Closed loop control of an Improved Dual switch Converter With Passive Lossless Clamping For High Step-Up Voltage Gain

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Abstract—The conventional dc-dc boost converters are unable to provide high step up voltage gain. The transformer less dc-dc converters are used to achieve high step up voltage gain without an extremely large duty ratio. The improved dual switch converter can achieve high voltage gain with a condition that the parameters are inconsistent. It has advantages of low voltage and current stress on the switches compared to the transformer less dc-dc converters. The proposed converter also provides the solution to balance the voltage on the switches and to suppress the resonance. This is possible due to the presence of passive lossless clamping. With the passive lossless clamping circuits, low voltage switches with small Rds (on) can be utilized, and hence the efficiency of the converter can be increased. The simulation of the circuit with 30 V input, 100V/1A output is done using MATLAB.

  Keywords—highstep-upvoltagegain,   passivelossless clamping, parameters are inconsistent,resonance.

Introduction

  The voltage conversion ratio of a traditional boost converter is limited. various technologies have been developed to provide a high step-up voltage gain. The traditional boost converter is hard to provide a large voltage conversion ratio. A large duty cycle is introduced that brings high conduction loss, and the peak current may impact the capacitors. The isolated converters will boost the voltage by increasing the turns ratio of the high frequency transformers. By using the multistage dc to ac to dc power conversion, the cost is increased because many isolated sensors and feedback controllers are required. But the main limitation of the leakage inductance should be handled carefully or it may cause high voltage spikes. The coupled inductors can serve as a transformer that is used to enlarge the voltage gain in transformer less dc/dc converters. By increasing the turns ratio, high voltage gain can be easily achieved but the leakage inductance of the coupled inductors is inevitable. It may also cause high voltage spike, which will increase the voltage stress. The switched inductor boost converter can provide a high

voltage conversion ratio, but the voltage stress on the power switches is relatively high. The switched capacitor boost converter can provide a high voltage conversion ratio, whereas multiple diode-capacitor units are utilized with low power density. The cascade boost converter can provide a high step-up voltage, whereas this topology is complicated and the efficiency may deteriorate with a multistage structure. The transformer less dual-switch converter has inherent high step-up characteristic with low voltage and current stress on the power switches. This converter is composed of two inductors and two switches sharing the same operation signals. This topology is very simple,and the voltage and current stress on the power switches is low compared with that on the boost converter. One of the main peculiarity of the transformer less dual-switch converter with passive lossless clamping is that its consistency. Else, the inductors and parasitic capacitors will constitute resonance circuit, which induces increased voltage stress and reduced efficiency. Passive lossless clamping is adopted to balance the voltage across the switches and to suppress the resonance. With the passive lossless clamping circuits, low voltage switches can be utilized, and the efficiency of the converter can be improved. Compared with the two stage boost converter, it has the same amount of power switches and passive components. However the converter has the advantages of the voltage stress across power devices is relatively low compared to the secondary stage of the two-stage boost converter and the system stability of the cascade structure is another issue which can be avoided. The voltage conversion ratio remains high, thus making the converter more suitable for step up dc-dc power conversion. The converter is simulated using MATLAB. Output levels are obtained as per the design values for both converter operations. Simulation results conveys the operability of the dual switch converter with passive lossless clamping structure.

LITERATURE SURVEY

The dc-dc converters with high step up voltage gain is widely used in many applications such as lasers, fuel cell energy conversion systems, X-ray systems, solar cell energy conversion systems, and high

intensity-discharge lamp ballasts for automobile headlamps. Theoretically, a dc–dc boost converter can achieve a high step up voltage gain with an extremely high duty ratio [1]–[3].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.

The conventional boost converter is used to provide a voltage conversion ratio with low voltage gain. It is hard to provide a large voltage conversion ratio, due to a large duty cycle that brings high conduction loss, and the large peak current may impact the capacitors seriously. Various topologies have been developed to provide a high step up voltage gain without an large duty ratio [4]. The isolated converters will boost the voltage by increasing the turns ratio of the high frequency transformer [5]-[6]. However, it may cause increased weight, volume, high switching losses, high electromagnetic interference. And also the leakage inductance should be carefully handled [7]-[9]. Otherwise, there will be a voltage spike across the power switches. The transformer less dc/dc converters are used instead of the isolated converters. The coupled inductors are used to achieve high voltage gain in the transformer less dc/dc converters. By increasing the turn's ratio, high voltage can be easily achieved [10]-[13]. Unfortunately, the leakage inductance of the coupled inductors is also inevitable. And also it may cause high voltage spike, that will increase the voltage stress [14],[15].

