

Theoretical analysis of Zero Voltage and Zero Current Switching Resonant Pulse Width Modulation for High Power Applications

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ABSTRACT: This paper presents a new soft switched DC DC boost converter for high step and high voltage gain applications such as fuel cell power conversion system, solar arrays, hybrid electrical vehicles etc. This application requires high voltage gain, low conduction losses. The proposed converter achieves soft switching, zero voltage switches are turn on in continuous conduction mode (CCM) causes low stress across the switches and zero current switched off the diodes which leads to negligible reverse recovery losses. The resonant pulse width modulation technique is achieved which allows the L_r , C_r resonance in auxiliary circuit. Also the auxiliary capacitor in the circuit reduces the cost and volume of the proposed converter and increases the efficiency as compared with the Pulse Width Modulation (PWM). Theoretical analysis and performance between PWM and RPWM technique is carried out.

KEYWORDS: Voltage gain, zero voltage zero current switching (ZVZCS), continuous conduction mode (CCM).

I. INTRODUCTION

As the demand for non transformer DC-DC boost converter with low duty loss and high voltage gain is increasing now a days. The renewable and green energy sources of power for example fuel cells, solar arrays requiring this DC-DC converter device. As the main purpose of using DC-DC converter is for isolation and voltage Boost. Since a general boost converter operates with high duty cycle is selected for increased voltage conversion ratio of converter. The used diode reverse recovery losses and electromagnetic interference problems. As a result Zero-Voltage Switching (ZVS) technique and Zero-Current Switching (ZCS) technique is incorporated for theoretical analysis and performance of proposed converter. Non transformer dc dc boost converter along with an improved switching method is presented in this paper. At switching turn off losses are reduced with continuous conduction mode and few converter achieves zero voltage switching turn ON of the switches. The capacitance of capacitor in the auxiliary circuit is greatly reduced as compared with the pulse width modulation. There are various requirements in DC-DC converters are,

- 1) High voltage gain
- 2) Low reverse recovery loss
- 3) Soft switching characteristics
- 4) Low voltage stress across the switches
- 5) Continuous input current
- 6) High efficiency

High step up DC-DC(Boost) converter is used in many applications such as Power factor correction, Fuel cell and solar cells. It is assumed that modern portable wireless communication and signal processing systems will use variable supply voltages to minimize power consumption and to extend life of battery. The boost converter is also used to solve problems invoked with interfacing the output voltage of photo-voltaic (PV) cells to grid connected system. Resonant pulse width modulation (RPWM) technique with improved switching by utilizing L_r , C_r resonance component in

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auxiliary circuit.

As the boost converter is step up converter with an output DC voltage greater than its input DC Voltage. It is the one of the class of Switching mode power supply having at least two semiconductor switches one diode & transistor and one energy storage component. Capacitor is used as filter and are normally added to the output of converter reduce the ripple at load side. Resonant pulse width modulation (RPWM) technique with improved switching by keeping L_r , C_r resonance component in auxiliary circuit.

II. RELATED WORK

Qun Zhao [1] had presented significant reduction in efficiency due to rectifier reverse recovery problems to remove this drawback this paper presents a solution that consist of shifting original rectifier current to new branch consisting coupled winding boost inductor and rectifier. Qun Zhao [2] presented, few converters provides high voltage gain but they operates with high duty cycle but converters with coupled winding and diode perform better. Marcos Prudente, etc. [3] had presented to obtain high voltage gain voltage multiplier technique is applied to dc dc converter and diode reverse recovery problems are minimized. Eung -Ho Kim, etc. [4] had presented the converter uses minimum number of devices and perform the soft switching of switches and due to all these advantages it is popular for high voltage applications. Hyun-Lark Do, etc. [5] had presented by controlling current changing rates of diode with use of coupled inductor reverse recovery problems are removed and also without using high duty cycle the converter provides high output voltage. Hyun-Lark Do [6] the use of transformer leakage inductance with controlling changing rate of current reverse recovery characteristics of output diodes are greatly improved. The high voltage gain provided by ZVS half bridge converter . Sungsik Park [7] presented in order to satisfy the required output voltage and power levels then converter is used with proper number of series parallel connected basic cells. The voltage rating of components are greatly reduced. S. Park, etc. [8] switches are turned on in continuous conduction mode and negligible reverse recovery loss is achieved due to zero current switch turn off of diodes. As compared to conventional boost converter voltage conversion ratio is doubled. Sewan choi , etc [9] had presented small duty loss caused increased step up ratio even in small duty cycle switching losse associated with diode reverse recovery is negligible. The auxiliary capacitor value is decreased by 20 fold which reduces the cost and volume of converter.

