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Implementation of Switched Inductor Based Quasi Z Source Inverter Using Embedded Controller

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ABSTRACT

High-efficient voltage source inverters are widely required in various industrial applications with reduced cost and more stable operation. Compared to the classical inverter, the proposed quasi switched inductor based inverter increases the voltage gain. Only a very small shoot-through zero state is required to obtain high voltage conversion ratios, which is advantageous for improving the output power level and quality. Due to the mutual limitation between the modulation index and shoot-through duty ratio of switched quasi - ZSI, constant capacitor voltage control method is proposed in a two-stage control method. Minimum switching stress on semi conductor devices can be achieved by choosing proper capacitor voltage reference. In addition, the voltage buck inversion ability is also provided in the proposed inverter for those applications that need low ac voltages. The circuit is implemented using PIC16F873A controller. This digital controller has more dynamic response and more accuracy compare than analog method. The proposed inverter has high voltage gain, low voltage stress and less harmonic compare than conventional inverter.

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INTRODUCTION

Now a day's high-performance voltage- and current-source inverters (VSI and CSI) (C. Yang, *et al*., 2008; T. Kerekes, *et al*., 2009) are widely required in various industrial applications with reduced cost and more stable operation. However, the conventional VSI and CSI have been seriously restricted due to their narrow obtainable output voltage range, shoot-through problems caused by mis-gating, more harmonics and some other theoretical difficulties due to their bridge-type topology. After 2000, the topology of the Z-source inverter (F. Z. Peng, 2002) was proposed to overcome the problems in the voltage source inverters in which the functions of the traditional dc–dc boost converter and the bridge-type inverter have been successfully combined.

As a research development in power electronics, the Z-source topology has been greatly explored from various aspects (F. Z. Peng, *et al*., 2005; M. Shen, *et al*., 2007) , but the related research on its improvement techniques of boost inversion ability and impedance network are seldom reported in open literatures. With a pair of inductor and capacitor combination coupling the inverter main circuit to the dc source, the conventional ZSI achieves voltage buck/boost in one stage, without introducing more components. (M.-S. Shen, *et al*., 2007) Shoot-through state enables energy to be stored in inductors and capacitor, which is released when at non-shoot-through state, followed by the voltage boost properties. For the conventional type ZSI (abbreviated as ZSI), voltage boost methods based on pulse width modulation (PWM) have been first investigated in different categories as simple boost, maximum boost control, and maximum constant boost control method (M.-S. Shen, *et al*., 2007; P. C. Loh, *et al*., 2009). Because of its single-stage voltage buck/boost features, the ZSI can deal with input voltage variations in a wide range, which is traditionally achieved by a two-stage dc–dc converter cascaded by dc–ac topology (T. Kerekes, *et al*., 2009; F. Z. Peng, *et al*., 2005; M.-S. Shen, *et al*., 2007; P. C. Loh, *et al*., 2009). With the economical advantages and improved stability due to the allowance of shoot-through state, The conventional ZSI gains increasing attention and was presented for use in several applications, such as uninterruptible power supply, variable speed control drives, Hybrid electric vehicles, PV or wind power conversion, and electronic loads(J. B. Liu, *et al*., 2007; Y. Tang, *et*

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al., 2007) . Different ZSI inverters are proposed in different application and different period (T. Kerekes, *et al*., 2009; Y. Tang, *et al*., 2009) . In this paper proposed a new topology to achieve high gain the voltage boost /buck using switched impedance network. This proposed inverter is called as quasi switched inductor based inverter. The proposed inverter has more reliability and high performance compare than other ZSI inverter (Shines T.S, *et al*., 2014).

Topology Analysis of Sl Quasi Z-Source Inverter:

As illustrated in Fig.1, the proposed SL quasi impedance source inverter consists of three inductors (*L*1, *L*2, and *L3*), two capacitors (*C*1 and *C*2), and four diodes (*D*1, *D2*, *D3* and *D4*).

