ISSN 0976 – 1411

Available online at www.internationaleJournals.com

International eJournals

International eJournal of Mathematics and Engineering 139 (2011) 1260 - 1266

INTERNATIONAL eJOURNAL OF MATHEMATICS AND ENGINEERING

www.InternationaleJournals.com

TRANSIENT PERFORMANCE OF THREE PHASE INDUCTION MACHINE USING SYNCHRONOUSLY ROTATING REFERENCE FRAME

Vikas Singhal[1], K.S.Sandhu[2], Vivek Pahwa[3], Aziz Ahmad[4]

1, 3. Department of Electrical and Electronics Engineering, Haryana College of Technology and Management, Kaithal, Haryana, India. Vikas.singla1986@gmail.com
2. Department of Electrical Engineering, National Institute of Technology, Kurukshetra Haryana, India.
4. Department of Electrical and Electronics Engineering, Al-Falah School of Engineering and Technology, Dhauj, Faridabad, Haryana, India.

ABSTRACT: This paper presents a generalized model for predicting the transient performance of three phase induction motor using MATLAB/SIMULINK. Synchronously rotating reference frame is used for simulation study of induction machine. Simulated results as obtained and verified with the experimental results on a test machine.

Keywords- Induction Machine, Modeling and Simulation, MATLAB/SIMULINK, Synchronously rotating reference frame

INTRODUCTION:

Ac drive systems have become a viable alternative to dc machines for variable speed applications due to advances in the development of high speed computers and power electronics technology with associated high speed microcontrollers. During the last 2/3 decades, Induction motor control has received a widespread interest in industrial applications. This increased interest in induction machine is mainly because of its merits over other industrial machines types. These advantages include: simplicity, ruggedness, less initial cost, lightness capability of much higher speed, ease of maintenance, higher torque-inertia ratio etc. Apart from the steady state analysis transient behavior is also important to compute the overall performance of induction motor for any desire application [1]. Zaher Daboussi [3] has suggested the digital simulation of induction motor using electromagnetic transient program (EMTP). Lavers [4] gives a simulation package that has been developed for the modeling the steady state and transient behavior of induction machines. Dynamic performance of induction machine is important because dynamic model considers the effects of stator frequency, varying voltages and torque disturbances. The dynamic model is derived for induction machines by using direct and quadrature axis. Qd axis model is found to be suitable for the investigation of the problems like harmonics, voltage dips, oscillatory torque and current during starting and transient condition [5-9]. Hoang Le Huy [10] has suggested a unified method for the modeling and simulation of electrical drives using state space formulation in Matlab/Simulink. Digital simulation and reduced order model development of three phase induction machine have been done by [11] and [12] respectively.

In this paper a generalized model for the three phase induction motor using synchronously rotating reference frame with the help of Matlab/Simulink has been developed. Simulated result as obtained are compared with the experimental result. Close agreement between two values proves the validity of proposed modeling.

MATHEMAICAL MODELING

The voltage equations for the qd coils in arbitrary reference frames are [5-7];

$$[v] = [z]\,[i] \tag{1}$$

where

$[v] = [v_{qs}^{c}\ v_{ds}^{c}\ v_{qr}^{c}\ v_{dr}^{c}]^{t}$, $[i] = [i_{qs}^{c}\ i_{ds}^{c}\ i_{qr}^{c}\ i_{dr}^{c}]^{t}$;

$$[z] = \begin{pmatrix} r_s+l_s p & w_c l_s & l_m p & w_c l_m \\ r_s+l_s p & -w_c l_s & l_m p & -w_c l_m \\ r_r+l_r p & (w_c-w_r) l_r & l_m p & (w_c-w_r) l_m \\ r_r+l_r p & -(w_c-w_r) l_r & l_m p & -(w_c-w_r) l_m \end{pmatrix} \tag{2}$$

By putting the $w_c = w_s$ and $Ø_c = Ø_s = w_s t$ into the equation (2), expressions for synchronously rotating reference frame can be obtained.