The non coupled inductor type transformer less converters are used such as the switched-capacitor-inductor converters. A small resonant inductor is used in these converters to limit the current peak caused by the switched capacitors. Here the voltage stress on the switch is smaller than the voltage stress on the switch in conventional boost converter [16]-[18]. The switched inductor multilevel boost converter [19]-[21] is having a single stage dc-dc boost converter topology with very large voltage conversion ratio based on the pwm technique. A high switching frequency is employed to decrease the

size of these components. But the voltage stress on power switches are relatively high. The switched capacitor boost converter [22]-[24] can provide a high voltage conversion ratio, where as the multiple diode-capacitor units are utilized with low power density. The cascade boost converter can provide a high step-up voltage, where as this topology is complicated and the efficiency may deteriorate with a multistage structure.

Many topologies have been presented to provide a high step-up voltage gain without an extremely high duty ratio [25]-[26]. A dc-dc fly back converter is a very simple structure with a high step-up voltage gain and an electrical isolation, but the active switch of this converter will suffer a high voltage stress due to the leakage inductance of the transformer. Transformer less dc-dc converters, which include the cascade boost type [27] which are complex and having a higher cost. The modified boost type with switched inductor technique is shown in Fig.1 [28]
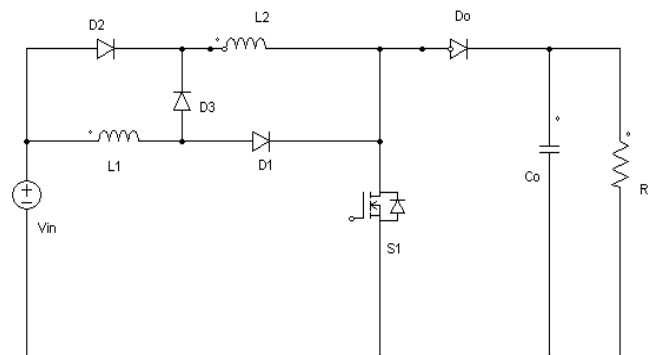

Fig. 1. Modified boost type with switched inductor technique

The structure of this converter is very simple. Only one power stage is used in this converter. But it has mainly two issues: 1) Three power devices exist in the current flow path during the switch-on period, and two power devices exist in the current flow path during the switch-off period, and 2) the voltage stress on the active switch is equal to the output voltage. A transformer less dc-dc high step up converter is shown in Fig.2 [29]. Compared with the converter [28], the proposed converter has the following merits: 1) Two power devices exist in the current flow path during the switch-on period, and one

power device exists in the current-flow path during the switch off period. 2) The voltage stresses on the active switches are less than the output voltage; and 3) under the same operating conditions, including input voltage, output voltage, and output power, the current stress on the active switch during the switch-on period is equal to half of the current stress on the active switch of the converter in [28]. The transformer less dual switch converter has an inherent high step-up characteristic with low voltage and current stress on the power switches [29]. However, the converter has very strict requirement of the device parameters consistency. Otherwise, the inductors and capacitors will constitute the resonance circuit, which induces increased voltage stress and reduced efficiency.

The improved dual switch converter with passive lossless clamping for high step-up voltage gain is works on the principle of device inconsistency. In the practical conditions the two inductors, the two parasitic capacitors and the switching speed of the two power switches are not exactly equal. Passive lossless clamping is adopted to balance the voltage across the switches and to suppress the resonance.
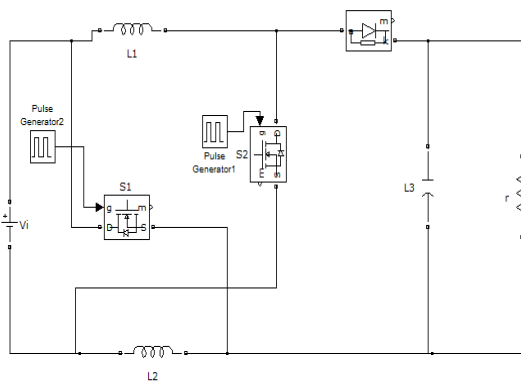

