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High Step-Up Forward Flyback Converter with Nondissipative Snubber for Solar Energy Application

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ABSTRACT: A high step-up forward flyback converter with nondissipative snubber for solar energy application is introduced here. High gain DC/DC converters are the key part of renewable energy systems .The designing of high gain DC/DC converters is imposed by severe demands. It produces high step-up voltage gain by using a forward flyback converter. The energy in the coupled inductor leakage inductance can be recycled via a nondissipative snubber on the primary side. It consists of a combination of forward and flyback converter on the secondary side. It is a hybrid type of forward and flyback converter, sharing the transformer for increasing the utilization factor. By stacking the outputs of them, extremely high voltage gain can be obtained with small volume and high efficiency even with a galvanic isolation. The separated secondary windings in low turn-ratio reduce the voltage stress of the secondary rectifiers, contributing to achievement of high efficiency. Here presents a high step-up topology employing a series connected forward flyback converter, which has a series connected output for high boosting voltage-transfer gain. A MATLAB/Simulink model of the Photo Voltaic (PV) system using Maximum Power Point Tracking (MPPT) has been implimented along with a DC/DC hardware prototype.

KEYWORDS: PV Model Parameter, Insolation, Dual-Voltage Doubler Circuits, Voltage Gain, Nondissipative snubber, Forward-Flyback Converter, MPPT Technique.

I.INTRODUCTION

One of the primary objectives of the forward flyback converter is to achive a high step up voltage gain, it make the converter for the utilisation of Photo Voltaic applications. In day by day our source of energy like oil, gas and water is decreasing, so we have to use the never ending energy like wind and solar. For using this type of energy we have to modify the existing circuitry or model suitable for this type of inputs. Such a model of converter system is introduced here. This converter input is provided by using a solar sell. In this new design a nondissipative snubber, is utilized to reduce voltage stress on the switch and a forward flyback converter, which transfer the maximum power to the load.

In this paper, it proposes a high step up forward flyback converter with nondissipative snubber for solar energy application. To enable high step-up gain and conversion efficiency with appropriate duty cycles, numerous researchers have high-efficiency nonisolated high step-up converters. These nonisolated converters for high step-up applications are used with switched-capacitor converters, voltage multipliers, cascaded converters and coupled inductors to obtain high step-up gain and to recycle leakage energy in order to improve efficiency. However, the high step-up gain of nonisolated converters cannot satisfy the requirements of the galvanic isolation standards. Thus, some isolated high step-up converters have been developed. These converters can be used with coupled inductors integrated with isolated transformers, voltage multipliers, coupled inductors integrated with voltage multipliers, primary-parallel–secondary-series structures integrated with coupled inductors and two coupled inductors in series with voltage multipliers. Despite the benefits, these isolated converters require two or more drive signals, which increase the complexity of the circuit design. The voltage stresses on the transformer winding and output diode are very high in the conventional isolated converters (e.g., flyback converter, forward converter, push–pull converter, and full-bridge converter). In a nondissipative snubber, which is utilized to reduce voltage stress on the switch, was presented in a forward flyback converter. It is well known that low efficiency results from the magnetized power transferred by a flyback transformer.

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In order to obtain high efficiency, a high step-up forward flyback converter with a nondissipative snubber is presented. For this, a forward and a flyback converter are fabricated on the secondary side to achieve high voltage gain.

II.LITERATURE SURVEY

Nondissipative LC turn-off snubber reduces the voltage stress on a switching transistor, which is caused by the energy stored in the transformer leakage inductance. The LC snubber has the advantage over the conventional RC snubber, in that the power dissipation by snubber resistor is eliminated [1]. Developments of a photovoltaic array maximum power point tracking techniques are discussed. It describes many different techniques for maximum power point tracking of photovoltaic (PV) array. It shows that 19 distinct methods have been introduced with many variations on implementation [2]. Develop a simulation model of PV array [4], [5]. Nonisolated converters for high step-up applications are used with coupled inductors [8], [14] to obtain high step-up gain and to recycle leakage energy in order to improve efficiency. However, the high step-up gain of nonisolated converters cannot satisfy the requirements of the galvanic isolation standards. Thus, some isolated high step-up converters have been proposed. These converters can be used with coupled inductors integrated with isolated transformers [10], voltage multipliers [11], coupled inductors integrated with voltage multipliers [12], primary-parallel–secondary-series structures integrated with coupled inductors [3]. The proposed topology has high step up voltage gain and low stress on switching device.

III.ISOLATED HIGH STEP-UP DC-DC CONVERTER

Isolation means existence of an electrical barrier between the input and output of the DC-DC converter. Fig.1 shows the existing step-up DC-DC converter.

