An ZVS DC-DC converter for High voltage and Efficiency gain With Reduced Ripple Current

S.Freeda Angeline Rachel, J.Jency Joseph

Abstract- The power-generation market, has shown obvious growth. However, a high voltage and efficiency gain is essential for the fuel cell and PV panel and for other appliances. The high step –up converter in the proposed converter provides ripple- free input current. The full bridge converter provides high voltage gain. An APWM Full Bridge Boost converters are widely used in application where the output voltage is considerably higher than the input voltage. Zero Voltage Switching(ZVS)is typically implemented in the switches.ZVS APWM DC-DC Full bridge converter that does not have any drawbacks of that other converters of this type have such as complicated auxillary circuit,.increased current stress in the main power switches and the load dependent ZVS operation. In this proposed method an interleaved technique of Boost and Full Bridge converter is used..The different modes of operation of MOSFET has been discussed.. Moreover converter has high efficiency because of soft switching operation in switches. A 24V input voltage, 350V output voltage, and 168W output power simulation circuit of the proposed converter has been implemented and its efficiency is up to 87.5%

Keywords— Full bridge converter, Boost converter, Zero-voltage switching, Soft switching, ZVS-APWM clamping circuit.

I. INTRODUCTION

DC-DC converters are used whenever DC electrical power is to be changed from one voltage level to another. They can be step up or down using a transformer. Mostly these are power electronic converters that can operate with semiconductor switches like MOSFETs and IGBTs. These switches are required to turn on and off periodically and they provide a regulated and isolated with wide output voltage for various applications.. Bidirectional converters are main types of DC-DC converter currently used in the industry today [1] Bidirectional DC-DC converter may be isolated or nonisolated depending on its application. It not only reduces the cost and improves the efficiency but also improves the performance of the system. Bidirectional DC-DC converters allow transfer of power between the sources, in both direction.They are used in many applications such as battery chargers/dischargers, dc uninterruptible power supplies, electrical vehicle motor drives, aerospace power system, telecom power supplies.The main application are in hybrid vehicles, battery chargers or super capacitors and space craft technologies. The advantage is that in a single converter using two switches power flow in either direction is possible.

Bidirectional DC-DC converters are being increasingly used to achieve power transfer between two dc power sources in either direction. It reduces the cost and improves the system efficiency, and also improves the performance of the system..DC to DC converters are important in portable electronic devices such as cellular phones and laptop such that their primary power supply is from a battery. Additionally, the battery voltage declines as its stored power is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing.

The step-up dc-dc converters can be classified into two types: voltage-fed type and current-fed type. Generally, voltage-fed converters shows low voltage stress of the switching devices, is confined to the input voltage. However, large input filters are needed at the input stage to smooth the large input current ripple. On the other hand, current-fed converters exhibit low input current ripple[2] Therefore, current- fed converters are often used in high step-up applications.

The Soft-Switching Technique are used in this project in order to improve efficiency and to increasing the high-voltage DC-DC Converters are being used for the improvement efficiency gain.[4]-[6] The Soft-Switching is done by using MOSFETs. Here we are using ZVS for soft switching purpose. Auxiliary power converters for traction rolling stock applications have to operate under difficult conditions, includes high input voltages which are subjected to wide fluctuations, high temperatures, and harsh environmental constraints. Additionally there is a need for silent operation, which implies switching frequency above 20 KHz[7]-[8]. For this purpose a dc-dc converters are being used, with their advantages of reduced size and weight The boost converter cell provides a ripple-free input current. The APWM full-bridge dc-dc converter cell with a voltage doubler provides a high voltage gain without a large turn ratio of the transformer. Moreover, ZVS operations of all the power switches are achieved and the reverse-recovery problem of the output diodes is significantly alleviated due to the leakage inductance of the transformer. Therefore, the proposed converter shows high efficiency. Also, the voltages across the switches are clamped as the dc-link voltage. To reduce the input ripple and to obtain a high voltage soft switching technique in switches is used. In order to obtain the high frequency and to eliminate the switching loss the switching frequency is increased. In this proposed method ZVS APWM technique is used to the circuit to obtain the high voltage gain

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* Correspondence Author (s)
S.Freeda Angeline Rachel, Department of EEE, Karunya University, Coimbatore, India.
J.Jency Joseph, Department of EEE, Karunya University, Coimbatore, India.

