International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 3 Issue: 6 3543 - 3546

# Performance Analysis of Induction Motor For Sudden Load Disturbance Using PI And FUZZY Controller

Ritu Gopal (M-Tech Scholar)
Electrical and Electronics Engg.Department
Dr. C V Raman Institute of Science and Technology Kota
Bilaspur, India
*gopalritu@gmail.com*

Dr. Dharmendra Kumar Singh (Head of the Department)
Electrical and Electronics Engg. Department
Dr. C V Raman Institute of Science and Technology Kota
Bilaspur, India
*Dmsingh2001@rediffmail.com*

Electrical and Electronics Engg. Department
Dr. C V Raman Institute of Science and Technology Kota
Bilaspur, India
*amitagrawal_bit@rediffmail.com*

***Abstract***—This paper presents the improved performance in speed of an induction motor by applying vector control techniques which transforms the induction motor from nonlinear to linear plant system and fuzzy control system provides the better running performance of the induction motor at various disturbances in load by tracking the waves to reach the steady state response earlier than PI controller. The benefits of squirrel-cage induction motors are high robustness and low maintenance which make it widely used through various industrial modem processes, with growing economical and demands. In conventional FOC, PI controller is used to control the speed response of the induction motor drive. The use of PI controller induces many problems like high overshoot, oscillation of speed and torque due to sudden changes in load and external disturbances. This behavior of the controller causes deterioration of drive performance. To overcome this disadvantages an intelligent controller based on fuzzy logic is employed in the place of the conventional PI controller.

***Keywords***-*Induction motor; fuzzy logic controller (FLC); PI controller; Vector control.*

*****

## I. INTRODUCTION

The cage induction motor drive with vector or field oriented control offers a high level of dynamics performance and the closed-loop control associated with this drive provides the long term stability of the system. IM drives are used in a multitude of industrial and process control applications requiring high performances. In order to achieve high performance, FOC of induction motor drive is employed [1]. In this paper, for the realization of variable speed induction motor drive a technique used is indirect vector control technique that can be performed in synchronously rotating reference frame. A comprehensive mathematical modeling of vector controlled induction motor drive system has been carried out to analyse the drive system.

Proportional-Integral (PI) control is most commonly used control system in industries due to its simplicity and robust performance in a wide range of operating condition. But due to some drawbacks of PI controller of high overshoot and oscillation of speed and torque at various load disturbances will replace it by intelligent fuzzy logic controller which will overcome all the above disadvantages occured in PI controller [7]. Fuzzy logic is a very powerful method of reasoning when mathematical formulations are infeasible and input data are imprecise. Fuzzy logic is a powerful tool for designing the control system accurately.

## II. MATHEMATICAL EQUATIONS USED IN INDIRECT VECTOR CONTROL TECHNIQUE

The indirect vector control method is essentially the same as the direct vector control, except that the rotor angle is generated in an indirect manner (estimation) using the measured speed and the slip speed. To implement the indirect vector control strategy, it is necessary to take dynamic equation into consideration and the following equations[1] [10]

$$\theta e = \int \omega e = \int (\omega r + \omega sl) = \theta r + \theta sl \qquad \text{...............................(i)}$$

For decoupling control, the stator flux component of current ids should be aligned on the de axis, and the torque component of current iqs should be on the $q^e$ axis, that leads to $\psi_{qr} = 0$ and $\psi_{dr} = \psi_r$ then:

$$\frac{L_r}{R_r}\frac{d\psi_r}{dt} + \psi_r = L_m i_{ds} \qquad \text{......................................(ii)}$$

The slip frequency is calculated from the stator reference current $i_{qs}$* and the motor parameters.

$$\omega_{sl} = \frac{L_m R_r}{\psi_r L_r} i_{qs} \qquad \text{.............................................(iii)}$$

It is found that the ideal decoupling can be achieved if the above slip angular speed command is used for making field-orientation. For a constant rotor flux ψr and $\frac{d\psi_r}{dt} = 0$

Substituting in equation yields the rotor flux set as

 ISSN: 2321-8169
3543 - 3546

$$\psi_r = L_m i_{ds} \qquad \text{.............................................(iv)}$$

The stator quadrature-axis current reference $i_{qs}$* is calculated from torque reference $T_e$* as

$$Te = \frac{3}{2}\frac{P}{2}\frac{L_m}{L_r}\psi_r i_{qs} \qquad \text{........................................(v)}$$

