Experiment 3

The Direct Current Motor – Part II

OBJECTIVE

- To locate the neutral brush position.
- To learn the basic motor wiring connections.
- To observe the operating characteristics of series and shunt connected motors.

DISCUSSION

In order of a DC motor to run, current must flow in the armature winding. The stator must develop a magnetic field (flux), either by means of a shunt winding or a series winding (or both).

The torque developed by a DC motor is directly proportional to the armature current and the stator flux. On the other hand, motor speed is mainly determined by the armature voltage and the stator flux. Motor speed increases when the voltage applied to the armature increases. Motor speed will also increase when the stator flux is reduced. As a matter of fact, the speed can attain dangerous proportions if, accidentally, there is a complete loss of the stator field. DC motors have been known to fly apart under these overspeed conditions. However, your DC motor has been carefully designed to withstand possible overspeed condition.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart, in Appendix A of this manual, to obtain the list of equipment required to perform this exercise.

PROCEDURE

CAUTION!

High voltages are present in this Experiment! Do not make any connections with the power on! The power should be turned off after completing each individual measurement!

Finding the Neutral

☐ 1. You will now determine the neutral brush position for your DC motor by using alternating current. Using your Power Supply, AC Voltmeter and DC Motor/Generator, connect the circuit shown in Figure 3-1. Terminals 4 and N on the power supply will furnish variable 0-120 V ac as the voltage output control is advanced.

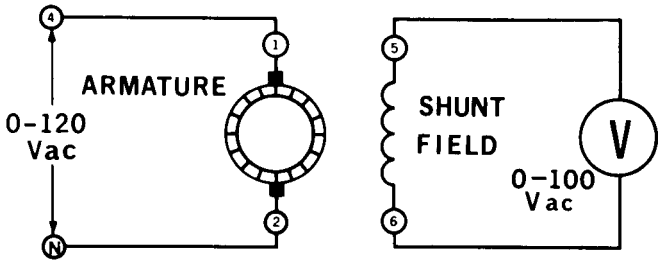

Figure 3-1.

DO NOT APPLY POWER AT THIS TIME!

☐ 2. Unlock the DC Motor/Generator and move it forward approximately 10 cm [4 in]. Reach behind the front face of the module and move the brush positioning lever to its maximum clockwise position. Do not slide the module back in place (you will later move the brushes again).

☐ 3. Turn on the power supply. Place the power supply voltmeter switch to its 4-N position. Slowly advance the voltage output control until the AC voltmeter connected across the shunt field winding indicates approximately 80 V ac. (The AC voltage across the shunt field is induced by the AC current through the armature. This will be covered in a later Experiment).

☐ 4. a. Carefully reach behind the front face of the module (preferably keeping one hand in your pocket) and move the brushes from one extreme position to another. You will notice that the induced AC voltage across the field drops to zero and then increases again as you approach the other extreme counter-clockwise position.

b. Leave the brushes at the position where the induced voltage is zero. This is the neutral point of your DC Motor/Generator.

Each time you use the DC Motor/Generator the brushes should be set at the neutral position.

c. Return the voltage to zero and turn off the power supply. Slide your DC Motor/Generator back in place and disconnect your circuit.

Series Motor Connections

☐ 5. Using your Power Supply, DC Voltmeter/Ammeter and DC Motor/Generator, connect the circuit shown in Figure 3-2. Notice that the armature is connected in series with the series field winding, across the input voltage.

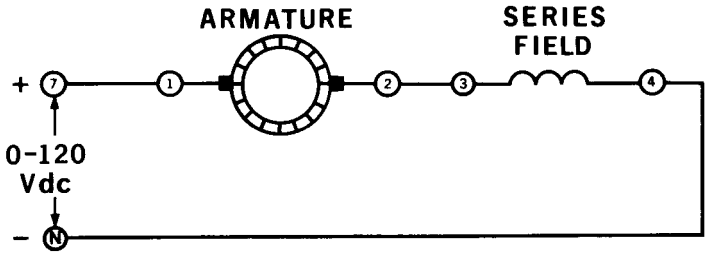

Figure 3-2.

☐ 6. Turn on the power supply. Place the power supply voltmeter switch to its 7-N position. Adjust the output voltage to 120 V dc.

☐ 7. a. Does the motor turn fast?

