EXPERIMENT MD2: CHARACTERISTICS OF DIRECT CURRENT POWER GENERATOR

Related course: KIE2009 (Machines and Drives) or KEEE2252 (Electrical Machines and Drives)

OBJECTIVES:
To study DC generator characteristics and compare characteristics of different excitation

EQUIPMENT:
DC generator driven by DC motor, load resistors, voltmeter, ammeter

INSTRUCTIONS:
1. Record all your results and observations in a log book
2. A DC motor must be started at maximum resistance in the armature circuit and minimum resistance in the field circuit
3. Make sure that the shunt field current of DC generator is zero or at its minimum before DC motor is started
4. Use appropriate level of voltage and current to measure armature winding resistance and field winding resistance
5. Your circuits/connections must be checked by lab demonstrator/technician before the test in conducted.

REFERENCE(S):
Refer to the main references of KIE2009 or KEEE2252

TESTS:
Test 1: Starting of DC motor
Test 2: Shunt generation – Separately-excited (Load Characteristics)
Test 3: Shunt generation – Self-excited (Load Characteristics and Voltage Control)
Test 4: Compound generation – Separately-excited (Load Characteristics)
Test 5: Compound generation – Self-excited (Load Characteristics)

INTRODUCTION:

A simple DC generator consists of the same basic elements as a simple AC generator: i.e., a multi-turn coil rotating uniformly in a magnetic field. The main difference between a DC generator and an AC generator lies in the manner in which the rotating coil is connected to the external circuit containing the load. In an AC generator, both ends of the coil are connected to separate slip-rings which co-rotate with the coil, and are connected to the external circuit via wire brushes. In this manner, the emf seen by the external circuit is always the same as the emf generated around the rotating coil.

In a DC generator, the two ends of the coil are attached to different halves of a single split-ring which co-rotates with the coil. The split-ring is connected to the external circuit by means of metal brushes. This combination of a rotating split-ring and stationary metal brushes is called a commutator. The purpose of the commutator is to ensure that the emf seen by the external circuit is equal to the emf generated around the rotating coil for half the rotation period, but is equal to minus this emf for the other half (since the connection between the external circuit and the rotating coil is reversed by the commutator every half-period of rotation). The positions of the metal brushes can be adjusted such that the connection between the rotating coil and the external circuit reverses whenever the emf generated around the coil goes through zero.

The variation of the emf with time is very similar to that of an AC generator, except that whenever the AC generator would produce a negative emf, the commutator in the DC

generator reverses the polarity of the coil with respect to the external circuit, so that the negative half of the AC signal is reversed and made positive. The result is a bumpy direct emf which rises and falls but never changes direction. This type of pulsating emf can be smoothed out by using more than one coil rotating about the same axis, or by other electrical techniques, to give a good imitation of the direct current delivered by a battery.

TEST 1: Starting of DC motor

1. Study and understand the DC generator and DC motor to be used. Obtain the ratings of both machines.
2. Study and understand the panels for circuit connection. Make sure that you understand the functionalities of all equipment to be used.
3. Starting of shaft driving DC motor:
   a) Request a lab demonstrator to demonstrate the procedures to start a shaft-driving DC motor. All students are required to have hand-on experience on starting a DC motor.
   b) Students are not required to connect circuitry for DC motor.
4. Measure the resistances of DC motor with an ohm-meter.

TEST 2: Shunt generation - Separately-excited (Load characteristics)

1. Connect the circuit as shown in Figure 1. Adjust the moveable contact of shunt resistor to position 'q' (maximum load). Start the generator (by starting the shaft-driving DC motor) and adjust load torque to achieve and maintain motor speed, N of 2500rpm.
2. Adjust field voltage for the field current, I_F to achieve and maintain at 0.1 A. Adjust the load resistance in steps to control the armature current, I_A given in Table 1 and obtain the corresponding generator voltage, V_G.

