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COMPARISON OF FULL BRIDGE AND TWO INDUCTOR BOOST CONVERTER SYSTEMS

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ABSTRACT

The DC-DC converter topologies have received increasing attention in recent years for high power and high performance applications. The advantages of DC-DC boost converters include increased efficiency, reduced size, reduced electromagnetic emission, faster transient response, and improved reliability. The front end inductors in a boost converter are magnetically coupled to improve electrical performance and reduce size and weight. It features several merits such as multiple-output capability with one shared choke, single-stage energy processing and good input current shaping ability. This paper compares conventional boost converter and two inductor boost converter designed for high voltage and high power applications. Results of conventional boost converter are compared with two inductor boost converter.

Keywords: *Comparison, Power Factor, Two Inductor Boost Converter, Bridge,*

1. INTRODUCTION

DC/DC Converters are mostly used for interconnections of two DC networks with different voltage levels. There are many different topologies, which varies in complexity of circuits, stress on used components and quality of input and output power.

The boost converter topology has been extensively used in various ac/dc and dc/dc applications. In fact, the front end of today's ac/dc power supplies with power factor correction is almost exclusively implemented with boost topology.

In the high-power bi-directional dc/dc converter, the isolated full-bridge boost converter has been a good choice due to its effectiveness to limit the overshoot of bridge switch's turn off voltage and to enable the energy stored in the transformer leakage inductance to be used for zero voltage switching [2]. Effectiveness of this circuit topology has been demonstrated in the applications of the alternative energy systems, or the hybrid vehicle systems [3].

Graphically model of the boost converter is shown in fig.1. The full details of the boost converter topology have been already discussed in [4, 5, 6].

Generally, a single-inductor, single-switch boost converter topology and its variations exhibit a satisfactory performance in the majority of applications where the output voltage is greater than the input voltage. The performance of the boost converter can be improved by implementing a boost converter with multiple switches and/or multiple boost inductors.

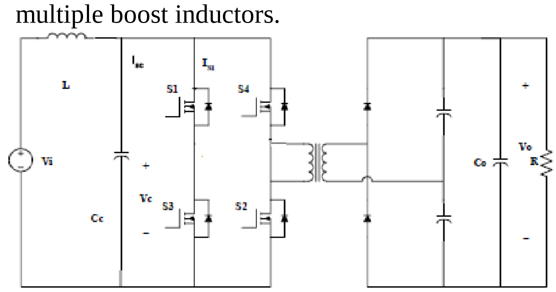

Fig.1.Conventional boost converter

The two inductor boost converter exhibits benefits in high power applications [7]-[14]: high input current is split between two inductors, thus reducing I^2R power loss in both copper windings and primary switches. Furthermore, by applying

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an interleaving control strategy, the input current ripple can be reduced [9]. Implementation of the topology can be in either non isolated [15] or isolated format. The isolated boost topology, which is shown in Fig. 2 [16], is attractive in applications such as power factor correction (PFC) with isolation and battery or fuel cell powered devices to generate high output voltage from low input voltage[15]-[18].

The main obstacle of the circuit in Fig.2 is its limited power regulation range. Inductor L_1 must support input voltage when-ever Q_1 turns on. Likewise, this is true for L_2 and Q_2. Since the minimum duty ratio of each switch is 0.5, the magnetizing currents of the two inductors cannot be limited. This leads to a minimum output power level. If the load demands less power than this minimum level, the output voltage increases abnormally because excessive energy has been stored in the inductors.

A recent solution to this limitation on minimum power is given in Fig.3 [17], [18]. An auxiliary transformer T_2 is inserted in series with inductor L_1 and L_2. Transformer T_2 magnetically couples two input current paths.

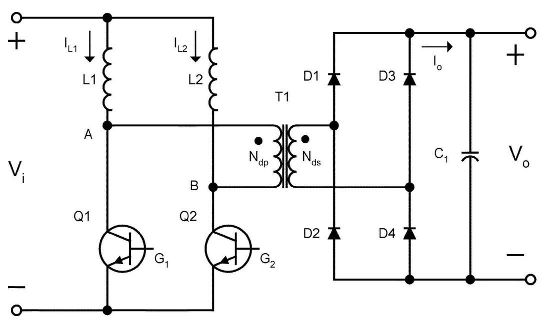

Fig.2.Conventional two inductor boost converter

The currents in the two inductors are then forced to be identical. Theoretically, the input current only increases when both Q_1 and Q_2 turn on. If the overlapping between two driving signals is small, the inductor currents become discontinuous. This improvement makes the two-inductor boost circuit attractive in application.

