COMPARATIVE STUDY OF VECTOR CONTROL OF INDUCTION MOTOR BY USING PI CONTROLLER AND FUZZY CONTROLLER

Kailash Chandra, M.Tech. Student, Power Electronics & Drives, DIT University, Dehradun, UK, India

Husain Ahmed, Assistant Professor, Department of Electrical Engineering, DIT University, Dehradun, UK, India

Dr. Gagan Singh, Head & Professor, Department of Electrical Engineering, DIT University, Dehradun, UK, India

---

Abstract: *Induction Motors have wide variety of applications because of their advantages like rugged development, low cost and powerful performance. In latest years, more than a few facets are investigated concerning controlling induction motor. In previous year's scalar control is use for controlling purpose it is also called V/F control. It is very simple method but the main disadvantages of this method are poor dynamic performance and also it takes more time to come in stable position. After this method vector control is used. Vector control method is more complex as compare to scalar control. The VCIM drive includes decoupling of the stator current component this produces torque and flux of induction motor. It has servable advantages like good transient and dynamic performance .But it has some disadvantages like large ripple in torque in the time of starting of IM. In this paper, speed control of an induction motor (IM) using vector control with fuzzy logic and PI controller procedure has been developed and simulated. The comparative study of VCIM with PI and VCIM with fuzzy logic is done on MATLAB/SIMULINK software. Results show the effectiveness of vector control with fuzzy logic controller over traditional PI based vector control method.*

Keywords: *Induction motor, vector control, mathematic modeling, Fuzzy logic controller.*

1. INTRODUCTION:

Induction motors are used in many industrial applications due less maintenance, robustness and simple construction. Maximum torque and efficiency can be obtained by accurate controlling of induction machine. In latest years, the control of the induction motor power is an active study discipline for engineers. Generally, the control and estimation of ac machines is difficult in the compression of dc drives, and this difficulty increase if high performance is demanded. In V/F control required feedback signal but due to presence of harmonic difficulty comes in the processing of feedback signal. The most common method for controlling of induction motor use in industries is vector control or field oriented control. There are nearly two common approaches of vector control. One called the direct or feedback system, and the other, the indirect or feed forward system. indirect vector controlled (IVC) induction motor (IM) drives used in high efficiency programs is very trendy in industrial applications as a result of their relative easy configuration, as in comparison with the direct method which requires flux and torque estimator. The most important advantages of indirect vector control are the decoupling of torque and flux easily. Vector control is also known as decoupling, orthogonal or Trans vector control. Vector control give more accurate result as compare to scalar control due to this advantages it become standard control of ac machines [1]. Conventionally PI controller used for controlling purpose and it gives good results. But in some application like ac drives it's not give desirable result. So we required an advance technique such as fuzzy logic for achieving desirable result. In this paper comparative study between the conventional vector control and fuzzy based vector control is done.

2. VECTOR CONTROL OR FIELD ORIENTED CONTROL:

The other name of Vector control is field-oriented control (FOC), is a frequency control method where the stator currents of a three-phase AC machine are divided as two orthogonal components that can be visualized with a vector. One component defines the magnetic flux of the machine, the other the torque. The control method of the drive calculates from the flux and torque references given by using the drive's speed control the corresponding present aspect references. Conventionally used proportional-integral (PI) controllers for comparing measured current with their reference values. According to PI controller output transistor switch and the stator voltage of motor produce according transistor switching. Vector control induction motor can be control like separately excited DC motor. Vector control is suitable for both induction and synchronous machine drives. In DC machine the field flux is 90 degree to the armature flux. These two fluxes produce no interaction with each other. By adjusting the field current can control the DC machine flux, and the torque may also be control independently of flux by using adjusting the armature current. the construction of AC machine is not simple like DC machine ,in AC machine both stator and rotor flux intersect each other and flux linking of stator and rotor change according to running condition We are able to obtain DC machine like efficiency in protecting a constant and orthogonal orientation between the field and armature fields. In an AC devices by way of orienting the stator current with admire to the rotor flux to be able to obtain independently managed flux and torque [3]. Vector control is suitable to each induction and synchronous motor drives. The cage induction motor drive with vector control presents a high stage of dynamics efficiency and the closed-loop control provide fast and accurate response of system. Induction Motor drives are used in a numbers of commercial and procedure control functions requiring excessive performances [4]. In high performance pressure methods, the motor speed will have to intently follow a distinct reference trajectory prevailing any load disturbances, parameter variants, and mannequin uncertainties. With a view to achieve excessive performance, field-oriented control of induction motor (IM) drive is employed. Nonetheless, the controller design of this type of procedure performs a critical role in approach efficiency. Due to parameter change decoupling characteristics of vector controlled IM are an affected. So the vector control is also known as an unbiased or decoupled control.

