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ANEW INTERLEAVED SOFT SWITCHING BOOST CONVERTER FOR PHOTOVOLTAIC APPLIATIONS

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Abstract

This paper introduces a new interleaved soft switching boost converter for photovoltaic applications. The proposed converter topology offers modularity, lower ripple for both input current and output voltage, and lower voltage and current ratings of the various circuit elements when compared to the basic boost converter. a non isolated interleaved, dc/dc boost converter with a high efficiency is proposed for use in photovoltaic system applications. The capacitor is also connected in series with output capacitors to transfer leakage energy to the output. Interleaved structure is used in the input side to minimize current ripple and reduce magnetic component.The capacitor is also connected in series with output capacitors to transfer leakage energy to the output. Interleaved structure is used on the input side to minimize current ripple and reduce magnetic components. Thus, renewable energy particularly solar energy is widely used. Whereas, with the rapid development of IT technologies, PV converter is facing many challenges, such as high efficiency, high power density, and low cost.This thesis is mainly about the design of an interleaved boost converter based on SiC device used for high power level PV system.A MATLAB and Simulink dynamic platform are used to simulate the transient performance of the proposed converter.

Introduction

Photovoltaics (PV) refers to the renewable energy methods and technologies employed to convert sunlight (solar energy), into direct current (DC) electricity. No pollution will be generated by PV, which is environment friendly. PV is a matured technology and has been widely used in specific applications like calculators and watches since mid 90's.PV industry gains more attention recently, due to the salient advantages of PV modules as size variability, environmental compatibility and modularity.Chiefly, utilizing high performance dc-dc boost converters is an essential factor in renewable energy sources in high power applications.Photovoltaic (PV) source is one of the significant players in the world's energy portfolio, and it will make one of the biggest contributions to electricity generation among all the renewable energy candidates by 2040, because it is a clean, emission-free, and renewable electrical generation source with high reliability [1], [2]. The PV grid-connected power system in the residential applications is recently becoming a fast growing segment in Europe, Japan, and the U.S.

Photovoltaic panels constitute the solar array of a PV system which could generate andoffer electricity for commercial and residential applications. Typically, the output power of each solar panel module is from 100 W to 365 W under standard test conditions. The area of every solar cell is determined by the efficiency of a module - an 8% efficient 230 Watt module will have twice the area of a 16% efficient 230 Watt module [5]. Hence, a single solar cell can only contribute to a limited amount of power. Furthermore, it is necessary to identify and connect solar panels either in series to achieve a desired output voltage or in parallel to provide a desired current output.

A generalized steady state analysis of multiphase interleaved boost converters has been previously reported in detail . Useful design equations for CCM operation of an interleaved boost converter along with the effects of inductor coupling on the key converter performance parameters such as inductor ripple current, input ripple current, minimum load current requirement for achieving CCM operation.

Any such renewable energy system requires a suitable converter to make it efficient. Interleaved boost converter is one such converter that can be used for these applications.

Interleaved boost converter is a promising interface between renewable energy sources such as fuel cells, PV and the DC bus of inverters. Due to interleaving operation, IBC exhibits both lower current ripple at the input side and lower voltage ripple at the output side. Inductor is the heaviest part in the interleaved boost converter. For reducing the size and cost of the converter, a coupled inductor was chosen recently [10-13], where common core is used for several converters. It enhances the input and inductor current ripple curves The existing system [13] consists of DC source, 2 phase interleaved boost converter and soft-switching cell. Two boost converters are joined in parallel Softswitching cells and capacitors are connected across the output stage. The switches are turned on by zero voltage transition (ZVT) method.

Here in this paper,the interleaved boost converter is introduced to achieve high voltage gain and reduced inductor ripple current .The single resonant circuit is used for zvs turn-on and turn –off the three switches. In this converter leakage inductance is minimized and switching operation can be maintained easily and efficiency is increased in significant level.The cost of the proposed system is considerably reduced by using coupled inductors and it is suitable for pv application.