However, a disadvantage of the app-roach is that the circuit requires four magnetic components on the primary side, thus, requiring additional board space.

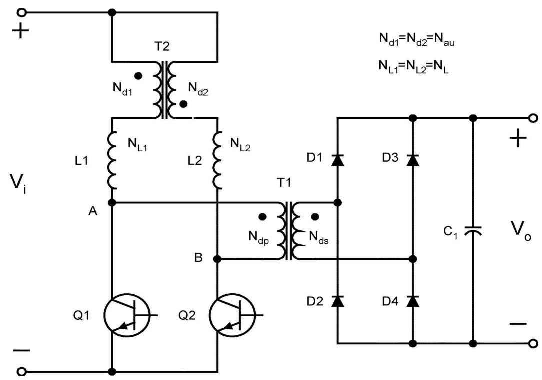

Fig.3. Two-inductor boost converter with auxiliary transformer

Advantages of the topology include the properties that it does

1) Implements the isolated two-inductor boost converter with one magnetic assembly, thereby reducing the board space.
2) Maintains wide power regulation range: that is, under the condition that the output voltage is regulated, the input power is limited when the overlapping of driving signals is small.
3) Has a reduced number of windings (two windings) on the primary side of the circuit compared to the topology in Fig. 3 (five windings). The copper loss can be reduced because of fewer windings and soldering connections.
4) Implements the start-up and protection windings within the same magnetic assembly without adding components to the primary circuit.

New integrated magnetic DC to DC converter is given by Bloom [13]. Modern switch mode DC to DC converters are given by Severns [14]. Core selection and design aspects of magnetic forward converter is given in [15]. Modelling and analysis of magnetic components is given by Cheng [16]. 1-φ UPF AC to DC boost converter is given by Bhim Singh [17]. Timer controller with constant frequency is given by Marcos [18].

In the literature [1] to [24] comparison of boost converter with two inductor boost converter is not present. In this work the parameters like input voltage, power and efficiency are presented.

2. ANALYSIS

The voltage across the inductor during on period is V_d. During this period the current raises

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linearly from a minimum level to maximum level. Therefore the voltage across the inductor is

$$V_L = V_d \quad (1)$$

And also

$$V_L = L\,(I_2 - I_1) / T_{on} = L(\Delta I) / T_{on} \quad (2)$$

From (1) and (2)

$$T_{on} = L(\Delta I) / V_d \quad (3)$$

The voltage across the inductor during off period is $(V_o - V_d)$ and the current drops linearly. Therefore the voltage across the inductor is

$$V_L = (V_o - V_d) \quad (4)$$

Also

$$V_L = L\,(I_2 - I_1) / T_{off} = L(\Delta I) / T_{off} \quad (5)$$

From (4) and (5)

$$T_{off} = L(\Delta I) / \ (V_o - V_d) \quad (6)$$

From (3)

$$L(\Delta I) = T_{on} * V_d \quad (7)$$

From (6)

$$L(\Delta I) = T_{off} * \ (V_o - V_d) \quad (8)$$

From (7) and (8)

$$T_{on} * V_d = T_{off} * (V_o - V_d)$$

Or $V_o = (T_{on} + T_{off}) * V_d / T_{off}$

Or $V_o = T * V_d / T_{off}$

Or $V_o = V_d / (1-\alpha)$ (9)

Where α is the delay angle. As firing angle varies, the output voltage increases from V_d to infinity. Hence the output voltage is boosted.

The selection of inductor and the capacitor in the Boost topology plays a major role in the output response. The inductance value is obtained using

$$L = \frac{V_0 D}{f \Delta I} \quad (10)$$

Where f is the switching frequency, D is the duty ratio, V_0 is the source voltage and ΔI is the peak to peak ripple current.

The Capacitance value is obtained using

$$C = \frac{D}{2\ fR} \quad (11)$$

3. SIMULATION RESULTS

Conventional two inductor boost converter is shown in Fig 4a. DC input voltage and current are shown in Fig's 4b and 4c respectively. DC input power is shown in Fig 4d. Driving pulse and voltage across the switches S_1 and S_2 are shown in Fig's 4e and 4f respectively. DC output voltage is shown in Fig 4g. DC output current is shown in Fig 4h. The circuit of two inductor boost converter is shown in Fig 5a. DC input voltage and current waveforms are shown in Fig's 5b and 5c respectively. Switching pulses and output voltage of S_1 and S_2 are shown in Fig's 5d and 5e respectively. DC output voltage, current and power are shown in Fig's 5f, 5g and 5h respectively. Table of comparison is given in Table 1.Comparison of output power is shown in Fig 5i. Comparison of efficiency is shown in Fig 5j. The efficiency increases by 2%.

