A NOVEL EFFICIENT SOFT SWITCHED TWO PORTS DC-DC BOOST CONVERTER WITH OPEN LOOP AND CLOSED LOOP CONTROL

T.NageswaraRao[1]
Research Scholar, Sathyabama University, Chennai, India
tnageswararao90@gmail.com

V.C. Veera Reddy[2]
Professor and Head of Department of EEE, S.V.U. College of Engineering, Tirupati, India
veerareddy_vc@yahoo.com

Abstarct

A multiport converter promises cost-effective, flexible and more efficient energy processing by utilizing only a single power stage. Multiport converters, a promising concept for alternative energy systems, have attracted increasing research interest recently. Zero Voltage Switching (ZVS) alleviates the switching losses and improves the converter overall efficiency. Zero voltage switching can be achieved with the help of coupled inductor which also regulates the input current during the load disturbances. To reduce the switching losses and henceforth to improve efficiency of converter system, Zero Voltage Switching (ZVS) is employed. . This paper presents a two output ports single stage boost converter with ZVS. The proposed multi output port converter with soft switching is simple and efficient. The analysis is carried out for open loop and closed loop control. The simulation results for the same are presented in this paper.

Key Words: Multiport DC-DC converter, Two Output DC-DC Converter, Single stage converter, Zero Voltage Switching, Soft Switching, Open Loop Control and Closed loop Control of DC-DC Converter.

1.INTRODUCTION

Multiport DC–DC converters are particularly interesting for sustainable energy generation systems where diverse sources and storage elements are to be integrated [4-7]. This paper presents a zero-voltage switched two-port bidirectional DC–DC boost converter. A simple and effective duty ratio control method is proposed to extend the ZVS operating range when input voltages vary widely. Soft-switching conditions over the full operating range are achievable by adjusting the duty ratio of the voltage applied to the transformer winding in response to the DC voltage variations at the port[2,9]. Keeping the volt-second product (half-cycle voltage-time integral) equal for all the windings leads to ZVS conditions over the entire operating range. Furthermore, for the two-port converter a PI-loop based control strategy is proposed to maintain constant output voltage irrespective of change in the input voltage.

2.MULTI OUTPUT PORT DC-DC CONVERTER

A Multi Output port DC-DC converter without ZVS arrangement is shown in Fig.1where several output voltages are provided by inserting capacitors in series. Voltages of the capacitors are controlled by the inductor current and correct switching states to share the energy stored in the inductor with each capacitor. For the present work two output ports are considered.

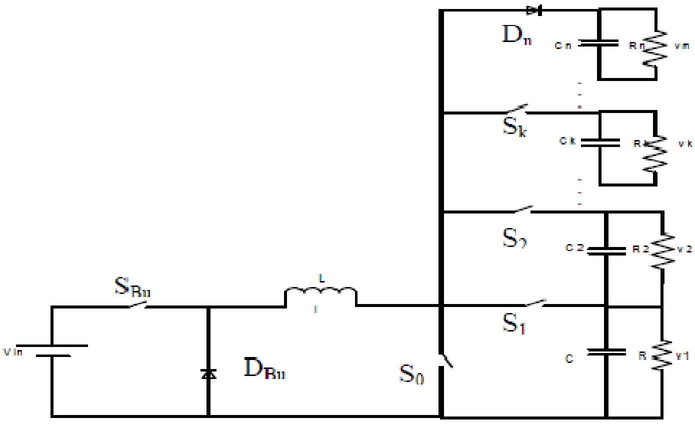

Fig.1 Multiport DC-DC Converter

The steady-state equations for N output voltage and currents are given by

$$V_k = \frac{V_i R_k (1-\sum D_{K-1})}{\sum R_k (1-\sum D_{K-1})^2} \quad \text{-----} \quad (1)$$

$$I = \frac{V_i}{\sum R_k (1-\sum D_{K-1})^2} \quad \text{-------} \quad (2)$$

Where K=1……N; V_i-Input Voltage and D_k is duty ratio of K^{th}port switch

3.SIMULATION RESULTS

Proposed ZVS based two out put DC-DC converter simulation circuit is shown in Fig.2 .

