International Journal of Electrical Engineering.
ISSN 0974-2158 Volume 8, Number 3 (2015), pp. 225-238

http://www.irphouse.com

Performance comparison of Quasi-Z-Source inverter with conventional Z-source inverter

Shines T.S. and Dr.S.Ramamoorthy

Research scholar, Dept of EEE, Bharath University, Chennai, Tamilnadu. India

Associate Professor, Dept of EEE, Bharath University, Chennai, Tamilnadu. India

Abstract

Renewable power systems as distributed generation units often experience big changes in the inverter input voltage due to fluctuations of energy resources. Z-source inverter (ZSI) is known as a single-stage buck/boost inverter. The ZSI achieves voltage buck/boost in one stage, without introducing more switching devices. Shoot-through state enables energy to be stored in inductors, which is released when at non-shoot-through state, followed by the voltage boost feature. The voltage-fed Z-source inverter/quasi-Z-source inverter (qZSI) has been presented suitable for photovoltaic (PV) applications mainly because of its single-stage buck and boost capability and improved reliability. The conventional Z-source and Quasi Z source inverter circuit is simulated using sine PWM technique. Their performance is compared. The proposed circuit has better performance compare than conventional inverter. Sine PWM method is used to reduce the harmonics and improve the output voltage control.

Index Terms – Impedance network, quasi impedance network, inverter, shoot through state.

I. Introduction

The increasing tension on the global energy supply has resulted in greater interest in renewable energy resources. This presents a significant opportunity for distributed power generation (DG) systems using renewable energy resources, including wind turbines, photovoltaic (PV) generators, small hydro systems, and fuel cells However, these DG units produce a wide range of voltages due to the fluctuation of energy resources and impose stringent requirements for the inverter topologies and controls. Usually, a boost-type dc–dc converter is added in the DG units to step up the dc voltage.

This kind of topology, although simple may not be able to provide enough dc voltage gain when the input is very low, even with an extreme duty cycle. Also, large duty cycle operation may result in serious reverse recovery problems and increase the ratings of switching devices. Furthermore, the added converter may deteriorate system efficiency and increase system size, weight, and cost. On the other hand, the upper and lower devices of the same phase leg cannot be gated on simultaneously in conventional voltage source inverter (VSI). Otherwise, shoot-through problems would occur and destroy the switching devices. Dead time is always used in case of shoot-through events in bridge type converters, but it will cause waveform distortion. Though dead-time compensation technology has been developed, it increases control complexity. So, it is desirable to have a single-stage high-gain boost inverter featuring no shoot through issues.

Single-stage topologies, which integrate performance of each stage in a multistage power converter, are becoming the focus of research. Though they may cause increased control complexity, they may offer higher efficiency, reliability, and lower cost. It is observed that many single-stage voltage source and current source inverters have been proposed. A Z-source inverter (ZSI) proposed in is able to overcome the problems in conventional VSI and conventional current source inverter. It can provide a wide range of obtainable voltage and has been applied to renewable power generation systems. However, this topology is complex and inductors and capacitors in the Z-network should have high consistency. Moreover, only shoot-through zero state can be regulated when higher voltage gain is required. Without requirements of any additional dc/dc converters or components, the qZSI with energy storage was first proposed for PV power generation system operates at the line frequency of 50Hz, passive filters require relatively large fixed-value inductors and capacitors to reduce the low frequency harmonic currents. These filters use resonant pass or resonant trap circuits sensitive to both frequency and load. It is difficult to achieve near unity power factor with passive filters. Also, very large currents may circulate in the filter. However the passive filter is an effective PFC solution in cases where the line frequency, line voltage and load are relatively constant. An active PFC performs much better and is significantly smaller and lighter than the passive PFC circuit. The active PFC circuits operate at a higher switching frequency than the line frequency to allow a large reduction in the size and cost of passive filter elements. Their function includes active wave shaping of the input current, filtering of the high frequency switching, feedback sensing of the source current for waveform control and feedback control to regulate output voltage. Buck, boost, fly back and other converter topologies are used for the active PFC circuits. The boost circuit-based PFC topology is the most popular and is employed in this study. The boost PFC circuit is an economical solution to comply with the regulations. It can be implemented with a dedicated single chip controller, making the circuit relatively simple with a minimum number of components. The boost inductor in the boost PFC circuit is in series with the ac power line. Therefore the input current does not pulsate minimizing conducted EMI at the line [6]. This allows the size of the EMI filter and the conductors in the input circuit to be reduced [8, 9]. This topology inherently accepts a wide input voltage range without an input voltage selector switch. The output voltage of a boost PFC circuit should be higher than the peak value of the maximum input voltage. Although this is a simple topology, it must be designed to handle the same power as the main power converter. The above literature does not deal with the DC drive fed from PFC converter. This work proposes the PFC converter for controlling the speed of DC drive.

