Research Journal of Applied Sciences, Engineering and Technology 3(1): 39-45, 2011
ISSN: 2040-7467

Received: November 17, 2010 Accepted: January 10, 2011 Published: January 20, 2011

Digital Implementation of Two Inductor Boost Converter Fed DC Drive

[1]G. Kishor, [2]D. Subbarayudu and [3]S. Sivanagaraju
[1]JNTUA, Anantapur, India
[2]GPREC, Kurnool, India
[3]JNTU, Kakinada, India

Abstract: The study deals with simulation and implementation of two inductor boost converter fed DC drive. The two inductor boost converter fed DC drive is simulated and implemented. The circuit has advantages like higher output voltage and improved power factor. The laboratory model is implemented and the experimental results are obtained. The experimental results were compared with the simulation results.

Key words: Power factor, two inductor boost converter

INTRODUCTION

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.

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 (Miwa, 1992; Kolar *et al.*, 1995; Elmore, 1996; Pinheiro, *et al.*, 1999; Braga and Barbi, 1999; Irving *et al.*, 2000; Bossche *et al.*, 1998; Wolfs, 1993): 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 (Elmore, 1996). Implementation of the topology can be in either non isolated (Zhang, 1995) or isolated format. The isolated boost topology, which is shown in Fig. 1 (Ivensky, 1994), 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 (Jang, 2002; Zhang *et al.*, 1995; Ivensky *et al.*, 1994; Jang and Jovanovic, 2001).

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 (Jang, 2002; Jang and Jovanovic, 2001). 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 app-roach is that the circuit requires four magnetic components on the primary side, thus, requiring additional board space.

Advantages of the topology include the properties that it does:

- Implements the isolated two-inductor boost converter with one magnetic assembly, thereby reducing the board space.
- 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.
- 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.
- Implements the start-up and protection windings within the same magnetic assembly without adding components to the primary circuit. Integrated

