International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169
Volume: 4 Issue: 5
496 - 499

Simulation of Field Oriented Control Variable Frequency Induction Motor Drive

Dhananjay kumar chandrakar[1]
(M Tech scholar) Electrical and Electronics Engineering Department
Dr.C.V.Raman University kota, Bilaspur,CG,India

Miss Smriti Kesharwani[2]
(Assistant Professor)Electrical Engineering Department
Dr.C.V.Raman University kota
BIlaspur,CG,India

Dr. Dharmendra Kumar singh
(Head Of Department) Electrical and Electronics Engineering Department
Dr.C.V.Raman University kota, Bilaspur,CG,India

e-mail: dcelex102@gmail.com

Abstract— now days replacing the DC motor with Induction motors are requirement of each plant due to very high operating cost associated with DC motors. To achieve the better dynamic response like as DC motors IM drives are developed. Field Oriented Control based drives with pulse width modulation technique for operation of inverter. In field oriented control method whole induction motor is converted into mathematical DC motor model and control like a dc motor. by Feedback control loop system a gate pulse is generated for the pulse width modulated inverter and according to that voltage and frequency to be controlled. These new technique improve the torque speed characteristics and reduced the response time. This results a very good speed controlling of induction motor and required speed torque characteristics

Keywords- *Induction Motors (IM), Field Oriented Control, Pulse width Modulation, matlab.*

*****

I. INTRODUCTION

Induction Motors are widely used in industries now days for speed variation applications. Evolution from dc drives to various form of AC drives has been motivated for continuously need for simultaneously performance, reliability and simplicity. Previously the DC motors were preferred as variable speed drives however DC motors have associated with high cost, high rotor inertia and maintenance problem with commutator and brushes. Induction Motors offers enviable operational characteristics such as robustness, reliabilities, and ease of control. The use of induction motors as its highest efficiency is the challenging task because there complex mathematical model and non linear characteristics during saturation. These factors make controlling of IM using scalar control V/Hz strategy limited. The scalar control method produce oscillation in produced torque hence to achieve better dynamic performance a more superior control scheme is needed for induction motors. With the mathematical processing capabilities offered by the micro-controllers, digital signal processing advance control strategies can be implemented to decouple the torque generation and magnetization functions called Field oriented Control scheme. Field oriented control describes the way in which the control torque and speed are directly based on Electromagnetic state of motor, similar to DC motor. With this method by decupling between the stator current components (magnetizing flux and torque) the torque producing component stator flux can be controlled independently. Decoupled control at low speeds, the magnetization state of motor can be maintained the appropriate level, and the torque can be control to regulate the speed.

II. PRINCIPLE OF FIELD ORIENTED CONTROL

The field oriented control consists of controlling of stator currents represented by a vector. This control is based projections that transform a 3phase time and speed depended system into a two quadrant (D and Q axis frame).these projection leads to a structure similar to DC machine control. Foc machine needs constant as an input reference: the torque component (aliened with q coordinate) and the flux component (aliened with d coordinate).The three phase voltage, current, and fluxes of induction motor can be analyzed in terms of complex vectors. If we take Ia, Ib, Ic as instantaneous current in the stator phases, then the stator current vector is defined as follows:

$$\vec{I_s} \approx i_a + i_b e^{j2\pi/3} + i_c e^{j4\pi/3}$$

Where (a, b, and c) are the axis of three phase system

This current space vector represents the three phase sinusoidal system. It needs to transform into two time invariant coordinate system. This transformed can be divide into two steps:

The (abc) into (αβ) projection ie clarck transformation Three phase quantities either voltage or current, varying in time along the axis a,b, and c can be mathematically transformed into two axis voltage or currents, varying in time along the axis α and β by following transformation.

$$i_{\alpha\beta o} \approx \frac{2}{3}\begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{pmatrix}$$

Assuming that the axis a and the axis α are in the same direction and β is the orthogonal to them we have following vector diagram.

