ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Design of sensor less induction motor based on MRAS using PI & FUZZY Controller


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ABSTRACT:

in order to improve the reliability and speed variations on induction motor, a speed sensor less vector control system for induction motor based on model reference adaptive system is designed.to reduce the cost of sensor for speed measurement for an induction motor and MRAC MODEL is used which consists of reference model and an adaptive model. First the dynamic model of induction model was developed in the arbitrary reference frame .with the help of synchronous reference frame model the indirect field oriented vector control, which is very popular and conviential method in real implementation was developed.

Third model reference adaptive system is studied as a state estimator. Rotor flux estimator scheme is applied to MRAS algorithm to estimate rotor speed. the motor speed is estimated based n difference between two flux estimators. the proposed control method, simulations, implementation data, and the test result are given and show the good performance for the vector control system in torque, speed robustness. An adaption algorithm with PI controller is used to tune the sped and to make the error zero. and the result are compared with fuzzy logic controller.

The IM can be operated directly from the mains, but variable speed and often better energy efficiency are achieved by means of a frequency converter between the mains and the motor. A typical frequency converter consists of a rectifier, a voltage-stiff DC link, and a pulse-width modulated (PWM) inverter. The inverter is controlled using a digital signal processor (DSP).

The majority of IMs are used in constant speed drives, but during the last decades the introduction of new semiconductor devices has made variable speed drives with IM's available. Variable speed IMs are usually fed by open loop frequency inverters. The rotor speed of the machine is not measured and a change in load torque will result in the speed to change.

The control and speed sensorless estimation of IM drives is a vast subject. Traditionally, the IM has been used with constant frequency sources and normally the squirrel-cage machine is utilized in many industrial applications, from chemical plants and wind generation to locomotives and electric vehicles. A typical construction of a squirrel cage IM is illustrated in Figure 2.1. Its main advantages are the mechanical and electrical simplicity and ruggedness, the lack of rotating contacts (brushes) and its capability to produce torque over the entire speed range.

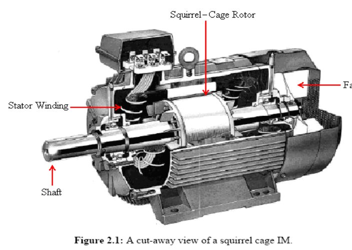

Figure 2.1: A cut-away view of a squirrel cage IM

Before going to analyze any motor or generator it is very much important to obtain the machine in terms of its equivalent mathematical equations. Traditional per phase equivalent circuit has been widely used in steady state analysis and design of induction motor,but it is not appreciated to predict the dynamic performance of the motor.

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The dynamics consider the instantaneous effects of varying voltage/currents, stator frequency, and torque disturbance. The dynamic model of the induction motor is derived by using a two-phase motor in direct and quadrature axes. This approach is desirable because of the conceptual simplicity obtained with two sets of windings, one on the stator and the other in the rotor. The equivalence between the three phase and two phase machine models is derived from simple observation, and this approach is suitable for extending it to model an n-phase machine by means of a two phase machine.

The concept of equivalence of mmfs and power invariance is introduced; the mmfs and power must be equal in the three-phase machine and its equivalent two-phase model. Derivations for electromagnetic torque involving the currents and flux linkages are given. The differential equations describing the induction motor are nonlinear. For stability and controller design studies, it is important to linearize the machine equations around a steady state operating point to obtain small signal equations. In adjustable speed drive, the machine is normally constituted as element within a feedback loop, and therefore its transient behavior has to be taken into consideration. The dynamic performance of an ac machine is somewhat complex because the three phase rotor windings move with respect to the three phase stator windings.

An induction motor can be looked on as a transformer with a rotating secondary, where the coupling coefficients between the stator and rotor phases change continuously with the change of rotor position θ¬¬r. The machine model can be described by differential equations with time varying mutual inductances, but such a model tends to be very complex. Hence, to reduce complexity it is necessary to transform the three-phase machine into equivalent two-phase machine besides high performance drive control, such as vector control, based on the dynamic d-q model of the machine. Therefore, to understand vector control principle, a good understanding of d-q model is mandatory.

REFERENCE FRAMES:

The required transformation in voltages, currents, or flux linkages is derived in a generalized way. The reference frames are chosen to be arbitrary and particular cases, such as stationary, rotor and synchronous reference frames are simple instances of the general case. R.H. Park, in the 1920s, proposed a new theory of electrical machine analysis to represent the machine in d – q model. He transformed the stator variables to a synchronously rotating reference frame fixed in the rotor, which is called Park's transformation. He showed that all the time varying inductances that occur due to an electric circuit in relative motion and electric circuits with varying magnetic reluctances could be eliminated. In 1930s, H.C Stanley showed that time varying Inductances in the voltage equations of an induction machine due to electric circuits in relative motion can be eliminated by transforming the rotor variables to a stationary reference frame fixed on the stator. Later, G. Kron proposed a transformation of both stator and rotor variables to a synchronously rotating reference that moves with the rotating magnetic field.

