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PERFORMANCE ANALYSIS OF AN E-VEHICLE

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Abstract: In recent years there is a rising interest in the study of Electric vehicles. The constant environmental threats due to pollution and fuel consumption as well as economic constraints to a fuel cars are paving the way for an all-electronic mode of transportation.

The paper aims to develop and simulate a model of an electric vehicle and analyse its parameters. The model uses a feature of regenerative braking to make it energy consumption efficient. The model consists of all the main components like battery, motor, motor controller and a PI controller. The plotted results are presented and discussed.

Keywords:- *Cloud computing, multi-keyword top-k search ,privacy preserving, random traversal, data encryption.*

I INTRODUCTION

Conventional vehicles work on an internal combustion engine that generates power by burning different fuels such as petrol or diesel. But over the years, it has been observed that this method is causing a lot of pollution and is even one of the reasons for global warming. This reason combined with depletion of natural resources put forward the need for an Electric Vehicle. As opposed to conventional vehicles, an E-vehicle operates on an electric motor. A large traction Battery pack is used to power the electric motor and the vehicle must be charged to a PowerPoint. Since it runs on electricity, there is no question about exhaust emitting.

A very early model of an Electric motor was invented in 1828 by Anos Jedlik. He created the small model car with his newly invented motor. But the practical car only came into being after rechargeable batteries that could store electricity was invented. And so, in the year 1881, the first people carrying electric motor with its own source came into the picture in Paris designed by French inventor Gustave Trouve.

II LITERATURE REVIEW:

[1] Ahmet OnurKiyakli, HamitSolmaz,"Modelling of an Electric Vehicle with Matlab/Simulink" International Journal of Automotive Science and Technology,2018 Vol 2.

This paper focused on creating a dynamic model of an electric vehicle on MATLAB/SIMULINK. The model determined energy consumption values and the effect of various parameters on energy consumption was observed. The model used two different drive cycles for simulation: NEDC and WLTP. The model consumed 15.82 kWh of energy per 100 kilometers.In the WLTP cycle, the vehicle consumes 17.93 kWh of energy per 100 kilometers and the vehicle had a 157 kilometers range.

[2] David McDonald," Electric Vehicle Drive Simulation with MATLAB/Simulink"

This paper presented a simulation of a basic electric vehicle. The model was used to investigate power flow during motoring and regeneration. The model consisted of an electric battery, motor controller, permanent magnet motor and a proportional integral controller. The model created was used to determine performance of the system and energy flow over a given set of speed/torqur conditions.

[3] Electric Vehicle Battery Parameter Identification and SOC Observability Analysis: NiMH and Li-S Case Studies July 2017IET Power Electronics 10(11)

This study focussed on electric vehicle battery management systems. Battery model identification was performed to be applied in e-vehicle bms. Circuit battery model parameterization was performed on two casesi.enickel-metal

hydride (NiMH)and lithium-sulfur (Li-S)using the Prediction-Error Minimization algorithm applied to experimental data. Li-S cell performance was tested based on urban dynamometer driving schedule (UDDS).The results were validated against exact values of battery parameters.Battery State Of Charge parameters were also discussed. Lastly, UDDS tests at 5,10,20,30,40 and 50 degree Celsius were repeated to discuss the effects of temperature on the results.

