Middle-East Journal of Scientific Research 23 (Sensing, Signal Processing and Security): 257-264, 2015
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2015.23.ssps.105

Design and Simulation of Quasi Z-Source Half Bridge Converter for Photovoltaic Application

V.V. Rajasegharan, L. Premalatha and N. Breethi

Department of EEE, Anand Institute of Higher Technology, India

Abstract: In this paper, a Quasi Z-source half bridge converter is proposed. The proposed converter employs an LC network between the DC source and inverter circuitry to achieve the boost as well as the inversion operation. The Quasi Z-source inverter acquire all the advantages of the Z-source inverter, which can realize buck or boost inversion and power conditioning in a single stage with improved reliability. In addition, the proposed Quasi Z-source inverter has the unique advantages of lower component ratings and constant dc current from the source. Many of the boost control methods have been developed for the Z-source inverter can be used by the Quasi Z-source inverter. The Quasi Z-source inverter has a wide range of voltage gain which is suitable for applications in photovoltaic systems, due to the fact that the solar cell's output widely vary with temperature and solar irradiation. A Quasi Z-source inverter prototype is built; experimental results are provided to verify and demonstrate the special features of the proposed circuit.

Key words: Z-source half-bridge inverter · Quasi Z-source inverter · Buck/Boost inversion and low cost

INTRODUCTION

Half-bridge converters have their switches in series, with which the shoot-through can occur which means that the strong current flowing through the switches makes them broken down. Besides the AC output voltage is limited below the DC voltage, which is named the limited voltage problem, output of the AC voltage is sometimes desirable to be higher than the DC voltage; furthermore an unbalanced midpoint of input capacitors in conventional half-bridge converters leads to large ripples making the unstable system. To solve the unbalanced midpoint problem, proposed the direct power control algorithm to balance the midpoint voltage in multi-level neutral-point-clamped (NPC) inverters. Although the method is designed for three phase inverters and multilevel NPC, it is also applicable to a single-phase half-bridge converter.

In common, a single-phase DC-AC inverter gets a full-bridge inverter proposed of four switches and this method using two converters with bipolar output voltages. A full-bridge inverter has weak point in that the AC output voltage is limited to below the input voltage and a boost converter necessary be used to generate an output voltage over input voltage [1, 2]. A single-phase DC-AC inverter using two DC-DC converters (Buck, Boost, Buck-boost, etc.) generates AC output voltages by the difference of the output capacitor voltages of each converter. Latterly, embedded Z-source DC-AC converters with bipolar output capacitor voltage have been proposed. The circuit diagram for Z-source half bridge converter is shown in Fig. 1.

Therefore this kind of inverter is advantageous because it does not need an LC output filter and their AC output voltage levels are not circumscribed by the input voltages. However, single-phase DC-AC inverter has a disadvantage in that the voltage stress of the whole system increases for that reason the output capacitor voltage of the DC-DC converter is only unipolar on the off-set voltage over the input voltage [3]. There is no need to cogitate the off-set voltage and direct output voltage of AC can be acquired from each converter. Since the positive half-cycle of AC output voltage from one embedded Z-source converter is inadequate by the input voltage, it is similar as a single bridge inverter [4, 5]. But, the output voltage of Buck/Boost AC voltage can be in the negative half-cycle voltage of the embedded ZSI, in any case of the input voltage.

Quasi Z-Source Inverter: To solve the aforesaid drawbacks in traditional Z-source inverter, Quasi Z-source inverter topology is used. The operation principle and merits of the proposed topology is explained in detail.

Corresponding Author: V.V. Rajasegharan, Department of EEE, Anand Institute of Higher Technology, India.

