DIGITAL SIMULATION AND IMPLEMENTATION OF Z-SOURCE INVERTER FED INDUCTION MOTOR

D.Devipriya¹ and N.Gnanasekaren²
Misrimal Navajee Munoth Jain Engineering College,
Chennai, India.
devipriya.0809@gmail.com
neelasekaren@yahoo.com

ABSTRACT: Simulation and implementation of z-source inverter fed induction motor is discussed in this paper. The impedancesource inverter employs a unique impedance network coupled with inverter main circuit and rectifier; it 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). The z-source inverter system provides ride-through capability during voltage sags, reduces line harmonics, improves power factor and high reliability, and extends output voltage range.

Keywords: Z-source inverter, induction motor, harmonic distortion, voltage sag.

I. INTRODUCTION

Z-Source Inverter for induction motor drives. Z-Source Inverter can be applied to the entire spectrum of power conversion. It is used as Boost-Buck conversion where a capacitor and inductor are used. In this thesis, the Z-Source Inverter is considered in place of Voltage Source Inverter and Current Source Inverter. By using this Z-Source Inverter, the problems mentioned are rectified and then we can get higher efficiency. Traditional source inverters have the following problems. There can be either a boost or a buck inverter operation and cannot be a buck-boost inverter operation. Their output voltage range is limited to either greater or smaller than the input voltage.

In other words, neither the voltage source inverter can be used for the current source inverter, nor vice-versa. They are vulnerable to EMI noise in terms of reliability. This Z-Source Inverter is issued to overcome these problems in the traditional source inverters. Bridge rectifier is commonly used in high power applications. The impedance network is a two port network. A two port network has input terminals and output terminals. This network also called as a lattice network. This lattice network consists of split inductors (L1 phase AC supply is given to the rectifier unit; rectification is a process of converting alternating current or voltage into a direct current or voltage. The three phase and L2) and capacitors (C1 and C2). The Impedance Source Inverter consists of voltage source from rectifiersupply, impedance network, three phase inverter and AC motor load.

This network is coupled with inverter main circuit and source. This impedance network is a second order filter, and also this network is energy storage or filtering element for the Impedance Source Inverter. DC to AC converters is known as inverter. The function of an inverter is to change a DC input voltage to AC output voltage of desired magnitude and frequency. Three phase inverters are normally used for high power applications.

Status and opportunities of photovoltaic inverters in grid-tied and micro-grid systems are presented in [1]. Z-source inverter is given in [2]. Comparison of traditional inverter and z-source inverter are presented in [3]. Constant boost control of the z-source inverter to minimise current ripple and voltage stress are given in [4]. PWM of z-source inverter are presented in [5]. AC output voltage control with minimisation of voltage stress across devices in the z-source inverter using modified SVPWM are given in [6]. Maximum boost control of the z-source inverter are given in [7].

Power loss oriented evolution of high voltage IGBTsand multi-level converters intransformerless traction application are presented in [8]. Loss oriented evaluation and comparison of z-source inverters using different PWM strategies are given in [9]. Current mode integrated control technique for z-source inverter fed IM drives are given in [10].

Analysis and simulation of z-source inverter control method are...
presented in [11]. The above literature does not deal with simulation and experimental verification of z-source inverter. This work aims to develop an experimental module for microcontroller-based z-source inverter.

II. Z SOURCE INVERTER

The z-Source Network is a combination of two inductors and two capacitors. This combined circuit, the z-Source Network, is the energy storage or filtering element for the z-Source inverter. This z-source network provides a second order filter. This is more effective to suppress voltage and current ripples. The inductor and capacitor requirements should be smaller compared to the traditional inverters. When the two inductors (L1 and L2) are small and approach zero, the Impedance source network reduces to two capacitors (C1 and C2) in parallel and becomes a traditional voltage source.

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![Figure 1. Z-source inverter](image)

Therefore, a traditional voltage inverter's capacitor requirements and physical size is the worst case requirement for the Impedance source inverter. Considering additional filtering and energy storage provided by the inductors, the Impedance Source Network should require less capacitance and smaller size compared with the traditional voltage source inverter. Similarly, when the two capacitors (C1 and C2) are small and approach zero, the Impedance Source Network reduces to two inductors (L1 and L2) in series and becomes a traditional current source. Therefore a current source inverter's inductor requirements and physical size is the worst case requirement for the Impedance Source Inverter. Considering additional filtering and energy storage by the capacitors, the Impedance Source Network should require less inductance and smaller size compared with the traditional Current Source Inverters.

III. MATHEMATICAL ANALYSIS

Impedance source network, a two port network which is used to provide mathematical analysis. Assume the inductors (L1 and L2) and capacitors (C1 and C2) have the same inductance and capacitance values respectively. L1 and L2 – series arm inductors; V1 is input voltage; C1 and C2 – parallel arm capacitors; V2 is output voltage.

