Hybrid Energy Storage System using Ultra capacitor

Sharad Dandge[1], Akshay Kharwade[2]

[1,2]*Student M. Tech Electrical Power System, Department of Electrical Engineering, VJTI, Mumbai, India*

***Abstract-* The Electric Vehicle is a key new transportation technology to reduce the pollution and to reduce use of fossil fuel. As the era of cheap fuel is coming to end, so the focus on Electric Vehicle in India is increasing. In this paper, an ultracapacitor based Hybrid Energy Storage System is proposed for Electric Vehicle. Compared to Energy Storage System using Battery, the proposed design satisfies the peak power demand and conserves the battery life cycle by utilizing the ultracapacitor as much as possible. Various drive cycles are used to study the behavior of ultracapacitor and battery according to speed change in Electric vehicle.**

The system model has been simulated in MATLAB/Simulink.

***Index Terms-* Electric Vehicle (EV), Bidirectional dc-dc Converter, Ultracapacitor (UC), Hybrid Energy Storage System (HESS), Battery Energy Storage System (BESS), Capacitor.**

I. INTRODUCTION

Now a days fossil fuel, particularly oil is dominating the current energy scenery, the dependency is turning crucial because of the reducing reserves. The transportation sector is very stricken by this example and desires to develop new energy sectors and systems to cut back the oil dependency while progressing to environmental problems. Due to the exclusion of IC engine, the emission in EV is zero and presents a higher efficiency of power train and environment friendly operation. Hence, vehicle manufacturers are turning to Hybrid and EV.

The basic idea is to use the battery as the energy storage system and use the boost converter to supply the power during the acceleration period of EV and store the energy during deceleration/regenerative braking period. As the battery cycles are limited up to thousands of time it gets exhausted because of frequent charging and discharging. As UC having cycle life over million and high power densities, So the UC is introduced to decrease the load on battery cycles as UC is used during acceleration and to store the regenerative power during deceleration. Battery is used during some constant low and constant high speed operation in this way battery cycles are conserved.

The BESS and battery monitoring, managing, protecting and balancing also hybrid power sources are proposed in the literature [1]. However, the design, modeling and control of bidirectional dc-dc converter for EV had been discussed in [2]. There are various topologies and control schemes for controlling of bidirectional converter and eventually HESS [3]-[4]. The concept of reducing converter losses and enhancing efficiency is discussed in [5].

II.BATTERY ENERGY STORAGE SYSTEM

The BESS topology is as shown in Fig.1. In this topology the battery is connected through boost converter to load. Battery voltage is boosted during the high constant speed period and acceleration period. Because of the frequent charges and discharges of battery during the acceleration and deceleration period the battery get exhausted in some finite period because of less battery cycles.

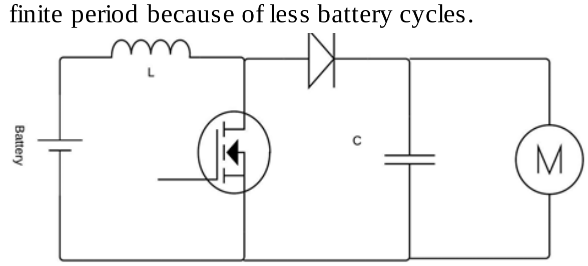

Fig.1. Battery Energy Storage System

III.ULTRACAPACITOR

Electric double layer capacitor or Ultra capacitor stores the energy by polarizing an electrolytic solution and have the high power densities and very long lifetimes also gives the stable performance over large temperature range.

The high surface area and very low thickness between the electrodes gives high capacitance value for the UC. Because of high capacitance value UC can satisfy the high current requirement during the acceleration period. As UC has very long lifetimes can be coupled with BESS could increase the charging profile and the life of battery as well [4].

