Simulation and Analysis of vector control of Induction Motor

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Abstract **:-With a rise in technology many control techniques have emerged to achieve good dynamic response of induction motor drives. The various control techniques are stator voltage control, slip-power control, V/Hz control, scalar control, vector control, direct torque and flux control and adaptive control. Intelligent control with expert systems, fuzzy logic and neural networks are recently developed techniques. High performance control and estimation techniques for induction motor drives are very fascinating and challenging subjects of research and development.**

keywords : induction motor; load; flux; simulation; stator; motor.

I. INTRODUCTION

Induction motors have always been considered as the workhorse of the industry, and the control of induction motors is a very challenging and interesting area for researchers and industrialists. Induction machines have been widely used for variable speed application in many industries in wide power ranges. These applications include pumps and fan drives, paper and textile mills, subway and locomotive propulsions, electric and hybrid vehicles, machine tool industries and robotics, home appliances, heat pumps and air conditioners, rolling mills, winding and generation systems etc.

The increasing users demand on electrical drives with inverter-fed induction machines lead to complex control schemes like field oriented control or direct self control. This control schemes satisfy the demands of the dynamics but if the full performance of these schemes is required the electrical parameters of the induction machine have to be known. The control and estimation of induction motor drives is quite complex as compared to its DC motor counterpart because of the inherent coupling effect present in them, which has both torque and flux as functions of voltage or current and frequency. The complexity even more increases with the high performance operation of the drive. The vector or field oriented technique allows the induction motor to operate as a separately excited DC motor. But it is difficult to achieve high performance of the drive, because of the factors like harmonic distortion, complex structure of the cage motor and machine parameter variation in steady state and dynamic conditions.

Among the above-mentioned reasons the induction motor parameter variation plays a very dominant role in the sluggish response of the drive. To achieve good dynamic response parameters must be measured accurately and tuned consistently

II. LITERATURE SURVEY

Many comprehensive articles, journals and conference papers can be found describing various vector control methods applicable to induction motor drives and the investigation of the machine parameters. Different tests are described in various articles and papers to find out the parameters of the machine. Some give direct voltage as an applied quantity and measure the current response, while others give the applied current as reference and measure the voltage response to find out the parameters. Nevertheless some literatures that are indirectly related to this thesis are used as a basis in this discussion.

Traditionally induction machine parameters were obtained by performing blocked rotor and no-load tests . But it is very difficult to perform these tests as the machine is usually coupled to load. Moreover under blocked rotor test at rated frequency, skin effect can heavily influence the accuracy of rotor resistance. J K Seoketal. presented a standstill test procedure in which the d-axis equivalent circuit of induction motor at standstill is considered to identify the rotor resistance. J K Seoketal. also presented another method of parameter identification which successfully determines all the parameters except stator resistance by monitoring the speed and current controller output of the device. Bunte et al presented an off-line method in which the parameters are identified in the first step and then the modified software for the controller or signal processor starts, where adoption to inertia factor and temperature variation is necessary. A. Gastli presented a method of identification of parameters by performing a single phase test using a variable frequency power supply. Jaochim Holtz et al. presented an on-line identification technique based on stator current trajectory which is the dynamic response of induction motor to PWM switching sequence

Standstill frequency response test have been performed on induction motors at standstill to derive the equivalent circuit parameters of induction motor. But the models derived from Standstill frequency response test require adjustment for saturation.

III. AUTO TUNNING METHOD

A. What is Auto Tuning?

The auto tuning of an induction motor drive is a new approach to identify the parameters of a vector controller prior to actual starting of an induction motor.In auto tuning the system itself determines the electrical parameters of the machine during commissioning and sets the control parameters accordingly. Information about the parameters is important for the estimation of feedback signals of vector-controlled drive. The proportional (P) and integral (I) gains of feedback control loops can also be tuned with knowledge of the machine's parameters. However, in auto tuning, we are concerned with initial parameters only, not the parameters during operating condition.

