PV based Sepic Converter FED Electric Vehicle Design using MatLAB/Simulink

K. Aravindha Shilpa[1], K. Swaroopa[2]

[1]Andhra University College of Engineering for Women, Visakhapatnam, Andhra Pradesh.
[2]Andhra University College of Engineering for Women, Visakhapatnam, Andhra Pradesh.

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Abstract: *A PV based SEPIC Converter fed Electric vehicle (EV) model is created to increase the reliability and to reduce the operating cost of Electric vehicle. In the modern era, people are facing problems like pollution and outage of fossil fuels which may become reason for the human destruction. Electrification will help reduce vehicular emissions and the usage of any non-renewable Resources. PV based SEPIC Converter fed Electric vehicle can run without use of any Charging stations and also with a very less amount of cost because the combination of PV array with SEPIC Converter reduces the cost. Here the Number of PV Arrays used can also be reduced by using SEPIC Converter, the voltage can be boosted. Sepic converter is placed in between PV array and Battery of Electric vehicle. Use of (VSI) Voltage Source Inverter helps to vary the speed of Electric vehicle smoothly in steps. Now-a-days people are moving to EV as it is eco-friendly, and also due to the petrol and diesel price hikes in our country. To overcome the major problems faced by many of them today we have designed Without any use of charging stations, with less cost and durability. PV based SEPIC Converter fed Electric vehicle is designed in MATLAB/SIMULINK and output is obtained.*

Key words: *Sepic Converter, PV Array, EV, VSI, Eco-friendly, EV design using MATLAB/SIMULINK.*

INTRODUCTION:

Due to the increasing awareness about the harmful effects of carbon dioxide emissions from transportation vehicles, many countries have started implementing programs that encourage the use of electric vehicles (EVs). Although the use of battery-powered vehicles is considered an alternative to CO2 reduction, their increased consumption leads to higher electricity load. This issue can be solved through the integration of various renewable energy sources such as solar, wind, and fuel cell.

SEPIC CONVERTER:

The proposed converter is designed to improve the DC link voltage of the BLDC motor while converting the high voltage from the PV supply.

Circuit diagram of the proposed circuit diagram is represented in fig

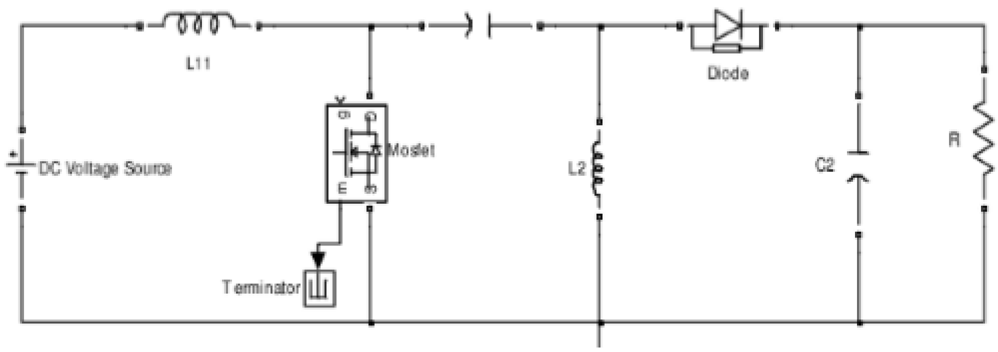


Figure 1:sepic converter

Electric Vehicle:

1. The type of a vehicle making use of electrical motor for its propulsion is known as an electric vehicle.
2. Electric vehicles types:
   - ➢ Electric plug-in type vehicle
   - ➢ Electric vehicle with fuel cell
3. In changing the environment and global economy over decades, these electric vehicles will play a significant role.

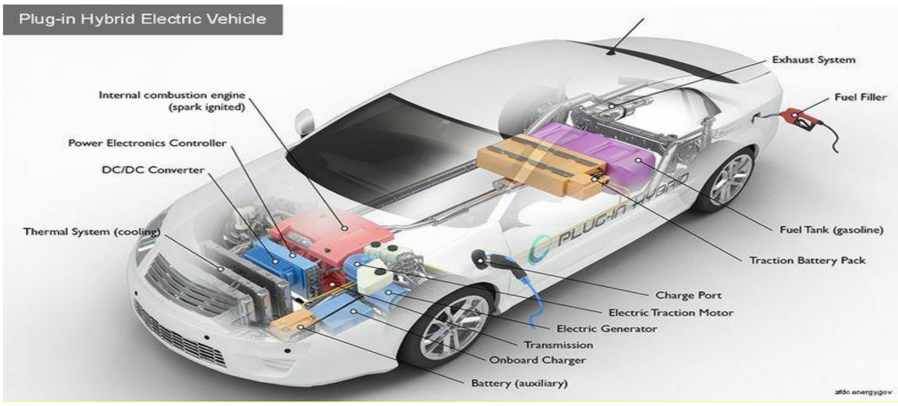


Figure 2 : EV Design

PHOTO VOLTAIC ARRAY:

A solar panel is an assembly that mounts to a framework and uses sunlight as a source of energy. It is commonly referred to as a PV module and is composed of several cells.

WORKING PRINCIPLE OF PV BASED SEPIC CONVERTER:

1. A solar PV cell uses a semi-conductor material to convert the solar radiation into electricity.
2. When the light hits the semi-conductor material's junction, the electric field generates a current, which can be used for external consumption.
3. To increase the electric current flowing from the photovoltaic system, the SEPIC converter is generally used. A DC bus is used and it is connected to it and this is the way to transport needed power to the system.
4. There are two semiconductor material layers in the PV cells in general
   - One with positive charge
   - The other one with negative charge

5.BLDC motors are known for their high performance and long lifespan. They are also small and have a low lifespan.

6.BLDCs are used to minimize the cost of PV system-wide power generation while also improving the system's performance. However, due to the effects of climate change and thermal gradients, the BLDC is no longer able to provide full capacity.

7. on the semiconductor material when light shines on the electric field between two layers at the junction, the electric flow is produced by these two layers, in this way direct current or DC is generated. When on the top and bottom of the PV cells, the metal contacts are used, for external use, we can draw off the current.

8.The SEPIC converter is being used in the proposed system to increase the power flow from a photovoltaic (PV) system. The grid is connected to a DC bus to supply power generated by PV if it is not demanded by the load.

9.To provide the bidirectional power flow control in between VSI and grid, single phase VSI is used. Switching losses are minimized in this system since the fundamental frequency is utilized.

10.The BLDC motor has a high performance and power density, requires less time, is small in size, and has a long lifespan. Because of these benefits, BLDC motors are more popular among industrial users.

11.. BLDC motors were introduced to minimize the cost of PV system-based power generation while also enhancing the system's performance. The BLDC's performance has been harmed as a result of climatic change and thermal gradients, and it is no longer able to operate at full capacity.

12. In the meantime, due to the lack of sunlight, the system shunts down throughout the night. Storage systems, such as battery packs, are available to store energy. PV electricity is utilized to charge the battery through the controller, and then the battery's charged energy is discharged to the Bldc via inverter circuit.

13.PV electricity is utilized to charge the battery via the controller, and then the battery's charged energy is released to the Via inverter circuit, the BLDC motor. 9. For the transfer of electrical energy from one to another point, the power converters are used.

14. To increase the performance of a system inside a traditional system, the sepic converters are used. The voltage is linked to the DC and by the power converter system, this achievement is made possible and, in this way, it can allow us to deal with more gain in voltage and stability of the system. At present, to offer switching signals, the control systems are used and from the source to the load, these are employed to convert power.

15. With the help of Simulink mathematical operations, toolkit and math functional block, the simplified PV cells models were stimulated for the equations of the models. The similar outputs and parameters are there in the physical model as that of the used mathematical model. Along with the maintenance of quality, the other parameters used are semiconductor band gap energy and the parallel cells number.

16. As a subsystem, to be integrated into other systems, the mathematical PV cell model was used and this offers a simplest way to add the modular characteristics of the PV. Since there are some additional features, like quality factor as well as semiconductor, there can be an adjustment and manipulation of band gap energy. As compared to physical models, the mathematical model has more advantages.

