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Performance analysis of Electric Vehicles with battery and Asynchronous machine using MATLAB Simulink Model

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Abstract: As the world's oil reserves are running out, there is a problem with air pollution brought on by diesel and gasoline cars, many researchers are driven to find alternate energy sources to power automobiles. Making an electric car by swapping out the combustion engine for an electric motor is one of the finest alternative approaches. The very first step in this research is to model the power flow in the energy system of an electric vehicle in hopes of determining its characteristics. As electric vehicles mainly rely on the limited electrical energy provided by a battery, the efficiency of power flow is crucial. This paper presented the simulation of battery with an electric motor and analysis the waveform from the output for electric vehicles.

Keywords Electric Vehicle (EV), Battery, Fuel, and State of charge (SoC), Hybrid electric vehicle (HEV)

INTRODUCTION

Electric automobiles are being developed as part of a worldwide effort to decrease reliance on fossil fuels and pollution. EVs play a vital role globally in the transportation system in terms of the availability of fossil fuel, pollution, and cost of fuel [1]. EVs are primarily made up of batteries and electric motors. An essential part of an electric vehicle is an electric motor, which uses switching devices to adapt the electrical energy source to the varying needs of the vehicle. On the other hand, electric vehicles commonly use batteries as their main energy source. In figure 1 types of EVs are described. However, the batteries in electric vehicles have the disadvantage of having a limited capacity and service life, which makes charging the batteries challenging. On EV charging, various researchers are presently engaged. Researchers mainly studied wireless charging methods and charging time in terms of charging. There are several researchers currently working on the charging of EVs. In terms of charging, researchers mainly focused on charging time and wireless charging systems.

In electric vehicles, the performance of EVs is an important aspect for any researcher. So, in order to improve the performance of the electric vehicle, analyze the harmonics and try to reduce the harmonics. EVs are more efficient than traditional vehicles. However, the overall well to wheel (WTW) efficiency will also depend on the power plant efficiency. For instance, total WTW efficiency of gasoline vehicles ranges from 11% to 27%, whereas diesel vehicles range from 25% to 37% [2]. By contrast, EVs fed by a natural gas power plant show a WTW efficiency that ranges from 13% to 31%, whereas EVs fed by renewable energy show an overall efficiency up to 70% [3].

So, this paper discussed EVs performance with battery and asynchronous machine in MATLAB Simulink model.

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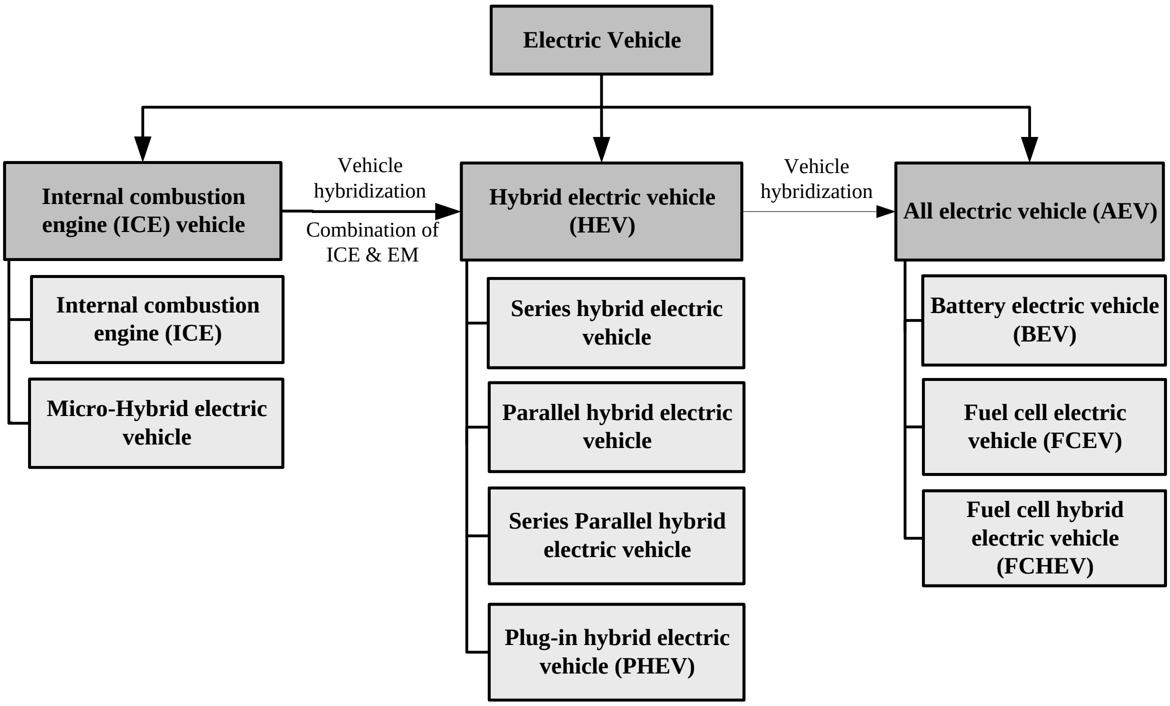

