ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Speed Estimation of Sensorless Vector Controlled Induction Motor Drive using ANN

B.Sowjanya[1], M.Vijaya Kumar[2], M.Anka Rao[3]

PG Student [PID], Dept. of EEE, JNTU, Anantapur, Anantapuramu, Andhra Pradesh, India[1]

Professor, Director of Admissions, JNTU, Anantapur, Anantapuramu, Andhra Pradesh, India[2]

Assistant Professor, Dept. of EEE, JNTU, Anantapur, Anantapuramu, Andhra Pradesh, India[3]

ABSTRACT: This paper presents the estimation of speed of a vector controlled squirrel cage Induction motor drive using an Artificial neural network. Reference Stator voltages and the stator currents are given as input to the ANN and rotor speed is taken as output. Neural network is first trained with test data and is finally the algorithm is tested taking various loads into consideration. For the training of artificial neural network, Levenberg-Marquardt algorithm is implemented. By the implementation of Artificial neural network, the speed of the Induction motor can be estimated accurately and is made independent of stator resistance variation. The proposed method is validated through computer simulation using MATLAB/SIMULINK environment.

KEYWORDS: Induction motor, Neural network, Sensorless vector control.

I.INTRODUCTION

In most of the industrial applications, three phase Induction motors are widespread due to the various methods available to control the speed of the motor. It adds the advantages like robust, high performance, easy to manufacture, almost maintenance free and gives fast response to speed and torque. The speed of the motor can be estimated by using mechanical sensors. But, with the use of speed sensors, the system reliability is lowered and needs special attention to noise. So, it is preferred to estimate the speed by using sensorless control. There are two fundamental ways to estimate and control the speed of an induction motor, Analogue way of control where the direct measurement of machine parameters (mainly the rotor speed) which are compared to the reference signals through the closed control loops, and the Digital way of control where estimation of the machine parameters is by sensorless control schemes. neural network based sensorless control is one of the digital direction of control. Artificial neural network based speed estimator approach is very attractive and gives good performance. Artificial neural network is a network of simple processing elements which can exhibit complex global behaviour, determined by the connections between the processing elements and the machine parameters. It is an adaptive system that changes its structure based on external or internal information that flows through the network. Neural networks are a form of multiprocessor computing systems with simple processing elements, a high degree of interconnection and adaptive interaction between the elements. To apply an artificial neural network, it is first necessary to train the network. Levenberg-Marquardt algorithm is used for the training of neural network.

The control methods of induction motors are basically of two types i.e., scalar control and vector control. Scalar control is simple and the purpose of this control is to control the chosen control quantities. Vector control is a complex control technique. Since, scalar control is not applied to control the systems with dynamic behaviour, vector control deals with the vector quantities, controlling the desired values by using the space phasors. Vector control works with the rotating vectors in a complex co-ordinate system. The magnitude and the phase of the controlled current change. With this control, It is possible to uncouple the field components. Uncoupling establishes two independent and single controlled currents, flux producing component and the torque producing component. Using these currents the flux and torque can be controlled independently. Moreover, a right angle is ensured between the uncoupled control currents. As a result, a high performance drive can b realised. This type of control ensures good and robust control in the case of transients. This method is also known as Field oriented, Decoupling, Orthogonal or Transvector control. There are basically two methods of vector control, direct vector control and indirect vector control. The direct vector

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

control method depends on the generation of unit vector signals from the stator or air-gap flux signals. The air-gap signals can be measured directly or estimated from the stator voltage and current signals. The stator flux components can be directly computed from stator quantities. In these systems, rotor speed is not required for obtaining rotor field angle information. In the indirect vector control method, the rotor field angle and thus the unit vectors are indirectly obtained by summation of the rotor speed and slip frequency.

This paper presents the speed estimation of sensorless Induction motor drive using an Artificial Neural Network. The Indirect Vector control scheme is employed for the control of Induction motor drive. This can be implemented by using MATLAB/SIMULINK.The estimated speed follows the actual speed of Induction motor drive and the Drive is made independent of stator resistance variation.

II.VECTOR CONTROL

Field oriented control or vector control can be carried out by system and coordinate transformations of the basic equations of the motor. In the vector control scheme, a complex current is synthesised from two quadrature components, one component produces the flux level in the motor, and the other component controls the torque production in the motor. In vector control, flux and torque are decoupled in nature so that both can be controlled independently. The indirect vector control scheme is better explained by the following figure.

