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FUZZY LOGIC CONTROLLED BASED Z SOURCE MULTILEVEL INVERTER FED INDUCTION MOTOR FOR POWER QUALITY ENHANCEMENT

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Abstract: In this project an attempt is being made on to present critical literature review and up-to-date and exhausts bibliography on the capacitor element in the Dynamic Voltage Restorer (DVR). Various rating and sizing concerning the capacitor in the DVR power circuit problem have been highlighted. The Dynamic Voltage Restorer (DVR) is series-connected power electronics based device. It provides technically advanced and economic solution to compensate voltage sag in both transmission and distribution systems. DVR output is determined according to the degree of disturbance in supply voltages. Sag compensation is achieved by injecting the required power into the line through DVR injection transformer. A variety of energy storage devices are used in DVR power circuit for supplying the input to inverter. The most important task for the Power companies is to maintain the quality in the power, in order to satisfy the consumer needs. The power quality (PQ) disturbances from the source side are the voltage sag, swell, notch, spike and transients etc. There are various methods for the compensation of voltage sag and swell. To solve this problem, custom power devices are used. In this project, Z-source inverter, based DVR topology is used that has several advantages regarding cost, reliability and simplicity. Power quality has obtained more attention in recent years due to growth in using industrial sensitive loads. Voltage sag is one of the most important power quality issues that occur in the shape of sudden voltage fall, which happens greatly due to short circuit fault. There are several solutions to this problem and DVR is the most effective of them (for load voltage control and compensation). DVR consists of a converter, energy storage device and a transformer to inject the appropriate voltage to clear the power quality problems. The simulation results of the proposed DVR system are demonstrated. Finally fuzzy logic controller is proposed to further improve the performance of DVR.

Key words**—**harmonics, voltage sag, voltage swell, motor drives, voltage sags, Z-source inverter.

I. Introduction

To overcome the problems of the traditional Voltage and current source converters, this paper presents an impedance source (or impedance-fed) power converter (abbreviated as Z-source converter) and its control method for implementing dc-to-ac power conversion. It employs a unique impedance network (or circuit) to couple the inverter main circuit to the power source for providing unique features that cannot be observed in the traditional Voltage and current source converters where a capacitor and inductor are used, respectively. The Z-source converter overcomes the above-mentioned limitations of the traditional Voltage and current source converter and provides a novel power conversion concept. Switches used in the converter can be a combination of switching devices and diodes such as the anti parallel combination, the series combination etc. The Z-source concept can be applied to all dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversion. To describe the operating principle and control, this paper focuses on an application example of the Z-source converter: a Z-source inverter for dc-ac power conversion needed for fuel-cell applications. The diode in series with the dc source is for preventing reverse current flow. The application of adjustable-speed drives (ASD's) in commercial and industrial sectors is increasing due to improved efficiency, energy savings, and process control. The traditional adjustable-speed drives system is based on the voltage-Source inverter, which consists of a diode rectifier frond end, DC link capacitor and Inverter Bridge. The new technology is used in adjustable-speed drive system based on Z-source inverter. The V-source inverter based adjustable speed drive system has certain limitations and problems they are i) Obtainable output is limited quite below the input line voltage, ii) Voltage Sags can interrupt an adjustable speed drive system and shut down critical Loads and processes, iii) Performance and reliability are compromised by V-source inverter structure. The Z-source inverter system employs a unique LC network in the DC link and a small Capacitor on the AC side of the diode front end. By controlling the Shoot-through duty cycle, the Z-source can produce any desired output AC voltage, even greater than the line voltage. The new Z-source inverter system provides ride-through capability during voltage sags, reduces line harmonics, improves power factor and reliability, and extends output voltage range. The Z-source inverter based adjustable speed drive system has certain limitations and problems they are i) The Z-source network inductor has the limited value to guarantee the input current Iin>0. In some

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applications, the inductance should be minimized in order to reduce cost, volume, and weight. The design of Z-source network inductor and system control become very complex, and the output voltage becomes uncontrollable with small inductor even operate in full load. ii) Light-load operation is the problem in Z-source inverter based adjustable speed drive system. The DC-link voltage is increasing infinitely when the system is operated with light load. The DC-link voltage will be uncontrollable and the system is unstable. The original Z-source inverter adjustable speed drive system cannot obtain the high performance due to its light-load operation limitation.

