Design of Full-Bridge Resonant AC-Link Boost Converter using Solar Energy System

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Abstract : ***This paper proposes a full-bridge AC-link boost converter with isolation transformer. The output voltage is regulated by dc-ac converter whose frequency changes with a constant turn-off time of transistors. The proposed converter has got parasitic oscillations, as all of the parasitic capacitances and inductances are included in a resonant tank circuit. The main advantage of such systems is that they include a capacitive output filter, which is preferred in higher voltage applications. Moreover, it achieves ZCS for all active switches and zero-voltage switching (ZVS) operation for all diodes on high voltage side, which is an additional benefit. In this paper, the system operation is first explained, then a mathematical description that is useful for its design is provided, and finally, a report on the implementation of a laboratory prototype with 125W power is presented.***

Keywords: ***Bridge converter, DC-DC converter, ZVS, ZCS.***

I. INTRODUCTION

High voltage DC-AC-DC converters with an isolation transformer are used in different types of electronic applications such as battery chargers and dischargers, uninterruptible power systems, hybrid electric vehicles. In the case of the applications where low input voltages have to be converted to high output voltages, full bridge boost converters are usually a good choice.

However, the design of high voltage dc-dc converters is problematic because transformer parasitic elements can change the converter behavior. The transformer leakage inductance causes undesirable voltage spikes that may damage the circuit components, and the winding capacitance may result in current spikes. A vital factor that determines the size and the cost of a converter is its operation frequency. In order to minimize the size and the cost, the frequency has to be maximized. However, higher frequencies result in the increase of transistor switching losses, and thus, the converter's effectiveness is limited. For that reason, many solutions have been proposed to minimize converter switching losses.

However, the switches must provide a reverse-voltage blocking capability. Thus, they have to be constructed by means of an MOSFET in series with reverse-voltage blocking diodes. The use of the diodes increases the component count and cost, although it also causes higher conduction losses. Another solution proposed to minimize converter switching losses is a PWM boost full-bridge converter, in which the leading switches realize ZCS under wide load range, and the lagging switches realize zero voltage switching (ZVS) under any load. Likewise in this solution, the leading switches have to be connected in series with reverse-voltage blocking diodes. In addition, a circulating current, which is a result of the introduction of an additional auxiliary inductance (connected parallel with the primary winding of the transformer), is the source of extra conduction losses.

II. EXISTING & PROPOSED SYSTEM

A. EXISTING SYSTEM DESCRIPTION

The active clamp network serves to limit bridge switch turn-off voltage overshoot and enable the energy stored in the transformer leakage inductance to be used for zero voltage switching. At switch turn-off that energy redistributes into the parasitic capacitance of the switches, causing a voltage overshoot capable of destroying devices. PWM phase-shift control of the bridge switches is utilized to obtain zero-current switching for two of the four bridge switches.

B. PROPOSED SYSTEM

The proposed converter system is devoid of parasitic oscillations as all the parasitic capacitances and inductances are included in the resonant tank circuit. The characteristic feature of resonant converters is that the transformer parasites do not disturb the circuit, because they are used as resonant circuit elements. In a current fed full bridge boost converter type the overlapping conduction time of the four converter switches is kept constant and the output voltage is regulated by varying the switching frequency.

The conduction time is particularly calculated to ensure ZCS operation under a wide load range. MOSFET's and body diodes are used as the converter switches without the need for any additional diodes in series. The converter transistor turn-off time is constant and is equal to the time of the parallel connected capacitor overcharge. During the ZCS switch off-time, the L-C tank circuit resonates. This traverses the voltage across the switch from zero to its peak, and back down again to zero. At this point the switch can be reactivated, and lossless zero voltage switching is facilitated. Therefore the switch transition losses go to zero regardless of operating frequency and input voltage. This could result in significant savings in power and improvement in efficiency. This feature of the converter makes it suitable for high frequency and high voltage converter design.

