International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 02, February 2017
www.ijates.com
ijates
ISSN 2348 - 7550

DC-DC CONVERTER WITH VOLTAGE MULTIPLIER CIRCUIT FOR PHOTOVOLTAIC APPLICATION

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ABSTRACT

In recent years, with the increasing development of power electronics technology, the boost DC-DC converters are more widely for the electricity-supply applications .In this paper, a new step up converter with voltage multiplier is proposed. the voltage multiplier module is composed of conventional boost converter and coupled inductor. Conventional boost converters are not able to provide high step-up voltage gains. Through a voltage multiplier module, an asymmetrical interleaved high step-up converter obtains high step-up gain without operating at an extreme duty ratio. The 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 MOSFETs. Efficiency improves because the energy stored in leakage inductances is recycled to the output terminal.

Key Terms: Boost–Fly back Converter, High Step-Up, Photovoltaic System, Voltage Multiplier Module.

I. INTRODUCTION

Renewable sources of energy are having high potential worldwide because of energy shortage and environmental contamination. Output of Renewable energy systems are low voltage output; thus, high step-up dc/dc converters are widely employed in many renewable energy applications, including fuel cells, and photovoltaic systems. Among renewable energy systems, Solar energy or photovoltaic systems are expected to play an important role in future energy production. Such systems transform light energy into electrical energy, and convert low voltage into high voltage via a step-up converter, which can convert energy into electricity using a grid-by-grid inverter or store energy into a battery set. Fig. 1 shows a typical photovoltaic system that consists of a solar module, a high step up converter, a charge-discharge controller, a battery set, and an inverter. The high step-up converter performs importantly among the system because the system requires a sufficiently high step-up conversion. Theoretically, conventional step-up converters, such as the boost converter and fly back converter, cannot achieve a high step-up conversion with high efficiency because of the resistances of elements or leakage inductance. Thus, a modified boost fly back converter was proposed, and many converters that use the coupled inductor for a considerably high voltage conversion ratio were also proposed. Despite these advances, conventional step-up converters with a single switch are unsuitable for high-power applications given an input large current ripple, which increases conduction losses. Thus, numerous interleaved structures and some asymmetrical interleaved structures are extensively used. The current study also presents an asymmetrical interleaved converter for a high step-up and high-power application.

A. Advantages of Photovoltaic system.

Photovoltaic (PV) systems provide green, renewable power by exploiting solar energy. We can use photovoltaic (PV) panels as an alternative energy source in place of electricity generated from conventional fossil fuels. Consequently, the more we use PV panels (or other renewable energy technologies) to cover for our energy needs, the more we help reduce our impact to the environment by reducing CO2 emissions into the atmosphere Output capacitor is larger than input capacitor that sup Photovoltaic(PV) panels constitute a reliable, industrially matured,green technology for the exploitation of solar energy.Photovoltaic (PV) companies give valuable warranties for PVpanels in terms of both PV panel life span (years of PV life)and PV panels' efficiency levels across time. PV panels canlast up to 25 years or more, some with a maximum efficiencyloss of 18% only, even after 20 years of operation.With respect to operating costs and maintenance costs, Photovoltaic (PV) panels, unlike other renewable energy technologies, require minimum operating or maintenance costs; just performing some regular cleaning of the panel surface is adequate to keep them operating at highest efficiency levels as stated by manufacturers' specs.

Modifying a boost–fly back converter, shown in Fig. 2(a), is one of the simple approaches to achieving high step-up gain; this gain is realized via a coupled inductor. The performance of the converter is similar to an active-clamped fly back converter; thus, the leakage energy is recovered to the output terminal. An interleaved boost converter with a voltage-lift capacitor shown in Fig. 2(b) is highly similar to the conventional interleaved type. It obtains extra voltage gain through the voltage-lift capacitor, and reduces the input current ripple, which is suitable for power factor correction (PFC) and high-power applications.

