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Battery/ultra Capacitor Hybrid Energy Storage System for Electric, Hybrid and Plug-in Hybrid Electric Vehicles

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Abstract: In this paper, battery/ultracapacitor hybrid energy storage system (HESS) is proposed for electric vehicles, it is used to large dc-dc converter by using ultra capacitor and battery. It is also use the dc link for the purpose of maintain the peak voltage value. By the help of battery and ultracapacitor they are operate. The battery is used to charging the capacitor in case of discharge the capacitor. In this case battery is working. It is also used to the regenerating breaking to store that energy in case of vehicles stoppage the energy will be loss. The battery life time increase by using ultra capacitor. In case of ultracapacitor working, the battery will isolated with power supply. This experiment is done successfully and verified output of proposed system.

Key words: Battery · Control · Dc/dc converters · Electric vehicles · Energy storage · Hybrid electric vehicles (HEVs) · Plug-in vehicles · Power electronics · Propulsion systems · Ultracapacitor (UC)

INTRODUCTION

ENERGY storage systems (ESSs) is very important in electric vehicles, Batteries is one of the major source of vehicles. In case of large voltage supply very difficult to arrange the battery power. This problem is solved by using the ultracapacitor. This energy is combined form of battery and ultracapacitor as hybrid energy. It is more than ten times decrease the size of the battery. It is used for compatability and reduces the size of the battery [1].

In order to solve the problems listed previously, hybrid energy storage systems have been proposed. The basic idea of an hybrid energy storage system is to combine ultracapacitors and batteries to achieve a better overall performance. This is because, compared to batteries, UCs have a high power density, but a lower energy density. This combination inherently offers better performance in comparison to the use of either of them alone.

In the most widely used conventional HESS designs, the battery pack is directly connected to the dc link while a half-bridge converter is placed between the UC bank and the dc link. To solve all these aforementioned problems, a new HESS is proposed in this paper [2].

Advance Energy Storage System: The battery is electrochemical device.it is high energy and low density function.Ultracapacitor has low energy and high density function.the life time of battery is very less in compare to Ultracapacitor life and Ultracapacitor having more life time [3].

The Passive Element Connection in Parallel: The passive element ultracapacitor in battery are combining together. it is shown that the voltage of battery and ultracapacitor is same then behaves like a low pass filter [4].

The voltage increased by the help of ultracapacitor, battery and dc-dc converter.

In fig 1 indicate that the supply voltage is given by battery and voltage increased by the help of ultracapacitor then given to the driver circuit and load.

In figure 2 indicate that the supply voltage is directly given by ultracapacitor is high. it is given to the dc-dc converter. in case of ultracapacitor will discharge then battery is working. Again capacitor will charge then battery is stop the working and capacitor is given the supply in inverter and battery.

In figure 3 is indicate that the battery voltage is increased by dc-dc converter then it will increase the voltage after that increasing in the voltage by using the

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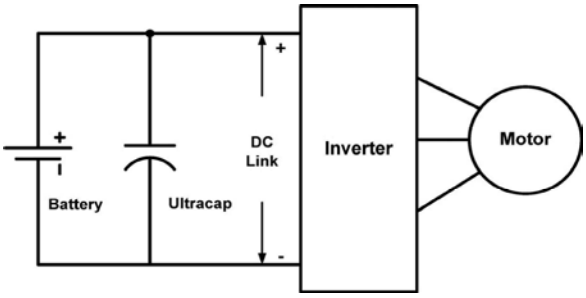

Fig. 1: Basic passive parallel hybrid configuration.

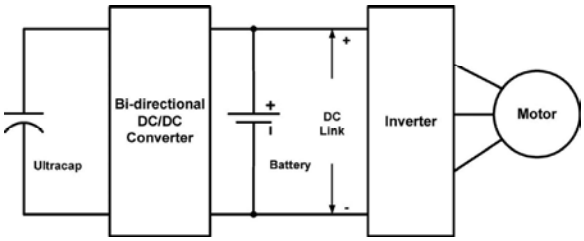

Fig. 2: UC/battery configuration

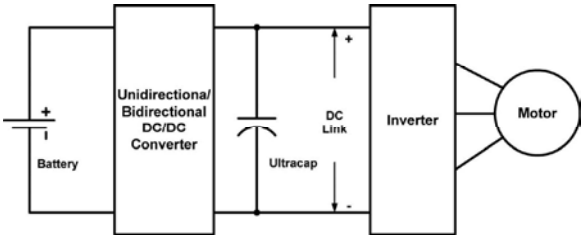

Fig. 3: Battery/UC configuration

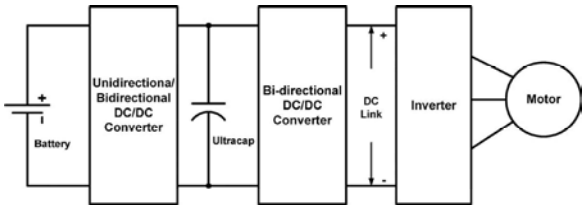

Fig. 4: Cascaded configuration.

ultracapacitor then given to the inverter and load. Whatever voltage level is required it is maintained by the ultracapacitor.

