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Modelling of New PWM Based Soft Switching for DC/DC Converters Incorporated with PID Controller

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ABSTRACT : A new PWM based soft switching with constant configuration is proposed. The proposed PWM based soft switching DC-DC converter is here. Complete analysis for the boost converter is given and the results obtained for other DC/DC converters are reported. Soft switching commutation is achieved for all semiconductor devices and consequently the switching losses, ripple factor and electromagnetic interference (EMI) are considerably reduced and efficiency, voltage profile is improved. Both simulation and experimental results are presented.

Keywords: DC/DC Converter, Electromagnetic Interference (EMI), PWM.

I. INTRODUCTION

In today's high-tech world the switching power supply market is flourishing quickly. Main target in power electronics is to convert electrical energy from one form to another. Power converters control the flow of power between two systems by changing the character of electrical energy from direct current to alternating current or vice versa, from one voltage level to another voltage or in some other way to make electrical energy to reach the load with highest efficiency is the target to be achieved. DC/DC converters are electronic circuits that change the DC operating voltage or current [1, 3].

They have recently aroused the interest in the current market due to its wide range of applicability. Reliability of the converters becomes a key industrial focus. Electronic devices and control circuit must be highly robust in order to achieve a high useful life. A special accent must

be set on the total efficiency of the power electronic circuits, Firstly because of the economic and environmental value of wasted power and, secondly because of the cost of energy dissipated that it can generate.

Pulse Width Modulated (PWM) converters have been widely used in industry. The PWM technique is praised for its high power capability and ease of control. Higher power density, faster transient response and smaller physical size of PWM converters can be achieved by increasing the switching frequency. However, as the switching frequency increases so do the switching losses and electromagnetic interference (EMI) noises. Switching losses and EMI noises of PWM converters are mainly generated during turn-on and turn-off transients. Resonant converters commutate with either zero-voltage-switching (ZVS) or zero-current-switching (ZCS) to reduce switching losses and EMI noises [2, 5, 6, 7].

Design engineers aren't always supplied with the desired amount of voltage they need in order to make their design work. Adding an additional voltage supply to a design is not always cost efficient. In traditional ways the boost converters were designed with power switches such as transistors, SCR's, IGBT's which required more switching time and having more losses with less efficient output. This work is intended to provide the designer with a method of soft switching of boosting DC voltage working efficiently with desired and stable output desired.

II. OPERATION PRINCIPLES AND ANALYSIS

Boost converter is used to obtain a load voltage higher than the input voltage V. The values of L and C are chosen depending upon the requirement of output voltage and current. When the switch is ON, the inductor L is connected across the supply. The inductor current 'I' rises and the inductor stores energy during the ON time of the switch, t_{on}. When the switch is off, the inductor current I is forced to flow through the diode D and load for a period, t_{OFF}. The current tends to decrease resulting in reversing the polarity of induced EMF in L. Therefore voltage across load is given by

$$V_O = V + L\frac{dI}{dt} \quad i.e., \qquad V_O > V$$

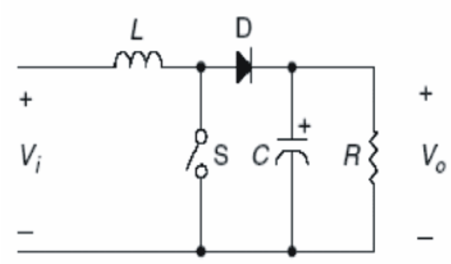


Fig. 1. Basic boost converter.

A large capacitor '*C*' connected across the load will provide a continuous output voltage. Diode *D* prevents any current flow from capacitor to the source.

The circuit that models the basic operation of the boost converter is shown in Fig 1. The input voltage in series with the inductor acts as a current source. The energy stored in the inductor builds up when the switch is closed. When the switch is opened, current continues to flow through the inductor to the load. Since the source and the discharging inductor are both providing energy with the switch open, the effect is to boost the voltage across the load. The load consists of a resistor in parallel with a filter capacitor. The capacitor voltage is larger than the input voltage. The capacitor is large to keep a constant output voltage and acts to reduce the ripple in the output voltage. There are several assumptions to be made to analyze the ideal circuit:

1. When the switch on, the drop across it is zero and the current through it is zero.
2. The diode has zero voltage drops in conducting state and zero current in reverse-bias mode.
3. The time delay in switching on and off the switch and the diode are negligible.
4. The inductor and capacitor are lossless.
5. The response in the circuit is periodic. The value of inductor current at the start and end of a switching cycle is the same. The net increase in inductor current over a cycle is zero.
6. The switch is made ON and OFF at a fixed frequency and let the period corresponding to the switching frequency be *T*. Given that the duty cycle is *D*, the switch is on for a period equal to *DT*, and the switch is off for a time interval equal to (1 – *D*)*T*.
7. The inductor current is continuous and is greater than zero
8. The capacitor is relatively large. The RC time constant is so large, that the changes in capacitor voltage when the switch is ON or OFF can be neglected for calculating the change in inductor current and the average output voltage. The average output voltage is assumed to remain steady.
9. The source voltage VS remains constant.

III. THE SOFT SWITCHING BOOST CONVERTER

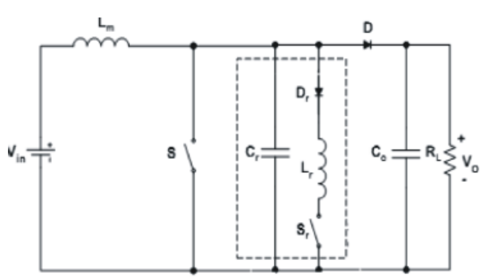


Fig. 2. Circuit diagram of the soft switching of boost converter.

