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Design of Full Bridge BoostConverter with aFly back Snubber for High Power Applications

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ABSTRACT: This paper deals with thedesign of full bridge boost converter with a fly back Snubberfor high conversion ratio, high output power, and soft start-up capability. The fly back Snubber is the combination of a capacitor, a diode, and a fly back converter. It clamps the voltage spike caused by the current difference between the current-fedinductor and leakage inductance of the isolation transformer.At the current-fed side, fly back Snubberreduces the current flowing through the active switches.Thefull bridge step up converter with flybackSnubber has been simulated using MATLAB software and its possibility is checked with the simulated results of the conventional circuit without flybackSnubber.

KEYWORDS: Fly back converter, Isolated full-bridge bidirectional converter, soft start-up.

I.INTRODUCTION

In Boost converters, usethe MOSFET switch which operates in the low frequency range. The circuit size and capacitor rating are reduced becausefrequency increased inthe converter operation. The Switch is operated in 20 KHz frequency range. To attain near ZVS turn-on soft start up feature, the inductor is placed in series with the main switch or the diode gets slow down diode reverse-recovery current. In theseSnubber, theinductor caneasy reverse-recovery current and would gain switching loss. Thus, a Snubber capacitor is required to absorb the stored energy in the Snubber inductor and to clamp the switch voltage. But the energy stored in the Snubber capacitor is recycled through the main switch and resulting in high current stress. To release the high current stress, active Snubberis applied to the boost converter.

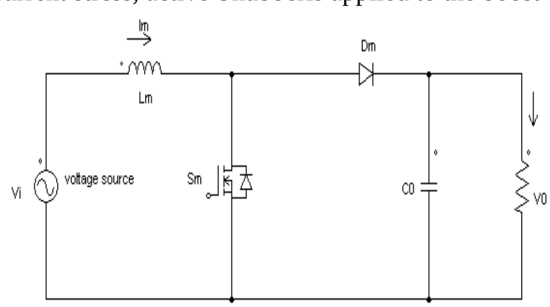

Fig.1 Normal Boost Converter

In renewableDC-supply systems, batteries are generallyrequired to back-up power for electronic equipment. Theirvoltage levels are very lower than the DC-bus voltage.Bi-directional converters are used in places where battery charging and regenerative braking is required. The power can flow in a bi-directional converter is usually from a low voltage side such as a battery or asuper capacitor to a high voltage side is called as boostoperation. The most of the DC-DC converters incorporate a high frequencytransformer.In boost converter, the output voltage is always greater than the input voltage. The main concept of this paper canreduce switching loss, voltagestress and current stress, and conduction loss due to circulation

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current. During switching transition, a more stern issue is due to leakage inductanceof the isolation transformer. Due to the leakage Inductance will raiseconduction loss and reduce effective duty cycle by the current freewheeling.

II. FLY BACK SNUBBER

It is a combination of clamping capacitor C_c, diode D & flyback converter forms a flyback Snubber. The energy absorbed in the clamping capacitor is fed back to the source. Here current does not circulate through the switches hence reduced stress.

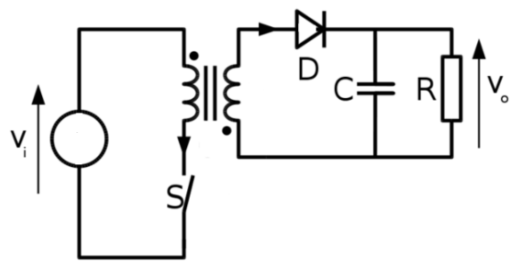

Fig .2FlybackConverter

The RCD Snubber that dissipates the stored energy through a resistor. In the clamping capacitor, thenflybackSnubberis recycling the absorbed energy. To regulate the voltage of the clamping capacitorcan be operated by the fly back Snubber. Therefore, the fly back Snubbercan compress the voltage to a preferred level slightly higher than the voltage across the low-side transformer winding.Under heavy-load condition, the current do not circulate through the full-bridge switches and the current stresses can be reduced significantly. During start-up,fly back Snubber can be controlled for pre-charge the high-side capacitor and it can improve visibility.