AXES TRANSFORMATION:

We know that per phase equivalent circuit of the induction motor is only valid in steady state condition. Nevertheless, it doesn't hold good while dealing with the transient response of the motor. In transient response condition the voltages and currents in three phases are not in balance condition. It is too much difficult to study the machine performance by analyzing the three phases. In order to reduce this complexity the transformation of axes from 3 – Φ to 2 – Φ is necessary. Another reason for transformation is to analyze any machine of n number of phases. Thus, an equivalent model is adopted universally, that is'd – q model'.

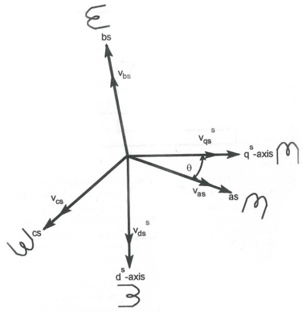

Fig 2.1(a) 3-to 2-Transformation

Consider a symmetrical three-phase induction machine with stationary as-bs-cs axis at 2/3 angle apart. . Our goal is to transform the three-phase stationary reference frame (as-bs-cs) variables into two-phase stationary reference frame (ds-qs) variables.

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International Journal & Magazine of Engineering, Technology, Management and Research
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Assume that ds- qs are oriented at angle as shown in fig: 2.1(a). The voltages $v_d{}^s$ and $v_q{}^s$ can be resolved into as-bs- cs components and can be represented in matrix from as,

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} \cos q & \sin q & 1 \\ \cos(q-120^0) & \sin(q-120^0) & 1 \\ \cos(q+120^0) & \sin(q+120^0) & 1 \end{bmatrix} \begin{bmatrix} V_q{}^s \\ V_d{}^s \\ V_o{}^s \end{bmatrix}$$

2.1 The corresponding inverse relation is

$$\begin{bmatrix} V_q{}^s \\ V_d{}^s \\ V_o{}^s \end{bmatrix} = \frac{2}{3} \begin{bmatrix} Cos q & Cos(q-120^o) & Cos(q+120^o) \\ Sin q & Sin(q+120^o) & Sin(q+120^o) \\ 0.5 & 0.5 & 0.5 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

Here $v_o{}^s$ is zero-sequence component, convenient to set = 0 so that qs axis is aligned with as-axis. Therefore ignoring zero-sequence component, it can be simplified as-

$$V_q{}^s = \frac{2}{3}v_a - \frac{1}{3}v_b - \frac{1}{3}v_c = v_a$$

$$V_d{}^s = \frac{-1}{\sqrt{3}}v_b + \frac{1}{\sqrt{3}}v_c$$

Equations 2.3 & 2.4 consistively called as Clark Transformation.

Figure 2.1 (b) shows the synchronously rotating de-qe axes, which rotate at synchronous speed we with respect to the ds-qs axes and the angle . $\theta_y = \omega_e * t$ The two-phase ds-qs windings are transformed into the hypothetical windings mounted on the de-qe axes. The voltages on the ds-qs axes can be transformed (or resolved) into the de-qe frame as follows:

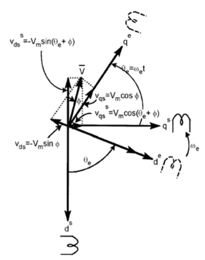

Fig 2.1(b) stationary frame ds-qs to synchronously rotating frame de-qe transformation.

$$v_{qs} = v_{qs}^s - v_{ds}^s \sin\theta_e \ldots\ldots\ldots\ldots 2.5$$
$$v_{ds} = v_{qs}^s \sin\theta_e + v_{ds}^s \cos\theta_e \ldots\ldots\ldots\ldots 2.6$$

Constitutively eq 2.5 and 2.6 are known as Park Transformation.For convenience, the superscript 'e' has been dropped from now on from the synchronously rotating frame parameters.

Again, resolving the rotating frame parameters into a stationary frame, the relations are

$$v_{qs}^s = v_{qs}\cos\theta_e + v_{ds}\sin\theta_e \ldots\ldots\ldots\ldots 2.7$$
$$v_{ds}^s = -v_{qs}\sin\theta_e + v_{ds}\cos\theta_e \ldots\ldots\ldots\ldots 2.8$$

Constitutively eq 2.7 and 2.8 are known as Inverse Park Transformation. Dynamic equations of induction machine Generally, an IM can be described uniquely in arbitrary rotating frame, stationary reference frame or synchronously rotating frame. For transient studies of adjustable speed drives, it is usually more convenient to simulate an IM and its converter on a stationary reference frame. Moreover, calculations with stationary reference frame are less complex due to zero frame speed. For small signal stability analysis about some operating condition, a synchronously rotating frame which yields steady values of steady-state voltages and currents under balanced conditions is used.

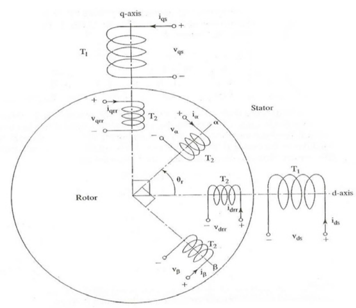

Fig 2.2(a) Two-phase equivalent diagram of induction motor

The two-phase equivalent diagram of three-phase induction motor with stator and rotor windings referred to d – q axes is shown in Fig 2.2(a). The windings are spaced by 900 electrical and rotor winding, is at an angle θr from the stator d-axis. It is assumed that the d axis is leading the q axis in clockwise direction of rotation of the rotor. If the clockwise phase sequence is dq, the rotating magnetic field will be revolving at the angular speed of the supply frequency but counter to the phase sequence of the stator supply. Therefore the rotor is pulled in the direction of the rotating magnetic field i.e. counter clockwise, in this case. The currents and voltages of the stator and rotor windings are marked in figure 2.2(a). The number of turns per phase in the stator and rotor respectively are T1 and T2. A pair of poles is assumed for this figure. But it is applicable with slight modification for any number of pairs of poles if it is drawn in terms of electrical degrees.