The combination of *L*1–*L*3–*D*1–*D2*–*D3* performs the function of the SL cell This SL cells are used to store and transfer the energy from the capacitors to the dc bus under the switching action of the main circuit.

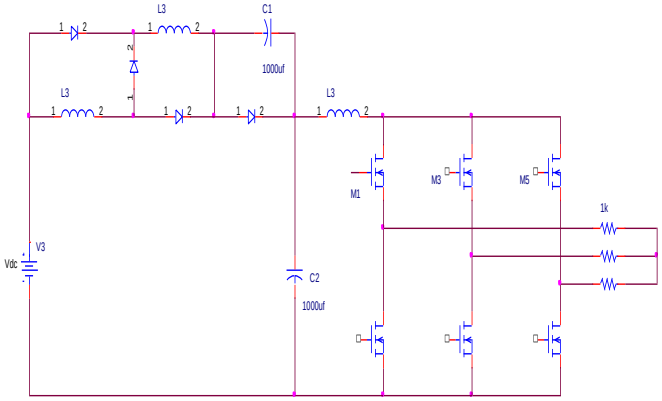

Fig. 1: Proposed Circuit Diagram.

a. Operation Principles:

The operation principles of the proposed impedance network are similar to the classical Z-source impedance network. For the convenience of analysis, the equivalent circuit of the proposed switched impedance network viewed from the dc bus is shown in Fig. This circuit has totally eight modes of operation. Two modes relevant to shoot through condition and another six modes are normal inverter operation. Shoot through states is classified into non shoot through and shoot through modes.

1) Shoot-Through State:

During this sub state, *S* is ON (in same leg top and bottom switch is ON), while both *D*3 and *D5* are OFF. For the SL cell, *D*1 and *D*2 are ON, and *D*3 is OFF. *L*1 and *L*3 are charged by *Dc source*. This state corresponds to the additional zero state produced by the shoot-through actions of the top and bottom arms, and its equivalent circuit is shown in Fig. It is seen that SL cells perform the same function to absorb the energy stored in the capacitors. The capacitors C2 transfer their electrostatic energy to magnetic energy stored in the inductors L2.

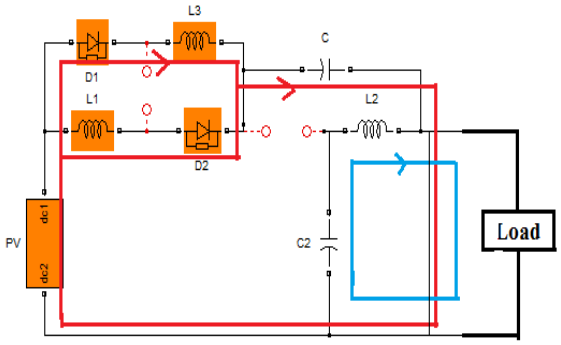

Fig. 2: Shoot through state.

2) Non-Shoot-Through State:

This state corresponds to the six active states and two zero states of the main circuit and the equivalent circuit is shown in Fig. During this sub state, *S* is OFF, while both *D*3 and *D5* are ON. For SL cell, *D*1 and *D2* are OFF. *L*1 and *L3* are connected in series, and the stored energy is transferred to the main circuit. The dc power source, as well as the inductors, charges the capacitors C2 and powers to the ac load, boosting the dc voltage across the inverter bridge.

B. 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. During normal operation of the inverter ,at any instant two device in same leg does not conduct.But in proposed Z source inverter this operation is possible.This operation is called as shoot through mode.This pulse pattern as shown in the figure 4 and fig 5.