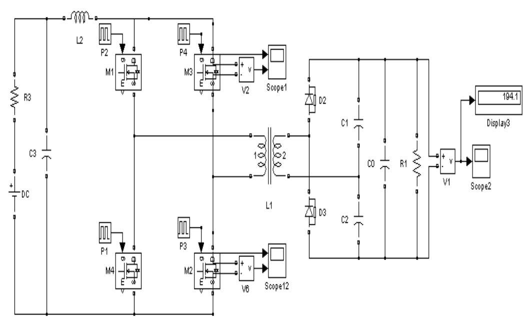

Fig.4a. Conventional two inductor boost converter

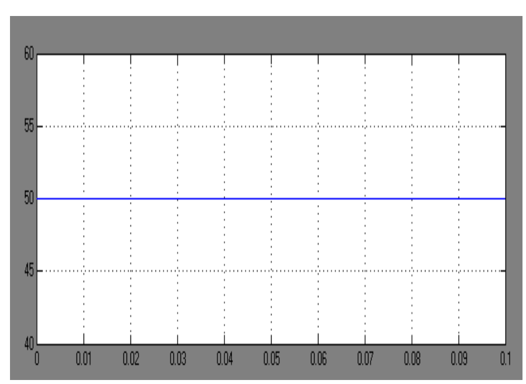

Fig.4b.Dc input voltage

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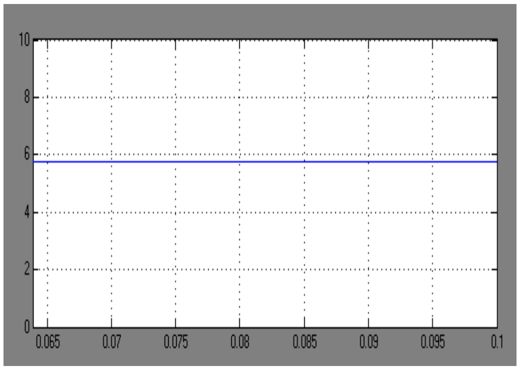

