ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 2, Issue 1, January 2014

Direct Flux and Torque Control of Three Phase Induction Motor using PI and Fuzzy Logic Controller

Dr.T.GOVINDARAJ[1], T.KEERTHANA[2]

Professor & Head, Department of EEE, Muthayammal Engineering College, Rasipuram, Namakkal, India[1]

Assistant Professor, Department of EEE, Muthayammal Engineering College, Rasipuram, Namakkal, India[2]

Abstract: This paper presents a direct flux and torque control of three phase induction motor drive using PI and Fuzzy logic controller. The DTC is one of the most excellent direct control strategies of stator flux and torque ripple of IMD. The conventional method of DTC, it uses PI for speed regulator where speed reduced under transient and dynamic state . This drawback was reduced by the proposed system the speed is regulated by PI and torque is controlled by fuzzy logic controller. The control system is based on DTC operating principles. The DTC is achieved by reference of stator flux and is generates from instantaneous actual and reference stator fluxes and the reference of torque is from FLC.

Index terms: Direct Torque Control (DTC), Fuzzy Logic Controller(FLC),Induction Motor Drive(IMD),PI controller

I INTRODUCTION

The electric drives are used for motion control. Now a days around 70% of electric power consumed by electric drives. This electric drives are mainly AC and DC drives. During last four decades AC drives are become more and more popular, especially induction motor Drives (IMD), because of robustness, high efficiency, high performance, and rugged structure ease of maintenance so widely used in industrial application, such as paper miles, robotics, steel miles, servos, transportation system, elevators, machines tools etc. The IMD control methods can be divided into two methods such as, scalar and vector control. The general classification of the variable frequency controls is presented and proposed control technique was shown in thick line in Fig.1. The scalar control is operating in steady state and controls the angular speed of current, voltage, and flux linkage in the space vectors. Thus, the scalar control does not operating in the space vector position during transient state. The vector control, which is based on relations valid for dynamic states, not only angular speed and magnitude but also instantaneous position of current, voltage, and flux linkage of space vector are controlled. In the vector control, one of the most popular control method for induction motor drives, known as Field Oriented Control (FOC) is presented by F.Blaschke (Direct FOC) and Hasse (Indirect FOC) in early 1970's, and FOC gives high performance, and high efficiency for industrial applications [1]. In this FOC, the motor equations are transformed into a coordinate system that rotates in synchronism with the rotor flux vector control [2]. The FOC is good in high dynamic performance, low stator flux and torque ripples, switching frequency, and maximum fundamental component of stator current, but FOC method has some drawbacks, such as requirement of two co-ordinate transformations, current controllers, and high machine parameter sensitivity. This drawback was eliminated using the new strategies for torque and flux ripple control of IMD using DTC was proposed by Isao Takahashi and Toshihiko Noguchi, in the mid 1980's [3]. Comparing with FOC, DTC has a simple control scheme and also very less computational requirements, such as current controller, and co-ordinate transformations are not required. The main feature of DTC is simple structure and good dynamic behaviour and high performance and efficiency [4,5,6]. The new control strategies proposed to replace motor linearization and decoupling via coordinate transformation, by torque and flux hysteresis controllers [7]. This method referred as conventional DTC [8].

In the conventional DTC has some drawbacks, such as, variable switching frequency, high torque and flux ripples, problem during starting and low speed operating conditions, and flux and current distortion caused by stator flux vector changing with the sector position [8], and the speed of IMD is changing under transient and dynamic state operating condition.

In order to overcome with this problem, the proposed DTC with PI and FLC is using. The PI controller is using for speed control in the SR loop and the FLC is using for stator flux and torque ripple reduction in the torque control loop [9]. The conventional and proposed DTC of IMD simulation results are presented and compared. Finally the effectiveness, validity, and performance of DTC of IMD using both conventional and proposed controllers are analyzed, studied, and confirmed by simulation results and the results shows low stator flux and torque ripples, and good speed regulator of IMD with the proposed technique using MATLAB/SIMULINK[11]-[28]

