International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 5, May - 2014

Analysis of Improved Trans Z-Source Inverter using PWM Technique

Rani Mathews
M. Tech Power Electronics, Dept. of EEE
Oxford College of Engineering, VTU
Bangalore, India

Anupama Sisodia
Asst. Prof., Dept. of EEE
Oxford College of Engineering
Bangalore, India

***Abstract*— The Z-source inverter (ZSI) utilizing a unique LC network and forbidden shoot through states overcomes the conceptual and theoretical barriers and limitations of the traditional voltage source inverter and current source inverter. This ZSI provides unique features such as the ability to buck and boost voltage with a single stage simple structure. This paper deals with a new family of high boost voltage inverters that improve upon conventional voltage source inverter (VSI) and quasi ZSI. The improved trans-Z-source inverter provides continuous input current and a higher boost voltage inversion capability. In addition it can suppress resonant current at start up which might destroy the device. With the same input voltage and the same modulation index, the improved inverter provides continuous input current and a higher boost voltage inversion capability.. Simulations are done using MATLAB /SIMULINK**

Keywords*— Modulation index, Quasi Z-source inverter, shoot through state, Z-source inverter.

I. INTRODUCTION

Z-SOURCE inverters have been proposed as an alternative power conversion concept as they have both voltage buck and boost capabilities unlike the traditional voltage source inverter. Modified topologies of ZSI includes quasi ZSI and improved trans ZSI. In order to overcome the inconvenience of inrush current suppression at start up, quasi ZSI has been proposed which provides continuous input current, reduced voltage stress on capacitors and lower current stress on inductors and diodes[2].

This paper presents a novel high step up inverter based on the transformer to improve the input current profile and the boost inversion ability of the traditional inverter. Like the traditional ZSI, it also allows two switches of the same leg to be gated in the circuit, thus eliminating the shoot through fault. The buck and boost capabilities of inverters are operated in the shoot through state.

In this paper, design of quasi ZSI and improved trans ZSI is proposed. Simulation is carried out to compare the buck and boost operation of both inverters to determine it's quality.

II. BLOCK DIAGRAM

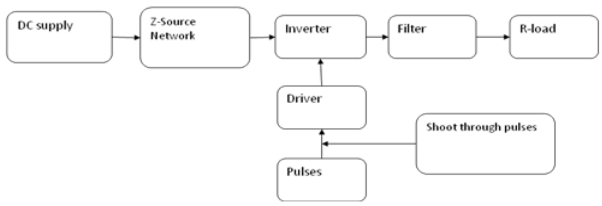


Fig.1: Block diagram of Z source network

Fig.1 represents the block diagram of the z source network. Here the dc voltage source can be a solar arrays, battery fuel-cell etc. Z-source network is a combination of 2 inductors and 2 capacitors. It is more effective to suppress voltage and current ripples that capacitor or inductors used alone in the traditional converters. In ZSI, both of the power switches in a leg can be turned on at the same time, which eliminates dead time and significantly improves the reliability while reducing the output waveform distortion. DC-AC converters are known as inverter. The function of an inverter is to change a dc input voltage to a symmetrical ac output voltage of desired magnitude and frequency. The output voltage could be fixed or variable at a fixed or variable frequency. A variable output voltage can be obtained by varying the input dc voltage and maintaining the gain of the inverter constant, on the other hand if the dc input voltage is fixed and it is not controllable a variable output voltage can be obtained by varying the gain of the inverter, which is normally accomplished by pulse width modulation (PWM) control within the inverter. The inverter gain may be defined as the ratio of the ac output voltage to dc input voltage.

III. SYSTEM DESCRIPTION

A. Z-Source Inverters

ZSI is a buck boost inverter that has a wide range of voltage. The shoot through period is the time period when two switches of the same leg are gated, this allows the voltage to be boosted to the required level when the input DC voltage is not up to the required level. The diode D is used to prevent the reverse flow of current in the circuit.

The pulse width modulation of the Z-source inverters produces the AC voltage boost by controlling the duty cycle of the switches used on the circuit.