III. DESCRIPTION OF E-VEHICLE

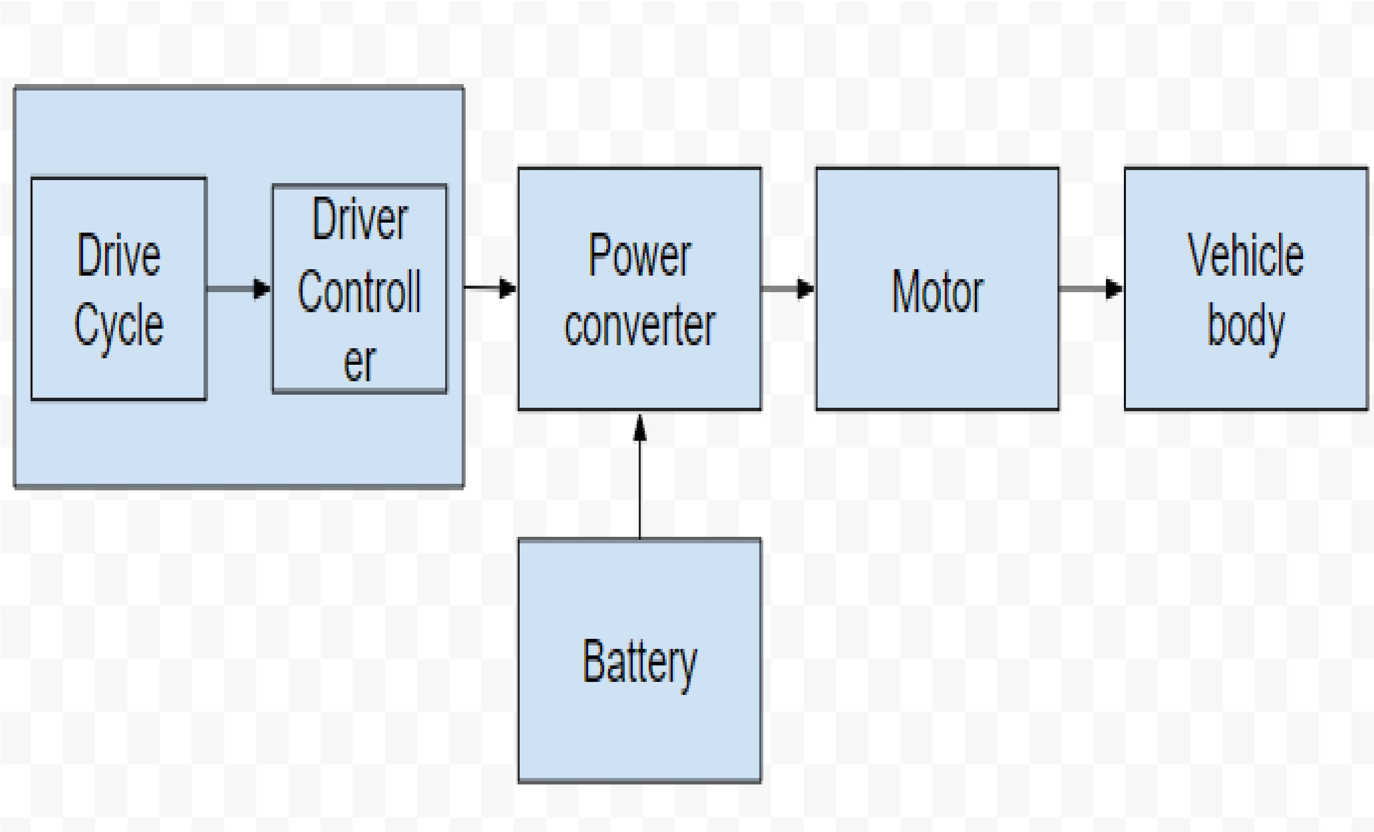

Figure 1: Block Diagram of the model

Figure 1 shows the block diagram of the model of an electric vehicle. A vehicle body will be connected through the transmission gear system to a Permanent magnet DC motor. A permanent magnet DC motor is used because it is the simplest motor to be followed. A battery will supply electrical power to the motor. The battery will have charging, discharging and SOC (State of Charge) calculations. The motor will then convert this electrical power to mechanical power to run the vehicle body. To control the vehicle, a motor controller is needed. The motor controllerused here is an H-bridge with regenerative braking power controller. Regenerative braking will ensure that when the vehicle is deaccelerating, the kinetic energy will be given back to the battery where the motor will act as a generator. Hence battery will feed the power to the power converter and the power converter will supply a controlled voltage and current to the motor and therefore the vehicle will be controlled.

To give a reference to themodelabout the conditions it will run on, a Drive Cycle will be needed. Drive cycle will be given to a driver controller and the same driver controller will give commands to the power controller. The drive cycle and driver controller together will refer to the simulation.

IV. DRIVE CYCLE

Invehicle modelling, the performance of the model is evaluated using different drive cycles.

The information included in various drive cycles is known to influence the optimization of the model and so including more drive cycles in the simulation will help to create a model suitable for different parameters.

4 different drive cycles are used to evaluate the performance of the model: -

a. Federal Test Procedure(FTP)
b. Urban Dynamometer Driving Schedule(UDDS)
c. The Highway fuel economy test(HWFET)
d. US06

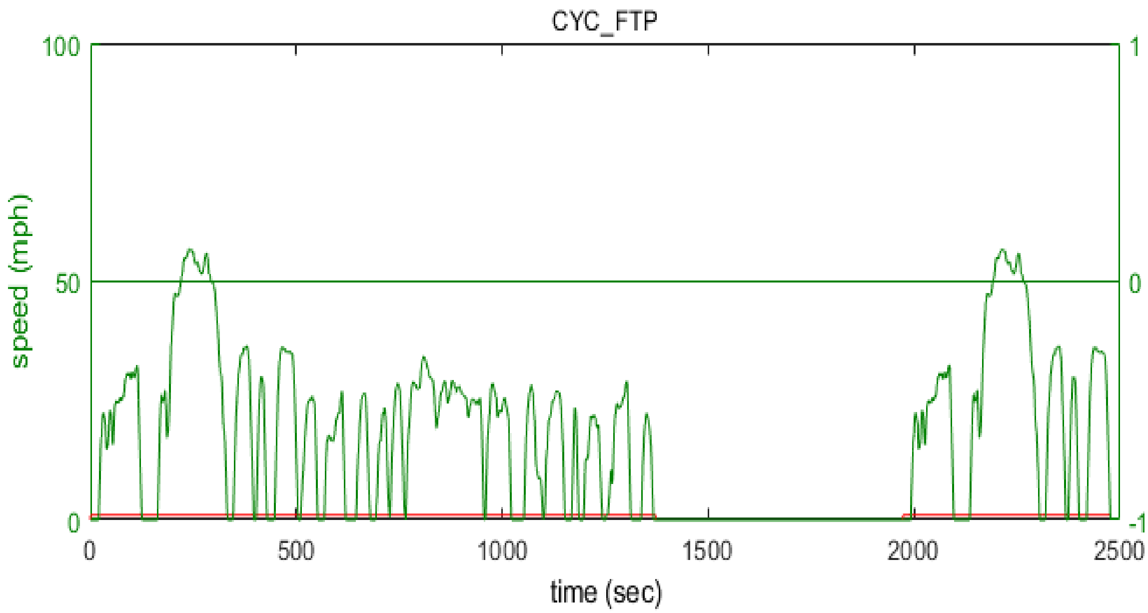

Figure 2:Drive Cycle- FTP

The drive cycle FTP as shown in Figure 2 simulates a distance of 11.4 miles and an average speed of 21.2 mph. It reaches maximum speed at 56.7 mph.