Resonant converters use just a few passive components to achieve ZVS operation, they have several drawbacks. One of these is that they usually suffer from high peak voltage or current stresses in comparison to conventional PWM converters so that they generally need to be implemented with more expensive, higher voltage or current rated switches. The main drawback, is resonant converters operate with more conduction losses than conventional PWM converters due to an increased amount of current that circulates in the transformer primary side of the converter. need for silent operation, which implies switching frequency above 20 KHz. For this purpose a dc-dc converters are being used, with their advantages of reduced size and weight.

The boost converter cell provides a ripple-free input current. The APWM full-bridge dc-dc converter cell with a voltage doubler provides a high voltage gain without a large turn ratio of the transformer. Moreover, ZVS operations of all the power switches are achieved and the reverse-recovery problem of the output diodes is significantly alleviated due to the leakage inductance of the transformer. Therefore, the proposed converter shows high efficiency. Also, the voltages across the switches are clamped as the dc-link voltage.

II. APPLICATION OF DC-DC HIGH STEP-UP CONVERTER

A. DC-DC Converters

For DC-DC converters, which can have transformers incorporated into their basic topologies even though a continuous DC voltage cannot be applied across them for a lengthy period of time. In the case of DC-DC converters with transformer isolation, these converters can operate with transformers also long as care is taken to impress waveforms with zero average voltage such as AC waveforms across their input

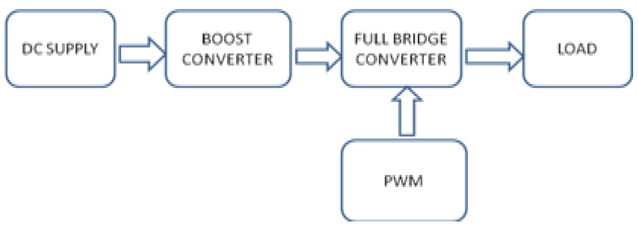

Figure.2. Block Diagram of Proposed System

The proposed converter system is controlled by APWM Technique. Compared to the symmetric PWM controller APWM controller has the same voltage and the current stress in the primary switches. Although the transformer voltage and current waveforms are different from symmetric PWM control. In asymmetric PWM control, the PWM control is employed in application for wide input voltage range because of switching loss, and transformer leakage inductance related to losses are reduced. Higher efficiency is expected with this technique. The stress distributionis asymmetric and it will be high compared to symmetric, dc bias of magnetizing current and non linear dc voltage gain all these features make asymmetric HB not suitable for applications with wide input voltage range. APWM technique is applied in order to regulate the output voltage and achieve ZVS of main switches by utilizing leakage inductance of the transformer and the intrinsic of the output capacitors. The duty cycle loss is neglected. In this technique there is not necessitate of any clamp circuit at the secondary side. In symmetric PWM the positive and the negative pulse of PWM is located at the middle of the cycle period.due to harmonic interference we prefer asymmetric PWM than the symmetric PWM. In asymmetric PWM the puses are aligned to the start or to the end of the PWM cycle

III. CIRCUIT OPERATION AND DESCRIPTION

This paper addresses by proposing a set of soft-switching techniques in a full-bridge forward topology. For this purpose, a special modulation sequence is developed to minimize conduction losses while maintaining soft-switching characteristics in the MOSFETs and soft transitions in the output rectifiers. Auxiliary elements in the primary, such as series inductors and capacitors that are impractical to realize due the extreme input current are avoided by reflecting them to the secondary of the circuit to minimize circulating current and generate soft transitions in the switches Detailed analysis of the techniques for efficiency gains is presented and a phase-shift ZVS topology.

