International Journal of Marketing and Technology

(ISSN: 2249-1058)

CONTENTS

Chief Patron

Dr. JOSE G. VARGAS-HERNANDEZ
Member of the National System of Researchers, Mexico

Research professor at University Center of Economic and Managerial Sciences,
University of Guadalajara
Director of Mass Media at Ayuntamiento de Cd. Guzman
Ex. director of Centro de Capacitacion y Adiestramiento

Patron

Dr. Mohammad Reza Noruzi
PhD: Public Administration, Public Sector Policy Making Management,
Tarbiat Modarres University, Tehran, Iran
Faculty of Economics and Management, Tarbiat Modarres University, Tehran, Iran
Young Researchers' Club Member, Islamic Azad University, Bonab, Iran

Chief Advisors

Dr. NAGENDRA. S.
Senior Asst. Professor,
Department of MBA, Mangalore Institute of Technology and Engineering, Moodabidri

Dr. SUNIL KUMAR MISHRA
Associate Professor,
Dronacharya College of Engineering, Gurgaon, INDIA

Mr. GARRY TAN WEI HAN
Lecturer and Chairperson (Centre for Business and Management),
Department of Marketing, University Tunku Abdul Rahman, MALAYSIA

MS. R. KAVITHA
Assistant Professor,
Aloysius Institute of Management and Information, Mangalore, INDIA

Dr. A. JUSTIN DIRAVIAM
Assistant Professor,
Dept. of Computer Science and Engineering, Sardar Raja College of Engineering,
Alangulam Tirunelveli, TAMIL NADU, INDIA

Editorial Board

Editorial Advisory Board

Technical Advisors

Associate Editors

Title

A NEW APPROACH TO SENSOR LESS VECTOR CONTROL OF INDUCTION MOTORS

Author(s)

G. Srinivas
Assistant professor
Gitam University Hyderabad

Dr. S. Tarakalyani
Assoc Professor
J.N.T.U.H Hyderabad

Abstract:

Induction motors are used in variable speed drive applications with the development of vector control technology. There are two forms of vector or field oriented control: direct field orientation, which relies on direct measurement or estimation of the rotor flux, and indirect field orientation, which utilizes an inherent slip relation. Though indirect field orientation essentially uses the command (reference) rotor flux, some recent works using the actual rotor flux are reported to achieve perfect decoupling Estimation rather than measurement of the rotor flux is an alternative approach for both direct and indirect field orientation that has received considerable attention. In this paper the rotor flux and speed control of induction motor is presented using a novel technique in which the induction motor model in rotor reference frame is considered. Controllers used for sensor less control of the drive. The estimation technique works well and the sensor less speed control scheme can achieve fast transient response as good as that of the induction motor with sensors and at the same time maintain a wide speed control range. This paper presents work on flux and speed estimation of induction motor by considering the rotor reference frame of the Induction motor using MATLAB / Simulink.

Index Terms— Induction motor, Kalman filter, Sensor less control, Simulink.

INTRODUCTION:

In a field oriented induction motor drive, the field flux and armature mmf are separately created and controlled based on the vector coordinate transformations. These projections lead to a structure similar to that of a DC machine control[1]-[3]. The field oriented control is used in most of the induction motor drive applications in order to obtain high control performance, but it needs motor flux position (rotor flux angle) information and utilizes AC excitation voltages for the current regulation. Current regulation is provided with advanced feedback control methods based on the current measurements taken at the output of excitation voltages supplied from voltage source inverter (VSI). The rotor flux angle can be measured by using shaft sensor and that information is utilized by field orientation scheme. However, as discussed in the current study, sensor less control algorithms[5]-[8] eliminate the need for a shaft sensor. The induction machine drives without the speed sensor are attractive due to low cost and high reliability. Therefore, flux and speed estimations have become particular issues of the field oriented control in the recent years. The main advantages of speed sensor less induction motor drives are lower cost, reduced size of the drive machine, elimination of sensor cable and increased reliability. As it is stated, for implementing vector control, the determination of the rotor flux position is required. Two basic approaches to determine the rotor flux position angle have evolved. One of them is the direct field orientation which depends on direct measurement or estimation of rotor flux magnitude and angle. From the feasibility point of view, implementation of the direct method is difficult. The other one is the indirect field orientation which makes use of slip relation in computing the angle of the rotor flux relative to rotor axis.

