

Smart Monitoring and Simulation of E-Vehicle using Simulink

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Abstract---The main objective of this project is monitoring of the parameters of Electric vehicle. E-vehicles use battery (for storing electricity) and motor (EV propulsion) instead of fuel and IC engine respectively. Instead of implementing a prototype to study EV parameters which maybe a tedious process we have used a software simulation approach. This approach reduces the time and cost investment needed for prototype implementation. Even if the results are not satisfactory, we can do trial and error method in simulation to get desired output which is not possible in case of prototype implementation approach. The simulation results from software are transferred to monitor using a processor by installing required library files. So, the user can have a check on his/her EV's parameters through that monitor. The software used for simulation in our project is MATLAB-SIMULINK. In this software we have created a virtual model of E-vehicle to monitor parameters of battery and motor. In the Simulink model, a PID controller is designed to analyse the battery working conditions. This battery is used for operating an E-vehicle. The processor/board used in our project is Raspberry Pi 3 Model B+.

Keywords---Electric Vehicle (EV or E-vehicle), MATLAB-Simulink, Raspberry pi 3 Model B+, Equation based design, State of charge(SOC), State of health(SOH), Proportional and integral based controller (PID controller)

I. INTRODUCTION

The first electric vehicle was produced by Thomas Parker in 1884, 25 years after the invention of lead-acid batteries. After that date, many electric vehicle models appeared. However, the development of internal combustion engine technology and the reduction in mass production costs have left electric vehicles behind. The issue of the depletion of oil reserves in the world, and the problem of air pollution produced by motor vehicles, motivate many researchers to seek alternative energy sources to propel the vehicle. One promising way is to replace combustion motor with an electric motor, which is known as an electric vehicle. First stages of this research is to model the flow of power in the electric vehicle energy system to obtain its characteristics. Power flow efficiency in electric vehicle is very important because this type of vehicle is highly dependent on the limited electrical energy supplied by a battery. Therefore, it should be managed properly. This study is to look into the power flow calculation so that the amount of electrical energy is in accordance with the needs of electric

vehicle. Conventional vehicles utilize petroleum derived fuels to provide good performance and long range. But there are some disadvantages such as low fuel economy and exhaust gas emissions causing environmental pollution. The energy crisis that lived between 1970 and 1980 brought electric vehicles back to the forefront. But they could not reach the high speeds and long ranges of conventional vehicles. For this reason, sufficient technological development could not be achieved. Until today, many companies have produced electric vehicles. However, the range of these vehicles is short and they cannot reach high speeds.

With the development of electric motor and battery technology, longer distance vehicles have begun to be produced. The time it takes to charge the battery is very high, despite the extended range of ranges. For this reason, electric vehicles are still not at the desired level. The design of small electric vehicle model using MATLAB/Simulink software is to get the best power flow response to the electric vehicle energy system.

SIMULINK is quasi standard tool that helps in the practical applications of industry and in colleges. This proposed project model helps in studying and monitoring the parameters of E-vehicles such as SOC, SOH etc. to ensure its safe operation. Safe operation here means that battery should not be charged/discharged to such a level that it may get damaged and motor must not get heated to a large extent due to its continuous operation. Simulation output results can be treated as a basis to examine the performance of EV and further the design of EV can be modified in simulation software accordingly to get best possible performance results of EV. Further, these results can be viewed on a monitor every time which may be installed in the EV without the need to carry the laptop in which we get the simulation results in software.

II. METHODOLOGY

The various parameters simulated are battery voltage, motor voltage, temperature etc. from which we get simulated outputs. These parameters are observed on a monitor every time which may be installed in an EV without the need of carrying laptop everywhere which has the actual software results.

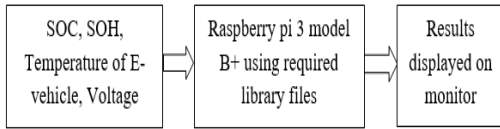


Fig. 1. Block diagram of proposed system

In this project, a model is designed in Simulink software according to our requirement and results such as SOC, SOH, are obtained. These results are then transferred to a board i.e., Raspberry pi 3 Model B by installing required library files in Simulink software. These results can be viewed on a monitor every time by the user.

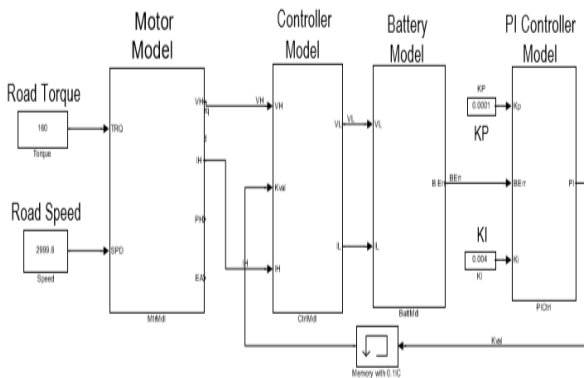


Fig.2.Simulation model of EV

The above simulation model presents the simulation of a basic electric vehicle motor-drive system that is used to investigate power flow during both motoring and regeneration. The simulation assumes a DC permanent magnet motor, an ideal motor controller combined with a proportional-integral controller, and the electric vehicle battery. The model can be used to evaluate the electric drive's energy flow and efficiency for specific speed and torque load conditions. Some of the key system parameters were specified and others were modelled as ideal. A stable MATLAB/Simulink model was developed and validated. It was then used to determine the system performance and energy flow over a given set of motoring and regeneration speed/torque conditions.

