High Step up DC-DC Converter with Soft Switching PV System

R.Devi[1] K.Padmanaban[2]
[1]M. E. Student [2]Assistant Professor
[1,2]Department of Electrical Engineering
[1,2]Gnanamani College of Engineering, Namakkal

Abstract— A High step-up converter, which is suitable for renewable energy system, is proposed in this paper. The photovoltaic systems provide promising ways to generate clean electric power. A Full-bridge dc–dc converter with a conversion ratio around nine times, soft start-up, and soft switching features for battery charging/discharging is proposed. The converter is equipped with an active fly back and two passive capacitor–diode snubbers, which can reduce voltage and current spikes and reduce voltage and current stresses. It can achieve near zero-voltage-switching and zero-current switching Through a Fly back converter and coupled inductors; a Luo converter obtains high step-up gain without operating at extreme duty ratio. Finally, the prototype circuit with 12V input voltage, 400 V output, and 2kW output power is operated to verify its performance. The highest efficiency is 97.1%.

Key words: Photovoltaic system, Fly back converter, Luo converter, Snubbers, Soft switching

I. INTRODUCTION

In past studies, bridge-type bidirectional isolated converters have been widely applied to fuel cell and electric vehicle driving systems For raising power level, a dual full-bridge configuration is usually adopted , and their low and high sides are typically configured with buck boost type topologies, respectively. However, component stress, switching loss, and electromagnetic interference (EMI) noise are increased due to diode-reverse-recovery current and MOSFET drain–source voltage, resulting in low reliability.

The proposed snubber configuration cannot only reduce the voltage spike caused by the current difference between the leakage inductance and current-fed inductor currents but also can relieve the drawbacks of high-current and high-voltage stresses imposed on the main switches at both turn-on and turnoff transitions. Moreover, it can achieve near ZVS and ZCS for the switches on both sides of the coupled inductor.

A DC–DC converter with a high step-up voltage gain is used for many applications, such as high- intensity discharge lamp ballasts for automobile headlamps, fuel-cell energy conversion systems, solar-cell energy conversion systems, and battery backup systems for uninterruptible power supplies. Theoretically, a dc-dc boost converter can achieve a high step up voltage gain with an extremely high duty ratio. However, in practice, the step-up voltage gain is limited due to the effect of power switches, rectifier diodes, and the equivalent series resistance (ESR) of inductors and capacitors. Symmetric PWM (PWM) is adopted to control four MOSFETs so that the general PWM IC with four isolated gate drives can be used in the proposed circuit. Based on the resonant behavior by the output capacitance of MOSFETs and the resonant inductance, MOSFETs can be turned on at ZVS.

The output voltage of pulse width modulation (PWM) based DC-DC converters can be changed by changing the duty cycle .The negative output Luo converter recently developed sub-set of DC-DC converters. A Fuzzy controller is developed in this work to regulate the output voltage of this converter under line and load disturbances. This DC-DC converter can convert the source voltage into a higher output voltage with higher efficiency, high power density and simple structure.

I-V and P-V curve for photovoltaic system with different irradiance and temperature

