SIMULATION FOR Z SOURCE INVERTER WITH DIFFERENT CONTROL TECHNIQUES

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Abstract – *Today, efficient power conversion is more important than before because of the alternative energy sources like solar energy, wind energy, fuel cells and ocean wave energy that requires proper power conditioning to adapt to different loads. Also hybrid vehicles are very promising new application of power converters. Moreover, the area of electric drives still is demanding new topologies in order to find more efficient and cheaper ways of converting the form of energy from electrical to mechanical or vice versa. Since clean, reliable and high quality energy is one of the main concerns in today's world, power electronics will definitely play an important role in filling this gap. uninterruptable power supplies, used in AC motor control, grid connected PV system etc. There are two types of traditional inverters, namely voltage source inverter and current source inverter. However, both inverters have some conceptual barriers. The newly presented Z source inverter has some unique features and also overcomes the limitations of traditional voltage source inverter and current source inverter. The purpose of this project is to investigate modeling, simulations and the fabrication of three phase Z source inverter and its control strategies for implementation of DC to three phase AC power conversion.*

*Key Words***: Converter, voltage source inverter, Current source inverter, Modulation index, Boost factor.**

1. INTRODUCTION

The z-source inverters are having the single stage buck-boost conversion facility. The network is having a unique impedance circuit which couples the main circuit of converter with source for obtaining a particular characteristic which cannot be achieved by traditional voltage source inverter (VSI) and current source inverter (CSI).

Both the V-source converter and the I-source converter have the following common problems.

- ▪ Their main circuits cannot be interchangeable.
- ▪ They are sensitive to EMI noise in terms of reliability.
- ▪ They can be either a buck converter or boost converter, they cannot be a buck-boost converter at the same time.

These limitations can be overcome by the by the z source-inverter. The Z-source inverter advantageously utilizes the shoot through states to boost the dc-bus voltage by gating on both the upper and lower switches of a phase leg. Therefore, the Z-source inverter can buck and boost voltage to a desired output voltage that is greater than the available dc bus voltage. Thus, it provides a low-cost, reliable, and highly efficient for buck and boost power conversion. The reliability of the ZSI can be improved.

2. TRADITINAL SYSTEMS

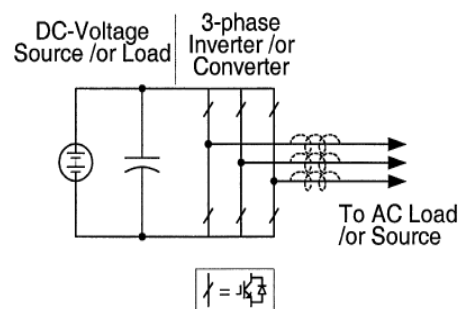Following are the some of the main Traditional of the inverter system.

Fig 1

The traditional three-phase current-source converter (abbreviated as I-source converter) structure. A dc current source feeds the main converter circuit, a three-phase bridge. The dc current source can be a relatively large dc inductor fed by a voltage source such as a battery, fuel-cell stack, diode rectifier, or thyristor converter. Six switches are used in the main circuit; each is traditionally composed of a semiconductor switching device with reverse block capability such as a gate-turn-off thyristor (GTO) and SCR or a power transistor with a series diode to provide unidirectional current flow and bidirectional voltage blocking.
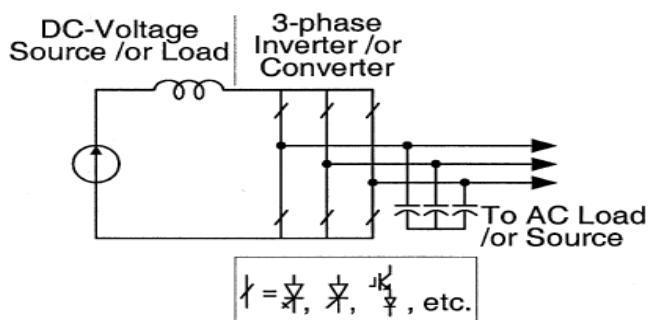
Fig 2

The ac output voltage has to be greater than the original dc voltage that feeds the dc inductor or the dc voltage produced is always smaller than the ac input voltage. Therefore, the I-source inverter is a boost inverter for dc-to-ac power conversion and the I-source converter is a buck rectifier (or buck converter) for ac-to-dc power conversion. For applications where a wide voltage range is desirable, an additional dc–dc buck (or boost) converter is needed. The additional power conversion stage increases system cost and lowers efficiency.