Hardware Implementation:

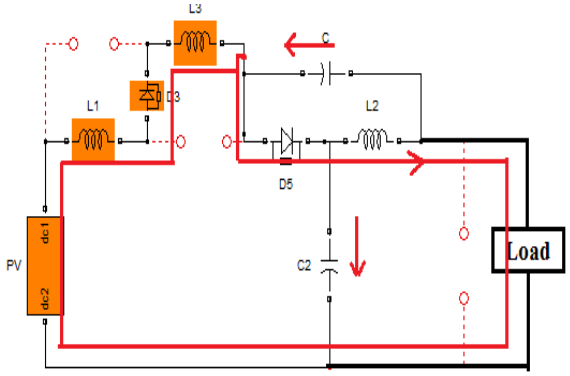

Fig. 3: Non-shoot through state.

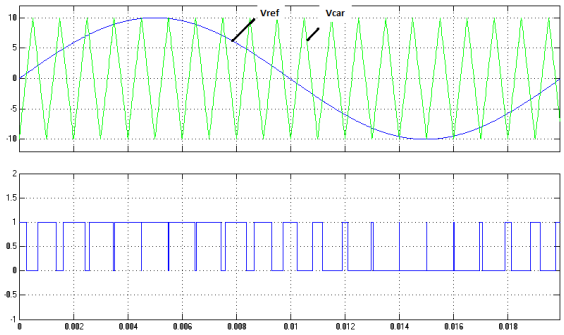

Fig. 4: Sine Pwm Generation Method and Pulse Pattern.

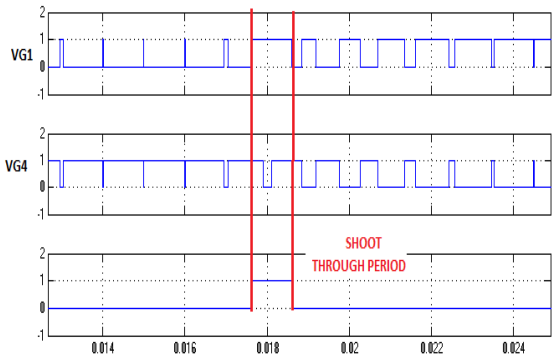

Fig. 5: Shoot through pulse pattern for switch s1 and s4.

Fig 6 shows the QUASI z-source inverter block diagram. Fig 7 shows the layout of the system It consists of DC source, impedance network, three phase inverter and load.

PIC16F873A pic controller is used to generate triggering pulse for switches. This controller has fast response inbuilt ADC and PWM generator.The impedance network is used to boost the voltage as well as to protect the circuit during short circuit condition (shoot through mode). Fig 9 shows the triggering pulses for switches S3 and S6. Fig. 8 shows triggering pulses for switches S1 and S4 with shoot through. Fig. 10 and Fig. 11 shows the inverter phase and line voltage. Fig 12 shows the overall control circuit.

Comparative Analysis:

The proposed circuit has high performance compare than conventional circuit. It is verified from graph as shown in Fig 13 and Fig14. The proposed circuit has high voltage gain and less THD compared than conventional system.

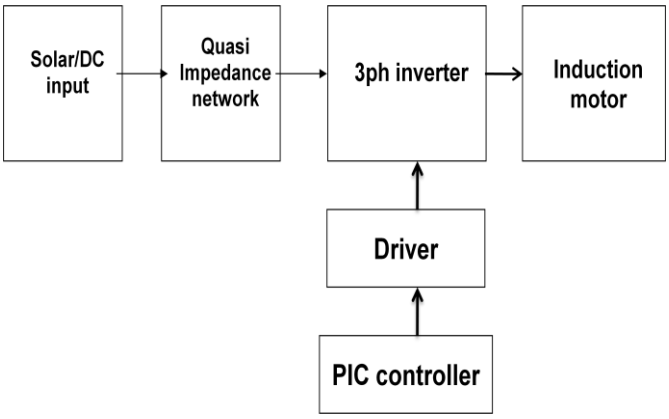

Fig. 6: Block diagram of proposed circuit.

