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Hybrid Energy Storage System for Electric Vehicles

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***Abstract*— This paper aims at modelling a hybrid energy storage system for electric vehicles. This system consists of two batteries one lithium ion and one lead acid battery. Initially, when the motor starts the system runs on lead acid battery.And gradually when the motor speed increases i.e., during normal cruising lead acid battery is switched to lithium - ion battery. Using MATLAB simulation is done and verified.**

Keywords*— Hybrid energy, electric vehicles, buck boost converters, pmdc motor.

I.INTRODUCTION

India is the third most polluted country. Of the most polluted cities in the world, 21 out of 30 were in India in 2019. Air pollution contribute to the premature deaths of about 2 million Indians every year. Air pollution is one of the dangerous consequences of conventionalautomobiles which use fossil fuels. To get pollution free environment,increasing the use of renewable resources in vehicle system is advisable.Switching to electric vehicles can reduce the air pollution to a large extent. Inorder to make electric vehicles comparable to conventional fuel vehicles with regards to fasttransient acceleration and long-lasting endurance a hybrid energy storagesystem is used.Conventional automobiles in use around the globe have been a serious threat to the environment as it causes air pollution to a large extent. A large portion of the fossil fuels is being consumed by conventional vehicles so it's high time to switch over to electric vehicles.

Most of the electric vehicles have battery as the only energy storage system. Greater dependency on the battery causes low efficiency and high cost.On travelling long distances there is a possibility for the battery to run out of charge so we should use an additional energy storage system. In most of the electric vehicles, a single battery is used for both the high power and low power needs, this can damage the battery and can reduce the battery life.

II.PROPOSED METHODOLOGY

Hybrid Energy Storage System (HESS)comprises of two batteries one lithium-ion battery and one lead acid battery, which is connected via a buck boost converter where the boost operation is performed. Both the batteries are of 12V are boosted to 24V with the help of buck boost converter.

In the proposed methodology the lithium-ion battery and lead acid battery get fully charged by the available power source and both the batteries are used to run the vehicle. Initially, the lead acid battery provides power to the load via a buck-boost converter to start the vehicle acceleration and during normal cruising lithium ion is used. The speed of the motor will be sensed by the controller and will be compared with the threshold speed which is fixed to switch between the two batteries. Thereby, this ensures safe battery life as the dependency on a single battery is reduced to a large extent.

Initially, the permanent magnet DC motor runs via the lead acid battery and during the normal cruising lithium ion is used. When the motor starts it needs high starting torque so to provide the necessary power lead acid battery is used as it has high specific power. As the motor speed gradually increases, the torque gradually decreases so, the lead acid battery is switched to lithium- ion battery as it has high specific energy as well as high specific power.

Initially lead acid battery runs the motor via the converter during acceleration and when high power is needed. And when the lithium - ion battery is used to run the motor via the converter during smooth running of the vehicle.

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III. BLOCK DIAGRAM

The blocks used in the block diagram are lead acid battery-12V, 1.3Ah, lithium-ion battery-12V, 2.6Ah, controller unit, buck boost converter and a load which is a pmdc motor. Both the batteries are connected separately to two buck boost converters where the voltage is boosted.

A Permanent magnet dc motor is used as the load. The motor is connected to a controller unit. The speed of the dc motor is sensed by the controller and is compared with the threshold speed and if the motor speed is greater than the threshold speed then the control unit is switched to Lithium ion battery. If the motor speed is less than the threshold speed then the control unit switches unit to Lead acid battery.

This below Fig.1 represents the block diagram of the hybrid energy storage system.

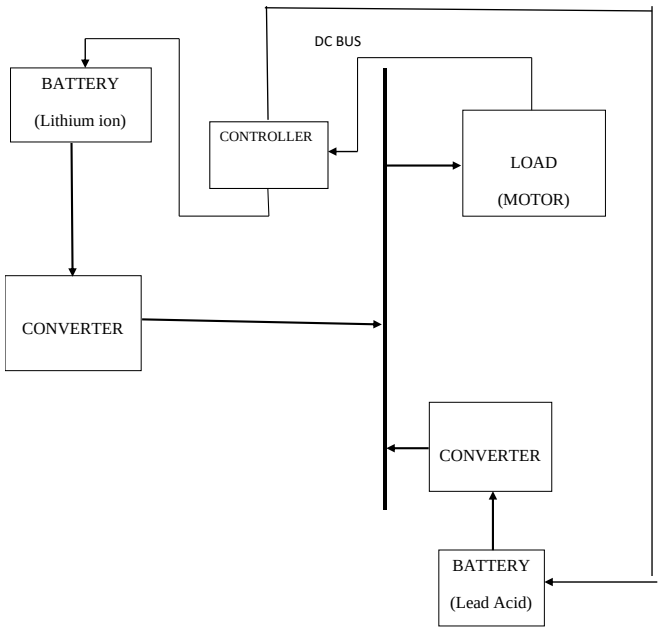

Fig.1 Block Diagram of hybrid energy storage system.