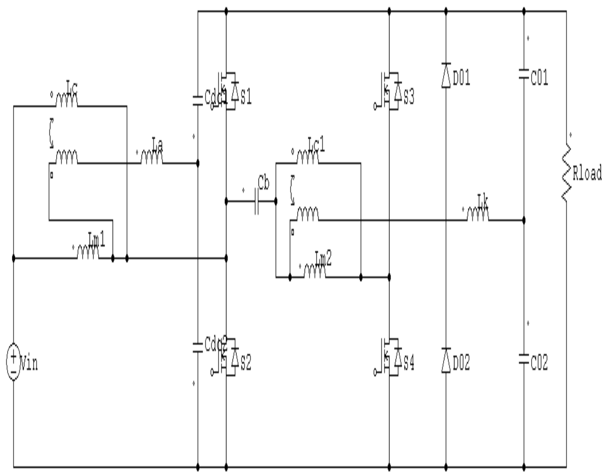

Figure .1 Circuit diagram of the whole system

The circuit diagram of the proposed ZVS dc-dc converter with a high voltage gain and a ripple-free input current is shown in fig.1. .It consists of a boost cell with a coupled inductor and an APWM full-bridge cell with a voltage doubler. The boost cell provides a ripple-free input by utilizing the coupled inductor and the auxiliary inductor.

To simplify the analysis of operation, components are considered idle except otherwise indicated. The main operation modes are described as follows.

Mode 1(t<t0)

In this mode, only switches S1 and S4 are turned off at the begining and the converter is in an energy transfer mode as energy is transferred from the input to the output through diodes . Before time t = t0, the converter operates as a standard PWM boost converter .the capacitors C_2 and C_3 start to discharge at zero and C_1 and C_4.are charged. Gate signals are applied to S_2 and S_3 and their voltages are clamped as zero and thus the current increases from its maximum value.

Mode 2(t0<t<t1)

The current i_{Lk2} changes its direction at t=to mode.and the output diodes are turned on and its current increases. The current changing rate of output diodes D_{o2} is controlled by the leakage inductance of the transformer.and the reverse recovery problem is alleviated.

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Mode 3(t1<t<t2)

In this mode, only switches S2 and S3are turned off at the begining and the converter is in an energy transfer mode as energy is transferred from the input to the output through diodes. At time t = t1, the converter operates as a standard PWM and.the capacitors $C_1$and C_4 start to discharge at zero and C_2 and C_3.are charged. Gate signals are applied to S_1 and S_4 and their voltages are clamped as.

Mode 4(t2<t<t3)

The current i_{Lk2} changes its direction at this mode.and the output diodes current i_{Do2} decreases to zero.and D_{02} are turned off and the ouput diode D_{01} is turned on and its current increases. The current changing rate of output diodes D_{o2} is controlled by the leakage inductance of the transformer.and the reverse recovery problem is alleviated. zero and thus the current increases from its minimum value.

IV. SIMULATION AND EXPERIMENTAL RESULTS

This simulation gives a sequential and conceptual manner (1) the steps taken to fulfill the requirements toward increasing the efficiency of the full-bridge forward converter. The over all simulink model is shown in fig 5.1 .In this the 24V DC is given as a input source voltage and it is given in to the auxillary inductor L_a ant to the split dc –link capacitors C_{dc1} and C_{dc2} to maintain the switching. Frequency.and it is fed to the DC blocking capacitor C_b and it is coupled it with the transformer and the leakage inductance . In this s1 and s4 acts as a main switch before the puses are given ant it is in off mode and ZVS conditions are apllied to the switches. The output diodes are under ZCS condition during turn off. Here the energy is transferred from low voltage side to the voltage source. Both the switches will operate in the same frequency. The auxillary switches is on for a small period of time and turned off immediately after the main switch is turned on. The input and the output waveforms are given below. The full bridge converter is given a APWM control signals and they are operated in four different modes with ZVS technique. The ouput is connected to a load of resistor 8Ω and the corresponding waveforms are obtained

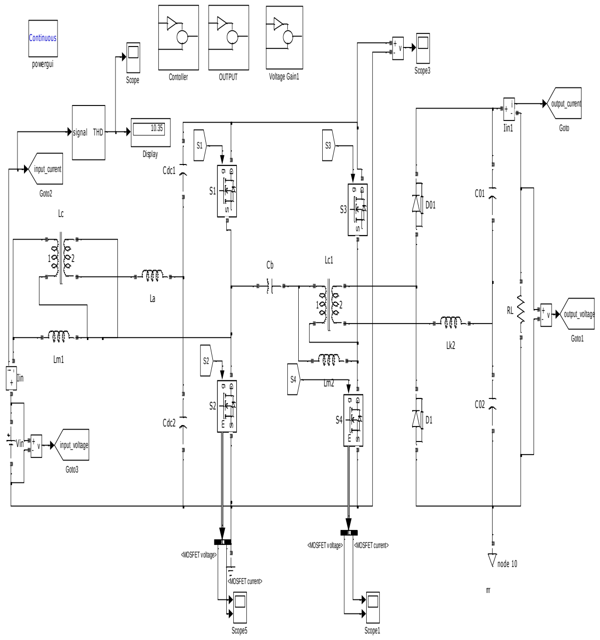

Figure 3.Simulation Model

Fig.3 . Shows the simulation of Boost Converter and full bridge converter using Matlab Simulink,.

