EEE301 - ELECTROMECHANICAL ENERGY CONVERSION

LABORATORY

LAB 5

Three-Phase Salient Pole Synchronous Generator

SECTION NUMBER : …………………………………….

GROUP NUMBER : …………………………………….

GROUP MEMBERS :

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LAB 5

Armature Resistance Measurement

OBJECTIVE

After completing this exercise, you should able to measure the armature resistance of a three-phase synchronous generator.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	DC Power Supply Module	EM-3310-1A
1	Three-phase Power Supply Module	EM-3310-1B
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Digital DCA Meter	EM-3310-3A
1	Digital DCV Meter	EM-3310-3B
1	Laboratory Table	EM-3380-1A
1	Experimental Frame	EM-3380-2B
	or Experimental Frame	EM-3380-2A
1	Connecting Leads Holder	EM-3390-1A
1	Connecting Leads Set	EM-3390-3A
1	Safety Bridging Plugs Set	EM-3390-4A

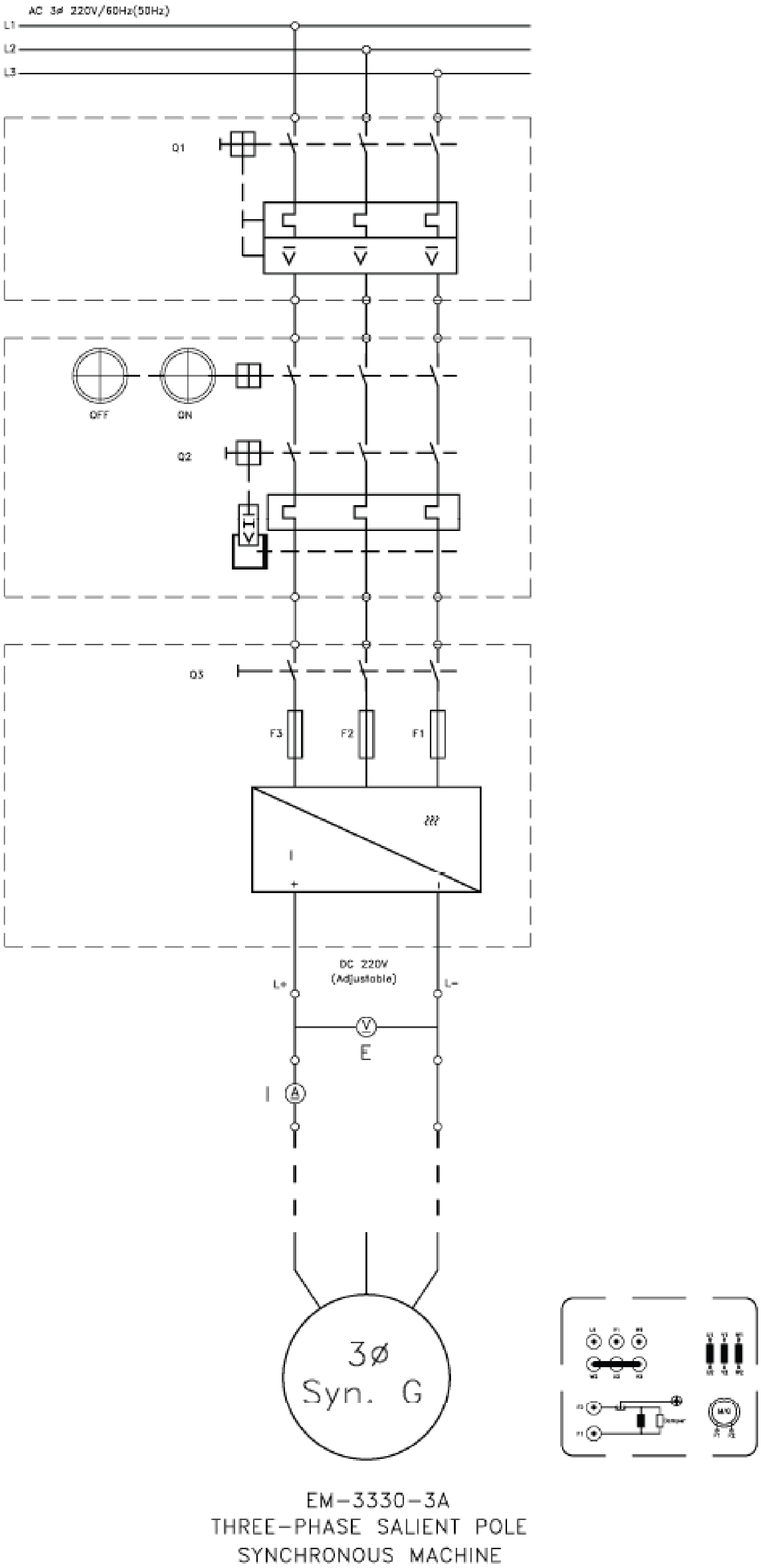

Fig. 15-1-1 Circuit diagram for armature resistance measurement

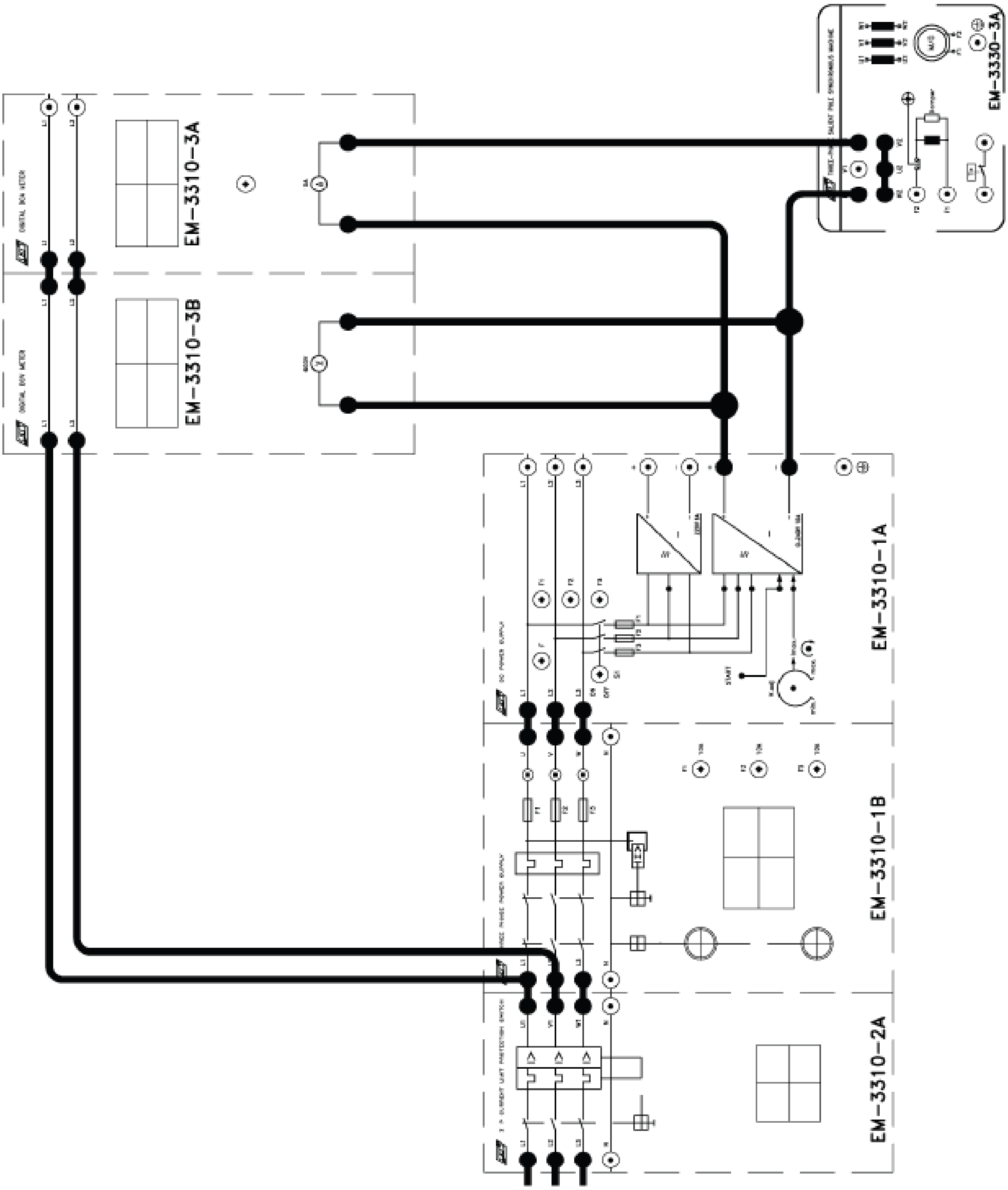

Fig. 15-1-2 Connection diagram for armature resistance measurement

PROCEDURE

CAUTION: High voltages are present in this laboratory exercise! Do not make or modify any connections with the power on unless otherwise specified! If any danger occurs, immediately press the red EMERGENCY OFF button on the Three-phase Power Supply Module.

1. Place the Three-phase Salient Pole Synchronous Machine on the Laboratory Table. Install the required Modules in the Experimental Frame. Construct the circuit in accordance with the circuit diagram in Fig. 15-1-1 and the connection diagram in Fig. 15-1-2. Have the instructor check your completed circuit. The synchronous generator operates in wye.

2. On the DC Power Supply Module, set the V.adj knob to the min. position (fully CCW).

