TRANSFORMING TECHNOLOGY
EXPLORING KNOWLEDGE

Volume 2 Issue 3
July 2014 - September 2014

ISSN: 2322-0821(online)
ISSN: Applied for (Printed)

INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING & APPLIED SCIENCES
www.irjeas.com

Sensorless Speed Estimation of Induction Motor

Akanksha Koshti[1], Amol Barve [2]

[1] *M.Tech Scholar, Dept. of Electrical & Electronics, LNCT, Bhopal, INDIA - 462021*
[2] *Asst. Professor, Dept. of Electrical & Electronics, LNCT, Bhopal, INDIA - 462021*

Abstract – In this paper, a method of speed identification for sensorless induction motor-drive based on MRAS, a model reference adaptive system is proposed. The adaptive full order observer based on IM equation is used to estimate stator currents and rotor flux. Lyapunav's stability criterion is employed to estimate rotor speed. The same algorithm reduced from Lyapunov's stability criterion is provided to estimate the stator resistance, which results in the speed estimation error. It is clear from the results of simulation that the motor speed is controlled well at very low speeds. The proposed speed and stator resistance identification methods can be considered and implemented for practical applications.

Nomenclature

L_r	Rotor inductance
L_s	stator inductance
L_m	Magnetizing inductance
i_{ds}	d-axis stator current
i_{qs}	q-axis stator current
i_{dr}	d-axis rotor current
i_{qr}	q-axis rotor current
P	Number of poles
p	Derivative factor
R_r	Rotor resistance
R_s	Stator resistance
T_e	Developed torque
T_L	Load torque
v_{as} , v_{bs} , v_{cs}	Phase voltages
v_{ds}	Direct axis stator voltage
v_{qs}	Quadrature axis stator voltage
v_{dc}	DC link voltage
ψ_{ds}	d-axes stator flux linkage
ψ_{qs}	q-axes stator flux linkage
ψ_{dr}	d-axes rotor flux linkage
ψ_{qr}	q-axes rotor flux linkage
α	Angle between V_{ds} and V_{qs}
J	Rotor inertia

I. INTRODUCTION

The sensorless induction motor have been widely used due to their attractive features such as reliability, flexibility, rohobustness and poor cost, especially in the field of general inverter where they are used successfully. The variation of other parameters such as the resistance of stator or rotor winding, however, may lead to the in accuracy of estimated speed The stator voltage being used for the estimation is obtained from DC link voltage the switching states of the inverter (The inverter is assumed to be supplied from an ideal AC-DC converter which takes AC voltage from the AC grid and provides the inverter a constant DC input). The switching states of the inverter is controlled directly by the central processor, therefore, the On-Off states of the transistors in the inverter are available to the processor. From the pre-defined value of DC link voltage, the processor can determine the stator phase voltage space vectors corresponding to those switching states. The stator phase currents are obtained from current sensors. In conventional speed control of DTC the actual value of rotor speed is required. The controller receives the signals of rotor speed from the speed sensors. Unfortunately, the accuracy of the control system will decrease with the appearance of noises, causing low reliability. Furthermore, the conventional sensors make the higher cost; increase the complexity of the systems because of noise filtering. The filtering will help to improve the quality of feedback speed, however, additional digital filters require higher computing capacities for faster signal processing and transmission. Therefore, they mount additional costs on the overall systems. Recently, many researches have been carried out for the design of speed sensorless control schemes. In these new schemes the speed is obtained from the determined stator voltages and measured stator currents instead of using a sensor. In this paper, two sensorless techniques are presented, an open loop and a close-

International Research Journal of Engineering & Applied Sciences
www.irjeas.com, ISSN: 2322-0821, Volume 2, Issue 3, July 2014 – September 2014, Page 52-56

loop (MRAS) scheme, which can overcome the necessity of the speed sensor.

II. PROPOSED SENSORLESS IM DRIVE

The proposed sensor less induction motor drive block diagram is shown in Fig. 2.1. It operates with constant rotor flux, direct stator flux and torque control. The speed controller is a classical PID regulator which produces the reference torque. Only the dc-link voltage and two line currents are measured. The used induction motor model is (1) - (4):

$$\underline{u}_s = R_s \underline{i}_s + s\underline{\varphi}_s + j\omega_e \underline{\varphi}_s \qquad (1)$$

$$\underline{0} = R_r \underline{i}_r + s\underline{\varphi}_r + j(\omega_e - \omega_r)\underline{\varphi}_r \qquad (2)$$

$$\underline{\varphi}_s = L_s \underline{i}_s + L_m \underline{i}_r \qquad (3)$$

$$\underline{\varphi}_r = L_r \underline{i}_r + L_m \underline{i}_s \qquad (4)$$

where: $\underline{U}_s$ is the stator voltage, $\underline{i}_s$ & $\underline{i}_r$ are the stator and rotor currents, φ_s, φ_r are the stator and rotor flux, R_s , R_r, Ls, Lr, Lm are the motor parameters, we is the reference frame speed (arbitrary), w_r is the rotor speed and s the derivation operator.

