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Mppt Controlled Dc-Dc Converter Using Passive Absorption Circuit

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Abstract: This paper introduces the use of the voltage multiplier technique and passive absorption circuit applied to the non-isolated dc-dc converter in order to obtain high efficiency and high voltage gain. A passive absorption circuit is inserted in the interleaved flyback converter to transfer the leakage energy to load. The operation principle of the circuit is explained. This paper also deals with MPPT controlled high step up dc-dc converter. The switching element used in the flyback converter is MOSFETs, which is completely on and completely off. This is because MOSFET has high power rating and high switching speed. Moreover, high voltage conversion ratio is achieved. The simulated results are presented with R load.

Keywords: Interleaved flyback converter, passive absorption circuit, high voltage gain

1 INTRODUCTION

A DC-DC converter is a device that accepts a DC input voltage and produces a DC output voltage. In many industrial applications, it is required to convert a fixed voltage dc source into variable voltage dc source. Typically the output produced is at a different voltage level than the input. In any type of DC-DC converter circuit, the selection of power device for a particular application not only the required voltage and current levels but also its switching characteristic. The key parameters to look for in the MOSFET are the switching time and current rating. These two parameters greatly affect the maximum switching frequency of the converter. Because switching speed and associated power losses are very important in the power electronics circuits. For example, the BJT is minority carrier device, whereas the MOSFET is a majority carrier device that does not have minority carrier storage delays, giving the MOSFET advantage in switching speeds. BJT transistor switching time may be a magnitude longer than for the MOSFET. Therefore, the MOSFET generally has lower switching losses. A DC-DC converter is normally chosen because of its high efficiency in converting the input power to output power. The switching element used in this flyback converter is MOSFET, which is completely off and completely on. This is because MOSFET has high power rating and high switching speed. Active clamp circuits are added to the high step up converter to realize soft switching performance and recycle leakage energy. But, active clamp circuits rarely contribute to the voltage gain, and the dead time between main switch and clamp switch causes duty loss. A passive clamp circuits are also developed in many high step up topologies, but those circuits have limited contribution to output voltage gain. Therefore it is important to develop a general passive clamp circuit which can clamp spike of MOSFETs, recycle the energy of leakage inductor to output and also have high voltage step up ability. Photovoltaic (PV) source is one of the significant players in the world's energy portfolio, and it will make one of the biggest contributions to electricity generation among all the renewable energy candidates by 2040, because it is a clean, emission-free, and renewable electrical generation source with high reliability. The output voltage generated by the photovoltaic arrays, the fuel stacks, the super capacitors or the battery sources is relatively low, even lower than 48V. It should be boosted to a high voltage, such as 380V for the full bridge inverter or 760V for the half bridge inverter in the 220V AC grid-connected power system. How to realize high step-up DC/DC converters with high performance is one of the main issues in the renewable energy applications. The limitations of the conventional flyback converter are analyzed and the conceptual solution for high step-up conversion is proposed in this paper. The key problems and the major concerns in the non isolated high-step-up PV grid-connected power applications can be summarized in the following two aspects.

1) Cost issue: The extreme duty cycle that exists in the conventional boost converters should be avoided to minimize the current ripple and to reduce the numbers of the electrolytic capacitors, which can reduce the circuit cost and can easily achieve the MPPT algorithms.

2) Efficiency issue: The high switch voltage stress that exists in the conventional boost converters in high-output voltage applications should be decreased to reduce the conduction losses and the power device cost. Furthermore, soft-switching performance should be achieved to reduce the switching losses and to improve system efficiency.

2 FLYBACK CONVERTER

The flyback converter is based on the buck-boost converter. Its derivation is illustrated in Fig. 1. Figure 1(a) depicts the basic buck-boost converter, with the switch realized using a MOSFET and diode. In Fig. 1(b), the inductor winding is constructed using two wires, with a 1:1 turns ratio. The basic function of the inductor is unchanged, and the parallel windings are equivalent to a single winding constructed of larger wire. In Fig. 1(c), the connections between the two windings are broken. One winding is used while the transistor Q1 conducts, while the other winding is used when diode D1 conducts. The total current in the two windings is unchanged from the circuit of Fig. 1(b); however, the current is now distributed between the windings differently. The magnetic fields inside the inductor in both cases are identical. Although the two-winding magnetic device is represented using the same symbol as the transformer, a more descriptive name is "two winding inductor". This device is sometimes also called a "flyback transformer". Unlike the ideal transformer, current does not flow simultaneously in both windings of the flyback transformer. Figure 1(d) illustrates the usual configuration of

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the flyback converter. The MOSFET source is connected to the primary-side ground, simplifying the gate drive circuit. The transformer polarity marks are reversed, to obtain a positive output voltage. A 1: n turns ratio is introduced; this allows better converter optimization.