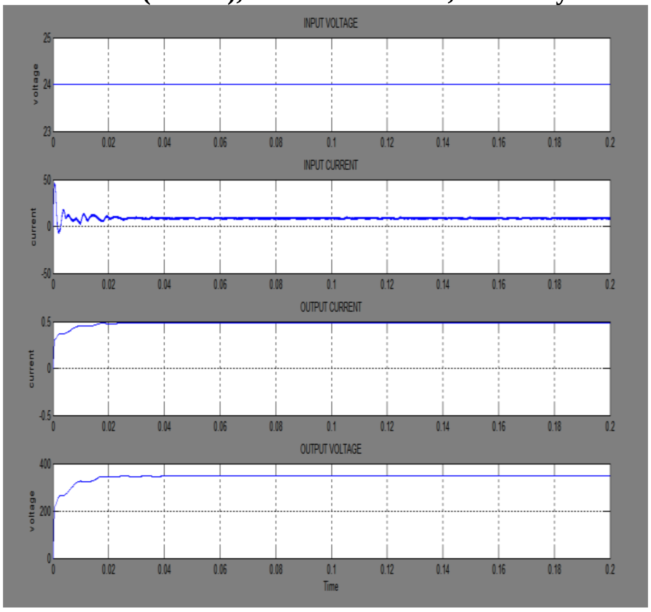

Figure. 4 .Output Voltage and current waveforms

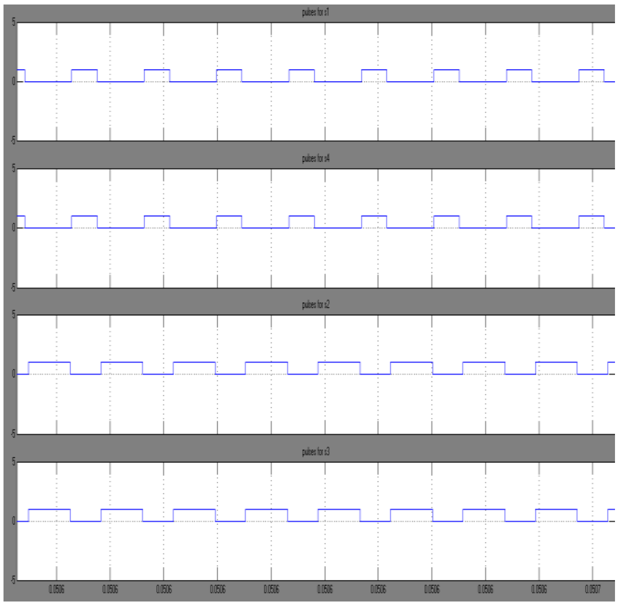

Figure- 5 Gate waveforms illustrating zvs technique in switches

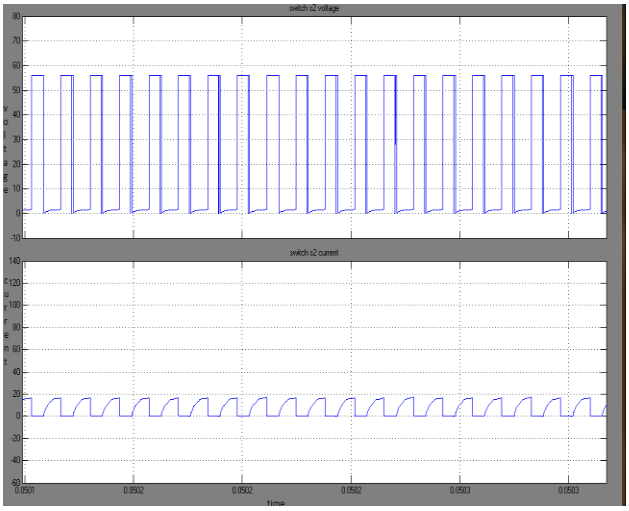

Figure- 6 Voltage and current waveform of switch s2

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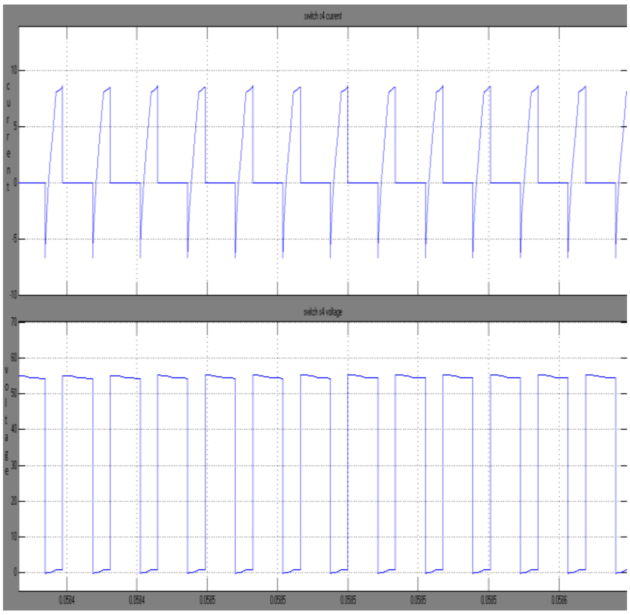

Figure- 7 Voltage and current waveform of switch S4

V. RESULTS AND VALIDATION

The proposed soft-switching techniques for improving waveforms are presented in this section. In fig.4 the voltage and current waveforms are given . The constant voltage of 24V dc is given and the output voltage of 350 V is obtained with the input power of about 192 W. The input current is measured as 8 A with the ripple less and the output current of 0.48A is obtained with the output power of 168W. The fig .5 shows the switching pulses for different switches. During this when s1 and s4 are on the corresponding switches of s2 and s3 will be off for a certain period of the switching frequency. The required amplitude, pulses. And pulse width are given to the pulse generators with the particular settling time is given to the switches. the signals are given with the controller. The fig.6 shows the voltage and current waveforms of the switch s2 for a constant dc source when the ZVS technique is applied to the switches. The switch s3 waveforms are similar to the s2 waveforms since they both conduct for the same switching pulse and the same settling time. The fig .7 shows the current and voltage waveforms of the switche s4 for a constant dc source when the ZVS technique is applied to the switches. The switch s1 waveforms are similar to the s4 waveforms since they both conduct for the same switching pulse and the same settling time. Thus the proposed converter shows 87.5%efficiency.

VI. CONCLUSION

