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A Novel High Step Up Converters With Photo Voltaic Energy Systems

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ABSTRACT-- In this project, a modular interleaved boost converter is first proposed by integrating a forward energy-delivering circuit with a voltage-doubler to achieve high step-up ratio and high efficiency. It is seen that, for higher power applications, more modules can be paralleled to increase the power rating and the dynamic performance of the high step-up converter is proposed for a frontend photovoltaic system. He two-phase configuration not only reduces the current stress through each power switch, but also constrains the input current ripple, which decreases the conduction losses of metal–oxide–semiconductor field effect transistors (MOSFETs).The voltage multiplier module is composed of a conventional boost converter and coupled inductors. An extra conventional boost converter is integrated into the first phase to achieve a considerably higher voltage conversion ratio. The low-voltage-rated MOSFETs can be adopted for reductions of conduction losses and cost. Efficiency improves because the energy stored in leakage inductances is recycled to the output terminal.

. These all simulation results are verified by using MATLAB/SIMULINK software.

Index Terms—RES, DC-DC Converter, high step-up converter, photovoltaic (PV), Inverter

I. INTRODUCTION

Photovoltaic (PV) power-generation systems are becoming increasingly important and prevalent in distribution generation systems. The use of new efficient photovoltaic solar cells (PVSCs) has emerged as an alternative measure of renewable green power, energy conservation and demand-side management. Photovoltaic solar cells have initial high costs; PVSCs have not yet been a fully attractive alternative for electricity users who are able to buy cheaper electrical energy from the utility grid. However, they have been used extensively for water pumping and air conditioning in remote and isolated areas where utility power is not available or is too expensive to transport.

Limited fossil energy and increased air pollution have spurred researchers to develop clean energy sources. One of these sources is the photovoltaic (PV) power generation system, which is a clean, quiet and an efficient method for generating electricity. In practical applications, PV arrays can be used in battery charging, water pumping, PV vehicles, satellite power systems, grid-connected power systems, standalone power systems, and so on. Due to the low conversion efficiency of PV arrays, on way to reduce the cost of the overall system is by using high efficiency power processors. The power processor usually adopts a dc/dc converter as its energy processing system.

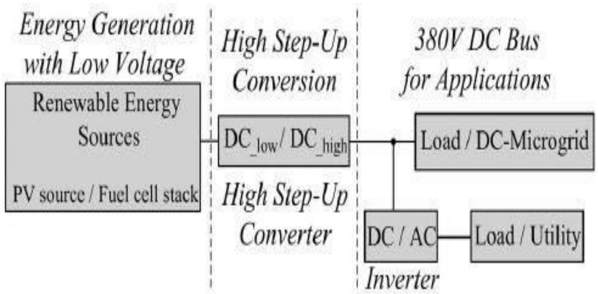

Fig .1: Block diagram of the whole system

Photovoltaic (PV) power-generation systems are becoming increasingly important and prevalent in distribution and generation systems. An conventional type of PV array is a serial connection of numerous panels to obtain higher dc-link voltage for main electricity through a dc–ac inverter. The total power generated from the PV array is sometimes decreased remarkably when only a few modules are free from shadow effects to overcome this problems several necessary steps are taken. Interactive inverter is individually mounted on PV module and operates so as to generate the maximum power from its corresponding PV module. The inverter includes dc–dc boost converter, dc–ac inverter with control circuit as shown in Fig. 1. The dc–dc converter requires large step-up conversion from the panel's low voltage to the voltage level of the application.

Generally speaking, the high step-up dc–dc converters for these applications have the following common features: 1) High step-up voltage gain. Generally, about a step-up gain is required.2) High

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efficiency.3) No isolation is required. 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.

There are two major factors related to the efficiency of a high step-up dc–dc converter: large input current and high output voltage. Fig. 1 shows the solar energy through the PV panel and micro inverter to the output terminal when the switches are OFF. When installation of the ac module is taking place, this potential difference could pose hazards to both the worker and the facilities. A floating active switch is designed to isolate the dc current from the PV panel, for when the ac module is off-grid as well as in the non operating condition.

II. OPERATING PRINCIPLES

The proposed high step-up interleaved converter with a voltage multiplier module is shown in Fig. 2. The voltage multiplier module is composed of two coupled inductors and two switched capacitors and is inserted between a conventional interleaved boost converter 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. Primary windings of the coupled inductors with *Np* turns are employed to decrease input current ripple, and secondary windings of the coupled inductors with *Ns* turns are connected in series to extend voltage gain. The turn ratios of the coupled inductors are the same. The coupling references of the inductors are denoted by "·" and "*".