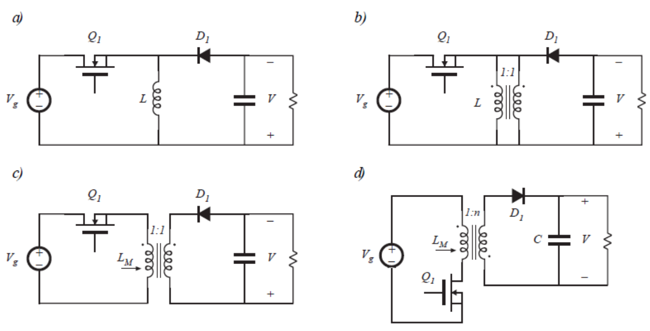

Fig. 1 Derivation of the flyback converter: (a) buck-boost converter, (b) inductor L is wound with two parallel wires (c) inductor windings are isolated, leading to the flyback converter, (d) with a 1: n turns ratio and positive output.

Applications of flyback converter

1. Low power switch mode power supplies (cell phone charger, standby power supply in PCs).
2. High voltage supply for the CRT in TVs and monitors.
3. High voltage generation (xenon flash lamps, lasers copiers, etc...).
4. Isolated gate driver.

3. PASSIVE ABSORPTION CIRCUIT

Usually, the conventional boost converter cannot realize high voltage gain even with high duty cycle due to the parasitic parameters limitation. Thus a lot of high step-up converters are developed which are mainly composed by coupled inductor, switched capacitor and cascaded methods [4-10]. In order to realize soft switching performance and recycle leakage energy, active clamp circuits are added [4-10]. However, active clamp circuit needs more MOSFETs and complicated control method. Furthermore, active clamp circuits rarely contribute to the voltage gain, and the dead time between main switch and clamp switch causes duty loss [8] Simple passive clamp circuits are also developed in many high Step - up topologies, but those circuits have limited contribution to output voltage gain [9]. Therefore it is important to develop a general passive clamp circuit which can clamp spike of MOSFETs, recycle the energy of leakage inductor to output and also have high voltage step-up ability. The passive absorption clamp circuit which is composed by two diodes and one capacitor. The passive absorption clamp circuits are employed to clamp main switch voltage spike and transfer the leakage energy to output.

Advantages of using passive absorption circuit

1. Recycle the energy of leakage inductor to output.
2. High voltage gain can be achieved.
3. Voltage spikes of MOSFETs are clamped.
4. Gives high efficiency.