Importance of auto tuning in an Induction Motor Drive**:**

In industrial applications, full use of the well-known advantages of modern A.C. drives with vector control can only be made, if during tuning the control system has been accurately adapted to the motor connected. In many applications, when inverter and motor are not sold as a unit, the parameters of the motor are not known beforehand. Therefore, special measurements and test runs had to be made during commissioning. However the structure of vector control is quite complex. Therefore, setting the control parameters used to be is a time-consuming procedure and it requires specially trained staff.

To overcome this disadvantage, auto tuning a novel feature to induction motor drive is developed. So in auto tuning the system itself determines all the electrical parameters necessary for the operation of vector controlled induction motor drive. Auto tuning secures a fast and accurate adjustment of PWM inverter control systems to the motor connected. Combining inverter and motor may be left up to the customer. As to the commissioning staff, no special knowledge is required, so that the customer's staff can commission the drive.

Common locked-rotor and no-load test or, more can measure the parameters of induction motors recently, by static tests using time domain and frequency domain analysis. This proposed method is more convenient since it is neither necessary to use special mechanical devices for blocking the motor shaft during the test nor to perform manual handling

The basic structure of the overall system used to perform the proposed estimation method is shown below. A three-phase power amplifier feeds the induction motor, the parameters of which are to be estimated. A DSP based card performs the reference signal generation for the power amplifier, the data acquisition as well as the estimation of machine parameters.

The motor parameters are determined by three automated tests:

- Test 1: determination of stator resistance
- Test 2:determination of stator and rotor leakage inductance and rotor resistance
- Test 3:determination of magnetizing inductance

IV. SIMULATION AND ANALYSIS

The simulation of the proposed auto tuning of induction motor has been performed with the software P-SIM, and the results obtained are presented in the following table.

The following test data has been used to verify the results of the proposed auto tuning system:

Output Power (kW)	2.2 kW	2.238 kW	3.730 kW	5.595 kW	11 kW

Voltage Line (V)	220 V	184 V	184 V	346 V	380 V
Rated Current (A)	4.6 A	5.8 A	11.7 A	9.33 A	16.9 A
Poles	4	4	4	4	4
Supply Frequency (Hz)	50 Hz	50 Hz	50 Hz	50 Hz	50 Hz
R_s (Ω)	2.74 Ω	0.435 Ω	0.2417 Ω	0.3 Ω	0.371 Ω
R_r (Ω)	2.55 Ω	0.816 Ω	0.2849 Ω	0.15 Ω	0.415 Ω
L_m (mH)	299 mH	69.3 mH	54 mH	35 mH	84.2 mH
L_σ (mH)	27.6 mH	4 mH	2.6 mH	8.5 mH	6 mH

Table No.4.1 Table showing the test data of Induction motors

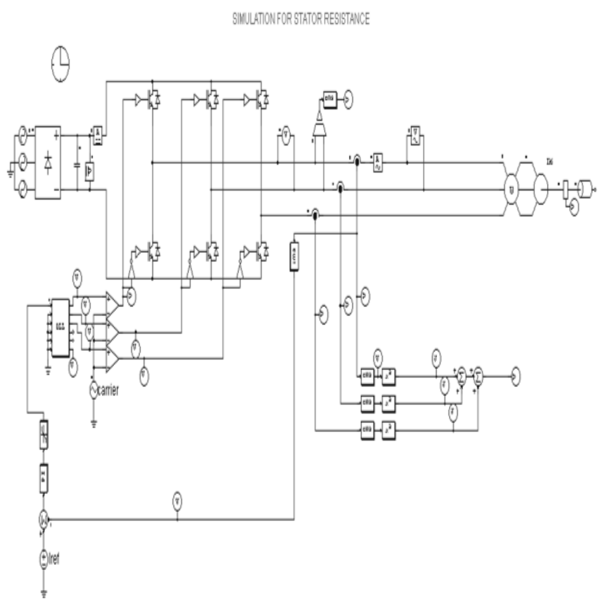

Fig. 4.1 Schematic diagram of Test 1 for calculation of stator resistance for 2.2 kW motor