3. Sequentially turn on the 3-P Current Limit Protection Switch, Three-phase Power Supply, and DC Power Supply Modules.

4. Press the START button on DC Power Supply Module. Slowly turn the V.adj knob and set the voltage E to 8 V. Record the current I displayed by the Digital DCA Meter in Table 15-1-1. Calculate the armature resistance R_a using the equation $R_a = E / 2I$.

5. Repeat step 4 for other E settings in Table 15-1-1.

6. Sequentially turn off the DC Power Supply, Three-phase Power Supply, and 3-P Current Limit Protection Switch Modules.

Table 15-1-1 Measured I and calculated R_a values

E (V)	I (A)	Calculated R_a (Ω)
8V		
10V		
14V		

No-Load Saturation Characteristic

OBJECTIVE

After completing this exercise, you should able to demonstrate the operating characteristic of a three-phase salient pole synchronous generator under no-load saturation condition.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	DC Permanent-magnet Machine	EM-3330-1A
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	DC Power Supply Module	EM-3310-1A
1	Three-phase Power Supply Module	EM-3310-1B
1	Synchronous Machine Exciter	EM-3310-1C
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
2	Digital DCA Meter	EM-3310-3A
2	Digital DCV Meter	EM-3310-3B
1	Digital RPM Meter	EM-3310-3G
	or Magnetic Powder Brake Unit	EM-3320-1A
	Brake Controller	EM-3320-1N
1	Digital Power Analysis Meter	EM-3310-3H
	or Digital ACA Meter	EM-3310-3C
	Digital ACV Meter	EM-3310-3D
1	Laboratory Table	EM-3380-1A
1	Experimental Frame	EM-3380-2B
	or Experimental Frame	EM-3380-2A
1	Connecting Leads Holder	EM-3390-1A
2	Coupling	EM-3390-2A
2	Coupling Guard	EM-3390-2B
1	Shaft End Guard	EM-3390-2C
1	Connecting Leads Set	EM-3390-3A
1	Safety Bridging Plugs Set	EM-3390-4A