IJMETMR
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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Note that r is the electrical rotor position at any instant, obtained by multiplying the mechanical rotor position by pair of poles. The terminal voltages of the stator and rotor windings can be expressed as the sum of the voltage drops in resistances, and rate of change of flux linkages, which are the products of currents and inductances.

From the above figure the terminal voltages are as follows,

$$\left.\begin{aligned}
Vqs &= Rqiqs + p\,(Lqqiqs) + p\,(Lqdids) + p\,(Lq\alpha\, i\alpha) + p\,(Lq\beta i\beta)\\
Vds &= p\,(Ldqiqs) + Rdids + p\,(Lddids) + p\,(Ld\alpha i\alpha) + p\,(Ld\beta i\beta)\\
V\alpha &= p\,(L\alpha qiqs) + p\,(L\alpha dids) + R\alpha i\alpha + p\,(L\alpha\alpha i\alpha) + p\,(L\alpha\beta i\beta)\\
V\beta &= p\,(L\beta qiqs) + p\,(L\beta dids) + p\,(L\beta\alpha i\alpha) + R\beta\, i\beta + p\,(L\beta\beta i\beta)
\end{aligned}\right\} \quad 2.9$$

Where *p* is the differential operator *d/dt*, and vqs, vds are the terminal voltages of the stator *q* axis and *d* axis. Vα, Vβ is the voltages of rotor α and β windings, respectively. iqs and ids are the stator *q* axis and *d* axis currents. Whereas iα and iβ are the rotor α and β

Winding currents, respectively and Lqq, Ldd, Lαα and Lββ are the stator q and d axis winding and rotor α and β winding self-inductances, respectively

The following are the assumptions made in order to simplify the equation 2.9.

i. Uniform air-gap

ii.Balanced rotor and stator windings with sinusoidally distributed mmfs

iii.Inductance in rotor position is sinusoidal and

iv.Saturation and parameter changes are neglected

From the above assumptions the equation (2.9) is modified as

$$Vqs = (Rs + Ls\ p)\ iqs + Lsr\ p\ (i\alpha \sin\theta r) - Lsr\ p\ (i\beta \cos\theta r)$$

$$vds = (Rs + Ls\ p)\ ids + Lsr\ p\ (i\alpha \cos\theta r) + Lsr\ p\ (i\beta \sin\theta r)$$

$$v\alpha = Lsr\ p\ (iqs \sin\theta r) + Lsr\ p\ (ids \cos\theta r) + (Rrr + Lrrp)\ i\alpha$$

$$v\beta = -\ Lsrp\ (iqs\cos\theta r) + Lsr\ p\ (ids \sin\theta r) + (Rrr + Lrrp)\ i\beta$$

Where $R_s = R_q = R_d$

$R_{rr} = R_\alpha = R_\beta$

$$\begin{bmatrix} i_{drr} \\ i_{qrr} \end{bmatrix} = \begin{bmatrix} \cos\theta_r & \sin\theta_r \\ \sin\theta_r & -\cos\theta_r \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \qquad 2.11$$

By applying Transformation to the α and β rotor winding currents and voltages the equation 2.10 will be written as

$$\begin{bmatrix} V_q \\ V_d \\ V_{qrr} \\ V_{drr} \end{bmatrix} = \begin{bmatrix} R_s + L_s p & 0 & L_s p & 0 \\ 0 & R_s + L_s p & 0 & L_s p \\ L_s p & -L_s q^{0}{}_{r} & R_r + L_r p & -L_r q^{0}{}_{r} \\ L_s q^{0}{}_{r} & L_s p & L_r q^{0}{}_{r} & R_r + L_r p \end{bmatrix} \begin{bmatrix} i_q \\ i_d \\ i_{qrr} \\ i_{drr} \end{bmatrix}$$

The rotor equations in above equation 2.12 are refereed to stator side as in the case of transformer equivalent circuit. From this, the physical isolation between stator and rotor d-q axis is eliminated.