The Field Oriented Control (Vector Control) of Induction Machines:

Basically, field oriented control[4],[9] (FOC) is a method based on vector coordinates. The term “vector” refers to the control technique that controls both the amplitude and the phase of AC excitation voltage. Vector control is used for controllers that maintain 90° spatial orientation between the two field components which are d and q co-ordinates of a time invariant system. In a field oriented induction motor drive, the field flux and armature mmf are separately created and controlled based on the vector coordinate transformations. These projections lead to a structure similar to that of a DC machine control. The field oriented control is used in most of the induction motor drive applications in order to obtain high control performance, but it needs motor flux position (rotor flux angle) information and utilizes AC excitation voltages for the current regulation. Current regulation is provided with advanced feedback control methods based on the current measurements taken at the output of excitation voltages supplied from voltage source inverter (VSI). The rotor flux angle can be measured by using shaft sensor and that information is utilized by field orientation scheme. However, as discussed in the current study, sensor less control algorithms eliminates the need for a shaft sensor. The induction machine drives without the speed sensor are attractive due to low cost and high reliability. Therefore, flux and speed estimations have become particular issues of the field oriented control in the recent years. The main advantages of speed sensor less induction motor drives are lower cost, reduced size of the drive machine, elimination of sensor cable and increased reliability. As it is stated, for implementing vector control, the determination of the rotor flux position is required. Two basic approaches to determine the

rotor flux position angle have evolved. One of them is the direct field orientation which depends on direct measurement or estimation of rotor flux magnitude and angle. From the feasibility point of view, implementation of the direct method is difficult. The other one is the

indirect field orientation which makes use of slip relation in computing the angle of the rotor flux relative to rotor axis.

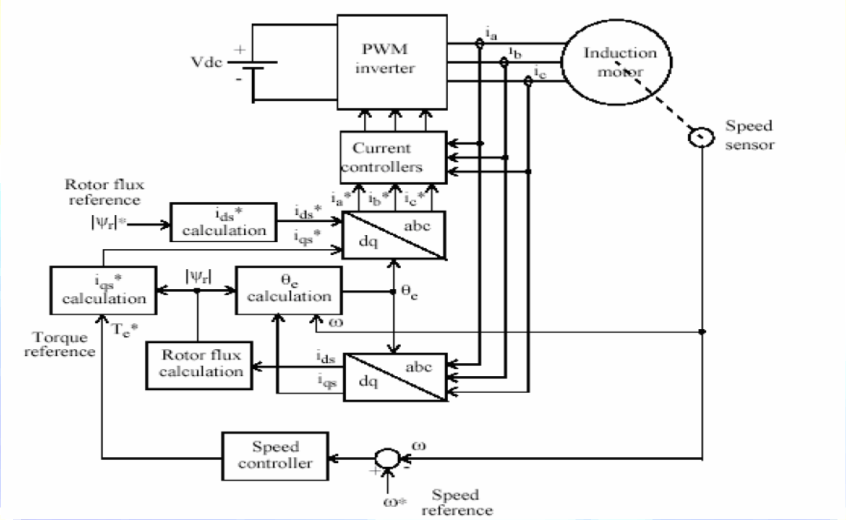


Fig.2 Field orientation control of Induction Motor

Field orientation control of Induction Motor

$$iqs *=\frac{2}{3}\frac{2}{p}\frac{Lr}{Lm}\frac{Te*}{\psi rest}$$

Stator quadrature axis flux linkage

$$Lr = \text{roror inductance}$$

$$Lm = \text{mutual inductance inductance}$$

$\psi rest = \text{estimated rotor flux linkage}$

ψrest= Lm ids/1+τ_{rs}

$\tau_{rs}=\frac{Lr}{Rr}$

$$i_{ds}* = \psi r*/Lm$$

Stator direct axis current reference

Rotor flux position :