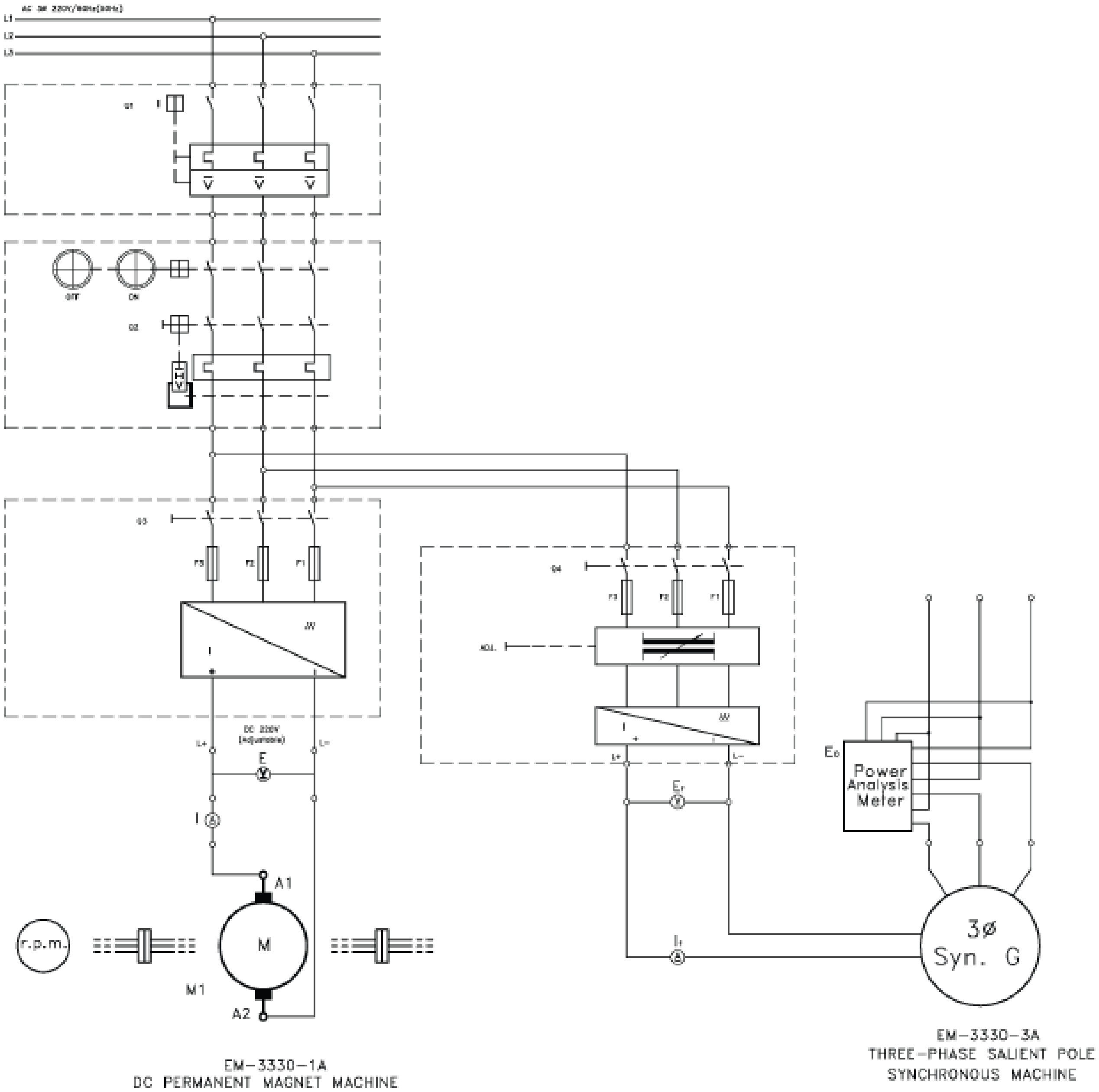

Fig. 15-2-1 Circuit diagram for no-load saturation test

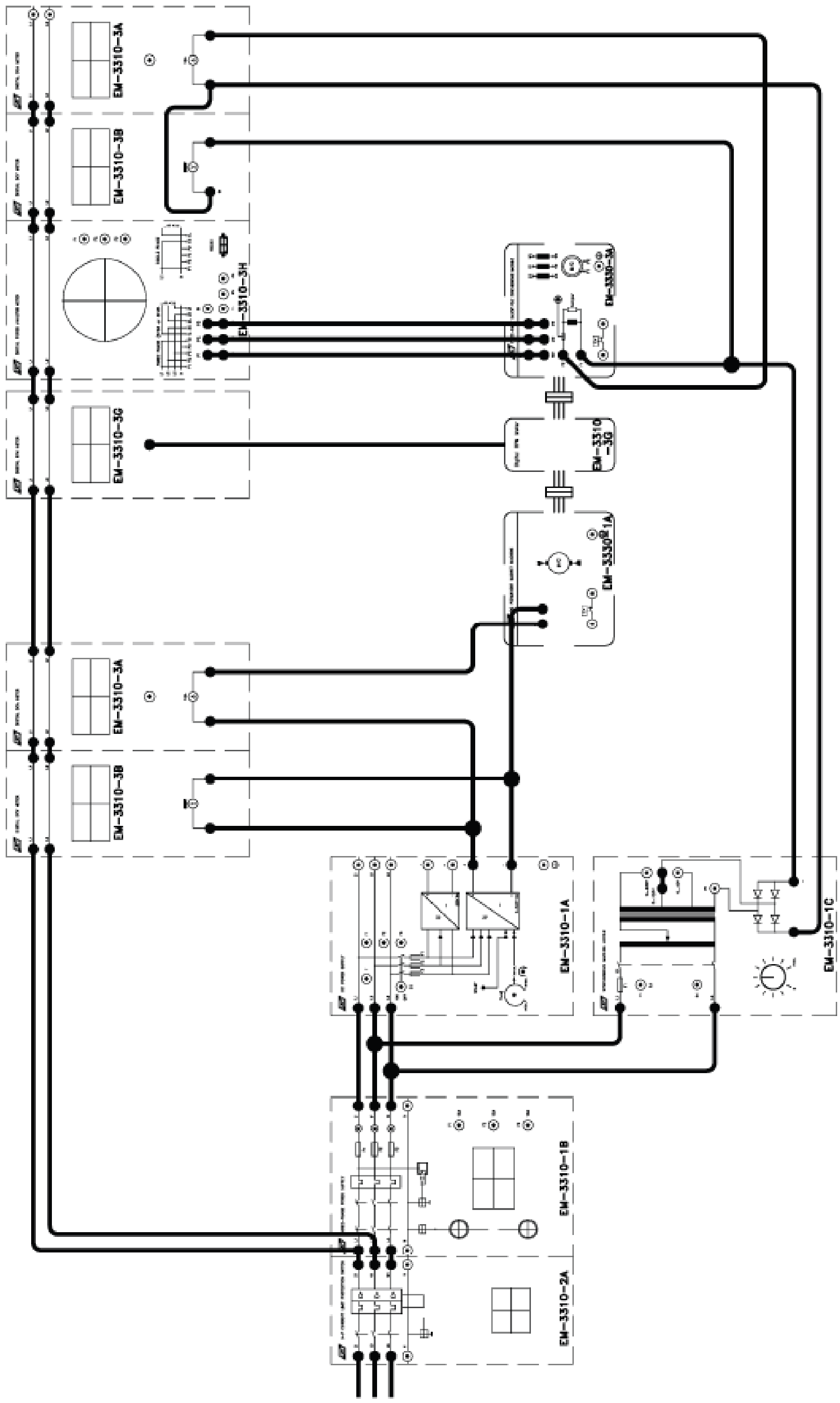

Fig. 15-2-2 Connection diagram for no-load saturation test

PROCEDURE

CAUTION: High voltages are present in this laboratory exercise! Do not make or modify any connections with the power on unless otherwise specified! If any danger occurs, immediately press the red EMERGENCY OFF button on the Three-phase Power Supply Module.