$\overset{o}{\theta}_r$ Is derivative of θr

a = transformer ratio = (stator turns)/(rotor turns)

$R_r = a^2 R_{rr}$; $\quad L_r = a^2 L_{rr}$

$i_{qr} = \dfrac{i_{qrr}}{a}$; $\quad i_{dr} = \dfrac{i_{drr}}{a}$

Vqr = avqrr; vdr = avdrr

Magnetizing and control inductances are

$L_m \ \alpha\ T_1^{\ 2} \qquad L_{sr}\ \alpha\ T_1\, T_2$

Magnetizing inductance of the stator is

$$L_m = aL_{sr} \qquad 2.15$$

From equations 2.13, 2.14 &2.15 the equation 2.8 is modified as

$$\begin{bmatrix} V_q \\ V_d \\ V_q \\ V_d \end{bmatrix} = \begin{bmatrix} R_s + L_s p & 0 & L_m p & 0 \\ 0 & R_s + L_s p & 0 & L_m p \\ L_m p & -L_m q^{0}{}_{r} & R_r + L_r p & -L_r q^{0}{}_{r} \\ L_m q^{0}{}_{r} & L_m p & L_r q^{0}{}_{r} & R_r + L_r p \end{bmatrix} \begin{bmatrix} i_q \\ i_d \\ i_q \\ i_d \end{bmatrix}$$

Where θ or = r = d/dt and p= d/dt

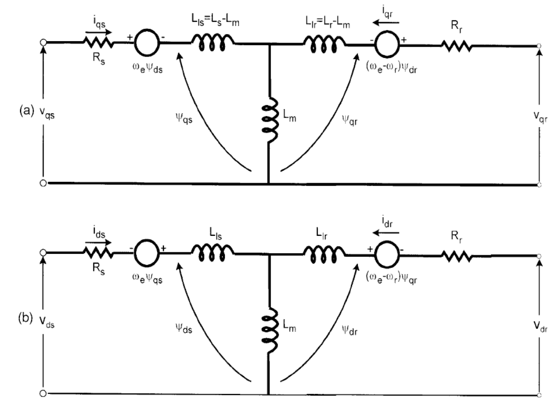

Figure 2.2 (b) Dynamic de-qe equivalent circuits of machine (a) qe-axis circuit, (b) de-axis circuit

Figure 2.2(b) shows the de-qe dynamic model equivalent circuit of induction motor under synchronously rotating reference frame, if vqr = vdr = 0 and we=0 then it becomes stationary reference frame dynamic model.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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The dynamic equations of the induction motor in any reference frame can be represented by using flux linkages as variables. This involves the reduction of a number of variables in the dynamic equations. Even when the voltages and currents are discontinuous the flux linkages are continuous. The stator and rotor flux linkages in the stator reference frame are defined as

$$\left.\begin{aligned}\psi_{qs} &= L_s i_{qs} + L_m i_{qr}\\ \psi_{ds} &= L_s i_{ds} + L_m i_{dr}\\ \psi_{qr} &= L_r i_{qr} + L_m i_{qs}\\ \psi_{dr} &= L_r i_{dr} + L_m i_{ds}\end{aligned}\right\} \text{.....................2.17}$$

$$\left.\begin{aligned}\psi_{qm} &= L_m(i_{qs} + i_{qr})\\ \psi_{dm} &= L_m(i_{ds} + i_{dr})\end{aligned}\right\} \text{......2.17. a}$$

From (2.12) and (2.13) we get

$$\left.\begin{aligned}v_{ds} &= R_s i_{ds} + p\psi_{ds}\\ v_{qs} &= R_s i_{qs} + p\psi_{qs}\\ v_{dr} &= R_r i_{dr} + \omega_r \psi_{qr} + p\psi_{dr}\\ v_{qr} &= R_r i_{qr} - \omega_r \psi_{dr} + p\psi_{qr}\end{aligned}\right\} \text{.......2.18}$$

Since the rotor windings are short circuited, the rotor voltages are zero. Therefore

$$\left.\begin{aligned}R_r i_{dr} + \omega_r \psi_{qr} + p\psi_{dr} &= 0\\ R_r i_{qr} - \omega_r \psi_{dr} + p\psi_{qr} &= 0\end{aligned}\right\} \text{.................... 2.19}$$

From (2.15), we have

$$\left.\begin{aligned}i_{dr} &= \frac{-p\psi_{dr} - \omega_r \psi_{qr}}{R_r}\\ i_{qr} &= \frac{-p\psi_{qr} + \omega_r \psi_{dr}}{R_r}\end{aligned}\right\} \quad 2.20$$

By solving the equations 2.17, 2.18, 2.19 and 2.20 we get the following equations

$$\psi_{ds} = \int (v_{ds} - R_s i_{ds})dt$$

2.21

$$\psi_{qs} = \int (v_{qs} - R_s i_{qs})dt$$

2.22

$$\psi_{dr} = \frac{-L_r \omega_r \psi_{qr} + L_m i_{ds} R_r}{R_r + sL_r}$$

2.23

$$\psi_{qr} = \frac{L_r \omega_r \psi_{dr} + L_m R_r i_{qs}}{R_r + sL_r}$$

2.24

$$i_{ds} = \frac{v_{ds}}{R_s + sL_s} - \left[\frac{\psi_{dr}.sL_m}{L_r.(R_s + sL_s)}\right]$$

2.25

$$i_{qs} = \frac{v_{qs}}{R_s + sL_s} - \left[\frac{\psi_{qr}.sL_m}{L_r.(R_s + sL_s)}\right]$$

2.26 From Figure 2.2 (c) the electromagnetic torque of the induction motor in stator reference frames is given by

$$T_e = \frac{3}{2}\frac{p}{2} L_m (i_{qs} i_{dr} - i_{ds} i_{qr})$$

2.27

(Or)

$$T_e = \frac{3}{2}\frac{p}{2}\frac{L_m}{L_r}(i_{qs}\psi_{dr} - i_{ds}\lambda_{qr})$$

2.28

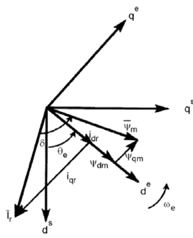

Figure 2.2(c) Flux and current vectors in de-qe frame

The electro-mechanical equation of the induction motor drive is given by

$$T_e - T_L = \frac{2}{p} J \frac{dw_r}{dt} \quad 2.29$$

By using the equations from 2.21 to 2.29, the induction motor model is developed in stator reference frame.