The modified interleaved boost converters have the following advantages

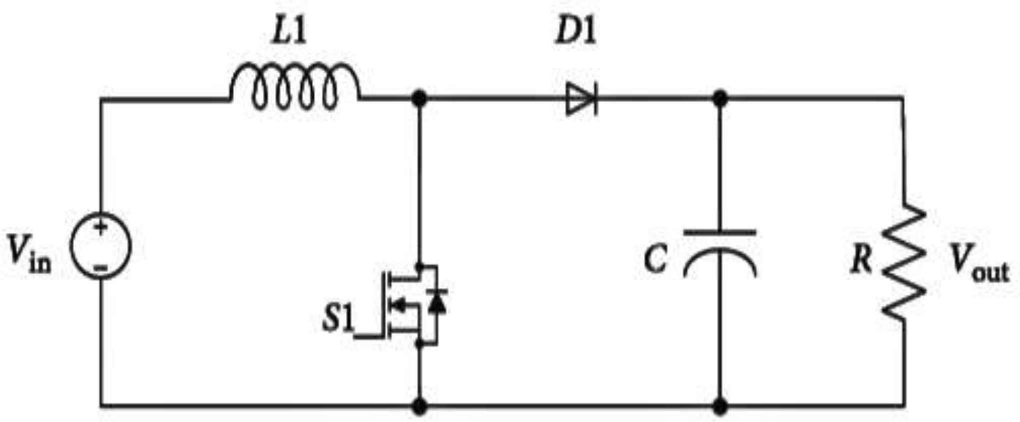
High voltage gain then the existing converter.

Minimized voltage stress on switching devices and increased the efficiency with the use of Zero Voltage Switching (ZVS).

Use of low power rating filter components and coupled inductor for reducing cost and size.

Better transient response.

PROPOSED CIRCUIT CONFIGURATION



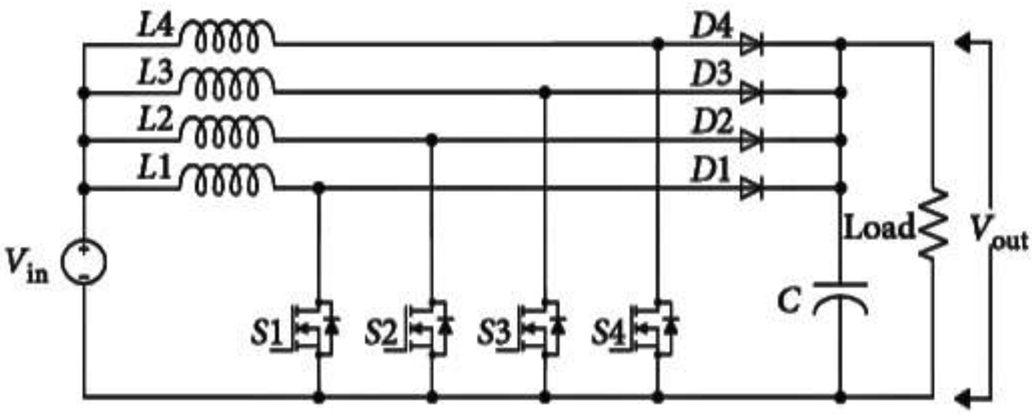
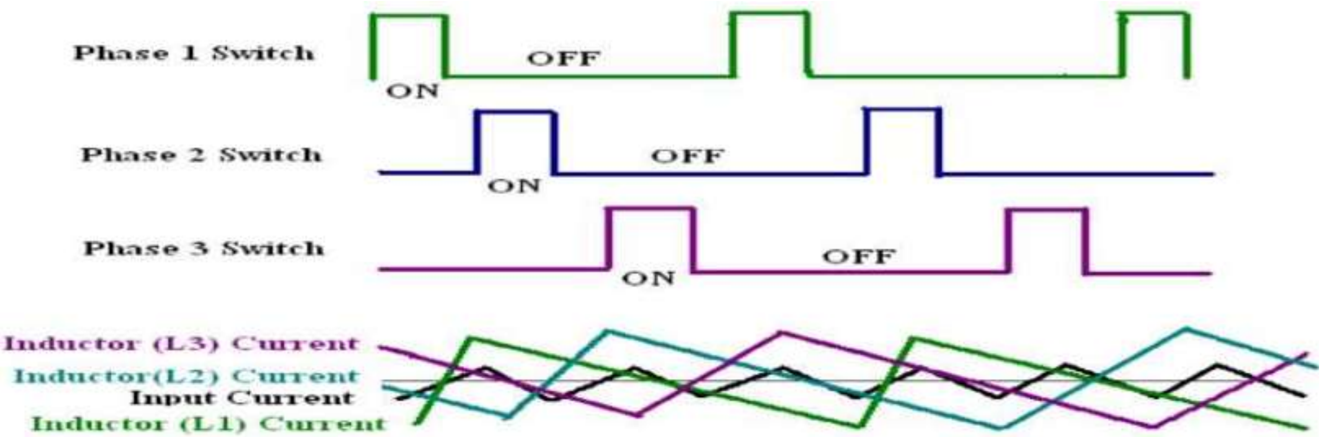


