ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 3, Issue 9, September 2014**

# Comparative Study on Nonisolated Boost Topologies with SIB Converter

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**ABSTRACT**: Power converting circuits play an important role in any electrical system, especially boost converters. They are mainly used in high power applications. Power converters overcomes the main issues associated with power delivering system such as load variations, high or low voltages etc. This paper studies and compares the merits and demerits of different non isolated boost topologies with SIB (Sepic Integrated Boost) converter. A sepic converter connected in series with the classical boost converter to maintain high gain and efficiency is presented in this paper. Simulation and hardware implementation of SIB Converter is included with 10-100V,60 kHz,50W prototype at the end of the paper.

**KEYWORDS:**Boost converter, Single Ended Primary Inductor Converter(SEPIC), Sepic Integrated Boost (SIB) converter, Zero Voltage switching (ZVS).

## I.INTRODUCTION

The demand of boost voltage with simple architecture is required in many applications such as uninterrupted power supplies (UPS), photo voltaic system, high intensity discharge lamp (HID), fuel cell system where the generated voltage may less than the required voltage, here comes the role of boost converter to step up the obtained voltage to high voltage [1],[2].Commonly used boost topologies are 1)Current fed type boost converter, 2)Voltage multiplier cell based boost converter,3)Coupled inductor based boost converter and4)Active Clamp approach ,Study of classical boost converter and each of the above listed topologies are discussed below.

*A.Classical Boost Converter.*

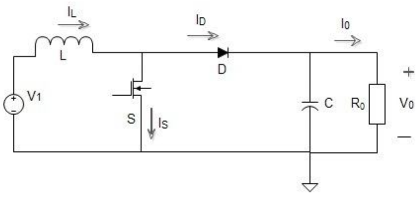


Fig.1Classical boost converter

Classical boost converter step up the input voltage according to the energy stored in the boost inductor .The main advantage of boost converter is its simple structure and continues input current .But it has several disadvantages such when the switch is turned off high output voltage is impressed on the switch also in this converter high efficiency and

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gain can't achieved at once. Due to the presence of parasitic resistance classical boost topology is not suitable for high power application.Another major problem is high voltage rating in diode causes reverse recovery problem[1],[2],[12]-[14]. To overcome these demerits several boost topologies were proposed and are discussed in the next section.

## II. STUDY OF DIFFERENT TOPOLOGIES

*A. Summary of Current Fed TypeBoost Converter*

Current fed type converter were introduced to improve the performance of zero voltage transition converter,other advantages includes ZVS for wide line and load ranges,low device voltage and current stress.Current fed type converters are used for applications such as battery chargers in various dc applications where tight regulation of output voltage is not required[6],[7]. But current fed type converters have several disadvantages like high voltage spike and high circulating conduction loss, In order to avoid this pulse width modulated ZVS bidirectional dc-dc converter can be implemented but which makes circuit complex and costly[8].

*B.Summary of Coupled Inductor Based Boost Converter*

Even with the issues of leakage inductance, using a coupled inductor with boost converter improves circuit's overall gain. Main advantages of this topology are the reverse recovery problem of diode can be solved by calculating the delay time associated with the cross of entering and leaving current of coupled inductor.Also the output diode can be selected as schottky diode with the reduction of switching and conduction loss. The source voltage drift problem due to the variation of loads can be reduced by closed loop control[9].Converter topology incorporates a coupled inductor is widely used in power conversion system with high gain.Coupled inductor based boost converter can be used for wide voltage ranges [3], [5]. The trapped energy in the leakage inductance can be recycled by a passive regenerative snubber, this introduce the idea of active clamp approach[10].

*D. Summary of Active Clamp Based Boost Converter*

Active clamp circuit is mainly used with coupled inductor based boost converter to reduce the voltage spike due to the trapped energy in leakage inductance and in this circuit buy incorporating ZVS in auxiliary and main switches,switching losses can be reduced with enhancement in the conversion efficiency. Active clamp approach has more number of switches and hence having complex structure which is a drawback [4].

