

ECE 370 POWER & ENERGY SYSTEMS

EXPERIMENT 6 INTRODUCTION TO ROTATING MACHINES AND ELECTROMECHANICAL ENERGY CONVERSION

Objective

The objectives of this laboratory experiment are summarized below:

1. Gain an understanding of the electromechanical energy conversion principles.
2. Become familiar with the operation of dc machines, ac induction machines, and ac synchronous machines.
3. Learn to connect dc machines and ac induction machines as electric motors or generators.
4. Learn to use a dynamometer to measure the electrical torque.

Pre - Lab

Read the entire lab instructions, before attending the lab. Machine ratings are specified in the Hampden Instructions Manual. Read the relevant pages of the Hampden Instruction Manual before starting the experiment.

This experiment is designed to allow you to use the dynamometer to measure the performance of rotating machines. This is mainly a qualitative experiment and you will not calculate many performance indicators. However, you should pay close attention and document the consequences of a change in the control variable and/or the dynamometer loading on the input current of the test machine.

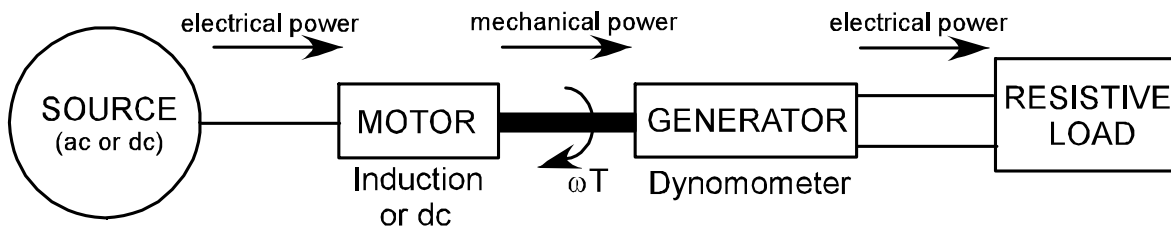


Figure 1. Electromechanical Energy Conversion.

Procedure

The following is the recommended procedure for performing this experiment. You may utilize a different procedure. However, it is suggested to observe all of the precautions expressed within the recommended procedure.

As you approach your bench, you will see the motor-generator set-up for the first part of the experiment. You will notice that an induction motor (IM-100) is mechanically connected to a dc dynamometer (DYN-100A-DM). The dynamometer is a resistively loaded dc generator (separately-excited). The electrical energy generated by the dynamometer is dissipated in the resistive load. The machine stator is mounted on bearings, so it can rotate. This is different from the conventional electric machines with the stator being bolted to the foundation. The reaction torque is provided by the blue strain gauge. Therefore, the torque produced by the generator can be displayed by the electronic LCD torque indicator. The dynamometer speed is measured by counting the visible light pulses reflected from the tape on the machine shaft coupling. The speed is displayed electronically by the red LED display.

Set all power supplies to zero volts and calibrate the torque indicator to read a zero value. Then proceed with the following parts of the experiment.

Part 1 - AC Induction Motor

1. Connect the dynamometer as shown in Figure 2. The input power is the shaft power plus the field power. Note that the output is connected to the resistive load box. Read the Hampden Manual instructions for this machine.