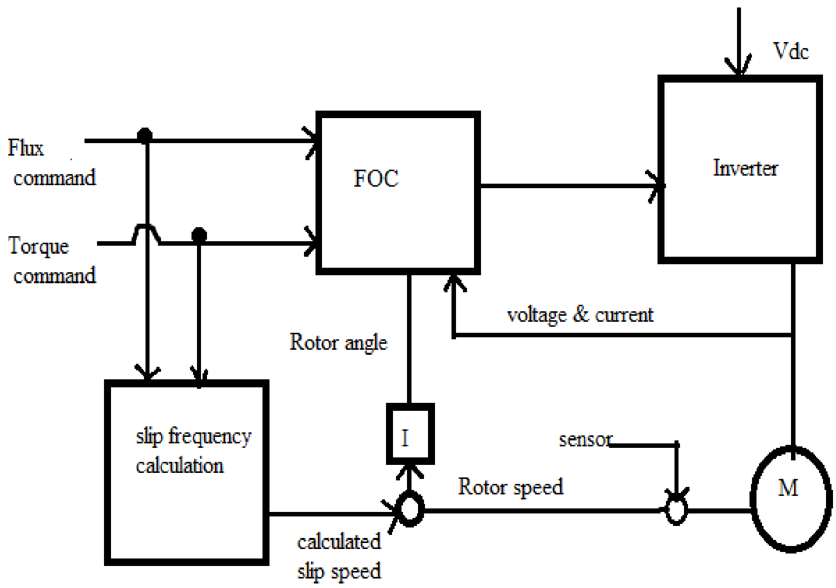


Fig 1: Field oriented control

3. INDUCTION MOTOR MODELLING:

So to reduce the complexity of the modeling the three phase quantities converted to two phase system. The modified voltage equations (1) for the rotor and stator on the synchronously rotating reference frame are as follows:-

$$Vds = RsIds + D\Psi ds - we\Psi qs \quad (1)$$

$$Vqs = RsIqs + D\Psi ds + we\Psi ds \quad (2)$$

$$Vdr = RrIdr + D\Psi dr - (we - wr)\Psi qr \quad (3)$$

$$Vqr = RrIqr + D\Psi qr + (we - wr)\Psi dr \quad (4)$$

= stator d axis voltage, = stator q axis voltage, = rotor d axis voltage, = stator d axis flux, = stator q axis flux, = rotor d axis flux, = rotor q axis flux

The above flux linkage in a synchronous rotating frame can be expressed as

$$\Psi ds = LsIds + LmIdr \quad (5)$$

$$\Psi qs = LsIqs + LmIqr \quad (6)$$

$$\Psi dr = LrIdr + LmIds \quad (7)$$

$$\Psi qr = LrIqr + LmIqs \quad (8)$$

$$Te = \frac{3}{2} p \, \Psi dsIqs - \Psi qs \, Ids \quad (9)$$

T_e = Electromagnetic torque

4. PI CONTROLLER DESIGN:

The output of a traditional PI controller is given with the aid of the following equation:

$$U = Kp * e + Ki * \int edt \quad (10)$$

Where, e = error (difference between reference speed and actual speed),

Kp = proportional gain, Ki = Integral gain.

5. FUZZY LOGIC CONTROLLER:

Fuzzy logic controller consist three parts.

- Fuzzification
- Inference
- Defuzzification
- In fuzzification covert crisp value in fuzzy set which is lie between (0, 1). Within the fuzzification step the error and change in error alerts are normalized to values which lie in between -1 to 1. The triangular and trapezoidal membership function makes the calculations less difficult and controller to be simple [2].
- In inference engine all rule are applied to the system and control output according to requirement.
- In defuzzification fuzzy set convert into crisp value.

ISSN: 2278-6244
Impact Factor: 6.111

Fuzzy logic control (FLC) is a control calculation taking into account an etymological control methodology which tries to account the human's learning about how to control a system without requiring a numerical model [9]. Basic block diagram of FLC shown in fig 2.

