CONTROL OF MULTI INPUT DC/DC CONVERTER USING BATTERY AND ULTRA CAPACITOR

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ABSTRACT

The search for a compact light weighted and efficient energy storage system that is affordable and has acceptable cycle life .In this paper energy storage devices such as battery and ultra-capacitor are used in hybrid electrical vehicles in order to guarantee load leveling, assuming braking energy recovery and good performances in transient operation. The paper focuses on design and control of a multiple input DC/DC converter, to regulate output voltage from different inputs. The proposed multi-input converter is capable of bi-directional operation and is responsible for power diversification and optimization. A fixed switching frequency strategy is considered to control its operating modes.

KEYWORDS: *Multi-input, Battery, Ultra-Capacitor, DC/DC converter, Hybrid vehicle.*

I. INTRODUCTION

An electric vehicle(EV) integrates vehicular engineering and electrical engineering .The multiple input DC/DC converter is useful for combining several energy sources whose power capability and voltage levels are different to obtain well regulated output voltage. Electric motor inverters and associated control technology has made substantial progress during the past decades and it is not the limiting factor to either vehicle performance or the large scale production of electric vehicle.

In this paper a multiple input DC/DC power converter devoted to combine power flowing from combined on board energy sources is presented in fig 1. This includes battery & ultra capacitor. In order to design an EV having comparable performance with conventional vehicle using internal combustion energy battery/ultra capacitor is introduced in the electric vehicle. Battery is the main power supply to drive the machine but during acceleration high burst of energy is required so, for that reason ultra-capacitor are used to transfer energy in short duration. For this reason the use of ultra-capacitor can be considered to relieve battery pack from peak power transfer stress due to capacitors higher specification power and cycling efficiency [2].

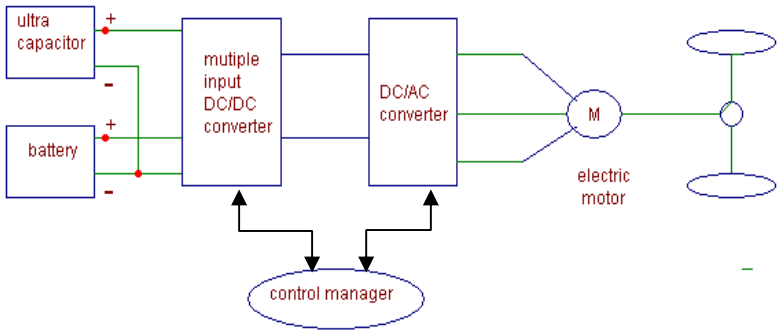


Figure 1. Proposed Block diagram of hybrid vehicle

II. CIRCUIT TOPOLOGY AND ANALYSIS

In this paper four quadrant chopper is been designed using buck-boost converter. Boost mode of operation is used in order to transfer energy from each power source to the load, whereas buck converter operation is used to charge both ultra-capacitor tank & battery storage system and to recover the braking energy [4]. The configuration shown in fig 2.was chosen for its feasibility in hardware arrangement and in control strategy accomplishment. The selected bidirectional topology is suitable to connect power sources in series is limited to improve the system reliability. The buck/boost converter composed of two bidirectional switches, power diodes, induction &output capacitors at different voltage level. In ultra-capacitor tanks and battery system the number of elements connected in series is limited to improve the system reliability.

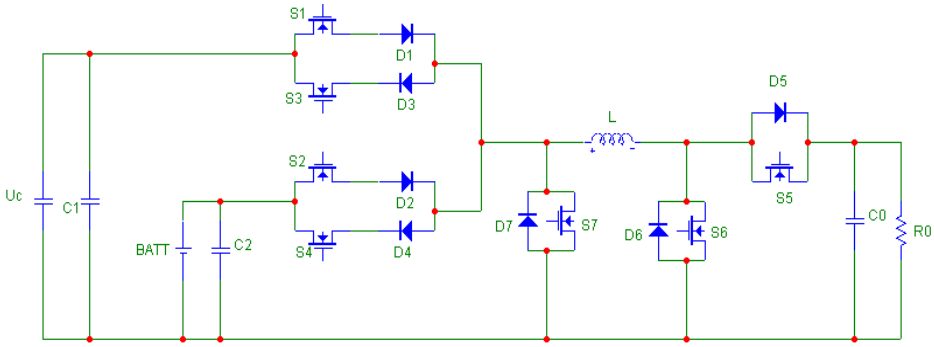


Figure 2. Multi-input power converter

In multi-input DC/DC converter input power & inductor are used in order to limit the ripple current stress over the power sources, in order to avoid dangerous over current at start up. Ultra-capacitor is used during acceleration & braking of the vehicle. For a continuous supply to the vehicle, the inductor current should be continuous, it means at least one switch and one diode is turned on all the time[13]. If more than one switch is turned on at the same time, the Inductor voltage equals to highest voltage of the input [8]-[12]

This operation has the flowing constraints

- Vo> Vbatt>V_{UC}
- Induction current I_L is continuous

2.1 MODE A: Boost Mode of Operation

In this mode both the source i.e. battery and ultra-capacitors delivers power to the load. As battery acts as a main source so the voltage level of battery is always higher than that of ultra-capacitor.so S1 is turned on all the time in this mode. The inductor current is controlled by the switch S6 & distribution of power from the battery and ultra-capacitor is controlled by S2. When the switch S6 is not conducting the diode D5 is turned on.

Let $V_{BATT}=V_1$, $V_{UC}=V_2$, $C_{BATT}=C_1$, $C_B=C_2$ and the equivalent of load can be defined as RO and operating at the same frequency of 1/T. So in this mode S1 &S2 are conducting & as V1 is greater than V2 it is applied to inductor L.

