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Performance Analysis of Z-source and Boost Multi Level Inverter

R. Uthirasamy*, C. Krishna Kumar and P.K. Arun Kumar*****

ABSTRACT

This paper presents a comparative analysis of Z Source Inverter (ZSI) and Boost Cascaded Multilevel Inverter (BCMLI) is proposed. *The maximum boost impedance inverter topology overcomes the limitations of conventional boost Voltage Source Inverter (VSI). By* this new topology, renewable energy is utilized properly with minimum controller circuit. On the other hand the switching stress and the filter circuit requirements are very high. With the view of industrial applications, this paper gives an overview of BCMLI with a focus on efficient utilization of battery power, reduced voltage stress and reduced filter circuits. The proposed configuration not only boost DC voltage but can also convert the DC power into high quality AC power for industrial drive applications. A model of ZSI and BCMLI are built in MATLAB/SIMULINK and its performance is analyzed.

Keywords: Boost Cascaded Multi Level Inverter (BCMLI), Irradiance, Z-Source Inverter

1. INTRODUCTION

The traditional power electronic inverters are VSI and Current Source Inverter (CSI). In VSI two switches of the same leg can never be gated ON at same time because it causes a short circuit, which would destroy the inverter. This limitation can be overcome by the proposed impedance source inverter system [1]. By adjusting the boost factor one can obtain maximum power output in accordance with solar power. For three phase applications ZSI require large size inductors and capacitors for boosting and filtering [2]. Also, the voltage stress across the ZSI switches is very high. To achieve soft switching, passive component circuits are needed; this leads to the complexity in overall circuit. Most solar cell installation involves the use of multiple solar panels or modules, which are connected in series or parallel with cascaded H-bridge type multilevel inverter. The most popular advantages of multilevel inverter compared with the traditional voltage source inverter (VSI) are lower semiconductor voltage stress, better harmonic performance, lower Electro Magnetic Interference (EMI) and lower switching losses. In this work, 7-level BCMLI with reduced battery count for renewable resource applications is introduced [3]-[4]. The proposed structure will also reduce the size and system cost. A novel Boost Multilevel Inverter (BMLI) is proposed to cater the needs of modern solar power applications.

2. ANALYSIS OF IMPDEANCE SOURCE INVERTER

The general block diagram of solar powered maximum boost ZSI system is shown in Fig. 1. By controlling the shoot-through duty cycle and modulation index any desired output AC voltage can be obtained, thus there is no need for a dc-dc booster and step up transformer. The equivalent circuit of ZSI is shown in Fig. 2.

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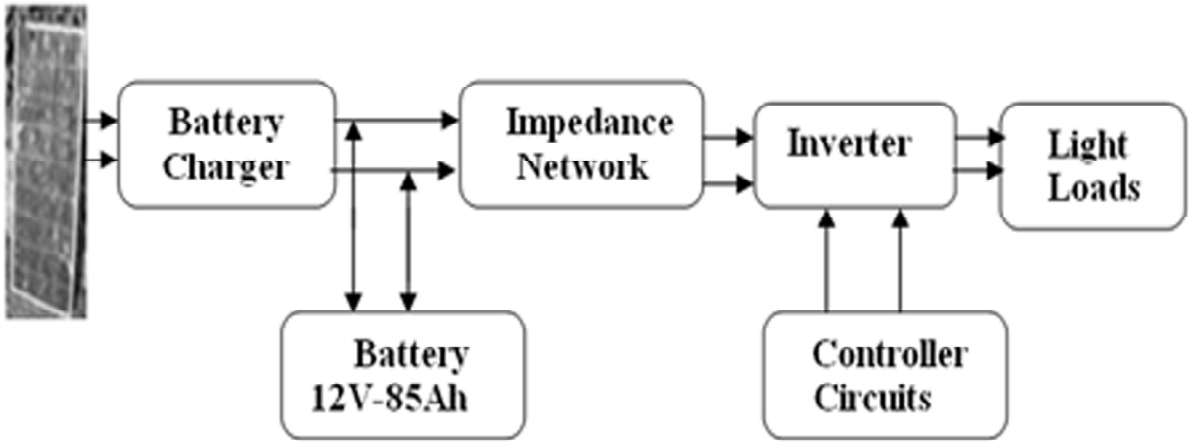