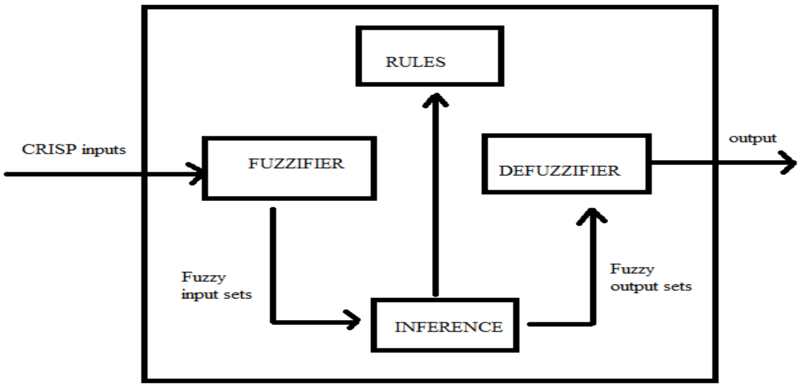
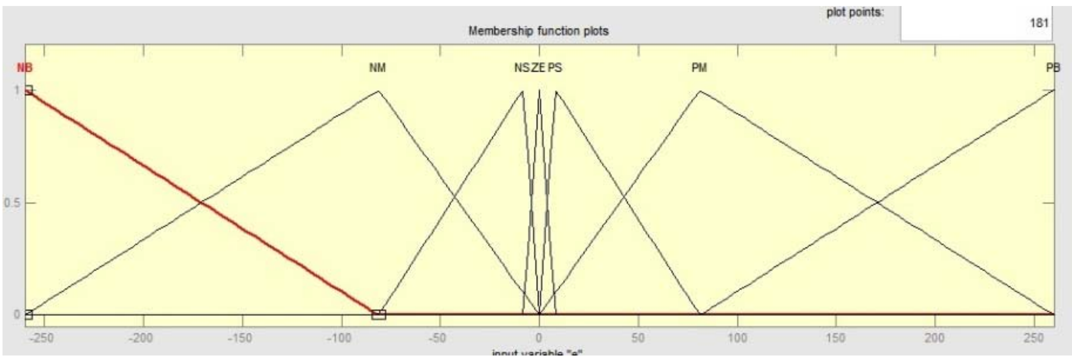


Fig 2: block diagram of fuzzy logic controller

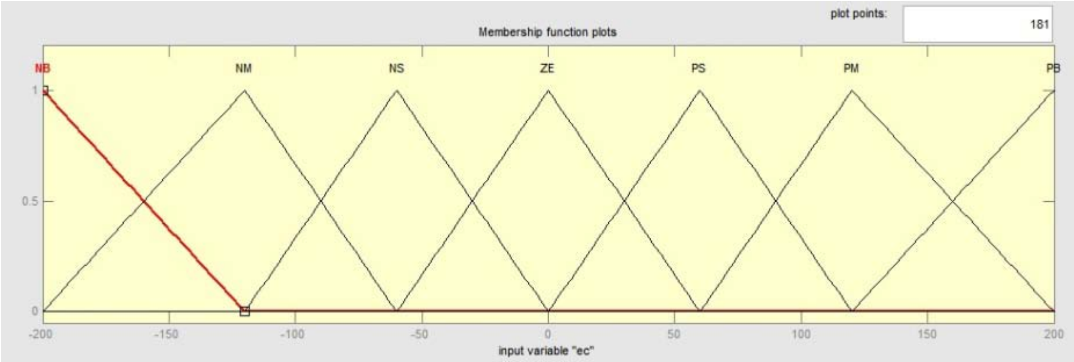
6. FLC DESIGN:

Membership Functions required for designing of a fuzzy logic controller. The membership functions should be picked such that they cover the whole universe of talk. Membership functions should be overlapping each other. This is done in order to avoid any kind of brokenness concerning the minor changes in the inputs. For better control, the membership function near the zero regions should be made tight. Broader member function works a long way from the zero regions gives speedier response to the system. Thus, the membership function should be adjusted as requirements are. After choosing suitable membership functions, a rule base should be made. It contains different Fuzzy If-Then chooses that thoroughly portray the behavior of the structure. These rules all that much take after the human perspective, in this way giving electronic thinking to the system [5, 6, 7, 8].

PLOT OF MEMBERSHIP FUNCTION



INPUT VARIABLE ERROR & CHANGE IN ERROR



OUTPUT VARIABLE

FLC RULE BASE TABLE

d_e \ e	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NM	NM	NS	NS	ZE
NM	NL	NM	NM	NS	NS	ZE	PS
NS	NM	NM	NS	NS	ZE	PS	PS
ZE	NM	NS	NS	ZE	PS	PS	PM
PS	NS	NS	ZE	PS	PS	PM	PM
PM	NS	ZE	PS	PS	PM	PLM	PL
PB	ZE	PS	PS	PM	PM	PB	PB

SIMULATION RESULTS:

Circuit Description:

The induction motor is connected through a current-controlled PWM inverter which consist block of Universal Bridge. The motor drives a mechanical load characterized by inertia J, friction coefficient B, and load torque TL. For speed control loop uses a PI and Fuzzy logic controller. q Axis current (iq*) control motor torque and motor flux is control by d axis current (id*). id* and iq* convert into current references ia*, ib*, and ic*by using block dq-abc for the regulating of current. Current and Voltage Measurement blocks are used to for signal visualization purpose. Motor current, speed, and torque signals are available at the output of the 'Asynchronous Machine' block give signal of motor torque, current and speed.