PRINCIPLE OF VECTOR CONTROL:

The fundamentals of vector control can be explained with the help of figure 3.5, where the machine model is represented in a synchronously rotating reference frame. The inverter is omitted from the figure, assuming that it has unity current gain, that is, it generates currents ia, ib, and ic as dictated by the corresponding command currents i_a^*, i_b^*, and i_c^* from the controller. A machine model with internal conversions is shown on the right. The machine terminal phase currents ia, ib, ic are converted to i_{ds}^s and i_{qs}^s components by 3ϕ-2ϕ transformation. These are then converted to synchronously rotating frame by the unit vector components cos θe and sin θe before applying them to the de- qe machine model.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
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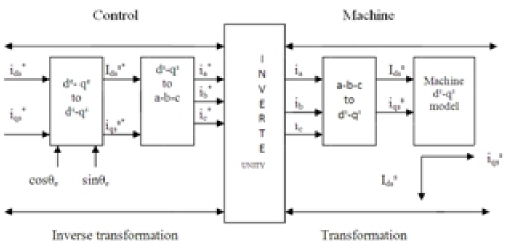

Fig 3.5 Basic block diagram of vector control

Vector control implementation principle with machine ds-qs model as shown The controller makes two stages of inverse transformation, as shown, so that the control currents and correspond to the machine currents ids and iqs, respectively. In addition, the unit vector assures correct alignment of ids current with the flux vector and iqs perpendicular to it, as shown. It can be noted that the transformation and inverse transformation including the inverter ideally do not incorporate any dynamics, and therefore, the response to ids and iqs is instantaneous (neglecting computational and sampling delays.

INVERTER:

Processing of the torque status output and the flux status output is handled by the optimal switching logic. Fig 3.8 shows the schematic diagram of voltage source inverter. The function of the optimal switching logic is to select the appropriate stator voltage vector that will satisfy both the torque status output and the flux status output.

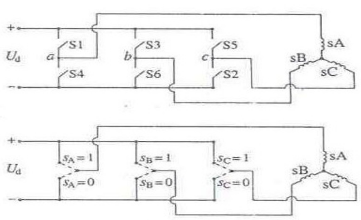

Fig 3.8: Schematic diagram of voltage source inverter

In reality, there are only six nonzero voltage vectors and two zero voltage vectors as shown in Fig 3.9(a) & (b).

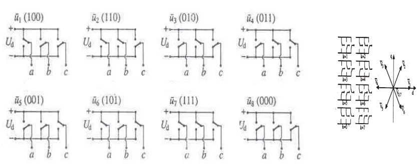

Fig 3.9(a) Inverter Switching Stages,(b) Switching –voltage space vectors

The machine voltages corresponding to the switching states can be calculated by using the following relations.

$$\left.\begin{aligned} v_{ab} &= v_a - v_b \\ v_b &= v_b - v_c \\ v_a &= v_c - v_a \end{aligned}\right\}$$

3.11And machine phase voltages for a balanced system are

$$\left.\begin{aligned} v_a &= \frac{v_b - v_a}{3} \\ v_b &= \frac{v_b - v_b}{3} \\ v_s &= \frac{v_a - v_b}{3} \end{aligned}\right\}$$

3.12And q and d axes voltages are given by

$$\left.\begin{aligned} v_q &= v_a \\ v_d &= \frac{1}{\sqrt{3}}\left(v_s - v_b\right) = \frac{1}{\sqrt{3}} v_b \end{aligned}\right\}$$

3.13 The total number of switching states possible with Sa, Sb and Sc is eight and they are elaborated in table 3.1.

Table 3.1 Switching states for possible Sa, Sb and Sc.

Switching States	Sa Sb Sc	Machine phase voltages vas	vbs	vcs	d and q axes voltages vqs	vds
1	1 0 0	(2/3) Vdc	(-1/3) Vdc	(-1/3) Vdc	(2/3) 0	Vdc
2	1 1 0	(1/3) Vdc Vdc	(1/3) Vdc	(-2/3)	(1/3) Vdc 1/√3) Vdc	(-
3	0 1 0	(-1/3) Vdc Vdc	(2/3) Vdc	(-1/3)	(-1/3) Vdc 1/√3) Vdc	(-
4	0 1 1	(-2/3) Vdc	(1/3) Vdc	(1/3) Vdc	(-2/3) 0	Vdc
5	0 0 1	(-1/3) Vdc	(-1/3) Vdc	(2/3) Vdc	(-1/3) (1/√3) Vdc	Vdc
6	1 0 1	(1/3) Vdc	(-2/3) Vdc	(1/3) Vdc	(1/3) (1/√3) Vdc	Vdc
7	0 0 0	0	0	0	0	0
8	1 1 1	0	0	0	0	0

The limited states of the inverter create distinct discrete movement of the stator-voltage phasor, Vs consisting of the resultant of vqs and vds.