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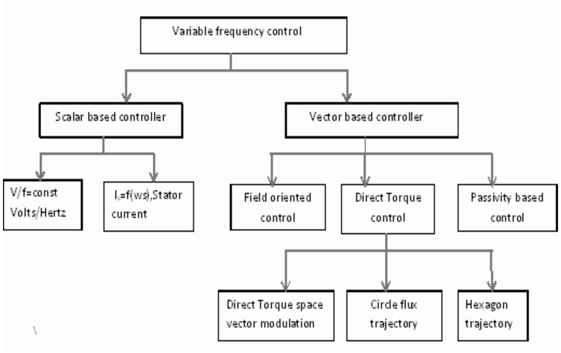

Fig 1.Classification of induction motor method

II DIRECT TORQUE AND FLUX CONTROL OF IMD

The conventional DTC of IMD is supplied by a three phase two level voltage source inverter(VSI).The main aim is to directly control the stator flux linkage or rotor flux linkage and electromagnetic torque by selection of proper voltage switching states of inverter.

A.Voltage source inverter(VSI)

The three phase and two level VSI is shown in fig 2,it has eight possible voltage space vectors, in those six voltage vectors(u_1-u_6) and the two zero vector (u_7,u_8),according to the combination of the switching modes are s_a,s_b,s_c. When the upper part of the switches is ON ,then the switching value is'1' and the lower part of the switches is ON ,then the switching value is '0'.

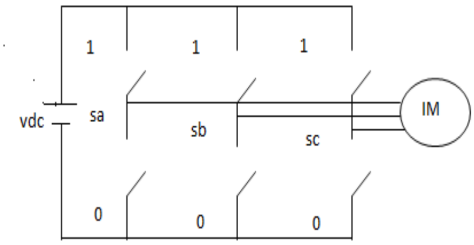

Fig 2 schematic diagram of voltage source inverter

The eight possible voltage vector switching configuration is shown in fig 3

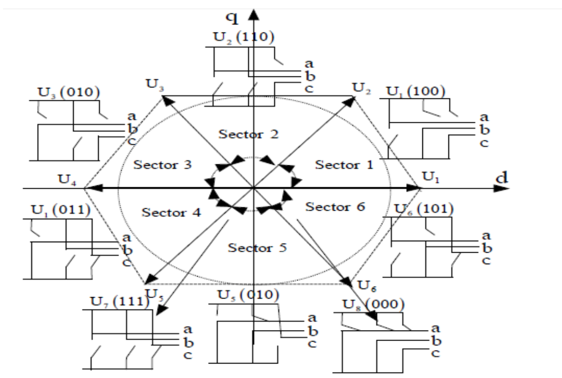

Fig 3 Eight possible configuration of the voltage source inverter

B.Direct Flux Control

The implementation of the DTC scheme requires the torque, flux linkage computation and generation of vector switching states through a feedback control of the flux and torque directly without inner current loops.

C.Direct Torque Control

If Uo or U7 is selected ,the rotation of flux is stopped and the torque decreases whereas the amplitude of flux remains unchanged with this type of torque and flux hysteresis comparator ,we can control and maintain the end of the voltage vector flux within a circular zigzag path in a ring

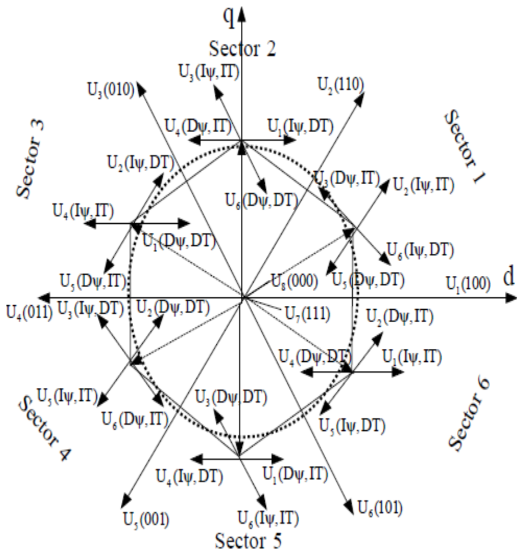

Fig 4 voltage space vector control of torque and flux in six space vectors

III FUZZY LOGIC CONTROLLER

The fuzzy logic control is one of the controller in the artificial intelligence techniques .In this paper ,mamdani type FLC is used and speed is regulated by PI controller. It uses precise mathematical model of the system and appropriate gain values of PI controller to achieve high performance drive. Therefore unexpected change in load conditions would produce overshoot ,oscillation of the IMD speed ,long settling time, high torque ripple. To overcome this problem, a fuzzy logic control is used with look up table which is designed from the performance of the torque .According to the torque error ,the proportional gain values are adjusted.

