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ON CHIP IMPLEMENTATION OF VSI FED INDUCTION MOTOR DRIVE

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ABSTRACT

The design, simulation and implementation of VSI fed three phase induction motor drive are presented. The drive system is modeled using the blocks of Simulink. Detailed simulation and implementation of the drive system are given in this paper. Speed response and spectrum analysis are also presented. This drive has advantages like reduced hardware and increased reliability. The experimental results are compared with the simulation results.

Keywords: induction motor, Mat lab, VSI, sine PWM.

INTRODUCTION

DC motors have been used during the last century in industries for variable speed applications, because its flux and torque can be controlled easily by means of changing the field and armature currents respectively. Furthermore, operation in the four quadrants of the torque speed plane including temporary standstill was achieved. Almost for a century, induction motor has been the workhorse of industry due to its robustness, low cost high efficiency and less maintenance. The induction motors were mainly used for essentially constant speed applications because of the unavailability of the variable-frequency voltage supply. The advancement of power electronics has made it possible to vary the frequency of the voltage supplies relatively easy, thus extending the use of induction motor in variable speed drive applications. But due to the inherent coupling of flux and torque components in induction motor, it could not provide the torque performance as good as the motor.

In ac grid connected motor drives, a rectifier, usually a common diode bridge providing a pulsed dc voltage from the mains is required. Although the basic circuit for an inverter may seem simple, accurately switching these devices provides a number of challenges. The most common switching technique is called Pulse Width Modulation (PWM). PWM is a powerful technique for controlling analog circuits with a processor's digital outputs. PWM is employed in a wide variety of applications like UPS, electric drives, HVDC reactive power compensators in power systems, ranging from measurement and communications to power control and conversion. In ac motor drives, PWM inverters make it possible to control both frequency and magnitude of the voltage and current applied to a motor. As a result, PWM inverter-powered motor drives are more variable and offer in a wide range better efficiency and higher performance when compared to fixed frequency motor drives. The energy, which is delivered by the PWM inverter to the ac motor, is controlled by PWM signals applied to the gates of the power switches at different times for varying durations to produce the desired output waveform. To improve the quality of the product variable speed is required, for that step less speed control is required.

Depending on the type of load and type of speed different methods are adopted for speed control of motors. For step less speed control below and above the rated speed with high torque and to avoid the harmonics the PWM inverter fed induction motor control is best suitable one.

THREE PHASE PWM INVERTER

The PWM inverter has to generate nearly sinusoidal current, which can be controlled the voltage and current with 120 degrees difference in each phase. The controlling signals of three-phase PWM inverters have many pattern controls. The operation of three-phase inverter can be defined in eight modes, which shows the status of each switch in each operations mode. In inverter operation, the necessary phase-leg-short is naturally realized through anti-parallel diodes in the three-phase bridge. Accordingly, the same gate pulses as in the conventional VSI can be applied. On the other hand, the switch on the dc link must actively operate.

The recent advancement in power electronics has initiated to improve the level of the inverter instead of increasing the size of the filter. In multilevel inverter, design involves parallel connection of the inverter. For these redundant switching a space vector modulation is needed which is based on vector selection in dq stationary reference frame. For a multi level system either space vector modulation or sinusoidal triangle modulation may be taken. However space vector modulation is having more advantages due to low harmonic production.

The performance of the multi level inverter is better than the classical inverter. The total harmonic distortion of the classical inverter is very high. The diode clamped inverter provides multiple voltage levels from a series capacitor bank. The voltage across the switches is only half of the DC bus voltage. These features effectively double the power rating of voltage source inverter to the given semiconductor device. The total harmonic distortion is analyzed between multilevel inverter and other classical inverter.

Field oriented control (FOC) of induction motor was introduced which has opened a new horizon to the induction motor applications. The method, which uses frame, has transformed the performance of induction motor similar to that of the DC motor. The implementation of this system however is complicated and furthermore FOC, in particularly indirect method which is widely used, is known to be highly sensitive to parameter variations due to the feed-forward structure of its control system. In the DTC drive, flux linkage and electromagnetic torque are controlled directly and independently by the selection of optimum inverter switching modes. The required optimal switching voltage vectors can be selected by using a so called optimum switching voltage vector look up Table. In the present work an attempt is made to simulate DTC system.