II. Conventional circuit topology

Modes of operation

Three phase inverters are normally used for high power applications. Three single-phase half or full bridge inverters can be connected in parallel to form the configuration of a three phase inverter. The gating signals of single phase inverters should be advanced or delayed by 120º with respect to each other in order to obtain three phase balanced voltages.

The three phase output can be obtained from a configuration of six switches and six diodes. Two types of control signals can be applied to the switches: 180ºconduction or 120ºconduction.

2.4.1 180° Conduction

Each switch conducts for 180°. Three switches remain on at any instant of time. When switch 1 is switched on, terminal ‗a‘ is connected to the positive terminal of the dc input voltage. When switch 4 is switched on, terminal ‗a‘ is connected to the negative terminal of the dc source. There are six modes of operation in a cycle and the duration of each mode is 60°. The switches are numbered in the sequence of gating the switches 123, 234, 345, 456, 561, 612. The gating signals are shifted from each other by 60° to obtain three phase balanced voltages.

2.4.2 120°Conduction

Each switch conducts for 120°. Only two switches remain on at any instant of time. The conduction sequence of switches is 61, 12, 23, 34, 45, 56, and 61. There are three modes of operation in a half cycle and the equivalent circuits for wye connected load are shown in Figure. 2.3.

During mode 1 for $0 \leq \omega t \leq \pi/3$ switches 1 and 6 conducts.

Van = Vs/2 Vbn = -Vs/2 Vcn = 0

During mode 2 for $\pi/3 \leq \omega t \leq 2\pi/3$, switches 1 and 2 conduct.

Van = Vs/2 Vbn = 0 Vcn = -Vs/2

During mode 3 for $2\pi/3 \leq \omega t \leq 3\pi/3$, switches 2 and 3 conduct.

Van = 0 Vbn = Vs/2 Vcn = -Vs/2

The line to neutral voltages can be expressed in Fourier series as given in equations 2.1 to 2.3.