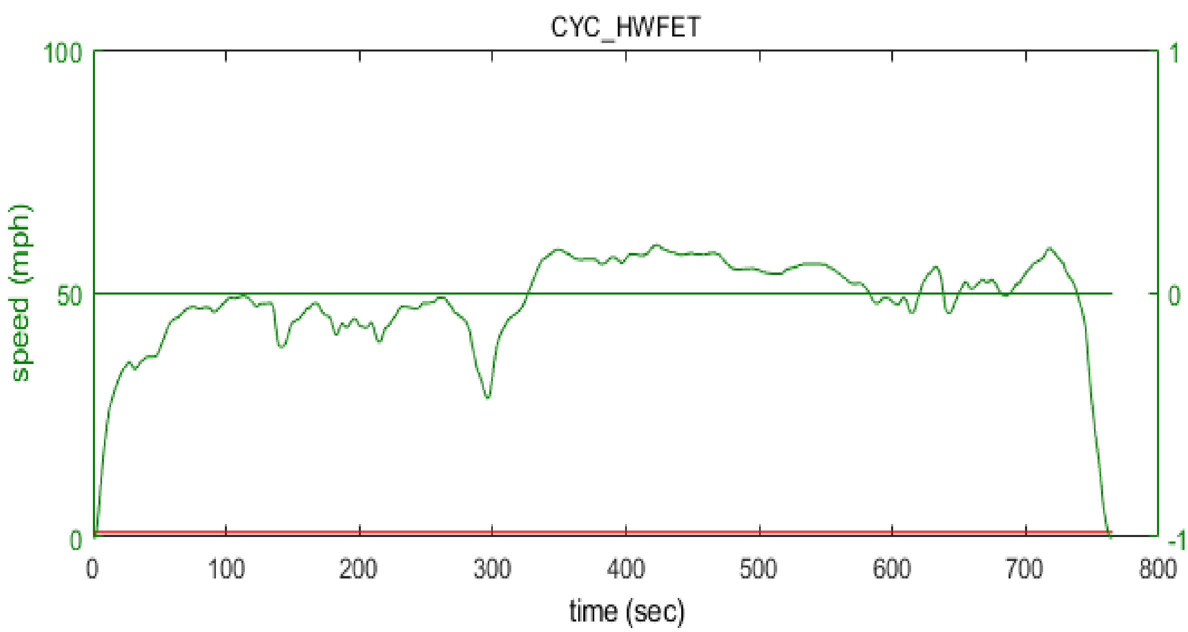

Figure 3: Drive Cycle-HWFET

The drive cycle for HWFET is shown in Figure 3 which uses an already warmed up engine. It travels with an average speed of 68mph and reaches a top speed of 60 mph over a 10-mile distance. This drive cycle has no stops in between.

