

# SWITCHED INDUCTOR BOOST CONVERTER FOR ELECTRIC VEHICULAR APPLICATIONS

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**Abstract**—In recent trends, DC-DC converters play an important role in various applications like automotive, domestic and industrial. Designing such an efficient and effective converter which is helpful for the above-mentioned fields are really hard. The purpose of this paper is to design an effective boost converter which gives high gain DC output voltage for renewable energy resources. This project presents a methodology that allows development of new converter to boost up the output voltage. In this project boost converter with high DC gain to increase the low output voltage have been designed. The converter chosen here is switched inductor boost converter (SIBC). Switched inductor boost converter is introduced by replacing the inductor of boost converter with a switched inductor branch. As a result, the conversion gain ratio of the boost converter can be increased. The performance of the proposed system is analysed through simulation, where Matrix laboratory (MATLAB) software is used for simulation and results are obtained. The converter is analysed for different loads and switching frequencies and the results are discussed.

**Keywords**—Electric Vehicle, Switched Inductor, Boost Converter.

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## I. INTRODUCTION

A chopper is a power electronic device that converts a Direct Current from a Direct Current source. It is a type of converter that converts a fixed Direct current into variable Direct current. In the year 1957, thyristors were introduced. Chopper circuit is used to refer to numerous types of electronics switching devices and circuit used in power control and signal application. The DC-DC converters are known as chopper. Today dc-dc power converters are becoming the main branch of power electronics. Recent reports indicate that dc-dc converters represent a largest percentage of total conversion equipment production. The

worldwide dc-dc converter market has grown to an average of 7.5% in recent years. In addition to its high growth rate, the dc-dc converter market is undergoing drastic changes because of two major trends in the electronics industry: low voltage and high-power density. The production of dc-dc converters in the world market is now much higher than that of ac-dc converters. The divided market comprises of three sub segments, including low power, medium power, and high power. The boost DC-DC converters are widely used in industrial application. A boost converter is a DC-DC converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply containing at least two semiconductors (a diode and a transistor) and at least one energy element: capacitor, inductor, or the two combinations. To reduce ripple, filters made of capacitor (sometimes in combination with inductors) are normally added to such a converter's output and input.

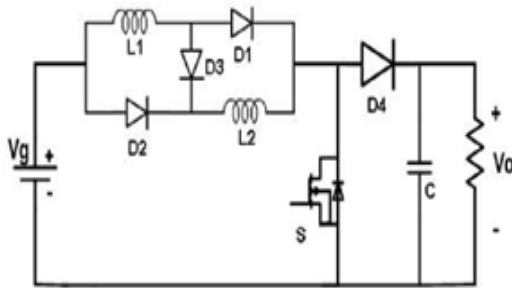
Theoretically, a boost dc-dc converter can achieve a high step-up voltage gain with an extremely high duty ratio near to 100%. However, in practice, the step-up voltage gain is limited due to the effect of power switches, rectifier diodes, the equivalent series resistance (ESR) of inductors and capacitors, and the saturation effects of the inductors and capacitors. The conversion efficiency and high voltage gain are not easy to achieve with conventional boost converter due to parasitic component. In order to obtain high output voltage, the conventional boost converter should operate at extreme duty cycle. This condition limits the switching frequency and converter size, and also increases the electromagnetic interference (EMI) levels. Many research papers are being proposed several compensation topologies for overcoming these challenges and improving quality. Many topologies have been presented to provide a high step-up voltage gain. The coupled inductor techniques provide solutions to achieve a high voltage gain, a low voltage stress on the active switch, and a high efficiency without the penalty of high duty ratio.

In this paper, the simulation and evaluation of Switched Inductor Boost DC-DC Converter is executed under

MATLAB Simulink software. The performance of Switched Inductor Boost DC-DC Converter was tested by considering the effect of duty cycle variation and the results are discussed..

## II. PROPOSED SWITCHED INDUCTOR BOOST CONVERTER

The switched inductor branch consists of two parts of inductors and three diodes. By replacing the inductor of the conventional dc-dc converter with the switched inductor branch, the result circuit is called switched inductor dc-dc boost converter (SIBC). Fig. (3) shows the circuit diagram of the switched inductor boost dc-converter. Switched inductor boost dc-dc converter consist of switched inductor branch, diode, MOSFET, capacitor and resistive load.