Van = n=1, 3, 5 …Σ ∞ 2Vs/nπ cos nπ/6 sin n (ωt + π/6) …2.1

Vbn = n=1, 3, 5 …Σ ∞ 2Vs/nπ cos nπ/6 sin n (ωt - π/2) …2.2

Vcn = n=1, 3, 5 …Σ ∞ 2Vs/nπ cos nπ/6 sin n (ωt - 7π/6) …2.3

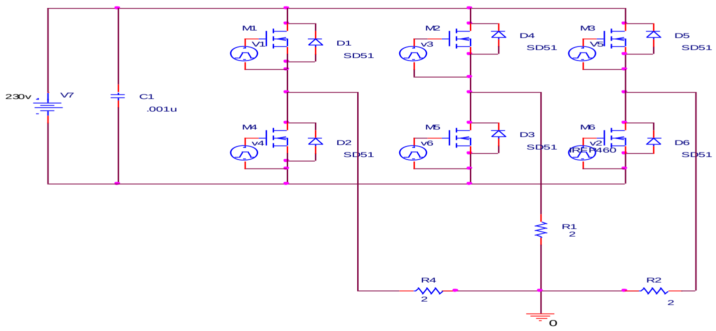

Figure. 1 Voltage source Inverter

Operating Principle of Z-source inverter

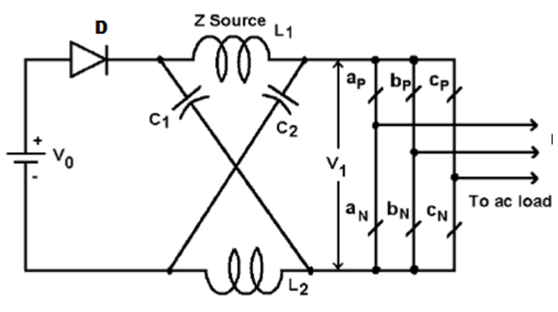

Figure 2 impedance source Inverter

Equivalent Circuit

Equivalent circuit of the Z-source inverter s when viewed from the link. When viewed from the Z-source network, the inverter bridge is equivalent to a short circuit when the inverter bridge is in the shoot-through zero state, ,whereas the inverter bridge becomes an equivalent current source as shown in when in one of the six active states. Note that the inverter bridge can be also represented by a current source with zero value (i.e., an open circuit)when it is in one of the two traditional zero states. Therefore, shows the equivalent circuit of the Z source inverter viewed from the dc link when the inverter bridge is in one of the eight non shoot-through switching states.

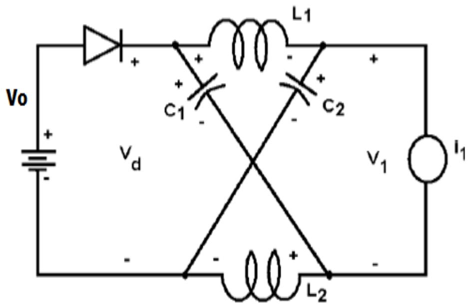

Fig 3Equivalent circuit of the Z-Source inverter viewed from the dc link

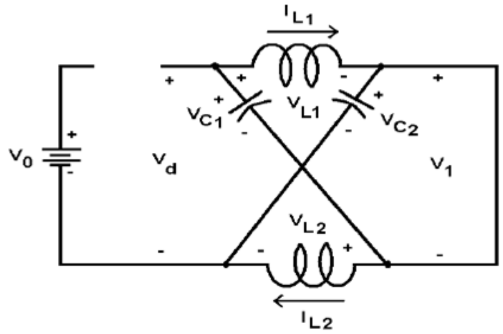

Fig 4 Equivalent circuit of the Z-Source inverter viewed from the dc link when the inverter bridge is in the shoot-through zero state

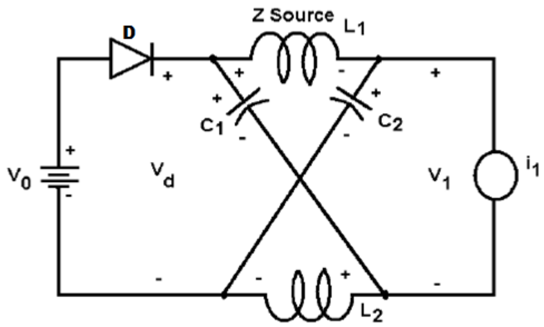

Fig 5 Equivalent circuit of the Z-Source inverter viewed from the dc link

III Proposed circuit topology

Block diagram:

DC source:

It is the first stage of this roject. So it is give the DC supply to Inverter. The DC source may be Battery or fuel cell or rectified from AC source

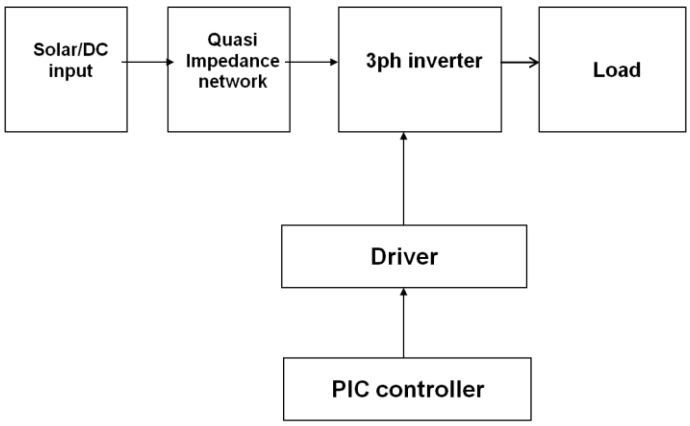

Fig 6 Block diagram of proposed circuit

Impedance network:

X shaped network is placed between dc and three phase inverter.it is used for improve the performance of the motor.

Three phase inverter:

Dc source is converted into three phase ac supply with help of inverter. Sine PWM method is used for controlling the inverter output voltage.

