Design and Development of Electric Scooter Battery Pack Management System

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ABSTRACT

Every country in the world is promoting the use of electric vehicles as a way to get around without making pollution as a way to cut down on greenhouse gas emissions. Indian government has started programs like the National Electric Mobility Mission Plan (2020) and the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme to raise awareness about national fuel security by promoting hybrid and electric vehicles. As a result, many electric cars buses and scooters are now on the road. The e vehicle industry is making progress by making the car and battery technology better by making the car faster and the battery able to hold more charge.

One of the most important parts of e vehicles is the Battery Management System. Battery Management Systems keep track of how the batteries work and make sure they are safe. Batteries must be kept from being overcharged or over discharged so that they don't get damaged lose their charge too quickly or cause fires or explosions. The Battery Management System uses functions like battery modelling battery state of charge estimation battery balancing and experimental testing to protect the battery and make the best use of batteries in e vehicles.

In this project, the research will look at how an Electric Scooters Battery Management System works. Probes will be used to check the current parameters the state of charge cell monitoring and safety measures to protect the battery and finally to increase the driving range. This will be made and improved in a similar way by adding a proton exchange membrane fuel cell (PEM FC) a lithium-ion battery and a super capacitor to the battery model of an electric scooter.

INTRODUCTION

In most industrial processes today, Direct Current (DC) motors are the main source of power. These motors are used for a wide range of things such as robotic motions automatic manipulations electric and hybrid vehicles traction systems servo systems rolling mills and other things that need the right process. When compared to the available Alternating Current (AC) motors and their drive systems DC motors and the control and drive systems that go with them are the first choice. The DC motor is so popular because it is easy to control and drive compared to its AC counterpart the speed and torque change linearly with the voltage applied to the armature the speed and torque can be controlled over a wide range Permanent Magnet DC (PMDC) motors are small and have high power efficiency and the overall cost is low.

To control the DC motors rotor position rotor speed or torque the motor field current or armature voltage is changed. Most motor control systems especially for machines with a lot of power use power electronic circuits to measure the voltage at the end of the armature.

When pulse width modulation (PWM) is applied to the motor windings with a high DC link voltage and a hard switching strategy (like in a traditional chopper circuit) the dynamic behavior is not good. When the PWM switches there are sudden changes in the voltage and the armature current. This causes a wide range of voltage and current harmonics which cause torque ripples and the mechanical vibrations and noise that come with them.

One of the most important things to think about when choosing an electric motor for a certain job is how loud and how much it shakes. The noise and vibrations in the motor are mostly caused by electromagnetic forces that aren't working right and are constantly changing in time and space to match the switching operation. This variable exciting force causes the mechanical structure to change shape and makes the motor vibrate.

DC motors are used a lot in modern industry because they are cheap to buy work well don't need much maintenance and don't make too much noise. As electronic technology advances quickly high-performance DC motor drives can be used in a wide range of areas such as rolling mills electric vehicle tractions electric trains electric bicycles guided vehicles robotic manipulators and home electrical appliances. DC motors can be controlled in some ways so the speed torque and even direction of rotation can be changed at any time to meet new needs. DC motors can also start with a lot of torque at a slow speed and the speed can be controlled over a wide range.

So, learning how to control a DC motor is more useful in the real world. Control theory is a part of both engineering and mathematics that looks at how dynamical systems behave. Any system that has a motor needs a controller which gives information to the gate driver. The DC motor is not directly turned on or off by the microcontroller. It will have something called a gate driver whose job is to move the motor. For this system a motor driver is used as a PWM amplifier to provide variable output voltage to control the speed of the motor and positive or negative voltage to control the direction of the motors rotation. In the real world, motors are used for more than just their top speed.

It might only use half of its speed. So, the motors speed must be controlled. In some situations, a motor is used to control a machine in more than one way. In the industrial field some machines or robots can't talk to each other because it wouldn't be safe or because they are in different places. Pulse width modulation is the new method and it is used a lot in motor controllers (PWM). Compared to other ways to control the speed of a DC motor PWM switching is the best. You can change the duty cycle to change the output voltage. The idea behind this system is the same as that of a DCDC converter in that the output voltage depends on how long the circuit is on. Converting from digital to analogue isn't needed because PWM is a digital signal that stays digital all the way from the processor to the rest of the system. By keeping the signal digital noise effects are kept to a minimum unless there is a change from logic 1 to logic 0. This will cause noise to affect the digital signal. The microcontrollers, Pulse Width Modulation (PWM) is used to control the duty cycle of a DC motor drive. Controlling the speed of a DC motor with PWM is a whole different thing. Power is sent to the motor in the form of a square wave which has a constant voltage but a pulse width or duty cycle that changes. Duty cycle is the percentage of one cycle that a continuous train of pulses takes up.