On chip implementation of Z-source inverter fed induction motor drive is given by K. Ravichandrudu [1]. This method presents an impedance-source inverter fed induction motor and its characteristics compared with other traditional inverters. Analysis and FPGA realization of a pulse width modulator based on voltage space vectors is given by R. Rajendran [2]. This method presents the analysis and realization of SVPWM for variable speed control of AC motor drives, employing Xilinx Spartan 3E FGPA device. Implementation of a fuzzy PI controller for speed control of induction motors using FPGA is given by R.Arulmozhiyal [3]. This method presents the design and implementation of voltage source inverter type SVPWM based speed control of an induction motor using a fuzzy PI controller. Analysis of variable frequency three phase induction motor drive is given by Thida Win [4]. This method presents directly contributed to the electronics design of inverter and controller for the induction motor drive. Implementation of Multilevel Inverter-Fed Induction motor Drive is given by G.Pandian [5]. This method presents the simulation and implementation of Multilevel Inverter fed Induction motor Drive. A novel carrier for sinusoidal pulse width modulation based full bridge inverter is given by M.Kaliamoorthy [6]. This method proposes a novel carrier in lieu of conventional triangular carrier. Design and Implementation of a Direct Torque Control of Induction Machine utilizing a Digital Signal Processor and the Field Programmable Gate Arrays is given by C.L. Toh [7]. This method presents a high performance DTC Induction motor drive with constant switching frequency and low torque and flux ripples. Dspace based experimental results of Indirect Field Oriented Control PWM VSI fed induction Motor is given by T. Jebali [8]. This method present a full digital implementation of indirect field oriented controlled induction motor drive with a Dspace DS 1102 hardware and software and matlab simulink environment. Hardware-in-the-loop simulation based design and experimental evaluation of DTC strategies is given by S. Vamshidhar [9]. This method presents designing and implementing direct torque control of induction motor based on Hardware-in-the-loop simulation. On-Line Dead-Time Compensation Technique for Open-Loop PWM-VSI Drives is given by Alfredo R. [10]. This method presents a simple and cost effective solution to the detection of the current direction problem by using an instantaneous back calculation of the phase angle of the current.

The above literature does not deal with embedded on chip implementation of three phase induction motor. This work gives the details of embedded controlled three phase induction motor drive.

SIMULATION RESULTS

In three-phase inverter fed drive system, AC is converted into DC using uncontrolled rectifier. DC is converted into variable voltage variable frequency AC using three-phase PWM inverter. The variable voltage variable frequency supply is applied to the motor. The circuit of six switch three phase inverter system is shown in Figure-2b. Phase voltages are shown in Figure-2c. The phase currents are in Figure-2d. Rotor speed is shown in Figure-2e. FFT analysis is done for the output voltage and the spectrum is shown in Figure-2f. The THD is 13.9 %.