The stator direct-axis current reference $i_{ds}$* is obtained from rotor flux reference input $|\psi_r|$*

$$i_{ds} = |\psi_r|^* / L_m \qquad \text{..........................................(vi)}$$

Where, $L_r$ is the rotor inductance, $L_m$ is the mutual inductance of the stator, and $|\psi_r|_{est}$ is the estimated rotor flux linkage.
The speed cannot normally be treated as a constant. It can be related to torque as

$$Te = T_L + J(dwm/dt) = T_L + 2/P\ J(dwt/dt) \text{.............(vii)}$$

$T_L$ =load torque, J = rotor Inertia, and wm=mechanical speed [10]

## III. METHODOLOGY

The principle behind the field oriented control or the vector control is that the machine flux and torque are controlled independently, same as a separately excited DC machine. Instantaneous stator currents transform to a reference frame rotating at synchronous speed aligned with the rotor stator or air gap flux vectors, to produce a d-axis and a q-axis component current. (SRRF).In this work, SRRF is aligned with rotor mmf space vector, the stator current space vector is divided into two decoupled components, in which one can controls the flux and the other can controls the torque.[1][4][5]

An induction motor is said to be in vector control mode , when decoupled components of stator current in space vector and the reference decoupled components defined by the vector controller in the SRRF match each other. Alternatively, in the place of matching the two phase currents in the SRRF, the close match can also be made in the three phase currents in the stationary reference frame. Hence in the place of induction machine's non linear and highly interacting multivariable control structure, its control is easy by using FOC. Therefore FOC technique operates the induction motor similar to a separately excitedly DC motor.[5]

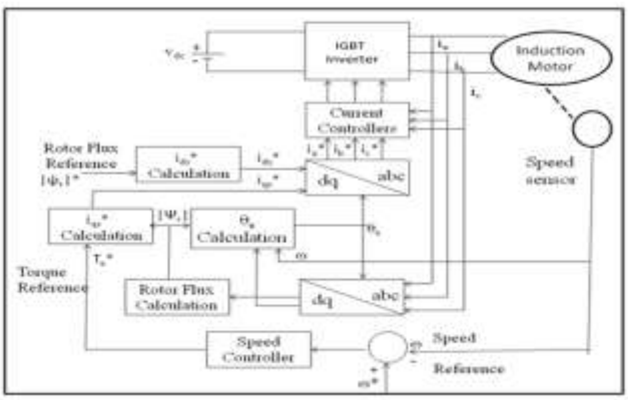


Figure 1.Block diagram for indirect Vector control of induction Motor

Proportional-Integral (PI) controller was the first simplest controller used in industries due to its simplicity in structure and its robustness. It is one of the most common and simple method used in industrial areas. PI controller is the simple and most commonly used controller because of its simple construction, low cost, easy to tune, and robust nature. No exact model is needed in it and hence, it can be used for processes whose models are considerably difficult to be driven. There are some disadvantages also in this controller due to which that controller is not performing good in some of the cases like when the operating point is changed in that case system will processed in nonlinear system so the performance will become poor, also in the case of time varying parameters, and also in the case when the compensation of frequent and strong disturbances arise.[7][9]