ISSN No: 2348-4845
International Journal & Magazine of Engineering,
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An almost continuous and uniform flux phasor is feasible with these discrete states

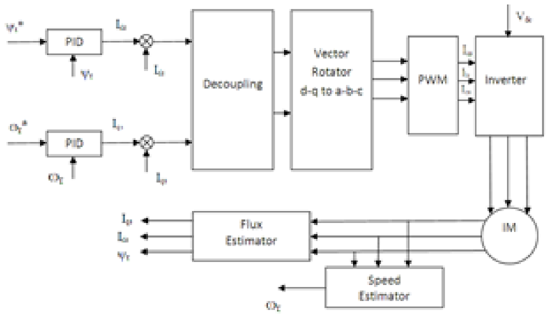

Fig 3.3Block Diagram of Sensor less Control of Induction Motor

The schematic diagram of control strategy of induction motor with sensor less control is shown in Fig 4.1. Sensor less control induction motor drive essentially means vector control without any speed sensor [5, 17]. The inherent coupling of motor is eliminated by controlling the motor by vector control, like in the case of as a separately excited motor. The inverter provides switching pulses for the control of the motor. The flux and speed estimators are used to estimate the flux and speed respectively. These signals then compared with reference values and controlled by using the PI controller.

IV MODEL REFERENCING ADAPTIVE SYSTEM (MRAS) :

Tamai [5] has proposed one speed estimation technique based on the Model Reference Adaptive System (MRAS) in 1987. Two years later, Schauder [6] presented an alternative MRAS scheme which is less complex and more effective. The MRAS approach uses two models. The model that does not involve the quantity to be estimated (the rotor speed, ωr) is considered as the reference model. The model that has the quantity to be estimated involved is considered as the adaptive model (or adjustable model). The output of the adaptive model is compared with that of the reference model, and the difference is used to drive a suitable adaptive mechanism whose output is the quantity to be estimated (the rotor speed). The adaptive mechanism should be designed to assure the stability of the control system. A successful MRAS design can yield the desired values with less computational error (especially the rotor flux based MRAS) than an open loop calculation and often simpler to implement.

The model reference adaptive system (MRAS) is one of the major approaches for adaptive control [6]. The model reference adaptive system (MRAS) is one of many promising techniques employed in adaptive control. Among various types of adaptive system configuration, MRAS is important since it leads to relatively easy- to-implement systems with high speed of adaptation for a wide range of applications.

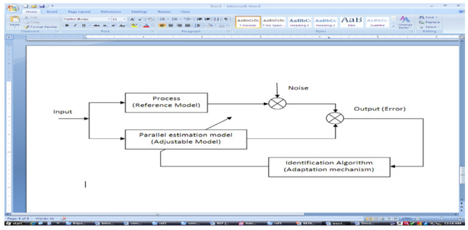

Fig 4.1 basic identification structures and their correspondence with MRAS

V. VECTOR CONTROL OF INDUCTION MOTOR:

The Vector Control or Field orientation control of induction motor is simulated on MATLAB/SIMULINK -platform to study the various aspects of the controller. The actual system can be modeled with a high degree of accuracy in this package.. This Chapter discusses the realization of vector control of induction motor using Simulink blocks.

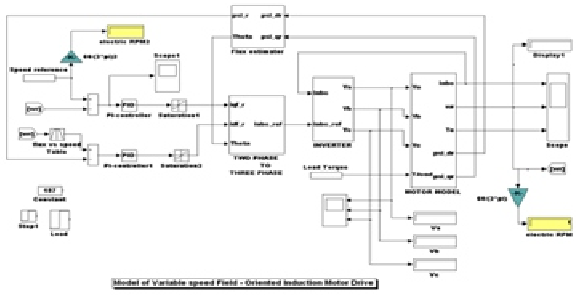

Fig. 5.1 shows the Vector controlled Induction Motor block simulink diagram for simulation

A INDUCTION MOTOR MODEL :

The motor is modeled in stator reference frame. The dynamic equations are given using these equations we can develop the induction motor model in stator reference frame. Fig 5.2 shows the simulink block diagram for motor model. Inputs to this block are direct and quadrature axes voltages and load torque. The outputs are direct and quadrate axis rotor fluxes, direct and quadrature axes stator currents, electrical torque developed and rotor speed.

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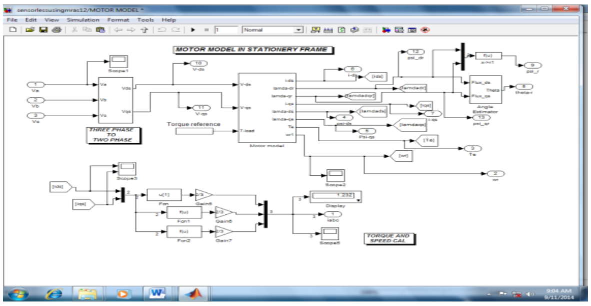

Fig.5.2: Simulink block diagram for induction motor model

B INVERTER :

The Function Of The Optimal Switching Logic Is To Select The appropriate stator voltage vector that will satisfy both the torque status output and the flux status output. Processing of the torque status output and the flux status output is handled by the optimal switching logic.

