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Parameter Estimation of Three Phase Induction Motor Using MATLAB-Simulink

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Abstract

This paper describes a simple method for parameter identification of induction motor. Experimental tests of induction motor, namely dc, no-load and blocked-rotor and load tests are conducted to identify the motor parameters. The no load and short circuit test results are used to develop the simulation model. Due to the errors in the measured instruments and approximations considered in the followed method, results obtained from practical machine and simulated machine will not match. So to identify the exact values of the parameters in MATLAB / simulink identification of parameter tool box is used. This tool box uses mean square error technique to identify the exact parameters which makes simulated data and practical data equivalent.

Keywords *:— Induction motor, parameters estimation, OC and SC tests,Online tuning of parameters.*

I. Introduction

The three-phase squirrel cage asynchronous motors are frequently used in industrial applications because of their features such as they are resistant to mechanical forces, have high reliability, are low cost and do not require much maintenance [1]-[4]. Simulation models have been developed to identify the parameter of induction motor using MATLAB/Simulink. Comparative study with experimental were done to determine the accuracy of the developed tests model [5]-[8].

In order to understand the behavior of the machine under various operating condition with different control strategies, in general mathematical models are developed and tested. The simulation results depend on the parameters provided to the machine model. Accuracy of parameter values brings the mathematical models of the machine very near to practical machine. With the invention of sensor less techniques parameter estimation has become very critical and it's importance has been doubled. Dynamic performance of induction motor field-oriented controllers strongly depends on model parameter accuracy. A parameter mismatch produces an error in field orientation and undesirable coupling between the flux and torque controllers. Identification of exact values of machine parameters is an important area to focus on. Using MATALAB/Simulink parameter estimation tool box exact values are identified.

II. Flow Chart

Initially OC and SC tests are conducted on inductions motor and machine parameters are calculated using the test data. Using these values, simulation models are developed. There will be difference between simulation results practical machine tests results. Hence to further tune the machine parameters parameter estimation tool box is used. Both actual data and simulation data are given to the tool box and until the simulation results matches with practical values iteration is continued. Figure 1 shows the flow chart implemented to estimate the parameters of the machine.

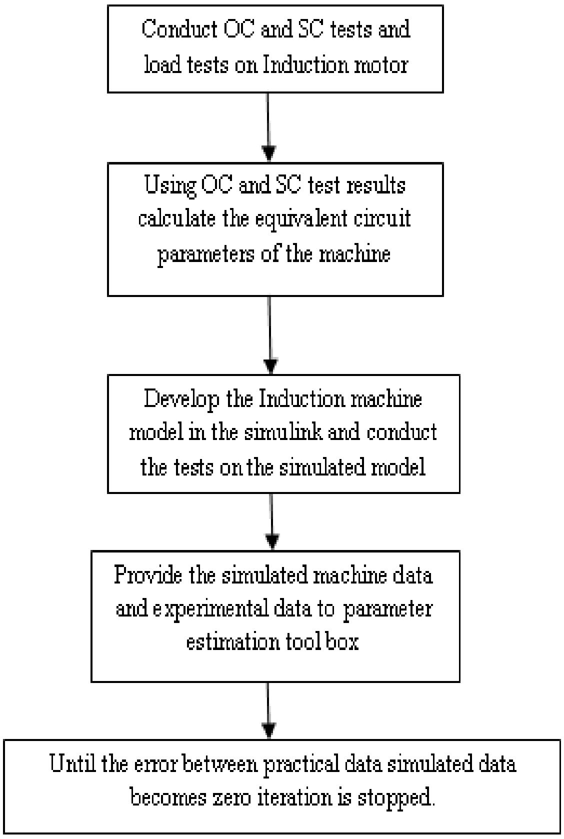

Figure 1 :Flow chart for parameter estimation

III. Modeling of Induction Motor

The following modeling equations are used to simulate the virtual machine. The stator and rotor equations are as follows.

$$\vec{V_s} = R_s \vec{I_s} + \frac{d}{dt}\Phi_s \qquad (1)$$

$$\vec{V_r} = R_r \vec{I_r} + \frac{d}{dt}\Phi_r \qquad (2)$$

Where Φ_s and φ_r the flux linkage corresponding to corresponding to stator and rotor, $\vec{V_s}$ and $\vec{V_r}$ represents voltage, R_s and R_r is stator and rotor resistance, $\vec{I_s}$ and $\vec{I_r}$ denote the stator and rotor currents.

