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An Overview of Boost Converter Topologies With Passive Snubber

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Abstract—This paper does the analysis of different passive snubber in soft switched boost converters with the help of SIMULINK. Here comparison of the converters with passive snubber have been done to determine which one is efficient in terms of performance such as efficiency, voltage stress, complexity etc. In this paper two types of passive snubber associated with boost converters are first discussed, then the respective converters are analyzed which includes simulation of the two topologies under the same conditions. This paper should act as a benchmark for future work in the dais of passive snubber.
Keywords— Boost converter, passive snubber, soft – switched, zero voltage switching, zero current switching

I. INTRODUCTION

Boost converters are DC-DC converters, which is having the ability to step up the input voltage. Growing era is mainly focused to meet the space constraints, hence to reduce the size and weight of the filter components high switching frequency is desirable. Which will simultaneously increases the switching losses. Turn on the switch at zero current &turn of at zero voltage are the best solution for this problem. In single switch converters the soft switching is mainly achieve by means of non-dissipative or low loss snubbers. The switching losses, voltage stress & EMI are increased due to high rate of change of switch voltage and diode reverse recovery current. So snubber circuits are introduced with typical boost converters, they are used to protect the switch from unfeasible conditions such as over voltage, over current etc. The energy from the parasitic elements in the power circuits are absorbed by the snubber elements in order to meet soft switching. There are mainly two types of snubber circuits are present-active, passive. Due to complexity, active snubber take minor role in low power applications. The only problem associated with passive approach are increased voltage and associated current stress on the semiconductor components. High stress further leads to the usage of high rated, much costlier components. If this limitation can be nullified by some means then passive approach become much efficient.

II. ANALYSIS OF DIFFERENT TOPOLOGIES

The 2 different topologies that are analyzed in this paper are
Boost converter with R-L-C snubber
Boost converter with L-C snubber

A. Boost Converter With R-L-C Snubber

The proposed converter shown in Fig.1 is a typical boost topology with a snubber consisting of a resonant inductor (Lr), resonant capacitor (Cr), a reset resistor (Rr) and 2 diodes (D1&D2). The boost inductor is denoted as L, Q is the switch, D0 is the output diode, C0 is the output capacitor, and R0 is the load.

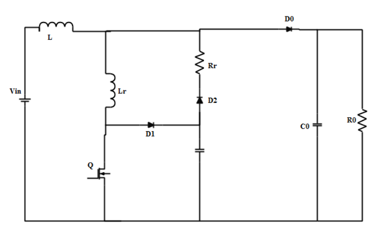

Fig. 1 Boost converter with R-L-C snubber

1) Operation: This circuit is analysed based on the conduction intervals of switches in different modes of operation. Here 8 modes of operation in this circuit.

Mode 1: The switch Q is off.

Mode 2: The switch Q is turned on under ZCS, is revers biased. At the end of this mode D0 is turned off and is forward biased.

Mode 3: Resonance occurs between Lr and Cr. Complete discharging of Cr occurs at the end of this mode.

Mode 4: Diodes D1 and D2 are forward biased. In this mode energy stored in Lr is dissipated in Rr. Recovery of snubber

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occur during this mode.

Mode 5: Power from the source is transferred to the boost inductor Lr.

Mode 6: The switch Q is turned off under ZVS. D1 is forward biased. At the end of this mode Cr is charged towards the output voltage V0.

Mode 7: Similar to mode 4. Rr resets Lr.

Mode 8: In this mode, D is forward biased and the power is transferred from the boost inductor L to the load R

B. Boost Converter With L-C Snubber

The proposed converter is shown in Fig 2. It consists of a MOSFET switch Q, Boost inductor L1, resonant inductor Lr two resonant capacitors are denoted by C1and C2, snubber circuit diodes are denoted as D1, D2and D3, output diode is D0 and output capacitor is C0. The input voltage is denoted by Vin and the output resistance is denoted as R0.

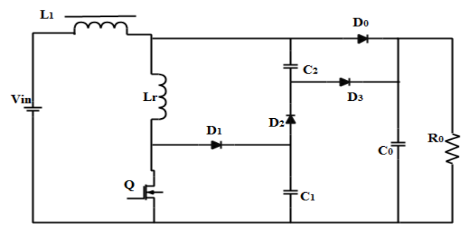

Fig. 2 Boost converter with L-C snubber

1) Operation: This circuit is analyzed based on the conduction intervals of switches in different modes of operation. There are 9 modes of operation in this circuit.

