# ELEC 302 Lab 9
# THREE PHASE INDUCTION MOTOR

REFERENCE: Appropriate chapters of ELEC 316 text.

OBJECTIVE: The objective of this experiment is to observe the basic principals of operation of an induction motor.

EQUIPMENT:

| | |
|---|---|
| Power Supply Module (0-120Vdc) | EMS 8821 |
| Resistance Module | EMS 8311 |
| Prime Mover/ Dynamometer Module | EMS 8960 |
| Wound Rotor Machine | EMS 8231 |
| Data Acquisition Interface (DAI) | EMS 9062 |
| DAI 24V Power Supply | EMS 30004 |

Notes:
1. This entire experiment is conducted at 60 Hz. All of the currents and voltages in this experiment are RMS.
2. For all portions of this experiment the induction motor should rotate in the CW (clockwise) direction. If the motor is not rotating in the CW direction, turn off the power, adjust the voltage control knob to zero, and reverse any two of the three supply voltage leads e.g., leads 4 and 6. If the motor does not turn in the CW direction after restoring power obtain instructor assistance.

## INTRODUCTION:

In this experiment, you will observe the torque-speed characteristics of a three-phase induction motor. You will also observe the behavior of the motor when the supply voltage is reduced.

## PRIOR PREPARATION:

Complete the following at a time determined by the laboratory instructor.

1. Sketch a typical torque vs. speed characteristics for an induction motor.

## PROCEDURE:

**WARNING!**
**High voltages are present in this laboratory experiment!**
**Do not make or modify any banana jack connections with the power on!**

**WARNING!**
**High speed rotating equipment are used in this laboratory experiment!**
**Ensure that loose clothing, cables, and leads are kept clear of this equipment. Do not open the protective closure when power is applied to the rotating modules!**

## Equipment Set-up

1. Verify the all components required in the equipment section are present at the EMS workstation.

2. Make sure the main power switch of the Power Supply is OFF and the voltage control knob is fully CCW. Set the voltmeter selector switch to position 4-5.

3. Ensure the Induction Motor Module is mechanically coupled the Prime Mover /Dynamometer Module using the timing belt

4. Check that the DAI USB connector is attached to the computer. Start the computer and the LVDAM EMS application. On the *File* menu open file C:\Program Files\Lab Volt\Samples\E302_9.dai. The Metering window should display meters for **E1, I1, N, and T**.

5. Select focus to the metering window by clicking on it. Select *Options* -> *Acquisition Settings*, set the *Sample Window* dialog box to *extended*. Then click OK, and close the box. Select *View* -> check *continuous refresh.*

6. Construct the Induction Motor circuit of Figure 1. Note that the stator windings are connected in a 3 phase delta configuration, and that the rotor windings are **not** connected.

## PART ONE: Induction Motor Magnetization Curve

7. Turn on the Power Supply and set the voltage control knob to obtain 60V on meter E1. Monitor both the installed EMS voltmeter, and the metering window for proper indications. If proper indications are not immediately established, turn the voltage control knob CCW , turn off the power supply, and obtain instructor assistance.

8. Open the *Data Table Application* use it to record the winding voltage (E1), winding current (I1). On the Power Supply, increase the voltage in 10V increments up to 180V. At each step record E1, and I1 in the data table.

Note that the above step requires applying a voltage that exceeds stator winding rated voltage. This will not cause any damage to the stator if applied for short periods of time. **DO NOT LINGER AT VOLTAGES ABOVE 120V.**

9. When all data is recorded, turn the voltage control knob CCW, and turn off the main power supply. Store or print the data table for your report.

10. Open the *Graph window* by selecting it from the *Data Application* toolbar. Obtain a plot of stator winding voltage (E1) vs. stator winding current (I1). Title the graph "Lab 9 Plot 1 Es vs. Is (no load) ", name the x-axis "Stator Current (amps)", and name the y-axis as "Stator Voltage (volts)." Then save or print the graph for your report.

## PART TWO: Characteristics of an Induction Motor

11. Ensure the Power Supply is turned off. Construct the circuit of Figure 2 be sure to connect the T, N, and G connections of the P.M. module to the D.A.I. module. Note that the stator windings are now connected in a wye, and all rotor windings are shorted.

