A Modified Boost Dc-Ac Inverter Using Z-Source: Operation, Analysis, Control and Experimentation

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Abstract- **This paper proposes a new voltage source inverter referred to as a modified boost inverter using z-source. The main attribute of this new inverter topology is the fact that it generates that an AC voltage larger than the DC input one, depending on the instantaneous duty cycle. The conventional dc to ac boost converter has resulted in several voltage ripples in load. In order to avoid these ripples, Z-source inverter is introduced between the source and the inverter circuit. The proposed control strategy achieves a very high reliable performance with fewer ripples than the conventional boost inverter. The main advantages are low cost, less number of switches used, compact size and reduce the power processing stages into single stage.**

Index Terms- **inductor, capacitor, ripple voltage.**

1. INTRODUCTION

The basic boost inverter topology is as shown in Fig.1.The conventional boost inverter produces the larger ac output voltage than the dc input voltage but with ripples. This can be modified further by adding z-source inverter between the source and the converter stage. The need of output voltage is said to be 150 volt. By law of conservation of energy the power produced at the input has to be equal to the power produced in the output by assuming no losses in the circuit

Input power (P_{in}) = Output power (P_{out})

Since $V_{in} < V_{out}$ in a conventional boost inverter, the output current is lesser than the input current. Therefore in conventional boost inverter

$I_{in} > I_{out}$

II. PRINCIPLE OF Z-SOURCE INVERTER

Z-Source Inverter (ZSI) is based on Z-Source network and it can be used to buck as well as boost the output AC voltage. This type of conversion is not possible using traditional VSI or CSI. It also has the unique advantage of shorting the dc link which is thereby not possible by traditional VSI. This results in the improved reliability of the circuit. Actually the concept of boosting the input voltage is based on the ratio of "shoot-through" time to the whole switching period. Here, Z-Source Inverter is an impedance network which is placed between d.c source and inverter. Z-Source Inverter (ZSI) provides a greater voltage than the d.c link voltage. It reduces the inrush current & harmonics in the current because of two inductors in Z-Source network. It forms a second order filter &handles the undesirable voltage sags of the d.c. voltage source.

The Fig.1. shows a topology of the single phase Z-Source inverter, where the impedance network is placed between the dc power source and the single phase inverter. The so called shoot-through state which means the two capacitors and the two inductors and the two capacitors on the same leg will be ON simultaneously in order to provide the boosting capability without damaging the switches. During shoot through state ,the Z-Source Inverter (ZSI) gains the voltage boosting capability as the energy is transferred from capacitor to inductor and the diode is required to prevent the discharge of overcharged capacitor through the source.

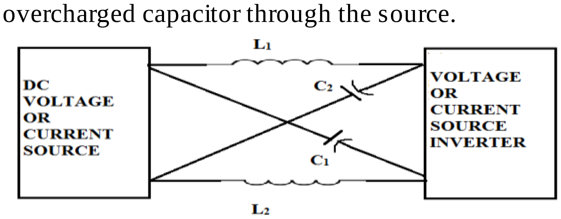

Fig.1. Z-Source Inverter

III. MODIFIED BOOST INVERTER USING Z-SOURCE

A. Design Calculation Of Inductors And Capacitors

a. For Inverter Circuit

Required output voltage V_o = 150 volt

Load current I_o = V_o / R_o

Inductor Ripple Current $\Delta I_L = V_s D / f_s L$

Capacitor Ripple Voltage $\Delta V_o = D / f_s C$

Load Ripple Voltage V_R = $(V_o - V_i)/(R_o C f)$

Where R_o = Load resistance in ohm

V_s = Supply Voltage in volt

D = Duty cycle

f_s = Supply frequency in hertz

= Inductance in henry

C = Capacitance in farad

V_i = Input voltage in volts

b. For Z-Source Inverter

Inductance $L = I_o/f \Delta I_L$

Capacitance $C = D/2fR_o$

Where D = Duty cycle

I_o = Load current in ampere

ΔI_L = Ripple Inductance current in ampere

R_o = Load resistance in ohm

B. Component Specification For Simulation Using Matlab/Simulink

Name Of The Components	Specifications
Inductors L_1 L_2 L_3 L_4	50 mH 50 mH 50 mH 15 mH
Capacitors C_1 C_2 C_3 C_4	1000 uF 1000 uF 1000 uF 1000 uF
Resistor R	100 ohm
DC input Voltage V_{in}	10 volt
MOSFET (Bi-Directional Switch)	8 A,500 V
Supply frequency Mosfet f_s	2 x 10^3 Hz
Input frequency f	50 Hz

C. Configuration of modified boost inverter using z-source

Fig.7. shows the circuit diagram of modified boost inverter using z-source in which the z-source inverter is connected between source and the converter circuit.

