**Lab #2 – Induction Motor Performance**

**ECE 325 - Electric Energy System Components**

**Instructor: Dr. Kai Sun**

**Lab TA’s: Denis Osipov and Wen Zhang**

**Objective:**

The objective of this lab is to understand the fundamentals of a 3-phase induction motor, to calculate the parameters of an induction motor equivalent circuit, and to compare the calculated values with measured values.

**Pre-lab:**

1. What are the two types of rotors used in AC induction motors?
2. Give the equation for synchronous speed. What is the synchronous speed for a four pole AC induction machine (standard line frequency)?
3. Define slip for an induction motor. If the synchronous speed is 1800 RPM and the slip (s) is 0.01, what is the rotor speed? If s = 0.1?
4. Draw a power flow diagram for an AC induction motor.
5. Draw a torque vs. speed curve for an AC induction motor. What is the torque produced at synchronous speed $(n\_{s})$?
6. Describe the no-load test and the blocked rotor test for an induction motor. What is the value of slip for a Blocked Rotor Test?
7. Draw the IEEE-recommended equivalent circuit.

Calculations:

Given the following test results:

No load test: Line voltage = 210 V Blocked-rotor test: Line voltage = 60 V

 Line current = 0.77 A Line current = 1.7 A

 Input power = 52 W Input Power = 100 W

Also given: stator resistance $\left(r\_{1}\right)$ = 5.3 Ω/phase

 Synchronous speed $(ω\_{syn})$ = 188.5 rad/sec

(Remember that you are working with a 3-phase machine.)

1. Calculate the parameters of the IEEE-recommended equivalent circuit. It is shown by



Figure 1. IEEE-recommended equivalent circuit

1. Calculate the induction motor no-load rotational loss.
2. Calculate $I\_{2}^{'}, I\_{1}, PF, P\_{in}, P\_{out}, Eff, and T\_{out} $for slip values ranging from 0 to 0.1 (with step size 0.01) $(P\_{out}=P\_{mech}-P\_{rot} $and $T\_{out}=T\_{mech})$
3. Plot output torque versus speed.
4. Plot power factor versus output power.
5. Plot AC line current versus output power.
6. Plot efficiency versus output power.

**Lab Exercise:**

Laboratory Setup:

1. Set up the DC machine as a separately excited generator with variable resistance load bank and the wound rotor motor as an induction motor to drive the DC generator. (Connect the induction motor stator windings in a delta configuration.) This is shown in the Lab #3 Wiring Diagram.
2. Connect a wattmeter to measure power into the induction motor.
3. Connect DC meters to measure DC generator terminal voltage and armature current.
4. Connect AC meters to measure line to neutral voltage and line current.

Laboratory Measurements:

1. Mechanically couple the induction motor to the DC generator.
2. Bring the 3-phase AC voltage up to 120 V (line to neutral).
3. When the induction motor is running (around 1783 RPM), bring the DC machine terminal voltage up to 125 V.
4. Record induction motor values of rotor speed $\left(n\right)$, voltage line to neutral $(V\_{t\left(L-N\right)})$, line current $(I\_{1})$, and power of one phase $(W\_{1})$.
5. Record DC generator values of voltage at terminal $(V\_{t})$ and armature current $(I\_{a})$.
6. First, take a set of measurements with all the resistance switches off.
7. Then, continue recording as the load is increased up to AC line current of 1.5 A. Do not exceed this current limit!

Calculations:

1. Calculate values for $P\_{in}, P\_{out}, PF, Eff, and T\_{out}$

$$P\_{in}=3\*W\_{1}$$

$$P\_{out}=V\_{t\left(DC\right)}\*I\_{a}+I\_{a}^{2}\*R\_{a}+P\_{rot}$$

$$PF={W\_{1}}/{\left(V\_{t\left(L-N\right)}I\_{1}\right)}$$

$$T\_{out}=P\_{out}\*{60}/{2πn}$$

1. Plot output torque versus speed.
2. Plot Power factor versus output power.
3. Plot AC line current versus output power.
4. Plot efficiency versus output power.
5. Compare the measured results with the calculated results.
6. Comment on the wisdom of buying an induction motor having a significantly greater horse power rating than is required to do the job.
7. Explanation for the variables:

$I\_{2}^{'}$ is the rotor winding current referred to the stator winding;

$I\_{1}$ is the stator winding current;

PF is the power factor;

$P\_{in}$ is the input power (power consumed from the grid);

$P\_{out}$ is the output power (power provided to the DC generator);

$Eff$ is the efficiency;

$T\_{out}$ is the output torque;

$P\_{mech}$ is the mechanical power (power developed on the rotor);

$P\_{rot}$ is the rotational loss (windage and friction power losses);

$T\_{mech}$ is the mechanical torque;

N is the rotor speed of the induction motor ;

$V\_{t\left(L-N\right)}$is the line to neutral voltage of the induction motor stator winding;

$W\_{1}$ active power consumed from the grid by one phase of the induction motor;

$V\_{t}$ is the terminal voltage of the DC generator;

$I\_{a}$ is the armature current of the DC generator;

There is no value on the DC generator plate let's use 1 Ohm for Ra.

**Lab #2 Wiring Diagram:**