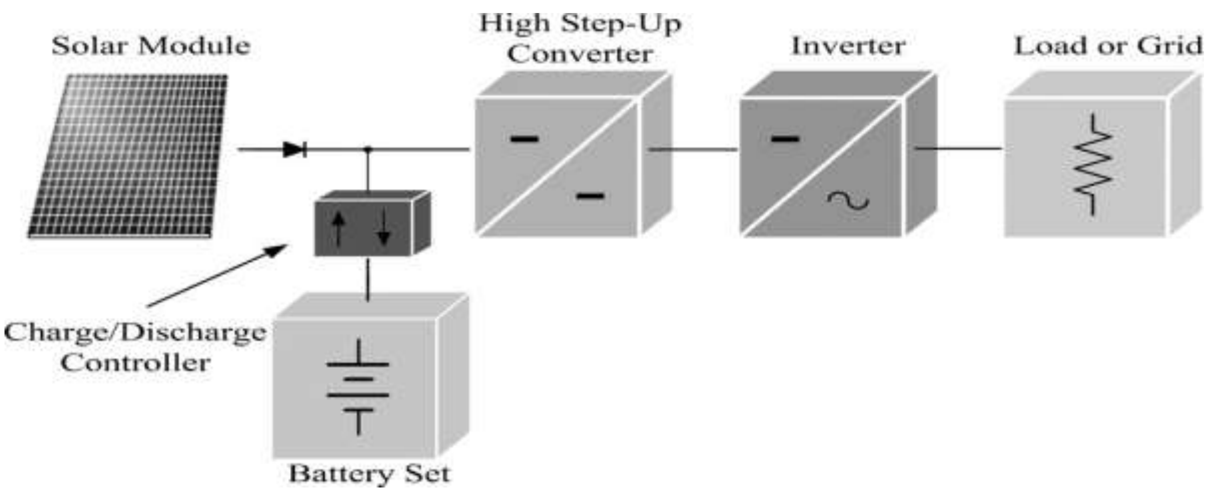

Fig.1.Typical Photovoltaic System

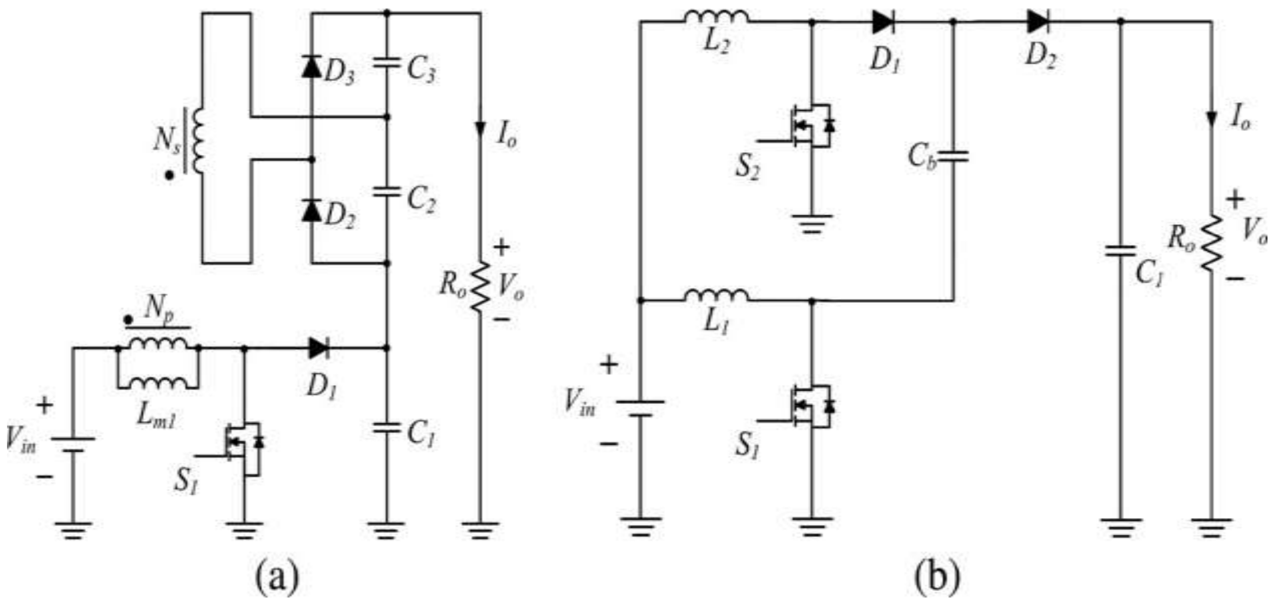

Fig. 2. High Step-Up Techniques Based on a Classical Boost Converter.