2.1 Traditional Dc to Ac block
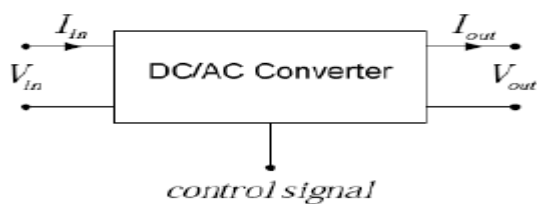
Fig 3

Form of DC/AC conversion is shown in figure 3 , which is known as the single phase bridge. Single phase DC/AC conversion an be obtained by alternately closing and opening the diagonal switches pairs, i.e S1 &S4 or S2&S3., respectively. Figure 4 shows the output voltage waveform, where either the input voltage or its counterpart is seen at the output depending on the switch states. Here the parameter of the AC voltage (its RMS value or amplitude of its fundamental component) is constant.
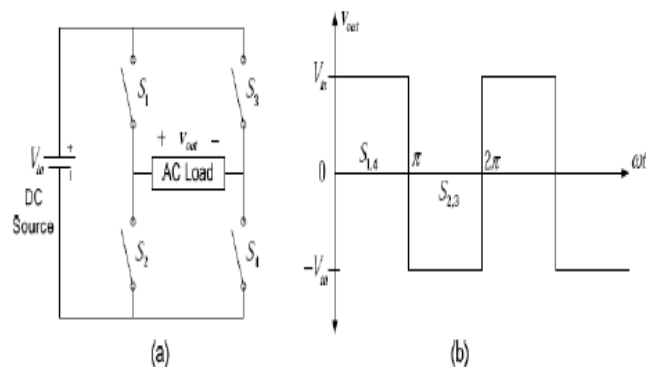

Fig 4

Pulse width modulation technique is common in DC/AC conversion using this high frequency switching technique, it is possible to eliminate the undesirable low frequency harmonics and frequency switching harmonics are easy to filters.

3.1 Z SOURCE INVERTER

Z Source Inverter overcome the above problems of the traditional V-source and I-source converters, this project presents an impedance -source (or impedance-fed) power converter (abbreviated as Z-source converter) and its control method for implementing dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion. Z-source converter structure proposed. It employs a unique impedance network (or circuit) to couple the converter main circuit to the power source, load, or another converter, for providing unique features that cannot be observed in the traditional V- and I-source converters where a capacitor and inductor are used, respectively. The Z-source converter overcomes the above-mentioned conceptual and theoretical barriers and limitations of the traditional V-source converter and I-source converter and provides a novel power conversion concept.
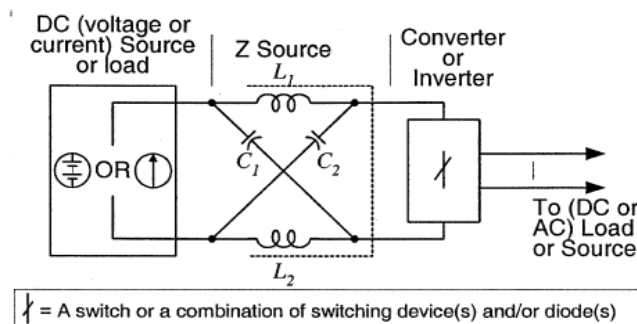
Following three types of z source inverter.

