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Voltage Regulation of Interleaved Boost Converter for Power Distribution of Solar Power Source

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ABSTRACT: Renewable Energy Sources (RES) have proved to be most suitable for power generation and transmission. Solar PV cell is the most widely used among other renewable energies. The main advantage of this cell include longer life and less maintenance. A novel high-step-up Interleaved Converter with a built-in transformer and a voltage-multiplier circuit is used to raise the voltage gain of the presented converter and to lower the voltage stresses on the power devices. This paper proposes Interleaved Boost Converter (IBC) uses high step-up conversionfeature for stepping up the low input voltage to high output voltage. Other features are high circuit efficiency and low input-current ripple. Output voltage obtained may vary due to many factors hence it has to be regulated for constant output. Closed loop topology helps to regulate the voltage and provide constant output. This paper includes closed loop topology for the detailed study of voltage regulation.

KEYWORDS: Renewable Energy Sources, Interleaved Boost Converter, Closed loop control.

I. INTRODUCTION

For overcoming energy-shortage and environmental-contamination issues, renewable and alternative power sources that feature cleanliness and sustainability play an important role in the world, and have begun to be employed worldwide for environment protection. The voltage levels of renewable and alternative power sources, such as photovoltaic cells and fuel cells, are generally low. Thus, high-step- up DC-DC converters have been widely utilized in such renewable energy systems in order to boost their voltage. The high step-up DC-DC converter can convert low levels of input voltage from renewable sources into high levels of output voltages which are then fed into a DC load or a DC-AC inverter for supplying AC sources with an AC load. Hence, the high-step- up DC-DC converter with high efficiency is essential in such power-conversion systems[1].

The substantial increase of research and development work in the area ofPhotoVoltaic (PV) systems have made the PV power generators a feasible alternative energy resource that complements other energy sources in hybrid energy systems. The trend of fast increase of the PV energy use is related to the increasing efficiency of solar cells as well as the improvements of manufacturing technology of solar panels. The PV generators can either be grid connected (operate in distributed generation systems) or can operate in stand-alone (autonomous) systems. With the development of distributed generation systems, the renewable electricity from PV sources became a resource of energy in great demand[3].

II.PROPOSED SYSTEM

Today, interleaved boost converters are widely applied in fuel cell, solar panels, and battery sources for boosting a very low voltage to an appropriate voltage for the alternating current (ac) inverters or front-end applications. The proposed interleaved boost converter not only lengthens the lifetime of the renewable power source by reducing the input-current ripple but also achieves high step-up conversion. In addition, the voltage stress of the main switches is lowered due to

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the lossless passive-clamp circuit. Hence, large voltage spikes across the main switches are alleviated and the efficiency is improved[1].

On the other hand, the built-in transformer does not deal with large DC magnetizing current, and the voltage gain can be extended by increasing the turns ratio of the build-in transformer without an air gap; thus, the volume of core is smaller and the coupling coefficient as well as the circuit efficiency is higher. This paper proposes a novel high-step-up interleaved boost converter that not only utilizes the clamp capacitors but also integrates the secondary winding of the built-in transformer; thus, high step-up voltage gain of the presented converter and lower voltage stresses of the power devices are achieved.

The interleaved boost converter with features of high step-up conversion, high circuit efficiency, and low input-current ripple, which can lengthen the life time of the input source, is suitable for distributed generation using renewable and alternative power sources. The conventional interleaved boost converter is an outstanding for high-power requirements and power factor correction. In addition, windings of the built-in transformer can be designed to extend the step-up gain, and two diodes and two capacitors in the proposed converter act as an active clamp circuit in order to lower voltage stress on the main switches; thus, low-voltage-rated semiconductor devices (such as power MOSFETs and diodes) can be adopted in the presented converter[10][5].

CHARACTERISTICS

The key characteristics of the proposed converter are listed as follows:

- Lowering the input-current ripple and reducing the conduction losses results in an increased lifetime of the power sources and makes the presented converter suitable for renewable and alternative energy applications.
- The converter is capable of achieving high step-up gain easily.
- By recycling the leakage energy, the voltage stresses of clamp diodes are alleviated and the circuit efficiency is improved.
- The voltage stresses on the semiconductor components are substantially lower than the output voltage.

Compared with existing converter, the proposed high step-up converter decreases the power switch count and achieves similarly high circuit efficiency without soft-switching function and active clamp circuit. Moreover, the proposed converter has features of cost-effectiveness and relatively low input current ripple.

