

# MATLAB based Performance Prediction of a Three-Phase Induction Motor Utilising its Test Results

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**Abstract**— The most common type of A.C motor being used throughout the world today is the induction motor. Induction motors are singly excited motor which drive loads at fairly constant speed This present study discusses about the development of a Simulink model of a three phase induction motor block which takes the inputs in form of the test results obtained by the No-load , Blocked rotor & DC resistance tests and simulates to give the equivalent circuit parameters as well as various operating characteristics.

**Keywords**— Induction motor, No-load test, Blocked rotor test, DC resistance test, MATLAB, Simulink

## I. INTRODUCTION

In 1893 Dolivo Dobrowolsky developed an induction motor, with a distributed stator winding and a cage rotor [1]. The motor was developed based on the principle of rotating magnetic field, produced by using poly phase currents, as explained by Tesla and Ferraris in 1889. The advantages of induction motor over other types of motors are,

- It requires less maintenance
- These are more rugged & less expensive in comparison to the d.c machine of equal kilowatt & speed ratings.

The induction motor derives its name from the fact that it operates on the principle of induction. The rotating magnetic field generated in the stator induces a magnetic field in the rotor. The two fields interact and cause the rotor to turn in the same direction as the rotating stator field. . The rotor receives power from the stator due to Induction. The rotor is not connected to an external source of voltage. To obtain maximum interaction between the fields, the air gap between the rotor and stator should be very small.

A three-phase squirrel-cage induction motor is one of the more readily used motors because it operates with its best efficiency and highest power factor at rated load. The motor is also more reliable since there are no brushes or slip rings to wear out. Consequently, there are no sparks produced, so this motor can be used in areas where volatiles are present.

Squirrel cage induction motors are generally used in low-speed applications. In fact, the speed of the rotor decreases as the load applied to the motor increases. For any given induction motor, the parameters of rotor speed, power factor, efficiency, and torque plotted versus output power provide all of the necessary information to determine the operating points

for that motor. The operating characteristics of a squirrel cage induction motor are determined experimentally by the blocked rotor test, the no-load test, and the load test..

## II. INDUCTION MOTOR TESTS

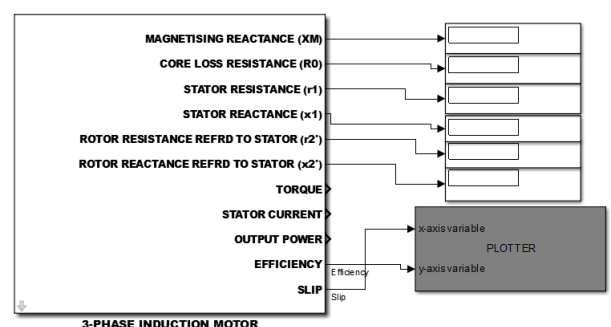
While selecting a proper motor it is necessary to know the various operating characteristics as well as the equivalent circuit parameters of the motor. For this purpose following tests are conducted on a three phase induction motor. No-Load Test Balanced voltages are applied to the stator terminals at the rated frequency with the rotor uncoupled from any mechanical load. Current, voltage and power are measured at the motor input. The losses in the no-load test are those due to core losses, winding losses, windage and friction.

**Blocked Rotor Test** The rotor is blocked to prevent rotation and balanced voltages are applied to the stator terminals at a frequency of 25 percent of the rated frequency at a voltage where the rated current is achieved. Current, voltage and power are measured at the motor input.

In addition to these tests, the DC resistance of the stator winding should be measured in order to determine the complete equivalent circuit.

## III. SIMULINK IMPLEMENTATION

The induction motor model developed is shown in Figure 1.