Three phase ac Load:
Three phase inverter is generate ac output voltage . it is used to run three phase ac motor or any three phase load.

PIC controller:
Micro controller is used to generate triggering pulse for mosfets. It is used to control the outputs. Micro controller have more advantage compare then analog circuits and micro processor such as fast response, low cost, small size and etc.

Control technique:
Three phase ac volatge is taken as reference this reference signal is compared with tringular carrier signal.this control method is called as Sine pwm technique. Durning Normal operation of the inverter at any instant two device in same leg not conduct.but proposed Z source inverter this operation is possible.this operation is called as shoot throgh mode.this pulse pattern as shown in the figure 7 and fig 8.

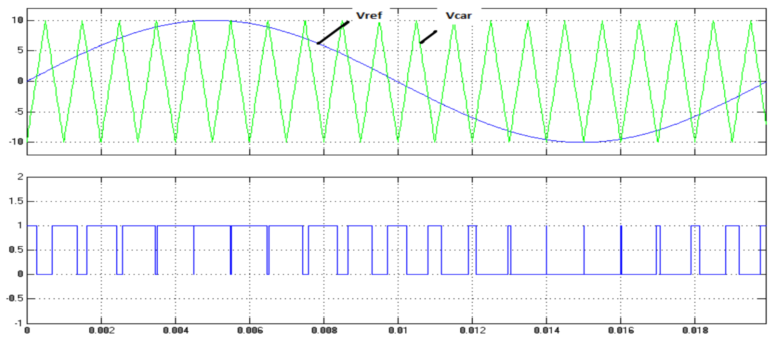

Fig 7 sine pwm generation method and pulse pattern

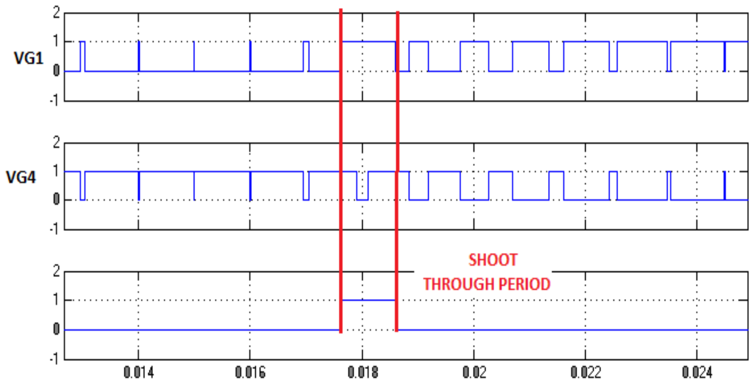

Fig 8 shoot through pulse pattern for switch s1 and s4

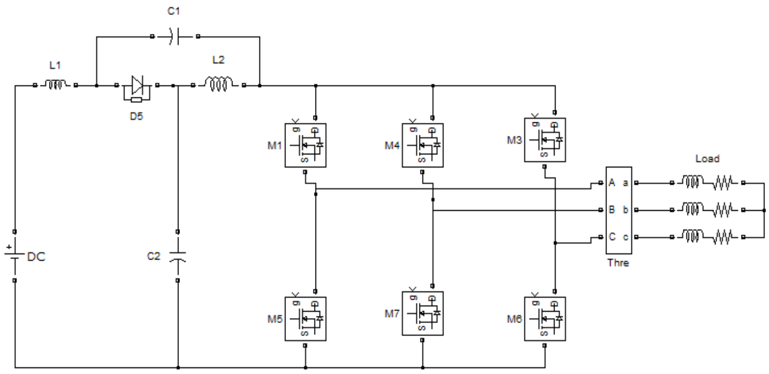

Fig 9 proposed circuit diagram

Shoot throgh mode

At the shoot-through state shown in Fig. 10, during this interval the one leg switch is shorted with short duration. At that time the current flow through inductor as shown in fig 10.the capacitors transfer their electrostatic energy to magnetic energy stored in the inductors.