(a) Integrated flyback–boost converter structure.

(b) Interleaved boost converter with a voltage-lift capacitor structure.

In this paper, an asymmetrical interleaved high step-up converter that combines the advantages of the aforementioned converters is proposed, which combined the advantages of both. In the voltage multiplier module of the proposed converter, the turns ratio of coupled inductors can be designed to extend voltage gain, and a voltage-lift capacitor offers an extra voltage conversion ratio.

The advantages of the proposed converter are as follows:

[1] The converter is characterized by a low input current ripple and low conduction losses, making it suitable for high power applications;

[2] The converter achieves the high step-up voltage gain that renewable energy systems require;

[3] Leakage energy is recycled and sent to the output terminal, and alleviates large voltage spikes on the main switch;

[4] The main switch voltage stress of the converter is substantially lower than that of the output voltage;

[5] Low cost and high efficiency are achieved by the low *rDS*(on) and low voltage rating of the power switching device.

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www.ijates.com
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II. OPERATING PRINCIPLE

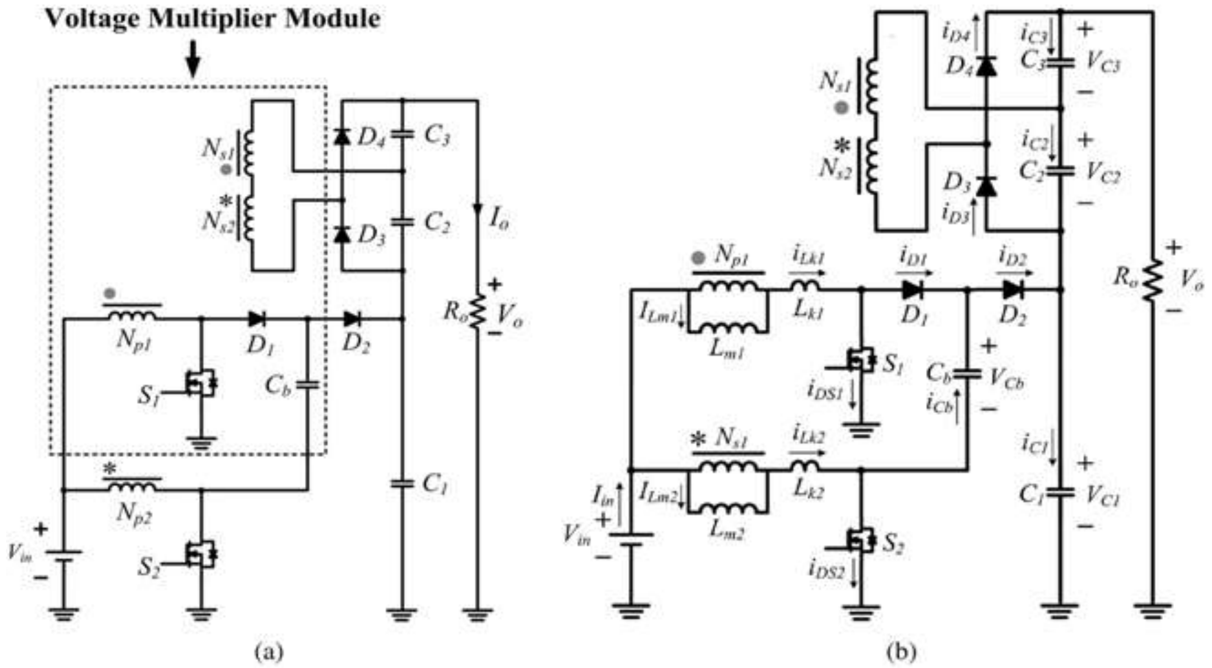

Fig. 3

(a) Proposed high step-up converter with a voltage multiplier module.

(b) Equivalent circuit of the proposed converter.