Corresponding Author: G. Kishor, JNTUA, Anantapur, India

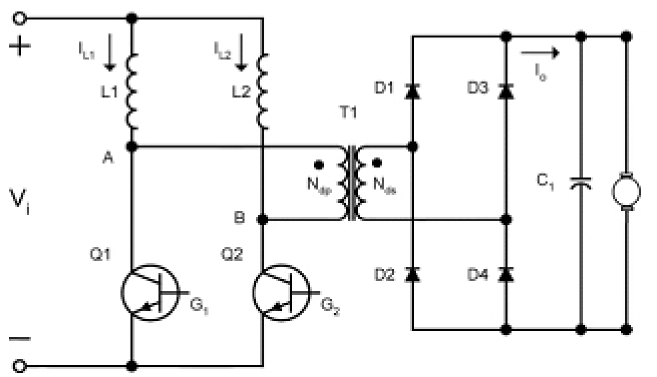


Fig. 1: Conventional two inductor boost converter fed DC Drive

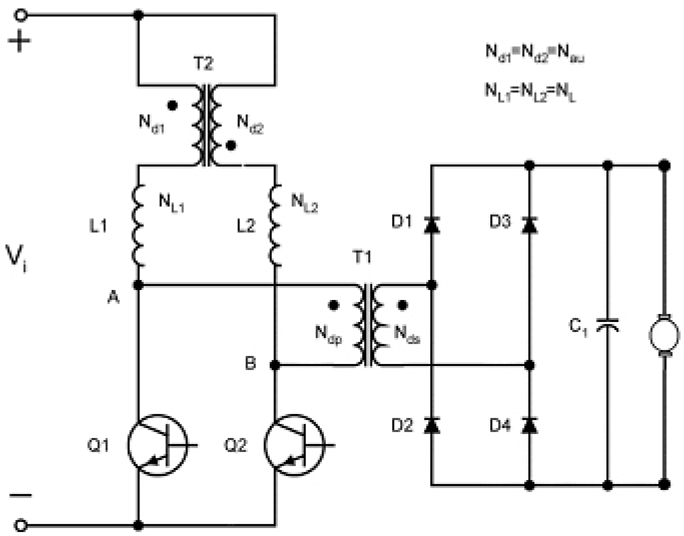


Fig. 2: Two-inductor boost converter with auxiliary transformer

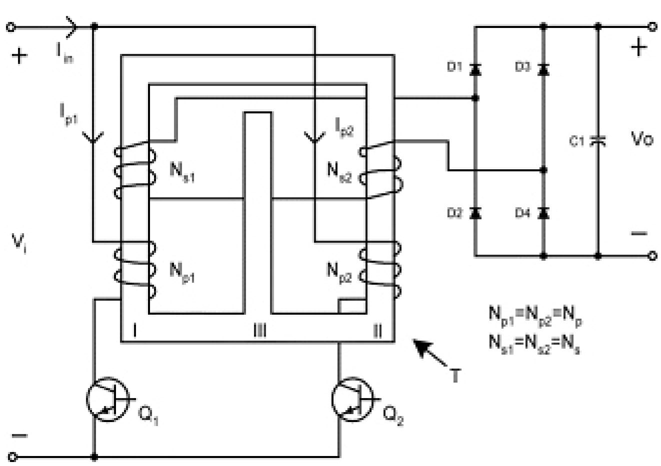


Fig. 3: Integrated magnetic two-inductor boost converter

magnetic two inductor boost converter circuit is shown in Fig. 3. DC is converted into AC using two inductor converter system and the output of this system is converted into DC using a rectifier.

New integrated magnetic DC to DC converter is given by Bloom (1987). Modern switch mode DC to DC converters are given by Severns (1985). Core selection and design aspects of magnetic forward converter is given in Bloom (1986). Modelling and analysis of magnetic components is given by Cheng *et al.* (2000). 1-ϕ UPF AC to DC boost converter is given by Pandey and Singh (2004). Timer controller with constant frequency is given by Marcos *et al.* (2005).

In the literature review simulink model for two inductor boost converter fed DC Drive is not present. In this study an attempt is made to implement two inductor boost converter fed DC Drive using Atmel microcontroller.

ANALYSIS

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:

$$L = V_0 D / f\Delta I \quad (1)$$

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:

$$C = D / 2fR \quad (2)$$

The equation for the armature circuit is:

$$V = Ri + L\,(d_i / d_i) + e_b \quad (3)$$

The equation for mechanical system is:

$$T_d = T_L + J\,(d_w / d_t) + B_\omega \quad (4)$$

RESULTS

Simulation results: Simulink model of two inductor boost converter fed DC drive is shown in Fig. 4a. Current through the transformer is shown in Fig. 4b. Output voltage across transformer is shown in Fig 4c. Dc output voltage is shown in Fig 4d. Rotor speed is shown in

