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Design and Implementation of Three Phase Γ-Z Source Inverter for Asynchronous Motor

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Abstract

A new setup of single-stage high step-up boost voltage inverter based on transformer is proposed in this paper called Γ-Z source inverters. With this proposed technique, a high-performance output voltage control can be achieved with an excellent transient performance of voltage gain when the turn ratio of the transformer is larger than one. Compared to the normal Z source inverter, the proposed Γ-Z source inverter uses a lower turn's ratio, which reduces the transformer's size and weight while producing the same output voltage gain. Γ-Z network is used to boost the voltage and DC is converted into three phase balanced AC using three phase inverter. The proposed inverter topology to DC link type and embedded type topologies are presented in this paper.

Index Terms: Trans-Z-source, Z-source, Γ-Zsource inverters.

1. Introduction

Traditional voltage-source inverter (VSIs) are perform only step down voltages and having some limitations and problems. For Voltage source inverters 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. Secondly Dead time 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.

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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.

2. Z-Source Inverter

The conventional Z-source inverter has a unique X-shaped impedance 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.

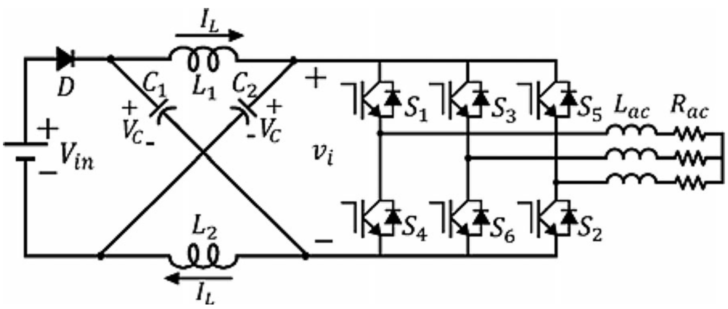

Fig. 1: Traditional Z-source inverter.

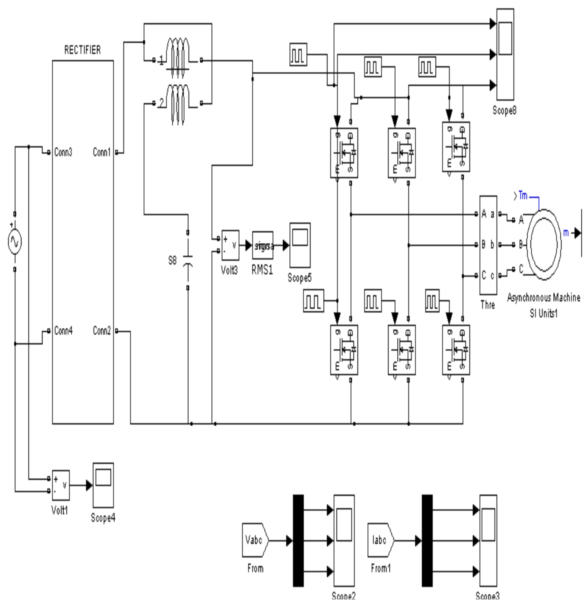

Fig. 2: Conventional Network of Open Loop System.

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 **Γ**-Z source network used R load in open loop system. As compared to **Γ**-Z source network the components is extra in conventional system and turns ratio is high at high gain.

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.