The proposed high step-up converter with voltage multiplier module is shown in Fig. 3(a). A conventional boost converter and two coupled inductors are located in the voltage multiplier module, which is stacked on a boost converter to form an asymmetrical interleaved structure. Primary windings of the coupled inductors with $N_p$turns are employed to decrease input current ripple, and secondary windings of the coupled inductors with $N_s$turns are connected in series to extend voltage gain. The turns ratios of the coupled inductors are the same. The coupling references of the inductors are denoted by " . " and " ∗ " The equivalent circuit of the proposed converter is shown in Fig. 3(b), where L_{m1} and L_{m2} are the magnetizing inductors, L_{k1} and L_{k2} represent the leakage inductors, S_1 and S_2 denote the power switches, $C_b$is the voltage-lift capacitor, and n is defined as a turns ratio N_s /N_p, The proposed converter operates in continuous conduction mode (CCM), and the duty cycles of the power switches during steady operation are interleaved with a 180◦ phase shift; the duty cycles are greater than 0.5. The key steady waveforms in one switching period of the proposed converter contain six modes, which are depicted in Fig. 4, and Fig. 5 shows the topological stages of the circuit.

Mode 1 [t_0, t_1]: At $t=t_0$, the power switches S_1 and S_2 are both turned ON. All of the diodes are reversed-biased. Magnetizing inductors L_{m1} and L_{m2} as well as leakage inductors L_{k1} and L_{k2} are linearly charged by the input ssvoltage source V_{in}.

Mode 2 [t_1, t_2]: At $t=t_1$, the power switch S_2 is switched OFF, thereby turning ON diodes D_2 and D_4. The energy that magnetizing inductor L_{m2} has stored is transferred to the secondary side charging the output filter capacitor

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C_3. The input voltage source, magnetizing inductor L_{m2}, leakage inductor L_{k2}, and voltage-lift capacitor $C_b$release energy to the output filter capacitor C_1 via diode D_2, thereby extending the voltage on C_1.

Mode 3 [t_2, t_3]: At t=t_2, diode D_2 automatically switches OFF because the total energy of leakage inductor L_{k2} has been completely released to the output filter capacitor C_1 Magnetizing inductor L_{m2} transfers energy to the secondary side charging the output filter capacitor C_3 via diode D_4 until t_3.

Mode 4 [t_3, t_4]:At t=t_3, the power switch S_2 is switched ON and all the diodes are turned OFF. The operating states of modes 1 and 4 are similar.

Mode 5 [t_4, t_5]:At t=t_4, the power switch S_1 is switched OFF, which turns ON diodes D_1 and D_3. The energy stored in magnetizing inductor L_{m1} is transferred to the secondary side charging the output filter capacitor C_2. The input voltage source and magnetizing inductor L_{m1} release energy to voltage-lift capacitor $C_b$via diode D_1, which stores extra energy in C_b.

Mode 6 [t_5, t_0]:At t=t_5, diode D_1 is automatically turned OFF because the total energy of leakage inductor L_{k1} has been completely released to voltage-lift capacitor C_b, Magnetizing inductor L_{m1} transfers energy to the secondary side charging the output filter capacitor C_2 via diode D_3 until t_0