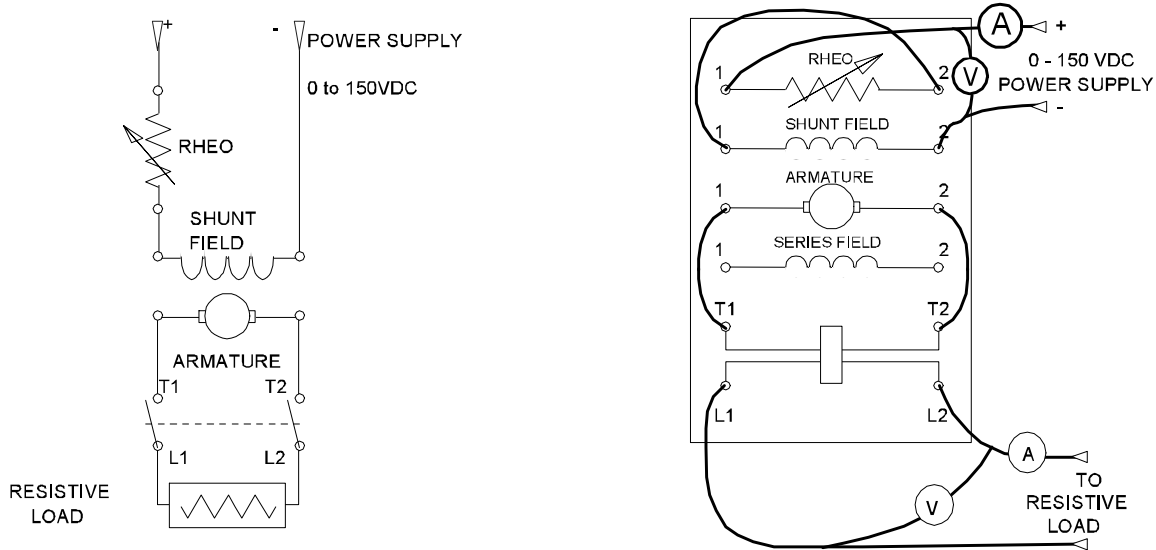


Figure 2. Dynamometer (Separately-Excited dc Generator) Connection.

2. Connect the induction motor to the variable three-phase power supply as shown in Figure 3. Read the Hampden Manual instructions for this machine.

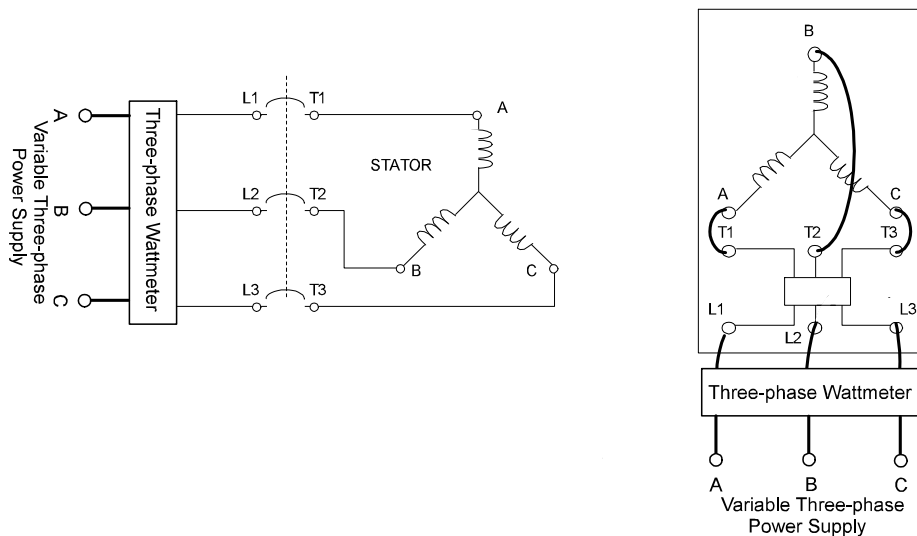


Figure 3. Three-Phase Induction Motor Connection.

Slowly increase the ac voltage until the wattmeter voltage indicates 120 V line-to-neutral (208 V line-to-line). Pay attention to the speed of the induction motor. Also, note the machine torque. This torque is due to the friction and windage losses of the dynamometer.

- Start increasing the dynamometer dc field voltage (0-150 V_{dc} 1A supply) with all load resistance switches off (down). Do not exceed the voltage rating of the field or the armature winding. Monitor the armature voltage of the dynamometer and document how the output voltage of the dynamometer changes as the field supply voltage increases. How can you tell that the dynamometer is operating as a dc generator?
- Now perform the following sensitivity studies and record the tabulated quantities. It is essential to identify the trends after you have completed this sensitivity study. Adjust the field voltage of the dynamometer to obtain 100 V for the armature voltage and keep this constant. Apply the resistive load and increase the load in four steps. Record the values of the following shaded variables in the table below. When the armature current on the induction motor is above 1.5 A, take the readings promptly to avoid overheating. Complete the table by calculating the values of the unshaded variables.

Parallel Load Ω	Shaft				Motor				Generator						
	T	rpm	rad/s	P _{shaft}	V	I	P	η	V _f	I _f	P _f	V _a	I _a	P _a	η
3 x 600															
3 x 300															
3 x 150															
All 9															

What can you conclude about efficiency and loading?

