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Effect of Snubber Circuit for Efficiency Improvement in SEPIC Converter

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ABSTRACT

Effect of Snubber Circuit for improvement of efficiency in SEPIC Converter presents the use of snubber circuit for the improvement of SEPIC converter. SEPIC converter is a type of dc-dc converter that can be used as step up or step down converter providing better efficiency. Snubber circuit may be active type or passive type i.e. combinations of inductors, capacitors, diodes etc. The different types of snubber circuits are used for the enhancement of converter which reduces the switching losses during the turn-on and turn-off of the power semiconductor device used in SEPIC converter. In this paper the performance of the SEPIC dc–dc converter with snubber circuit is presented to obtain the higher voltage. The resultant converter is obtained by modifying the SEPIC converter with inductor, diode and capacitor. This converter provides better output than ordinary converter by reducing the losses. The simulation is done using MATLAB simulink. The simulation results of input voltage, input current, output voltage and output current in ordinary SEPIC converter and SEPIC converter with snubber circuit are obtained. This converter provides higher voltage at the output side like as in boost converter which can be used with low input voltage.

Keywords: SEPIC dc-dc converter, MATLAB Simulink, Snubber Circuit

INTRODUCTION

There is a need of bidirectional power flow in Industrial applications like as in automobile, telecom, aircraft and space operation. This bidirectional power flow is obtained by the power electronic converters. These converters are used as battery backup in all the power conversions for charging and discharging. The dc-dc converters are classified generally in two ways, first is Isolated and other is non-Isolated dc-dc converters. Generally non- Isolated dc-dc converters have no auxiliary circuit to enhance the operation of inductor current. The auxiliary circuit provides continuous inductor current with fixed switching frequency and the switch stresses. Both, the Isolated and non-Isolated converters are operated in bidirectional power flow conditions. The most common technology in all the electronic converters is switched mode power converters. Switched mode power converters convert the voltage input to another voltage signal by storing the input energy and them releasing that energy to the output at a different voltage as per switching operation. The power is modified by controlling the timing that the switches are on and off. Due to the fact of switching at high frequency in a very efficient way, the switched mode conversion has a particular interest. Although to achieve high power efficiency in low power level electronic technology, a much greater emphasis is required. Thus for this converters are used in order to change the supply voltage according to performance requirements for power efficiency reasons. The magnetic coupling allows increasing the static gain with a reduced switch voltage which gives low switch voltage and high efficiency for low input voltage and high output voltage applications [1]. Ac-dc conversion of electric power is widely used in different applications like as in adjustable-speed drives, switch-mode power supplies, uninterrupted power supplies, and utility interface with nonconventional energy sources such as solar Photovoltaic etc., battery energy storage systems, in process technology such as electroplating, welding units, etc., battery charging for electric vehicles, and power supplies for telecommunication systems, measurement and test equipment. Using the coupled inductors, an appropriate coupling capacitor is required to prevent big input and output ripple currents. This modified topology provides higher static gain than the ordinary SEPIC converter and also predicts the ripple and the appropriate size of the coupling capacitor [2-5].

Dc-dc converters are classified into different types like as buck, boost, buck-boost, cuk, SEPIC converters etc. These are the non- isolated dc-dc converter which are suitable for high voltage applications with some modifications. The SEPIC converter is widely used. Because of well controlled and regulated dc to provide comfortable and flexible operation of the system, these converters are used by many markets and in many products. The SEPIC converter provides both step up and down operating modes. Hence wherever power conversion from a wide input voltage range is needed, SEPIC converters are used like as in consumer electronics, industrial controls, medical and computing etc. Conventionally ac-dc converters are developed using diodes and thyristors to provide controlled and uncontrolled dc power with unidirectional and bidirectional power flow. The splitting of this secondary inductor into two windings reduces the voltage stresses on the main switch and diodes. The additional diode helps to circulate the leakage inductance energy to the load in a non-oscillatory manner. The transistor turns on/off with soft switching. The voltage stress on both the transistor and diodes is less than the output voltage [6-10].