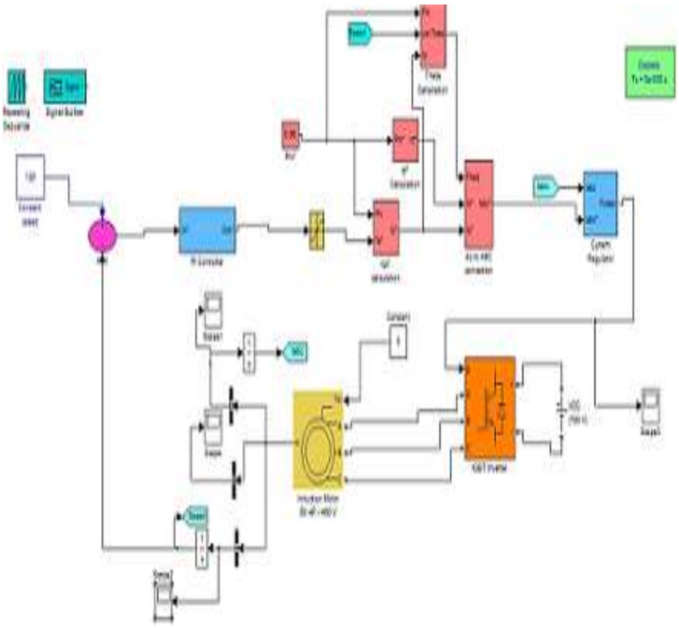

Figure 2. PI Controller based indirect Vector control of induction motor

In this paper Fuzzy logic controller and PI controller is used here for speed regulation of three phase induction motor. It is multi-valued logic that can be derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. In contrast with "crisp logic", in which the binary sets has its own binary logic, fuzzy logic variables must have truth value that will ranges between 0 and 1 and is not constrained to the two truth values of classic propositional logic. when we use the linguistic variables, such degrees will be managed by specific functions.
Fuzzy logic is a very powerful method of reasoning when mathematical formulations are infeasible and input data are imprecise. Fuzzy logic is a powerful tool for designing the control system perfectly. To calculate a fuzzy rule from each i/o data pair, the first step is to find the degree of each data value in every membership region of its corresponding fuzzy domain. so that the variables are assigned to the region with the maximum degree. When each new rule is generated from the i/o data pairs, a rule degree or truth is assigned for that

ISSN: 2321-8169
3543 - 3546

rule, where such rule degree is defined as the degree of confidence that the rule does in fact correlate to the function relating voltage and current to the angle. A degree will be assign in the developed method which is the product of the membership function degree of each variable in its respective region. Speed error is calculated with comparison between reference speed and speed signal feedback.

## IV. EXPERIMENTAL RESULTS

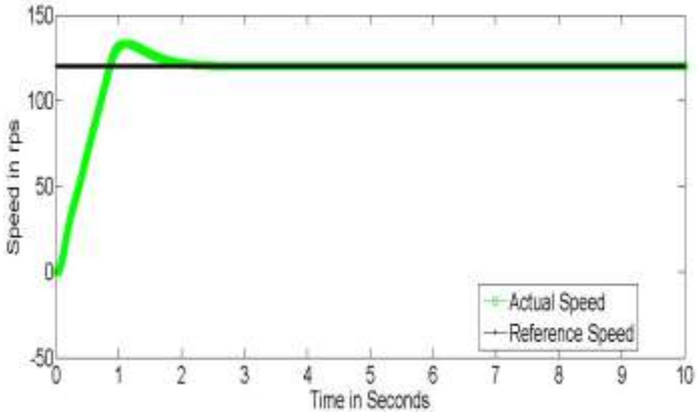


Figure.3(a)

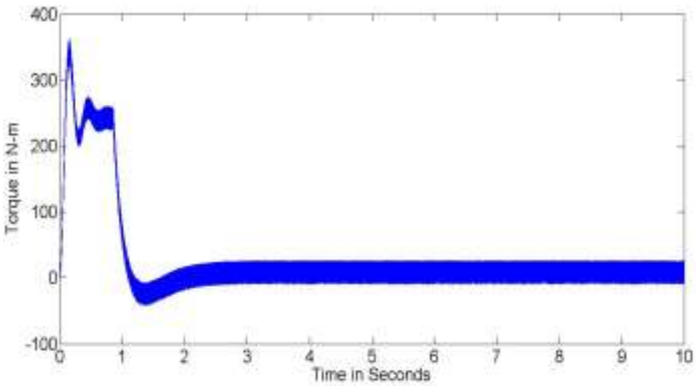


Figure.3(b)

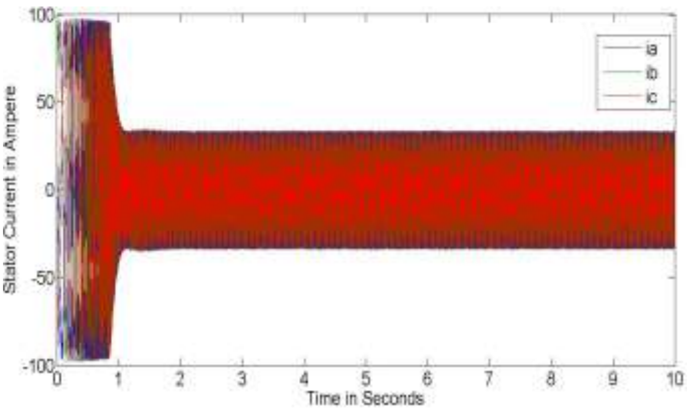


Figure.3(c)