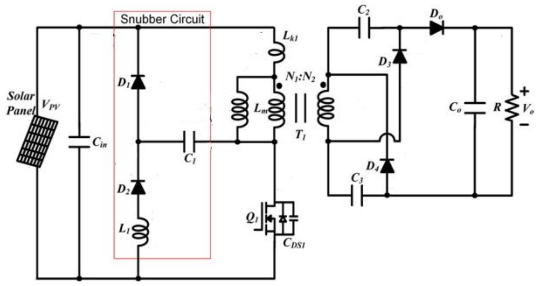

Fig. 1 Isolated high step-up dc–dc converter (Existing System)

This converter consists of the voltage of the solar panel V_{PV}, an input capacitor C_{in}, snubber diodes D_1 and D_2, a snubber inductor L_1, a snubber capacitor C_1, a coupled inductor T_1, a main switch Q_1, two step-up capacitors C_2 and C_3, two step-up diodes D_3 and D_4, an output diode D_o, an output capacitor C_o and an output load R. This system voltage gain is 8. But the modified system voltage gain is 9. The modified system is shown in Fig.2.

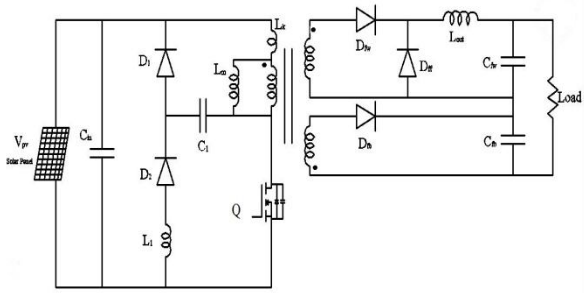

Fig. 2 Isolated high step-up dc–dc converter (Modified System)

Primary side is same as that of existing system; only the difference is in the secondary side of the transformer. The secondary side has a combination of forward and flyback converter. The converter consist of D_{fw} , the forward diode;

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D_{fb}, the flyback diode; D_{ff}, the freewheeling diode; C_{fw}, the forward capacitor; C_{fb}, the flyback capacitor and L_{out} , the output inductor. This converter has high voltage gain because of stacking the outputs of forward and flyback converter. The separate secondary winding reduces the voltage ratings of rectifying diodes. The energy stored in the nondissipative snubber capacitor is recycled to the voltage of the solar panel V_{PV} and the input capacitor C_{in}, thereby improving the system efficiency. Moreover, Maximum Power Point Tracking (MPPT) is important for solar energy applications. Here, the Perturb and Observe (P&O) algorithm is utilized to achieve an MPPT function for solar energy conversion applications.

IV.OPERATING PRINCIPLES OF THE PROPOSED CONVERTER

The proposed converter has seven operating modes as shown in Fig. 3 to Fig. 9.

Mode I: In this mode the diode D_1 is reverse biased. The switch Q is ON, current flows to the magnetizing inductance and the primary winding of transformer. The primary current is transferred to the secondary coil of the forward converter via the magnetic linkage. In this mode the capacitor C_1 releases energy to inductor L_1.

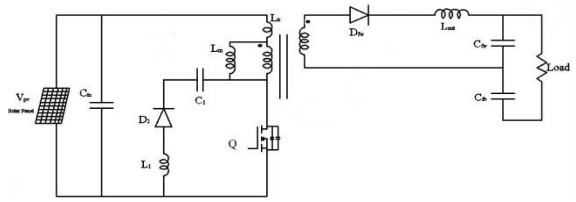

Fig. 3 Equivalent circuit of mode I

Mode II: The operating principle of the main circuit is same as mode I. The only difference is in the snubber circuit as shown in Fig. 4. The energy of inductor L_1 is recycled mainly to the load.

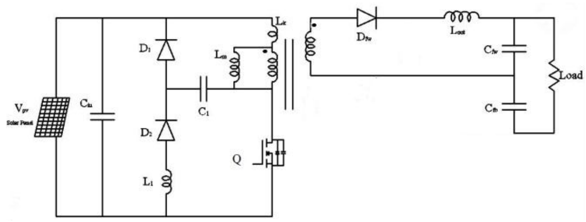

Fig. 4 Equivalent circuit of mode II

Mode III: The switch Q is ON as shown in Fig. 5. The energy stored in L_1 is zero so the snubber circuit is totally inactive. The main operating principle is same as mode II.

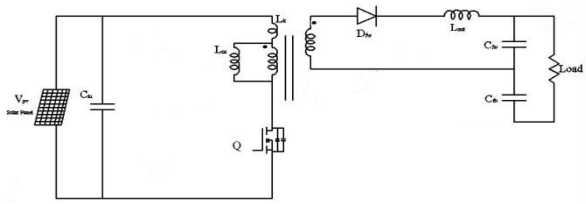

Fig. 5 Equivalent circuit of mode III

Mode IV: In this mode the switch Q, diode D_2 and diode D_{fw} is turned OFF as shown in Fig. 6. The leakage inductance current $i_{LK,}$ charges the snubber capacitor C_1 and parasitic capacitor of Q. The energy stored in L_{out} is transferred to load by the freewheeling diode. At the same time the energy magnetically stored at L_m is also supplied to the load through D_{fb}.