III. SYSTEM STRATEGY

Fig.1.shows basic circuit diagram of Resonant pulse width modulation (RPWM) has same circuit topology as PWM Method. The converter consist of two circuits namely as first is main circuit it is generally boost converter and second one is auxiliary circuit. The auxiliary circuits mainly consist of resonant components such as Resonant capacitor C_r , inductor L_r and two diodes D_U , D_L . This auxiliary circuit mainly acts as resonant circuit which not only increases output voltage but also zero voltage switching turn on the two switches in continuous conduction mode(CCM). Due to this resonance operation capacitance of auxiliary capacitor is reduced by 20 fold. Also the switches are turn off with low peak current as compared with the Pulse Width Modulation Technique. Therefore reducing turn off current of switches and cost and volume of the converter.

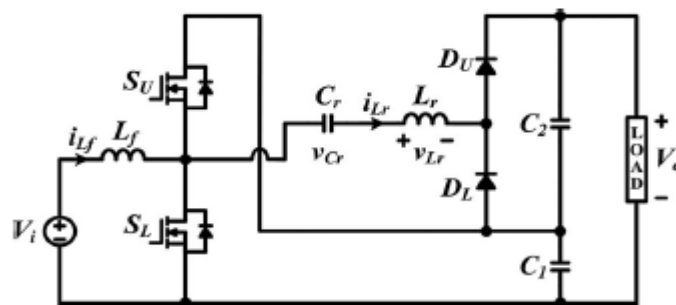


Fig.1 Proposed RPWM ZVZCS dc-dc converter

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A) PWM versus RPWM Technique:-

Fig.2 shows the simulated comparative analysis between PWM and RPWM methods. The turn off current of RPWM converter is smaller than the Turn off current PWM technique. Also the turn off current of RPWM converter and general boost converter is same. The size of auxiliary capacitor is reduced by 1/20th fold as compared with PWM Method.