IV. DESIGN

Design of the buck boost converters is given below.

Input voltage Vs = 12V , Output voltage Vo = 24V

Switching frequency f = 25kHz, Ripple current $\Delta I = 0.8$

Ripple voltage of capacitor = 0.05V, Load current=1.25A

k = Duty ratio

$$Vo = (-Vs \times k) \div (1 - k) \ldots . Eqn(1)$$

$$-24 = (-12 \times k) \div (1 - k)$$

$$k = 0.66$$

$$L = (Vs \times k) \div (f \Delta I) \ldots . Eqn(2)$$

$(12 \times 0.66) \div (25 \times 10^3 \times 0.8)$ = 396 microH

L = 396microH

$$C = (Io \times k) \div (f \Delta Vc) \ldots . Eqn(3)$$

$$(1.25 \times 0.66) \div (25 \times 10^3 \times 0.05) = 660 microF$$

C = 660microF

V. SIMULATION

This simulation was done by using MATLAB Software. MATLAB is a Matrix Laboratory. In this simulation, two batteries are used one lithium ion and one lead acid battery both are of 12V. It is then connected to a buck boost converter where the 12V is boosted to 24V. The converters of both the batteries are connected to the input ports of hybrid switching circuit. The hybrid switching circuit is then connected to the dc motor via controlled voltage source.

A step input is given as the input to the load torque which is connected to the R port of the pmdc motor. Ideal rotational motion sensor is connected to the dc motor which measures the motor speed and is displayed on the scope. The motor speed is given to the feedback circuit.

In order to convert the rpm of the motor to a measurable quantity the motor rpm is fed to feedback circuit. In the feedback circuit the input signal is squared and multiplied with the gain. A zero- crossing detector is placed in parallel which maintains the positive value of the signal. Then both these values are multiplied and given to the input port of the hybrid switching circuit. The input signal from the feedback circuit is compared with the threshold speed and accordingly the switching takes place between the two batteries.

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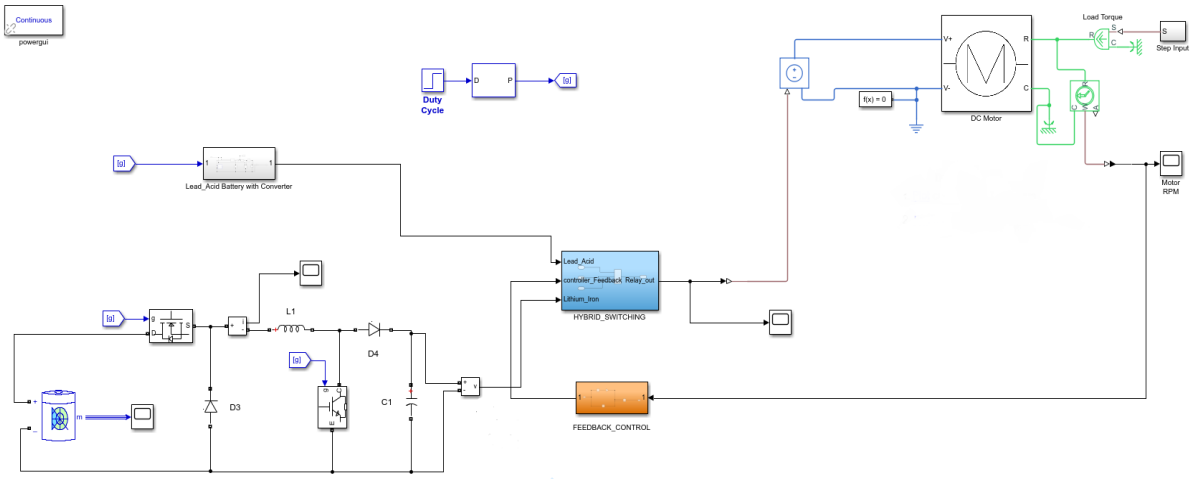

Fig .2 Simulation Diagram of the hybrid energy storage system

VI. SIMULATION RESULTS

Battery voltage is given as input voltage to the buck boost converter. The red line shows the battery input voltage 12V.

