

(An ISO 3297: 2007 Certified Organization) Vol. 4, Special Issue 6, May 2015

Implementation of Three Phase Interleaved Converter for Renewable Energy System

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ABSTRACT: Renewable energy system, such as photovoltaic system, fuel cells, and wind power generation are playing a more and more important role in energy production. The proposed system deals with a high step-up interleaved converter for renewable energy system. Interleaved Converter consists of a number of boost converter connected in parallel controlled by interleaved method which has the same frequency and phase shift. The proposed converter reduces not only the current stress but also limits the input current ripple, which reduces the conduction loss and prolong the life of the input source. The three phase interleaved reduces the input current ripple and distributes the current through each component. Moreover, because of lossless passive clamping power leakage energy is returned to the output terminal.. Thus, a large voltage spike is reduced through the main switch and the efficiency is improved. The proposed Interleaved Boost Converter (IBC) is designed and modelled, and its performance is evaluated in Mat lab–Simulink environment.

KEYWORDS: Interleaved Boost-converter, high step-up, photo-voltaic system, voltage multiplier module.

I. INTRODUCTION

The renewable energy system is mostly used worldwide because of energy shortage and environmental contamination. Recently, energy prevented from clean, efficient and environmentally-friendly sources has become one of the major challenges for engineers and scientists. Among them, the photovoltaic (PV) generation system has received great attention in research because it appears to be one of the possible solutions to the environmental problem.

A photovoltaic power system, solar PV system or informally solar array, is a power system designed to supply solar power by means of photovoltaic. It consists of an arrangement of various components, including solar panels to absorb and directly convert from sunlight into electricity, and the inverter is used to change the electrical current from DC to AC, as well as mounting, wiring and other electrical accessories to set-up a working system. Renewable energy systems generate low voltage output, and thus, high step-up dc/dc converters have been widely employed in many renewable energy applications such fuel cells, wind power generation, and photovoltaic (PV) systems [1]–[4]. Such systems transform energy from renewable sources into electricity using a grid-by-grid inverter or dc micro grid.



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Fig. 1 Typical renewable energy system

The high step-up conversion may require two-stage converters with cascade structure for enough step-up gain, which decreases the efficiency and increases the value of cost. Therefore, a high step-up converter is seen as an important stage in the system because such a system requires a sufficiently high step-up conversion with high efficiency. Thus, in recent years, many novel high step-up converters have been developed [5]–[6]. Despite these advances, high step-up single-switch converters are unsuitable to operate at heavy load given a large input current ripple, which increases transmission losses. The conventional interleaved boost converter is an excellent candidate for high-power applications and power factor correction.

Unfortunately, the step-up gain is limited, and the voltage strains on semiconductor components are equal to output voltage. Therefore the traditional interleaved boost converter is modified for high step-up and high-power application. The synchronous service of coupled inductors and switched capacitors is a better concept; moreover, high step-up gain, high efficiency, it have low voltage strains and its attained even for high-power applications [7]–[10].

The proposed converter is a conventional interleaved boost converter integrated with a voltage multiplier module, and the voltage multiplier module is composed of switched capacitors and coupled inductors. The coupled inductors can be designed to extend step-up gain, and the switched capacitors offer extra voltage conversion ratio. In addition, when one of the switches turns off, the energy stored in the magnetizing inductor will transfer via three respective paths; thus, the current distribution not only decreases the conduction losses by lower effective current but also makes currents through some diodes decrease to zero before they turn off, which alleviate diode reverse recovery losses. In this proposed converter we will solve the problems of existing system using pulse generation technique.



II. BLOCK DIAGRAM FOR HIGH STEP-UP INTERLEAVED CONVERTER

Fig. 2 Block diagram for interleaved converter



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The input is taken as DC sources. The output of the source can be given to the interleaved boost converter. The two or more converter are connected in parallel is called as interleaved converter. The output of the interleaved boost converter can be connected to the voltage doubler to increase the voltage level. The output of the interleaved boost converter can be given to the PID converter and compare to the reference voltage. The error can be given to the PWM signal generator. The duty cycle can be generated by the PWM generator. The duty cycle can be given to the switches of the boost converter. The main concept of interleaved boost converter when one of the switches gets turn ON before the switch is turned OFF.

III. PROPOSED INTERLEAVED BOOST CONVERTER

The proposed high step-up interleaved boost converter with a voltage multiplier module is shown in Fig. 3. The voltage multiplier module consists of two coupled inductors and two switched capacitors and is inserted between the conventional interleaved boost converters to form a modified boost flyback–forward interleaved structure. When the switches turn off by turn, the phase whose switch is in OFF state performs as a flyback converter, and the other phase whose switch is in on state performs as a forward converter[11-14].



Fig. 3proposed high step-up converter

Primary windings of the coupled inductors with N_p turns are employed to reduce the current ripples in input current and secondary windings of the coupled inductors with N_s turns are connected in series to lengthen the voltage gain. The turn ratios of the coupled inductors are the same.