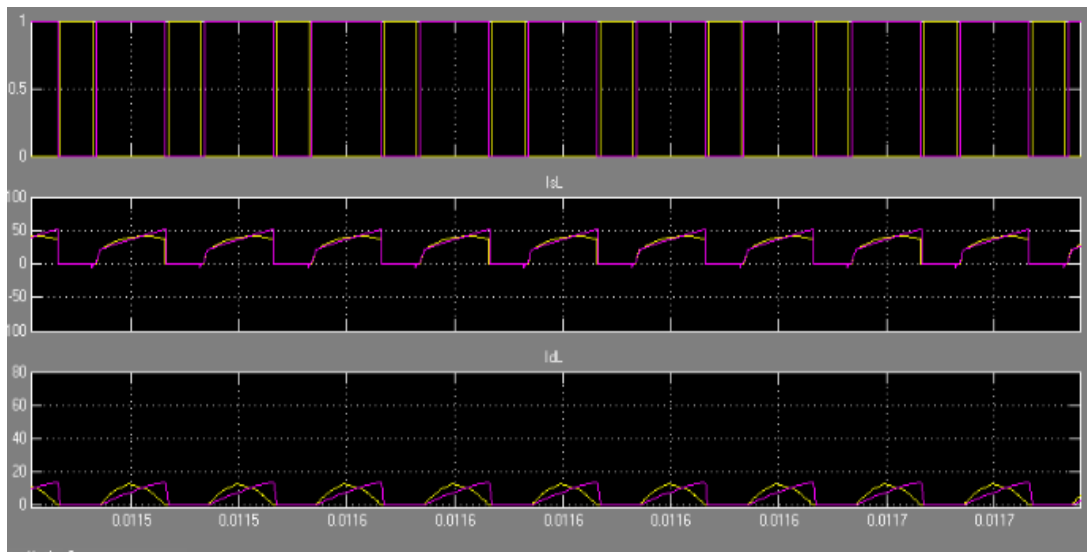


Fig.2 Comparison between PWM and RPWM Technique

(B) Comparison of Various Resonance Conditions:-

There are two resonance operation according to the variations of resonance frequency f_r such as,

- 1) Above resonance condition
- 2) Below Resonance Condition

As we know that,

$$\omega r = 2\pi f r \tag{1}$$

$$= \frac{1}{\sqrt{LrCr}} \tag{1}$$

$$f r = \frac{1}{2\pi\sqrt{LrCr}} \tag{2}$$

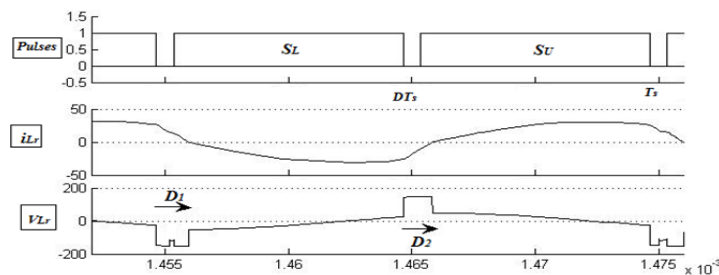


Fig.3 Above Resonance Operation

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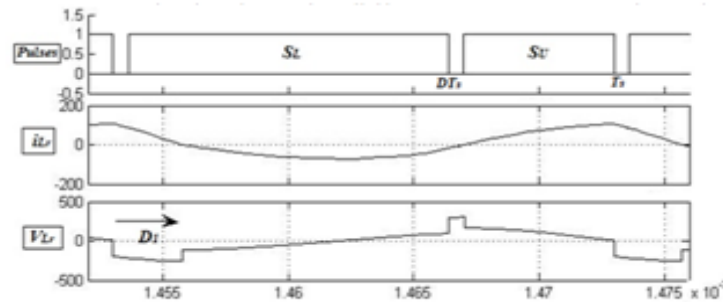


Fig.4 Below Resonance Operation

From above figure 3 and 4 it shows that below resonance operation is preferred as compared to the above resonance operation. The duty loss of both below and above resonance is compared. The advantages of Below resonance as follows,

- 1) Due to smaller switch turn off current & diode di/dt ,the turn off switching losses are smaller
- 2) Duty loss D1 is smaller than above resonance operation

So below resonance operation is preferred,

Resonance frequency is defined as,

$$F_s > 0.5 \frac{F_s}{D_{eff}} \quad (3)$$

Where D_{eff} is the effective duty cycle
 f_r is the resonant Frequency

As the Voltage gain for Below resonance operation is high as compared with above resonance operation so,Below resonance operation is chosen for proposed converter.

IV. CONCLUSION

In this paper simulated comparison analysis of PWM and RPWM converter is designed. The advantages of RPWM over PWM is as follows,

- 1) The capacitance of auxiliary capacitor is reduced by 1/20th fold which reduces the cost an volume of converter.
- 2) Soft switching is achieved by using RPWM technique using Zero Voltage Zero Current Switching.
- 3) Due to Resonant operation turn off current across switches is greatly reduced ac compared with the PWM .
- 4) Step ratio increased by reducing the duty cycle loss.

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