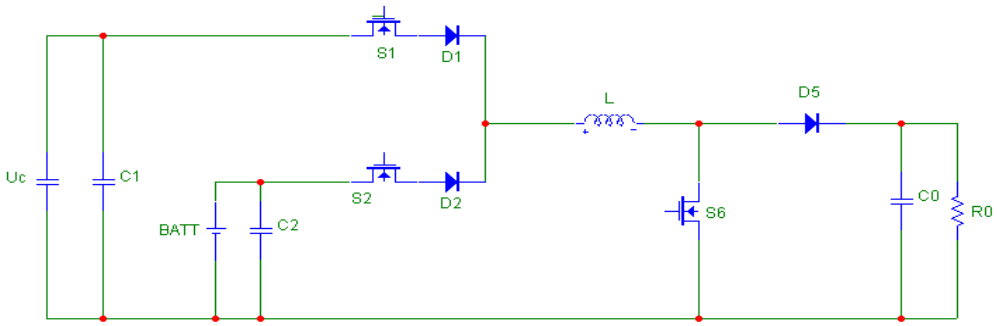


Figure 3. Boost mode converter

2.2 MODE B: BUCK MODE OF OPERATION

In this mode of operation regenerative action takes place. The energy is delivered to V1&V2 from the load .The inductor current is controlled by Switching S5 and the distribution of power between V1&V2 is controlled by S3. D6 will not be conducting until S5 is turned off. The inputs are modeled by two resistive loads respectively. In buck mode, ultra-capacitor will get charged first when both S3&S4 are conducting. Therefore S4 is turned on all the time.

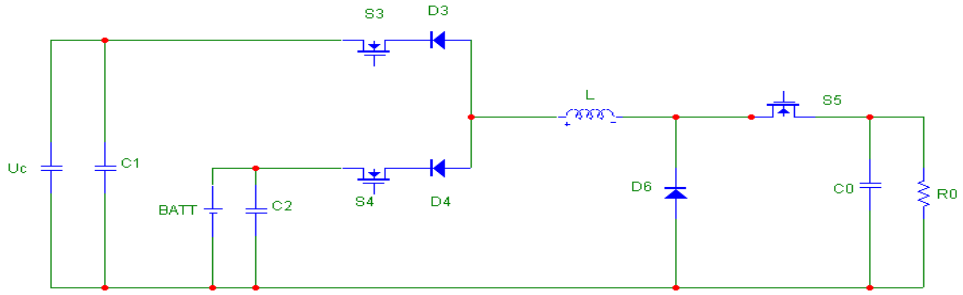


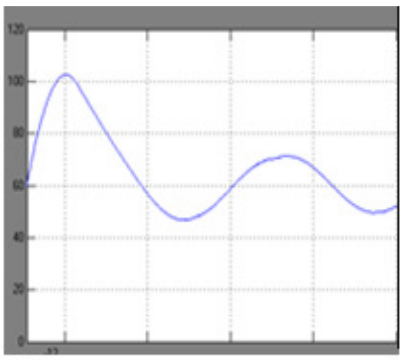
Figure 4. Buck mode converter

2.3 MODE C:

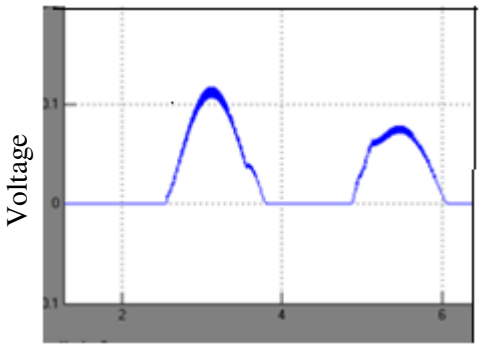
During the driving ,the vehicle is either continuously accelerated or braked, the system has to either generate energy during de-acceleration or supply the stored energy during guaranteed that both battery and ultra Capacitors shouldn't get discharged completely during acceleration transient, thereby the system control algorithm has to be induce suitable regulation of the state of charge(soc) values of battery and ultra capacitor ,so that the actual soc is always kept within preset upper and lower bound. So during continuous acceleration the ultra capacitor energy will get reduce so, at that time, battery is going to provide energy to the ultra capacitor during continuous acceleration.

2.4 RESULTS

For the simulation a potion of this drive Cycle is used to perform all modes of operation instead of using the whole period. In the selected time period, both accelerating and decelerating operations are included in order to present the bi-directional power flow Fig. 5 and Fig. 6 show the voltage waveforms of battery and ultra-capacitor. Comparing Fig. 5 and Fig. 6, it is shown that the battery current waveform is much smoother than that of the ultra-capacitor current. The battery supplies the main power to the load and there are no significant oscillations in the battery current waveform. For the battery, it is not desired to have large magnitude of oscillations since fast charging and discharging will reduce the lifetime of battery. However, the ultra-capacitor has better and faster cycling characteristics. From Fig.6 it is obvious to find that ultra-capacitor is always handling the fast change of energy variations. Both battery and ultra-capacitor enable to follow the power variation of the load very well, which ensures the ideal performance of the vehicle during driving conditions.



time (ms)
Figure 5 Battery voltage



time (ms)
Figure 6 Ultra-capacitor voltage.

III. CONCLUSIONS

This study presents a battery/ultra-capacitor based multiple-input buck-boost converter utilized in a small electric vehicle. The two input sources are share one common inductor. The battery bank is designed to supply average demand power of the vehicle, on the other hand, ultra-capacitor bank supplies or recaptures the large bursts of power with high C-rates. In this topology, only one input inductor is required, which significantly reduce the cost and size of the whole system. Input sources are effectively controlled to deliver desired power levels to the load fast and accurate enough. Regenerative energy can be efficiently recaptured by battery and ultra-capacitor during braking periods.

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