4 .FLYBACK CONVERTER WITH PASSIVE ABSORPTION CIRCUIT

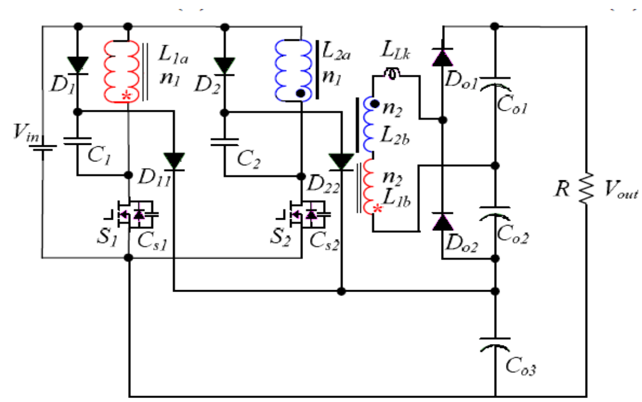

Fig. 2 Flyback converter with passive absorption circuit

The passive absorption clamp circuit consists of two diodes and one capacitor. Fig. 2 shows flyback forward dc-dc converter with passive absorption circuit. Passive absorption clamp circuits are employed to clamp main switch voltage spike and transfer the leakage energy to output. There are two coupled inductors in the proposed high step-up converter, which are named L1 and L2. The primary inductors L1p and L2p with np turns are coupled with secondary inductors L1s and L2s with ns turns. The coupling references are remarked as "*" and ".". The secondary windings of L1 and L2 are in series to achieve boost-type conversion. Llk is the summation of the leakage inductance of the two coupled inductors. D1, D11, D2 and D22 are rectifier diodes, C1 and C2 are self-lift capacitor, Co1, Co2,Co3 are output capacitors. Do1 and Do2 are output rectifier diodes. Capacitors CS1 and CS2 are the parasitic capacitors of S1 and S2 respectively. D1, D11, and C1 compose the passive absorption clamp circuit, thus the leakage energy can be recycled and the spike voltage of main switch S1 can be clamped. Based on the influence of leakage inductance, there are two typical operation modes. The first one is the small leakage inductance operation and the other one is the large leakage inductance mode. When the leakage inductance is low, the working waveforms are as follows. Two 180 ° out-of-phase gate signals with the same duty cycle are applied to S1 and S2. Based on the steady state, there are 12 operational modes in a switching period. Due to the symmetry of the circuit, 6 models are analyzed briefly. The mode of operation is explained below.

MODE 1: S1, S2 in on state.During mode1 capacitor C1 being charging. Output diode D01 are in reverse biased while Do2 is positive biased. The capacitor Co1 discharges through the diode Do2.

MODE 2: The current in Do2 decreases to 0.Both Do1 and Do2 are reverse biased. The two coupled inductors operate in flyback state to store energy. The energy to the load is sustained by the output capacitors Co1, Co2 and Co3.

MODE 3: The main switch S2 is turned off, which makes the voltage flows through the parallel capacitor CS2.Because of large winding and small parallel capacitor, this interval is short. During this mode the diode Do1 conducts.

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MODE 4: The voltage on CS2 increases to its maximum limit and the diode D22 conducts. The current in L2a decreases in linear way. Both the current in L1a and Do1 increases in a linear way. During this stage, the coupled inductor L1a operates in forward mode and L2a works in flyback mode to transfer energy to the load.

MODE 5: The current in L2a decreases to 0. Then the voltage on capacitor CS2 reduces to zero. During this stage the current in diode Do1 reduces slowly.

MODE 6: The main switch S2 turns on with zero voltage switching (ZVS) performance. The secondary diode Do1 is still in the conduction state. At mode6, the leakage current decreases to zero and the diode D01 turns off with zero current switching (ZCS) operation. Then the two primary inductors are charged linearly by the input voltage.

The operation of MODE (7to12) is similar to that of MODE (1to6). The passive clamp circuit can absorb the turnoff voltage spikes on the main switches S1 and S2, and recycle the leakage energy.

5. SIMULATION RESULTS

Digital simulation is done by using the elements of MATLAB Simulink and the results are presented here.

A. high step up dc-dc converter with dc source

The Simulink diagram of Non-isolated high step-up converter with R-Load is shown in Fig 3. The voltage and current measurement blocks are connected to measure the output voltage and output current. DC input voltage and current are shown in the Fig 4.The gating pulses for the switch is shown in Fig 5.The output current and output voltage is shown in the Fig. 6.

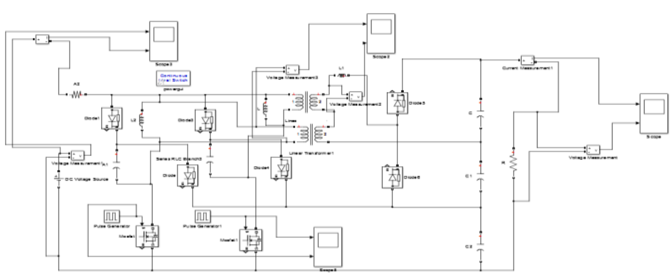

Fig.3 Circuit Diagram of interleaved flyback converter with R-load.