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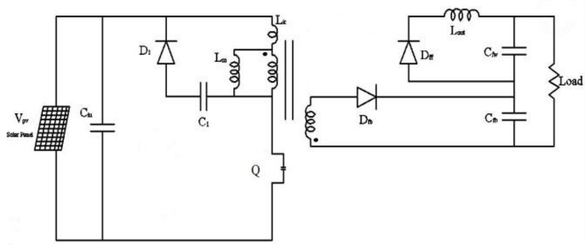

Fig. 6 Equivalent circuit of mode IV

Mode V: In this mode the operating principle is same as mode IV. The stored energy in C_1 is released to V_{pv},C_{in} and to the winding of flyback converter. Thus the leakage energy can be recycled.

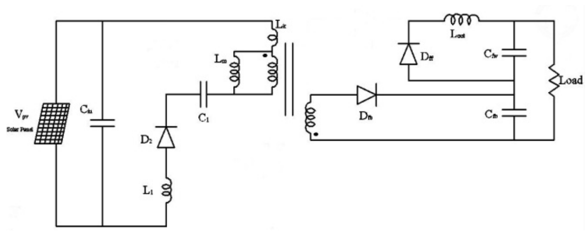

Fig. 7 Equivalent circuit of mode V

Mode VI: The leakage inductor current become zero. The magnetizing inductance L_m releases energy to the load via D_{fb}. In this mode the diode D_{ff} is turn OFF. In this mode the energy stored in L_m is only supplied to the load.

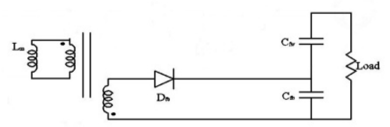

Fig. 8 Equivalent circuit of mode VI

Mode VII: The transformer of the forward flyback converter is demagnetized completely during this period and the output voltage is maintained by the discharging of the output capacitor. All the rectifier diodes are turn OFF as shown in Fig. 9.

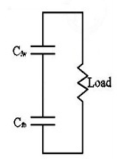

Fig. 9 Equivalent circuit of mode VII

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V:MATLAB/SIMULINK SIMULATION AND HARDWARE MODEL OF PV INTEGRATED DC-DC CONVERTER

In the simulation model the input voltage is 30V DC and gets the output as 274V DC. Fig. 10 shows the simulation model. The gate pulse given to the switch is using the P&O MPPT technique.

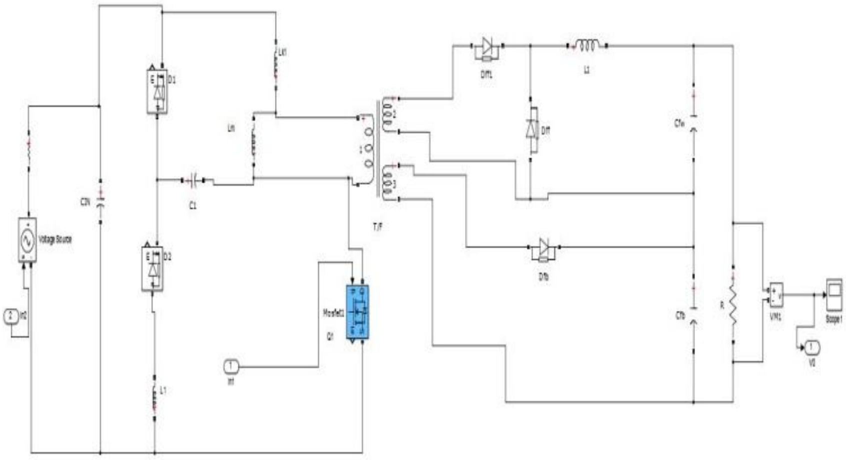

Fig. 10 Matlab simulation model

The experimental setup is shown in Fig. 11. It consists of a controller board, driver board and the forward flyback converter circuit board design.