The voltage equations of a three phase induction motor in the d–q reference frame are as follows

$$v_{ds} = R_s i_{ds} + \frac{d}{dt}\Phi_{ds} - \omega_e \Phi_{qs} \qquad (3)$$

$$v_{qs} = R_s i_{qs} + \frac{d}{dt}\Phi_{qs} + \omega_e \Phi_{ds} \qquad (4)$$

$$v_{dr} = 0 = R_s i_{dr} + \frac{d}{dt}\Phi_{dr} - \omega_e \Phi_{qr} \qquad (5)$$

$$v_{qr} = 0 = R_r i_{qr} + \frac{d}{dt}\Phi_{qr} + \omega_e \Phi_{dr} \qquad (6)$$

The flux linkages can be calculated by using the following equations,

$$\psi_{ds} = L_s i_{ds} + L_m(i_{ds} + i_{dr}) \qquad (7)$$

$$\psi_{qs} = L_s i_{qs} + L_m(i_{qs} + i_{qr}) \qquad (8)$$

$$\psi_{dr} = L_r i_{dr} + L_m(i_{ds} + i_{dr}) \qquad (9)$$

$$\psi_{qr} = L_r i_{qr} + L_m(i_{qs} + i_{qr}) \qquad (10)$$

The electromagnetic torque T_e developed in an induction machine is given by

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right) L_m \left(i_{dr} i_{qs} - i_{qr} i_{ds}\right) \qquad (11)$$

The equations for active and reactive power are as shown,

$$P_s = \frac{3}{2}(V_{ds} i_{ds} + V_{qs} i_{qs}) \qquad (12)$$

$$Q_s = \frac{3}{2}(V_{ds} i_{ds} - V_{qs} i_{qs}) \qquad (13)$$

IV. Results and Discussions

Case Study: 1 H.P Motor

The following are the details of 1 H.P induction motor.

Case Study 1: 1HP induction motor

Speed 1415 rpm, current 1.9A, voltage 415V star connection.

Motor parameters from oc and sc test:

Stator resistance R_s: 19.35Ω,

Rotor resistance R_r: 8.04Ω,

Stator and rotor inductance L_s and L_r: 0.633H, mutual inductance L_m: 0.601H,

Moment of inertia J: 0.0049Nm

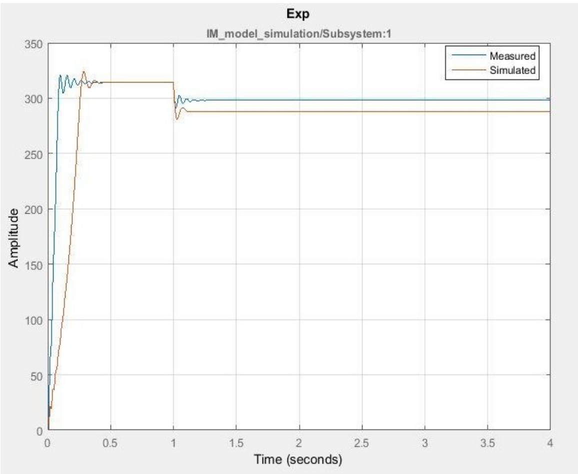

Figure 2: Practical and Simulated Speed Before Parameter Estimation

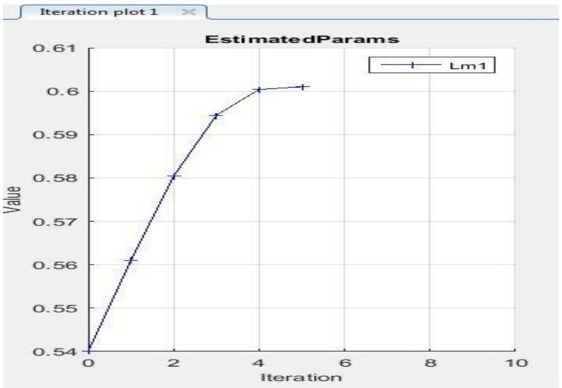

Figure 3. Change of Mutual Inductance Value During Estimation

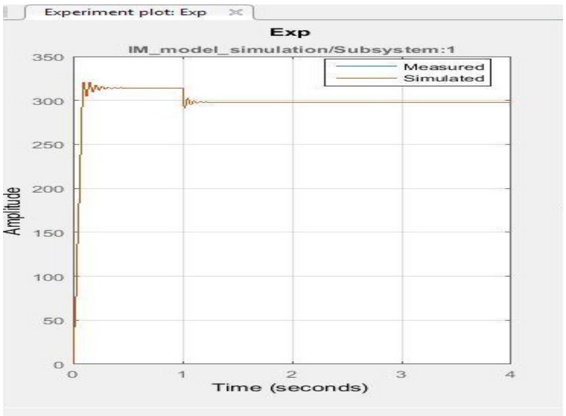

Figure 4: Practical and Simulated Speed After Parameter Estimation

Figure 2 shows the data of simulated and practical machine. There is a difference between these values due to the error in parameter values Figure 3 shows after identification of exact value of mutual inductance. Mutual inductance initially identified as 0.54 but after the iterations it has reached value of 0.61. Figure 4 shows the response of practical and virtual

Table 1: Shows the Practical and Simulated Values for Various Torques. The Error is only 2-4%