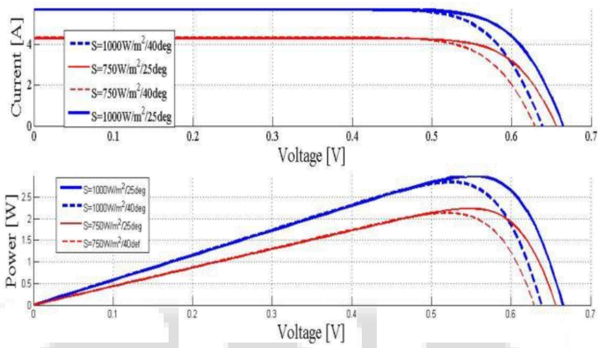

Fig. 1: I-V and P-V curve

II. PROPOSED BLOCK DIAGRAM

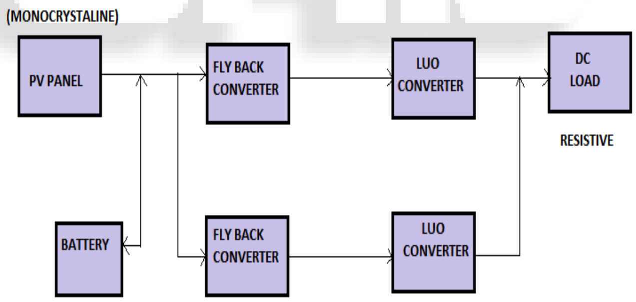

Fig. 2: Block diagram

The renewable energy (PV) system is connected in low voltage side Passive and active clamp circuits were proposed to suppress the voltage spike due to the current difference between the current-fed inductor and leakage inductance current.

The fly back converter is used in DC/DC conversion with galvanic isolation between the input and any outputs. The fly back converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation.

As with Negative output Luo converter is another series of new DC-DC step-up(boost) converters, which were developed from prototypes using the voltage lift technique. These converters perform positive to negative DC-DC voltage-increasing conversion with high power density, high efficiency and cheap topology in simple structure.

III. PROPOSED CIRCUIT DIAGRAM

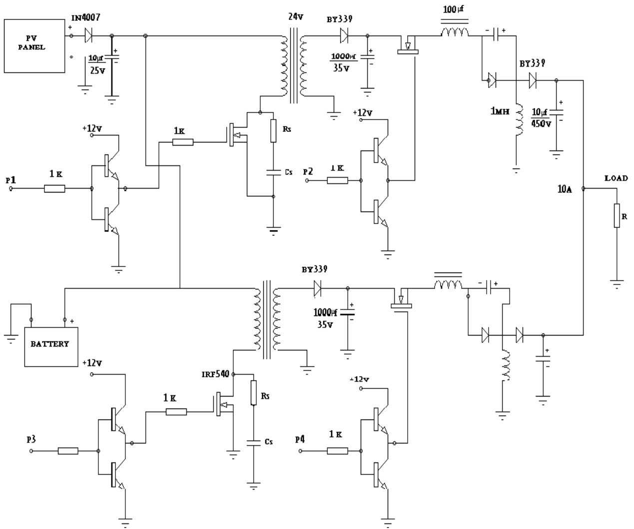

Fig. 3: Circuit diagram

A. Circuit Diagram Operation:

1) PV Panel to Flyback Converter:

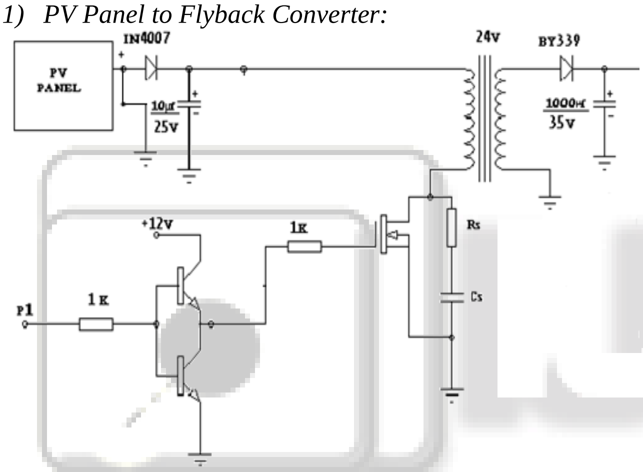

Fig. 4: Flyback converter

The Flyback converter of Fig 4 is based on the buck-boost converter.

2) Mode1:

When MOSFET *Q*1 conducts, diode *D*1 is reverse-biased. The primary winding then functions as an inductor, connected to the input PV source *V*g. Energy is stored in the magnetic field of the Flyback transformer.

3) Mode2:

When MOSFET *Q*1 turns off, the current ceases to flow in the primary winding. The magnetizing current, referred to the secondary winding, now forward-biases diode *D*1. Energy stored in the magnetic field of the flyback transformer is then transferred to the proposed converter.

