Role of DC-DC Converter with Ultra Capacitor as Energy Source

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Abstract: This paper demonstrates how the load voltage driven from the ultra capacitor can be maintained by using DC-DC converter. Since ultra capacitors have very charging/discharging rate so a DC-DC converter circuit is must for maintaining the available load voltage The paper also demonstrates the use of protection circuit to overcome the low voltage condition.

Keywords: Ultra capacitor, DC-DC converter

Introduction

Ultra capacitor or super capacitors are high capacity capacitors which have the ability to store about 100 times more energy compared to conventional electrolytic capacitor in terms of per unit volume or mass. They have a rapid charging and discharging rate and hence are used as power devices in comparison to electrolytic capacitor which are used more as energy devices. So as such they find applications as power backups in SRAMS [1,2]. Such Ultra capacitors are used as burst mode power supply system which have exceptionally high ability to transfer charge at a very high rate and have better life than conventional capacitors. These super capacitors have electrostatic double layer capacitance while the conventional capacitors have solid dielectric medium. Besides this super capacitors also have electrochemical pseudo capacitance this allows 0.3 – 0.8 nano meter charge separation. Thus they have comparatively smaller physical size. One of the major disadvantages of ultra capacitors is that they can't be used for AC applications.

Converter based Circuit

The basic scheme involving the use of Ultra capacitor and DC-DC converter is shown in figure 1 below. The basic scheme involves a ultra capacitor as voltage source to step up DC-DC converter. Followed by a low charge protection circuit which measures the charge across the ultra capacitor and the voltage across the load. The combined circuit is connected to the variable laod.

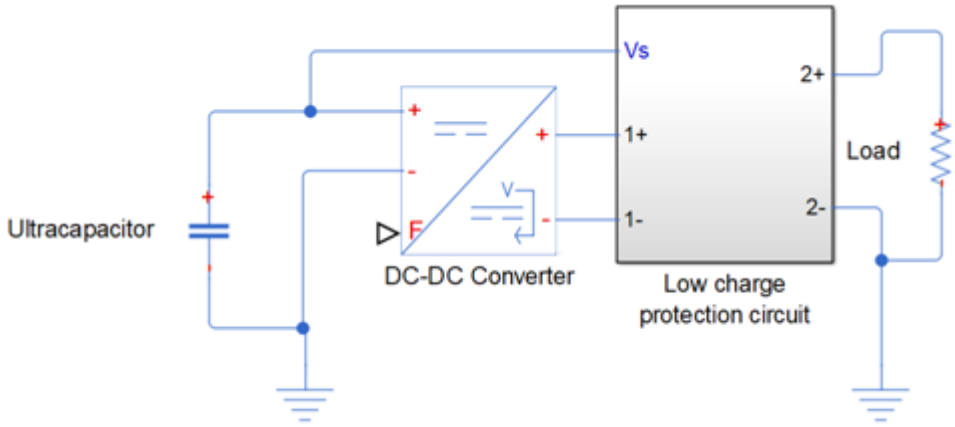

Figure 1: Ultra capacitor with DC-DC converter

The Protection circuit is shown in fig 2 below. The objective of this circuit is to disconnect the laod when the voltage of the ultra capacitor falls below the preset value known as the threshold value. In the present case it is fixed at 4V