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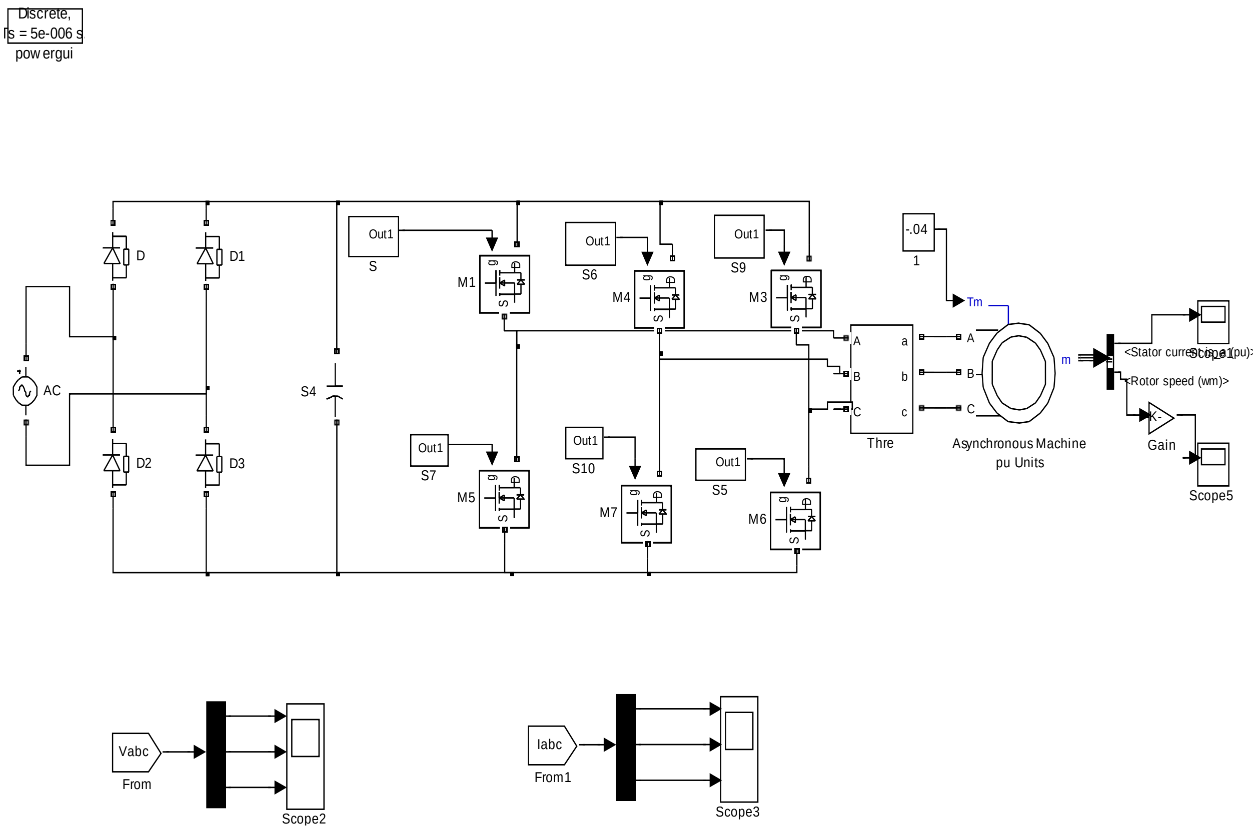

Figure-2a. Six switch three phase inverter fed drive.

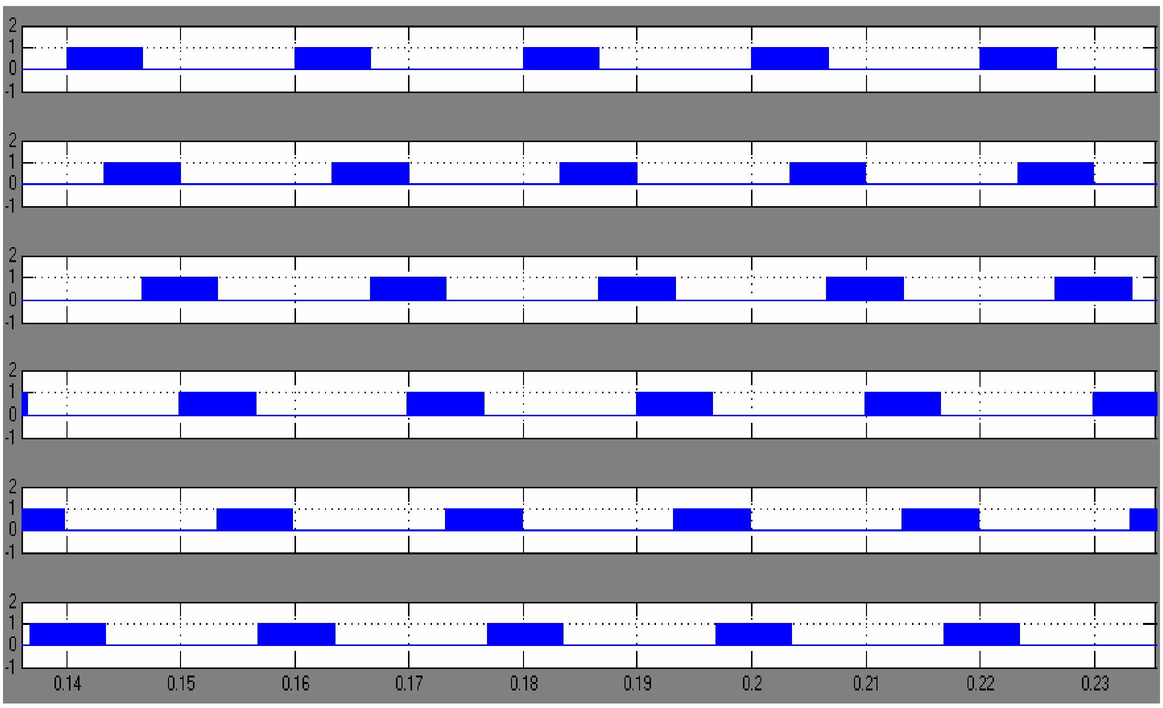

Figure-2b. Gate pulse for 3 phase invertor.