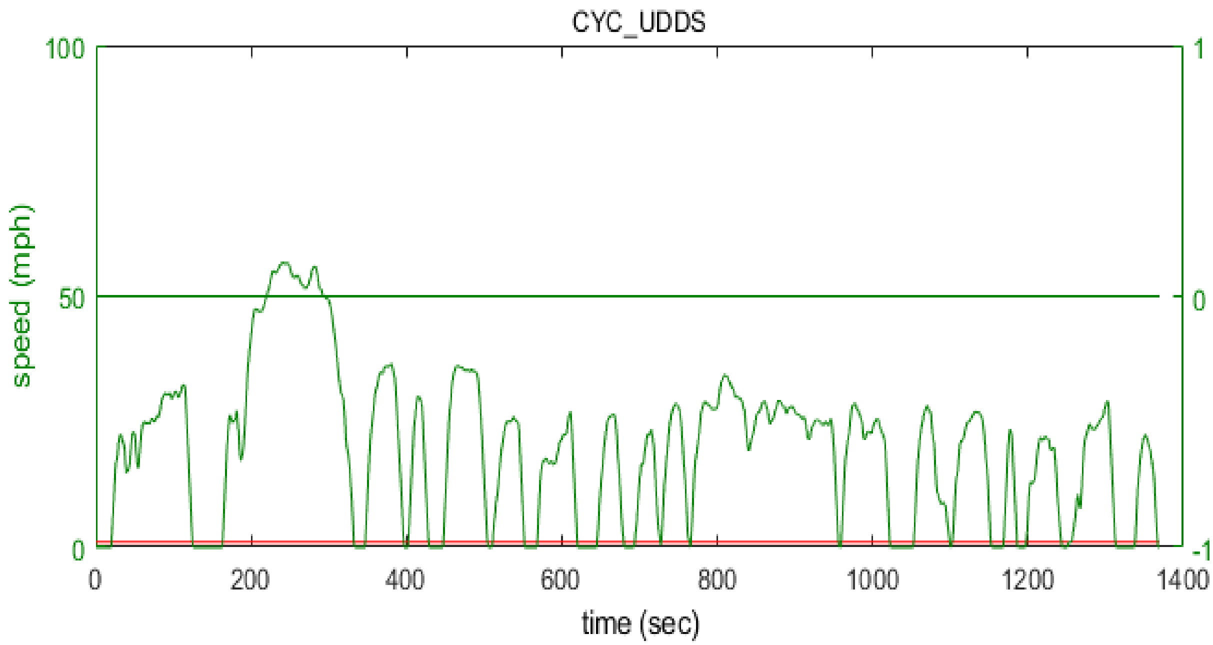

Figure 4:Drive Cycle-UDDS

UDDS drive cycle as shown in Figure 4 covers an urban route of 7.5 miles. According to the figure,it can be deduced that the vehicle takes a lot of stops. This drive cycle attains a maximum speed of 56.7mph and an average speed of 19.6mph.

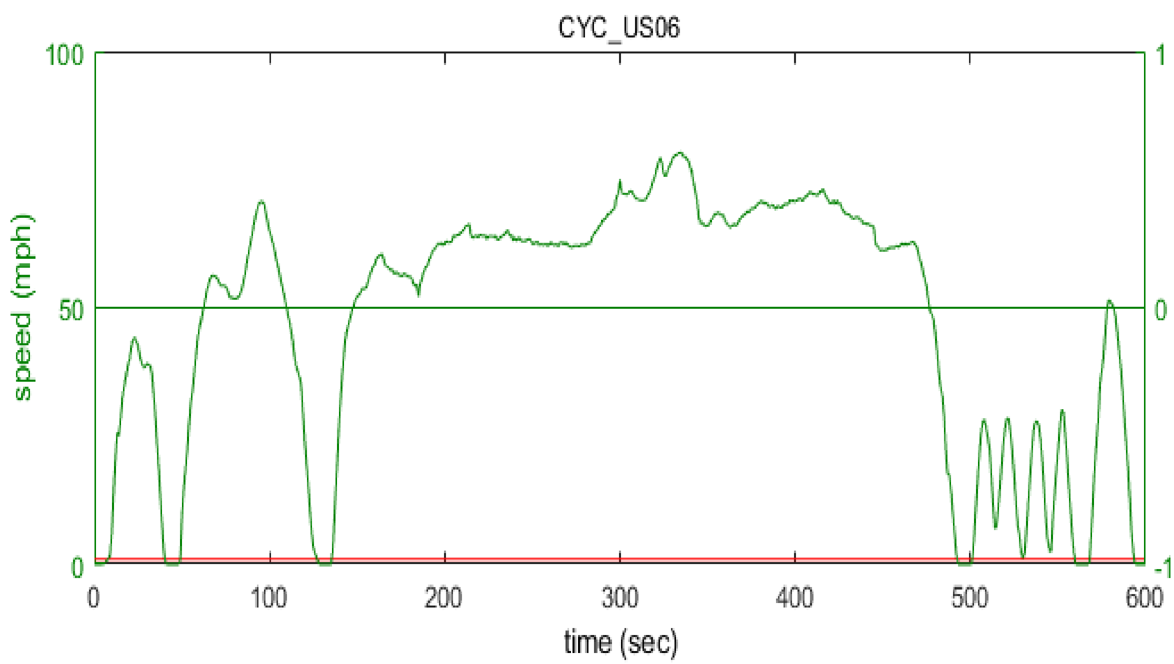

Figure 5: Drive Cycle-US06

SFTP (Supplemental Federal Test Procedure) US06 shown in Figure 4 simulates a high speed/quick acceleration loop lasting for 10 minutes. This cycle covers a distance of 8 miles and the average speed is of 48mph reaching top speed at 80 mph.

V KEY COMPONENTS

DC Motor

The DC motor block in MATLAB/Simulink represents the electrical and torque characteristics.

This block assumes that there is no loss in electromagnetic energy, therefore the back electromotive force and torque constant have the same numerical value.

Battery

In MATLAB/Simulink there is a battery block available which is used. For the battery charge capacity parameter, if it is selected as infinite the block models the battery as a series internal resistance and constant voltage source. And if the same is selected as finite then the block models the battery as a series internal resistance plus a charge dependent voltage source given by

$$V = Vnom * \frac{SoC}{1 - beta * (1 - SoC)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where SoC= State of Charge, Vnom =nominal voltage and beta is a coefficient calculated to satisfy a user-defined data point [AH1,V1].

Motor Controller

An H-Bridge motor drive block has been used as a motor controller. InMATLAB/Simulink this block can be driven by the Controller PWM Voltage block in two different modes i.e. either in PWM mode or in Averaged mode. In PWM mode, the motor is powered if the PWM voltage is above the enabled threshold voltage whereas, in Averaged mode, the PWM voltage divided by the PWM signal amplitude parameter defines the ratio of the on-time to the PWM period.

PI Controller

A Longitudinal driver block is used to model a PI controller. A longitudinal driver generates normalized acceleration and braking commands based on reference and feedback velocity.

VI SIMULINK MODEL

The E-vehicle Simulink model developed is as shown in Figure 6.

