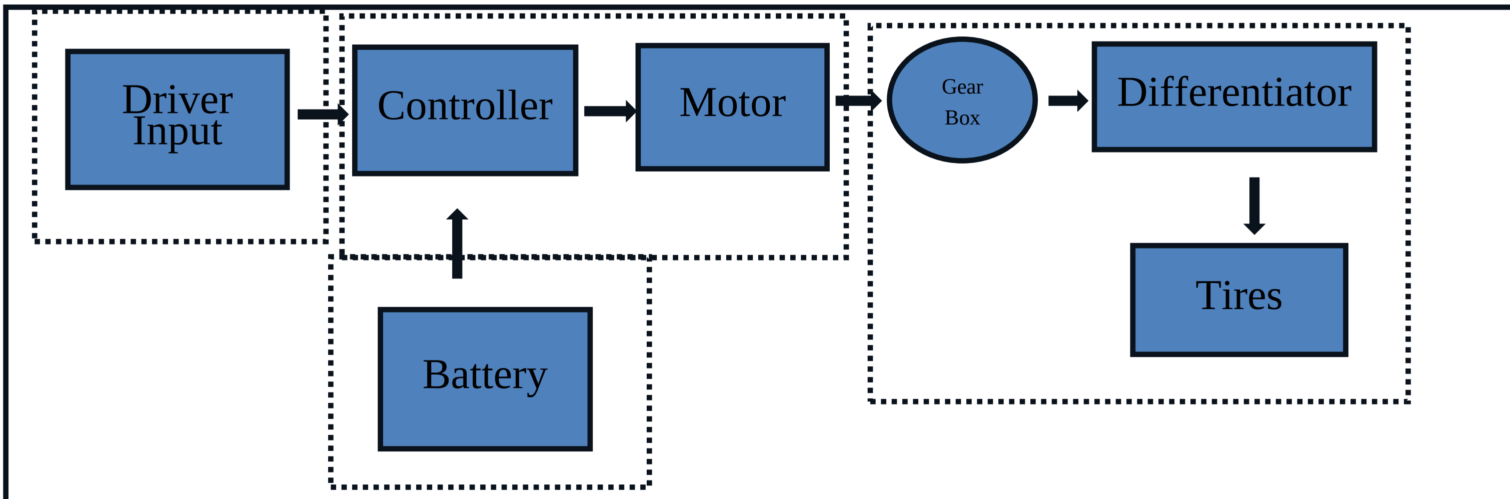
An electric vehicle (EV) is a vehicle type that runs on electrical energy stored in rechargeable batteries or other energy storage devices. It employs one or more electric motors for propulsion. Electric cars primarily run on electricity, as opposed to traditional internal combustion engine vehicles, which burn fossil fuels to provide power. The automotive industry is undergoing a significant transformation, driven by the increasing concerns over environmental sustainability and the need to reduce greenhouse gas emissions. In response to these challenges, there has been a growing interest in the development and adoption of electric vehicles as a cleaner and more sustainable alternative to traditional internal combustion engine vehicles. Among various types of electric vehicles, Battery electric vehicles (BEVs) have gained considerable attention due to their emission operation and potential to significantly reduce dependence on fossil fuels. BEVs rely solely on electric propulsion, utilizing rechargeable batteries as their primary source of energy. This reliance on electricity makes BEVs an attractive option for reducing carbon emissions, particularly when powered by renewable energy sources. The development and optimization of BEVs heavily relies on their design and simulation. The development of simulation tools such as MATLAB Simulink has allowed engineers and researchers to precisely simulate diverse BEV systems and components in order to evaluate how well they function under various operating situations. Before actual prototypes are constructed, this enables iterative design optimizations and upgrades, thereby cutting down on development time and expenses. In this research, we use MATLAB Simulink to build and simulate a battery-electric car. Our goal is to give a thorough rundown of the modelling procedure, including important elements such the electric motor, battery pack, power electronics, and vehicle dynamics.

Literature Survey :

The articles concentrate on the analysis and optimization of battery-electric vehicles (BEVs) using mathematical modelling, simulation-based parameter evaluations, and energy consumption analysis. They seek to determine the best setups and settings in order to improve BEV performance, efficiency, and sustainability. Without doing a lot of actual testing, researchers investigate ways to increase battery efficiency, range, and overall vehicle performance using simulations and mathematical models. These studies offer insightful information that will help advance BEV technology and advance environmentally friendly transportation.