Fig 1: Basic boost converter

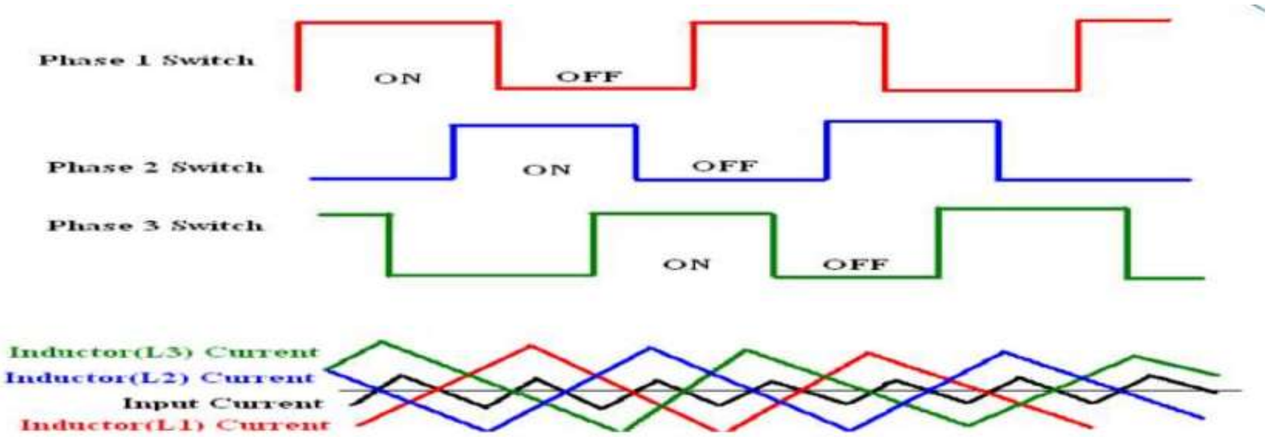
Fig 2: Interleaved boost converter

The interleaved boost converter is a circuit designed basedontheoriginalboostconverter.Theoriginal boost converter is designed to work in parallel while the circuit operation is interleaved. The interleaved depends on interleaved boost converter helps to solve the problem of overload burden the original boost converter has. As the circuit load increases, it is necessary to design largerequipmentasaresult.Also,switch operation will get a higher load as a result. The interleaved boost converter can solve this problem. This also helped in reducing the ripple of input and output.

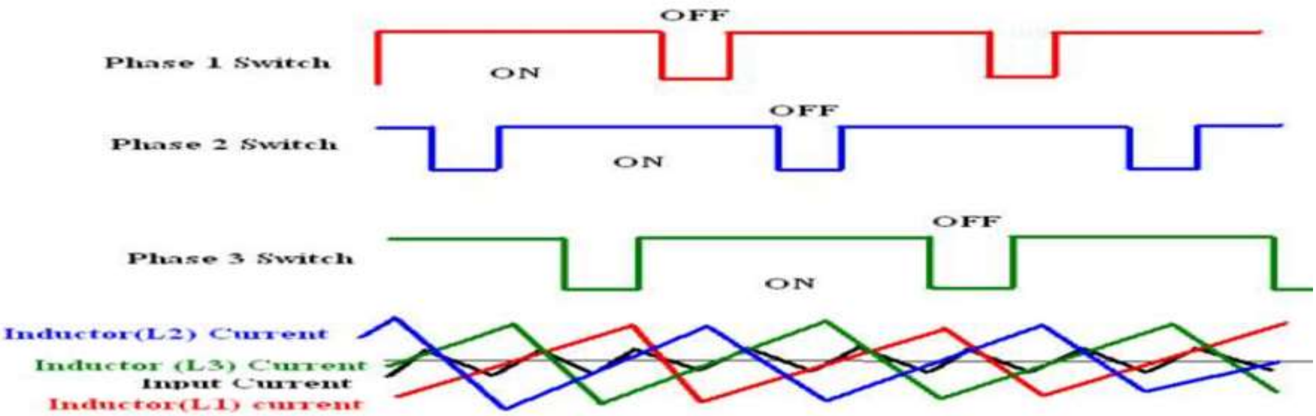
Ideal Waveform for &< 0.5 when the duty ratio is less than 0.5mthe waveforms are obtained as shown below



Ideal Waveforms for™= 0.5 When the duty ratio is at 0.5 the waveforms are obtained as shown below



Ideal Waveforms for™> 0.5 When the duty ratio is greater than 0.5 the waveforms are obtained as shown below.