CIRCUIT DIAGRAM

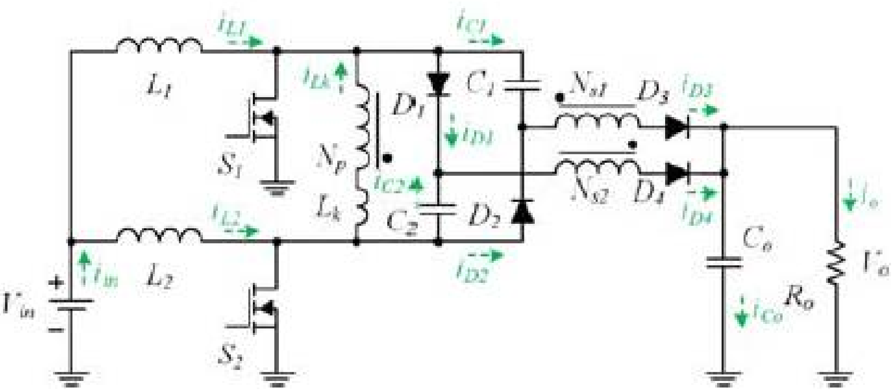

Fig. 1 High step-up interleaved boost converters

The proposed high-step-up interleaved boost converter is shown in Fig. 1, where L_1 and L_2 are the energy storage inductors; S_1 and S_2 denote the power switches; C_1 and C_2 are the clamp capacitors; C_o is the output capacitor; D_1 and D_2

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are the clamp diodes, and D_3 and D_4 are the rectified diodes. The built-in transformer consists of a primary winding N_p, a secondary winding N_{s1}, a third winding N_{s2} and a leakage inductor L_k [1].

III.CLOSED LOOP MODEL

The proposed converter eliminates the limitations of the conventional converters and they have the advantages like interleaving structure, non-isolated structure and soft switching scheme. Due to soft switched scheme, the current stress and voltage stress are eliminated and hence reduced switch losses. Interleaving structure guarantees equal current sharing and hence reduced component size. Non-isolated structure reduces the circuit size and complexity. A closed loop control method is adopted to overcome the voltage drift problem. To regulate the output of the converter, closed loop control is used. In order to obtain load regulation, a PI (Proportional Integral) controller is added to get the desired output voltage. Here the output voltage is given as input to the (Pulse Width Modulation) PWM generator, which in turn gives the pulses to the switches in the circuit as depicted in Fig 2.Variation of input may deviate the desired output voltage. This variation is regulated using closed loop topology.

