www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC
Gestão, Inovação e Tecnologias

Design and Analysis of Electric Vehicle with Battery System

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Abstract
In this work, our focus on the Electrical Vehicle with Battery System. With the development of technology, there is a huge change in the automobile industry. The automation of the vehicle and the safety is our key issue to be addressed. Apart from this the automobile industry also looking for alternative fuel-driven vehicles than petrol and diesel. The electric vehicle is a better solution in this direction. The electric vehicle is a better solution for alternative fuel and its non-pollution nature. So, more research is going on, this green technology. The pollution is a key factor, as the pollution contribution from road and transport is stood second than the industrialization. So the electrical vehicle is a good solution regarding this. Here our work is to model an electrical vehicle and its battery system i.e., the power distribution to all battery-driven components of an Electrical Vehicle.

Key-words: Electric Vehicle, Battery System, Green Technology, Dc-Dc Converter, Fuel Cell Vehicle.

1. Introduction

In today's world, technology is changing rapidly, which takes effect in our day-to-day life. At present time the urbanization is increasing rapidly with industrialization. Road transport is playing a key factor in this. With the increase in urbanization and industry, there is a huge increase in the vehicle; this vehicle is generally run-on fossil fuel, which is limited in nature. The pollution in the air is another factor because the road transport contributes to it, the road and transport stand second to the industry. The pollution in air cause problem to all living being on this planet. To check or reduce the pollution level, the electrical vehicle can play a major role. The electrical vehicle is a better solution in this regard. Major automobile industries across the globe are working on this to provide better electrical vehicles to the customer. The electrical vehicles run on battery. The utilization of battery power in the vehicles is a key factor, it makes the battery life shorter or longer. There is research work is going on for better battery technology for longer life with more power for the vehicle. A good electrical vehicle will save fossil fuel and address the pollution issue, which is a key character to address.

2. Previous Work and Challenges

With the new technology introduced to the automobile sector, there is a huge development in the electrical vehicle, this is due to the research development in battery technology for more life and capacity, low power electronics high-speed ICs, and processors for automation. The research and technology were also responsible for the design of efficient FVC vehicle dynamics. The CAD tool makes the design analysis is faster, which leads to the betterment of the design of any EV.

The utilization of electricity for a vehicle from a battery was done by Gaston Planté[1], the year 1859, where he used a lead-acid battery. This work led to developing an electric driven three-wheeled bicycle, developed by Gustave Trouvé, in the year 1881[2]. Morris and Phals's Electrocoat, designed the first EV[3], a car used as a taxi with a maximum speed of 32 Km/hr and cover a distance of 40Km.

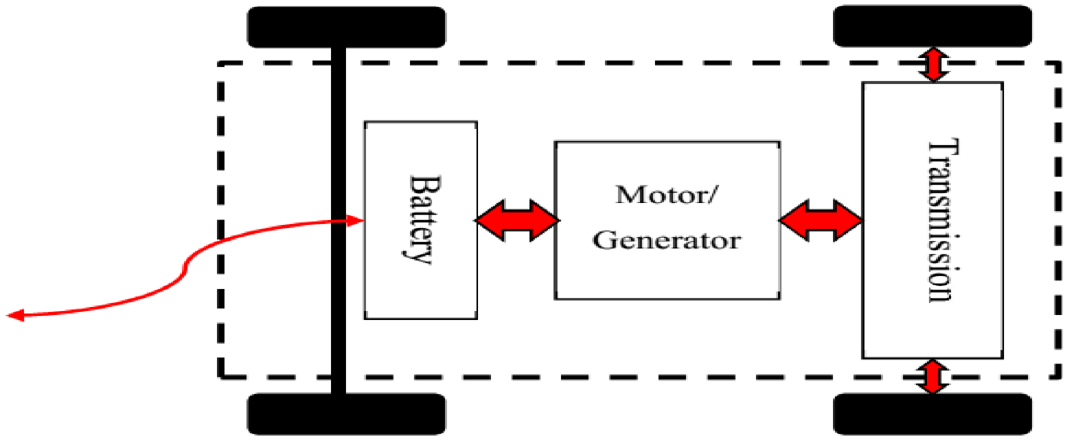
3. Electric Vehicle Technology

In the present time many Governments, keen for the development of EVs for road transportation, as pollution is a key issue, need to address in road transportation. The majority of the automobile manufacturers are addressing the same by developing their EV. The sales of EVs increased by 54% -87% in 2012-2014[4]. Initially, the EV development is based on grid-to-car (G2V), where the flow of power is unidirectional by nature. Later Vehicle-to-grid (V2G) is introduced, which allows the dual power flow[5-6].

Power Train

Power trains, which provide drive from the engine to the pivot of an automotive. A power train is an integrated unit of a battery, its charger, an electric motor, and a transmission[7], as shown in Figure 1.

