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Ultracapacitor circuit for solar E-vehicle

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ABSTRACT

This paper proposes a new system for storage of energy which can be used in solar e-vehicles, e-vehicles and hybrid e-automobile. Supercapacitors are charge storage devices that look similar to batteries, have low energy density, high power density and exceptional life cycle. Though they have less energy capacity than the state-of-the-art batteries, however they are able to deliver 10-100 times more power than the li-ion batteries. Unlike other conventional systems, this system uses just a portion of the vehicle power via a DC-DC converter. This concept is new and reduces the converter losses, helps in the complete utilization of stored energy in storage units and gives stable DC bus voltage irrespective of the operating situations and conditions. In the proposed system a controller is added between the solar panel setup and the battery to improve performance. The aim is for a simple yet feasible way to extract and store the energy from a PV source. Here we are using buck boost converters, i.e. SEPIC (Single Ended Primary Inductor Converter) converters which allows potential at the output to be varied as per requirement. In battery and supercapacitor circuits both energy is stored, but in battery chemistry is changed when it is discharged, which is not so in the case of this system.

Keywords: *Solar E-Vehicle, Supercapacitors, Converter, PV Source, Sepic Converter*

1. INTRODUCTION

Energy storage systems are of great importance in the field of electric, hybrid electric, and solar electric vehicles. In comparison to all other energy storage devices, batteries are one of the most widely used ones. However, a battery-based ESS has many challenges which give the impetus to search for additional solutions. In the general these types of systems require the power.

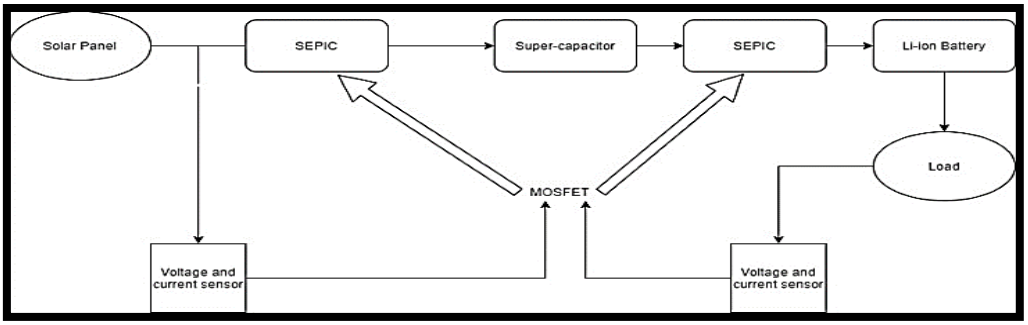

Fig.1: Flow chart of Proposed system

density of the battery to be high enough to meet the peak power demand. Although batteries having higher power densities are available, but they are typically priced higher in comparison to the lower power density ones. A simple solution to this problem is by increasing the size of the battery but this will also increase the price. In addition, thermal management is a big challenge for the batteries to work safely in high power-load conditions. The challenges are not only of general cooling of battery but can also be regarding warming it in cold temperature in order to reach the desired power limits. One of the solutions can be by increasing the battery pack size but the hindrance is that it will eventually increase the weight of the system and also the cost. Further, the high charging-discharging rates of the batteries result in shortening the lifetime of the battery.

In order to solve the above-mentioned problems, we propose a system which aims at the idea to combine ultracapacitors or supercapacitors (SCs) and batteries to achieve a better overall better performance. This is because of the reason that when compared to batteries, SCs have a high-power density, but a relatively lower energy density and the combination together offers better performance when compared to the use of either of them alone.

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2. MATERIALS AND METHODS

In this system the aim is to develop a simple, yet low cost way to extract and store energy from a PV source in a Solar-e vehicle. The main problem with these types of vehicles is that the system does not always work in optimal situations to convert solar energy to usable form.

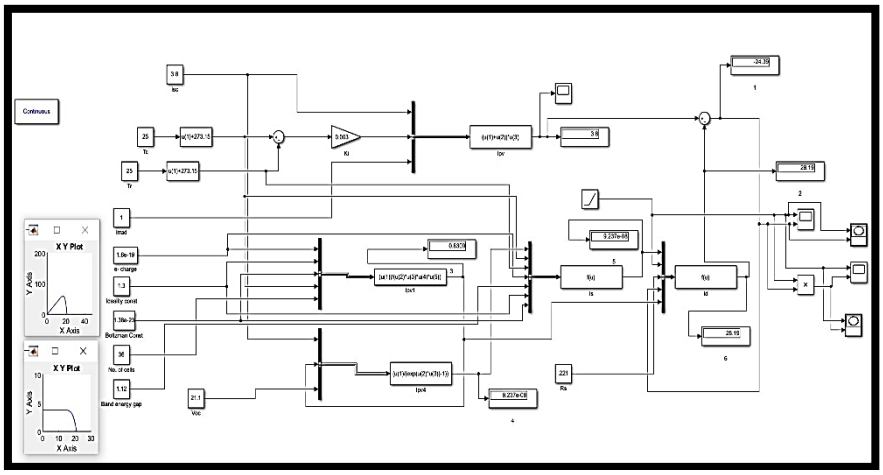


Fig. 2: Simulation of PV Module with current vs voltage and Power vs voltage graph

Though adding a controller between the PV panel and battery might work but still, the issue of charging the battery in presence of a fluctuating power source still remains. Here we propose the use of supercapacitors as well as Li-ion batteries for the storage of energy from PV source. The main advantage here is that supercapacitors can operate over higher range of temperatures.