Figure 1: Block diagram of solar powered impedance inverter system

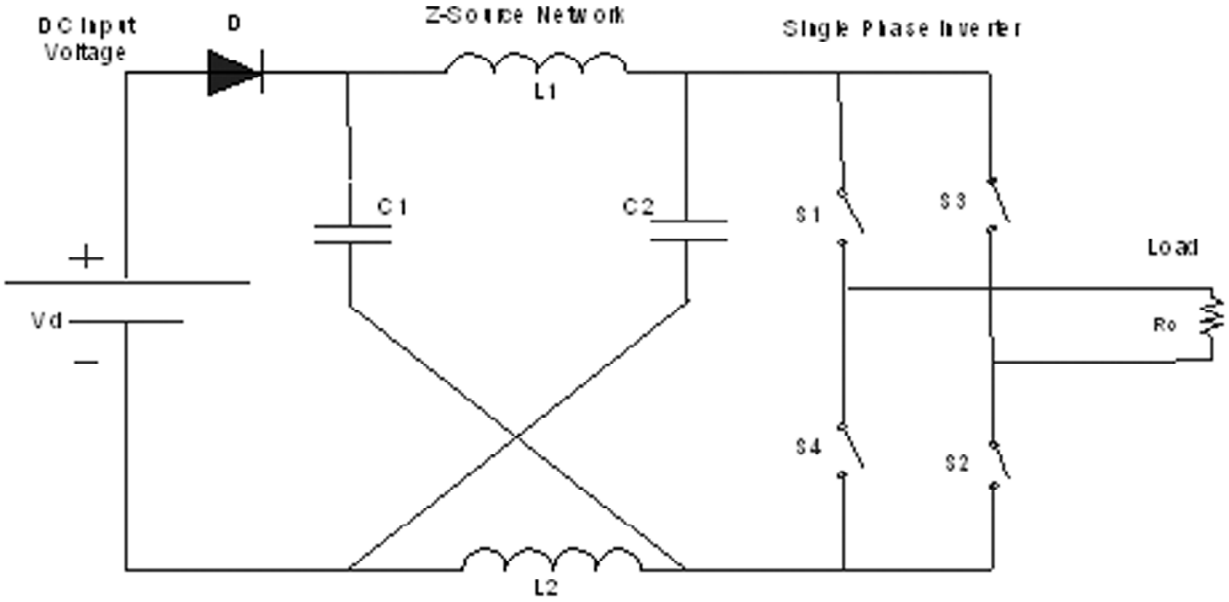

Figure 2: Equivalent structure of impedance source inverter

The ZSI has two operating modes:

1. Non shoot-through mode
2. Shoot-through mode

The non shoot through state of the Z-source is the one of the active switching states of the ZSI. When the Z-source inverter is working in non shoot through states during time interval T_1, the diode D is on, and the H-bridge inverter can be considered as a current source I_{in}. Thus, any desired output voltage can be obtained by properly selecting the boost factor and the modulation index regardless of the battery bank voltage.

3. ANALYSIS OF BCMLI

The multilevel inverters have drawn tremendous interest in the power industry. Cascaded H-bridge inverter, which is composed of a series of single phase H-bridge power cells, which are well suited for use in reactive power compensation. It may be easier to produce a high power, high voltage inverter with multilevel structure because of the way in which the device voltage stresses are controlled in the structure. The unique structure of multilevel inverter (MLI) allows them to reach high voltages with low harmonics without the

use of transformers or series connected synchronized switching device. The voltage stress across the inverter switches are reduced in CMLI or in BCMLI. As the number of voltage level increases, the harmonic content of the output voltage waveform decreases. A CMLI consists of a series of H-bridge inverter units [12-15]. The work of MLI is to synthesize a desired voltage from several separate DC sources. To reduce the battery counts with best possible back up period, the conventional CMLI is interfaced with boost converter named BCMLI is shown in the Fig. 3. The handling of boost converter circuit is simpler than battery banks. Each H-bridge has separate DC source or equivalent solar PV, which is interconnected with each other in series manner through the proper switching of CMLI.

The equivalent structure of boost chopper develops the output voltage of 75 V with the input of 12 V.

4. SIMULATION MODEL OF ZSI SYSTEM

The simulated model of maximum boost ZSI system is shown in Fig. 4. The DC power obtained from the solar panel is stored in battery (12V, 85Ah). The battery voltage is boosted using maximum boost ZSI circuit and the pulses for the maximum boost ZSI are generated by using maximum boost control method. The AC output is given to AC load arrangements through LC filter.

