Abstract—This paper deals with simulation and implementation of two inductor boost converter. This converter is capable of giving higher output voltage with smaller inductor. Open loop and closed loop circuit models are developed and they are used for simulation studies. The digital simulation is done using Matlab and the results are presented. The experimental results are compared with the simulation results.

Index Terms—Digital simulation, Two Inductor Boost Converter

I. INTRODUCTION

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.

The two inductor boost converter exhibits benefits in high power applications [1]-[8]: high input current is split between two inductors, thus reducing $I^2R$ power loss in both copper windings and primary switches. Furthermore, by applying an interleaving control strategy, the input current ripple can be reduced [3]. Implementation of the topology can be in either non isolated [9] or isolated format. The isolated boost topology, which is shown in Fig. 1 [10], 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 [9]-[12].

The main obstacle of the circuit in Fig. 1 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.2 [11], [12]. 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. 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 approach is that the circuit requires four magnetic components on the primary side, thus, requiring additional board space.

This paper proposes an integrated magnetic isolated two-inductor boost converter that uses only one magnetic assembly as shown in Fig.3.

Advantages of the topology include the properties that it does the following.

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. 2 (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.

The parameters $L$ and $C$ are obtained as follows:

$$L = \frac{V_0 D}{f\Delta I} \quad (1)$$

Fig.1. Conventional two inductor boost converter

Fig.2. Two-inductor boost converter with auxiliary transformer

Fig.3. Integrated magnetic isolated two inductor boost converter system

Experimental Investigations on Two Inductor Boost Converter System

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In the literature [1] to [16] simulink model for two inductor boost converter is not present. In this work an attempt is made to develop closed loop circuit model for two inductor boost converter. The hardware is implemented using Atmel microcontroller is also presented.

II. SIMULATION RESULTS

Two inductor boost converter circuit is shown in Fig 4a. DC is converted into high frequency AC using two inductor based inverter. The output of inverter is converted into DC using a rectifier. Driving pulses given to $S_1$ & $S_2$ are shown in Fig 4b. Input and output voltages of $S_1$ & $S_2$ are shown in Fig 4c and Fig 4d respectively. It can be seen that the output of MOSFET is compliment of the input. Inverter output voltage is shown in Fig 4e. Voltage across $C_1$ & $C_2$ is shown in Fig 4f. DC output voltage is shown in Fig 4g. It can be seen that the DC output is free from ripple. The DC voltage settles at 380V. The variation of output with the input is shown in Fig 4h. Output voltage increases with the increase in the input voltage. The variation of output power with the input power is shown in Fig 4i. The output power increases with the increase in the input power.
Open loop system with a step disturbance applied at the input is shown in Fig 5a. Step rise in input voltage is shown in Fig 5b. Open loop response of the output is shown in Fig 5c. There is a step rise in the output due to the increase in the input.

The circuit model of closed loop system is shown in Fig 6a. The output is sensed and it is compared with a reference voltage. The error is processed through a PI controller. The output of PI controller adjusts the pulse width to maintain the output constant. The response of closed loop system is shown in Fig 6b. It can be seen that the output voltage remains constant due to the control action of the closed loop system.
III. EXPERIMENTAL RESULTS

The hardware is fabricated and tested in the laboratory. The top view of the hardware is shown in Fig 7a. The hardware consists of control board and power board. Oscillogram of driving pulses are shown in Fig 7b. Voltage across S₁ is shown in Fig 7c. Voltage across S₂ is shown in Fig 7d. DC output voltage is shown in Fig 7e. The DC output voltage is free from ripple.

IV. CONCLUSION

Closed loop controlled two inductor boost converter system is designed and simulated using MATLAB and the results are presented. The closed loop system maintains constant voltage. Two inductor systems is realized using a transformer. The size of the converter is reduced due to the reduction in the size of the transformer. Output voltage regulation is improved by using closed loop system. Laboratory model of two inductor boost converter is fabricated and tested. Experimental results closely agree with the simulation results.

REFERENCES


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