1. Place the DC Permanent-magnet Machine, Three-phase Salient Pole Synchronous Machine, and Digital RPM Meter on the Laboratory Table. Mechanically couple the DC Permanent-Magnet (PM) Machine to the Three-phase Salient Pole Synchronous Machine and the Digital RPM Meter using Couplings. Securely lock the Machine Bases together using the delta screws. Install the Coupling Guards and the Shaft End Guard.

2. Install the required Modules in the Experimental Frame. Construct the circuit in accordance with the circuit diagram in Fig. 15-2-1 and the connection diagram in Fig. 15-2-2. Have the instructor check your completed circuit. The synchronous generator operates in delta.

   Complete this laboratory exercise as quickly as possible to avoid the rise in temperature under load condition.

3. Set the V.adj knob on DC Power Supply Module to the min. position. Set the voltage control knob on the Synchronous Machine Exciter Module to the 0 position.

4. Sequentially turn on the 3-P Current Limit Protection Switch, Three-phase Power Supply, and DC Power Supply Modules.

5. On the DC Power Supply Module, press the START button and slowly turn the V.adj knob to increase the motor voltage until the generator rotates at its rated speed. Maintain the speed through this exercise. **Note:** The rated speed of the generator (Three-phase Salient Pole Synchronous Machine) is 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power).

6. Turn on the Synchronous Machine Exciter.

7. On the Synchronous Machine Exciter Module, slowly turn the voltage control knob so that the field current I_f (obtained from the Digital DCA Meter) is 0 A. Record the generator output voltage E_o (obtained from the Digital Power Analysis Meter) and the speed N (obtained from the Digital RPM Meter) values in Table 15-2-1.

8. Repeat step 7 for other I_f settings listed in Table 15-2-1.

9. Sequentially turn off the DC Power Supply, Synchronous Machine Exciter, Three-phase Power Supply, and 3-P Current Limit Protection Switch Modules.

10. Using the results of Table 15-2-1, plot the E_o vs I_f curve on the graph of Fig. 15-2-3.

Table 15-2-1 Measured values of I_f, E_o, and N

I_f (A)	0	0.02	0.04	0.06	0.08	0.1	0.12	0.14
E_o (V)								
N (rpm)								
I_f (A)	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3
E_o (V)								
N (rpm)								

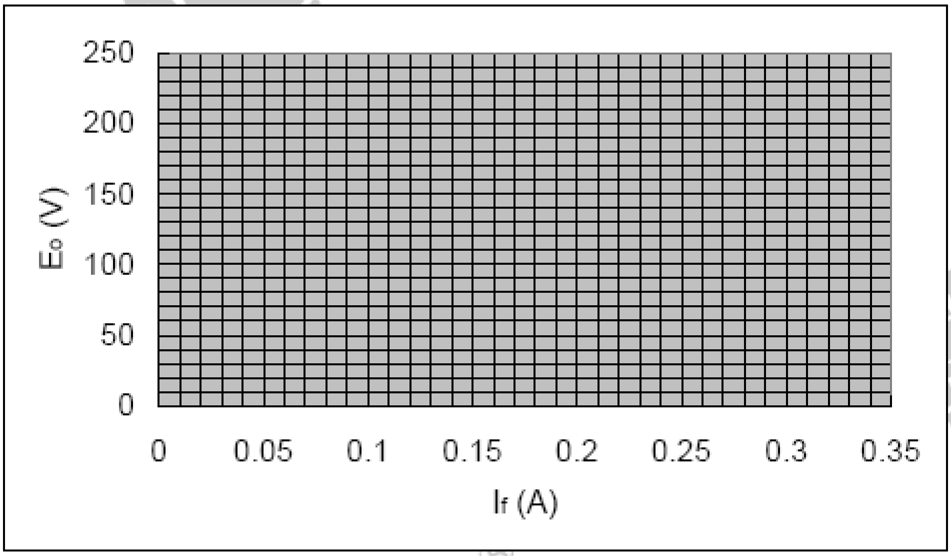

Fig. 15-2-3 The E_o vs I_f curve

Short-Circuit Characteristic

OBJECTIVE

After completing this exercise, you should able to demonstrate the operating characteristic of a three-phase salient pole synchronous generator under short-circuit condition.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	DC Permanent-magnet Machine	EM-3330-1A
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	DC Power Supply Module	EM-3310-1A
1	Three-phase Power Supply Module	EM-3310-1B
1	Synchronous Machine Exciter	EM-3310-1C
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
2	Digital DCA Meter	EM-3310-3A
2	Digital DCV Meter	EM-3310-3B
1	Digital RPM Meter	EM-3310-3G
	or Magnetic Powder Brake Unit	EM-3320-1A
	Brake Controller	EM-3320-1N
1	Digital Power Analysis Meter	EM-3310-3H
	or Digital ACA Meter	EM-3310-3C
	Digital ACV Meter	EM-3310-3D
1	Laboratory Table	EM-3380-1A
1	Experimental Frame	EM-3380-2B
	or Experimental Frame	EM-3380-2A
1	Connecting Leads Holder	EM-3390-1A
2	Coupling	EM-3390-2A
2	Coupling Guard	EM-3390-2B
1	Shaft End Guard	EM-3390-2C
1	Connecting Leads Set	EM-3390-3A
1	Safety Bridging Plugs Set	EM-3390-4A