17. Furthermore, without having to duplicate the block schematics, parallel and series PV cell combinations can be created. On the other hand, in order to create a parallel combination in the physical model, the PV cell block must be repeated, which adds to the model's complexity.

18. The results are achieved by adjusting two key solar cell characteristics, which are stated below:

I The impact of changing levels of solar radiation
ii) The Influence of Temperature Variation

19. After adjusting two key parameters and plotting the I-V and P-V curves of solar cells, it was discovered that solar radiation has a direct effect on solar cell power and open circuit voltage. The output current and voltage characteristics were observed while the radiation values were adjusted from 400w/m2 to 1000w/m2.

20. However, the photocurrent shows a substantial effect. Second, when the temperature rises, the open circuit voltage of the cell falls. The temperature ranges from 250 to 420 degrees Celsius.

LITERATURE REVIEW:

1. On the planet Earth, the solar energy is regarded as the most usable form of energy and that is renewable as well. By the conversion of solar radiation into the direct electrical current with the help of semi conductor, the PV (photovoltaic cell) is an ideal method exhibiting the photovoltaic impact. The modelling and simulation of PV arrays in MATLAB are presented in this paper with the help of SimElectronics Library, solar cell block. To implement and find out the features of a specific photovoltaic cell panel, this method is used. Concerning photovoltaic cells, the influence of various values of solar radiation at various temperatures are used. For a photovoltaic circuit model, this model can be used for any array of photovoltaic cells. From the model of photovoltaic system, all modules are modelled individually and in simulink they are validated. Authors: Banerjee," Modelling of PV array and performance IJSER@2015http://www.ijser.org.
2. For the systematic testing and estimation of evolution of I-V featured photovoltaic curves, a versatile system of measurement is suggested and investigated in this investigation. A circuit slutuon based on DC and DC converters are used in this system of measurements involving the advantages that are relative to various customary ways such as simplicity of structure, faster and quick response, scalability and less price. For the PV generators, the measurement of the characteristics desired also includes high fidelity and higher and speedier responses. A microcontroller is used that controls the prototype system and it has been proven by the outcomes of experiments that this system of measurement is highly useful. VI was developed as well from the computer for the fuller control of the system. The monitoring is allowed to a suitable sized operation in real time for the PV generator as we all know, it lets the comparison possible between the actual curves and the curves that a manufacturer provides. Author: E. Durain, M. Pilliougine, M. Sidrach-de-cardona, J. Galan and J.M.Andujar "Different methods to obtain the i-v curve of PV modules; a review," proceedings of the 33rd IEEE photo voltaic specialists conference(PVSC 08)2008.
3. A method of modelling and simulation of PV arrays was suggested by the work of M.G. Villalva. By the adjustment of curves at three points, the parameters of nonlinear IxV equations are obtained. These three points are, short and open circuits, maximum power. Datasheets of commercial arrays are provided by all these points used. For

the single diode photovoltaic model, the method finds the best IxV equation including the series and parallel resistance impact that are possible and also it ensures that the model's maximum power satisfies with the real array's maximum power. For the adjusted IxV equation along with the parameters adjusted, it is possible for us to develop a model of a photovoltaic circuit with the help of basic math blocks with any circuit simulator. The method of modelling is used and suggested model of the circuits are used in this unique project that is very speedy, more efficient in terms of accuracy and easier to use in the photovoltaic system simulation modelling.

Authors: M.G.Villalva, J.R.Gazoli, E. Ruppert F,"comprehensive approach to modelling and simulation of photo voltaic arrays," IEEE Transactions on power electronics,2009 vol.25, no.5, pp.1198-1208, ISSN0885-8993.

4 The modelling and simulation of the model of photovoltaic cell according to this paper is considered at the irradiance of sun and temperature. There is a modelling of PV array and the features of its voltage are simulated along with the characteristic power and voltage. The dynamics of PV system are allowed by it to become more easily simulated and hence, its optimisation is easier as well. By the environmental factors, as observed, the output characteristics of PV array are influenced and there is a lower efficiency of conversion. Hence, MPPT (an abbreviation of maximum power tracking) technique is required for the right tracking of the peak power to increase the production of energy. In the power, the maximum power point is generally identified by power voltage graph with the help of algorithmic perturbation and observation and this method is abbreviated as P&O method or the method of climbing hill. The suitable duty ratio is identified by this algorithm in which the converter of DC-DC is used to increase the power output at maximum speed. The photovoltaic array as confirmed by the outcomes suggested that there is a controller named MPPT that is able to function in the maximised power point for the solar data assumed for irradiance and temperature. Authors:SridharDr.Jeevan NathanN.Thamizh SelvanSaikat Banerjee10.5120/1157-1429R. Sridhar,Dr.Jeevananathan, N.Thamizh Selvan and Saikat Banerjee. Article: Modeling of PV Array and Performance Enhancement by MPPT Algorithm. International Journal of Computer Applications 7(5):35–39, September 2010. Published By Foundation of Computer Science

5. The MATLAB and simulink model of the photovoltaic cell is studied and examined in this paper. There are various mathematical equations used in this model and is explained via circuit of equivalent form that include the photocurrent source, a resistor connected in series, diode, a shunt resistor. The prediction of PV cell behaviour is possible by this developed model under various parameters of environment and physical aspects. To extract the physical parameters, this model is used as well for the PV cell of a given voltage and solar based radiation. Along with this, the principle of PV module along with PV array, this study also outlines the way of working. For the model's validation, the test bench was made experimentally and the outcomes obtained display reasonable agreement with the ones having simulation.

Author: Tarak Salmi, Mounir Bouzguenda, AdelGastli, Ahmed Masmouli ,MATLAB/Simulink based modelling of solar photo-voltaic cell,INTERNATIONAL JOURNEL OF RENEWABLE ENERGY RESEARCH Tarak salmi et al, Vol 2,(2017)

SIMULATION:

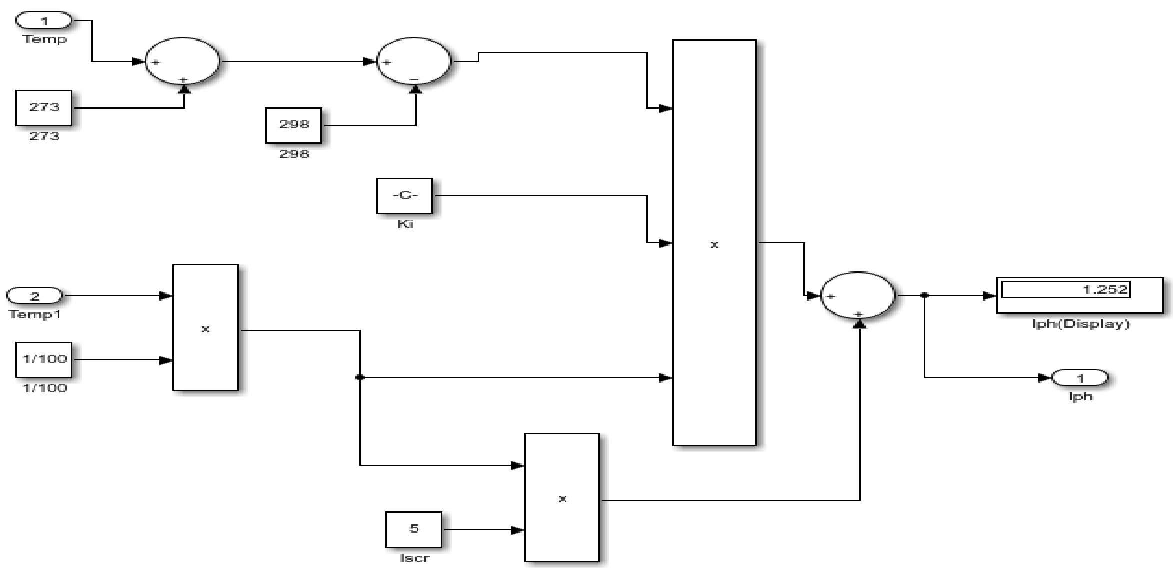


Figure 3: Iph subsystem

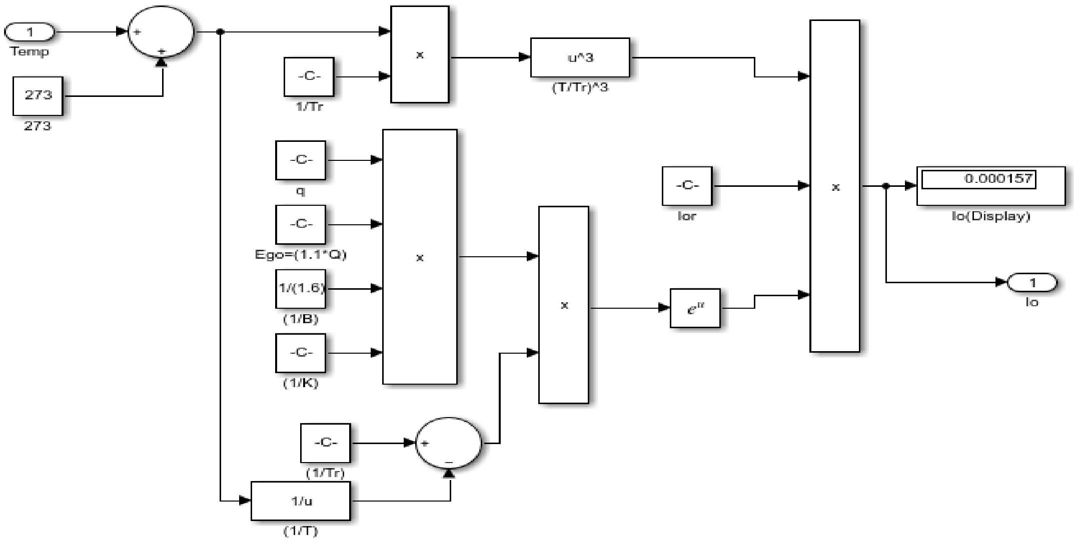


Figure 4: Io subsystem

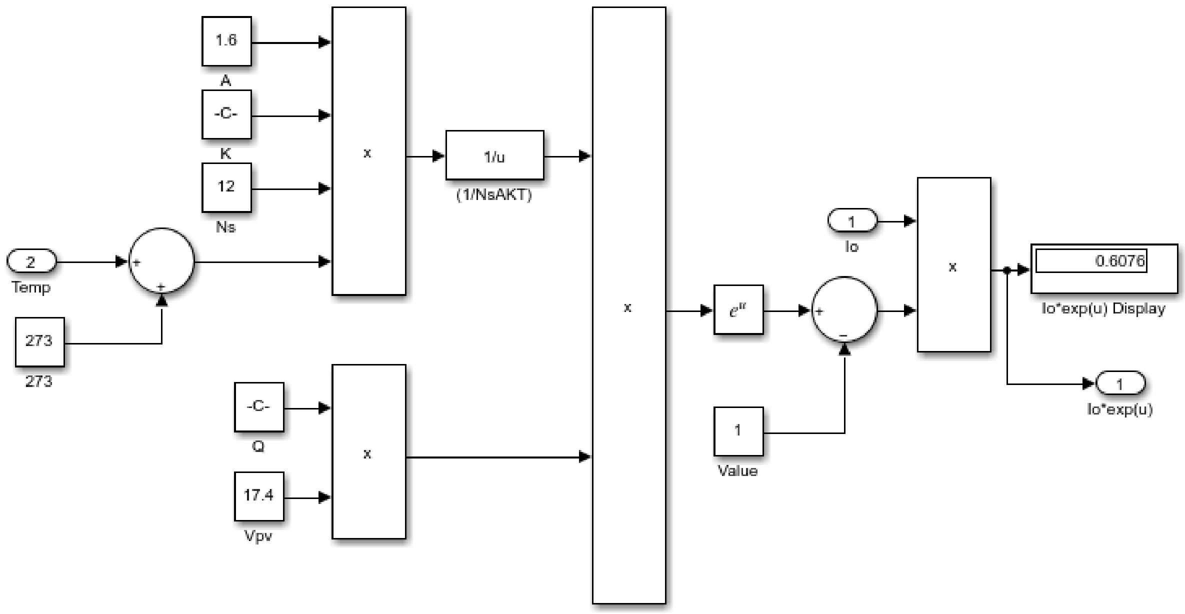


Figure 5: Io* exp (u) subsystem

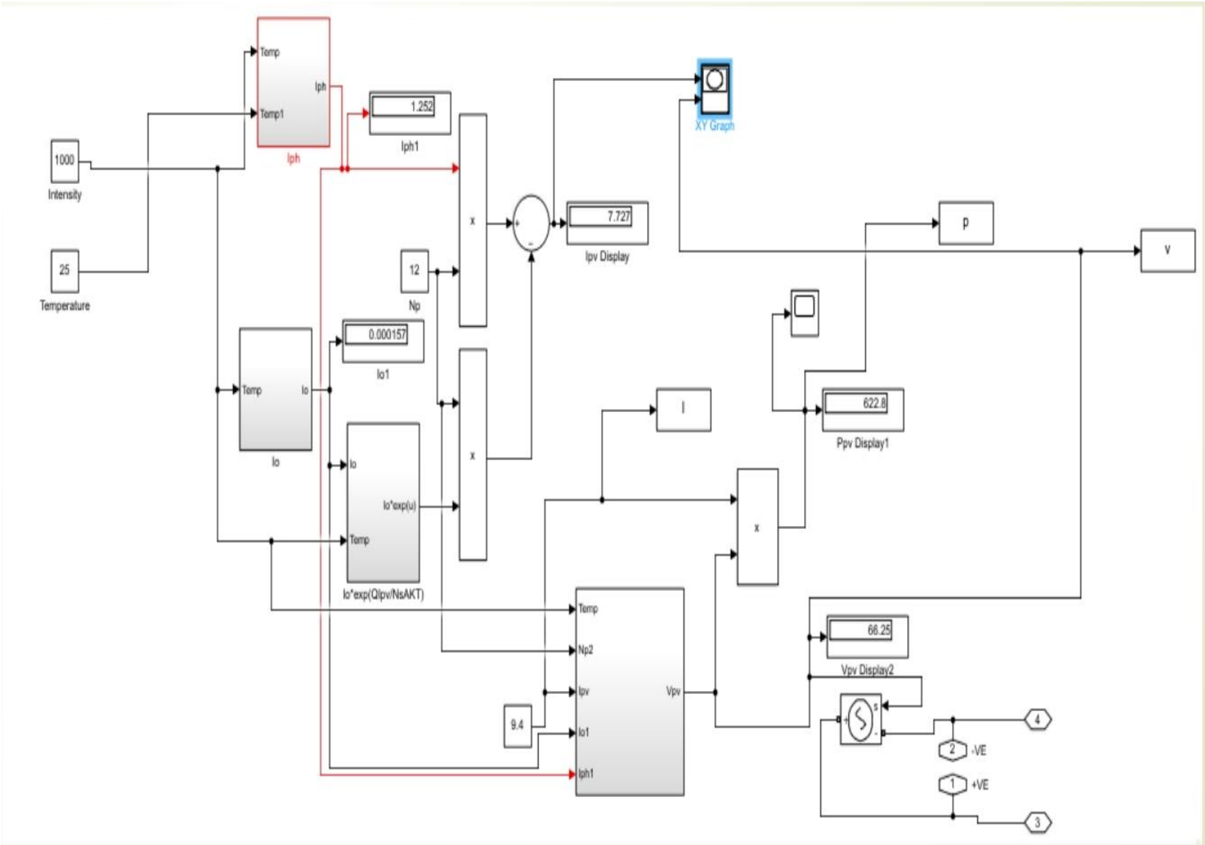


Figure 6: Simulink model of PV array

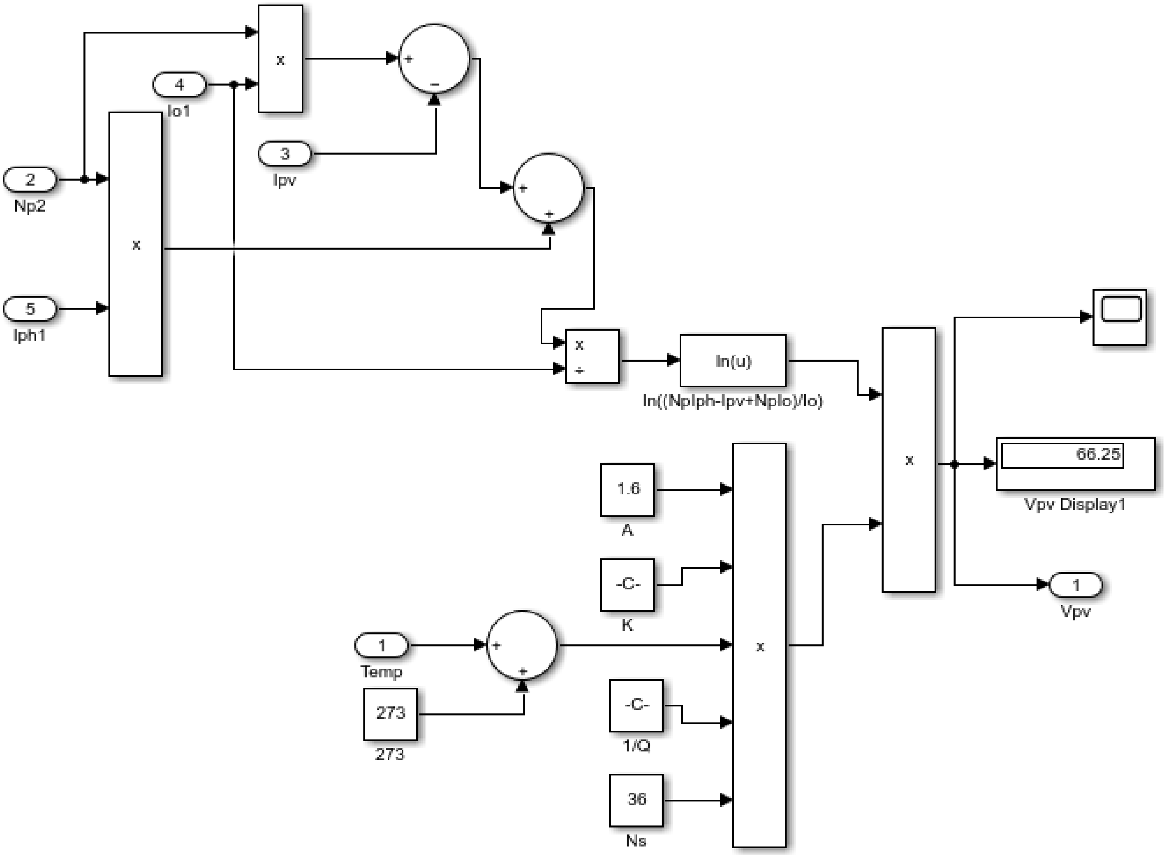