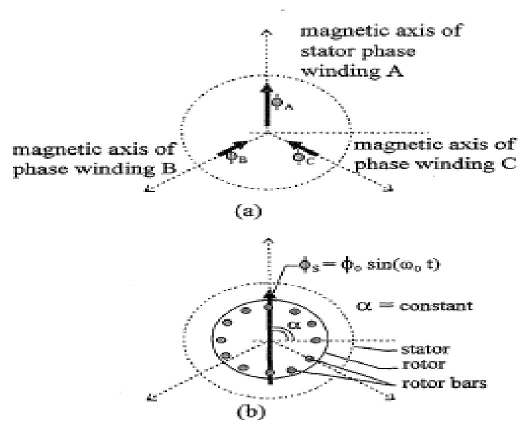

Fig 4.2 (a) Vector sum of stator winding fluxes; (b) Resultant stator flux vector

From the figure we observe that fig 4.2(a) represents the vectorial sum of stator winding fluxes ϕ_a, ϕ_b,ϕ_c, and fig 4.2(b) represents the resultant stator flux vector equal to ϕ_s=$\phi_0$sin(ω_2t) during the second test.

Simulated test results of stator resistances:

Ratings of motor (kW)	Actual value of Rs (Ω)	Simulated Rs (Ω)
2.2 kW	2.74 Ω	2.731 Ω
2.238 kW	0.435 Ω	0.441 Ω
3.730 kW	0.2417 Ω	0.2236 Ω
5.595 kW	0.3 Ω	0.31 Ω
11 kW	0.371 Ω	0.322 Ω

Table .4.2 Table showing simulated results of stator resistances

The simulation has been performed and the value of Rs has been calculated by taking 10 random samples of power and corresponding sum of the squares of currents at that instants and averaging them after t=0.8 seconds. The above table shows the validity of the test procedure for finding the stator resistance. Fig 4.2shows the total active power absorbed by the motor.

Ratings of motor (kW)	Actual value of Rs+Rr(Ω)	Simulated Rs+Rr(Ω)
2.2.kW	5.29.Ω	5.16. Ω
2.238.kW	1.251. Ω	1.222. Ω
3.730.kW	0.5266. Ω	0.5098. Ω
5.595.kW	0.45. Ω	0.42. Ω
11.kW	0.786. Ω	0.742. Ω

Table 4.3Table of simulation result comparison of actual and simulated values of Rs+Rr.

V. FUTURE SCOPE

- The parameters required for auto-tuning of an induction motor which have been estimated can be used in the sensorless mode of vector control, by still increasing the accuracy of the estimation by using a floating point processor as Q-formatting of the numbers has reduced the accuracy of calculation.
- The estimated parameters can be used in the implementation of the sensorless vector control which remains as the future work.
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VI. CONCLUSION

The method discussed for auto tuning of induction motor determines the parameters required for a single phase equivalent circuit: stator and rotor resistance, stator and rotor leakage inductance and the total magnetizing inductance. The proposed method does not require the use of special mechanical devices for blocking the motor shaft during tests. These simplify the parameter identification process and reduce the required time to perform tests. After satisfactory results from the simulations performed in P-SIM, code has been developed for the implementation of the tests on TMS320C2406 DSP processor control card. The test procedure adopted estimates the results with a percentage error of 5.5%, which is within the acceptable limits. The following are the comparisions between the actual data of the 2.2 kW motor, the simulated results and the results obtained with hardware implementation.

Data of 2.2 Kw Induction	R_s (Ω)	R_s+R_r (Ω)	L_{ls}+Llr (mH)	L_{ls}+L_m (mH)
Actual Motor Parameters	2.74. Ω	5.29. Ω	27.6.mH	312.8.mH
Parameters Estimated from P-	2.731 . Ω	5.16. Ω	26.88.mH	306.8.mH
Parameters Estimated from	2.728 . Ω	4.968 . Ω	29.523.mH	328.653.mH

Table 4.4 showing the comparison of results

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