# SPEED CONTROL OF THREE PHASE INDUCTION MOTOR BY USING MRAS

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**Abstract -**

In recent time there is increase in demand of Induction Motor in industries. In this paper we present the sensorless method for speed estimation and control of three phase induction motor . No sensors are used so this system isrugged and simple. The dynamic model of the induction motor is derived by using a two-phase motor in direct and quadrature axis.

Here MRAS method is used for speed estimation and control because of it's less complexity and more efficient. MRAS contain two models, Reference and Adaptive model. Output of adaptive model is compared with that of reference model and this difference is used to estimate the speed of the three phase induction motor.

***Key Words***:- modelling of induction motor, Axes Transformation, MRAS speed control scheme

## I.INTRODUCTION:

Induction Motor is a main part in all of the industries now a days, because Induction Motor have various features such as, low cost, high reliability, low inertia, simplicity and ruggedness. squirrel cage type Induction motor are generally used for single speed applications majority of Induction Motors are operated at constant speed which is generally determined by the numbers of pole pair and the stator supply frequency.

Electrical energy consumption of the appliances can be reduced by controlling the speed of the motor .therefore variable speed three phase Induction Motor to be used industries

New control technique of Induction Motor was developed and presented by I.Takahashi which is Direct Torque Control (DTC) and by M. Depenvrock. as Direct Self Control(DSC) In which by using Direct Torque Control It is possible to obtain good dynamic control of torque without any mechanical transducer on the shaft of machine thus DTC can considered as ''sensor less type ''control technique.

Direct Torque Control name is derived from fact that ,on the basis of error between reference and the estimated values of torque and flux. error within the prefixed band limit.

For the implementation of the vector control technique, information of the motor speed is required. tachogenerators, resolvers encoders are generally used for detection of rotor speed. These sensors for the speed sensation impacts on reliability and simplicity of the Induction Motor also they required careful alignment and mounting to install the speed sensors additional space is required due to which For energy auditing of institute, size and cost of drive system get increased. on the other hand if we use sensor less drive system, then all above problem associated with the sensors can be minimized but is a big challenge for engineers that elimination of speed sensor without any degrading the performance.

Varity of solutions for sensor less AC drive have proposed, kalman filtering technique, Luenberger observer, adaptive observer, Model Reference Adaptive System(MRAS) and sensor less control with parameters adaptation. In these of Model Reference Adaptive System is a very effective, simple and best method than other. So in this paper we present MRAS technique for the AC motor control. .

## 2. Principle of sensorless control:

MRAS method is used for the sensor less control of induction motor. sensor less control induction motor drive essentially means vector control without any speed sensor for the sensation of any parameter. For the control of induction motor inverter is used to provide switching pulses. The flux and speed estimated with help of flux and speed estimators, then these signals are compared with reference values and controlled by using PI controller.

The determination of speed signal from an induction motor drive system without using sensor. The dynamic equation of induction motor used to estimate the rotor speed component for control purpose. From the voltage and current estimation of rotor speed component is carried out. An incremental shaft mounted speed encoder, usually an optical type is required for closed loop speed or position control in both scalar and vector controlled drives. without mechanical speed sensors induction motor speed control scheme are employed. The information on the rotor speed is extracted from measured stator voltage and current at the motor terminals.

## 3. Modeling of Induction motor:

Sensor less control and speed estimation of Induction motor drives is vast and complicated subject. Squirrel cage induction motors are widely used in industries, because of it's electrical and mechanical simplicity. Analysis of any motor is obtained from it's equivalent mathematical equations. per phase equivalent circuit has been widely used but it is not appreciated to predict the dynamic performance of the motor. Equivalence between three phase and two phase is established from which a dynamic model for the three phase induction motor can be derived from two phase machine. We know steady state conditions is derived from per phase equivalent circuit of the induction motor. In order to reduce this complexity the transformation of axes from 3 – Φ to 2 – Φ is necessary. Machine of n number of phases can be easily analyzed by the use of transformation scheme. Thus, an equivalent model is adopted universally, that is 'd – q model. Figure show the Simulink block diagram of induction motor model.