III.BLOCK DIAGRAM & CIRCUIT DIAGRAM OF PROPOSED METHOD

A. BLOCK DIAGRAM DESCRIPTION

In Fig.1 Solar energy supply is given to an Inverter. The Inverter converts the DC power into AC power. The DC input voltage is converted to AC in order to increase the efficiency of the converter.

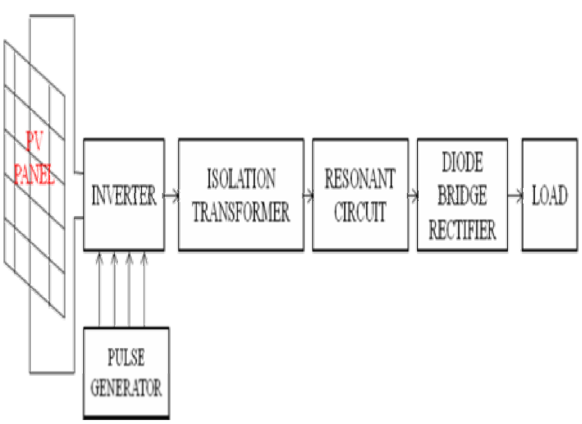

Figure.1: Block Diagram of proposed converter

The boosting operation is done in the Inverter circuit it's also a boost converter. Each Mosfet acts as a switch without any switching losses and facilitates the operation of the converter. Now the boosted voltage is further passed through an isolation transformer to isolate output from the input variations if any and also the input from the load variations. The isolation transformer is connected to the rectifier circuit on the other half, where the AC voltage is converted to the DC output voltage.

B. CIRCUIT DIAGRAM DESCRIPTION

The proposed converter scheme is shown in Fig.2. The Circuit consists of two parts one is the inverter and other is the rectifier both separated from each other by an isolation transformer. DC converters are used in conjunction with an inductor (L_{in}) to generate a dc current source for current source inverter. The inverter converts the low input dc voltage into high power ac output voltage.

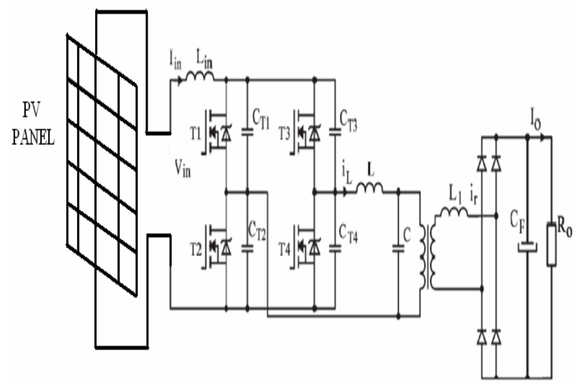

Figure.2: main circuit of proposed converter

The output of dc converter with resistive load is discontinuous and contains ripples. The ripple content in the dc output can be reduced by using capacitive filter The inductance L1 represents the transformer leakage inductance, the capacitance C includes the transformer parasitic capacitance, and the capacitances CT include the transistor parasitic capacitances. The transistor control pulse waveforms are shown in the Fig.3

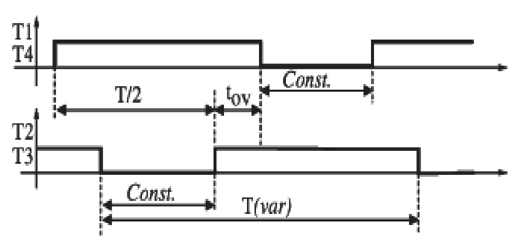

Figure.3: Control pulse waveform

The converter is controlled by varying the switching frequency f=1/T, while simultaneously keeping a constant break between the pulses. Thus, the transistor pulse overlap t_{ov} gradually decreases while the switching frequency increases. The maximal output voltage (power) is achieved with the minimum switching frequency, which is marked as nominal, i.e.,fn. For this frequency, the converter operates in the optimal operation point while its transistors are switched at zero-current conditions.