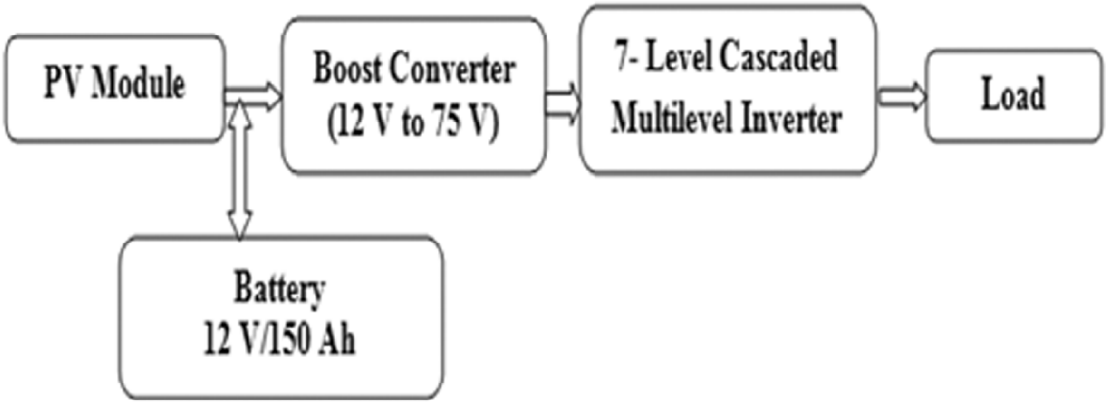

Figure 3: Structure of boost cascaded multilevel inverter

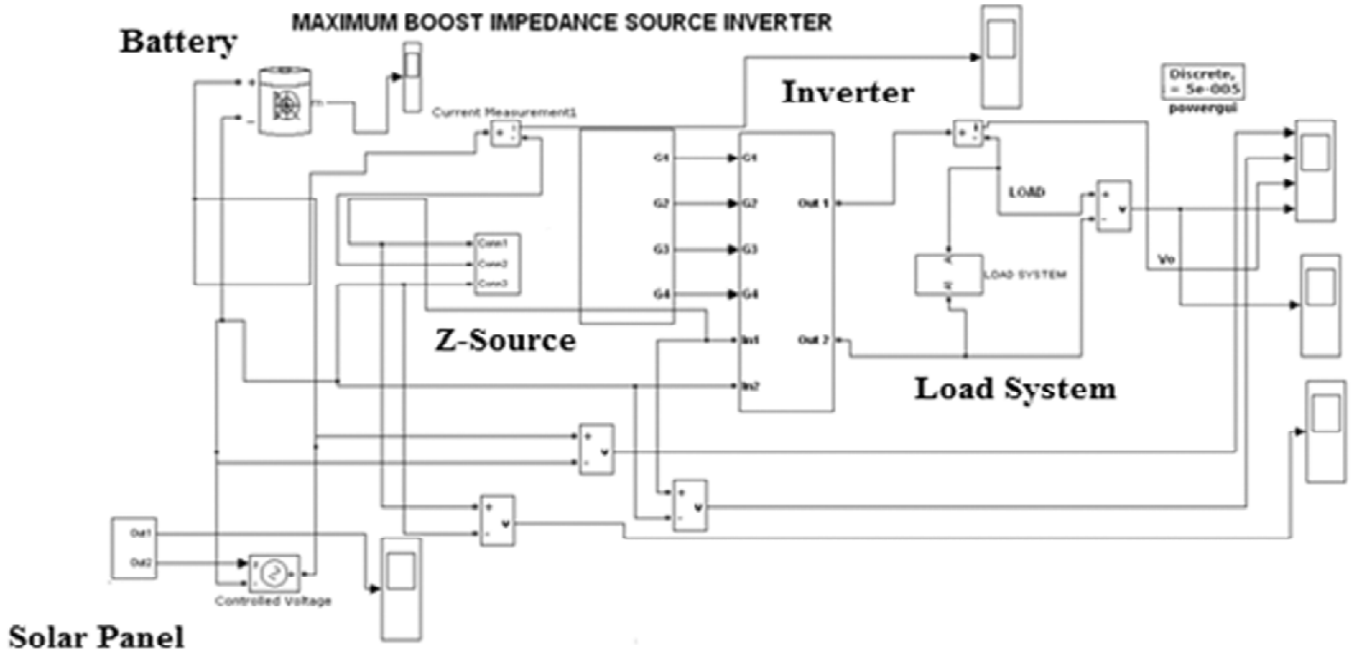

Figure 4: Simulation model of ZSI system

The simulated maximum boost ZSI network output voltage is shown in Fig. 5. The maximum DC voltage of 240 V is obtained when the switching takes place at shoot through states. In single phase system, the voltage anxieties across the ZSI switches are moderate but in three phase system, the voltage level which has been boost by impedance network is around 600 V. So, this acts as a voltage anxiety across ZSI switches. So, voltage stress is occurred across the H-bridge inverter switches. In this instant, the controllability of the battery parameters is unstable. Hence, the entire system parameters are under damping conditions.