The power electronic converters have so many types of configurations, control approaches, design features, selection of components and other related considerations to improve the power quality. To control a power electronic system, there are so many types of methods like as power factor corrected boost converter which includes voltage-doubler characteristic, boost-interleaved buck-boost converter, which can offer significant performance improvements over simple buck-boost converters etc. Similarly, there are so many modifications which are done in SEPIC converter to improve the performance of the power electronic system. Also there is a requirement of good efficiency, low electromagnetic interference, noise, higher switching frequency operation, less no. of components etc. in industrial applications for which a variety of switched mode power supplies, uninterrupted power supplies systems are available. The SEPIC converter is a type of these converters. This plays an important role in consumer electronic appliances for which an ordinary SEPIC converter is not suitable. Hence so many topologies are obtained with the inclusion of different elements like as inductor, diode, transformer, switch etc. in SEPIC converter. A general boost converter is not suitable for high step-up applications limited voltage step-up ratio. The solution is obtained by combining a boost converter with SEPIC converter. This new integrated boost-SEPIC (IBS) converter now provides additional step-up ratio with the help of an isolated SEPIC converter. Since the boost converter and the SEPIC converter share a boost inductor and a switch, its structure is simple [11- 15].

SEPIC CONVERTER WITH SNUBBER

Single-ended primary-inductor converter (SEPIC) is a type of converter that allows the electrical potential i.e. voltage at its output to be greater than or less than to that at its input. The output of the SEPIC converter is controlled by the duty cycle of the switch. The SEPIC converter exchanges energy between the capacitors and inductors in order to convert from one voltage to another. The amount of energy exchanged is controlled by switch S. The energy to increase the current I_{L1} comes from the input source. The power circuit of the SEPIC converter is presented in Fig. 1.

When the switch is on then switch acts like a short circuit, and the instantaneous voltage V_{C1} is approximately V_i, the voltage V_{L2} is approximately $-V_i$. Therefore, the capacitor C_1 supplies the energy to increase the magnitude of the current in I_{L2} and thus increase the energy stored in L_2.

When switch S is turned off, the current I_{C1} becomes the same as the current I_{L1}, since inductors do not allow instantaneous changes in current. The power is delivered to the load from both L_2 and L_1. C_1, however is being charged by L_1 during this off cycle, and will in turn recharge L_2 during the on cycle.

The advantages of SEPIC converter are that the output voltage can be less than or greater than the input voltage, having non-inverted output i.e. the output voltage is of the same polarity as the input voltage, the output stage rectifier diode is used as a reverse blocking diode and the isolation between its input and output i.e. provided by a capacitor in series. The main disadvantage of SEPIC converter is circuit complexity.

Applications of the dc-dc Converters

- Used in high performance dc drive systems like electric traction, electric vehicles and machine tools.
- Used in radar and ignition systems.
- Used as photo voltaic arrays, fuel cells or wind turbines.
- Used in drivers where the breaking of dc motor is desired like transportation system with frequent stops.
- In the utility ac grid as backup source of energy like battery pack.
- In uninterrupted power supplies to adjust the level of a rectified grid voltage to that of back up source.
- In solar systems and in high brightness light emitting diodes.
- In computer power supplies, battery chargers, dc motor power systems and in different industrial applications.

The proposed converter can be obtained by including additional components inductor, capacitor and diode to the ordinary circuit as shown in Fig.2. The capacitor C_s limits the dv/dt at the switch turned-off. The inductor L_s limits the di/dt at the switch turn-on, and when the power switch is turned-off, the energy stored in this inductance is transferred to the capacitor C_s through the diode. The initial condition of the voltage in the capacitor C_s is zero, and the reduced capacitance value limits the dv/dt of the power switch voltage.