Electromagnetic Torque is:-

$$T_e = \frac{3}{2}\frac{p}{2} l_m (i_{qs}^{s}\, i_{dr}^{s} - i_{ds}^{s}\, i_{qr}^{s}) \tag{3}$$

$$T_e - T_L = J(2/P)\, dw_r/dt \tag{4}$$

Induction machine model using MATLAB/SIMULINK

The complete simulink model of proposed system is as shown in fig 1. The various sub blocks i.e. power supply sub block, three phase to two axis transformation sub block, electrical sub block, torque sub block and mechanical sub block which are building blocks of the complete model of induction motor, have been shown in figures 1a-1d respectively.

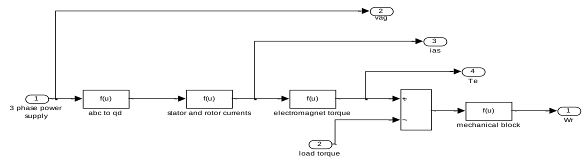

Fig. 1 Complete model of proposed system.

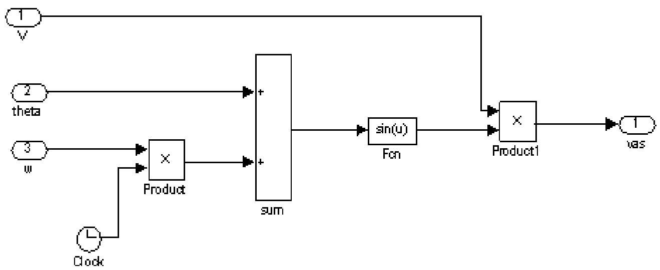

Fig 1a Power supply sub block.

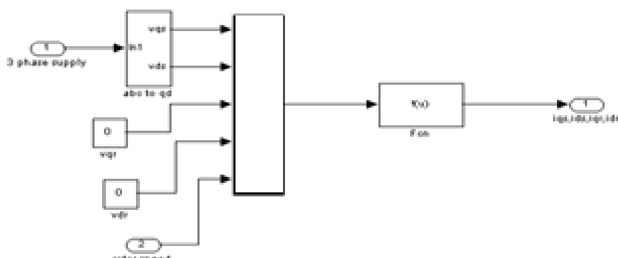

Fig 1b Electrical sub block.

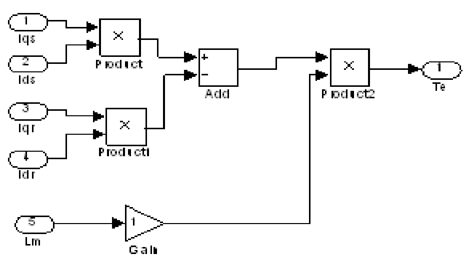

Fig 1c Torque sub block.

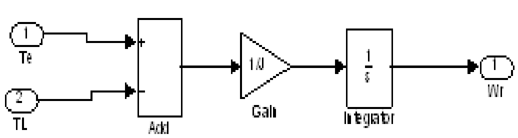

Fig 1d Mechanical sub block

RESULTS AND DISCUSSIONS

Figure 2 shows the comparison of simulated results with experimental results i.e. stator phase currents in phase a, b and c. Simulated results of model are very close to the experimental results and this confirms the validity of the model. Figures 3-5 shows the dynamic responses of three phase induction motor. These figures include the line voltage, current (instantaneous), rotor speed and developed torque. A critical study of various variables associated with three phase induction machine leads to following valuable observations;

- It can be seen from fig 3 that inrush current during direct-on-line starting is 7-10 times to normal current. Therefore it is recommended to use some means to reduce the high inrush current particularly in high power rating of induction machine drive system.
- Oscillatory torque will be produced during starting and it stabilizes within one second (refer fig 4).