Application of the principle of inductor volt-second balance to the transformer primary winding leads to the following solution for the conversion ratio of the flyback converter:

$$M(D) = V/Vg = n \ (D/(1 - D)$$

Thus, the conversion ratio of the flyback converter is similar to that of the buck-boost converter, but with an added factor of *n*.

The flyback converter has traditionally been used in the high-voltage power supplies of televisions and computer monitors.

4) Wave form for flyback converter:

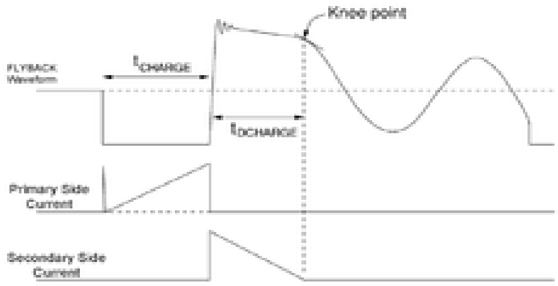

Fig. 5: Wave form for flyback converter

It also finds widespread application in switching power supplies at the 50 W to 100 W power range. This converter has the advantage of very low parts count. Multiple outputs can be obtained using a minimum number of added elements: each auxiliary output requires only an additional winding, diode, and capacitor.

B. Snubbers and Soft Switching:

Today, most of the medium power (up to 200 kVA) and medium voltage (up to 800 V) inverters are hard-switched. Compared with low-power switched mode power supplies, the high voltage involved in the power inverters makes the dv=dt, di=dt, and switching stress problems more serious. In addition, the reverse recovery of power diodes in the inverter leg may cause a very sharp current spike, leading to severe EMI problems. It should be noted that some high-power devices such as GTO thyristors do not have a square safe operating area (SOA). It is therefore essential that the switching stress they undergo must be within their limits. Commonly used protective measures include the use of snubber circuits to protect high-power devices.

Among various snubbers, two snubber circuits are most well-known for applications in power inverters.

C. The Proposed Converter:

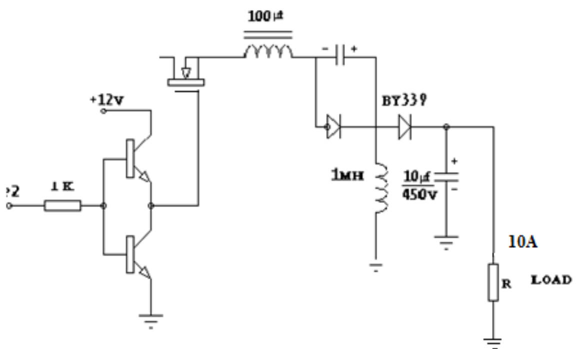

Fig. 6: The Proposed Converter

The energy storage passive elements are inductors L1, L2 and capacitors C1, C2, R is the load resistance. To analyze the operation of the Luo converter, the circuit can be divided into two modes. When the switch is ON, the inductorL1 is charged by the supply voltage E. At the same time, the inductor L2 absorbs the energy from source and the capacitorC1. The load is supplied by the capacitor C2. Its output voltage and current are

$$V_O = \frac{k}{1-k} V_I \quad \text{and} \quad I_O = \frac{1-k}{k} I_I$$

The voltage-transfer gain in the continuous mode is

$$M_E = \frac{V_O}{V_I} = \frac{I_I}{I_O} = \frac{k}{1-k}$$

During switch is in OFF state, and hence, the current is drawn from the source becomes zero. Current I, L1 flows through the freewheeling diode to charge the capacitor C1. Current I, L2 flows through C2 –R circuit and the freewheeling diode D to keep itself continuous. If adding additional filter components like inductor and capacitor to reduce the harmonic levels of the output voltage. The output voltage in the discontinuous mode is

$$V_O = k(1-k)\frac{R}{2fL}V_I \quad \text{with} \quad \sqrt{\frac{R}{2fL}} \geq \frac{1}{1-k}$$