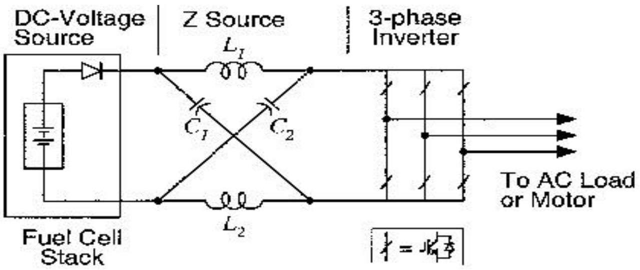


Fig.2: Z source network

The pulse width modulation of the Z-source inverters produces the AC voltage boost by controlling the duty cycle of the switches used on the circuit

Sinusoidal PWM is employed to turn on the switches. The extent to which the dc voltage is boosted is decided by the modulation index of the PWM used. The switches 1, 4 are simultaneously gated to provide the shoot through condition for the inverter. This enables the voltage to be increased to the required value without the additional need of switches. The shoot through condition is also used to buck the voltage given to the load side through proper gating signals thus providing a dual buck/ boost function using the same ZSI.

B.Quasi Z-source Inverter

Quasi ZSI are enhanced version of the ZSI that retain its main features and improve on other features like lower component rating, less switch pulse, reduced EMI etc. Specifically there exist voltage fed Quasi ZSI were designed to overcome the shortcomings of the classic ZSI. This quasi ZSI with continuous input current is well suited to DC-AC conversion requiring minimum current harmonics for increased life time. Despite the boost inversion ,it has drawbacks like huge resonant current flows to the diode ,transformer windings etc.

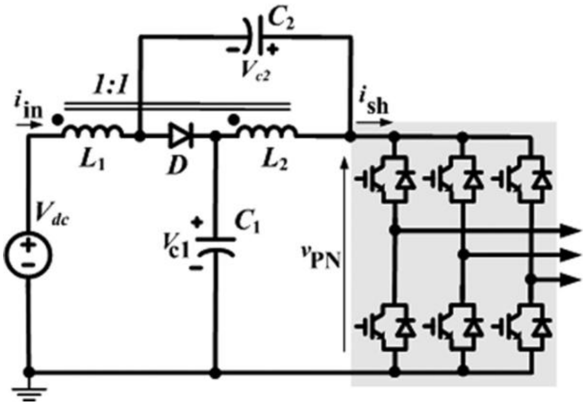


Fig. 3: Quasi Z-source inverter

Boost factor can be defined as the ratio between the DC link voltage across the inverter bridge V_{PN} and the input voltage V_{dc}. Boost factor

$$B= V_{PN}/ V_{dc} = 1/ 1-2 (T_0/T) = 1/ 1-2D \qquad (1)$$

Where T_0 is the interval of the shoot through state during the switching period T and duty cycle $D=T_0/T$

Boost factor is increased to,

$$B = 1/1- (1+n)(T_0/T = 1/ 1-(1+n)D \qquad (2)$$

C. Improved Trans ZSI

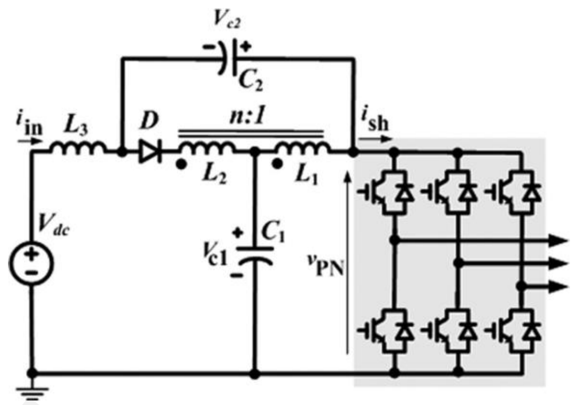


Fig. 4: Improved trans ZSI

Fig. 4 shows the improved trans ZSI with continuous input current and boost inversion capability. The main characteristics of this inverter are,

1. Input current is continuous
2. Higher output voltage can be obtained
3. The voltage buck boost can be possible by varying the shoot through interval.