A Full-Bridge DC-DC converter with Zero Voltage Switching (ZVS) is modelled using the blocks of simulink.. A new improved ZVS dc –dc converter with high voltage gain and a ripple free input current is simulated and studied here. The outstanding features of proposed converter is that it can operate with continuous inductor current, with the switching frequency and the switching stress of conventional converter regardless of direction of power flow. . The modes of operation were studied with related circuit diagrams. Current and voltage waveforms of the converter components were provided to show soft switching operation of main switches and auxiliary switch. This method is used to obtain high voltage gain and used for high frequency applications. From the result it can be concluded that the operation is done with the 24 V input to obtain the 350V output and the input current ripple is also reduced upto 40A. The efficiency of the proposed converter is higher than the conventional because of active clamp auxillary circuit.It was shown that converter main switches operate with ZVS and the converter auxillary switch operate with ZCS turn on and turn off. This proposed system is simulated and the results are verified with MATLAB/SIMULINK.

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S. Freeda Angeline Rachel received her B.E. degree in Electrical and Electronics Engineering from Anna University, Tirunelveli, Tamil Nadu, India. Presently She is pursuing M.Tech in Power Electronics and drives from Karunya University, Coimbatore, Tamil Nadu, India.

J.Jency Joseph received her B.E. degree in Electrical and Electronics Engineering from Anna University, Chennai, Tamil Nadu, India. She obtained M.E from Anna University Chennai, Tamil Nadu, India. Presently She is working as an Assistant Professor in the School of Electrical Science, Karunya Institute of Technology and Sciences (Karunya University), Coimbatore, Tamil Nadu, India. She is pursuing PhD degree in Anna University, Coimbatore, India.

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