Here the duty ratio is 0.75.

Design Equations

1. Duty ratio Duty ratio is defined as

$$V_o/V_{in} = 1/1-D$$

Where Vo is the output voltage, Vin is the input voltage and D is the duty ratio.

2. Input current The input current can be calculated by the formula,

$$I_{in} = P_{in}/V_{in}$$

Where Iin is the input current, Pin is the input power and Vin the input voltage.

3. Inductor current ripple peak-to-peak amplitude The inductor current ripple peak-peak amplitude is given by

$$\otimes l_1, l_2 = V_{in} D / F_s L$$

Where Vin represents the input voltage, D represents the duty ratio, Fs represents the switching frequency and L represents the value of the inductor.

4. Selection of inductor and capacitor The value of the inductor can be found out by the following formula

$L \geq V_{in} D T_s / 2 \Delta I_o$

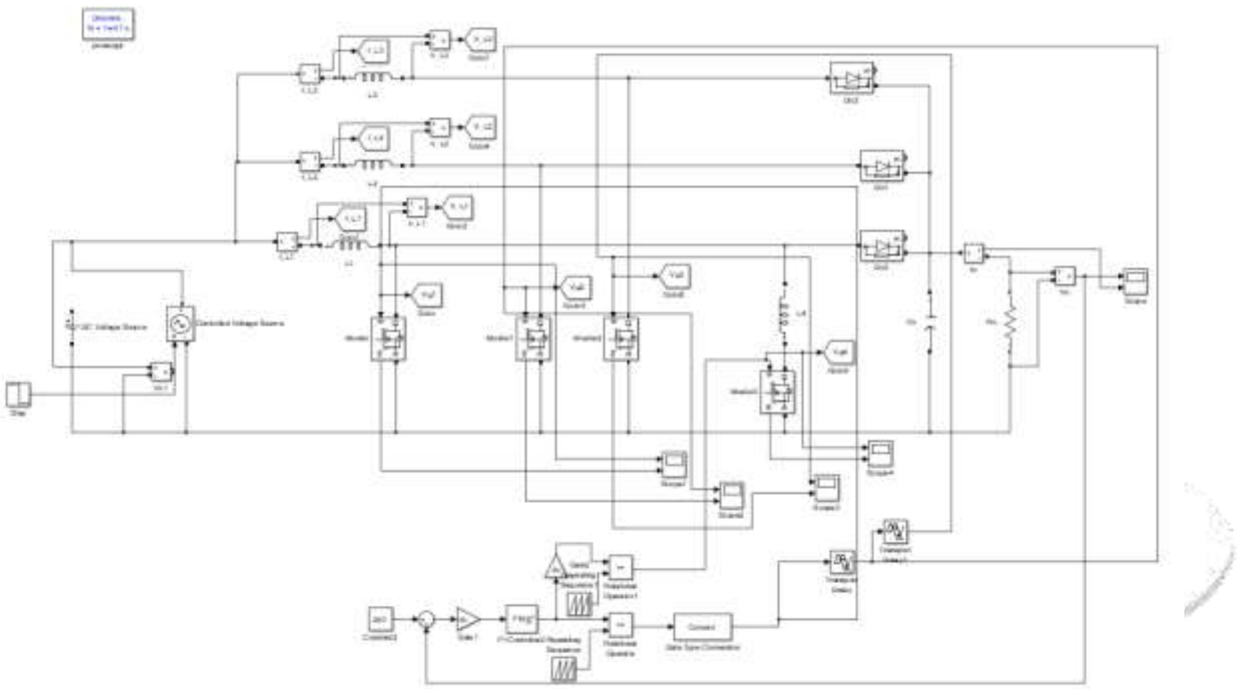
Where,TS -Switching period and ΔI_o -Output current ripple