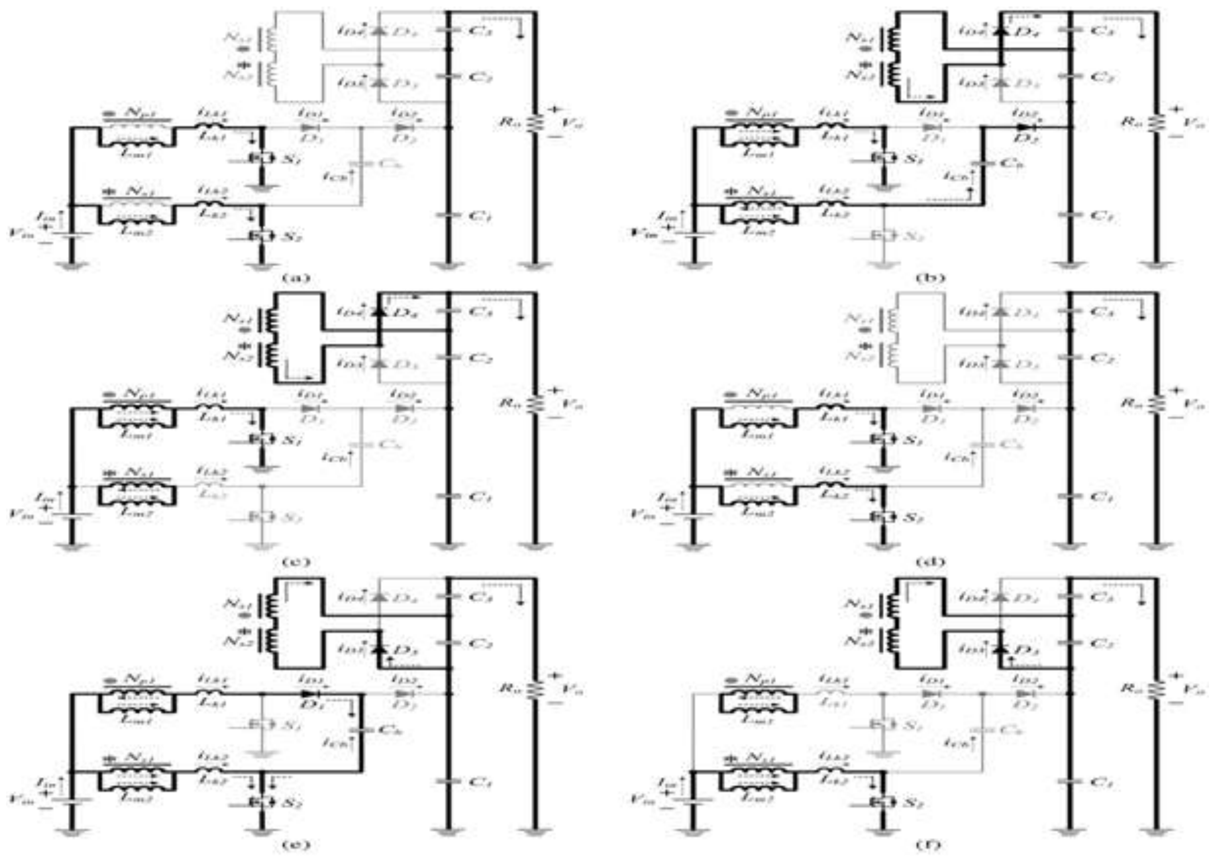

Fig.4. Operating Modes of the Proposed Converter.

(a) Mode 1 [t_0, t_1], (b) Mode 2 [t_1, t_2], (c) Mode 3 [t_2, t_3], (d) Mode 4 [t_3, t_4], (e) Mode 5 [t_4, t_5], (f) Mode 6 [t_5, t_0].

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 L_{k1} and L_{k2} are neglected

3) Voltage V_{Cb}, V_{C1}, V_{C2}, and V_{C3} are considered to be constant because of infinitely large capacitance.

A. Voltage Gain

The first-phase converter can be regarded as a conventional boost converter; thus, voltage V_{Cb}can be derived from

$$V_{Cb} = \frac{1}{1-D} * Vin \quad \ldots\ldots 1$$

When switch S_1 is turned ON and switch S_2 is turned OFF, voltage V_{C1} can be derived from

$$V_{C1} = \frac{1}{1-D} Vin + VCb = \frac{2}{1-D} * Vin \ldots\ldots 2$$

The output filter capacitors C_2 and C_3 are charged by energy transformation from the primary side. When S_2 is in turn-on state and S_1 is in turn-off state, V_{C2} is equal to induced voltage of N_{s1} plus induced voltage of N_{S2}, and when S_1 is in turn-on state and S_2 is in turn-off state, V_{C3} is also equal to induced voltage of N_{S1} plus induced voltage of N_{S2} Thus, voltages V_{C2} and V_{C3} can be derived from

$$V_{C2} = V_{C3} = n * Vin * \left(1 + \frac{D}{1-D}\right) = \frac{n}{1-D} * V_{in} \ldots\ldots 3$$

The output voltage can be derived from

$$V_o = V_{C1} + V_{C2} + V_{C3} = \left(\frac{2n+2}{1-D}\right) * V_{in} \ldots\ldots 4$$

The voltage gain of the proposed converter is

$$\frac{Vo}{Vin} = \frac{2n+2}{1-D} \ldots\ldots 5$$

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 turns ratio *n* and duty cycle is shown in Fig. 6.When the duty cycle is merely 0.6, the voltage gain reaches 10 at a turns ratio *n* of 1; the voltage gain reaches 30 at a turns ratio *n* of 5.

