🌐 ***United International Journal of Engineering and Sciences*** 🌐
(UIJES – A Peer-Reviewed Journal); ISSN:2582-5887 | Impact Factor:8.075(SJIF)
📘 *Volume 5 | Special Issue 1 | 2025 Edition*
National Level Conference on "Advanced Trends in Engineering Science & Technology" – Organized by RKCE

Simple Boost Control of the Z-Source Nine Switch Inverter

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***Abstract* – This paper proposes aZ-source Nine switch inverter (Z-NSI) which can be used to run two loads static /dynamic or mixed loads independently. It finds application in axle mounted motors in electric traction, washing and drying motors in washing machines. This paper proposes an impedance-fed power converter (abbreviated as Z-source converter) and it can be implemented in dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power convertors. The Z-source network couple the power converter circuit to the power source. It has unique voltageboost characteristic feature which is absent in the traditional voltage-source and current-source converters. The Z-source converter is novel power conversion concept. This paper has been divided into four sections, namely section (1) deals with the introduction and mathematical analysis involved in the Z-Source inverter. Section (2) deals the implementation of Matlab circuit. Section (3) deals with Simulation results and this will be followed by sections (4) which eventually discuss the results and further improvement in converter control design.**

***Keywords* – Z-Source Nine switch inverter, Active states, Zero states and shoot through phenomenon.**

1. INTRODUCTION

There are two traditional converters: voltage-source (or voltage-fed) and current-source (or current-fed) converters (or inverters depending on power flow directions). The V-source converter is widely used. It, however, has the following limitations. 1. The maximum amplitude of ac output voltage is quite below the input dc. Therefore, the V-source inverter is a buck (step-down) inverter for dc-to-ac power conversion but V-source converter is a boost (step-up) rectifier (or boost converter) for ac-to-dc power conversion. For AC drive applications this holds limitation and this is overcome by using LC network connected in X form mostly known Z-source network. A three phase six switch inverter has six active states, two zero states. Only active states can be used for signal transmission and zero states are deliberately does't yield any output voltage. This makes the output ac voltage to be less. The Z network helps in introduction of seven more extra states which are shoot through states in which converter is isolated from dc supply and the energy stored in LC elements is transferred to load. This is not possible in the traditional inverters.

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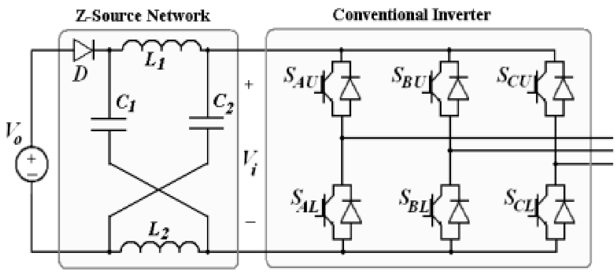

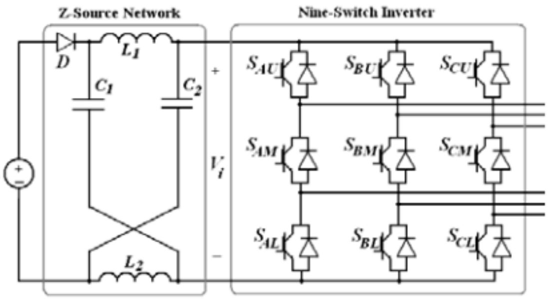

Fig. 1: Z-source inverter   Fig.2: Z-source nine-switch inverter

Z network is symmetrical, so we write, $\mathbf{V_{C1} = V_{C2} = V_C}$ **and** $\mathbf{V_{L1} = V_{L2} = V_L}$.**D**uring shooth through state

$\mathbf{V_L = V_C}$ $\mathbf{V_d = 2V_C}$ **and** $\mathbf{V_i = 0}$

$\mathbf{V_L = V_o - V_C}$ $\mathbf{V_d = V_o}$ **and** $\mathbf{V_i = V_C - V_L = 2V_C - V_o}$