III. CIRCUIT CONFIGURATION

The converter consists of two modes, one is buck mode and another one is boost mode. It consists of two bridges: a current-fed bridge and avoltage-fed bridge. In a current-fed switch bridge, a fly back Snubber at the low-voltage side and a voltage-fed switch bridge on the high-voltage side. Alternatively, when power is transferred from the batteries to the high-voltage side is called as a boost mode. During switching commutation, clamp branch capacitor $C_C$and diode $D_C$is used to absorb the current difference between current-fed inductor $L_m$and leakage inductance $L_{ll}$and $L_{lh}$of isolation transformer T_x. The Snubber can be separately controlled to regulate $V_c$to the preferred value, which is slightly higher than V_{AB}.

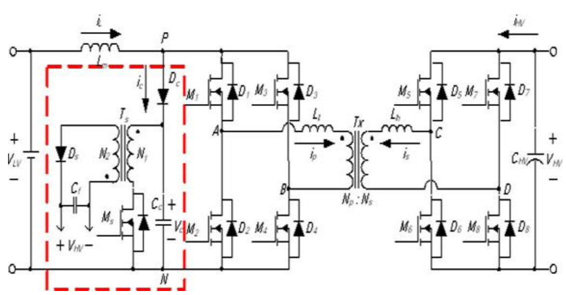

Fig.3 Boost Converter

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Therefore, the voltage stress of switches *M*1–*M*4 can be limited to a low level. It can include no spike current circulates through the power switches and clamping the voltage across switches *M*1–*M*4 and improving system reliability significantly. High spike current can result in over current density,charge migration, and extra magnetic force, which will depreciate in carrier density, channel width, and wire bonding and in turn increased its conduction resistance.

IV. CIRCUIT OPERATION

4.1 Step-Up Conversion

In a step up conversion, MOSFET switches *M*1–*M*4 are operated like a boost converter. The switch pairs are (*M*1, *M*2) and (*M*3, *M*4) are turned ON to store energy in L_m. The body diodes of switches *M*5–*M*8 will conduct to transfer power to V_{HV}, at the high voltage side. When theMOSFET switch pair (*M*1, *M*2) or (*M*3, *M*4) is switched to (*M*1, *M*4) or (*M*2, *M*3), the current difference ($i_C = i_L - i_P$) will charge the capacitor, and then, increase $i_P$up to i_L.TheSwitches M5-M8 are operated by synchronous switching to reduce conduction losses. In the current-fed side switches are mainly used to limit the transient voltage imposed by the clamp branch. To avoid over current by using the fly back converter can be controlled to charge the high-voltage-side capacitor. During both start-up and regular boost operation modes, the clamp branch and the fly back Snubber are activated. Duringstart-up and regular boost operation mode, a non phase-shift PWM is used to control the circuit to achieve a smooth transition.

$$P_C = \frac{1}{2} C_c (i_L Z_0)^2 + 2 i_L Z_0 V_{C(R)} \quad (1)$$

Where,

$$Z_0 = \sqrt{\frac{L_{eq}}{C_C}} \quad (2)$$

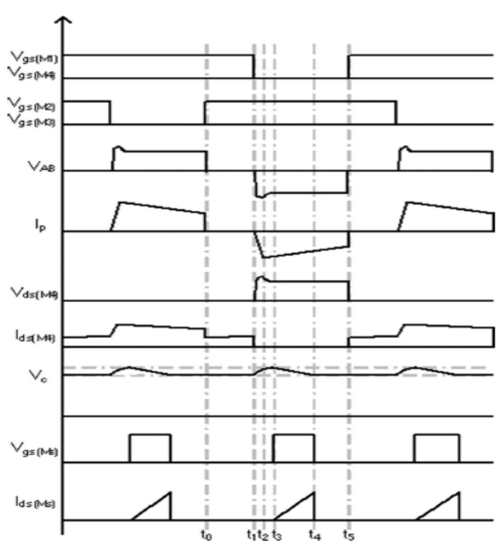

Fig.4 Operation Waveform of step up mode

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Mode 1 [$t_0 \leq t < t_1$]:

In Mode 1, the four MOSFET switches $M1$ *to* $M4$ are turned ON. At the low voltage sideV_{LV}, the inductor $L_m$gets charged, inductor current $i_L$increases linearly at a slope of V_{LV}/L_m, and the primary winding of the transformer is short-circuited.

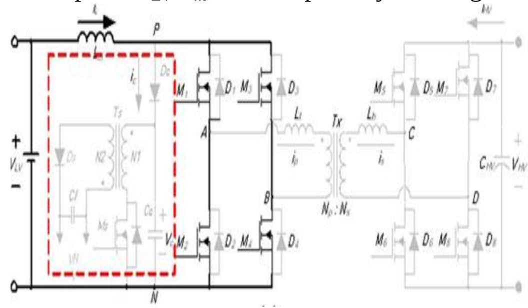

Fig .5 Mode 1

Mode 2 [$t_1 \leq t < t_2$]:

At t_1, the MOSFET switch$M1$ and $M4$ remain conducting, while $M2$ and $M3$ switches are turned OFF. At $t = t_{2,}$ Clamping diode $D_C$conducts awaiting the current difference ($i_L(t2) – i_P(t2)$) drops to zero. Additionally, the body diodes of switch pair ($M5$,$M8$) are conducting to transfer power. The current difference (($i_L(t) - ip\ (t)$) flows into clamping capacitor $C_{C,}$ during this interval.

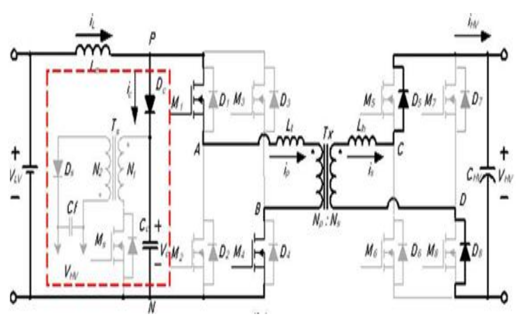

Fig . 6Mode 2

Mode 3 [$t_2 \leq t < t_3$]:

In mode 3, the clamping diode $D_c$stops conducting, and then flyback Snubber starts to operateat t_2. At the present time, clamping capacitor $C_c$is discharging, and flyback inductor is storing energy. The Switches $M1$ and $M4$ still stay in the turn ON state, while $M2$ and $M3$ remain OFF. The body diodes of switch pair ($M5$, $M8$) remain ON to transfer power. The equivalent circuit is shown in Fig.7.

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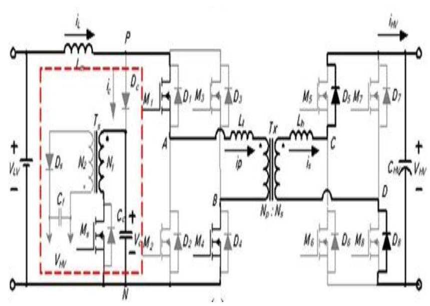

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Fig .7Mode 3

Mode 4 [$t_3 \leq t < t_4$]:

The flyback inductor is stored the energy is transferred to the high-voltage side,at t_3.During this interval, flyback Snubber will operate separately to regulate capacitor voltage $V_C$to $V_C(R)$. Alternatively, switches ($M1$,$M4$) and diodes ($D5$,$D8$) are still conducting to transfer power from low voltage side $V_{LV}$to high voltage sideV_{HV}.The equivalent circuit is shown in Fig.8.