The simulated circuit of BCMLI is shown in Fig. 6. The DC voltage of 12V is boosted to 75V using boost converter. The obtained boost output is fed to each H-bridge of multilevel inverter.

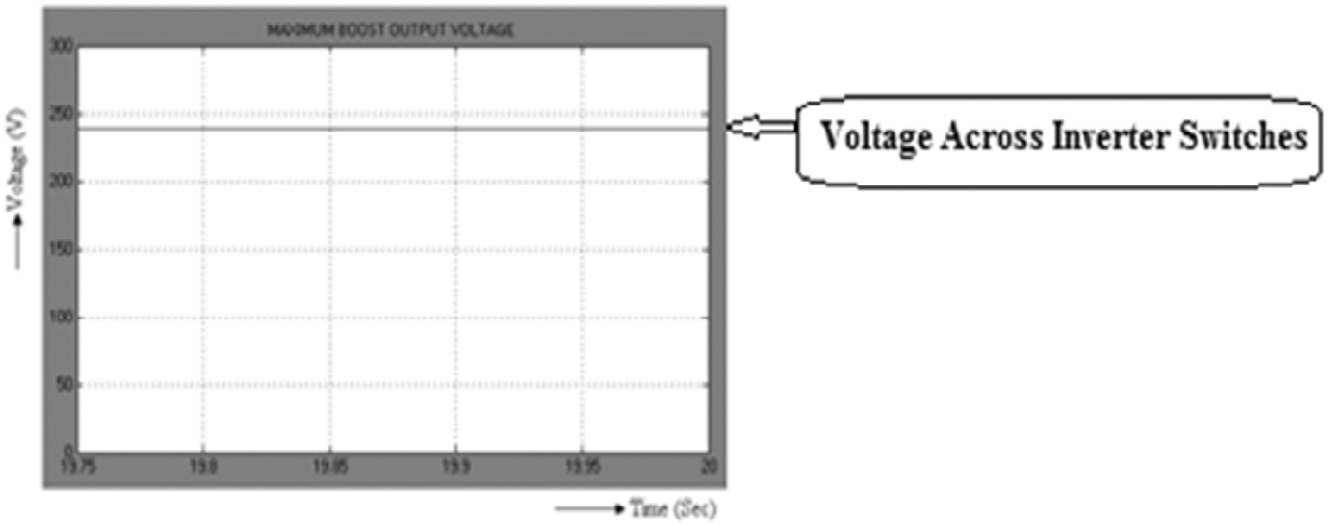

Figure 5: Maximum boost output voltage (240 V)