Fig.2 A transformer less dc-dc high step up converter

Fig. 3. Shows the Circuit configuration of the improved dual switch converter with passive lossless clamping for high step-up voltage gain. Switches S1 and S2 share the same operation signals; when the switches are turned on simultaneously, inductors L1 and L2 are parallel connected; and when S1 and S2 are turned off, L1 and $L2$ are series connected. The figure shows the solutions to suppress the resonance by dividing the original output diode D into two diodes D1 and D2, and a capacitor Cc is added to clamp the switches.
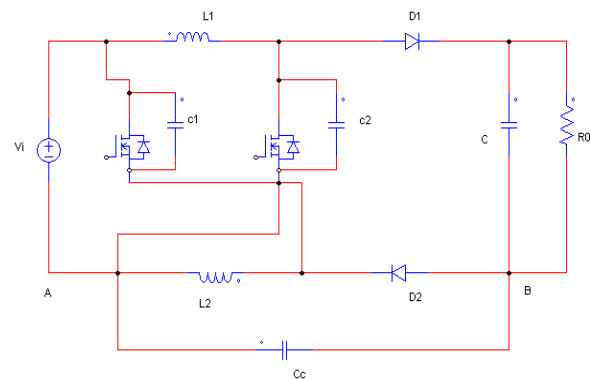

Fig. 3: Circuit configuration of the improved dual switch converter with passive lossless clamping for high step-up voltage gain

The voltage conversion ratio of the conventional boost converter is D/1-D whereas the voltage conversion ratio of the improved dual switch converter with high step-up voltage gain is 1+D/1-D. And also the voltage stress across the switches are half as compared to the transformer less dual switch converter. In order to simplify the design procedure, all the parameters are designed in the ideal conditions, and the switching transition time is too short and can be omitted.

SIMULATION RESULTS

The simulation of the improved dual switch converter with improved step up voltage gain has been carried out and the simulink model is shown in Fig. 4. An input voltage of 30V and switching frequency of 50 kHz is chosen and an output of 100V/1A is obtained. The duty ratios of both the switches are equal to 0.538 and the corresponding parameters are listed in Table I.

