EXPERIMENT P1: CHARACTERISTICS OF THREE-PHASE GENERATOR

Related course: KIE3009 (Energy Conversion and High Voltage Transmission)

OBJECTIVES:
To investigate the characteristics of a three-phase generator

EQUIPMENT:
Motor-generator set, voltmeter, ammeter, DC power supplies, 3-phase resistive load

INSTRUCTIONS:
1. Record all your results and observations in a log book / paper
2. Follow the demonstrator's instructions throughout the experiment

REFERENCE(S):
Refer to the main references of KIE3009

TESTS:
Test 1: Open-Circuit Test
Test 2: Short-Circuit Test
Test 3: Load Test

INTRODUCTION:

Generator converts mechanical to electrical energy. Generators are driven by steam turbine, hydro turbines or gas turbines. Stator is a stationary part where the armature windings are, while rotor is a rotating part. The equivalent circuit of a generator is shown in Figure A, where V_G is the generated e.m.f., I_A is the load current, V is the terminal voltage, X is the generator reactance, R_A is the armature resistance, V_F is the field voltage, I_F is the field current, R_F is the field resistance and L_F is the field inductance.

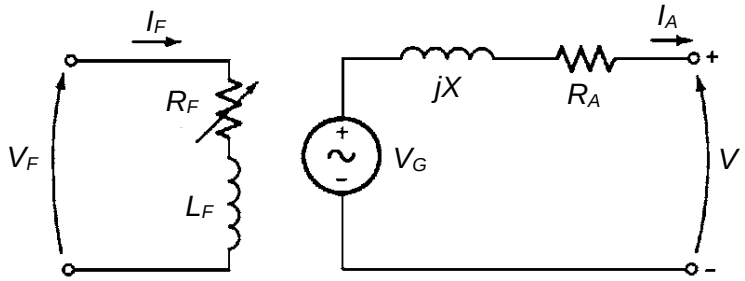

Figure A

Neglecting R_A, the equation which relates parameters in Figure A, where δ = load/power angle and θ = angle between V and I_A is $V_G\angle\delta = V\angle 0° + jXI_A\angle\theta$.

TEST 1: Open-Circuit Test

1. This test consists of 2 sets of circuit connection, the generator and motor circuits. On the generator circuit, connect a voltmeter between U1 and V1 of the generator output, as shown in Figure 1. Do not change any connection in the motor circuit.
2. Turn ON all DC power supplies. Adjust the variable DC power supply that is connected to the motor so that the generator speed N achieves 1500 rpm. Adjust the variable DC power supply that is connected to the generator so that the field current I_F achieves the values according to Table 1. Record the generated voltage V_G (using

voltmeter) in Table 1. The field current I_F can be read from the ammeter. The speed can be read from the control unit.

3. Repeat step 2 but with decreasing field current I_F and fill in Table 1. The speed of the generator has to be fixed at 1500 rpm (rated speed).
4. Set the field current I_F to 0.3A and maintain it throughout this test. Set the generator speed N according to the values shown in Table 2 and record the generated voltage V_G (using voltmeter). I_F and N can be adjusted using the variable DC power supplies that are connected to the generator and motor.

Table 1

Generator speed N (rpm)	1500									
Field current I_F (A)	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Generated voltage V_G (V) [for increasing I_F]										
Generated voltage V_G (V) [for decreasing I_F]										

Table 2

Field Current I_F (A)	0.3									
Generator speed N (rpm)	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500
Generated voltage V_G (V)										