Fig .3 represents the input voltage of the batteries i.e., 12V.

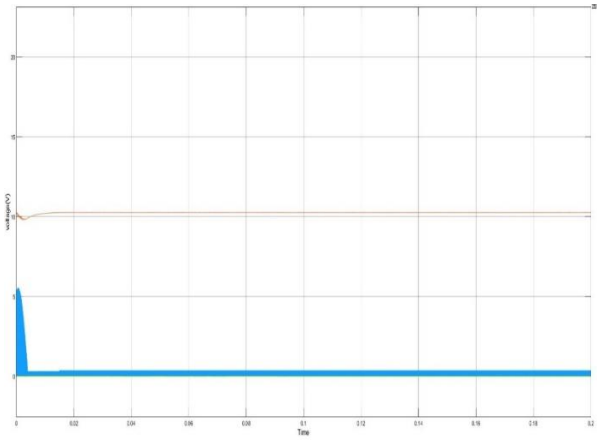

Fig. 3 Battery input voltage

The 12V battery is connected to two buck boost converter where the voltage is boosted up from 12V to 24V.

Fig. 4 represents the converter output voltage

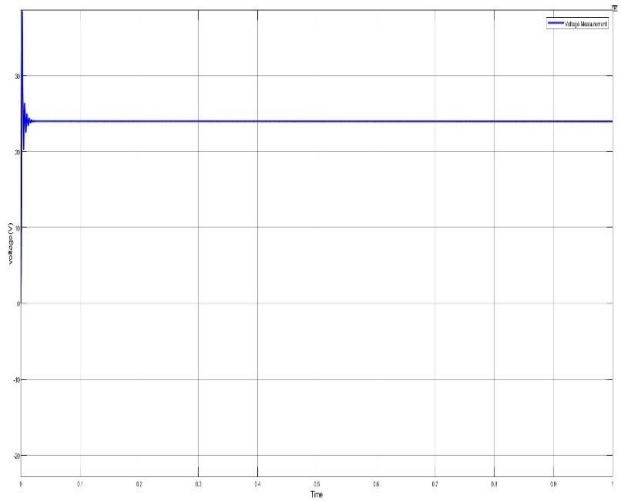

Fig.4 Converter output voltage

Converter output voltage is fed to the input of the pmdc motor.

Fig. 5 represents the torque characteristics of the motor.

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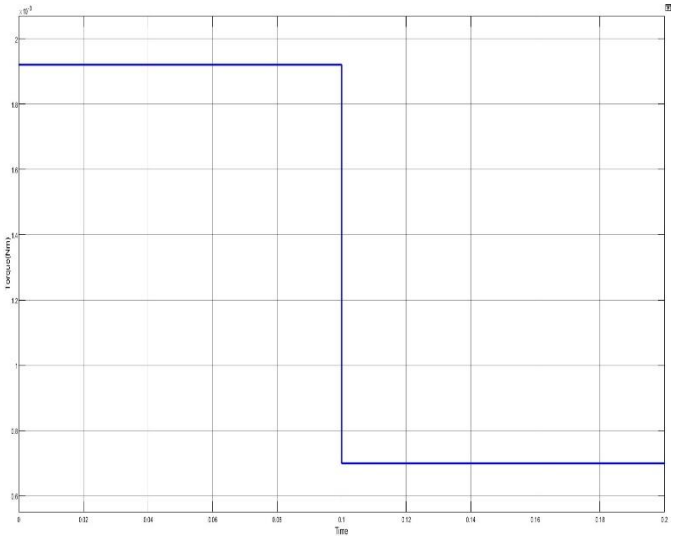

Fig. 5 Torque characteristics of the motor

Initially, the motor starts it has high starting torque and gradually when the motor runs its torque decreases.