Equations used for the simulink modeling are,

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

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

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

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

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

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

the electromagnetic torque of the induction motor in

stator reference frame is given by

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

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

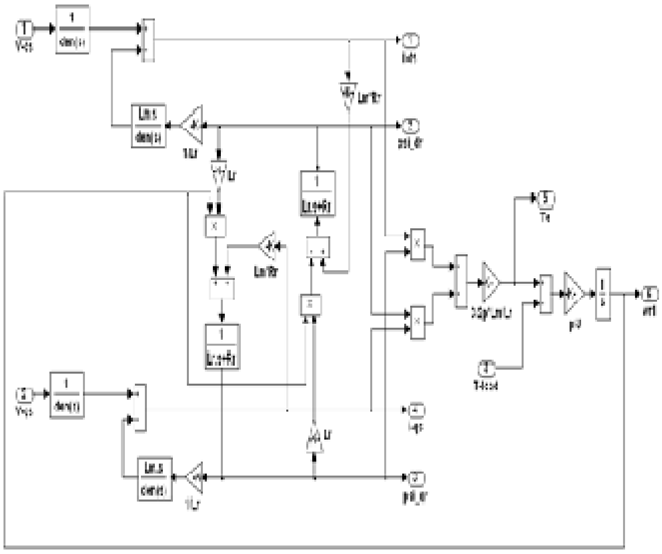

**Figure 3.1** Simulink block diagram of induction motor model

## 4. Model Reference adaptive System (MRAS) :

For the adaptive control of the Induction Motor control application Model Reference Adaptive(MRAS) System technique is used. MRAS scheme is less complex and more efficient. this scheme have two models one is reference model and another one is adaptive model. in which reference model does not involves quantity to be estimated (rotor speed, Wr) and adaptive model involve the quantity to be estimated. In this MRAS scheme output from reference model and adaptive model is compared and difference is used to drive suitable adaptive mechanism, whose output is quantity to be estimated(rotor speed). output of these two model compared until error between two model vanish to zero. with the correct valve of rotor speed, the fluxes determined by two models should match. an adaptation algorithm with PI controller can be used to tune speed valve until the two flux value match.

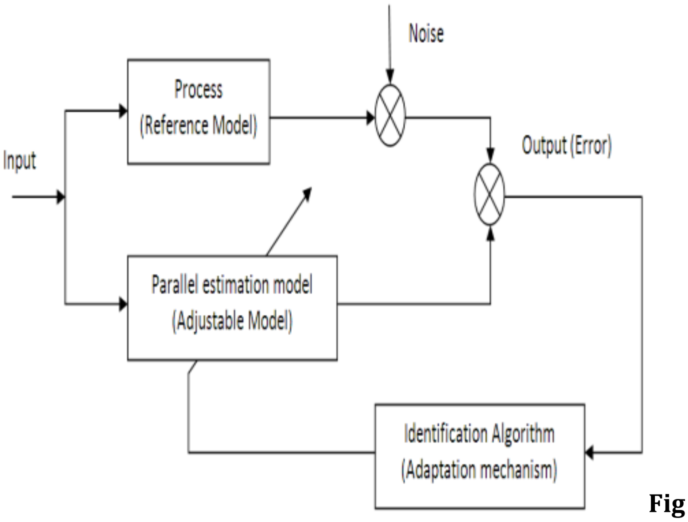


**Figure 4 a)**: basic identification structures and their correspondence with MRAS

### 4.1 Reference Model:

The reference usually expressed as VM (voltage model), represent the stator equation. It generate the reference of rotor flux component in the stationary reference frame from stator voltage and monitored current component, the reference rotor flux component obtained from reference model are given by,

$$\frac{d}{dt}\varphi_{dr} = \frac{L_r}{L_m}[v_{ds} - (R_s + \sigma s L_s) i_{ds}] \qquad ........(1)$$

$$\frac{d}{dt}\varphi_{qr} = \frac{L_r}{L_m}[v_{qs} - (R_s + \sigma s L_s) i_{qs}] \qquad .........(2)$$

Where, $\sigma = 1 - \frac{L_m^2}{L_s L_r}$, $L_{ls} = L_s - L_m$ , $L_{lr} = L_r - L_m$