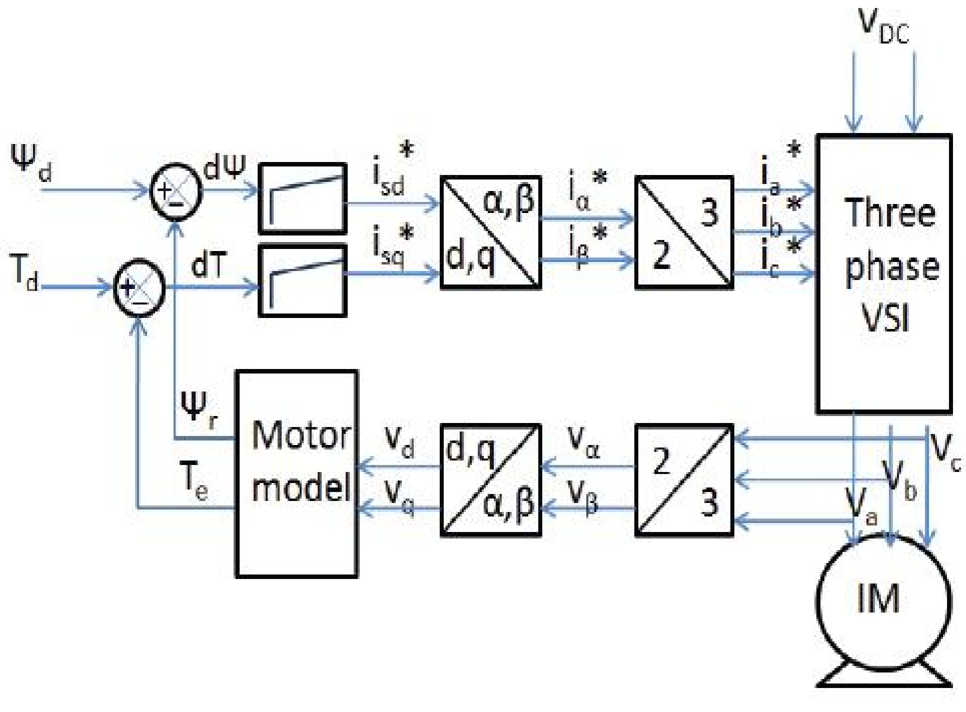

Fig:1:-Indirect vector controlled IM drive

Stator resistance estimation:

The IM stator voltages in the synchronously rotating reference frame can be expressed as:

$$V_{sq}= R_s i_{sq}+\omega_e \sigma L_s i_{sd}+\rho\sigma L_s i_{sq}+L_m(\omega_e \psi_{rd}+\rho\psi_{rq})/L_r$$

$$V_{sd}= R_s i_{sd}-\omega_e \sigma L_s i_{sq}+\rho\sigma L_s i_{sd}+L_m(\omega_e \psi_{rq}-\rho\psi_{rd})/L_r$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

For a field oriented drive, substituting $\psi_{rd}=L_m i_{sd}$ and $\psi_{rq}=0$, then the above equations at steady state become,

$$V_{sq}= R_s i_{sq}+\omega_e i_{sd}((L_m^2/L_r)+\sigma L_s)$$

$$V_{sd}= R_s i_{sd}-\omega_e \sigma L_s i_{sq}$$

Now eliminating ω_e from the above two equations, we get

$$R_s= (V_{ds} i_{ds}+\sigma V_{qs} i_{qs})/(\sigma i_{qs}^2+i_{ds}^2)$$

III.ARTIFICIAL NEURAL NETWORK

Artificial neural network is a circuit, computer algorithm, or mathematical representation greatly inspired by a massively connected set of neurons that form a biological neural network. It is specified by a neuron model- the information processing unit of NN, an architecture- a set of neurons and links connecting the neurons, a learning algorithm- for training the NN by modifying the weights in order to model the particular learning task. This network is an alternative computing Technology that have proven useful in a variety of signal processing, pattern recognition, and control problems.