Fig.4c.DC input current

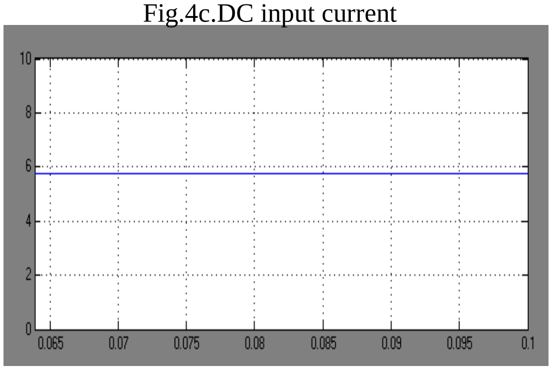

Fig.4d.Dc input power

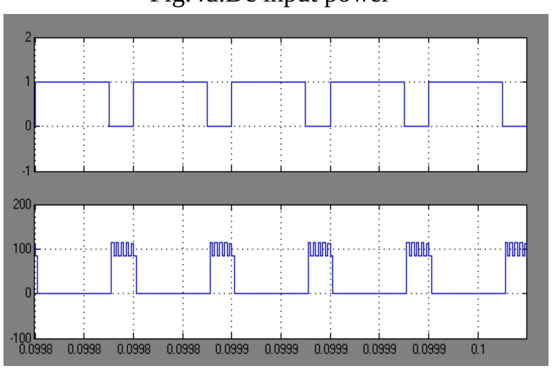

Fig.4e.Switching pulse and voltage across S_1

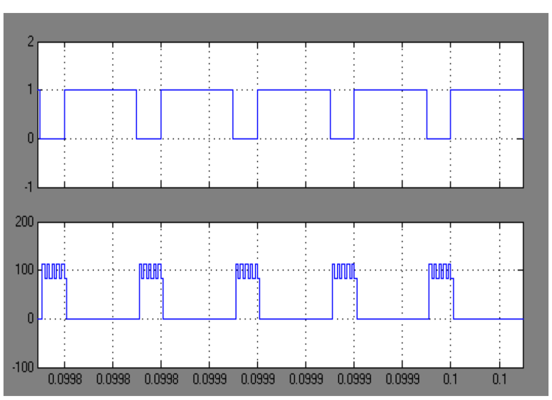

Fig.4f.Switching pulse and voltage across S_2

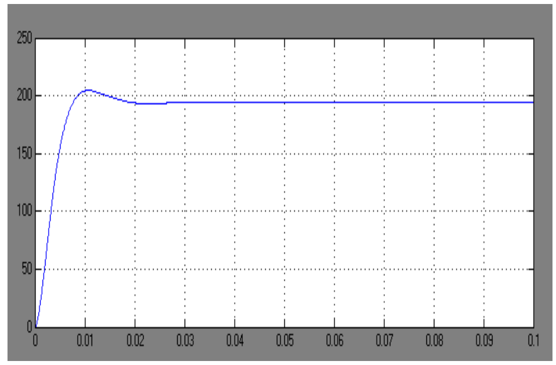

Fig.4g.Dc output voltage

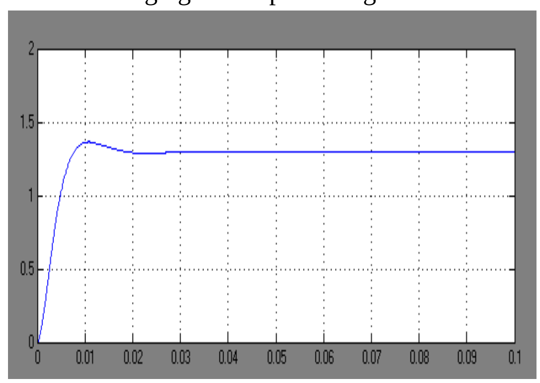

Fig.4h.Dc output current

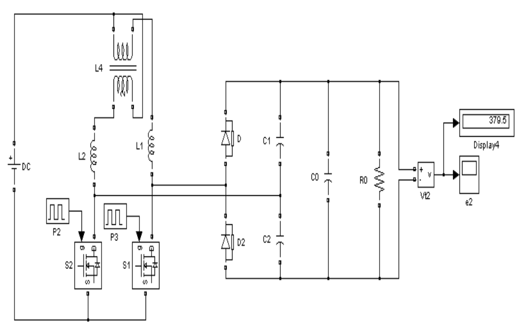

Fig.5a.Circuit diagram of Two Inductor Boost Converter

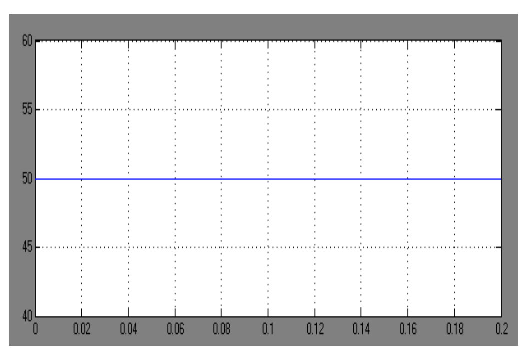

Fig.5b.Dc input voltage

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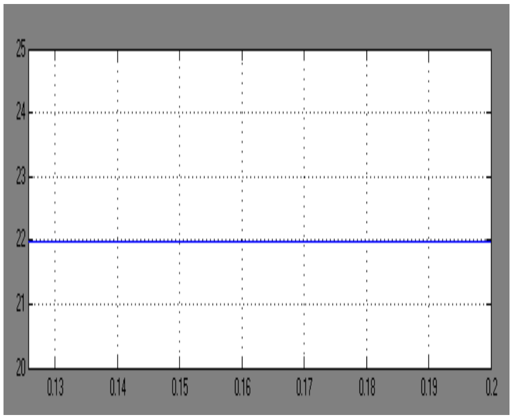