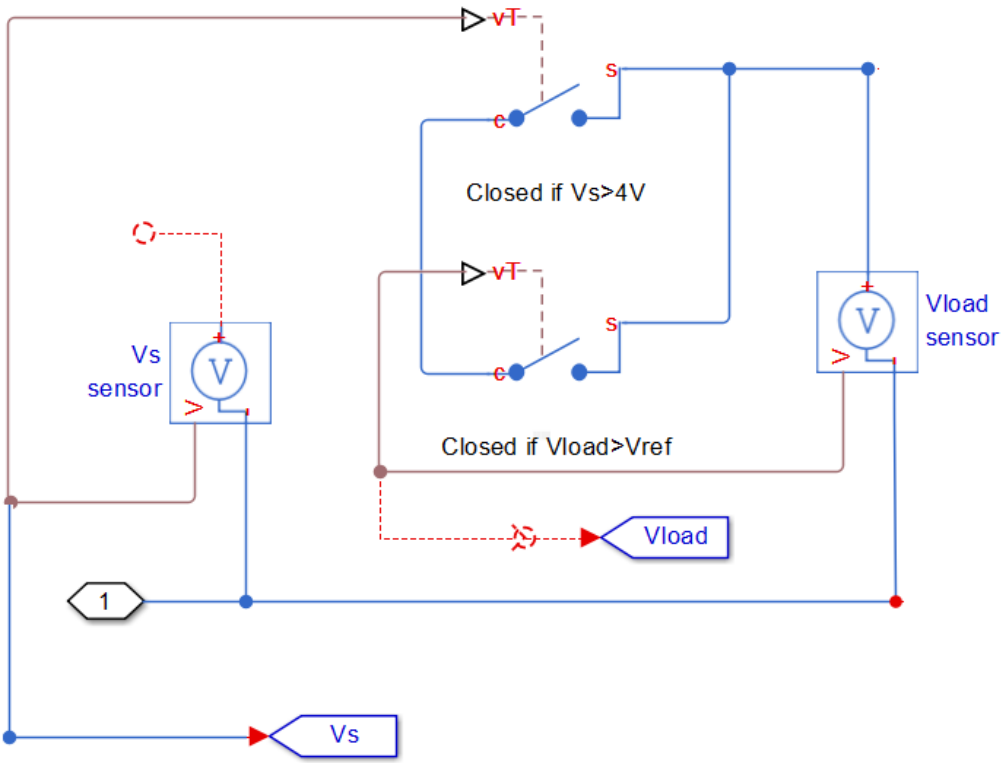

Figure 2: Low voltage protection circuit

Results and Discussion

The basic aim of the circuit is to use low voltage step up DC-DC converter. Low voltage side is connected to the ultra capacitor and the high voltage side is connected to the load. In the current case the load assumed is variable drawing more of the current hence there is drop in the voltage. Since it is an open loop control hence

the voltage at the input end will reduce. In order to increase the voltage a generator is connected to the load end thus supplying both the load and charging the ultra capacitor. The complete circuit is shown in fig. 3 below

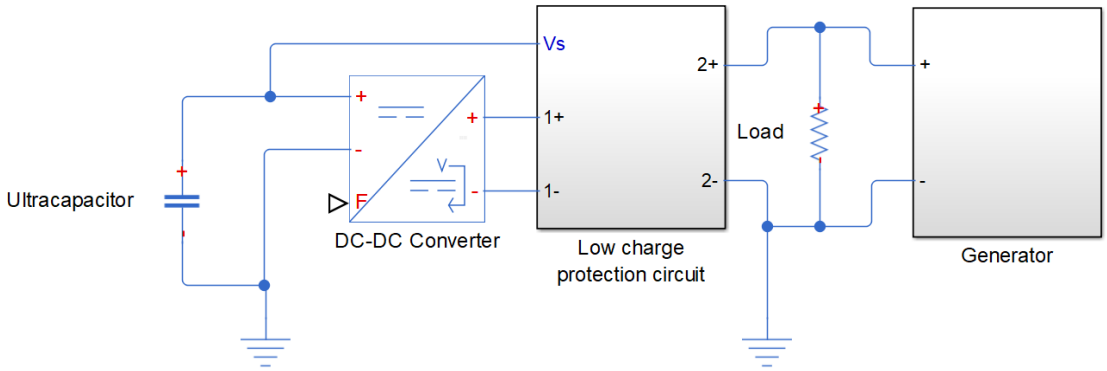

Figure 3: Complete set up

The simulation results are shown in fig 4 and fig 5. The change in the ultra capacitor voltage is shown in figure 4 where it is obvious that as the load starts drawing the current from the ultra capacitor, the ultra capacitor starts to discharge and the voltage falls from 10 V as it reaches to 4 V the set threshold value for the protection circuit, it stops the further decay in voltage and at 10 seconds the system is connected to the generator and it charges the ultra capacitor.