i. Operating Principle

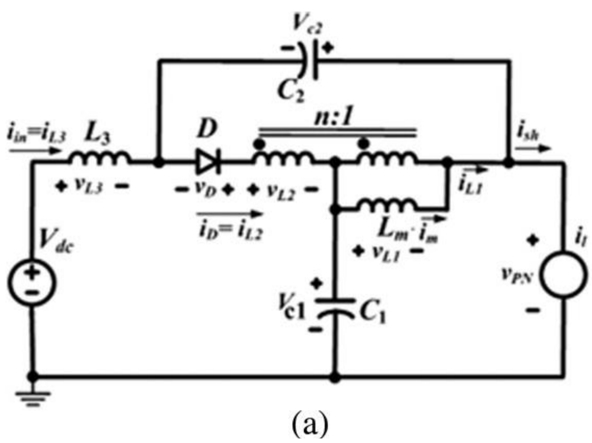
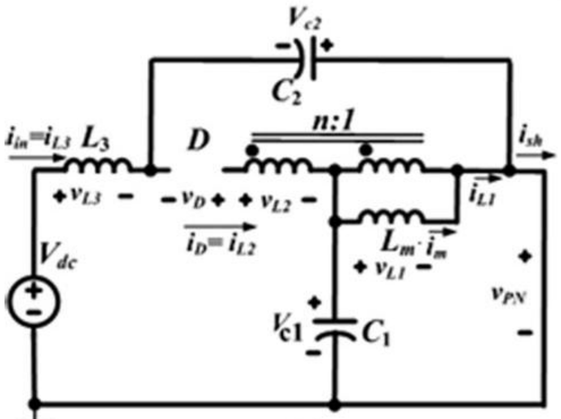


Fig: 5; Equivalent circuit

Fig.5 shows the equivalent circuit of the improved trans ZSI. It has two modes of operation shoot through state and non shoot through state

ii. Modes of Operation

1) Mode 1:Shoot through state



(b)

Fig.6: Shoot through state

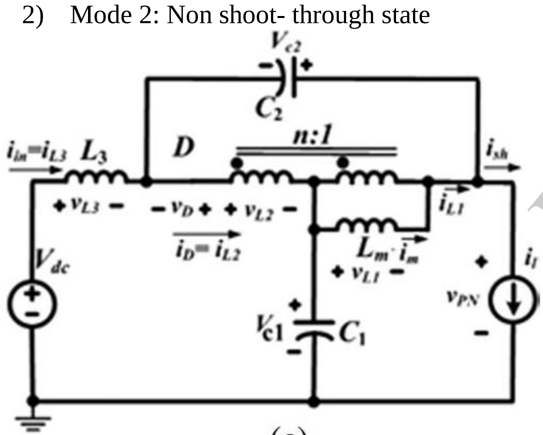
Fig.6 shows the shoot through state. During this state, diode D is OFF.

$$v_{L1} = V_{C1} \quad (3)$$

$$v_{L2} = nV_{L1} = nV_{C1} \quad (4)$$

$$v_{L3} = V_{dc} + V_{C2} \quad (5)$$

2) Mode 2: Non shoot- through state



(c)

Fig .7:Non shoot- through state

Fig.7 shows the non shoot through state. Diode is forward biased through which the transformer windings get energized. Thus the main power flowing through to the inverter bridge is the total power from the transformer and capacitor C2

$$vL1_{-non} + v_{L2\text{-non}} = -V_{C2} \quad (6)$$

$$v_{L3} = V_{dc} - V_{C1} - v_{L2\text{-non}} \quad (7)$$

$$v_{PN} = V_{C1} - v_{L1\text{-non}} \quad (8)$$

The peak dc link voltage across the inverters main circuit is expressed in equation (8) can be re-written as

$$V_{PN} = \{1/1-(2+n)D\}*V_{dc} = BV_{dc} \quad (9)$$

The boost factor can be re-written as

$$B= 1/1-(2+n)D = 1/1-(2+n)\ T_0/T \quad (10)$$

Comparing (10) and (2), the improved inverter uses lower transformer ratio than the conventional inverters by the use of transformer.

