An ImprovedStep-Up Converter With a Voltage MultiplierModule for a Photovoltaic System

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Abstract: Anew voltage multiplier module composed which is havingswitched capacitors and coupled inductors, with itscombination a conventional interleaved boost converterobtains high step-up gain without operating at extremeduty ratio is designed. This proposed converter reducesthe current stress and also reduces constrains the inputcurrent ripple, which decreases the conduction lossesand lengthens the lifetime of the input source. Hence,large voltage spikes across the main switches arereduced, and hence the efficiency will be improved. Eventhe low voltage stress makes the low-voltage-ratedMOSFETs be adopted for reductions of conductionlosses and cost.

Keywords: Boost–flyback converter, high step-up, photovoltaic system, voltage multiplier module

I. INTRODUCTION

Nowadays renewable sources of energy are used in worldwide, because of energy shortage and environmentalcontamination. The high step-up DC-DC converter is widely used in the renewable systems because they produce lowvoltage output. Among the renewable energy resources the photovoltaic systems having a greater hand in future energyproduction. The photovoltaic systems transforms light energy in to electrical energy and convert low voltage into highvoltage via step-up converter which can convert energy in to electricity using grid-by-grid inverter or store energy intobattery set [1]-[2]. A typical photovoltaic system consists of a solar module, a high step-up converter, a chargedischarge controller, a battery set, and an inverter. The high step-up converter performs importantly among the systembecause the system requires a sufficiently high step-up conversion.The conventional step-up converters, such as the boost converter and flyback converter, cannot achieve a high step-upconversion with high efficiency because of the resistances of elements or leakage inductance. Thus, a modified boost–flyback converter was proposed [3]–[5].The conventional step-up converters with a single switch are unsuitable forhigh-power applications given an input large current ripple, which increases conduction losses. Thus, numerousinterleaved structures and some asymmetrical interleaved structures are extensively used .This study also presents anasymmetrical interleaved converter for a high step-up and high-power application [6].

Theoretically, conventional step-up converters, such as theboost converter and flyback converter, cannot achieve a high step-up conversion with high efficiency because of the resistances of elements or leakage inductance. Thus, a modifiedboost–flyback converter was proposed [18]–[20], and many converters that use the coupled inductor for a considerably highvoltage conversion ratio were also proposed [21]–[25].Despite these advances, conventional step-up converters witha single switch are unsuitable for high-power applications givenan input large current ripple, which increases conduction losses.Thus, numerous interleaved structures and some asymmetricalinterleaved structures are extensively used. The current study also presents an asymmetrical interleaved converterfor a high step-up and high-power application.Modifying a boost–flyback converter, shown in Fig. 2(a), isone of the simple approaches to achieving high step-up gain; thisgain is realized via a coupled inductor.

PV Panel: A PV array is a group of several PV cells whichare electrically connected in series and parallel circuitsto generate the required current and voltage. Thecharacteristics have a current source region and avoltage source region. The impedance is low at voltagesource region, whereas high at current source region.Solar radiation is an important factor determining theI-V characteristics, hence these factors are required forthe designing and implementation of solar cell. Theshort circuit current increases with the increase insolar radiation and open circuit voltage decreases withincrease in temperature for constant radiation onsurface of the cell. Partial shading is a phenomenonoccurring in solar cells causing several numbers ofmaximum power points. The diodes are provided forreducing the reverse currents caused due to theproblems of partial shading. These reverse currentcauses heating on solar cells, affecting the efficiencyand performance at higher temperatures.

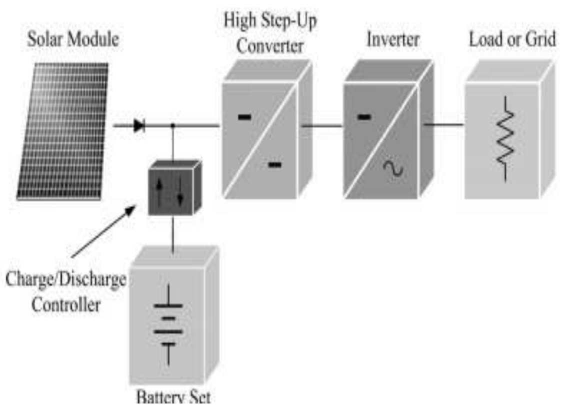

Fig. 1.Typical photovoltaic system.

