THE HASHMITE UNIVERSITY

ELECTRICAL ENGINEERING DEPARTMENT

ELECTRICAL MACHINES LAP

LAP REPORT # 1

Induction Motor I

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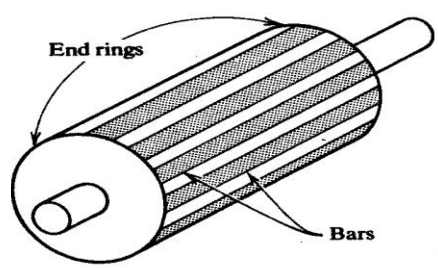
Objectives :

The objective of this experiment is to perform deferent tests on the induction motor to determine the parameters of the equivalent circuit , and to demonstrate the operating characteristics of the squirrel cage induction motor .

Theoretical Background :

The induction motor is the most common of all motors , it consists of a rotor and stator, the rotor is mounted on bearings and separated from the stator by an air gap .

Alternating current is supplied to the stator windings and an electromagnetic field is induced , this induced electromagnetic field will induce a current in the rotor windings , the rotor of the induction motor is cylindrical and consists of conducting bars shortened at the ends by conducting rings (this type of rotor is called squirrel cage rotor and this type is what we used in the lap) , the figure below shows this rotor :

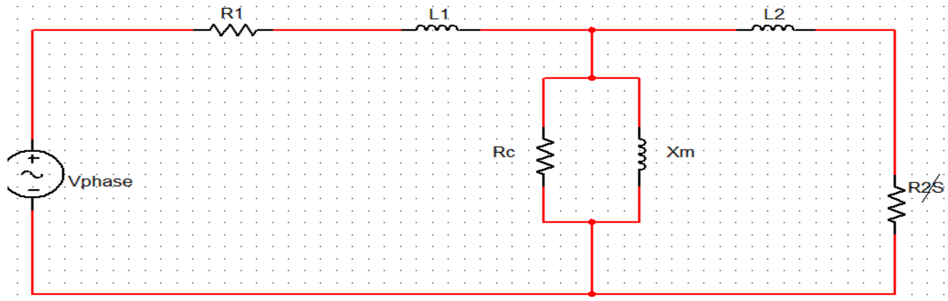


squirrel cage rotor

Note : There is another type of rotors used and it's called wound rotor but we didn't use it in the lap .

The induction motor works operates on the basis of interaction between air gap field and the induced rotor current , if the machine is allowed to run under the influence of this interaction the machine will operate as a motor .

The general equivalent circuit for the induction motor is shown in the figure below :



General equivalent curcuit

We will perform three tests to determine the different parameters of this circuit , these tests are discussed below :

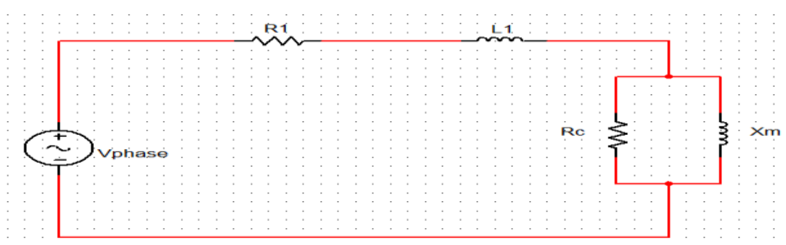
1.)The Resistance measurement test :

We simply used a very sensitive multimeter to measure the resistance of each winding when they are disconnected .

<u>This test is used to determine R1 .</u>

2.) The no load test :

The no-load test, like the open circuit test on a transformer, gives information about exciting current and rotational losses. The test is performed by applying balanced rated voltage on the stator windings at the rated frequency. The small power provided to the machine is due to core losses, friction and winding loses.
The machine will rotate at almost a synchronous speed, which makes slip nearly zero .
The equivalent circuit for this test is shown in the figure below :



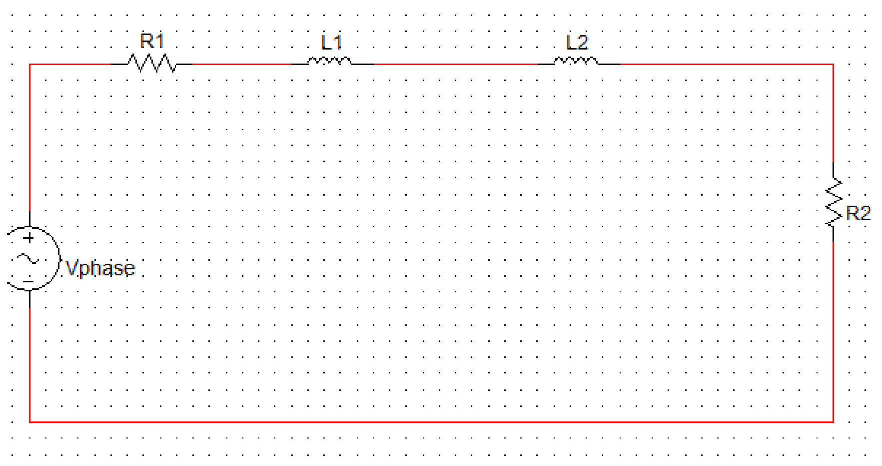
The no load test equivalent circuit

Comparing this circuit with the original circuit the motor is running at ***almost*** *synchronous speed so the slip(s) is almost 0 , therefore R2/s is very large , so we assumed that it will be an open circuit , we already calculated R1 in the previous test , and since Xm is much greater than L1 we will assume that X1 + Xm ≈ Xm .*

This Test Is used to calculate Xm & Rc .