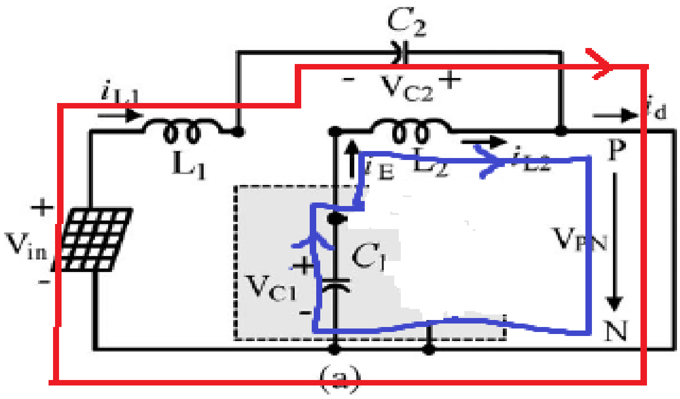

Fig 10 Shoot throgh mode

Non Shoot throgh mode:

At the non-shoot-through states shown in Fig. 11 the dc power source, as well as the inductors, charges the capacitors and powers the external ac load, boosting the dc voltage across the inverter bridge

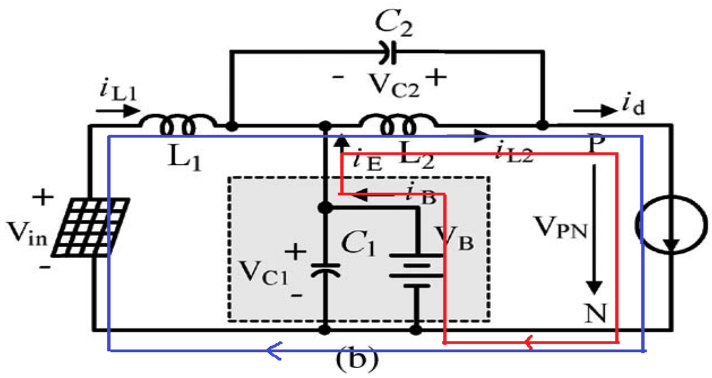

Fig 11.Non Shoot throgh mode

IV SIMULATION RESULT

Fig 12 shows the conventional z-source inverter circuit diagram .it consists PV cell, impedance network, three phase inverter and load. The impedance network is used to boost the voltage as well as to protect the circuit during short circuit condition. Fig 13 shows the PV cell output voltage. Fig 14 shows the inverter output voltage. Fig 15 shows the inverter output current. Fig 16 shows the FFT analysis for current waveform. From this result the current has THD 6.78%.