Where V_o is the input dc source voltage and $\mathbf{T = T_0 + T_1}$

The average voltage acoss inductors in switching cycle is zero in the steady state, hence from (2) and (3) we get,

$$\mathbf{V_L} = \bar{v}_L = \frac{T0.Vc + T1(Vo - Vc)}{T} = 0$$

$$\therefore \frac{T1}{T1-T0} = \frac{Vc}{Vo}$$

Similarly the average dc link voltage across the inverter bridge can be found as follows:

$$\mathbf{V_i} = \bar{v}_i = \frac{\mathbf{T0.\ O + T1(2Vc-Vo)}}{\mathbf{T}} = \frac{\mathbf{T1}}{\mathbf{T1-T0}}\mathbf{Vo = Vc}$$

The maximum dc-rail voltage across the inverter is expressed as$\mathbf{V_i = V_C - V_L = 2V_C - V_o}$

which is further equal to

$$\mathbf{V_i = V_C - V_L = 2V_C - V_o} = \frac{\mathbf{T}}{\mathbf{T1-T0}}\mathbf{Vo} = \boldsymbol{B}.\mathbf{Vo}$$

Where, $\boldsymbol{B} = \frac{\mathbf{T}}{\mathbf{T1-T0}} = \frac{\mathbf{1}}{\mathbf{1-2T0/T}} \geq \mathbf{1}$**,** here B is boost factor whose value can be obtained in the shoot through state.

$$\bar{v}_{ac} = \mathbf{M}\boldsymbol{B}\frac{\mathbf{V0}}{\mathbf{2}}$$

Noting for traditional inverter, $\bar{v}_{ac} = \mathbf{M}\frac{\mathbf{V0}}{\mathbf{2}}$thus the factor B_B is known as buck-boost factor given as MB.

