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An Investigation and Analysis of Two Leg Interleaved Boost Converter for Renewable Energy Systems

R. Puviarasi[1], J. Chandra Kumar[2], Yeshwanthkumar.P.[3]
kamalesh Kumar. K.S[4]

[1](Department of Electronics and Communication Engineering, Saveetha School of Engineering, Saveetha University, India)
[2, 3, 4](Department of Energy and Environmental Engineering, Saveetha School of Engineering, Saveetha University, India)

ABSTRACT : *In recent years, a DC-DC converter with high output voltage is mainly used for transferring the energy from any renewable sources to conventional AC systems. The Photo Voltaic (PV) energy system is a very new concept in use, which is gaining popularity due to increasing importance to research on alternative sources of energy over depletion of the conventional fossil fuels world-wide. Among various converter topologies the Interleaved Boost Converter has low ripples in both input current and output voltages. Reductions in size and electromagnetic emission along with an increase in efficiency, transient response, and reliability are among the many advantages to using such interleaved boost converters. In this paper a two phase interleaved boost converter is designed for photo voltaic generation system using MATLAB/Simulink software.*
Keywords - *PV cells, boost converter, interleaved boost converter, ripples*

I. INTRODUCTION

Renewable energy sources occur in nature which are regenerative (or) inexhaustible like solar, wind, tidal etc. particularly solar energy is available in abundance, easiest and cleanest renewable energy [1]-[4]. There are many routes for direct conversion of solar radiation into usable form like, solar thermal, solar photovoltaic cell etc. when compare to various topologies the photovoltaic generation systems posses the advantages of long life, good reliability and pollution free environment. The power converters are very important in renewable energy generation systems in order to achieve a good operation for supplying the load when main sources are not sufficient. Generally the DC-DC converters are used to boost the input voltage level to required output voltage level and to get the high voltage gain [6]. The circuit diagram of a simple boost converter circuit is shown in fig .1.For getting high voltage gain the converter must operate with the duty cycle of less than 0.50. The conventional boost converter has the drawback of low voltage gain, to solve this problem an interleaved boost converter is analysed in this paper for renewable energy generation systems. In two phase interleaved boost converter the current ripples and voltage stresses across the switches are low and also it is very much suitable for photovoltaic generation systems for getting high efficiency [10]. The interleaved converters are controlled by the switching signals, which have the same switching frequency and phase shift. The switching signal of a conventional boost converter is shown in fig.2.

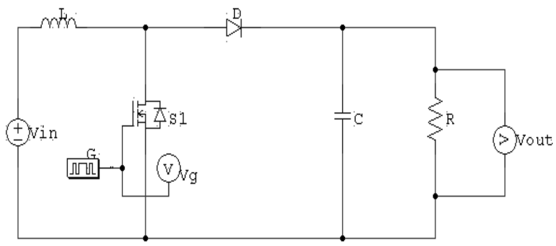

Fig .1. Circuit diagram of conventional boost converter

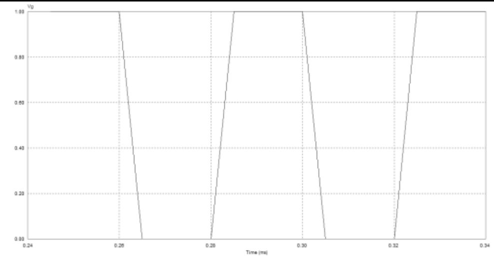

Fig .2. Gate pulse for boost converter switch S1

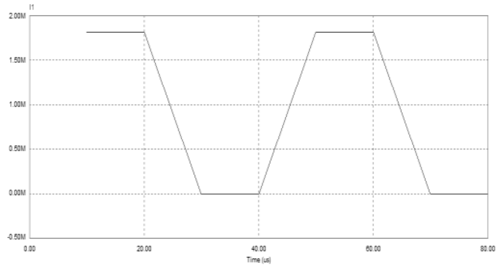

Fig .3. Input current waveform for boost topology

II. PV GENERATION SYSTEM

1. Overview

Distinct advantages to PV power such as pollution free and absence of the need to transport fuel to the generating site make it attractive in many applications [6]. The use of PV as the single source of electrical power requires batteries or other storage devices. The main advantage of PV system is that it has high efficiency and less manufacturing cost compare to other renewable sources [9]-[12]. Photovoltaic systems with storage equipment are more suitable for low power and remote applications.

The PV array consists of a number of individual photovoltaic cells. The PV cells are connected in a series and parallel array to acquire a unit with a suitable power rating.

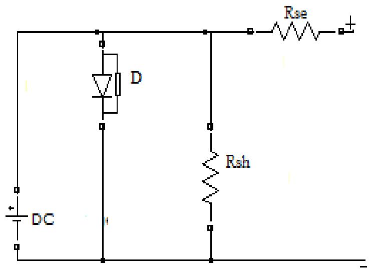

Fig .4. Equivalent circuit of PV cell

There are two types of applications. Such that,

I. Grid connected applications
II. Standalone applications

In standalone mode of solar energy generation systems are not connected to the grid. These systems have PV array, coupled with a power conditioning device and a battery to store the energy.