12. Set the Prime Mover / Dynamometer controls as follows:
    - MODE switch ……..….DYN
    - DISPLAY switch……..……TORQUE (T)
    - LOAD CONTROL MODE switch ……..…..MAN.
    - LOAD CONTROL knob……..……MIN. (fully CCW)

13. Turn on the main voltage power supply and set the voltage control knob so that the line voltage indicated by meter E1 is 180 V. Monitor both the installed EMS voltmeter, and the metering window for proper indications. If proper indications are not immediately established, turn the voltage control knob CCW and turn off the power supply, and obtain instructor assistance.

Note: If the motor does **not** turn in the CW direction turn off the power supply and follow note 2 in the beginning of the lab.

14. Record the motor no-load speed below.

$N_{NL}$ = _____(rpm)

15. In the metering window, make sure the torque correction function is selected for meter T.

16. Open the *Data Table Application* use it to record the motor line voltage (E1), line current (I1), speed (N), and output torque (T). On the Dynamometer, adjust the LOAD CONTROL KNOB so that the torque on the display module increases by 0.1 Nm increments until the motor speed begins to decrease rapidly (breakdown torque region). For each torque setting record E1, I1, N, and T in the data table.

17. When all data is recorded, turn the voltage control knob CCW, and turn off the main power supply. Store or print the data table for your report.

18. Open the *Graph window*. Obtain a plot of motor speed (N), vs. output torque (T). Title the graph "Lab 9 Plot 2 Induction Motor N vs. T ", name the x-axis "Output Torque (Nm)", and name the y-axis as "Motor Speed (rpm)." Then save or print the graph for your report.

19. From Plot 2 record breakdown torque (knee of curve), and the minimum speed torque (locked rotor torque).

$T_{BREAKDOWN}$ = _____(Nm) $T_{LOCEDROTOR}$ = _____ (Nm)

20. Open the *Graph window*. Obtain a plot of output torque (T) vs. motor speed (N),. Title the graph "Lab 9 Plot 3 Induction Motor T vs. N ", name the x-axis "Motor Speed (rpm)", and name the y-axis as "Output Torque (Nm)." Then save or print the graph for your report.

21. Open the *Graph window*. Obtain a plot of motor line current (I1) vs. output torque. Title the graph "Lab 9 Plot 4 Line Current vs. Torque ", name the x-axis "Output Torque (Nm)", and name the y-axis as "Motor Line Current (amps). Then save or print the graph for your report.

## PART THREE: Induction Motor Characteristics at Reduced Line Voltage

22. Verify construction of the induction motor circuit of Figure 2.

23. On the Dynamometer set the LOAD CONTROL KNOB fully CCW (Min).

24. Turn on the main voltage power supply and set the voltage control knob so that the line voltage indicated by meter E1 is 150 V.

25. Repeat steps 14 through 17 above to obtain data at the reduced line voltage. Record step 14 data below.

14. $N_{NL}$ = _____(rpm)

26. Obtain a plot of motor speed (N), vs. output torque (T). Title the graph "Lab 9 Plot 5 Reduced Voltage N vs. T (E = 150V)", name the x-axis "Output Torque (Nm)", and name the y-axis as "Motor Speed (rpm)." Then save or print the graph for your report.

27. From Plot 5 record breakdown torque, and the minimum speed torque (locked rotor torque).

$T_{BREAKDOWN}$ = _____(Nm)  $T_{LOCKEDROTOR}$ = _____ (Nm)

28. Open the *Graph window*. Obtain a plot of output torque (T) vs. motor speed (N),. Title the graph "Lab 9 Plot 6 Induction Motor T vs. N ", name the x-axis "Motor Speed (rpm)", and name the y-axis as "Output Torque (Nm)." Then save or print the graph for your report.

29. Turn off the 24Vdc power supply, turn off the computer, and remove all leads. Leave the timing belt installed.

## REPORT:

Your report should be completed in the format requested by the instructor. Specifically, it must contain the following items.

