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Implementing Buck Converter for Battery Charging

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ABSTRACT: In this paper, we study on a new buck-boost dc/dc converter of high efficiency by soft switching technique. The switching devices in the proposed converter are operated by soft switching with a resonant circuit. In this paper combination of zero voltage switching (ZVS) and zero current switching (ZCS) for Buck converter (non-isolated type) has been proposed. Used as a converter for battery charger. Which has been seen as a good and convincing solution for switched mode electronic power converter. The proposed charger circuits with both zero Voltage switching and zero current switching were analyzed and tested using MATLAB-SIMULINK software for a Nickel Metal Hydride battery. The structure of the proposed circuits does not require complex control mechanisms or large number of components. In comparison with the conventional buck-boost dc/dc converter, some simulation results on computer and experimental results are confirmed the validity of analytical results of the proposed converter.

Keywords: Zero Current Switching, Zero Voltage Switching, Battery Charging, Buck Converter, Soft Switching.

I. INTRODUCTION

Now a day batteries are an essential component of all electrical equipment and appliances. Since each electric appliances requires continuous electrical supply through battery. Therefore it is necessary to design a battery charging circuit which can do fast charging of battery with high power density and low maintenance cost. Previous or old conventional battery charger having a demerit that they gives a low power density and low efficiency because their linear regulator works only at low power levels. But modern appliances and their battery required a battery charger of high power density, high efficiency ,high quality small in size and light weight . With technological developments, the demand for small size, lightweight, and high reliability for dc–dc converter increases sharply.

A lot of research is going on switching mode power converters for battery charging. The advantage of switch mode technique is that it reduces the switching and conduction losses by increasing the switching frequency.

To improve the efficiency, a new buck-boost dc/dc converter with high efficiency is proposed in this paper and is shown in Fig. 2. The proposed buck-boost dc/dc converter is composed of controlling devices, a step up-down inductor *L*, and a snubber capacitor *C* used in similar way for the conventional converter.

There are many switching topologies that can achieve higher power flow. These topologies can provide highly efficiencies by minimizing the switching losses and the overall size of the converter. Zero Voltage switching (ZVS) and zero current switching (ZCS) are able to limit the switching losses during ON and OFF switching, and both can work at a high switching frequency compared to a PWM hard switching converter. To get a smaller physical size and component value, the switching frequency is set to a higher level. The reason for the need to reduce the total size of the power supply is the miniaturization of electronic systems. This paper describes the principle and operation of the buck converter using soft switching in battery charger applications.

II. PRINCIPLE OF THE BUCK CONVERTERS

Buck converter can be defined as a switch-mode dc-dc converter that uses switches and a low pass filter to reduce the Voltage value of a DC supply.

However, the efficiency of the conventional converter is very low due to the power loss of the snubber circuit.

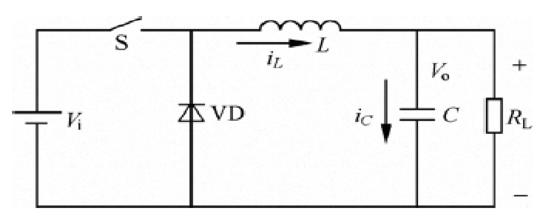

Fig.1. The conventional buck converter.

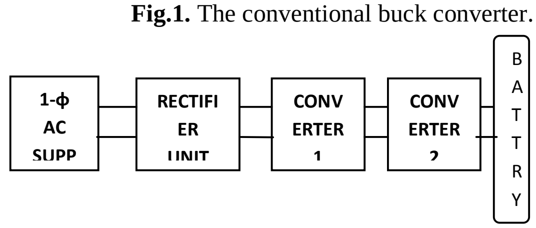

Fig. 2. Proposed new converter.

To improve the efficiency, new buck-boost dc/dc converter with high efficiency is proposed in this paper and is shown in fig.2. The main task of the inductor in conventional converter is to regulate the switching current, but it also reduces the ripple current value; higher inductor values produce less ripple current in order to obtain the maximum output current. Due to the fact that the current through the inductor does not change instantaneously, the current value will never fall to a zero value (continuous mode).