II.MATLAB IMPLIMENTATION

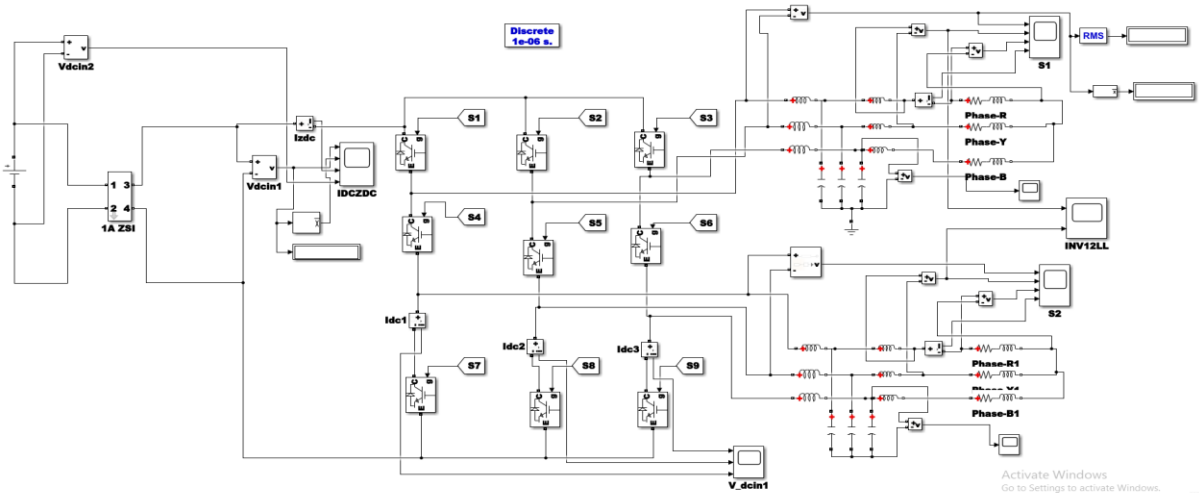

Fig.3: MatlabSimulation Circuit for Z-source nine-switch inverter

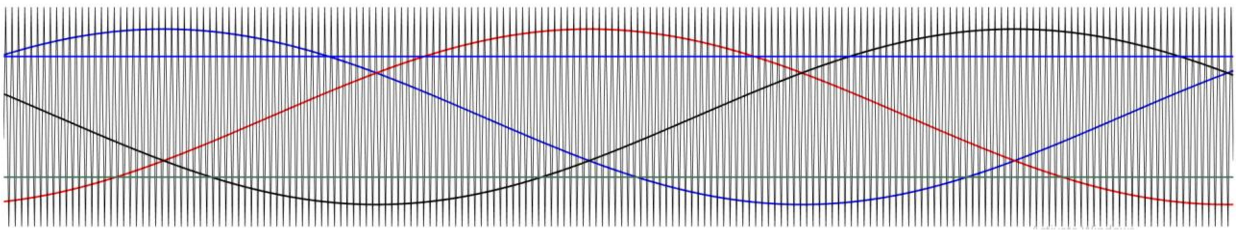

Fig.4: Carrier wave superimposed on Modulated wave with +ve and –ve DC rails less then Max. value of V_a, V_b and V_c respectively.

III.SIMULATION RESULTS

[For MI = 0.8, ST=0.55 & -0.55, Input Vdc = 40 Volts; Vz(o/p) = 486.23 V]

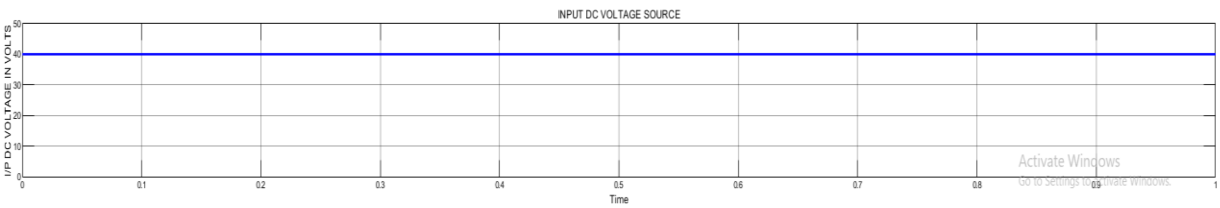

Fig.4: Input DC Voltage to Z Source network

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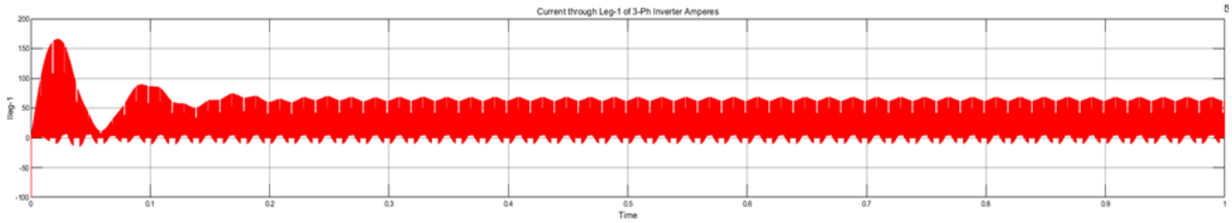

Fig.5: Current through leg-1 of the bridge Inverter

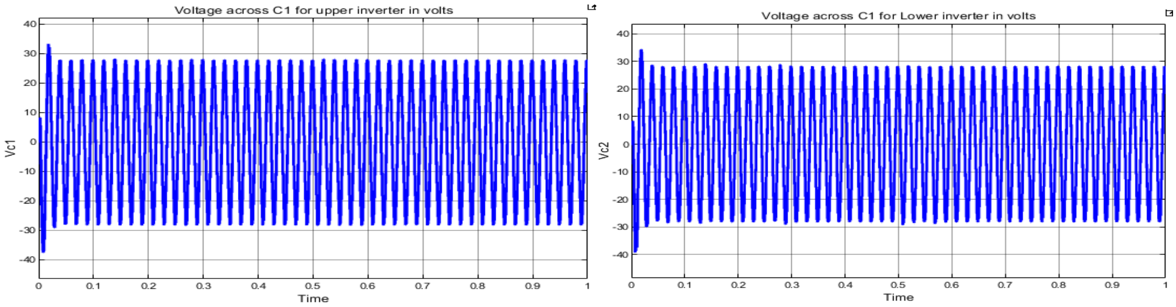

Fig.6: Voltage across the C1 and C2 (Filter circuit)

