Speed Control of Induction Motor Using Vector Controlled Technique Using MRAS

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Abstract: **To implement the vector control technique, the motor speed information is required. Infrared Tacho-meters, resolvers or incremental encoders are used to detect the speed. These sensors require careful mounting and alignment and special attention is required with electrical noises. Speed sensor requires additional space for mounting and maintenance and hence increases the cost and the size of the drive system .These problems are decreased by speed sensor less vector control by using model reference adaptive system(MRAS). Model reference adaptive system is a speed estimation method having two models namely reference and adaptive model .The error between two models determines induction motor speed. This paper proposes a Model Reference Adaptive System (MRAS) for estimation of speed of induction motor. An Induction motor is developed in stationary reference frame and Space Vector Pulse Width Modulation (SVPWM) is used for inverter design. PI controllers are designed controlling for this purpose. It has good tracking and attains steady state response very quickly which is shown in simulation results by using MATLAB7.8/SIMULINK.**

Keywords – **Sensorless vector control, Model Reference Adaptive System (MRAS), Induction motor, stationary reference frame, Speed estimation.**

I. INTRODUCTION

In few years, the vector control theory has been adopting much attention because of the better steady and dynamic performance over conventional control methods in controlling motors torque and speed. In various vector control schemes, the speed sensor less vector control has been a relevant area of interest for many researchers due to its low drive cost, high reliability and easy maintenance. There are two main parameters which are required in speed sensor less vector control of induction motor, those are, the motor flux and speed estimation. These parameters are necessary for establishing the outer speed loop feedback and also in the flux and torque control algorithms. . In order to get good performance of sensor less vector control, different speed estimation methods have been proposed. Such as direct calculation method, model reference adaptive system (MRAS), Observers (extended Kalman filter, luenberger etc), Estimators using artificial intelligence etc .

Out of various speed estimation methods, MRAS-based speed sensor less estimation has been commonly used in AC speed regulation systems due to its good performance and ease of implementation.

MRAS, we have to form rotor flux equation in the form of stator side parameters. In adaptive model, speed is the adaptive parameter.

II. MODELING OF INDUCTION MOTOR IN STATOR REFERENCE FRAME

The required transformation in voltages, currents, or flux linkages is derived in a generalized way. R.H. Park, in the 1920s, proposed a new theory of electrical machine analysis to represent the machine in d – q model.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. The Equations of the induction motor in stationary 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

$$\left.\begin{aligned} \psi_{qs} &= L_s i_{qs} + L_m i_{qr} \\ \psi_{ds} &= L_s i_{ds} + L_m i_{dr} \\ \psi_{qr} &= L_r i_{qr} + L_m i_{qs} \\ \psi_{dr} &= L_r i_{dr} + L_m i_{ds} \end{aligned}\right\} \quad \text{-------------- (1)}$$

2.17

$$\left.\begin{aligned} \psi_{qm} &= L_m (i_{qs} + i_{qr}) \\ \psi_{dm} &= L_m (i_{ds} + i_{dr}) \end{aligned}\right\} \quad \text{-------------- (2)}$$

Stator and rotor voltage and current equations are as follows

$$\left.\begin{aligned} v_{ds} &= R_s i_{ds} + p\psi_{ds} \\ v_{qs} &= R_s i_{qs} + p\psi_{qs} \\ v_{dr} &= R_r i_{dr} + \omega_r \psi_{qr} + p\psi_{dr} \\ v_{qr} &= R_r i_{qr} - \omega_r \psi_{dr} + p\psi_{qr} \end{aligned}\right\} \quad \text{-------------- (3)}$$

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

$$\left.\begin{aligned} R_r i_{dr} + \omega_r \psi_{qr} + p\psi_{dr} &= 0 \\ R_r i_{qr} - \omega_r \psi_{dr} + p\psi_{qr} &= 0 \end{aligned}\right\} \quad \text{---------------- (4)}$$

From (5), we have

$$\left.\begin{aligned} i_{dr} &= \frac{-p\psi_{dr} - \omega_r \psi_{qr}}{R_r} \\ i_{qr} &= \frac{-p\psi_{qr} + \omega_r \psi_{dr}}{R_r} \end{aligned}\right\} \quad \text{--------------(5)}$$

By solving the equations (4)-(6) we get the following equations

III. MODEL REFERENCING ADAPTIVE SYSTEM (MRAS)

MRAS is a speed estimation method. 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.

