

A Monthly Peer Reviewed Open Access International e-Journal

Model Reference Adaptive System (MRAS) Based Sensor less Induction Motor Using Artificial Neural Networks

L.Santosh Kumar M.Tech Scholar, Department of EEE, SSIT, Chilakapalem, Srikakulam. P.Taviti Naidu Assistant Professor, Department of EEE, SSIT, Chilakapalem, Srikakulam.

D.Prabhavathi

Associate Professor, Department of EEE, SSIT, Chilakapalem, Srikakulam.

ABSTRACT:

The aim of this paper is to develop a vector controlled induction motor drive operating without a speed or position sensor but having a dynamic performance comparable to a sensored vector drive. This thesis presents the control of an induction motor through sensorless vector control. The theoretical basis of each algorithm is explained in detail and its performance is tested with simulations implemented in MATLAB/SIMULINK. First the Dynamic model of induction machine 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 convenient method in real time implementation was developed. and Model Reference Adaptive System is studied as a state estimator. Rotor flux estimation scheme is applied to MRAS algorithm to estimate rotor speed using pi controller. With pi controller speed estimation can be done by using trial and error method. It is difficult in practical conditions. So it was replaced with a artificial neural networks. The speed obtained by using ANN is compared with pi controller.

1 INTRODUCTION:

The two names for the same type of motor, induction motor and asynchronous motor, describe the two characteristics in which this type of motor differs from DC motors and synchronous motors. Induction refers to the fact that the field in the rotor is induced by the stator currents, and asynchronous refers to the fact that the rotor speed is not equal to the stator frequency.which makes it very simple and cheap to manufacture. As motors, they rugged and require very little maintenance. However, their speeds are not as easily controlled as with DC motors. They draw large starting currents, and operate with a poor lagging factor when lightly loaded. 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.

2.1INDUCTION MOTOR MODELLING:





Sensor less vector control induction motor drive essentially means vector control without any speed sensor. An incremental shaft mounted speed encoder, usually an optical type is required for closed loop speed or position control in both vector control and scalar controlled drives. A speed signal is also required in indirect vector control in the whole speed range and in direct vector control for the low speed range, including the zero speed start up operation.



A Monthly Peer Reviewed Open Access International e-Journal

Speed encoders undesirable in a drive because it adds cost and reliability problems, besides the need for a shaft extension and mounting arrangement.[13].

Controlled induction motor drives without mechanical speed sensors at the motor shaft have the attractions of low cost and high reliability. To reduce total hardware complexity, costs and to increase mechanical robustness, it is desirable to eliminate speed and position sensors in vector-controlled drives.

Drives operating in hostile environments or in high speed drives speed sensors can't be mounted. To replace the sensor the information on the rotor speed is extracted from measured stator voltages and currents at the motor terminals.

The operation of speed controlled ac drives without mechanical speed or position sensor's requires the estimation of internal state variables of the machine. The assessment is based exclusively on measured terminal voltages and currents. Continuing research has concentrated on the elimination of the speed sensor at the machine shaft without deteriorating the dynamic performance of drive control system.

Speed estimation is an issue of particular interest with induction motor drives where the mechanical speed of the rotor is generally different from the speed of the revolving magnetic field. The advantage of speed sensorless induction motor drives are reduced hardware complexity and lower cost, reduced size of the drive machine, elimination of the sensor cable, better noise immunity, increased reliability and less maintenance requirements.[5,17].

2.1.1 Problems with estimation [31]:

Before looking into individual approaches, the common problems of the speed and flux estimation are discussed briefly for general field-orientation and state estimation algorithms [31].

2.1.2 Parameter sensitivity :

One of the important problems of the sensorless control algorithms for the sensorless IM drives is the insufficient information about the machine parameters which yield the estimation of some machine parameters along with the sensorless structure. Among these parameters, stator resistance, rotor resistance and rotor time-constant play more important role than the other parameters since these values are more sensitive to temperature changes.

The knowledge of the correct stator resistance Rs is important to widen the operation region toward the lower speed range. Since at low speeds the induced voltage is low and stator resistance voltage drop becomes dominant, a mismatching stator resistance induces instability in the system.

On the other hand, errors made in determining the actual value of the rotor resistance Rr may cause both instability of the system and speed estimation error proportional to Rr. Also, correct Tr value is vital decoupling factor in the sensorless control scheme.

4.2.2 Pure integration :

The other important issue regarding many of the topologies is the integration process inherited from the IM dynamics where an integration process is needed to calculate the state variables of the system. However, it is difficult both to decide on the initial value, and prevent the drift of the output of a pure integrator. Usually, to overcome this problem a low-pass filter replaces the integrator.

4.2.3 Overlapping-loop problem :

In a sensorless control system, the control loopand the speed estimation loop may overlap and these loops influence each other. As a result, outputs of both of these loops may not be designed independently and in some bad cases this dependency may influence the stability or performance of the overall system.

The algorithms, where terminal quantities of the machine are used to estimate the fluxes and speed of the machine, are categorized in two basic groups. First one is "the open-loop observers" in a sense that the on-line model of the machine does not use the feedback correction.