Figure 1. Classification of electric vehicles

Instead of using conventional fuel while the car is accelerating, flywheel energy may be used. The energy gained from regenerative braking and the battery's residual charge are both stored in this flywheel. A dynamic model of an entirely electric car, including controllers, inverters, traction motors, batteries, and brakes, has also been built. The modelwas constructed using Matlab/Simulink (Mathworks). There are various types of EVs. Battery electric vehicles (BEVs), Hybrid electric vehicles (HEVs), Plug-in hybrid electric vehicles (PHEVs), and Fuel cell electric vehicles (FCEVs).

Table 1. Types of EVs with driving component and key feature [4]

EV Type	Driving component	Energy source and infrastructure	Key feature
BEV [5-6]	Electric motor	Battery and Ultra-capacitor	Zero emission, short range, crude oil independent, and commercially available
HEV [7-14]	Electric motor and ICE	Battery, Ultra-capacitor and ICE	Very low emission, long driving range, Oil dependent
PHEV [15-18]	Electric motor and ICE	Battery and gasoline or diesel	Some emission present, and long driving range
FCEV [19]	Electric motor	Fuel cell	Ultra low emission, High energy efficiency, and independent to the supply of electricity

Batteries use in EVs

A battery is an electrochemical device that converts and stores chemical energy into electricity. It is categorized into two types non-rechargeable primary batteries and rechargeable secondary batteries. A secondary battery is rechargeable and ideal for vehicular applications.

The storage of electrical energy is a major purpose that batteries perform. Lithium-ion batteries were adopted by the great majority of hybrid and electric vehicle manufacturers. This storage device is commonly necessary for all sorts of electric automobiles, including hybrid electric vehicles, plug-in hybrid electric vehicles, and regular electric vehicles. The majority of car manufacturers now utilize rechargeable batteries as a consequence of developments in technology.

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Table 2. Battery type and their characteristic [20-26]

Battery type (→) Characteristics (↓)	Pb-PbO_2	Ni-Cd	Ni-MH	Zn-Br_2	Na-NiCl	Na-S	Li-Ion
Working Temperature (°C)	-20-45	0-50	0-50	20-40	300-350	300-600	-20-60
Specific Energy (Wh/kg)	30-60	60-80	60-120	75-140	160	130	100-275
Energy Density (Wh/L)	60-100	60-150	100-300	60-70	110-120	120-130	200-735
Specific Power (W/kg)	75-100	120-150	250-1000	80-100	150-200	150-290	350-3000
Cell Voltage (V)	2.1	1.35	1.35	1.79	2.58	2.08	3.6
Cycle Durability	500-800	2000	500	>2000	1500-2000	2500-4500	400-3000

In following Table 3 various parameters of battery estimation for different types of batteries with machine learning algorithms are summarized.

Table 3. Batteries with extracted parameters using different machine learning algorithms [27]