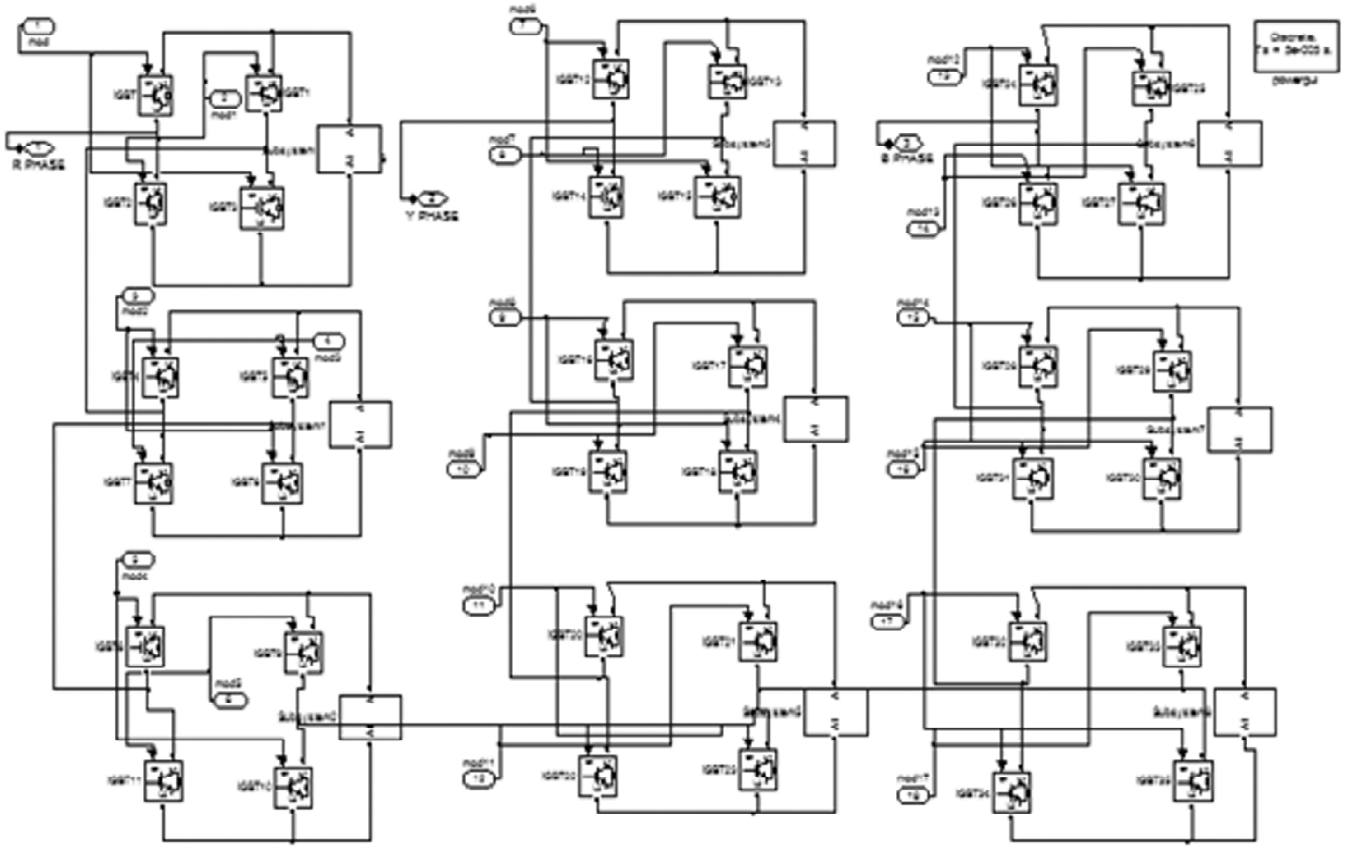

Figure 6: Structure of boost cascaded multilevel inverter

The DC output voltage and boost chopper output voltage waveforms are shown in Fig. 7. The input to the chopper is 12 V and boosted to 75 V using boost chopper, which is the voltage anxiety across each H-bridge. Compared to single phase ZSI system the voltage anxiety across the MLI switches are very low. The control parameters of the battery banks are under stable operation.

The output phase voltage waveform of 7-level multilevel inverter fed three phase induction motor drive system is shown in Fig. 8. From the obtained result it is viewed that the output phase voltage of multilevel inverter is 300V. Harmonic analysis is made for the Z-Source and BCMLI systems as shown in Fig. 9 and Fig.10 respectively. From the attained THD spectrum, it is understood that BCMLI generates reduced voltage THD.