Mode 1: The switch Q is off. Stored energy in L1 is transferred to load through D0. C1 is charged towards V0, C2 is not charged. When Q is on, current through the resonant inductor increases linearly.

Mode 2: When current through D0=0, D2 forward biased. Lr, C1 and C2 begin to resonate. When resonance is completed the stored energy in C1 is transferred to C2.

Mode 3: At V=0, D1 is forward biased and Lr, C2 start to resonate.

Mode 4: When $I_{L1}=I_{Lr}$, the turn on commutation is completed.

Mode5: Q is off.

Mode 6: D3 is forward biased. Energy stored in C2 is discharged through D3.

Mode 7: When V_{C1}=V0, D2 is forward biased. Hence the current through Lr is transferred to load through D2 and D3.

Mode 8: I_{Lr}=0, until Q is on

Mode 9: At V_{C2}=0, another operation mode starts.

III. SIMULATION RESULTS AND DISCUSSIONS

The 2 topologies are simulated in MATLAB/SIMULINK, with the following common parameters

TABLE I
SIMULATION PARAMETERS

Parameter	**Value**
Supply Voltage (Vin)	55V
Switching Frequency (fsw)	30 kHz
Duty Ratio (D)	0.5
Boost Inductor (Lin)	380µH
Output Capacitor (C0)	470µF
Coupling Inductor (L2)	20µH
Load (R0)	25Ω

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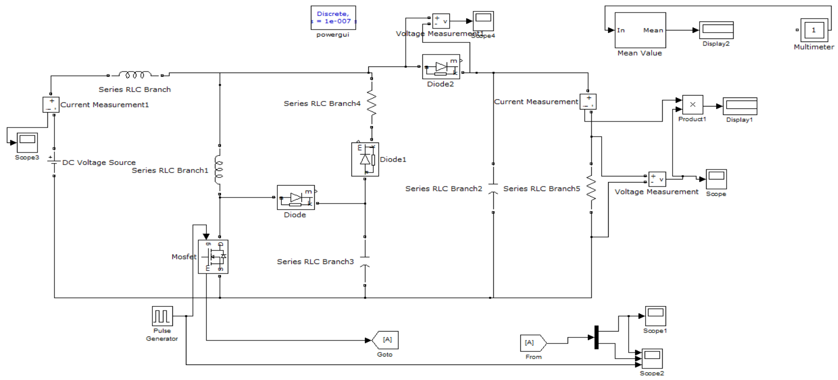

Fig. 2 Simulation diagram of boost converter with R-L-C snubbeR

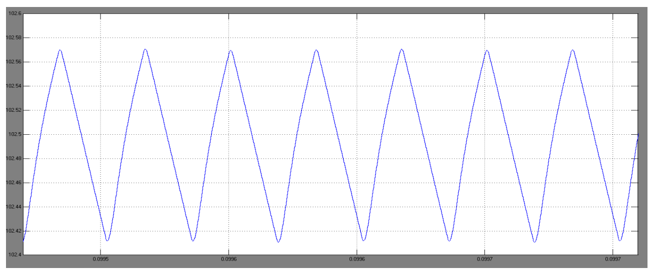

Fig. 4 Output voltage waveforms of boost converter with R-L-C snubber

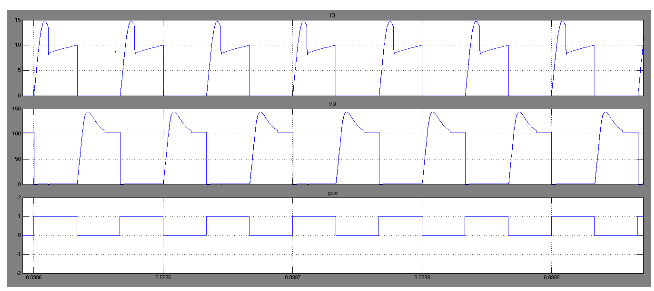

Fig. 5 Waveforms of VQ, IQ and gate of boost converter with R-L-C snubber

Fig. 3 represents the simulation diagram of softswitched boost converter with R-L-C snubber.During simulation the output voltage of the converter,shown in Fig.4 is obtained below 110V,ie. gain of the converter is lower than 2.Whereas in softswitched boost converter with L-C snubber the output voltage is grater than 110V,hence gain is more than 2.Which is shown in Fig.7. Both the converter have ZCS turn on and ZVS turn off othe main switch.Thus the switching losses are very much reduced.