The proposed improved Trans ZSI has a lower voltage stress across the active switching devices. This is because the improved trans Z-source inverter has a stronger power capability at the high modulation index.

IV. SIMULATION RESULTS

To verify the advantages of the proposed improved trans ZSI, MATLAB simulation compares its performance with the conventional quasi ZSI for both buck and boost operation. The simulation parameters selected are :

Input DC voltage	100V
Capacitors	100µf
Transformer turn ratio	1:2
Inductor	0.737mH
Switching frequency	10 kHz
Three phase output filter L_f	1.5mH
Three phase output filter C_f	10µf
Three phase restive load	50Ω/phase

The gate pulses are provided to the switches by comparing the three reference wave with a carrier triangular wave. Filter is used to reduce the distortion in the output waveform.

A. *Simulation Circuit of Quasi ZSI*

Fig.8 shows the simulation circuit of the quasi ZSI. In this method the output voltage can be varied by modifying the modulation index. Fig.9 below shows when constant =0.78, -0.78 output voltage decreases to 40V and when constant = 0.86, -0.86 output voltage increases to 150V and various other parameters like input current, output current, dc link voltage are also shown.

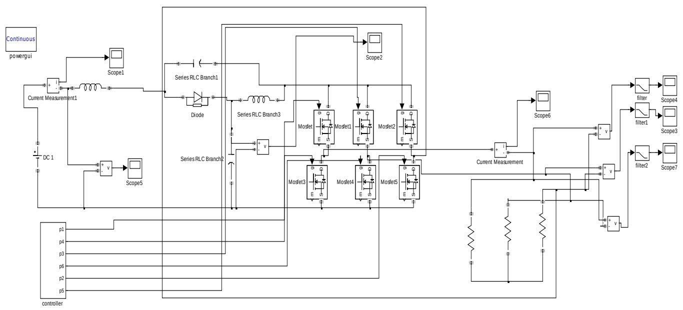


Fig.8: Simulation circuit of q-ZSI

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 5, May - 2014

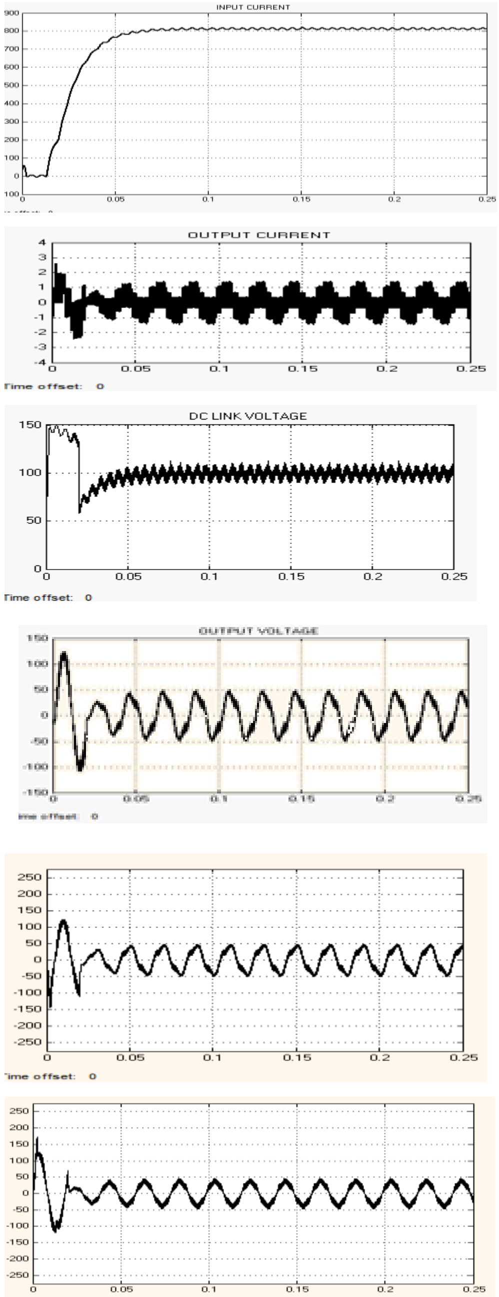


Fig.9: Simulation results for buck operation when M=.78,-.78 From top to bottom: input current; output current ;dc link voltage and output voltage.