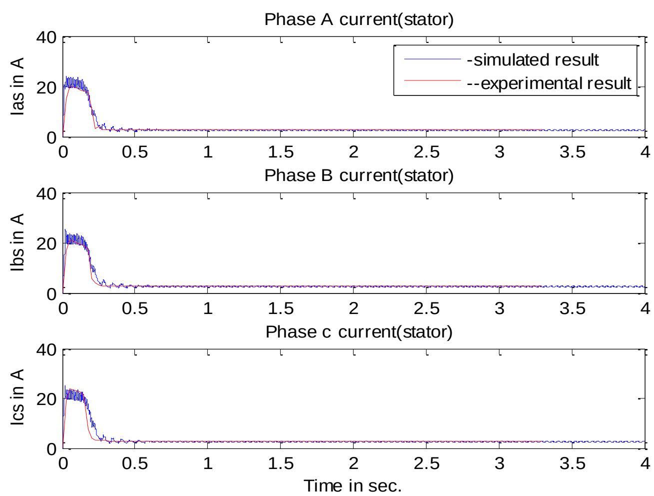

Fig 2. Comparison of simulated and experimental results of stator currents.

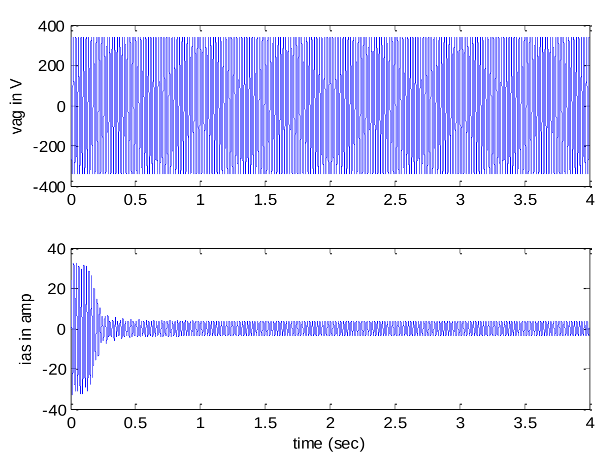

Fig 3. Simulated results of stator voltage and current.

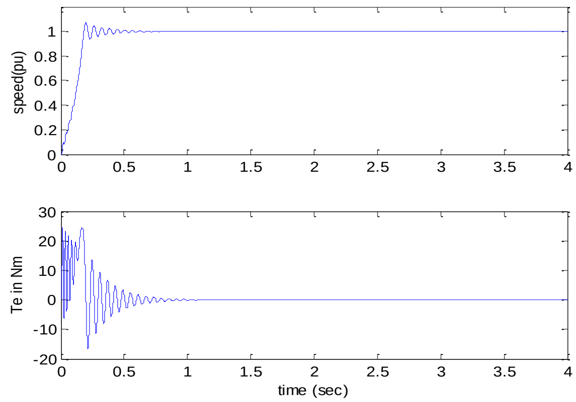

Fig 4. Simulated results of rotor speed and electromagnetic torque.

Figure 5 shows the simulated results of torque speed characteristics for different values of rotor resistances. Further it can be observed that as the rotor resistances is increasing, the transients are reducing.

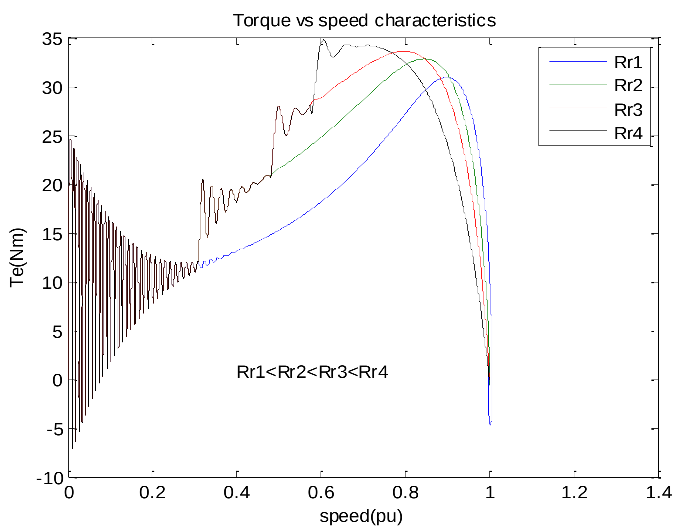

Fig 5. Transient torque speed characteristics.