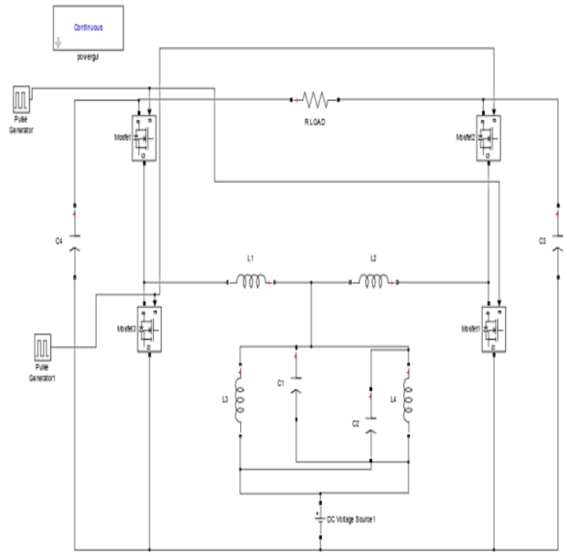

Fig.2. Circuit Diagram of modified boost inverter using z-source

D. Modes of operation

Mode 1:

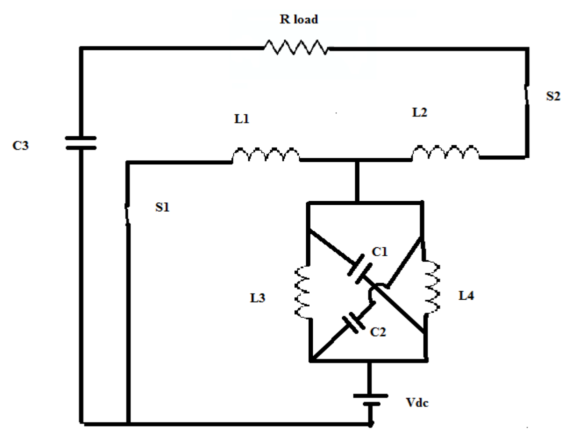

Fig.3.Operation of z-source inverter for the positive cycle

When the switches S_1 and S_2 are closed,inductors L_3 and L_4 gets charged and L_1 gets charged,L_2 gets connected to the resistive load R.Thus we obtain the positive half cycle of voltage by having the output voltage of added DC input voltage and the discharging inductor current resulting in boosting up of output voltage.The capacitor C_1 just discharges.The capacitors are mentioned to be acting as filters.The additional capacitors C_1 and C_2 further filters the ripples in the DC input voltage to give better efficiency.

Mode 2:

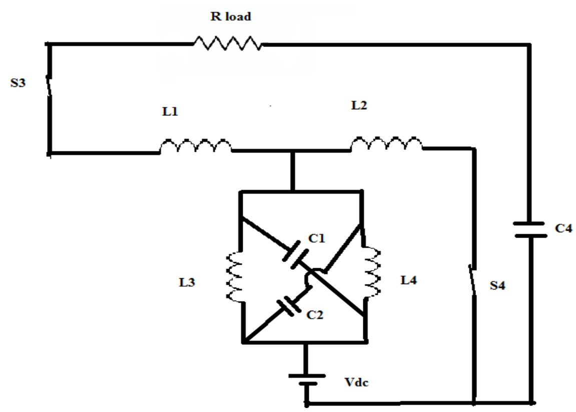

Fig.4.Operation of z-source inverter for the negative cycle

When the switches S_3 and S_4 are closed, the inductor L_1 gets discharged and L_2 gets connected to resistive load as well as the inductors L_3 and L_4 also gets charged resulting in further more increase in the output voltage. Thus the polarity of the resistive load changes to give the negative cycle of output voltage due to the addition of voltage of the inductor and the DC input voltage. In this too the capacitor C_4 acts as a filter by reducing the ripples in the load voltage. The capacitors C_1 and C_2 in the Z-Source also further filters the ripples in the input side.