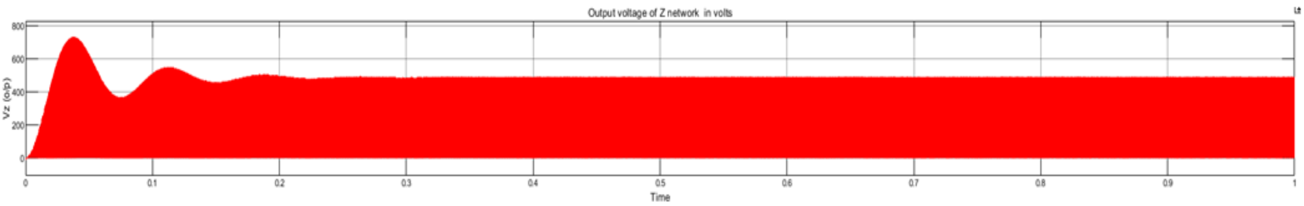

Fig.7: Output Voltage of Z-Network

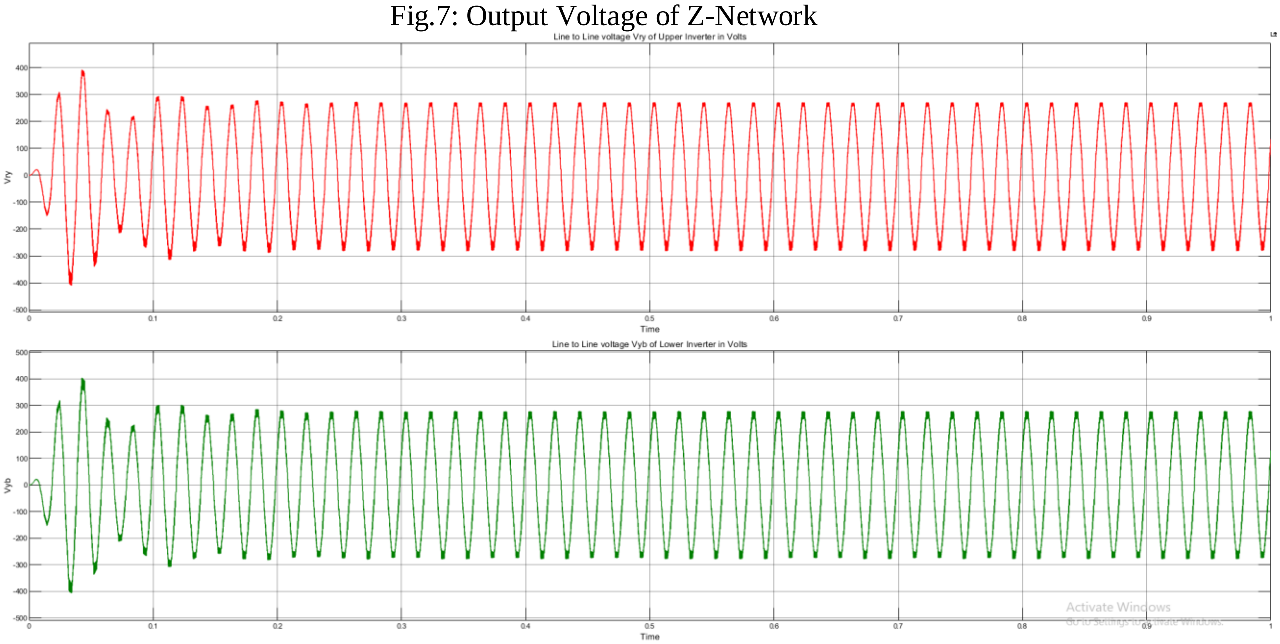

Fig.8: Output Voltage of Upper Inverter & Lower Inverter (L-L)