In figure 4 is indicate that the supply is given by the battery voltage is increased by dc-dc converter.that voltage again increased by the ultracapacitor. The voltage again is increased or constant whatever it required. it is maintained by dc-dc converter. Then supply given to the inverter and motor as load [5].

In the figure 5 indicate that the voltage supply is given by parallel connection because in the case of any fault in the previous circuit then it will not work. But in the parallel connection any fault in the one circuit then supply

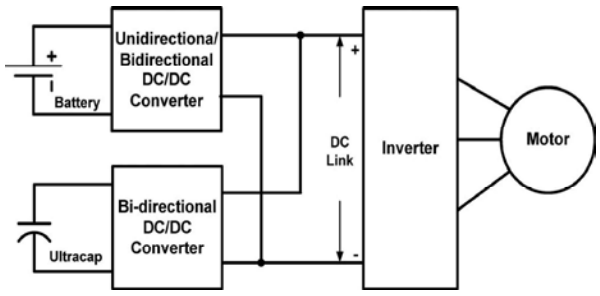

Fig. 5: Multiple converter configuration.

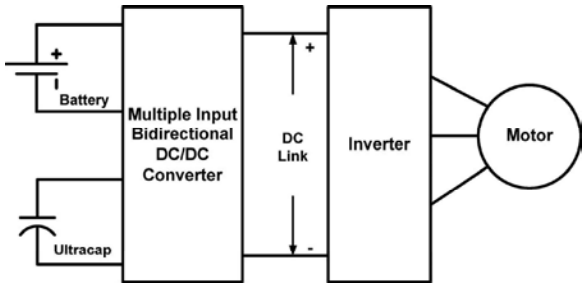

Fig. 6: Multiple input converter configuration

given by the other parallel connection. The working is same like previous circuit. But here advantages is parallel connection and it will work properly at the time of in one circuit fault.

In this figure indicate that supply is given by Battery and capacitor in at a time dc-dc converter. The voltage range required high then apply is given by ultracapacitor when voltage range is required less then supply is given by battery directly. After that the dc-dc converter increased the voltage, that voltage given to the inverter. Before inverter using the dc link it will maintain the peak voltage and fluctuation of voltage wave form [6].

Energy Storage System: The selection of voltage storage system or energy storage component. The characteristics of battery like the storage capacity is high but power density is less and it is also storing time is more. It will increase the size when voltage range will increase. The size of battery is the biggest problem to carry from one place to another place. And also using the vehicles and any starting device.

The characteristics of ultracapacitor is the power density is very high but storage capacity is negligible. But the combination of an ultracapacitor the voltage is increases and size will also decreases. The cost of high voltage battery is very high but the combination of low voltage battery and ultracapacitor to produce high voltage. By combining of both the cost of source very decreases.

After increasing the voltage using the dc link it will maintain the peak voltage and fluctuation the wave form.

Safety of Battery: It is very important to increase the life time of the battery and fully use the energy. By using the ultracapacitor it will help the increase the speed of vehicles and also the working time of the battery is very less because the maximum time capacitor is working. It is also very important to store the energy at the timing of stopping the vehicles. When vehicles is stopping that time some distance will cover for using the regenerative braking process. It will store the energy by regenerative braking, in that time the motor is behaves like a generator [7].

Total Cost Of Project: Compare to existing system it is less cost and smaller size operating characteristics like speed is very good because the existing system the conventional battery is used. The conventional battery of voltage range depend upon size of the battery.

Using the ultracapacitor and battery the power density, energy density and efficiency will increases. Also Overall cost is less.

The management of battery and cost is very important because it is directly proportional to the cost of the project and also efficiency. Weight of vehicles is increases then efficiency is decreases and also cost increases.

Proposed of Hybrid Energy Stored System:

Overall View: The conventional capacitor and dc-dc converter is not get proper peak power demand. The capacity of capacitor is very less than ultracapacitor. By using ultracapacitor and battery easy to get peak power. It is controlled by dc link.