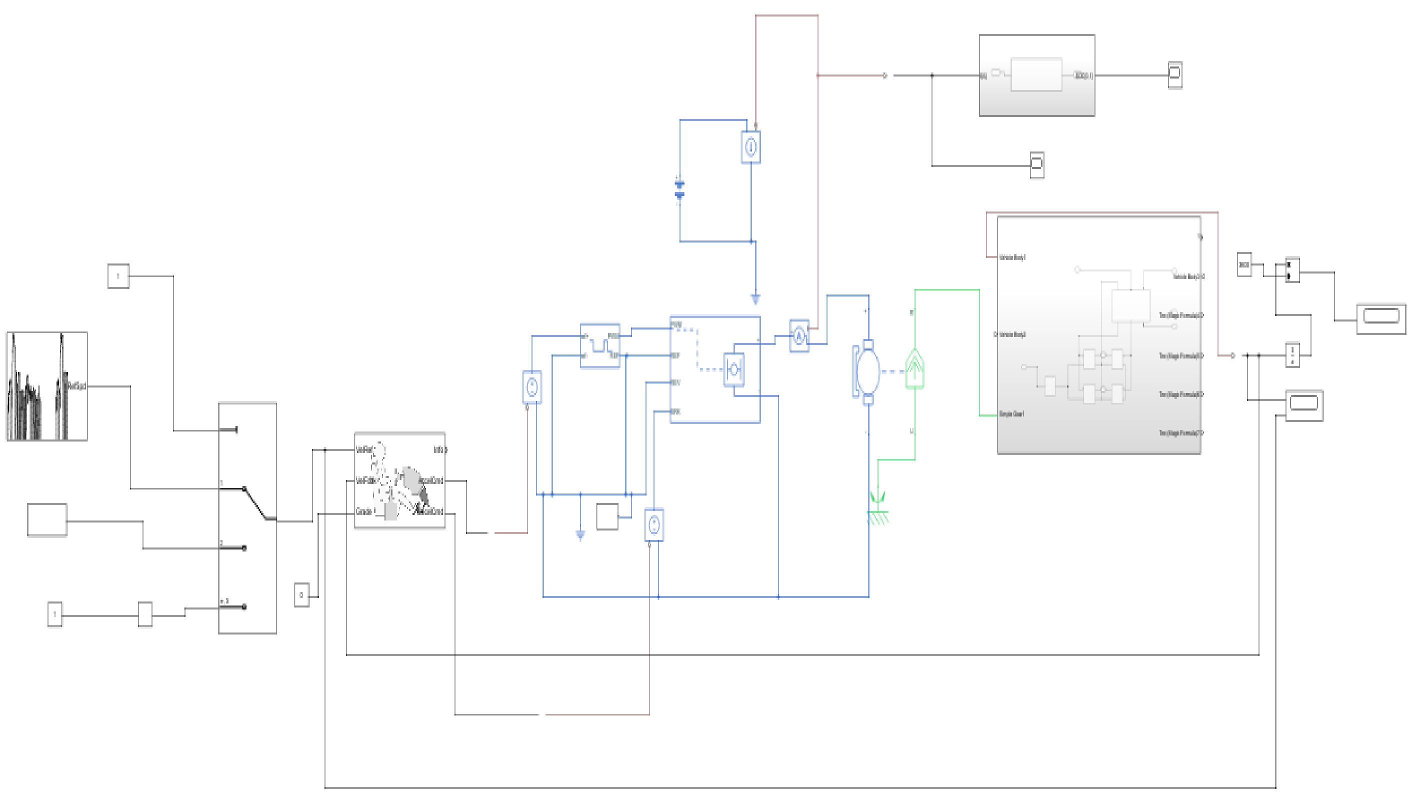

Figure 6:Simulink model

The model consists of two subsystems. The model can take input from different drive cycles through the multiport block. This is connected to the longitudinal driver that generates braking command. The longitudinal driver is further connected to the battery and then the battery to the H-bridge.

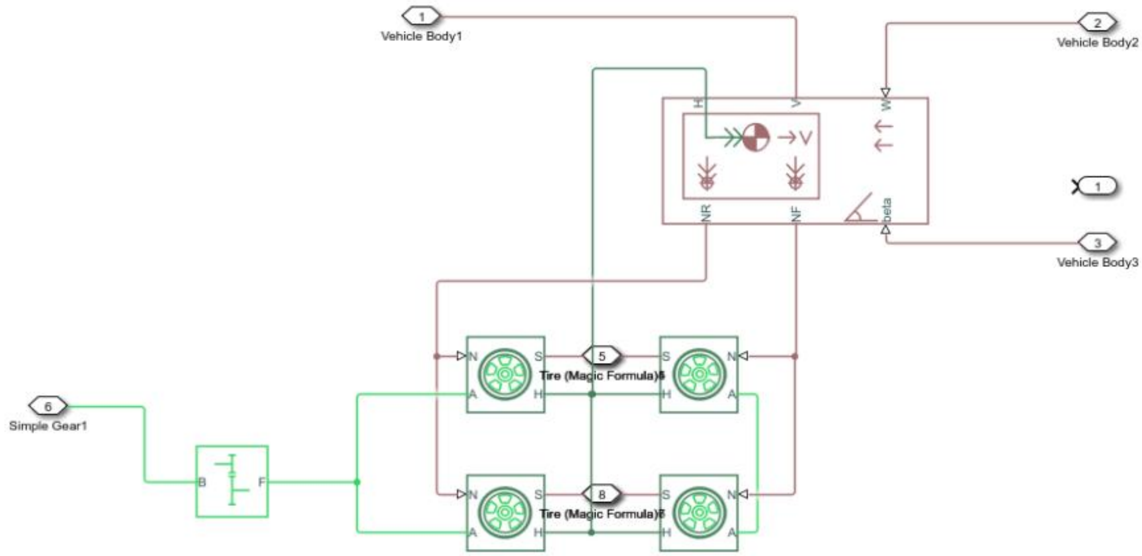

Figure 7: Subsystem of the vehicle body

One of the subsystems as shown in Figure 7 is of the vehicle body which consists of the vehicle chassis. It consists of a simple gear with an NF/NB ratio given to it. The wheels have four terminals which are: - hub, tyre slip, axel connection and normal force applied to the tyre. The vehicle body is connected to the wheels.