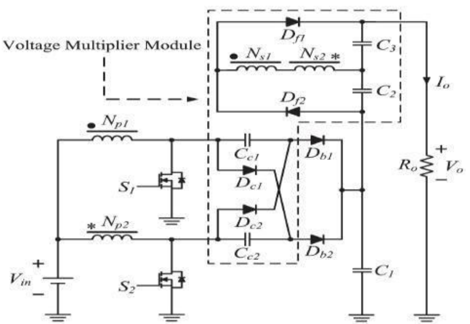

Fig. 2 Proposed high step-up converter

The DC-DC converter requires a large step-up voltage conversion from low voltage obtained from the panel low voltage to the required voltage level for the application. In the previous research on various converters for high step-up applications has included analyses of the switched – capacitor type the voltage-lift type the capacitor-diode voltage multiplier and the boost type integrated with coupled inductor, these converters by increasing turns ratio of coupled inductor obtain higher voltage gain than conventional boost converter. Some converters successfully combined boost and fly back converters, some converters, since various converter combinations are developed to carryout high step up voltage gain by using the coupled-inductor technique. The efficiency and voltage gain of the DC-DC boost converter are constrained by either switches or the reverse recovery issues of the diodes.

At $t = t_0$, the power switch S_2 remains in ON state, and the other power switch S_1 begins to turn on. The diodes D_{c1}, D_{c2}, D_{b1}, D_{b2}, and D_{f1} are reversed biased, as shown in figure. The series leakage inductors L_s quickly release the stored energy to the output terminal via flyback–forward diode D_{f2}, and the current through series leakage inductors L_s decreases to zero. Thus, the magnetizing inductor L_{m1} still transfers energy to the secondary side of coupled inductors. The current through leakage inductor L_{k1} increases linearly, and the other current through leakage inductor L_{k2} decreases linearly. At $t = t_1$, both of the power switches S_1 and S_2 remain in ON state, and all diodes are reversed biased, as shown in figure. Both currents through leakage inductors L_{k1} and L_{k2} are increased linearly due to charging by input voltage source V_{in}. At $t = t_2$, the power switch S_1 remains in ON state, and the other power switch S_2 begins to turn off. The diodes D_{c1}, D_{b1}, and D_{f2} are reversed biased, as shown in figure. The energy stored in magnetizing inductor L_{m2} transfers to the secondary side of coupled inductors, and the other modes of operations are presented in the simulation cases.

III. STEADY-STATE ANALYSIS

The transient characteristics of circuitry are disregarded to simplify the circuit performance analysis of the proposed converter in CCM, and some formulated assumptions are as follows. 1) All of the components in the proposed converter are ideal. 2) Leakage inductors $Lk1$, $Lk2$, and Ls are neglected. 3) Voltages on all capacitors are considered to be constant because of infinitely large capacitance. 4) Due to the completely symmetrical interleaved structure, the related components are defined as the corresponding symbols such as $Dc1$ and $Dc2$ defined as Dc.

A. Step-Up Gain

The voltage on clamp capacitor Cc can be regarded as an output voltage of the boost converter; thus, voltage VCc can be derived from

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$$V_{Cc} = \frac{1}{1-D} V_{\text{in}}$$
(1)

When one of the switches turns off, voltage $VC1$ can obtain a double output voltage of the boost converter derived from

$$V_{C1} = \frac{1}{1-D} V_{\text{in}} + V_{Cc} = \frac{2}{1-D} V_{\text{in}} \quad (2)$$

The output filter capacitors $C2$ and $C3$ are charged by energy transformation from the primary side. When $S2$ is in ON state and $S1$ is in OFF state, $VC2$ is equal to the induced voltage of $Ns1$ plus the induced voltage of $Ns2$, and when $S1$ is in ON state and $S2$ is in OFF state, $VC3$ is also equal to the induced voltage of $Ns1$ plus the induced voltage of $Ns2$. Thus, voltages $VC2$ and $VC3$ can be derived from

$$V_{C2} = V_{C3} = n \cdot V_{\text{in}} \left(1 + \frac{D}{1-D}\right) = \frac{n}{1-D} V_{\text{in}} \quad (3)$$

The output voltage can be derived from

$$V_o = V_{C1} + V_{C2} + V_{C3} = \frac{2n+2}{1-D} V_{\text{in}} \quad (4)$$

In addition, the voltage gain of the proposed converter is

$$\frac{V_o}{V_{\text{in}}} = \frac{2n+2}{1-D} \quad (5)$$

Equation (5) confirms that the proposed converter has a high step-up voltage gain without an extreme duty cycle. The curve of the voltage gain related to turn ratio n and duty cycle is shown in Fig. 3. When the duty cycle is merely 0.6, the voltage gain reaches ten at a turn ratio n of one; the voltage gain reaches 30 at a turn ratio n of five.

