

# Design and Implementation of T-Z Source Inverter System

**R. Sinthiya Jothi**

EEE (PG Scholar), Anna University, Chennai, Tamil Nadu, India

## ABSTRACT

In this paper, a new family of single-stage high step-up boost voltage inverter based on transformer is proposed, called T-Z source inverters. By replacing two inductors in the classical Z-source inverter with two transformer, the proposed inverter produces a very high boost voltage gain when, the turn ratio of the transformer is larger than one. Compared to the trans-Z source inverter, the proposed T-Z source inverter uses a lower turn's ratio, which reduces the transformer's size and weight while producing the same output voltage gain. Single phase AC is converted into DC using uncontrolled rectifier. T-Z network is used to boost the voltage from 230 volt to 400 volt. DC is converted into three phase balanced AC using three phase inverter. The output of inverter is used to control the speed of induction motor. The extension of the proposed inverter topology to DC link type and embedded type topologies are presented.

## Keywords

Trans-Z-source, Z-source, T-Z source inverters

## I. INTRODUCTION

Traditional voltage-source inverter (VSIs) are perform only step down voltages and having some limitations and problems. For VSIs: 1) AC output voltage cannot exceed the dc source voltage. So a dc-dc boost converter is placed before the VSIs for the application purpose. Alternatively, single-stage buck-boost inverter can be used like the Cuk, SEPIC and other similar dc-ac inverters. 2) Dead time is required to prevent the shoot-through of the upper and lower switching devices of each phase leg, it induces waveform distortion. Research in buck-boost inverter named as the Z-source inverter has grown rapidly with its modulation, dynamic control and sizing. It's application to motor devices, solar generation and electric vehicles using the same basic Z-source impedance network.

The Z-source network solutions are added extra inductors, capacitor and diodes for raising gain. It's not economically as amount of components are added. Then investigation continues using coupled inductors or transformers for gain boosting. So, they particularly use only one coupled transformer and one capacitor and there turns ratio is less as compare to previous network.

The proposed network used a voltage boosting by transformer and a capacitor. Their gain is raised by lowering their transformer turn's ratio, rather than increasing it. So far, this feature has not been matched by other Z-source circuits. Performance of the proposed circuits has been tested in the experiment.

## II. METHODS AND MATERIAL

### 2.1 Z-SOURCE INVERTER

The conventional Z-Source inverter has a unique X-shaped impedance network. This network allows switches from the same phase leg to be turned ON simultaneously without causing damages. In this network the shoot-through state created causes the inverter output to be boosted without distortion if it is used properly with the other eight non shoot-through active and null states.

In traditional Z-source network is a combination of two inductors and capacitors. The Z-source network is the energy storage/filtering elements for the Z-source

inverter. It provides a second order filter and is more effective to suppress voltage and current ripples Z-source is modified version of T-Z source network. In the conventional system, traditional Z-source network used R load in open loop system. As compared to T-Z source network the components is extra in conventional system and turns ratio is high at high gain.

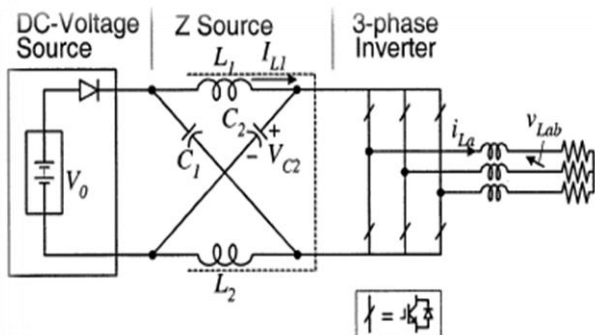


Figure 1: Traditional Z source inverter

$$\text{Loss in capacitor} = 2I^2R_2 \quad (2)$$

$$\text{Overall } \eta = \frac{P_0}{P_0 + \text{loss in IM} + P_L + P_C} \quad (3)$$

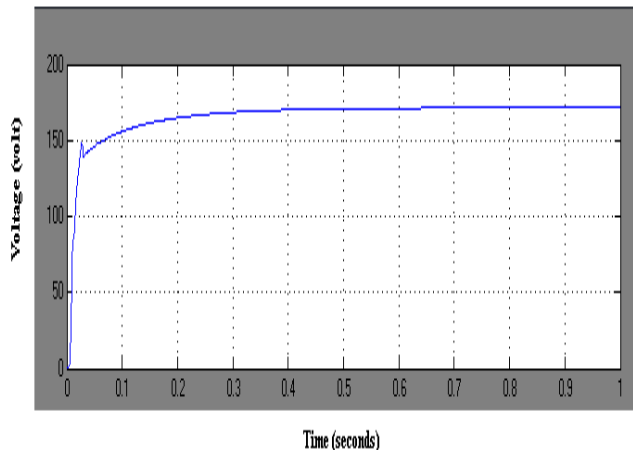


Figure 3: Z Source Output Voltage in Open Loop System

From the above given figure3 the conventional system results of Z source inverter voltage obtained as 171.32 volt in open loop system with R load. To improve the efficiency of system and to avoid the constraints, the trans-Z source or T-Z source inverter are proposed