*C.Summary of Voltage Multiplier Cell Based Boost Converter*

Voltage multiplier cell includes a diode, inductor and capacitor arrangement. This converter topology is used in order to achieve high step up gain, reduction in switch stress and to reduce the reverse recovery problem of diode. Another main advantage is that voltage multiplier cell based circuit have low commutation loss and low EMI generation and is achieved with the limitation of the di/dt and with the minimization of the negative effects of diode reverse recovery current. But this circuit requires more capacitors and diodes as the voltage level is increased [11].

## III.STUDY AND IMPLEMENTATION OF SIB CONVERTER

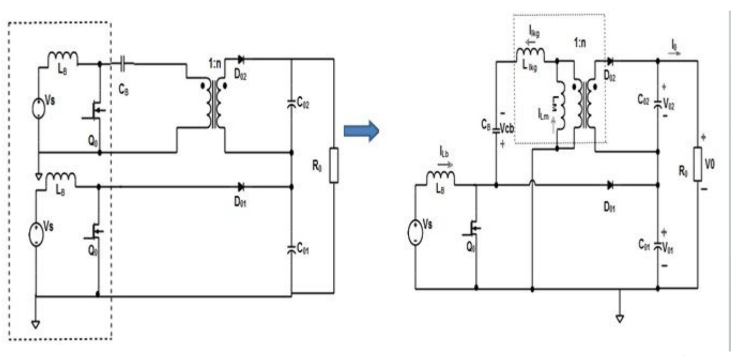

Fig.2 Common parts sharing between boost converter and SEPIC converter to form SIB converter.

We have discussed various topologies in boost converter for non isolated applications.In this section we are providing an expanded knowledge of boost converter by combining sepic converter with boost converter through application of theory, simulation and hardware implementation.Sepic and boost converter shares common parts such as boost inductor and switch as shown in Fig 2.So SIB converter has simple structure.Inductor in the sepic converter is modeled as a transformer,so that the leakage inductance component reduces the reverse recovery problem of diode $D_{02}$. Leakage inductance element will act as current snubbing element.SIB converter also maintains the advantages of sepic and boost converter.

For analyzingSIB converter, we are taking the assumptions as input voltage, output voltageof boost and sepic converter modules are constant. Switches and diodes are ideal.

SIB converter operates with boost converter's and sepic converter's function with the additional effect of leakage inductance $L_{lkg}$ of the transformer [2].

## IV.DESIGN

In designing a SIB converter, input power and output power is assumed to be same. The turns ratio and the duty cycle should be selected carefully. The design procedure of SIB converter is done for 10-100V, 60 kHz, 50W ratings. The gain equation of SIB converter is the combined gain equation of boost and SEPIC converter. $V_{01}$ and $V_{02}$are output voltage equation of boost and SEPIC converter respectively.

$$\frac{V_0}{V_S} = \frac{1+nD}{1-D} \quad \text{......(1)}$$

Gain equation of boost converter is,

$$V_{01} = \frac{V_S}{1-D} \quad \text{......(2)}$$

Gain equation of SEPIC converter is,

$$V_{02} = \frac{nDV_S}{1-D} \quad \text{......(3)}$$

The gain of SIB is 10, taking transformer turns ratio as 5, therefore substituting on the equation (1). Duty ratio is designed as 0.6. From equation (2), the output voltage of boost converter is obtained as 25 V and from equation (3), the output voltage of SEPIC converter is obtained as 75 V. Therefore output voltage of SIB Converter is,

$$V_0 = V_{01} + V_{02} = 100\ \text{V} \quad \text{......(4)}$$

## V. SIMULATION AND HARDWARE IMPLEMENTATION

To verify the response of a SIB converter simulation of the SIB converter is done using MATLAB 7.9.0.The circuit have been simulated by giving an input of 10 V, 60 kHz Switching frequency and 50W power rating.