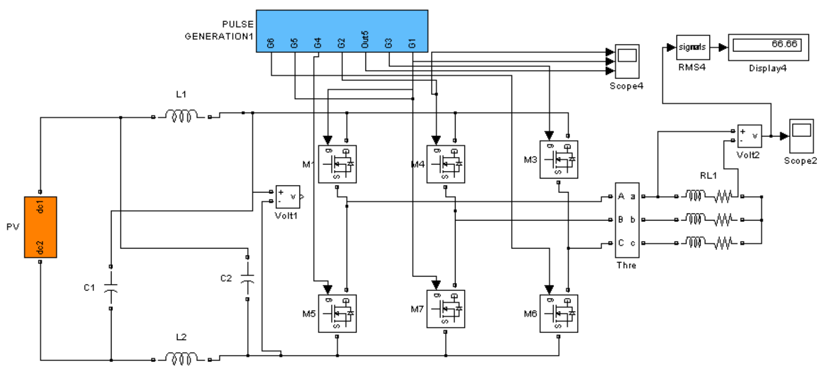

Fig 12 conventional Z-source inverter

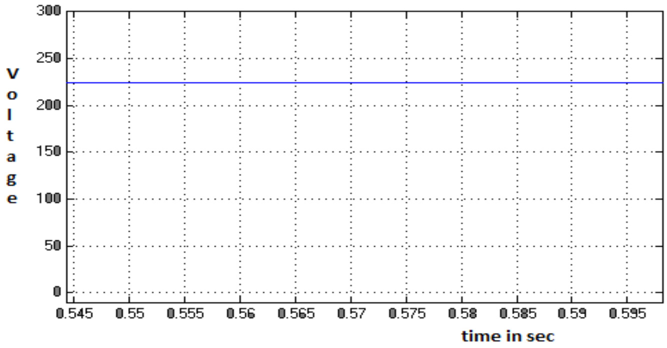

Fig 13 PV cell output voltage

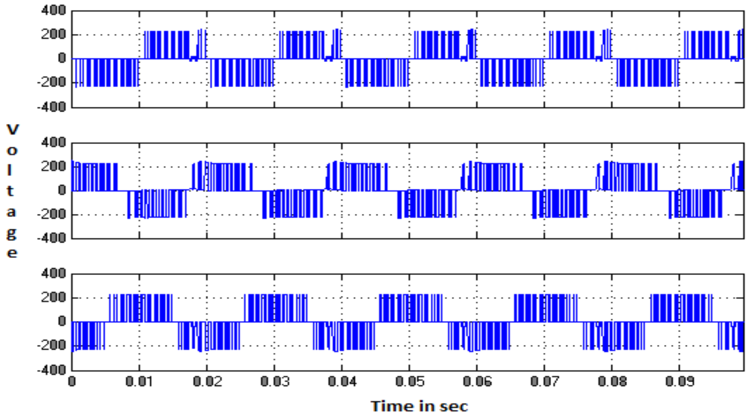

Fig 14 inverter Phase to phase voltage

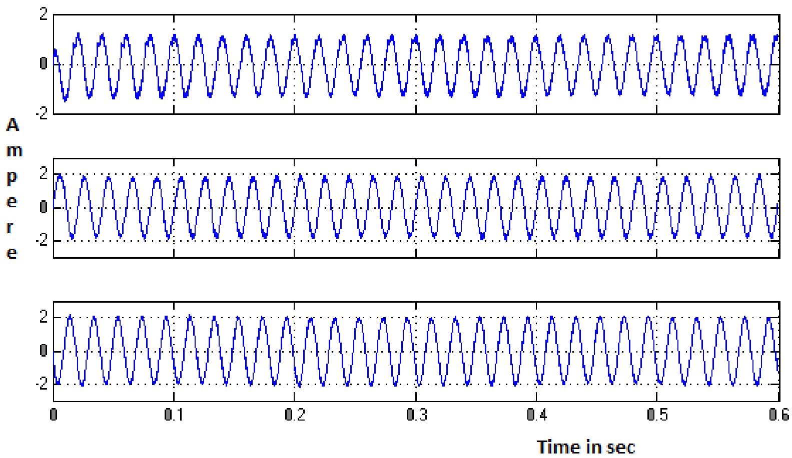

Fig 15 Inverter output current

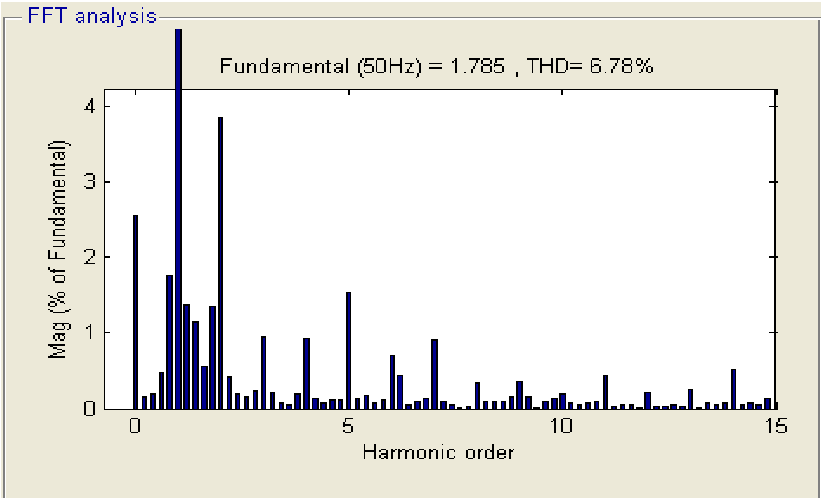

Fig 16 FFT ANALYSIS for output current

Fig 17 shows the proposed quasi z-source inverter circuit diagram. It consists PV cell, impedance network, three phase inverter and load. The impedance network is used to boost the voltage as well as to protect the circuit during short circuit condition. Fig 18 shows the inverter output voltage. Fig 19 shows the inverter output current. Fig 20 shows the FFT analysis for current waveform. From this result the current has THD 5.66%.