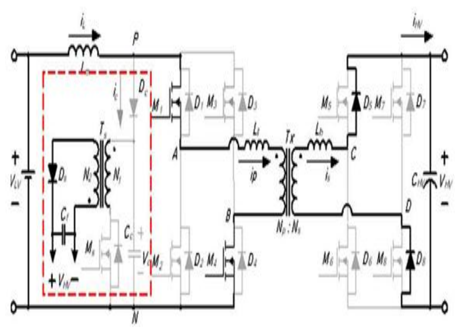

Fig .8Mode 4

Mode 5 [$t_4 \leq t < t_5$]:

In mode 5, the capacitor voltage $V_C$has been regulated to $V_C(R)$, and the Snubber is constant, at t_4. Afterthis interval, the power transfer from V_{LV} toV_{HV}.At t_5 ,half-switching cycle operations arestopped and completely. The equivalent circuit is shown in Fig.7.

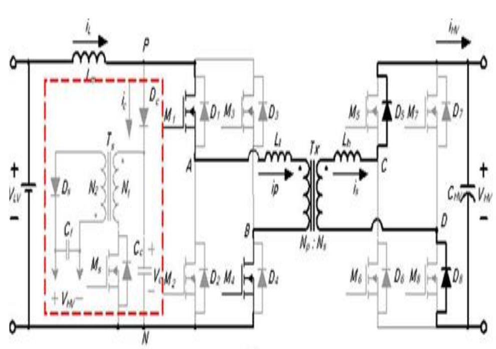

Fig .9Mode 5

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V. SIMULATION RESULTS

Considering the boost mode which has to step up an input voltage of 48V to an output of 360V.

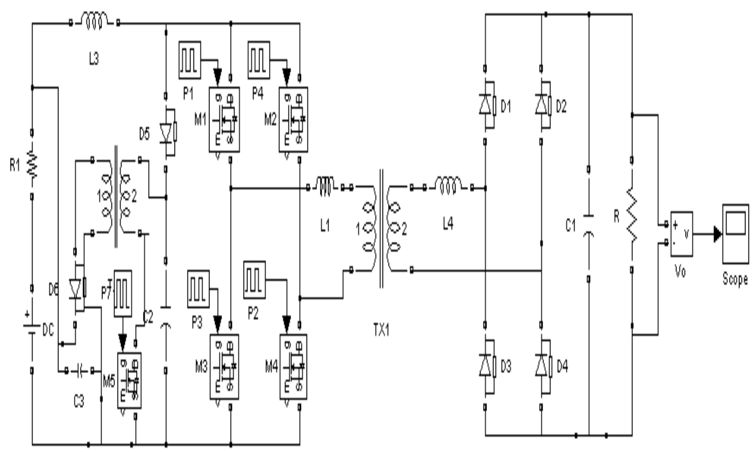

Fig.10Simulink of Boost Converter

Table 1:System Parameters

S.NO	Parameters	Values of simulation
1	Switching Frequency	25kHZ
2	HF Transformer Turns Ratio	4.26
3	Input Voltage	48V
4	Current-fed inductor	L=500µH
5	Clamping capacitor C_c	C=10µF
6	Filter capacitance	C=670µF
7	Output Voltage	360V
8	Output Power	1.5kW
9	Output Current	3.7Ampere

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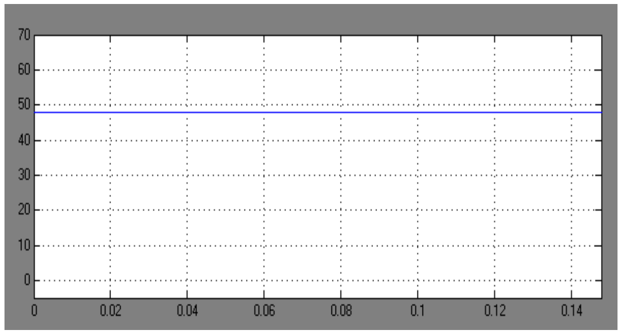