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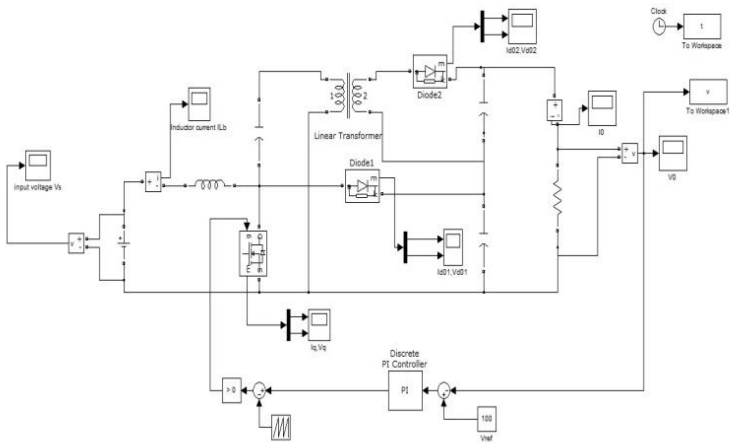


Fig.3 Simulation diagram

Obtained output voltage is 98V. ie, the obtained gain is nearly 10. The MATLAB/ Simulink block diagram for SIB converter with closed loop control circuit is shown in Fig 3. Obtained output voltage is shown in Fig4.

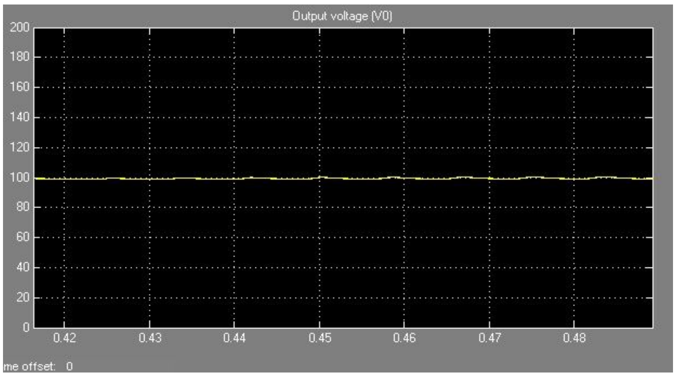


Fig.4 Output voltage

Hardware implementation of SIB converter is also done with the same rating. Control signal for the switch is generated using a dsPIC 30f2010.Complete circuit diagram of SIB converter hardware is shown in Fig 5.

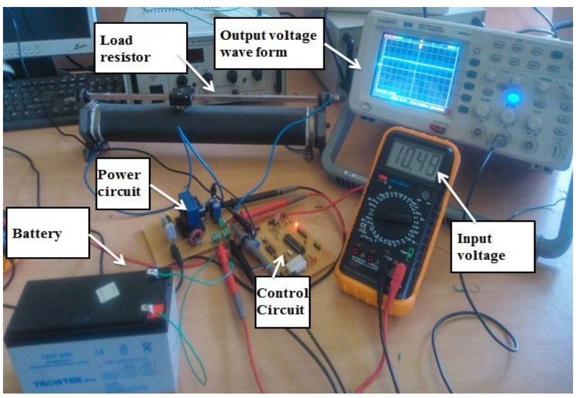


Fig.5 Complete hardware setup of SIB converter

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Fig 6shows output voltage waveform of the prototype. From the waveform it is clear that by giving an input voltage 10V, obtained output voltage is 66V.

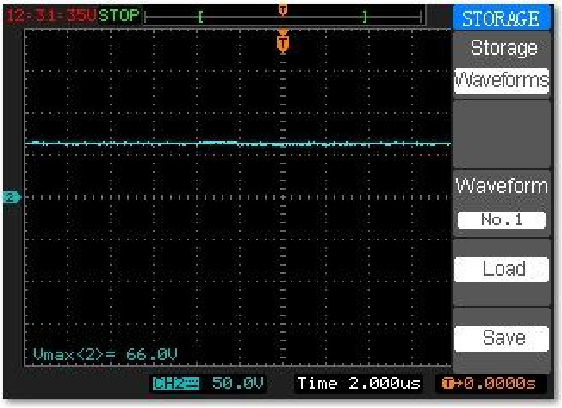


Fig.6 Output voltage waveform

## VI.CONCLUSION

Different topologies exist for non isolated high step up applications, each of them having their own merits and demerits. So we cannot say which converter is best,it depends upon the application for which we are using the converter. SIB converter is best suited for non isolated high step up applications because of its simple structure. Drawbacks ofSIB converter are the switching stress and problems associated with leakage inductance, problems of leakage inductance can be minimized to an extend by closely winding the transformer winding.