Note : To view the characteristics connect the two outputs from the block to the inputs of PLOTTER & run the simulation. Doubleclick the PLOTTER after the simulation, to see the characteristics

Figure 1: The Induction motor block

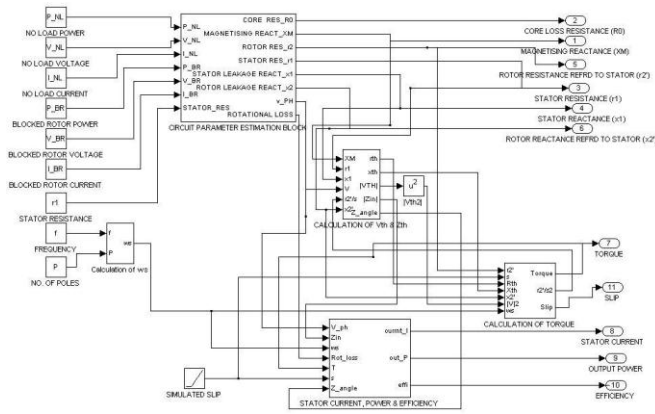


Figure 2 : Different blocks of the developed model

It consists of three major blocks:.

**A. The Circuit parameter estimation Block**

This block calculates the equivalent circuit parameters

**B. The Torque estimation Block**

This block calculates the shaft torque of the motor.

**C. Stator Current-Power-Efficiency estimation Block**

This block calculates the shaft power, stator current & efficiency of the motor. While calculating the above parameters the equivalent circuit model is approximated to as shown in Figure 3.

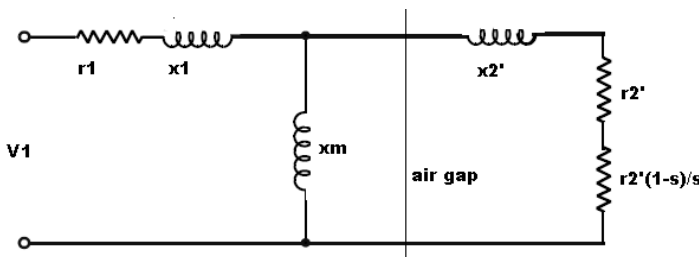


Figure 3 : Equivalent circuit diagram of the Induction motor

Here the Core loss resistance value is neglected, as it is very high. In order to simplify the determination of torque and power equations from the induction machine equivalent circuit, the network to the left of the reflected components is replaced by a Thevenin equivalent source.

The Thevenin voltage (open-circuit voltage) for the stator portion of the equivalent circuit (to the left of the air gap) is

$$V_{TH} = V_1 \frac{jx_m}{r_1 + j(x_1 + x_m)}$$

The Thevenin impedance (impedance seen after shorting  $V_1$ ) is

$$Z_{TH} = jx_m \parallel (r_1 + jx_1) = R_{TH} + jX_{TH}$$

Inserting the Thevenin equivalent source into the induction machine equivalent circuit yields the approximated equivalent circuit as shown in Figure 4.

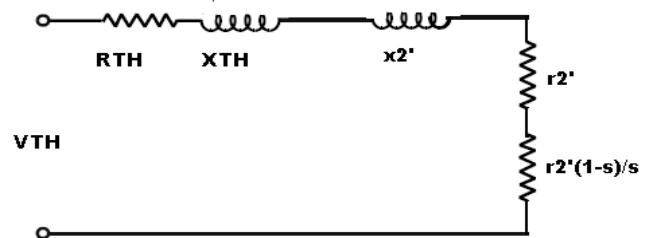


Figure 4 : Approximate equivalent circuit with Thevenin's equivalent source & impedance

**IV. DIALOG BOX AND INPUT PARAMETERS**

To use the model data is fed through a dialog box as shown in Figure 5. The input parameters are,

- Nominal Power – power rating of the motor in Kw
- Rated Voltage – rated voltage of the motor
- Frequency - operating frequency
- No. of poles - no. of poles in motor
- Stator Connection - stator connection type (e.g. Delta or Star)
- Class of Motor - motor class (e.g. Squirrel cage Class A, B, C, D)
- No Load Line Current, Voltage & Power – No-load test results
- Blocked Rotor Line Current, Voltage & Power – Blocked rotor test results
- Stator Resistance - measured stator resistance by DC test.

**Block Parameters: 3-PHASE INDUCTION MOTOR**

Squirrel cage Induction motor (mask)

Implements a three-phase asynchronous machine (squirrel cage). The motor test results (No Load, Blocked rotor & DC stator resistance test) are used to get the performance characteristics of the motor.