IV. MATLAB/SIMULINK MODELING

A simulation modeling of a PV distributed system with high step up dc -dc converter is shown below

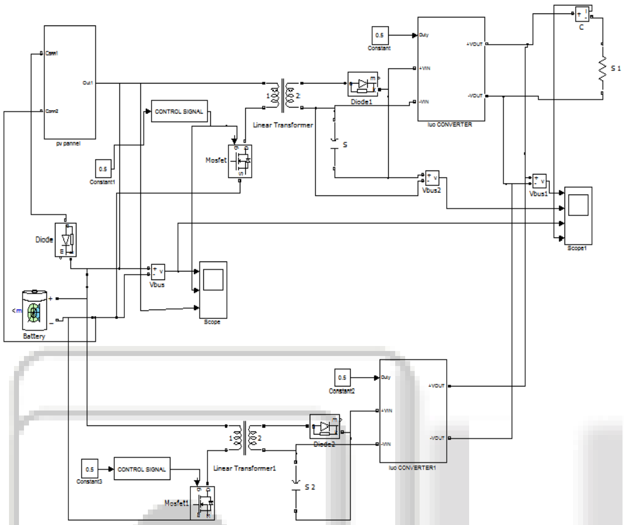

Fig. 7: MATLAB/SIMULINK MODELING

From the simulink, its figure out that due to the input voltage 12V, output voltage of Luo converter is 24V.

This output is feed to the Luo converter 24 to 400 voltage step up and connected to load.