3.)The Locked Rotor Test :

The locked rotor test, like short circuit test on a transformer, provides the information about leakage impedances and rotor resistance. Rotor is at the stand still, while low voltage is applied to stator windings to circulate rated current. Measure the voltage and power to the phase. Since there is no rotation slip, s=1 which gives us following equivalent circuit :



Locked Rotor Test equivalent circuit

In this circuit we assumed that Rc and Xm are open circuit because when the slip is 1 R2 / S = R2 which is very small resistance comparing to Xm and Rc.

This Test is to calculate R2 , X1 & X2 .

Note : More details on who we can obtain the values of R1 , R2 , X1 , X2 , Rc & Xm will be discussed in the procedure .

Equipments :

We used the induction motor , a sensitive multimeter , a muserment unit & eddy current brake in this experiment .

Procedure :

1-) Resistance Measurement :

We simply measured the resistance of each winding using an ohmmeter, and we had the following results :

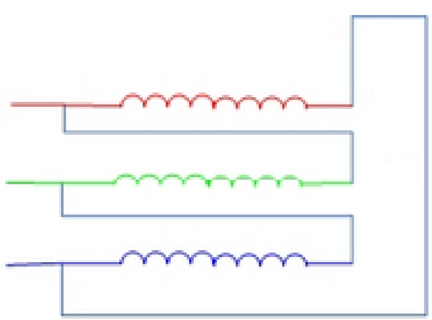
U1 , U2 = 8.025 Ohm , V1 , V2 =8.025 Ohm , W1 , W2 = 8.025 Ohm .

These values represent R1 .

2-)The No load Test :

We connected the wires from the power supply through a measurement unit to the induction motor and we used the practical diagram figure to connect the windings in a star configuration .

The eddy brake in internally connected to the induction motor so simply turned the "brake force" to the minimum torque (zero) (we disconnected eddy brake force insted) .



Delta connection we made on our experiment

The we adjusted AC voltage using the power supply to 220 volts and used the measurement unit to measure the current and power for our calculations.

Calculations for The No load Test :

We obtained the following results from our experiment :

Measured Values		
V(v)	I(A)	Pin (w)
220	2.8	190

Now we need to calculate the power factor we will use the formula :

$$Cos\ (\theta) = \frac{Pin}{\sqrt{3}\ Vt\ \ Iin}$$

So $Cos\ (\theta) =\ .178$

And $\theta = \cos^{-1}(.178) =\ 79.742\ lagging$.

Now we need to calculate the total impedance for the equivalent circuit of this test :

$$Zm = \frac{Vt}{Iln}$$

Zm = 78.5714 Ohm .

The real part of this impedance equals the sum of R1 and Rc .

So we can calculate Rc using the formula :

*Rc = Zm ** $Cos\ (\theta)$ *- R1*

So Rc = 5.724 Ohm .

The imaginary part of the impedence equals Xm :

*Xm= Zm ** $Sin\ (\theta)$

Xm = 77.3155 Ohm .

The summury of calculations is next :

Calculated Values				
$Cos\ (\theta)$	θ	Zm	Rc	Xm

.178	79.742	78.5714	5.724	77.3155

3.)The Locked Rotor Test :

We used the same exact previous connection , but in the test we used eddy brake force to prevent the rotor from rotating , we adjusted the AC power supply so had the rated current read at the measurement unit and we took measurements of the voltage and power of the machine under these conditions , The calculations for this part is shown next :

Calculations for The Locked Rotor Test :

We obtained The following results from the measurement unit :

Measured Values		
Il Rated Current (A)	Voltage (v)	Pin (w)
4.8	54	340

No we need to calculate the power factor using the formula :

$$Cos\ (\theta) = \frac{Pin}{\sqrt{3}\ Vt\ \ Iin}$$

$Cos\ (\theta)$ = .7573

So θ = 40.77 .

Now we calculate the magnitude of the total impendence for this circuit using the relation :

Zm = $\frac{V}{Il}$ so Zm = 11.25 Ohm .

Now the real part of this impedance equals the sum of R1 and R2 .

Real Part = Zm * $Cos\ (\theta)$ = R1 + R2

We already measured R1 so we can now calculate R2 :

*R2 = Zm * $Cos(\theta)$ - R1 = .4946 Ohm .*

Now the imaginary part of this impedance equals the sum of X1 and X2 .

*Imaginary Part = Zm * $Sin(\theta)$ = X1 + X2 = Xlr*

Imaginary Part = 7.3465 Ohm = Xlr .

To determine X1 and X2 we use the "Experince Tables", which we can determine X1 and X2 depending on the class of the motor .

Referring to this table we have an indeuction motor of class B , so we have :

X1 = .4 Xlr and X2 =.6 Xlr .

So finally X1 = 2.9386 Ohm and X2 = 4.408 Ohm .

The summury of calculations is next :

Calculated Values					
$Cos(\theta)$	θ	Zm	R2	X1	X2
.7573	40.77	11.25 Ohm	.4946	2.9386	4.408

Conclusions :

1. In this experiment we saw how the motor is started and we the loads are connected

2. we learned how to make a star connection in the induction motor , and learned how to make measurement for voltage , current and power .

3.We used three tests to determine the different equivalent circuit parameters , which are the resistance measurement to determine the windings resistance R1 , the No load Test to determine_Xm & Rc_ , and finally the Locked Rotor Test to R2 , X1 & X2.