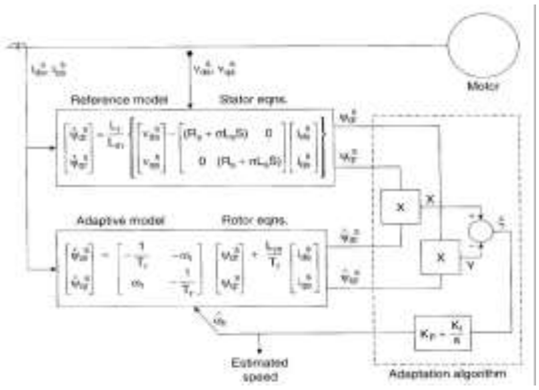


Fig 1: Block diagram of MRAS

The basic block diagram of MRAS speed estimation system is shown in Fig 1.

We can develop the induction motor model in stator reference frame. 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

Reference frame model flux equations are

$$\frac{d}{dt}\psi_{dr} = \frac{L_r}{L_m}\left[v_{ds} - (R_s + \sigma S L_s) i_{ds}\right]$$

$$\frac{d}{dt}\psi_{qr} = \frac{L_r}{L_m}\left[v_{qs} - (R_s + \sigma S L_s) i_{qs}\right]$$

Adaptive model flux equations are

$$\frac{d}{dt}\psi_{qr} = \frac{L_m}{T_r} i_{qs} + \omega_r \psi_{dr} + \frac{1}{T_r}\psi_{qr}$$

$$\frac{d}{dt}\psi_{dr} = \frac{L_m}{T_r} i_{ds} - \omega_r \psi_{qr} - \frac{1}{T_r}\psi_{dr}$$

Adaptive mechanism for speed

$$\omega_r = \varsigma\, k_p + \frac{k_i}{s}$$

$$\varsigma = A - B = \hat{\psi}_{dr}^{s}\psi_{qr}^{s} - \hat{\psi}_{qr}^{s}\psi_{dr}^{s}$$

IV DIRECT VECTOR CONTROL OF INDUCTION MOTOR DRIVE

The Vector Control or Field orientation control of induction motor is simulated MATLAB7.8/ 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. It provides a user interactive platform and a wide variety of numerical algorithms. This chapter discusses the realization of vector control of induction motor using Simulink blocks.

This system consisting of Induction Motor Model, Three Phase to Two phase transformation block, Two phase to Three phase block, Flux estimator block and In

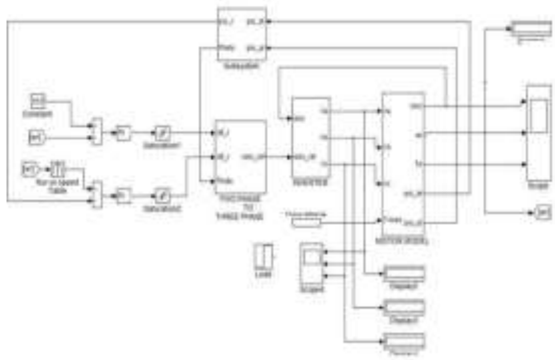


Fig 2: Simulink Model of Direct Vector Controlled Induction motor

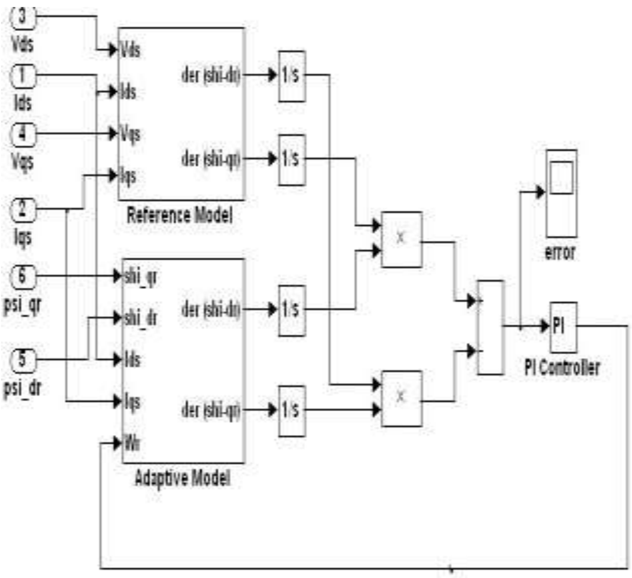
A. Induction Motor Model

The motor is modeled in stator reference frame. The dynamic equations are given by (1) to (14). By using these equations

C. Model Reference Adaptive System (MRAS)

Fig 3 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, (16) & (17) are defined as a Reference Model and the simulink block diagram of Reference Model is shown in Fig3. The Adaptive Model receives the machine stator voltage and current signals and calculates the rotor flux vector signals, as indicated by equations, (18) and (19) which is shown in Fig . By using suitable adaptive mechanism the speed ω_r, can be estimated and taken as feedback.

Fig 3: Simulink block diagram for Model Referencing Adaptive System



V. SIMULATION RESULTS

The simulation of Vector Control of Induction Motor is done by using MATLAB7.8/SIMULINK. The results for different cases are given below.