The duty cycle of PWM is set by the pulse width since the frequency stays the same while the on off time changes. In PWM the power goes up as the duty cycle goes up. A DC (direct current) motor turns DC (direct current) electricity into mechanical energy. It makes the motor shaft rotate mechanically and the shaft is physically connected to a machine or other mechanical device to do work. DC motors work well in a lot of different industrial settings. DC motors for example are used when the speed or position of the load needs to be controlled precisely and when the motor needs to speed up or slow down quickly and smoothly. Plus, the direction could be changed easily.

Literature survey

1. Kristaps Vitols and Eizens Poiss, Development of Electric Scooter Battery Management System in 2018, IEEE 59TH International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON).

The rise of electric transportation includes not only four-wheeled vehicles but two-wheeled personal mobility devices as well. One of such is the electric scooter which can be used for personal as well as commercial use as in this case. The present status of a scooter design and development is described - the need for an in-house designed battery management system is given. A set of commercial monitoring integrated circuits are used in conjunction with central controller and measurement circuitry to perform cell monitoring, balancing, current measurement, charge control and emergency shutdown.

2. Ali Ahmed Adam Ismail and A. Elnady ,2019, Advanced Drive System for DC Motor Using Multilevel DC/DC Buck Converter Circuit.

This paper presents a new topology of clamped diode multilevel DC/DC buck power converter for a DC motor system. The proposed converter circuit consists of four cascaded MOSFET power switches with three clamping diodes and four voltage sources (voltage cells) connected in series. The main objective of the new topology is to reduce current ripples and torque ripples that are associated with hard switching of the traditional chopper circuit. When the voltage profile of this converter is applied on a DC motor, it positively affects the performance of the DC motor armature current and the generated dynamic torque.

3. M.A.Hannan Analysis of Multi-power Sources Energy Management System for Electric Hybrid Vehicle, 2011.

This paper presents a new energy management system (EMS) for small hybrid electric vehicle (HEV), which utilizes energy from the combination of battery, fuel cell (FC) and super capacitors (SC). These alternative energy sources are excellent potential solution to the ever-rising price of petrol. The major focus of this paper is the energy management system, which consists of a strategy to coordinate the three different sources. This novel strategy for small HEV allowed the model to meet various load demand condition of an electric scooter or any three-wheeled vehicles. The model is simulated in MATLAB SIMULINK and its performance is analyzed by using the European test drive cycle (ECE-47). The simulation model system includes three renewable energy sources, EMS, DC machine, vehicle speed and feedback control system. The comparison result shows that the model capable to perform the proposed driving cycle.

PROPOSED SYSTEM CONFIGURATION

The escalated increase of oil prices due to resource depletion, global warming issues and enforcement of compulsory standard gas emissions in the cities attribute tremendous impact in developing new transportation technology these days. Thus, an alternative solution like the HEV with its consumption efficiency, economical value and lower toxic gas emission is anticipated to be the technology of the future. The term HEV refers to cars in most cases, whereas the term small HEV is restricted to referring to scooters or three-wheeled vehicles. The automotive industry recognizes that electric vehicles (EVs) and hybrid electric vehicles (HEVs) are in the forefront for fuel efficiency, and reduced emissions. One major challenge for the high voltage battery in the HEVs is to have a long operating life, and yet have a high charge-discharge cycle rate in order to:

i. Recover as much of the vehicle's kinetic energy as possible

ii. To supply high peak energies on demand

Hence, the problem addressed in this project is to improve driving range by improving energy storage system. And to observe the battery function with different charging sources.