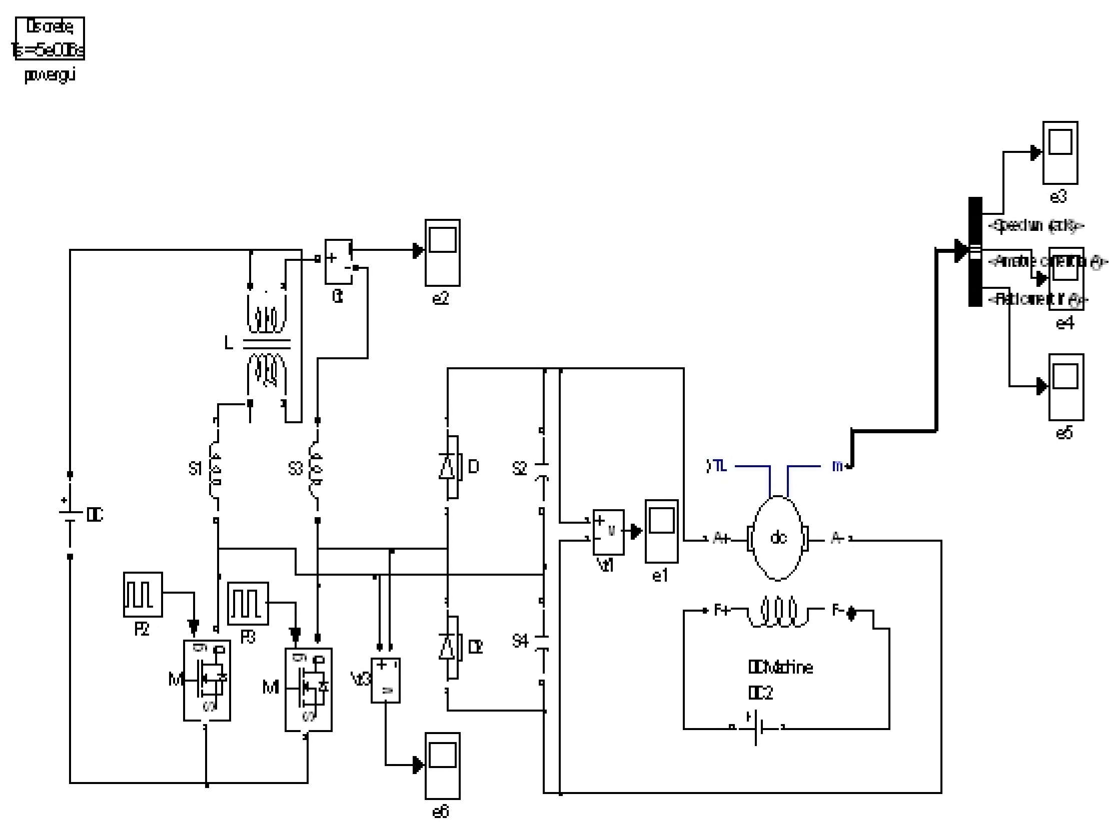


Fig. 4a: Two inductor boost converter with DC Drive

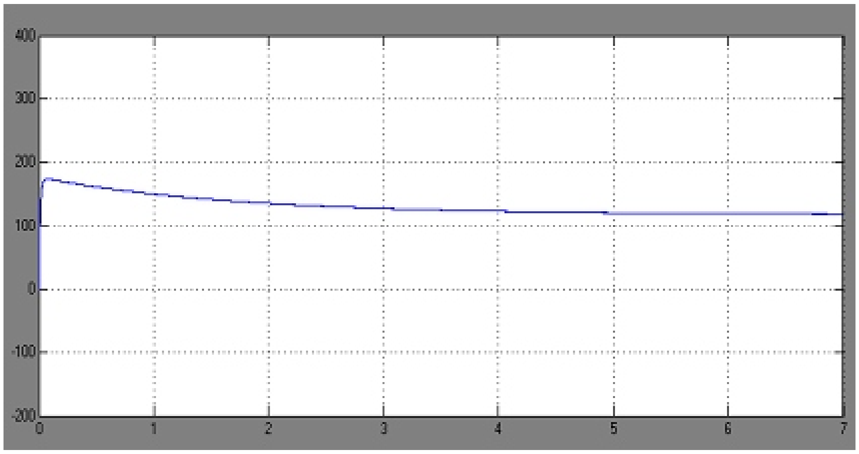


Fig. 4b: Current through the transformer

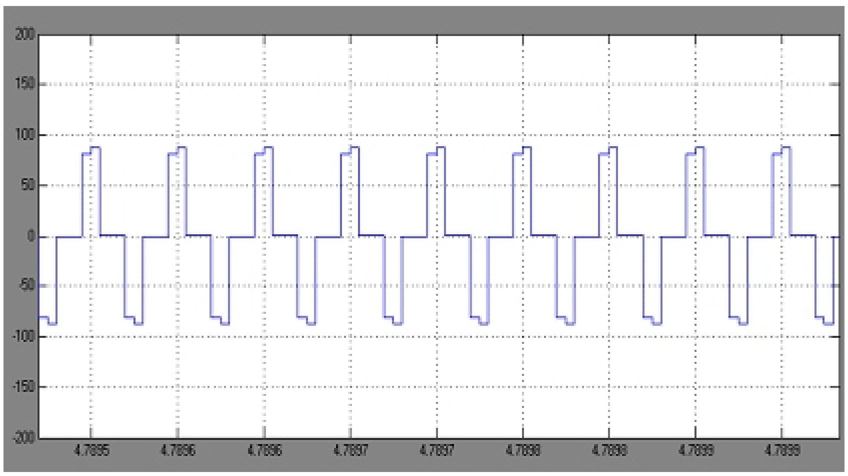