The electromagnetic torque is (5):

$$T_e = 1.5p(\varphi_{sd} i_{sq} - \varphi_{sq} i_{sd}) \qquad (5)$$

With p the number of pole pairs.

The stator flux and torque close loop control is achieved by the DTC-SVM unit. In order to reduce the torque an flux pulsations and, implicitly, the current harmonics content, in contrast to the standard DTC, we do use decoupled PI flux and torque controllers and space vector modulation.

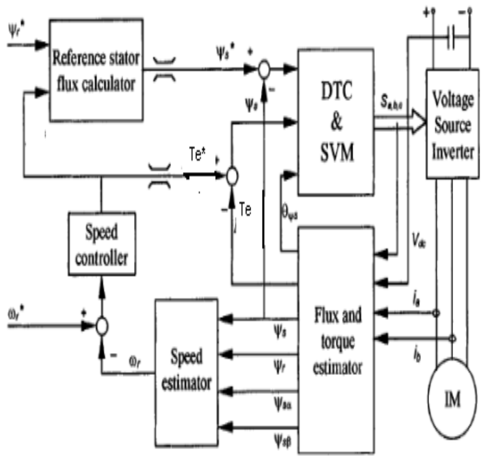

Fig.2.1- DTC-SVM Sensor less Ac Drive

III. MODEL REFERENCING ADAPTIVE SYSTEM (MRAS)

The speed can be calculated by the Model Referencing Adaptive System (MRAS). The basic block diagram of MRAS speed estimation system is shown in Fig. 3.1 The model reference approach (MRAS) makes use of redundancy of two-machine model of different structures that estimate the same state variables. Both models are referred to in the stationary reference frame. The MRAS in Fig 3.1 can be interpreted as a vector Phase Locked Loop (PLL) in which the output flux vector from the reference model is the reference vector and the adjustable model is a vector phase shifter controlled by ω_r. In practice, the rotor flux synthesis based on the reference model is difficult to implement, particularly at low speeds, because of the pure integration of the voltage signals. The MRAS speed estimation algorithm remains and valid if, instead of integration, the corresponding CEMF signals are compared directly through some low-pass filters. Estimation accuracy can be good if machine parameters are considered as constant. However, accuracy, particularly at low speeds, deteriorates due to parameter variation.

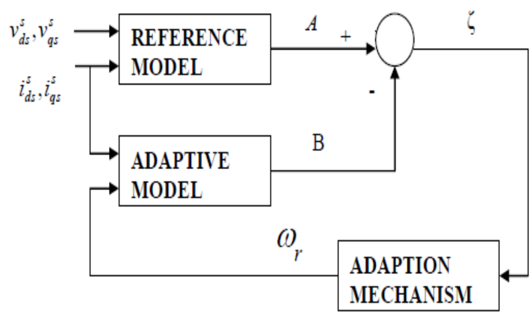

Fig. 3.1- Basic Block Diagram of MRAS speed estimation

IV. SIMULATION RESULT

The simulation of Sensorless control of induction motor is done by using MATLAB-SIMULINK.
Fig.4.1 Shows that the actual speed of induction motor and estimated speed using MRAS are same. Fig. 4.2 Show direct and quadrature axes currents (I_{ds} & I_{qs}). From the graph it is observed that both currents are displaced by 90^0. Hence the coupling effect can be eliminated.Fig.4.4 shows the no load line currents, speed and torque wave forms. It can be seen that at starting the values of currents and torque

will be high. The motor reaches to its final steady state position within 0.2 sec. Hence it has fast dynamic response. Fig 4.5 shows the speeds obtained in the Vector Control and in Sensorless Control. From this it is observed that the speed obtained in the Sensorless Control is same as Vector Control without any speed sensor.

