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Performance Comparison of Switched Inductor Based Quasi Impedance Source Inverter with Current Source Switched Boost Quasi Impedance Source Inverter

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Abstract: This paper presents the comparison of switched inductor based quasi impedance source inverter (SLq-ZSI) with boost switched based quasi impedance inverter (bsqZSI). Mainly this type of inverter is used for interfacing low voltage dc to high voltage ac conversion applications for reducing converter stages and components count. The bsqZSI has additional switch for controlling the input power flow through inductor. The bsqZSI inverter is used for further reduction of components count. The sqZSI has less input current ripple, less THD and improve the dc voltage gain with help of switched inductor and shoot through condition. The sine PWM technique is used to control the inverter output voltage and harmonics. The proposed inverter operation is explained in detail. The circuit is simulated using MATLAB simu-link.

Index Terms: Switched inductor based quasi ZSI, voltage gain, current harmonics and THD

1. INTRODUCTION

The increasing demand on the global energy supply has resulted in greater interest in renewable energy resources. As a result, usage of renewable energy resources increased very rapidly for distributed power generation (DG) systems. The distributed power generation (DG) system generates variable voltage. It affects the system stability. Mostly, a boost-type dc–dc converter is included in the DG units to step up the dc voltage. This chopper produce high voltage gain with large duty cycle .It makes many problems such as diode reverse recovery problem, more voltage stress and reducing the life time of capacitor in the boost converter section. In VSI side it is not possible for shoot through operation with boost combination. This type of conversion increases the stages and complexity.

Impedance-source (IS) inverters are an emerging technology of single-stage buck-boost electric energy conversion for renewable energy sources applications. [1]. The quasi-Z-source inverter (qZSI) was developed from basic ZSI by rearrangement of the input source components to achieve continuous input current and lower voltage stress [2],[3]. This inverter provides buck operation by controlling the modulation index and boost operation in the shoot-through state. The switched-boost inverter (SBI) was proposed in [4] as a simpler alternative to the ZSI that contains less components compare than ZSI. But this inverter has discontinuous input current and lower dc voltage gain compared than ZSI/qZSI. The quasi-switched-boost inverter (qSBI) is an improved version of SBI [5]. The qSBI provides continuous input current and the same dc voltage gain comparable than SBI. The qSBI has more voltage gain and less parasitic losses with minimum passive components compared than the qZSI [6].In general, energy requirement with wide voltage variations like solar photovoltaic, wind, non-isolated inverters with high dc voltage gain are required for stable operation of grid injection.

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The boost inverters allow utilization of low voltage level and thus increase the energy level in unfavorable climatic conditions. DC voltage gain can be improved using the following methods such as IS network can be cascaded to enhance dc voltage gain [7], coupled inductors can be used to derive a new IS network with higher dc voltage gain [8]-[13] and switched-inductor and switched-capacitor cells implemented in IS network in [14]. From the all methods there are some problems such as requiring additional passive components, duty cycle loss caused by leakage inductance of a coupled inductor etc.

The switched-inductor cell network (SL) is used most extensively for dc voltage gain enhancement. The switched-inductor cell network (SL) is included with SBI in [15] to improve the voltage gain. The proposed qsZSI has more voltage gain due to SL network. For interfacing low voltage to high voltage applications the proposed inverter is more suitable comparable than other ZSI inverters. The proposed method has high voltage gain, low input ripple current and less no. of components count. The operation and simulation result of proposed inverter is discussed in next section.

2. CURRENT SOURCE SWITCHED INDUCTOR BASED BOOST QUASI IMPEDANCE SOURCE INVERTER

Figure 1 shows the circuit diagram of current source switched inductor based boost quasi impedance source inverter. This inverter has three modes of operation such as one Shoot Through Mode and two Active Modes.

2.1. Shoot Through state

Equivalent circuit for this state is shown in Fig. 1*a*. Both switches are turned on in the same leg. The output of the active impedance network is short-circuited with the switch *Spn*. The input source *voltage and* the

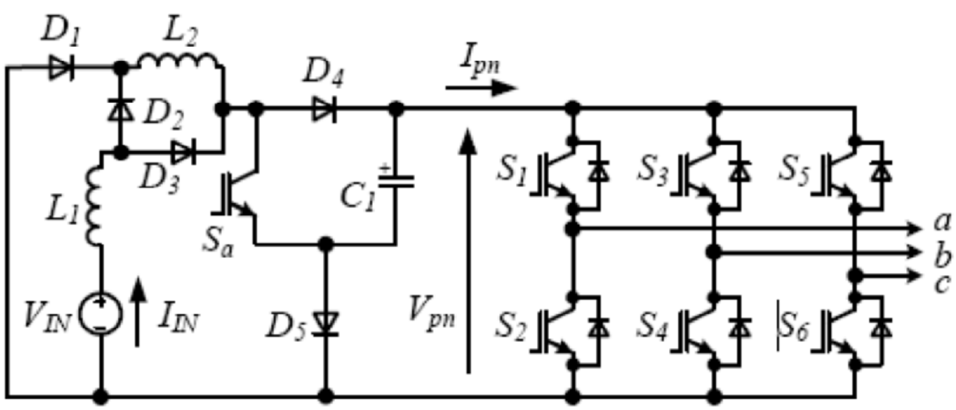

Figure 1: Current source SL-qSBI

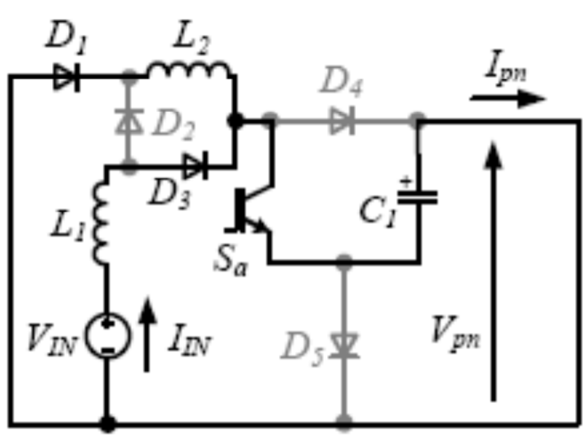

Figure 1a: Shoot through state *SS*

capacitor *C1* charge inductors *L1*, *L2*. In this circuit inductor current *IL1* reaches higher value than the current *IL2*, considering that *L1* = *L2*. The capacitor *C1* is discharging with current *(IL1* + *IL2)* during this interval. The switched inductors accumulate energy to be released during the active state. The duration of this interval is *DS·T*, where *DS* is the shoot-through duty cycle.

2.2. First Active state *A1*

During this time interval, the inductors L1 and L2 start to release energy to the load. An equivalent circuit for first active state is shown in Fig. 1*b*. A process of current equalizing of the switched inductors defines this interval, which ends when currents of the SL inductors are equal. The diode *D3* is conducts the surplus current *(IL1-IL2)*. Hence, zero voltage is applied to the inductor *L2* and thus its current *IL2* is constant, while the current *IL1* is decreasing. The switched inductor supplies the load current and charges the capacitor *C1* simultaneously. The duration of this interval is *DA1·T*.