TABLE I.   PARAMETER VALUES OF THE SIMULATED CONVERTER

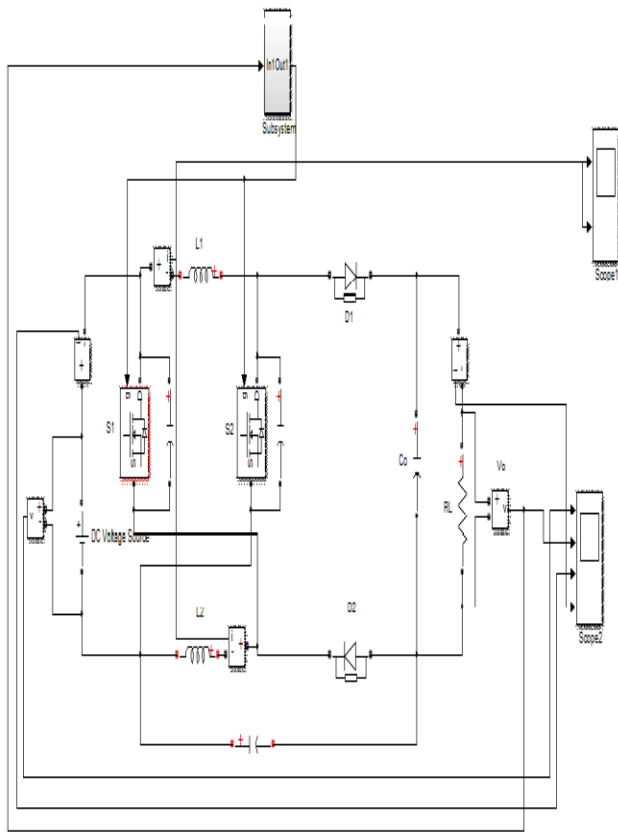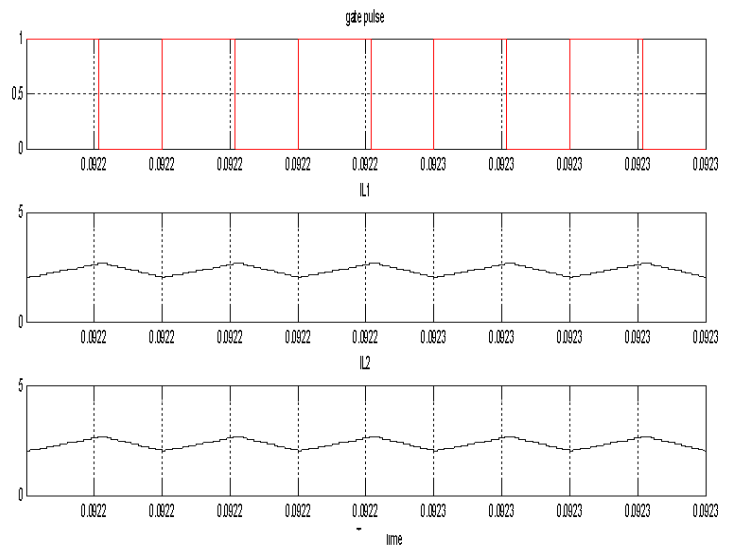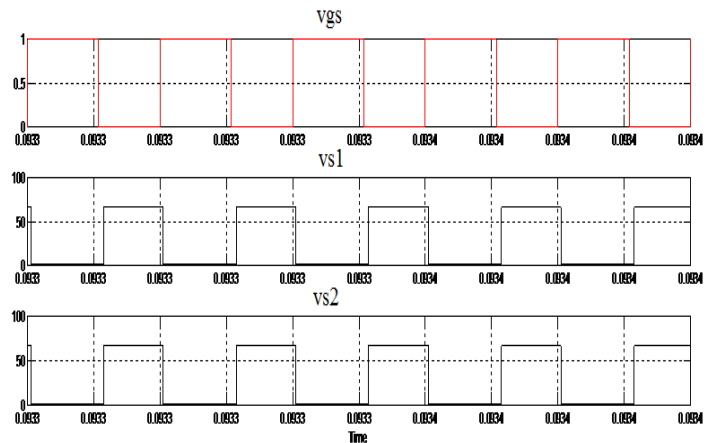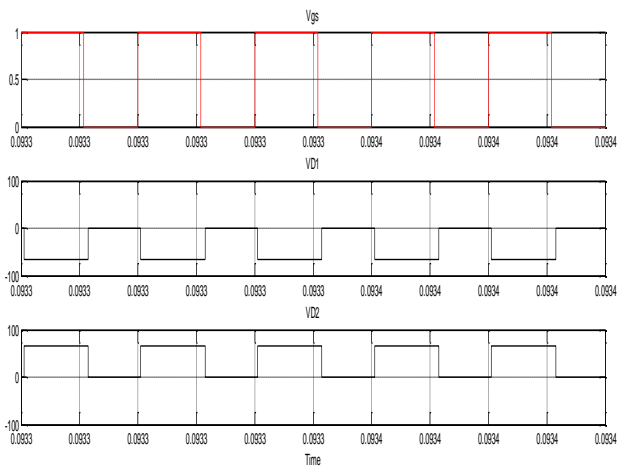| Parameters	Values
Input Voltage	30V
Output Voltage	100 V
Power Level	100 W
Switching Frequency	50kHz
L_1 and L_2	500µH
C	470 µF
Cc	1 pF
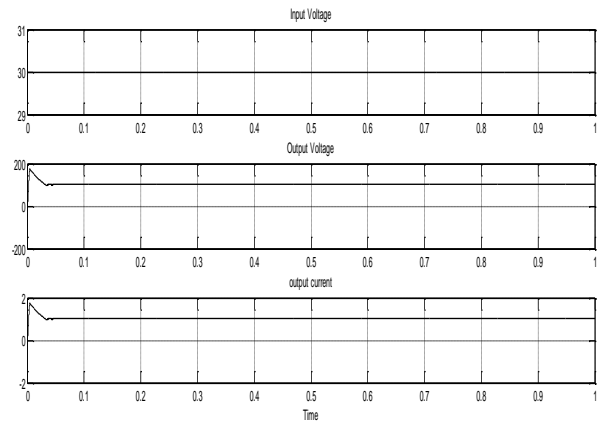
(a)