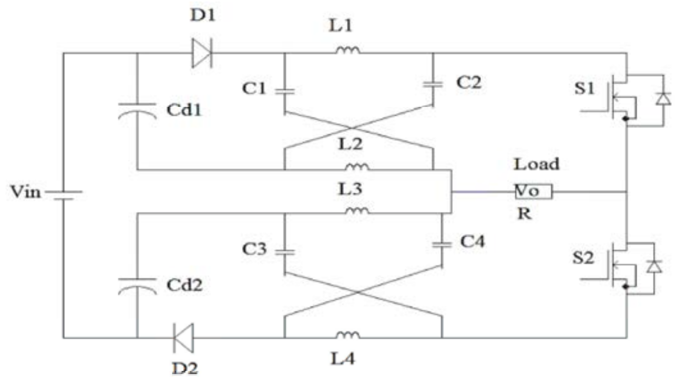


Fig. 1: Z-Source Half-bridge Converter

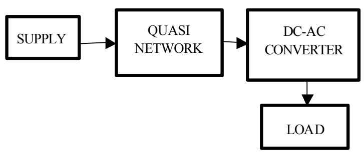


Fig. 2: Block Diagram Of Proposed System

Quasi Z-Source inverters have been developed which feature several improvements and minimal disadvantages when compared to the traditional ZSIs.

The Quasi Z-source inverter topologies also feature a common dc rail between the source and inverter, unlike the traditional ZSI circuits [6-8]. Furthermore, these Quasi Z-source inverter circuits have no disadvantages when compared to the traditional ZSI topologies. These Quasi Z-source inverter topologies therefore can be used in any application in which the ZSI would traditionally be used. The block diagram of the proposed converter is shown in Fig. 2.

The block diagram composed of DC source, Z-source network, dc-ac converter and load. Input supply is from the dc source and it is given to stability network. After filtering and then boosting, it is given to dc-ac converter. The output is connected to the load.

The quasi z-source inverter (QZSI) is a single stage power converter and it is derived from the Z-source network topology, employing a unique impedance network. The conventional VSI and CSI have the limitation that triggering two switches in the same leg or phase leads to a source short and the maximum obtainable output voltage cannot exceed the dc input, therefore they are buck converters and it can produce a output voltage lower than the dc input voltage. Both Z-source inverters and quasi-Z-source inverters overcome these problems; by utilizing the several shoot-through states. The basic Quasi Z-source network topology is shown in the Fig. 2.1.

Quasi-Z-source inverters (QZSI) gain all the advantages of traditional Z-source half bridge inverter. The impedance network conjugates the source and the inverter to obtain voltage boost and inversion in a single stage [9, 10]. It also have the features such as the lower component ratings, reduces the switching ripples to PV panels, causes less EMI problems and reduced source stress compared to the traditional Z-source inverter. The input to the proposed system is dc voltage. The quasi Z source network will separate this input voltage and also regulates it. So the voltage fluctuation of the input voltage is also controlled. This regulated voltage is given to an inverter. So the dc voltage is transferred into ac voltage. After this, the voltage is rectified and output voltages are obtained.

Modes of Operation and Circuit Analysis

Active or Non-Shoot Through State: In this state the load is directly connected to the supply through the switches, so the equivalent circuit of Quasi Z-Source Inverter Bridge becomes a current source. During the non-shoot through or active state the current flow through the diode is zero, the equivalent circuit diagram of the inverter is shown in the Fig. 3.

By deriving the mesh equations for the above circuit we get,

$$V_{L2} = V_{in} - V_{C1} \tag{1}$$

$$V_{L2} = - V_{C2} \tag{2}$$

$$V_{out} = V_{C1} - V_{L1} = V_{C1} + V_{C2} \tag{3}$$

Then the diode gets turned ON at this switching state. In this condition, the current flow through the diode becomes zero.