Fig. 4c: Secondary voltage of transformer

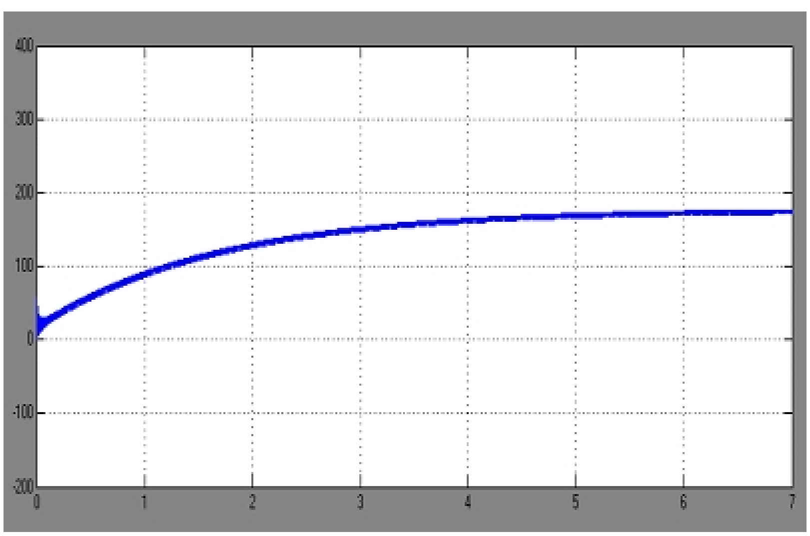


Fig. 4d: DC output voltage

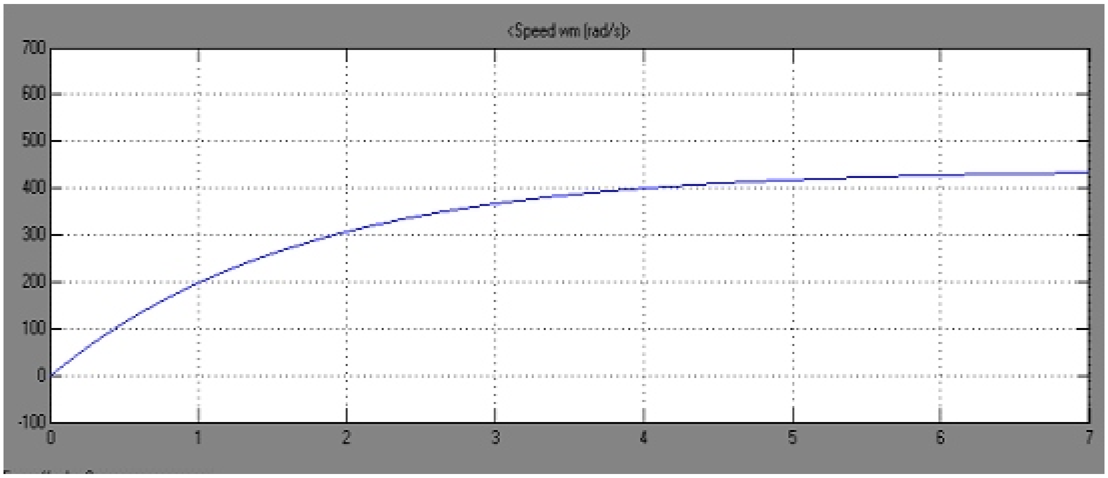


Fig. 4e: Rotor speed (rad/sec)