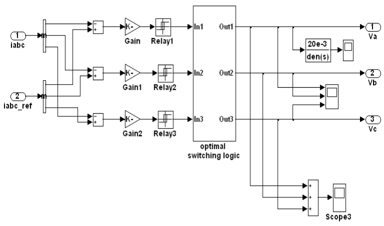

Fig 5.3 Voltage Source Inverter

C SENSORLESS CONTROL OF INDUCTION MOTOR :

The Sensorless control of induction motor using Model Reference Adaptive System (MRAS) is simulated on MATLAB/SIMULINK - platform to study the various aspects of the controller.. Here we are going to discuss the realization of Sensorless control of induction motor using MRAS for simulink blocks..

Main subsystems are the 3-phase to 2-phase transformation, 2-phase to 3-phase transformation, induction motor model, Model Reference Adaptive System (MRAS) and optimal switching logic & inverte

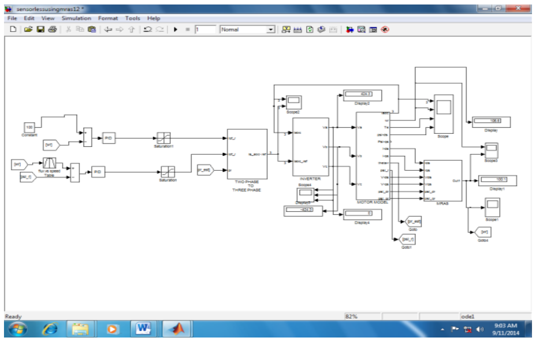

Fig 5.4 Simulink root block diagram of Sensorless control of induction motor using MRAS

D SIMULATION OF MODEL REFERNCE ADAPTIVE SYSTEM (MRAS):

Fig 5.5 shows the Simulink block diagram Model Referencing Adaptive System (MRAS). Which is consists Two blocks one is called Reference Model and other is Adaptive Model.

The voltage model's stator-side equations, are defined as a Reference Model and the Simulink block diagram of Reference Model is shown in Fig5.4. The Adaptive Model receives the machine stator voltage and current signals and calculates the rotor flux vector signals, as indicated by equations, which is shown in Fig 5.5. By using suitable adaptive mechanism the speed r, can be estimated and taken as feedback.

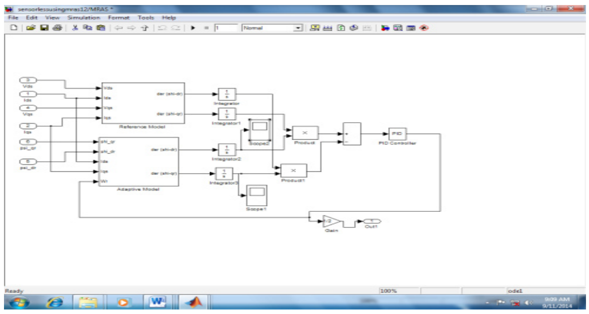

Fig 5.5 Simulink block diagram for Model Referencing Adaptive System

VI. SIMULATION RESULTS :

The simulation of Vector Control of Induction Motor is done by using MATLAB/SIMULINK. The results for different cases are given below.

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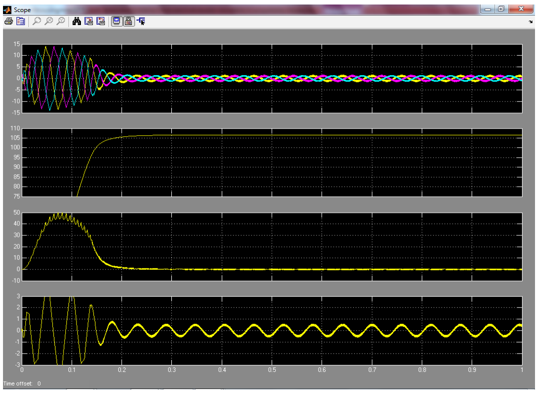
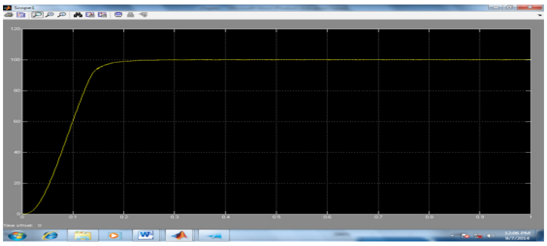


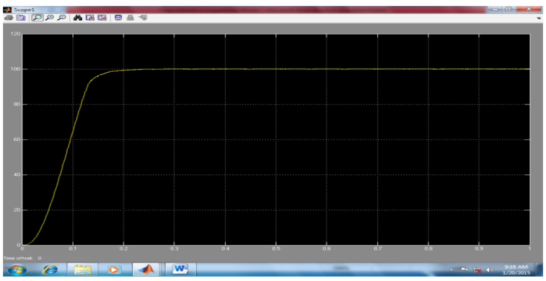
Reference speed = 100 rad/sec and on no-load
3- currents, Speed, and Torque for no-load reference speed of 100 rad/sec