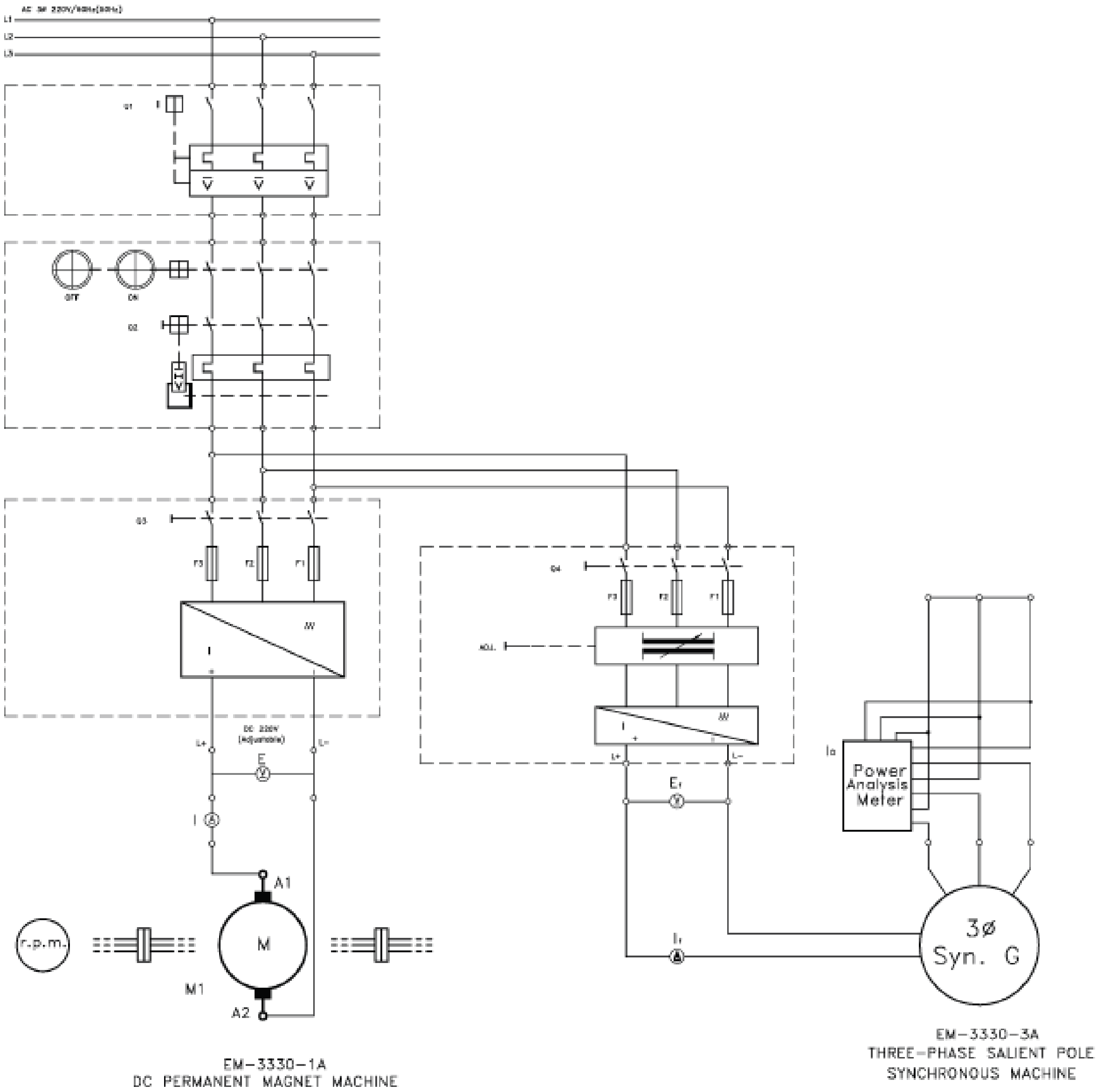

Fig. 15-3-1 Circuit diagram for short-circuit test

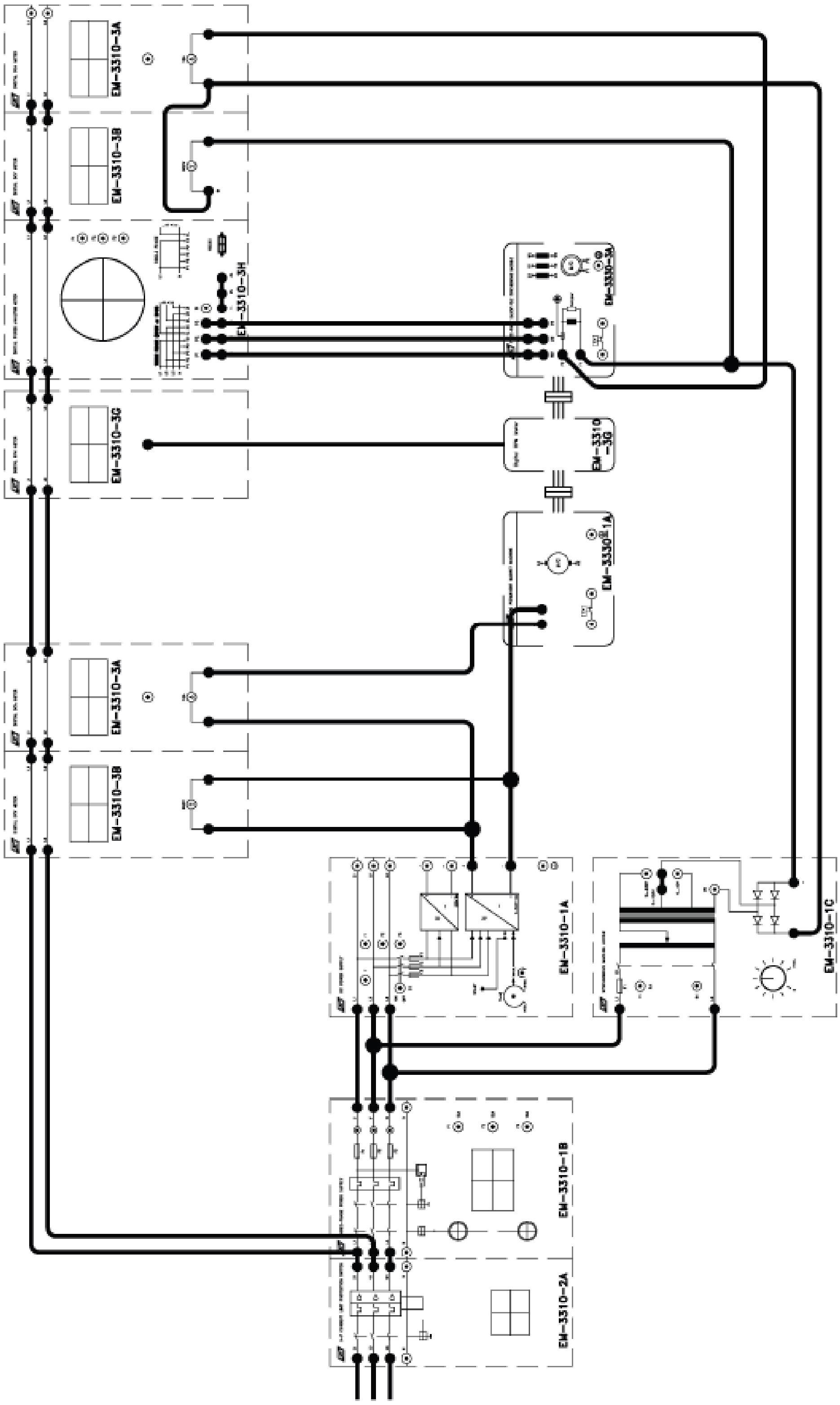

Fig. 15-3-2 Connection diagram for short-circuit test

PROCEDURE

CAUTION: High voltages are present in this laboratory exercise! Do not make or modify any connections with the power on unless otherwise specified! If any danger occurs, immediately press the red EMERGENCY OFF button on the Three-phase Power Supply Module.

1. Place the DC Permanent-magnet Machine, Three-phase Salient Pole Synchronous Machine, and Digital RPM Meter on the Laboratory Table. Mechanically couple the DC Permanent-Magnet (PM) Machine to the Three-phase Salient Pole Synchronous Machine and the Digital RPM Meter using Couplings. Securely lock the Machine Bases together using the delta screws. Install the Coupling Guards and the Shaft End Guard.

2. Install the required Modules in the Experimental Frame. Construct the circuit in accordance with the circuit diagram in Fig. 15-3-1 and the connection diagram in Fig. 15-3-2. Have the instructor check your completed circuit. The synchronous generator operates in delta.

3. Set the V.adj knob on the DC Power Supply Module to the min. position. Set the voltage control knob on the Synchronous Machine Exciter to the 0 position.

4. Sequentially turn on the 3-P Current Limit Protection Switch, Three-phase Power Supply, and DC Power Supply Modules.

5. On the DC Power Supply Module, press the START button and slowly turn the V.adj knob to increase the motor voltage until the generator rotates at the its rated speed. Maintain the speed through this exercise. **Note:** The rated speed of the generator (Three-phase Salient Pole Synchronous Machine) is 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power).

6. Turn on the Synchronous Machine Exciter.