III. SOFTWARE SPECIFICATION

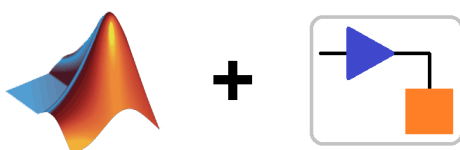


Fig. 3. MATLAB/Simulink logo

Simulink is a graphical extension to MATLAB for modelling and simulation of systems. In Simulink, systems are drawn on screen as block diagrams. Many elements of block diagrams are available (such as transfer functions, summing junctions, etc.), as well as virtual input devices (such as function generators) and output devices (such as oscilloscopes). Simulink is integrated with MATLAB and data can be easily transferred between the programs. The version of MATLAB/Simulink version used here is R2017a.

IV.HARDWARE SPECIFICATION



Fig. 4. Raspberry Pi 3 Model B+

The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT. The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market. It has Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz, 1GB LPDDR2 SDRAM, 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps), Extended 40-pin GPIO header, Full-size HDMI, 4 USB 2.0 ports, CSI camera port for connecting a Raspberry Pi camera, DSI display port for connecting a Raspberry Pi touchscreen display, Micro SD port for loading your operating system and storing data, 5V/2.5A DC power input.

V. RESULTS

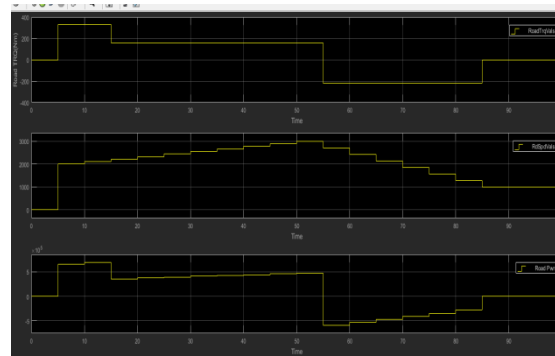


Fig. 5. Road speed, torque and power curves

When both torque and speed are positive values the DC Motor is providing torque in the direction of rotation. This is normal motoring operation. However, when the motor torque is in the opposite direction to the speed, then the motor is being pushed and acting as a generator.

When the speed and torque have the same polarity then power is being transferred from the motor to the load, and the motor is in the motoring mode or 1st Quadrant operation. However, when the speed is positive and the torque is negative, then the motor is being pushed by the external mechanical source. This results in energy being transferred back to the battery.

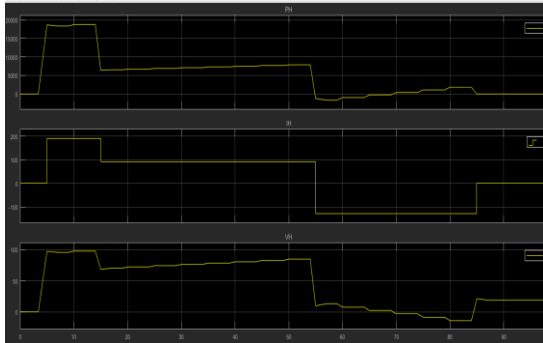


Fig. 6. Motor voltage, current and power

The motor draws power from the battery as shown in Fig. 6. Motor Voltage, Current, and Power. By comparing Fig. 5. and Fig. 6. , the voltage and speed curves generally follow each other, and the torque and current curves also generally follow each other. This general relationship reflects the voltage and torque equations.

The Motor Power plot in Fig. 6. shows both Motoring and Regeneration. When both current and voltage are positive values then the DC Motor is providing torque in the direction of rotation and power is being transferred to the load. This is normal motoring operation. However, when the motor current is in the opposite polarity of the voltage, then the motor is being pushed and acting as a generator with current flow back into the battery.

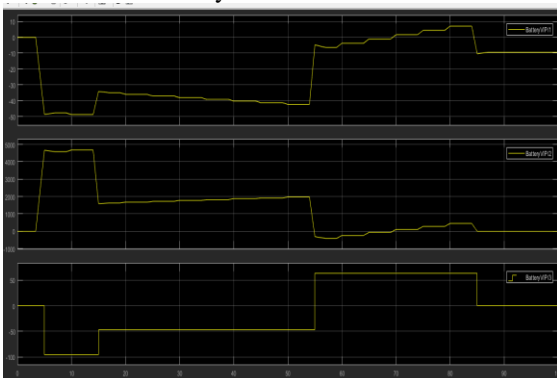


Fig.7: Battery voltage, current and power

The motor draws power from the battery as shown below in Fig. 7. Battery Voltage, Current, and Power. By comparing Fig. 5., Fig. 6., and Fig. 7., the motor torque, motor current, and battery current curves generally follow each other because torque is proportional to current. Thus as the torque requirement increases, then the motor must draw more battery current.

The Battery Power plot in Fig. 7. shows both Motoring and Regeneration. When both current and voltage are positive values then the DC Motor is providing torque in the direction of rotation and power is being transferred to the load. This is

normal motoring operation. However, when the motor current is in the opposite polarity of the voltage, then the motor is being pushed and acting as a generator with current flow back into the battery.

VI. CONCLUSION

Simulation is a very real and necessary part of electric vehicle development and needs to be integrated into learning experiences within engineering education. Simulation-based testing in the form of Hardware-In-The-Loop testing is also a very necessary part of current engineering development especially in advanced systems such as hybrid and electric vehicle drive systems that rely heavily on complex embedded system subsystems. This project is intended to develop a virtual model of E-vehicle to assess and analyse its parameters such as SOC, SOH, temperature of battery etc. Time and cost effective method was the main aim of this project. The performance of EV was altered as per the user's requirement by trial and error method in Simulink by changing various parameters. Further all these results were able to be seen in a monitor.

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