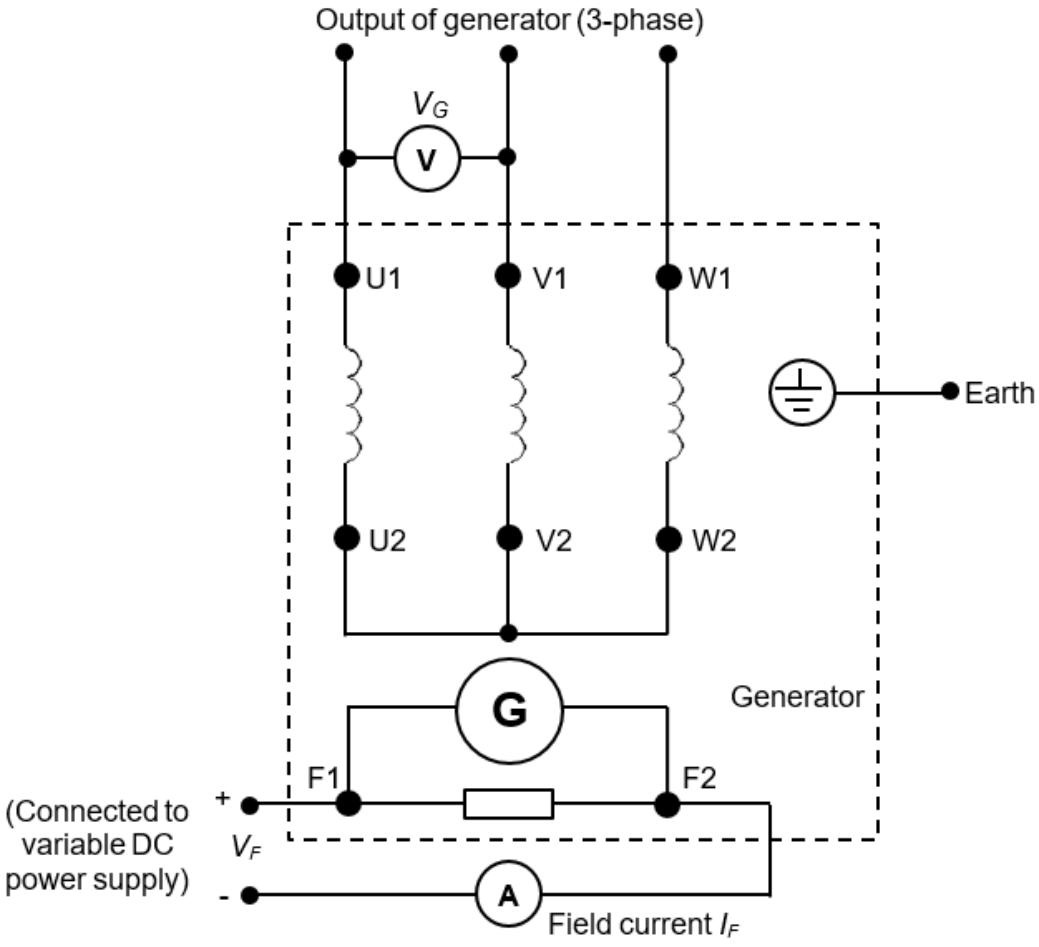

Figure 1

QUESTION: Plot V_G against I_F (increasing and decreasing) from Table 1 in one graph. Then, plot V_G against N in another graph. Explain the shape of both graphs.

TEST 2: Short-Circuit Test

1. Switch OFF all DC power supplies. Remove the voltmeter between U1 and V1. Short circuit the generator output by connecting a wire between U1 and V1 and connect an ammeter between V1 and W1, as shown in Figure 2.
2. Switch ON all DC power supplies. Adjust the variable DC power supplies that are connected to the generator and motor so that the generator speed N achieves 1500 rpm and the field current I_F achieves the values according to Table 3. Record the short-circuit current I_{SC} from the ammeter in Table 3.
3. Repeat step 2 but fix the generator speed N to 1200 rpm. Record the results.
4. Switch OFF all DC power supplies. Remove the wire between U1 and V1 and remove the ammeter between V1 and W1.