II. Types Of Inverters

There are three basic types of inverters commonly employed in adjustable AC drives system i) voltage source inverter ii) current source inverter iii) Z-source inverter.

The variable voltage inverter (VVI), or square-wave six-step voltage source inverter (VSI), receives DC power from an adjustable voltage source and adjusts the frequency and voltage. The current source inverter (CSI) receives DC power from an adjustable current source and adjusts the frequency and current. Z-source inverter is the combination of voltage source inverter and current source inverter.

1. Voltage-Source Inverter

Fig.1 shows the three-phase voltage-source inverter structure. A DC voltage source supported by a relatively large capacitor feeds the 3-phase inverter circuit. The DC voltage source can be a battery, fuel-cell stack, diode rectifier, and/or capacitor. Six switches are used in the main circuit each is traditionally composed of a power transistor and an anti-parallel (or freewheeling) diode to provide bidirectional current flow and unidirectional voltage blocking capability. It has certain limitation of the voltage source inverter. The AC output voltage is limited below and cannot exceed the DC voltage. The V-source inverter is a buck (step-down) inverter for DC-to-AC power conversion.

The upper and lower devices of each phase leg should not be gated on simultaneously because a shoot-through would occur and destroy the devices. The shoot-through problem by electromagnetic interference (EMI) noise's misgating-on is a major killer to the converter's reliability.

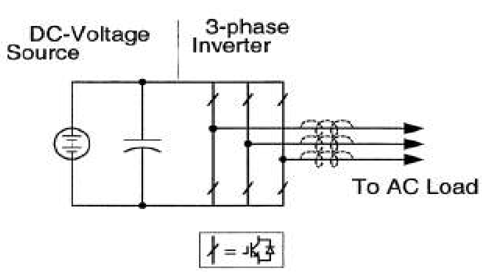

Fig.1. Voltage-source inverter

2. Current-Source Inverter

Fig.2 shows the three-phase current-source inverter structure. A DC current source feeds the 3-phase inverter circuit. The DC current source can be a relatively large DC inductor fed by a voltage source such as a battery, fuel-cell stack, diode rectifier, or thyristor converter. Six switches are used in the main circuit each is traditionally composed of a semiconductor switching device with reverse block capability such as a gate-turn-off thyristor (GTO) and SCR or a power transistor with a series diode to provide unidirectional current flow and bidirectional voltage blocking.

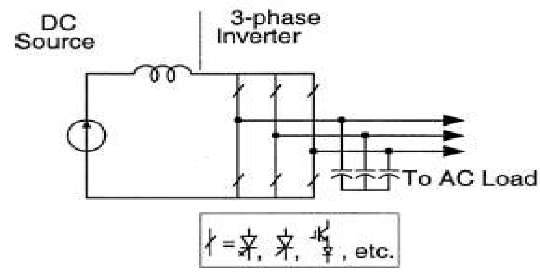

Fig.2. Current-source inverter

The current source inverter has certain Limitations of the AC output voltage has to be greater than the original DC voltage that feeds the DC inductor or the DC voltage produced is always smaller than the AC input voltage. The I-source inverter is a boost inverter for DC-to-AC power conversion. At least one of the upper devices and one of the lower devices have to be gated on and maintained on at any time. Otherwise, an open circuit of the DC inductor would occur and destroy the devices. The open-circuit problem by EMI noise's misgating-off is a major concern of the inverters reliability. The main switches of the I-source inverter have to block reverse voltage that requires a series diode to be used in combination with high-speed and high-performance transistors such as insulated gate bipolar transistors (IGBTs). This prevents the direct use of low-cost and high-performance IGBT modules and intelligent power modules (IPMs).

