Parameters Estimation Tests of Induction Machine Using Matlab/Simulink

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Abstract. This paper describes special tests through the Matlab/Simulink program with induction machine to estimate the parameters of the equivalent circuit step by step because they have a direct impact on the performance of induction machine while running steady-state machines and dynamic status. There are three tests to determine the parameters of the induction machine (R1, R2, X1, X2, Xm) is a DC test and No-Load test (open-circuit test) and Blocked rotor test (short-circuit test). Despite the fact that temperature and the skin effect are not taken into account in DC resistance modelling, the results obtained are approximate and rational. For control and verification, the parameters of an induction machine can be accessed through the above three tests. Simulation and experimental results confirm the effectiveness of the proposed method. This work can be easily applied by students to enable them to know the parameters in the absence of the information provided in the motor.

Keywords: Induction Machine, The Equivalent Circuit, Test of IM, Estimation parameters, Matlab/Simulink

1. Introduction

Induction motors are the most common type used in factories because they have special features that differ from other motors. These features that distinguish induction motors from others are their simple construction, easy operation, simplified maintenance, easy control, and high efficiency [1]. The modelling of induction machines has continually attracted the attention of researchers because these machines are the most widely used, with an estimated ratio of about 80% [2]. Figure 1 represents the equivalent circuit for each phase of an IEEE recommended induction motor induction motors can be treated as a transformer basically, the stator winding is called the primary winding, and the rotor winding is called the secondary winding [3]. On the practical side, decisions are always intended to be taken for the continuation of work, and these parameters are always unknown or unknown for other reasons. To achieve the performance of induction motors and accurately estimate the parameters, determining these parameters is of utmost necessity in all stages of the induction machine operation [4]. The purpose of this study is to create a computer lab, assess the parameters of the induction machines, and provide simulation models for the three tests mentioned above, to serve as pre-preparation exercises for the student using the Matlab/Simulink program and to design a computational laboratory as stand-alone applications for each test.
There are several previous extensive studies that talk about calculating the parameters of the induction motor from them, a simple induction motor parameter estimation method for vector control [5]. Parameter Identification of an Induction Machine at Standstill Using the Vector Constructing Method [6]. Robust on-line rotor time constant estimation for induction machines [7]. Parameter identification of induction motors at a standstill based on integral calculation [8]. All of them seek to obtain the closest possible value that leads us to the true values of the motor. But some of them are accurate and some of them are more accurate and less accurate. The proposed method in this paper and through the Matlab program confirms the effectiveness of the work and the results obtained, due to its accuracy and the small differences between the real and obtained values.

2. Setup of Experimental three Test of Induction Machine

Most often, the equivalent circuit for each phase is used to investigate the operating characteristics of induction motors by representing their steady-state, where $R_1$, $X_1$ represent resistance and the leakage reactance and of the stator part of the circuit and $R_2$, $X_2$ represent resistance and the leakage reactance of the rotor of the circuit. Resistance $R_c$ which means core losses, represents magnetization reactance, and slip is denoted by $s$, the purpose of using the equivalent circuit is to facilitate calculations of operating quantities of induction machines such as stator current, efficiency, losses, torque, etc. [9]. In the following, each test is described through the Matlab/Simulink program, independent and separated from the other, for easy access to the equivalent circuit parameters clearly and smoothly so that each student can take these tests because of the importance mentioned previously.