7. Slowly turn the voltage control knob on the Synchronous Machine Exciter Module and set the field current I_f (obtained from the Digital DCA Meter) to 0 A. Record the

generator output current I_o (obtained from the Digital Power Analysis Meter) and the generator speed N (obtained from the Digital RPM Meter) value in Table 15-3-1.

8. Repeat step 7 for other field current I_f settings listed in Table 15-3-1.

9. Sequentially turn off the DC Power Supply, Synchronous Machine Exciter, Three-phase Power Supply, and 3-P Current Limit Protection Switch Modules.

10. Using the results of Table 15-3-1, plot the I_o vs I_f curve on the graph of Fig.15-3-3.

Table 15-3-1 Measured values of I_f, I_o, and N

I_f (A)	0	0.02	0.04	0.06	0.08	0.1
I_o (A)						
N (rpm)						

I_f (A)	0.12	0.14	0.16	0.18	0.2	0.22	0.24
I_o (A)							
N (rpm)							

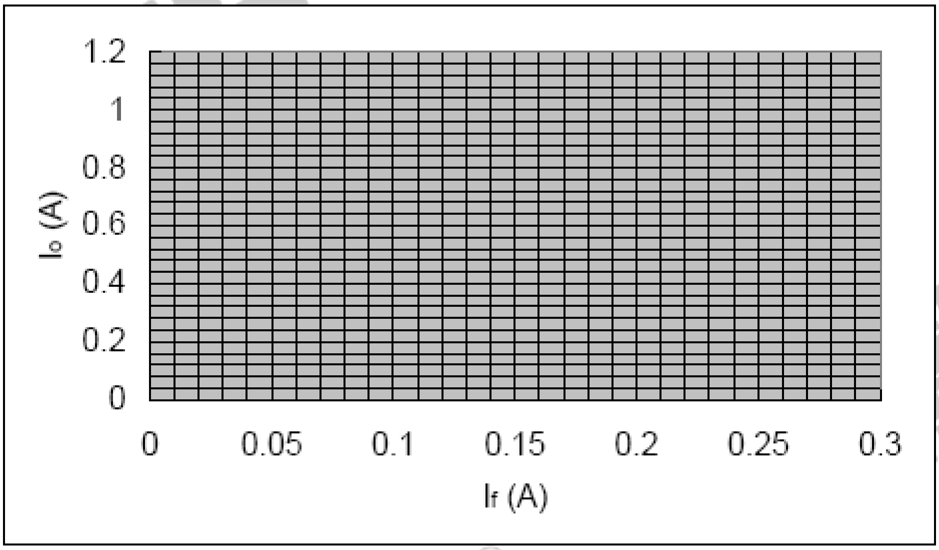

Fig.15-3-3 The I_o vs I_f curve

Load Characteristic

OBJECTIVE

After completing this exercise, you should able to demonstrate the operating characteristic of a three-phase salient pole synchronous generator under load condition.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	DC Permanent-magnet Machine	EM-3330-1A
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	DC Power Supply Module	EM-3310-1A
1	Three-phase Power Supply Module	EM-3310-1B
1	Synchronous Machine Exciter	EM-3310-1C
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Resistive Load Module	EM-3310-4R
1	Capacitive Load Module	EM-3310-4C
1	Inductive Load Module	EM-3310-4L
1	Four-pole Switch Module	EM-3310-2B
2	Digital DCA Meter	EM-3310-3A
2	Digital DCV Meter	EM-3310-3B
1	Digital RPM Meter	EM-3310-3G
	or Magnetic Powder Brake Unit	EM-3320-1A
	Brake Controller	EM-3320-1N
1	Digital Power Analysis Meter	EM-3310-3H
	or Digital ACA Meter	EM-3310-3C
	Digital ACV Meter	EM-3310-3D
	Digital Three-phase Watt Meter	EM-3310-3E
	Digital Power Factor Meter	EM-3310-3F
1	Laboratory Table	EM-3380-1A