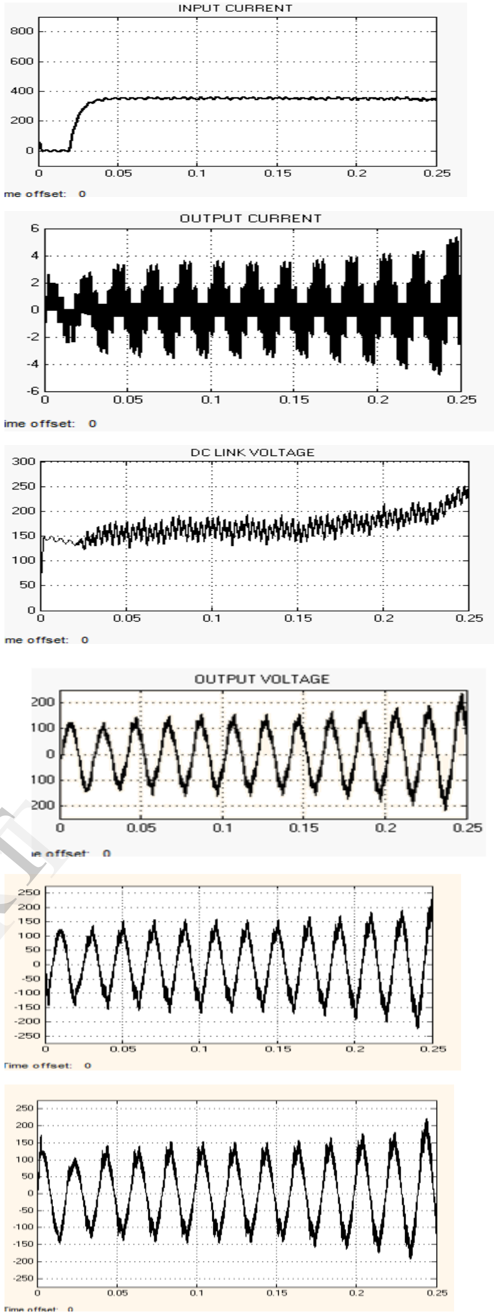


Fig 10: Simulation results for boost operation when M=.86,-.86 From top to bottom: input current; output current; dc link voltage and output voltage.

B. Simulation circuit of Improved Trans ZSI

Fig.11 shows the simulation circuit of improved trans ZSI. Here also the output voltage can be able to be varied by modifying the modulation index. Fig .12 and13 below shows the buck and boost operation .When M =0.78, -0.78 output voltage decreases to 40V and when constant = 0.86, -0.86 output voltage increases to 300V and various other parameters like input current, output current ,dc link voltage and output voltage are also shown in fig.12 and fig.13.