Figure 1 - Schematic Diagram of BEV Power Train

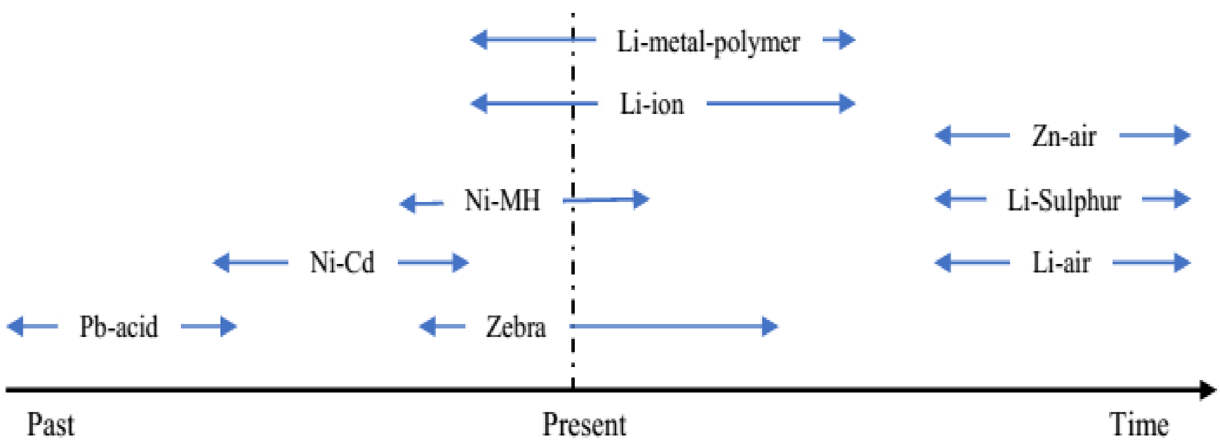


Besides these, there are different kinds of Electronics Control Units (ECU) available which are communicating with each other through CAN protocol[8].

Energy Storage System

The energy storage system (ESS), is the main source of energy of the BEV, the battery, is the sole source of propulsion. So the battery needs to be used in BEV, have good storage, and robust by nature. The time for battery development technology is given below in figure 2[9]. The customer of BEV looks at the factor acceleration, range, and cost, which mostly batter-driven nature and its dynamics. The improved battery technology performs better with the FVC dynamics[10].

Figure 2 - Timeline of Battery Technology Development

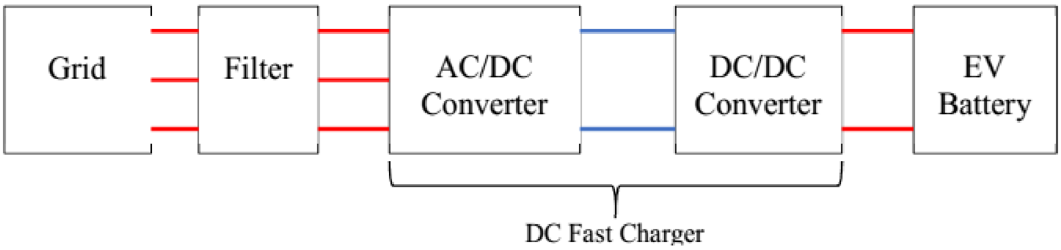


ISSN: 2237-0722
Vol. 11 No. 3 (2021)
Received: 19.04.2021 – Accepted: 10.05.2021

Charging Infrastructure

The battery is the main source of energy, it is charged from external electricity sources i.e. the grid. Generally, these sources are alternating current (AC) by nature, so an ac-dc converter has to deploy, which fed-forward to a DC-DC converter this charging to the battery needs to be faster[11], so the electronics components conversion and switching time need to be faster. The fabrication technology offers this character to make suitable faster charging for the battery of EV. The block diagram schematic is shown in figure-3.

Figure 3 - Block Diagram Representation for Faster DC Charging Station



4. Design Issue and Modeling

For the modeling, the series type FCV powertrain has considered, present in the Honda FCX Clarity[12], which is consists of a fuel cell and a battery-powered electric motor. The FCV consist of the following, electric motor, battery, fuel cell, and DC / DC converter.

The specification used, Permanent Magnet Synchronous Motor (PMSM) with 100 KW and 288V Which have 8 poles and salient rotor nature magnet.

Flux weakening process is used with consideration of maximum speed 12500rpm and Lithium-ion battery set with voltage rating is 288 V and power capacity 25 kWh.

Flux weakening vector control method has used to get a maximum motor speed of 12,500 rpm, using a Lithium-ion battery pack of 288 V, 25 kWh capacities.

The current is regulated by the buck DC/DC converter.