Fig. 4: Simulink model of the converter

(b)
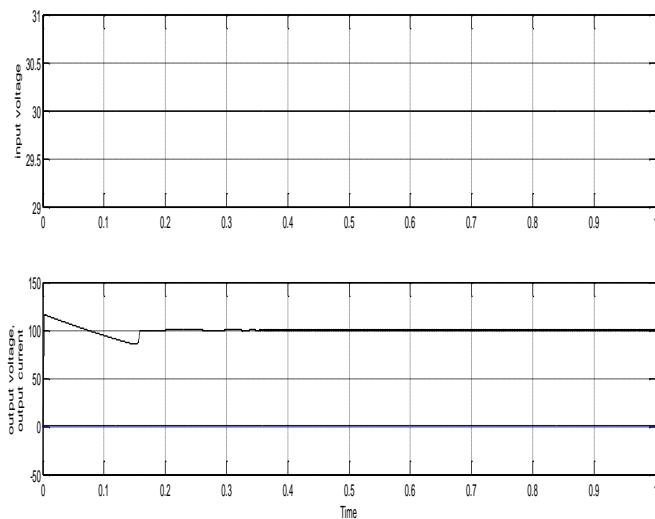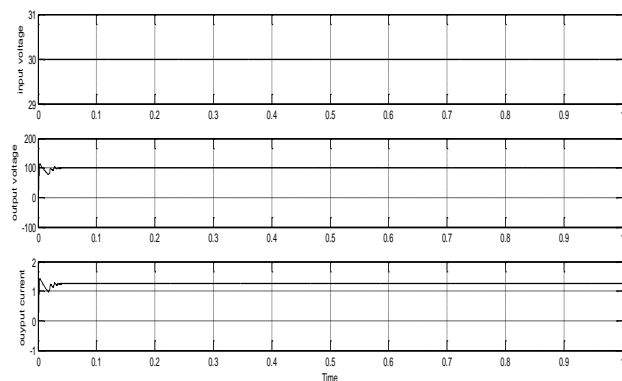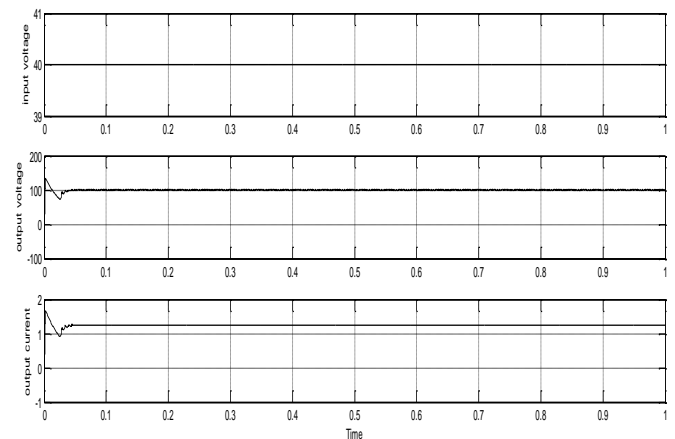

(c)

(d)

Fig. 5: Simulated key waveforms of the converter

Fig. 6: Load regulation of the converter

(a)

(b)

Fig . 7: Line regulation of the converter at (a)V_{in} = 30 V (b) V_{in} = 40V

Fig. 5(a). shows the input voltage (30 V), output voltage and output current waveforms. It is clear from Fig. 5(a) that the output current is continuous. It can be noted that the output voltage current is highly increased. The gate pulses applied to the two switches and the inductor current ripples of L_1, L_2 can be seen in Fig. 5(b). Fig. 5(c) shows the voltage stress of the switches and Fig. 5(d) shows the voltage stress of the diodes. The voltage stress of the diodes and the switches are approximately 50 V, i.e., approximately half the output voltage whereas in the conventional transformerless dual switch converter, the voltage stress of the semi-conductor devices are equal to the output voltage. The no load regulation can be seen in Fig. 6. The line regulation at Vin = 30 V and Vin = 40 V are given if Fig 7(a) and Fig. 7(b) respectively.

CONCLUSION

The main features of the improved dual switch converter with high step-up conversion ratio has been discussed. The main advantages of the converter compared to the two stage boost converter include: 1) The voltage stress across power devices is relatively low compared to the secondary stage of the two-stage boost converter. 2) The system stability of the cascade structure is another big issue; the proposed converter can avoid it. 3) The voltage-conversion ratio remains high, thus making the converter more suitable for step-up dc–dc power conversion (The simulation of the converter with 30 V input and 100V/1 A output has been carried out using MATLAB software.

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