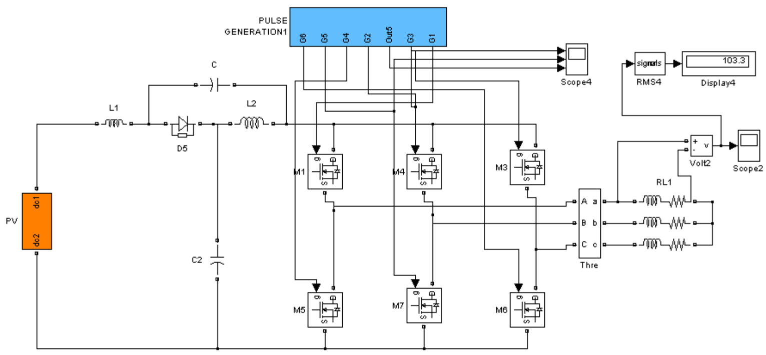

Fig 17 proposed Zsource inverter

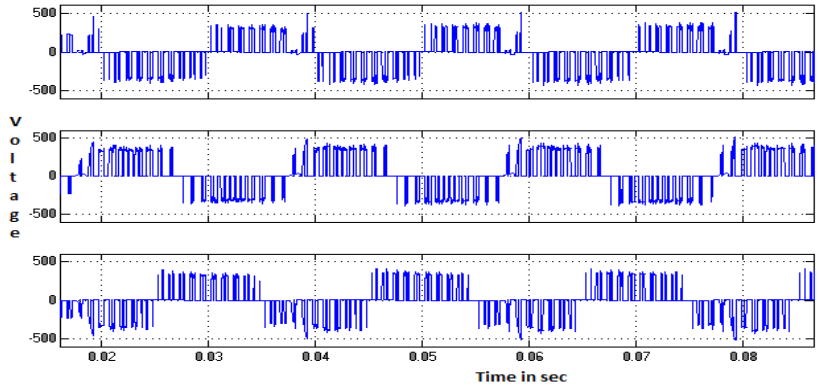

Fig 18 inverter Phase to phase voltage

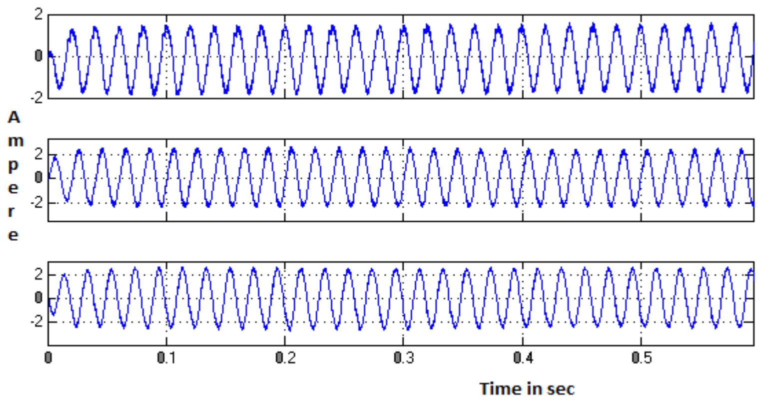

Fig 19 Inverter output current

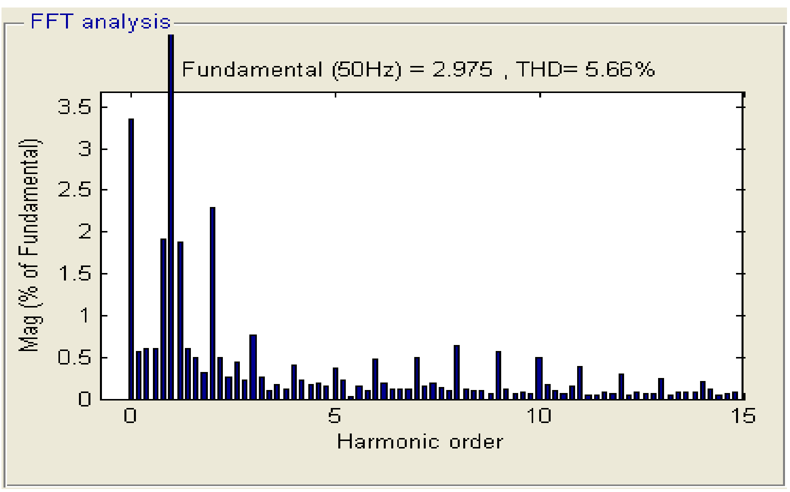

Fig 20 FFT ANALYSIS for output current

Comparative analysis

The conventional circuit and proposed circuit simulation results are compared the proposed circuit has better performance compare than conventional circuit it is shown from the following table.