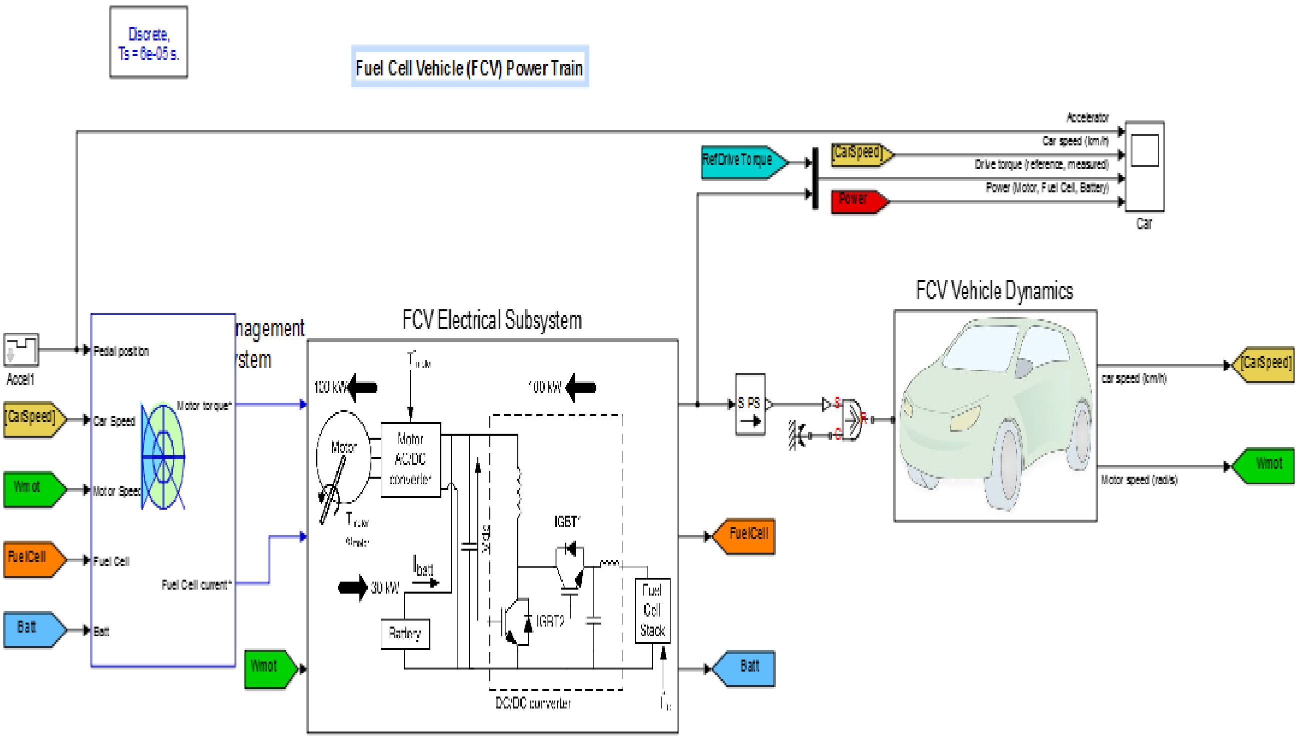
Vehicle Dynamics of all the Mechanical Parts

Single reduction gear slows down the speed of the motor to arise in the torque. The differential unit produces two equal torque from referral input l torque produced. Application of force ground is characterized by tire dynamics. The dynamics of the vehicle indicate the effect of motion applies to the whole system. All types of friction patterns are all disadvantages of a mechanical system.

5. Simulation and Result

The Electric vehicle has been designed and simulated by using the MATLAB computing tool. The Energy Management Subsystem (EMS) determines the reference signals for the electric motor drives, the fuel cell system, and the DC/DC converter to distribute accurately the power from the two electrical sources. These signals are calculated using mainly the position of the accelerator, which is between -100% and 100%, and measured FCV speed. The Battery management system maintains the State-Of-Charge (SOC) between 40 and 80%. The different operating modes of the FCV over one complete cycle: accelerating, cruising, recharging the battery while accelerating, and regenerative braking has shown in this model. Simulink model and output observation for the FCV power train are shown in Figures 4 & 5 respectively.

Figure 4 - Simulink Model for FCV Power Train



ISSN: 2237-0722
Vol. 11 No. 3 (2021)
Received: 19.04.2021 – Accepted: 10.05.2021

Figure 5 - Output Observation for FCV 7yPower train (accelerometer, car speed, drive torque, power)