Analysis of SIB converter is done by studying various boostconverter topologies and by theoretical analysis of SIB converter. Simulation and hardware implementation is also done as a continuation of the analysis for 10-100V, 60kHZ, 50W ratings. The following conclusions have been made from the study,

1) SIB converter can be constructed by using the advantages of boost converter and SEPIC converter which gives high step up ratio.
2) MATLAB/Simulink model and hardware of the SIB converter is implemented and obtained efficiency is 80% from the simulation model and 86% from the hardware setup.

## REFERENCES

1. R.W. Erickson and D. Masksimovic, Fundamentals of Power Electronics,2nd ed. New York: Wiley, pp. 39-55, 1950
2. Ki-Bum Park, Gun-Woo Moon, and Myung Joong Youn,“ Nonisolated High Step-up Boost converter integrated with SEPIC converter”, IEEE Trans. On Power Electron, Vol. 25, No. 9, Sep 2010.
3. A.Grant, Y. Darroman, and J. Suter, “Synthesis of tappedinductor switched mode converters”,IEEE Trans. Power Electron., Vol. 22, No. 5, pp.1964-1969, Sep 2007.
4. T.-F. Wu, Y.S. Lai, J.C. Hung and Y.-M. Chen, “Boost converter with coupled inductors and buck-boost type of active clamp”, IEEE Trans. Ind. Electron, Vol. 55, No. 1, pp.154-162, Jan 2008.
5. T. Ahmed, S. Nagai, and M. Nakaoka,“A new three winding coupled inductor-Assisted high frequency boost chopper type DCDC power converter with a high voltage conversion ratio”,J.Power Electron., Vol. 5, No. 2, pp.99-103, Apr. 2005.
6. J.-G. Cho, C.-Y. Jeong, H.-S. Lee, and G.-H. Lim, “Novel zero-voltage transition current-fed full-bridge PWM converter for single-stage power factor correction”, IEEE Trans. Power Electron, Vol. 13, No. 6, pp.1005-1012, Nov. 1998.
7. Sang-Kyoo Han, Hyun-Ki Yoon, Gun-Woo Moon, Myung-Joong Youn Yoon-Ho Kim, Kang-Hee Lee,“A New Active Clamping Zero-Voltage Switching PWM Current-Fed Half-Bridge Converter”, IEEE Trans. Power Electron,Vol. 20, No. 6, Nov 2005.
8. Huafeng Xiao and Shaojun Xie,“A ZVS Bidirectional DC-DC Converter With Phase-Shift Plus PWM Control Scheme”, IEEE Trans. Power Electron., Vol. 23, No. 2, Mar 2008.
9. Rong-Jong Wai, Chung-You Lin, Rou-Yong Duan, and Yung-Ruei Chang, “High-Efficiency DC-DC Converter With High Voltage
10. Gain and Reduced Switch Stress”,IEEE transactions on industrial electronics, Vol. 54, No. 1, Feb 2007.

11. Rong-Jong Wai, Rou-Yong Duan, "High Step-Up Converter With Coupled-Inductor", IEEE Trans. Power Electron,., Vol. 20, No. 5, Sep 2005.
12. Marcos Prudente, Luciano L. Pfitscher, Gustavo Emmendoerfer, Eduardo F. Romaneli, and Roger Gules, "Voltage Multiplier Cells Applied to Non- Isolated DCDC Converters", IEEE Trans. Power Electron,Vol. 23, No. 2, Mar 2008.
13. C. J. Tseng andC. L.Chen,"A passive lossless snubber cell for nonisolated PWM DC/DC converters", IEEE Trans. Ind. Electron, Vol. 45, No. 4, pp. 593–601, Aug 1998.
14. K. M. Smith and K. M. Smedley, "Properties and systhesis of passive lossless soft-switching PWM converters", IEEE Trans. Power Electron, Vol. 14, No. 5, pp. 890–899, Sep 1999.
15. M.M. Jovanovic andY. Jang, "State-of-the-art, single-phase, active powerfactor- correction techniques for high-power applications – An overview", IEEE Trans. Ind. Electron, Vol. 52, No. 3, pp.701–708,Jun 2005.