Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

High efficiency bidirectional buck boost converter fed dc drive

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ABSTRACT

This paper is to implement the regenerative braking concept with bidirectional DC-DC converter fed DC motor to charge the external battery and also to reduce power consumption. This paper uses hybrid battery ultra-capacitor power source for fast current changes and while battery responds for slow current changes which in turn increase the lifetime of the battery. Energy developed at the time of braking is not useless, it is reutilized to store the energy in the ultra-capacitor. An experimental prototype is developed. The advantage is that state of charge (SOC) of the battery and ultra-capacitor voltage and current and voltage are within the limits. A prototype model is developed.

Keywords: Bidirectional Converter, Regenerative braking, Energy storage

INTRODUCTION

Recently Bidirectional converters are developed for various applications like battery charging and discharging of electric vehicles and UPS systems and the converter fed DC motor is developed for electric vehicle system (EVS) applications for both motoring and regenerative braking. DC-DC converters are used to interface the electric vehicles to boost (or) reduce the voltage level. Energy storage devices vary the output with load. Ultra capacitor is a newer technology to store twenty times more than the conventional electrolyte capacitor. Fast and sudden changes battery discharge during acceleration (or) fast charging during regenerative braking can be avoided by using ultra capacitor. Individual fuel cell can recover regenerative braking energy and storing of auxiliary source has the advantage of maximum power and also has reduced cost. Bidirectional DC/DC converter is operated as Boost and Buck mode operation. Regenerative braking is the defined as the method of injecting the from the running motor to the battery during braking process at that moment motor acts as generator, it is not possible in the conventional vehicles. A bidirectional control can be used for boosting control because the back EMF generated will be lesser than the voltage of the battery, then back EMF needs to be boosted to charge the battery. The bidirectional converters are used for transferring the power one DC source to another DC source in either direction which is to be utilized for various applications like hybrid electric vehicle energy systems, photo voltaic hybrid power systems. Bidirectional converter is utilized for stimulation of the battery charging and discharging. Hybrid power sources are the combination of the fuel cells, secondary batteries for example Lead–acid battery which are combined to high energy density of the fuel cell and high power density of the battery, DC-DC converter is placed in order to balance the power flow which can able to provide the high power output. High power density is the major application. High efficiency is achieved. Converters have no switching loss and more suitable for high frequency operations.

Bidirectional converter: The bidirectional converter consists of two converters they are boost converter and buck converter. Fig.1 shows the conventional bidirectional dc-dc boost/buck converter. The projected converter for step-up mode is shown in fig.2 .The pulse width modulation technique is used to control the switches S1 and S2 simultaneously varying the duty cycle.

Boost mode of operation: During this mode Switch S_1 and diode D_2 is turned on and switch S_2 and D_1. The energy of the low voltage side is transferred to the inductor. The energy stored in the capacitor C is discharged to the load (motor).Thus the boost operation takes placed in forward direction of rotation of the motor.

Buck mode of operation: Fig.3 shows the proposed converter in buck operation i.e., step-down mode. The PWM technique is used to control the switches S_3 and S_4 simultaneously by varying the duty cycle. During this mode of operation, Switch S_4 and diode D_3 is turned ON, while that of the switch S_3 and diode D_4 is turned off. Here the energy of high voltage V_H is transferred to inductor and capacitor and then to the load (motor).Thus the buck operation takes place in reverse direction of rotation of the motor.

Regenerative braking: Regenerative braking is the method of injecting energy from the running motor to the battery for future use at the time of braking, When the vehicle force the running motor to generator. Regenerative braking concept is

utilized to recycle the energy in an efficient way. Usually when power is cutoff from the supply then motor will also losses it supply then due to kinetic energy flywheel gets rotate for sometimes even after the power supply is cut off then energy will be getting stored in the form of back emf in the motor. This back emf produced during the braking is again restored in the battery for future use. Usually in the conventional electrical vehicles Regenerative braking is not utilized. The reason for going regenerative braking is that driving range obtained is more rather than the mechanical braking. Whenever motor starts rotating in reverse direction then motor acts as a generator getting only the mechanical energy and then converting it into electrical energy to be stored in the battery in the form of a capacitor. Here the voltage stored in the capacitor is to used whenever required. Compared with the mechanical braking of the efficiency obtained from the regenerative braking is more.