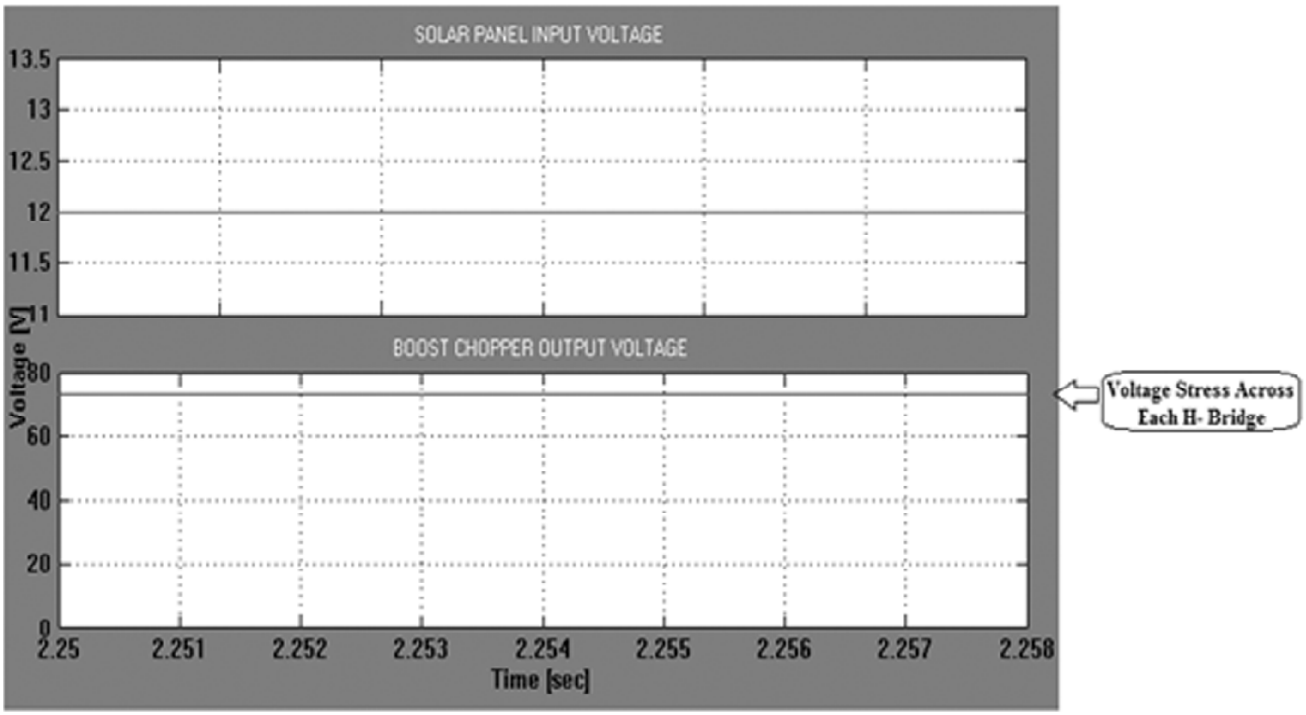

Figure 7: DC output voltage and boost chopper output voltage waveform

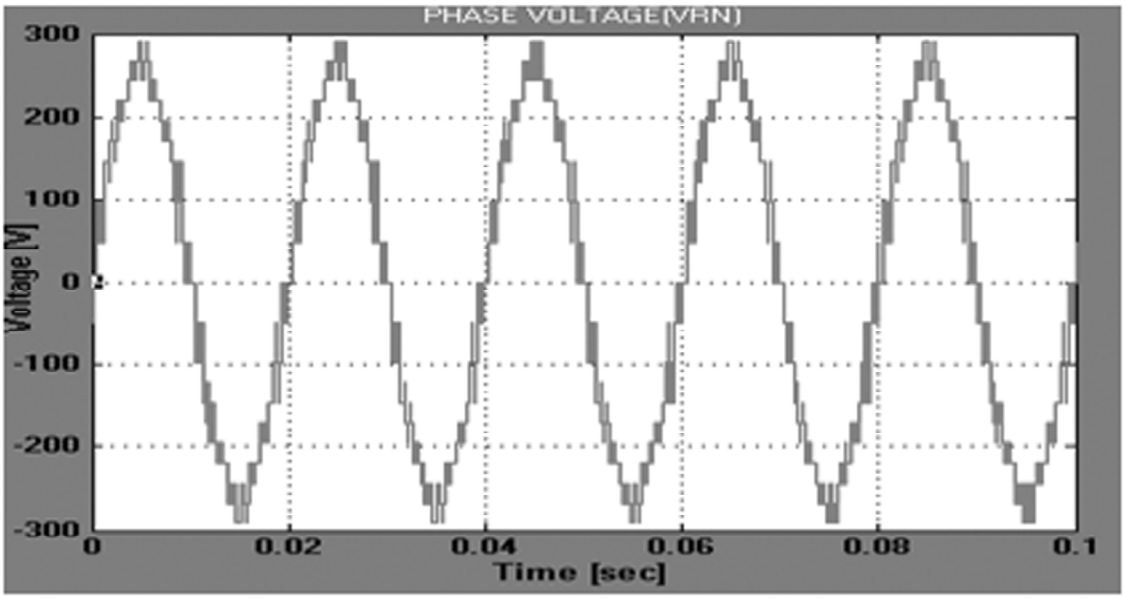

Figure 8: BCMLI Output voltage (300 V)