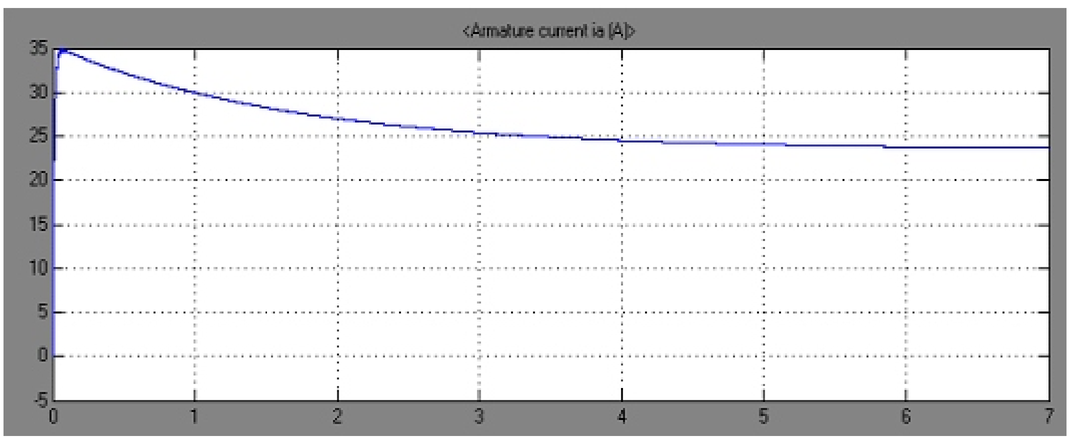
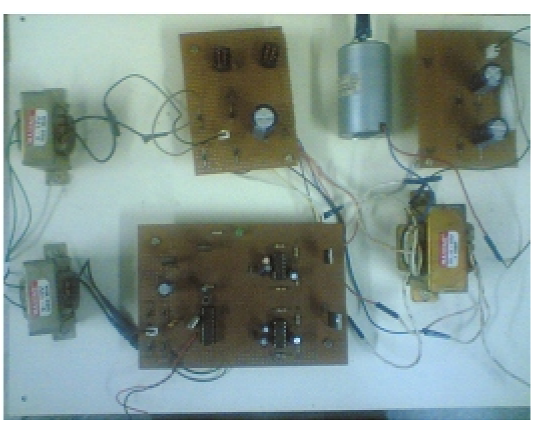


Fig. 4f: Armature current



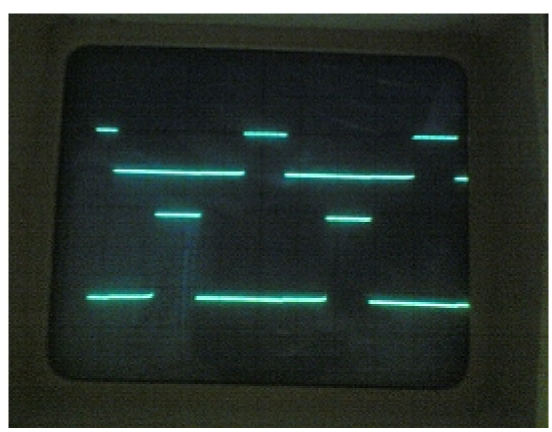


Fig. 5a: Top view of the hardware

Fig. 5b: Driving pulses

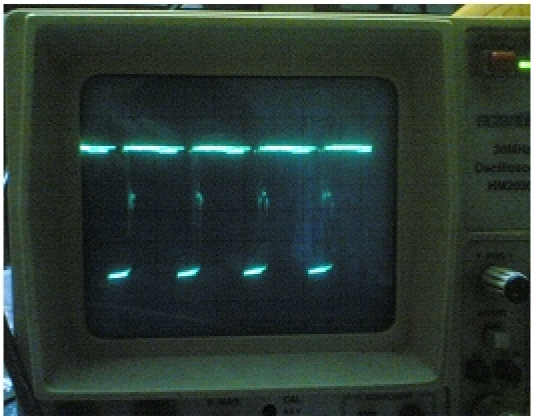


Fig. 5c: Transformer output voltage

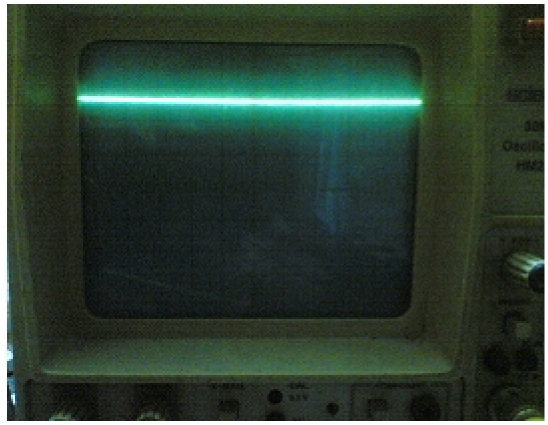


Fig. 5d: DC output voltage

Fig 4e. The speed settles at 50 rad/sec. The armature current is shown in Fig. 4f. The current settles at 23A. The current free from ripple. Therefore, the torque ripple is minimum.