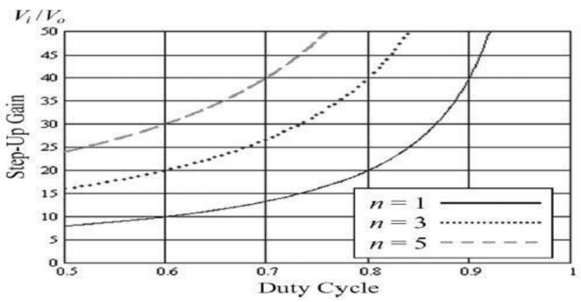

Fig. 3.Voltage gain versus turn ratio n and duty cycle

B. 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. The voltage stress on power switch S is clamped and derived from

$$V_{S1} = V_{S2} = \frac{2}{1-D} V_{\text{in}} = \frac{1}{2n+2} V_o \quad (6)$$

Equation (6) confirms that low-voltage-rated MOSFET with low RDS(ON) can be adopted for the proposed converter to reduce conduction losses and costs. The voltage stress on the power switch S accounts for a fourth of output voltage Vo, even if turn ratio n is one. This feature makes the proposed converter suitable for high step-up and high-power applications.

The voltage stress on diode Dc is equal to $VC1$, and the voltage stress on diode Db is voltage $VC1$ minus voltage VCc. These voltage stresses can be derived from

$$V_{Dc1} = V_{Dc2} = \frac{2}{1-D} V_{\text{in}} = \frac{1}{n+1} V_o \quad (7)$$

The voltage stress on diode Db is close to the voltage stress on power switch S. Although the voltage stress on diode Dc is larger, it accounts for only half of output voltage Vo at a turn ratio n of one. The voltage stresses on the diodes are lower as the voltage gain is extended by increasing turn ratio n. The voltage stress on diode Df equals the $VC2$ plus $VC3$, which can be derived from

$$V_{Df1} = V_{Df2} = \frac{2n}{1-D} V_{\text{in}} = \frac{n}{n+1} V_o \quad (8)$$

Although the voltage stress on the diode Df increases as the turn ratio n increases, the voltage stress on the diodes Df is always lower than the output voltage.

IV. PHOTOVOLTAIC (PV) SYSTEM

A Photovoltaic (PV) system directly converts solar energy into electrical energy. The basic device of a PV system is the PV cell. Cells may be grouped to form arrays. The voltage and current available at the terminals of a PV device may directly feed small loads such as lighting systems and DC motors or connect to a grid by using proper energy conversion devices.

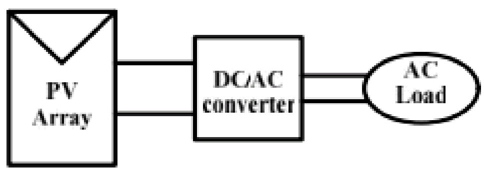

Fig.4. Block diagram representation of Photovoltaic system

This photovoltaic system consists of three main parts which are PV module, balance of system and load. The major balance of system components in this systems are charger, battery and inverter. The Block diagram of the PV system is shown in Fig.4.

A. Photovoltaic cell A photovoltaic cell is basically a semiconductor diode whose p–n junction is exposed to light. Photovoltaic cells are made of several types of semiconductors using different manufacturing processes. The incidence of light on the cell generates charge carriers that originate an electric current if the cell is short circuited1

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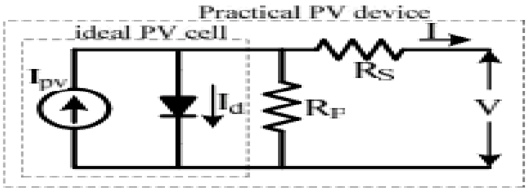

Fig.5. Practical PV device

The equivalent circuit of PV cell is shown in the fig.5. In the above figure the PV cell is represented by a current source in parallel with diode. Rs and Rp represent series and parallel resistance respectively. The output current and voltage form PV cell are represented by I and V. The I-V characteristics of PV cell are shown in fig.4. The net cell current I is composed of the light generated current IPV and the diode current ID.