IV. SIMULATION AND EXPERIMETAL RESULTS

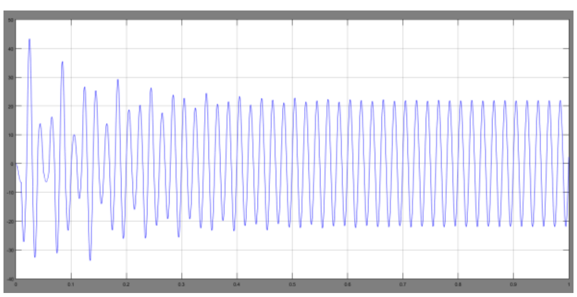

Fig.5. Waveform of output voltage of modified boost inverter using z-source

The magnitude of the output ac voltage is found to be 20 volts as shown in Fig.10.The output voltage is found to be with the ripples of about 5 volts out of those 20 volts. The positive half cycle of the output voltage is due to the conduction of the mosfet switches S_4 an S_3 and the negative half cycle is due to the conduction of the mosfet switches S_1 an S_2.For the input DC input voltage of 75 volts , it is found that the output AC voltage has been boosted to about 150 volts.

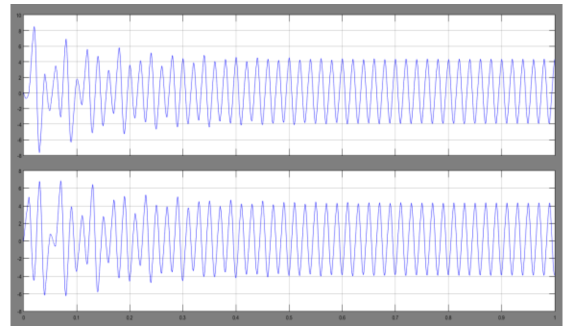

Fig.6.Waveform of the currents through the inductors L_1 and L_2

The magnitude of the currents of the inductors L_1 and L_2 are found to be 4 A as shown in Fig.11.In the first half cycle i.e., for the positive half cycle the inductor L_1 gets discharged while the inductor L_2 gets charged.The graph shows some oscillations which become constant at later values.

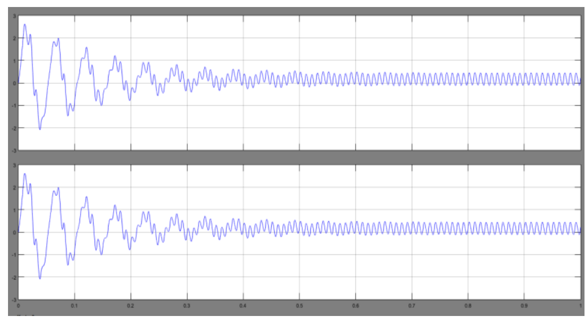

Fig.7.Waveform of the currents through the inductors L_3 and L_4

The Z-Source has two inductors namely L_3 and L_4 which have the current of 0.5 A as shown in Fig.12.Both the inductors have the identical charging by which the Z-Source acts to be a boosting circuit as well as filter circuit to boost up the output voltage as well as to reduce the ripples in the output AC voltage in the input side itself.

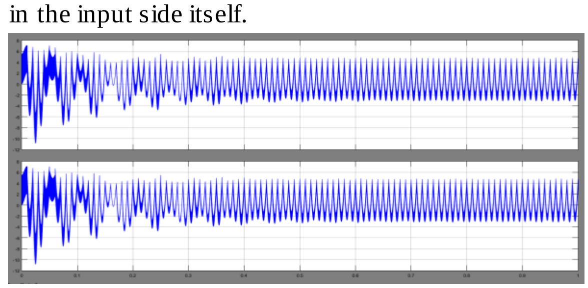

Fig.8. Waveform of the voltage across the capacitors C_1 and C_2

The capacitors C_1 and C_2 of the Z-Source charges and discharges to be acting as an active filter by allowing AC current to flow by blocking DC output voltage.It also helps in filtering the ripples in the input side rather than in the output side.The magnitude of capacitor is found to be about 5 volts of which it has many oscillations in the beginning.