The electrical system connecting to thephotovoltaic system depends on cell temperature, alsosudden change in weather condition result in varyingsolar irradiation on the surface. The output voltage andcurrent varies with the change in these parameters.These will affect in tracking maximum power from thecell.

Maximum Power Point Tracking (MPPT): MPPT technique is to extract maximum powerfrom photovoltaic systems. MPPT maintains theoperation of maximum power with efficient MPPTtechniques and they differ in many aspects such asrequired sensors, complexity, cost, range ofeffectiveness, convergence speed, correct tracking etc.Hill Climbing Techniques are used for trackingmaximum power. Here the PV system uses P & Oalgorithm because of simplicity, less time andparameters requirement. The algorithm starts withsetting the reference voltage and power of the module.

Perturbation and Observation method is a Hillclimbing method. In this method the operating voltagesare increased or decreased for attaining a maximumpoint of operating and it compares the present valuewith previous value in each cycle of perturbation. Theperturbation value decrease or increase the value ofpower, then the voltages are adjusted for obtaining amaximum power point. The operating point shifts withthe perturbation on voltages, with a step increase ordecrease in the duty cycle of the converter connected.

The operating point oscillates around the maximumpoint causing power loss is a disadvantage of thismethod of tracking power. The step size is decreased toreduce the oscillation around the operating point. If thepower and voltage are increased comparing to theprevious cycle, then increase the voltage in order totrack maximum power from left of the curve. If thechange in power is increased and change in voltage isdecreased, then decrease the voltage to track MPP fromright of the curve. If the change in power is decreasedand change in voltage is increased, then also decreasethe voltage to track the operating point back to MPP,which is moving away from maximum point.

Operating principles of converter: The step up converter is a non-isolatedtopology for boosting low voltage input to high voltageoutput. The input current is usually continuous innature and is supplied to the load by either theconduction of diodes or capacitors. The boostconverter with voltage multiplier by means of coupledinductor insertion increases the output voltage, hencethe voltage gain and efficiency, with low value of dutycycle. The output voltage across the load is the sum ofthe voltage from boost converter and the voltageacross the voltage multiplier capacitors. The requiredduty cycle can be obtained by adjusting the voltagemultiplier, which increases the output voltage. Thevoltage multiplier module is composed of two coupledinductors and two switched capacitors and is insertedbetween a conventional interleaved boost converter toform a modified boost–flyback–forward interleavedstructure.

When the switches turn off by turn, the phase whoseswitch is in OFF state performs as a fly back converterand the other phase whose switch is in ON stateperforms as a forward converter.

II. SYSTEM CONFIGURATION

The step up converter is a non-isolatedtopology for boosting low voltage input to high voltageoutput. The input current is usually continuous innature and is supplied to the load by either theconduction of diodes or capacitors. The boostconverter with voltage multiplier by means of coupledinductor insertion increases the output voltage, hencethe voltage gain and efficiency, with low value of dutycycle. The output voltage across the load is the sum ofthe voltage from boost converter and the voltageacross the voltage multiplier capacitors.