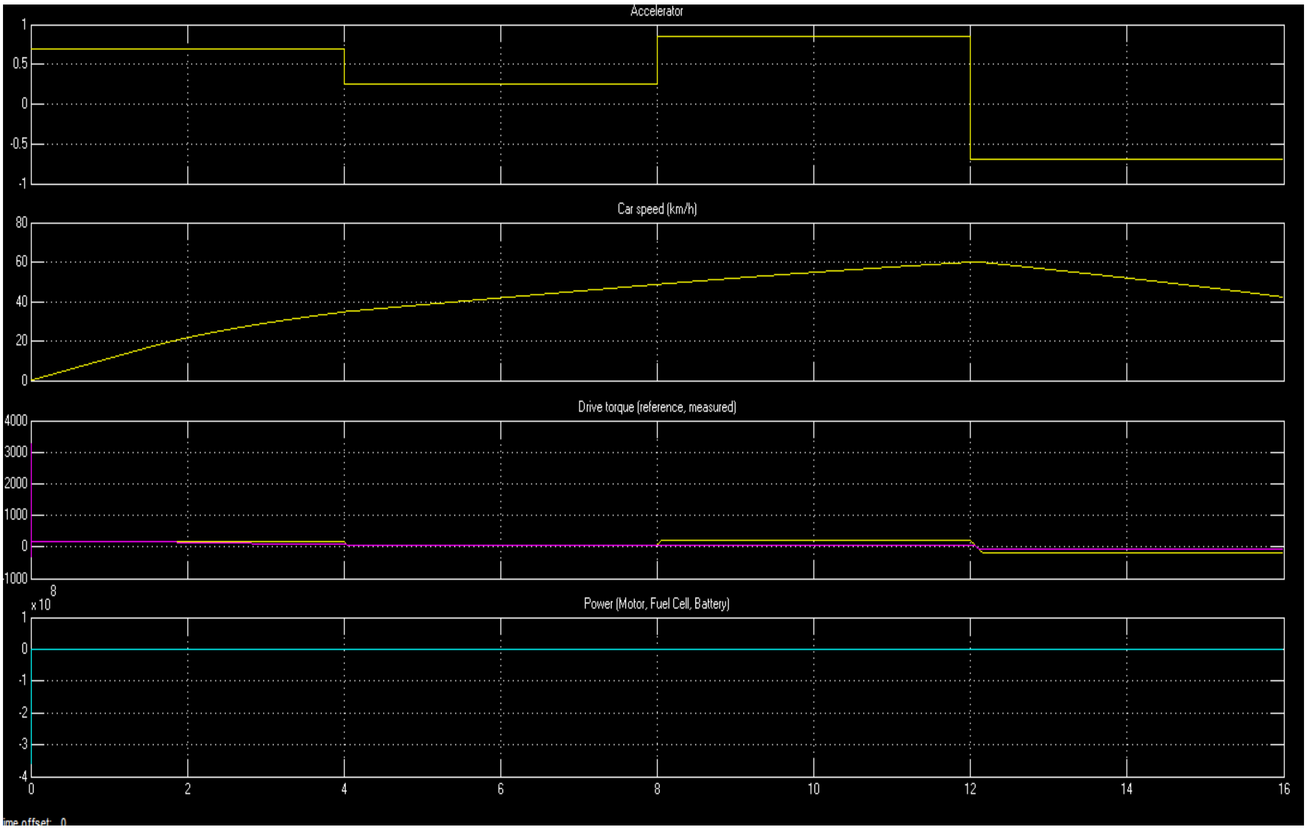
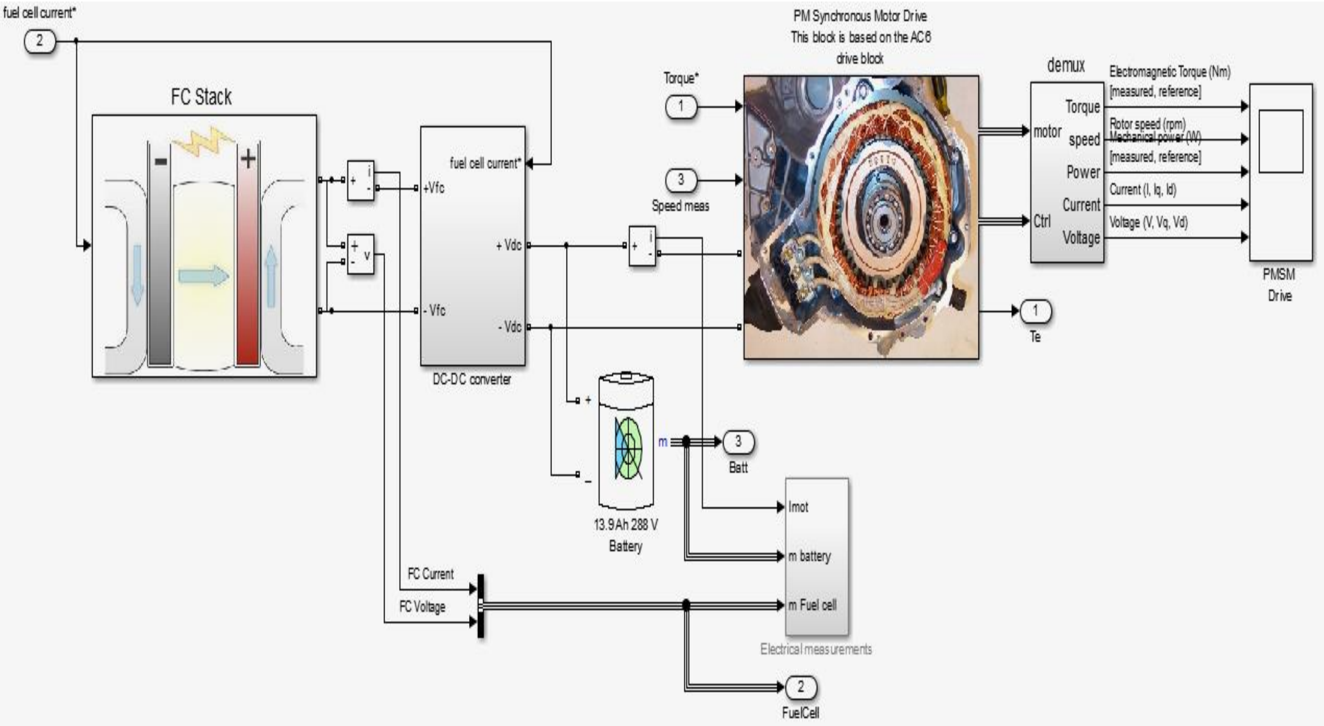


