

ELEC 302 Lab 6
Separately Excited DC Motor

REFERENCE: Appropriate chapters of ELEC 316 text.

OBJECTIVE: The objective of this experiment is to observe the basic principals of operation of a separately excited DC motor.

EQUIPMENT:	Power Supply Module (0-120Vdc)	EMS 8821
	Prime Mover/ Dynamometer Module	EMS 8960
	DC Motor/Generator Module	EMS 8211
	Data Acquisition Interface (DAI)	EMS 9062
	DAI 24V Power Supply	EMS 30004

INSTRUCTOR NOTE:

Prior to operation of the DC Motor /Generator ensure that the brushes are adjusted to the neutral point.

DC Motor/Generator neutral point adjustment.

Connect terminals 4-N of the AC Power Supply to the armature of the DC Motor/Generator (terminals 1-2) through current input I1 of the DAI module. Connect the shunt windings (terminals 5-6) to the voltage input E1 of the DAI module. Turn on the Power Supply and adjust the voltage to achieve a current of approximately 0.2A on meter I1. Adjust the brush adjustment lever on the DC Motor/Generator so that the voltage across the shunt winding (E1) is a minimum. Turn off the power supply and remove all leads.

INTRODUCTION:

In this experiment, you will measure the armature resistance, armature current, input voltage, torque, and speed, of a separately excited DC motor. The experiment has four parts. The first part will demonstrate the measurement of DC motor armature resistance. The second part will demonstrate the relationship between the speed of the separately excited DC motor and the armature voltage under no load conditions. The third part will investigate the relationship between motor torque and armature current. The final part will investigate DC motor saturation effects.

PRIOR PREPARATION:

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

A 120 V separately excited DC Motor is operated at a fixed field current. It has an armature resistance $R_a = 10$ ohms, and a machine constant $K = 0.1$ V/rpm. The armature current is 0.5 amps with no load, and 3.0 amps at full load. Determine the % Speed Regulation.

$$SR = \frac{n_{nl} - n_{fl}}{n_{fl}} \times 100\%$$

PROCEDURE:

WARNING!

High voltages and currents 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!

PART ONE: Measuring Armature Resistance

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 7-N.
3. Mechanically couple the Prime Mover /Dynamometer Module to The DC Motor using the timing belt.
4. Connect the LOW POWER INPUTS for the Prime Mover /Dynamometer Module and the DAI to the 24V supply and turn it on.
5. 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_6.dai. The Metering window should display meters for E1, I1, N, E2, I2, and T.
6. 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*.
7. Construct the DC Motor armature circuit of Figure 1. Set the Prime Mover / Dynamometer controls as follows:
 - MODE switchDYN
 - DISPLAY switch.....SPEED(N)
 - LOAD CONTROL MODE switchMAN.
 - LOAD CONTROL knob.....MAX. (fully CW)
8. Turn on the main voltage power supply and **slowly** adjust the DC supply voltage (7-N) to produce rated armature current (**3.0A**) as measured on meter I1. Note only 20-30 V should be required. **Do not exceed the current rating of the armature.** Quickly obtain the measurement to prevent damage to the armature winding.

Note that the motor may turn even though no field circuit is established. Without opening the protective enclosure, carefully place a large screwdriver in the notch of the rotor shaft to prevent rotation. The instructor will demonstrate.

9. Record the measured input voltage (E1) and current (I1) and compute the armature resistance R_a .

$$E1 = \underline{\hspace{2cm}} \text{ V} \quad I1 = \underline{\hspace{2cm}} \text{ A} \quad R_a = \underline{\hspace{2cm}} \Omega$$

10. Turn the voltage control knob CCW, and turn off the main power supply.

PART TWO: Motor Speed versus Armature Current

11. Complete the DC Motor connections by constructing the DC Motor field circuit of Figure 2.
12. Set the Prime Mover / Dynamometer LOAD CONTROL knob to the MIN. position (fully CCW).
13. Turn on the power supply. Leave the 0 – 120V supply (7-N) at zero volts. On the DC Motor, set the FIELD RHEOSTAT so that the field current indicated on meter I2 is 0.3A.
14. In the metering window, select the torque correction function for meter T (right click meter T, select *Meter Settings*, select *Mode* -> *C*). Meter T now indicates the DC Motor output torque.

