EET 365 ELECTRICAL POWER AND MACHINERY LAB
EXPERIMENT 2

Direct Current Generator Polarity and Saturation Curve

PURPOSE: To show the dependence of the output polarity of a self-excited shunt generator on direction of field flux and rotation, and to develop the saturation curve for a DC generator.

APPARATUS: 1 DM-100A DC Machine 1 0-5 Ampere DC Ammeter
1 Fluke Digital Voltmeter
1 SPM-100 Split Phase AC motor (prime-mover)

REFERENCES: Electric Machines; Theory, Operation, Applications, Adjustment, and Control by Charles I. Hubert, or Electrical Machines, Drives, and Power Systems by Theodore Wildi.

DISCUSSION:

The voltage induced in a conductor is dependent on the flux density and orientation, conductor velocity, and length of the conductor. In a DC generator, these factors are dependent on direction of rotation, number and size of armature conductors, and the field current which sets up the magnetic flux. In part A of this experiment, you will examine how these factors affect the output voltage polarity and magnitude of a self-excited generator. You will also examine two ways to reverse the output voltage polarity other than reversing the connections to the entire generator.

In the second part of this experiment, you will vary the field current over a wide range on a separately-excited DC generator. In any particular DC generator, the generated emf is directly proportional to the magnetic flux produced by the current in the field windings and the speed at which the armature conductors cut the magnetic flux. In this experiment, the speed of the generator is kept essentially constant, using a single-phase AC motor as a prime mover. Thus, the generated emf will be proportional to the magnetic flux. However, due to magnetic saturation of the iron, the flux, and therefore the generated emf, will not be proportional to the field current. The effect of this magnetic saturation can be determined by plotting the relationship between the generated emf and the field current.

PROCEDURE:

A. Shunt Generator Output Polarity:

1. Couple the DC generator to the prime mover (AC motor) and connect the 120 VAC to the motor as shown in Figure 2-1. Install the shield over the shaft coupling. Have the instructor check your connections.

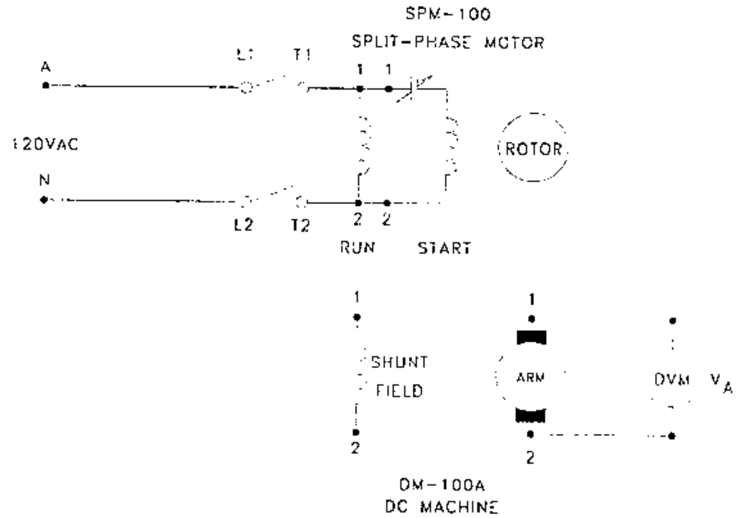

Figure 2-1

2. Connect only the digital multimeter across the armature connections (1 and 2) of the DC generator and set the meter to read DC volts on the 20 volt scale. Start the AC motor and measure the DC voltage on the armature terminals (to avoid confusion in reading the polarity, if the digital voltmeter reads negative, reverse the voltmeter leads). This voltage is due solely to the residual flux in the field poles. Record in Table 2-1 the generated voltage E_g, which armature terminal is positive, and the direction of rotation. Let CW or CCW be as seen looking at the generator end of the test stand.

3. Now add the shunt field connections as shown in Figure 2-2. Change the digital voltmeter to the 200 volt DC range. Start the motor and observe that the generator output voltage is 115-155 VDC. If the voltage does not build up, stop the AC motor, reverse the shunt field connections, and repeat. Record the generated voltage E_g, the field and armature connections, and the direction of rotation in Table 2-1. This is the <u>NO-LOAD</u> generator voltage.

Step No.	Generated Voltage E_g	+ Armature Terminal (1 or 2)	+ Field Terminal (1 or 2)	Direction CW or CCW
2			N/A	
3				Same as 2
4			N/A	
5				Same as 4
6				Same as 2

Table 2-1

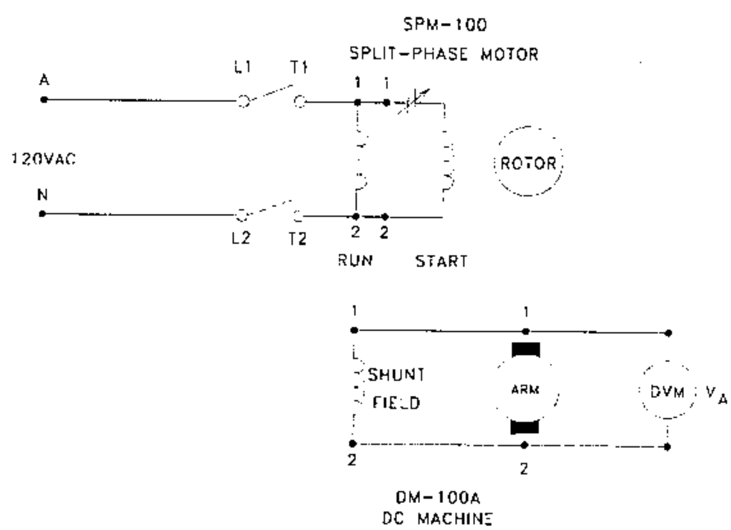

Figure 2-2

4. Stop the motor and reverse the direction of rotation by reversing the connections to the AC motor start winding. Disconnect the field and repeat Step 2. Record your measurements in Table 2-1.