2.3. Second Active state *A2*

During this time interval the SL inductors continue releasing energy to the load. Equivalent circuit for second active state *A2* is shown in Fig. 1*c*. This interval ends at the end of the period, i. e. *DA2* = *(1-DS-DA1)*. The diode *D3* stops conducting because the currents of the SL inductors are equal: *IL1* = *IL2*. These currents are decreasing with the same slope. The switched inductor continues supplying the load current and charging the capacitor *C1* simultaneously.

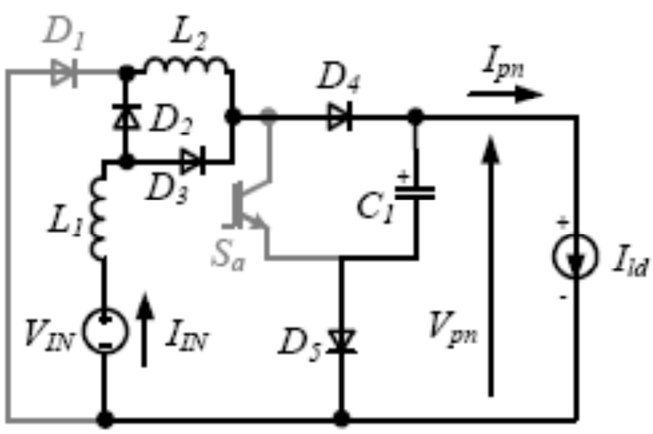

Figure 1(b): first active state *A1*

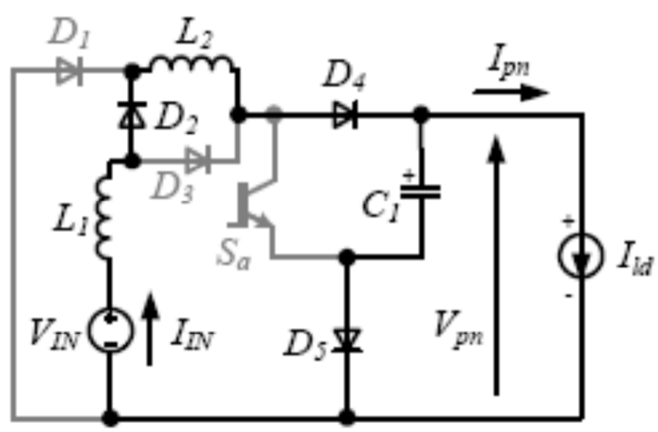

Figure 1 (c): Second active state ***A2*.**

3. SWITCHED INDUCTOR BASED QUASI Z-SOURCE INVERTER

As illustrated in Fig. 2, the proposed SL quasi impedance source inverter consists of three inductors (*L*1, *L*2, and *L*3), 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

3.1. Operation Principles

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.

3.1.1. 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

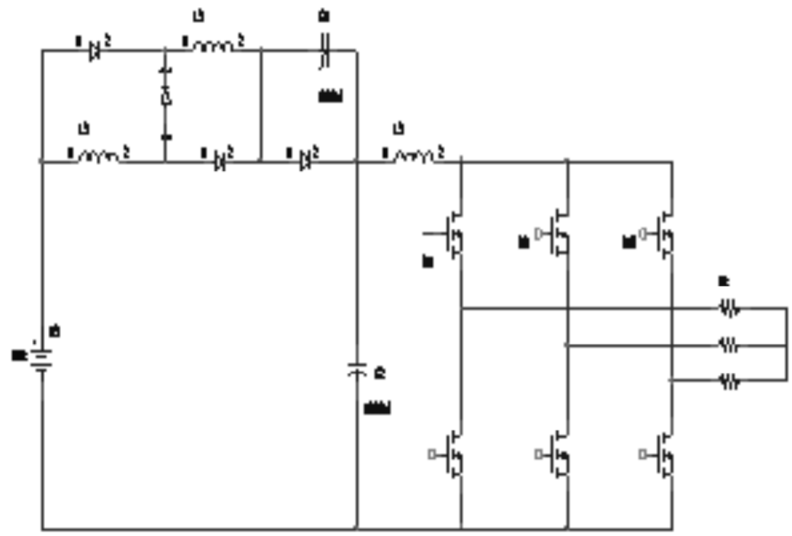

Figure 2: Switched inductor based quasi z-source inverter

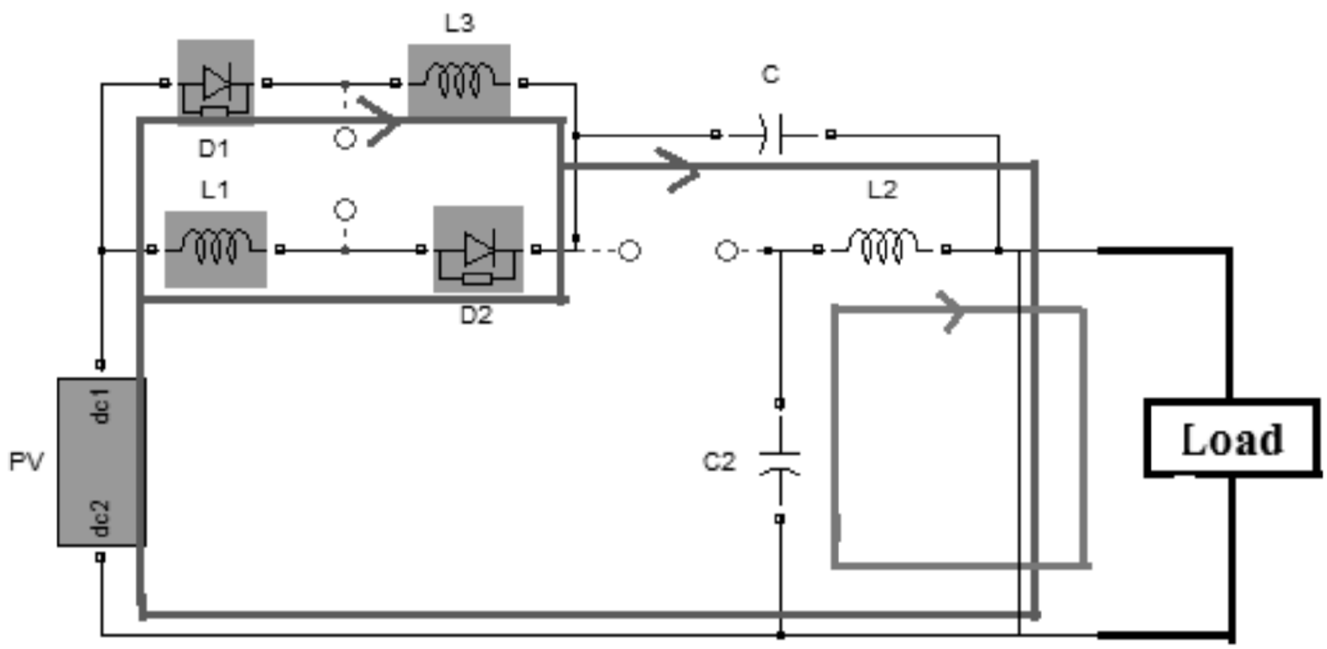

Figure 2a: Shoot Through state

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.2a. 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.

3.1.2. 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.2b. 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. Fig 2c shows the pulse pattern for shoot through condition.