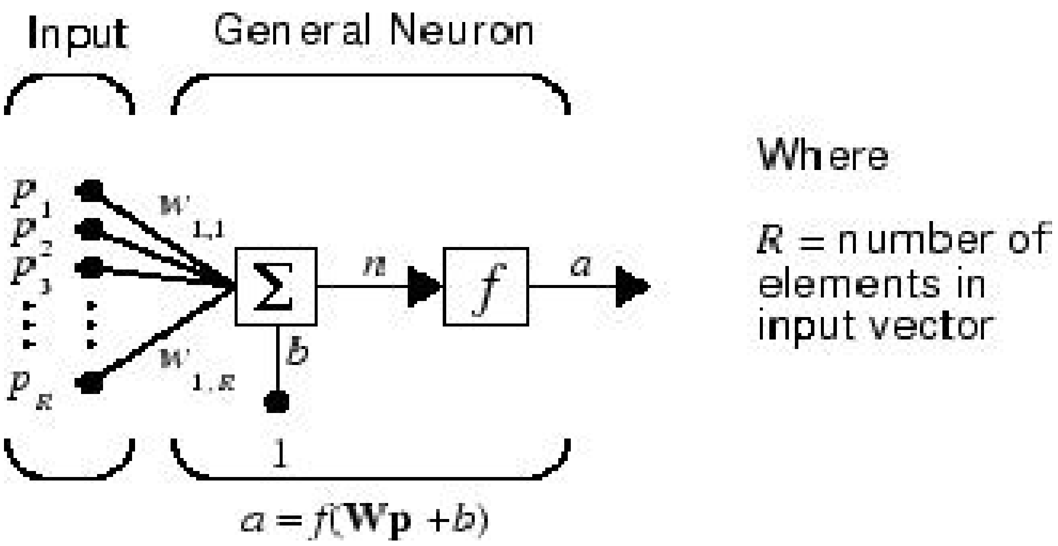

Fig:2:- Basic structure of ANN

Levenberg-Marquardt algorithm:

It is one of the most effective training algorithms for the feed-forward neural networks. This algorithm modified the values of weights in a group way, after the application of all the training vectors.

Steepest descent method(error back propagation)

$$\mathbf{W_{k+1}=W_k-\alpha g}$$

Where g is a gradient vector

Newton method,

$$\mathbf{W_{k+1}=W_k- A_k^{-1}g}$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Where A_k is a Hessian matrix

$$\mathbf{A=2J^TJ} \quad \text{and} \quad \mathbf{g=2J^Te}$$

Gauss-Newton method:

$$\mathbf{W_{k+1}=W_k-(J_K{}^TJ_K)^{-1}J_K{}^Te}$$

Levenberg-Marquardt algorithm:

$$\mathbf{W_{k+1}=W_k-(J_K{}^TJ_K+\mu I)^{-1}J_K{}^Te}$$

Where J is a Jacobian matrix

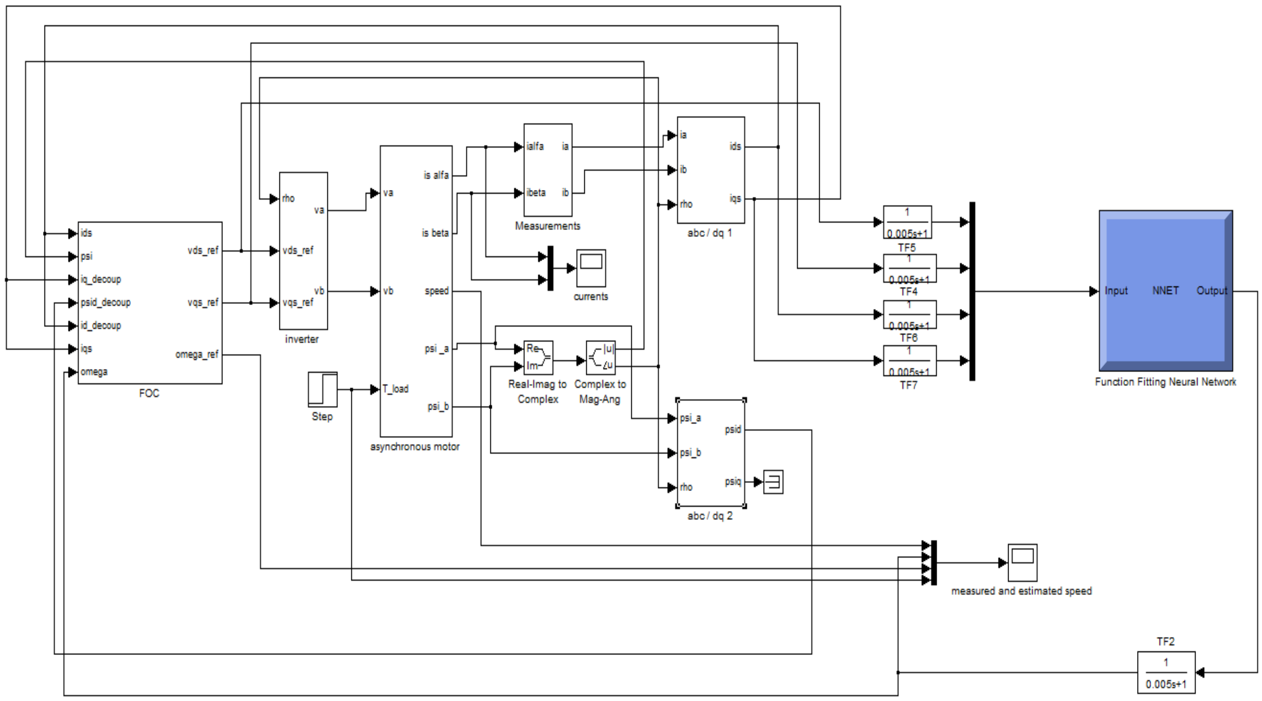

Fig:3:- Sensorless Indirect vector controlled IM drive with ANN

IV.SIMULATION RESULTS

Mean squared error is the average squared difference between the outputs and the targets. Lower values are better. Zero means no error. Training automatically stops when generalisation stops improving, as indicated by an increase in the mean square error in the validation samples. The performance plot of neural network is shown below.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

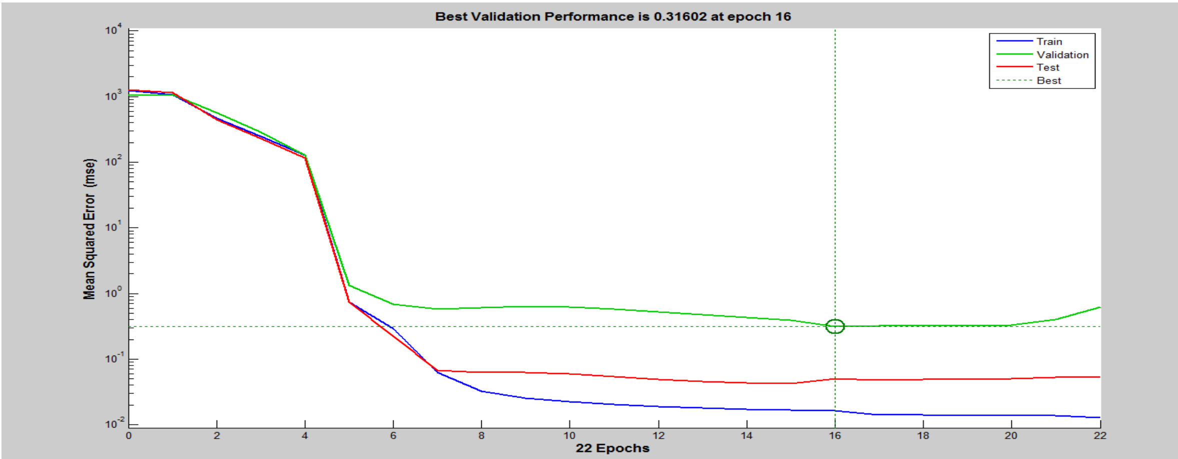

Fig:4:- neural network performance plot

Regression R values measure the correlation between the outputs and the targets. An R value of 1 measures a close relationship and an R value of 0 measures a random relationship between the outputs and the targets. The following plot represents the regression of neural network.