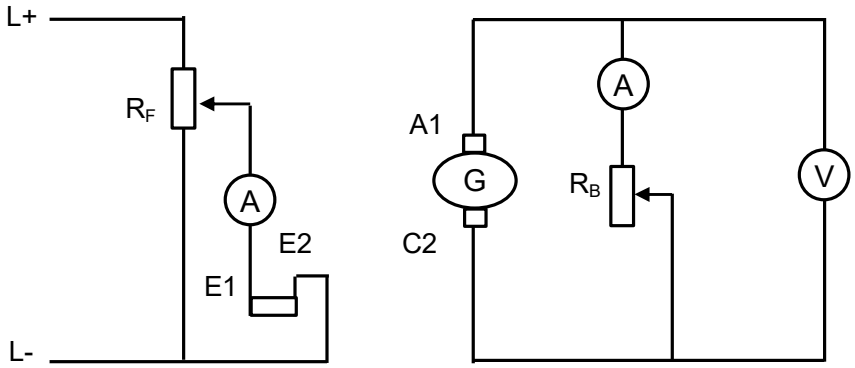


Figure 1: Connection for Shunt-generator (separately excited)

Table 1

Speed, N (rpm)	Field current, I_F (A)	Armature current, I_A (A)	Generated Voltage, V_G (V)	Generated Power, $P_2=V_GI_A$
2500	0.1	0.5		
		1.0		
		1.5		

		2.0		
		2.5		
		3.0		
		3.5		

QUESTIONS:

1. From Table 1, plot the graph of generated voltage, V_G and generated power, P_2 versus armature current, I_A. Then, find the maximum power point.
2. Discuss the results obtained from Table 1.

TEST 3: Shunt generation - Self-excited (Load Characteristics and Voltage control)

1. Connect the circuit as shown in Figure 2, Start the generator and adjust load torque to achieve speed of 2500 rpm. Adjust the field current, I_F to reach 0.07 A and maintain it throughout the test.
2. Adjust the armature current, I_A by varying the moveable contact of load resistor, as shown in Table 2, and obtain the corresponding generated voltage, V_G.

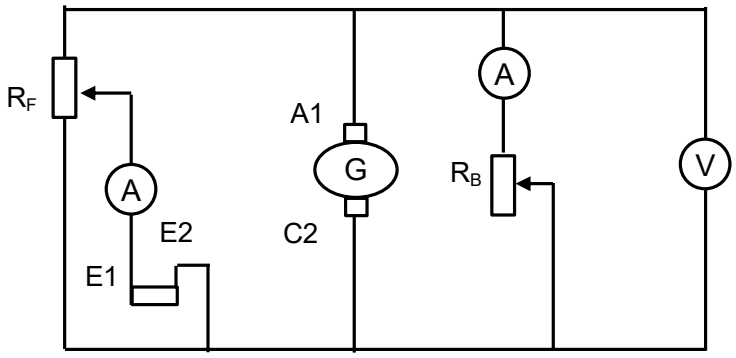


Figure 2

Table 2

Speed, N (rpm)	Field current, I_F (A)	Armature current, I_A (A)	Generated Voltage, V_G (V)
2500	0.07	1.0	
		2.0	
		2.5	
		3.0	
		3.5	
		4.0	

3. Adjust load torque for the armature current, I_A to achieve 2A and maintain it throughout the test. Adjust shunt resistance in steps to achieve the field current, I_F shown in Table 3 and obtain the corresponding generated voltage, V_G.

Table 3

Speed, N (rpm)	Armature current, I_A (A)	Field current, I_F (A)	Generated Voltage, V_G (V)
2500	2.0	0.03	
		0.05	
		0.07	
		0.10	
		0.15	
		0.20	

QUESTIONS:

1. Compare Table 2 and Table 3 and give comments referring to readings obtained.

TEST 4: Compound generation – Separately-excited (Load Characteristics)

1. Connect the circuit as shown in Figure 3. Adjust the shunt field resistance to position 'q' and load to its maximum.
2. Start the generator and adjust load torque to achieve and maintain speed, N at 2500 rpm. Adjust the shunt field resistance to achieve and maintain field current, I_F at 0.13A. Armature current, I_A can be adjusted by varying the load resistance. Complete Table 4.