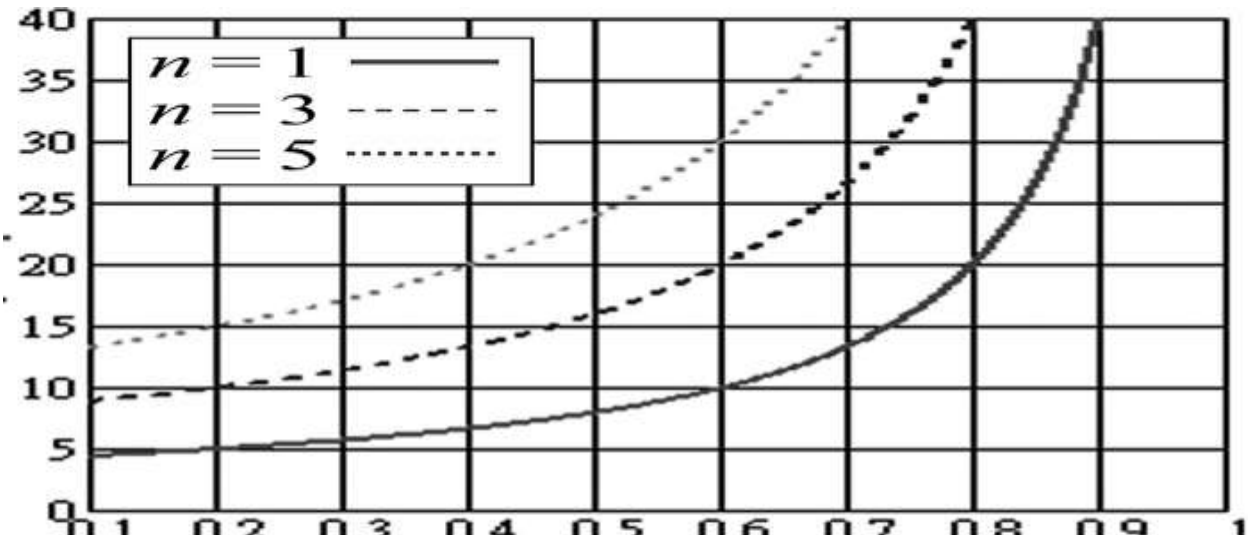

Fig. 5 Voltage Gain versus Turns Ratio *N* and Duty Cycle

IV. OPEN LOOP SIMULATION

The system proposed can be simulated with MATLAB software. The components and various parameters used for simulation is as shown in table 1.Fig shows the simulated block diagram of the proposed converter. And fig shows the voltage gain.