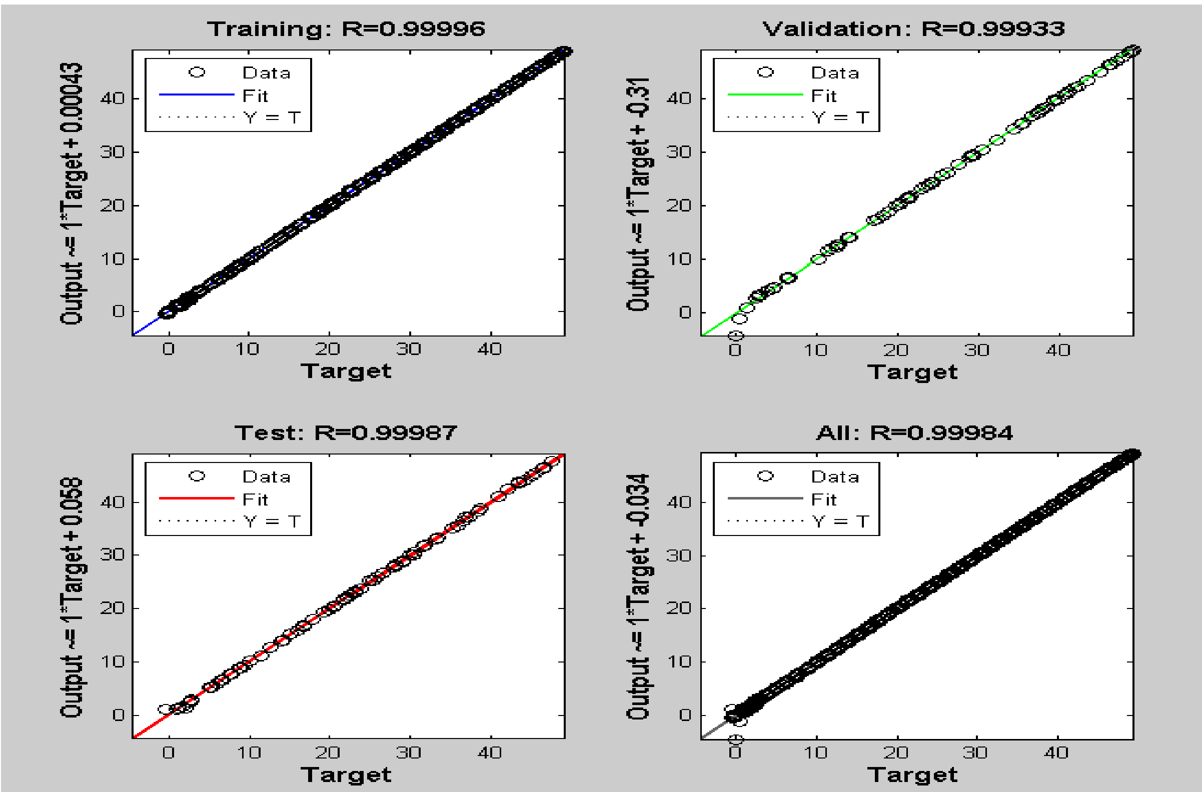

Fig:4:- Neural network training Regression plot

By using the indirect vector control of an Induction motor, The actual speed is measured and compared with reference speed. The reference speed and the actual speed of sensorless vector controlled Induction motor drive is given.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