SPEED OUTPUT WAVE FORMS:

Under PI Controller:



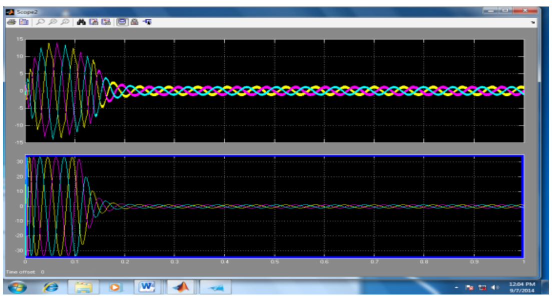
WAVE FORM OF speed for no-load reference speed of 100 rad/sec Under FUZZY Controller:



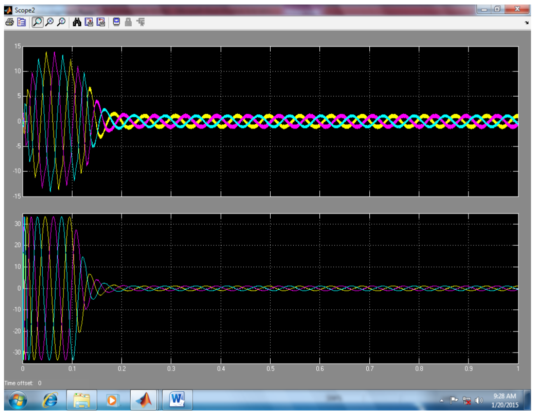
Wave Form Of Speed For No-Load Reference Speed Of 100 Rad/Sec

CURRENT OUTPUT WAVE FORM

Under PI controller



Waveform of 3phase current for no-load reference speed of 100rad/sec Under Fuzzy Controller

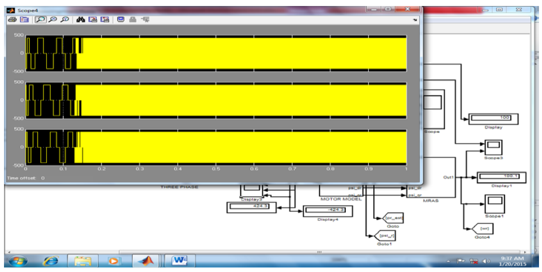


Waveform of 3phase current for no-load reference speed of 100rad/sec

VOLTAGE OUT PUT WAVE FORMS

Under PI Controller:

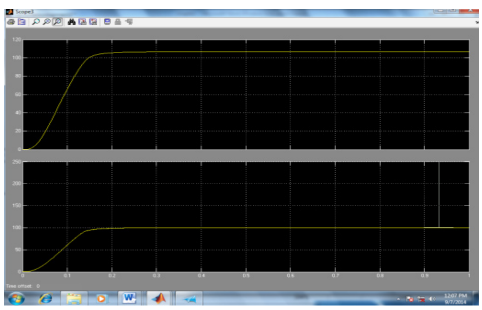
Waveform Of 3 Phase Voltage For No-Load Reference Speed 100rad/Sec Under FUZZY Controller:



Waveform Of 3 Phase Voltage For No-Load Reference Speed 100rad/Sec.

SPEED AND TORQUE OUTPUT WAVEFORMS:

Under PI Controller:



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International Journal & Magazine of Engineering, Technology, Management and Research
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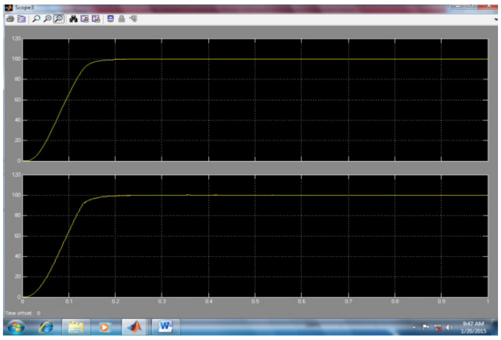
Waveform of speed and torque for no-load reference speed of 100rad/sec. Under FUZZY Controller:



Waveform of speed and torque for no-load reference speed of 100rad/sec

VII. CONCLUSION:

In this thesis, Sensor less control of induction motor using Model Reference Adaptive System (MRAS) technique has been proposed. Sensor less control gives the benefits of Vector control without using any shaft encoder. In this thesis the principle of vector control and Sensor less control of induction motor is given elaborately. The mathematical model of the drive system has been developed and results have been simulated. Simulation results of Vector Control and Sensor less Control of induction motor using MRAS technique were carried out by using MATLAB/SIMULINK and from the analysis of the simulation results, the transient and steady state performance of the drive have been presented and analyzed.From the simulation results, it can be observed that, in steady state there are ripples in torque wave and also the starting current is high. The main results obtained from the Simulation, the following observations are made.

- The transient response of the drive is fast, i.e. we are attaining steady state very quickly.
- The speed response is same for both vector control and Sensor less control.
- By using MRAS we are estimating the speed, which is same as that of actual speed of induction motor.Thus by using sensor less control we can get the same results as that of vector control without shaft encoder. Hence by using this proposed technique, we can reduce the cost of drive i.e. shaft encoder's cost, we can also increase the ruggedness of the motor as well as fast dynamic response can be achieved.

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