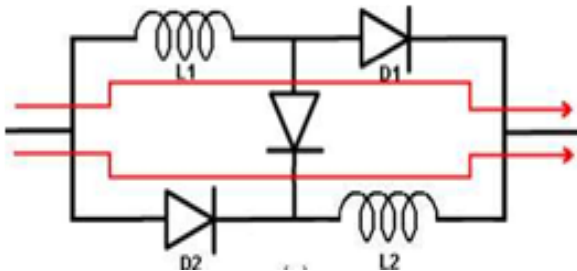


**Figure 1 Switched inductor boost dc-dc converter**

### A. Operation of Proposed Switched Inductor Boost Converter

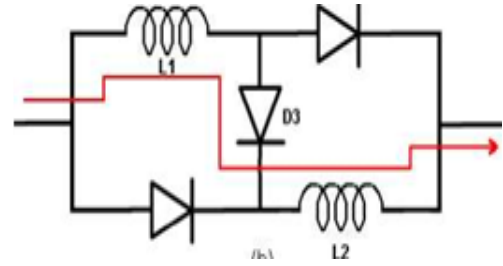
In a switched inductor boost converter, the switch operations of the converter can be explained as follows:

- (a) When the switch is closed, current flows from voltage source through both of the inductors in parallel connection as shown in Figure 2 both of inductors store some energy by generating a magnetic field. Polarity of the left side of the inductor is positive.



**Figure 2 current flow in switched inductor branch mode1**

- (b) When the switch is opened, current will be reduced as the impedance is higher. The current flows from voltage source through both of the inductors in series connection as shown in Figure 3.

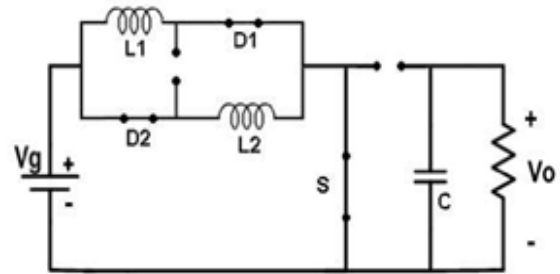


**Figure 3 current flow in switched inductor branch mode2**

The magnetic field previously created will be destroyed to maintain the current towards the load. Thus the polarity will be reversed, and left side of inductor will be negative. As a result, voltage source will be in series with both of inductors causing a higher voltage to charge the capacitor through the diode.

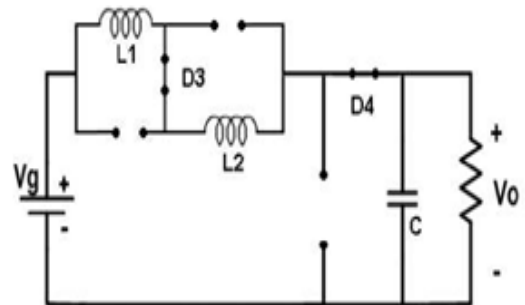
The switched inductor boost converter has two modes of operations.

- (a) Mode 1 occurs when switch S is ON, this causes diodes D1 and D2 to be ON and diodes D3 and D4 to be OFF. Both of inductors are charging in parallel. Figure 4 shows the converter circuit of mode 1.



**Figure 4 operation mode of (SIBC) Mode-1**

- (c) Mode 2 occur when switch S is OFF, this causes diodes D1 and D2 to be OFF and diodes D3 and D4 are ON. Both of inductors discharge in series. Figure 5 shows the converter circuit of mode 2.



**Figure 5 operation mode of (SIBC) Mode-2**

The gain ratio between input and output voltage obtain from SIBC is

$$\text{Gain} = V_0/V_{in} = (1+D)/(1-D)$$

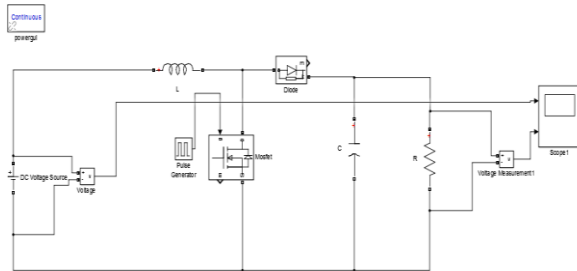
By comparing gain ratio of the Switched Inductor Boost converter with conventional boost converter SBIC has the higher gain by the factor(1+D). The coupled inductor technique provides a high voltage gain, a low voltage stress on the active switch, and a high efficiency without penalty of high duty ration. Thus Switched Inductor Boost (SIBC) type provides high gain and high efficiency

### III. RESULTS AND DISCUSSION

This chapter describes the simulation modelling of proposed and conventional DC-DC boost converter and results were analysed using MATLAB simulation software. MATLAB (matrix laboratory) is a multi-paradigm numerical computer environment and fourth-generation programming language.