Loss I inductors

$$2I^2R_L \tag{1}$$

Loss in capacitor

$$2I^2R_2 \tag{2}$$

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

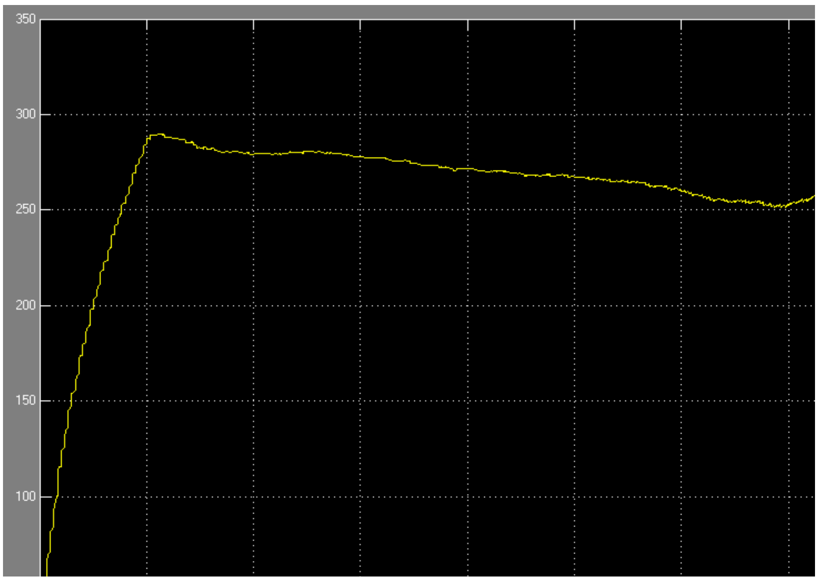

Fig. 3: Z Source output voltage in Open Loop System.

From the above given figure3 the conventional system results of Z source inverter voltage obtained as 170 volt in open loop system with R load. To improve the efficiency of system and to avoid the constraints, the trans-Z source or **Γ**-Z source inverters are proposed.

3. Γ-Z Source Inverter

The Trans Z source inverter with source placed in series diode is a voltage **Γ**-Z type source inverter are proposed in this letter. They use a unique **Γ**–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. **Γ**-Z source network is symmetric network and pole zero diagram is same as per the mathematical calculation is proved.

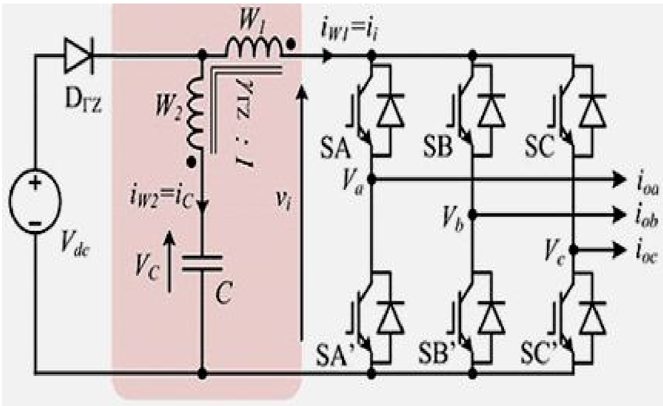

Fig. 4: **Γ**-Z source Inverter.

$$V_a = \frac{V_1}{LCS^2 + 1} \tag{4}$$

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

$$V_2 = V_a - V_b$$

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

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

$$= \frac{(S+\omega)(S-\omega)}{(S+j\omega)(S-j\omega)} \tag{6}$$

To redesign the Z source network into Γ-Z Source network in this proposed network the two inductance value is obtained as 0.002mH and capacitance value is obtained as 3000μF from the reference paper of Z source inverter by F.Z Peng the formula obtained as

$$L = \frac{\frac{V\,\delta}{i}}{f\ \Delta I} \tag{7}$$

$$C = \frac{\delta}{2\ fR'} \tag{8}$$

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

The advantages of system which reduced voltage spikes and current spikes during conversion of Γ-Zsource filter into three phase inverter circuit and voltage can be boostered by Γ-Z source filter. The application of system is used to control the speed of induction motor **and** synchronous motor.