3. Z-Source Inverter

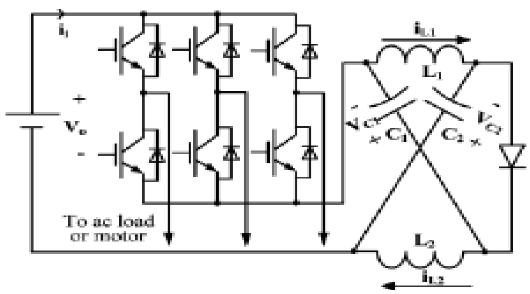

Fig.3. General Structure of the Z-Source inverter

Z-source inverter is the combination of voltage source inverter and current source inverter. A two-port network that consists of a split-inductor L1 and L2 and capacitors C1 and C2 connected in X shape is employed to provide an impedance source (Z-source) coupling the inverter to load, or another converter. Switches used in the inverter can be a combination of switching devices and diodes such as the anti-parallel combination as shown in Fig.1.The series combination as shown in Fig. 2.

The Z-source inverter intentionally utilizes the shoot through zero states to boost DC voltage and produce an output voltage greater than the original DC voltage .At the same time, the Z-source structure enhances the reliability of the inverter greatly because the shoot through states that might be caused by EMI noise can no longer destroy the inverter. For the traditional V-source inverter, the DC capacitor is the sole energy storage and filtering element to suppress voltage ripple and serve temporary storage. For the traditional I-source Inverter, the DC inductor is the sole energy storage/filtering element to suppress current ripple and serve temporary storage. The Z-source network is a combination of two inductors and two capacitors. This combined circuit, the Z-source network is the energy storage/filtering element for the Z-source inverter. The Z-source network provides a second-order filter and is more effective to suppress voltage and current ripples than capacitor or inductor used alone in the traditional inverters. Therefore, the inductor and capacitor requirement should be smaller than the traditional inverters. The Unique features of Z-source inverter are i) it's the buck-boost function by one stage conversion. ii) Immunity to EMI noise and misgating (i.e., misgating on and off by EMI noise will not destroy the inverter).iii) Low or no in-rush current compared with the V-inverter and has low common mode noise.

III. Proposed High-Performance Z-Source Inverter Adjustable Speed Drives System

The Fig.4 (A) Block diagram of Z-source inverter adjustable speed drives system (open loop).The Fig.4 (B) shows the block diagram of proposed high-performance Z-source inverter ASD system (closed loop). It consists of AC source, diode rectifier, IGBT switch, Z-source network, three phase inverter, AC motor, gate pulse generator and PWM controller.

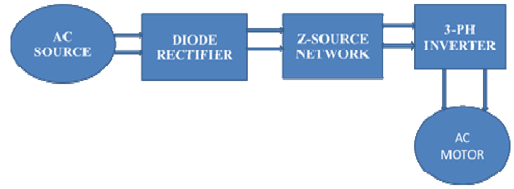

Fig. 4(A).Block diagram of z-source inverter adjustable speed drive system (open loop)

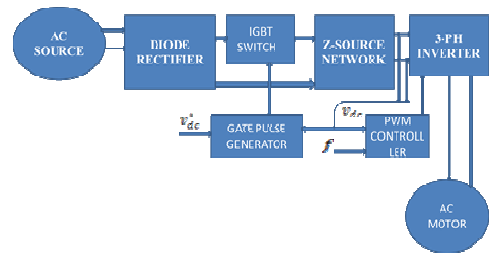

Figure 4 (B) Block diagram of proposed high-performance Z-source inverter adjustable speed drive system (closed loop).