1	Experimental Frame	EM-3380-2B
	or Experimental Frame	EM-3380-2A
1	Connecting Leads Holder	EM-3390-1A
2	Coupling	EM-3390-2A
2	Coupling Guard	EM-3390-2B
1	Shaft End Guard	EM-3390-2C
1	Connecting Leads Set	EM-3390-3A
1	Safety Bridging Plugs Set	EM-3390-4A

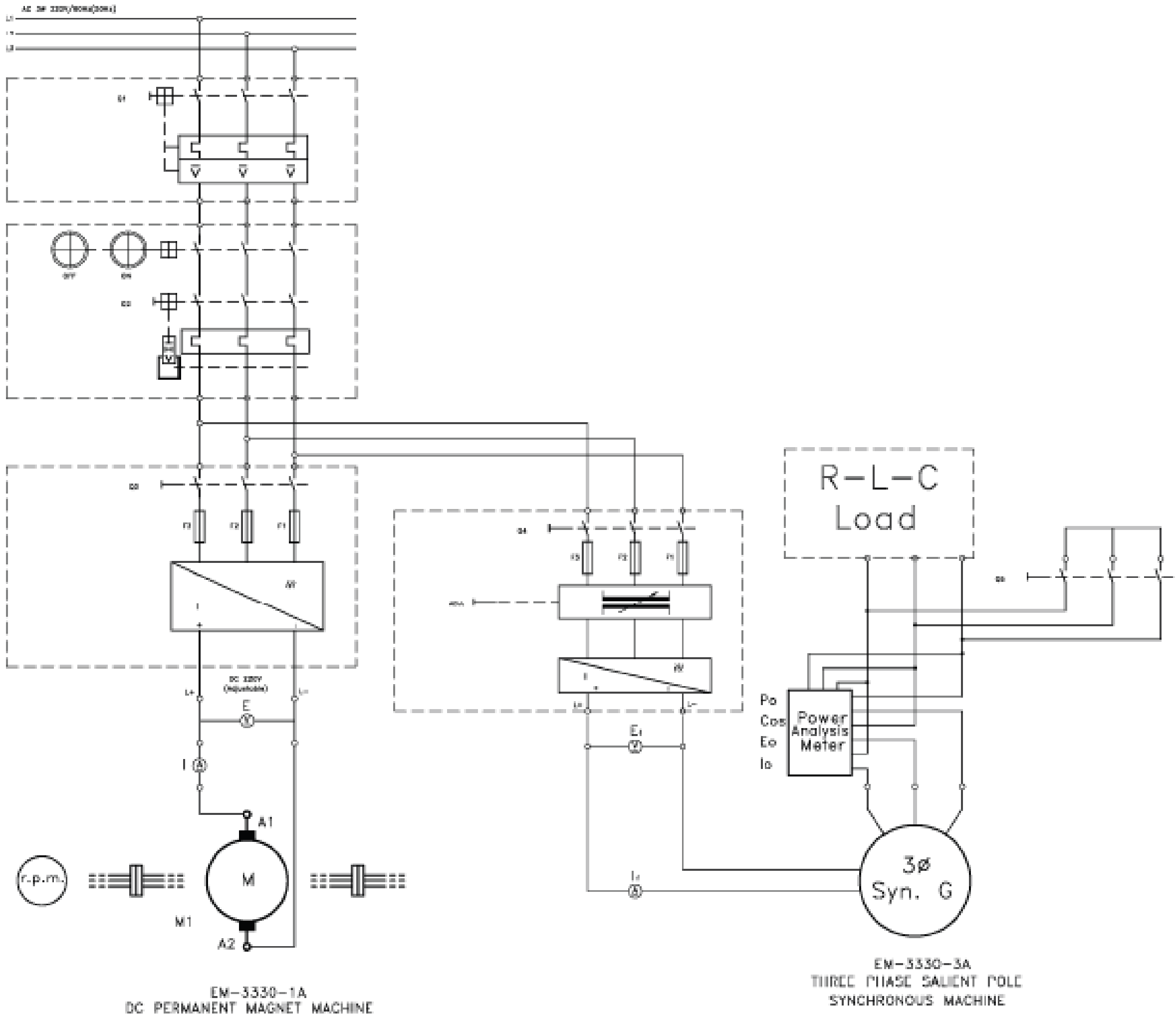

Fig. 15-4-1 Circuit diagram for load characteristic test

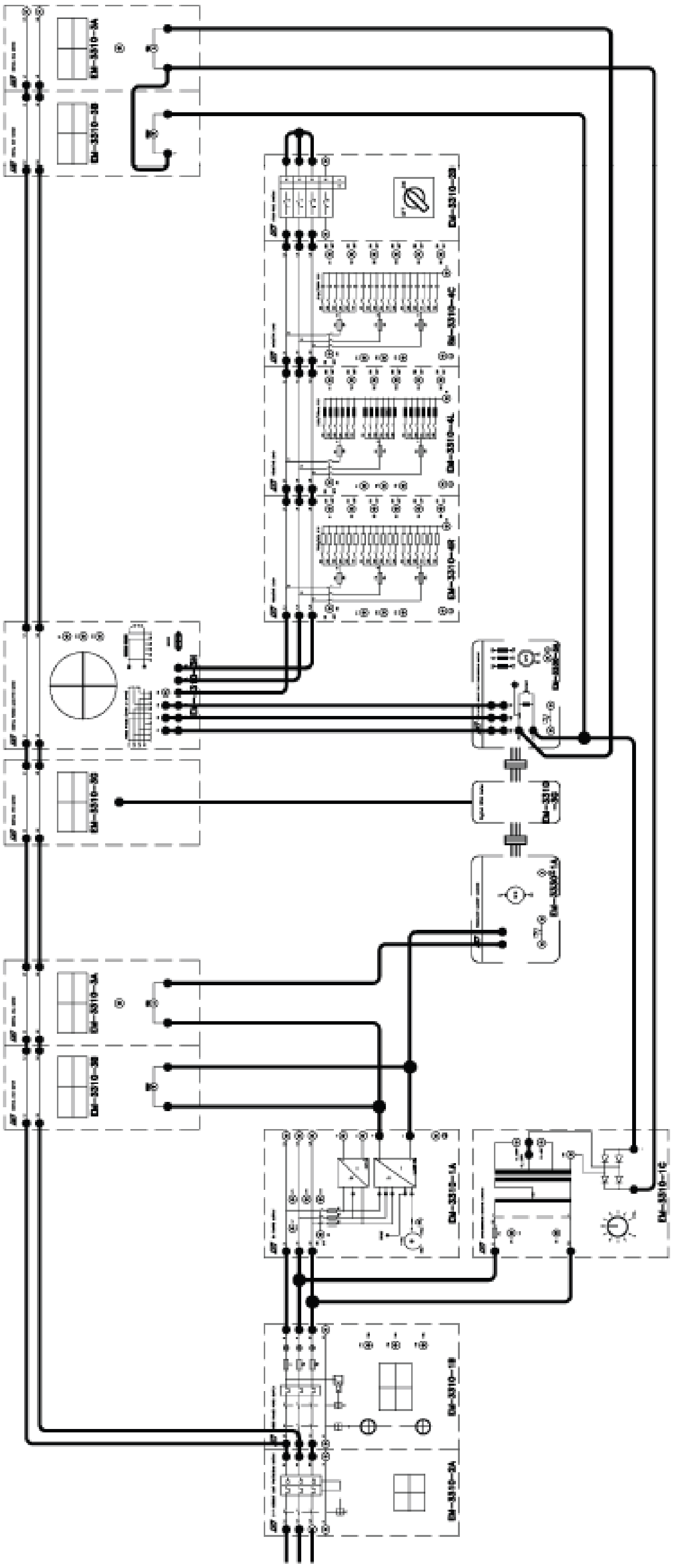

Fig. 15-4-2 Connection diagram for load characteristic test

PROCEDURE

CAUTION: High voltages are present in this laboratory exercise! Do not make or modify any connections with the power on unless otherwise specified! If any danger occurs, immediately press the red EMERGENCY OFF button on the Three-phase Power Supply Module.

1. Place the DC Permanent-magnet Machine, Three-phase Salient Pole Synchronous Machine, and Digital RPM Meter on the Laboratory Table. Mechanically couple the DC Permanent-Magnet (PM) Machine to the Three-phase Salient Pole Synchronous Machine and the Digital RPM Meter using Couplings. Securely lock Machine Bases together using delta screws. Install the Coupling Guards and the Shaft End Guard.

2. Construct the circuit in accordance with the circuit diagram in Fig. 15-4-1 and the connection diagram in Fig. 15-4-2. Have the instructor check your completed circuit. **<u>The synchronous generator operates in delta.</u>**

   Complete this laboratory exercise as quickly as possible to avoid the rise in temperature under load condition.

3. Set the V.adj knob on the DC Power Supply Module to the min. position. Set the voltage control knob on the Synchronous Machine Exciter Module to the 0 position. Set the on-off switch on the Four-Pole Switch module to the OFF position. On the Resistive Load module, set the switches S0 through S4 to ON position.

4. Sequentially turn on the 3-P Current Limit Protection Switch, Three-phase Power Supply, and DC Power Supply Modules.

5. On the DC Power Supply Module, press the START button and slowly turn the V.adj knob to increase the motor voltage until the motor rotates at its rated speed N=1,800 rpm for 60-Hz power (or 1,500 rpm for 50-Hz power). Maintain this speed through this exercise.

6. Turn on the Synchronous Machine Exciter.

7. Slowly turn the voltage control knob on the Synchronous Machine Exciter to set the generator output voltage E_O to 220 V. Record the field current I_f in the S0-S4=ON field of Table 15-4-1. **Note:** The I_f value must be maintained in this laboratory exercise.

8. **In the laboratory excise, if the rotor of generator is locked by a load, turn off the power immediately. Note: The motor (prime mover) current must not exceed 130% of the rated current. The generator current must not exceed 130% of the rated current, 0.8A x 1.3 = 1.04A.**