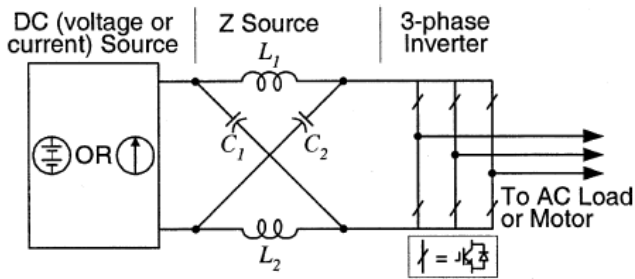Fig 5-General structure of Z source inverter

Fig 6- Z-source converter structure using the antiparallel combination of switching device and diode.
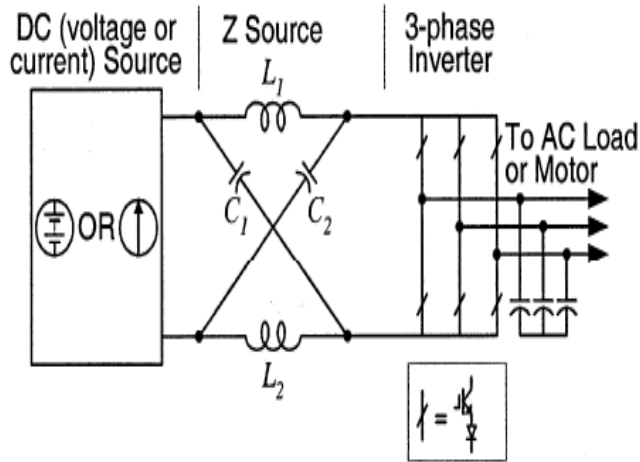

Fig 7-3Z-source converter structure using the series combination of switching device and diode

The unique feature of the Z-source inverter is that the output ac voltage can be any value between zero and infinity. That is, the Z-source inverter is a buck–boost inverter that has a wide range of obtainable voltage. The traditional V- and I-source inverters cannot provide such feature. 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.
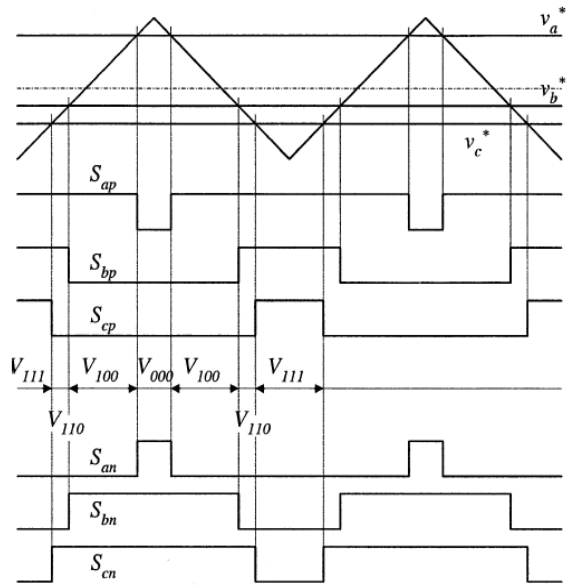

Fig 8- Traditional carrier-based PWM control without shoot-through zero states
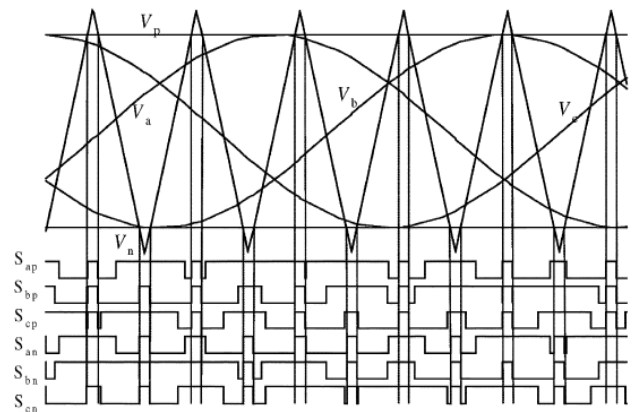
3.2 SIMPLE BOOST CONTROL