Fig. 2 shows the proposed Snubber topology for the boost converter. The proposed configuration achieves zero-voltage switching for the main switch and zero- current switching with zero-voltage at turn-off for the auxiliary switch. Furthermore, there is no reverse- recovery problem for the main diode since its current decreases linearly [4].

To analyses the steady state operation of the proposed mixed converter, the following assumptions are made:

1. The output capacitor *Co* is large enough to assume that the output voltage *Vo* is constant and ripple free.
2. The main inductor *Lm* is large enough to be treated as a constant-current source *ILM*.
3. Main inductor *Lm* is much greater than resonant inductor *Lr*.
4. The semiconductor devices and the reactive elements are ideal.

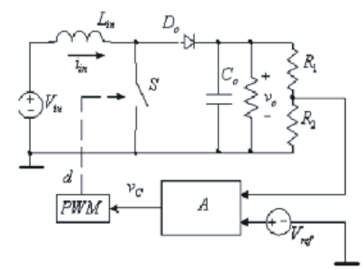
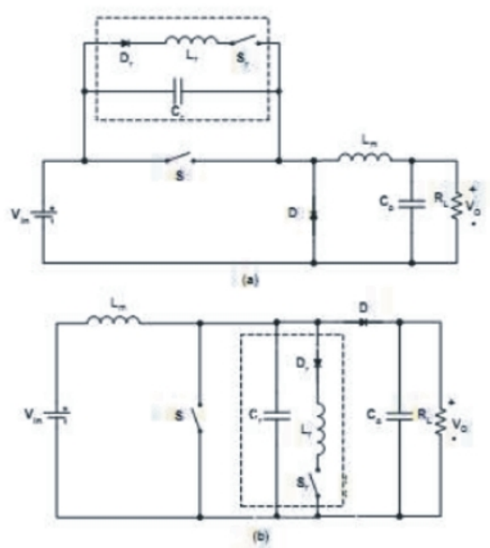


Fig. 3. Block model of PWM based soft switching Boost converter.

IV. THE SOFT SWITCHING OF DC/DC CONVERTERS

The concept of the proposed soft switching for the boost converter can be extended to other DC/DC converters. The three remaining topologies (Buck, Buck-boost and Cuk) were analyzed. Fig. 4 shows the four basic DC/DC converters feedback with linear system. The results of this analysis are reported.



V. DESIGN EXAMPLE

To verify the operation principles of the proposed converter, the following design specification for the boost converter is given here:

V_{in} = 24 V, V_{out} = 48 V, I_{out} = 0.1 A, L = 80 mh, C = 1.68 mf, RL = 80 m-ohms, RC = 5 m-ohms, R_{load} = 120 ohms and fs = 100 kHz, PWM = 100 e3, PID controller = 0, 100, 0.

VI. SIMULATED AND EXPERIMENTAL RESULTS

The results for this specific design example were obtained using the simulink and are presented in Figure 4. As can be seen, the simulated results are in close agreement with the theoretical ones. The experimental waveforms of the designed converter are presented in Fig. 5. It is clearly seen that the experimental results are in close agreement with the simulated ones.

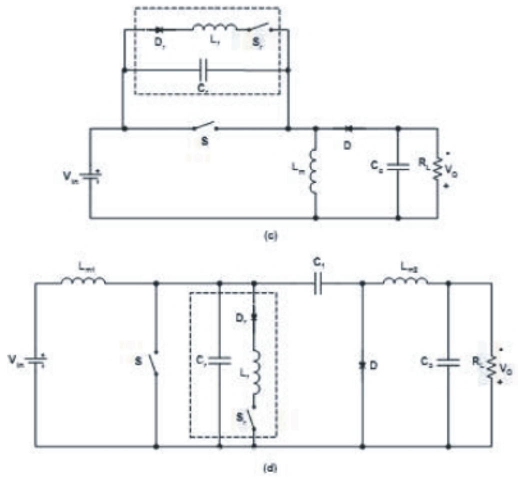


Fig. 4. Four basic circuits of DC/DC converters with soft switching.

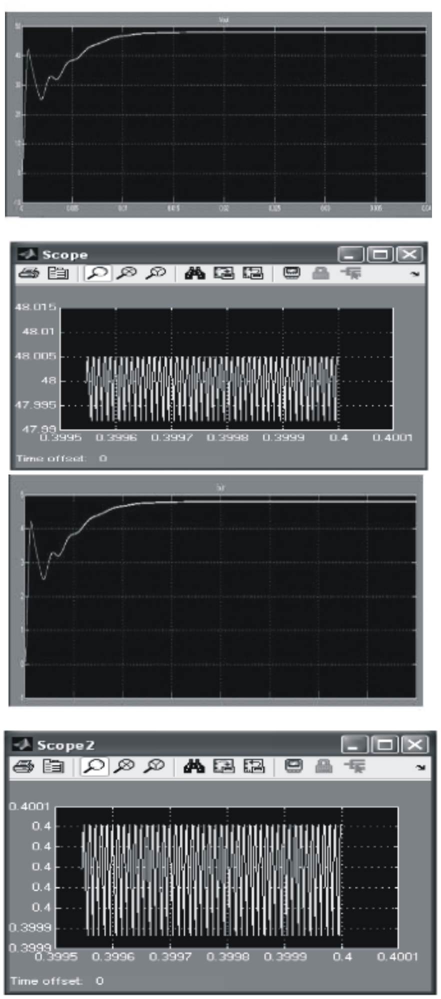


Fig. 5. Simulated waveforms of designed boost converter.

VII. CONCLUSION

In this paper, soft switching PWM based DC/DC converters was proposed. To reduce switching losses and EMI noises to improve efficiency and voltage profile, soft switching was applied to all semiconductors devices in the new converters. The theoretical results for the proposed converter were confirmed by both simulated and experimental results.

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