In this project, two simulation models are used. The first model has batteries of nickel metal hydride and the second model is a hybrid model made of fuel cells, super capacitor and batteries. The PI controller with PWM is designed to control the speed and rotation of the machine. And a system is designed to maintain the voltage and SOC in batteries and to protect and recharge them. The picture 1 is the simulation model for battery working without BMS. In this, the battery is getting discharged and is not protected. And the waveforms for this is shown respectively [5.1.a and 5.1.b] where the voltage and SOC are decreasing with time. The envisioned circuit diagram of a multi-tenant rescue helicopter switch (mlcc) for such a dc power framework is seen in fig.4.1. The above tried to suggest system that consists of envisioned electrolytic capacitors wall h bridge form in order to manage this same orientation of a vehicle dynamic permanent magnet synchronous engine along with countless regulate slabs a certain organize as well as maintaining the order a function of that very software. Therefore, in research it and recommended multistory heli loop (mlcc) is still a 5 and 8 power conversion and although demonstrated in fig.4.2 this is consists of four voltage regulation switches

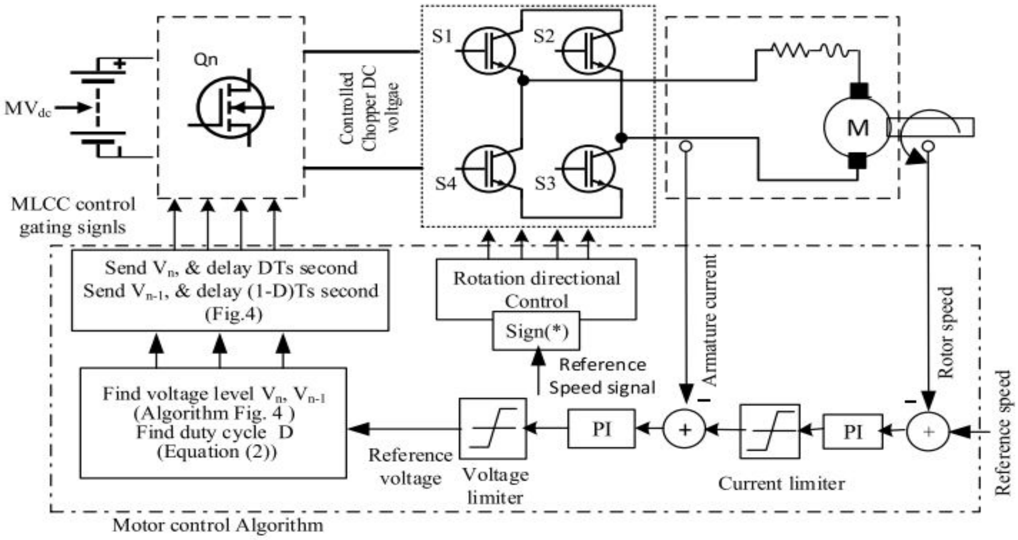

Fig 1 Block Diagram of MLCC driving a DC motor

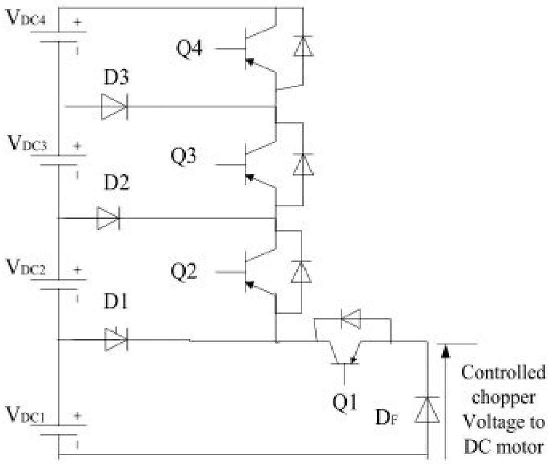

Fig 2 Configuration of 5-level diode clamped multilevel chopper circuit(MLCC)

Controller design for any system needs knowledge about system behavior. Most of the time this means giving a mathematical description of how the process inputs state variables and outputs are related. The mathematical equations that describe how the system works (the process) are called a model of the system. This paper talks about a good way to learn about power electronic converters analyze them and simulate them by using system level nonlinear and switched state space models. Power converters can be simulated in a useful way with the help of the MATLABSIMULINK software package. The goal of this study is to make models for all basic converters and study how they work when there is no load on them. These models can then be used to design any close loop scheme. Also, as a full exercise a closed scheme case with cascaded control for a boost converter has been looked at.