IV.PROPOSED HESS USING ULTRACAPACITOR

There are various topologies used for combining the battery and UC by using Bidirectional dc-dc converter. Some of them are Basic passive parallel, UC/battery Configuration, battery/UC configuration, Cascade configuration, multiple converter configurations, and multiple input converter configurations. The proposed HESS topology is as shown in Fig.2

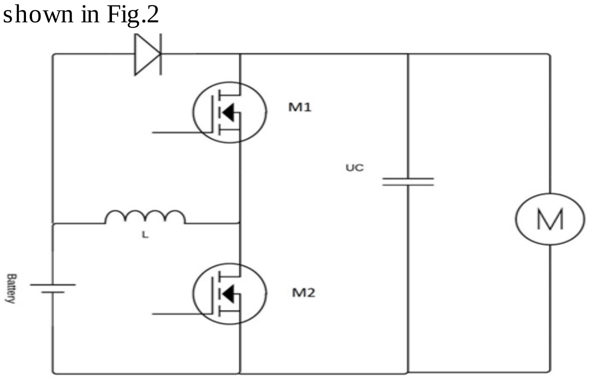

Fig.2. HESS Topology

In this topology, Ultra capacitor is directly connected to the load and the battery is connected to the load through bidirectional dc-dc converter and main diode. There are two modes of operation of the bidirectional dc-dc converter namely buck and boost. During buck mode switch M2 will operate and provide/ store energy from/in low voltage and in boost mode the switch M2 will operate and gives the high voltage to the load or can store energy in UC.

V.SIMULATION RESULTS FOR BESS

The simulation for the BESS is designed in MATLAB/Simulink. The Ni-MH battery is used with the boost converter and the pulse generator to give pulses to switch. DC machine is connected as the load. Speed pulse as shown in Fig.3 is given as the input to the DC machine to study the behavior of battery according to the speed change

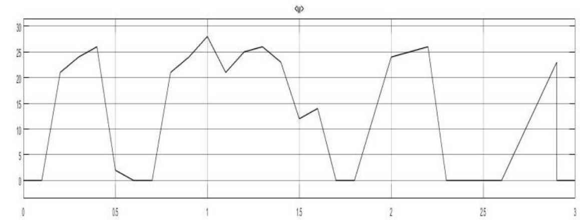

Fig.3 Speed input to DC machine

The behavior of battery current, voltage and battery SOC is as shown below in Fig. 4-6. It shows that as the speed change the battery charges and discharges several times.

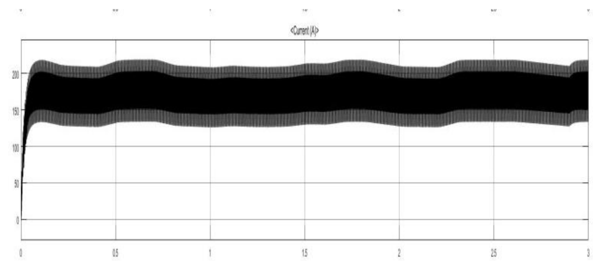

Fig.4 Battery Current in BESS

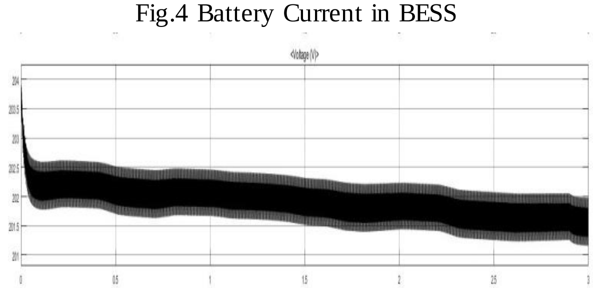

Fig.5 Battery Voltage in BESS

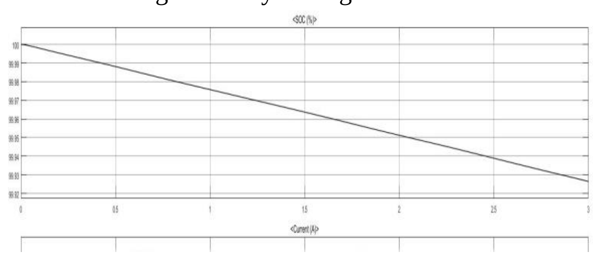

Fig 6 Battery SOC in BESS

VI.SIMULTION RESULTS FOR HESS

The feasibility of proposed converter is evaluated by simulation. Here control strategy developed for HESS and results are verified by using MATLAB SIMULINK software. The HESS simulation contains the 172.8V battery and 2500F ultra capacitor connected using the bidirectional dc-dc converter. The simulation is done and the result of Battery current, voltage and SOC is as shown in Fig.7-9.