III. INTERLEAVED BOOST CONVERTER

A two phase interleaved boost converter is mainly used in high input to high output voltage conversion applications and also the interleaved boost converter is used to reduce the current ripple in both input and output. In interleaved boost converter the number of phases is increased with the ripple content in input the complexity of the circuit is increased thereby the cost of implementation also increasing [10]. Therefore to minimize the ripples, size and cost of input filter a two phase Interleaved boost converter fed photovoltaic generation system is simulated using MATLAB/Simulink software in this paper.

The advantages of interleaved boost converters are reducing input current ripple, increasing efficiency, improving reliability etc. The number of switching devices, number of inductors and diodes are same as the number of phases used in the circuit [5]. The circuit diagram of proposed two phase interleaved boost converter is shown in fig.5. The input voltage is 100-300V [4]. Each leg of the converter has the switching frequency of 20 KHz. The gating pulses of the power electronic switches are shifted by,

$$\frac{360}{n}$$

Where 'n' is the number of phases. Such that,

$$\frac{360}{2} = 180°$$

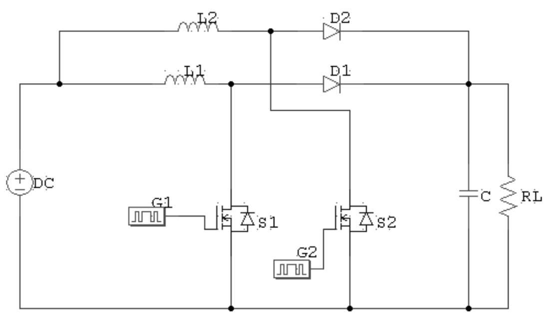

Fig .5. Circuit diagram of Proposed Interleaved Boost Converter

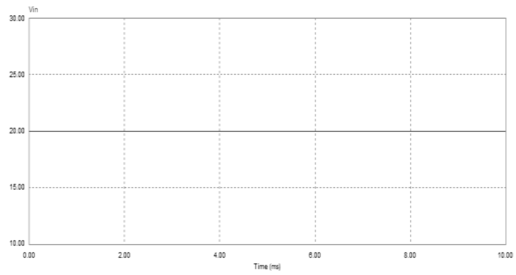

Fig .6. Input voltage of Proposed IBC

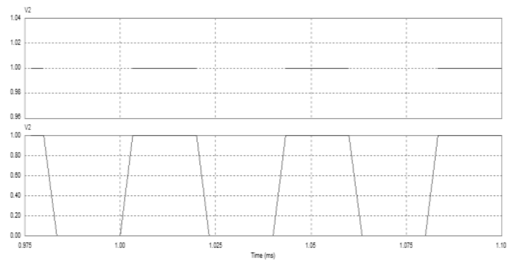

Fig .7. Switching pulses of Mosfet

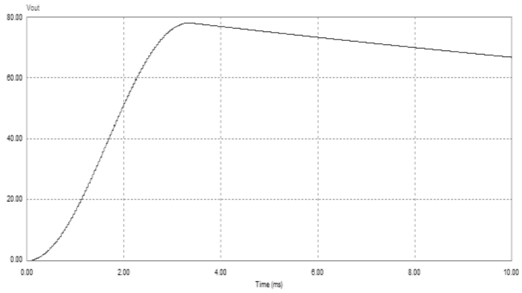

Fig .8. Output voltage of Proposed IBC

IV. DESIGN AND OPERATION OF AN IBC

1. SELECTION OF SWITCHES:

The MOSFET, is a device that is voltage controlled device and not current-controlled. MOSFETs have a positive temperature coefficient, stopping thermal runaway. The on-state-resistance has no theoretical limit; hence on-state losses can be far lower. The MOSFET also has a body-drain diode, which is particularly useful in dealing with limited freewheeling currents. All these advantages and the comparative elimination of the current tail soon meant that the MOSFET became the device of choice for power switch designs.

2. SELECTION OF INDUCTOR:

The inductance value of the IBC is calculated using the following formula,

$$L = \frac{V_s D}{\Delta iLF}$$

Where V_s is the source voltage, F is the frequency in Hz and ΔiL is the inductor current ripple.

3. SELECTION OF OUTPUT FILTER:

The selection of output capacitor is done by the following formula. The capacitance value is depends on output voltage, load resistance, duty ratio and the frequency.

$$C = \frac{V_O DF}{R \Delta V_O}$$

Where V_o is the output voltage in volts, R indicates resistance in Ω, D is the duty ratio and ΔV_o is the change in output voltage in volts.

4. OPERATION OF IBC

The two MOSFET switches are used for the controlling the converter by the gate pulses.