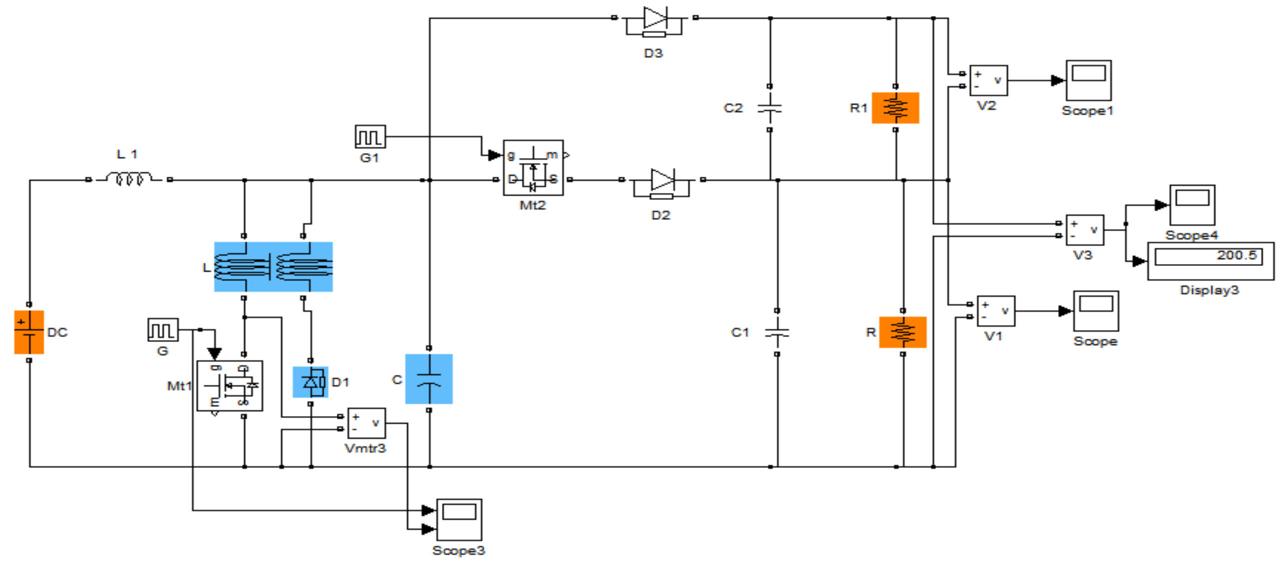

Fig.2 ZVS based two output DC-DC Converter Simulation Diagram

The input Dc voltage is 100 V and is shown in Fig.3. The gate pulse for the main switch M_{t1} and voltage across M_{t1} are shown in Fig.4 . The gate pulse for the auxiliary switch M_{t2} and voltage across M_{t2} are shown in Fig.5. The two output voltages are shown in Fig.6 and Fig.7 respectively. The sum of the two output voltages is shown in Fig.8.