4. Simulation Model And Result

The design of the proposed system is given below

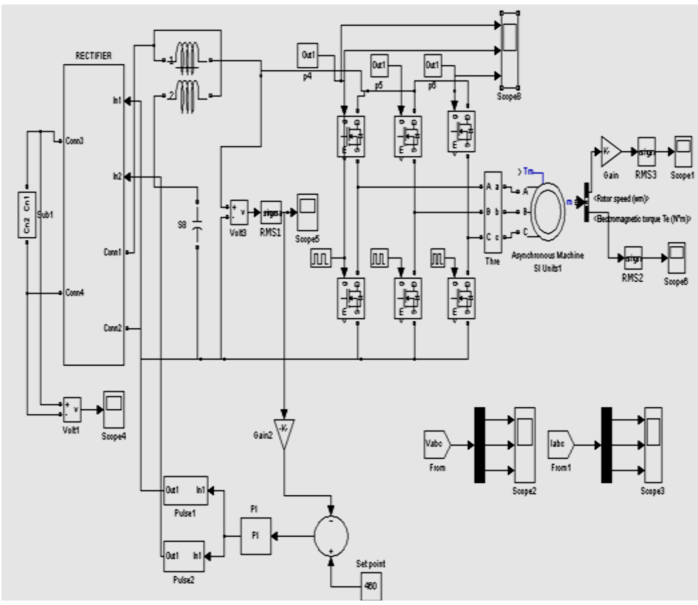

Fig. 5: Γ-Z Source Network of Closed Loop System

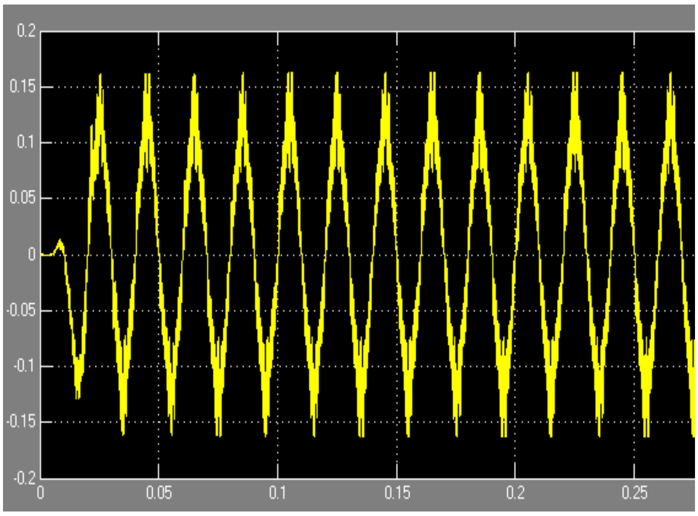

Fig. 6: Proposed system Output Voltage in Closed Loop.

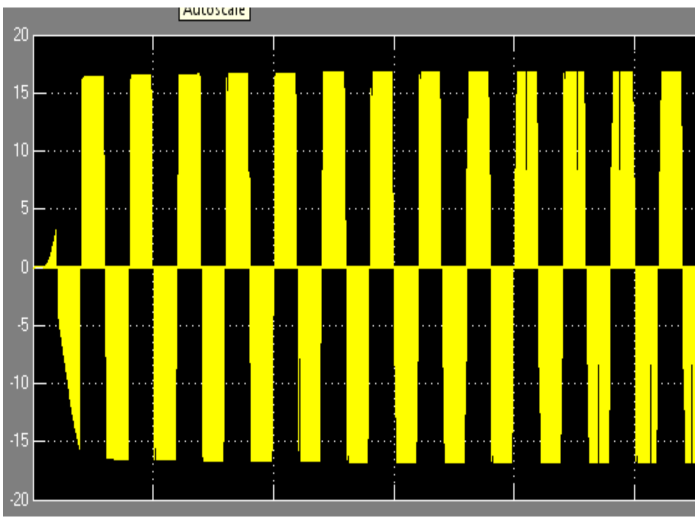

Fig. 7: Output voltage of asynchronous Motor in Closed Loop System.

5. Conclusion

Thus the above proposed system it known that the output voltage is improved by using Γ-Z Source inverter. when the conventional system is compared with the proposed system ,it neglected shoot-through effect towards the conversion technique without distortion. Hare with the simulation results from the mat lab environment and mathematical calculation of inductor and capacitor clearly discussed for the proposed system. Additionally the closed loop results of output voltage for asynchronous motor using PI controller present in this paper. Finally that the speed control of asynchronous motor attain 1500 rpm and controlled using Γ-Z source inverter.

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