Improved Z Source Inverter Performance with Reduced Z-Source Voltage Stress and Current Mechanism Using Buck and Boost Approach

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Abstract:- This paper presents a novel topology of Z-source inverter which can control the velocity of induction motor. The objective of our proposed topology is to improve the performance of Z-source inverter (ZSI) by reducing the voltage stress throughout the capacitors present in the impedance network. Therefore the voltage range of the Z-source capacitors is reduced which also reduces the cost of the proposed Z-source network topology. The ZSI is combined with an additional feature called buck and boost. Thus, it is otherwise known as buck-boost inverter. The proposed topology can effectively reducethe capacitor voltage which increases the efficiencyof the Z-source circuit. When compared to conventional Z-source inverter, our proposed topology is low cost with smaller in size and weight. The operational principle, proposed protocol and parameters design are discussed in detail. Experimental results are given to analyze the performance of proposed Z-source topology.

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1. Introduction

The Z-source inverter is a type of single stage converter which can either buck or boost the output ac voltage from a dc power supply. The limitations of conventional Voltage Source Inverter (VSI) and Current Source Inverter (CSI) are overcome by this Z-source inverter topology where in VSI and CSI the ac voltage output is either less or more than the dc voltage input. Thus, the combined operation of voltage source and current source inverters are performed by the Z-source inverter which can eliminate the requirement of a separate dc-dc converter. Therefore, it increases the performance of the circuit with reduced cost. The Z-source inverter also eliminates the shoot through fault by allowing two switches of the same leg that is to be operated in the same circuit. The elimination of shoot through fault is considered as an important feature of Z-source inverter which provides dead time elimination of the circuit. By eliminating the dead time, the output distortion is reduced and the reliability is increased in the inverter circuit. The traditional Z-source inverter has some other operating problems such as (i) the measure of voltage across the capacitors is equal to the measure of input voltage of the circuit which increases the intensity and cost of the capacitors. (ii) the startup voltage and current in the inverter circuit is so high that may dismantle the circuit devices at anytime. In order to overcome the above problems in conventional Z-source inverter, a novel topology of Z-source inverter is proposed which is used to drive and control the speed of the induction motor.

Recently proposed Z-source inverter has attracted extensive attention of many researchers owing to its significant merits like: (i) it does not require any dc-dc converter to boost the voltage drawn from dc supply in order to produce ac output voltage which is greater than the input dc voltage. (ii) it ignore the shoot-through trouble produced by the electromagnetic interference (EMI). (iii) it can remove the harmful influence provoked by dead-time of the circuit switches owing to the creation of Z-source network.

The conventional Z-source inverters has the following drawbacks (i) it provides poor load balancing capacity when the circuit is operated with small inductance of the Z-source inductor. While considering the peak voltage the dc supply produces infinitely increasing voltage and distortions present in the dc voltage when the inverter circuit is operated with low power factor or light load and small inductance. This produces uncontrollable output voltage that leads to unstable system. (ii) it has the complication in the selection of circuit capacitors since the voltage stress across the capacitors are too high which builds the entire system much heavier and also larger. (iii) it has too large amount of startup inrush current.

2. Proposed System

Z-SOURCE INVERTER- CAPACITOR MODEL

The major operation of inverter circuit is to produce ac output voltage from dc power supply and the Z-source consist of a unique impedance network which comprises of two identical capacitors and inductors C1, C2 and L1, L2 respectively. These identical capacitors and inductors are coupled the power supply circuit to the Z-source inverter circuit.
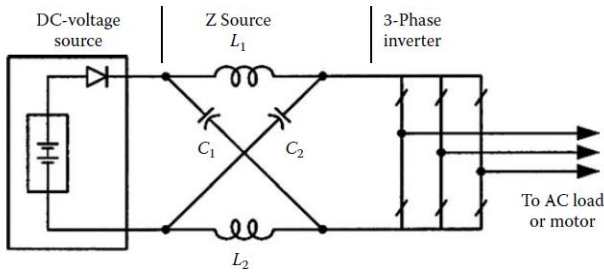
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Fig 1 Z-Source Inverter

The shoot-through problem occurs when any two switches of the same semiconductor are mistakenly turned on at the same time, inducing extremely high current flow which may destroy the entire circuit or device. This shoot through trouble is overcome by the Z-source inverter by allowing any two switches of the same leg that is to be gated in the same circuit. It does not require any dc-dc converter to boost the output voltage. The shoot through period is defined as the time period when the switches of the same semiconductor leg to be gated, permits the operation of voltage boost to the required level while the input dc voltage is low. The ZSI can operate as both buck-boost inverters unlike the traditional VSI and CSI.