IV. Matlab/Simulink Results

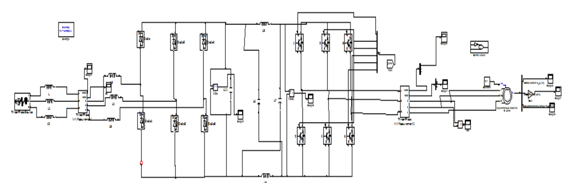

Fig.5. Matlab/ Simulation of IM for conventional z-source inverter

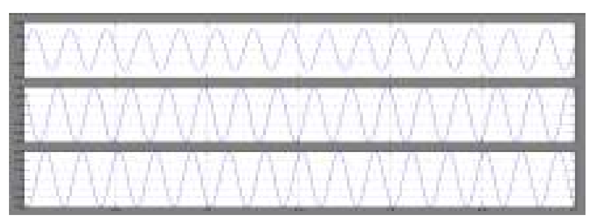

Fig.6.simulation of AC input waveform

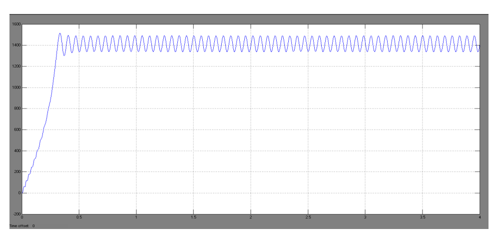

Fig.7. Induction motor operated at 1500rpm (no-load)