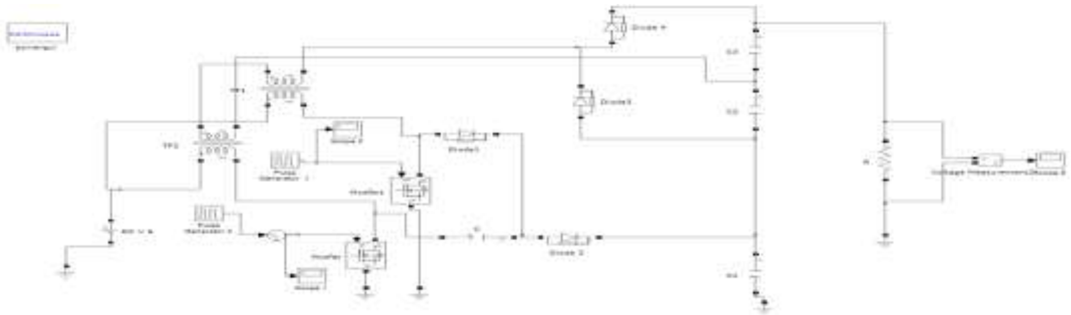

Fig.6 Matlab Model of proposed converter

SIMULATION RESULT

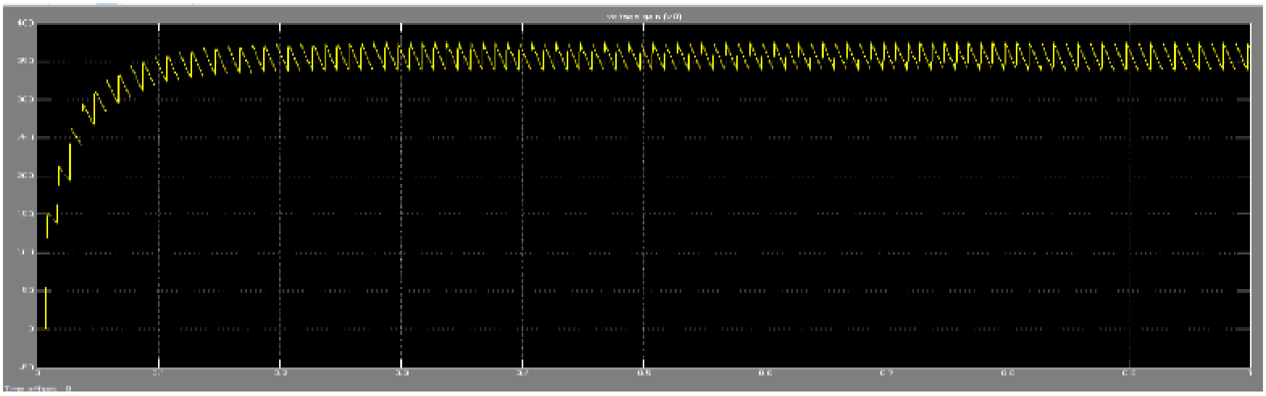

Fig.7 Output Voltage

V. CONVERTER COMPONENTS AND PARAMETERS

Component	Symbols	Parameters
Magnetizing inductances	L_{m1}, L_{m2}	$133*10^{-6}$H
Switching frequency		40 kHz
Leakage inductance	L_{k1}, L_{k2}	$1.6*10^{-6}$H
Turns ratio	n(Ns/Np)	1
Power Switches	S_1 , S_2	IRFP4227
Diodes	D_1, D_3, D_4	FCFO6A-40
	D_2	BYQ28E-200
Capacitors	C_b, C_2, C_3	$220*10^{-6}$F
	C_1	$470*10^{-6}$F

Table1. Design Parameter

VI. CONCLUSION

This paper has presented the topological principles, steady state analysis, and experimental results of the proposed converter. It has been successfully implemented in an efficiently high step up conversion without an extreme duty ratio and a number of turns ratios through the voltage multiplier module and the voltage clamp feature. Here, the voltage stresses over the power switches are restricted and are much lower than the output voltage So the proposed system is suitable for renewable energy applications, that need high step- up high power energy conversion.

REFERENCES

1. IEEE Papers

[1] C. Hua, J. Lin, and C. Shen, “Implementation of a DSP-controlled photovoltaic system with peak power tracking,” IEEE Trans. Ind. Electron., vol. 45, no. 1, pp. 99–107, Feb. 1998.

[2] J. M. Carrasco, L. G. Tranquillo, J. T. Bialasiewicz, E. Galvan, R. C. P. Guisado, M. A. M Prats, J. I. Leon, and N. Moreno-Alfonso,“Power-electronic systems for the grid integration of renewable energy sources: A survey,” IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1002–1016, Jun. 2006.

[3] J. T. Bialasiewicz, “Renewable energy systems with photovoltaic power generators: Operation and modeling,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2752–2758, Jul. 2008.

[4] Y. Xiong, X. Cheng, Z. J. Shen, C. Mi, H.Wu, and V. K. Garg, "Prognostic and warning system for power-electronic modules in electric, hybrid electric, and fuel-cell vehicles," IEEE Trans. Ind. Electron., vol. 55, no. 6, pp. 2268–2276, Jun. 2008.

[5] F. S. Pai, "An improved utility interface for micro-turbine generation systemwith stand-alone operation capabilities," IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1529–1537, Oct. 2006.

[6] H. Tao, J. L. Duarte, and M. A. M. Hendrix, "Line-interactive UPS using a fuel cell as the primary source," IEEE Trans. Ind. Electron., vol. 55, no. 8, pp. 3012–3021, Aug. 2008.

2. Books

[1] Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers By. C. V. Solanki (Prentice Hall India Learning Private Limited -2013)