IV. SYSTEM DESCRIPTION

A. DC SOURCES

Direct current (DC) is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, thermocouples, solar cells, and commutator -type electric machines of the dynamo type. Direct current may flow in a conductor such as a wire, but can also flow through semiconductors, insulators, or even through a vacuum as



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in electron or ion beams. The electric current flows in a constant direction, distinguishing it from alternating current (AC). A term formerly used for direct current was galvanic current. The abbreviations AC and DC are often used to mean simply alternating and direct, as when they modify current or voltage. Direct current may be obtained from an alternating current supply by use of a current-switching arrangement called a rectifier, which contains electronic elements (usually) or electromechanical elements that allow current to flow only in one direction. Direct current may be made into alternating current with an inverter or motor- generator set.

B. INTERLEAVED BOOST CONVERTER

Interleaved boost converter mainly used for renewable energy sources has a number of boost converters connected in parallel which have the same frequency and phase shift. These interleaved boost converter (IBC) are distinguished from the conventional boost converter by critical operation mode, discontinuous conduction mode (DCM) and continuous conduction mode (CCM) so that the devices are turned on when the current through the boost rectifier is zero.

In the Critical conduction mode the design becomes tedious as the critical point varies with load. In the DCM, the difficulties of the reverse recovery effects are taken care but it leads to high input current and conduction losses and it is not best suited for high power applications. CCM has the lower input peak current, less conduction losses and can be used for the high power applications. By dividing the output currents into 'n' paths higher efficiency is achieved and eventually reducing the copper losses and the inductor losses[15].

C. PID CONTROLLER

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an error value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process through use of a manipulated variable.

D. PULSE WIDTH MODULATION

PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on and power is being transferred to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero.

V. PROPOSED STEADY STATE MODULATION TECHNIQUE

a.Voltage Stress on Semiconductor Component

The voltage ripples on the capacitors are ignored to simplify the voltage stress analysis of the components of the proposed converter. Low-voltage rated can be adopted for the proposed converter to reduce conduction losses and costs. This feature makes the proposed converter suitable for high-up and high-power applications.

b.Performance of Current Distribution

The configuration of the proposed converter makes the energy stored in magnetizing inductors transfer three respective paths as one of the switches turns off. Thus, the current distribution decreases the conduction losses by lower effective value of current and increases the capacity by lower peak value of current. In addition, if the load is not heavy then currents through some diodes decrease to zero before they turn off, which improve diode reverse recovery losses. Under light/medium-load condition, the currents through diodes D_b and D_c decrease to zero before they turn off. When the load is continuously added, only the current i_{Dc} decreases to zero before diode D_c turns off. Under heavy loaded conditions, every current through the diode cannot decrease to zero before the related diode turns off, the reduction of conduction losses and the increase of capacity.

c. Consideration for Applications of Renewable Energy Source and Low-Voltage Source

Many low-voltage sources, such as battery and a renewable energy sources such as solar cell or fuel cell stack, need a high step-up conversion to supply power to high-voltage applications and loads. However, an excellent high step-up converter not only supplies efficient step-up conversion but also should lengthen the lifetime of sources such as battery



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set and fuel cell stack. Thus, decreasing in input current ripple for lengthening the lifetime of sources is also a main design consideration. The proposed converter can satisfy the above-mentioned applications even for high-power load due to the interleaved structure, which makes the power source or battery set discharge smoothly.

The proposed converter operated in CCM is even more suitable than that operated in discontinuous conduction mode (DCM) for suppression of input current ripple, because the peak current in DCM is larger. For PV system, maximum power point tracking (MPPT) is an important consideration MPPT is implemented by adjusting the duty cycle within a range. However, the duty cycles of the proposed converter are greater than 0.5 due to the interleaved structure.

d.Analysis of Conduction Losses

Some conduction losses are caused by resistances of semiconductor components and coupled inductors. Thus, all the components in the proposed converter are not assumed to be ideal, except for all the capacitors. Diode reverse recovery problems, core losses, switching losses, and the equivalent series resistance of capacitors are not discussed in this section. The characteristics of leakage inductors are disregarded because of energy recycling. The magnetizing currents and capacitor voltages are assumed to be constant because of the infinite values of magnetizing inductors and capacitors.

VI. MATLAB SIMULATION



Fig. 4 simulation diagram



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Time (sec) ---->

Fig. 5waveform for voltage multiplier

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Fig. 6 output waveform of controller



Fig. 7 output voltage waveform



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VII. CONCLUSION

This paper presented a high step-up, high efficiency through three phase interleaved converter with the voltage multiplier module using PID controller compare the reference value. The duty cycle can be generated by PWM generator. The interleaved structure decreases the input current ripple and increases the efficiency value. Thus, the proposed converter is suitable for high power and dc micro grid or renewable energy applications that need high step-up conversion.

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