Figure 6 - Simulink Model for FCV Electrical Section



ISSN: 2237-0722
Vol. 11 No. 3 (2021)
Received: 19.04.2021 – Accepted: 10.05.2021

Figure 7 - Output Observation for FCV Electrical Section (EM Torque, Rotor Speed, Voltage, Current)

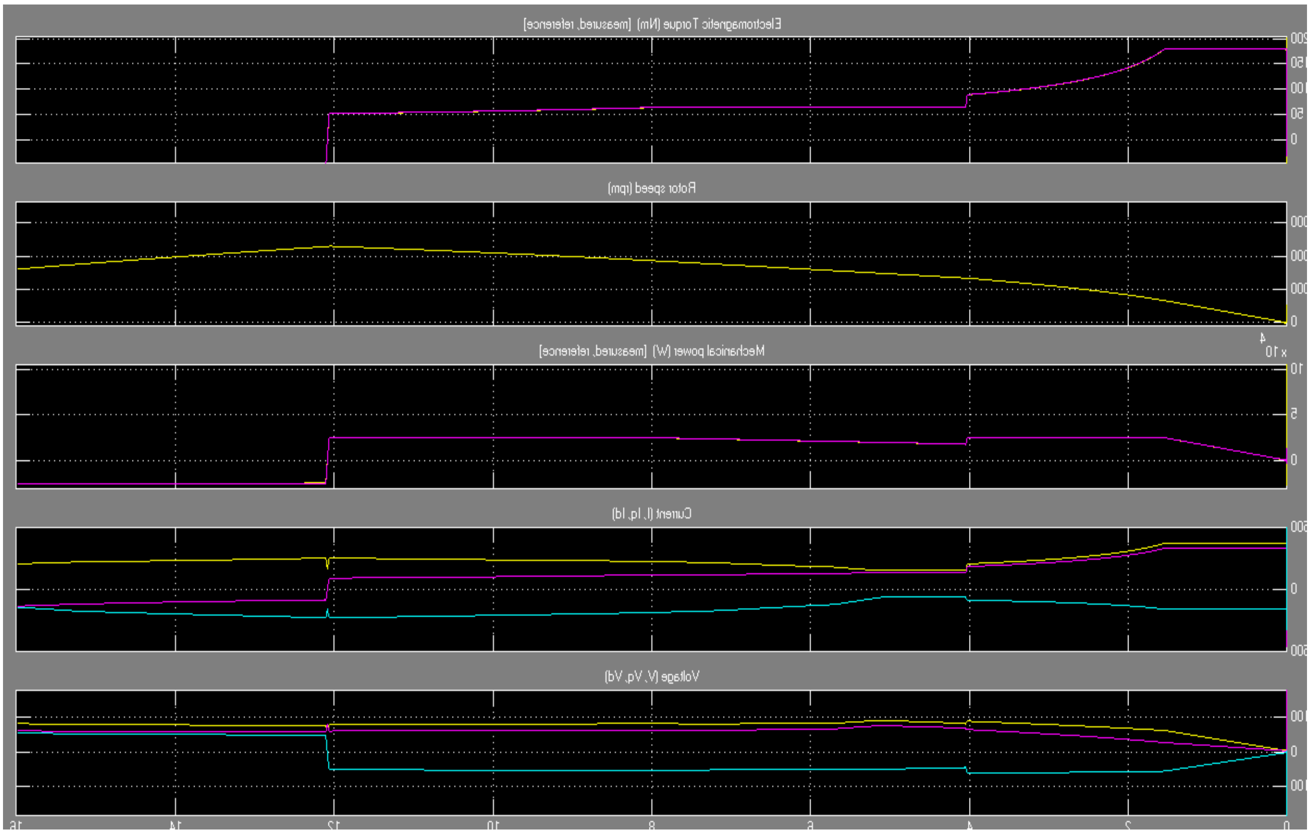
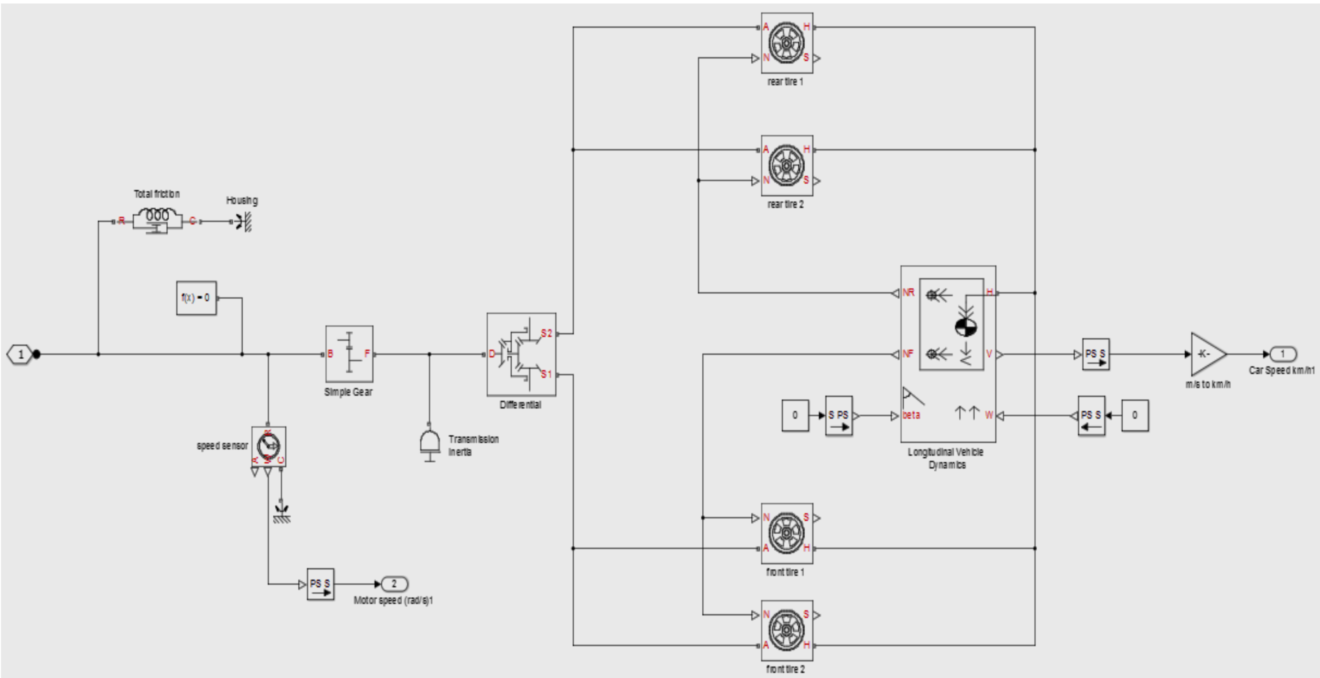