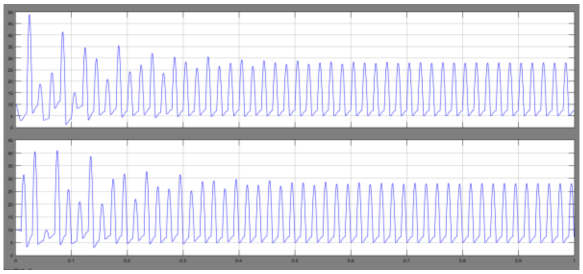

Fig.9. Waveform of the voltage across the capacitors C_3 and C_4

The peak to peak value of voltage across the capacitors C_3 and C_4 is found to be 28 volt as shown in Fig.14.The capacitor C_3 discharges while the capacitor C_4 charges. Here also there are some oscillations initially but later become constant.

A. *Experimental Waveforms*

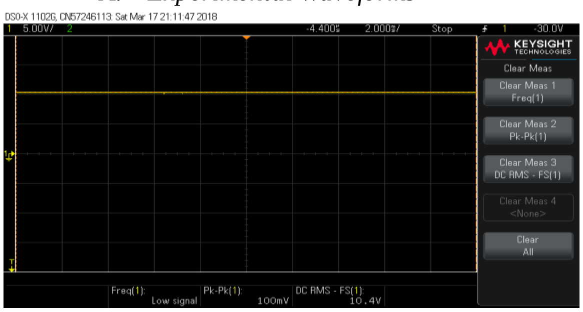

Fig.10.Waveform of Input Supply

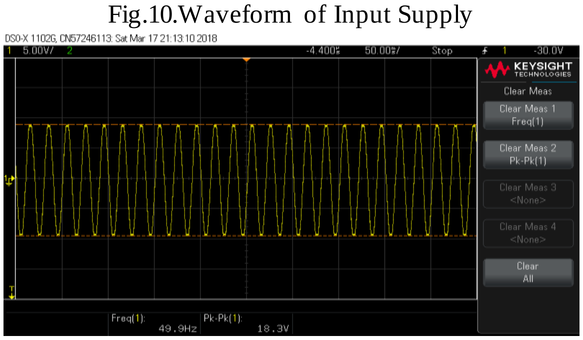

Fig.11.Waveform of Output voltage

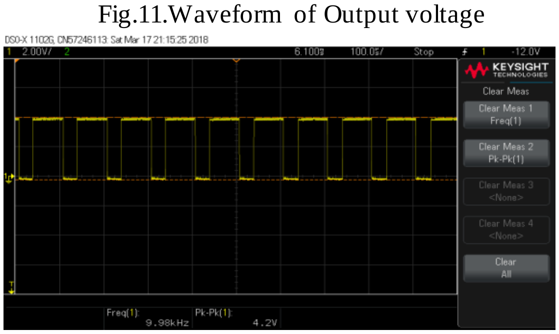

Fig.12.Waveform of the gate signal across mosfet switches 1 and 3

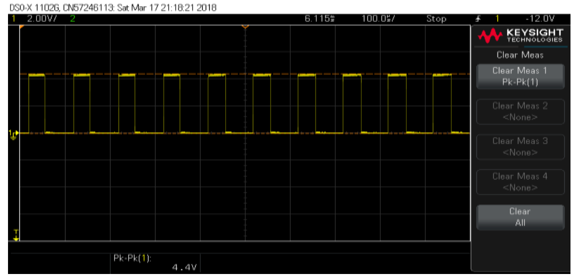

Fig.13.Waveform of gate signal across the mosfet switches 2 an 4

VII. CONCLUSION

The ripple voltage produced by the modified boost inverter by using z-source is lower than the ripple voltage produced by the conventional boost inverter. And the output voltage on comparison of both designs is found to be higher in modified boost inverter using z-source than the conventional boost inverter. Thus, this model effectively utilizes the power and minimizes the harmonic distortions in a compact and cost effective way.

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