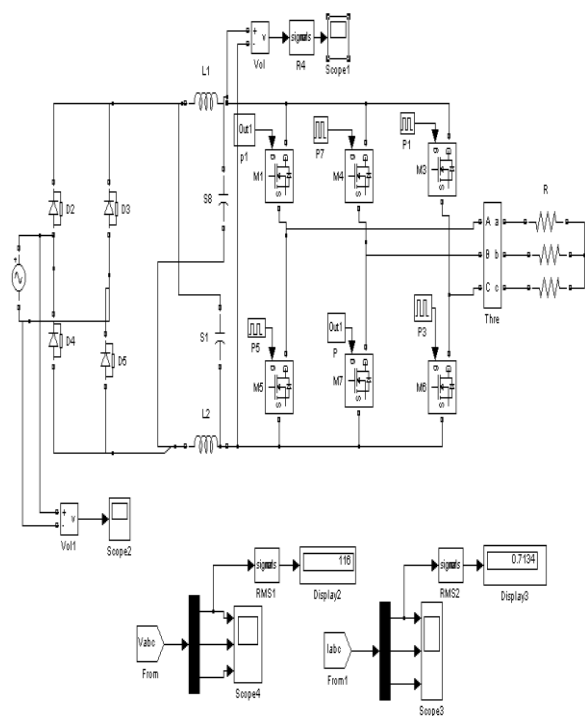


Figure 2: Conventional Network of Open Loop System

In the conventional system the loss of inductor is obtained as 1.37 watt and loss of capacitor is obtained as 2.7 watt. Therefore, the overall efficiency of conventional system is obtained as 79.3% which is mathematically calculated by using following equations.

$$\text{Loss in inductors} = 2I^2R_L \quad (1)$$

## 2.2 T-Z SOURCE INVERTER

The Trans Z source inverters with source placed in series diode is a voltage type T-Z source inverters are proposed in this letter. They use a unique T-shaped impedance network for boosting their output voltage in addition to their usual voltage buck behavior. The proposed inverters use lesser components and a coupled transformer for producing the high-gain and modulation ratio simultaneously. The gain can be tuned by varying the turn's ratio of the transformer within the narrow range of 1:2. This leads to lesser winding turns for high gain, as compared to other related topologies. T-Z source network is symmetric network and pole zero diagram is same as per the mathematical calculation is proved.

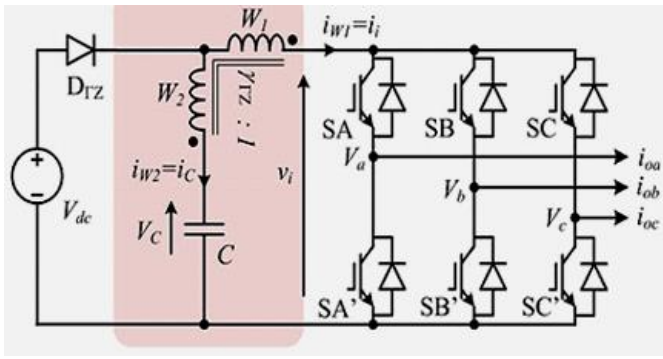


Figure 4: T-Z Source Inverter

$$V_a = \frac{V_1}{LCS^2 + 1} \quad (4)$$

$$V_b = \frac{V_1(LCS^2)}{LCS^2 + 1} \quad (5)$$

$$V_2 = V_a - V_b \quad (6)$$

$$V_2 = \frac{V_1}{LCS^2 + 1} (1 - LCS^2)$$

$$\frac{V_2}{V_1} = \frac{(S^2 - \omega^2)}{(S^2 + \omega^2)}$$

$$= \frac{(S + \omega)(S - \omega)}{(S + j\omega)(S - j\omega)} \quad (7)$$

To redesign the Z source network into T-Z source network in this proposed network the value of two inductances value is obtained as 0.02mH and capacitance value is obtained as 3000μF from the reference paper of Z source inverter by F.Z Peng the formula obtained as

$$L = \frac{V_i \delta}{f \Delta I} \quad (8)$$

$$C = \frac{\delta}{2fR'} \quad (9)$$

In the proposed system the loss of inductance value is obtained as 1.37watt, the loss of capacitance value is obtained as 1.37 watt and the overall efficiency of T-Z network is 79.5%.