Fig. 7 is shown the simulation battery power. It is first introduced in united states by applying driving cycle. The first time cycle was running 12km and direct stop. Then maximum speed is get 91 km per hours and average speed 31 km per hour. By removing the stop condition and increasing the speed. It is using the combination of battery and ultracapacitor. It is shown in figure 8.

The charging and discharging process is increase by using ultracapacitor. According to simulation find the average speed and peak power. It is very good compare to existing system.

The difference between peak and average power. Consider a water cane and mug. The energy density of water cane is very high but power density is less but in

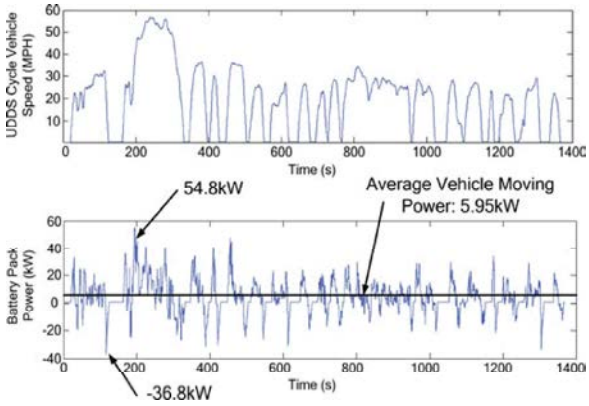

Fig. 7: Simulation results

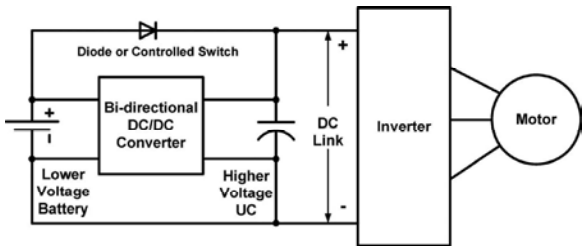

Fig. 8: Proposed HESS configuration

a mug the energy density is less but power density is high. For example like discharging the water. The mug will rapidly discharge with compare to water cane. The average value is water cane and peak value is mug. Based on the average concept design the system in fig 8. The battery is connected to dc-dc converter. And it is also connected to diode or any controlling switch and bi directional dc-dc converter connected to the ultracapacitor. The battery voltage is increased by dc-dc converter. It is directly charging the ultracapacitor.

In the operation of vehicles the supply separately depending upon battery and ultracapacitor. After that the supply given to the dc-dc converter. In the power supply depend upon the battery and ultracapacitor supply. the driving of vehicles depend upon changing the power supply.

The voltage range of the battery is less than capacitor. Then supply is given by the ultracapacitor. It is high voltage operation but in the case of ultracapacitor will discharge then supply given by battery and also charging the capacitor. It will operating as boost converter.

Mode I: Vehicle Low Consistent Speed Operation: In this case the battery voltage is greater than ultracapacitor voltage. The battery voltage supply going to diode. After that it will go to load. In same time capacitor will charge.

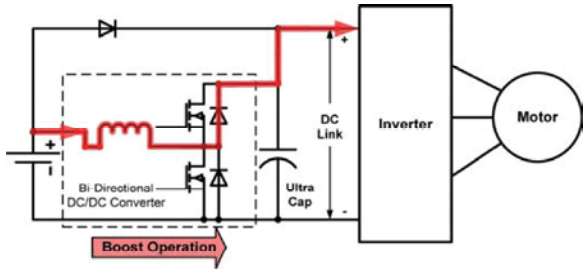

Fig. 9: Low consistent speed operation

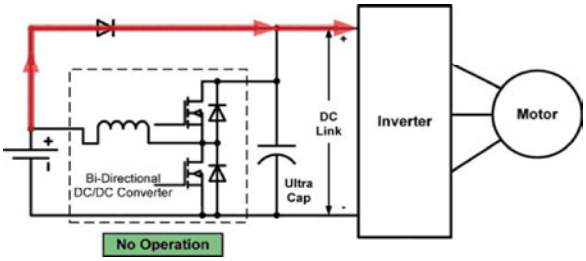

Fig. 10: High constant speed operation energy flow.

