

Introduction – Part A

In this exercise you will investigate various characteristics of a DC generator including the saturation-curve for the machine and its armature resistance.

Procedure (Generator Testing)

1. Configure the dynamometer to function as a Prime Mover. A DC supply is required for this mode.
2. Configure the DC test machine as a separately-excited DC generator whose “*shunt*” field coil is supplied by a (second) variable DC power supply. Utilize the Data Acquisition system to measure the field current of the test machine along with its armature terminal voltage.
3. Energize the Prime Mover and adjust its supply voltage such that it is rotating at a speed of **900** rpms.
4. While keeping the speed constant, energize the supply connected to the field coil of the test machine and adjust the supply to raise the field current from **0** to **500mA** in **50mA increments**. Using the Data Acquisition system, measure and record the induced armature terminal voltage for each of the specified field-current settings.

Note: if you overshoot any current setting by more than 5mA such that you have to reduce the current to obtain the correct value, you must reduce the field current back to 0mA and begin the test again.

I_f (mA)	0	50	100	150	200	250	300	350	400	450	500
V_a (volts)											

5. Increase the speed of the test machine to **1800** rpm and repeat the measurements of step 7 while maintaining this new speed.

I_f (mA)	0	50	100	150	200	250	300	350	400	450	500
V_a (volts)											

6. Decrease the field current supplied to the DC Generator to zero and then decrease the speed of the generator by lowering the voltage supplied to the Prime Mover.

Report Guide (To Be Completed at Home)

7. Based on the voltages that you measured when the DC machine was driven at 900 rpm, **calculate a set of “theoretical” armature voltages** for the machine at a speed of 1800 rpms.
8. **Combine into a single table** both sets of measured armature voltages along with the set of “theoretical” voltages as a function of applied field current. Be sure to clearly label the speed at which each set of voltages applies.
9. **Plot all three sets of armature voltages** as a function of applied field current on one full-page plot.
10. Briefly **discuss** the relationship between induced armature voltage, field current, and rotor speed as represented by your plot.

Introduction – Part B

In this exercise you will investigate the operational characteristics of a shunt-excited DC motor under various load conditions while supplied at 100% of rated voltage and at 80% of rated voltage.

Procedure (Motor Testing)

System Configuration

1. Configure the DC test machine as a shunt-excited DC motor supplied by the variable (0-120V_{DC}) supply. Connect the “variable resistance” available on the front panel of the DC machine in series with the machine’s field circuit and set the external resistance R_{ext} to its 0Ω (CW) position.
2. Belt the test machine to the dynamometer. Be sure to connect the required 24V_{AC} supply to both the Data Acquisition Interface (DAI) and the dynamometer, and connect the “T”, “n”, and “gnd” test leads between the DAI and the dynamometer.
3. Connect the DAI to the DC test machine such that voltmeters E_1 and E_2 are both set to measure the terminal voltage V_T , ammeter I_1 is set to measure the armature current I_A , and ammeter I_2 is set to measure the field current I_F of the machine.
4. Start-up the LVDAM-EMS software. Utilizing the digital meters interface, configure the software to display the measured voltages and currents along with their associated electrical power values, and the torque, speed and mechanical power values provided by the dynamometer.

Initial Motor Startup

5. Be sure the variable DC source is initially set at zero volts. Turn **ON** the Lab-Volt supply.
6. With the field circuit’s external resistance set to 0Ω , raise the terminal voltage of the test machine from zero up to the rated voltage. Record the rotational speed of the motor and the magnitude of the field current while operating at rated voltage. Note that the machine will be operating below its rated speed.

$$n_{r(R_{ext}=0)} = \text{_____ rpm} \quad I_{f(R_{ext}=0)} = \text{_____ amps}$$

7. Slowly increase the value of the field circuit’s external resistance by rotating the knob CCW. Note that this causes the motor’s speed to increase. Raise R_{ext} until the motor is rotating at rated speed. Record the magnitude of the field current while operating at rated voltage and rated speed.

$$I_{f(\text{rated speed})} = \text{_____ amps}$$

Note: The procedure described in the steps 5 and 6 is the standard procedure that you will use whenever you need to start the motor and accelerate it up to rated speed. Once the motor is operating at rated speed, you may apply a mechanical load to the motor as needed.

Utilize the reverse procedure when stopping the motor; I.e. – remove any mechanical load, decrease the external resistance to zero, and then lower the source voltage to zero.

Motor Operation

8. A load test will now be performed on the DC machine. During this test, be sure that the terminal voltage **remains constant** at rated voltage and that the field current also remains constant.
(I.e. – do **NOT** adjust the external resistance until the entire load test is complete)
9. With zero initial torque applied by the dynamometer, use the DAI to measure and record all of the parameters specified in Table 11.1 in the 0 lb-in column.
10. Raise the load torque from 0 to 10 inch-pounds in 1 lb-in increments and record all of the parameters specified in Table 11.1 at each load-step.
11. Once all the measurements for Table 11.1 have been completed, decrease the load torque to zero.
12. Decrease the terminal voltage to 80% of rated voltage and then re-adjust the external resistance until the motor is once again rotating at rated speed.
13. Repeat the previous load test, but this time only vary the load torque from 0 to 8 inch-pounds. Be sure that the terminal voltage and the field current **remain constant** during this load test.
14. Once all load-steps have been performed, stop the motor following the correct procedure and turn **OFF** the main supply.
15. Have your instructor check your results before removing all connections to the test machine.