Fig 9-1 simple boost control waveform

Voltage gain of the Z-source inverter can be expressed as;

$$\frac{|\hat{V}_{ac}|}{V_o/2} = MB$$

where V_{ac} is the output peak phase voltage, V_0 is the input dc voltage, M is the modulation index, and B is the boost factor,

$$B = \frac{1}{1 - 2\frac{T_0}{T}}$$

which is determined by   Where, T_0 is the shoot-through time interval over a switching cycle T, or is the shoot-through duty ratio. $\frac{T_0}{T} = D_0$
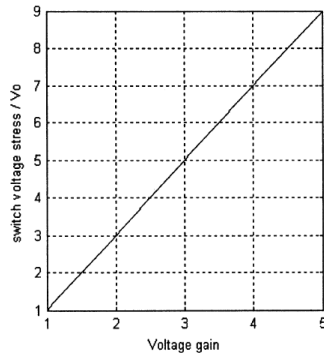
$$V_s = BV_o = (2G - 1)V_o.$$

Fig.5.1.3 Switch voltage stress versus voltage gain.

3.3 MODIFIED PWM CONTROL FOR SHOOT THROUGH

The inverter with maximum constant boost control with third harmonic injection shoots through twice in one cycle (triangular waveform cycle); the equivalent frequency to the inductor is doubled, thus reducing the requirement to the inductors.
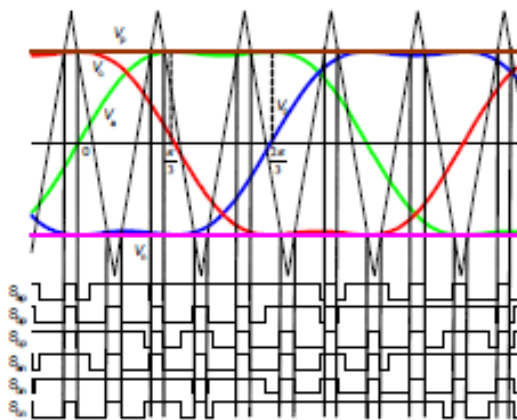

Fig 10-Maximum Constant Boost with Third Harmonic Injection

There are two types of zero states, Zero 1 and Zero 2, Zero 1 occurs when all upper three switches are turned on, and Zero 2 occurs when all lower three switches are turned on.
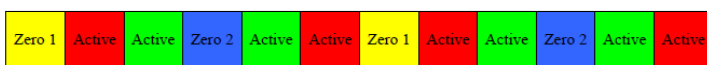