### 4.2 Adaptive Model:

Adaptive model usually represented by the CM(current model) described the rotor equation, where the rotor flux component are expressed in term of stator current component and rotor speed. the flux component obtained from adaptive model are given by,

$$\frac{d}{dt}\varphi_{dr} = \frac{L_m}{L_r} i_{ds} - \omega_r \varphi_{qr} - \frac{1}{T_r}\varphi_{dr} \qquad ........(3)$$

$$\frac{d}{dt}\varphi_{qr} = \frac{L_m}{L_r} i_{qs} + \omega_r \varphi_{dr} - \frac{1}{T_r}\varphi_{qr} \qquad .......(4)$$

Where,

$$T_r = \frac{L_r}{R_r}$$

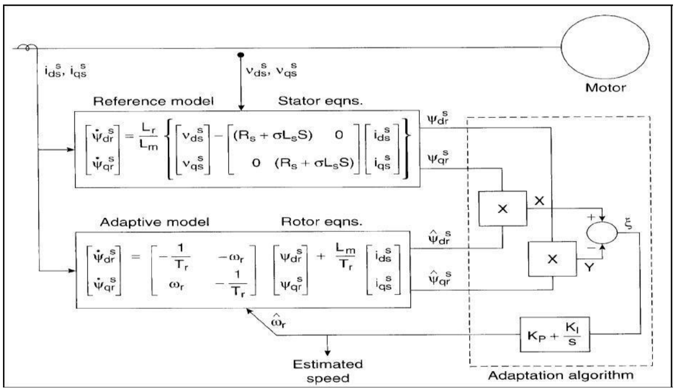


**Figure 4 b)**: Basic block diagram of MRAS system

## 5. SIMULINK BLOCK DIAGRAM:

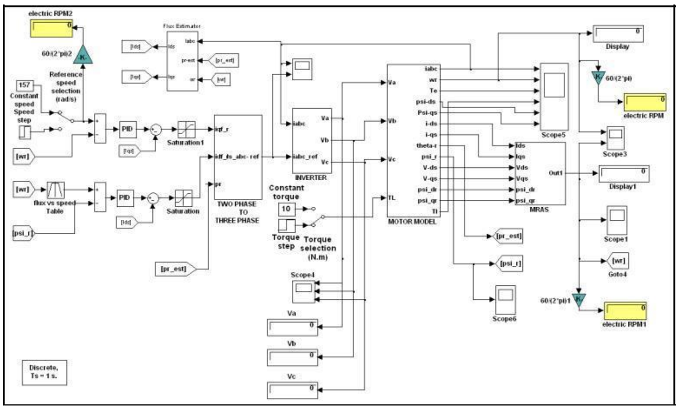