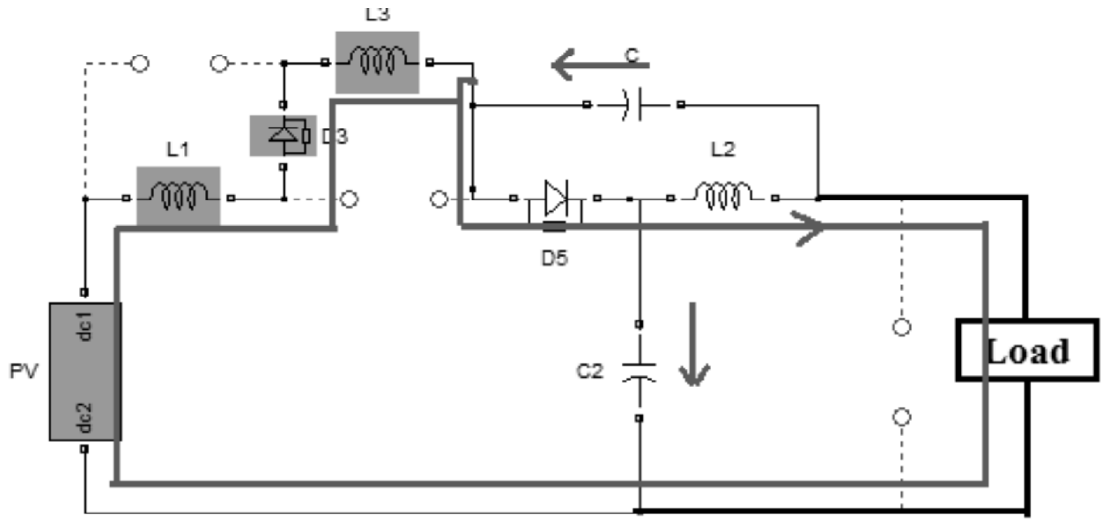

Figure 2b: Non-shoot Through state

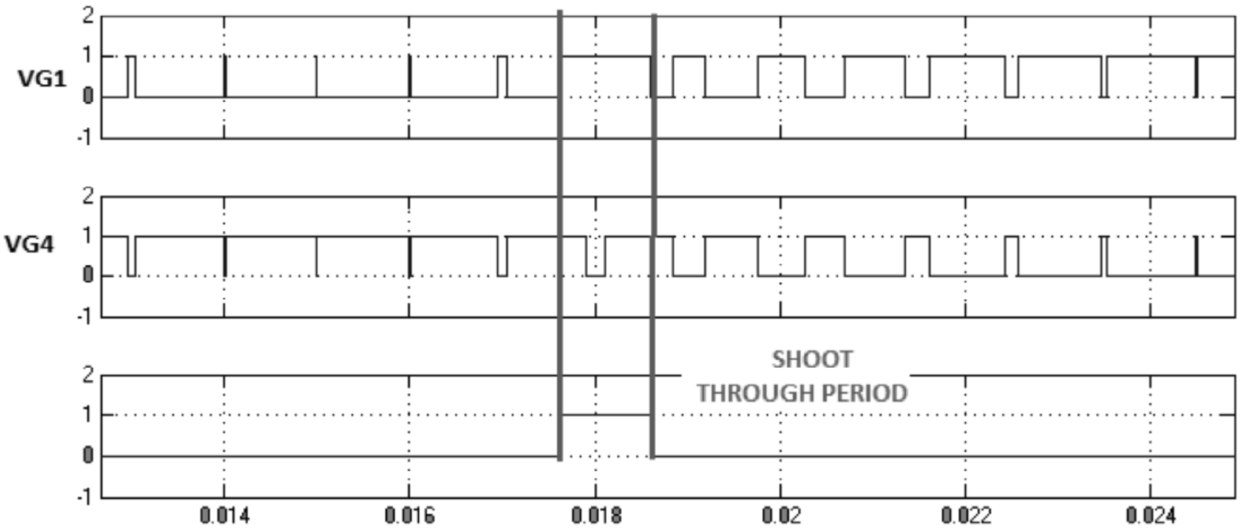

Figure 2c: Shoot through pulse pattern for switch s1 and s4

4. SIMULATION RESULTS

Fig 3 shows the boost converter based quasi impedance source inverter circuit diagram. It consists of current source, impedance network, boost switch and inverter. In this circuit the input supply voltage is 100v is amplified to 200v with help of impedance source as shown in fig 4. Fig 5 and Fig 6 shows the inverter line and phase voltage respectively. This voltage has voltage spikes due to shoot through operation. Fig 7 shows the inverter current waveform. It also contains more distortion.

Fig 8 shows the switched inductor based quasi impedance source inverter circuit diagram. It consists of switched inductor network, quasi impedance and inverter. In this circuit the input supply voltage is 100v is amplified to 240v with help of impedance source as shown in fig 9. Fig 10 and Fig 11 shows the inverter line and phase voltage respectively. Fig 12 shows the inverter current waveform. It contains less current distortion.

4.1. Comparative analysis

Table 1 shows the performance comparison of above two ZSI inverters. From these two circuits, the switched inductor based ZSI has better performance comparable than boost ZSI. It is proved from the simulation