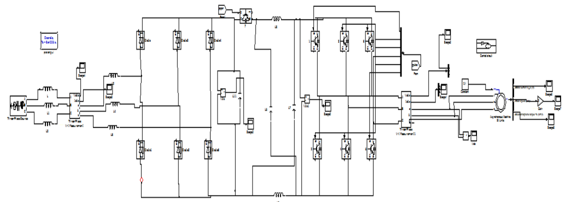

Fig.8.Simulation of IM for proposed high performance z-source inverter

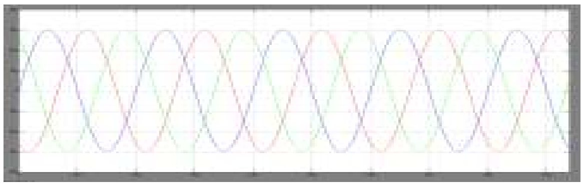

Fig.9.simulation waveform of Three phase current

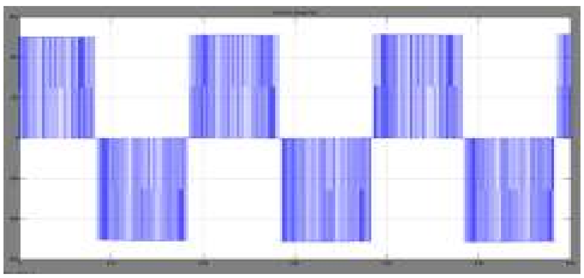

Fig.10.simulation waveform of Line voltage

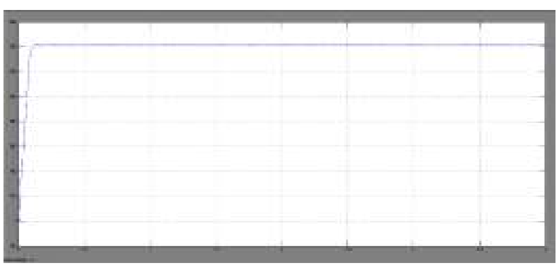

Fig.11.simulation of Induction motor operated at 1500rpm

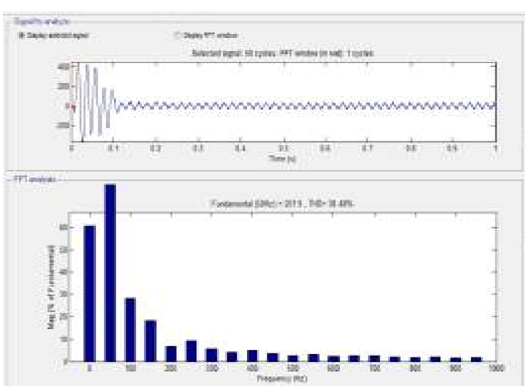

Fig.12. THD analysis of conventional inverter

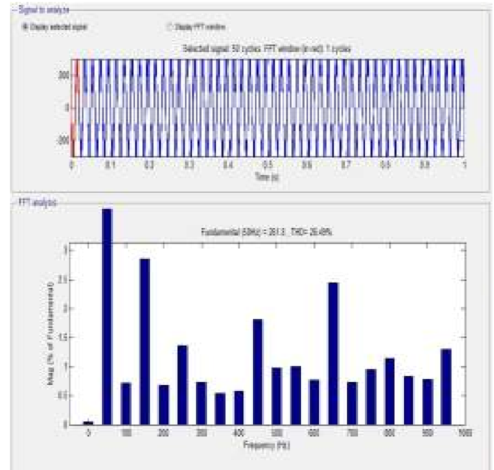

Fig.13. THD analysis of proposed inverter

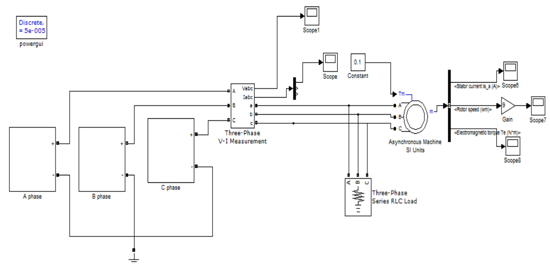

Fig.14.Implementation of 7-level z-source inverter with induction motor drive

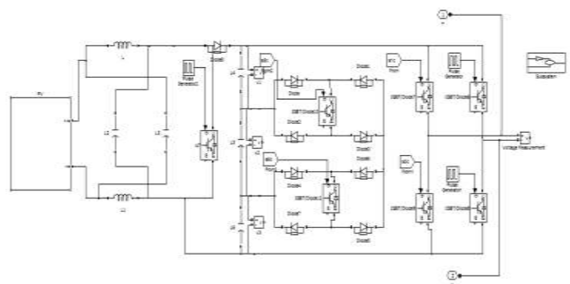

Fig.15.Sub circuit 7-level inverters

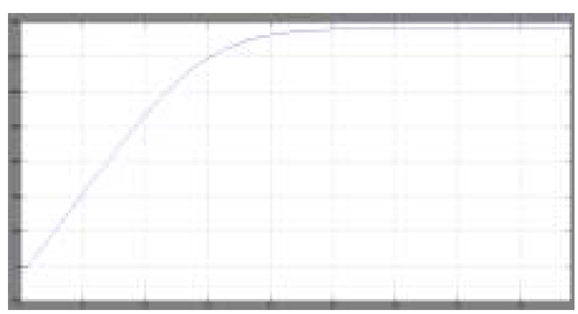

Fig.16.Induction motor operated at 1400rpm speed

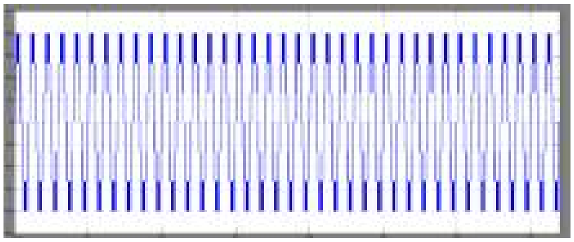

Fig.17 simulation of voltage waveform of seven level inverter

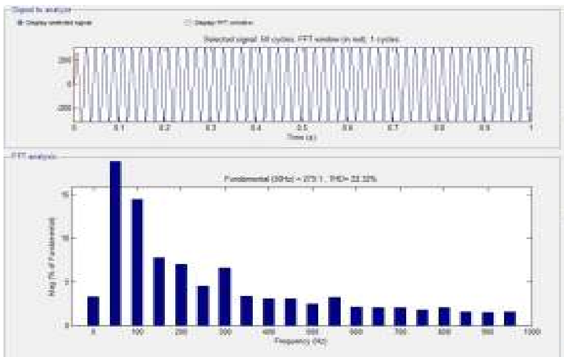

Fig.18. THD analysis of proposed seven level inverter

V. Conclusion

A new multilevel inverter based Z-source inverter fed induction motor is designed and implemented. It can overcome limitations of conventional Z-source inverter system. We can observe that the quality of voltage and current waveforms increases with voltage level. The notches in the current and voltage waveforms reduce with increase in voltage level. Finally by varying the modulation indexes output voltage is increased and the output current ripple is decreased. Thus comparing the results it is observed that harmonic content has also been predominantly reduced and drives performance is improved.

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