Note that the Torque meter should be set to read in Nm (vice lbf-in). If necessary, on the main menu bar select *Tools* -> *Options* -> *units* -> select -> T(Nm), P(W).

15. Open the *Data Table Application* use it to record the input voltage (E1), armature current (I1), field current (I2), speed (N), and output torque (T). Use the power supply voltage control knob to increase armature voltage from 0 – 120 volts in approximately 10 volt steps. For each voltage setting, wait until the motor speed stabilizes, then record the data in the data table.
16. When the 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.
17. Open the *Graph window* by selecting it from the *Data Application* toolbar. Make the appropriate setting to obtain a plot of DC Motor speed (N) vs. input voltage (E1). Use the edit graph function to title the graph “Lab 6 Plot 1 N vs. E1.” Name the x-axis “Input Voltage (V dc)”, and name the y-axis as “DC Motor Speed (rpm).” Then save or print the graph for your report.

PART THREE: Motor Torque Versus Armature Current

18. Turn on the power supply. On the DC Motor, set the FIELD RHEOSTAT so that the field current indicated on meter I2 is **0.3A**.
19. On the Power Supply, adjust the voltage control knob to obtain DC Motor speed of 1500 rpm. Record the value of the input voltage (E1).

E1 = _____ V (n = 1500 rpm)

20. Open the *Data Table Application*, use it to record the input voltage (E1), armature current (I1), field current (I2), speed (N), and output torque (T).
21. On the Dynamometer, set the DISPLAY switch to the TORQUE (T) position and slowly turn the LOAD CONTROL knob clockwise to increase load torque from 0 – 1.8 Nm in increments of 0.2 Nm. For each torque setting, readjust the voltage control knob of the Power Supply to obtain the voltage recorded in step 19. After the speed stabilizes, record the data in the data table.

Note: It may not be possible to achieve 1.8 Nm of torque with out exceeding rated armature current. Monitor armature current carefully. Do not exceed its rated value of 3.0A.

22. On the Power Supply module, turn the voltage control knob CCW, and turn off the main power supply. On the Dynamometer, turn the LOAD CONTROL knob to MIN. (fully CCW). Store or print the data table.

23. Open the *Graph window*. Obtain a plot of DC Motor Torque (T) vs. Armature Current (I₁). Title the graph “Lab 6 Plot 2 Torque vs. I_a.” Name the x-axis “Armature Current (A)”, and name the y-axis as “Torque (Nm).” Then save or print the graph for your report.
24. Open the *Graph window*. Obtain a plot of DC Motor Speed (N) vs. Armature Current (I₁). Title the graph “Lab 6 Plot 3 Speed vs. I_a.” Name the x-axis “Armature Current (A)”, and name the y-axis as “Speed (rpm).” Then save or print the graph for your report.
25. Open the *Graph window*. Obtain a plot of DC Motor Speed (N) vs. Torque (T). Title the graph “Lab 6 Plot 4 Speed vs. Torque.” Name the x-axis “Torque (Nm),” and name the y-axis as “Speed (rpm)”. Then save or print the graph for your report.

PART FOUR: Effect of saturation on Torque

26. On the Dynamometer, set the Load Control knob to MAX. (fully CW). Turn on the power supply. **Slowly** adjust the voltage control knob to obtain an armature current of 1.5 A. Note only 10-20V DC should be required. On the DC Motor, set the FIELD RHEOSTAT knob fully CCW.
27. Open the *Data Table Application* use it to record the input voltage (E₁), armature current (I₁), field current (I₂), speed (N), and output torque (T). Use the Field Control Rheostat to increase the field current in 50ma (0.05A) increments. At each increment readjust the voltage control knob to maintain 1.5 A of armature current.