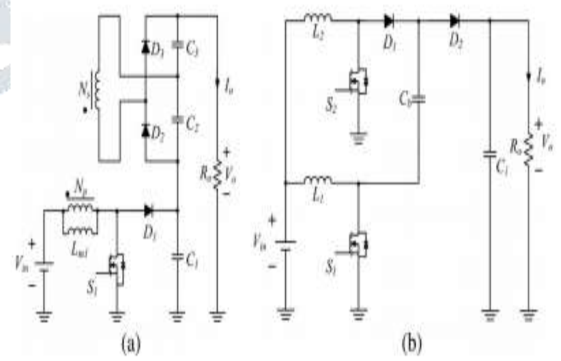

Fig. 2. High step-up techniques based on a classical boost converter. (a) Integrated flyback–boost converter structure. (b) Interleaved boost converter with avoltage-lift capacitor structure

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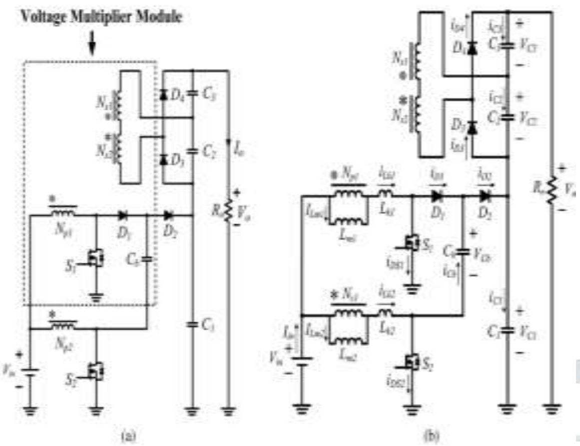

Fig. 3. (a) Proposed high step-up converter with a voltage multiplier module. (b) Equivalent circuit of the proposed converter.

The equivalent circuit of the proposed converter isshown in Fig. 3, where Lm1 and Lm2 are the magnetizinginductors; Lk1 and Lk2 represent the leakage inductors; Lsrepresents the series leakage inductors in the secondary side;S1 and S2 denote the power switches; Cc1 and Cc2 are theswitched capacitors; and C1, C2, and C3 are the outputcapacitors. Dc1 and Dc2 are the clamp diodes, Db1 and Db2represent the output diodes for boost operation withswitched capacitors, Df1 and Df2 represent the output diodesfor flyback–forward operation, and n is defined as turn ratioNs/Np.

In the circuit analysis, the proposed converteroperates in continuous conduction mode (CCM), and theduty cycles of the power switches during steady operationare greater than 0.5 and are interleaved with a 180◦ phaseshift. The key steady waveform in one switching period ofthe proposed converter contains six modes,ofthe circuit.