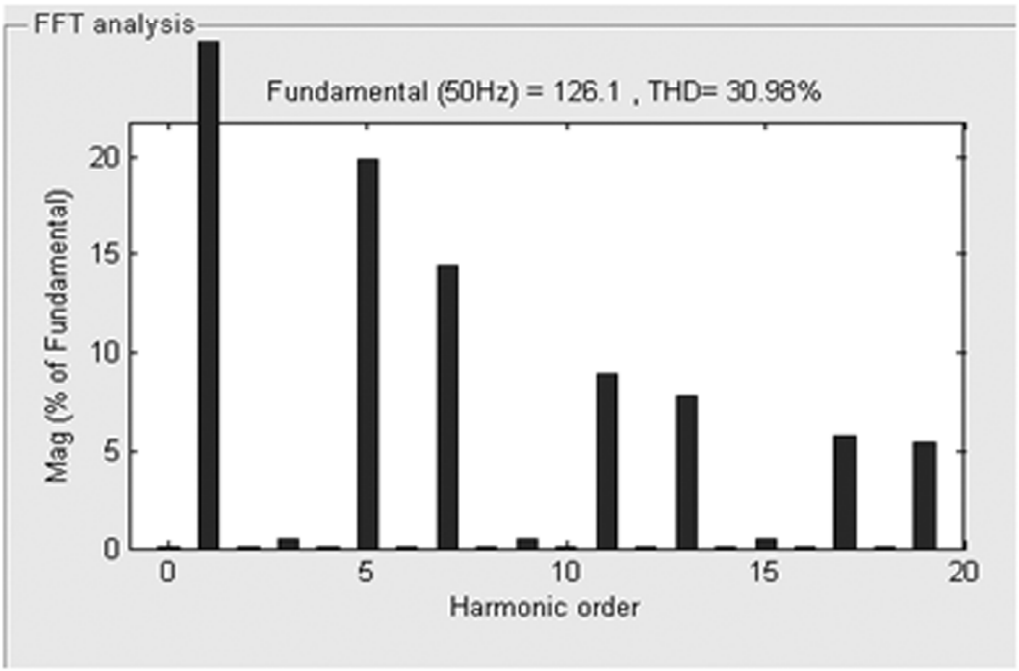

Figure 9: THD spectrum of Z-source inverter

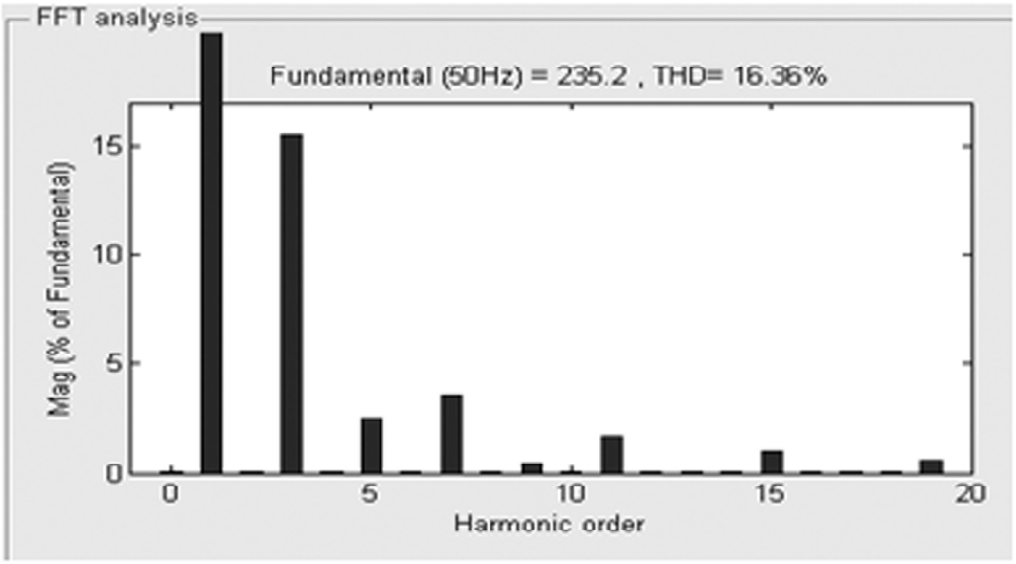

Figure 10: THD spectrum of BCMLI inverter

Table 1
System Comparison

Single Phase System	*Voltage Stress across Inverter Switch (V)*	*Battery Discharge Current (A)*
Proposed Maximum boost ZSI System	240	Very Large
Proposed Boost CMLI System	75	Small

8. CONCLUSION

In this paper a comparative analysis was made between ZSI topology and BCMLI topology for the maximum utilization of DC power. The advantages of Buck-Boost operation at one stage, minimizes the component counts and reduced cost but also, has the demerits of high voltage stress and bulky filter circuit requirements.

The voltage stress across the inverter switches of BCMLI was clearly discussed and concluded that BCMLI generates reduced harmonic content in the output voltage with reduced filter component.

REFERENCES

[1] Chandana Jayampathi Gajanayake, Fang Lin Luo, Hoay Beng Gooi, Ping LamSo, and Li Kian Siow, "Extended boost Z-source inverters," *IEEE Trans. on Power Electron.*, vol. 25, no. 10, pp. 2642-2652, Oct. 2010.

[2] F. Z. Peng, "Z-source inverter," *IEEE Trans. Ind. Appl.*, vol. 39, no. 2, pp. 504–510, Mar./Apr. 2003.

[3] Zhi Jian Zhou, Xing Zhang, Po Xu, and Weixiang X. Shen, "Single phase uninterruptible power supply based on Z-source inverter," *IEEE Trans. Ind. electron.*, vol. 55, no. 8, Aug. 2008.