1. All data tables (3) and all plots (6).

2. Does plot 1 indicate saturation of the stator above nominal terminal voltage for the wound rotor machine?

3. Use a plotting application such as Matlab® or Excel® to combine the data for plots 3 and 6 onto one set of axis for comparison. Discuss the shape of the plots. Compare the no load speeds, breakdown and locked rotor torques.

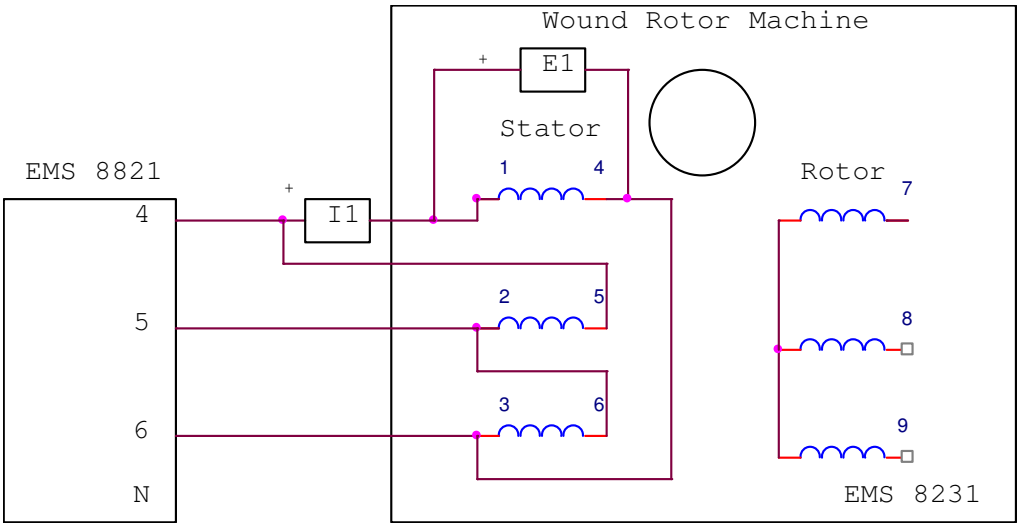


**Figure 1:** Part One Induction Motor Line Voltage vs. Line Current

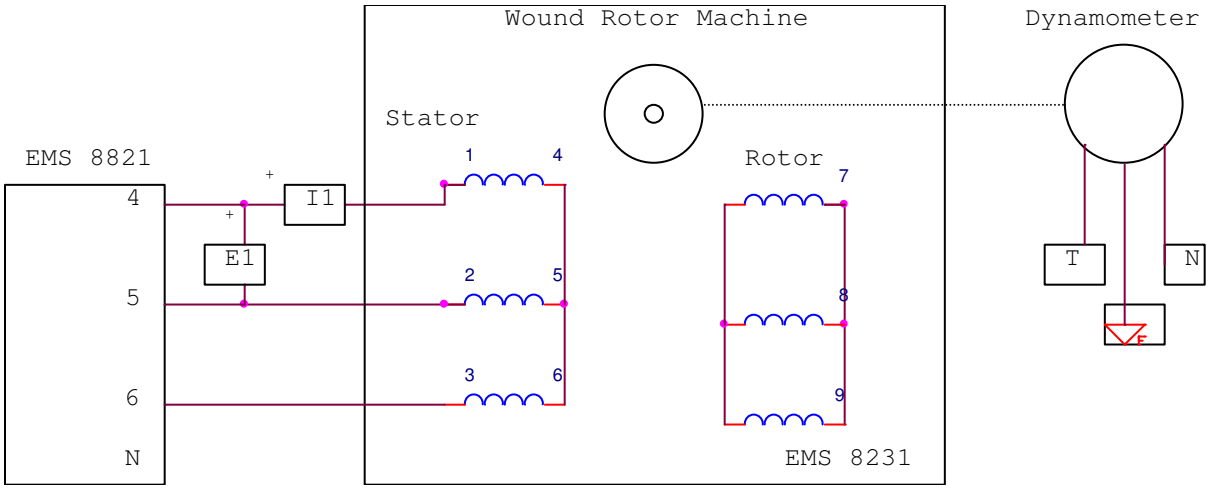


**Figure 2:** Part Two and Three Induction Motor Speed vs. Torque