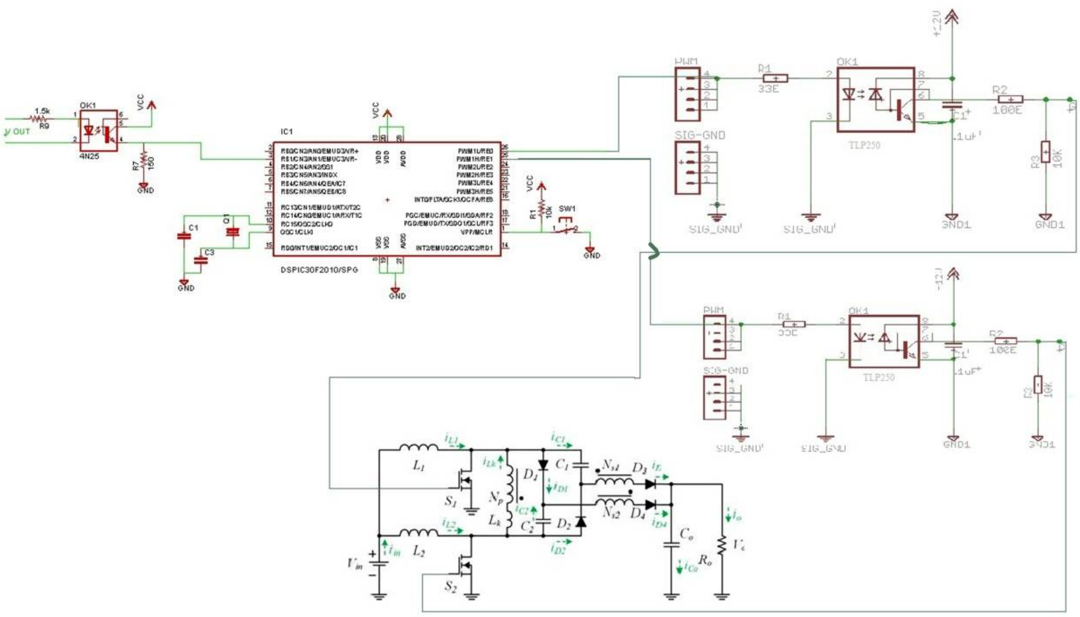

Fig. 2 Schematic diagram of proposed system

IV. HARDWARE MODEL

The prototype circuit of proposed high step-up converter has been built and tested. Electrical specifications of the circuit are shown in TABLE I. Input voltage applied to Interleaved Boost Converter circuit performs the step-up conversion. Input value is selected in the range of 5V-20V and output voltage is obtained as 50V in the below model. Output voltage will vary whenever input value changes.Closed loop circuit helps to the regulate the output voltage.

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TABLE I

ELECTRICAL SPECIFICATIONS

Components	Parameters
Input Voltage V_{in}	5V – 20V
Output Voltage V_{out}	50V
Switching Frequency F_s	50Hz
Main Switches S_1 and S_2	IRFP260
Diodes D_1 and D_2	MBR20200
Diodes D_3 and D_4	BYQ2080
Capacitors C_1 and C_2	10µF
Output Capacitor Co	120 µF
Filter Inductors L_1 and L_2	110 µF
Turn Ratio Ns/Np	1:1
ADC	DSPIC30F2010

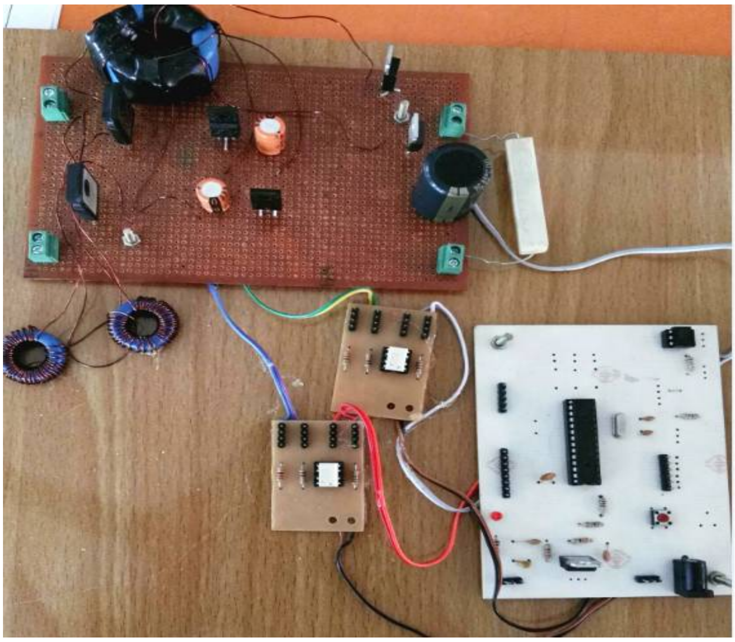

Fig 3. Hardware model of converter and closed loop circuit.

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IV. HARDWARE DESCRIPTION

Varying DC voltage is appliedand the voltage is stepped up by IBC circuit. This varying output voltage is fed to the feedback circuit. PWM pulses are generated using ADC DSPIC30F2010.PWM pulses cannot directly trigger the MOSFET switches as the $V_{GS}$of the MOSFET is above 10V.Also the developed voltage in controller is 5V. Hence to trigger the switch, an opto coupler TLP250 is used as driver circuit. Separate driver circuits are used for each switches.

Output of the IBC is connected to the feedback circuit 4N25.Feedback value is passed to the LED of the circuit.Based on the LED brightness transistor will conduct. Resistance connected in series to the transistor will have a voltage drop.This voltage drop is measured as feedback.PWM generate the pulses based on the feedback value using PI controllerso as to provide constant output.

EXPERIMENTAL RESULTS

Below table shows constant output voltage with varying input. Output voltage is captured using multimeter.

TABLE II

OUTPUT RESULT

Input Voltage(V)	Output Voltage(V)
5.8V	50.2V
8.2V	50.5V
9.4V	50.4V
11.9V	50.4V
13.8V	50.4V
15.3V	50.4V
17.4V	50.4V
18V	50.3V
19V	50.3V

V.CONCLUSION

This project has proposed a high-step-up interleaved boost converter for distributed generation using renewable and alternative power sources.IBC circuit and closed loop circuit have been developed and tested. The interleaved structure inside the presented converter converted the low input voltage to high output voltage without any disturbances. Closed loop circuit helped to obtain the regulated output.Constant output is obtained from the closed loop circuit even with the variation of input value.

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