Fig 11-Switching states sequence of traditional PWM control
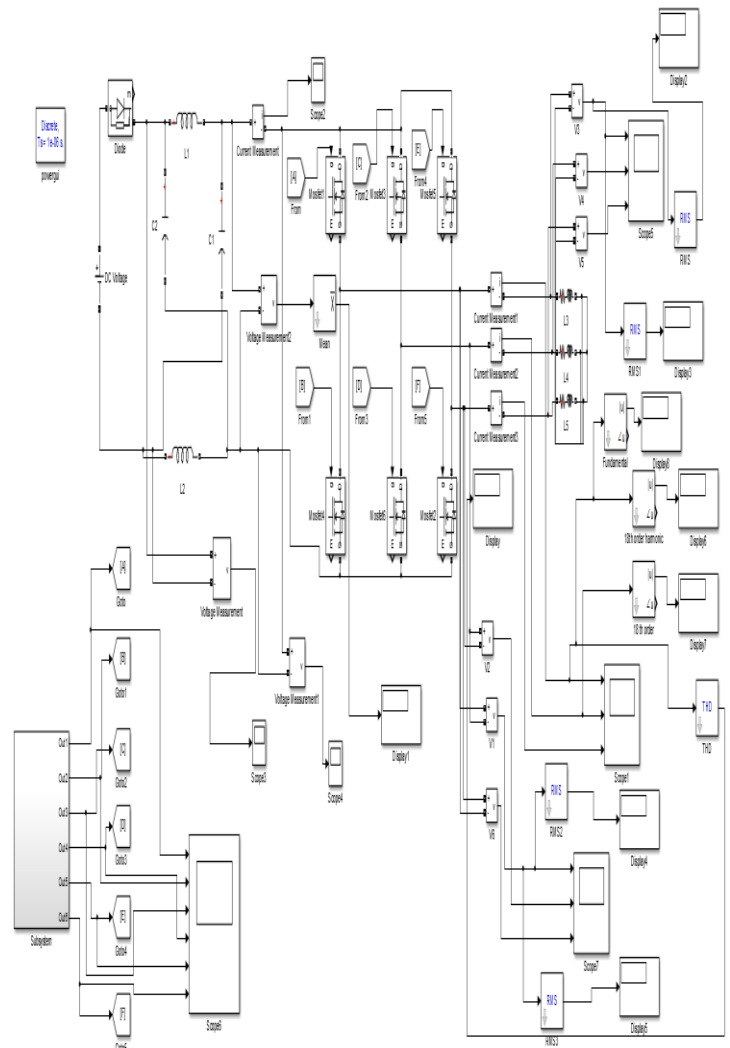
4. SIMULATION MODEL AND RESULTS

Fig 12 -System simulation model
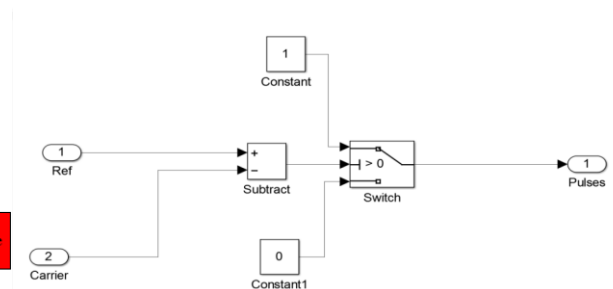
4.1 Basic Comparator Circuit
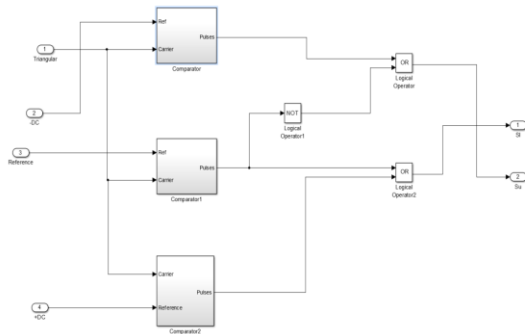

Fig 13 Basic Comparator Circuit

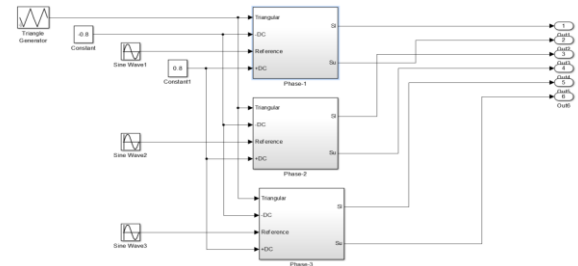Fig 14 Generation of Gate Pulses For One Phase

