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Non-Dissipative Snubber Circuit Based SEPIC Converter for High Static Gain Applications

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Abstract: In this paper different non-dissipative snubber circuits in which RCD snubber circuit, CD snubber circuit, LCD snubber circuit and proposed LCD snubber circuit are implemented in SEPIC converter to obtain high static gain. The snubber circuit is used for the protection of the power semiconductor devices. The requirement of high static gain is necessary in different applications of dc-dc converters, so that efficient operation of the system can be obtained. The basic idea of the snubber circuit used in this paper is to reduce the turn-on and turn-off losses at the time of switching processes. For this purpose, inductor and capacitor combination is required so that during turn-on process, sudden change in current through semiconductor device which is used as a switch, can be reduced. Similarly, during turn-off process, sudden change in voltage across switch can be minimized. Here, different snubber circuit based SEPIC converters are analyzed with the help of MATLAB simulink and results of output voltages and currents are obtained. The results are summarized which clearly shows that the proposed SEPIC converter has high static gain in comparison of the others topologies. Hence non-dissipative snubber circuit based SEPIC converter provides high efficiency than the other modifications in SEPIC converter.

Keywords: Dc-dc converters, SEPIC, Snubber circuit, Matlab and simulink.

I. INTRODUCTION

There are different areas of applications where electrical power is being used like as ASDs, SMPS, UPS etc. in which conversion of ac power supplies and dc power supplies play very important role. The other application is solar photovoltaic panels to charge the batteries for electrical vehicles. Thus various conversion methods have very essential role for the improvement of efficiency and power factor of the electrical energy so that energy can be saved for the future. The choppers are widely used for conversion of fixed dc power supply into variable supply as per the requirement of system.

In light of their increased applications, a new breed of rectifiers has been developed using new power devices such as MOSFET, IGBT, GTO etc. A comprehensive survey on the topic of dc-dc converters is done which are classified as buck, boost, buck–boost etc. with unidirectional and bidirectional power flow. The art of IPQC technology, components selection, control approaches, configurations, comparative features and others options for power quality improvement, selection considerations for specific applications, latest trends and future developments and conclusive observations are summarized [1]. A single-stage LED driver has been developed integrating SEPIC with half-bridge LLC resonant converter. Proposed topology reduces system's cost, enhancing reliability. A careful study of SEPIC converter for LED lighting has been studied. Six mode of operating has been analyzed: uncoupled inductors continuous conduction, uncoupled inductors discontinuous conduction, coupled inductors continuous conduction without leakage inductance, coupled inductors discontinuous conduction without leakage inductance, coupled inductors continuous conduction with leakage inductance, coupled inductors discontinuous conduction without leakage inductance. The result of this study is that the mode coupled inductors discontinuous conduction with leakage inductance is interesting.

The proposed modified SEPIC enables the use of lower voltage rated semiconductors compared to other single-switch buck-boost derived topologies with a resulting performance comparable to the boost topology [2]-[3]. High static gain DC-DC converters are nowadays an important research focus due to the crescent demand of this technology for some applications as renewable energy sources, fuel-cells etc. Also The use of Photovoltaic systems is increasing rapidly due to its various advantages. The performance of PV system depends upon in plane radiation and temperature.

The steady-state and dynamic analysis of the SEPIC converter in the discontinuous conduction mode is completed by means of averaging techniques [4]. A new topology of a SEPIC converter is used in power factor correction circuits. The conventional SEPIC converter was primarily designed to provide a non-pulsating input current, operating with both inductors in continuous current mode. Here a simple feedback control technique is implemented in order to regulate the output voltage [5]- [8]. Many techniques are used to derive average models. State-space average method is the best well known of these techniques [9].

II. METHODOLOGY

There are different modifications done in ordinary SEPIC converter for the improvement of static gain. The different snubber circuit based SEPIC converters used in this paper are as follows:

SEPIC converter with RCD snubber:

This converter is obtained with the inclusion of resistor Rs1, capacitor Cs1 and Diode Ds1. The circuit diagram of this converter is shown below:

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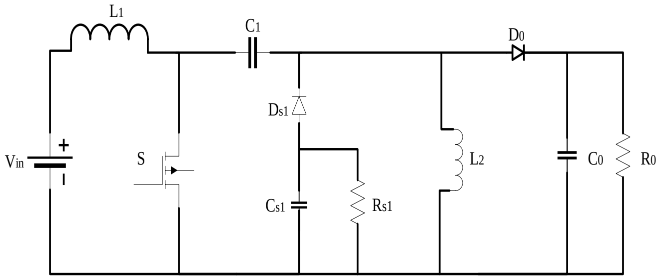