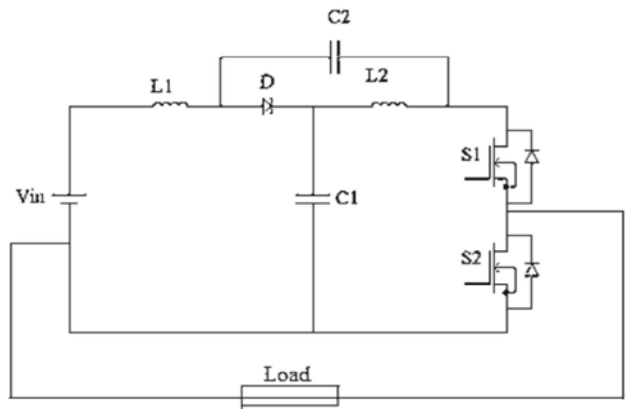


Fig. 2.1: QZSI Network Topology

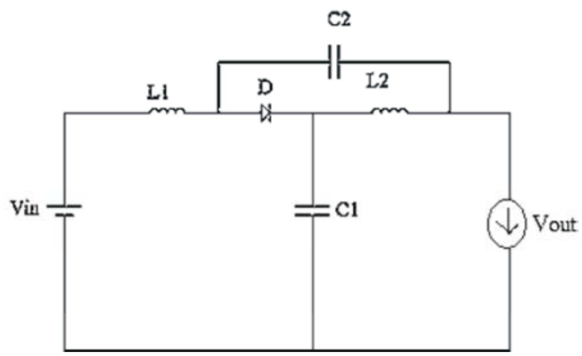


Fig. 3: Equivalent circuit of QZSI in active state

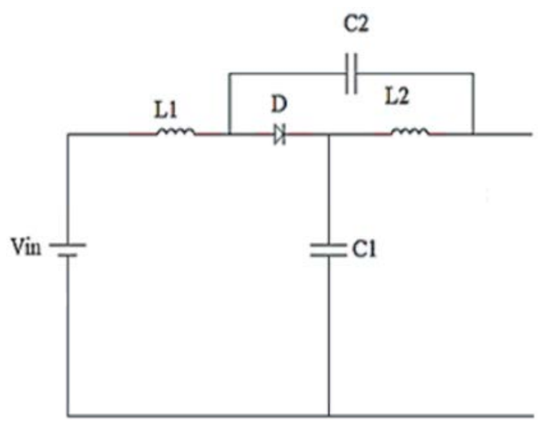


Fig. 3.1: Equivalent circuit of QZSI in zero state

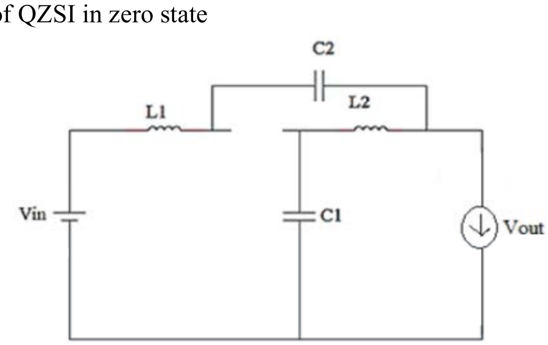
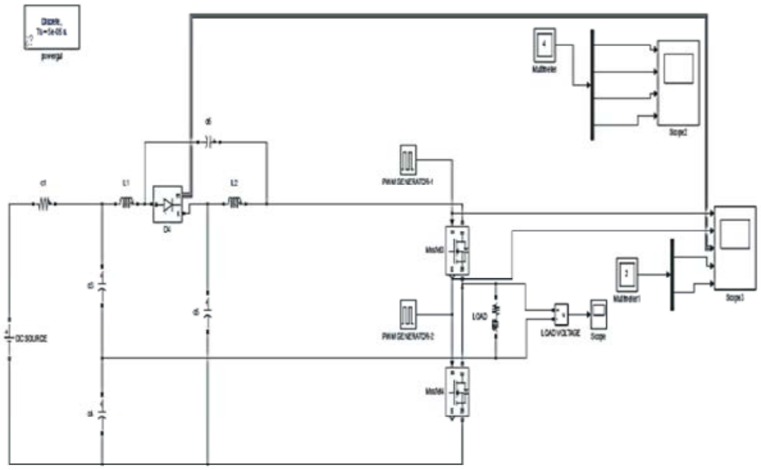
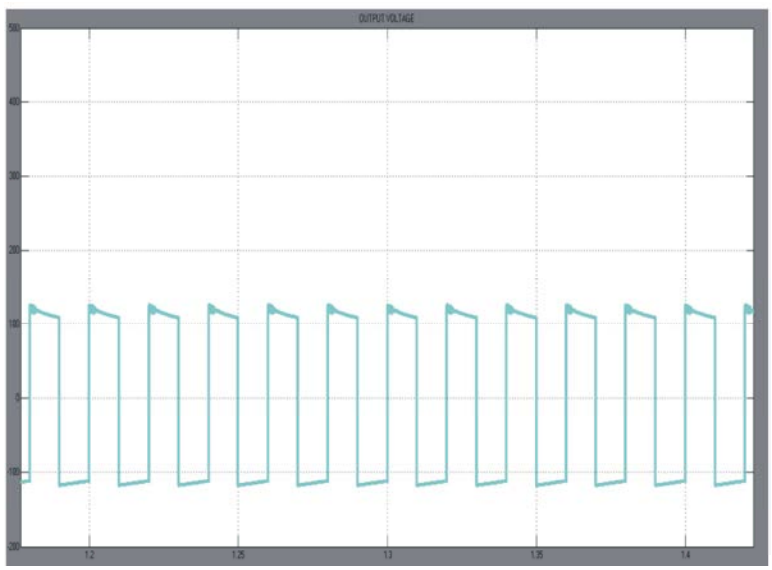


