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High Step up Voltage Capability DC-DC Converter for Renewable Energy Distribution System Using Low Resistance Method

E.Iswariya, R.Lekaa, M.Muthu Nandhini, S.Merlin Diyana

Department of Electrical and Electronics Engineering, K.Ramakrishnan College of Engineering, Trichy, Tamilnadu, India

ABSTRACT: In this paper, a high step-up dc/dc converter is presented for renewable energy applications. The circuit consists of a coupled inductor and two voltage multiplier cells, in order to obtain high step-up voltage gain. The energy stored in the leakage inductance is recycled with the use of passive clamp circuit. The voltage stress on the main power switch is also reduced. Therefore, a main power switch with low resistance can be used to reduce the conduction losses. The operation principle and the steady-state analyses are discussed here. To verify the performance of this converter, a 400v laboratory prototype circuit is implemented. The results validate the theoretical analyses and the practical analyses of the high step-up converter.

I. INTRODUCTION

Some transformer-based converters like forward, push-pull or fly back converters can achieve high step-up voltage gain by adjusting the turn ratio of the transformer. However, the leakage inductor of the transformer will cause serious problems such as voltage spike on the main switch and high power dissipation. In order to improve the conversion efficiency and obtain high step-up voltage gain, many converter structures have been presented. Switched capacitor and voltage lift techniques have been used widely to achieve high step-up voltage gain. However, in these structures, high charging currents will flow through the main switch and increase the conduction losses. Coupled-inductor-based converters can also achieve high step-up voltage gain by adjusting the turn ratios.

However, the energy stored in the leakage inductor causes a voltage spike on the main switch and deteriorates the conversion efficiency. To overcome this problem, coupled-inductor-based converters with an active-clamcircuit have been presented. Some high step-up converters with two-switch and single-switch are introduced recently. However, the conversion ratio is not large enough. Coupled-inductor-based converters can also achieve high step-up voltage gain by adjusting the turn ratios. However, the energy stored in the leakage inductor causes a voltage spike on the main switch and deteriorates the conversion efficiency. To overcome this problem, coupled-inductor-based converters with a passive clamp circuit is used.

II. BLOCK DIAGRAM

The block diagram consists of PIC controller which generates the gate pulses. So that the switch gets on and off. The buffer circuit is used to boost up the values of PIC controller. Opto coupler is an isolation device, which is used to isolate the high voltage circuit(voltage multiplier) and low voltage circuit (PIC and buffer circuit).The output of the optocoupler circuit is given to the coupled inductor integrated with switch. It will takes energy when the switch is ON and it will transfer those energy when the switch is OFF.

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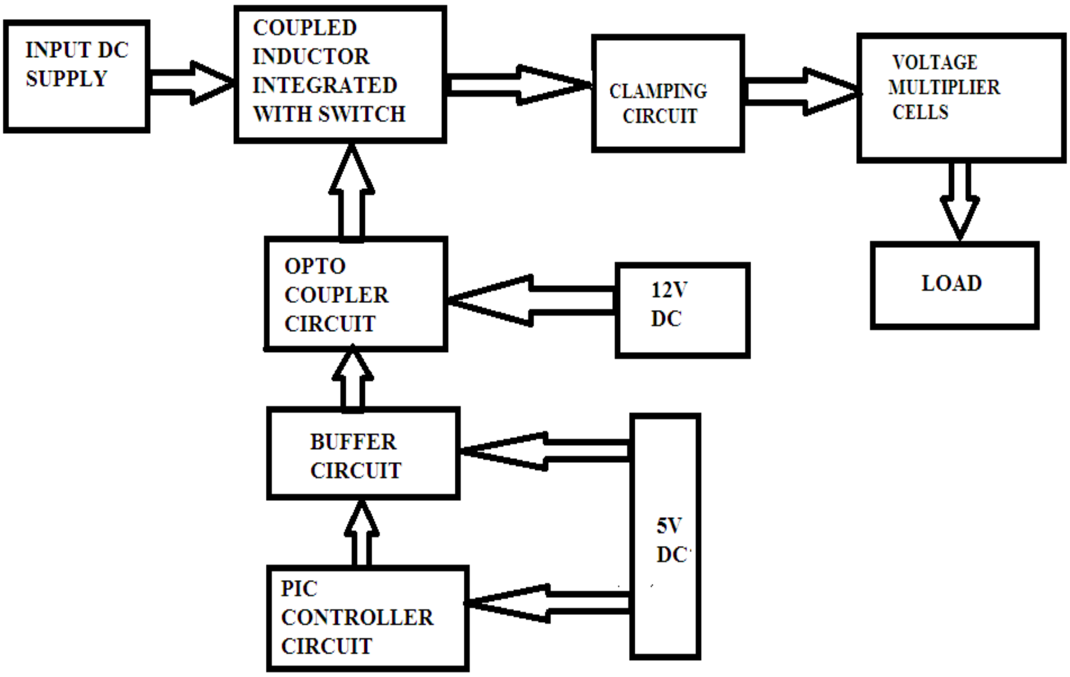
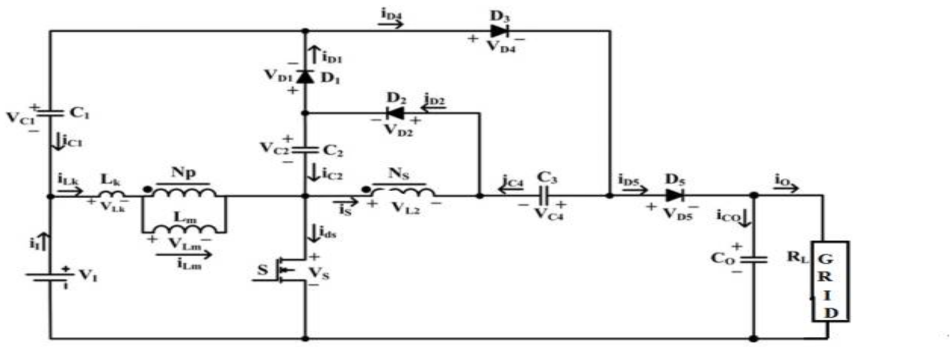