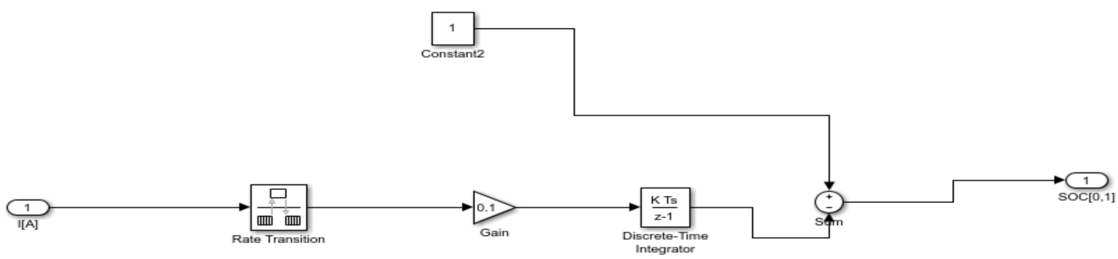

Figure 8: Subsystem of SoC Estimation

The second subsystem is created for SoC Estimation and is as shown in Figure 8. It consists of rate transition gain and discrete-time integrator which is then summed with a constant to give the State of Charge estimation.

VII RESULTS

As seen in Figures from 9 to 12,according to different drive cycles, the speed of the vehicle matches the speed of the drive cycle. This ensures that the model is accurate and working.

The State of Charge gives the amount of the charge that is left in the battery at a particular amount of time.The SoC is either represented in percentage form varying from 0% to 100% or in ratio form from 0 to 1. When the State of Charge is 100% (or 1 in the ratio), the battery is said to be fully charged, whereas when the SoC is at 0% (or 0 in the ratio) the battery is completely discharged.

Usually, the SoC is not allowed to exceed 50% and thus the cell recharges when SoC reaches 50%.

In the results, the SoC is seen to be decreasing overall with small instances of its increase in between. This happens because of the regenerative braking system. As mentioned above regenerative braking will ensure that when the vehicle is deaccelerating, the kinetic energy will be given back to the battery where the motor will act as a generator.

Following are the results of SoC of different drive cycles:

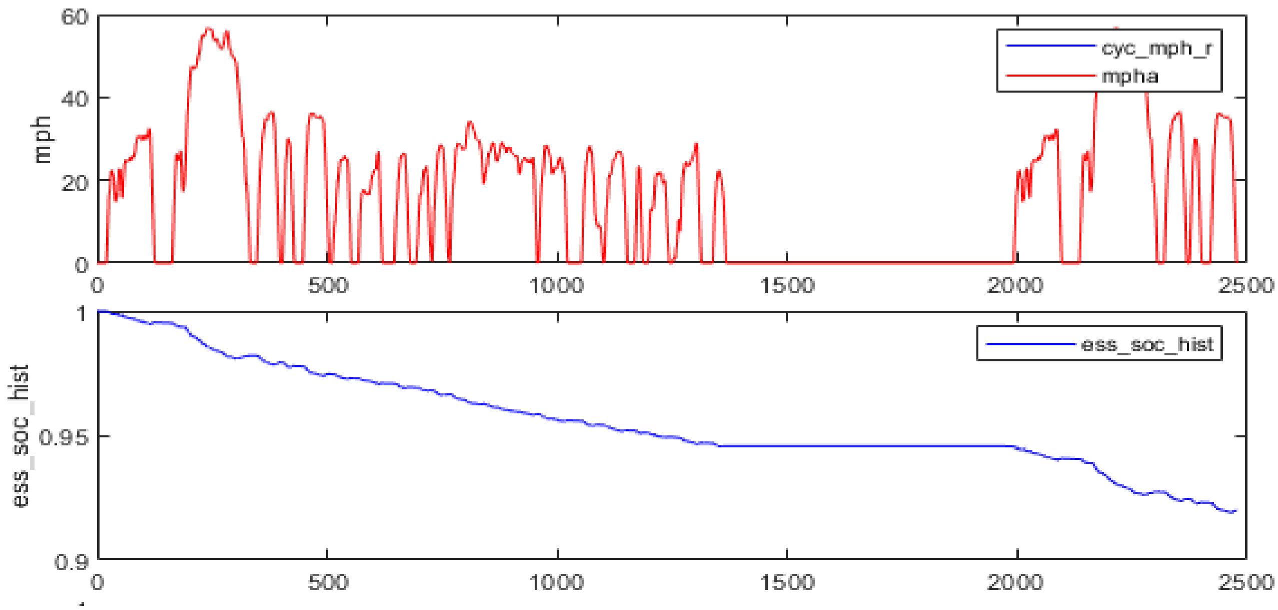

Figure 9: Speed and SoC graph of drive cycle FTP

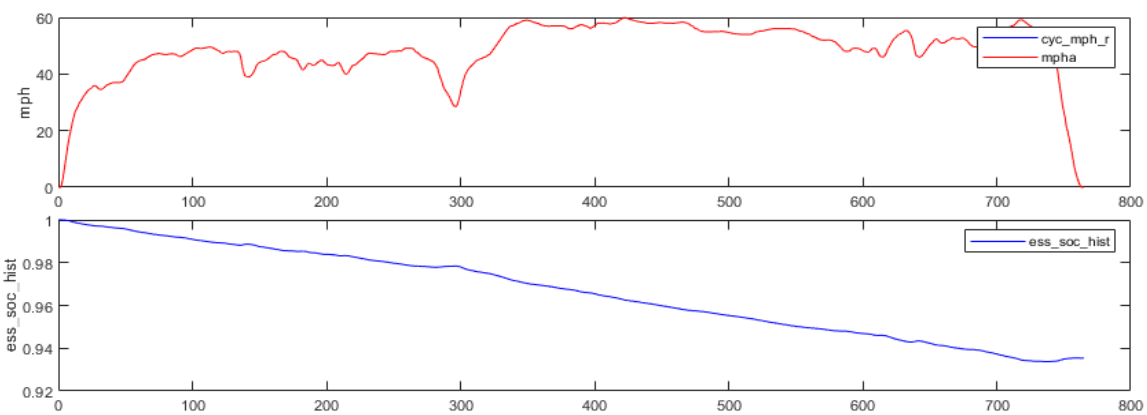

Figure 10: Speed and SoC graph of drive cycle HWFET

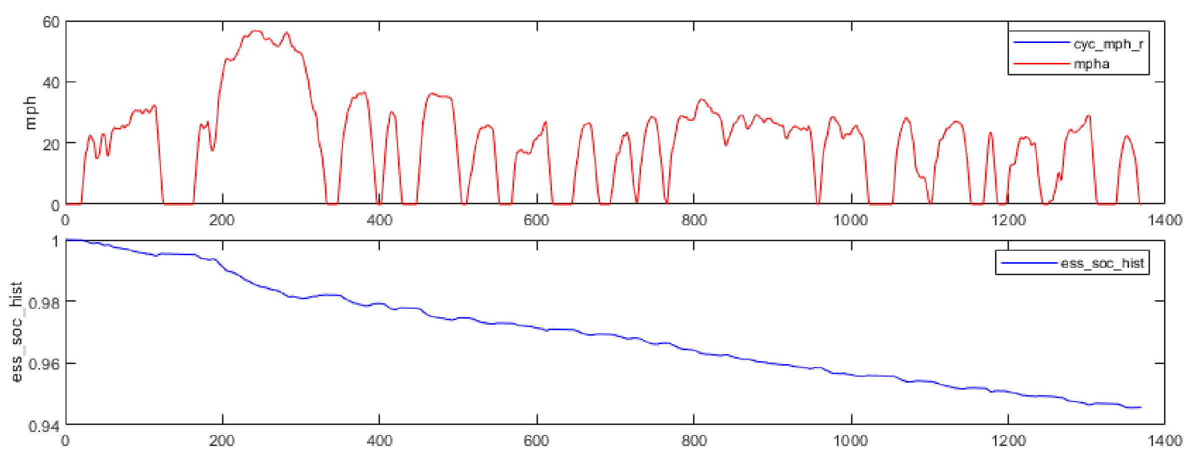

Figure 11: Speed and SoC graph of drive cycle UDDS

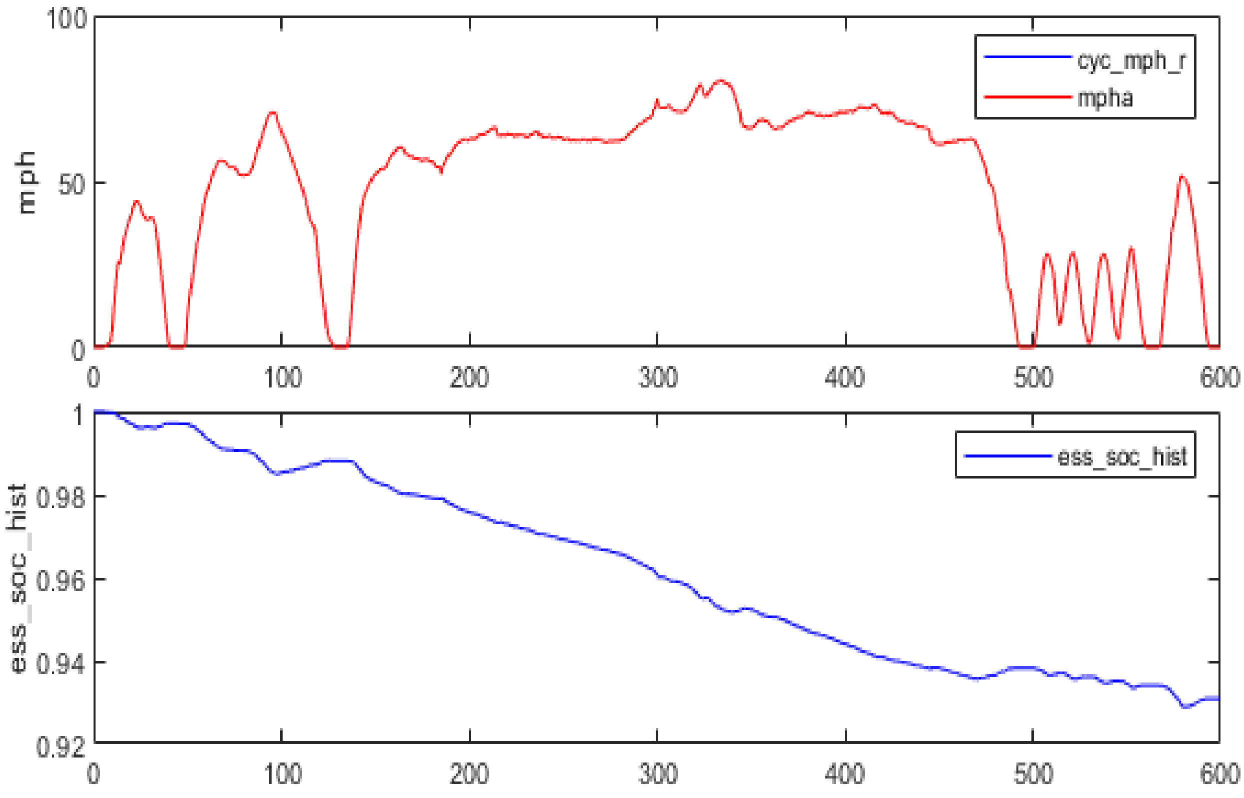

Figure 12: Speed and SoC graph of drive cycle US06

Table1depicts a comparison between various parameters observed during the model simulation. Different drive cycle covers different distances and each drive cycle has its own unique speed, acceleration and deceleration values. The State of Charge of the battery when the model is given different drive cycles is depicted in the form of a ratio.

The table also compares the equivalent gasoline that would be used if the model was a fuel car. Hence it shows the fuel and cost savings for the model considering different drive cycles.

Table 1: Comparison between different cases

	Case 1	**Case 2**	**Case 3**	**Case 4**
Drive cycle	UDDS	FTP	HWFET	US06
Distance	7.45 miles	11.04 miles	10.26 miles	8.01 miles
Top speed	56.7mph	56.7 mph	59.9mph	80.3mph
Vehicle weight	656kg	656kg	656kg	656kg
Max accel	4.84ft/s^2	4.84ft/s^2	4.69ft/s^2	12.32ft/s^2
Max decel	-4.84ft/s^2	-4.84ft/s^2	-4.84ft/s^2	-10.12ft/s^2
SoC at end of drive cycle(in ratio)	0.95	0.93	0.94	0.93
Gasoline Equivalent	136.1	136.8	174.7	111.9

VIII CONCLUSION

The results of the speed achieved by the model is similar to the drive cycle given as an input. This ensures that the model is correct. The regenerative braking used in this model proved to be of importance. The regenerative braking system are a type of kinetic energy recovery system that transfers the kinetic energy of an object in motion into stored energy to slow down the vehicle and thus it will increase the fuel efficiency.