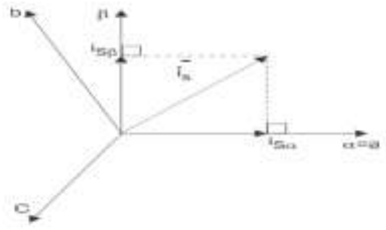

Fig 1-Iabc to Idq

 ISSN: 2321-8169
496 - 499

The above projection modifies three phase system into (α β) two dimensional orthogonal system as follows.

$$I_{s\alpha} = I_a$$

$$I_{s\beta} = I_a / \sqrt{3} + 2I_b / \sqrt{3}$$

But this two (α β) current still depends upon time and speed.

So we move towards **Park transformation.** This is the most important transformation in the FOC. In fact, this projection modifies the two phase fixed orthogonal system (α, β) into d,q rotating reference system. The transformation matrix is given below:

$$i_{dqo} = 2/3 * \begin{bmatrix} \cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ \sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

Where, 'θ' is the angle between the rotating and fixed coordinate system.

If you consider the d axis aligned with the rotor flux, Figure 2 shows the relationship from the two reference frames for the Current vector:

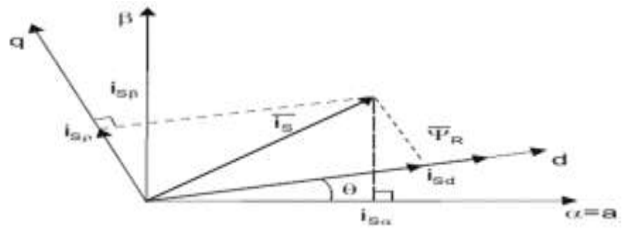

Fig 2- Current orientations

Where, "θ" is the rotor flux position. The torque and flux components of the Current vector are determined by the following equations:

$$i_{sq} = i_{s\alpha}\sin\theta + i_{s\beta}\cos\theta$$
$$i_{sd} = i_{s\alpha}\cos\theta + i_{s\beta}\sin\theta$$

These components depend on the Current vector (α, β) components and on the rotor flux position. If you know the accurate rotor flux position then, by above equation, the d,q component can be easily calculated. At this instant, the torque can be controlled directly because flux component (isd) and torque component (isq) are independent now [1][2].

III. PULSE WIDTH MODULATION CONTROL OF INVERTER

The control of modem adjustable speed drives and static power converters is increasingly based on the real-time Digital generation of pulse-width modulated (PWM) waveforms Using either microprocessors or application-specific integrated Circuits. Microprocessor-based PWM generation techniques offer significant advantages, particularly for optimizing the PWM waveform. However, the maximum switching frequency of the inverter can be severely limited by the computation time needed to generate the PWM switching times in the microprocessor, particularly when advanced PWM strategies are used. Past development of these more advanced PWM strategies has involved considerable offline computation, using a mainframe computer to determine the PWM switching angle characteristics. This has been necessary because the equations relating the PWM switching angles to voltage are transcendental and cannot be solved on-line by a microprocessor-based controller. In this pulse width modulation scheme the base signal is modulated with the carrier signal or switching frequency of the inverter. The modulation generator produces a sine wave signal that determines the width of the pulses, and therefore the RMS voltage output of the inverter. [3]

IV. SIMULATION OF DRIVE

To simulate a variable frequency induction motor drive using d q coordinate a d q coordinates reference frame locked to the rotor flux space vector is used to achieve decoupling between the motor flux and torque. They can thus be controlled separately by stator direct-axis current and quadrature-axis current respectively, as in a DC motor. A block diagram of a field-oriented induction motor drive is shown in fig-3. The induction motor is fed by a current-controlled PWM inverter, which operates as a three-phase sinusoidal current source. The motor speed ω is compared to the reference ω* and the error is processed by the speed controller to produce a torque command Te*. As shown in fig-1 the rotor flux and torque can be separately controlled by the stator direct-axis current ids and quadrature-axis current Iqs, respectively. The stator quadrature-axis current reference iqs* is calculated from torque reference Te* as[3]

$$I_{qs}^{*} = \frac{2}{3} \cdot \frac{2}{p} \cdot \frac{L_r}{L_m} \cdot \frac{T_e^{*}}{|\psi_r|_{est}}$$