$\theta e = \int (\omega m + \omega sl)dt$

$$\omega sl = \frac{Lm}{\psi r\ est} \frac{R_r}{L_r} i_{qs}{}^{*}$$

Sensor less Vector Control of Induction Machine:

To implement vector control, determination of the rotor flux position is required. Rotor speed or position could be measured by a shaft sensor. Moreover, rotor flux position could be taken by sensing the air-gap flux with the flux sensing coils. The main drawbacks of using speed/position sensor are high cost, lower system reliability and special attention to noise. Such problems make sensor less drives popular. The recent trend in field-oriented control [11]-[14] is towards avoiding the use of speed sensors and using algorithms based on the terminal quantities of the machine for the estimation of the fluxes. Different solutions for sensor less drives have been proposed in the past few years. Saliency based fundamental or high frequency signal injection is one of the flux and speed estimation techniques. A method involving modulation of the rotor slots results in a salient rotor, and the saliency can be tracked by imposing a balanced, three-phase, high-frequency set of harmonics from the inverter. An alternative method is to use saliency caused by magnetic saturation the absolute rotor position can be detected. The advantage of the saliency technique is that the saliency is not sensitive to actual motor parameters the rotor speed[10] can be estimated through nonlinear observers alternatively, the rotor speed can be considered as a parameter and estimated using recursive identification. The latter method can also be augmented to include machine parameter estimation (inductances, resistances, and time constants). These methods do not need to rely on harmonics or saliency, and the hardware requirements are the same as for the digital implementation of vector control, given that the estimation algorithm is not too complex. Their drawback is that the rotor speed estimate will be inaccurate if the non-estimated machine parameters are not known..

Induction motor modeling:

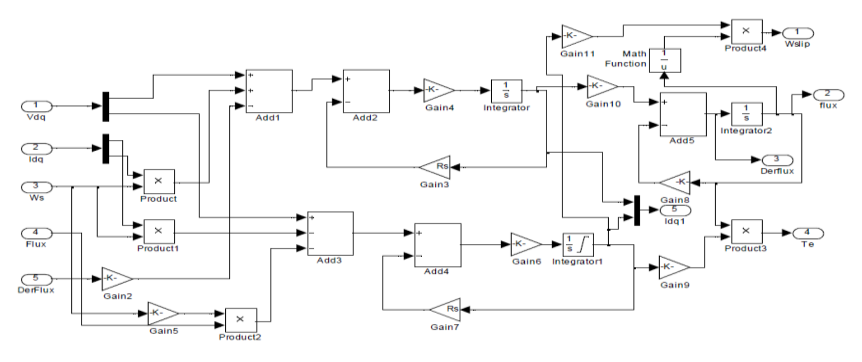


Fig.2 Induction motor block diagram

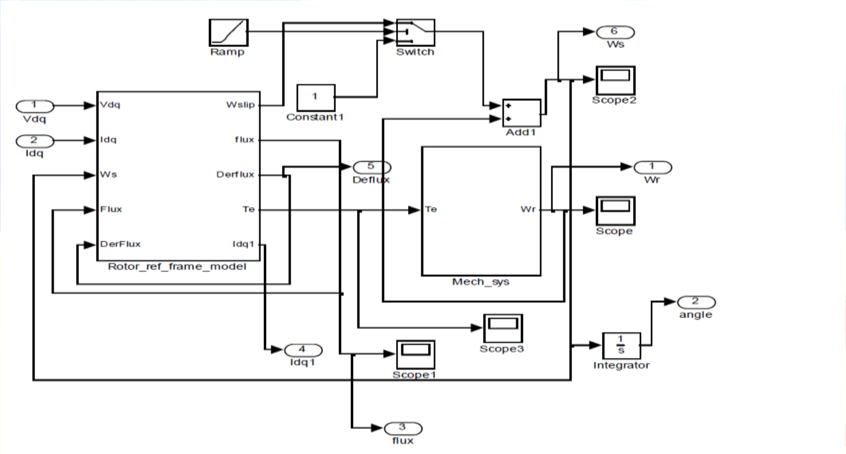


Fig.3 Speed and Estimator block

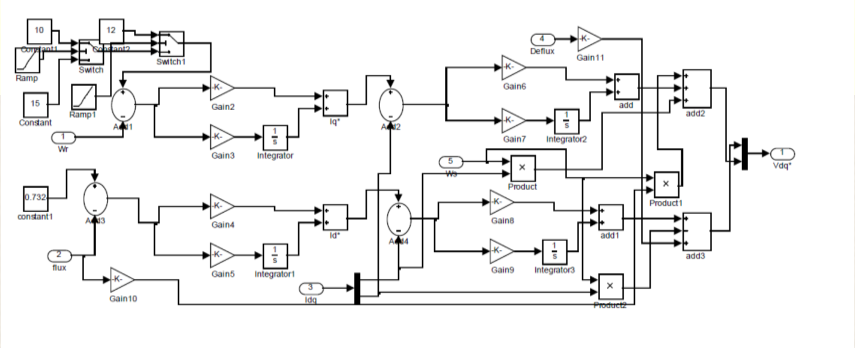


Fig.4 control and logic block

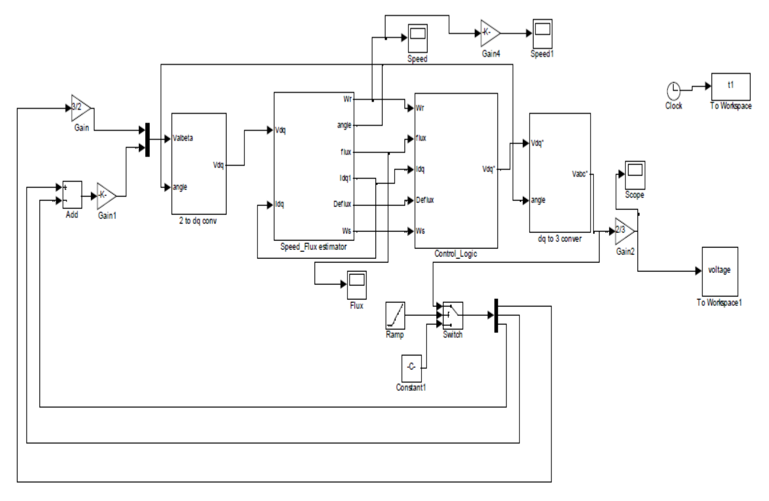
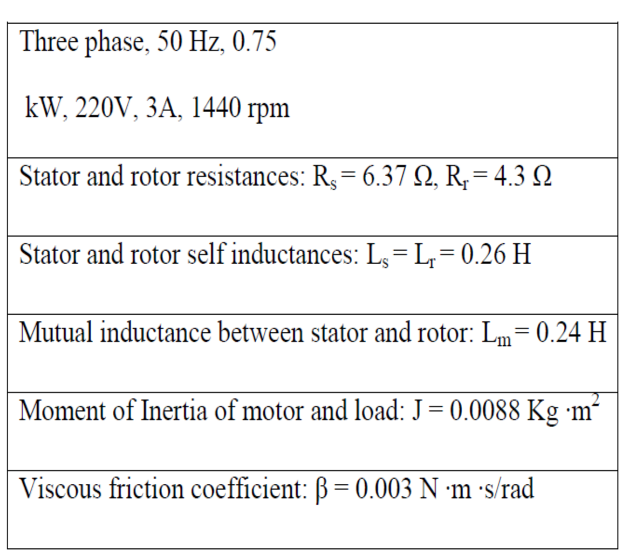


Fig.5sensorless vector control induction motor Mat lab/Simulink model

Table.1

Ratings and parameters of induction motors



Three phase, 50 Hz, 0.75 kW, 220V, 3A, 1440 rpm
Stator and rotor resistances: $R_s = 6.37\ \Omega$, $R_r = 4.3\ \Omega$
Stator and rotor self inductances: $L_s = L_r = 0.26$ H
Mutual inductance between stator and rotor: $L_m = 0.24$ H
Moment of Inertia of motor and load: $J = 0.0088$ Kg ·m^2
Viscous friction coefficient: $\beta = 0.003$ N ·m ·s/rad

SIMULATION RESULTS:

Direct Torque Control of Induction machine is simulated on MATLAB or SIMULINK- platform to study various aspects of the controller. This chapter discusses a realization of difference in response of induction motor with regular input and the implementation of Direct Torque Control (DTC) technique.