The fuzzy controller is characterized as follows
1.Seven fuzzy sets for each input and output variables
2.Fuzzification using continuous universe of discourse
3.Implication using mamdani's min operator
4.De-fuzzification using the 'centroid'method.

Fuzzification

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The control process of converting a numerical variable convert to a linguistic variable is called fuzzification.

De-fuzzification

The rules of the FLC generate required output variable in a linguistic variable, according to the real world requirements, linguistic variable have to be transformed to crisp output.

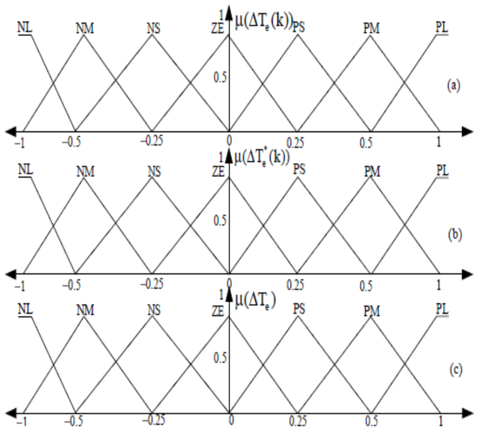

Fig 5.Membership function of input variables a) torque error b) change in torque error c) output variable

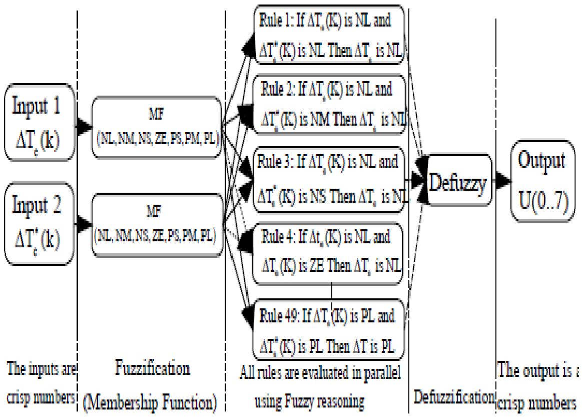

Fig 6 Flowchart of fuzzy logic controller

A FLC converts a linguistic control strategy into an automatic control strategy and the fuzzy rules are constructed by expect knowledge or experience database. Firstly ,the input torque and the change in torque error have been placed as the input to the FLC.Then the output variable of the FLC is presented by the control of change in torque

Table 1: Fuzzy logic controllers

$\Delta T_e^*(k)$ \ $\Delta T_e(k)$	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	ZE
NM	NL	NL	NL	NM	NS	ZE	PS
PS	NL	NL	NM	NS	ZE	PS	PM
ZE	NL	NM	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PM	PL	PL
PM	NS	ZE	PS	PM	PL	PL	PL
PL	ZE	PS	PM	PL	PL	PL	PL