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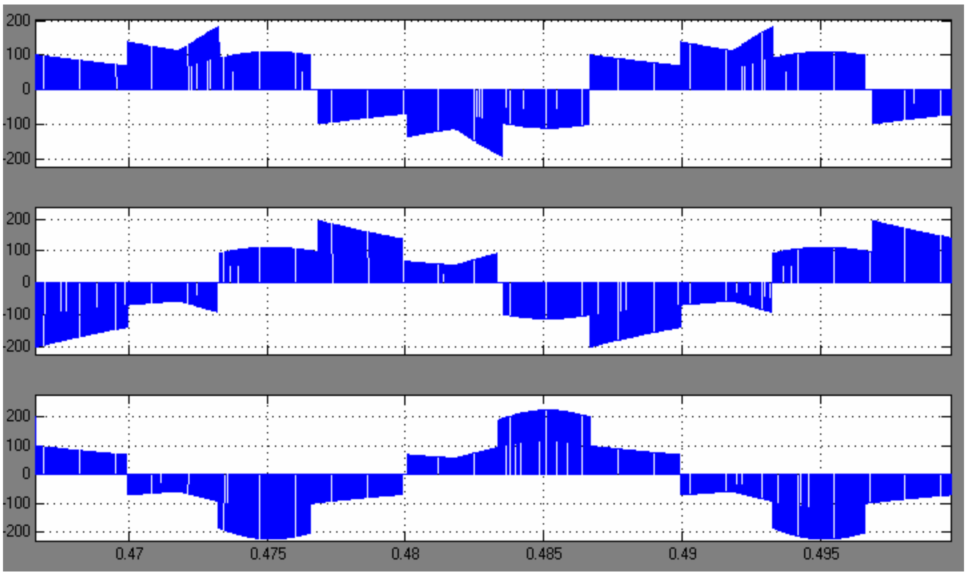

Figure-2c. Phase voltages V_a, V_b, V_c.

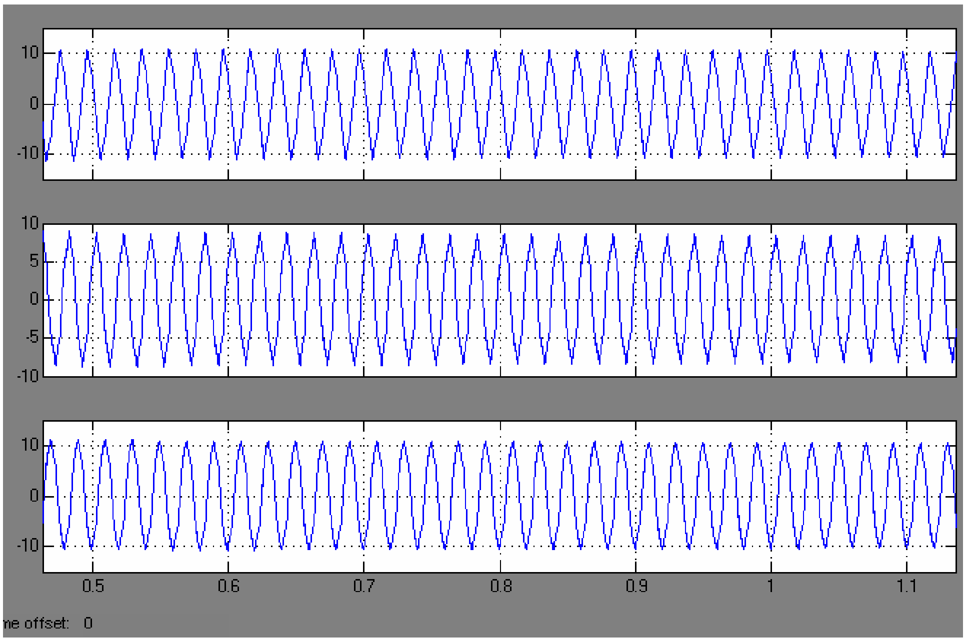

Figure-2d. Current waveforms I_a, I_b, I_c.