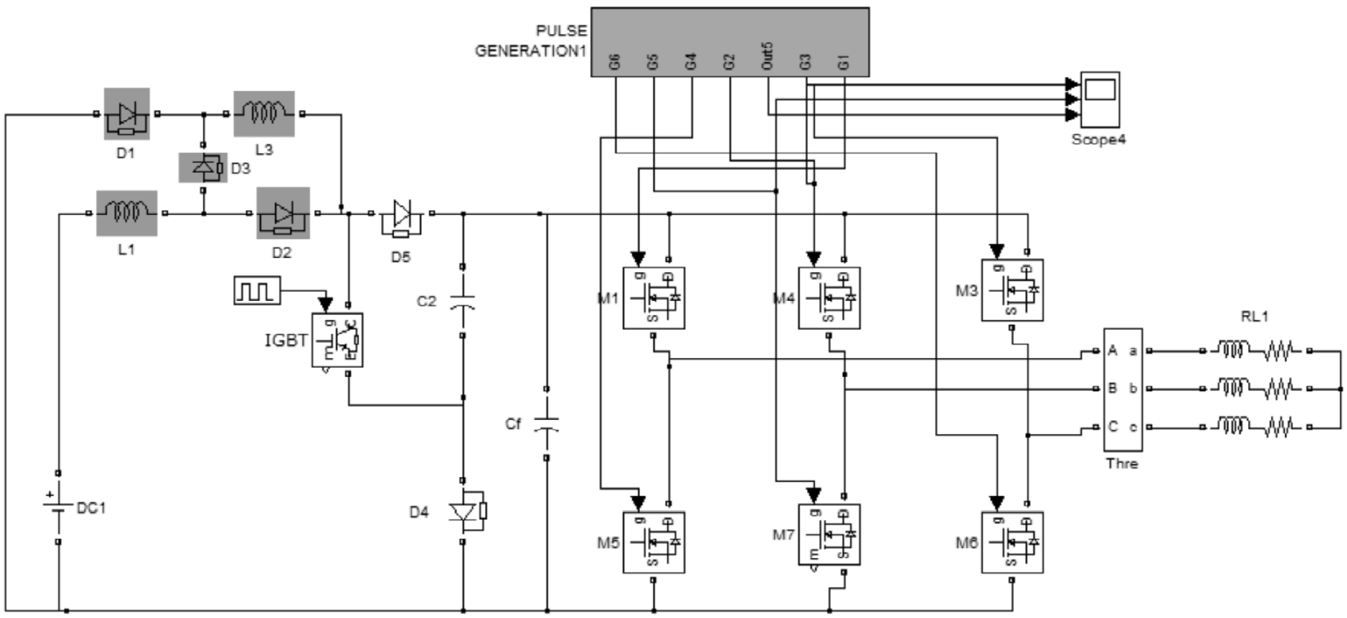

Figure 3: Boost switched inductor based quasi z-source inverter

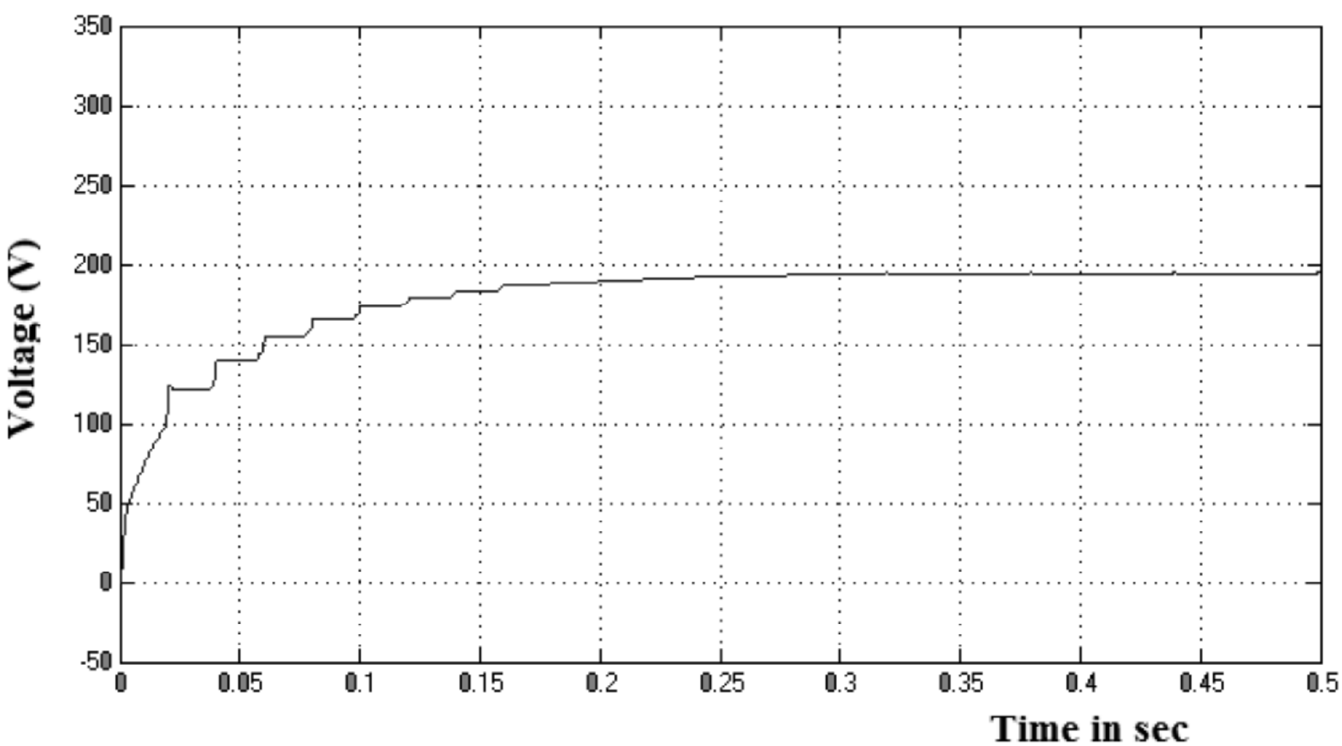

Figure 4: Dc link VOLTAGE

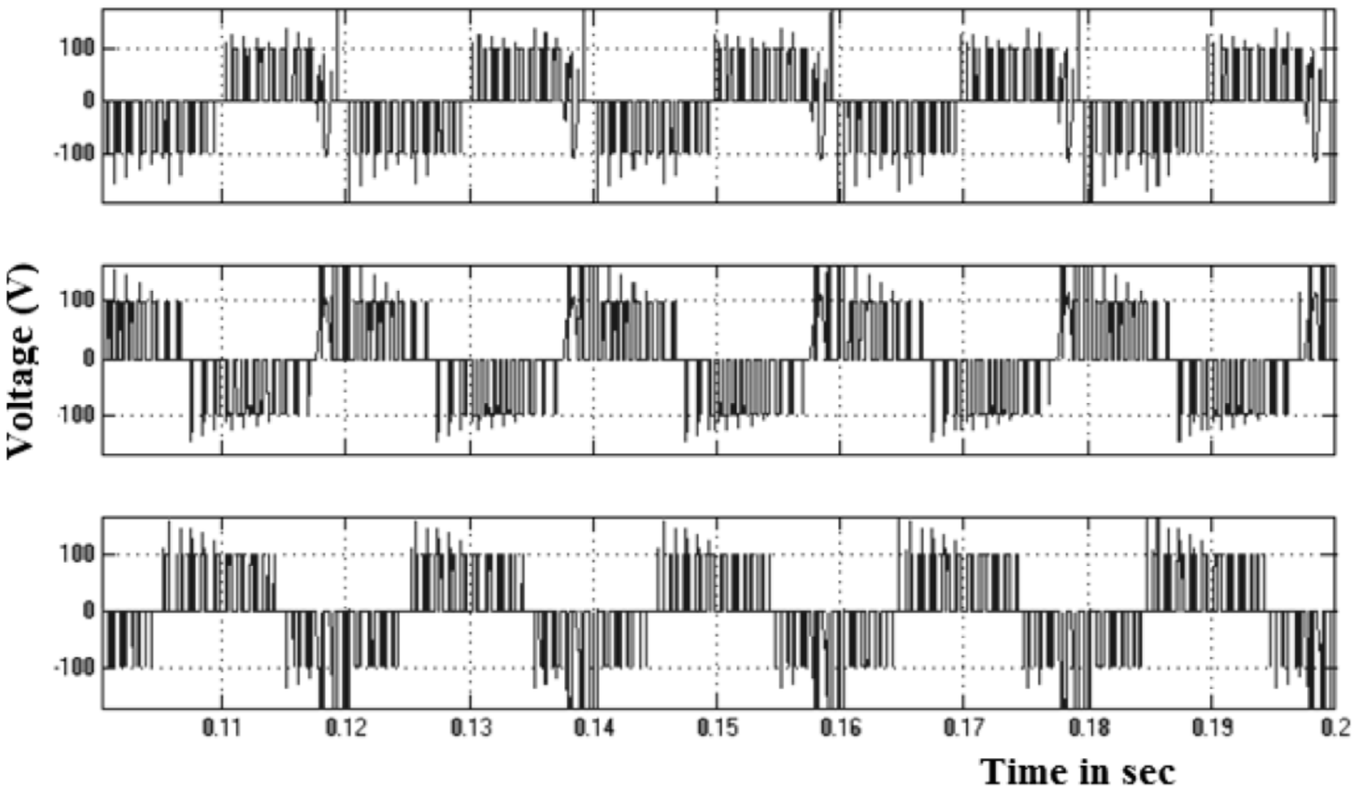

Figure 5: inverter line voltages

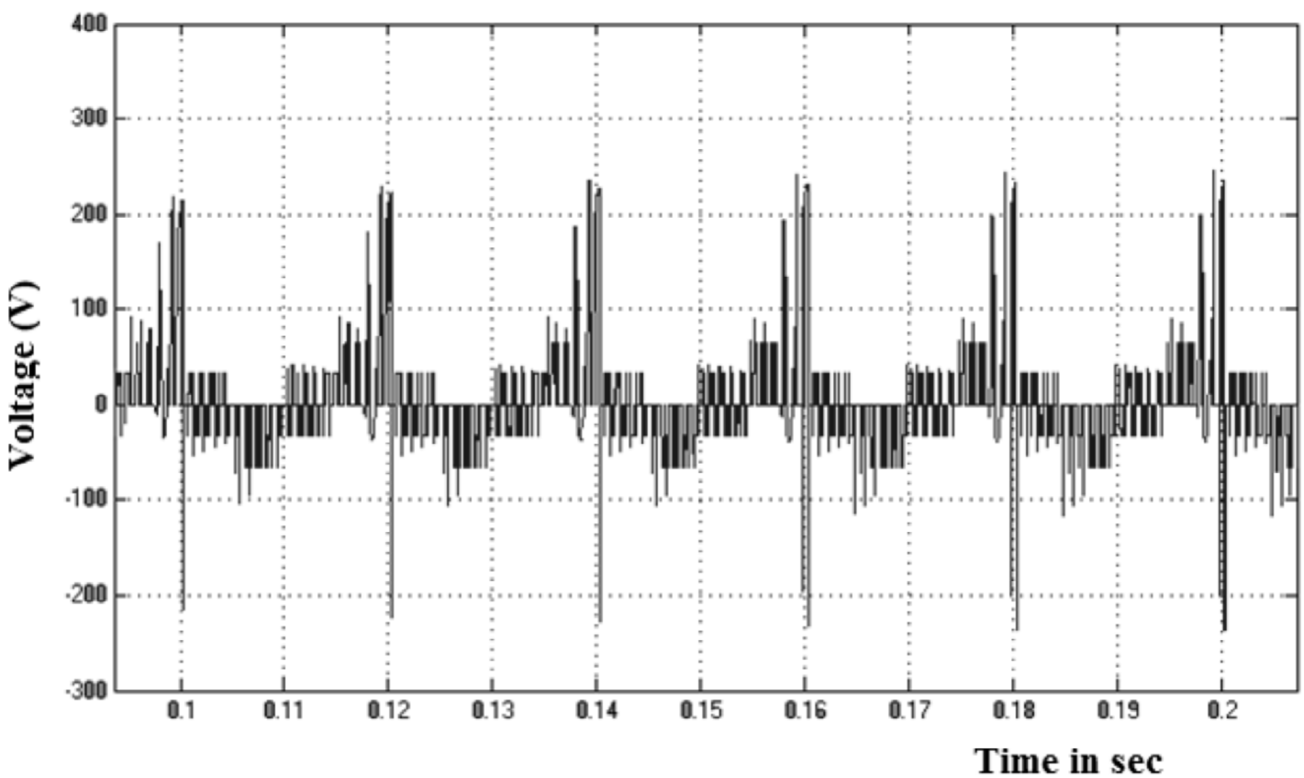