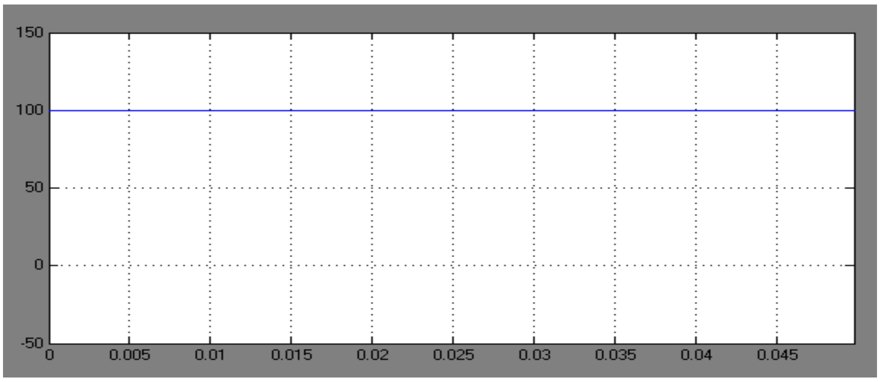

Fig.3 DC input voltage

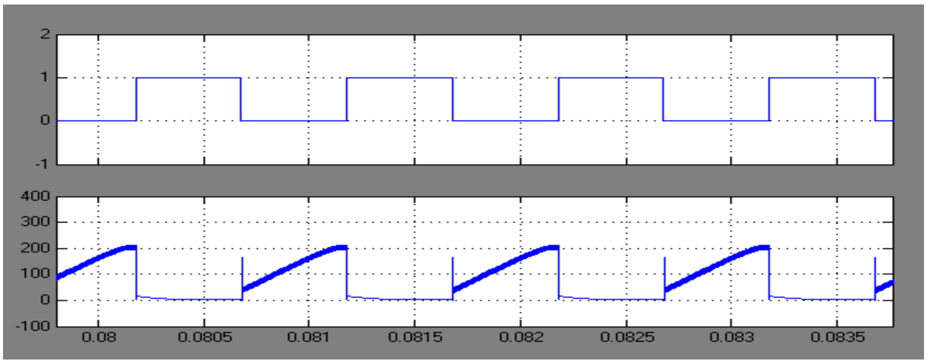

Fig.4 Gate Pulse and V_{ds} Across Main Switch M_{t1} (ZVS)