Fig 15 3 Generation of Gate Pulses For All Three Phases

5 .SIMULATION RESULTS

1.1 **For Load R=1000 Ohm, Load L=50mH, Switching Frequency=10kHz, Vin=220VAnd Varying Values Of Capacitor And Inductor.**

sr. No.	Inductor (mH)	Capacitor (microF)	Dc link voltage	Load voltage	Vp (pp)	Inverter voltage	Load voltage	% THD current
1.	1	1	578.3	640	202	961	350	0.1636
2.	2	2	392.8	382	138.6	572	240	0.1573
3.	3	3	332.3	300	117.7	450	204	0.154
4.	4	4	304.8	272	107	392	186	0.1538
5.	1	0.5	584	680	205	995	355	0.163
6.	1	0.25	594	705	210	1050	363	0.162
7.	1	0.2	597	724	211	1086	366	0.1616
8.	1	0.1	597.4	785	215	1187	372	0.1609
9.	0.5	1	950.1	1150	329	1732	571	0.1669
10.	0.25	1	1687	2195	584	3300	1011	0.1673
11.	0.2	1	2043	2700	707	4057	1224	0.1671

1.2 **For Vin=220v, F=1000HZ, R=1000 Ohm, L=50mH, M=0.8 & Varying Values Of Capacitor And Inductor.**

Sr. No	Inductor (mH)	Capacitor (microF)	Dc link voltage	Load voltage RMS	Load voltage True RMS	Inverter voltage RMS	Inverter Voltage True RMS	% current THD
1.	1	1	1759	622.5	859.4	1078	1489	0.6935
2.	2	2	1707	617.9	873.4	1070	1514	0.7301
3.	3	3	1367	483.8	679.7	835	1175	0.7282

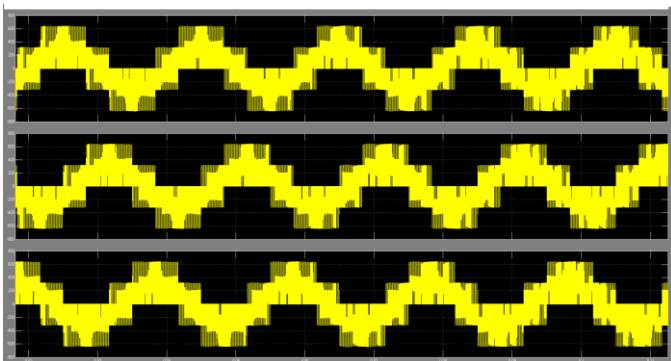## Third Harmonic Injection

2.1 For Load R=1000 Ohm, Load L=50mH, Switching Frequency=10kHz, Vin=220VAnd Varying Values Of Capacitor And Inductor for TH.

| L (mH)	C (microF)	Dc link V	Load voltage RMS	Load voltage True RMS	Inverter voltage RMS	Inverter Voltage True RMS	% current THD
1	1	593.8	190.8	301.5	307.2	498.2	0.5897
2	2	400.8	132.3	206.5	214.4	341.1	0.5762
3	3	337.9	112.5	174.2	183.1	288	0.5708
4	4	309.1	102.1	157.9	167	261.8	0.5799

2.2 For Load R=1000 Ohm, Load L=50mH, Switching Frequency=10kHz, Vin=220V, inductor = 1mH &Varying Values Of Capacitor.

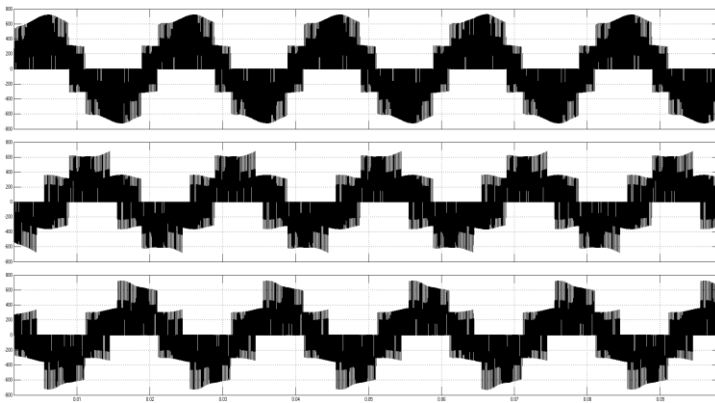| Sr no	Inductor (mH)	Capacitor (microF)	Dc link voltage	Load voltage RMS	Load voltage True RMS	Inverter voltage RMS	Inverter Voltage True RMS	% current THD
1.	1	0.5	603.3	194.4	305.1	313.6	504.7	0.5665
2.	1	0.25	616.3	199.6	311.6	322.8	515.7	0.5458