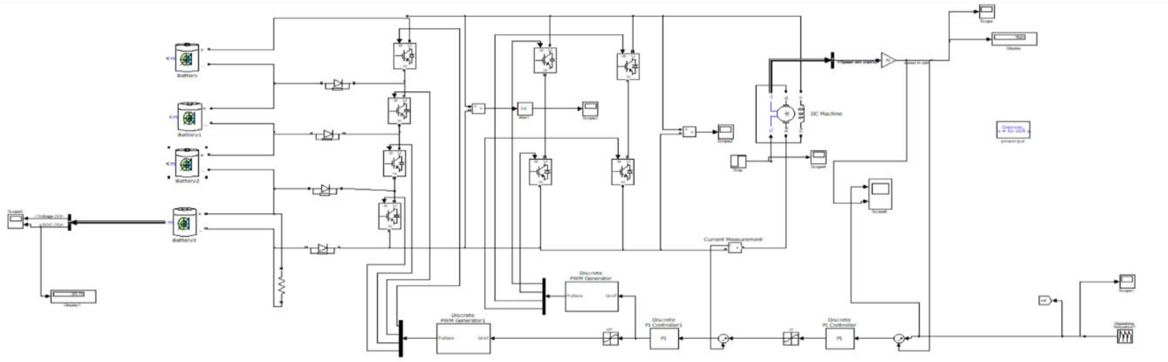

Fig 3 Battery Pack Without BMS

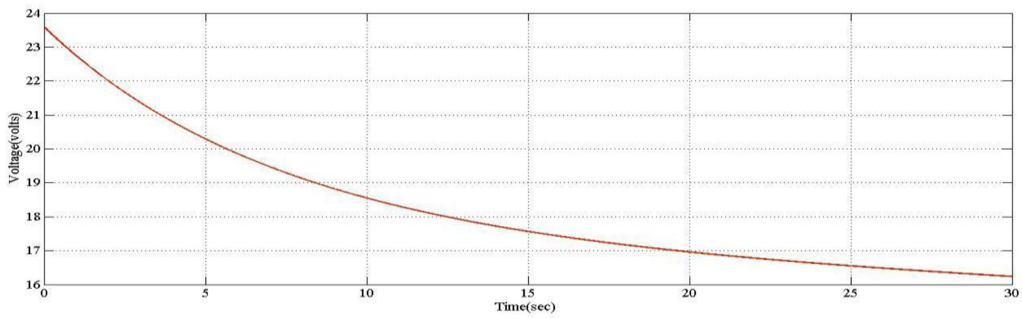

Fig 4 Voltage of Battery without BMS

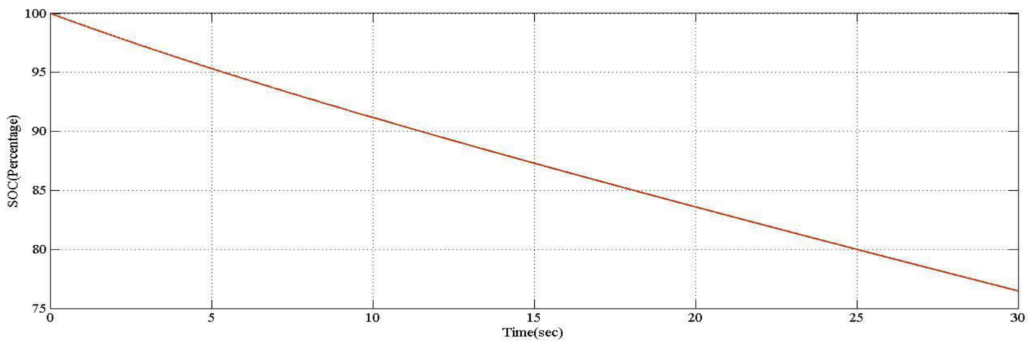

Fig 5 SOC of Battery without BMS

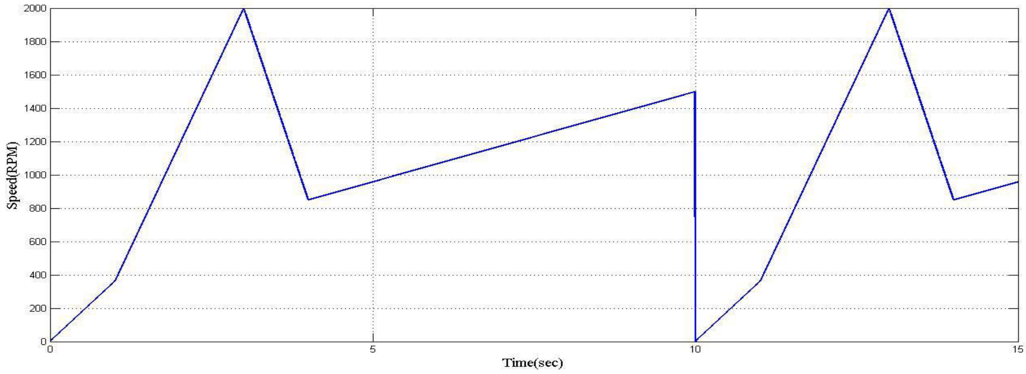

Fig 6 Desired Speed input

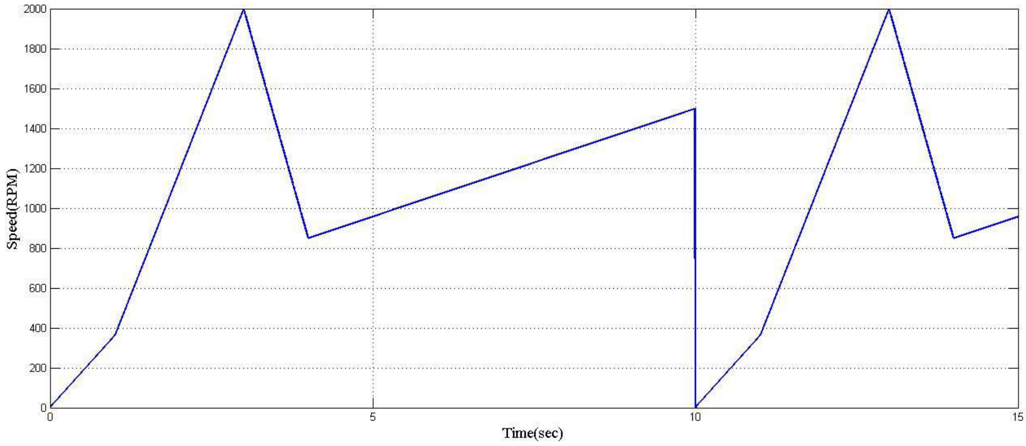

Fig 7 Speed output of the Vehicle

The figure shows the battery pack with BMS and it's working. Here, the battery pack is recharged with the BMS circuit and the SOC is always maintained between 95% to 100%. It is simulated for 30 seconds and the waveforms are shown below [5.2.a, 5.2.b, 5.2.c and 5.2.d].