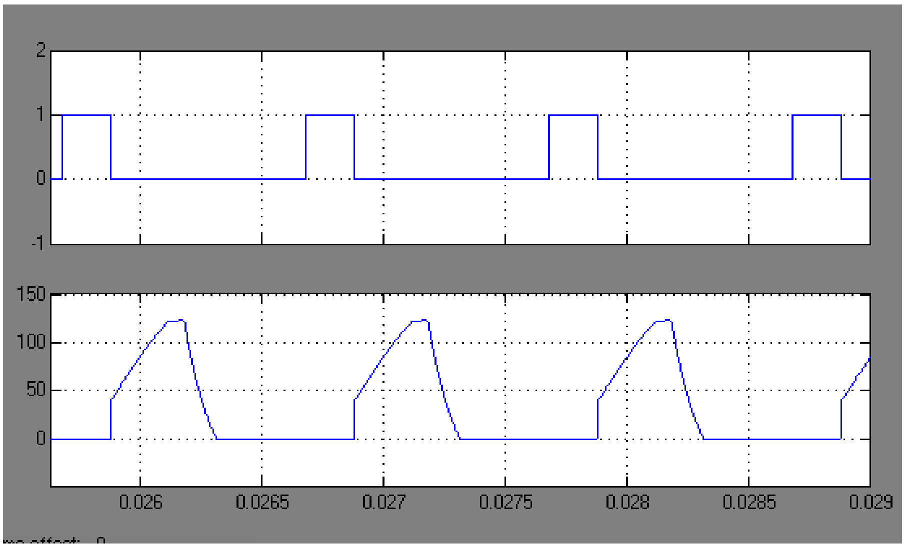

Fig.5 Gate Pulse and V_{ds} Across auxiliary Switch M_{t2}

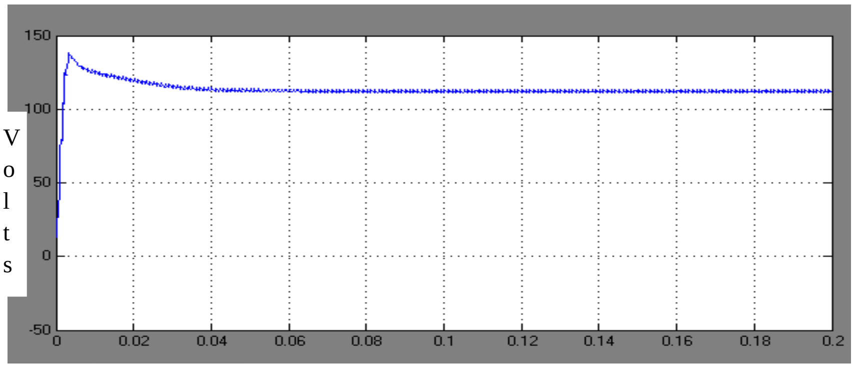

Fig.6 Port 1 Output voltage V_1

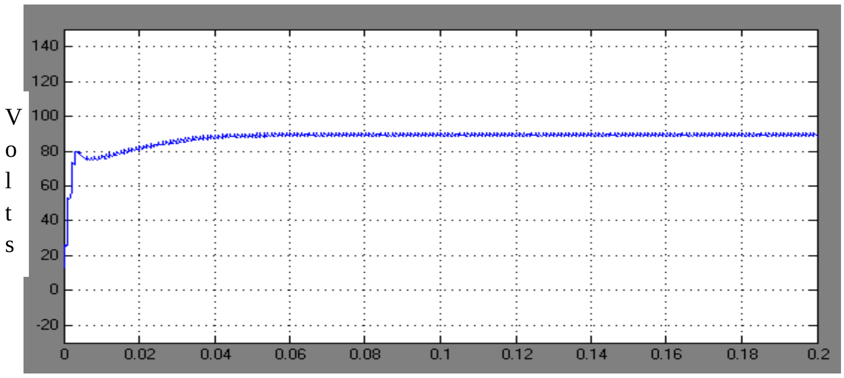

Fig.7 Port 2 Output voltage V_2

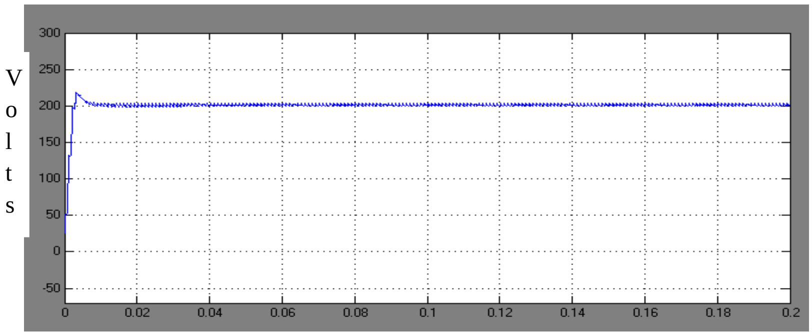

Fig.8 Sum of two output voltages $V_2^+ V_2$

From Fig.4 it is observed that the switching of main switch Mt1 is achieved at zero voltage. Hence this ensures soft switching. As observed from Fig.6, the output voltage is 120V which is greater than the input voltage. Therefore the output voltage is boosted. From Fig.5, it is concluded that there is ZVS turn on of main switch, hence the switching losses are reduced. To achieve this, a single coupled inductor is used. Therefore the proposed ZVS based Two output DC-DC converter has high efficiency compared to the conventional topologies. Since only one inductor is used, the circuit complexities are reduced.

The open loop system for a disturbance in supply voltage is Fig.9. The input voltage is increased from 100V to 108V at 0.2 Sec. The input voltage with this disturbance and corresponding sum of output voltages are shown in Fig.10.