5. In order to cause the generator to build up in this direction of rotation, it will be necessary to reverse the shunt field connections from those of Step 3, since the voltages induced by the shunt field and the residual flux must be of the same polarity. Make this change and repeat the procedure of Step 3. Record your measurements in Table 2-1.

6. Another way to reverse the output polarity of a DC generator is to simply reverse the connections of both the field and armature. However, it is sometimes necessary to obtain reversed polarity without changing the direction of rotation, as might be the case if the generator were driven by a non-reversible prime mover such as a turbine. This can be done if the residual flux is reversed by <u>flashing the field</u>. Disconnect the shunt field from the circuit and connect it directly to 125 VDC from the 0-150 VDC supply with the polarities reversed from that used in Step 3. This will magnetize the core in the opposite direction. Leave 125 VDC applied to the shunt field for approximately 20 seconds. Referring to Table 2-1, reconnect the shunt field to the armature terminals as in Step 3 and repeat the rest of Step 3. Make sure the direction of rotation is the same as in Step 3. Record your measurements in Table 2-1.

B. <u>Generator Saturation Curve</u>:

1. Connect the DC generator as a separately-excited generator as shown in Figure 2-3.

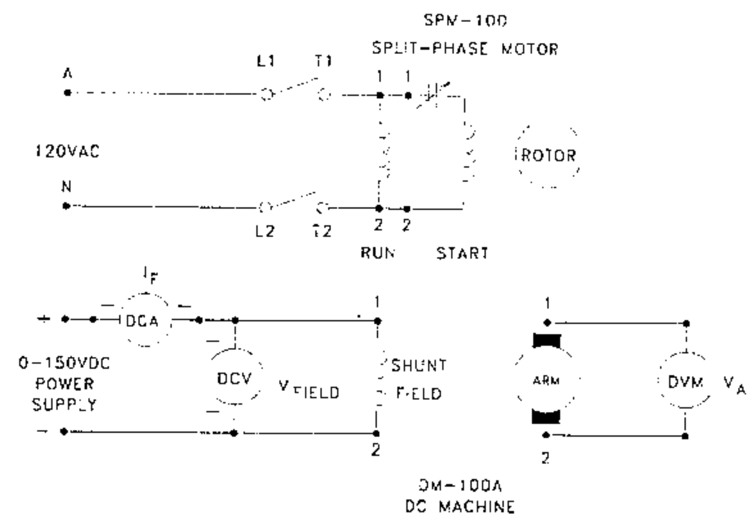

Figure 2-3

2. With the 150 VDC power supply turned off, turn on the AC motor and measure the armature voltage of your generator with no field current. This is the voltage due to residual magnetism or flux. Record the armature voltage on the first line of Table 2-2.

3. Turn on the DC power supply and slowly increase the voltage. Measure and record in Table 2-2 the armature voltage every 0.04 amperes (40 milliamperes) of field current, until the DC power supply reaches 150 VDC or the table is filled. Avoid having to decrease field current to get to a measurement point.

Field Current	Armature Voltage	Field Current	Armature Voltage
0.00		0.40	
0.04		0.44	
0.08		0.48	
0.12		0.52	
0.16		0.56	
0.20		0.60	
0.24		0.64	
0.28		0.68	
0.32		0.72	
0.36		0.76	

Table 2-2

4. Turn off all power, and disconnect and store all equipment.

PRESENTATION OF RESULTS:

1. Sketch simple DC circuit schematics of the five conditions (Steps 2 to 6) found in Section A. Show the armature, shunt field, and DC power supply (do not show the prime-mover). Note polarities and terminal designations

of the components. Indicate the direction of rotation. Annotate with any pertinent comments.

2. Discuss the various ways by which the polarity of the terminals of a DC self-excited shunt generator may be changed.

3. Prepare a graph with armature voltage as the vertical axis and field current as the horizontal axis. On the graph, plot the following two lines.

   a) Saturation Curve - This is the data from Table 2-2. See Figure 12-1 of the reference.

   b) Field Resistance Line or Field Excitation Line - Using the shunt field resistance found in Experiment #1 calculate the field voltage (using Ohm's law) at I_F = 0.5 amp. Plot the point on the graph and extend a straight line from the origin through this point to the edge of the graph. When you label this line, indicate the value of shunt field resistance R_{SF}. See Figure 12-1 of the reference.

4. The intersection of the saturation curve and field excitation line should be the NO-LOAD generator voltage. Compare this value to that found in Step 3 of Table 2-1. Comment on the similarity or difference between the two points.

5. Comment on your overall results.