Estimated Battery Parameter	Type of Battery	Implemented Machine Learning Algorithm
State of Charge	Lithium Iron Manganese Phosphate ($LiFeMnPO_4$) battery	Support Vector Machine
	High Power Ni-MH rechargeable Battery	Adaptive Neuro-Fuzzy Inference System (ANFIS)
	Lithium iron phosphate ($LiFePO_4$)	RBF Neural Network, OLS Algorithm and AGA
	Lithium Iron	Neural Networks and Extended Kalman Filter (NN and EKF)
	Lithium-ion battery U1-12XP	Neural Networks and Extended Kalman Filter (NN and EKF)
	NiMH battery with 1.2 V and 3.4 AH	Neural Networks and Extended Kalman Filter (NN and EKF)
	Li-ion cells with 3.2 V/50 AH supplied by Huanyu New Energy Technology Company Ltd.	Support Vector Machine Based on Particle Swarm Optimization
	Panasonic 18650PF battery cells	Recurrent Neural Network with Gated Recurrent Unit (GRU-RNN)
	Samsung 18650-20R battery cells	Recurrent Neural Network with Gated Recurrent Unit (GRU-RNN)
	A lithium polymer battery manufactured by KOKAM Company	Adaptive Unscented Kalman Filters (AUKF) and Least-Square Support Vector Machines (LSSVM).
State of Health	Two commercial Li-ion batteries with Li $(NiCoMn)1/3O_2$ cathode and graphite anode	Support Vector Machine
	Li-Co batteries	Probabilistic Neural Network
	Lithium Nickel-Manganese-Cobalt Oxide	Advanced Sparse Bayesian Predictive Modelling (SBPM)
State of Charge, State of Heath	Lithium iron phosphate ($LiFePO_4$)	Dynamically Driven Recurrent Networks (DDRNs)
	Lithium iron phosphate ($LiFePO_4$)	Dynamically Driven Recurrent Networks (DDRNs)
	Li-ion cells	Feed-Forward Artificial Neural Network

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Aging, State of Charge, State of Heath	Lithium iron phosphate ($LiFePO_4$)	Input Time-Delayed Neural Networks
Capacity	Nickel-manganese-cobalt (NMC)/Graphite pouch cells	Random Forest Regression
Capacity and State of Charge	Lithium iron phosphate battery cell	Ampere Hour Counting with Correction and Dual Adaptive Extended Kalman Filter Algorithm
Capacity and Resistance	Lithium-ion battery	Support Vector Machine (SVM)
Charging Current	Lithium Iron Phosphate ($LiFePO_4$)	ANN and Backpropagation Algorithm Ensemble Learning
Remaining useful Life (RUL)	Selected IFP1865140 type batteries were developed by HeFei Guo Xuan High-Tech Power Energy Company Limited of China	Feed Forward Neural Network (FFNN)
	High-energy 18650 lithium-ion batteries manufactured by Panasonic, labelled NCR18650PF	Long Short-Term Memory (LSTM) Recurrent Neural Network (RNN)