RESULTS

The fig.8 shows the simulation diagram of bidirectional converter with a DC motor drive in which it consists of a DC source along with the input sense and an inductor connected in series with a bidirectional converter acting as a boost converter. Here two MOSFETs are triggered by PWM pulses generated by a PWM circuit. The scope 4 is obtained for the input voltage along the DC source. On the other hand there is a capacitor on the left end along with the voltage sense which is connected in series with an inductor for storing the energy, which is connected in series with a bidirectional converter which consists of two MOSFET's which are driven by the MOSFET gate driver circuit in which all the MOSFETS are triggered by the PWM pulses generated by a PWM circuit. The scope 1 can be obtained for the voltage across the capacitor. The pulse generation for whole DC-DC converter can be viewed in the scope 9.A capacitor is connected across the two bidirectional converters in which the output voltage is obtained in the scope 2.A self-excited DC motor is connected across the bidirectional converter for forward and reverse direction of the rotation. Here the self-excited DC motor acts as a load of the circuit. The speed of the motor during the motoring and regenerative braking can be obtained from the scope 6.There is a two circuit breakers are connected in series with DC source at the input side and another in series with the capacitor for preventing any short circuits. Again a circuit breaker is utilized to prevent any short circuit across the DC motor. A timer is attached at the input side in order generate the signal changing at specified times. Here scope 3 is used for getting all the outputs in a single scope, where the input voltage of the DC source, motor speed, battery voltage, output voltage. The bidirectional buck boost converter fed DC drive is simulated using Matlab and the results are presented.

Input voltage of the battery: The input voltage of the battery is shown in Fig.4.The result shows that upto motoring mode of operation, voltage is constant and after regenerative braking occurs the voltage starts reducing.

Output voltage: The output voltage waveform is shown in Fig.5.From the results it is clear that voltages starts gradually increasing from zero then attains the steady state output up to the motoring mode of operation then after the regenerative braking occurs, the voltage starts decreases and attains stabilized voltage after braking.

Speed of the motor: The speed of the motor is shown in the Fig.6.The results shows that the speed of the motor starts increasing from zero speed and reaches the maximum and attains the normal speed up to motoring mode of operation and starts gradually decreasing during regenerative braking operation and after sometimes the speed the motor reaches to zero.

Battery voltage: The battery voltage waveform is shown in Fig.7. The results shows that initially battery voltage is zero up to the motoring mode of operation and whenever the regenerative braking occurs the battery starts to charging from zero volts and attains the voltage of above 60 volts to reuse it again.

