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Simulation of Z-Source Inverter Fed Induction Motor Drive

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Abstract- The Z-source inverter system is control for general-purpose motors and motor drives. The Z-source inverter system employs a unique LC network in the dc link. By Regulating the shoot-through duty cycle, power deliver source can produce any desired output ac voltage, alike greater than the line voltage . As a result, the new source inverter system provides ride-through capability under voltage sags, reduces line harmonics, improves power factor and reliability, and extends output voltage range. The Z-source inverter is an optional energy conversion topology that can both buck and boost the input voltage using passive components. With its unique structure, Z-source inverter can utilize the shoot through states to boost the output voltage, which improves the inverter reliability greatly, and provides an attractive single stage dc to ac conversion that is able to buck and boost the voltage. This paper focuses on study of model of Z-source inverter followed by their harmonics study as compared to traditional inverters i.e. voltage and current source inverter.

Index Terms - Voltage Source Inverter (VSI), Current Source Inverter (CSI), Z Source Inverter (ZSI.

1. INTRODUCTION

Inverters are the dc to ac converters. The input dc supply is either in the form of voltage or current is converted in to variable output ac voltage. The output ac voltage can be handle by varying input direct current source or by varying the gain of the inverter. There are two types of traditional inverters based on input source used in industries for variable speed drive and many other applications; those are a) Voltage-source inverter and b) Current-source inverter.

Figure.1 shows the traditional three-phase voltage-source inverter [10]. The direct current voltage source connected at the input side across a large capacitor.

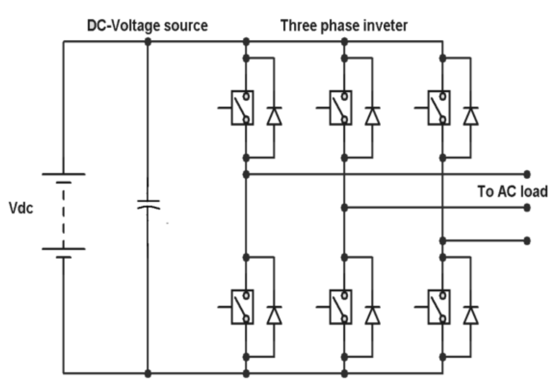

Fig.1.Traditional voltage source inverter.

DC link voltage produced across this capacitor feeds the main three-phase bridge. The input dc supply can be a battery or fuel cell stack or diode rectifier, and/or capacitor. Three phase bridge inverter circuit consists of six switches; each is composed of a power transistor and an anti-parallel diode to provide bidirectional current flow and reverse voltage blocking capability.

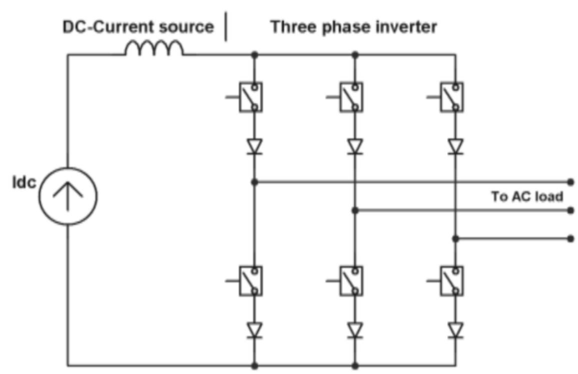

Fig.2.Traditional current source inverter.

Figure 2 shows the traditional current-source inverter (CSI). The DC current Power source is formed by a large dc Inductor fed by a voltage source such as a battery or fuel-cell stack or diode rectifier or converter etc. Like VSI three phase bridge inverter circuit consists of six switches; each is composed of a

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switching device with reverse block capability such as a gate-turn-off thyristor and SCR or a power transistor with a series diode to provide one direction current flow and two direction voltage blocking. For voltage supply electrical converter and current supply electrical converter the on/off time the switch devices is management led by applying management voltage (PWM) to the management terminal i.e. gate of the device generally in most of industries these voltage-source electrical converter and current-source electrical converter square measure employed in adjustable speed drives. . however these ancient inverters have several limitations as summarized below:

1) they're either a buck or a lift device [2] and can't be a buck–boost device. That is, the output voltage is either higher or lease giver than the input voltage. The output voltage of voltage supply electrical converter is usually less than input voltage thus it's referred to as a buck inverter; therefore extra voltage booster circuit has to be added. whereas for current supply electrical converter the output voltage is usually larger than input voltage thus it's referred to as a voltage-source electrical converter main circuit can not be used for the curreoost electrical converter, therefore extra transformer circuit has to be added . This will increase extra element price.2) For VSI and CSI main bridge electrical converter circuits can't be interchangeable. In different words the voltage-source electrical converter or contrariwise. 3) The shoot-through downside for Voltage supply electrical converter and electric circuit downside for current supply electrical converter by magnetism interference (EMI) sound cut back the inverter's reliableness.. In case of voltage supply electrical converter each higher and lower transistor mustn't be switched on at the same time, otherwise it'd cause shoot-through, which can harm electrical converter circuit as a result of giant current. therefore dead time to dam each higher and lower devices has to be provided within the V-source electrical converter, that causes wave form distortion.4) In case of current supply electrical converter each higher and lower transistors shouldn't be shifted at the same time, otherwise it would cause open circuit along the bridge arm, which may damage inverter circuit due large voltage drop across open circuit. Hence overlap time wherever each higher and lower devices conduct at the same time has to be provided for safe operation, which causes waveform distortion.

2. Z SOURCE INVERTER

To overcome the issues related to the normal voltage supply and current supply inverters, this paper presents Associate impedance-source electrical converter (abbreviated as Z-source inverter) and its management methodology for implementing dc-to-ac, ac-to- dc, ac-to-ac, and dc-to-dc power conversion. Figure. three shows the overall structure of Z-source electrical converter [3].

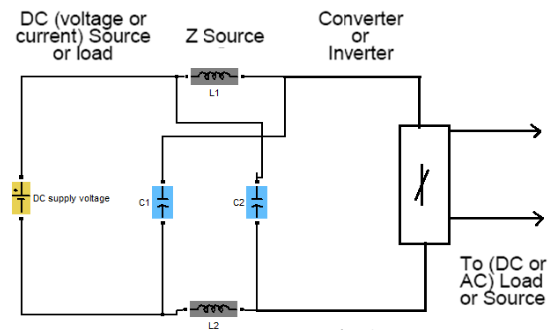

Fig.3. Z Source Inverter 1.

The traditional voltage and current supply electrical converter has six active vectors (or change states), once the dc voltage is affected across the load, and 2 zero vectors once the load terminals ar shorted through either the lower or higher 3 devices. Theses total eight change states and their combos have resolved several PWM management schemes. The Z-source electrical converter has a further zero vector, the shoot through change state, that is proscribed within the ancient voltage and current supply inverters. the way to insert this shoot through state becomes the key purpose of the management ways [4-6]. it's obvious that in the shoot through state, the output terminals of the electrical converter ar shorted and therefore the output voltage to the load is zero. The output voltage of the shoot-through state is zero, that is that the same because the ancient zero states, thus the duty quantitative relation of the active states has got to be maintained to output a curving voltage, which implies shoot through solely replaces some or all of the standard zero states. to explain the in operation principle and management of the Z-source electrical converter think about the Z-source electrical converter structure shown in Figure.4.

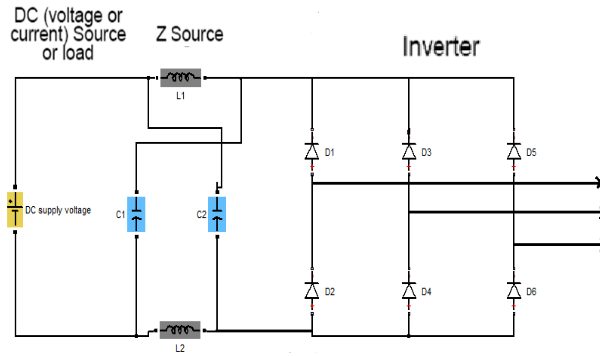

Fig.4. Z-source inverter 2.

3. MATHEMATICAL ANALYSIS

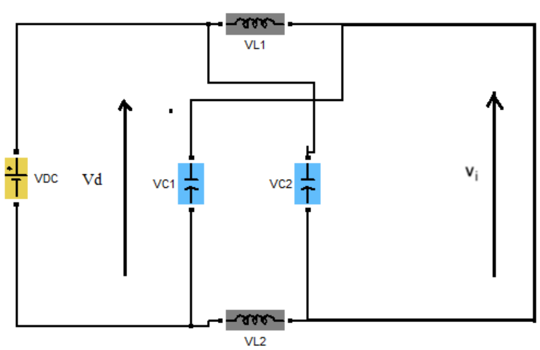

Fig.5.Equivalent circuit when ZSI in shoot through state.