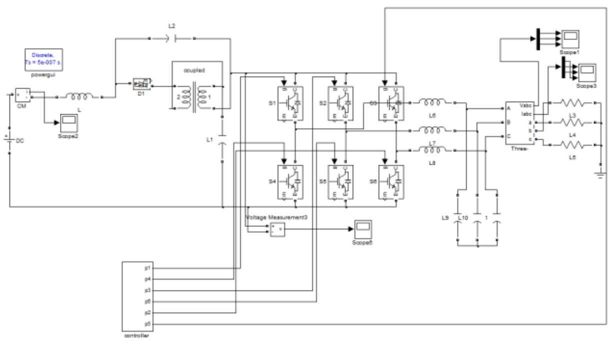


Fig.11: Simulation circuit of improved trans ZSI

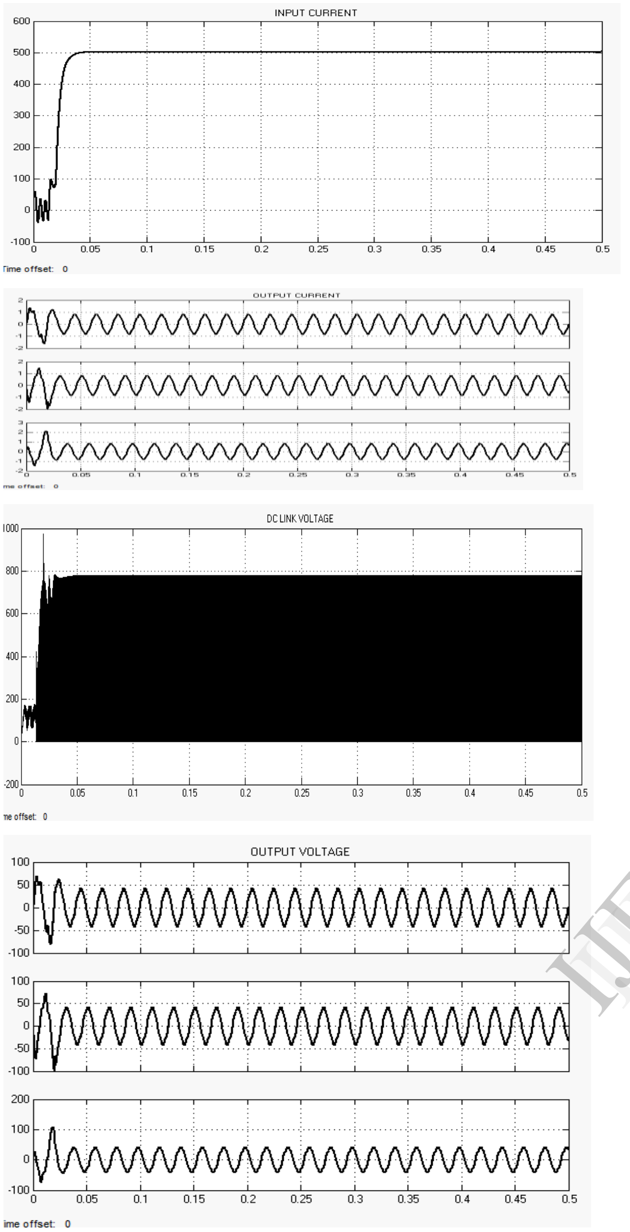


Fig.12 Simulation results for buck operation when M=.78,-.78 From top to bottom: input current; output current dc link voltage and output voltage.

V. EXPERIMENTAL SETUP AND RESULTS

The PWM control technique of improved trans Z-Source inverter was successfully developed and tested in Power Electronics Laboratory and the photograph of the complete set up is as shown in fig.14. Components used here are: MOSFET IRF 250 N, Diode IN4004, Capacitor 1000µF / 25V, Opto coupler MCT2E, Transistor 2N 2222 & SK 100, Resistors 1KΩ & 100Ω.

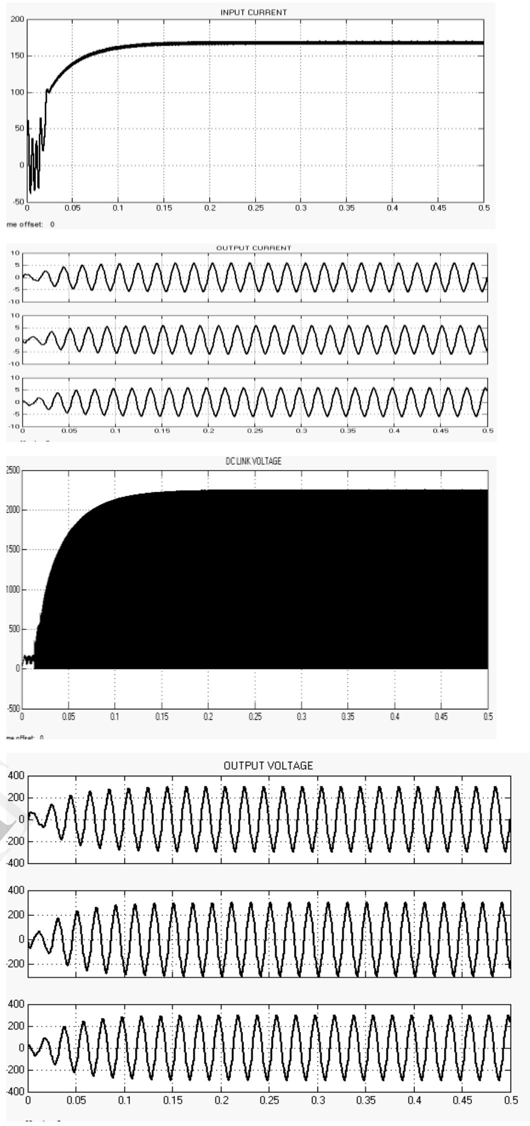


Fig13: Simulation results for boost operation when M=.86,-.86 From top to bottom: input current; output current; dc link voltage and output voltage.