Parameters

Nominal Power ( w )  
3746

Rated voltage (Volt)  
415

Frequency (Hz)  
50

No. Of poles  
4

Stator connection DELTA

Class of Motor CLASS A

No Load Line current (Amp)  
3

No Load Line Voltage (Volt)  
400

No Load Power (Watt)  
645

Blocked Rotor Line Current (Amp)  
12

Blocked Rotor Line Voltage (Volt)  
200

Blocked Rotor Power (Watt)  
1660

Stator Resistance (From DC Test)  
5

OK Cancel Help Apply

Figure 5 : Input Dialog Box

## V. SIMULATION AND RESULTS

The model was used to simulate the performance of a three phase, 4 pole, 3 hp, 50 Hz, 5 A, 415 Volt , class A squirrel cage induction motor whose Test results are

### No-Load Test

Stator Line to line voltage = 415 V

Stator Line to Line Current = 3.04 A

Power input to Stator = 232 watts

Speed = 1486 rpm

### Blocked Rotor Test

Stator Line to line voltage = 84 V

Stator Line to Line Current = 5 A

Power input to Stator = 433 watts

### DC resistance Test

Stator Resistance = 7.5 ohms

On conducting the simulation using the test results various operating characteristics obtained are shown in Figure 5. These characteristics will predict the operational behaviour of the motor.

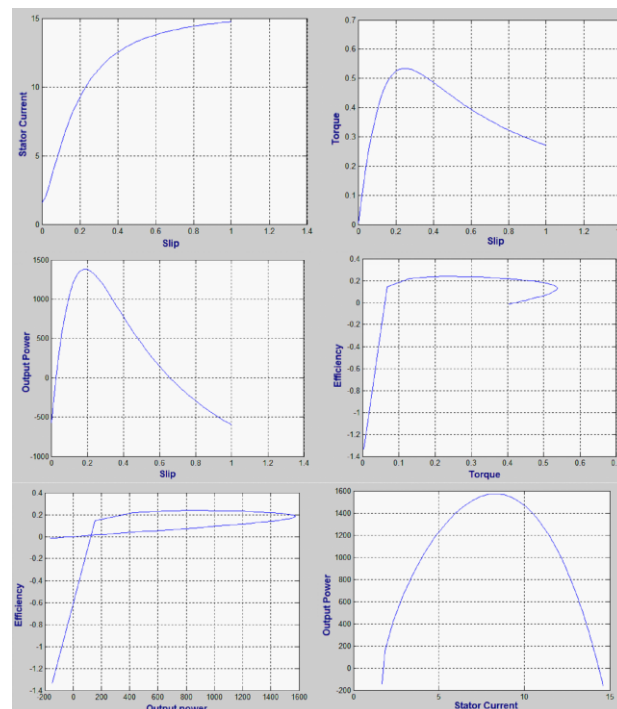


Figure 6 : Various performance characteristics

## V. CONCLUSIONS

The developed Simulink Model is modular and easy to use. The model can be a very handy tool in conducting undergraduate laboratory. The block developed can be used as a library block for further usage. The future scope of work includes developing similar models for other machines and improvement in parameter calculations by removing the approximations made during creation of the model. The developed model file can be downloaded from <http://www.mathworks.com/matlabcentral/>.

## REFERENCES

- [1] George G. Karady & Keith Holbert - Energy Conversion and Transport
- [2] N.M. Ghasem, M.A. Hussain, I.M. Mujtaba - The use of simulink block diagram to solve mathematical models and control equations
- [3] Saffet aYasun Chika o. Nwankpa - Transformer Tests Using MATLAB/Simulink and Their Integration Into Undergraduate Electric Machinery courses
- [4] Erxuan Liu - GUI Development for a Harmonic Measurement Technique
- [5] Robert Babujska and Stefano Stramigioli - Matlab and Simulink for Modeling and Control -
- [6] Brian D. Storey - Solving Differential Equations with Simulink