Part 2 - DC Motor

- Replace the induction machine with the dc machine. Connect the dc machine (DM100A) as shown in Figure 4. Read the Hampden Manual instructions for this machine. Remove the resistive load from the dynamometer by turning all the switches off.

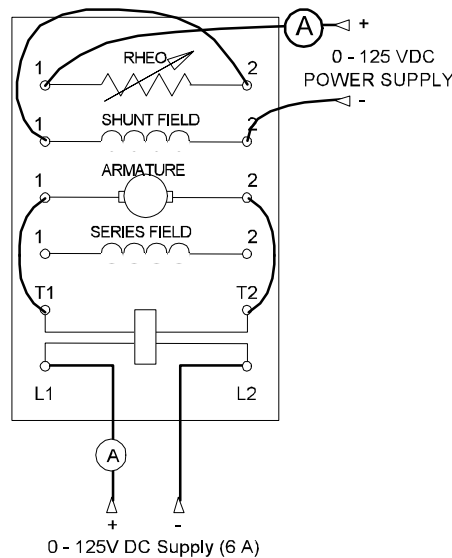


Figure 4. Connections of the Separately-Excited dc Motor.

2. Since both machines need to have both field and armature current measured all Fluke meters will have to be configured as ammeters. Use the handheld DMM to measure the voltages.
3. Set the dc motor (the machine on the left) field voltage to approximately 90% of its maximum rating. Next, increase the armature voltage from zero until the motor reaches 1500 RPM. Document how the motor speed changes as the armature voltage is increased. Reduce the motor field voltage and document how the motor speed changes.
4. Adjust the motor field current until the machine reaches 1800 RPM. Now use the dynamometer to perform the following sensitivity studies. It is essential to identify the trends after you have completed this sensitivity study. Adjust the field voltage of the dynamometer to obtain 100 V for the armature voltage and keep this constant. Apply the resistive load and increase the load in four steps. Record the values of the following shaded variables in the table below. When the armature current on either machine is above 2.5 A, take the readings promptly to avoid overheating. Complete the table by calculating the values of the unshaded variables (print the table larger if you need to). Switch-off all supplies when you are finished.

Parallel Load Ω	Shaft				Motor							Generator						
	T	rpm	rad/s	P_{shaft}	V_f	I_f	P_f	V_a	I_a	P_a	η	V_f	I_f	P_f	V_a	I_a	P_a	η
3 x 600																		
3 x 300																		
3 x 150																		
All 9																		

5. Measure the developed torque vs. armature current characteristic for a separately-excited dc motor. Proceed with the following steps:
 - a. *Lock* the dynamometer shaft.
 - b. Connect the DM-100A as a separately-excited motor. The dynamometer is left electrically disconnected.
 - c. Set both dc supplies to zero and turn them on.
 - d. Set the DM-100A field current to 0.5 A and keep this constant.
 - e. Gently increase the DM-100A armature current from 0 to 3 A in 0.5 A steps. Record the armature current and torque at each step.
 - f. Plot the torque vs. armature current characteristic of the separately-excited motor.
6. Measure the developed torque vs. armature current characteristic for a series dc motor. Proceed with the following steps:
 - a. *Lock* the dynamometer shaft.
 - b. Connect the DM-100A as a series motor, as shown in Figure 5. The dynamometer is not electrically connected.

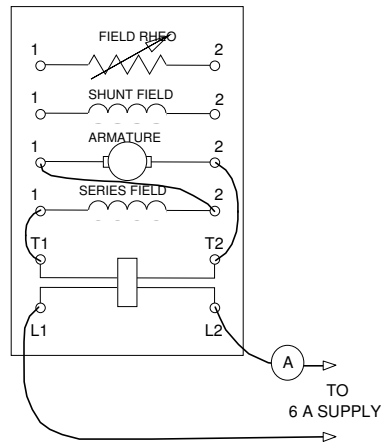


Figure 5. Series-Connected DC Motor.

- c. Set the 6 A dc supply to zero, and turn it on.
- d. Gently increase the DM-100A armature current from 0 to 3 A in 0.5 A steps. Record the armature current and torque at each step.
- e. Plot the torque vs. armature current characteristic of the series motor.

Documentation

The experiment should be documented in your lab notebook in a lab log format. Your documentation should be complete and clear, so you would be able to write a formal report based on the logged information.