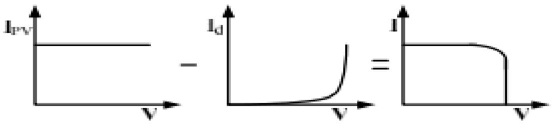

Fig.6. Characteristics I-V curve of the PV cell

V. SIMULATION RESULTS

Here the simulation carried by two different cases they are 1) high step-up interleaved converter with a voltage multiplier module 2) PV as input source of proposed converter with inverter module

Case-1 High step-up interleaved converter with a voltage multiplier module

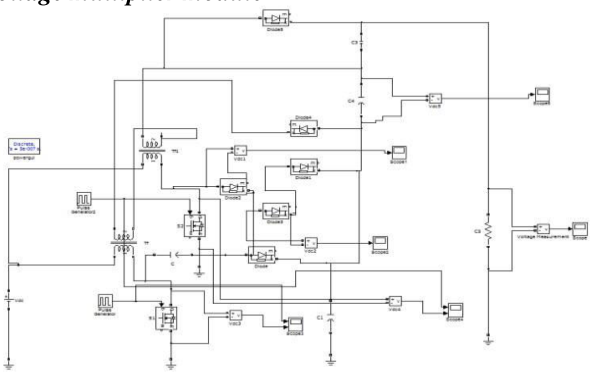

Fig.7 Simulink model of conventional high step-up interleaved converter with a voltage multiplier module

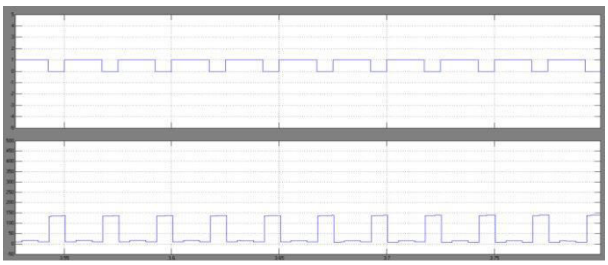

Fig.8 power switch S1 gating pulse and output voltage

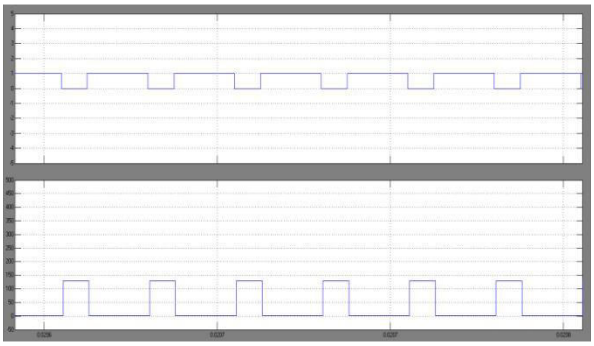

Fig.9 power switch S2 gating pulse and output voltage

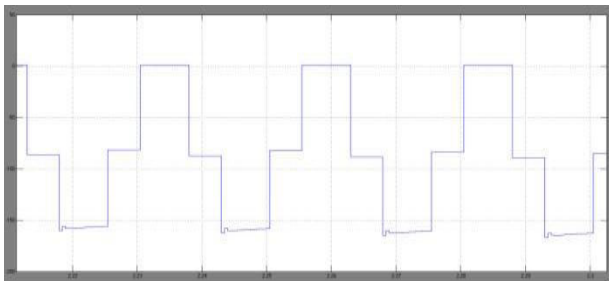

Fig.10 shows the simulated output waveform voltage across switched capacitor

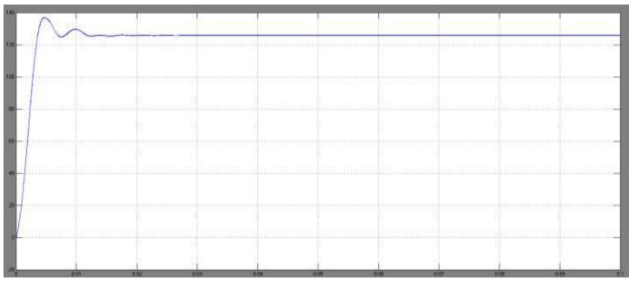

Fig.11 output voltage of clamp diode

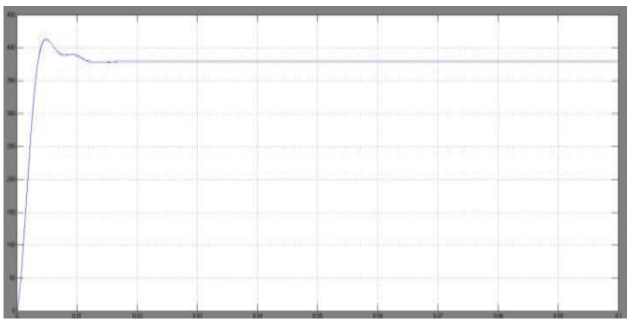

Fig.12 shows the ooutput voltage of conventional high step-up interleaved converter