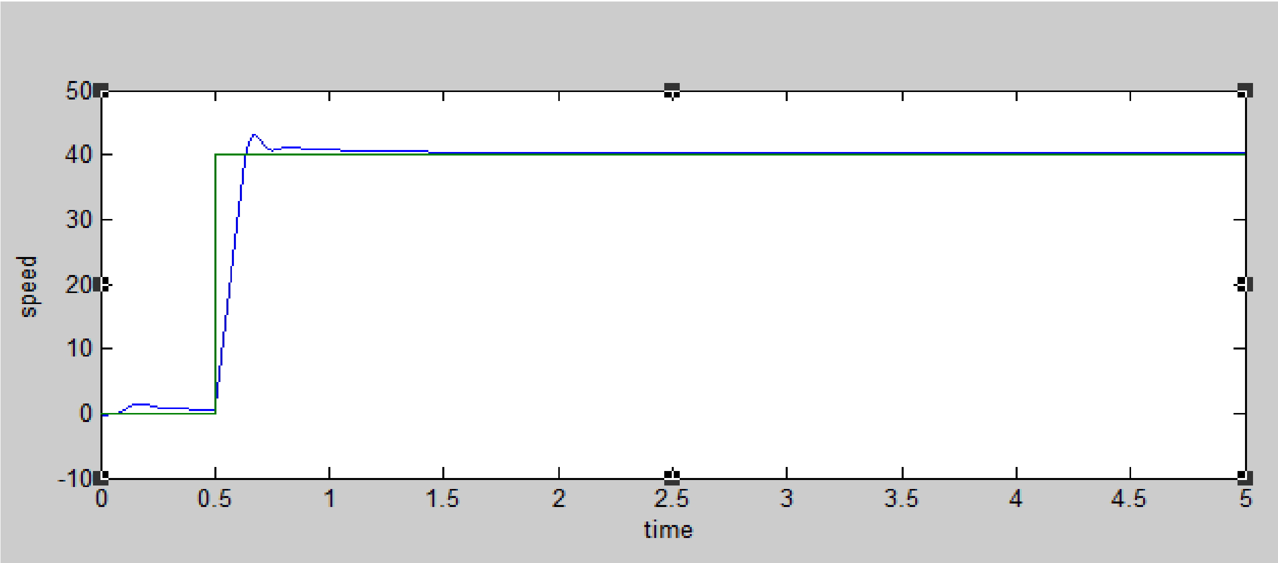

Fig:6:-reference and actual speed

The speed of sensorless vector controlled Induction motor is estimated by using an artificial neural network based speed estimator using levenberg-marquartz algorithm. Now, The actual speed and the estimated speed is presented.

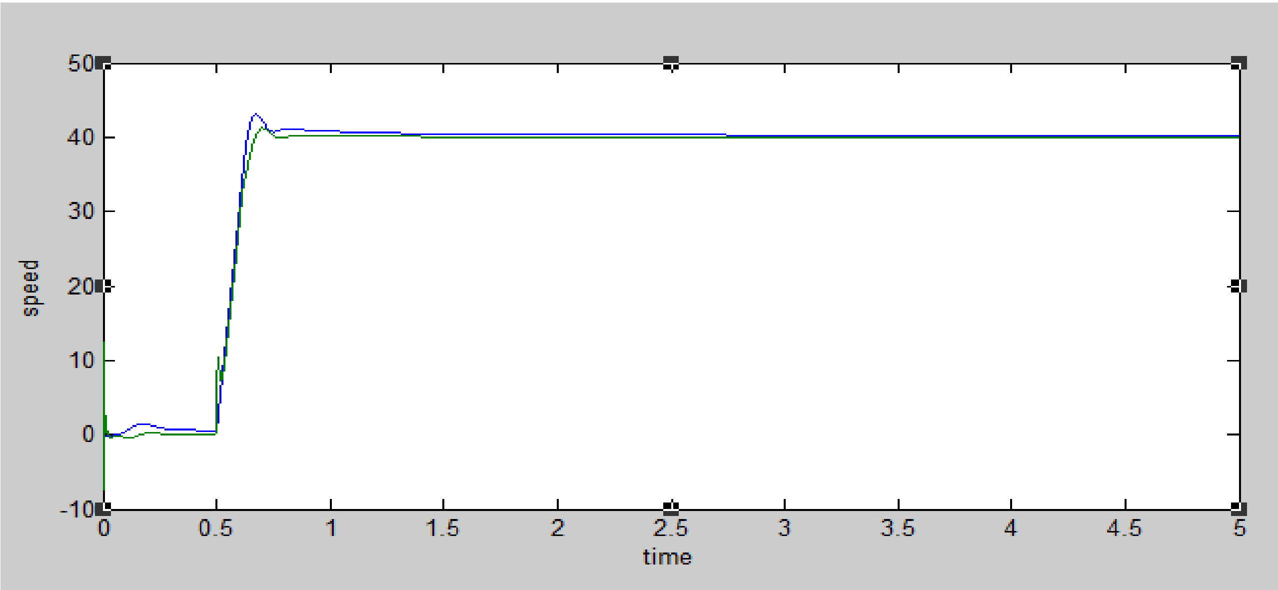

Fig:5:-actual and estimated speed

The sensorless Induction motor can be controlled by the scheme of vector control.The variation of output stator currents of the Induction motor with respect to time are shown.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