**Figure 5a)**: Simulink root block diagram of Sensorless control of induction motor using MRAS.

## 6 SIMULATION RESULTS:

### 6.1 Vector Control of Induction Motor:

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

**Case-1: No-Load Condition**

Reference speed = 100 rad/sec and on No-load

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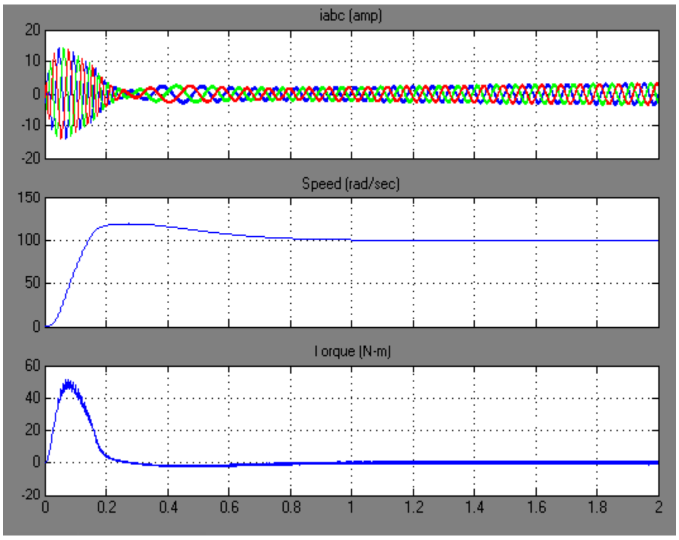
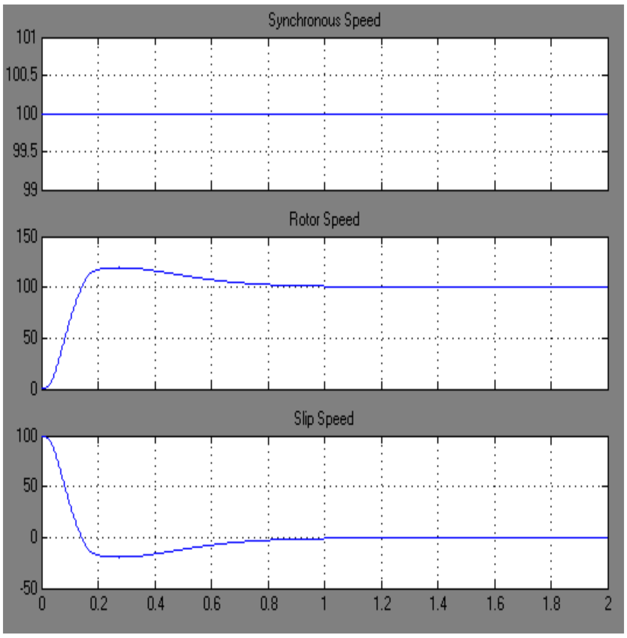
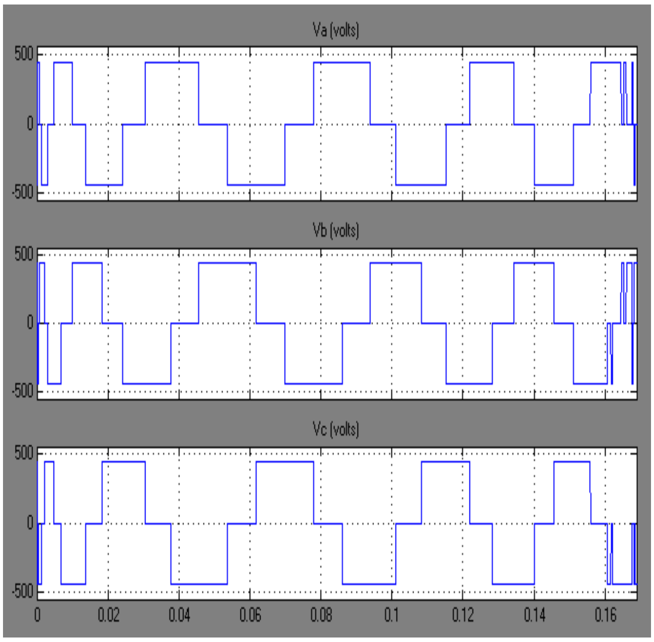



**Fig 6.1 a):** Simulation results of 3-phase currents, Speed, and Torque for no-load reference speed of 100 rad/sec



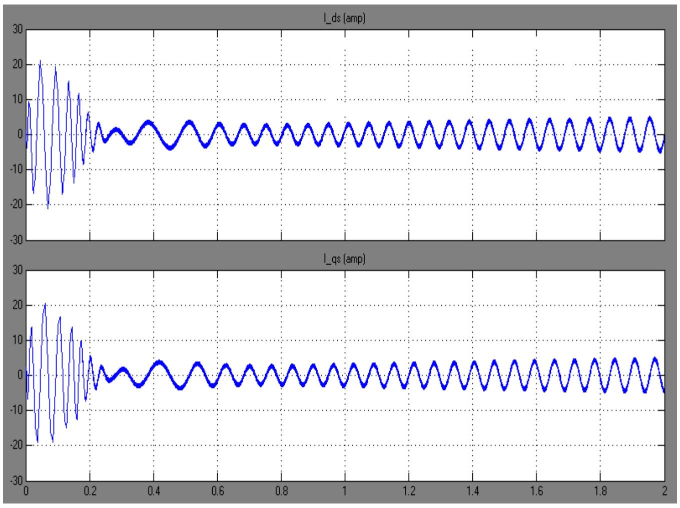

Time (sec)

**Figure 6.1 b):** Simulation results of Reference Speed, Rotor Speed & Slip Speed Respectively




Time (sec)

**Figure 6.1 c):** Simulation results of Inverter output Voltages for No load speed of 100 rad/sec.




Time (sec)