In modern day applications, regenerative braking systems are used to decrease the environmental impacts of the transportation fleet. Thus, electronic vehicles are the future of a growing economy which battles both pollution and economical problems.

REFERENCE

[1] Ahmet OnurKiyakli, HamitSolmaz,"Modelling of an Electric Vehicle with Matlab/Simulink" International Journal of Automotive Science and Technology,2018 Vol 2.

[2] David McDonald,"Electric Vehicle Drive Simulation with MATLAB/Simulink"

[3] Electric Vehicle Battery Parameter Identification and SOC Observability Analysis: NiMH and Li-S Case Studies July 2017IET Power Electronics 10(11)

[4] Staubel, Tesla, in article "Meeting the technology challenge" AEInt., SAE Sept 2009

[5] R&D Engineer at EVs Start-up at Electric Vehicles,2014

[6] Husain Iqbal," Electric and Hybrid Vehicles: Design Fundamentals"

[7] KristerAhlersten,"An Introduction to Matlab", Publisher: BookBoon, 2012.

[8] Darryl Morrell,"An Introduction to Solving Engineering Problems with Matlab" Publisher: CK-12 Foundation, 2009

[9] Y Mastanamma, Dr M Aruna Bharathi, "Electric Vehicle Mathematical Modelling and Simulation Using MATLAB-Simulink" in IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)

[10] Eric Schlatz, "Electric Vehicle Design and Modelling"

[11] Research Study on Reuse and Recycling of Batteries Employed in Electric Vehicles: The Technical, Environmental, Economic, Energy and Cost Implications of Reusing and Recycling EV Batteries, September 2019

[12] Iqbal Husain and Mohammad S. Islam,"Design, Modeling and Simulation of an Electric Vehicle System",SAE Transactions Vol. 108, SECTION 6: JOURNAL OF PASSENGER CARS, Published by SAE International

[13] Space-Vector PWM Control Synthesis for an H-Bridge Drive in Electric Vehicles July 2013IEEE Transactions on Vehicular Technology.