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Performance Analysis of Z-source Inverter for Speed Control of an Induction Motor using Wind Energy Conversion System

Habeeb Fathima ,`Dr. S. Tara Kalyani
Department of Electrical& Electronics Engineering
JNTU College of Engineering.

***Abstract* - The operation and speed control of induction motor fed from Z-Source Inverter that has both buck and boost capabilities is shown, as the former allows the operation of the inverter in the shoot through state. It has Z-Source Network which connects inverter with new adjustable-speed drives. The Z-source network makes the shoot-through zero state possible. This shoot-through zero state provides the unique buck-boost feature to the inverter. A closed loop speed control of induction motor using SVPWM control is proposed. Finally, by using Matlab/simulink the simulation results are verified for proposed high-performance Z-source inverter ASD system.**

I. INTRODUCTION

Depletion of fossil fuels and conventional energy crisis has steadily increased the environmental concern. This concern has led to major interest in exploiting the renewable form of energy for the generation of electrical power. Best of the available sources of energy are Solar and Wind. Wind Turbines usage as sources of energy has increased significantly in the world. With growing application of wind energy conversion systems (WECS), various technologies are developed for them. Induction motors characteristics represents an important trend in development of wind power applications to realize these objectives, the ac–ac converter is one of the best topology for Wind Energy Conversion system.

Traditional voltage-source inverter (VSI) and current source inverter (CSI) are either a buck or a boost converter and not a buck-boost converter. That is, their obtainable output voltage range is limited to either greater or smaller than the input voltage. Z-source inverter (ZSI) was proposed as an alternative power conversion concept as it can have both voltage buck and boost capabilities. In addition to that it has the following advantages: Immune to EMI noise and mis-gating, low or no in-rush current compared with the voltage source inverter and low common mode noise. Obtainable output voltage range can be varied.

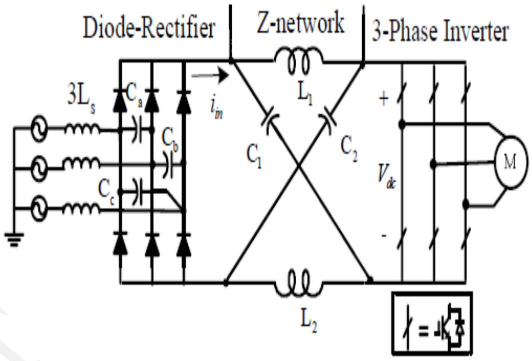

Fig.1 Z-Source inverter ASD system

The recently developed Z-source inverter adjustable speed drive (ASD) system [2], as shown in Fig. 1 can: 1) produce any desired output ac voltage, even greater than the line voltage, regardless of the input voltage, thus reducing motor ratings; 2) provide ride-through during voltage sags without any additional circuits; 3) improve power factor and reduce harmonic current and common-mode voltage.

However, it has many limitations as following: a) The Z-source network inductor has the limited value to guarantee the input current Iin>0. In some applications, the inductance should be minimized in order to reduce cost, volume, and weight. From [3], the design of Z-source network inductor and system control become very complex, and the output voltage becomes incontrollable with small inductor even operate in full load. Light-load operation is the problem in Z-source inverter based ASD system. The DC-link voltage is increasing infinitely when the system operated with light-load as shown in Fig. 4 (b), which causes voltage-aberrances at the DC-link shown in Fig. 4 (a). The DC-link voltage will be uncontrollable and the system is unstable. Since light-load operation is the significant situation of the adjustable-speed drives, the original Z-source inverter ASD system can obtain the high performance.

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II.WIND TURBINE MODEL:

There are two types of wind turbines namely vertical axis and horizontal axis types. Horizontal axis wind turbines are preferred due to the advantages of ease in design and lesser cost particularly for higher power ratings.

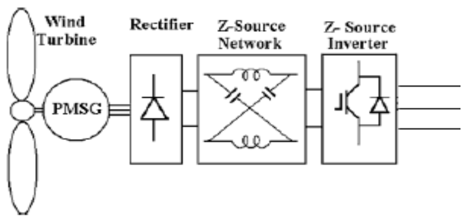

Fig.2 Proposed WECS with Z Source inverter.

III. TOPOLOGY OF Z SOURCE NETWORK

The main circuit of the proposed Z-source inverter based induction motor drive system is in fig 1. A voltage-type Z source inverter is utilized, instead of the traditional voltage source inverter (VSI) or current source inverter (CSI), to feed electric energy from the dc source to the induction motor. To gain the buck/boost ability, the space width modulation (SVPWM) method should be used to control the Z-source inverter to generate shoot-through states. The Z-source inverter in the proposed IM drive system are composed of square waveforms of 120° electrical degree. Consequently, the operation principle, the modelling method and the control are all different from the Z-source inverter based ASD system with induction machines.