The advantages of system which reduced voltage spikes and current spikes during conversion of T-Z source filter into three phase inverter circuit and voltage can be boosted by T-Z source filter. The applications of system are used to control the speed of induction motor and synchronous motor.

### III. RESULTS AND DISCUSSION

#### SIMULATION and MODEL RESULTS

The design of the proposed system is given below

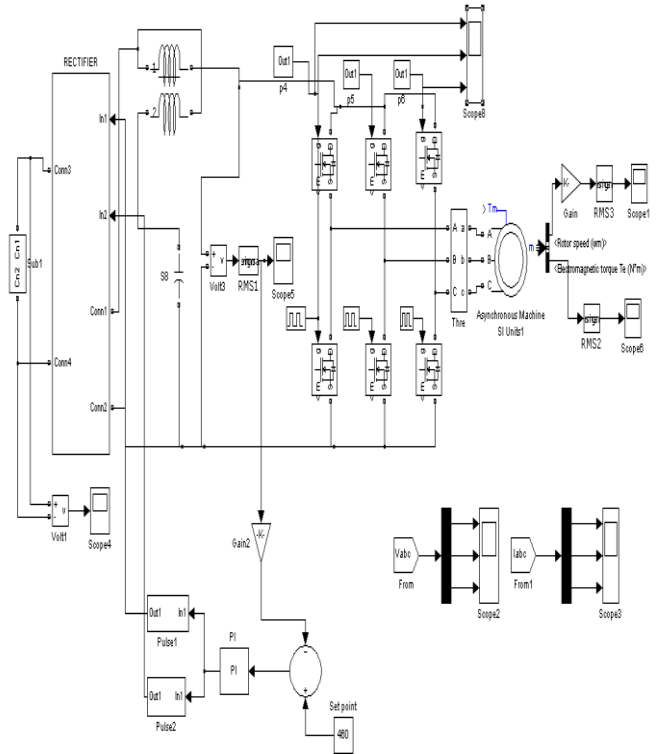


Figure 5: T-Z Source Network of Closed Loop System

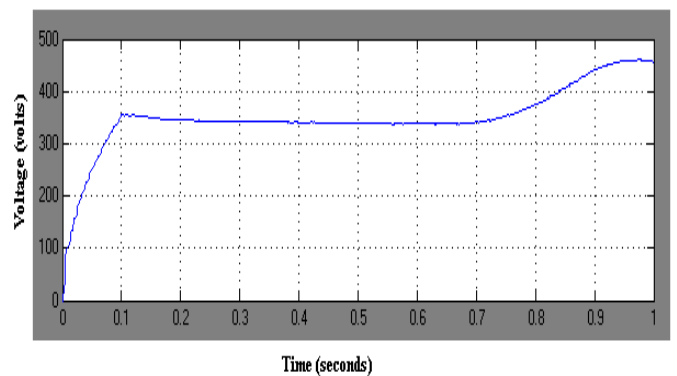


Figure 6: T-Z Output Voltage in Closed Loop System

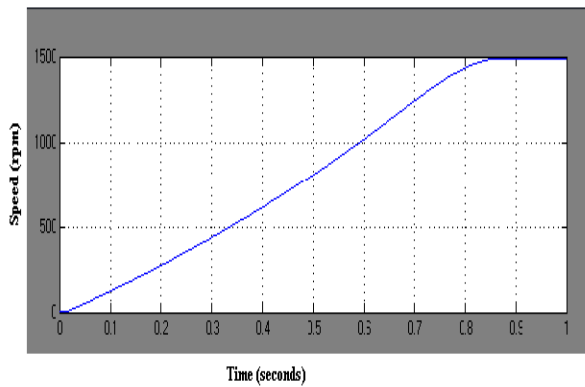


Figure 7: Output Speed of Induction Motor in Closed Loop System

In fig-6 the closed loop system of T-Z source inverter voltage obtained as 450 volt and in fig-7 closed loop system T-Z source inverter output speed of AC load obtained as 1500 rpm.

#### IV. CONCLUSION

The proposed system output voltage from the three phase inverter to run the AC load with the help of T-Z source filter to boost up the voltage as compare to conventional system which is mathematical and simulation proved. Conventional network of open loop is obtained an unfiltered AC voltage as 171.32 volt and closed loop is not performed. In proposed system of closed loop is obtained as output voltage as 450 volt using PI controller and output speed is 1500 rpm.

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