Second one is "the closed-loop observers" where the feedback correction is used along with the machine model itself to improve the estimation accuracy.



A Monthly Peer Reviewed Open Access International e-Journal

2.2.4 Basic Theory:



Fig 4.1Block Diagram of Sensorless Control of Induction Motor

3. Simulation block digrams 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. 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.

Fig. 5.1 shows the Vector controlled Induction Motor block simulink diagram for simulation. This system consisting of Induction Motor Model, Three Phase to Two phase transformation block, Two phase to Three phase block, Flux estimator block and Inverter block.





3.2 Induction Motor Model:

The motor is modeled in stator reference frame. The dynamic equations are given by (2.21) to (2.29). By 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.



Fig.5.5: Simulink block diagram for 2-2 to 3-2 transformation.

3.4 Inverse Park Transformation:

The Inverse Park Transformation is transforms rotating reference frame vectors to two-phase stationary reference frame. The Dynamic Equations are given by (2.7) & (2.8) are respectively known as inverse Park Transformation. Fig 5.6 shows the simulation block diagram of Inverse park transformation.



Fig 5.6 Inverse Park transformation.

Volume No: 1(2014), Issue No: 11 (November) www.ijmetmr.com

November 2014 Page 296



A Monthly Peer Reviewed Open Access International e-Journal

3.5 Inverter:

Fig 5.7 shows the Voltage Source Inverter (VSI), it consists of an Optimal Switching Logic which is shown in Fig 5.8. 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 5.7 Voltage Source Inverter.



Fig 5.8 Optimal Switching Logic

3.6 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. 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. Here we are going to discuss the realization of Sensorless control of induction motor using MRAS for simulink blocks. Fig. 5.9 shows the root-block simulink diagram for simulation. 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 & inverter.



Fig 5.9 Simulink root block diagram of Sensorless control of induction motor using MRAS.

5.2.2 Model Reference Adaptive System (MRAS):

Fig 5.11 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, (4.7) & (4.8) are defined as a Reference Model and the simulink block diagram of Reference Model is shown in Fig5.12. The Adaptive Model receives the machine stator voltage and current signals and calculates the rotor flux vector signals, as indicated by equations, (4.15) and (4.16) which is shown in Fig 5.13. By using suitable adaptive mechanism the speed Dr. can be estimated and taken as feedback.



A Monthly Peer Reviewed Open Access International e-Journal



Fig 5.11 Simulink block diagram for Model Referencing Adaptive System.



Fig 5.12 Simulation diagram for Reference Model.

Gain4 Derivative1



Fig 5.13 Simulation diagram for Adaptive Model.



MRAS with ANN controller Simulation results Sensorless with pi controller



Under No-Load Reference speed = 100 rad/sec



Time (sec) Fig 6.17 Actual Speed and Estimated speed Using MRAS With ANN in rad/sec

Volume No: 1(2014), Issue No: 11 (November) www.ijmetmr.com



A Monthly Peer Reviewed Open Access International e-Journal

4.Conclusion:

In this thesis, Sensorless control of induction motor using Model Reference Adaptive System (MRAS) technique has been proposed. Sensorless control gives the benefits of Vector control without using any shaft encoder. In this thesis the principle of vector control and Sensorless 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 Sensorless Control of induction motor using MRAS technique were carried out by using Matlab/Simulink and from the analysis of the simulation results. From the simulation results, it can be observed that, speed error is reduced using MRAS and ANN. The results are compared with mras pi and mras ann.it shows that the speed of the machine tracks perfectly when we use ann.

5 REFERENCES:

1.Abbondanti, A. and Brennen, M.B. (1975). Variable speed induction motor drives use electronic slip calculator based on motor voltages and currents. IEEE Transactions on Industrial Applications, vol. IA-11, no. 5: pp. 483-488.

2.Nabae, A. (1982). Inverter fed induction motor drive system with and instantaneous slip estimation circuit. Int. Power Electronics Conf., pp. 322-327.

3.Jotten, R. and Maeder, G. (1983). Control methods for good dynamic performance induction motor drives based on current and voltages as measured quantities. IEEE Transactions on Industrial Applications, vol. IA-19, no. 3: pp. 356-363.

4.Baader, U., Depenbrock, M. and Gierse, G. (1989). Direct self control of inverter-fed induction machine, a basis for speed control without speed measurement. Proc. IEEE/IAS Annual Meeting, pp. 486-492.

5.Tamai, S. (1987). Speed sensorless vector control of induction motor with model reference adaptive system. Int. Industry Applications Society. pp. 189-195.

6.Griva, G., Profumo, F., Illas, C., Magueranu, R. and Vranka, P. (1996). A unitary approach to speed sensorless induction motor field oriented drives based on various model reference schemes. IEEE/IAS Annual Meeting, pp. 1594-1599.

7.Viorel, I. A. and Hedesiu, H. (1999). On the induction motors speed estimator's robustness against their parameters. IEEE Journal. pp. 931-934.