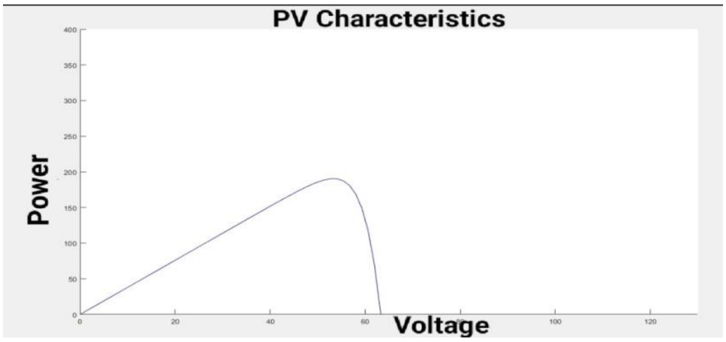


Figure 7: Vpv Subsystem

CHARACTERISTICS OF PV ARRAY:



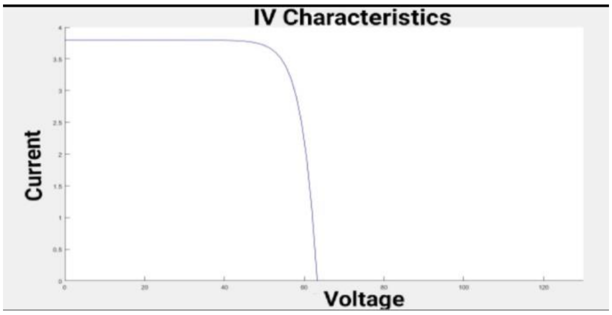


Figure 8: PV Characteristics

Figure8: IV characteristics

Figure 9: PV Characteristics

SIMULINK MODEL:

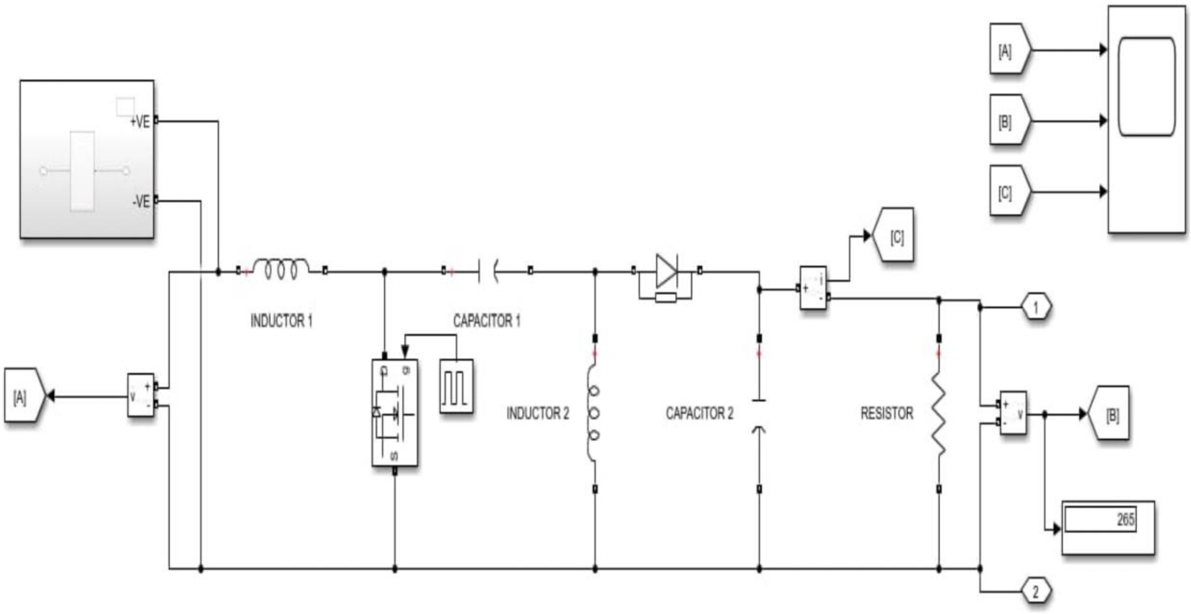
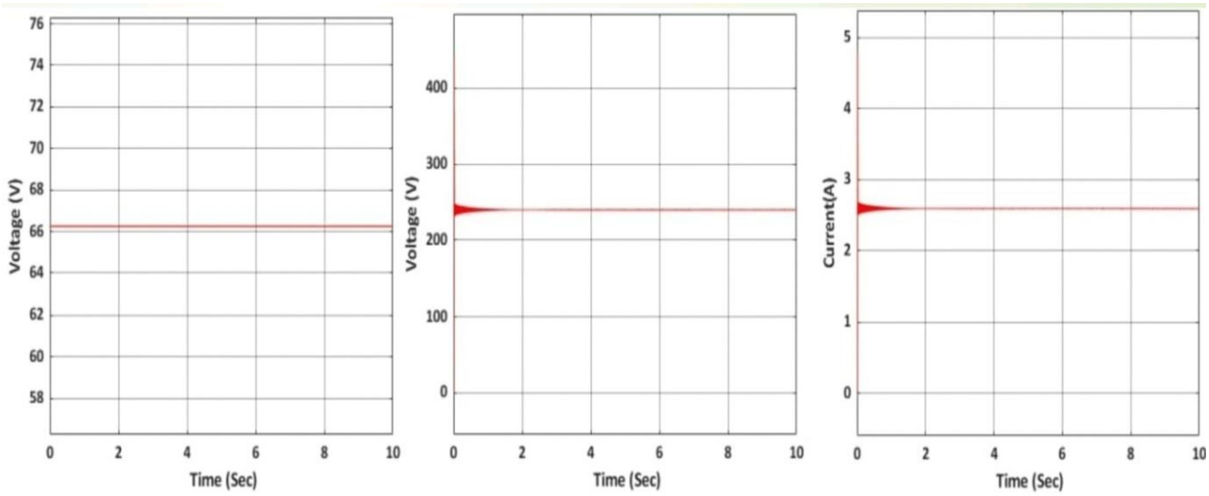