Figure 8 - Simulink Model for FCV Vehicle Dynamics



Observation

At Time (t) = 0 Second, the Fuel Cell turned off and the accelerator pedal was pushed up to 70%. At that time motor was taking power from the battery pack until restating of the fuel cell.

With simulation time, 0.7 Second, the motor was continuously powered with the battery, due to the larger time constant, the fuel cell fails to deliver energy up to the reference.

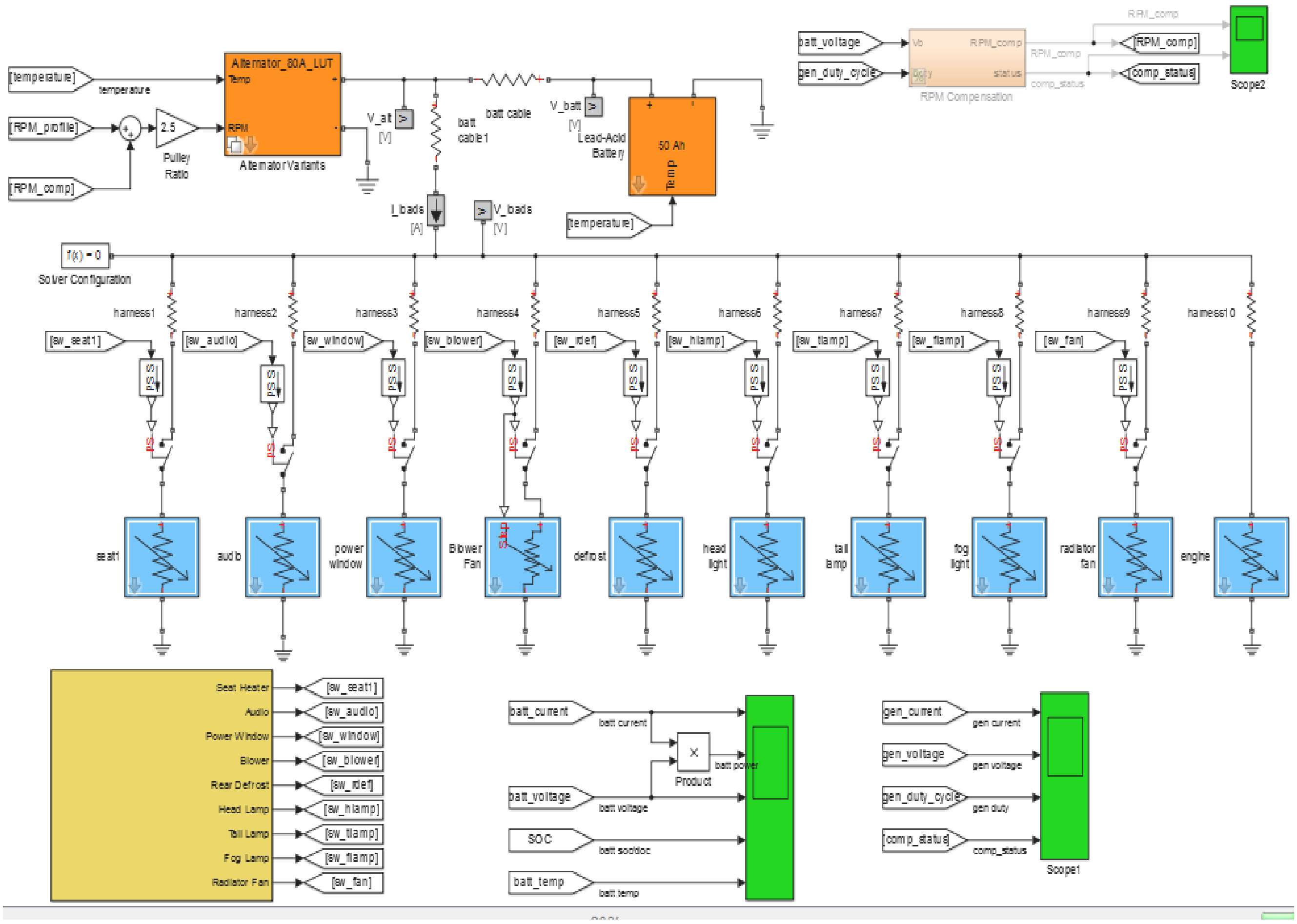
With simulation time, 4 Seconds, the accelerator pedal released to one-fourth of the total. The Battery maintains the required torque.

With simulation time, Second, the reference point reached by the fuel cell leads to the battery to cutoff.

With simulation time, Second, with the acceleration arise to 85% of the maximum speed, where the fuel cell borrowed the extra energy from the battery.

With a simulation time, 15 Seconds, the fuel cell had reached a minimum power of 2 KW.