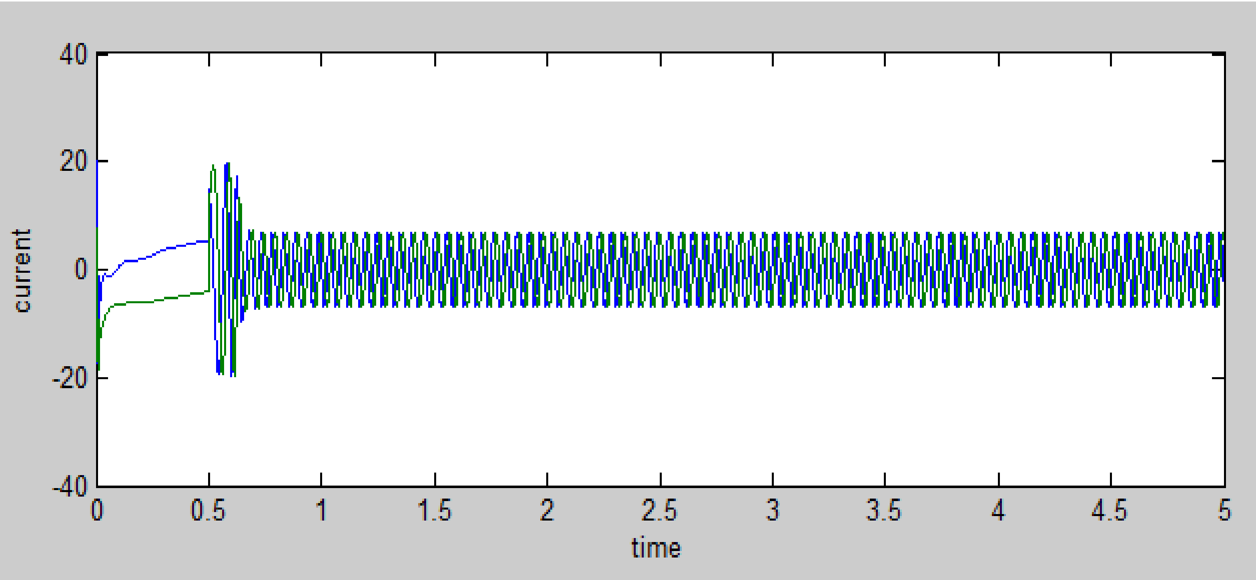

Fig:7:- stator current Vs time

Parameters:
Magnetising Inductance, (L_m) =0.0915mH
Leakage Inductance, (L_s) =0.1004mH
Leakage Inductance, (L_r) =0.0969mH
Rotor resistance, (R_r) =1.294ohm
Rotor inertia, (J) =0.15Kg-m^2/sec

V.CONCLUSION

In this paper, a new speed estimation algorithm using Artificial neural network is proposed for a sensorless vector control Induction motor drive. The proposed algorithm is estimated the speed accurately and the system is made independent of stator resistance variation. Hence, at low speeds, satisfactory performance is obtained. Simulation is carried out in MATLAB/SIMULINK.

REFERENCES

[1] B.K.Bose, Modern Power Electronics and AC Drives. New Delhi, India: Prentice-Hall, 2006, Ch. 8, pp. 333–435.
[2] J. W. Finch and D. Giaouris, “Controlled AC electrical drives,” IEEE Trans. Ind. Electron., vol. 55, no. 2, pp. 481–491, Feb. 2008.
[3] P. Vas, Sensorless Vector and Direct Torque Control. New York: Oxford Univ. Press, 1998.
[4] T. Ohtani, N. Takada, and K. Tanaka, “Vector control of induction motor without shaft encoder,” Conf. Rec. IEEE-IAS. Annu. Meeting, 1989, pp. 500–507.
[5] C. Schauder, “Adaptive speed identification for vector control of induction motor without rotational transducers,” inConf. Rec. IEEEIAS. Annu. Meeting, 1989, pp. 493–499.
[6] M. Rashed and A. F. Stronach, “A stable back-EMF MRAS-based sensorless low speed induction motor drive insensitive to stator resistance variation,”Proc. Inst. Elect. Eng.—Electr. Power Appl., vol. 151, no. 6,pp. 685–693, Nov. 2004
[7] J. Holtz and J. Quan, “Drift and parameter compensated flux estimator for persistent zero stator frequency operation of sensorless controlled induction motors,”IEEE Trans. Ind. Appl., vol. 39, no. 4,pp. 1052–1060,Jul./Aug. 2003.
[8] I. Ben-Brahim and T. Kudor, “Implementation of an induction motor speed estimator using neural networks,” inProc. IPEC, 1995, pp. 52–57.