Fig. 6 represents the speed characteristics of the pmdc motor

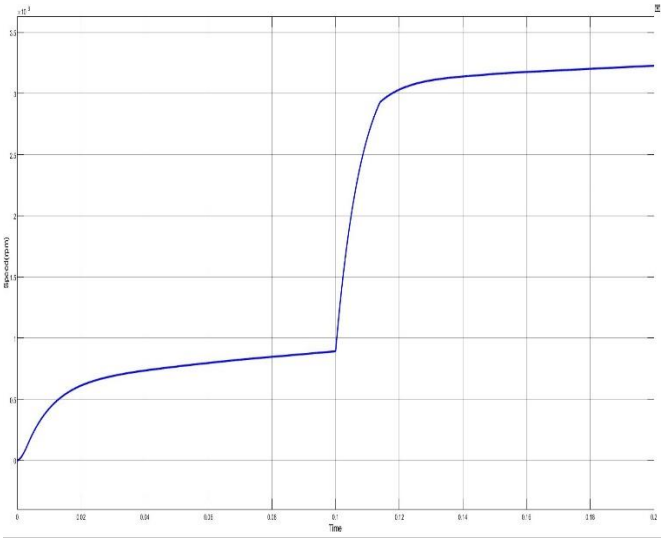

Fig. 6 Speed characteristics of the pmdc motor

Initially, the motor runs on lead acid battery after 0.1s it switches to lithium - ion battery.
Fig. 7 represents the switching characteristics of hybrid energy storage system.

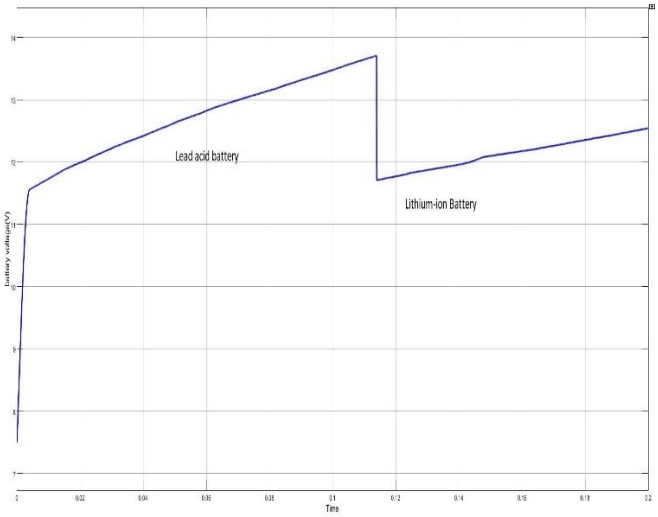

Fig. 7 Switching characteristics

The graph represents the speed torque characteristics of the motor which is derived from the torque and the speed characteristic of the motor.

Fig. 8 represents the speed torque characteristics

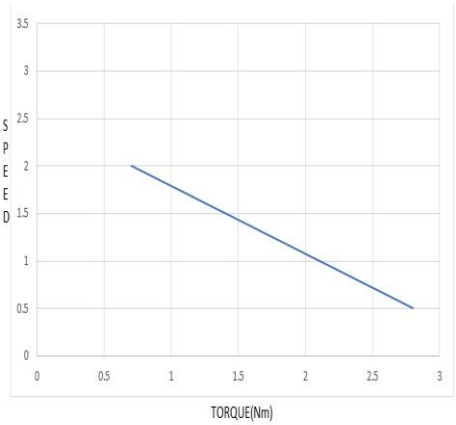

Fig. 8 speed torque characteristics

VI. CONCLUSION

The work focuses on designing a hybrid energy storage system consisting of two batteries which is applicable for electric vehicles. The proposed system shows an improved performance considering both power density and energy density.Hence the simulation of the hybrid energy storage system consisting of lithium ion and lead acid battery is simulated and verified.

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REFERENCES

[1] Chunhua Zheng, Weimin Li, Quan Liang "An Energy Management Strategy of Hybrid Energy Storage Systems for Electric VehicleApplications" IEEE transactions on sustainable energy, vol.1 pp.28118-28129, Nov 2018.

[2] Xiangyang Xia, Xinxin Zhao, Heqing Zeng, Xiaoyong Zeng, "A Novel Design of Hybrid Energy Storage System for Electric Vehicles" IEEE transactions on sustainable energy, vol. 2 pp.2010-2021, March 2018.

[3] Zahra Amjadi and Sheldon S. Williamson, "Prototype Design and Controller Implementation for a Battery-Ultracapacitor Hybrid Energy StorageSystem,IEEE transactions on a smart grid,vol.3,no.1,March 2016.

[4] Bin Wang, Qiao Hu, Zhiyu Wang "Improving Power Output of Battery and Mode Switching Frequency Based on Real-Time Average Power Method for Multi-Mode Hybrid Energy Storage System in Electric Vehicles" IEEE journal ,Postdoctoral Science Foundation of China under Grant 2018M631143, and in part by the China Scholarship Council,vol. 8,pp. 34654-34664, Feb 2020.

[5] K.W.E Cheng " Recent Development on Electric Vehicles" IEEE International Conference on Power Electronics System and Applications vol 4,pp. 4032-4044, March 2019.

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