MODE 1:

When the switch S1 is turned ON, the current in the inductor is increasing linearly from zero. During this time interval the energy is stored in the inductor L1.

MODE 2:

When the switch S2 is turned OFF, the diode D1 starts to conduct and the energy in inductor ramps down. In this time interval inductor starts to discharge and the current flowing through the diode and to the load. After half switching cycle of S1, the switch S2 also turned ON completing the same cycle.

V. SIMULATION RESULT ANALYSIS

Fig .9. Shows the simulation diagram of an two phase interleaved boost converter for photovoltaic generation system. The simulation is done by the MATLAB/Simulink software.

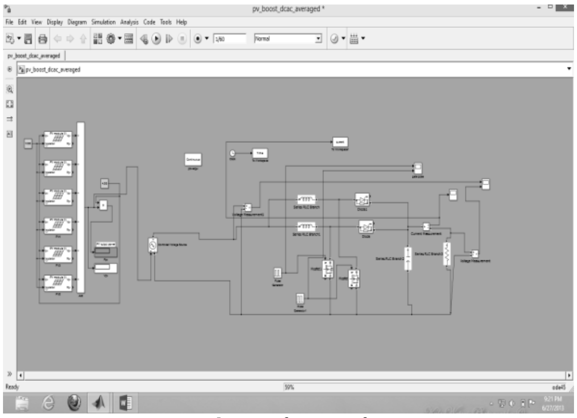

Fig .9. Simulation of an IBC for PV array

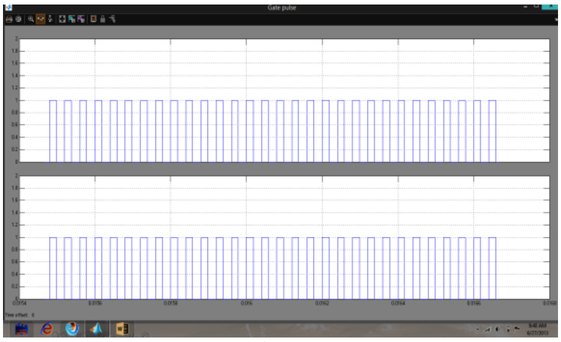

Fig. 10. Gate pulses for the Switching devices

Fig.10.Shows the gating pulses of the MOSFET switches S1 and S2. Fig. 11 indicates the input voltage of 100V waveform and output voltage of 200V waveform.

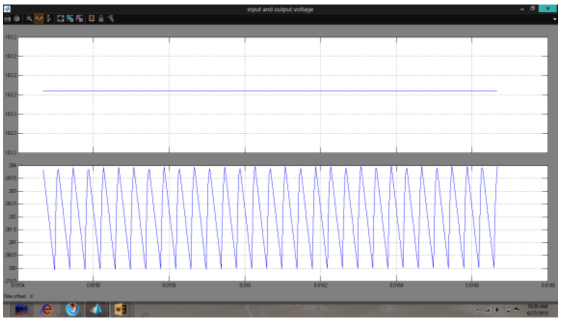

Fig. 11. Input and Output Voltage

Fig. 12. Showing the simulation output of inductor current iL

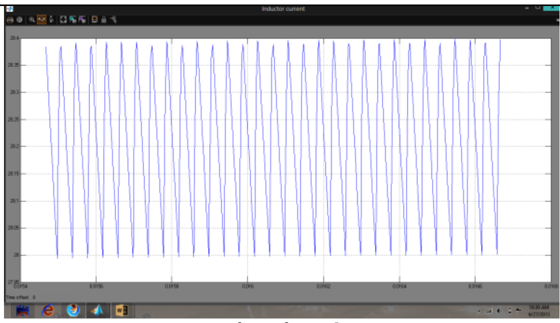

Fig. 12. Waveform for Inductor current

TABLE1. SIMULATION PARAMETERS

S.No	PARAMETER FOR AN IBC	VALUE
1.	Input (Vin)	100V
2.	Output Voltage (Vo)	200V
3.	Output Power	550W
4.	Switching Frequency	20kHz
5.	Inductance (L1 & L2)	0.01552
6.	Output Capacitor (C)	
7.	Resitance (R)	46Ω
7.	Duty ratio (D)	0.45
8.	Phase shift	180°
9.	Ripple of current inductance	11% of iL
10.	Switching devices	MOSFET

VI. CONCLUSION

In this paper a two phase interleaved boost converter is simulated for the photovoltaic generation system using MATLAB/Simulink software. This interleaved boost converter is easy to control because the two switches are controlled by the same switching frequency signal. The proposed converter has better efficiency and it is able to deliver the power to the load with stable operation.

The various waveforms of interleaved boost converter are shown in figures. The IBC has more advantages like high efficiency; low ripple etc. when compared to the conventional boost converters. This IBC can be applied to the grid connected system with the inverter circuit for converting DC-AC signal. The proposed interleaved boost converter is also suitable for the applications such as high-efficiency converters, a power-factor-correction circuit, and battery chargers.

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