Grid Interfaced DC-DC Converters with Renewable Energy Sources

K. Saritha[1] | Dr. D. Ravi Kishore[2]

[1]PG Scholar, Department of EEE, Godavari Institute of Engineering and Technology, Rajahmundry, Andhra Pradesh, India.
[2]Professor & HOD, Department of EEE, Godavari Institute of Engineering and Technology, Rajahmundry, Andhra Pradesh, India.

ABSTRACT

In this paper an DC-DC interleaved boost converter with Zero voltage Switching (ZVS) and Pulse Width modulation (PWM) techniques are proposed. The interleaved boost converters are preferred widely for the high power circuits since it has less input current ripple, reduced filter size, low cost and high efficiency. It regulates the DC output voltages by adjusting the duty cycle of the switches. In this proposed converter two boost DC-DC converters with interleaved operation is used to increase the output power and also it reduces the ripples in voltage and current. By incorporating ZVS and PWM technique the output voltage of 460V and 1450W is produced with 100V input supply. The simulation analysis by using MATLAB/ simulink shows that the soft switching techniques will reduce the switching losses and it improves the overall efficiency (97%) of the proposed system when compared to the conventional interleaved boost converter.

KEYWORDS:
DC-DC Converters, Hybrid Power System, Power coordination

I. Introduction

Generally, electric power generated by renewable energy sources is unstable in nature, thus producing a bad effect on the utility grid. This fact spurs research on energy storage systems to smooth out active-power flow on the utility grid. simplified existing energy storage system employing a line-frequency (50- or 60-Hz) transformer, a PWM converter, a bidirectional chopper, and an energy storage device such as electric double layer capacitors (EDLCs) or lithium-ion batteries. The transformer is indispensable for some applications that require voltage matching and/or galvanic isolation between the utility grid and the energy storage device. Replacing the line-frequency transformer with a high-frequency isolated dc-dc converter would make the energy storage system more compact and flexible.

Various bidirectional isolated dc-dc converters have been proposed as the interface to energy storage devices with focus on automotive or fuel cell applications. Most of the presented dc-dc converters have asymmetrical circuit configurations to couple the two dc links having largely different voltages, several tens volts and several hundreds volts.

A bidirectional isolated dc-dc converter presented in 1991. It had two symmetrical single-phase voltage-source full-bridge converters. It suffered from a low efficiency because the first-generation IGBTs were used as switching power devices at that time. However, advancement in power device technology over the last decade has enabled the dc-dc converter to operate at an efficiency as high as 97% by using the latest trench-gate IGBTs. A similar dc-dc converter has also achieved an efficiency of 97%. In addition, the use of silicon-carbide power devices in the near future will raise it to 99%. Therefore, the dc-dc converter has become a promising candidate as a power electronic interface for an energy storage system. A bidirectional converter has been discussed to exchange electric power between a fuel cell, a battery, and a load, based on a three-port extension of the circuit presented. The energy storage system using the bidirectional isolated dc-dc converter appropriately choosing the transformer turn ratio enables to design the voltage rating of the energy storage device, independent of the utility voltage. The energy storage device is directly connected to one of the dc links of the dc-dc converter without any chopper circuit. Nevertheless, the dc-dc converter continues operating even when the voltage across the energy storage device, Vd2drops along with its discharge. Here Vd1 is input side DC voltage and Vd2 is DC output secondary voltage

II. Conventional Boost Converter

A. Circuit operation

The figure 1 below shows a step up or PWM boost converter. It consists of a dc input voltage source Vg; boost inductor L controlled switch S, diode D, filter capacitor C, and the load resistance R. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at that time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the output RC circuit.

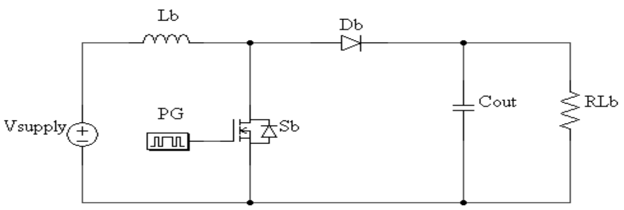

Figure 1. General boost converter.