III. THE PROPOSED BUCK CONVERTER CHARGER

The zero Voltage switching (ZVS) and zero current switching (ZCS) for the operating switches without any switching losses also called "soft switching". This soft switching buck converter is suitable for different application. So the proposed converter battery charger design having several advantages like high efficiency, high power density, least size due to small use of small components.

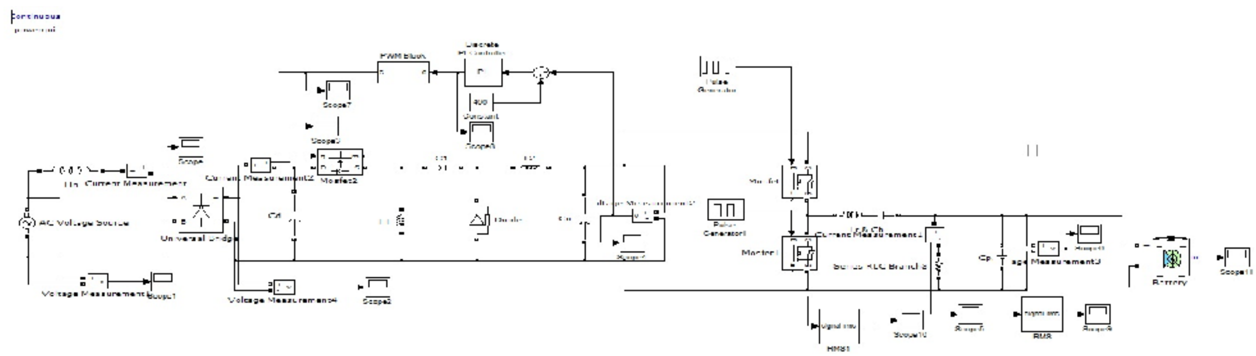

FIG.3. PROPOSED CONVERTER SIMULATION MODEL.

The proposed buck-boost dc/dc converter is composed of controlling devices, a step up down inductor *L* capacitor *C* used in similar way for the conventional converter and a snubber capacitor *C* used in similar way for the conventional converter. In the block diagram shown in Fig. 2, the first stage is ac to dc converter (diode rectifier) used as a first stage of conversion. Another two stage involve first one is a closed loop PWM controlled DC to Dc converter and another one is open loop Voltage controlled DC to Dc converter with battery as load. The closed loop PWM techniques improve the voltage o/p with the feedback path involved with PID controller it gives stability to the proposed circuit with respect to load variation and efficiency is Improved.

IV. AN OVERVIEW OF THE SOFT SWITCHING TECHNIQUE

Many modifications have been suggested for the purpose of raising the value of the switching frequency. The most commonly-used method is to add a resonant circuit component LI, CI, the resonant circuit will allow the electromagnetic interference resulting from di/dt and dv/dt to be limited. Moreover, the resonant transient components will increase the possibility of having a Zero Current Switching (ZCS) or even a Zero Voltage Switching (ZVS).
The first stage is ZVS stage and the second stage id ZCS stage.

A .Zero Voltage Switching, Zero Current Switching

The concept of a zero switching current can be summarized as the moment that the switches turn on and off while the current is zero. The ZCS is able to overcome the current and Voltage overlap by ensuring that the switch current is zero before the Voltage rises, which makes the ZCS more effective and useful than the ZVS. The ZCS technique was used in order to decrease the losses and stress during switching. Consequently, there will be a significant increase in the efficiency and reliability of the converters, which leads to the performance of the battery charger being improved.
It is necessary to set the condition on the battery charger circuit to ensure that the charger operates under ZCS technique.

$$Vin/Z > I_0.$$

According to Fig. 3 the resonant inductance and capacitance can be calculated by:

$$\frac{\omega_0}{Z_0} = \frac{1}{L_1}$$

$$\omega_0 Z_0 = \frac{1}{C_1}$$

Similarly, we assume that the dissipation power is neglected as in the ZVS situation. Therefore the relationship between the output Voltage and input Voltage can be determined by the equality formula of the input energy and the energy released.

$$E_{in} = E_{out}$$

$$\int_0^{T_s} iL_s\,(t)\,dt = v_0 I_0 T_s$$

The relationship between the input Voltage and the output Voltage is $X=V_0/V_{in}$

$$\frac{v_{out}}{v_{in}} = \frac{f_s}{2\pi f_1}\left\{\frac{X}{2r} + \pi + \sin^{-1}\left[\frac{X}{\gamma}\right] + \frac{X}{\gamma}\left[1 + \sqrt{1 - \left(\frac{X}{\gamma}\right)^2}\right]\right\}$$