☐ Yes ☐ No

b. Using your hand tachometer, measure the motor speed in revolutions per minute.

Series speed = _____ r/min

Note: *The operating instructions are enclosed within the tachometer container.*

☐ 8. a. Reduce the power supply voltage and note the effect on motor speed. Comments:

_____

b. Reduce the voltage until you can determine the direction of rotation (clockwise or counterclockwise).

Rotation = _____

c. Reduce the voltage to zero and turn off the power supply.

☐ 9. Reconnect your circuit as shown in Figure 3-3. (The only change made to the circuit of Figure 3-2 is that the connections to the armature have been reversed).

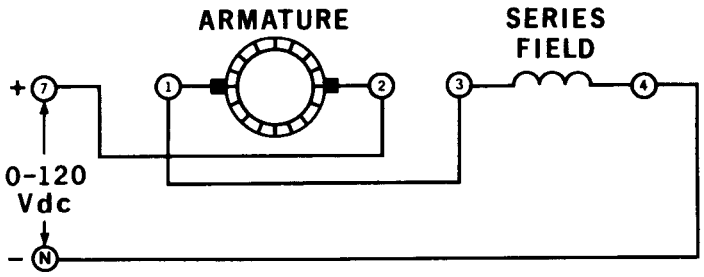

Figure 3-3.

☐ 10. Repeat procedures 6 through 8 (using the reversed armature connections shown in Figure 3-3).

Series $speed_{(reversed)}$ = _____ r/min

Rotation = _____

☐ 11. State a rule for changing the direction of rotation of a series connected DC motor.

_____

Shunt Motor Connections

☐ 12. Connect the circuit shown in Figure 3-4. Notice that the rheostat is in series with the shunt field, and that this combination is in parallel with the armature, across the input voltage.

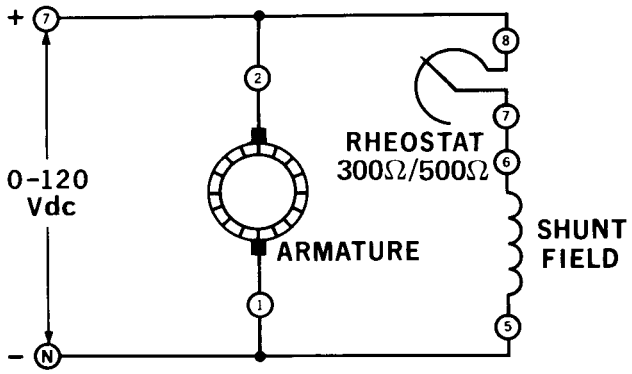

Figure 3-4.

☐ 13. a. Adjust the rheostat for minimum resistance (approximately 0 Ω, when turned fully clockwise).

b. Turn on your power supply and adjust for 120 V dc.

c. Using your tachometer measure the motor speed.

Shunt speed$_{(\text{zero ohms})}$ = _____ r/min

d. Adjust the rheostat for maximum resistance (approximately 500 Ω).

e. Determine the direction of rotation.

Rotation = _____

☐ 14. a. Return the voltage to zero and turn off the power supply.

b. Reverse the polarity of the input voltage by interchanging the power supply connection leads only.

☐ 15. Repeat procedure 13 and compare your results:

a. Did the rotation change direction?

☐ Yes ☐ No

b. Did the speed change?

☐ Yes ☐ No

c. Return the voltage to zero and turn off the power supply.

☐ 16. Interchange the connection leads to the power supply. Your circuit should be the same as the one shown in Figure 3-4. Now reverse the connections to the armature only.

☐ 17. Repeat procedure 13 and compare the direction of rotation to that found in procedure 13.

Rotation = _____

☐ 18. a. While the motor is still running, momentarily open the shunt field circuit by removing the connection lead from one of the terminals of the shunt field winding (5 or 6). Be extremely careful not to touch any of the other terminal connections or any metal during this procedure. Be prepared to immediately cut power to the motor by turning off the power supply.

b. Explain what happens when a DC motor loses power to its shunt field.

_____

_____

c. Could the same thing occur in a series field connected DC motor? Explain.

☐ Yes ☐ No

_____

_____

☐ 19. Connect the circuit shown in Figure 3-5. Note that the armature is connected to the variable 0-120 V dc output (terminals 7 and N) while the shunt field is now connected to the fixed 120 V dc output (terminals 8 and N).