(i)   Inrush Current at Startup:

At the start-up of Z-source inverter, a huge inrush current is present and the initial voltage throughout the capacitors (C1 and C2) is zero. This huge inrush immediately charges the capacitors up to 0.5V. Subsequently, the capacitors and inductors resonance starts that leads to large current and voltage surge. This topology cannot attain the soft-start capacity since it has inherent current path at the inverter start-up.
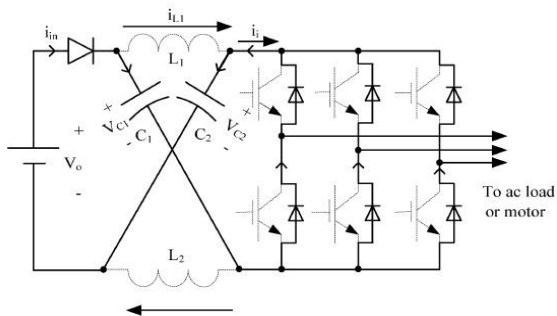

Fig 2 Improve Z-Source Inverter

(ii)   Merits of the proposed topology

(i)   The voltage polarity of the Z-source capacitors remains same in order to provide similar voltage boost capacity with minimized voltage stress across the capacitors.

(ii)   The proposed topology effectively reduces the inrush current at start-up because there is no path is present for current start-up.

(iii)   Control Methods for Z-Source Inverter:

As compared with conventional voltage source and current source inverters, the Z-source inverter features an additional switching state called shoot-through state. The output voltage across the load terminals becomes zero when the Z-source inverter circuit performs shoot-through state which is same as the traditional zero vector states. For inverter circuits, it is necessary to preserve the sinusoidal output voltage by maintaining the active-state duty cycle and turn few or entire zero states into shoot through state.

(iv)   Simple Boost Control:

The simple boost control mechanism requires two straight lines in order to control the shoot through states and the circuit enters into shoot through state when the output waveform (triangular) is greater than the upper envelope (or smaller than lower envelope). If the shoot through problem does not occur, the circuit functions just as Carrier-based Pulse Width Modulation (PWM). This type of boost control is very simple but the resulting output voltage stress across the circuit is comparatively so high since the circuit does not utilize few of the traditional zero states.

(v)   Maximum Boost Control:

In order to minimize the voltage stress throughout the device, it is necessary to utilize all the zero states present in the circuit and this maximum boost control mechanism turns all the zero states into shoot through state. The range of modulation index is extended by the utilization of third harmonic injection. Thus, this turning of shoot-through state can reduce the voltage stress and this makes the variation of shoot-through duty cycle ratio in line cycles. As a result, the inductor receives current with ripples which may involve high inductance for variable or low-frequency applications.