SIMULATION WAVEFORM

1 .1 Load Voltage waveform
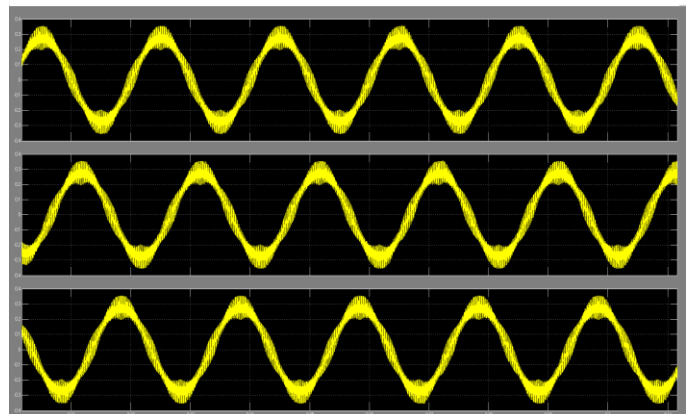
1 .2 Load Voltage waveform

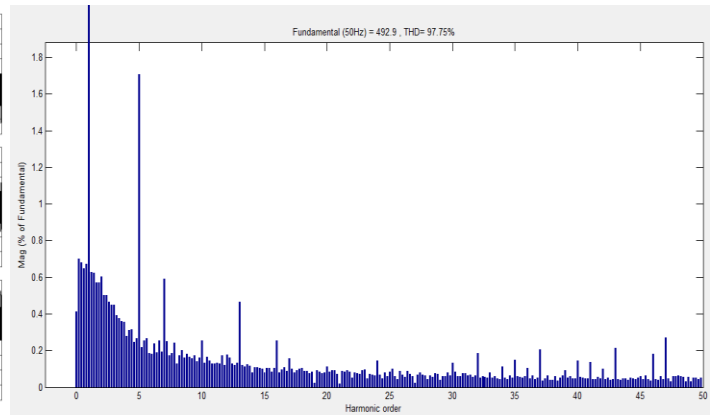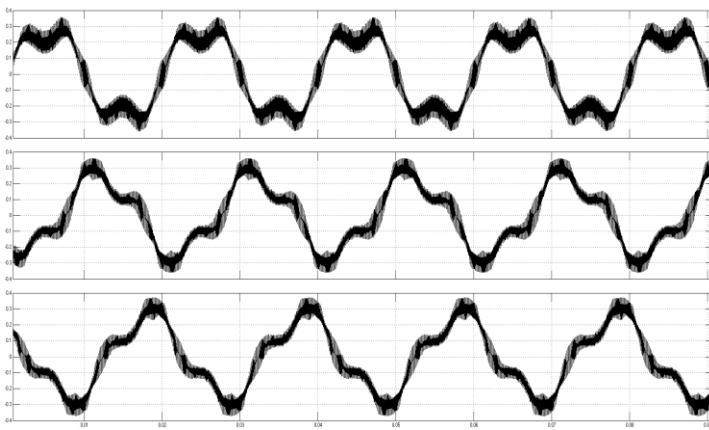2.1 Load Voltage waveform