**Figure 6.1 d):** Simulation results of Stator Currents $I_{ds}$ and $I_{qs}$

**6.2 Sensorless Vector Control of Induction Motor:**

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

**Case-1: Under No-Load Condition**

Reference speed = 100 rad/sec

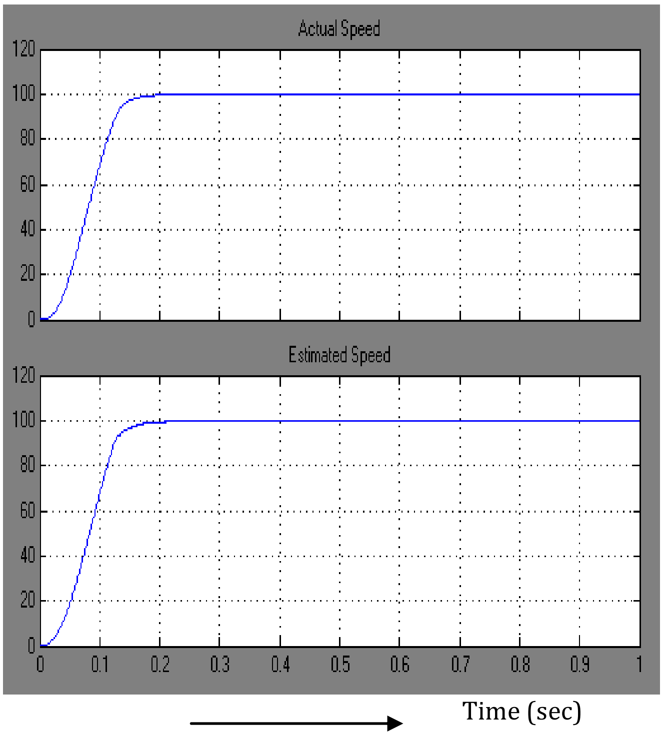



**Figure 6.2 a):** Simulation results of Actual Speed and Estimated speed Using MRAS in 100 rad/sec

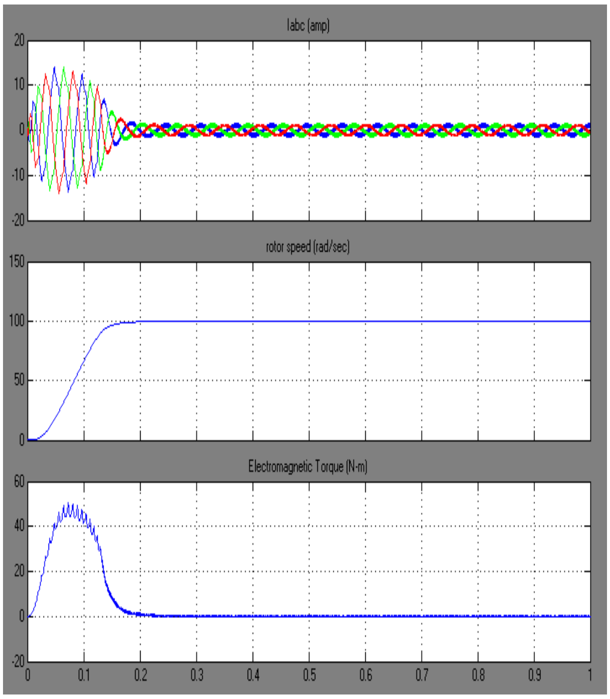



**Figure 6.2 b):** Simulation results of 3-ϕ currents, Speed and Torque for no-load reference speed of 100 rad/sec

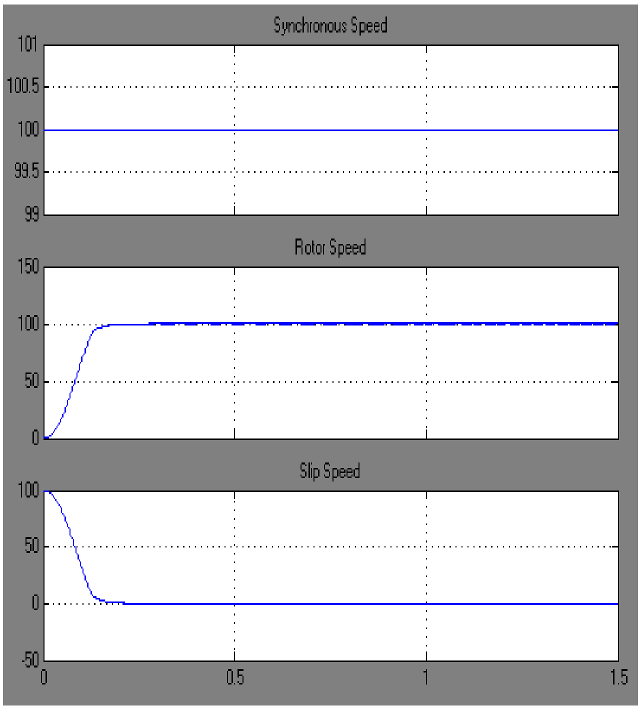



**Figure 6.2 c):** Simulation results of Reference speed, Rotor Speed, Slip Speed Respectively

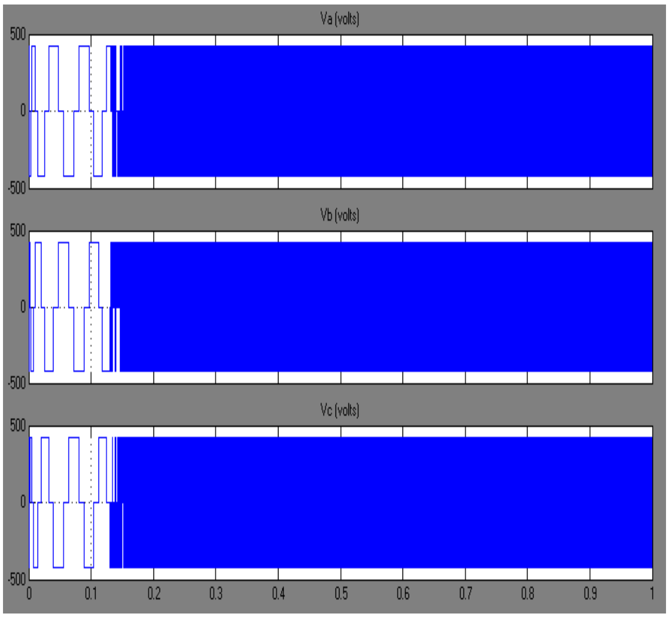