V. SIMULATION RESULTS

A. *PV System Output:*

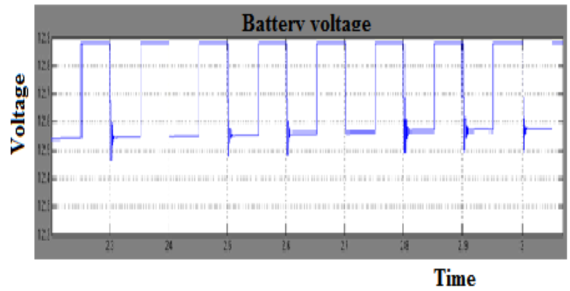

Fig. 8: PV system output

B. *FLYBACK Converter Output:*

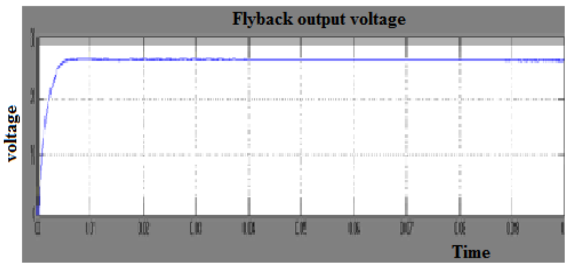

Fig: 9: Flyback output voltage

C. *LUO Converter Output Voltage:*

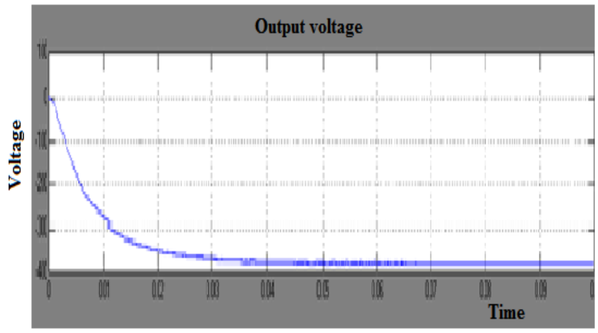

Fig. 10: Luo converter output voltage

D. *LUO Converter Output Current:*

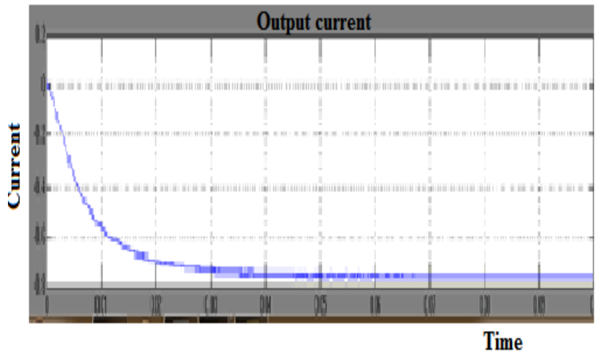

Fig. 11: Luo converter output current

VI. CONCLUSION AND FUTURE WORK

This project has presented a soft-switching flyback converter, which allows input voltage variation from 12 to 24 V, for battery charging/discharging applications. The proposed converter has successfully implemented an efficient high step-up conversion through the Luo converter. The proposed converter can reduce the voltage spike caused by the current difference between leakage inductance and current fed inductor currents, the current spike, and the current and voltage stresses, while it can achieve near ZVS and ZCS soft-switching features.

The passive snubber can hold voltage and improve the slew rate, which can reduce duty loss. However, near ZVS turn-on transition cannot be achieved under light-load condition in step-down conversion. Experimental results measured from the types of 2kW flyback converters have verified that the proposed converter can yield the performance of lower voltage and current spikes, higher efficiency, and less ringing. The negative output Luo converter with PI control and Fuzzy control are use in applications such as switch mode power supply, medical equipment's and high voltage projects etc. This paper has successfully demonstrated the design, analysis, and suitability of the converter.

REFERENCES

[1] K. C. Tseng, C. C. Huang, and W. Y. Shih, "A high step-up converter with a voltage multiplier module for a photovoltaic system," IEEE Trans. Power Electron., vol. 28, no. 6, pp. 3047–3057, Jun. 2013.
[2] Q. Zhao and F. C. Lee, "High-efficiency, high step-up dc–dc converters," IEEE Trans. Power Electron., vol. 18, no. 1, pp. 65–73, Jan. 2003.

[3] W. Li and X. He, "Review of non-isolated high-step-up DC/DC converters in photovoltaic grid connected applications," IEEE Trans. Ind. Electron.,vol. 58, no. 4, pp. 1239–1250, Apr. 2011.
[4] C. T. Pan and C. M. Lai, "A high-efficiency high step-up converter with low switch voltage stress for fuel-cell system applications," IEEE Trans. Ind. Electron., vol. 57, no. 6, pp. 1998–2006, Jun. 2010.
[5] Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang, "Novel high step-up DC–DC converter for distributed generation system," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1473–1482, Apr. 2013.
[6] T.-F. Wu, Y.-C. Chen, J.-G. Yang, and C.-L. Kuo, "Isolated bidirectional full-bridge DC–DC converter with a flyback snubber," IEEE Trans. Power Electron., vol. 25, no. 7, pp. 1915–1922, Jul. 2010.
[7] L.-S. Yang and T.-J. Liang, "Analysis and implementation of a novel bidirectional DC–DC converter," IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 422–434, Jan. 2012.
[8] R. Kayalvizhi, S. P. Natarajan and P. Padmaloshani "Development of a Neuro Controller for a Negative output Elementary Luo Converter" Journal of Power Electronics, Vol. 7, No. 2, April 2007
[9] L. S. Yang, T. J. Liang, and J. F. Chen, "Transformer less DC–DC converter with high voltage gain," IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 3144–3152, Aug. 2009.
[10] F. L. LUO, " Luo converters – voltage lift technique (negative output)," Proceedings of the second World Energy System international conference WES'98, Tornoto, Canada, 19-22, pp.253-260, May. 1998.
[11] K. C. Tseng and T. J. Liang, ―Novel high-efficiency step-up converter, ‖ Proc. Inst. Elect. Eng.—Elect. Power Appl., vol. 151, no. 2, pp. 182–190, Mar. 2004. IEEE Transactions On Industrial Electronics, Vol. 56, No. 8, August 2009