CONCLUSIONS:-

In this paper prediction of transient performance of a three phase induction machine has been done using synchronously rotating reference frame. Proposed model used is validated using experimental results on a test machine. The proposed model is used to predict the effect of change of rotor resistance on transient behaviour of torque speed characteristics. Further from Fig 5 it is observed that the transient behaviour of the machine may be controlled by proper design of rotor circuit.

Nomenclature:-

V_m = Maximum voltage
v_{qds}^c, v_{qdr}^c = q and d axis voltages of stator and rotor in arbitrary reference frame.
i_{qds}^c, i_{qdr}^c = q and d axis currents of stator and rotor in arbitrary reference frame.
r_s, r_r = per phase resistances for stator and rotor winding.
l_s, l_r = Stator and rotor self inductances.
l_m = Mutual inductance
w_c, w_s = Arbitrary and synchronously rotating angular frequencies.
T_e, T_L = Electromagnetic and Load Torque.
p = Differentiator.
P = Number of poles

ACKNOWLEDGEMENT:-

Authors are thankful for the financial grant of Rs 6.1 Lakhs given by AICTE under MODROB scheme 8024/RID/BOR/MOD/601/9/10 on dated 21.12.09 to Electrical and Electronics Engineering department of Haryana College of Technology and Management, Kaithal.

Appendix-A

3 phase, 3 hp, 415V, 50Hz, star connected induction motor. The parameters are;

Stator resistance, R_s = 4.44 ohms

Rotor resistance, R_r = 0.9512 ohms

Moment of inertia, J = 0.23 kgm^2

Stator and rotor self inductance $l_s = l_r$ = 14.97 mh

REFERENCES:-

[1] Burak Ozpineci and Leon M.Tolbert, “Simulink implementation of induction machine model -A modular approach”. IEEE International Conference on Electric Machines and Drives , 2003 pp. 728-734.

[2] M.L. De Aguiar, M.M.Cad, “The concept of complex transfer function applied to the modeling of induction motors”, Power Engineering Society Winter Meeting 2000, pp. 387-391.

[3] Z. Daboussi and N. Mohan, “Digital simulation of field-oriented of induction motor drives using EMTP”, IEEE Trans. Energy Conversion. Vol. 3, Sept. 1988 pp. 667-673.

[4] J. D. Lavers and R. W. Y. Cheung, “A software package for the steady state and dynamic simulation of induction motor drives”, IEEE Trans Power System Vol. PWRS-1, May 1986. pp. 167-173.

[5] R. Krishnan, “ Electric Motor Drives, *Modeling Analysis and Control*” , Pearson Prantice Hall, 2007.

[6] Paul C. Krause, O.Wasynezuk and S.D Sudhoff, “Analysis of Electric Machinery and Drive System” , IEEE Press Series on Power Engineering, John Wiley and Sons Publication 2004.

[7] B.K. Bose, “ Power Electronics and Ac Drive”, Pearson Prantice Hall, 2007.

[8] Shi, K. L.Chan, T. F. and Wong, Y. K., “Modeling of the three-phase induction motor using SIMULINK”, Record of the 1997 IEEE International Electric Machines and Drives Conference, USA, pp. WB3-6 (1997)

[9] C.M. Ong, “Dynamic simulation of Electric Machinery”, Prantice Hall PTR, Upper Saddle River, N J, Publication 1998.

[10] H.Le- Huy, “Modeling and simulation of electrical drives using Matlab/Simulink and power system blockset,” The 27th annual conference of the IEEE industrial electronics society pp. 1603-1611.

[11] Ghani, S. N., “Digital computer simulation of three-phase induction machine dynamics a generalized approach”, IEEE Trans Industry Appl., Vol. 24, No. 1, (1988) pp. 106–114

[12] F. D. Rodriguez O.Wasynczuk, “A Refined Method of Deriving Reduced Order Models of Induction Machines”, IEEE Trans. En. Conv. Vol. EC-2, No. 1, March 1987 pp. 31-37.