APPLICATIONS

(i)   Photovoltaic systems
(ii)   Fuel cell
(iii)   Vehicular applications

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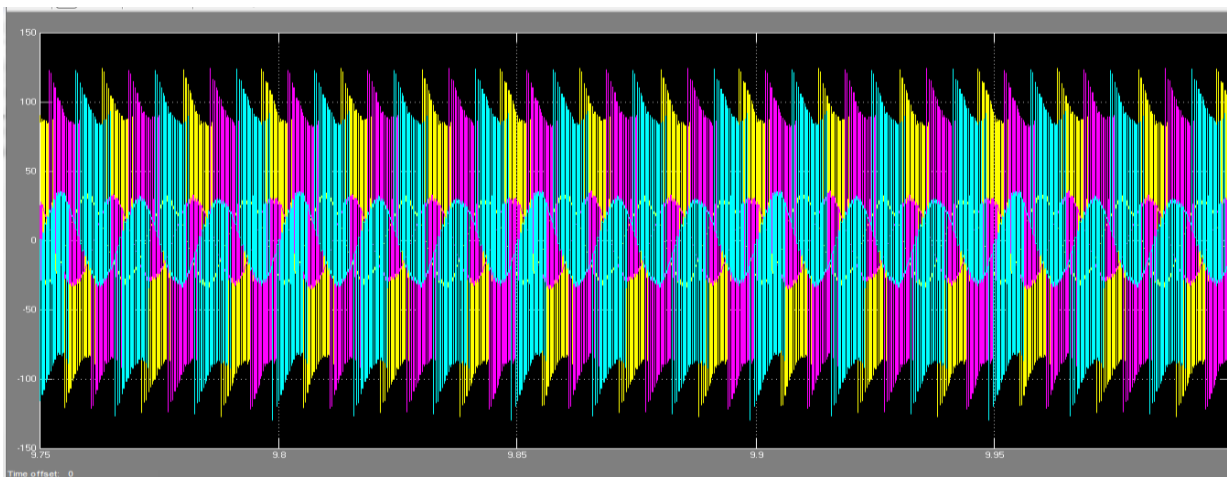### 3. Experimental Results

Fig 3 :Z-Inverter Voltage and Current Measurement
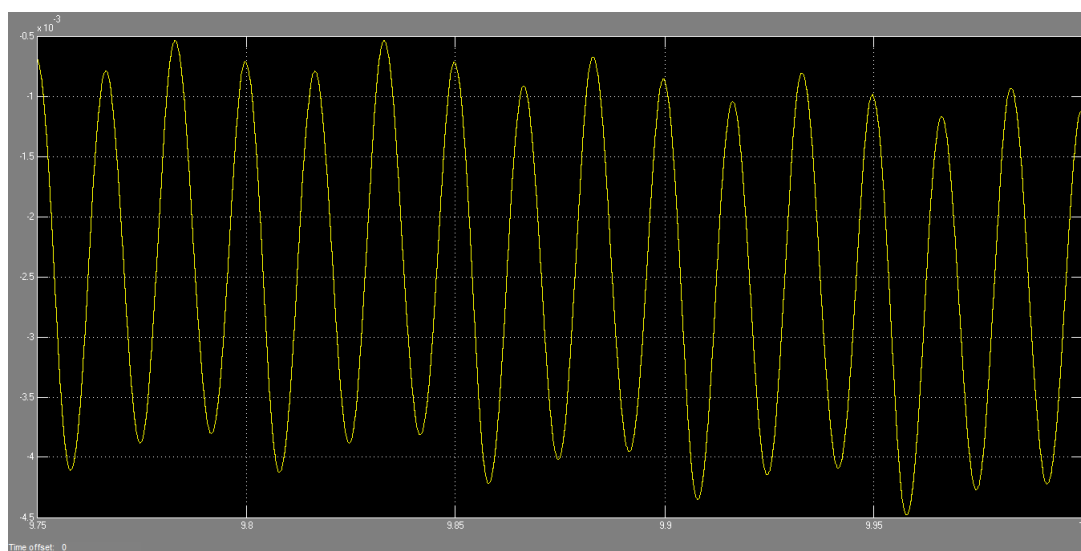