PARAMETER	**ZSI**	**QZSI**
INPUT VOLTAGE (V)	225	225
B OOST OUTPUT VOLATGE (V)	225	343
RMS PHASE VOLTAGE (V)	119	191
RMS LINE VOLTAGE (V)	66	103
RMS CURRENT (A)	0.80	1.28
THD (%)	6.78	5.66

V Conclusion

This paper has presented a novel single-stage boost inverter with sine PWM, which exhibits several merits.

1) It employs a unique impedance network including passive components to connect the three-phase inverter bridge to the power source. By designing the inductor properly and adjusting the previously forbidden shoot-through zero state, the magnitude of the bus voltage can be greatly stepped up.

2) Shoot-through states, which are forbidden in conventional VSIs, are utilized to store and transfer energy within the impedance network to boost the amplitude of the bus voltage. Waveform distortion of the ac output voltage caused by dead time is essentially avoided.

Thus the proposed inverter has more voltage gain, less capacitor rating and less harmonics compare than conventional inverter.

References

1. Yufei Zhou*, Student Member, IEEE*, and Wenxin Huang ―Single-Stage Boost Inverter With Coupled Inductor ―IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 27, NO. 4, APRIL 2012
2. J. Anderson and F. Z. Peng ,―Four quasi-Z-source inverters," in *Proc. IEEE Power Electron. Spec. Conf.*, 2008, pp. 2743–2749.

3. F. Z. Peng, M. Shen, and K. Holland, ―Application of Z-source inverter for traction drive of fuel cell-battery hybrid electric vehicles," *IEEE Trans.Power Electron.*, vol. 22, no. 3, pp. 1054–1061, May 2007
4. B. Sahan, A. N. Vergara, N. Henze, A. Engler, and P. Zacharias ―A single stage PV module integrated converter based on a low-power current-source inverter," *IEEE Trans. Ind. Electron.*, vol. 55, no. 7, pp. 2602–2609, Jul.2008.
5. S.-H. Hwang and J.-M. Kim ―Dead time compensation method for voltage-fed PWM inverter," *IEEE Trans. Energy Convers.*, vol. 25, no. 1, pp. 1–10, Sep. 2010.
6. M. Mohr, W. T. Franke, B. Wittig, and F. W. Fuchs, ―Converter systems for fuel cells in the medium power range—A comparative study," *IEEE Trans. Ind. Electron.*, vol. 57, no. 6, pp. 2024–2032, Jun. 2010.
7. Muhammad Rashid ," Power electronics circuits ,devices and application
8. Bimal .K.Bose ,"modern power electronics and drives ―
9. www.mathworks.com

Mr Shines.T.S, aged 39. He received B.E. in Electrical Engineering from NI College of Engineering during 1998 and M.E. in Applied Electronics from Hindustan College of Engineering during 2001. He has undergone Apprenticeship Training in Indian Space Research Organisation (ISRO) for One year. He also acted as Assistant Professor and Head of the Department in various engineering colleges for the past 10 years. Currently, he is working as Assistant Professor in Electrical & Electronics Engineering in Sivaji College of Engineering & Technology, Manivila, Tamilnadu, India. He is presently a research scholar in Bharath University, Chennai, and Tamilnadu. He is working in the area of harmonic reduction, voltage gain improvement and stability of the inverter.

Dr. S. RAMAMOORTHY . He has completed Bachelor of Engineering under Madras University during 1983 in PSG college of Technology , Coimbatore in Electrical and Electronics Engineering. He completed M.Tech in IIT Delhi during 1988 in Industrial Engineering and PhD in Sathya Bama University Chennai during 2012. He has completed 25 years in teaching and 15 years in industries. He has also guided a project on Electrical Bike which has won a presidential award.