III.CIRCUIT DIAGRAM

This circuit consists of a coupled inductor and two voltage multiplier cells in order to obtain high-step-up voltage gain. In addition, a capacitor is charged during the switch-off period using the energy stored in the coupled inductor, which increases the voltage transfer gain. The energy stored in the leakage inductance is recycled with the use of a passive clamp circuit. The voltage stress on the main power switch is also reduced in the proposed topology. Therefore, a main power switch with low resistance can be used to reduce the conduction losses.



The circuit configuration of the proposed converter is shown in circuit diagram. The proposed converter comprises a dc input voltage , active power switch S, coupled inductor, four diodes, and four capacitors. Capacitor *C*1 and diode *D*1 are employed as clamp circuit respectively.

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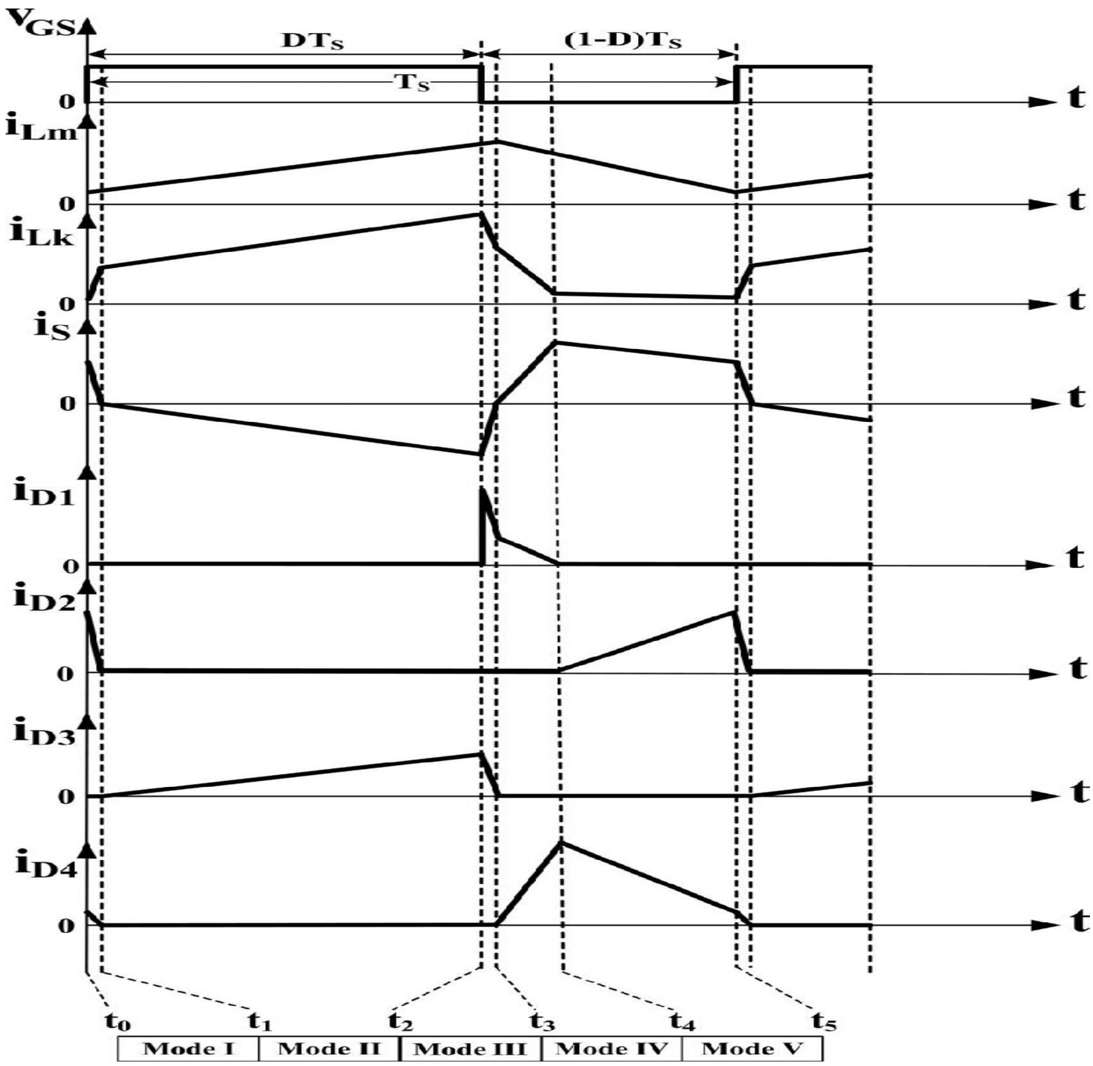
The capacitor *C*3 is employed as the capacitor of the extended voltage multiplier cell. The capacitor *C*2 and diode *D*2 are the circuit elements of the voltage multiplier which increase the voltage of clamping capacitor *C*1 .The coupled inductor is modeled as an ideal transformer with a turn ratio, a magnetizing inductor *Lm* and leakage inductor *Lk* . In order to simplify the circuit analysis of the converter, following assumptions are made:

1) All Capacitors are sufficiently large; therefore *VC*1 , *VC*2 ,*VC*3 , and *VO* are considered to be constant during one switching period.

2) All components are ideal but the leakage inductance of the coupled inductor is considered.

According to the above assumptions, the continuous conduction mode (CCM) operation of the proposed converter includes five intervals in one switching period.



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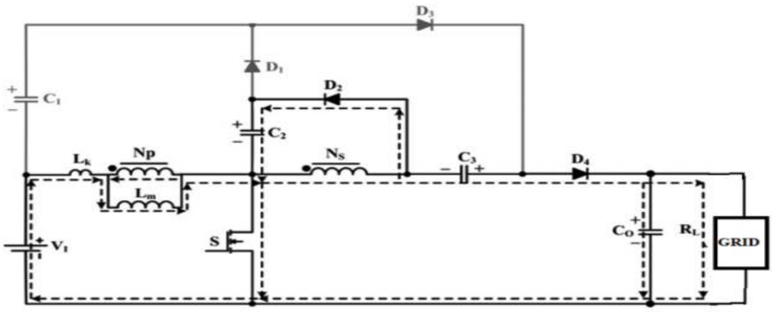
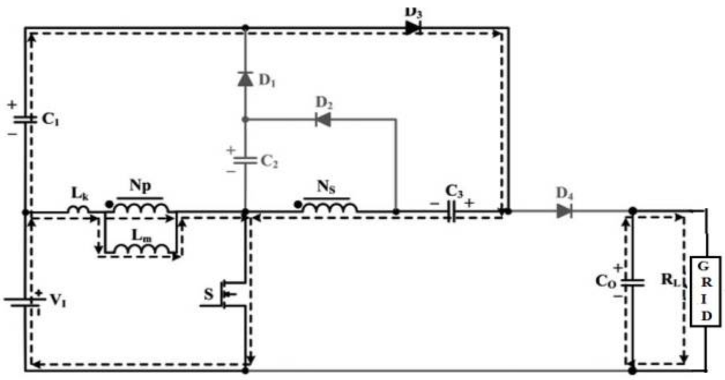
MODE 1:



In this mode, switch s is on.The current flows through the Lm and this inductor gets magnetized.The leakage inductance charges so that the current increases linearly.The current flowing through the secondary of coupled inductor linearly decreases.Now the current flows through it.So diode D4 gets turned ON.All the other three gets turned OFF.

MODE 2 :



In this mode, switch S is ON. Since, the current flowing through the secondary of coupled inductor linearly decreases.The capacitor C3 is reverse biased. Now the current flows through it.So diode D3 gets turned ON.All the other three gets turned OFF.At this time C3 is charging. The C0 drives the load.