Figure 6: inverter phase voltage

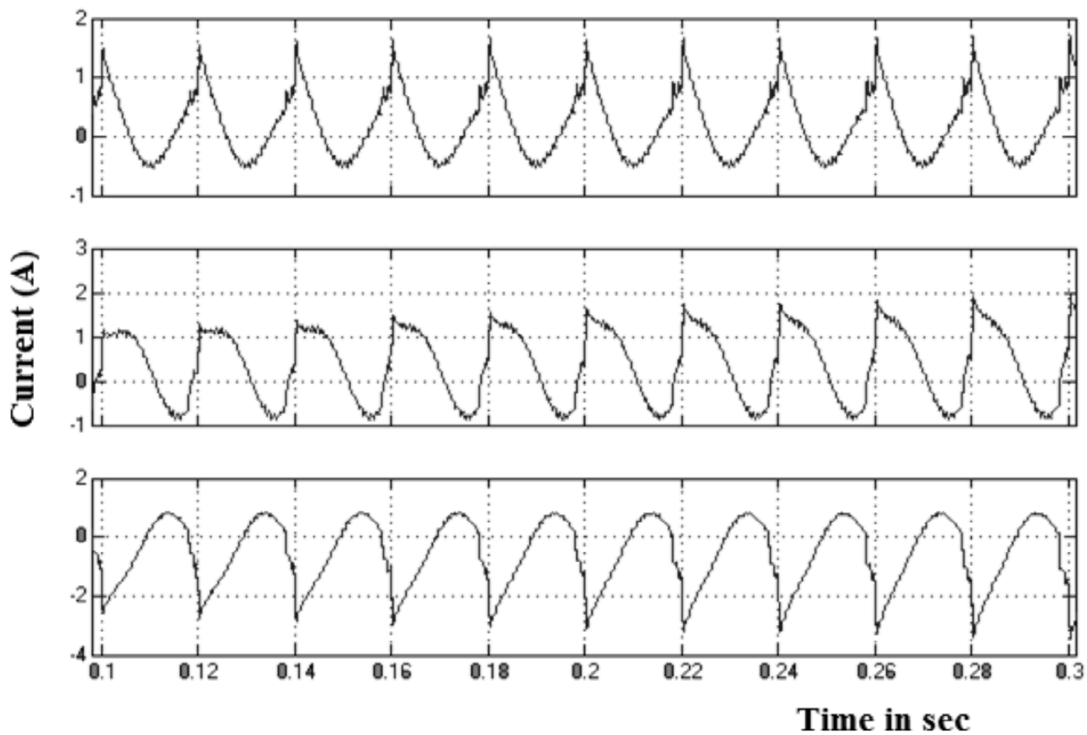

Figure 7: inverter phase current

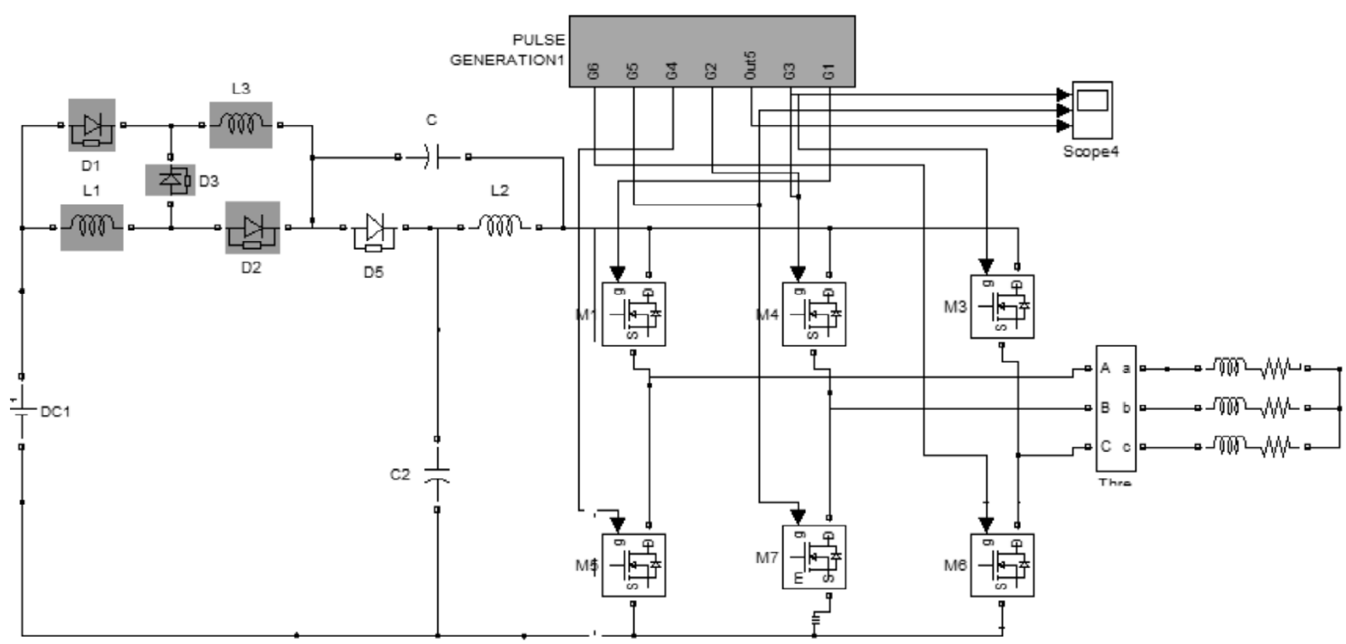

Figure 8: Boost switched inductor based quasi z-source inverter

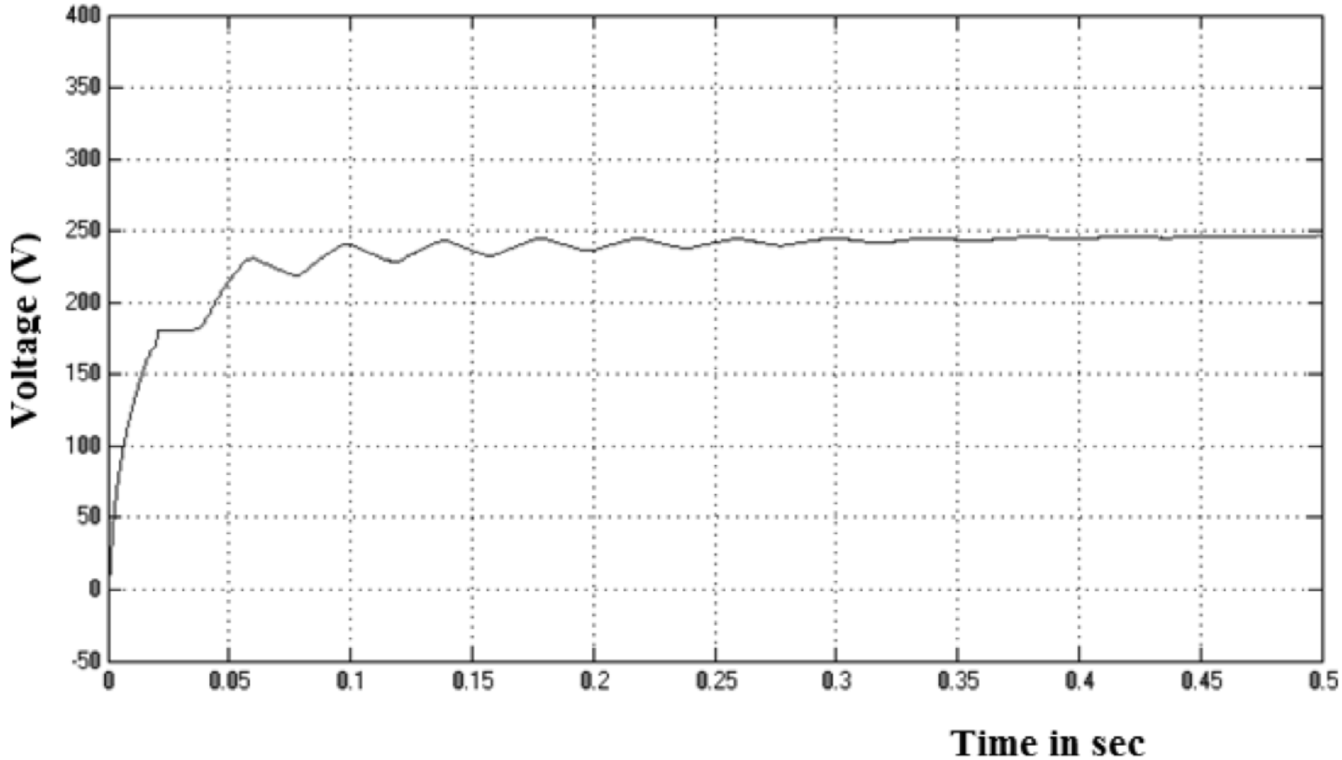

Figure 9: DC link voltage