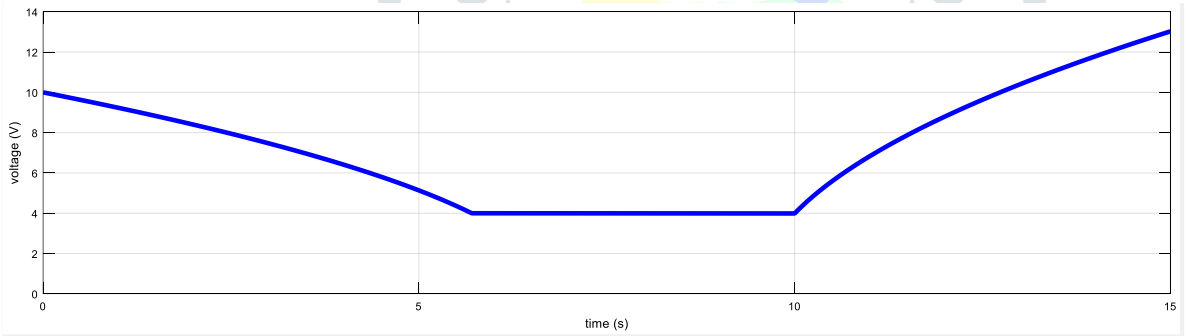

Figure 4: Ultra capacitor voltage

Figure 5 shows the load side voltage. Comparing this to figure 4 it can be observed that load voltage is always 10 V irrespective of the voltage across the capacitor till the ultra capacitor decays to 4V charge . Protection circuit disconnects the load from the source when this threshold voltage is reached upon.

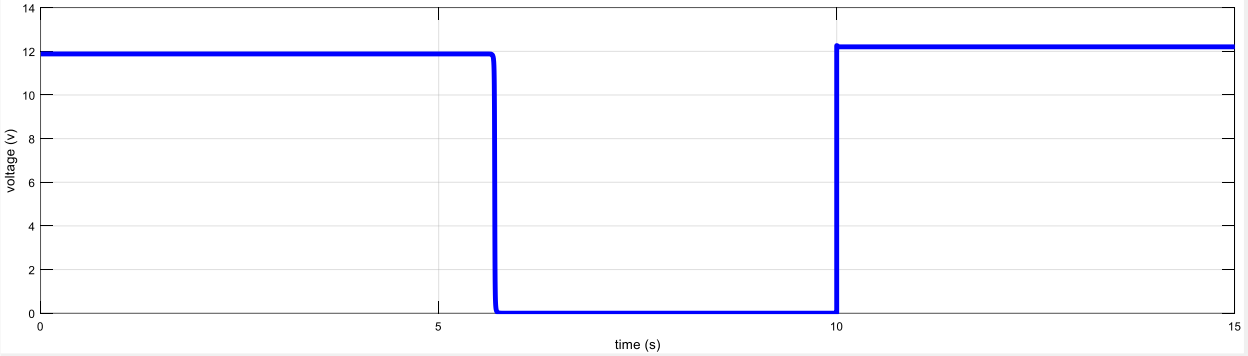

Figure 5: Load side voltage

Conclusion

In this paper role of DC-DC step up converter is demonstrated which hold the load voltage to pre-defined value. From the simulations it is shown that ultra capacitors have a very high charging and discharging rate. Still with the use of DC-DC step up converter fixed voltage can be supplied to the load for high power short burst applications

References

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[2] K. Alobeidli and V. Khadkikar, "A New Ultracapacitor State of Charge Control Concept to Enhance Battery Lifespan of Dual Storage Electric Vehicles," in IEEE Transactions on Vehicular Technology, vol. 67, no. 11, pp. 10470-10481, Nov. 2018.