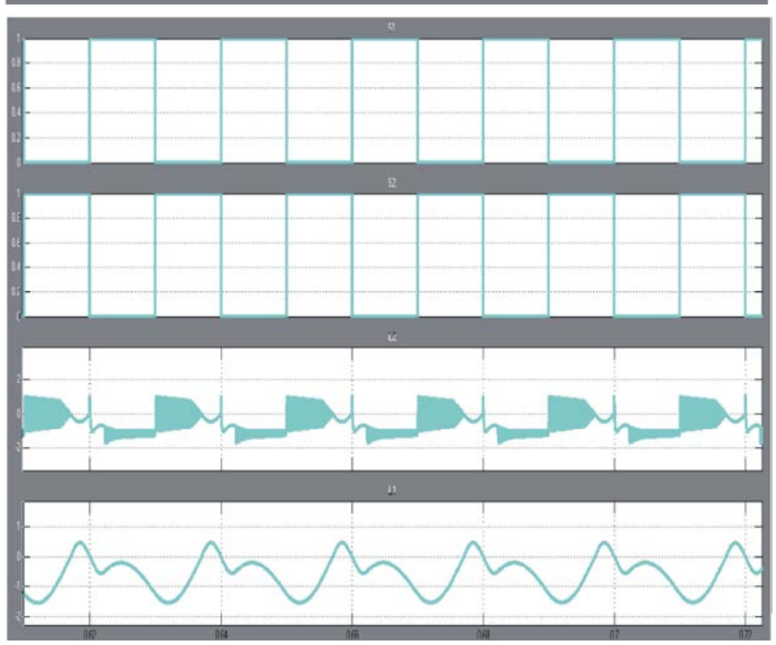
Fig. 3.2: Equivalent circuit of QZSI in shoot-through state



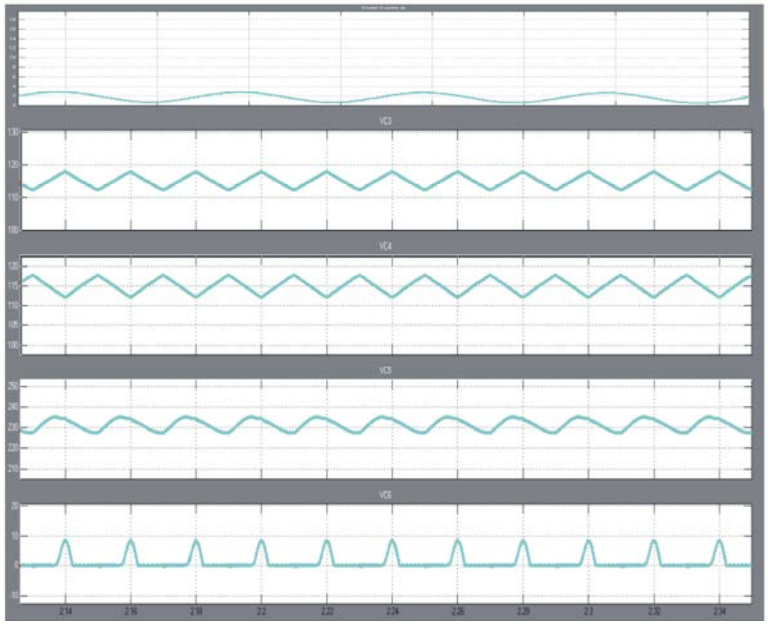
(a)