IV.FFT ANALYSIS AND RESULTS DISCUSSION

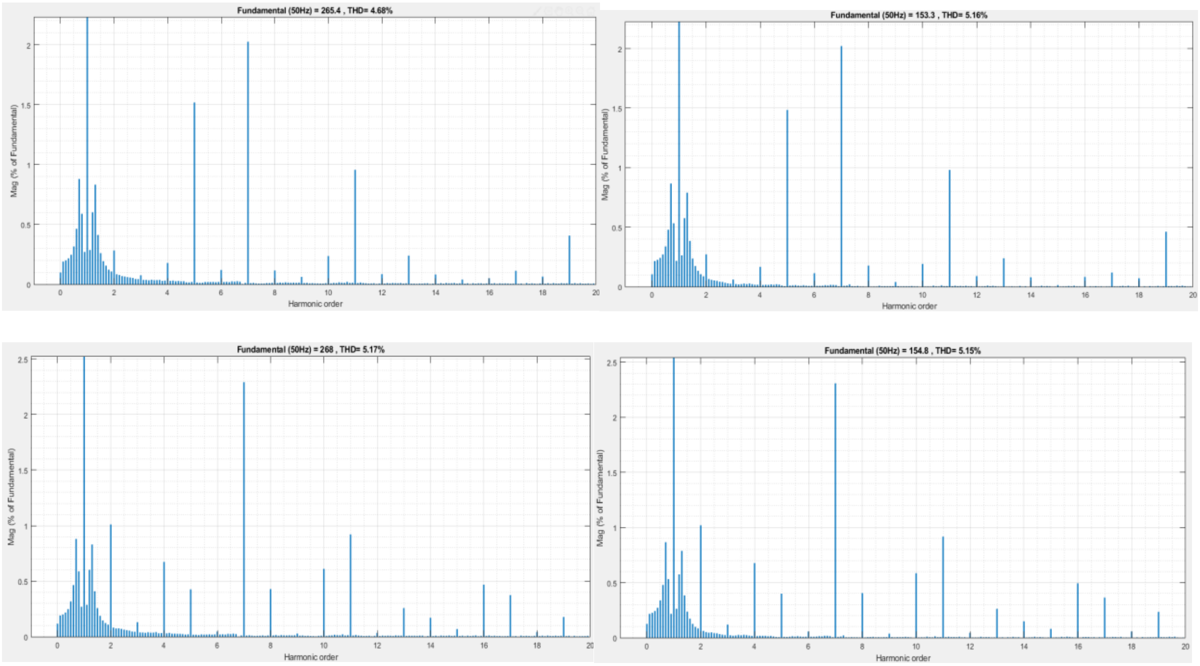

Fig.9: FFT Analysis of L-L Voltage and L-N Voltage for Upper & Lower Inverter

The results are obtained with Modulation Index fixed at 0.8 and shoot through interval (T_0) has been changed from 0.8 to 0.55. Shoot interval provides an short circuit of the bridge inverter circuit and disconnected from the dc rail. There by system is protected. When ST either goes beyond MI or its below certain value the output waveform is distorted. The results have also been compared with Nine switch Inverter. The modulation technique used in the this paper is SPWM and for circuit simulation Matlab simulation is used.

Table (1) shows effective boost voltage on increasing the shoot through time. The shoot through is obtained by considering two rails of DC voltage, one is positive and other is a negative DC voltage respectively. The carrier wave is a triangular wave whose switching speed is 1000 Hzand reference wave is a sine wave with frequency is equal to 50 Hz. The DC voltage selected is always less then or equal to the maximum value of the reference wave.

MI	ST (+)	ST (-)	**Vdc**	**Vz(o/p)**	**V(o/p)rms**	**V(o/p)max**
0.8	0.8	-0.8	40	**65.34**	**43.43**	**61.24**
0.8	0.75	-0.75	40	81.54	53.63	75.61
0.8	0.7	-0.7	40	97.83	63.48	89.51
0.8	0.65	-0.65	40	122.32	77.98	109.95

0.8	0.6	-0.6	40	195.33	120.75	170.18

Table (1): Ouput voltage (**V(o/p)rms) with shoot through period.**

V.CONCLUSION& FUTURE SCOPE

This paper proposes an impedance-fed power converter (abbreviated as Z-source converter) and it can be implemented in dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power convertors. The Z-source network couple the power converter circuit to the power source. It has unique voltage boost characteristic feature which is absent in the traditional voltage-source and current-source converters. The Z-source converter is novel power conversion concept. As another example, the Z-source concept can be easily applied to adjustable-speed drive (ASD) systems. The NSI used here produces voltages of equal amplitude. Further research can be done to produce output differential voltage with differential frequency.

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