Figure.3(a)(b)(c) are speed, torque, current Performance of indirect vector control of induction motor using PI controller at no load with reference speed 120rps

## V. CONCLUSION

Designing of controllers for speed control loop is very complex because of high computation burden .A conventional P-I controller and fuzzy logic controllers for speed control of induction motor using indirect vector control method are designed. The mathematical modelling, Operational function and performance are obtained through simulation. A FL control in IVCIM gives superior performance in terms of fast dynamic responses and stiffer speed regulation. Simulation results shows the fuzzy logic controller is more robust during load changes and eliminates the transients during sudden changes in speed. The results of both controllers under the dynamics conditions are compared and analyzed.

## REFERENCES

[1] F. Blashke, "The Principle of Field Orientation as Applied to the New Transvector Closed Loop Control System for Rotating-Field Machines", Siemens Review, vol-34, no.3, May 1972, Pp.217-220.

[2] Y. Ohdachi, Y. Kawase, M. Hirako,"Dynamic Analysis of Vector Controlled Induction Motor Using Finite Element Method", IEEE Transactions, vol-31, May 1995,Page(s) 1904 – 1907.

[3] R. Krishnan,"Review of Flux-Weakening in High Performance Vector Controlled Induction Motor Drives", Industrial Electronics Proceedings of the IEEE International Symposium on Power Electronics, vol-2, June 1996, Page(s):17-20.

[4] Ogasawara, S. Akagi, A. H. Nabae, "The Generalized Theory of Indirect Vector Control for AC Machines", IEEE Transactions on Industry Applications, May-June 1988 Page(s):470 – 478.

[5] W. Leonard, "Field Orientation for Controlling Ac Machines – Principle and Application", In proc. 1988 Power Electronics and Variable Speed Drive Conf.,1988,
pp. 277-282.

[6] A Tewari , A Tripathi, S. P. Das, "A Fuzzy Logic Controller Based Indirect Field-Oriented Induction Motor Drive System", Proceedings of IEEE International Conference on Industrial Technology,vol.2, 19-22 Jan. 2000, Page(s):359 – 364.

[7] M. N. Uddin, T. S . Radwan , M. A. Rahman,"Performances of Novel Fuzzy Logic Based Indirect Vector Control for Induction Motor Drive", Industry Applications Conference ,vol-2, 2000, Page(s):1225 – 1231.

[8] Bharat Bhushan, Madhusudan Singh, Prem Prakash,"Performance Analysis of Field Oriented Induction Motor Using Fuzzy PI and Fuzzy Logic based Model Reference Adaptive Control", Proceedings of 39th IAS Annual Meeting Industry Applications Conference ,vol-4, 17, 2004, Page(s): 2630 - 2636.

[9] Arulmozhiyal, K.Baskaran, R.Manikandan,"An Intelligent Speed Controller for Indirect Vector Controlled Induction Motor Drive", International Conference on Computational Intelligence and Computing Research , 28-29 Dec. 2010 , page(s): 1-5.

[10] Norman Mariun, Samsul Bahari Mohd Noor, Jasronita Jasni, Omar S. Bennanes,"A Fuzzy Logic Based Controller For An Indirect Vector Controlled Three-Phase Induction Motor", 10th Conference on TENCON, vol-D, 2004, page(s):1-4.

[11] R.Arulmozhiyal, K.Baskaran, R.Manikandan "Fuzzy Based PI Speed Controller For Indirect Vector Controlled Induction Motor Drive", International Conference on Power Electronics (IICPE), 2011,page(s):1-7.

[12] Biranchi Narayan Kar, K.B. Mohanty, Madhu Singh Manikandan "Indirect Vector Control of Induction Motor Using Fuzzy Logic Controller", 10th International Conference on Environment and Electrical Engineering (EEEIC), 2011,page(s):1-4.

[13] M. Masiala, B. Vafakhah, A. Knight and J. Salmon,"Performances of PI and Fuzzy–Logic Speed Control of Field–Oriented Induction Machine Drives", Canadian Conference on Electrical and Computer Engineering, 2007,page(s):397-400.

[14] Rajesh Kumar, R.A. Gupta, S.V. Bhangale,"Indirect Vector Controlled Induction Motor Drive With Fuzzy Logic Based Intrlligent Controller", ICTES 2007 Dec. 20-22, 2007. pp.368-373.