In this Simulink block diagram the induction motor is fed from a balanced three phase supply. For the induction motor block torque and speed estimation block is added in order to observe response of an induction motor. The balance three phase supply is converted into the voltages of the d-q axis components for the estimation of the motor parameters. In the fallowing block only the subsystems of induction motor and torque & speed estimation block are presented for the simplicity purpose. From the above simulation results it is observed that the induction motor parameters can be estimated by simulating the induction motor model equations. Fig 6. shows the plot between rotor speed versus time. Fig 7-9 shows the estimated value of the induction motor. For all the results the initial time taken is 2 msec after that it comes to steady state.

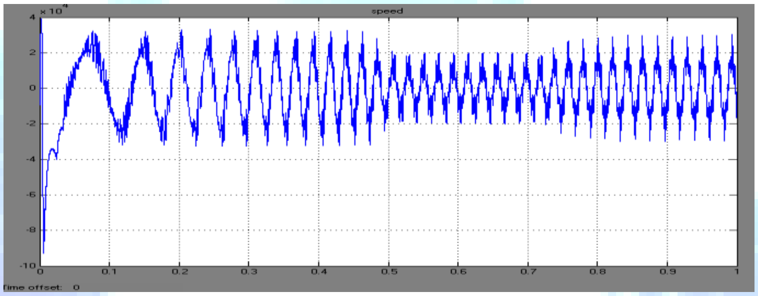


Fig.6. rotor torque

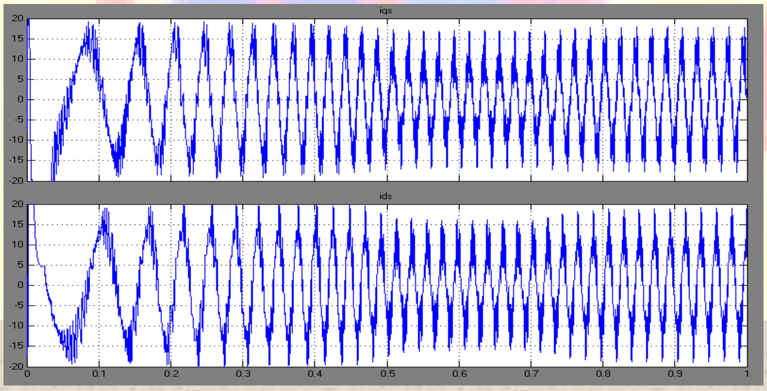


Fig.7. stator currents direct axis and quadrature axis (Ids, iqs)