Experimental results: The hardware fabricated and tested in the laboratory. The device IRF 840 used for MOSFET. Driver IC IR 2110 used. Top view of the hardware is shown in Fig. 5a. Driving pulses are shown in Fig. 5b. Transformer output voltage is shown in Fig. 5c. Dc output voltage is shown in Fig. 5d. It can be seen that the experimental results are similar to the simulation results.

CONCLUSION

Two inductor boost converter fed DC drive system simulated using simulink and implemented using an embedded microcontroller. This drive has advantages like reduced hardware, reduced transformer size and filter requirement. The experimental results closely agree with the simulation results.

The drawback of this circuit is that, it requires two controlled devices and a transformer.

ACKNOWLEDGMENT

The authors would like to thank the HOD, EEE, JNTU for providing the facilities to do the investigations on two inductor boost converter system.

REFERENCES

Bloom, E., 1986. Core selection for and design aspects of an integrated-magnetic forward converter. Proceeding IEEE APEC'86 Conference, pp: 141-150.

Bloom, E., 1987. New integrated-magnetic DC-DC power converter circuits and systems. Proceeding IEEE APEC'87 Conference, pp: 57-66.

Bossche, A.V.D., V. Valtchev, J. Ghijselen and J. Melkebeek, 1998. Two-phase zero-voltage switching boost converter for medium power applications. Proceeding IEEE Industry Applications Soc. Annual Meeting, New Orleans, LA, pp: 1546-1553.

Braga, H.A.C. and I. Barbi, 1999. A3-kW unity-power-factor rectifier based on a two-cell boost converter using a new parallel-connection technique. IEEE Trans. Power Electron., 14(1): 209-217.

Cheng, D.K., L.Wong and Y.S. Lee, Design, 2000. modeling, and analysis of integrated magnetics for power converters. Proceeding IEEE PESC'00 Conference, pp: 320-325.

Elmore, M.S., 1996. Input current ripple cancellation in synchronized, parallel connected critically continuous boost converters. Proceeding IEEEAPEC'96 Conference, pp: 152-158.

Irving, B.T., Y. Jang and M.M. Jovanovic, 2000. A comparative study of soft-switched CCM boost rectifiers and interleaved variable-frequency DCM boost rectifier. Proceeding IEEE APEC'00 Conference, pp: 171-177.

Ivensky, G., I. Elkin and S. Ben-Yaakov, 1994. An isolated dc/dc converter using two zero current switched IGBT's in a symmetrical topology. Proceeding IEEE PESC'94 Conference, pp: 1218-1225.

Jang, Y. and M.M. Jovanovic, 2001. Two-Inductor Boost Converter. U.S. Patent 6239584, May 29.

Jang, Y. and M.M. Jovanovic, 2002. New two-inductor boost converter with auxiliary transformer. Proceeding IEEEAPEC'02 Conference, pp: 654-660.

Kolar, J.W., G.R. Kamath, N. Mohan and F.C. Zach, 1995. Self adjusting input current ripple cancellation of coupled parallel connected hysteresis controlled boost power factor correctors. Proceeding IEEE PESC'95 Conference, pp: 164-173.

Marcos, T.G. and S.V. Marcio, 2005. Proposal of a timer controller with constant switching frequency and power factor correction. IEEE, pp: 102-109.

Miwa, B.A., D.M. Otten and M.F. Schlecht, 1992. High efficiency power factor correction using interleaving techniques. Proceeding IEEE APEC'92 Conference, pp: 557-568.

Pandey, A. and B. Singh, 2004. Comparative evaluation of single-phase unity power factor AC-DC boost converter topologies. IEEE Proceeding, November 30, pp: 102-109.

Pinheiro, J.R., H.A. Grundling, D.L.R. Vidor and J.E. Baggio, 1999. Control strategy of an interleaved boost power factor correction converter. Proceeding IEEE PESC'99 Conference, pp: 137-142.

Severns, R. and E. Bloom, 1985. Modern DC/DC Switch mode Power Converter Circuits. Van Nostrand Reinhold, New York, December.

Wolfs, P.J., 1993. A current-sourced DC-DC converter derived via the duality principle from the half bridge converter. IEEE Trans. Ind. Electron., 40(1): 139-144.

Zhang, M.T., Y. Jiang, F.C. Lee and M.M. Jovanovic, 1995. Single-phase three-level boost power factor correction converter. Proceeding IEEE APEC'95 Conference, pp: 434-439.