(b)

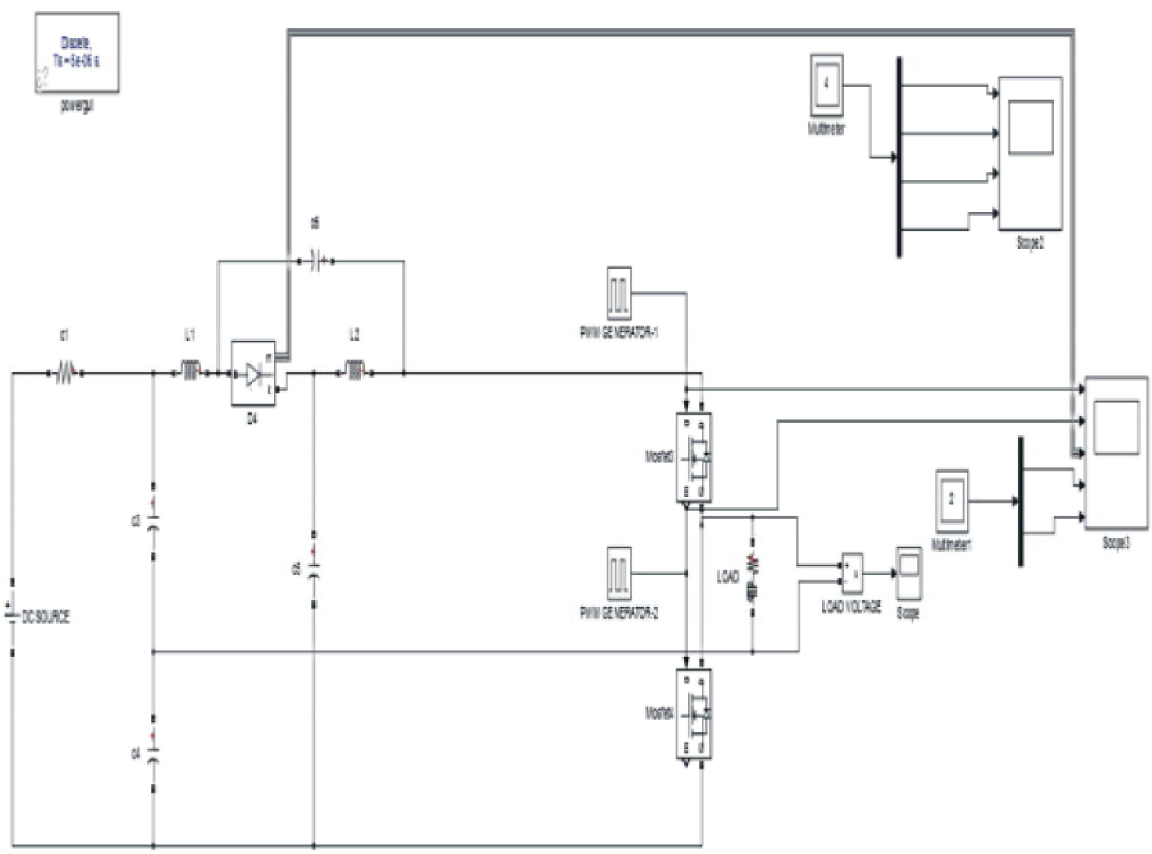


(c)