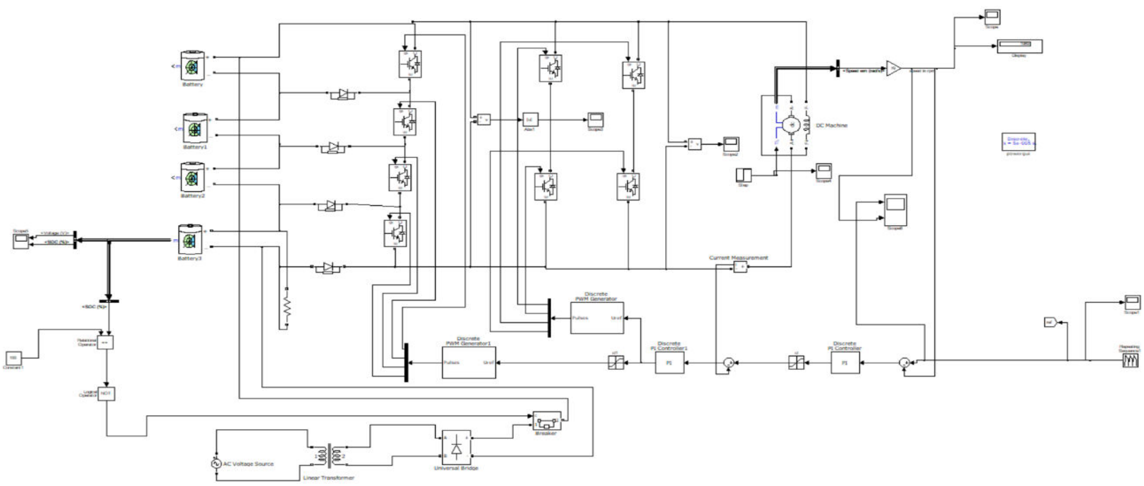

Fig 8 Proposed circuit configuration for Battery Pack with BMS

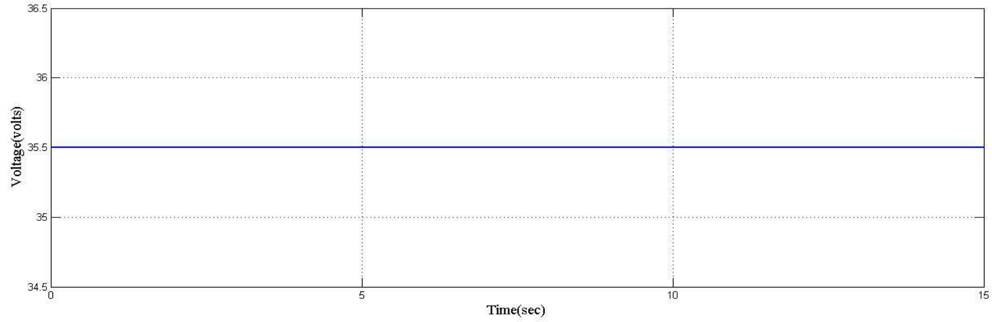

Fig 9 Voltage of Battery with BMS

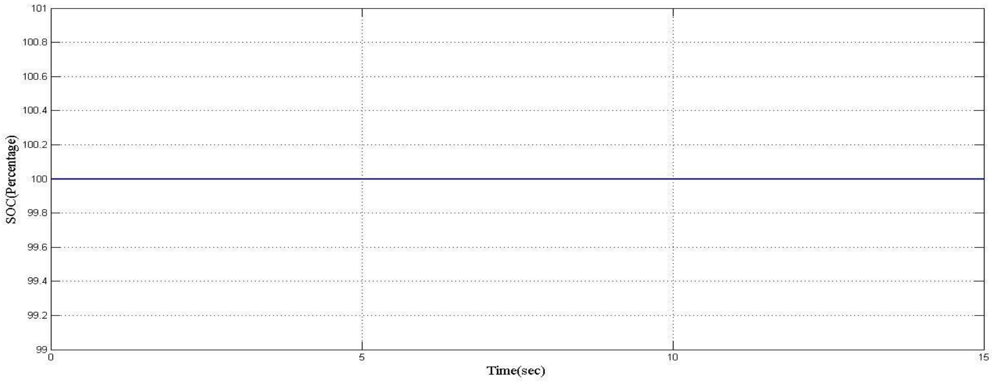

Fig 10 SOC of Battery with BMS

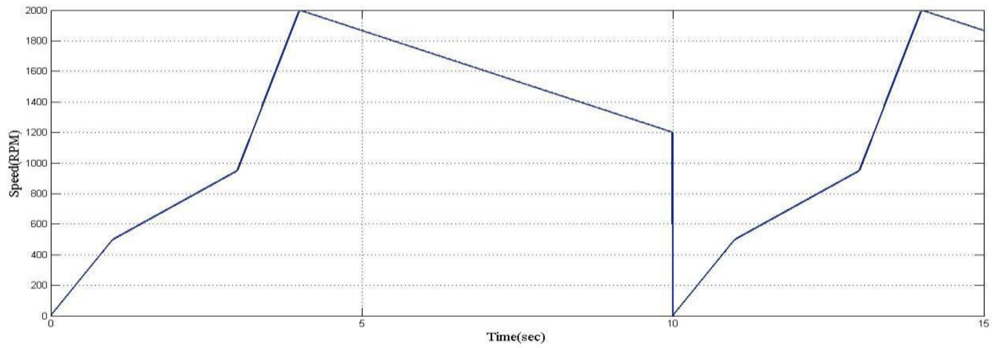

Fig 11 Desired Speed Input