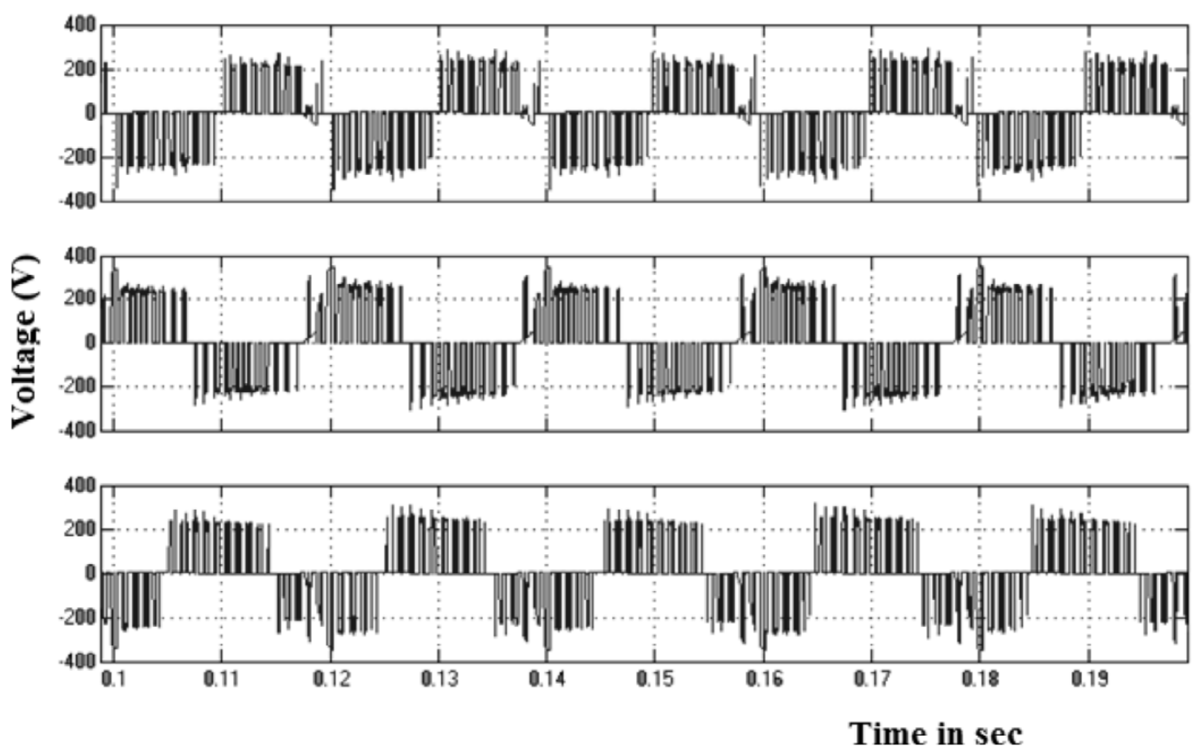

Figure 10: inverter line voltages

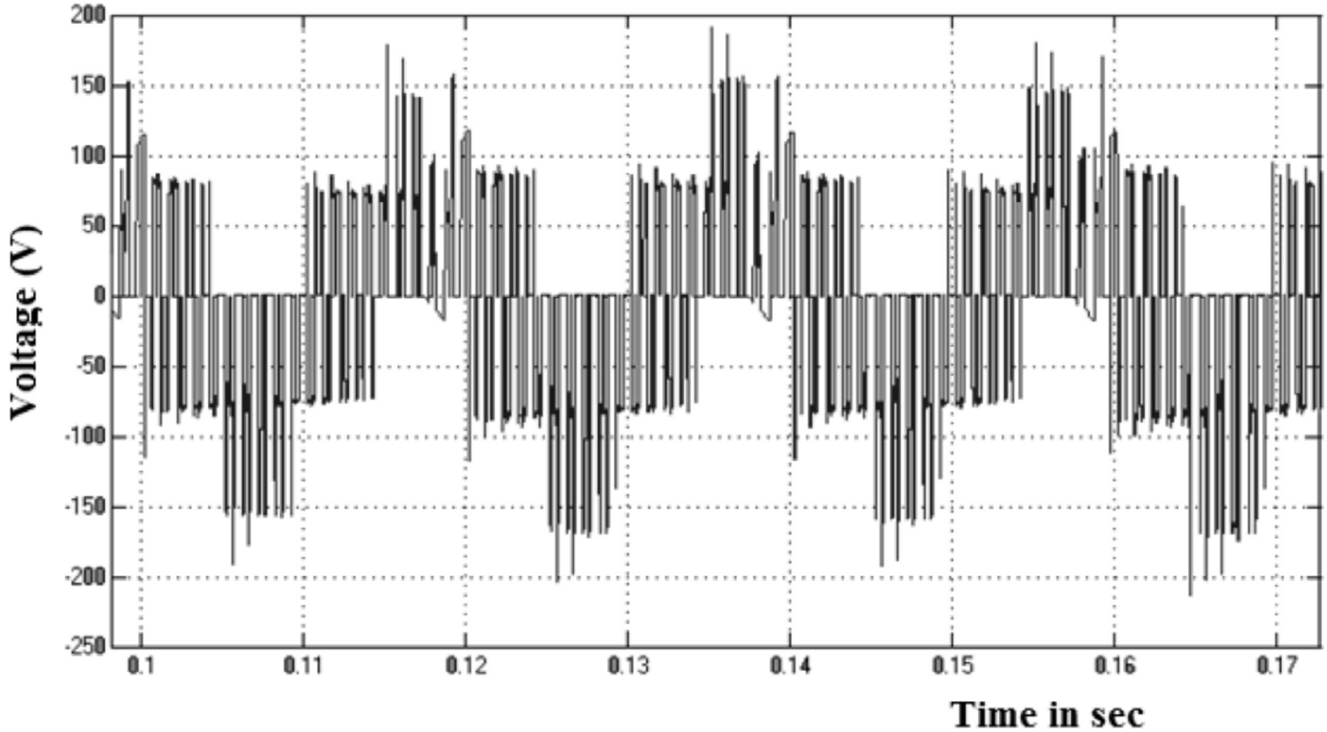

Figure 11: inverter phase voltage

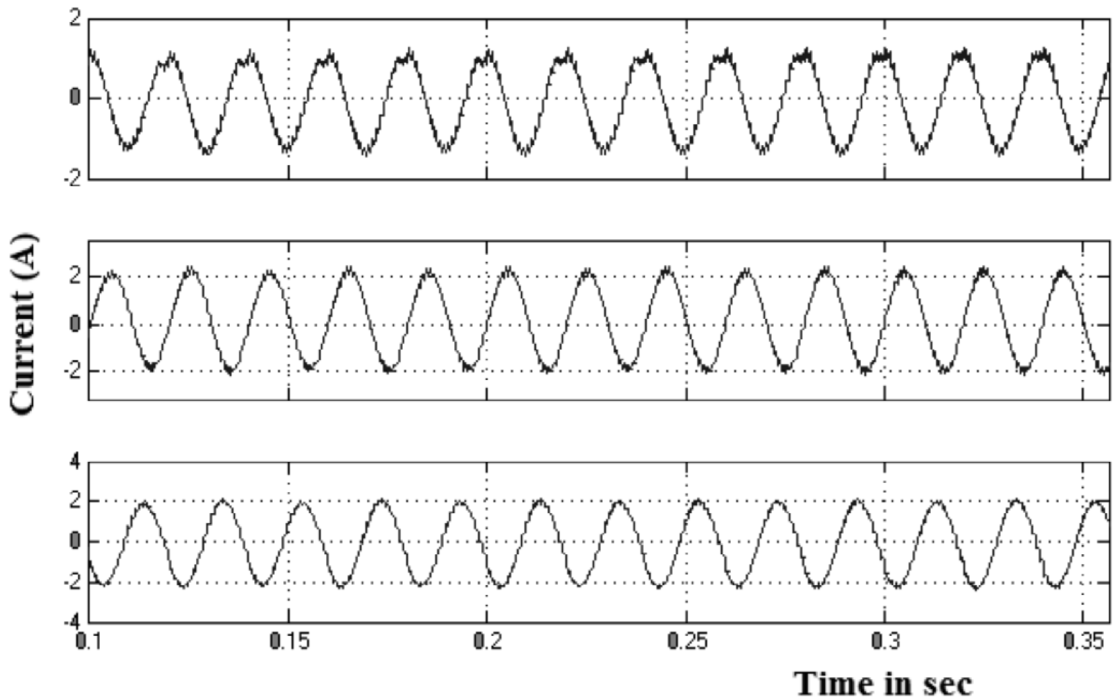

Figure 12: inverter phase current

result and table 1. The switched inductor based SLq-ZSI has less THD compare than bq-ZSI. It is shown from fig 14 and 13

5. CONCLUSION

This paper presents the comparison of switched inductor based quasi impedance source inverter (SLq-ZSI) with boost switched based quasi impedance inverter (bsq-ZSI). Both circuits are simulated using MATLAB