Fig.11Dc Input Voltage

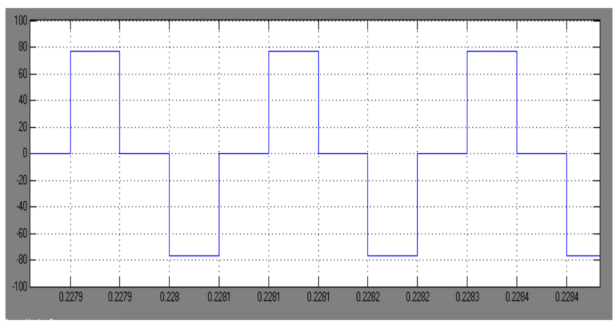

Fig .12 Transformer Primary Side Voltage

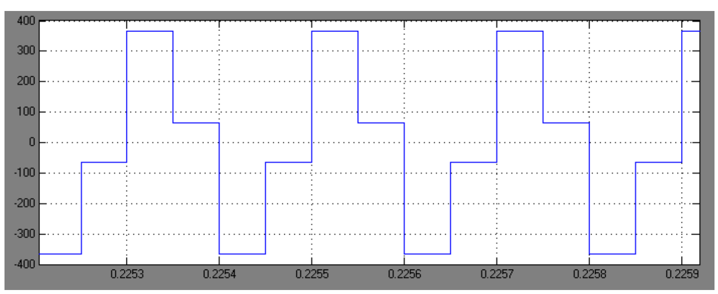

Fig .13Transformer Secondary Side Voltage

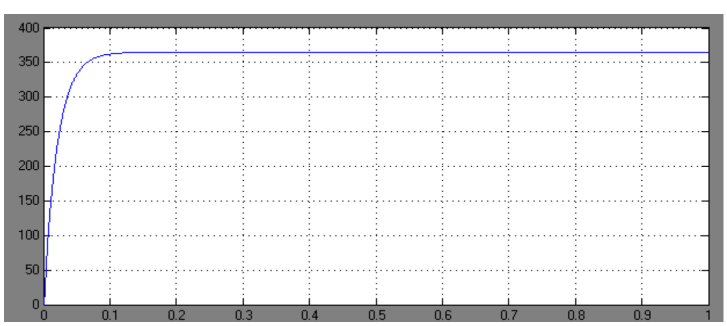

Fig .14Output Voltage For Boost Mode

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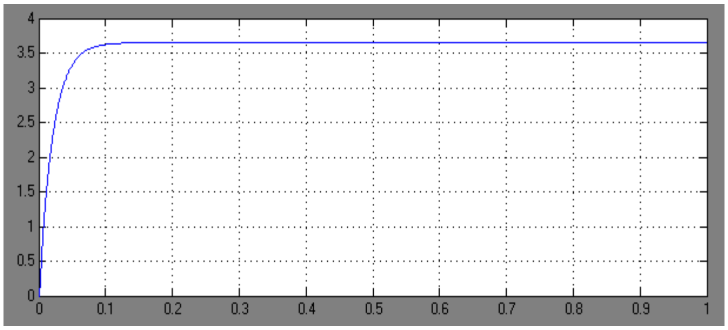

Fig .15Output Current For Boost Mode

VI. CONCLUSION

In this project,avoltage spike clamping capability that has significance.FlybackSnubber is improving the voltage spike. Under heavy-load condition, the current does not circulate through the full-bridge switches, their current stresses can be reduced significantly and thus improving system reliability. Flyback Snubber can be also controlled to achieve a soft switching feature. It has been successful in suppressing inrush current which is usually found in a boost-mode start-up transition.A 1.5-kW prototype with input voltage of 48 V and output voltage of 360 V has been implemented, from which experimental results have verified its possibility.

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