2.1. Test of DC Resistance

A dc voltage is applied to the stator windings of an induction motor in order to compute the stator winding resistance $R_1$. [10]. As a consequence of the DC current flowing through the stator windings, no voltage is induced in the rotor circuit, and the motor reactance is 0V. The only circuit parameter that limits current flow is the stator resistance. Show figure 2. To illustrate this test

$$R_1 = 0.5 \frac{V_{dc}}{I_{dc}}$$

(1)

Where; $R_1$, the stator resistance

$V_{dc}$, Dc voltage
2.2. Test of No-Load

A no-load test on a squirrel cage induction motor is carried out to assess the motor's rotational losses and some of its equivalent circuit parameters [11]. When the stator is operating at no load, a rated, balanced ac voltage at a rated frequency is applied, and input power, voltage, and phase currents are calculated. Show figure 3. To illustrate this test.

\[ X_0 = X_1 + X_m \]  
(2)

\[ X_0 = \frac{(V_{\phi})^2}{Q_{\phi}} \]  
(3)

Where:
- \( X_0 \), No-load reactance
- \( X_1 \), The stator reactance
- \( X_m \), The magnetizing reactance
- \( V_{\phi} \), Phase voltage
- \( Q_{\phi} \), Reactive power/phase

**Figure 2.** DC-Resistance Test
2.3. Test of Blocked Rotor

The purpose of this test is to determine $R_2$, $X_1$, and $X_2$, [12]. This is done by applying zero speed as an input to the motor and reading input electrical power, current, and voltage. Show figure 4. To illustrate this test

\[ R_2 = R_{B.R} - R_1 \]  \hspace{2cm} (4)

\[ R_{B.R} = \frac{P_{B.R}}{(I_{B.R})^2} \]  \hspace{2cm} (5)

\[ X_{B.R} = \frac{Q_{\phi}}{(I_{B.R})^2} \]  \hspace{2cm} (6)

But the model is A-type, then $X_1 = X_2$

$X_1 = 0.5X_{B.R}$

$X_2 = 0.5X_{B.R}$

Where; $R_2$, rotor resistance

$R_{B.R}$, Blocked rotor resistance

$P_{B.R}$, Blocked rotor power

$I_{B.R}$, Blocked rotor current

$X_{B.R}$, The reactance of blocked rotor
3. Results simulation and discussion

Table 1. Shows the differences between the parameter values that were taken from the Matlab/Simulink program, which is Model No. 17 with specifications 15kW 400V 50Hz 1460rpm induction motor with squirrel cage. And between the values that we extracted from by simulating in Matlab and setting the error ratio between the two values. It was found that there is a convergence between the two values by observing the small error rate. Therefore, this proposed modelling can be relied upon to be a work that facilitates students and researchers to know the parameters of induction machines. And Table 2. Shows the information that we got from the tests and on which we performed our mathematical calculations.

Table 1. Assess parameters and Error for Induction Motor with 15kW

| Parameters       | \( R_1 \) | \( R_2 \) | \( X_1 \) | \( X_2 \) | \( X_m \) |
|------------------|----------|----------|----------|----------|----------|
| Preset Model     | 0.2147   | 0.2205   | 0.3114   | 0.3114   | 20.166   |
| In Matlab/Simulation | 0.1986 | 0.2138   | 0.3101   | 0.3101   | 20.1719  |
| Error %          | 1.61     | 0.67     | 0.13     | 0.13     | -0.59    |

Figure (4) Blocked Rotor Test
Table 2. Information of Tests in Matlab/Simulink

| Parameters   | $I_a$(A) | $I_b$(A) | $I_c$(A) | $V_a$(V) | $w_m$(rad/s) |
|--------------|----------|----------|----------|----------|--------------|
| No-Load Test | 11.28    | 11.28    | 11.28    | 230.9    | 157          |
| Blocked Rotor Test | 306.3    | 306.3    | 306.3    | 230.9    | 0.00         |

4. Conclusion

In this work, we presented a virtual arithmetic lab that simulates a practical laboratory by means of a Matlab/Simulink program that supports the teaching of inductive machines, particularly the computation of equivalent circuit parameters. Because it has a direct effect on the performance of the squirrel cage asynchronous motors. The goal that we wanted to achieve was achieved, and the result was good, by reading the error rate between the real values of the machine and the proposed method. As each test was separated from the other and knowing what results from each test to make it easier for future researchers to find the parameters of induction motors easily. We show that this program is a good simulation tool for such tests, and it is possible to use other programs in the future in order to compare them.

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