The impact of the part leg shoot through on the electrical converter performance will be analyzed victimization the equivalent circuit shown in Figure.4 and Figure.5 [7]. Assume the inductors (L1 and L2) and capacitors (C1 and C2) have constant inductance and capacitance values respectively; the Z-source network becomes symmetrical

In shoot through state the electrical converter facet of Z-Source network is shorted throughout amount T0 as in Fig.4.Therefore L1=L2=L and C1=C2=C

VC1 = VC2 = VC =VL1= VL2= VL

Cupid's itch = VL +VC= 2VC …………….(1)

Vi = 0

Or else, once in non shoot through active or null state current flows from Z-Source network through the electrical converter topology to attach ac load throughout amount T1.The electrical converter facet of the Z-source network will currently be portrayed by constant circuit as shown in Figure.6

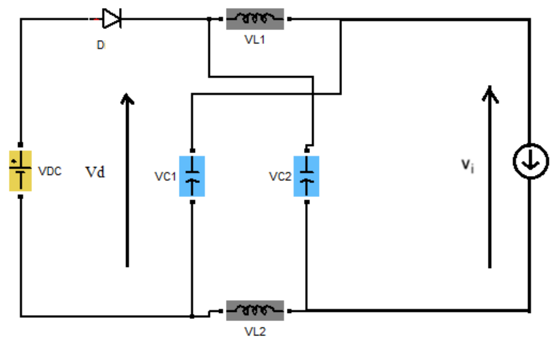

Fig.6.Equivalent circuit when ZSI in non shoot through state.

From on top of circuit

VL = Vdc – VC

Vd = Vdc

Vi = VC – VL = two VC –Vdc …………(2)

Averaging the voltage across a Z-source inductance over a switch amount (0 to T)

VC = T1 / (T1 - To) Vdc ……….(3)

The peak DC-link voltage across the electrical converter bridge is

Vi= 2VC –Vdc =Vdc[(2T1 / T1-TO) - 1].(4)

Vi = B. Vdc

Where, B could be a boost issue and is given by

B = [(2T1 / T1-To) - 1] i.e. ≥1

The peak ac output section voltage, For Z- supply

Vac = M.Vi /2 = B.M Vdc /2

In the ancient sources

Vac = M. Vdc /2

Where, M is modulation index.

4. SIMULATION RESULTS

Simulations have been performed. Figure.5 shows the circuit configuration of Z- Source fed Induction motor. The simulation parameters are as follows:
1. DC input voltage: 230 V
2. Z-source network: L1 = L2 = 1 mH, C1 = C2 = 9000 μF.
4. Switching frequency: 10 KHz.

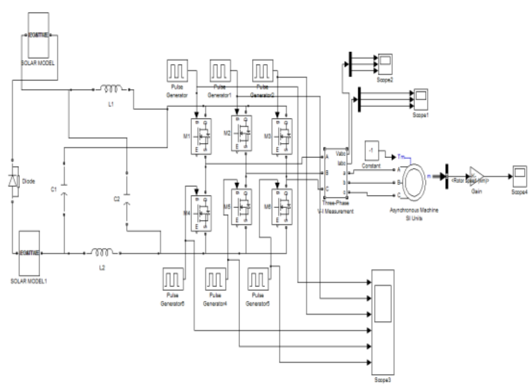

Fig.7.Z Source Inverter Fed IM

The following figures shows the simulation result of ZSI fed Induction motor.Figures.8, 9 and 10 shows the output voltage, current, speed waveforms respectively.