(a) **Direct Vector control**: Reference speed = 100 rad/sec on no-load

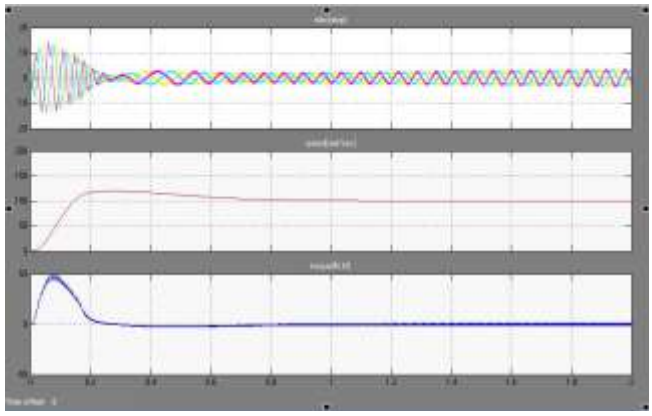
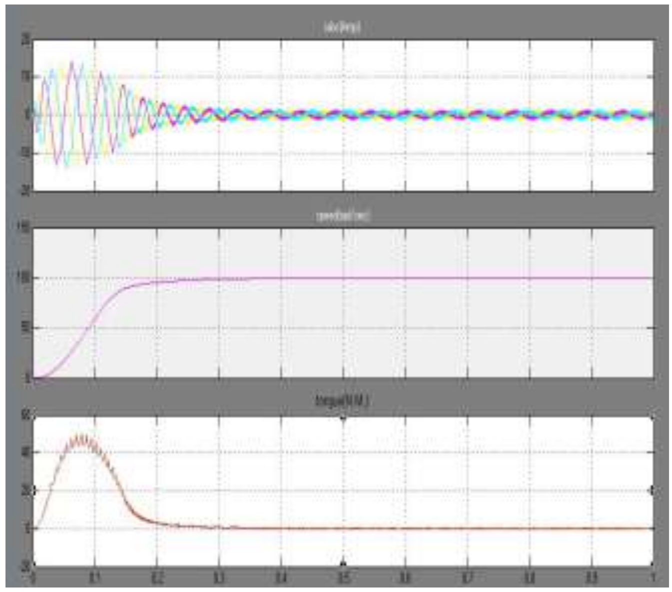


Fig 4: 3-ϕ currents, Speed, and Torque for no-load reference speed of 100 rad/sec



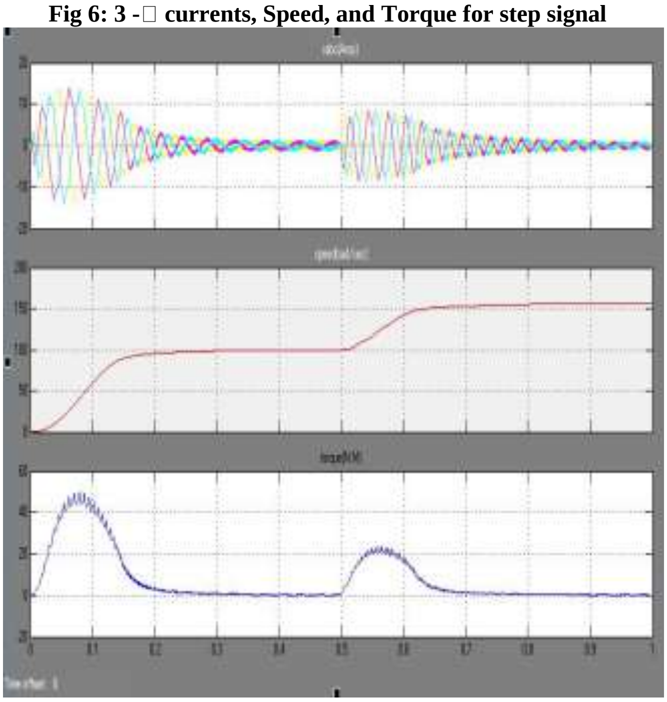
SENSORLESS SPEED CONTROL USING MRAS a) under no load **:**Reference speed 100 rad/sec

Fig 5:3-ϕ currents, Speed, and Torque for no-load reference speed of 100 rad/sec

b) step is applied at t=0.5 sec:

157 rad/sec at 0.5 sec

Fig 6: 3 -□ currents, Speed, and Torque for step signal



VI. 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 are given elaborately. Simulation results of Vector Control and Sensor less Control of induction motor using MRAS technique were carried out by using Matlab7.8/Simulink. From the simulation results, the following observations are made.

i) The transient response of the drive is fast, i.e. we are attaining steady state very quickly and so fast.
ii) By using MRAS we are determining 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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