Torque (Nm)	Current (simulated)	Current (Practical)	Active power (Sim.)	Active power (Prac.)	Rective power (Sim.)	Rective power (Prac)	Speed (Sim.)	Speed (Prac.)
3	1.34	1.a	578.8	600	735	690	1455	1448
3.7	1.414	1.52	708	680	732	693	1442	1436
4.1	1.55	1.67	785	720	733	692	1434	1429
4.5	1.65	1.74	864	820	735	693	1426	1421

machine results, where error is nullified. Table.1 shows the practical and simulated values for various torques. The error is only 2-4 %

Case Study 2: 5 HP Induction Motor

Nameplate details:

Speed: 1440 rpm

Current: 7A

Voltage:415V Connection: Delta

Motor Parameters Obtained from O.C and S.C Results

Stator resistance: 8.25Ω, Rotor resistance: 7.081Ω

Mutual inductance: 0.513H

Parameter values obtained from O.C and S.C test results of induction motor are shown above for 5 h.p induction motor. Mathematical model is developed using these values. The results obtained from mathematical model in simulink were not matching with the practical machine results. So simulation data and practical values are given to parameter identification tool box along with the calculated parameter values. The tool box estimates the parameters until the simulation results equated to the practical.

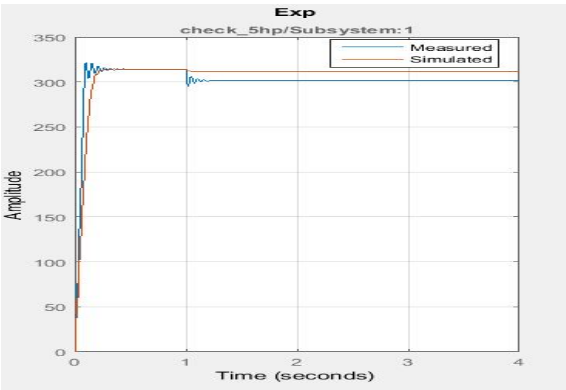

Figure 5: Practical and Simulated Speed Before Parameter Estimation of 5HP

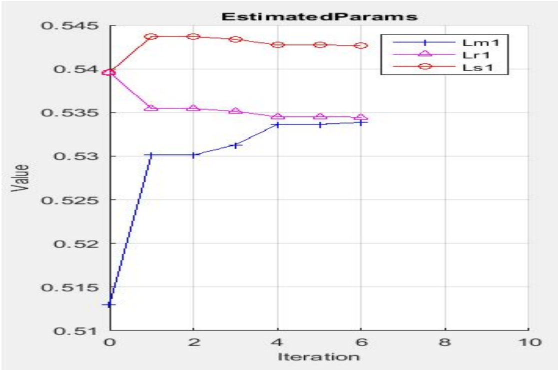

Figure 6: Change of Parameters Values During Estimation

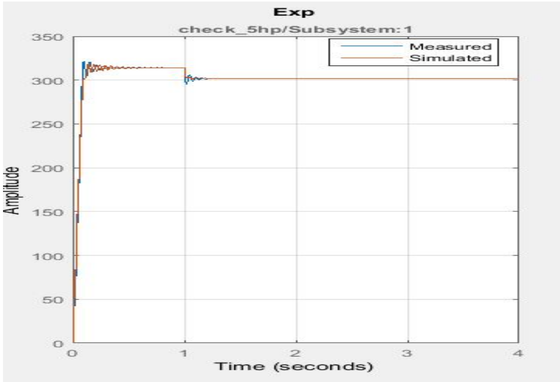

Figure 7: Practical and Simulated Speed After Parameter Estimation of 5HP

The Figure 5 shows the simulated and measured data of speed before estimation. Error is observed between simulated and measured results. Figure 6 shows the trajectory of variation of parameters during estimation and where each parameter is represented by their respective colors in the legend box. Figure 7 shows the simulated and practical results after proper estimation of parameters. The following table shows the simulated and practical values and it can be observed that the errors are within the range 2-5%.

Motor parameters obtained from tool box after estimation

Stator resistance: 7.5456Ω,

Rotor resistance: 4.5222Ω

Stator and rotor inductance: 0.5427H

Table 2: Simulated vs. Practical Results of 5HP

Torque (Nm)	Current (simulated)	Current (Practical)	P(Simu)	P(Pract)	Q(Simu)	Q(Pract)	Speed (simu)	Speed (pract)
11.85	4.05	3.9	2106	2270	4312	4496	1461	1470
13.68	4.396	4.5	2394	2645	4309	4513	1455	1460
16.59	4.95	5.2	2895	3097	4321	4524	1441	1456
19.257	5.82	6.10	3341	3423	4341	4532	1435	1448

Mutual inductance: 0.5357H

Stator and rotor inductances: 0.5396H

V. CONCLUSIONS

The parameter values obtained from O.C and S.C test values are further tuned using estimation toolbox of MATLAB/Simulink. Using these updated values practical machine is mathematically modeled and becomes a virtual machine. Further results obtained from the sensor less schemes, which are highly dependent on machine parameters can give accurate results. Field oriented control of induction machine gives perfect decoupling.

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