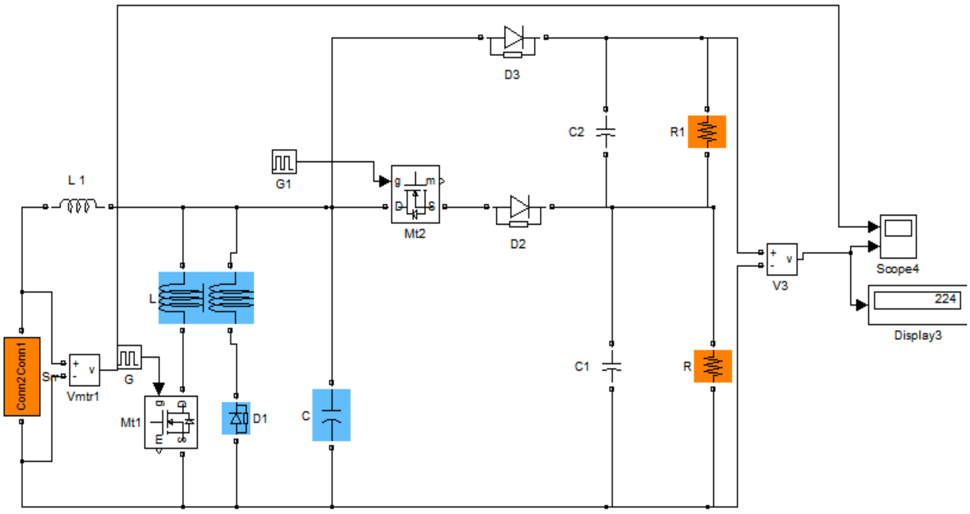

Fig.9 Open Loop System with Line Disturbance

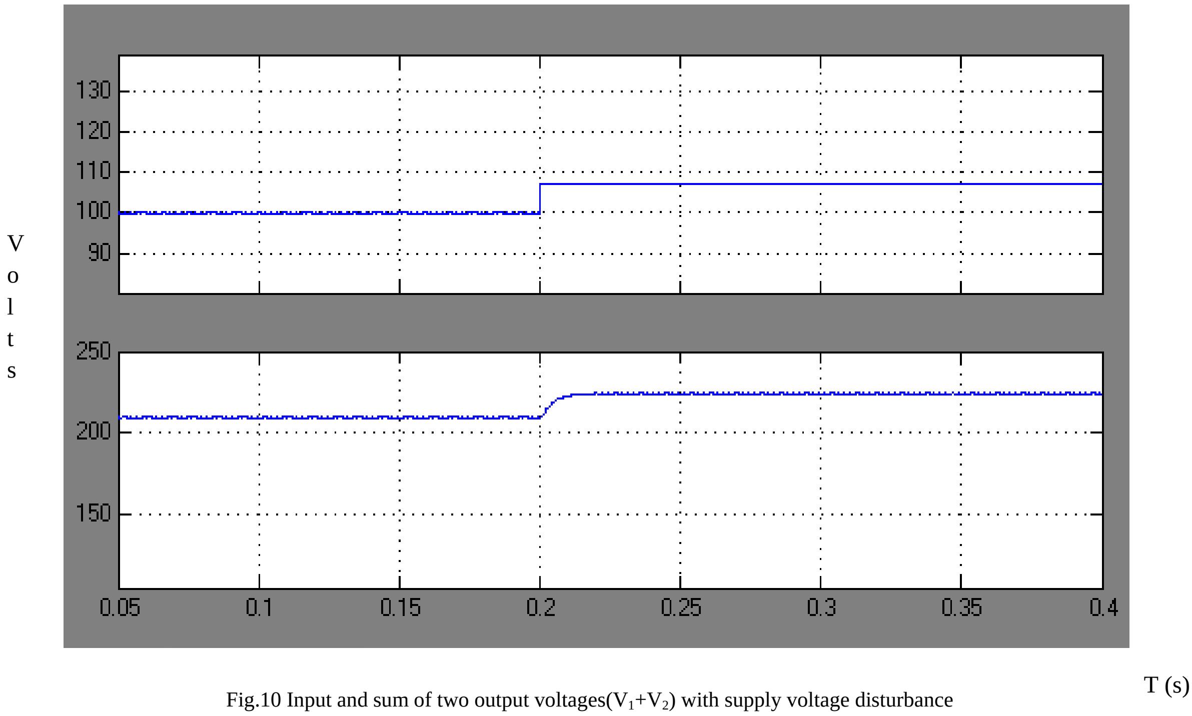

Fig.10 Input and sum of two output voltages(V_1+V_2) with supply voltage disturbance

From Fig.9, it is observed that in open loop control, when input voltage is increased at 0.2 Sec., the sum of two output voltages rises slightly but at 0.22 Sec. settles at higher value of 225V. The closed loop system with supply disturbance is shown in Fig.11. The input voltage with this disturbance and corresponding sum of two output voltages are shown in Fig.12