#### A. Conventional Boost Converter

The boost converter is used to step up an input voltage to some higher level required by load. This unique capability is achieved by storing energy in an inductor and releasing it to the load at higher voltage. For this model a separate source of 25V dc supply is applied to the boost converter and by the source inductor the voltage gets magnified and



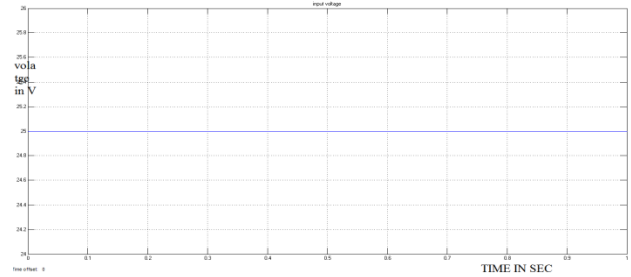
**Figure 6** Simulink model of DC-DC boost converter

Desired output is obtained. The figure 6 shows the MATLAB simulation for the boost converter, here input voltage of DC (25 V) supply is given to the converter, the desired output voltage is obtained by controlling the switching frequency, the switch used here is MOSFET and diode is used to make current flow in one direction. Capacitor and inductor is a charge storage device; this is used for the boosting the output voltage.

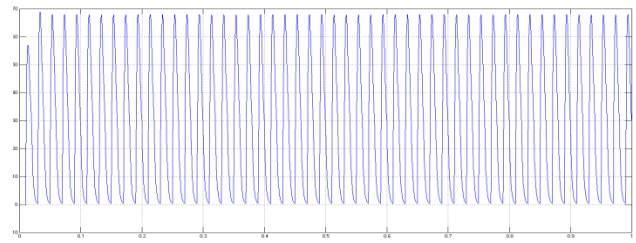
#### B. Simulation Result of Conventional Boost Converter

The figure 7 and figure 8 shows the input and output voltage waveforms; 25v input voltage is fed to the circuit at the source side. Due to the inductor present in the source side it will produce a magnified output. In the boost converter, the

output voltage reaches up to 70V.



**Figure 7** Input voltage waveform of boost converter



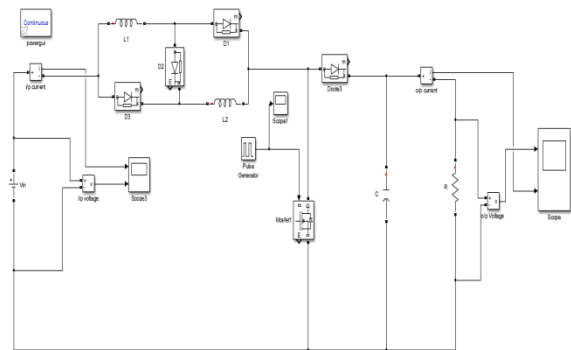
**Figure 8** output voltage waveform of boost converter

#### C. Switched Inductor Boost Converter

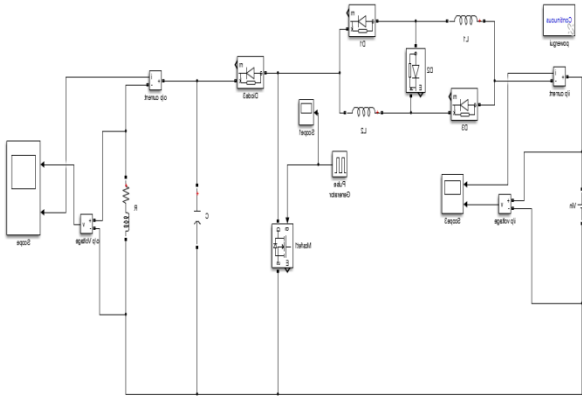
SIBC is type of DC/DC converter allowing the electrical potential at its output to be greater than, less than, or equal to that of its input. The output of the SIBC is controlled by the duty cycle of the control transistor. A SIBC-boost converter consists of switched inductor branch. This converter provides the step up output voltage for given input voltage with R and RL load.