Table 3

Generator speed N (rpm)	1500										
Field current, I_F (A)	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.22
Short-circuit current I_{sc} (A)											

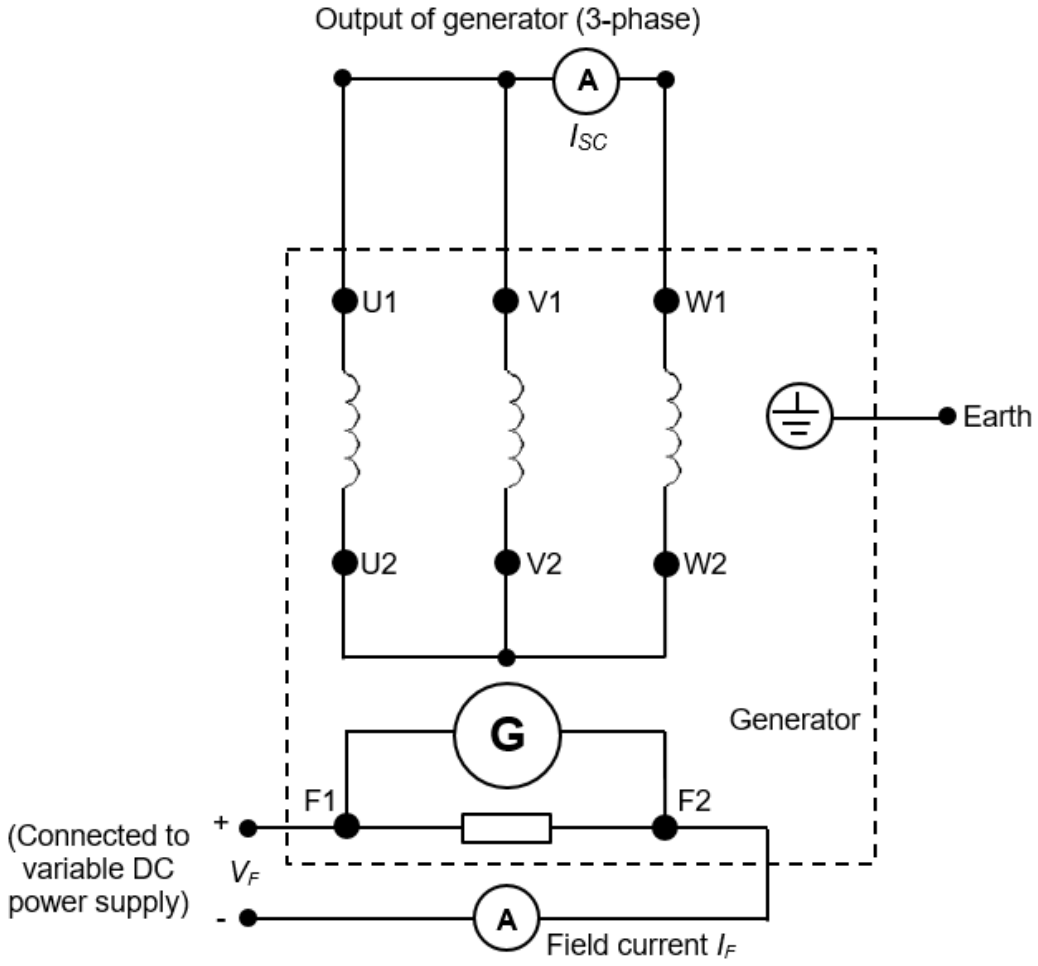

Figure 2

QUESTION: Plot I_{sc} against I_F from Table 3 for both N. Explain the graph.

TEST 3: Load Test

1. Switch OFF all DC power supplies. As shown in Figure 3, connect a voltmeter between V1 and W1. Connect a 3-phase resistive load to the output of the generator and connect an ammeter between U1 and the resistive load.
2. Adjust the resistive load to 100% (maximum) and switch ON all DC power supplies.
3. Adjust the variable DC power supplies that are connected to the generator and motor so that the generator speed N achieves 1200 rpm and the field current I_F achieves 0.3 A. Record the generated voltage V_G (using voltmeter) for each load current I_L in Table 4. The load current can be changed by tuning the resistive load. Make sure that the speed N and field current I_F remain constant.