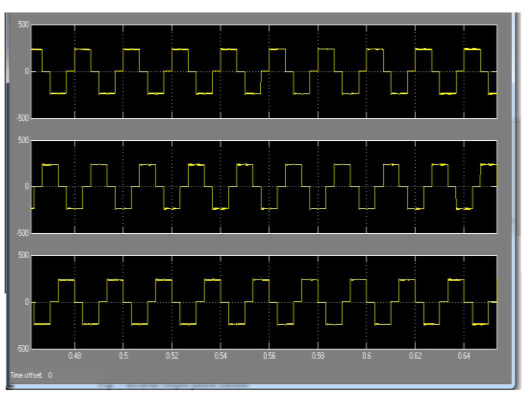

Fig.8.ZSI phase to phase output voltage waveform

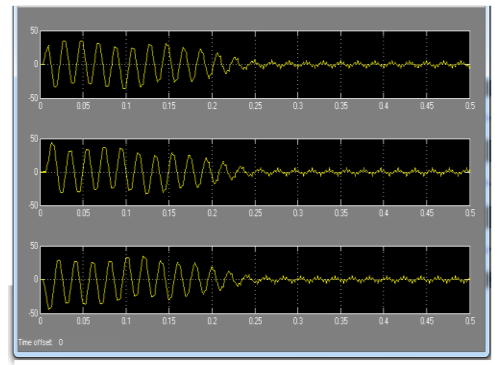

Fig.9.ZSI output phase current waveforms

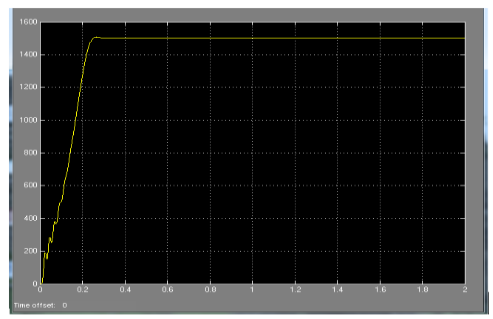

Fig.10.Rotor speed waveform

The following section is the comparison between VSI, CSI, ZSI methods to fed Induction Motor on their FFT analysis. The Figure.11 gives the FFT analysis of VSI fed IM and Figure.12 gives the FFT analysis of CSI fed IM. Figure.13 gives the FFT analysis of ZSI fed Induction Motor

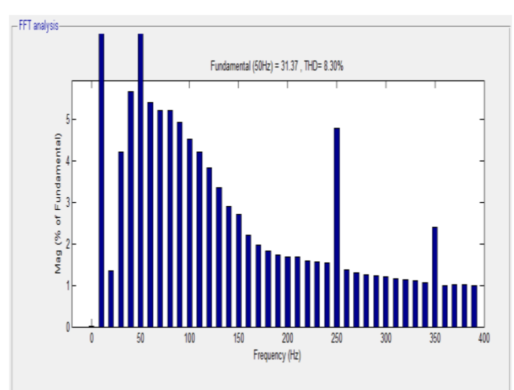

Fig.11.FFT analysis of VSI fed IM

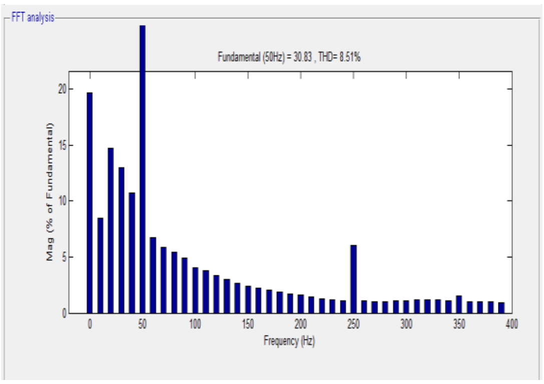

Fig.12.FFT analysis of CSI fed IM

Figure.13 shows FFT analysis of ZSI fed induction motor drive. The total harmonic distortion is found to be 6.28% which is very less when compare to VSI and CSI fed induction motor drive.

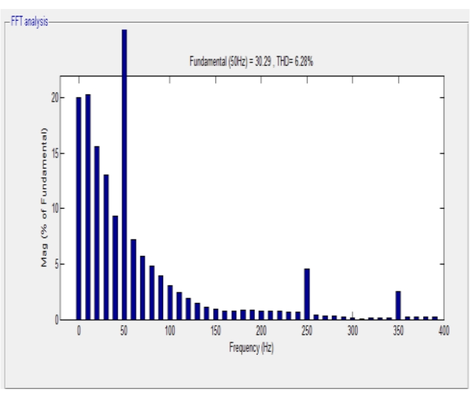

Fig.13.FFT analysis of ZSI fed IM

5. CONCLUSION

The Z-source converter employs a unique impedance network (or circuit) to couple the converter main circuit to the power source, thus providing unique features that cannot be obtained in the traditional voltage-source (or voltage-fed) and current-source (or current-fed) converters where a capacitor and inductor are used, respectively. The Z-source converter overcomes the conceptual and theoretical barriers and limitations of the traditional voltage-source converter (abbreviated as V-source converter) and current-source converter (abbreviated as I-source converter) and provides a novel power conversion concept. 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. The Z-source inverter has a unique single stage buck boost feature that it can generate any AC output voltage regardless DC input voltage by regulating of shoot-through time. The Z-source inverter based Induction Motor Drive system is proposed. The proposed system worked effectively with the input DC voltage lower than the input voltage. The proposed Z-source inverter was higher efficient, higher performance, cost effective, and uses fewer active components.

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