Fig 1. SEPIC Circuit for RCD snubbers

SEPIC converter with CD snubber:

This converter is obtained with the inclusion of capacitor Cs1 and Diode Ds1. The circuit diagram of this converter is shown below:

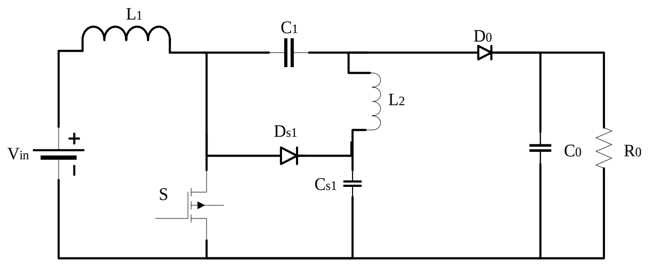

Fig 2. Circuit diagram of SEPIC converter with CD snubber

SEPIC converter with LCD snubber:

This converter is obtained with the inclusion of capacitors Cs1, Cs2, inductor Ls1 and Diodes Ds1, Ds2, Ds3. The circuit diagram of this converter is shown below:

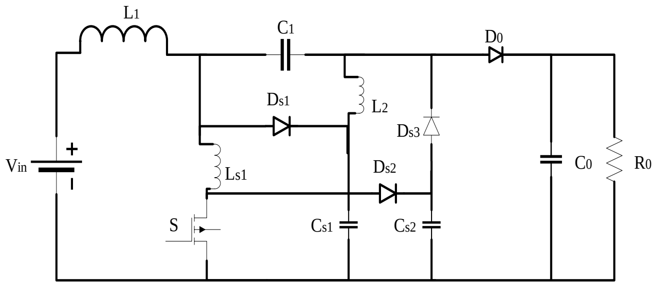

Fig 3. Circuit diagram of SEPIC converter with LCD snubber

SEPIC converter with proposed LCD snubber:

This converter is obtained with the inclusion of capacitors Cs1, Cs2, inductors Ls1, Ls2 and Diodes Ds, Ds1, Ds2. The circuit diagram of this converter is shown below:

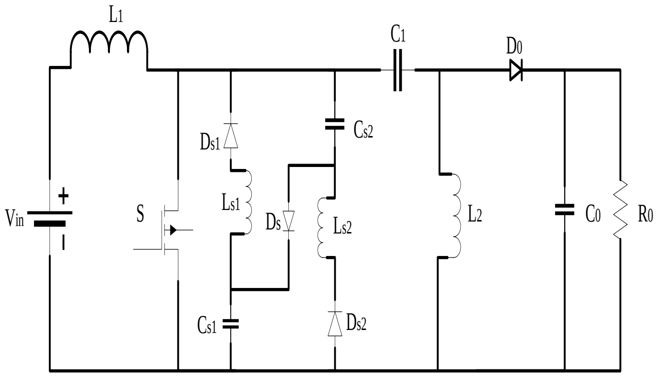

Fig 4. SEPIC Circuit for proposed LCD snubbers

III. SIMULINK MODELS AND RESULTS

The simulink models and their results of output voltage and currents are as follows:

Simulink Models:

The simulink models of different topologies obtaining high static gain and high efficiency in SEPIC converter are as follows:

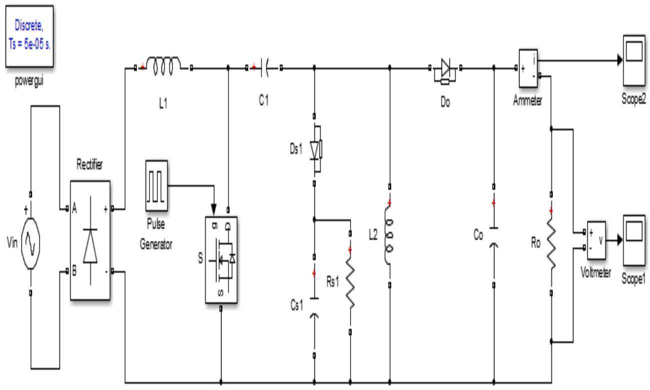

Fig 5. Simulink diagram of SEPIC converter with RCD snubber

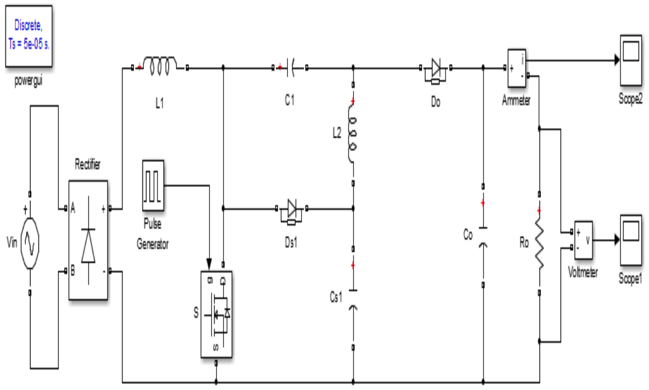

Fig 6. Simulink diagram of SEPIC converter with CD snubber

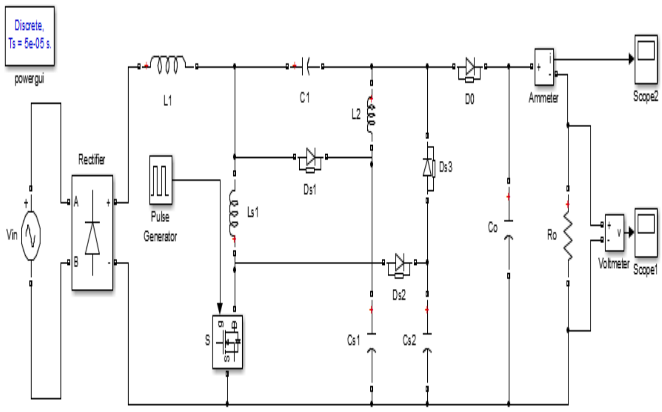

Fig 7. Simulink diagram of SEPIC converter with LCD snubber

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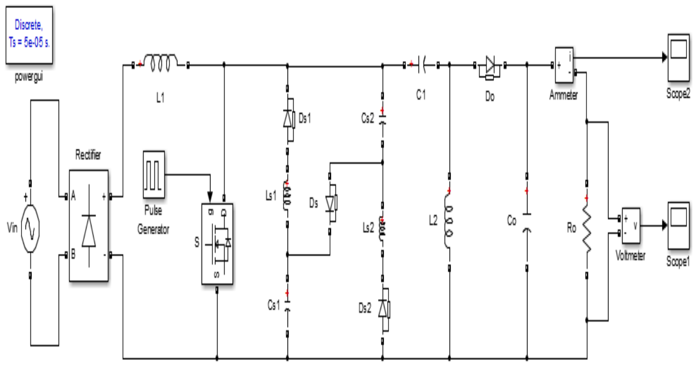

Fig 8. Simulink diagram of SEPIC converter with proposed LCD snubber

Simulated Results:

The different simulink models of SEPIC converter with snubber circuits are observed with Matlab and different waveforms for these converters are obtained. These waveforms are as follows:

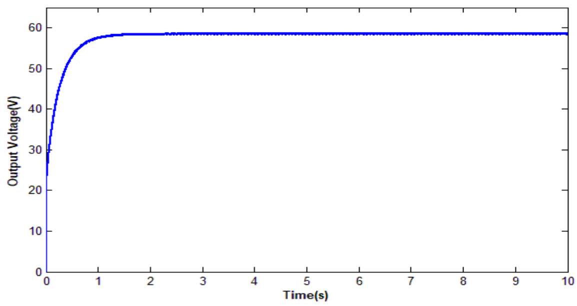

Fig 9. SEPIC voltage waveform for RCD snubbers

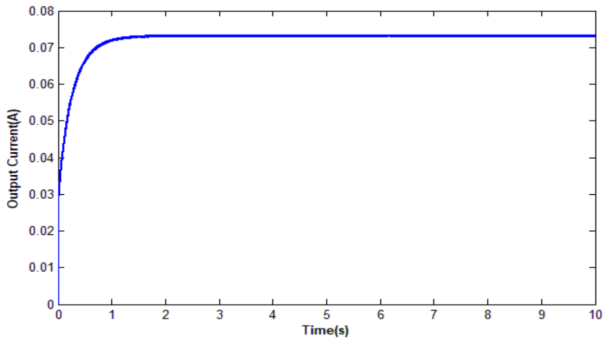

Fig 10. Output current of SEPIC converter with RCD snubbers

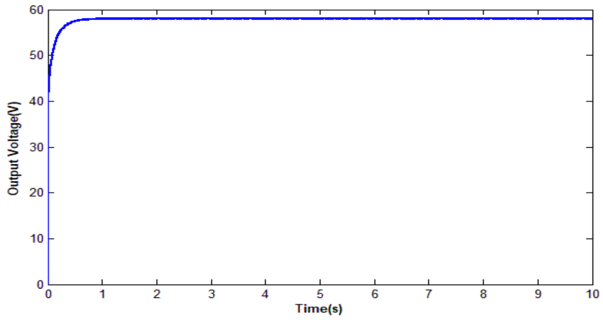

Fig 11. SEPIC voltage waveform for CD snubbers

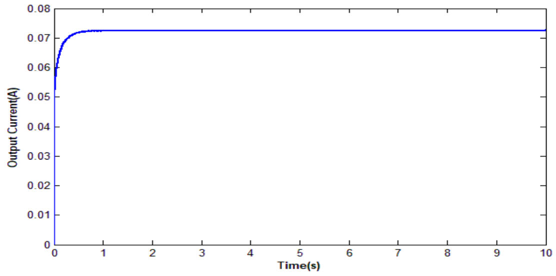

Fig 12. SEPIC output current for CD snubbers

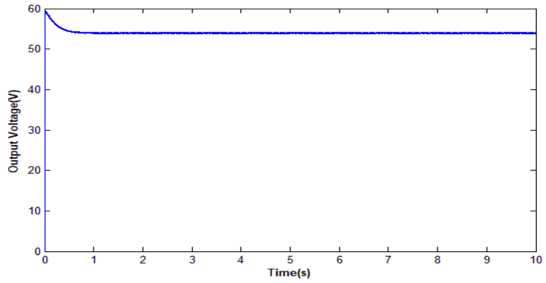

Fig 13. SEPIC voltage waveform for LCD snubbers

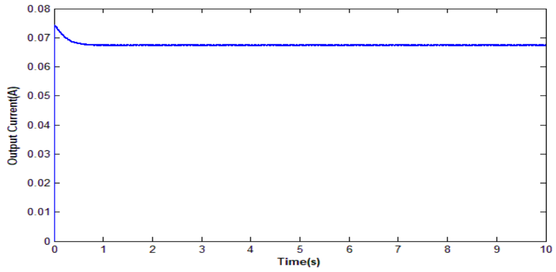

Fig 14. Output current of SEPIC converter with LCD snubber

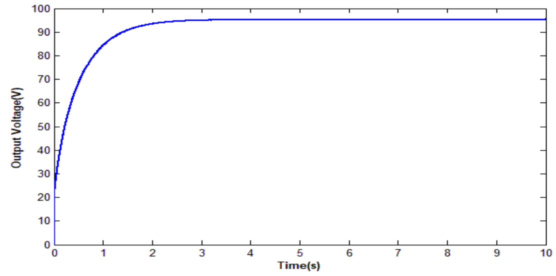

Fig 15. SEPIC voltage waveform for proposed LCD snubbers

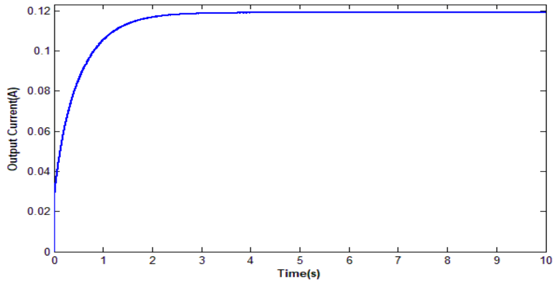

Fig 16. Output voltage of SEPIC converter with proposed LCD snubber

The result comparison of SEPIC converter with snubber circuits is done which can be understand by Table I.

Table- I: Output comparison of converters

S.No.	SEPIC Converter with	Output Voltage (V)	Output Current (A)
1	RCD snubber	59	0.08
2	CD snubber	57	0.07
3	LCD snubber	54	0.06
4	Proposed LCD snubber	95	0.11

IV. CONCLUSIONS

Many industrial applications require high efficiency, operation at high switching frequency, and a small amount of losses. Also switched mode power supplies are used widely in consumer electronic appliances. Designing of high performance power converter with low cost and high efficiency make the design a more challenging task. The designing task becomes even more difficult for applications that demand wide range of voltage gain with reduced input. Several modifications in dc-dc converters are required for this purpose. Different modifications are performed in ordinary SEPIC converter suitable for high step-up applications. Hence, different non-dissipative snubber circuits in which RCD snubber circuit, CD snubber circuit, LCD snubber circuit and proposed LCD snubber circuit are implemented in SEPIC converter. The different models with Matlab are observed with multiple output of voltages of the converters. The comparison between these converters clearly shows that the proposed converter provides high static gain in reference of other types of modifications using snubber circuits.

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