During the constant break between the control pulses, two transistors and two capacitors alternatively conduct T1T4CT3CT2 or T2T3CT1CT4. Because of the system symmetry, each transistor and each capacitor conducts, as in the previous subinterval, half values of the input and output current. The main task of the system design is the calculation of the transistor pulse overlap t_{on} and the constant break between the control pulses in accordance with the resonant circuit element parameters, i.e., C, L, and CT , and the load resistance for the assumed value of the nominal switching frequency, in order to achieve the converter optimal operation point. The control pulse waveform is shown in the Fig. 3.

IV. DESIGNCALCULATION

A. Simulation Design Calculation

A simple design calculation is shown below,

Resonant frequency = 1000Hz (1)

Input voltage = 500V

Formula : F r= 1/2√LrCr (2)

1000 = 1/ 2√ Lr Cr (3)

Lr Cr = 2.533*10^-8

Let us assume Cr = 1000nF .Then by calculation the Lr value is designed as 16.5µH.

B. Simulation Parameters

Table I. Simulation Parameters

S.No	Parameters	Values
1.	Input voltage,Vin	15V
2.	Switching frequency, FN	1000 Hz
3.	Transformer voltage ratio, Kt	1
4.	Leakage inductance, L1	350µH
5.	RL	80 Ω
6.	Input Voltage	24V
7.	Input Inductance	350µH
8.	Operating frequency	220Hz
9.	Resonant Inductance	250µH
10.	Resonant capacitance	1mF
11.	Output Voltage	4V

V.SIMULATION AND RESULT ANALYSIS

A. Simulated circuit diagram

The Fig. 4 shows the simulation circuit of the proposed converter where a solar PV panel is the power supply unit. It is then fed to the inverter and the inverted output is fed to the LC tank circuit (resonance circuit). Then it is fed to the isolation transformer and then it is given to the diode bridge rectifier.

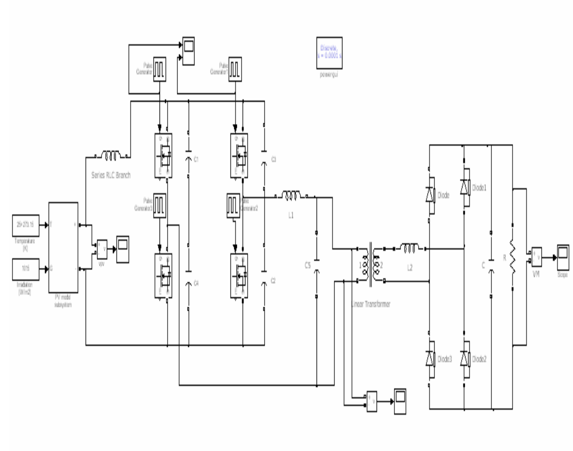

Figure.4: Simulation diagram of the proposed converter

B. Simulated Waveforms:

The output of the solar panel is shown in the below simulated waveform Fig.5. Its output is nearly 15V and the input of a converter circuit is also same.

Finally the output of the proposed converter circuit is taken in two places. First will be measured in inverted side, the output wave form is shown in below Fig.6. Then the other place is resistive load of the diode bridge converter side, the output wave form is shown in below Fig.8. The output of the proposed converter circuit will be attained 26.9 volt.