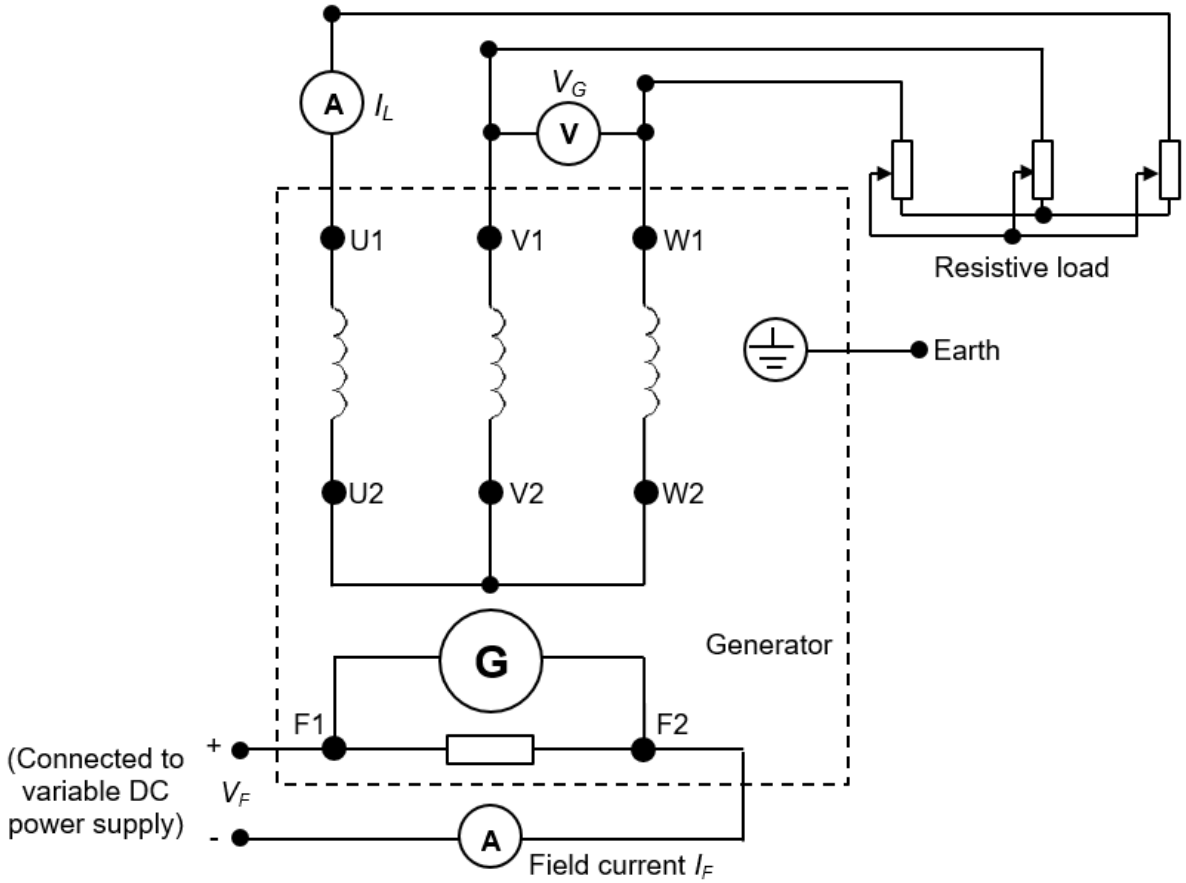

Figure 3

Table 4

Generator speed N (rpm)	1200					1200				
Field current I_F (A)	0.3					0.25				
Load current I_L (A)	0.3	0.25	0.2	0.15	0.1	0.3	0.25	0.2	0.15	0.1
Generated voltage V_G (V)										
Apparent power $S = \sqrt{3}V_G I_L$ (VA)										

QUESTIONS:

1. From Table 4, plot S against I_L for both I_F in one graph. Explain the graph.
2. What are the effects of load change on the generated voltage?

END OF EXPERIMENT