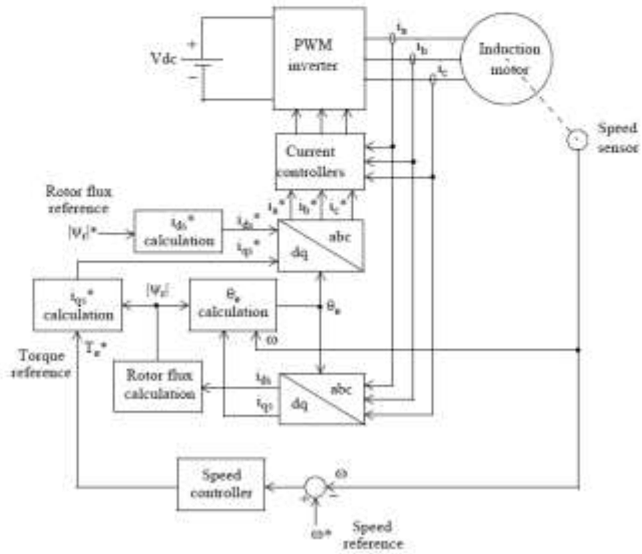

Fig 3- Simulation Diagram

Where Lr is the rotor inductance, Lm is the mutual inductance, and |ψr| est is the estimated rotor flux linkage given by

$$|\varphi| = \frac{L_m I_{ds}}{1 + \tau_r s}$$

Where $\tau_r = L_r / R_r$ is the rotor time constant.

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

$$I_{qs}^* = \frac{2}{3} \cdot \frac{2}{p} \cdot \frac{L_r}{L_m} \cdot \frac{T_e^*}{|\psi_r|_{est}}$$

The rotor flux position θ_e required for coordinates transformation is generated from the rotor speed ω_m and slip frequency ω_{sl}:

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

$$\omega_{sl} = \frac{L_m}{|\psi_r|_{est}} \cdot \frac{R_r}{L_r} \cdot i_{qs}$$

The i_{qs}^* and i_{ds}^* current references are converted into phase current references i_a^*, i_b^*, i_c^* for the current regulators. The regulators process the measured and reference currents to produce the inverter gating signals. The role of the speed controller is to keep the motor speed equal to the speed reference input in steady state and to provide a good dynamic during transients. It can be of proportional-integral type.

By using these formulas we developed a simulink block as shown in fig-3.

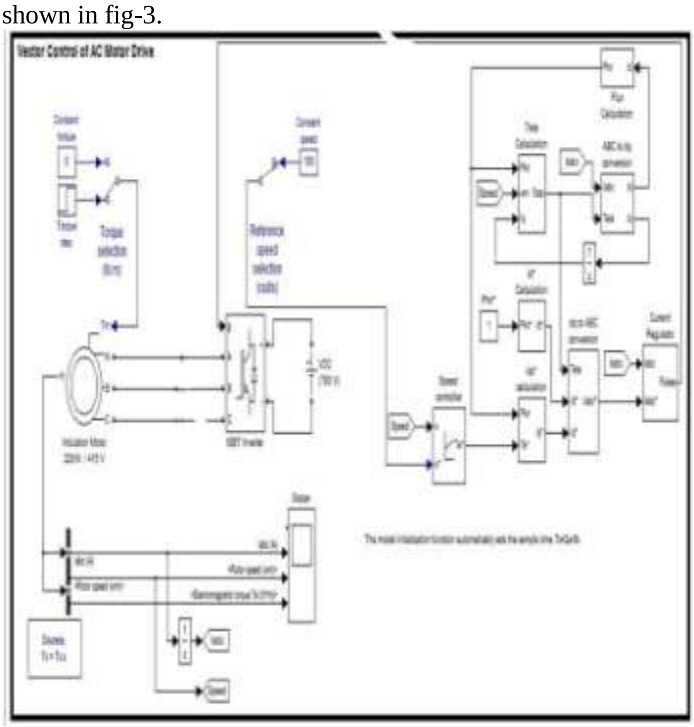

Fig 4- Simulink Block diagram

V. RESULTS AND CONCLUSION

CASE 1:- where there is no any mechanical input is provide at constant reference RPM=120 .so we get the following results shown in fig-4