Report Guide (To Be Completed at Home)

16. For both 100% and 80% rated voltage operation, **calculate the total electric power** supplied to the DC motor at each operating point by summing the armature and field circuit powers. **Add a row** to each of your data tables (immediately below the rows displaying P_F) and label the new row P_{elec} . Display your calculated values for P_{elec} in the appropriate tables.
17. For both 100% and 80% rated voltage operation, **calculate the efficiency** of the motor at each operating point. **Add a row** at the bottom of your data tables to display the calculated efficiencies.
18. On one full page, **plot the load torque** of the motor as a function of **rotor speed**.
19. On a second full page, **plot the efficiency** of the motor as a function of (shaft) **output power**.
20. Briefly **discuss** the operation of the motor in terms of operational efficiency, taking into account the rated shaft power ($\frac{1}{4}$ hp) of the motor. Is it better to purchase a motor that is rated much higher than the load that the motor will be required to drive?

Loss Investigation

21. Reconfigure the system such that the Test Machine is wired as a separately-excited DC machine. Connect the shunt field-winding in-series with both the external resistor and an external switch.
22. Connect the **constant** 120V_{DC} source across the entire field circuit. (Do not energize the source!)
23. Configure the Data Acquisition system to measure the field current supplied to the Test Machine.
24. Switch the dynamometer to function as a Prime Mover and supply the Prime Mover with the variable (0-120V) DC source. Be sure the variable DC source is initially set at zero volts.

25. Configure the Data Acquisition system to measure both the voltage and the current supplied to the dynamometer.
26. Turn ON the Lab-Volt supply.
27. Increase the value of the field circuit's external resistance until the field circuit is being supplied with the same current as that measured in Step 7 when the motor was rotating at rated speed.
28. Increase the DC voltage supplying the Prime Mover until the system is rotating at the rated speed of the Test Machine. Measure and record the DC voltage, current, and power being supplied to the Prime Mover by the variable DC source (with the Test Machine at Full Excitation).
29. Turn OFF the external switch connected in-series with the field winding.
30. Adjust the DC voltage supplying the Prime Mover until the system is rotating at the rated speed of the Test Machine. Measure and record the DC voltage, current, and power being supplied to the Prime Mover by the variable DC source (with the Test Machine at Zero Excitation).
31. Turn OFF the Lab-Volt supply.
32. Remove the belt connecting the shafts of the Test Machine and the Prime Mover.
33. Turn ON the Lab-Volt supply.
34. Adjust the DC voltage supplying the Prime Mover until it is rotating at the rated speed of the Test Machine. Measure and record the DC voltage, current, and power being supplied to the Prime Mover by the variable DC source.
35. Turn OFF the Lab-Volt supply.
36. Have your instructor check your results.

Report Guide (To Be Completed at Home)

37. Based on the measurements performed during the Loss Investigation, determine:
 - a) The **friction and windage losses** in the system at rated speed when the Test Machine is belted to the dynamometer, and
 - b) The **iron losses** in the Test Machine at full excitation when rotating at rated speed.
38. Briefly **discuss** the impact that the results of the Loss Investigation would have if incorporated into the Efficiency Calculations performed during the Motor Operation portion of this experiment

Generator Operation – Part A Steps 4 & 5

I_f (mA)	0	50	100	150	200	250	300	350	400	450	500
V_a (V)[900RPM]											
V_a (V)[1800RPM]											

Initial Motor Startup – Part B

Step 6: **n_r(R_{ext}=0) = _____ rpm I_f(R_{ext}=0) = _____ amps**

Step 7: **I_f(rated speed) = _____ amps**

Motor Operation – Part B

V_A (volts)											
I_A (amps)											
P_A (watts)											
V_F (volts)											
I_F (amps)											
P_F (watts)											
T_{shaft} (lb·in)	0	1	2	3	4	5	6	7	8	9	10
n_r (rpm)											
P_m (watts)											

Table 11.1 – Load Test Parameters for the DC Motor Operating at 100% Rated Voltage

V_A (volts)										X	X
I_A (amps)										X	X
P_A (watts)										X	X
V_F (volts)										X	X
I_F (amps)										X	X
P_F (watts)										X	X
T_{shaft} (lb·in)	0	1	2	3	4	5	6	7	8	9	10
n_r (rpm)										X	X
P_m (watts)										X	X

Table 11.2 – Load Test Parameters for the DC Motor Operating at 80% Rated Voltage

Loss Investigation

Step 28 – Prime Mover with DC at Full Excitation

V_{FE} = _____ volts I_{FE} = _____ amps P_{FE} = _____ watts

Step 30 – Prime Mover with DC at Zero Excitation

V_{ZE} = _____ volts I_{ZE} = _____ amps P_{ZE} = _____ watts

Step 34 – Prime Mover Only

V_{PM} = _____ volts I_{PM} = _____ amps P_{PM} = _____ watts