III. SIMULATION RESULTS

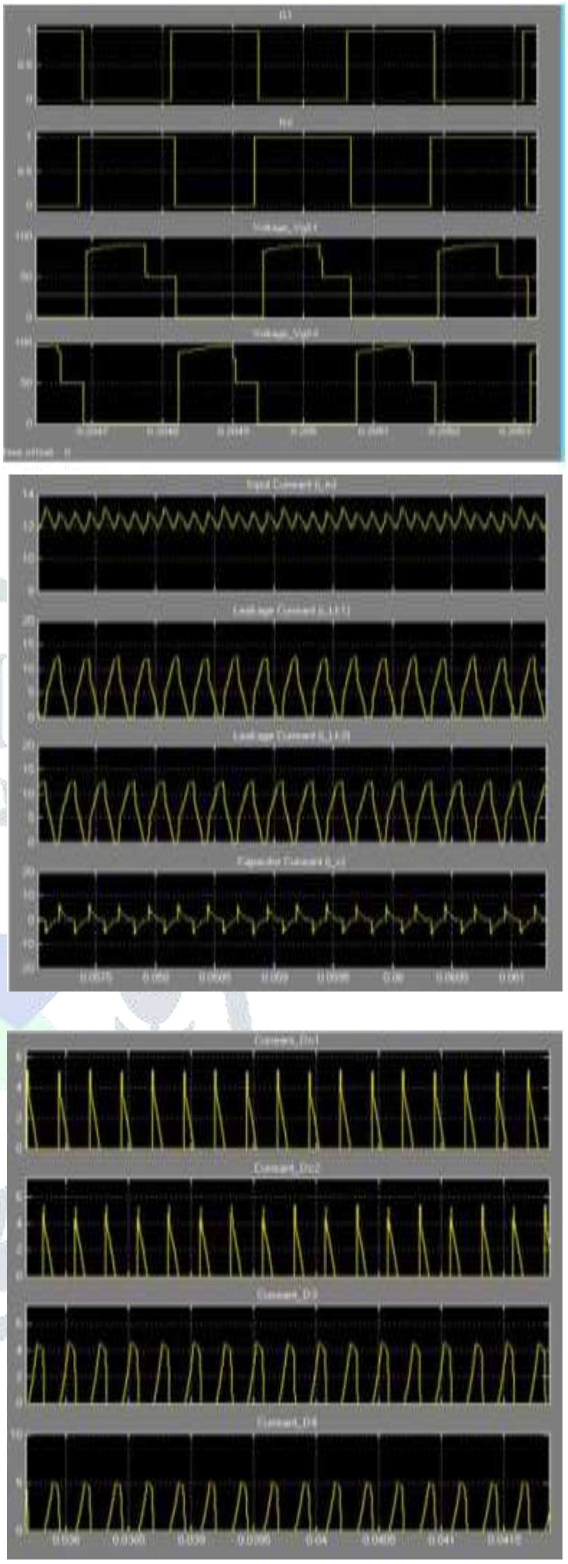

Fig 4 measured waveforms of proposed system

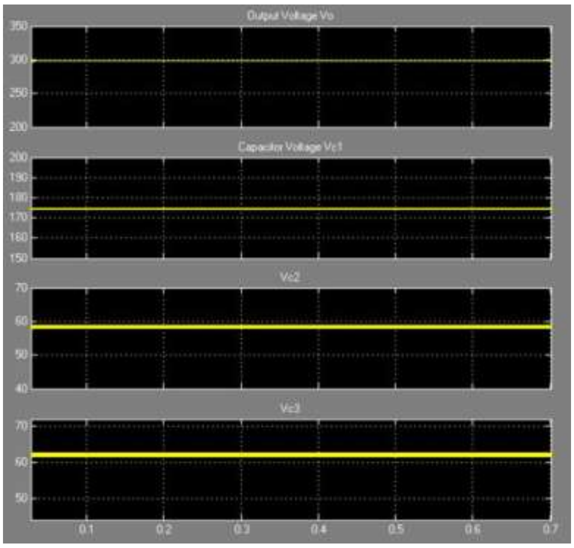

Fig 5 measured voltage waveforms of capacitors

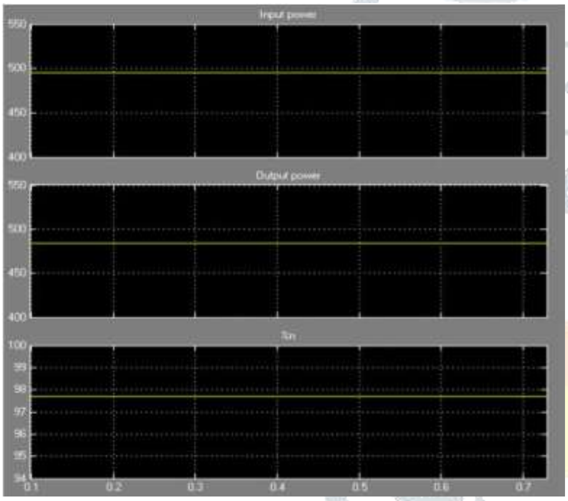

Fig 6 waveforms of input power, output power with efficiency

IV. CONCLUSION

The proposed converter hassuccessfully implemented an efficient high step-upconversion through the voltage multiplier module. Theinterleaved structure reduces the input current ripple anddistributes the current through each component. In addition,the lossless passive clamp function recycles the leakageenergy and constrains a large voltage spike across the powerswitch. Thus the proposed converter is suitable for PV systems or other renewableenergy applications that need high step-up high power conversion. full-load efficiency

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