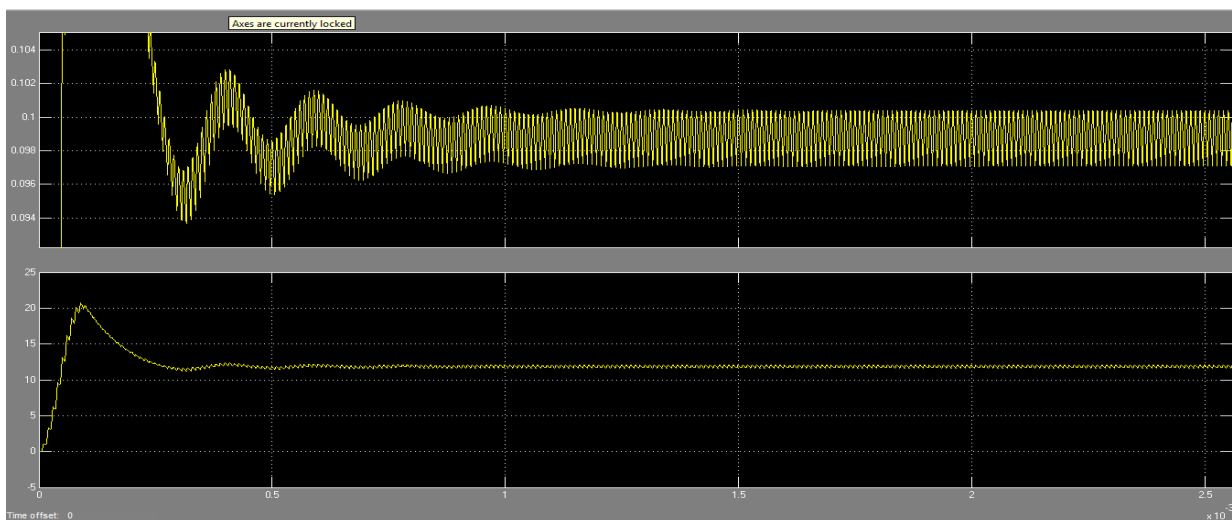**Fig 3 :Ac voltage output from Z source network via the inverter.**

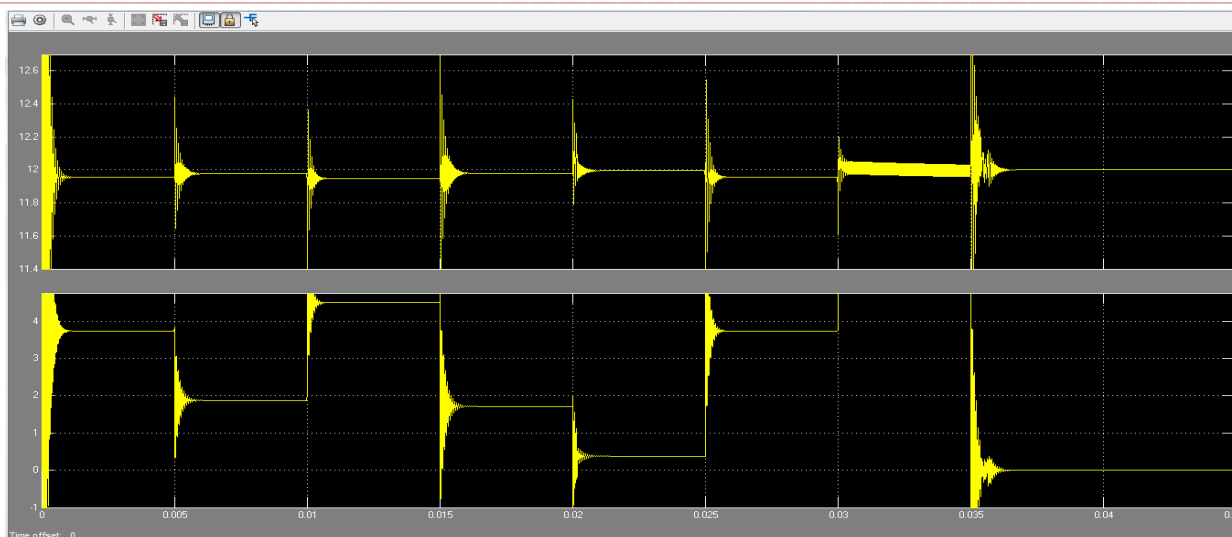**Fig 4 Z-Source Inverter Boost Control**

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Fig 5 Output Voltage Inductor Current

4. CONCLUSION

Thus, this paper has presented a novel topology of Z-source inverter that can effectively control the speed of the induction motor. The proposed topology greatly reduces the voltage stress across the Z-source capacitors to accomplish same boost capability. Therefore low voltage capacitors are used which can reduce the cost and intensity as well. This proposed Z-source topology has perfect soft-start approach which can avoid the inrush current start-up and reduces the capacitors and inductors resonance. Experimental and simulation result shown the performance improvement of proposed topology.

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