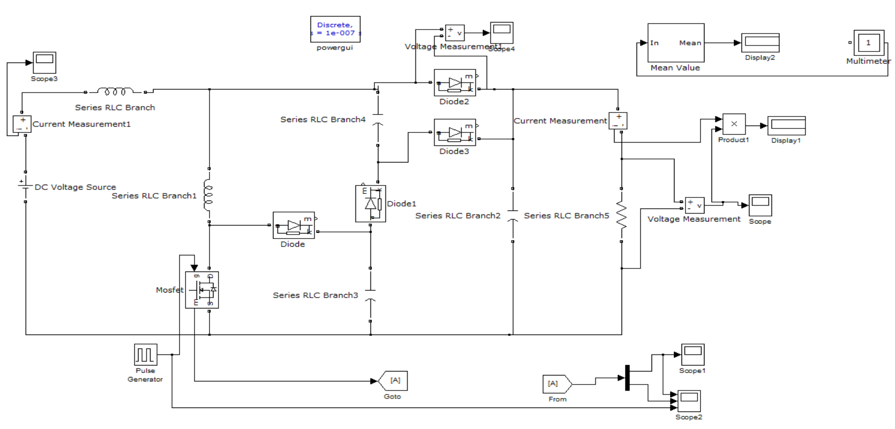

Fig. 6 Simulation diagram of boost converter with L-C snubber

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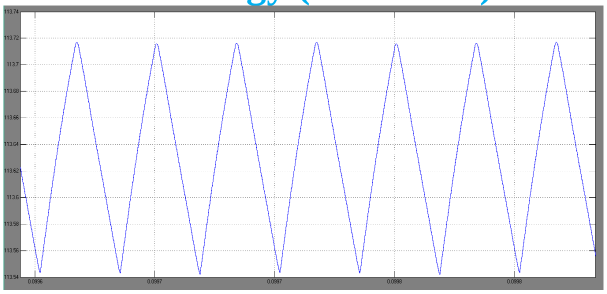

Fig. 7 Output voltage waveforms of boost converter with L-C snubber

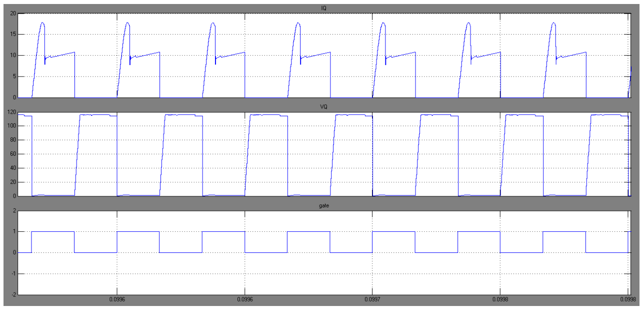

Fig. 8 Waveforms of VQ, IQ and gate of boost converter with L-C snubber

A. Inference

A comparison of 2 different soft switched topologies with passive snubber circuit is shown in Table II. Simulation is performed by MATLAB/SIMULINK using the same parameters. The result shows that converter of [2] has higher efficiency, less voltage stress. Converter [1] has reduced peak switch current. The number of components used in converter of [1] is less compared to converter of [2] but the performance is poor in terms of efficiency.

TABLE III
COMPARISON BETWEEN THE 2 TOPOLOGIES BASED ON THE VARIOUS PARAMETERS

Parameter	Converter of [1]	Converter of [2]
Output voltage (V0)	102.57	113.71
Voltage Gain	1.864	2.06
Efficiency (%)	85.40	95.487
Voltage Stress on the switch (V)	143.757	116
Peak Switch Current (A)	14.75	17.55
Voltage stress on Output Diode (V)	0.812	0.813
Output power (W)	420.8	517.2
Number of Extra Components	5	6

IV. CONCLUSIONS

This paper presents comparison of 2 different soft switched boost converter with passive snubber. The boost converter with L-C snubber is highly efficient because it recycles the energy stored in the leakage inductor. The comparison table should serve as a benchmark in choosing the appropriate converter topology for several applications related to renewable energy. The simulation results of 2 topologies for an input voltage of55V and load of 25are presented.