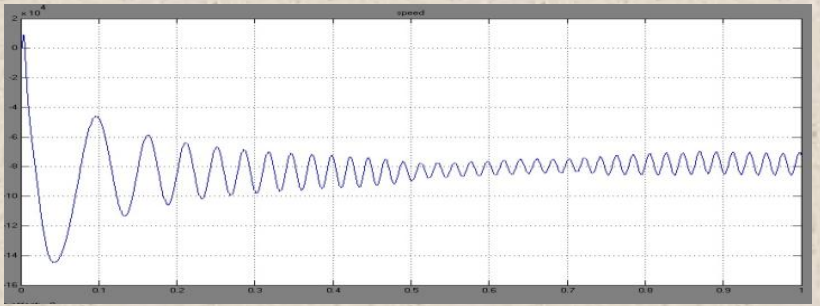


Fig.8. rotor speed

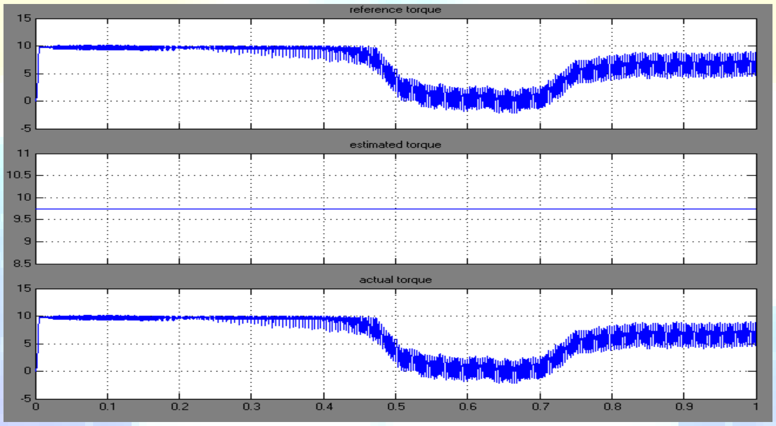


Fig.9. Rotor currents direct axis and quadrature axis (idr, iqr)

Conclusion:

The estimation of rotor flux and speed of induction motor is presented by the rotor reference frame model equations by using the flux and speed estimator. The dynamic response of sensor less speed control is as fast as that of the machine with physical sensors. Sensor less speed control scheme works for a wide speed control range.

Reference:

- G. C. Verghese, and S. R. Sanders, “Observers for flux estimation in induction machines”, IEEE Trans. on Indust. Elect., vol. 35, no. 1, pp. 85-94, 1988.
- H. Kubota, K. Matsuse and T. Nakano, “DSP-based speed adaptive flux observer of induction motor,” IEEE Trans. on Ind. Applicat., vol. 29, pp. 344-348, March/April 1993.

- L. Harnefors and H.P. Nee, "Full-order observers for flux and parameter estimation of induction motors," EPE'97, vol. 3, Trondheim, 1997, pp. 375-381.
- J.H. Kim, J.W. Choi and S.K. Sul, "Novel rotor-flux observer using observer characteristic function in complex vector space for field-oriented induction motor drives," IEEE Trans. Ind. Applicat., vol. 38, pp. 1334-1343, Sept./Oct. 2002.
- M. Hinkkanen, "Analysis and design of full-order flux observers for sensorless induction motors," IEEE Trans. Ind. Electron., vol. 51, pp. 1033- 1040, Oct. 2004.
- F. Alonge, F. D'Ippolito, G. Giardina and T. Scaffidi, "Design and low cost implementation of an optimal robust reduced order rotor flux observer for induction motor control," IEEE Transaction on Industrial Electronics, vol. 54, n.6, December 2007.
- T. Du, P. Vas and F. Stronach, "Design and applications of extended observers for joint states and parameter estimation in high-performance AC drives," IEE Proc. Electric Power Applicat., vol. 142, No. 2, pp. 71-78, March 1995.
- M. Barut, S. Bogosyan, and M. Gokasan, "Speed-sensorless estimation for induction motors using Extented Kalman Finters," IEEE Trans. Ind. Electron., vol. 54, NO. 1, February 2007, pp. 272-280.
- S. Bogosyan, M. Barut, and M. Gokasan, "Braided extended Kalman filters for sensorless estimation in induction motors at high-low/zero speed,"IET Control Theory Appl., vol. 1, no. 4, 2007, pp. 987-998.
- L. Cai, Y. Zhang, Z. Zhang, C. Liu and Z. Lu, "Application of Genetic Algorithms in EKF for Speed Estimation of an Inducion Motor, Proc. on IEEE Power Electronics Specialist Conference, Vol. 1, 15-19 June 2003, pp. 345-349
- F. Alonge, F. D'Ippolito and F.M. Raimondi, "Least squares and genetic algorithms for parameters identification of induction motors," Control Engineering Practice, June 2001, vol. 9/6, pp.647-657.
- K. Rajashekara, A. Kawamura, K. Maytsuse, Sensorless Control ofAC Motor Drives – Speed and Position Sensorless Operation, IEEE Press, 1996.
- P. Vas, Sensorless Vector and Direct Torque Control, Oxford University Press, New York, 1998.
- B. K. Bose, Modern Power Electronics and AC Drives, Prentice Hall PTR, Upper Saddle River: 2002.