Thus proposed converter eliminates the turn-on and turned-off losses with the help of inductor, capacitor and diode used in snubber circuit. The inductor limits the change in current at the switch turn-on and zero-current switching is obtained. When the power switch is turned-off, the energy stored in the L_s inductor is transferred to the capacitor C_1 through the diode and capacitor limits the change in voltage providing zero-voltage switching. Hence high output voltage is obtained in comparison of ordinary SEPIC converter.

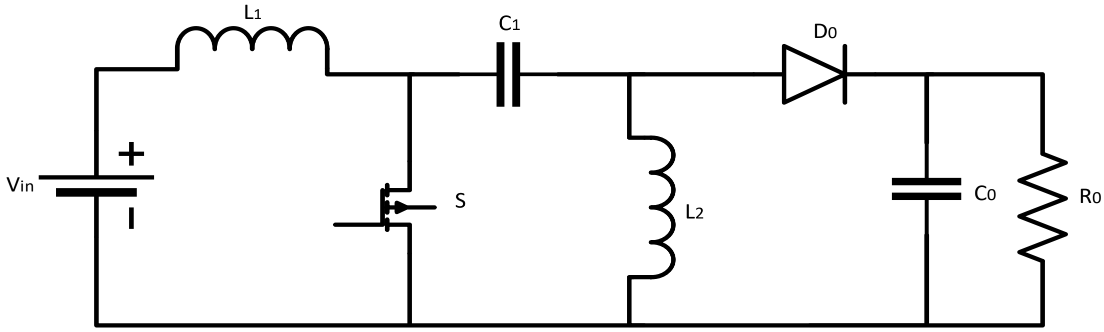

Fig. 1 Circuit diagram of SEPIC converter

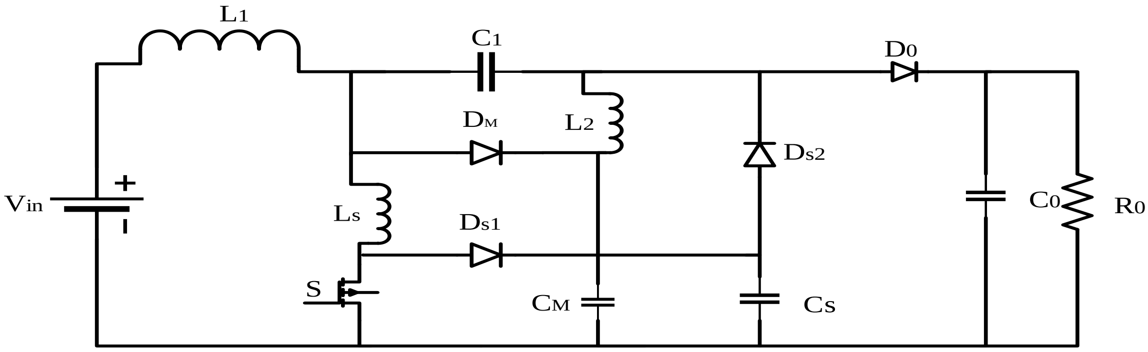

Fig. 2 Circuit diagram of SEPIC converter with Snubber Circuit

SIMULINK MODELS AND RESULTS

The simulink model for ordinary SEPIC and SEPIC converter with snubber circuit is shown in Fig. 3. The specifications for ordinary SEPIC and SEPIC converter with snubber circuit is shown in table-1.