A thorough review of the literature on battery electric vehicle (BEV) design and simulation addresses a number of important topics. Scholars delving into battery technology investigate cutting-edge lithium-ion chemistries such as LiFePO4, NCM, LMO, and NCA, in addition to modelling approaches including physics-based, equivalent circuit, and electrochemical models. Studies of vehicle architecture cover a wide range of designs, such as platform-based, purpose-built, and hybrid setups, with an emphasis on powertrain components including motor choice and heat management systems that are optimized. The goal of energy management research is to reduce consumption and increase driving range by using optimization-based techniques and predictive control algorithms. Vehicle dynamics and performance are modelled with the help of simulation programs such as MATLAB/Simulink, AVL Cruise, and OpenModelica. This modelling is essential for assessing energy economy, braking, and acceleration. A crucial component of BEV integration is the smart charging infrastructure and electric grid impact analysis; studies have focused on vehicle-to-grid (V2G) technology, optimization for mass deployment, and grid impact analysis. The utilisation of this multifaceted approach enables a more profound comprehension and progression of BEV design and simulation techniques.

Block Diagram :



4.Modelling operating principles of EV :

The BEV and its components were recreated to investigate energy flow, performance, and efficiency. MATLAB-Simulink shows battery voltage, current, and state of charge information. The goal is to optimize the battery's voltage, current, potency, state of charge, and component size while minimizing energy consumption using modelling and simulation.

1.Vehicle Longitudinal Dynamics:

The longitudinal dynamics of a Battery Electric Vehicle (BEV) refer to the forces and motions that cause the vehicle to accelerate and decelerate along its route of travel. This covers things like traction force, air resistance, rolling resistance, and braking force. Understanding these dynamics is critical to improving the vehicle's performance, energy efficiency, and overall driving experience. For example, longitudinal dynamics have a considerable impact on the vehicle's range, which is a major concern for BEVs due to limited battery capacity. The longitudinal dynamics are influenced by factors such as vehicle mass, aerodynamics, tire properties, and electric powertrain efficiency.

$$M\frac{dy}{dx} = (F_{tf} + F_{tr})-(F_{rf} + F_{rr} + F_{ad} + F_{hc}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where M is the vehicle mass, $\frac{dy}{dx}$ is the linear acceleration of the vehicle along the longitudinal direction. F_{tf} and F_{tr} is the traction force of the front and rear tires, F_{rf} *and* F_{ff}s the rolling resistance force of the front and rear tires, F_{ad} is the aerodynamic drag force and F_{hc} is the hill climbing force.

2.Motor model

There are many ways to measure motor speed, including instructions and voltage. The equation clearly indicates that it is an input to the motor controller.

$$W_v = \alpha U + b$$

Where U is the characteristic curve that approximates a line, V is the motor speed regulation instruction voltage, and a and b are the equation coefficients that differ with the motor load.

The motor model is based on a dc motor with a stiff rotor and shaft. Friction torque is proportional to shaft angular velocity.

$\frac{d^2\theta}{dt^2} = \frac{1}{J}\left(K_t i - b\frac{d\theta}{dt}\right)$ ……………………………..(2)

$\frac{di}{dt} = \frac{1}{L}\left(-Ri + V - K_e\frac{d\theta}{dt}\right)$ …………………………(3)

here $\frac{d\theta}{dt}$ is the angular velocity, $\frac{d^2\theta}{dt^2}$is the angular acceleration, $\frac{d^2\theta}{dt^2}$ is the moment of inertia, b is the motor viscous friction constant, $K_t$is the motor torque constant, K_e is the electromotive force constant.

The DC motor model depicts the motor's electromechanical characteristics. This encompasses torque-speed characteristics, efficiency, and power output. Typically, DC motors are represented by equations that characterize their electrical and mechanical characteristics.

3.Battery Charge Controller Mode:

The longevity of the batteries is due to this tool. It is crucial for developing the electric system of a BEV with an efficient Battery Management System (BMS). The State of Charge (SoC), measurement, cell balancing, battery voltage, current, and temperature are all displayed by the BMS. This model covers a basic battery pack and is based on the IRIZ battery.