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IV.SIMULATION RESULTS

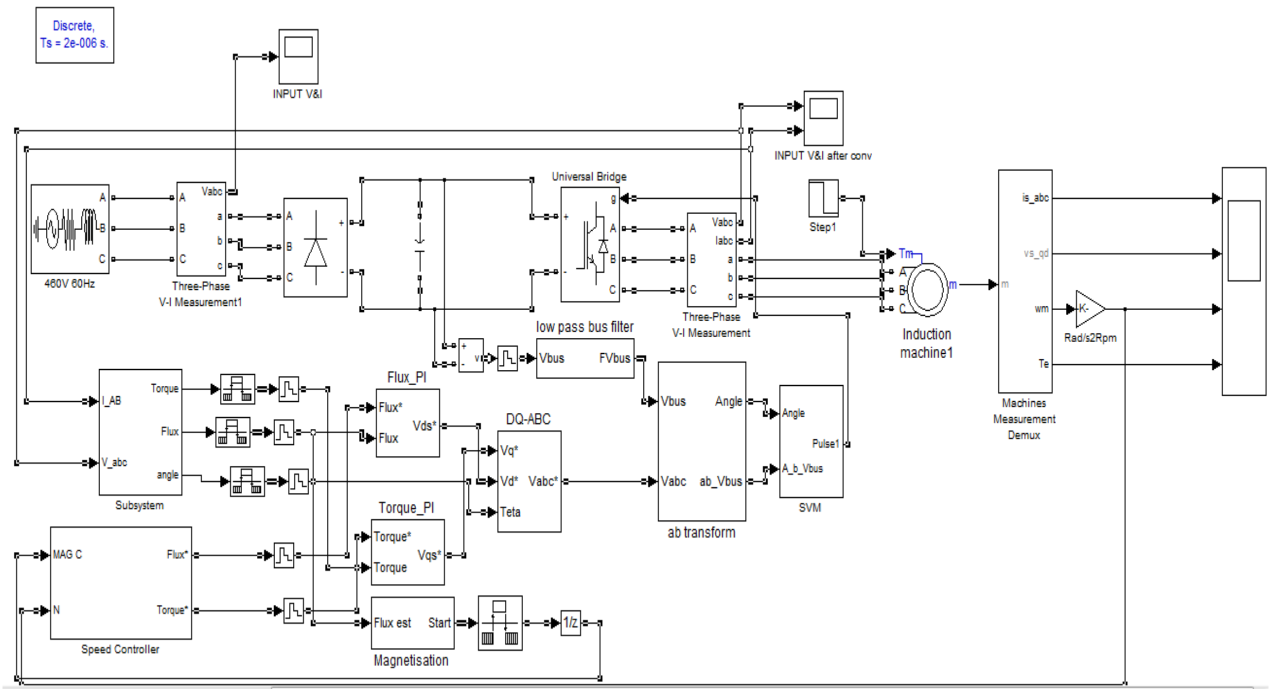

Fig 7 Simulation diagram

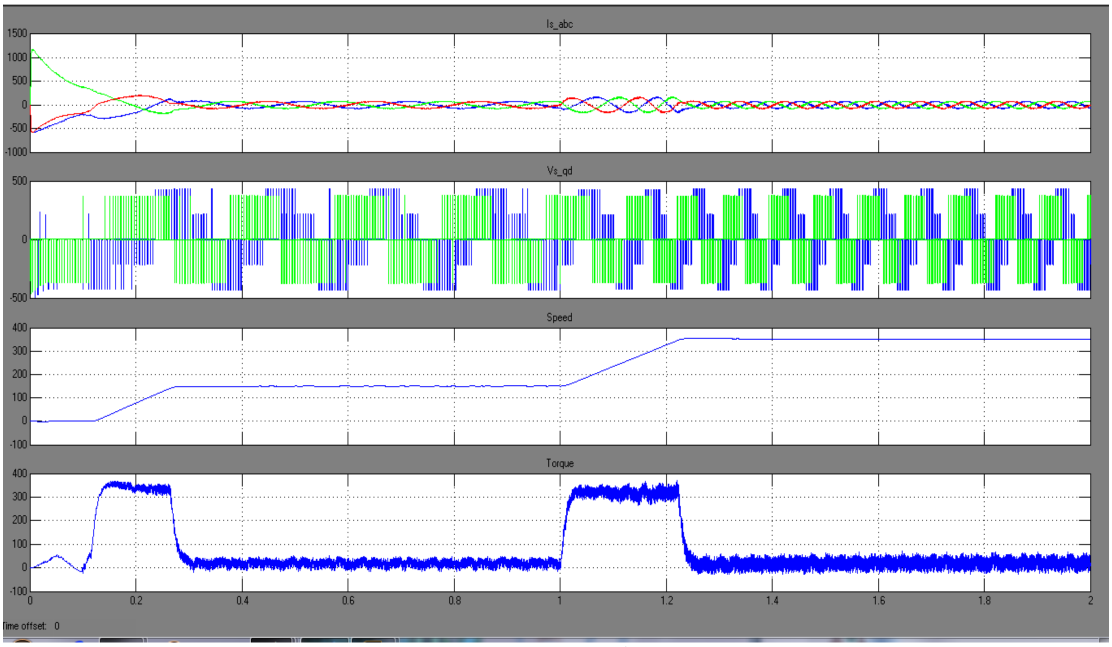

Fig .8. Output waveform

V.CONCLUSION

In this paper ,the effective control technique is presented for direct flux and torque control of three phase induction motor drive.In this proposed control technique the pi controller is regulating the speed of IMD and the fuzzy logic controller is reducing the stator flux and the electromagnetic torque ripples .It is proposed a decoupled vector control between the stator flux and the electromagnetic torque hysteresis controller for generating the pulses for VSI.The two independent torque and flux hysteresis band controllers are used in order to control the limits of the torque and flux.The simulation result shows the low stator flux linkage,torque ripple and good speed regulator with the proposed technique than the conventional DTC technique

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BIOGRAPHIES

Dr.Govindaraj Thangavel born in Tiruppur , India in 1964. He received the B.E. degree from Coimbatore Institute of Technology, M.E. degree from PSG College of Technology and Ph.D. from Jadavpur University, Kolkatta,India in 1987, 1993 and 2010 respectively. His Biography is included in Who's Who in Science and Engineering 2011-2012 (11th Edition). Scientific Award of Excellence 2011 from American Biographical Institute (ABI). Outstandin Scientist of the 21st century by International Biographical centre of Cambridge, England 2011.Since July 2009 he has been Professor and Head of the Department of Electrical and Electronics Engineering, Muthayammal Engineering College affiliated to Anna University, Chennai, India. His Current research interests includes Permanent magnet machines, Axial flux Linear oscillating Motor, Advanced Embedded power electronics controllers,finite element analysis of special electrical machines,Power system Engineering and Intelligent controllers.He is a Fellow of Institution of Engineers India(FIE) and Chartered Engineer (India).Senior Member of International Association of Computer Science and Information. Technology (IACSIT). Member of International Association of Engineers(IAENG), Life Member of Indian Society for Technical Education(MISTE). Ph.D. Recognized Research Supervisor for Anna University and Satyabama University Chennai. Editorial Board Member for journals like *International Journal of Computer and Electrical Engineering*,International Journal of Engineering and Technology,International Journal of Engineering and Advanced Technology (IJEAT).International Journal Peer Reviewer for Taylor &Francis International Journal "Electrical Power Components & System"United Kingdom,Journal of Electrical and Electronics Engineering Research,Journal of Engineering and Technology Research

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Vol. 2, Issue 1, January 2014

(JETR),International Journal of the Physical Sciences,Association for the Advancement of Modelling and Simulation Techniques in Enterprises,International Journal of Engineering & Computer Science (IJECS),Scientific Research and Essays,Journal of Engineering and Computer Innovation,E3 Journal of Energy Oil and Gas Research,World Academy of Science, Engineering and Technology,Journal of Electrical and Control Engineering（JECE),Applied Computational Electromagnetics Society etc.. He has published 155 research papers in International/National Conferences and Journals. Organized 40 National / International Conferences/Seminars/Workshops. Received Best paper award for ICEESPEEE 09 conference paper. Coordinator for AICTE Sponsored SDP on special Drives,2011.Coordinator for AICTE Sponsored National Seminar on Computational Intelligence Techniques in Green Energy, 2011.Chief Coordinator and Investigator for AICTE sponsored MODROBS - Modernization of Electrical Machines Laboratory. Coordinator for AICTE Sponsored International Seminar on "Power Quality Issues in Renewable Energy Sources and Hybrid Generating System", July 2013

T.KEERTHANA received her B.E and M.E. PED from Kongu Engineering College and Muthayammal Engineering College respectively. Now she is working as Assistant Professor,in the Department of EEE Muthayammal College of Engineering Rasipuram, Namakkal,India. Her area of interest are Electrical drives, DTC,DFC and FLC.