V. ACKNOWLEDGMENT

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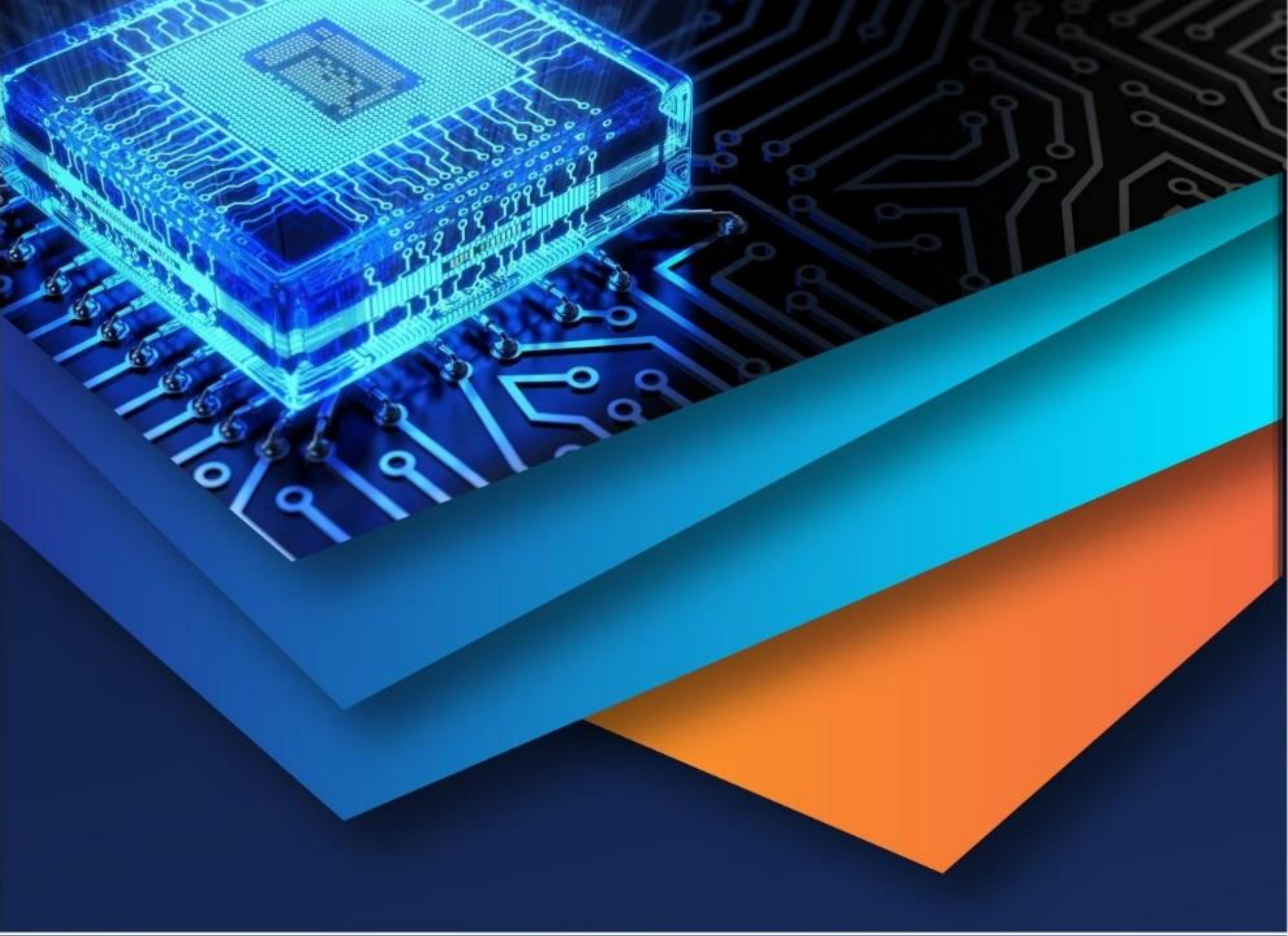

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