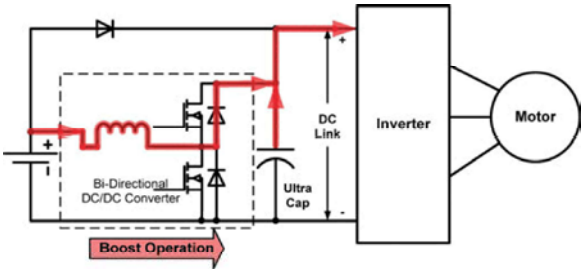

Fig. 11: Phase 1 Acceleration

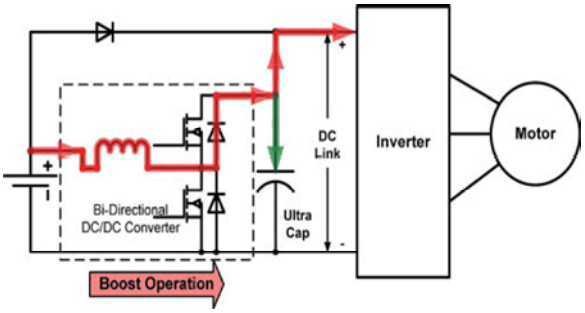

Fig. 12: Phase 2 Acceleration

The supply is going inductor and diode is forward to main supply. it is charging the capacitor and also supply is going to dc link. Dc link is easy to control the peak value because the voltage range is less.

Mode II: High Consistent Speed Operation: The battery supply directly given to the diode or any controlling switching device. The supply is directly given to the inverter. In this case the capacitor will not charging and discharging. And dc-dc converter is also not working.

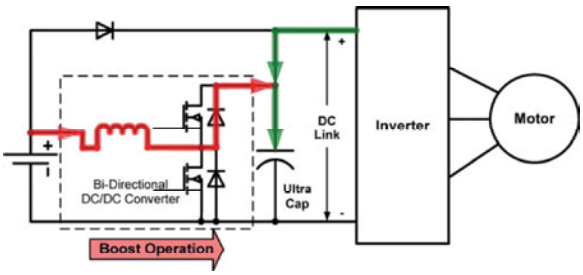

Fig. 13: Deceleration

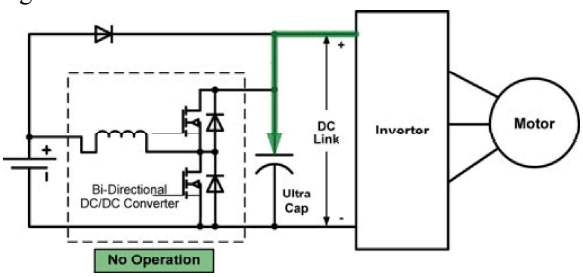

Fig. 14: Deceleration phase I

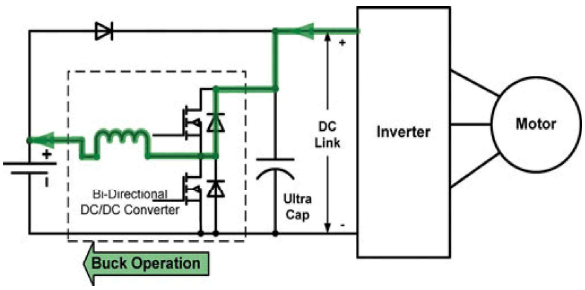

Fig. 15: Deceleration phase II

The voltage supply is greater than previous circuit. In the previous circuit the voltage is distribute two part. One is for charging purpose of capacitor and another is given for the driving the load.

Mode III: Acceleration: In this case the supply is given by battery in the way of boost converter and ultracapacitor is also. It is very high speed operation because supplying source is two ultracapacitor and boost converter operation. in this case the role of dc link is very crucial. Because the peak power supply is vary and also more fluctuation. And after that going to inverter and motor.

In this case the supply is given by boost converter and capacitor is charging also by same supply. the speed of vehicles is decrease compare to above circuit. Because above circuit supply is given by boost converter and ultracapacitor but here supply is given by only boost converter. Same supply also goiung for charging the capacitor. The dc link easy to operate because peak voltage is less.

Mode IV: Deceleration: Deceleration mode operation motor behaves like a generator. It will give the supply when vehicles will stop the given supply. but running vehicle will not stop at a time. In this case only motor behaves like a generator. The generator supply directly given to the capacitor and capacitor will charge. It is generally low speed operation. There is no dc-dc operation happened.

In this case the generator supply is given to the boost converter. After that it will again charging the battery the process is only happened when ultracapacitor is charge. The dc-dc converter behaves as a bulk converter.

CONCLUSION

This is a new project in compare to existing system. This project is fully based on battery and ultracapacitor. There is no need to matching the supply. In this project used fully dc-dc converter. In case of ultracapacitor will discharge the voltage then the voltage range will be less than battery voltage, after that battery is working.

In this project the battery use very less generally capacitor is working, that's why the lifetime of the battery will increase. It is also reducing the challenge of the battery range.

The proposed system is very small size compare to existing system. Also this project having cost is very less in compare to existing system and scope is more.

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