Steady state analysis of the Boost converter

(a) OFF STATE:

In the OFF state, the circuit becomes as shown in the Figure 2. Below

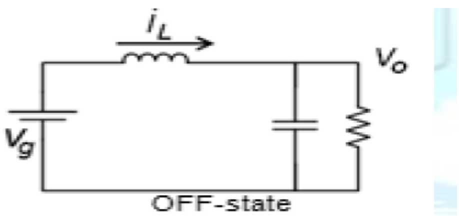

Figure 2. The OFF state diagram of the boost converter

When the switch is off, the sum total of inductor voltage and input voltage appear as the load voltage.

(b) ON STATE:

In the ON state, the circuit diagram is as shown below in Figure 3:

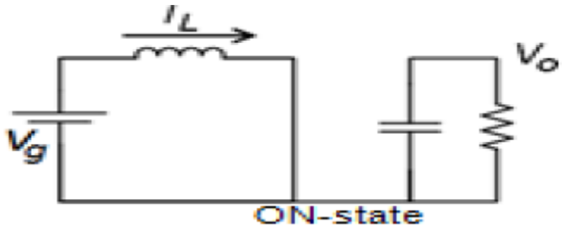

Figure 3. The ON state diagram of the boost converter

When the switch is ON, the inductor is charged from the input voltage source Vg and the capacitor discharges across the load. The duty cycle, D=Ton/T, where T=1/f

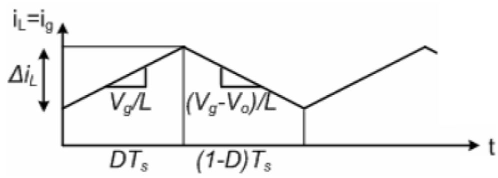

Figure 4.Inductor current waveform

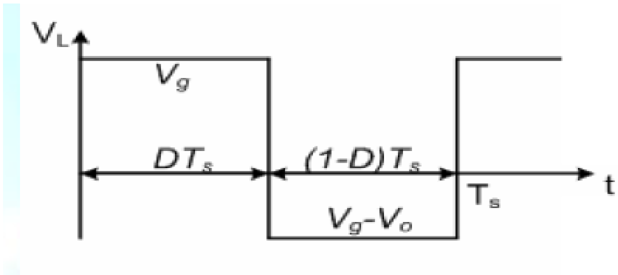

Figure 5.Inductor voltage waveform

The current supplied to the output RC circuit is discontinuous. Thus a large filter capacitor is used to limit the output voltage ripple. The filter capacitor must provide the output dc current to the load when the diode D is off.

Boost converters are popularly employed in equipments for different applications. For high-power-factor requirements, boost converters are the most popular candidates, especially for applications with dc bus voltage much higher than line input. Boost converters are usually applied as pre regulators or even integrated with the latter-stage circuits or rectifiers into single-stage circuits. Most renewable power sources, such as photovoltaic power systems and fuel cells, have quite low-voltage output and require series connection or a voltage booster to provide enough voltage output.

Several soft-switching techniques, gaining the features of zero-voltage switching (ZVS) or zero-current switching (ZCS) for dc/dc converters, have been proposed to substantially reduce switching losses, and hence, attain high efficiency at increased frequencies.

There are many resonant or quasi-resonant converters with the advantages of ZVS or ZCS presented earlier. The main problem with these kinds of converters is that the voltage stresses on the power switches are too high in the resonant converters, especially for the high-input dc-voltage applications. Passive snubbers achieve the ZVS, which are attractive, since no extra active switches are needed.

III. Operation of ZVS-PWM DC-DC Converter

The proposed ZVS-PWM interleaved boost converter is shown in Figure 6. The operation of proposed converter is alienated into two parts, first division consists

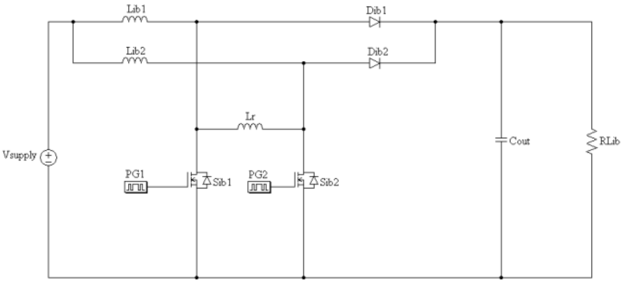

Figure 6. Interleaved boost converter.