The value of the capacitor is given by the formula

$C \varepsilon D\ V_o / R \otimes V_o F_s$

Where, R- Load resistor, ΔVo -Output voltage ripple and V o - Output voltage

SIMULATION RESULTS OF INTERLEAVED BOOST CONVERTER

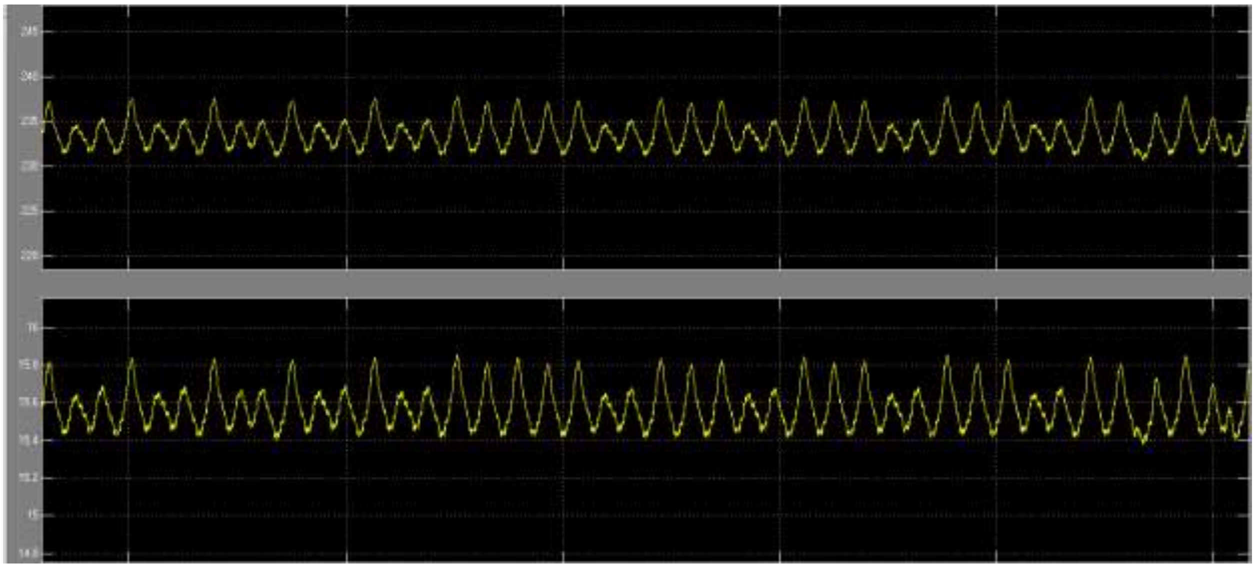


Simulation Results

i) For ™< 0.5 The switching patterns of three MOSFETs (M, M1and M2) used in the three phase IBC is shown in Fig.20.The phase shift is 120(360/n) degrees. The input and inductor currents are shown in Fig.21.They can be obtained as 6 A (8) (9) (10) (11) (12) (13) (14) (15) 1]2014 001-026 and 2.9A respectively. Using these waveforms the input current ripple is obtained as 0.0033A and inductor current ripple is obtained as 0.0086A. The output current waveform is shown in Fig.It is obtained as 4.3 A. The output voltage waveform is shown in Fig.It is obtained as 24 V. Output current ripple waveform is shown in Fig.Ripple current of 0.00025 is also calculated using this waveform. Output Voltage Ripple waveform is shown in Fig.. Voltage Ripple of 0.00025V is also calculated using this waveform.

ii) For ™= 0.5 The switching patterns of three MOSFETs (M, M1and M2) used in the three phase IBC is shown in Fig..The phase shift is 120(360/n) degrees. The input and inductor currents are shown in Fig..They can be obtained as 15.5 A and 4.9A respectively. Using these waveforms the input current ripple is obtained as 0.0032A and inductor current ripple is obtained as 0.015A. The output current waveform is shown in Fig.It is obtained as 7.7 A. The output voltage waveform is shown in Fig.It is obtained as 38.6 V. Output current ripple waveform is shown in Fig..Ripple current of 0.00014A is also calculated using this waveform. Output Voltage Ripple waveform is shown in Fig.. Voltage Ripple of 0.00016V is also calculated using this waveform. iii) For ™> 0.5 The switching patterns of three MOSFETs (M, M1and M2) used in the three phase IBC is shown in Fig. The phase shift is 120(360/n) degrees. The input and inductor currents are shown in Fig.33. They can be obtained as 16 A and 5.3A respectively. Using these waveforms the input current ripple is obtained as 0.00019A and inductor current ripple is obtained as 0.005A. The output current waveform is shown in Fig..It is obtained as 14.6 A.

EXPERIMENTAL VERIFICATION



CONCLUSION AND FUTURE SCOPE

A three level interleaved boost converter is projected in this paper. The single resonant circuit is used for ZVS turn-on and turn-off the three switches. In this converter leakage inductance is minimized and switching operation can be maintained easily and efficiency is increased in significant level .The cost of the proposed system is considerably reduced by using coupled inductors and it is suitable for PV application.

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