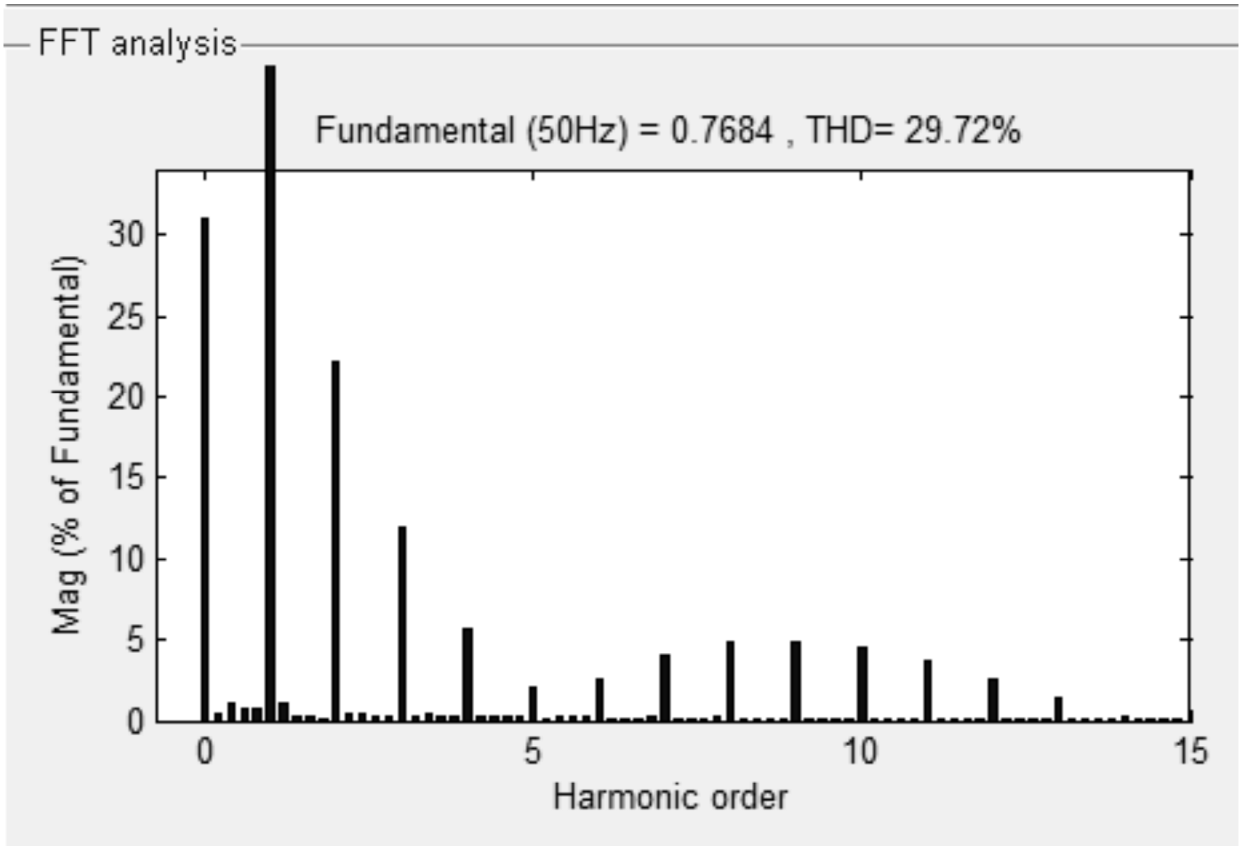

Figure 13: FFT analyses for current (bq-ZSI)

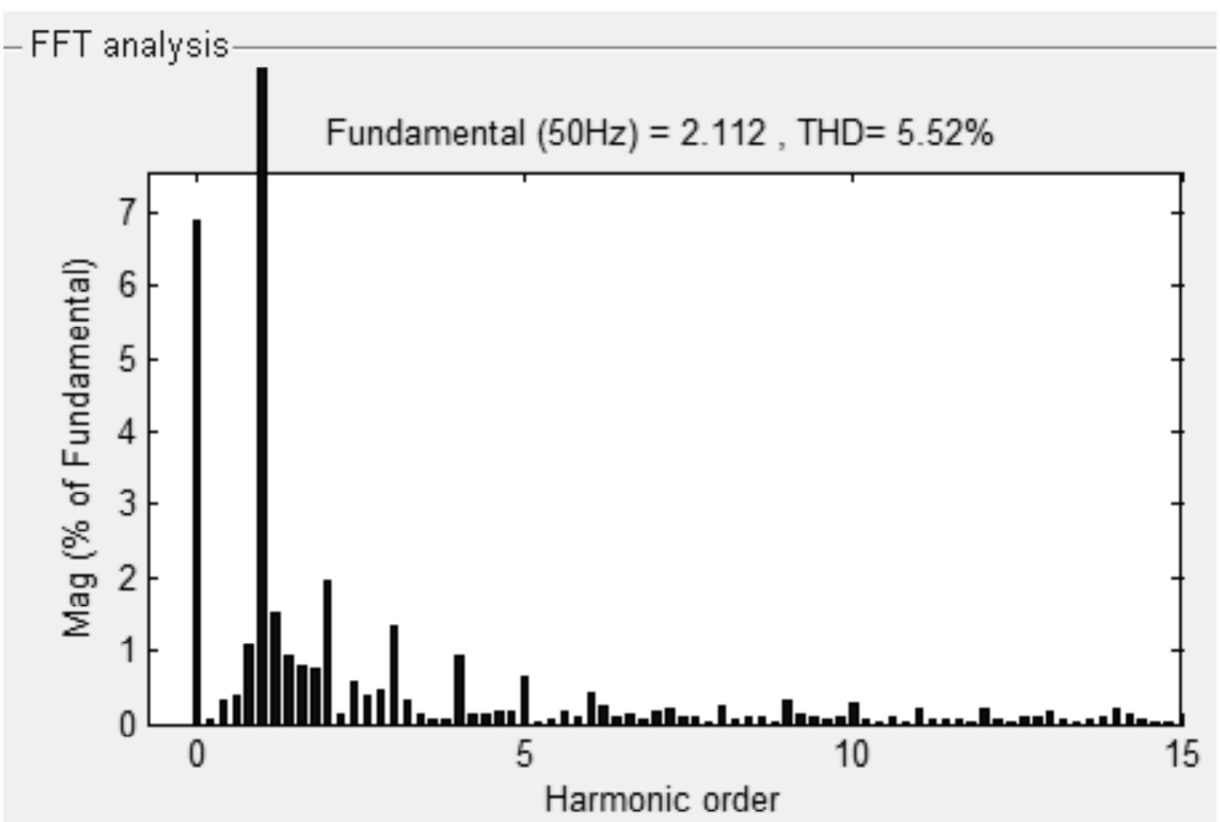

Figure 14: FFT analyses for current (SLq-ZSI)

Table 1

Parameters	*SL-qZSI*	*Sq-ZSI*
Input dc voltage	100V	100V
Impedance network output voltage(RMS)	246V	195V
Output current(RMS)	0.904A	0.62A
Phase voltage(RMS)	73	57
Line voltage(RMS)	136	71
THD%	5.52	29.72
inductor	0.5mH	0.5mH
capacitor	1000uf	1000uf

simu-link. The circuit performances are compared from the simulation results. From the result the SLq-ZSI has high voltage gain, less THD and balanced output current compared than bsq-ZSI. The SLq-ZSI do not need boost switch also. From this result the SLq-ZSI is most suitable for low voltage dc to high voltage conversion.

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