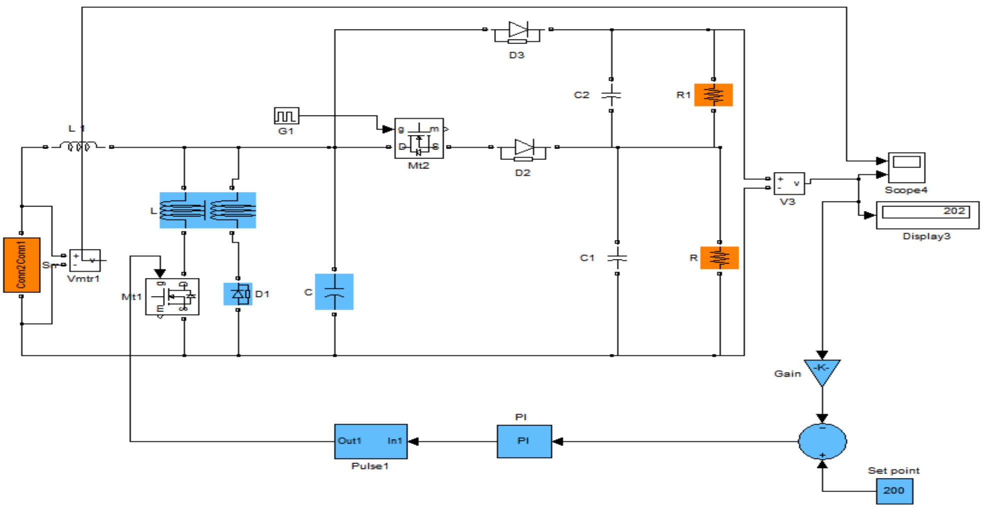

Fig.11 Closed loop system with source side disturbance

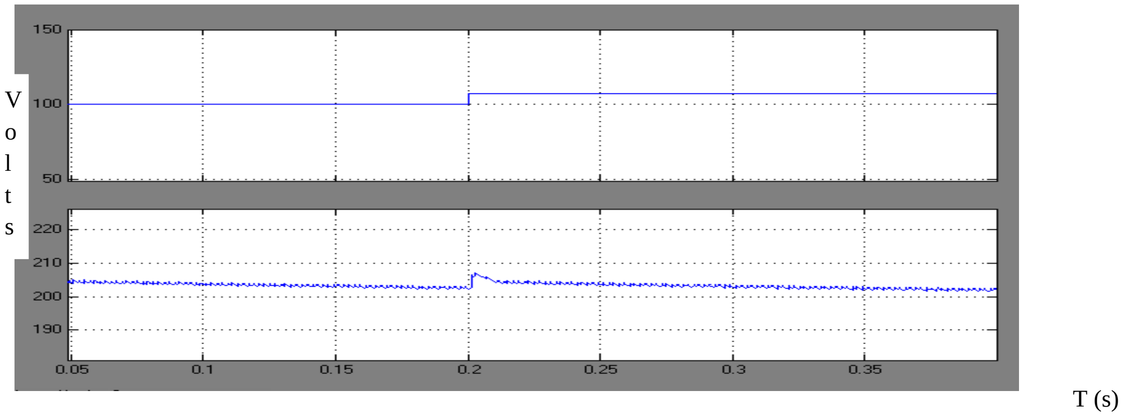

Fig.12 Input and sum of two output voltages (V_1+V_2) with supply voltage disturbance-Closed loop control

From Fig.12, it is observed that in closed loop control, when input voltage is increased at 0.2 Sec., the sum of two output voltages rises slightly but at 0.2 Sec., but after that settles at the original value after 0.22 sec.. Therefore a constant volatge is maintained at the output side.

4.CONCLUSION

A novel ZVS (Single Inductor) based two ouput port DC-DC converter is proposed. From the simulation results it is concluded that soft switching of main switch is achieved due to which the losses are minimized. From the simulation results it is concluded that the closed loop system with PI controller maintains constant output volatge irrespective of disturabance in the supply voltage.