MATLAB Modelling

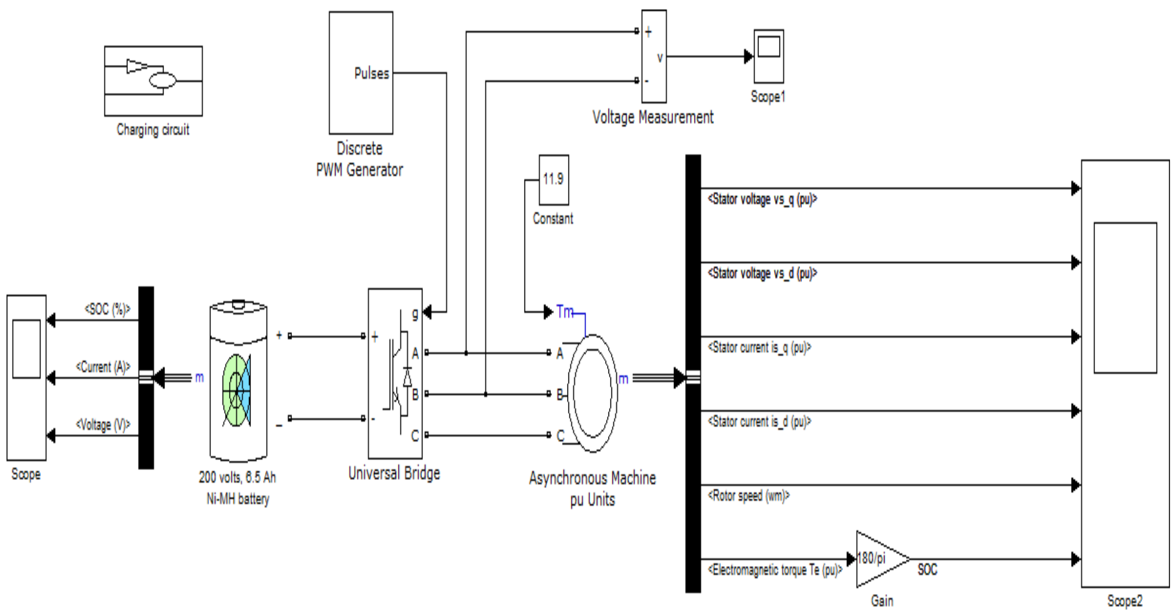

Figure 2. Matlab Simulink model for Electric vehicle

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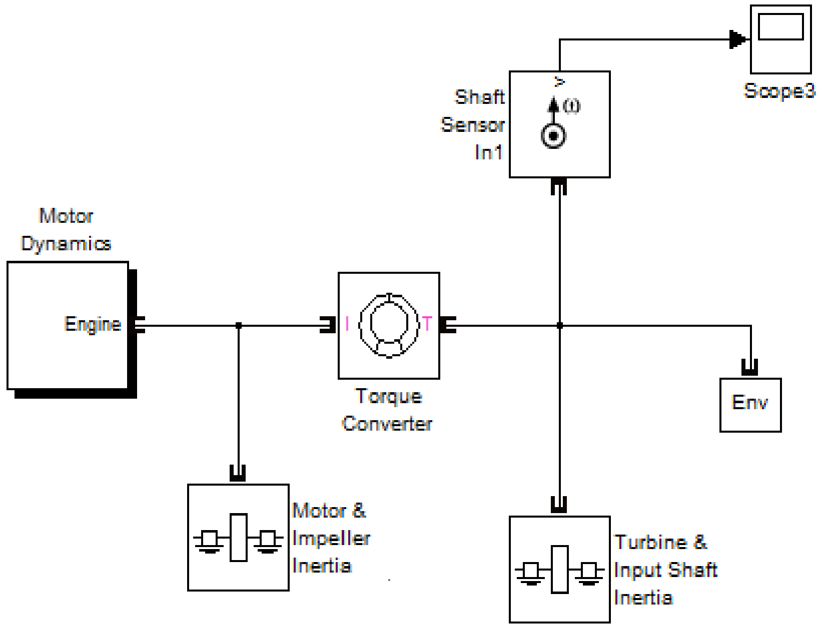

Figure 3. Power flow of electric vehicle

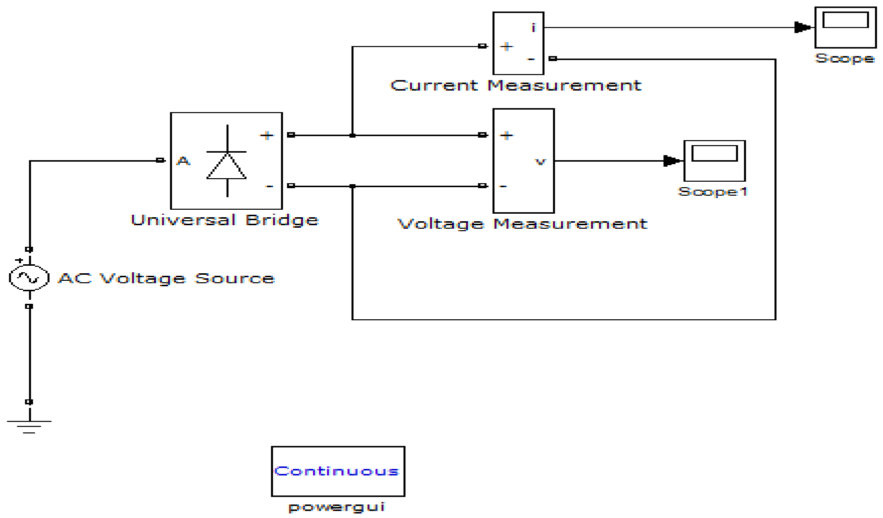

Figure 4. Power flow of electric vehicles charging circuit.