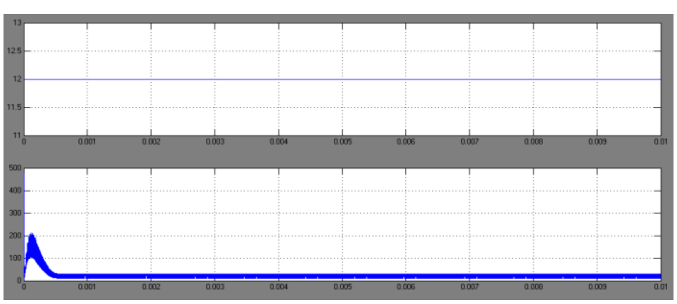

Fig.4 Input Voltage and Input current for the converter

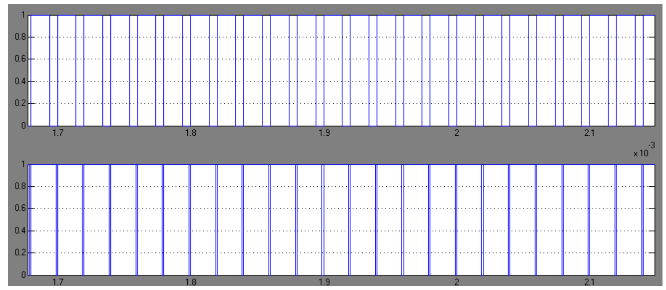

Fig.5 Gate pulses for MOSFETs

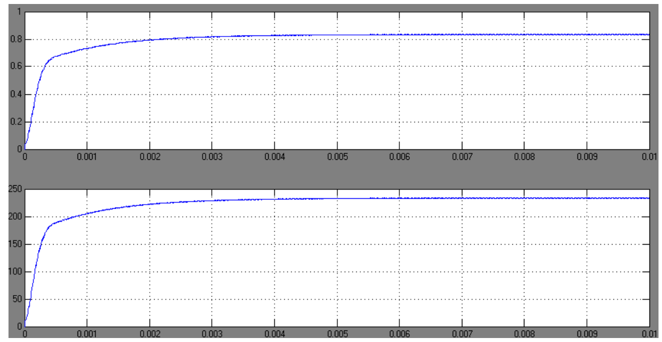

Fig. 6 DC output voltage and current

B. high step up dc-dc converter with PV panel as source

The simulink diagram of Non-isolated high step-up converter with PV panel as source is shown in Fig 5. The voltage and current measurement blocks are connected to measure the output voltage and output current. DC input voltage and current are shown in Fig 6. The output voltage and output current is shown in Fig 7.

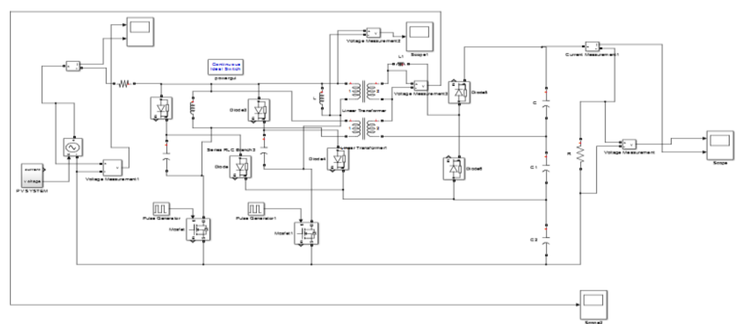

Fig. 5 Circuit Diagram of interleaved flyback converter with PV panel as source.

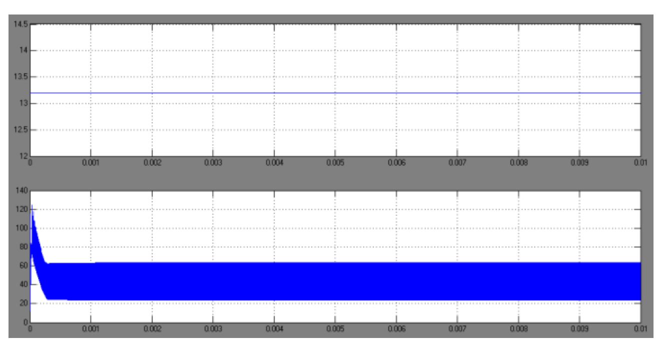

Fig. 6 Input voltage and Input current for the converter

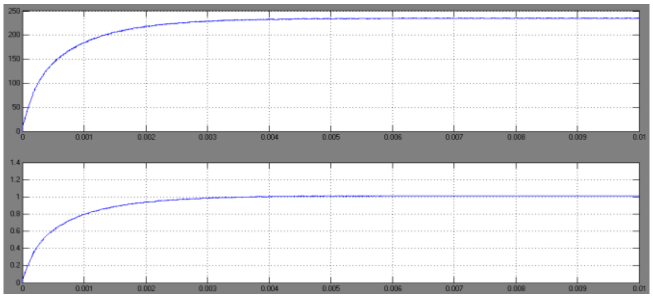

Fig .7 Output voltage and output current of the converter

C. high step up dc-dc converter with MPPT technique

The simulink diagram of Non-isolated high step-up converter with PV panel as source and gate pulse for MOSFETs given by MPPT technique is shown in Fig 8. The voltage and current measurement blocks are connected to measure the output voltage and output current. DC input voltage and current are shown in Fig 9. The output voltage and output current is shown in Fig 10. The gate pulse for MOSFETs are shown in Fig 11.