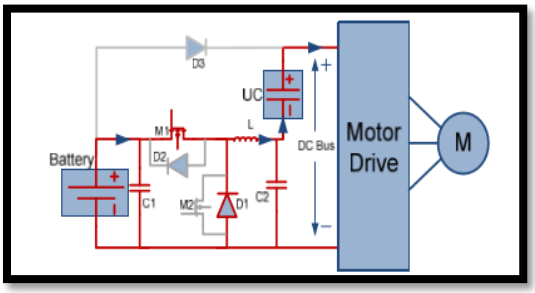
3. RESULTS AND DISCUSSION

Here a controller is added between the solar panels and the battery to improve the system performance. In SEPIC converter the output can be higher or lower than the input. SEPIC converter is a DC-DC converter that permits potential difference at its output to be greater than, less than or equal to input. SEPIC converters are used across supercapacitors which can be applied for step up and step down operations according to requirement. Voltage and current sensor can be added at source and load sites and information can be given to controller. So, switching pulse should be provided to SEPIC converter via a MOSFET.

The battery and supercapacitor configuration propose here is a low power rated converter which is about 25% of the load to integrate SC with the battery bank. The nominal voltage in the SC is more than that of the battery which is about twice that of the battery. Therefore, when the power required by the load is less than the rating of the converter, the load is given supply by the battery via the converter. So, the power required by the load is higher than that of the power rating of the converter, the SC gives supply to the load until the voltage of the SC falls below that of the battery. This configuration enables the use of low rated power converter, and provides better load profile for the battery bank as it directly provides power when the SC voltage drops below the battery voltage.

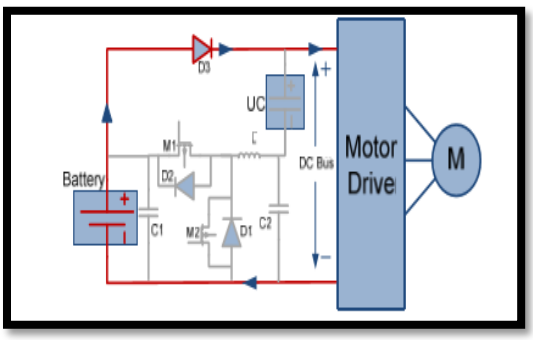
<u>Mode I: Vehicle Acceleration Interval-</u>

Mode I takes place during the acceleration interval when the peak power demand is supplied from both the UC and the battery through the DC/DC converter



<u>Mode II: Vehicle Constant Speed Interval</u>

It takes place when the vehicle has constant speed intervals. During the constant speed interval, the bypass diode (D3) is enabled automatically to bypass the DC/DC converter and connect the battery directly to the DC bus.



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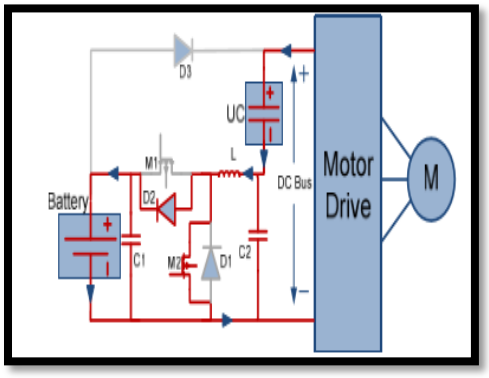
Mode III: Vehicle Regenerative Braking Interval

The last observed operating mode of the proposed system configuration is the regenerative braking. This operating mode starts as soon as the braking pads are pressed and the vehicle starts to decelerate. In this mode, energy supplied by the braking charges the SC and the battery. The share of the charging between the battery and UC can be adjusted through the control of the DC-DC converter.



4. CONCLUSION

In this paper a new storage system by using Supercapacitors and batteries has been proposed. We can use the supercapacitors because of many reasons like it can be used in extreme climatic situations, harsh environment and requires less maintenance, can charge and discharge within less time without any damage. It adds on life and improves stability of the system. Especially in solar e vehicle where there is chances of getting current spike from PV, it can absorb the spike. Moreover, it can also supply the initial high current required to start the vehicle which in turn saves the battery system and improves battery life as SC has absorbs as well as gives out high amount of current. We believe that it can bring a great change in regenerative braking system and can show that the profitability of SCs is much better in urban areas where the rate of braking and acceleration is high.

5. REFERENCES

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