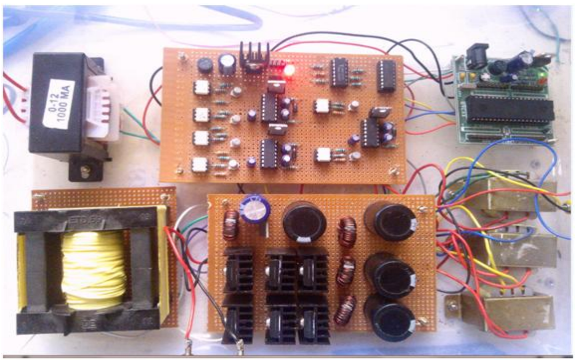


Fig.14 Complete hard ware diagram

The experimental setup consists of five basic circuits: Power circuit, Control circuit, Driver circuit, Z-source circuit and Output filter circuit.

Fig.15-20 shows the experimental results of the improved trans Z-Source inverter when the voltage is given as 12V.

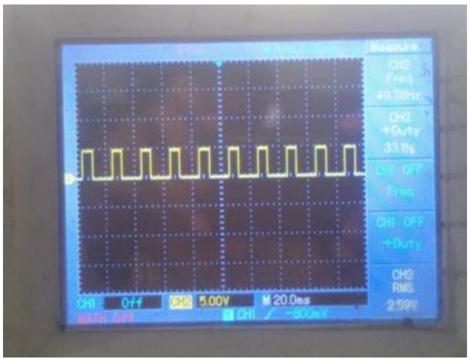


Fig.15 Micro controller output pulse (5V)

Fig.16 Microcontroller output $ NOT gate output (5V and inverted 5V)

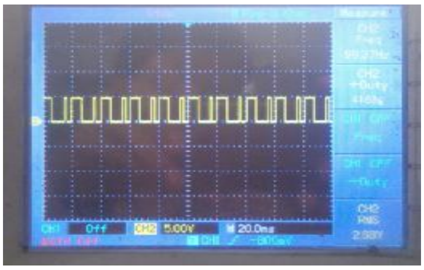


Fig.17 Microcontroller output pulse with shoot through(5V)

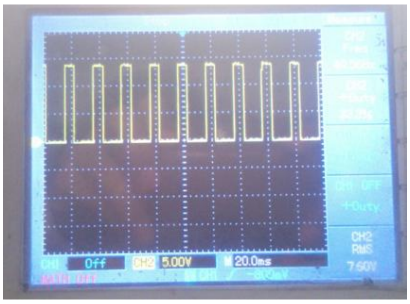


Fig.18 Output pulse of driver circuit with shoot through(12V)

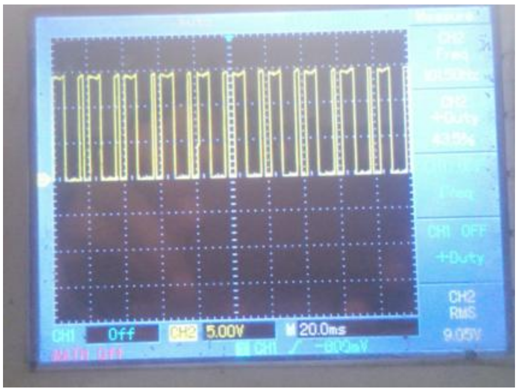


Fig.19 Output pulse of driver circuit with shoot through(12V)