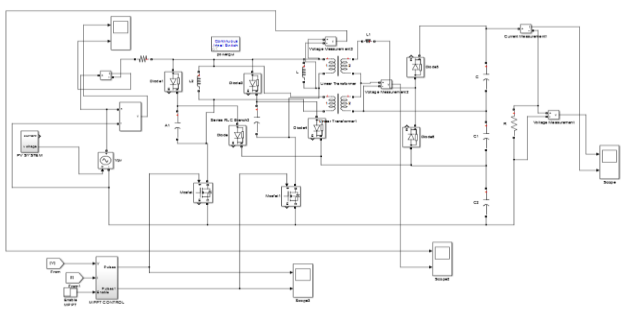

Fig. 8 Circuit diagram for high step up dc-dc converter with MPPT technique.

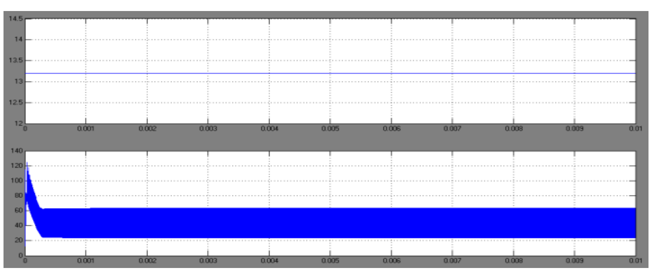

Fig. 9 Input voltage and current for the converter.

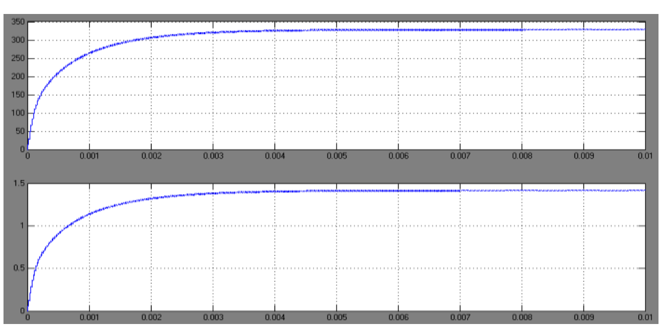

Fig. 10 Output voltage and output current of the converter

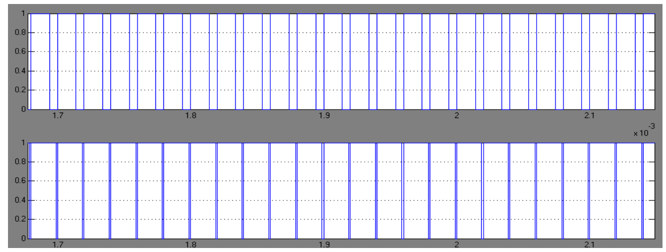

Fig. 11 Gate pulses for MOSFETs

6. DESIGN SELECTION FOR SIMULATION

Selection of right converter for specific application is an important task for the users. The following are the few criteria to be considered in the selection of appropriate topology of the converter for a particular application.

Vin=12V

L1, L2 = (1-D)2DR/2F
C01, C02, C03= (DV0) VrRF
C1,C2=V0TS/4R
Fs= 50Khz
V0/Vs = D/n(1-D)
n- transformer turns ratio.

7. CONCLUSION

A high step-up dc–dc converter has been presented in this paper. The coupled-inductor and passive absorption circuits are integrated in the proposed converter to achieve high step up voltage gain. The energy stored in the leakage inductor of the coupled inductor can be recycled. The improved Flyback-Forward converter with passive absorption circuit has been proposed. By the proposed passive absorption circuit, the number of switch devices can be reduced, the output voltage can be lifted dramatically. The high step-up voltage gain and high efficiency can be achieved. Because the passive absorption circuit can transfer the leakage energy to the load, the improved Flyback-Forward converter has little influence on the leakage inductance of coupled inductor.

8. ACKNOWLEDGMENT

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