The battery's overall charge is simply deducted from the motor's current draw. Next, the battery's voltage output is obtained using a typical discharge graph plot. The charge state (SOC) is

$$SOC = \frac{C_{max} - C_{used}}{C_{max}}$$

Vehicle Parameters:

Electric The vehicle design parameters in might be divided into three categories: (1) vehicle parameters, (2) electric element parameters, and (3) environment parameters. Vehicle parameters comprise information regarding the mass, rolling resistance, frontal area, drag coefficient, brake and steering forces, and tire specifications of the vehicle. The inclination angle, wind speed, and tire inflation factor are included in the environmental parameters, while the features of the electric motor, battery pack, motor controller, and battery charger are included in the electric elements.

Circuit Diagram:

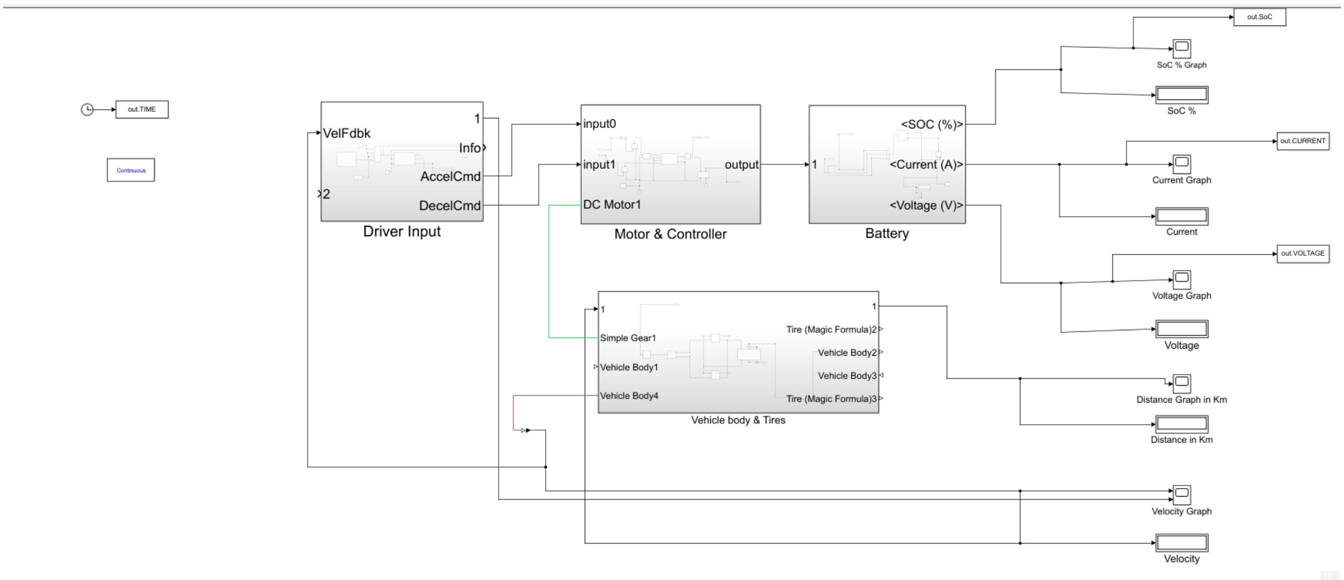


Fig 1 . Circuit Diagram

This circuit diagram explains the working of battery electric vehicle by using battery voltage, current and state of charge**.**

Simulation Results:

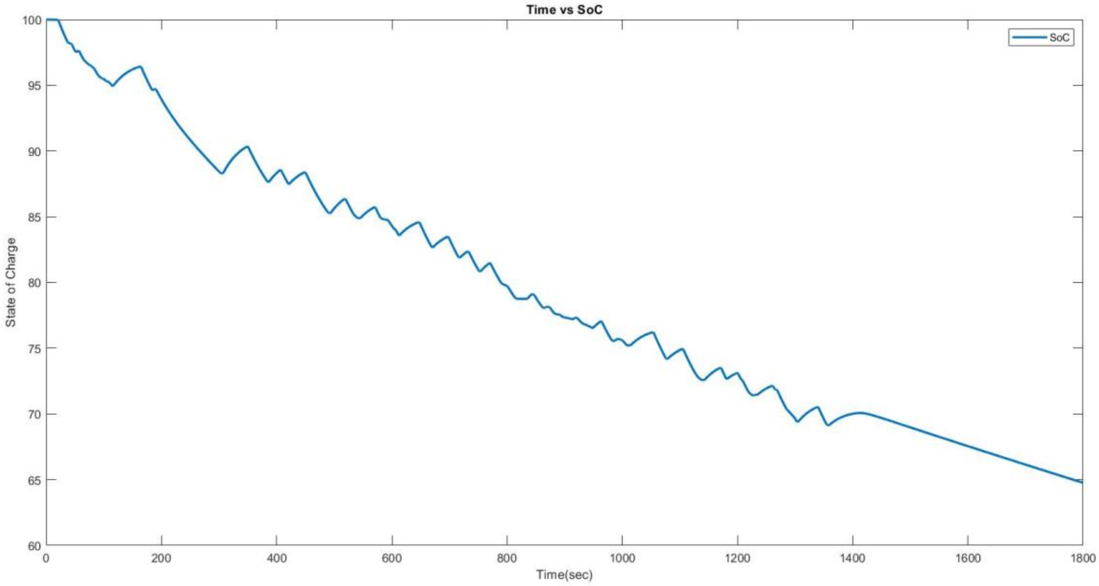


Fig 2 FTP-75 we gave 1800 seconds State of Charge graph

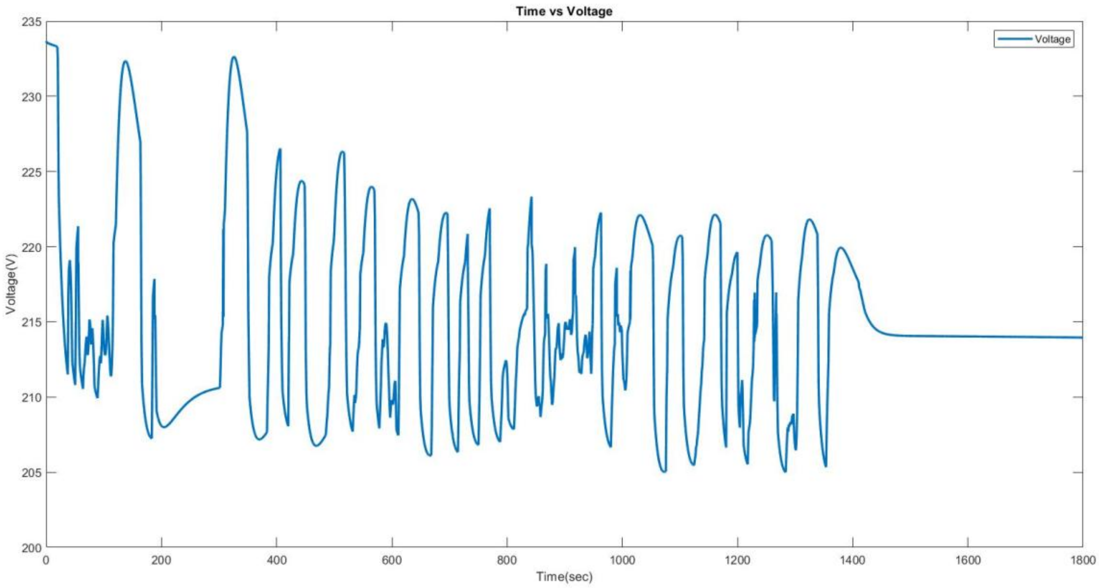


Fig 3 FTP-75 we gave 1800 seconds Voltage graph

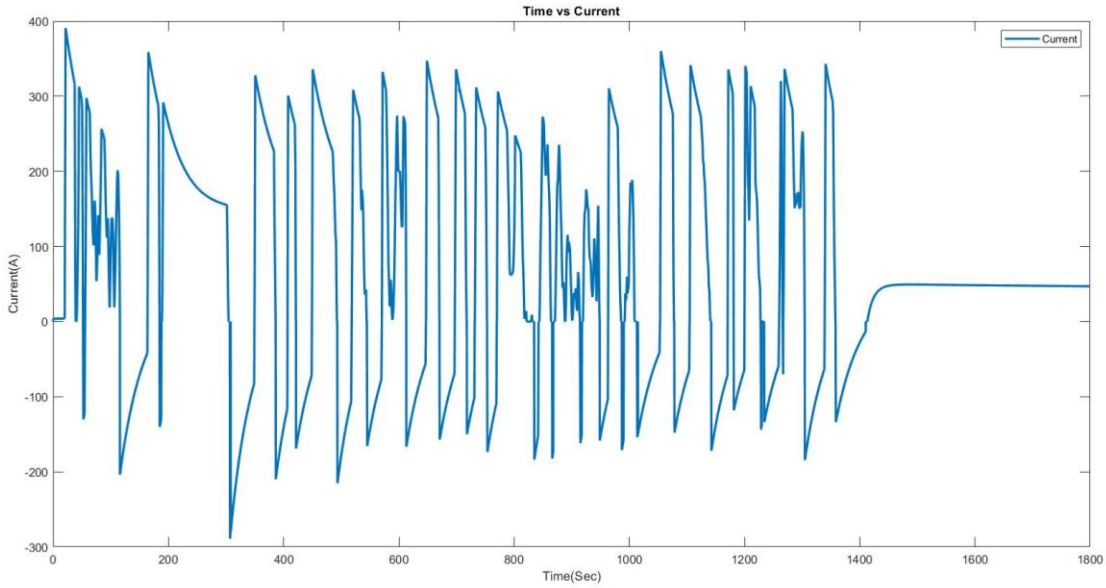


Fig 4 FTP-75 we gave 1800 seconds Current graph

Working Of Lithium-ion Battery :

The lithium-ion battery works on the basis of circulating electrons through the creation of a potential difference between two electrodes, one positive and the other negative, submerged in an electrolyte, a conductive ionic liquid. The discharging phase occurs while a battery is powering a device because the electrons built up in the negative electrode are released to move to the positive electrode via an external circuit. On the other hand, when the battery is being charged, the electrons are transferred from the positive electrode to the negative by the energy provided by the charger.

The various battery types differ in terms of the associated electrolytes, electrode materials, and ion kinds. For instance, the 12-volt lead-acid battery that is typically used to power a car's combustion engine starter depends on lead-based electrodes and an electrolyte that contains lead ions. Regarding the lithium-ion battery, its nomenclature comes from the fact that it operates on lithium ions (Li+). A lithium-ion battery, like the one found in the ZOE, is made up of several battery units, or cells, that are coupled to one another and are under the control of a certain electronic circuit. The battery's capacity, or the total quantity of electricity it can store, is determined by the number, size, and arrangement of its cells as well as the voltage it delivers. In the automotive sector, this is typically expressed in watt-hours (Wh) or kilowatt-hours (kWh).

Methodology:

Battery electric vehicles (BEVs) require several critical stages for modelling and simulation. Gather data first on the characteristics of the battery, the motor's efficiency, and the vehicle's dynamics. Next, develop mathematical models that show how these parts behave while accounting for factors like vehicle mass, powertrain efficiency, and energy consumption. These models can be included into simulation software to replicate real-world driving conditions and evaluate performance metrics like range, acceleration, and energy usage. Cross-check the simulation results with empirical data from real tests to ensure correctness. Iterate and update the models in response to validation feedback to enhance their predictive power. Utilize environmental details like temperature and terrain to increase realism even further. Lastly, use the validated simulation tool for a range of activities such as calculating the ideal battery size, assessing increases in vehicle economy, and developing control schemes for the best possible energy management.

Conclusion:

The report underscores the critical importance of addressing climate change by reducing energy consumption and greenhouse gas emissions. It highlights transportation as a key sector for achieving sustainability goals and emphasizes the urgent need for action. MATLAB-Simulink emerges as a powerful tool for modeling. Battery Electric Vehicles (BEVs), enabling the creation, integration, and detailed analysis of BEV components. Through simulations, the program provides valuable insights into the performance of BEV systems, with outputs such as voltage, current, and state of charge data offering crucial information on energy usage and battery performance. By leveraging MATLAB-Simulink, researchers can better understand the complexities of BEV technology and make informed decisions to advance sustainable transportation solutions in the face of climate change challenges.

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