Figure 10: Simulink model PV based Sepic converter

SIMULATION RESULTS:



11.1Figure :PV ARRAY GRAPH 11.2Figure:SEPIC CONVERTER GRAPHS

Figure 11.1,11.2: SIMULATION RESULTS

MODELLING OF AN ELECTRIC VEHICLE USING MATLAB/SIMULINK:

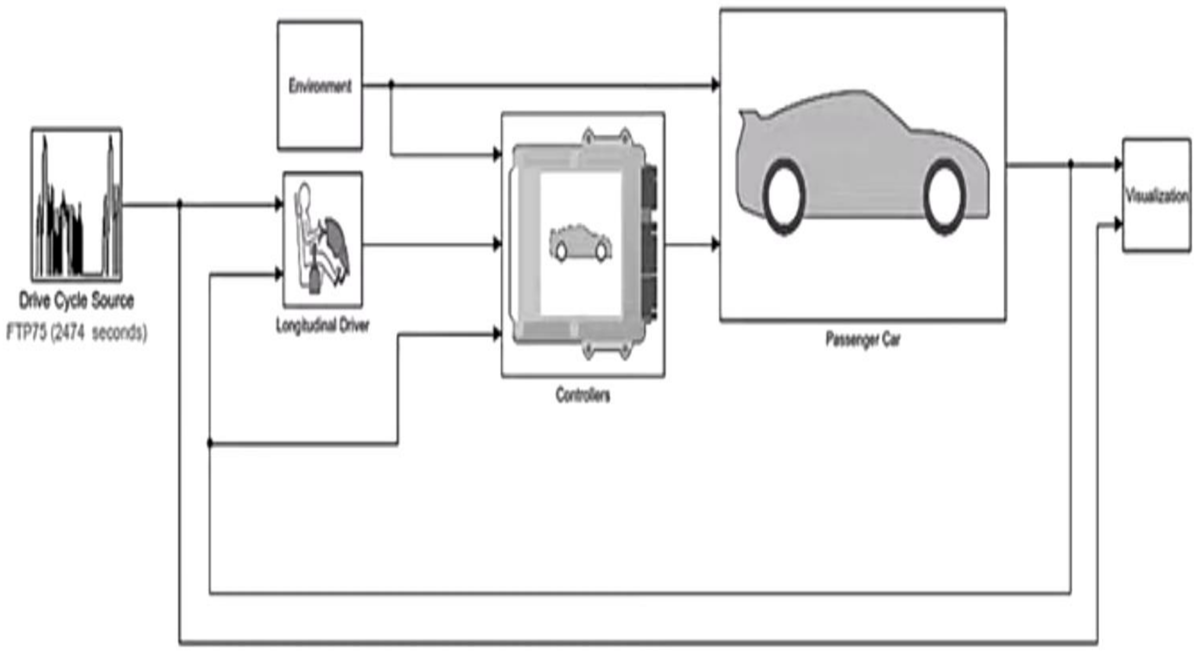


Figure 12: SIMULINK MODEL OF EV

- It has six subsystems namely
  - I. Drive cycle source block
  - II. Environment subsystem
  - III. Longitudinal driver subsystem
  - IV. Controllers' subsystem
  - V. Passenger car subsystem
  - VI. Visualization subsystem

SUBSYSTEMS OF ELECTRIC VEHICLE:

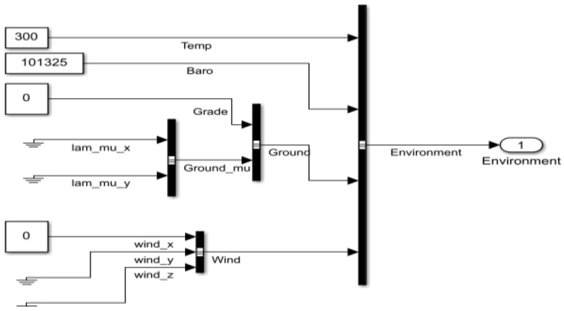


Figure 13: ENVIRONMENT SUBSYSTEM

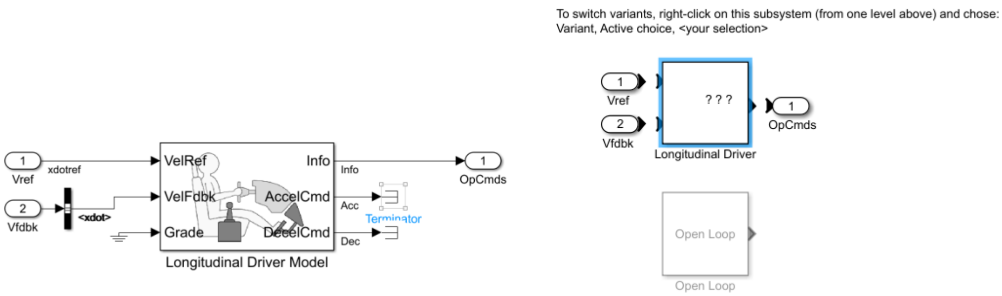


FIGURE:14 LONGITUDINAL DRIVER SUBSYSTEMS

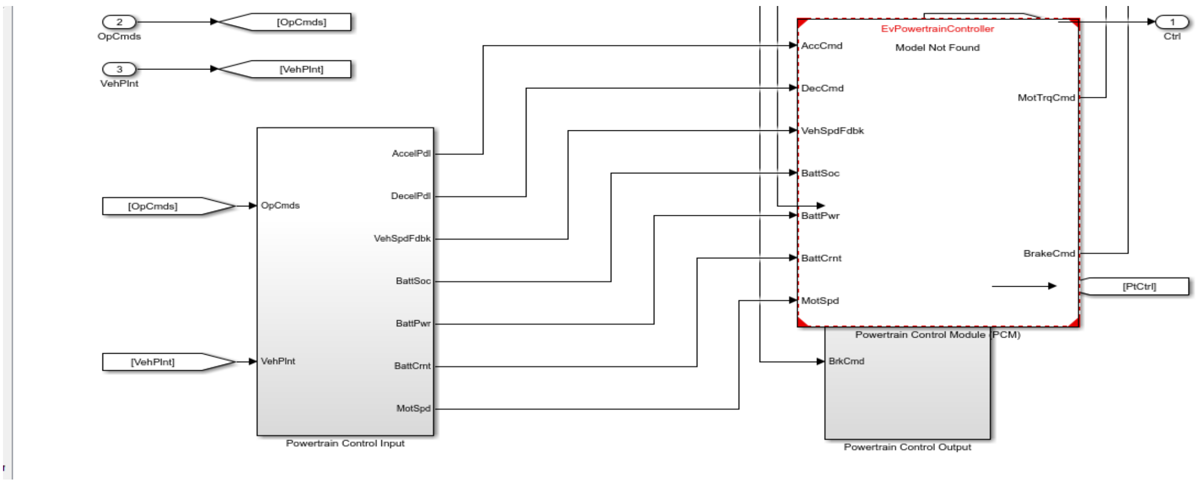


Figure 15: CONTROLLER SUBSYSTEM

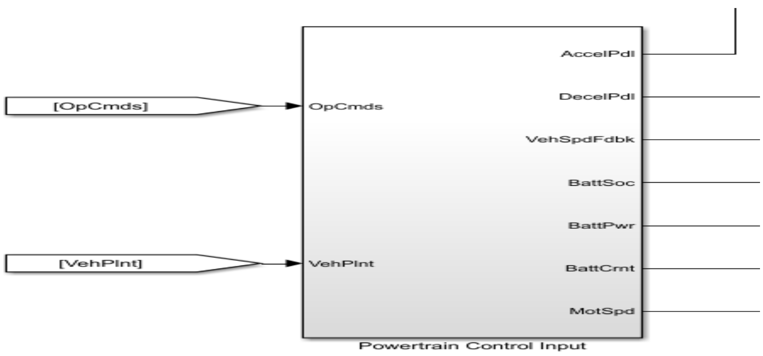


Figure16: POWERTRAIN CONTROLL UNIT

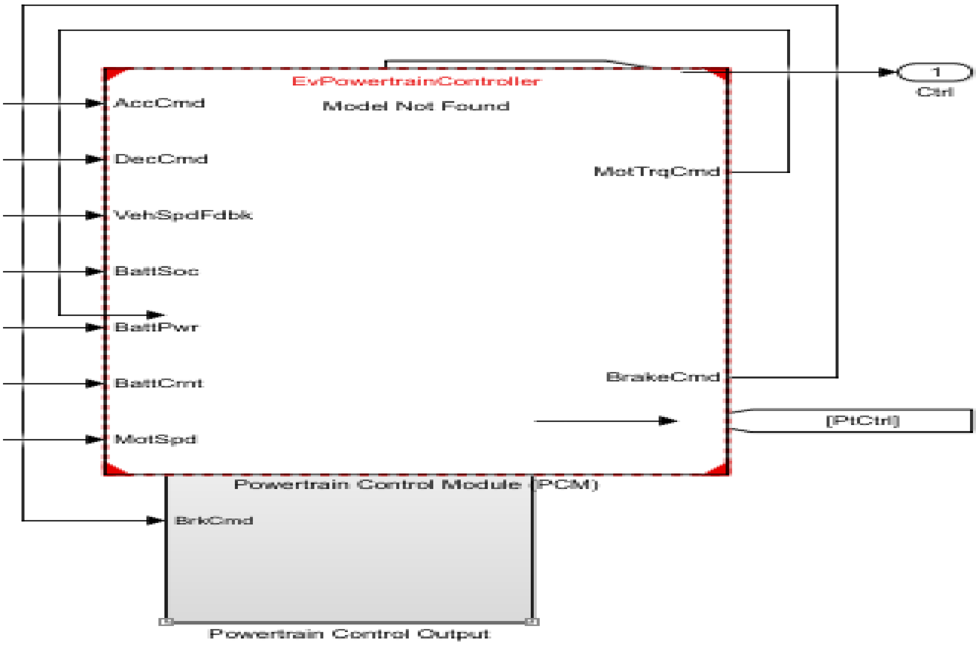


Figure17: POWERTRAIN CONTROLL MODULE

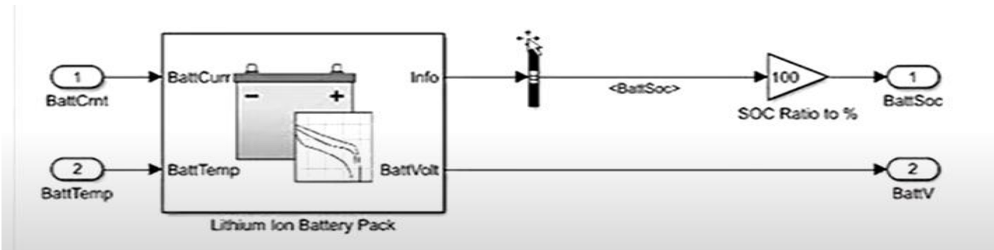


Figure 18: BATTERY

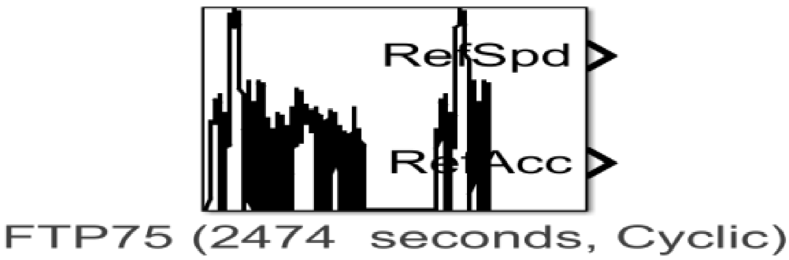


Figure 19: DRIVE CYCLE SOURCE BLOCK

1. The drive cycle velocity is generated in the standard form in contrast to the time-based profile.
2. The batteries containing Lithium Ion: these are the special kind of batteries offering extraordinary working and range. On the other hand, highest price tag is also carried by it. As compared to lead acid and nickel metal, the lithium-ion batteries are lighter. The digital cameras and smart phones are also made using these batteries.

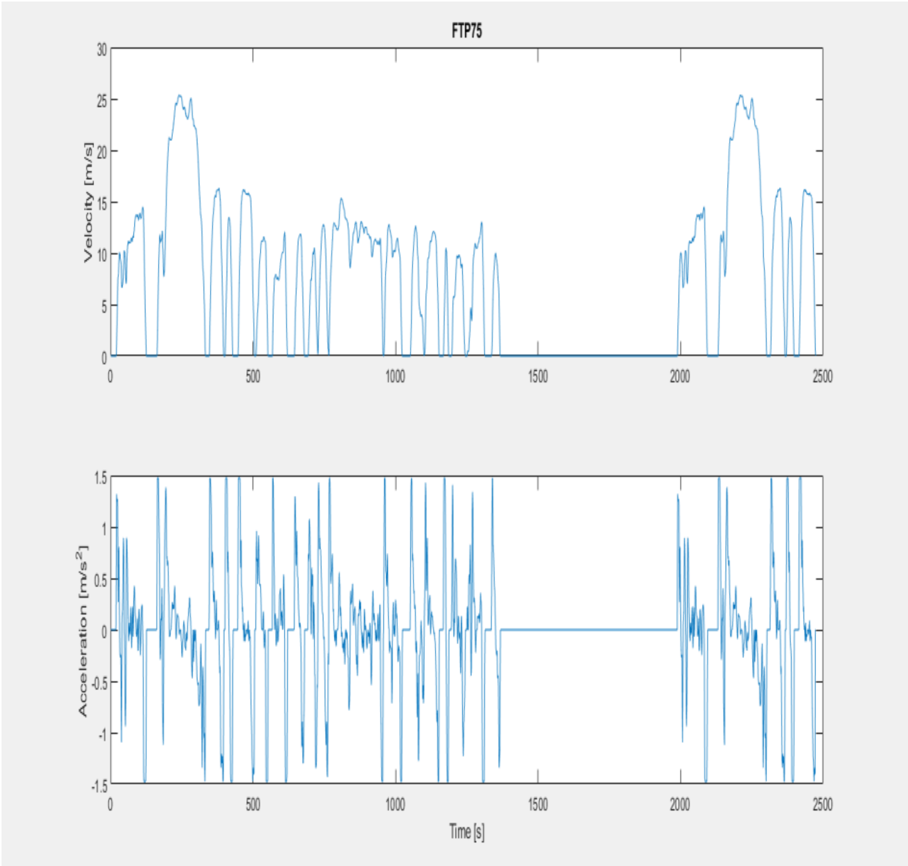


Figure 20: DRIVE CYCLES(FTF5)