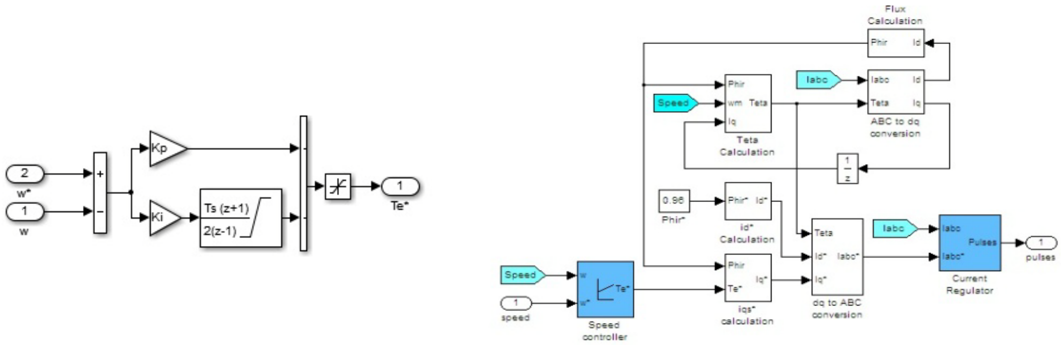


Fig 3 PI based vector control

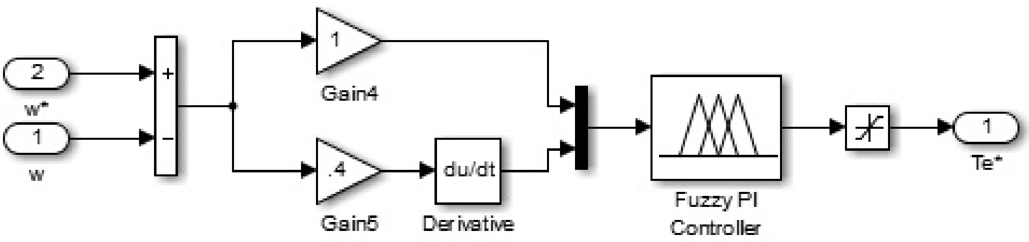


Fig 4 Fuzzy based vector control

At no load

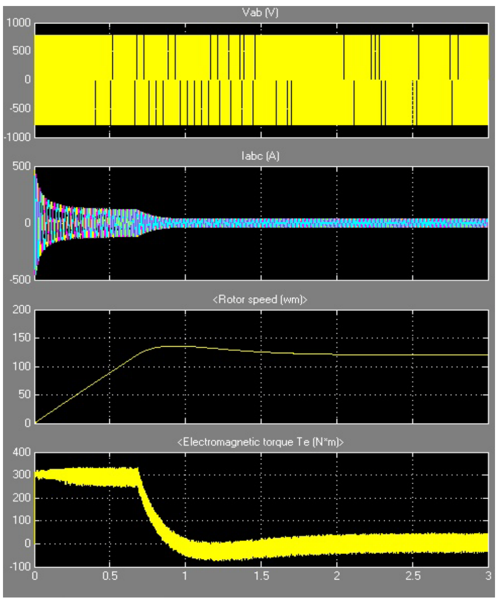


Fig 5: PI base vector control

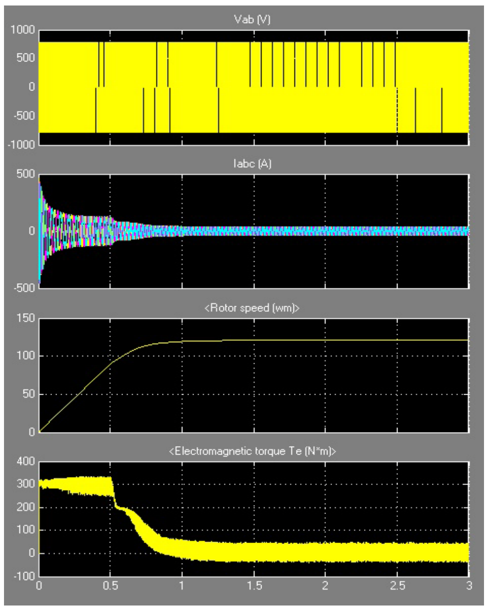


Fig 6: Fuzzy base vector control

The results shows that, When a speed reference step from zero to one hundred twenty rpm is applied at t = 0 sec, the speed set point doesn't go instantly at one hundred twenty rpm however follows the acceleration ramp as proven in fig 3 and fig 4. Motor reached at stable state at 2.5 sec in conventional PI base vector control but in fuzzy based vector control motor reached stable state in 1.5 sec.