Fig.5c.Dc input current

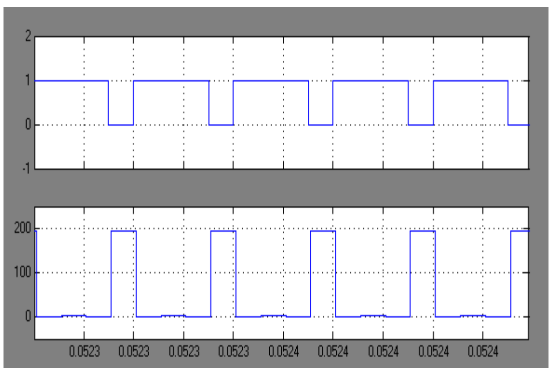

Fig.5d.Switching pulse and voltage across S1

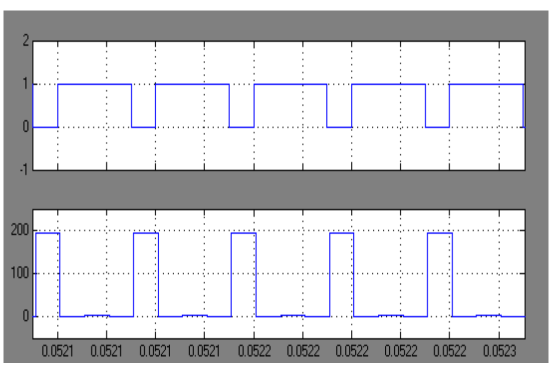

Fig.5e. Switching pulse and voltage across S2

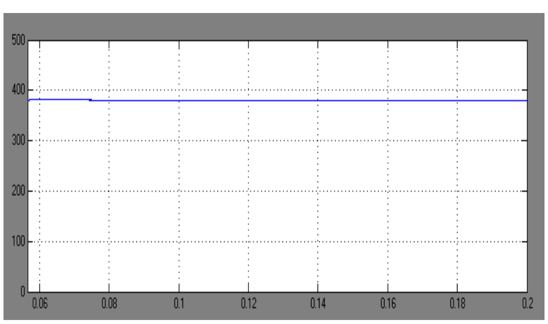

Fig.5f. Dc output voltage

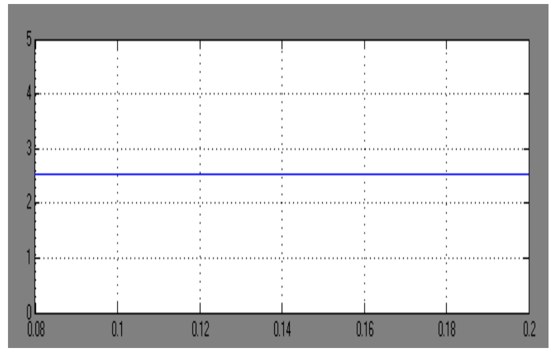

Fig.5g. Dc output current

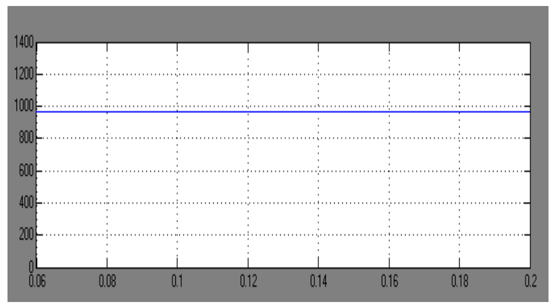

Fig.5h. Dc output power

Table 1: Comparison

Vin	Input power		Output power		Efficiency	
	Conventional	Proposed	Conventional	Proposed	Conventional	Proposed
40	185	702	159	617	85.95	87.89
50	290	1100	251	969	86.55	88.09
60	416	1568	361	1394	86.78	88.90
70	570	2135	495	1900	86.84	88.99

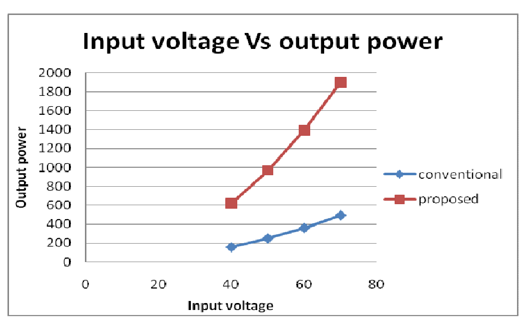

Fig.5i. Graph between input voltage and output power

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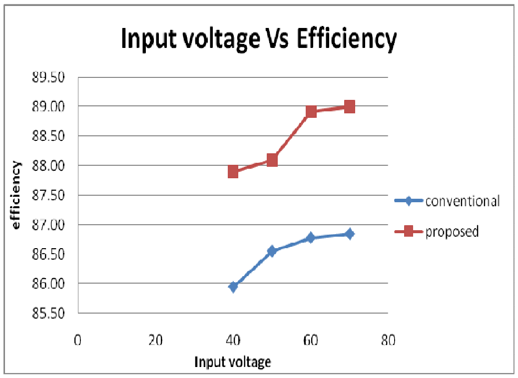

Fig.5j. Graph between input voltage and efficiency

4. CONCLUSION

Full bridge boost converter and Two inductor boost converter systems are simulated using simulink. Two inductor boost converter has advantages like reduced hardware, reduced transformer size and filter requirement. Two inductor boost converter is capable of giving higher output power. The efficiency increases by 2%. Therefore two inductor boost converter is better than full bridge type boost converter.

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