Figure 9 - Simulink Model for Battery Management model



ISSN: 2237-0722
Vol. 11 No. 3 (2021)
Received: 19.04.2021 – Accepted: 10.05.2021

Figure 10 - Output Observations at the Battery

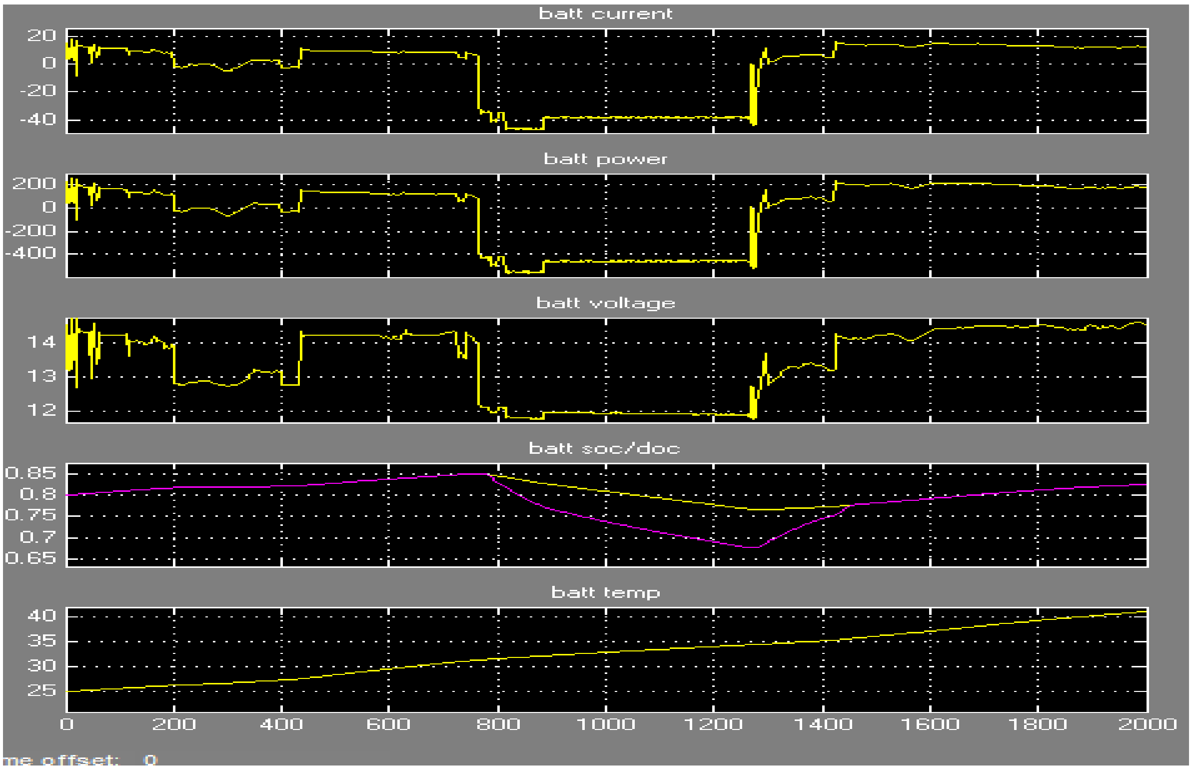
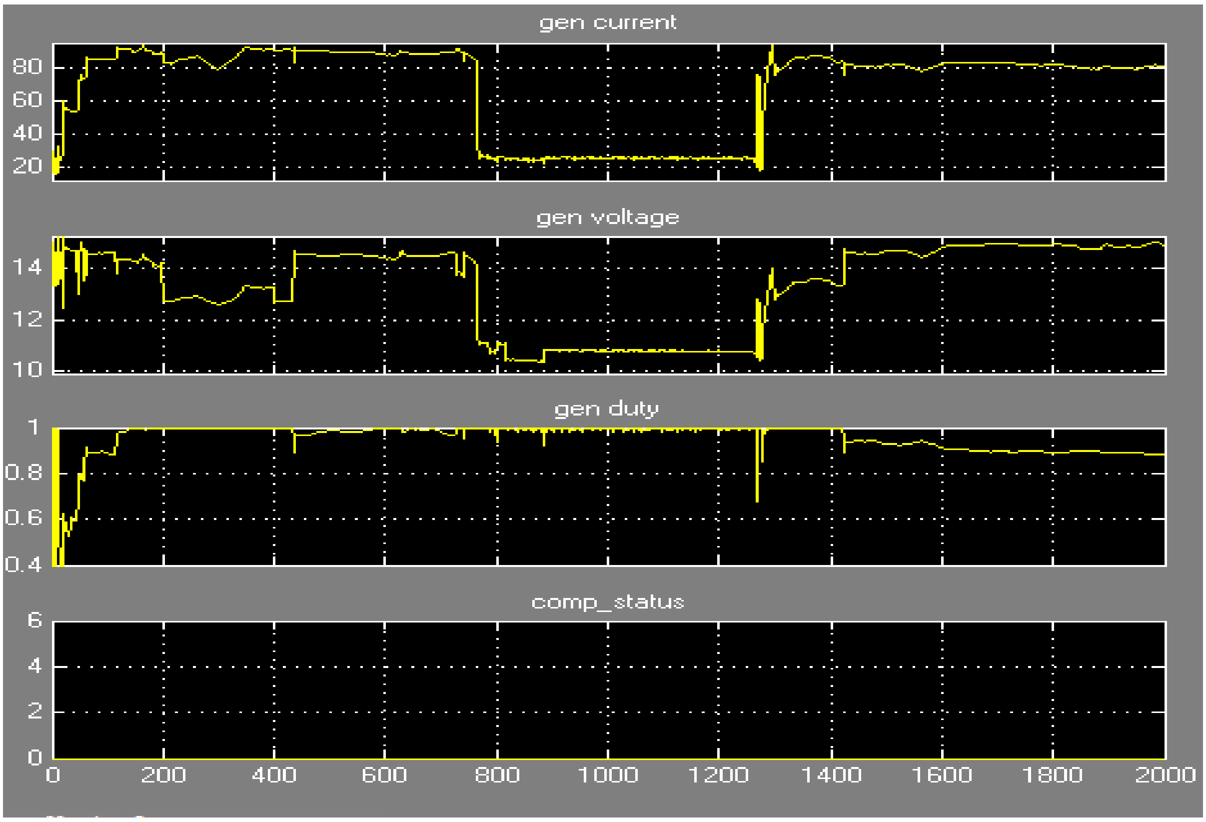


Figure 11 - Output Observations at Generator Current, Voltage, Duty Cycle



6. Conclusion

The result of both models shown above was observed. This model needs to realize in real-time by assembling the component and more study to carry as in simulation that considers good road condition and there is no wear & tear, which affect the performance of EV. Then the modified model will be efficient design according to the above model as used.

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