#### D. Simulink Model For Switched Inductor Boost Converter

A single (25V DC) supply is given to the SIBC- boost converter. SIBC consist of switched inductor which magnetically stores the energy provide continually supply to the load. By changing the duty ratio of the switch high output gain is obtained.



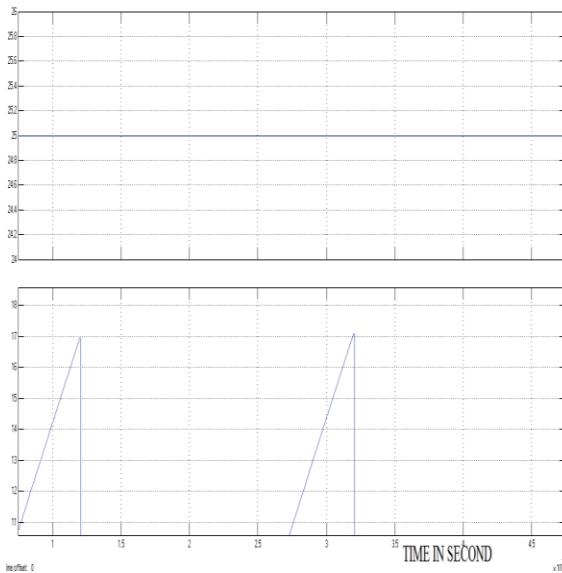
**Figure 9** Simulink model of SIBC DC-DC converter



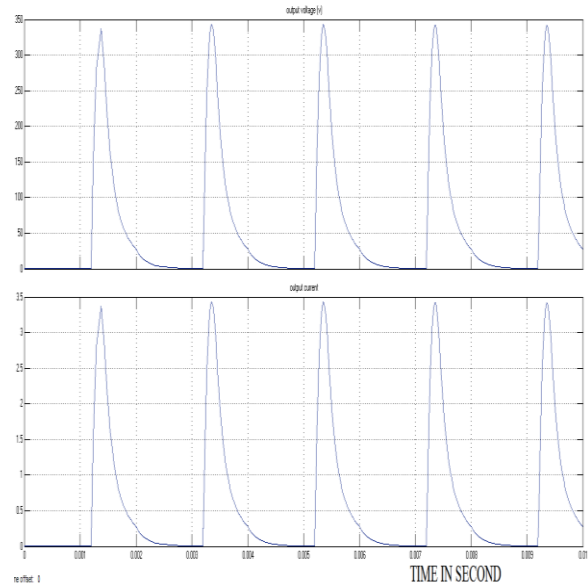
**Figure 10 Simulink model of SIBC with RL load**

Figure 9 and figure 10 shows the simulink model of the switched inductor boost converter with different load. The input voltage (25V DC) is given, here we employed switched inductor branch by replacing inductor the desired step up output voltage is obtained by controlling the duty cycle of the switch.