No-Load Condition

Reference speed = 100 rad/sec

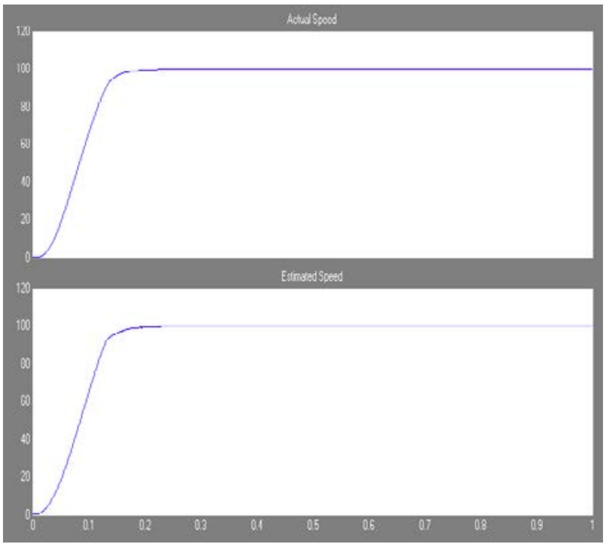

Fig.4.1- Actual Speed and Estimated speed Using MRAS in rad/sec

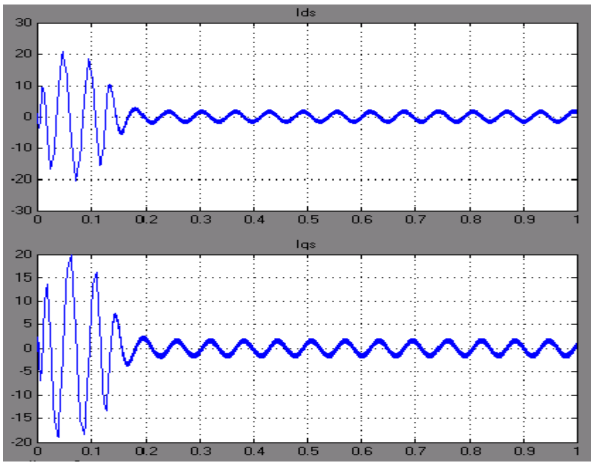

Fig.4.2 - Direct and Quadrature axes currents (I_{ds} & I_{qs})

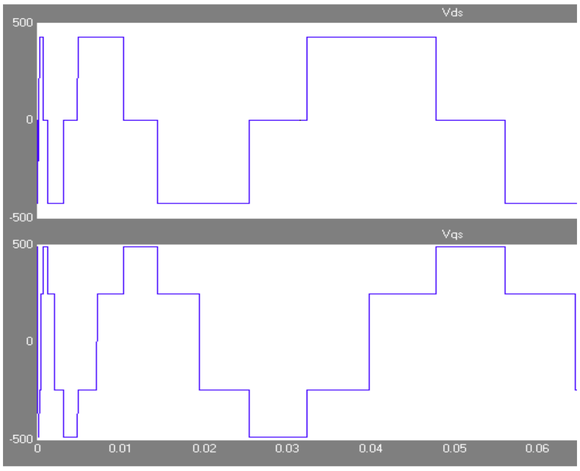

Fig. 4.3 - Direct and Quadrature axes voltages (V_{ds} & V_{qs})

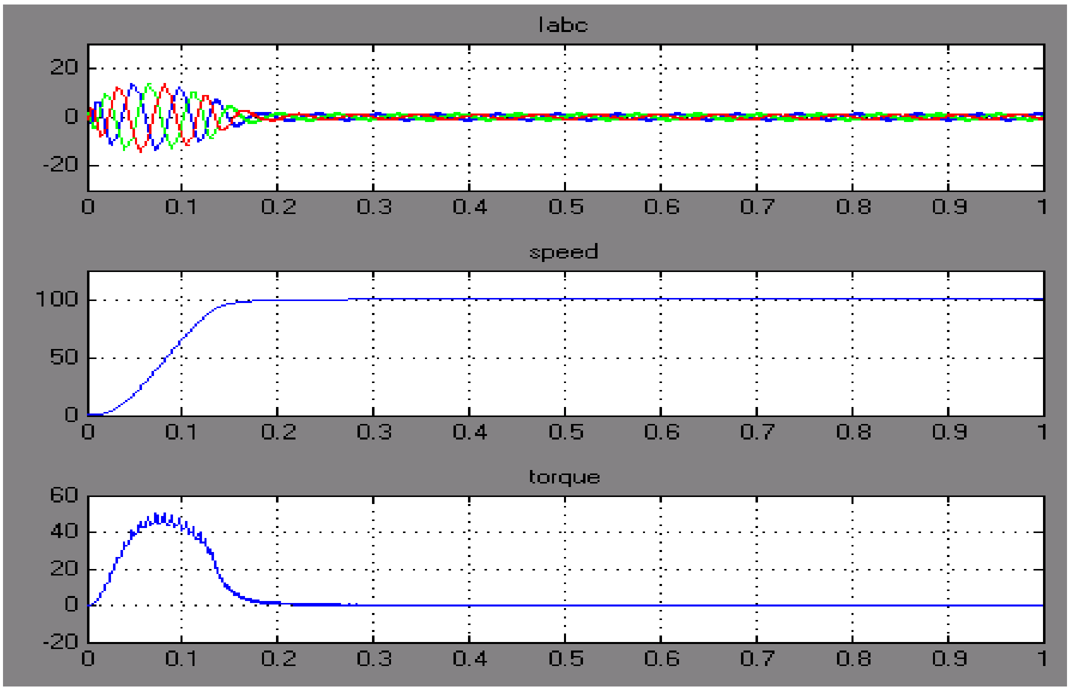

Fig.4.4 - Line currents in Amps (b)Speed in rad /sec (c) Torque in N-m on no load