Table -1 Specifications for Ordinary SEPIC and SEPIC Converter with Snubber Circuit

Model Parameters	Parameters Values	Model Parameters	Parameters Values	Model Parameters	Parameters Values
Input voltage, V_i	115V	Inductor, L_s	1µH	capacitor C_o	500µF
Output voltage, V_o	345V	Capacitor, C_1	660nF	Switching frequency, f_S	48kHz
Inductor, L_1	1mH	Capacitor, C_M	660nF	Supply or grid frequency, f_G	50Hz
Inductor, L_2	500µH	Capacitor, C_s	1nF		

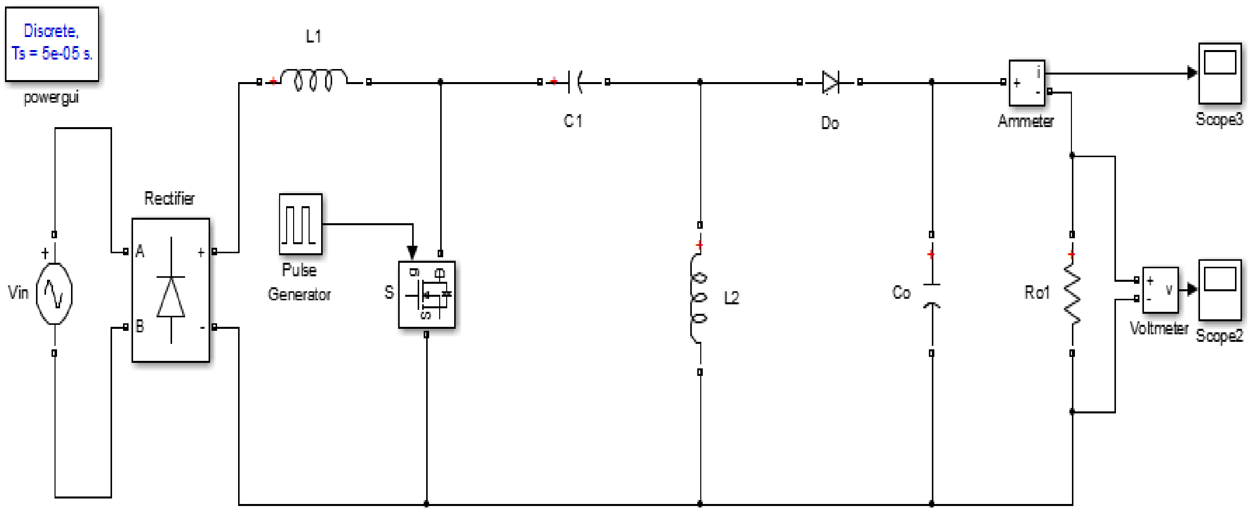

Fig. 3 Simulink model for ordinary SEPIC converter

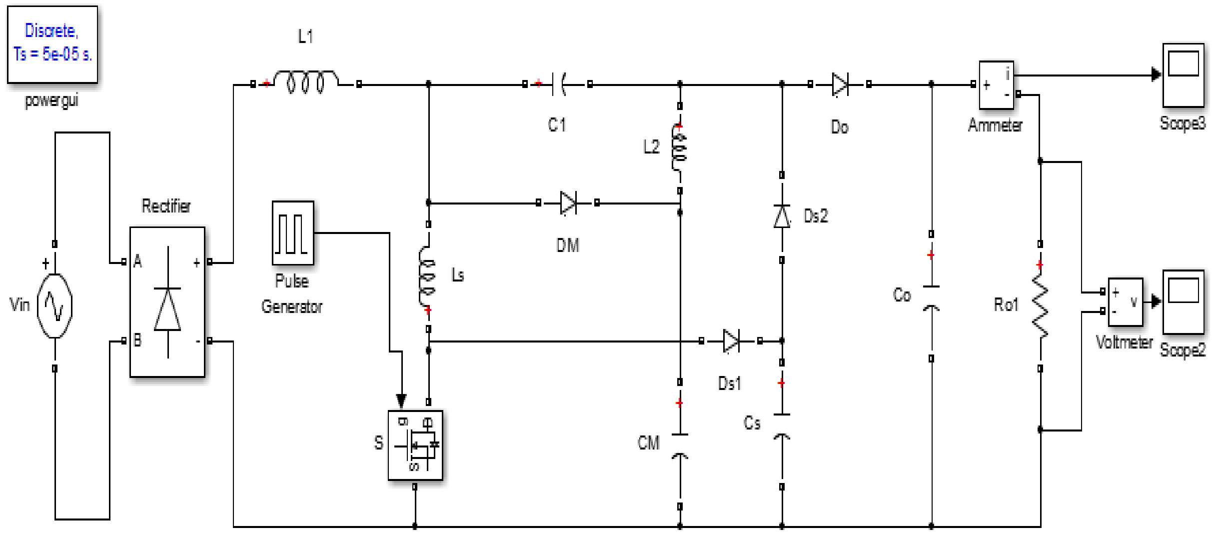

Fig. 4 Simulink model for SEPIC converter with snubber circuit

Output Voltage and Current Waveforms

The output voltages and currents waveforms for the ordinary and proposed SEPIC converter are measured with input voltage 115V and shown in Fig. 5-8:

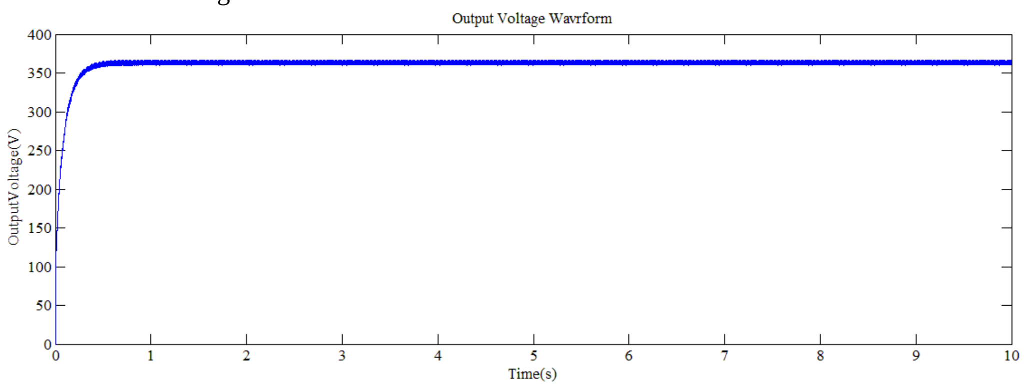

Fig. 5 Output voltage waveform of ordinary SEPIC converter

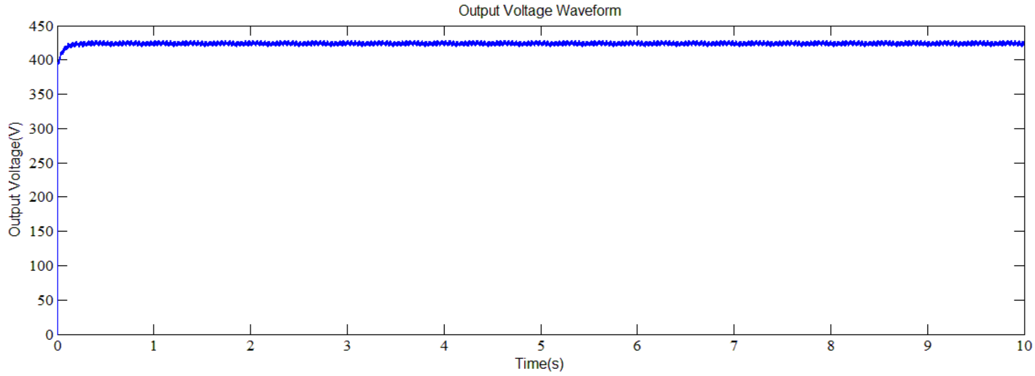

Fig. 6 Output voltage waveform of SEPIC converter with snubber circuit

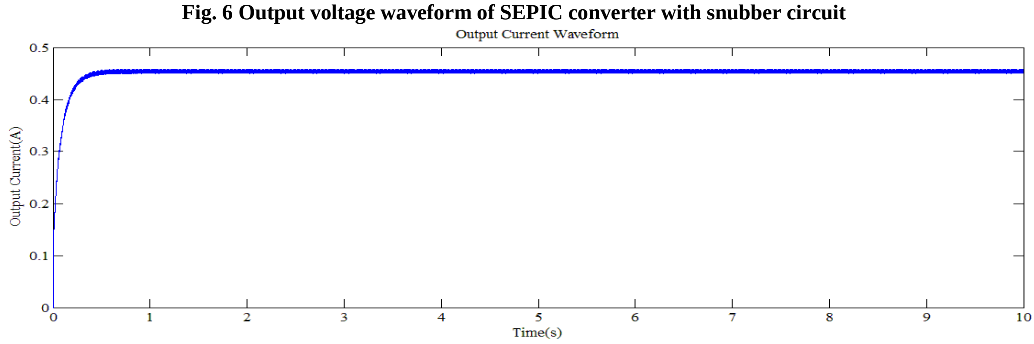

Fig. 7 Output current waveform of ordinary SEPIC converter

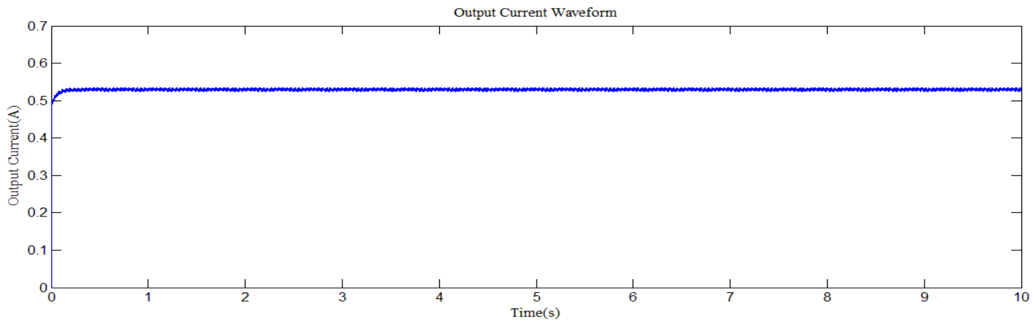

Fig. 8 Output current waveform of SEPIC converter with snubber circuit

The results comparison of ordinary and SEPIC converter with snubber circuit is shown in Table -2:

Table -2 Results Comparison of Ordinary and SEPIC Converter with Snubber Circuit

Parameters	Ordinary SEPIC	SEPIC Converter with Snubber Circuit
Input voltage	115V	115V
Output voltage	360V	425V
Output current	0.45A	0.53A
Rise time	0.15sec	0.04sec
Settling time	0.38sec	0.15sec

CONCLUSION

The advancement in SEPIC dc-dc converter can be done with the use of snubber circuit. A new approach for this improvement of SEPIC converter is presented in this paper which is very useful for high power factor rectifiers. Ac-dc conversion of electric power is widely used in different applications like as in adjustable-speed drives, switch-mode power supplies, uninterrupted power supplies, and utility interface with nonconventional energy sources such as solar Photovoltaic etc., battery energy storage systems, in process technology such as electroplating, welding units, etc., battery charging for electric vehicles, and power supplies for telecommunication systems, measurement and test equipment's. In the present time, SEPIC converters are widely used in various industrial and commercial applications. These converters provide well controlled and regulated dc to dc conversion. These converters provide comfortable and flexible operation of the system. SEPIC converter based products operate from batteries which benefits most from the wide ranging step down and step up operating modes of the SEPIC topology. There is the requirement of large conversion rate in converters for many industrial applications. The requirements also include good efficiency, little electromagnetic interference noise, operation at high switching frequency, and a small amount of elements. The behaviour of proposed open loop SEPIC converter Model with Snubber Circuit has been analysed. The comparison shows that output voltage of proposed SEPIC converter is more than the output voltage of ordinary SEPIC converter.

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