Interleaved boost converters are applied as power factor-correction front ends. An interleaved converter with a coupled winding is proposed to provide a lossless clamp. Additional active switches are also appended to provide softswitching characteristics. These converters are able to provide higher output power and lower output ripple. This paper proposes a soft-switching interleaved boost converter composed of two shunted elementary boost conversion units and an auxiliary inductor. This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency. Since the two parallel-operated boost units are identical, operation analysis and design for the converter module becomes quite simple. Therefore feature a simpler control scheme and lower cost. However, the circuit topology is complicated and not easy to analyze. Auxiliary active snubbers are also developed to reduce switching losses. These snubbers have additional circuits to gate the auxiliary switch and synchronize with the main switch. Besides, they have an important role in restraining the switching loss in the auxiliary switch. Converters with interleaved operation are fascinating techniques now-a-days

A. *Circuit configuration*

Fig.2 shows the proposed soft-switching converter module. Inductor L1, MOSFET active switch S1 and diode D1 comprise one step-up conversion unit, while the components with subscript ―2‖ form the other Dsx.and Csx are the intrinsic anti parallel diode and output capacitance of MOSFET Sx respectively. The voltage source Vin, via the two paralleled converters, replenishes output capacitor Co and the load. Inductor Ls Is shunted with the two active MOSFET switches to release the electric charge stored within the output capacitor Csx Prior to the turn-ON of Sx to fulfill zero-voltage turn- ON (ZVS), and therefore, raises the converter efficiency.

IV. Simulation Results

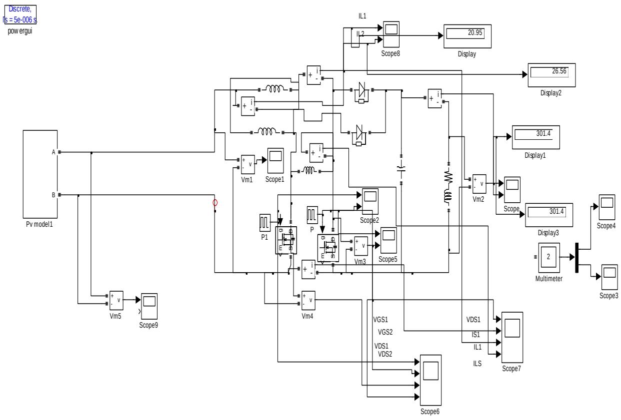

Figure 7. Simulation circuit of Interleaved boost converter.

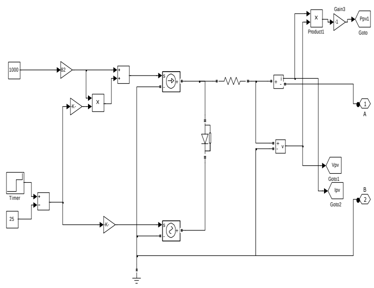

Figure 8 Simulation circuit of PV Cell.