Note: Slightly exceeding the shunt winding rated current of 0.4 A is necessary to display the saturation effect. **Do not delay at currents above 0.4 A, do not exceed 0.45 A.**

28. When the data is recorded, turn the field rheostat knob CCW, turn the voltage control knob CCW, and turn off the main power supply. Store or print the data table for your report
29. Open the *Graph window*. Obtain a plot of DC Motor Torque (T) vs. Field Current (I₂). Title the graph “Lab 6 Plot 5 Torque vs. Field Current.” Name the x-axis “Field Current (A)”, and name the y-axis as “Torque (Nm).” Then save or print the graph for your report.
30. 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 (5).
2. Using the data from table 2 and plot 3, determine the DC motor speed regulation.
3. Using plot 1, determine the motor constant K₁ in units of volts/rpm. Using K₁, the measured value of R_a, and the input voltage from step 19, determine the DC motor speed for armature currents of 1.0, 2.0, 3.0 amps. Compare this to that recorded on plot 3, and discuss.
4. Using plot 2, determine the motor constant K₂ in units of Nm/A.
5. Compare the shape of plot 3 to plot 4, and discuss why they are similar and how they are related to K₂.
6. Discuss the shape of plot 5.

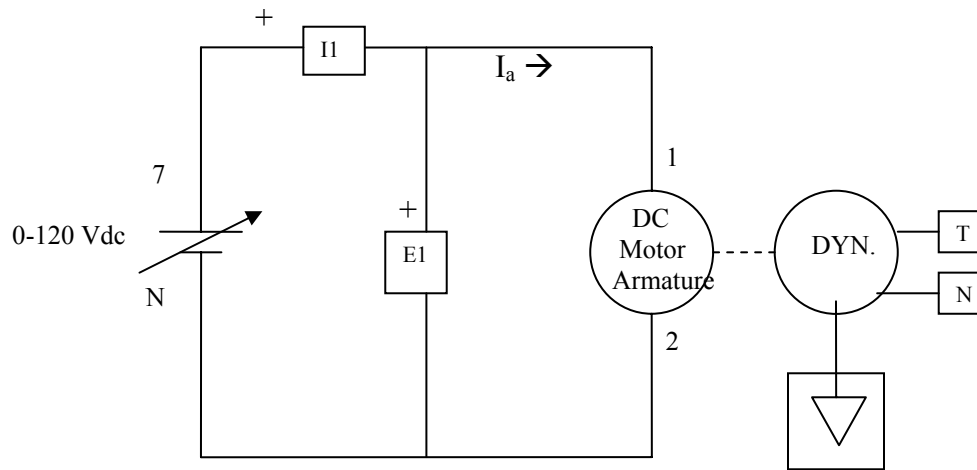


Figure 1: DC Motor Armature Circuit

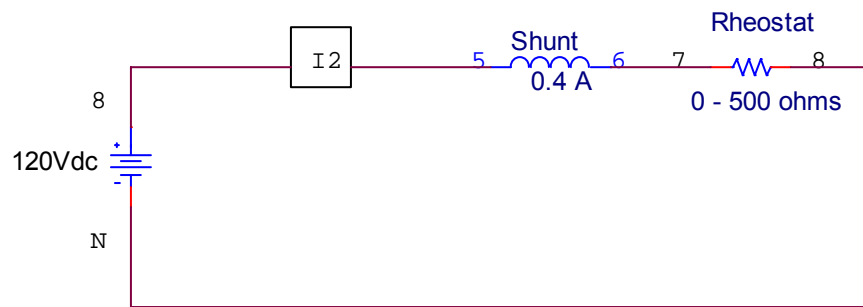


Figure 2: DC Motor Field Circuit