[4] Brendan Peter McGrath, Student Member, IEEE, and Donald Grahame Holmes, Member, IEEE "Multicarrier PWM Strategies for Multilevel Inverters" *IEEE Transactions on Industrial Electronics*, Vol. 49, No. 4, August 2002.

[5] Kuei-Hsiang Chao, Ching-Ju Li and Sheng-HanHo, "Modeling and Fault Simulation of Photovoltaic Generation Systems Using Circuit Based Model", *in proceedings on IEEE-ICSET Annual Meeting*, Taichung, Taiwan, 2008, pp. 290-294.

[6] Jeyraj Selvaraj and Nasrudin Rahim A, "Multilevel Inverter for Grid-Connected PV system Employing Digital PI Controller", *IEEE Transactions on Power Electronics*, Vol. 56, No. 1, pp 149-158, Jan. 2009.

[7] Martina Calais, Agelidis V.G, "A Transformer less Five Level Cascaded Inverter Based Single Phase Photovoltaic System ", *in proceedings on IEEE-PESC Annual Meeting*, Perth, Australia, 2001, Vol. 3, pp. 1173-1178.

[8] Esram T. and Chapman P. L, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", *IEEE Transactions on Energy Conversion*, Vol. 22, No. 2, pp 439-449, June 2007.

[9] Femia N., Petrone G., Spagnuolo G. and Vitelli M., "Optimizing Duty-cycle Perturbation of P&O MPPT Technique", *in proceedings on IEEE-PESC Annual Meeting*, Aachen, Germany, 2004, Vol. 3, pp. 1939-1944.

[10] Kung-Yen Lee, Niu J.H. and Lin G.W., "A Simplified Analog Control Circuit of a Maximum Power Point Tracker*", in proceedings on IEEE-EPARC Annual Meeting*, Chia-Yi, Taiwan, 2008.

[11] X. Liu and L. A. C. Lopes, "An Improved Perturbation and Observation Maximum Power Point Tracking Algorithm for PV Arrays", *in proceedings on IEEE-PESC Annual Meeting*, Aachen, Germany, 2004, Vol. 3, pp. 2005-2010.

[12] Park S. J., Kang F. S., Lee M. H. and Kim C. U., "A New Single-Phase Five Level PWM Inverter Employing a Deadbeat Control Scheme", *IEEE Transactions on Power Electronics*, Vol. 18, No. 18, pp. 831-843, May 2003.

[13] Calais M., Borle L. J. and Agelidis V. G., "Analysis of Multicarrier PWM Methods for a Single-Phase Five-Level Inverter", *in proceedings on IEEE-PESC Annual Meeting*, Perth, Australia, 2001, Vol. 3, pp. 1173-1178.

[14] J. Rodriguez, J.S. Lai and F. Z. Peng, "Multicarrier PWM Strategies for Multilevel Inverters", *IEEE Transactions on Industrial Electronics*, Vol. 49, No. 4, pp. 724–738, Aug. 2002.

[15] X. Kou, K. Corzine and M. Wielebski, "Over distention Operation of Cascaded Multilevel Inverters", *IEEE Transactions on Industrial Applications*, Vol. 42, No. 3, pp. 817–824, June 2006.

[16] J. Rodriguez, P. Hammond, J. Pontt, R. Musalem, P. Lezana and M. Escobar, "Operation of a Medium-Voltage Drive Under Faulty Conditions", *IEEE Transactions on Industrial Electronics*, Vol. 52, No. 4, pp 1080–1085, Aug. 2005.

[17] D.W. Kang, B.K. Lee, J.H. Jeon, T.J. Kim and D.S. Hyun, "A symmetric Carrier Technique of CRPWM for Voltage Balance Method of Flying Capacitor Multilevel Inverter", *IEEE Transactions on Industrial Electronics*, Vol. 52, No. 3, pp. 879–888, June 2005.

[18] Remus Teodorescu, Frede Blaabjerg "Multilevel Inverter by Cascading Industrial VSI " *IEEE Transactions On Industrial Electronics*, Vol. 49, No. 4, August 2002.

[19] K.A. Corzine and Y.L. Familiant, "A New Cascaded Multilevel H-bridge Drive," *IEEE Transaction on Power Electronics*., Vol. 17, pp. 125–131, Jan. 2002.

[20] Leon M. Tolbert, Senior Member, IEEE, and Thomas G. Habetler, Senior Member, IEEE "Novel Multilevel Inverter Carrier-Based PWM Method" *IEEE Transactions on Industry Applications*, Vol. 35, No. 5, September/October 1999.