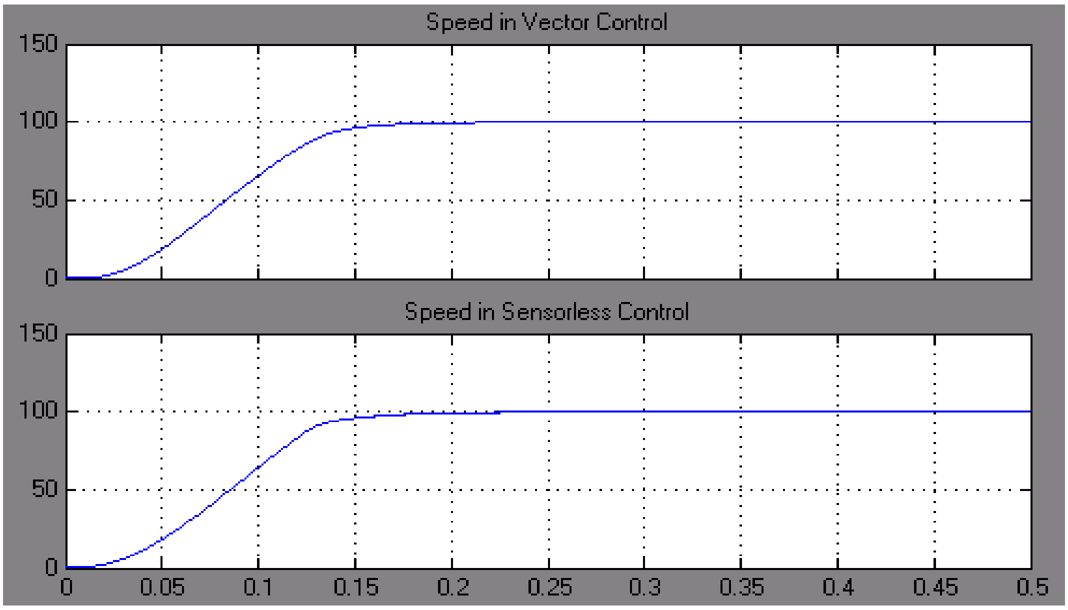

Fig.4.5 - Speed in Vector Control and Sensorless Control

International Research Journal of Engineering & Applied Sciences
www.irjeas.com, ISSN: 2322-0821, Volume 2, Issue 3, July 2014 – September 2014, Page 52-56

V. CONCLUSION

Without using any shaft encoder, sensor-less control gives the benefits of Vector control. Simulation results of 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. By using this method we got to know that the speed variation is very low at low speeds as well as at high speeds.

VI. REFRENCES

[1] Takahashi Isao, Noguchi Toshihiko, "A New Quick-Response and High Efficiency Control Strategy of an Induction Motor", IEEE Transactions on Industry Applications, volume 22, no.5, pp.820–827, September/October 1986.

[2] P.Vas, *Sensorless Vector and Direct Torque Control*, Oxford University Press.pp.406-559, (1998).

[3] P.Vas , *Sensorless Drivers*, State-of-Art. University of Aberdeen, (2002).

[4] Bimal K.Bose, *Modern Power Electronics and AC Drivers*, Prentice Hall PTR.pp.408-418, (2002

[6] Joachim Holtz, 'Sensor less Control of Induction motor Drives' Proceedings of the IEEE, Vol.90, no.8.August 2002

[7] Holtz, 'Methods for Speed Sensor less Control of AC Drives' IEEE Press Book, 1996

[8] Edward P.Carnell and T.A.Lipo, 'Modeling and Design of Controlled Current Induction Motor Drive systems' IEEE Trans.Indu.Appl.IA-13, pp.321-330, July/August 1977.

AUTHORS' PROFILE

Akanksha koshti is post graduate student in Lakshmi Narain College Of Technology, Bhopal (INDIA). Her interest for research is in the area of micro processors. Currently she is working at the "SENSORLESS SPEED ESTIMATION OF n INDUCTION MOTOR" which is also her thesis title in post graduation.

Amol Barve is head of electrical and electronics engineering department in Lakshmi Narain College Of Technology, Bhopal (INDIA). He is eminent professor in the field of control system and his research interest is process control, digital control and non linier control. Mr. Barve has published various publications in the field of control system in various international publications.