The Circuit model is derived in equations 3.1 to 3.12.

\[ Vc_1 = Vc_2 = VC \quad \ldots 3.1 \]
\[ VL_1 = VL_2 = VL \quad \ldots 3.2 \]
\[ VL = VC \]
\[ VD = 2Vc \]
\[ VI = 0 \]

During the switching cycle T

\[ VL = VO - VC \quad \ldots 3.3 \]
\[ VD = VO \]
\[ VI = VC - V L = 2 VC - VO \]
\[ VI = 2Vc - V O \quad \ldots 3.4 \]

Where VO is the dc source voltage and
\[ T = T_0 + T_1 \quad \ldots 3.5 \]

The average voltage of the inductors over one switching period (T) should be zero in steady state

\[ VL = VL = T_0 .Vc + T_1 (Vo-Vc) / T = 0 \]
\[ VL = (T_0 .Vc + Vo.T_1 - Vc.T_1) / T = 0 \]
\[ VL = (T_0 - T_1) VC / T + (T_1.Vo) / T \]
\[ Vc/Vo = T_1/(T_1-T_0) \quad \ldots 3.6 \]

Similarly the average dc link voltage across the inverter bridge can be found as follows from equation (3.4)

\[ VI = VI = (T_0+T_1).(2Vc.Vo)/T \quad \ldots 3.7 \]
\[ VI = (2Vc. T_1/T) - (T_1.Vo/T)2Vc=VO \]

From equation (3.6)

\[ T_1.Vo / (T_1-T_0) = 2Vc.T_1/ (T_1-T_0) \]
\[ VC = Vo.T_1/ (T_1-T_0) \]

The peak dc-link voltage across the inverter bridge is

\[ VI = VC - VL = 2 VC - VO \]
The buck-boost factor $BB$ is determined by the modulation index $M$ and the Boost factor $B$. The boost factor $B$ can be controlled by duty cycle of the shootthrough zero state over the non-shootthrough states of the PWM inverter. The shootthrough zero state does not affect PWM control of the inverter. Because it equivalently produces the same zero voltage to the load terminal. The available shoot through period is limited by the zero state periods that are determined by the modulation index.

IV. SIMULATION RESULT

Simulations have been performed to confirm the above analysis. Fig.2 shows the circuit configuration of Z-source inverter fed induction motor. Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. Simulation is one of the best ways to study the system or circuit behavior without damaging it. The open loop results and closed loop result for Z-source inverter are given below. Fig.[ 4.1].CIRCUIT DIAGRAM = $T / (T1To)$. $Vo = B.Vo$ Where $B = T/(T1To)$ is a boost factor. The output peak phase voltage from the inverter $Vac = M.Vi/2$. In this source $Vac = M.B.Vo /2$. In the traditional source $Vac = M.Vo/2$. For Z-Source $Vac = M.B.Vo$.

The output voltage can be stepped up by choosing an appropriate buck-boost factor $B$. The capacitor voltage can be expressed $Vc2 = VT$ Fig[3].

![Figure.2 Circuit Diagram](image)

![Figure.3. Rectifier output voltage](image)

![Figure.4 Inverter phase output voltage](image)

![Figure.5 FFT Analysis](image)
V. EXPERIMENTAL RESULTS

A 0.5 KW, 3 – Φ Induction Motordrive is fabricated and tested in the laboratory. The hardware consists of power circuit and control circuit. The power circuit uses MOSFET’s (IRF 840) and Z – network. The control circuit uses 8 – bit Atmel μC 89C2051.

This has 15 programmable I/O lines, two 16 – bit timers, 6 interrupt sources & one UART channel. This chip has built in analog comparator. It can work in lower power ideal and power down modes. The pulses are generated using the μC 89C2051. They are amplified
by using the driver IC IR2110. The topview of hardware circuit are shown in fig. The driving pulse, Line voltage with r load, Phase voltage with r load, Line voltage with motor load are shown below.

VI. CONCLUSIONS

This paper compares simulation results with experimental results of Z-source inverter system. The Z-source converter overcomes the limitations of the traditional V-source converter and 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. It improves power factor and high reliability, and extends output.
voltage range. In summary, the Z-source inverter has several unique advantages that are very desirable for many applications. It can produce any desired output ac voltage, even greater than the line voltage. Provides ride-through during voltage sags without any additional circuits and energy storage. Minimizes the motor ratings to deliver a required power. Reduces in-rush and harmonic current. Unique drives features include buck-boost inversion by single power-conversion stage, improved reliability, strong EMI immunity and low EMI.

REFERENCES