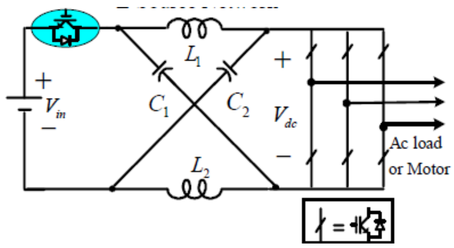

Fig.3 Z-Source inverter topology

Generally, the Z-source network can operate in six possible states, in which three states are desired while the other three are undesirable. And the undesirable states can be avoided by choosing appropriate values of the inductors and capacitors of the impedance network. It is supposed that only the three desired states are considered in the following analysis. The desired open state, active state and shoot-through state are illustrated in Fig.4(a),(b)and(c),respectively.

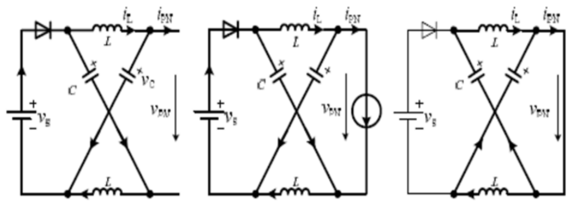

Fig.4 Equivalent circuit of Z – source network in (a) open state (b) active state (c) shoot – through state

IV. SPACE VECTOR PULSE WIDTH MODULATION:

Space vector modulation (SVM) is an algorithm for the control of pulse width modulation (PWM). There are various variations of SVM that result in different quality and computational requirements. One active area of development is in the reduction of total harmonic distortion (THD) created by the rapid switching inherent to these algorithms.

A Z Source inverter as shown above converts a DC supply, via a series of switches, to three output legs which could be connected to a three-phase motor.

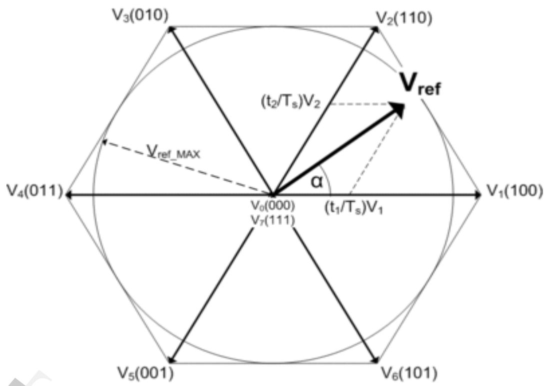

Fig.5 SVM Diagram

The switches must be controlled so that at no time are both switches in the same leg turned on or else the DC supply would be shorted. This requirement may be met by the complementary operation of the switches within a leg. i.e. if A^+ is on then A^- is off and vice versa. This leads to eight possible switching vectors for the inverter, V_0 through V_7 with six active switching vectors and two zero vectors. The active switching vectors V_{1-6}, the output voltages vary as a pulsed sinusoid, with each leg offset by 120 degrees of phase angle.

To implement space vector modulation, a reference signal V_{ref} is sampled with a frequency f_s ($T_s = 1/f_s$). The reference signal may be generated from three separate phase references using the $\alpha\beta\gamma$ transform. The reference vector is then synthesized using a combination of the two adjacent active switching vectors and one or both of the zero vectors. Various strategies of selecting the order of the vectors and which zero vector(s) to use exist. Strategy selection will affect the harmonic content and the switching losses.

V. SIMULATION RESULTS

The simulation model of the proposed system consists of wind energy conversion system model, subsystem of Z-source inverter and the induction motor drive. In this paper, a most recent Z-Source Inverter (ZSI) feeder with static as well as dynamic load (induction motor drive) is proposed and implemented for remote and rural areas. The ZSI have recently been proposed as an alternative power conversion concept as it has both voltage buck and boost capabilities.

The proposed wind energy conversion system with ZSI is modelled in MATLAB/SIMULINK as shown.

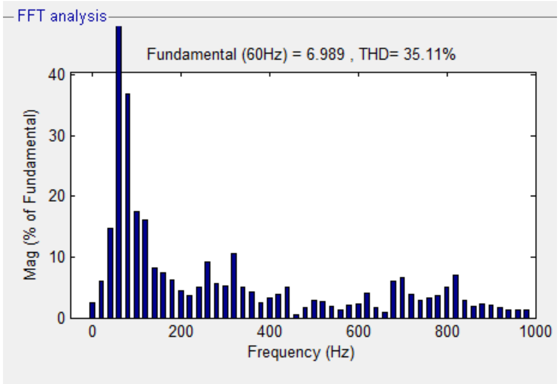

Fig. 6 THD (35.11%) Value of the inverter output voltage waveform.