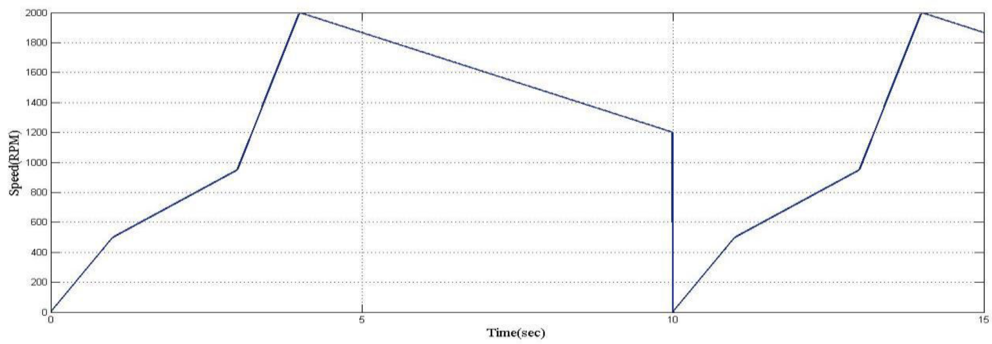

Fig 12 Speed Output of the Vehicle

Fig shows the simulation model for hybrid battery pack and it is too designed with a BMS. The BMS maintains the battery SOC to it’s full by recharging and also protects it. The waveforms of voltage and SOC and the vehicle speed are shown in fig 5.3.a, 5.3.b, 5.3.c and 5.3.d respectively.