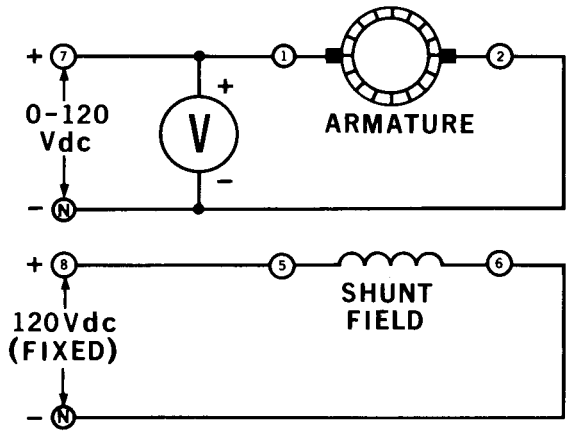

Figure 3-5.

☐ 20. a. Turn on the power supply. Adjust the armature voltage to 30 V dc as indicated by the meter.

b. Use your hand tachometer and measure the motor speed. Record your speed measurement in Table 3-1. (Wait until the motor speed stabilizes before you take your measurement).

c. Repeat (b) for each of the voltage values listed in the Table. Return voltage to zero and turn off the power supply.

E (volts)	**0**	**30**	**60**	**90**	**120**
SPEED (r/min)	**0**				

Table 3-1.

d. Plot each of the points from Table 3-1 on the graph shown in Figure 3-6. Draw a smooth curve through your plotted points.

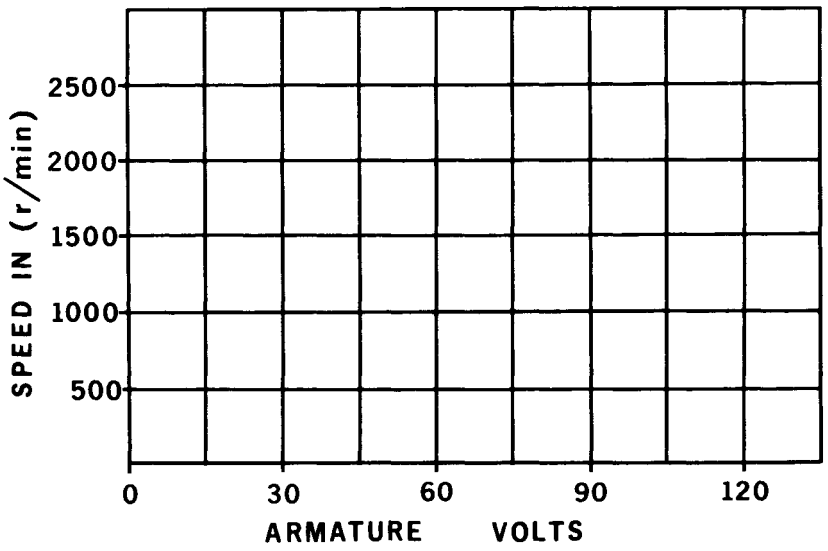

Figure 3-6.

e. Does varying the armature voltage (with the shunt field voltage held constant) offer a good method of speed control?

☐ Yes ☐ No

REVIEW QUESTIONS

1. Explain how to locate the neutral brush position in a DC motor.

_____

2. Would the motor turn if only the armature were excited (had voltage applied across it)?

☐ Yes ☐ No

3. Why is it dangerous to supply power to an unloaded series connected DC motor?

_____

4. In what two ways may the rotation of a shunt connected DC motor be reversed?

_____

5. Why are field loss detectors necessary in large DC motors?

_____

6. In procedure 20:

   a) Does the motor speed double when the armature voltage is doubled? Explain.

      ☐ Yes ☐ No

      _____

   b) Would it be correct to say “with a fixed field voltage, the speed of a shunt motor is proportional to its armature voltage?” Explain.

      ☐ Yes ☐ No

      _____

7. Draw a circuit showing how you would connect:

   a) a shunt motor to a DC supply.

b) a shunt motor to a DC supply, using a field rheostat.

c) a series motor to a DC supply.

8. In what two ways can the speed of DC motor be varied?

a) _____

b) _____

9. Of the two methods given in (8):

   a) which method gives the greatest speed range? _____

   b) which method is the most economical (uses fewer parts)? _____