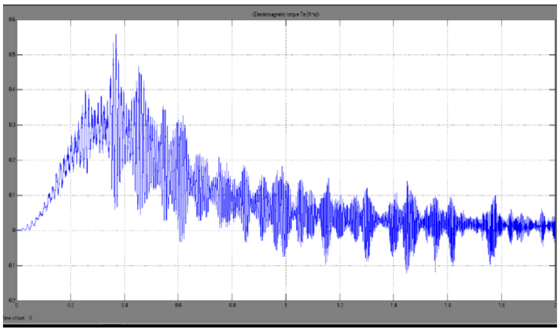

Fig.7 Electromagnetic Torque.

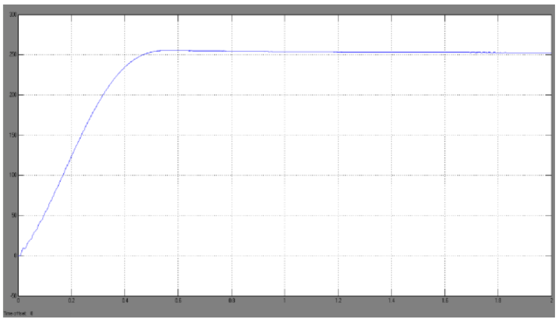

Fig.8 Input Voltage Fed To Inverter.

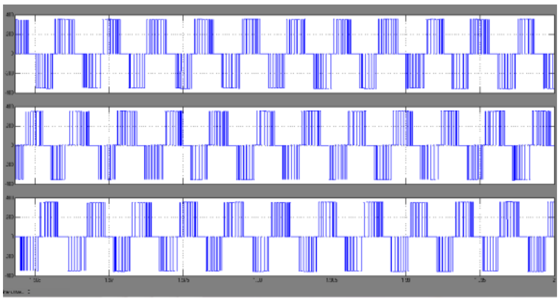

Fig.9 Voltage Fed to Induction Motor (350V).

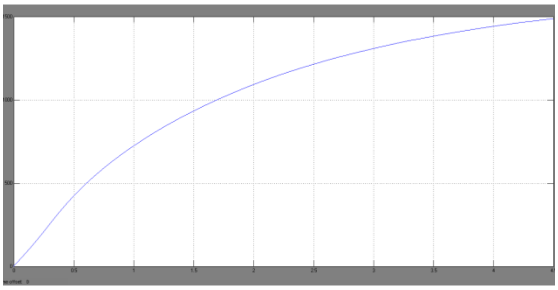

Fig.10 Speed nearly 1440rpm at the Rotor of Induction Motor.

CONCLUSIONS

Hence Z Source inverter ASD system can operate with wide range of loads even at no loads with a small inductor which is very suitable for ASD system. The Z-source converter employs a unique impedance network to couple the converter main circuit to the power source, thus providing unique features that cannot be obtained in the traditional voltage-source or current-source inverter where a capacitor and inductor are used separately. The performance of proposed speed control method of 1.8 KW Induction motor results in good dynamic and steady state performance. The stator current speed and electromagnetic torque waveforms may be obtained for various operating conditions by implementing speed feedback in SVPWM generation.

REFERENCES

[1] Xinping Ding; Zhaoming Qian; Shuitao Yang; Bin Cui; Fangzheng Peng, "A New Adjustable-Speed Drives (ASD) System Based on High- Performance Z-Source Inverter". *42nd IAS Annual Meeting. Conference*, Sept. 2007.

[2] Amin M.M and O.A. Mohammed, "Development of High-performance Grid connected wind energy conversion system for optimum utilization of variable speed wind turbines",*IEEE Transactions on Sustainable Energy*, vol. 2, issue 3, pp.235-245, June 2011

[3] F. Z. Peng, "Z-source inverter," IEEE Trans. Ind. Appl., vol. 39, no. 2, pp. 504-510,Mar./Apr. 2003

[4] Fang Z. Peng, Miaosen Shen and Alan Joseph, "Z-Source Inverters, Control and Motor Drive Applications," *KIEE International Transaction on Electrical Machinery and Energy Conversion System*, 2005.

[5]] S.Yang, X. Ding, F. Zhang, F. Z. Peng, and Z. Qian, "Unified control technique for Z-source inverter," in *Proc. IEEE Power Electron. Spec. Conf.*, 2008, pp. 3236–3242.