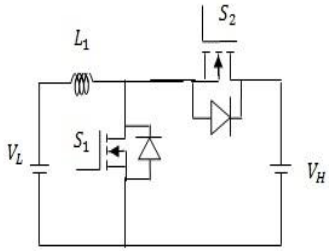

Fig.1.Conventional bidirectional converter

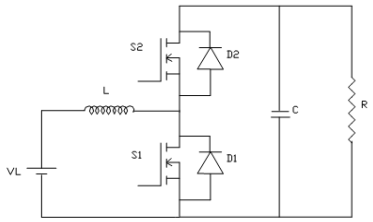

Fig.2.Boost converter

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

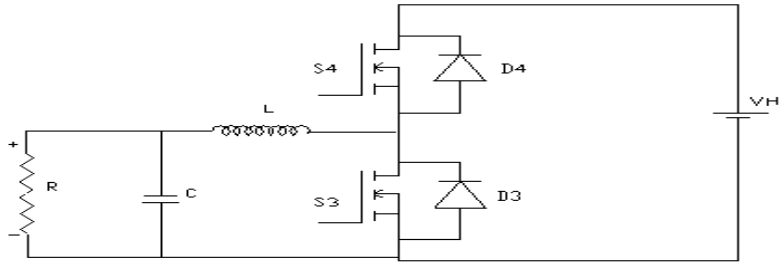

Fig.3.Buck converter

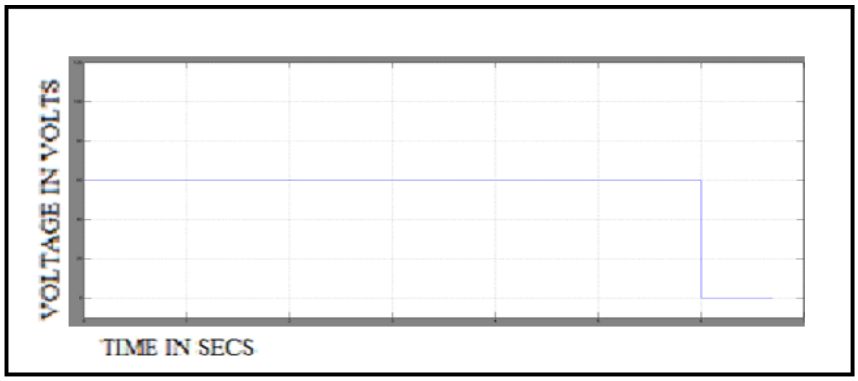

Fig.4.Input voltage of the battery

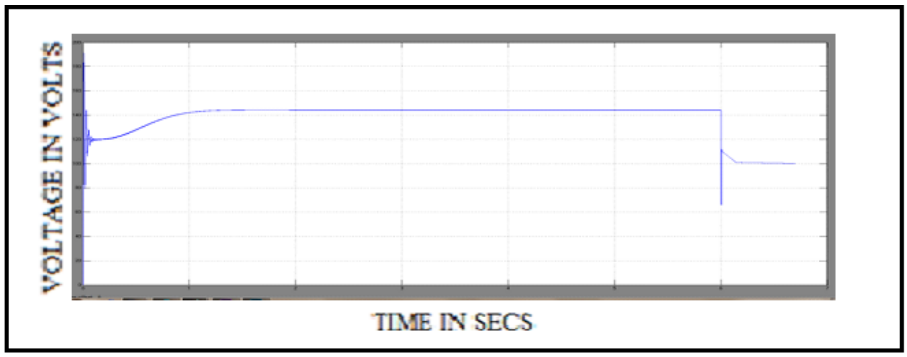

Fig.5.Output voltage of the converter

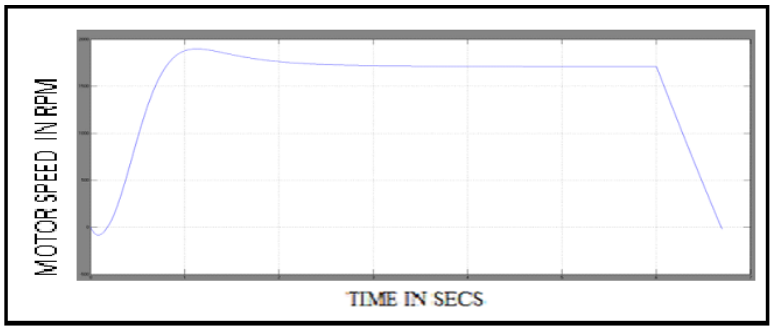

Fig.6.Speed of the motor

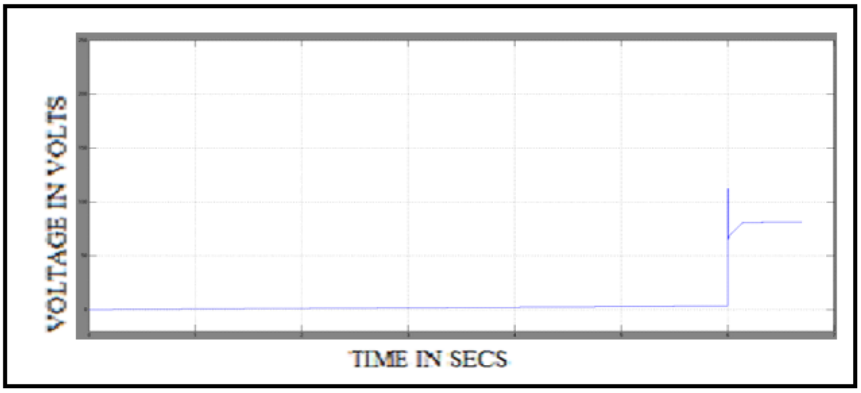

Fig.7.Battery voltage

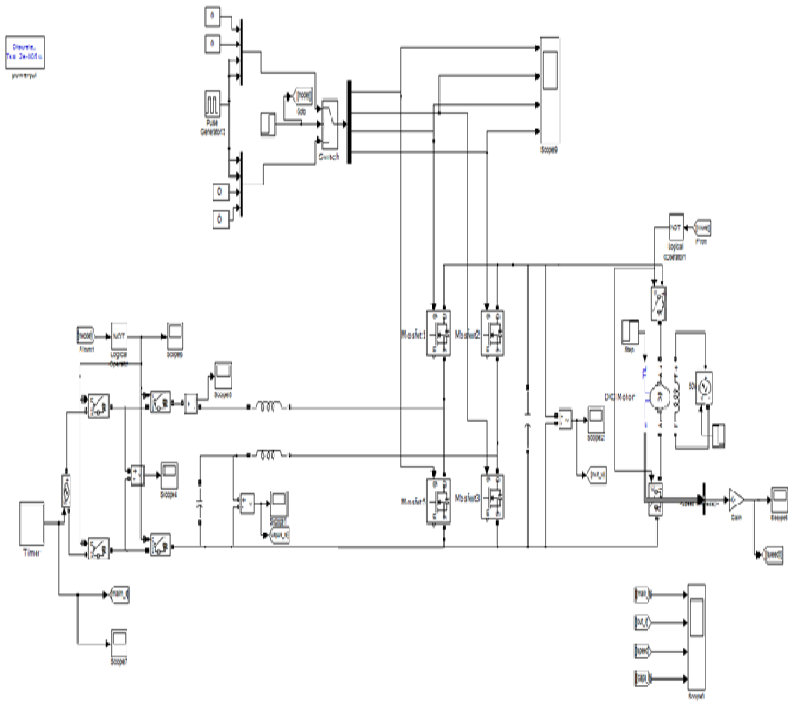

Fig.8. Simulation diagram of the bidirectional converter with a dc motor drive

CONCLUSION

In this paper Bidirectional buck boost converter is simulated using MATLAB simu link and the results are presented. The result shows that the output voltage waveform is smooth without ripple. High efficiency is achieved with a battery voltage. The converter have reduced switching losses, less power consumption and recharging of battery is achieved at the time of braking. The main important advantage is all driving, charging are estimated in the single embedded system. Fast current changes reducing the lifetime of the battery can be controlled by means of capacitor used.

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