MODE 3 :

In this mode, switch S is OFF.The clamp capacitor C1 is charged. Here, diode D4 gets turned OFF.All the other three gets turned ON.At this time C3 is charging.The C0 drives the load. The energy stored in both the inductance get decreased and transferred to capacitor C3.After this mode , D1 turned OFF.

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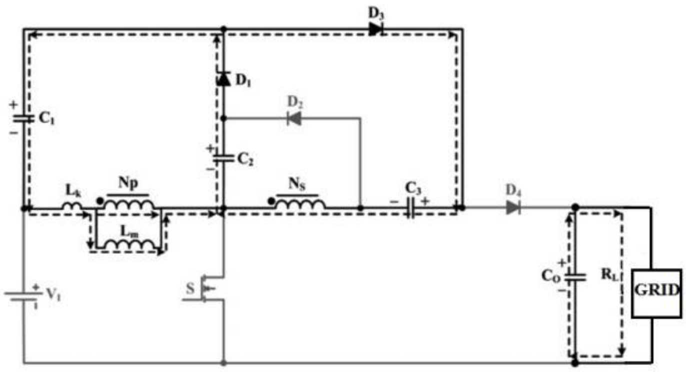
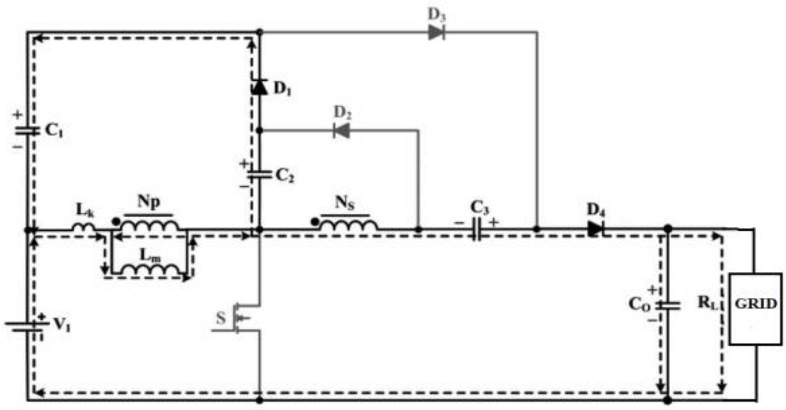


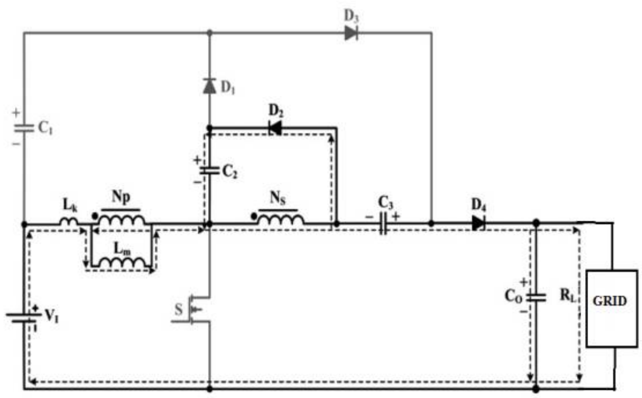
MODE 4 :



In this mode,the capacitor C3 charges.SO, diode D4 gets turned ON.It is forward biased.Already C1,C3 and both inductance are charging. Now C1 and both inductance get de-energized.Here C2,D2,C3,Ns works.

MODE 5 :

In this mode, switch S gets turned ON.Here,the energy stores to battery.The capacitor charge and discharge to boostup the voltage.



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These five modes of operation is continued untill the voltage gets boost-up.

SPECIFICATIONS VALUES	
Input dc voltage V_{in}	40 V
Output dc voltage V_{out}	400V
Switching frequency F	60 kHz
Coupled inductor	LK =1 μH;L=300 μH
Capacitors $C1$, $C2$, $C3$, Co	47, 47, 100, 220 μF
Power Switch (MOSFET) IRFP260	

V. CONCLUSION

This paper presents a high-step-up dc/dc converter for renewable energy applications. Also suitable for DG systems based on renewable energy sources, which require high-step-up voltage transfer gain. The energy stored in the leakage inductance is recycled using passive clamp circuit to improve the performance of the this converter. Furthermore, voltage stress on the main power switch is reduced. Therefore, a switch with a low on-state resistance can be used. The steady-state operation of the converter has been analyzed in detail. Also, the boundary condition has been obtained. Finally, a simulation Results are implemented which converts the 40-V input voltage into 400-Voutput voltage. The results prove the feasibility of the this converter.

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