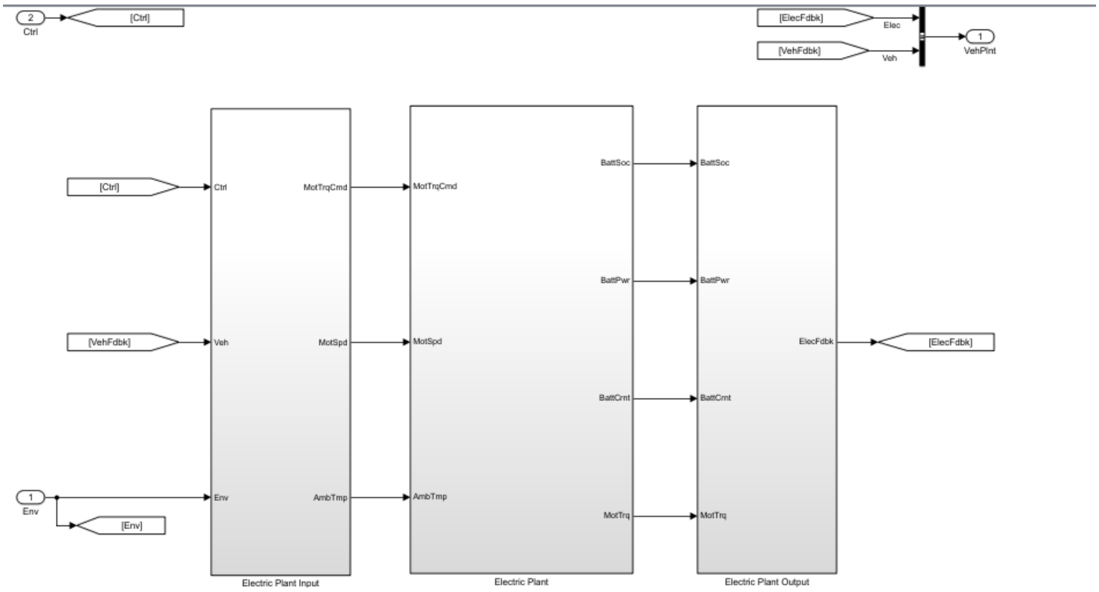


Figure 21: PASSENGER CAR SUBSYSTEM (Drive train)

I. To implement a passenger car, the passenger car subsystem contains a driver train and electric plant subsystem

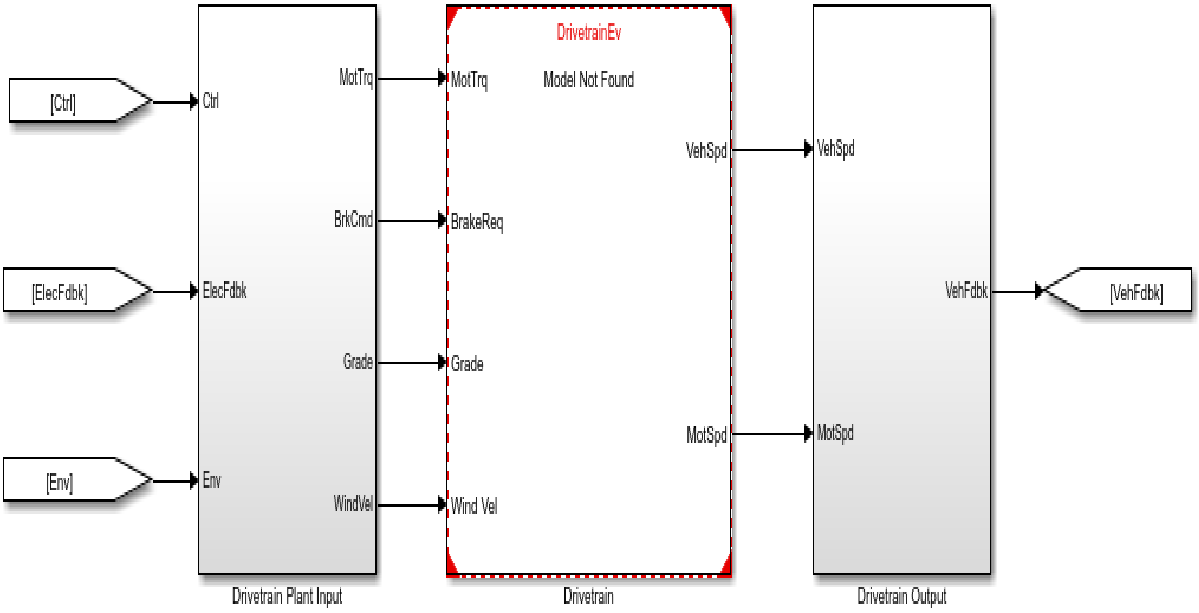


Figure 22: ELECTRIC PLANT SUBSYSTEM

SIMULATION RESULTS:

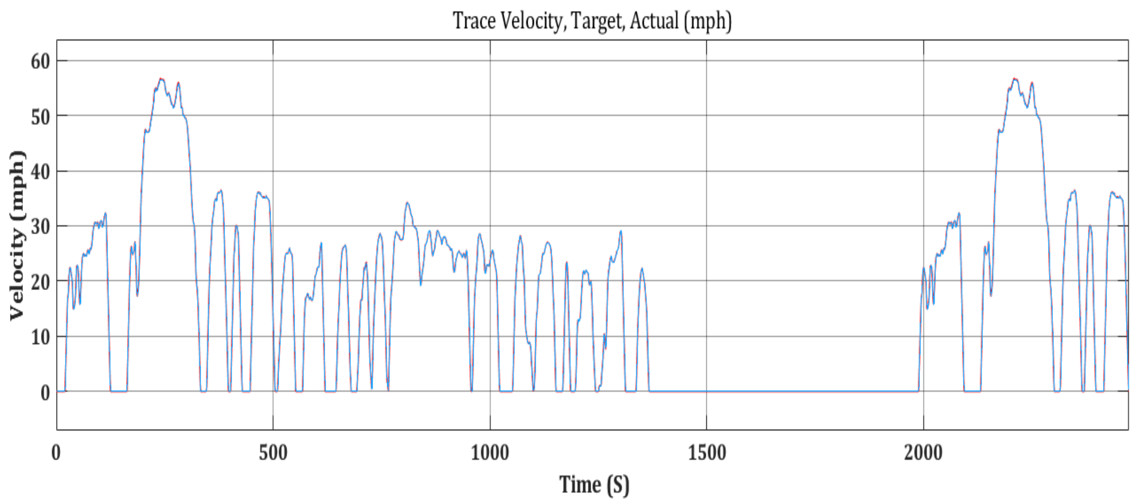


Figure 23: TRACE VELOCITY, TARGET ACTUAL (mph) graph

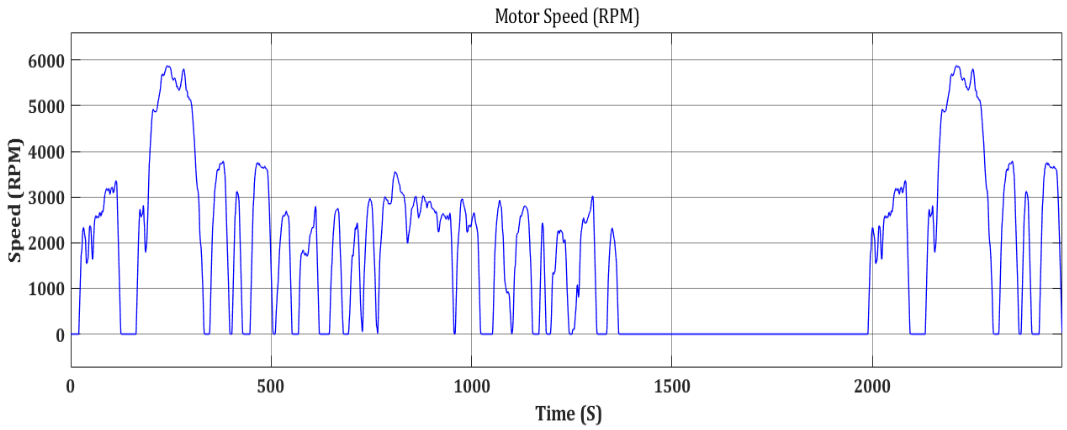


Figure 24: Motor speed (RPM)graph

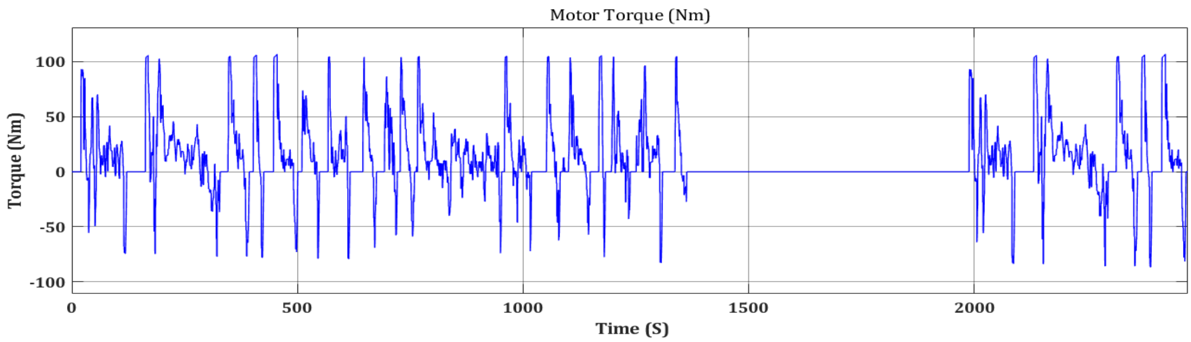


Figure 25: Motor Torque (Nm)graph

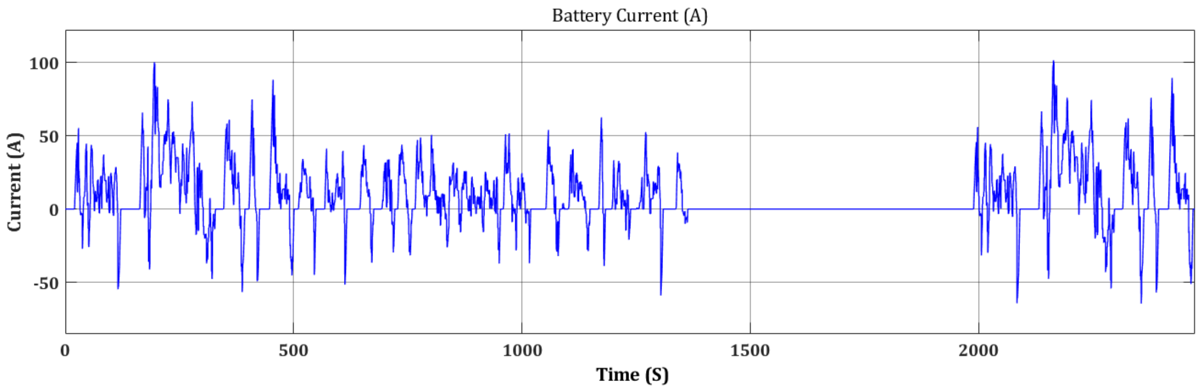


Figure 26: BATTERY CURRENT (A)

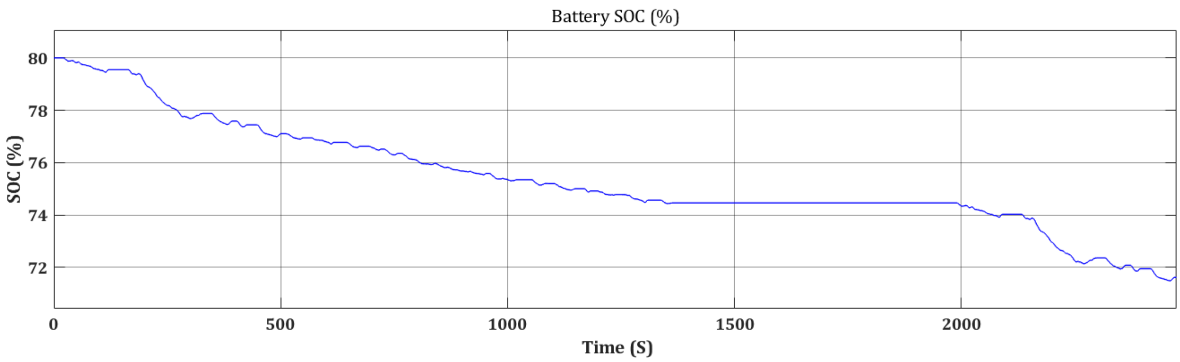


Figure 27: BATTERY SOC (%)

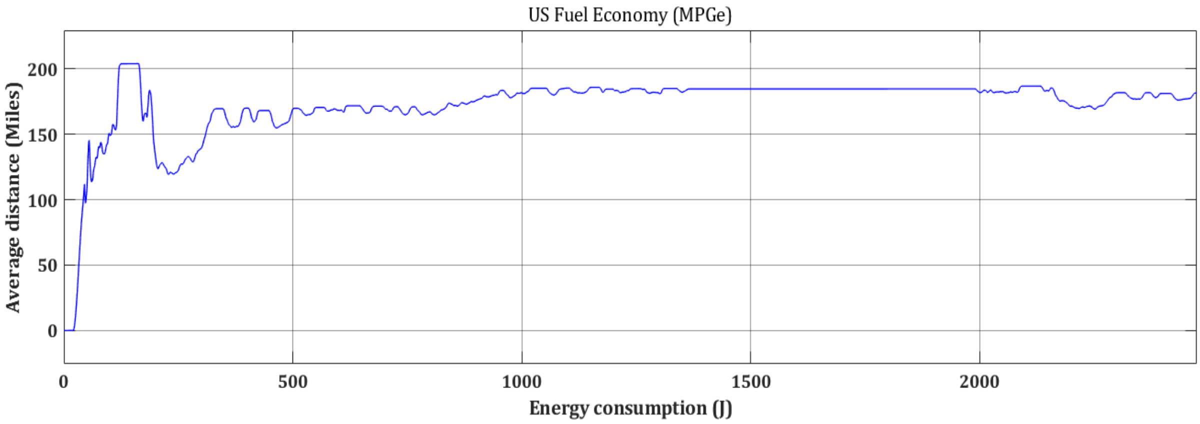


Figure 28: FUEL ECONOMY (MPGe)

PARAMETERS:

TABLE1: Parameters used for PV ARRAY:

CHARACTERISTICS	SPECIFICATIONS
Typical peak power($P_{p.}$)	622.8
Voltage at Peak power(V_{pp}.)	66.25
Current at peak power(I_{pp})	7.727
Short circuit current(I_{sc})	7.84
Open circuit voltage(V_{oc})	36.3
Number of series cells in array	3
Temperature	25 centigrade
Irradiance	1000
Output	66KV

TABLE2: ParametersSEPIC CONVERTER:

PARAMETERS	VALUES
Input	66V
Output	256V
Current	2.6A

TABLE3: Parameters used forELECTRIC VEHICLE:

PARAMETERS	VALUES
Input	256V

Motor speed(rpm)	0-6000
Motor torque (Nm)	80-100
Battery current	0-100A
Trace velocity	0-55Mph
Battery SOC	72-80%
AVG Distance	0-200 Miles

CONCLUSION:

For the betterment of the capability of power transfer and power conversion efficiency, the research workers developed high speed and high gain sepic converter that is operated by the hybridized solar PV/battery in electric vehicles. The solar system's bidirectional power flow is delivered to a brushless DC motor. The suggested system, which includes a sepic converter, is designed to increase power flow from solar PV systems. When and if power is not needed to load, the grid is connected via a DC bus to supply the power generated by PV. The utilization of photovoltaic, as well as the power conversion of a sepic converter, improves an electric vehicle's reliability. The creation of a PV-based SEPIC Converter fed Electric vehicle model will improve the vehicle's reliability and lessen its operating costs. The energy for the electric vehicle is provided by the voltage source inverter of the DC bus. The bi-directional power flow control between the VSI and the grid is fed via single phase VSI. The fundamental frequency is employed in this system to minimize switching losses. MATLAB/SIMULINK was used to obtain the suggested PV-based sepic converter fed Electric car results.

FUTURE SCOPE

The future of mobility promises to be quiet,effective,and environmentally friendly with the acquisition of four-wheeler cars for government offices, three-wheeled vehicles, and buses for public transportation,public procurement is likely to be a key-driver of growth in the coming years,investments by fleet operators like ola and uber,as well as several food distribution companies.After taking into account a certain amount of batteries, India might save RS.8lakh crore on gasoline and diesel imports for the sector if the governments's 2030 targets are satisfied .the timely adoption of electric vehicles and the expansion of the charging infrastructure will result in a transition,the effects of which will be seen particularly in metropolitan cities.especially,because pollution has reached toxic levels.the younger generations in india,with an age bracket of 27,is focused on innovation.sustainability and environmental conservation.various established conglomeraters and star-ups can ensure indigeneous availability of products by manufacturing automobiles,components,and batteries together..

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