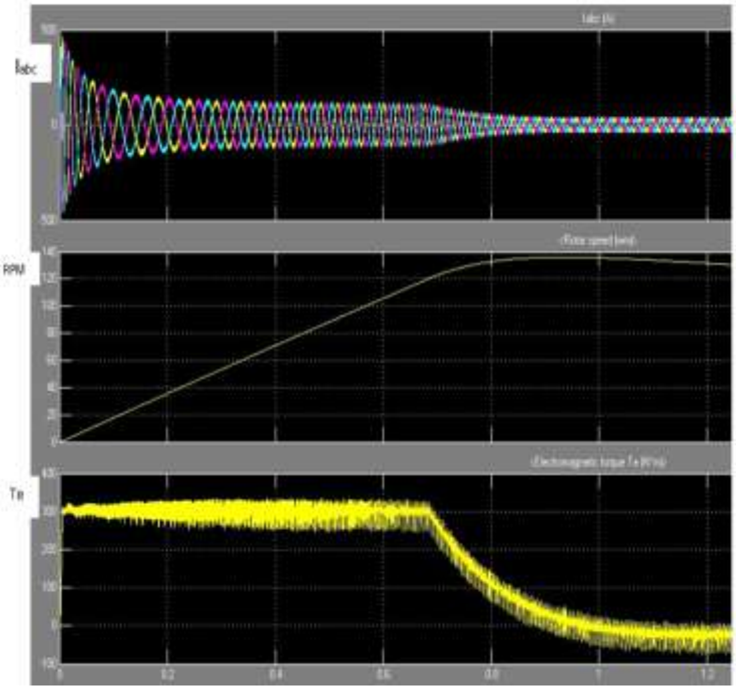

Fig 5- when no load condition with 120ref rpm

This graph shows that starting with speed of motor is riches to 120 rpm then due to feed back control system of drive the speed is reduced till ref speed when the motor reaches to its speed more than the ref speed then the torque of motor negative and the overall electromechanically torque drastically decrease after that when the speed of motor is equal to motor ref speed then the motor runs at its nominal torque. Here in the graph it is shows that at starting the current are high in magnitude then it's become normal after reaching the desired speed. From equation it is clear that Te= Kt Ia means at starting the Te is highest so that starting current is also highest ie 10 times of full load current. Since Te is applied on the motor so motor starts rotation but after reaching the desired RPM Te drastically decrease and maintain a small torque only to maintain that speed which is minimum since torque is minimum so that motor takes a minimum current to Run.

CASE 2:- In this condition when the step mechanical load is applied to the motor and constant speed reference is provided. So we get the following results. Shown in fig 5