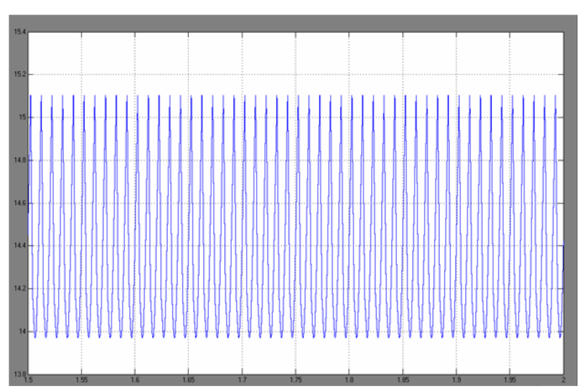

Figure.5: Simulated waveform for solar PV module

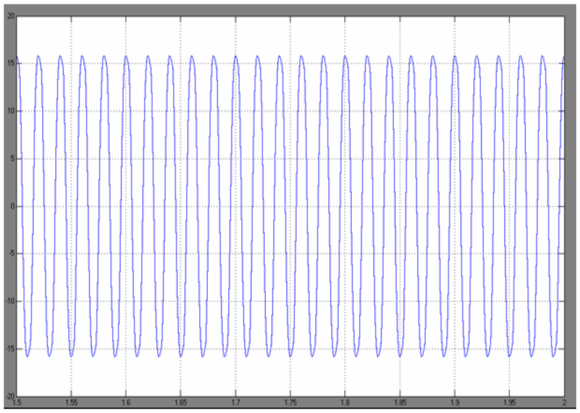

Figure.6: Simulated Inverter boost output waveform

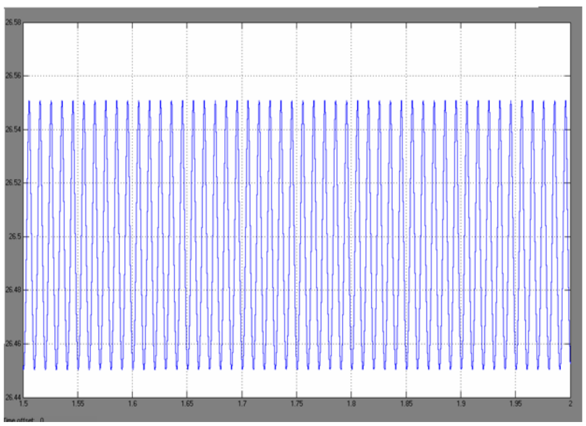

Figure.7: Output waveform of proposed converter circuit

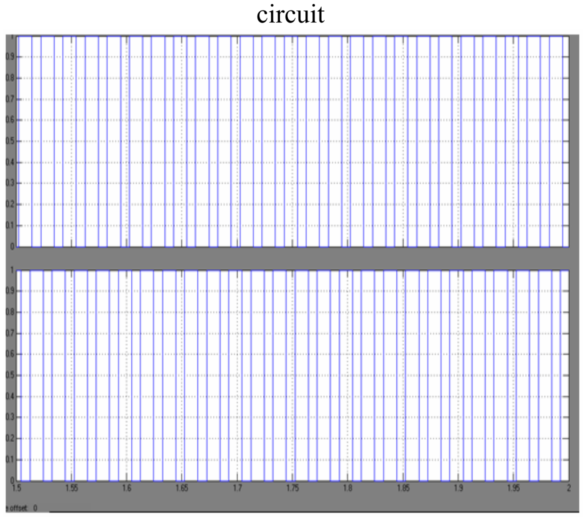

Figure.8: Transistor control pulse waveform

VI. CONCLUSION

In this paper full-bridge AC-link boost converter with isolation transformer has been proposed. Detailed matlab simulation results have been presented to evaluate the performance of the converter. The simulated parameters are shown and it's very less deviation. So a dc-ac-dc converter can be used for high power application which gives constant dc output voltage with fewer losses.

The main features of the proposed converter are, the primary benefit of using a Full-Bridge dc-dc converter is its power handling capabilities and stability. The ac-dc rectifier diodes operate in discontinuous range with zero voltage switching so their switching power dissipations are also minimized. All the parasitic capacitances and inductances are included in the resonant circuit, so the system does not generate parasitic oscillations and is devoid of uncontrolled voltage and current spikes.

VII. FUTURE WORK

In future we have to extend this paper as current fed full-bridge AC-link boost converter with isolation transformer.

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