V. THE SIMULATION RESULTS

The new model of the battery charger using resonant buck converter with zero Voltage switching and zero current switching were simulated using Matlab/Simulink, and the charger is connected to a 1.2V, 6.5Ah Nickel Metal Hydride battery. The circuit parameters are- Input Voltage = 270V, Switching frequency = 80KHz, Duty cycle = 50%, Resonant inductor = 30mH, Resonant capacitor = $3e^{-9}$ F, Resonant frequency = 50Hz.

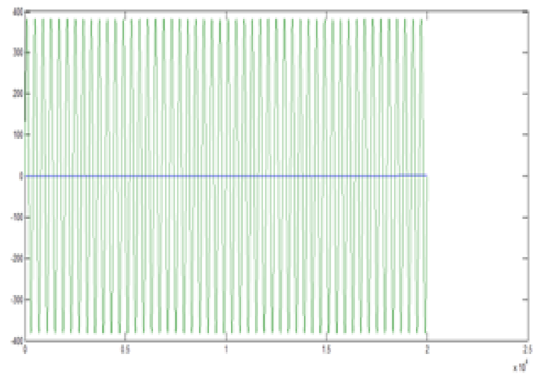

Fig. 4. Input Voltage Wave Form.

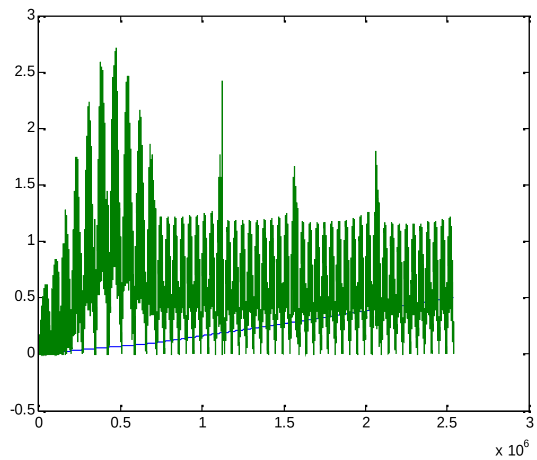

Fig. 5. Rectified Input Current Wave Form.

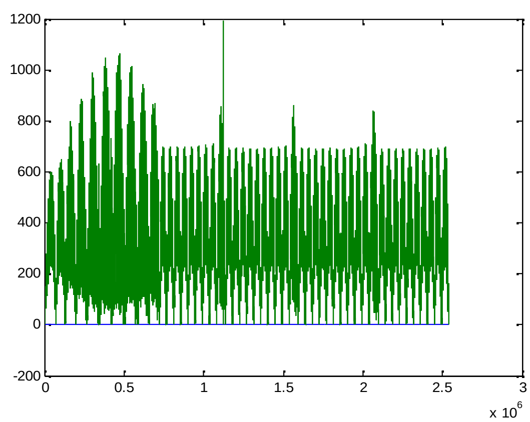

Fig. 6. Rectified Voltage waveform.

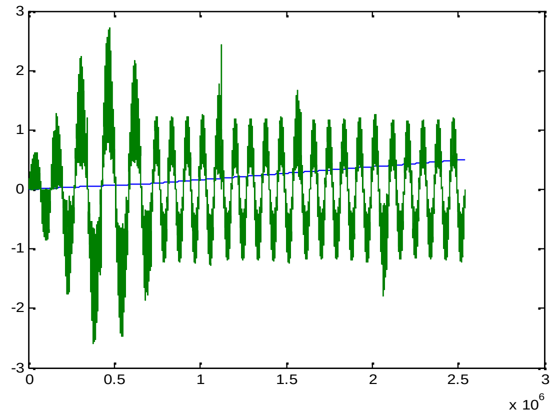

Fig. 7. Input Current.