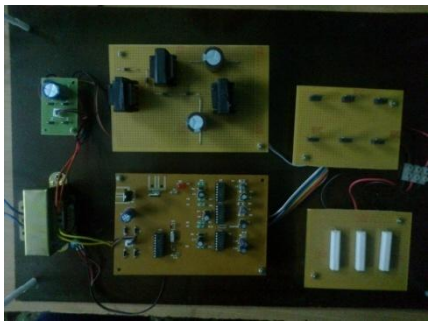

Fig. 7: Hardware implementation circuit of QUASI Z-source Inverter.

Fig. 8: Shows the triggering pulses for switches S1 and S4 with shoot through.

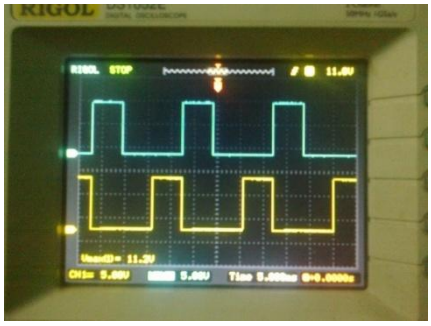

Fig. 9: Shows the triggering pulses for switches S3 and S6.

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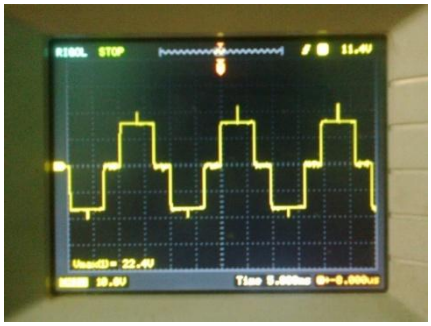

Fig. 10: Inverter phase output voltage.

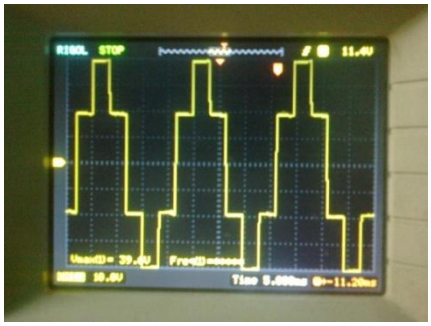

Fig. 11: Inverter Phase to phase voltage.