#### E. Simulink Result Of Switched Inductor Boost Converter

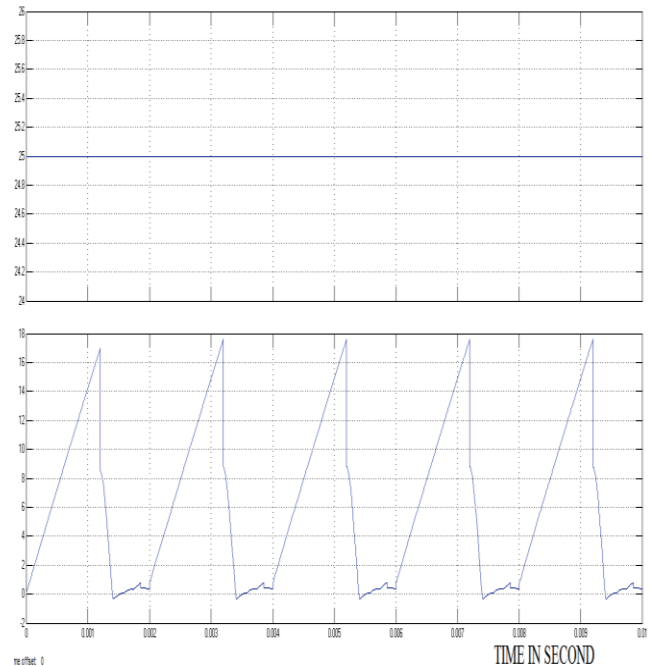


**Figure 11 input voltage and current of SIBC with R load**

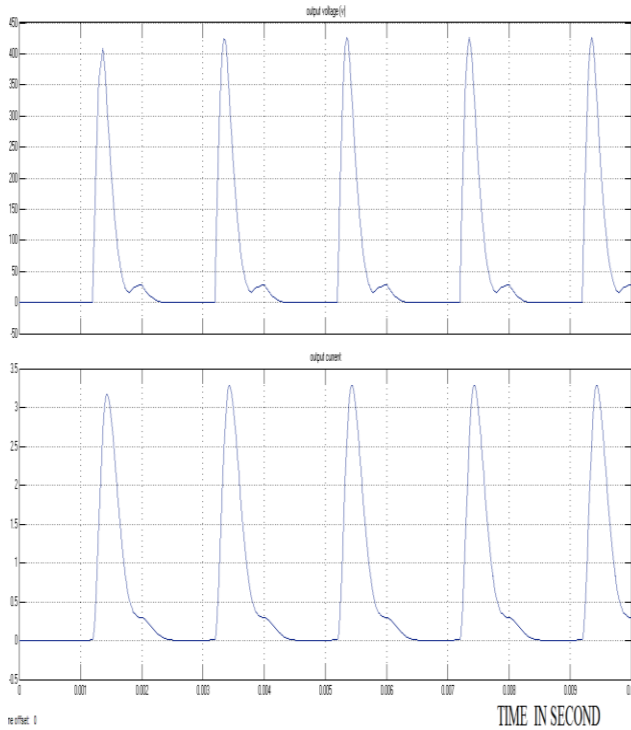


**Figure 12 output voltage and current of SIBC with R load**

Figure 11 and figure 12 shows the input and output voltage and current waveform of SIBC converter with R load, here the input is given as 25V is given to the circuit at the source side. Then the voltage collapsing magnetic field will be produced in switched inductor branch, the over voltage spike will be produce and it cause the current flow in the circuit, SIBC converter circuit has switch it will be able to produce higher voltage with duty ratio. The SIBC convertre able to produce step-up voltage, the output voltage reach up to 350.



**Figure 13input voltage and current waveform of SIBC with RL load**



**Figure 14** output voltage and current waveform of SIBC with RL load

Figure 13 and figure 14 shows the input and output voltage and current waveform of SIBC converter with RL load, here the input is given as 25V is given to the circuit at the source side. Then the voltage collapsing magnetic field will be produced in switched inductor branch, the over voltage spike will be produce and it cause the current flow in the circuit, SIBC converter circuit has switch it will be able to produce higher voltage with duty ratio. The SIBC convertre able to produce steo-up voltage, the output voltage reach up to 400.

#### F. Analysis of SBIC Converter

The table1 and table2 shows the different analysis of the switched inductor boost converter with various voltage and pulse width the output voltage and output current is measured.

Table 1 Analysis of SIBC with 60% duty Ratio for different voltage

I/P voltage (in V)	I/P current (in A)	O/P voltage (in V)	O/P current (in A)
10	50	140	1.4
25	120	350	3.5
30	150	400	4
40	200	580	5.8

From table 1 it is seen that the output voltage obtained

from the converter is a boosted value and the current increases as the voltage increases. A high gain is obtained for an input voltage of 40V and the current is reasonable to drive a load.

**Table 2: analysis of SIBC with 24V for different Duty ratio**

Duty Ratio (%)	O\P voltage (in V)	O/P current (in A)
5	60	0.6
10	90	0.9
20	160	1.6
25	180	1.8
30	210	2.1
40	250	2.5
50	310	3.1

The table 2 shows that on increasing the duty ratio the output voltage and output current increases. A high boost is obtained for the duty ratio of 50%.

#### IV. CONCLUSION

A Switched inductor boost converter is studied in this paper. It produces a very large DC-DC conversion ratio at low duty cycle far away from unity. The simulation and evaluation of Switched Inductor boost DC-DC converter is done in MATLAB and the results were presented. It is seen that a high voltage boost is obtained for a small voltage and the voltage boost increases with the increase in the duty ratio. The simulation results show that the gain of Switched Inductor Boost converter is higher than the gain of conventional boost DC-DC converter. Thus the switched inductor boost converter could be used for DC-DC applications in renewable energy systems.

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