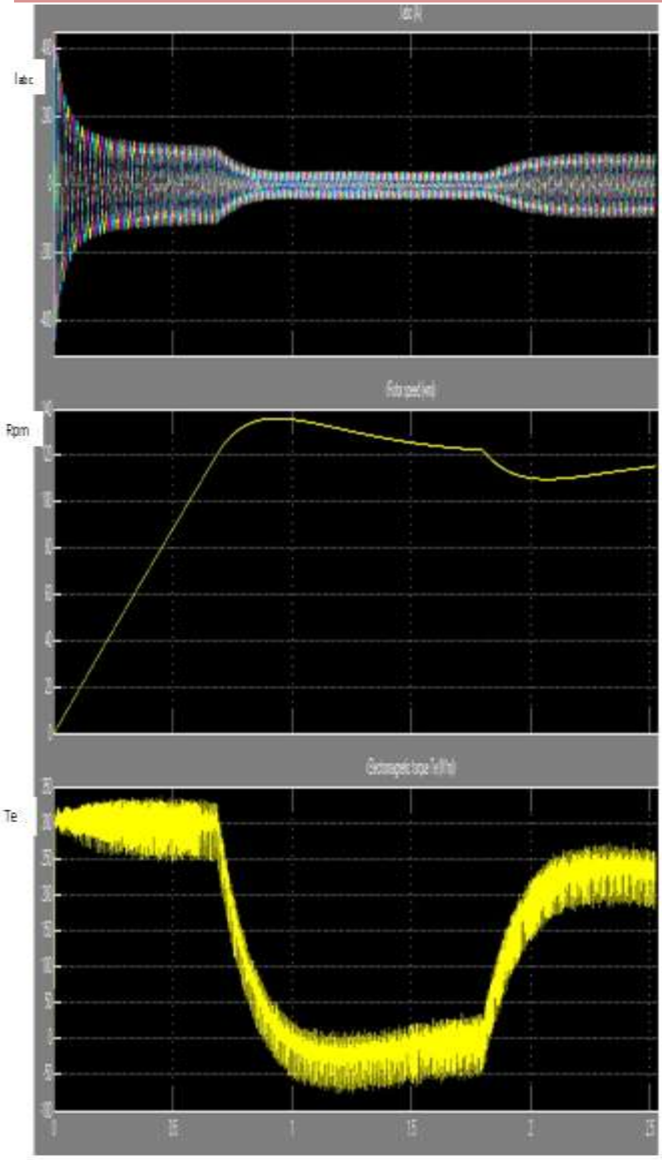

Fig 6- response with variable mechanical load

This graph shows the Dynamic state torque capability of a flux control drive. The speed control has been improved. Second, the torque output capability is better. In this graph we found that when the step mechanical torque is applied to the motor so that the motor produces high starting torque and motor accelerate till 136 rpm and then due to speed f/b system its try to manage its constant reference speed. So at that time higher speed the electromagnetic torque across the motor is negative. So it decelerates the motor till its ref speed and the torque across motor is nominal. when the torque is changed in step time 1.8 second and riches to its final value 200Nm then at that time this mechanical torque is more than the electromagnetic torque so motor starts deceleration and decelerate till 110 rpm but due to speed hysteresis block the speed is tries to reach its ref speed so that motor electromagnetic torque increases which counter the mechanical torque applied and when the ref speed is achieved the torque become constant and the motor starts runs at reference speed. So by using field oriented control method motor speed tuning at different mechanical loading condition is very good and takes very few seconds in this graph it takes only 1 sec to reach the reference speed. So we can say that the FOC improve the dynamic behavior of motors.

VI. ACKNOWLEDGEMENT

On the submission of my paper on **"Simulation Of Field Oriented Control Variable Frequency Induction Motor Drive"** I would like to articulate my deep gratitude and sincere thanks to my supervisor **Assistant Prof. Ms. Smiriti Kesharwani for** his most valuable guidance and thoughtful suggestions during the course of my work throughout the year. His help and advice has been a constant source of inspiration.

I am sincerely thankful to **Associate Prof. Dr.Dharmendra Kumar Singh,** Head of the Department, Electrical and Electronics Engineering and all the faculty members for providing a solid background for my studies and research thereafter. I am thankful to the laboratory staff of the department for their timely help.

Dhananjay Kumar Chandrakar is a Mtech scholar from Dr. C .V. Raman university bilaspur. He is doing his Mtech in the field of power system but he is much interested in power electronics and drives. He spent his year in the field of induction motors and variable frequency drives.

REFRANCES

[1] Boston, Chapman, S. J., Electric Machinery Fundamentals, 3RD, McGraw-Hill,1999, page no358 .

[2] Ben-Brahim, L.Tadakuma, S.and Akdag, A.,"Speed control of induction motor without rotational transducers," IEEE Transactions on Industry Applications, vol. 35, no. 4, 1999.

[3] Advanced Regular-Sampled PWM Control Techniques for Drives and Static Power Converters by Sidney R. Bowes, Senior Member, IEEE, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 42, NO. 4, AUGUST 1995.