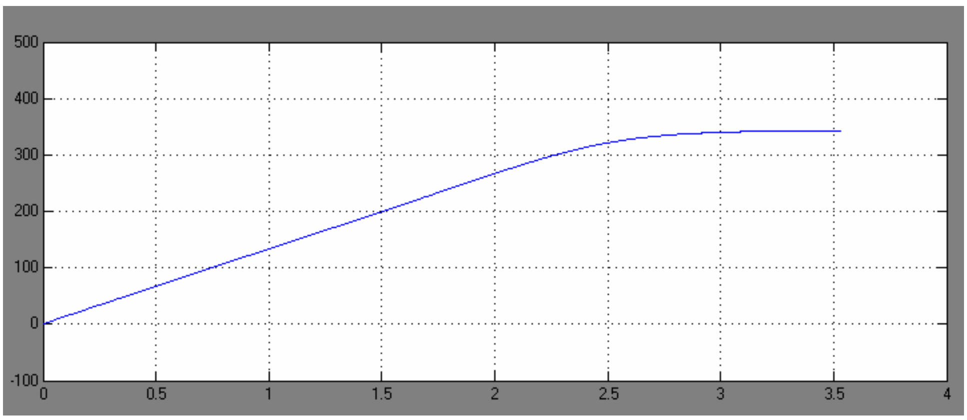

Figure-2e. Rotor speed (rad /sec).

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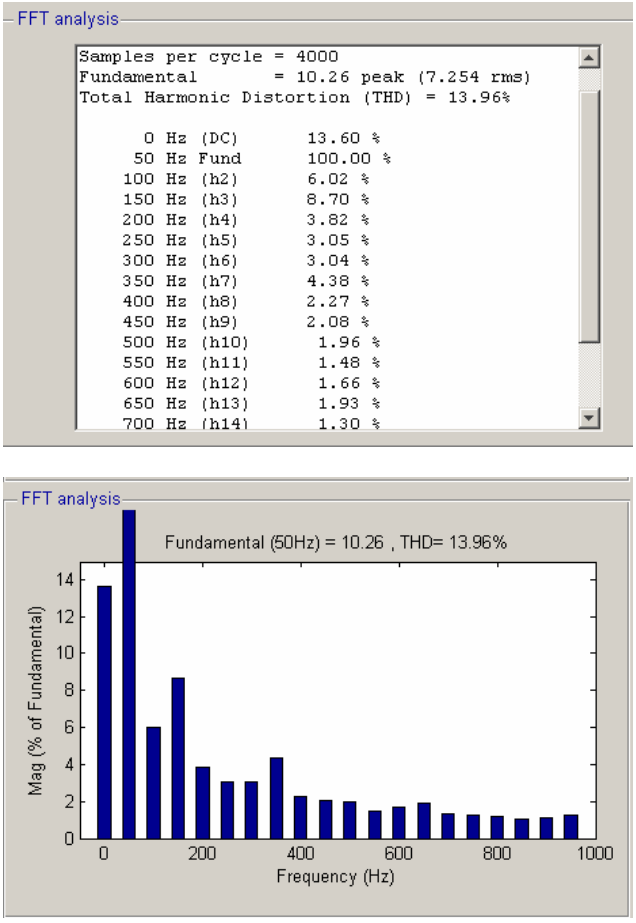

Figure-2f. FFT analysis.

EXPERIMENTAL RESULTS

Laboratory model of hardware is fabricated and tested. The pulses required by the motor are generated using microcontroller. The hardware is shown in figure 3a. Driving pulses are shown in Figure-3b. The line to line voltage of the motor is shown in Figure-3c. The notches are due to the emf induced in the motor.

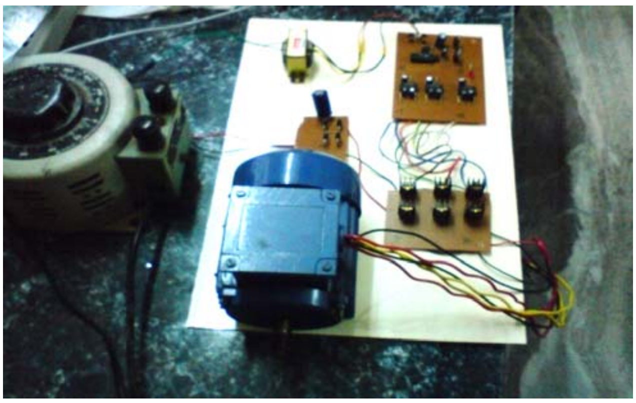

Figure-3a. Hardware proto type.