Fig 17- Analysis of Z source Inverter
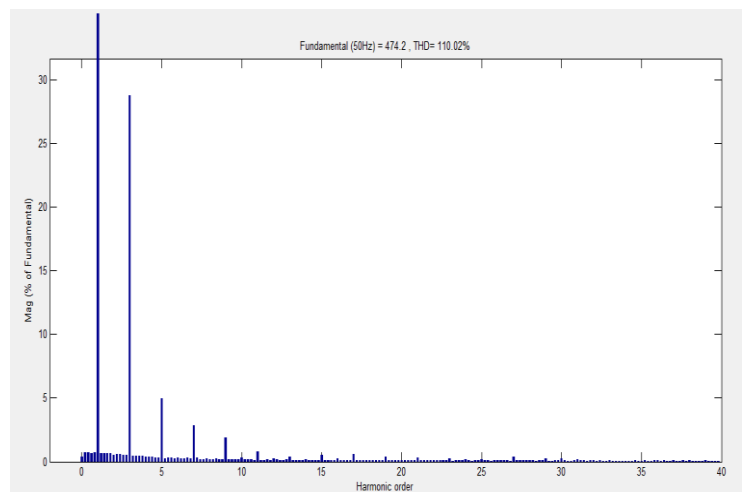

2.2 Load Voltage waveform

Fig 17-Analysis of Z Source Inverter with Third Harmonic Injection

6. FFT ANALYSIS

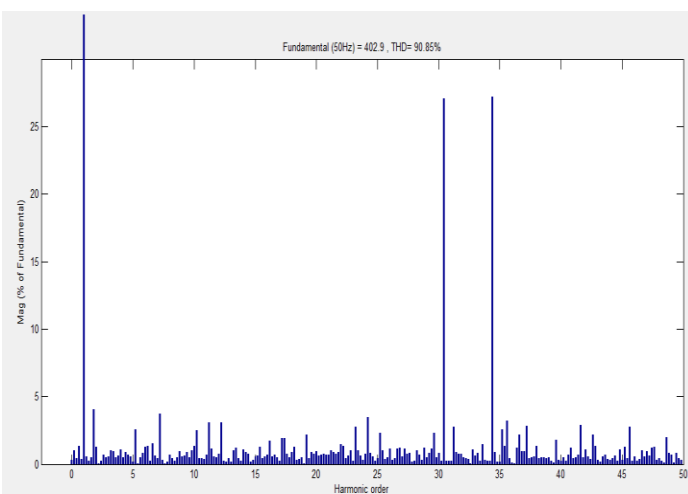### 6.1.FFT Analysis Of Volatge Source Inverter

Fig 16 Analysis Of Volatge Source Inverter

7. CONCLUSIONS

A Z-Source Inverter is a buck boost inverter that has a wide range of obtainable value of output voltage, which is verified through MATLAB/SIMULINK model. The various control strategies such as simple boost control , maximum boost control and third harmonic injection control are studied and results are verified through simulations and it is observed that third harmonic injection control method is more advantageous than other methods. The performance of the scheme has been evaluated on the basis of THD & load voltage, load current and found that the output voltage quality is good.

As per the results obtained from various simulations, following conclusions are obtained

1. For constant Z source inductance and modulation index, if Z source capacitance decreases then output voltage increases.

2. For constant Z source capacitance and modulation index, if Z source inductance decreases then output voltage increases.
3. For constant modulation index, if Z source capacitance and inductance decreases then output voltage increases.
4. For constant Z source inductance & capacitance, if modulation index increases then output voltage decreases.
5. For constant Z source capacitance and inductance if load resistance decreases then output voltage decreases.

REFERENCES

[1]   F. Z. Peng, "Z-source inverter," IEEE Trans. Ind. Applicat., vol. 39, no.2, pp. 504–510, Mar./Apr. 2003.

[2]   F. Z. Peng, X. Yuan, X. Fang, and Z. Qian, "Z-source inverter for adjustable speed drives," IEEE Power Lett., vol. 1, no. 2, pp. 33–35, Jun. 2003.

[3]   M. Z.Zizoui, B.Tabbache, F.Belkhiri , "Maximum Constant Boost Control of 9-Switch zSource Power Inverter-Based Electric Vehicles", The 5th International Conference on Electrical Engineering – Boumerdes (ICEE-B) October 29-31, 2017, Boumerdes, Algeria

[4]   Chaib Ibtissam, Behlouli Asma, Comparative study between different control strategy of the Z-Source inverter.2017