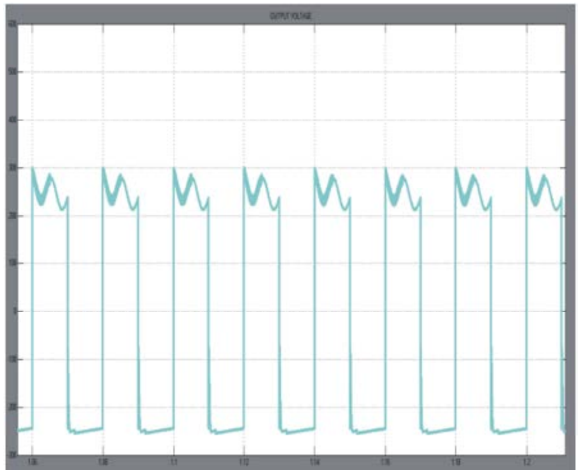


(d)

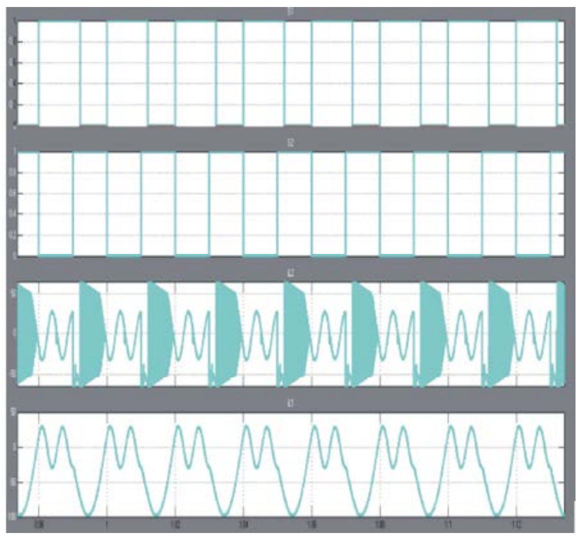
Fig. 4.1: Simulation Output a) Non-shoot through QZSI
b) output voltage
c) pulse waveform of switches and inductor current waveform
d) Diode current waveform and capacitor voltage waveform



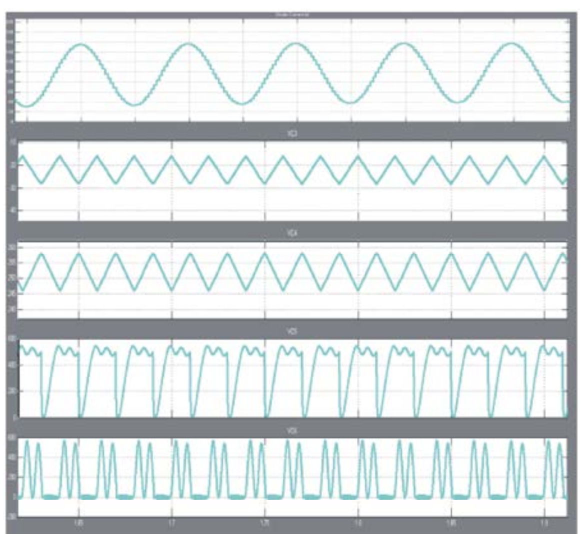
(a)



(b)



(c)



(d)

Fig. 4.2: Simulation Output a) Shoot through QZSI
b) output voltage
c) pulse waveform of switches and inductor current waveform
d) Diode current waveform and capacitor voltage waveform

Table 1: Comparison Between Shoot Through and Non-shoot Through State

Parameters	Quasi Z-source Converter	Z-source Converter
Output Voltage	300v	240v
Capacitor Voltage	600v	400v
Capacitor Voltage	600v	400v
Inductor Current	25a	20a
Inductor Current	25a	20a

Zero State: During one of the traditional zero state the load is shorted by the turning ON of upper devices or lower devices alone, so the inverter bridge is represented by a current source with zero value. During the zero state the equivalent circuit diagram of the inverter is shown in the Fig. 3.1.

Shoot-Through State: The main feature of the Quasi Z-source inverter is the shoot through state, during this state the devices in the same leg are switched ON. Since there are the inductors and capacitors available in the network this switching that lasts for a very short duration does not impairment the switches as in the case of VSI. The equivalent circuit diagram of the inverter bridge is shown in Fig. 3.2.