**Figure 6.2 d):** Simulation results of Inverter output Voltages for Noload speed of 100 rad/sec

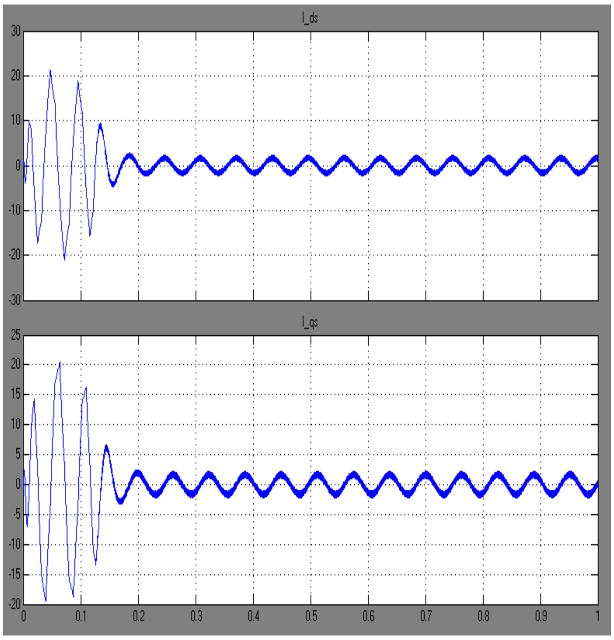



**Figure 6.2 e):** Simulation results of Stator Currents $I_{ds}$ and $I_{qs}$

## Conclusion:

In this paper, Model Reference Adaptive System Technique has been employed for sensorless control of Induction Motor

In this thesis the principle of vector control and sensorless control of Induction Motor is proposed. The mathematical model of Induction Motor are expressed by using equation and results are shown by using simulation. sensorless control of Induction Motor using MRAS scheme has been developed in MATLAB/SIMULATION.S

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