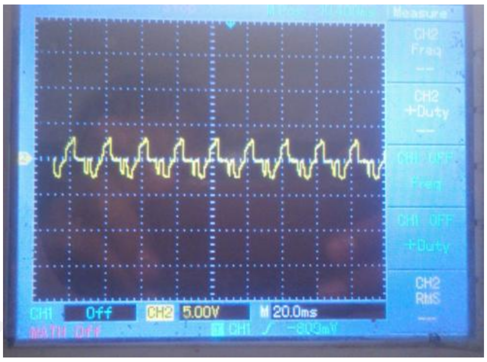


Fig.20 Output voltage waveform (32 V) for 12 V input

ACKNOWLEDGMENT

The tests are conducted at Power Electronics lab at Oxford College of Engineering. The authors would like to acknowledge the HOD, EEE department for providing the facilities to conduct the experiments.

CONCLUSION

A new topology was designed to improve the conventional quasi ZSI with the following characteristics such as high boost voltage, buck boost is possible by varying the shoot through interval and the input current is continuous. The simulation results for input voltage 100V DC, we obtain 150V AC output voltage for quasi ZSI, where as for improved Trans ZSI, it has gone up to 300V.

The experimental results for 12 V dc and 32 V dc verified the high step up conversion ability and the simulation and experimental results shows that the proposed inverter has high boost inversion ability with continuous input current .

REFERENCES

[1]. "Quasi Z-source Inverter for photovoltaic system connected to single phase AC grid" A. Yazdian Varjani, member IEEE, 2010 IEEE 1st Power electronic and drive systems and technologies conference.

[2]. "Switched inductor Z-source Inverter" Fang Lio Luo IEEE senior member, IEEE transactions on power electronics vol.25, No 8, august 2010.

[3]. "Low cost semi Z-source inverter for single phase photovoltaic systems" Dang Cao, student member IEEE, Shuai Yiang, student member , IEEE, IEEE transactions on power electronics, vol 26 No.12 December 2011.
[4]. "Performance evaluation of three phase induction motor drive fed from z-source inverter" Bindeshwar Singh , S.P. Singh, J. Singh, International journal on computer science and engineering vol 3, No 3 March 2011.
[5]. "Analysis of Quasi Z-source inverter under control strategies", V Saravanan, HOD EEE, International conference on computing and control engineering (12 & 13 April 2012).
[6]. "Power Control for a PV Generation System using a single phase Grid connected Quasi Z-Source Inverte"2011 IEEE,T.W Chun,H.H Lee,H.G Kim and E.C Nho,8th International Conference on Power Electronics –ECCE Asia.
[7]. "A Literature Survey on Z-Source Inverter ",Vrushali suresh Neve,P.H Zope and S.R Suralkar,VSRD International Journal of Electrical, Electronics and Communication Engineering ,Vol.2,No:11,Nov 2012.
[8]. "Design and Simulation of Quasi Z-Source Grid connected PV inverter with Battery Storage",Zulhani Rasan,2012 IEEE International Conference on Power and Energy, December 2012.
[9]. Modeling and novel modulation of enhanced Z-Source inverter, Yan bin Qu and Yang Zhang, P.R China, Journal of Computers,vol.8,No.1,Jan. 2013.
[10]. "Impedance Source Buck-Boost Converter for linear and Non-linear load using MATLAB simulation", Sudhir Ranjan,Sushma Gupta,International Journal of Chem Tech Research,Vol.5,No:2,pp 993-1002,April-June 2013.
[11]. "Quasi Z-source inverter based Induction Motor drive with voltage sags/swells mitigation",Nirmal Kumar Kushwaha,Mayank Kumar,2nd International Conference on advances in Electronics,Electrical and computer engineering-EEE 2013.
[12]. Wind power conversion based on Quasi Z-source Inverter ,T.Maitry,EEE Dept, 2013 IEEE.
[13]. Improved Trans Z-source with continuous input current and boost inversion capability. Minh-Khai Nguyen, Member, IEEE, Young-Cheol Lim, Member, IEEE, and Sung-Jun Park
[14]. "Z-Source Inverter", Fang Zheng Peng, Senior Member, IEEE, IEEE transactions on industry applications, Vol. 39, No. 2, March/April 2003.