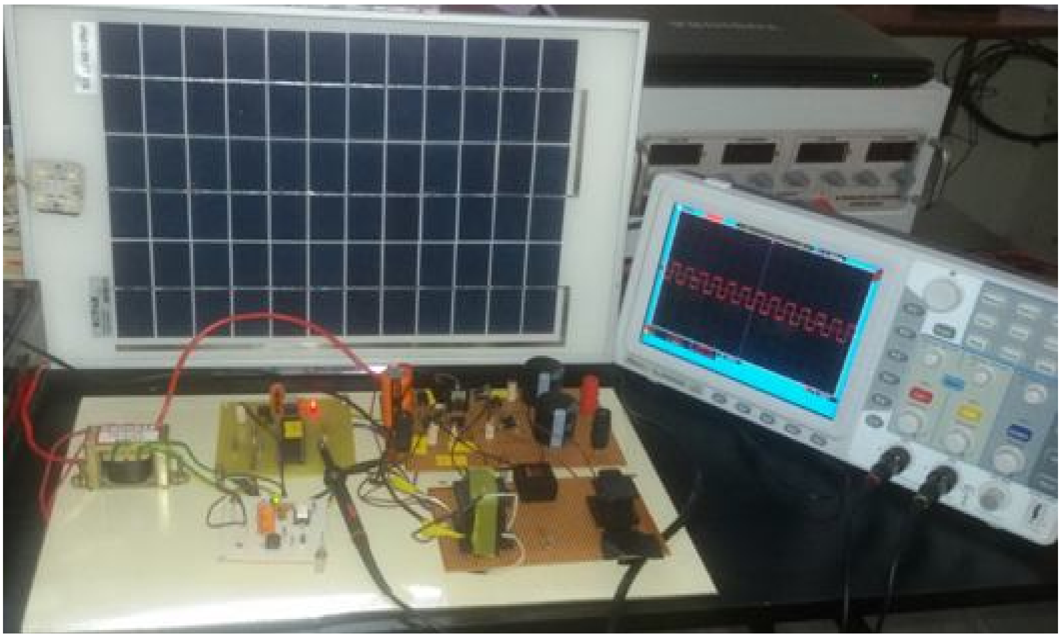

Fig. 11 Experimental setup

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VI. RESULT AND DISCUSSION

Fig. 11 shows the input and output waveforms of the converter simulation model. It shows that input voltage is 30V and obtains the output as 274V DC.

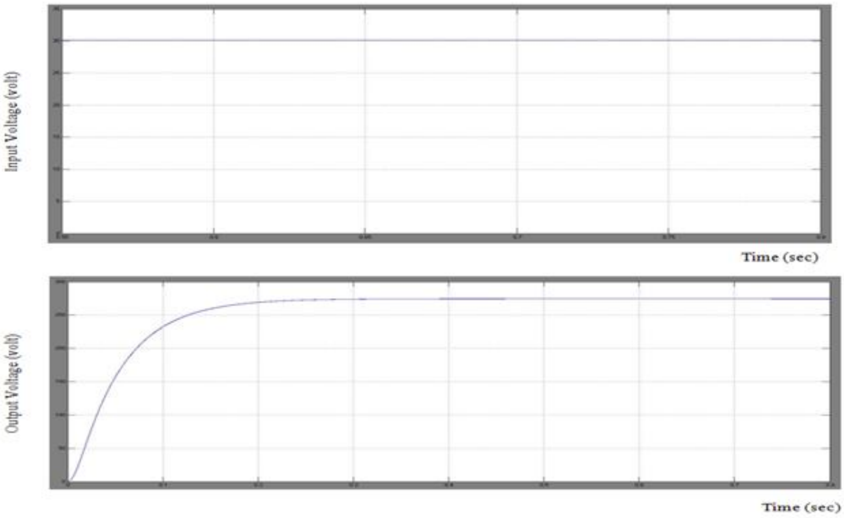

Fig. 12 Input and output waveforms

Fig. 12 shows the gate pulse given to the switch using MPPT technique. This gate pulse is obtained in the matlab simulation model. In the hardware design this pulse is generated using ATMEGA16 microcontroller.

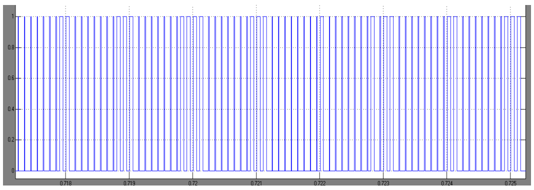

Fig. 13 Gate pulse

VII.CONCLUSION

PV module has been developed and verified using MATLAB/Simulink. The simulation model of PV is developed using the mathematical equations and basic math functions. There is an isolated coupled-inductor integrated DC-DC converter with a nondissipative snubber. The proposed converter topology has larger voltage gain as that of existing converter topology. It consists of a combination of forward and flyback converter on the secondary side. By stacking the outputs of them, extremely high voltage gain can be obtained. The energy in the coupled inductor leakage inductance can be recycled via a nondissipative snubber on the primary side. The separated secondary windings in low turn-ratio reduce the voltage stress of the secondary rectifiers, contributing to achievement of high efficiency. The detailed simulation diagrams and the corresponding waveforms have been provided. The result shows that high stepup voltage gain and high efficiency are achieved. A hardware prototype of DC-DC converter is also developed.

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