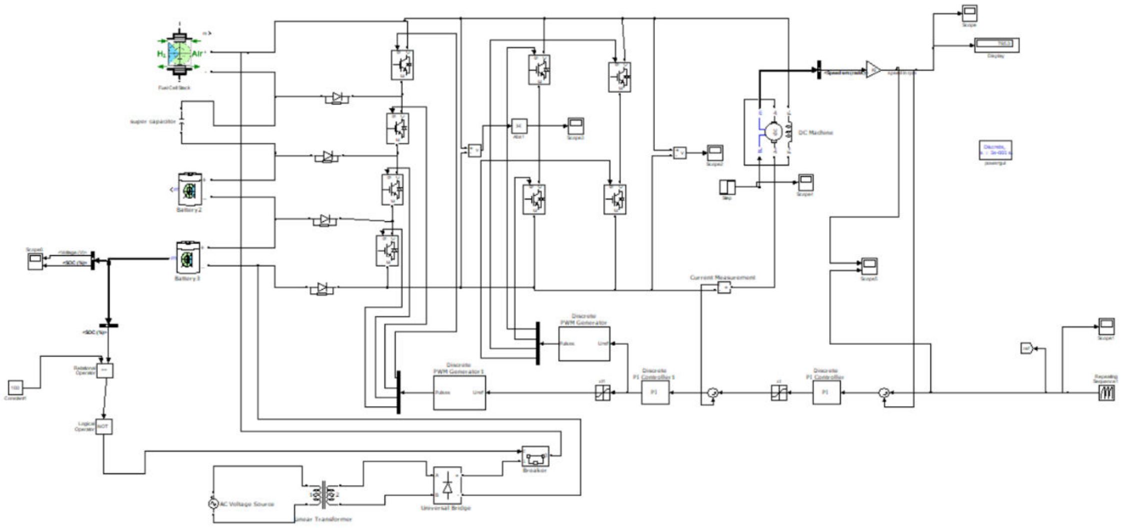

Fig 13 Proposed circuit configuration for Hybrid Model

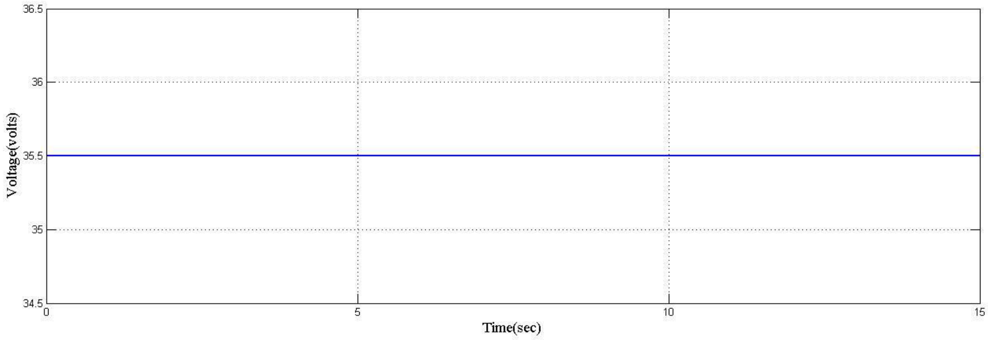

Fig 14 Voltage of Battery in Hybrid Model with BMS

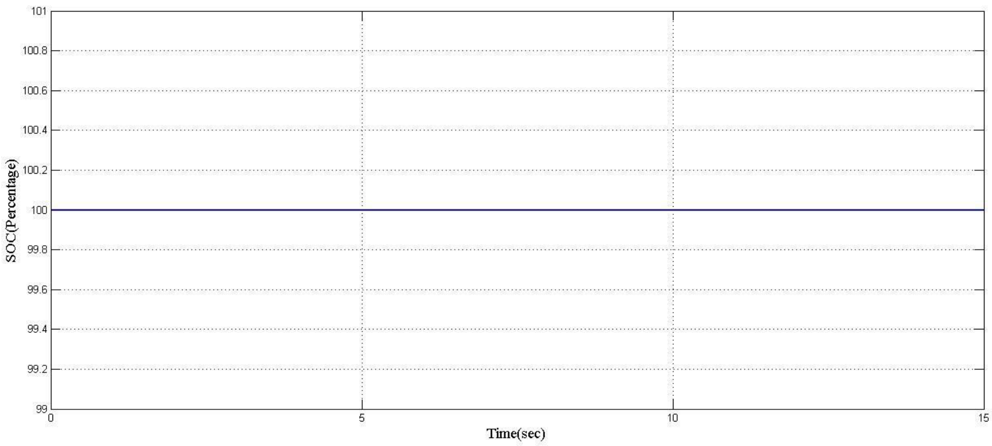

Fig 15 SOC of Battery in Hybrid Model with BMS

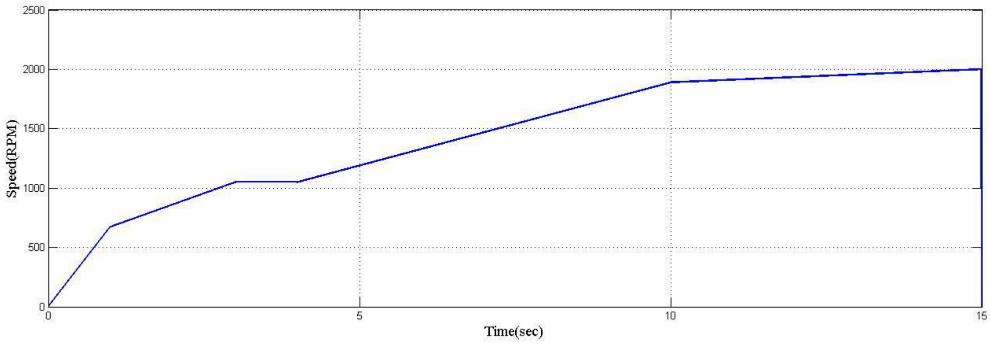

Fig 16 Desired Speed in Hybrid Model

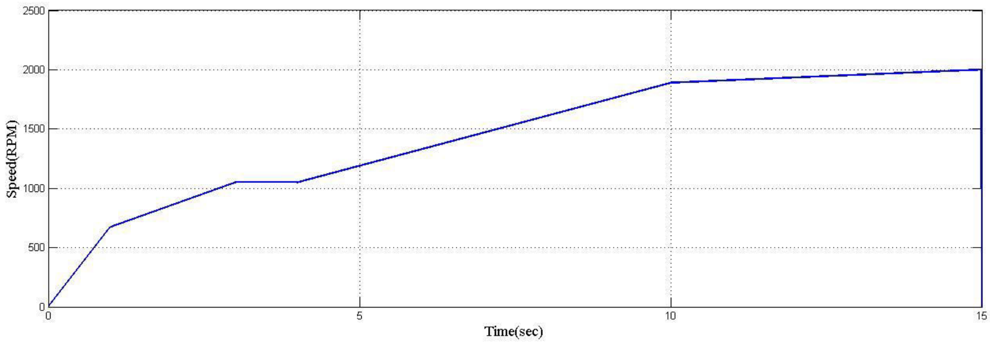

Fig 17 Output Speed in Hybrid Model

CONCLUSION

In this paper, we have designed and developed the battery pack management system of an electric scooter. It is designed where the SOC of the batteries of the electric scooter are studied, then recharged and protected by BMS using the cell balancing technique. The used PI controller along with PWM controls the speed of the motor. Hence, increasing the accuracy of the output speed of the vehicle. In the simulation, two models are shown. One has batteries of Nickel metal hydride and another is a hybrid model made of fuel cell, super capacitor and batteries. It can be concluded that the hybrid model is more efficient than the first model in terms of charging and recharging of them. This project also shows how a new topology for a multilevel chopper DCDC converter for a DC motor system works through simulations and tests. The main goal of the proposed topology is to reduce the current ripples and torque ripples

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