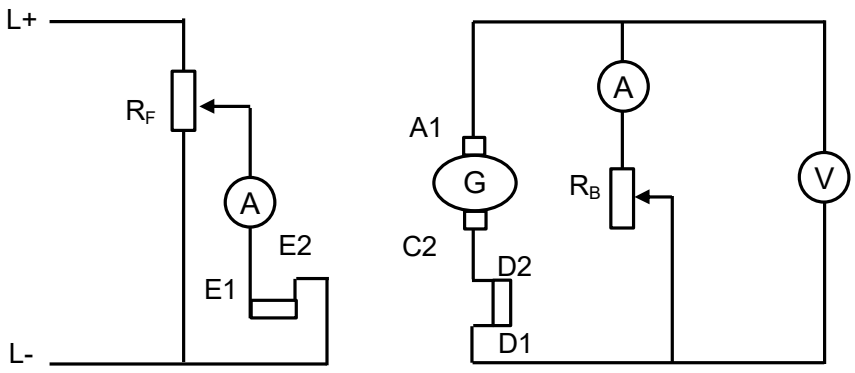


Figure 3

Table 4

Speed, N (rpm)	Field current, I_F (A)	Armature current, I_A (A)	Generated Voltage, V_G (V)	Generated Power, $P_2=V_GI_A$
2500	0.13	0.5		
		1.0		
		1.5		
		2.0		
		2.5		
		3.0		

QUESTIONS:

1. From Table 4, plot V_G versus I_A and P_2 versus I_A in one graph.
2. Give comments for adding series field winding to shunt field winding in compound generation.
3. From Table 4, give comments on the effect of field current, I_F and armature current, I_A on the generated voltage, V_G.

TEST 5: Compound generation – Self-excited (Load Characteristics)

1. Connect the circuit as shown in Figure 4. Adjust the shunt field resistance to position 'q' and load to its maximum. Start the generator and adjust load torque to achieve and maintain speed, N at 2500 rpm. Adjust the shunt field resistance to achieve and maintain field current, I_F at 0.13 A.

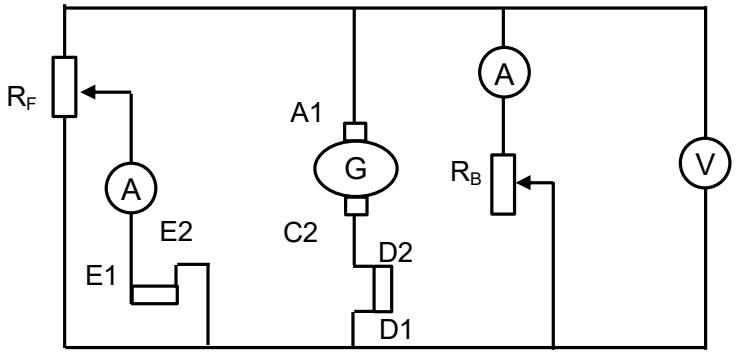


Figure 4

Table 5

Speed, N (rpm)	Field current, I_F (A)	Armature current, I_A (A)	Generated Voltage, V_G (V)	Generated Power, $P_2=V_GI_A$
2500	0.13	0.5		
		1.0		
		1.5		
		2.0		
		2.5		
		3.0		

QUESTIONS:

1. From Table 5, plot V_G versus I_A and P_2 versus I_A in one graph.
2. Give comments for adding series field winding to shunt field winding in compound generation.
3. From Table 5, give comments on the effect of field current, I_F and armature current, I_A on the generated voltage, V_G.

END OF EXPERIMENT