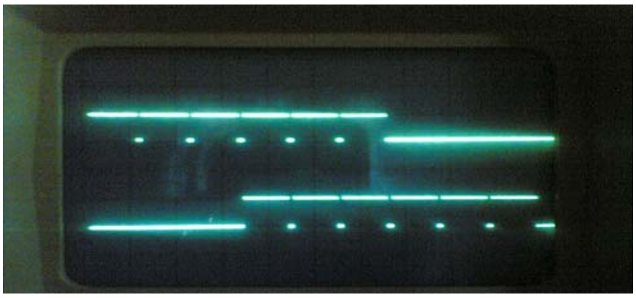

Figure-3b. PWM pulses.

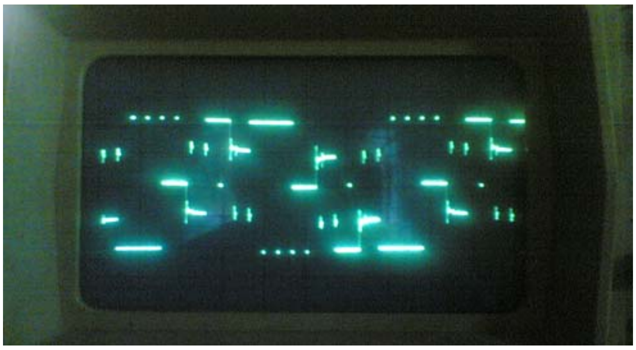

Figure-3c. Line voltage with motor load.

CONCLUSIONS

VSI fed three-phase induction motor drive is simulated, fabricated and tested. The hardware is reduced since single phase rectifier is used. The reliability is increased by using microcontroller as the on chip intelligent controller. The scope of this work is the simulation and implementation of six switch inverter fed induction motor drive. The speed is varied by varying the driving frequency of the inverter. The experimental results closely agree with the simulation results.

REFERENCES

[1] K. Ravichandrudu, P. Sangameswara Raju, GVP Anjaneyulu. 2011. On chip implementation of Z-source inverter fed induction motor drive. International Journal of Advanced Engineering Sciences and Technology. Vol. No. Issue No.1, 015-021.

[2] R. Rajendran, Dr. N. Devarajan. 2010. Analysis and FPGA realization of a pulse width modulator based on voltage space vectors. International Journal of Computer Applications (0975-8887). 2(6), June.

[3] R. Arulmozhiyal, K. Baskaran. 2010. Implementation of a fuzzy PI controller for speed control of induction motors using FPGA. Journal of Power Electronics. 10(1), Januvary.

[4] Thida win, Nang sabai, Hnin maung. 2008. Analysis of variable frequency three phase induction motor drive. World Academy of Science, Engineering and Technology. 42.

[5] G. Pandian, S. Rama Reddy. 2008. Implementation of Multilevel Inverter-Fed Induction motor Drive. Journal of Industrial Technology. 24(2).

[6] M. Kaliamoorthy, B. Ramireddy, B. Saravanan, N. Senthilkumar. 2007. A Novel Carrier for Sinusoidal Pulse Width Modulation Based full bridge Inverter. I-manager's Journal on Electrical Engineering. 1(2), October-December.

[7] C.L. Toh, N.R.N. Idris, H.M. Yatim, Fazlli Patkar. 2005. Design and Implementation of a Direct Torque Control of Induction Machine utilizing a Digital Signal Processor and the Field Programmable Gate Arrays. 0-7803-9296-5/05, IEEE PEDS.

[8] T Jebali, M. Jemli, M. Boussak, M. Gossa, M.B.T. Kaumoun. 2004. Dspace based experimental results of Indirect Field Oriented Control PWM VSI fed induction Motor. 569-573, IEEE International Conference on Industrial Technology.

[9] S. Vamsidhar, B.G. Fernandes. 2004. Hardware-in-the-loop simulation based design and experimental evaluation of DTC strategies. 35th Annual IEEE power electronics specialist's conference, Aachen, Germany.

[10] Alfredo. R, Munoz Thomas. A, Lipo. 1999. On-Line Dead-Time Compensation Technique for Open-Loop PWM-VSI Drives. IEEE Transactions on Power Electronics. 14(4), July.