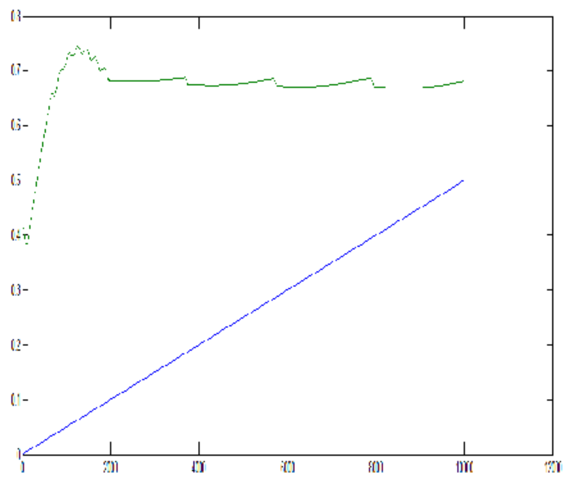

Fig. 8. Discreet PI controller output.

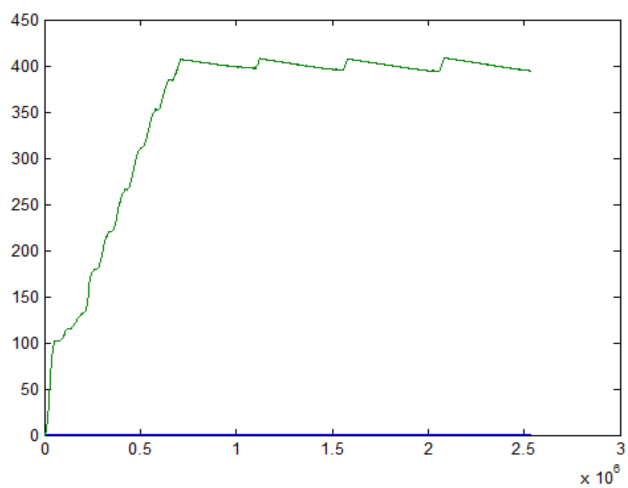

Fig. 9. ZVS output Waveform.

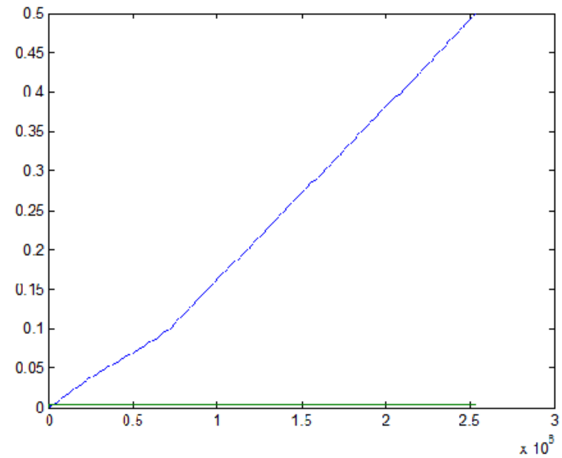

Fig. 10. ZCS output Waveform.

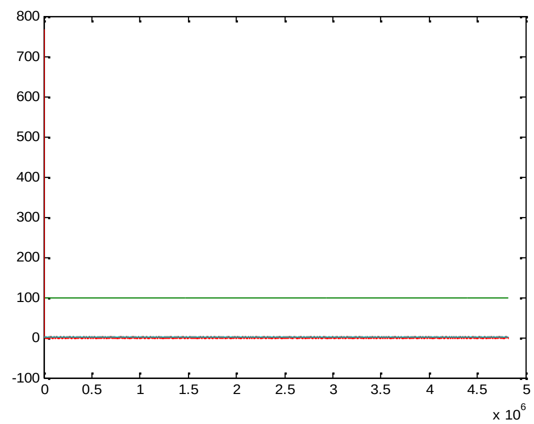

Fig. 11. Battery output.

VI. CONCLUSION

A combination circuit of ZCS and ZVS buck converter battery charge has been presented in this paper. The proposed circuit observed suitable for increasing the efficiency and reducing the losses in a battery charger. This Circuit involve less complex control circuit and less number of components. Their fore it is small in size. For this reason, these charger are considered cheaper and much simpler than others available circuitry. The results of using the chargers with Nickel Metal Hydride battery were simulated using Matlab/Simulink software. The results demonstrated that both ZVS and ZCS are suitable for achieving good performance of active power switches for battery charger applications.

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