AT Load

At 1.8 sec, a load torque 200 N-M is applied at the shaft of motor due to this speed of induction motor decrease and electromagnetic torque increase. When Electromagnetic torque is equal to load torque the speed of motor stop decreasing and flow reference speed. In fuzzy based vector control take less time for reaching stable condition and approx follow reference speed (fig 6) and pi based vector control far away from reference speed (fig 5).

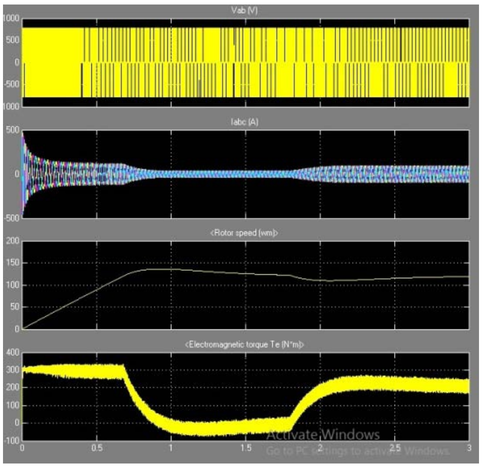


Fig 7: PI base vector control

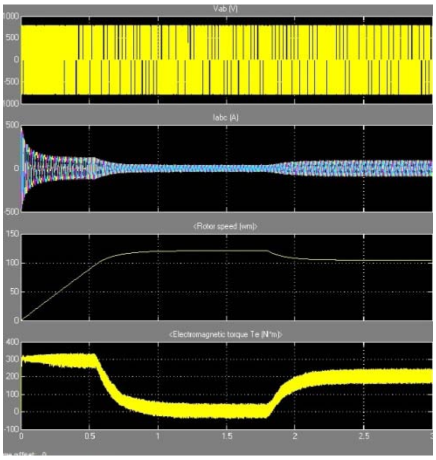


Fig 8: Fuzzy base vector control

CONCLUSION

On this paper we determined that conventional PI has more settling time than fuzzy controller, so fuzzy controller makes the process faster. The maximum overshoot additionally within the conventional PI controller is observed greater than fuzzy controller. Once more the variant within the approach parameters as a result of load disturbances is also less with fuzzy controller, which proves that the fuzzy controller is stronger than the conventional PI controller. So it may be concluded that the fuzzy controller improves the system performance and is better suited to excessive performance drives.

REFERENCES

1. Bimal K. Bose. “Modern Power Electronics and AC Drives” New Delhi, Prentice- Hall, 2002.

2. X. Xu, D. W. Novotny, “Selecting the flux reference for induction machine drives in the field weakening region,” IEEE Trans. Ind. Applicat., vol. 28, pp. 1353–1358, Nov. /Dec. 1992.
3. Atkinson D. J., P. P. Acarnley and J. W. Finch, “Application of estimation technique in vector controlled induction motor drives,” IEE Conference Proceeding, London, July 1990, pp. 358-363.
4. Zihong Lee, “Methods for improving performance of PI type fuzzy logic controller,” IEEE trans. on fuzzy systems, vol.1, no. 4, Nov 1993.
5. M. Masiala, J.Salmon, “Fuzzy self tuning speed control of an indirect field-oriented control induction motor,” IEEE Trans. industry appl., vol. 44 , No. 6 ,Dec 2008.
6. R.K. Mudi and N.R. Pal, “A robust self tuning scheme for PI and PD type fuzzy controllers,” IEEE Trans. fuzzy systems, vol. 7, no. 1, Feb 1999.
7. J. Sun, P. Su, Y. Li, and L. Li, “Application of self-adjusting fuzzy controller in a vector-controlled induction motor drive,” in Proc. 3rd IEEE Int. Conf. Power Electron. Motion Control, Aug. 15–18, 2000, vol. 3.
8. S. N. Bhadra, D. Kastha, and S .Banerjee, Wind Electrical Systems, Oxford University Press, New
9. Gilberto C D Souse, Bimal K Bose, “A fuzzy set theory based control of phase controlled converter DC motor drive”, IEEE Transactions On Power Delivery, vol.14, no.2, july 2011.