References

[1] A. Nami F. Zare A. Ghosh F. Blaabjerg, “Multi-output DC–DC converters based on diode-clamped converters configuration:topology and control strategy”,IET Power Electronics, 2010, Vol. 3, Iss. 2, pp. 197–208.

[2] N. D. Benavides and P. L. Chapman, “Power budgeting of a multiple inputbuck-boost converter,” *IEEE Trans. Power Electron*, vol. 20, no.6, pp. 1303–1309, Nov. 2005.

[3] H. Tao, A. Kotsopoulos, J. L. Duarte, and M. A. M. Hendrix,“Multi-input bidirectional dc–dc converter combining DC-link andmagnetic-coupling for fuel cell systems,” in *Proc. IEEE Ind. Appl.Soc. Conf. Annu. Meeting (IAS’05)*, Hong Kong, China, Oct. 2005,pp. 2021–2028.

[4] D. Liu and H. Li, “A ZVS bi-directional dc–dc converter for multipleenergy storage elements,” *IEEE Trans. Power Electron*, vol. 21, no. 5,pp. 1513–1517, Sep. 2006.

[5] H. Tao, A.Kotsopoulos, J. L. Duarte, and M. A. M. Hendrix, “Family ofmultiport bidirectional dc–dc converters,” *Proc. Inst. Elect. Eng.*, vol.153, no. 3, pp. 451–458, May 2006.

[6] H. Tao, A. Kotsopoulos, J. L. Duarte, and M. A. M. Hendrix,"Triple-half-bridge bidirectional converter controlled by phaseshift and PWM," in *Proc. IEEE Appl. Power Electron. Conf. Expo(APEC'06)*, Dallas, TX, Mar. 2006, pp. 1256–1262.

[7] H. Al-Atrash, F. Tian, and I. Batarseh, "Tri-modal half-bridge convertertopology for two-port interface," *IEEE Trans. Power Electron.*, vol.22, no. 1, pp. 341–345, Jan. 2007.

[8] M. Marchesoni and C. Vacca, "New dc–dc converter for energy storagesystem interfacing in fuel cell hybrid electric vehicles," *IEEE Trans.Power Electron*, vol. 22, no. 1, pp. 301–308, Jan. 2007.

[9] J. L. Duarte, M. Hendrix, and M. G. Simoes, "Two-port bidirectional converter for hybrid fuel cell systems," *IEEE Trans. Power Electron*, vol. 22, no. 2, pp. 480–487, Mar. 2010.

[10] Arash A Boora, Firuz,ArindamGhosh"A General Approach to Control a Positive Buck-Boost Converterto Achieve Robustness against Input Voltage Fluctuations andLoad Changes", IEEE conference proceedings, PESC 2008.

Authors' Profile

T.NageswaraRao is a Research Scholar at SathybamaUniversity,Chennai,India. He obtained B.Tech.from,JNTU,Hyderabad, Andhra Pradesh, India in 1977,M.S. from BITS, Pilani, India in 1991 and M.E in Applied Electronics fromSathyabama University, Chennai, India in 2004. His areas of interest includeElectrical Machines, Control Systems and Power Electronics. He has 31years of teaching experience in Engineering Colleges. He has authored text books on Basic Electrical Engineering, Circuit Theory and Control Systems. He is presently working as a Professor and Head in the department of ECE at SRR Engineering College, Chennai, India.

Dr. V.C. Veera Reddy obtained his M.E & Ph.D. degrees from SriVenkateswaraUniversity, Tirupati, Andhra Pradesh, India in 1981 & 1999. He is presently working as Professor and Head, Department of EEE, S.V.U. College of Engineering. He pursued research in the area of Power Systems. He has 31 years of teaching experience. Under his guidance 8 scholars received the Ph.D and 6 more are on the verge of completion.He is a life member of CSE, IETE, and former member of IEEE. He has published 47 papers in the area of Power Systems in various journals.