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Simulation Results

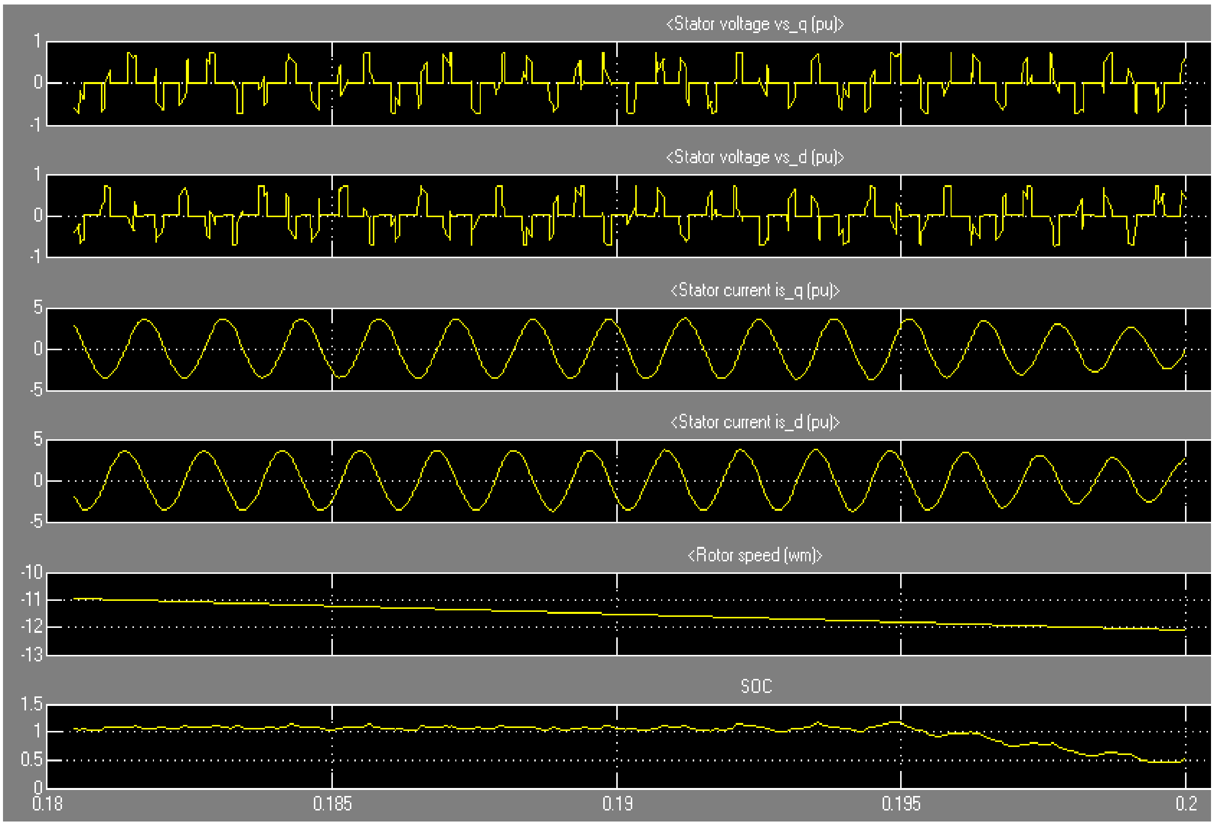

Figure 5. Simulation result of electric vehicle system

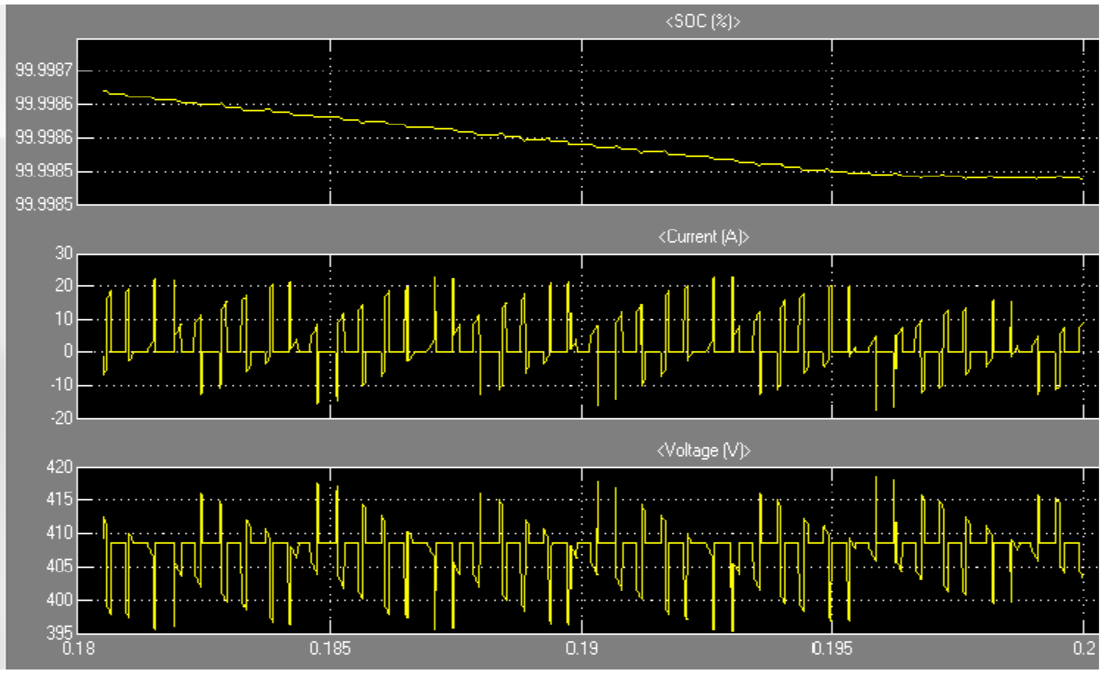

Figure 6. Simulation result of electric vehicle battery

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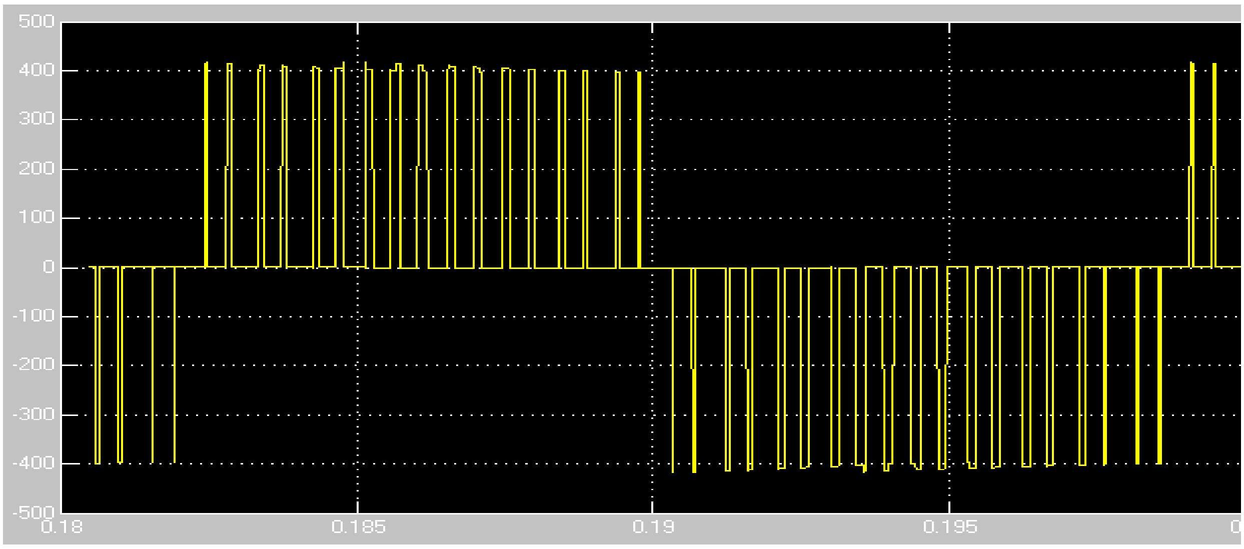

Figure 7. Simulation result of electric vehicle system voltage

DISCUSSION AND CONCLUSION

In this research paper, figure 5 shows the final output of the electric motor voltage and current obtained as a sinusoidal wave, which is desired for the system. From the model obtained less harmonics waveform then the performance of EV will increase. Designing electric vehicle equipment makes it very easy and simple to determine many times the recharge to a rechargeable battery for an electric car with a specific need to travel a particular distance. This model may be used and calculate how long an electric car's battery can be utilized. The model may also be used to estimate an electric vehicle's capabilities, such as how quickly it will start or how long it will run at a constant speed.

The collection of regenerative braking energy is one critical area where this approach might be considerably improved. To maximize energy recovery when braking, downshifting switching locations may be fine-tuned.

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