Simulation Results

Non-Shoot Through State: In the non-shoot through condition, the inverter is operated entirely a non-shoot through state. The diode will conduct and the voltage on capacitor C_1 will be equal to the input voltage while the voltage on capacitor C_2 will be zero. The simulation circuit and the results of Quasi Z-source half bridge converter is shown below.

Shoot Through State: During the shoot-through state, the switches in the same leg are switched ON at the same time. The simulation circuit and the results of Quasi Z-source half bridge converter is shown below.

CONCLUSION

Thus the proposed Quasi Z-source inverter inherits all the advantages of the Z-Source inverter and the feature merits are highly unique. It can recognize buck or boost power conversion in a single stage with a wide range of profit that is well suited for applications in photovoltaic power generation systems. The proposed Quasi Z-source inverter has the advantages of continuous input current, dwindle source stress and the lower component ratings. Moreover, the converter has been examined in two different conditions, including the shoot-through and non-shoot-through conditions. Finally simulations and experiments have been sustained out to validate the efficacy of the proposed converter.

REFERENCES

1. Hung, Y.C., F.S. Shyu, C.J. Lin and Y.S. Lai, 2003. “New voltage balance technique for capacitors of symmetrical Half-Bridge Converter with current mode control,” in proc. PEDS, pp: 365-369.
2. Liu, Z., B. Liu, S. Duan, Y. Kang and K.N.J. Soon, 2012. “A novel DC capacitor voltage balance control method for cascade multilevel STATCOM,” IEEE Trans. Power Electron., 27(1): 14-27.
3. Boroyevich, D., D. Zhang and P. Ning, 2010. “A shoot-through protection scheme for converters built with Sic JFETs,” IEEE Trans. Ind. Appl., 46(6): 2495-2500.
4. Shen, M.S., J. Wang, A. Joseph, F.Z. Peng, L.M. Tolbert and D.J. Adams, 2006. “constant boost control of the Z-source inverter to minimize current ripple and voltage stress,” IEEE Trans. Ind. Appl., 42(3): 770-778.
5. Bradaschia, F., M.C. Cavalcanti, P.E.P. Ferraz, F.A.S. Nevas, E.C. Dos Santos and J.H.G.M. Da Salvia, 2011. “Modulation of the three phase transformerless Z-source inverter to reduce leakage currents in photovoltaic systems,” IEEE Trans. Ind. Electron., 58(12): 5385-5395.
6. Vinnikov, D. and I. Roasto, 2011. “Quasi Z-source-based isolated DC/DC converters for distributed power generation,” IEEE Trans. Ind. Electron., 58(1): 192-201.
7. Ding, X.P., Z.M. Qian, S.T. Yang, B. Cuil and F.Z. Peng, 2007. “A direct peak Dc-link boost voltage control strategy in Z-source inverter,” in Proc. 22nd Annu. IEEE APEC, Mar. 2007, pp: 648-653.
8. Li, Y., S. Jiang, J.G. Cintron-Rivera and F.Z. Peng, 2013. “Modelling and control of quasi-Z- source inverter for distributed generation applicatons,” IEEE Trans. Ind. Electron., 60(4): 1532-1541.
9. Gajanayake, C.J., F.L. Luo, H.B. Gooi, P.L. So and L.K. Siow, 2010. “Extended-Boost Z-source inverters,” IEEE Trans. Power Electron., 25(10): 2642-2652.
10. Anderson, J. and F.Z. Peng, 2008. “Four quasi-Z-source inverters,” in Proc. IEEE PESC, Rhodes, Greece, pp: 2743-2749.

11. Lei, Q., F.Z. Peng and S. Yang, 2011. "Discontinuous operation modes of current-fed quasi-Z-source inverter," in Proc. 26th Annu. IEEE Appl. Power Electron. Conf. Expo. (APEC), Mar. 6-11, 2011, pp: 437-441.
12. Yang, S., F.Z. Peng, Q. Lei, R. Inoshita and Z. Qian, 2009. "Current-fed quasi-Z-source inverter with voltage buck-boost and regeneration capability," in Proc. IEEE Energy Convers. Congr. Expo., Sep. 20-24, 2009, pp: 3675-3682.