KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

Electric Engineering Department

EE 306 Electric Energy Engineering-Experiment#10

DETERMINATION OF INDUCTION MOTOR PARAMETERS

Objective

The goal of this experiment is to determine the electrical parameters of a 3-φ induction motor (primary and secondary resistance and reactance and the magnetization branch values).

APPARATUS
1) 1 Three-Phase Induction Motor.
2) 1 Prony Brake.
3) 2 Digital Wattmeters.
4) 1 Three-Phase Variable AC Power Supply.
5) 1 DC Power Supply.
6) 1 DC Ammeter.
7) 1 DC Voltmeter.
8) 2 Three Phase Switches.

Introduction

Induction motor is an AC machine in which an alternating current is supplied to the stator armature windings directly and to the rotor windings by induction. Because it operates at balanced conditions, only a single phase is necessary. So, the per-phase equivalent circuit of the induction motor in which the rotor parameters are referred to the stator side is shown in Figure 1. It can be seen from Figure 1 that the core loss represented by R_C is neglected since its effect is lumped with the rotational losses. The following equations can be derived:

$$V_1 = E_1 + (R_1 + jX_1)I_1 \quad \text{...} (1)$$

$$E_1 = \left(\frac{R_2}{s} + jX_2\right)I_2 \quad \text{...} (2)$$

To determine the parameters of the equivalent circuit of the three-phase induction motor, it is subjected to three tests.

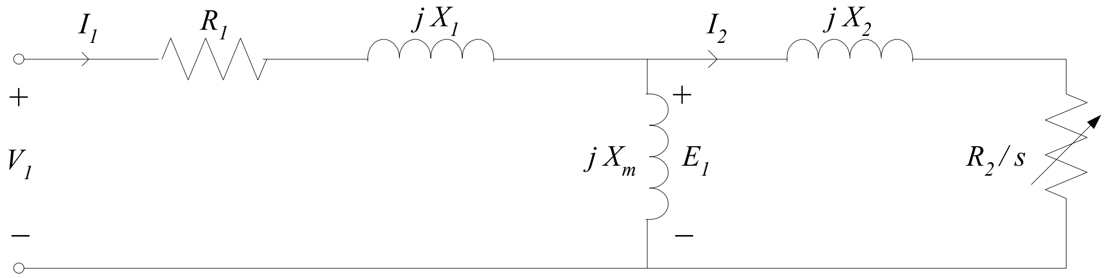

Figure 1: Per-phase equivalent circuit of a three-phase induction motor referred to the stator

Proceedure

A. DC Test

Connect the circuit as shown in Figure 2 (while the motor is at standstill), apply the dc voltage V_{dc} until the current I_{dc} flowing in the induction motor is the rated value. The stator resistance per phase can be calculated as $R_1 = V_{dc} / (2\ I_{dc})$..

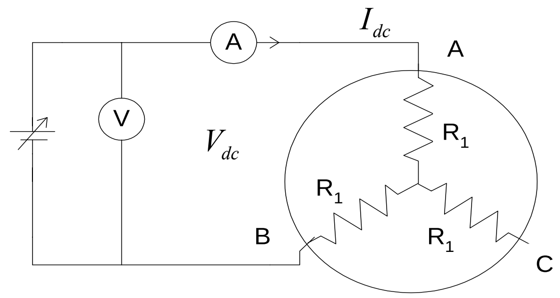

Figure 2: DC test for the determination of the stator resistance

B. No Load Test

Rated balanced voltage at rated frequency is applied to the stator, and the motor is allowed to run on no-load. When the machine runs on no-load, the slip is close to zero, and the circuit to the right of the shunt branch in Figure l is taken to be an open circuit. Thus the equivalent circuit to the no-load test conditions is given in Figure 3. Because of the relatively low value of rotor frequency, the rotor core loss is practically negligible at no-load. From Figure 3, it follows that

$$P_{rotational} = P_{nl} - 3I_{nl}^2 R_1 \quad \text{.......} \quad (3)$$

$$R_{nl} = \frac{P_{nl}}{3\,I_{nl}^2} = R_1 + lumped\ losses \quad \text{.......} \quad (4)$$

$$Z_{nl} = \frac{V_{nl}}{\sqrt{3}\ I_{nl}} = \sqrt{R_{nl}^2 + X_{nl}^2} \quad \text{.......} \quad (5)$$

$$X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2} = X_1 + X_m \quad \text{.......} \quad (6)$$

$$No\ load\ power\ factor = \cos\varphi_0 = \frac{P_{nl}}{\sqrt{3}\,V_{nl} I_{nl}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