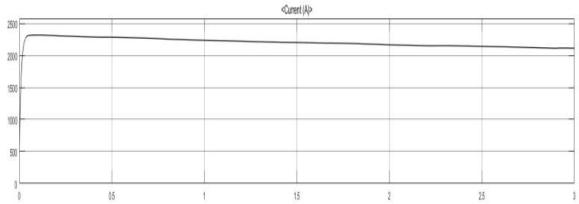

Fig.7 Battery Current in HESS

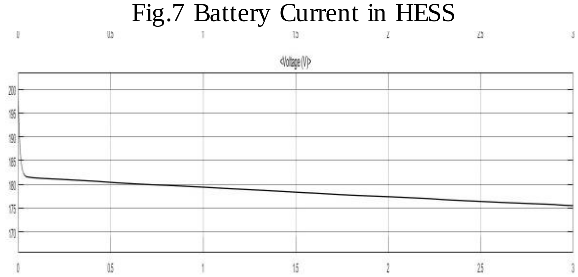

Fig.8 Battery Voltage in HESS

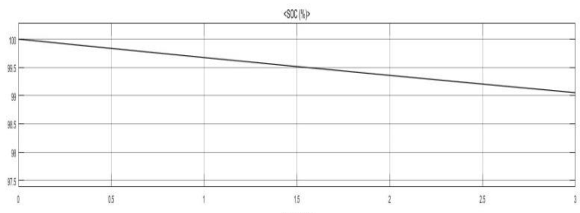

Fig. 9 Battery SOC in HESS

The voltage, current of the UC is as shown in Fig. 10-11. The UC will supply to the load during the acceleration period and stores the energy during the regenerative braking period.

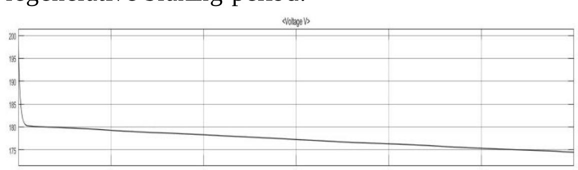

Fig.10 UC voltage

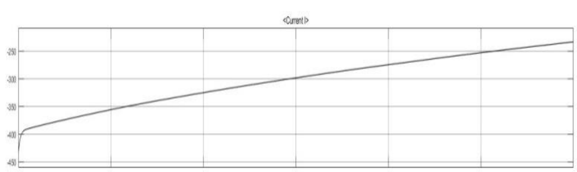

Fig. 11 UC Current

The torque characteristics of Dc machine is come similar in BESS and HESS as shown in the Fig.12

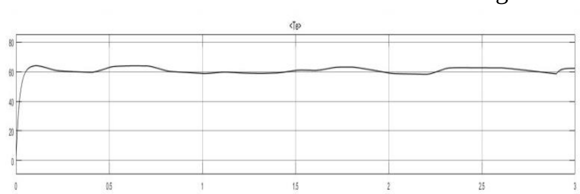

Fig. 12 Torque Characteristics of BESS and HESS

By comparing results from fig 4-12 it is cleared that the battery cycles are conserved by using HESS.

VII. CONCLUSION

The study of Hybrid Energy Storage System using ultracapacitor is presented. The analysis shows that the battery charging and discharging cycles are conserved by using HESS. This configuration allows the EV to operate in various speed change conditions. It was shown that the HESS can deliver three times the power of battery pack alone also the peak power capability of the EV is increased. The proposed HESS topology has greater size of bidirectional dc-dc converter and not fully utilizing the UC. So, the future work will focus on the sizing of bidirectional dc-dc converter and increasing the efficiency of HESS.

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