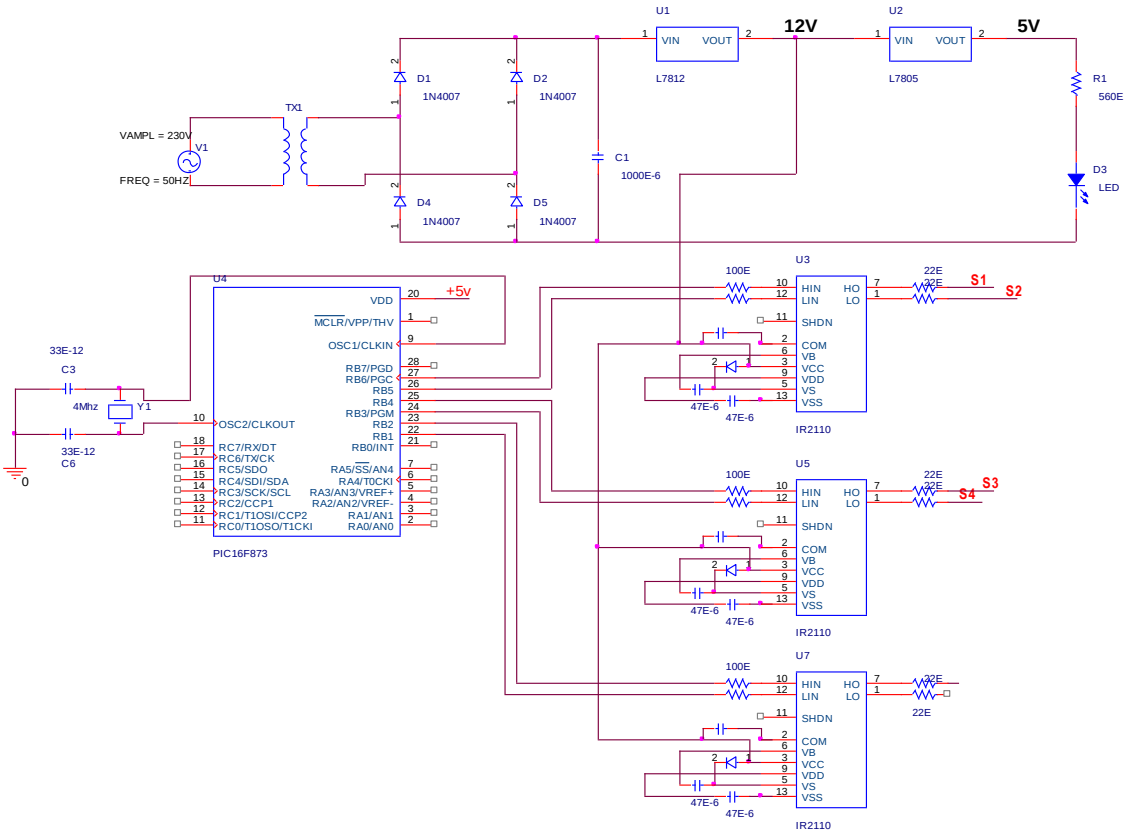

Fig. 12: Overall control circuit diagrams.

Conclusion:

This paper has presented a novel switched inductor based quasi inverter with PWM technique, which exhibits several merits. The proposed system is implemented using PIC16F873A controller. It has fast dynamic response compare than other analog controller.

The switched inductor cell is used to store and transfer the energy from source to the load as a result it increase the voltage gain of the inverter. During Shoot through state the high current is stored in inductor and capacitor as a result to avoid the short circuit and protect the switching devices. Waveform distortion of the ac output voltage caused by dead time is essentially avoided. Thus the proposed inverter has high voltage gain, less capacitor rating and less harmonics compare than conventional inverter.

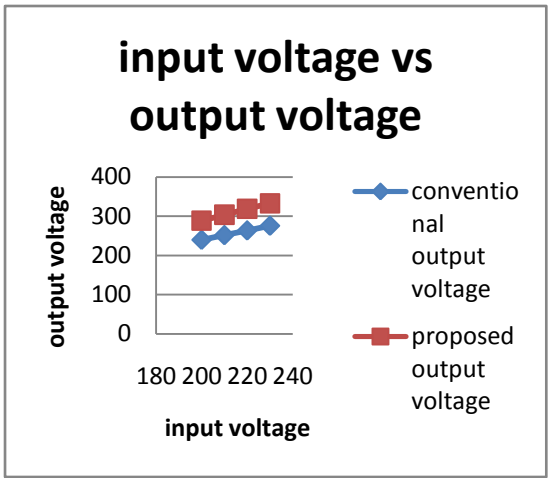

Fig. 13: Graphs between input voltage and output voltage.

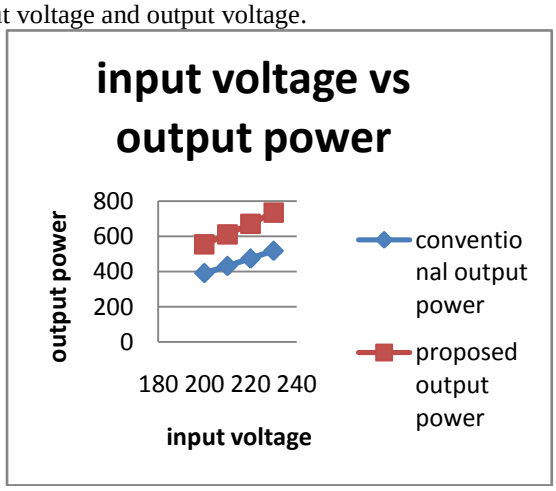

Fig. 14: Graphs between input voltage and output power.

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