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Case-2 proposed converter with AC load

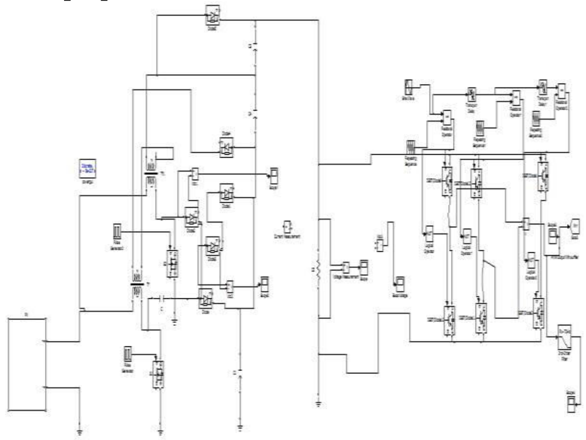

Fig13. Simulink model of PV as input source of proposed converter with inverter module

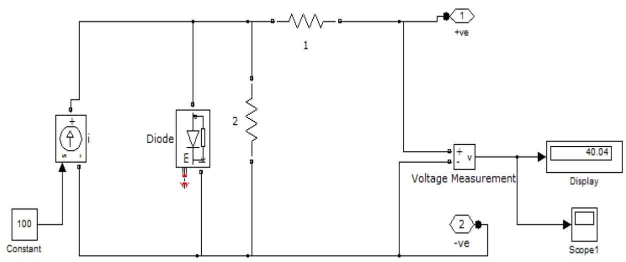

Fig.14 simulation model of PV system

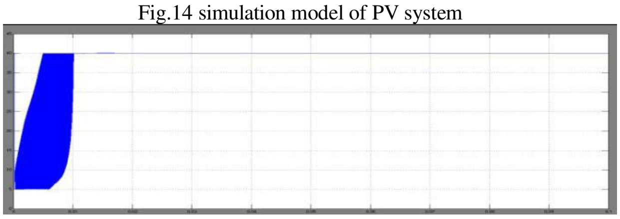

Fig.15 shows simulated PV output voltage

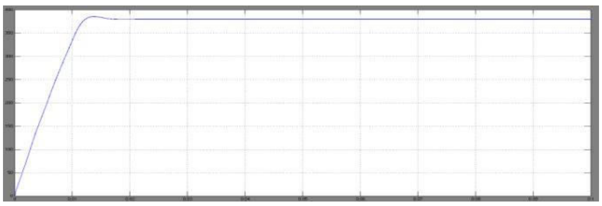

Fig.16 shows Input voltage of proposed inverter

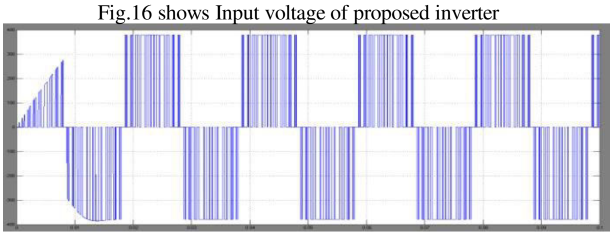

Fig.17 shows output voltage of proposed inverter without filter

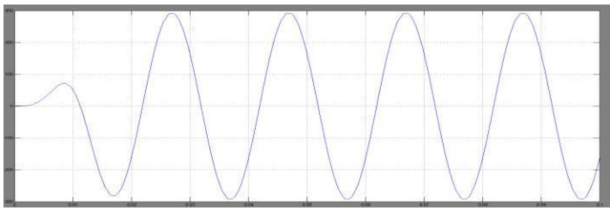

Fig.18 shows output voltage of proposed inverter with filter

CONCLUSION

Renewable energy is the energy generated from natural resources like solar, wind and tidal etc. Solar energy is the radiant light and heat from the sun, which can be converted directly into electrical energy by using photovoltaic effect. As the temperature and isolation changes the output power will change. So in order to achieve more output power from the panel lot of measures should taken, have to reduce the shadow effect etc. We make an analysis for different types of converters with applications in photovoltaic systems, this analysis allow compare quantitatively and qualitatively in source side voltage and load side voltage. The proposed converter has successfully implemented an efficient high step-up conversion through the voltage multiplier module. The interleaved structure reduces the input current ripple and distributes the current through each component. The proposed converter output apply to AC loads PV is the input source. These all simulation results are tested and verified by using MATLAB/SIMULINK software

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