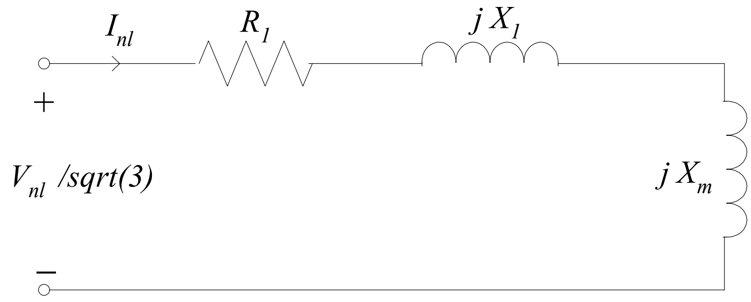

Figure 3: Approximate equivalent circuit for no load test

Perform the following:

1. Connect the circuit as shown in Figure 4. Apply the rated voltage.
2. Measure the rated voltage $V_o = V_{nl}$.
3. Measure the line current ($I_a = I_b = I_c = I_{nl}$).
4. Measure the wattmeters powers W_1 and W_2, so $P_{nl} = W_1 + W_2$.
5. Calculate R_{nl}, X_{nl}, Z_{nl}, and φ_0 from equations (4)–(7).

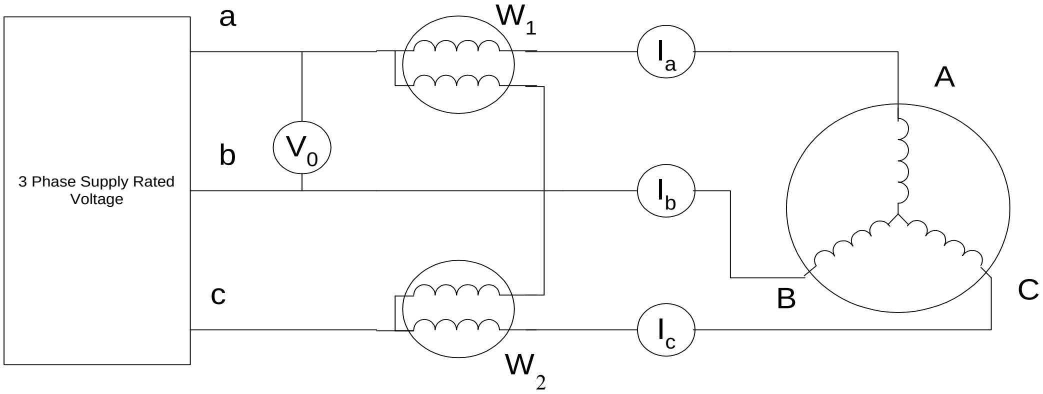

Figure 4: Schematic diagram for the no load test

C. Blocked-Rotor Test

In this test, the rotor of the induction motor is blocked so that the slip is equal to unity, and a reduced voltage value is applied to the machine stator terminals so that the rated current flows through the stator windings. The iron losses are assumed to be negligible in this test. Also, the shunt branch is neglected for this test since the excitation current is small. The equivalent circuit corresponding to the blocked rotor test condition is given in Figure 5. From Figure 5, it then follows that

$$R_{bl} = \frac{P_{bl}}{3 I_{bl}^2} = R_1 + R_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$Z_{bl} = \frac{V_{bl}}{\sqrt{3}\, I_{bl}} = \sqrt{R_{bl}^2 + X_{bl}^2} \quad \text{.. (9)}$$

$$X_{bl} = \sqrt{Z_{bl}^2 - R_{bl}^2} = X_1 + X_2 \quad \text{.. (10)}$$

The following assumption can be taken:

$$X_1 = X_2 = \frac{1}{2} X_{bl} \quad \text{.. (11)}$$

Finally, the magnetization reactance can be found:

$$X_m = X_{nl} - X_1 \quad \text{.. (12)}$$

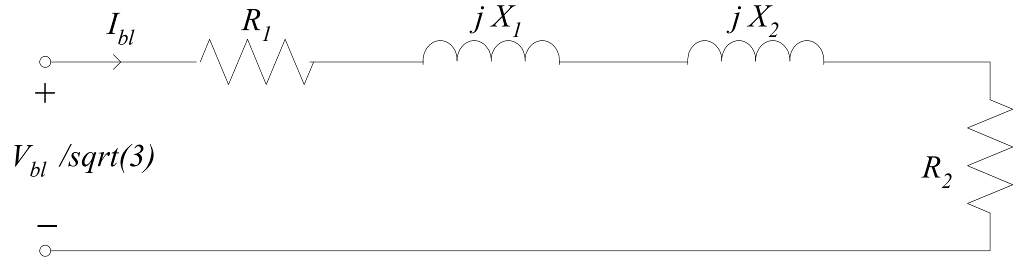

Figure 5: Approximate equivalent circuit for blocked rotor test

Perform the following:

1. Connect the circuit as in Figure 6. Keep the applied voltage to zero at starting.
2. Increase the applied voltage until the rated current flows in the stator winding.
3. Measure the applied voltage $V_S = V_{bl}$.
4. Measure the line current ($I_a = I_b = I_c = I_{bl}$).
5. Measure the wattmeters powers W_1 and W_2, so $P_{bl} = W_1 + W_2$.
6. Apply equations 8–12 to calculate the parameters X_1, X_2 , X_m , R_2 .

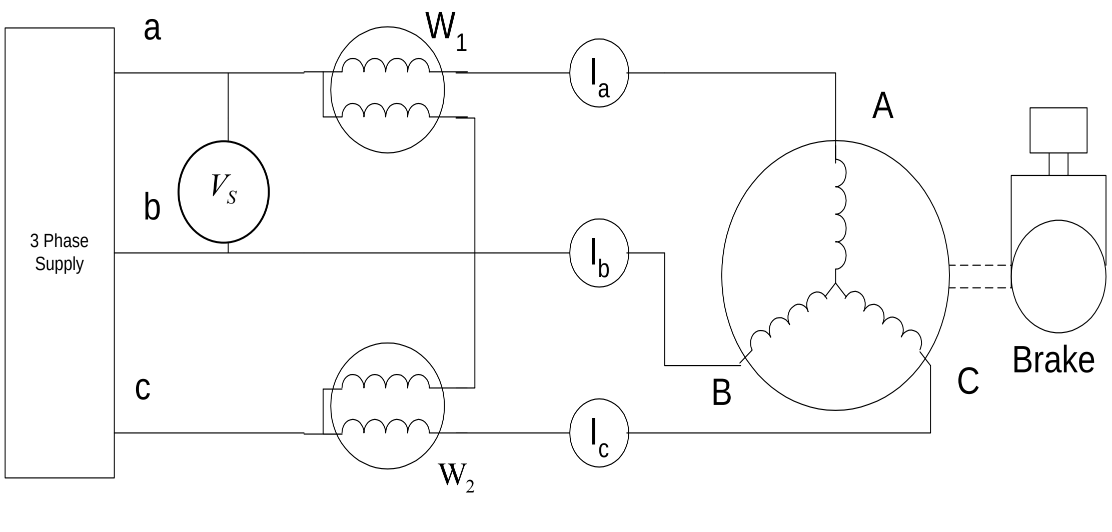

Figure 6: Schematic diagram for the blocked-rotor test

Report

1. Record the ratings of the induction motor and determine the number of its poles.
2. Find the parameters of the equivalent circuit of the three-phase induction motor.
3. Draw the equivalent circuit of the induction motor and put the values of the parameters that you found in the previous question along with their symbols.
4. Determine the no load power angle.
5. Determine the combined rotational losses of the motor.