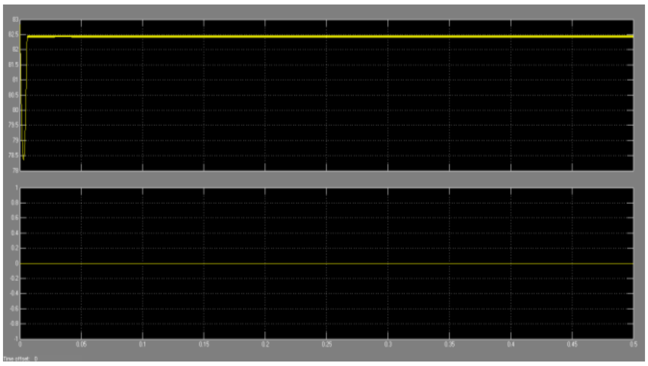

Fig.9 PV Output voltage

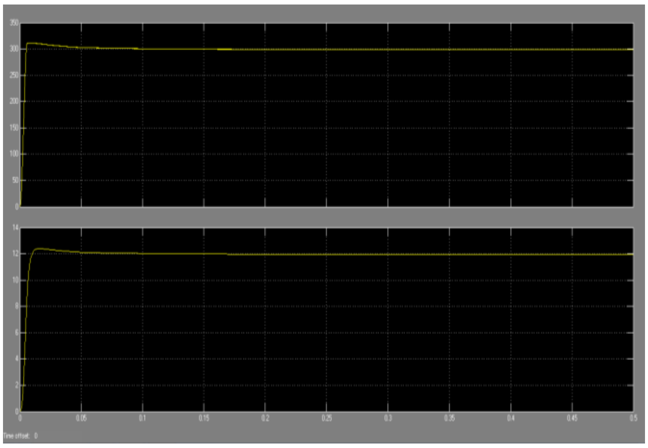

Fig.10 DC-DC Converter Output voltage

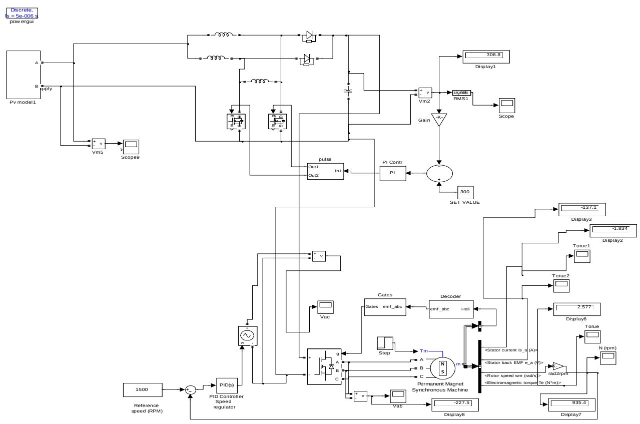

Fig 11simulink model continuous conduction mode

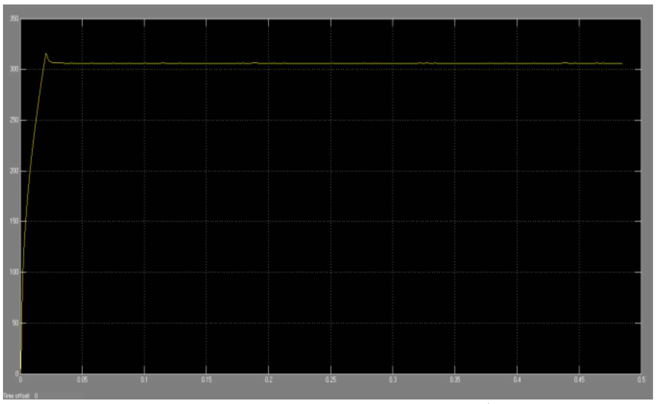

Fig 12 DC-DC Converter Output voltage

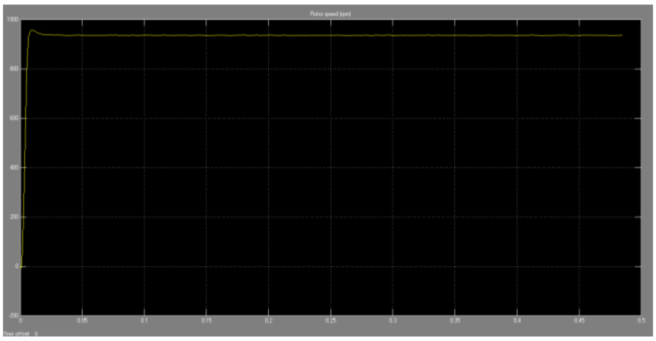

Fig 13 BLDC Motor Speed

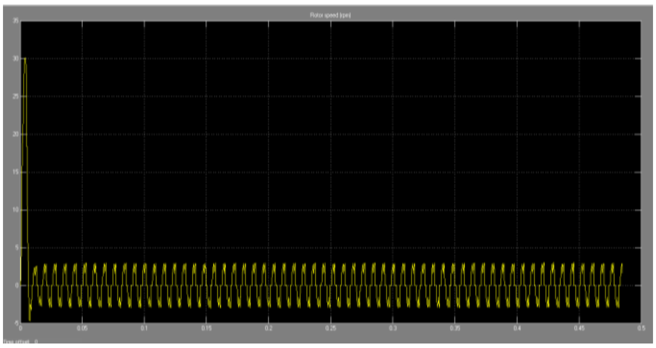

Fig 14 BLDC Back EMF

V. Conclusion

Thus a novel soft-switching interleaved boost converter composed of two shunted elementary boost conversion units and an auxiliary inductor is proposed .This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency. Since the two parallel-operated elementary boost units are identical, operation analysis and design for the converter module becomes quite simple. The resulting system has high-efficiency, lower-cost, low ripple current and reduced switching losses.

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