9. Maintain the speed (N=1,800 rpm) and the field current I_f obtained in Step 7. On the Resistive Load module, set the switches for each of the listed positions in Table 15-4-1. Record the generator output current I_o, generator output voltage E_o, generator output power P_o, and power factor cos θ (obtained from the Digital Power Analysis Meter), and the generator speed N (obtained from the Digital RPM Meter) values in Table 15-4-1. The "shorted" position is that the rotor windings are short-circuited by setting the on-off switch on the Four-Pole Switch module to ON position.

10. Sequentially turn off the Capacitive Load, Inductive Load, Resistive Load, DC Power Supply, Synchronous Machine Exciter, Three-phase Power Supply, and 3-P Current Limit Protection Switch Modules.

11. Repeat Steps 3 through 10 for resistive and inductive loads. On the Resistive Load and Inductive Load modules, set the switches for each of the listed positions in Table 15-4-2. Record the generator output current I_o, generator output voltage E_o, generator output power P_o, and power factor cos θ (obtained from the Digital Power Analysis Meter), and the generator speed N (obtained from the Digital RPM Meter) values in Table 15-4-2. The "shorted" position is that the rotor windings are short-circuited by setting the on-off switch on the Four-Pole Switch module to ON position.

12. Repeat Steps 3 through 10 for resistive and capacitive loads. On the Resistive Load and the Capacitive Load modules, set the switches for each of the listed positions in Table 15-4-3. Record the generator output current I_o, generator output voltage E_o, generator output power P_o, and power factor cos θ (obtained from the Digital Power

Analysis Meter), and the generator speed N (obtained from the Digital RPM Meter) values in Table 15-4-3. The "shorted" position is that the rotor windings are short-circuited by setting the on-off switch on the Four-Pole Switch module to ON position.

13. Using the results of Tables 15-4-1 through 15-4-3, plot the E_o vs I_o curves on the graph of Fig. 15-4-3.

Table 15-4-1 Measured values of I_f, I_o, E_o, P_o, N, and cos θ

	Switch Positions on Resistive Load Module							
	S0=OFF	S0-S1=ON	S0-S2=ON	S0-S3=ON	S0-S4=ON	S0-S5=ON	S0-S6=ON	Shorted
I_f (A)								
I_o(A)								
E_o (V)					220			
cos θ								
P_o (W)								
N (rpm)								

Table 15-4-2 Measured values of I_f, I_o, E_o, P_o, N, and cos θ

	Switch Positions on Resistive Load and Inductive Load Modules							
	S0=OFF	S0-S1=ON	S0-S2=ON	S0-S3=ON	S0-S4=ON	S0-S5=ON	S0-S6=ON	Shorted
I_f (A)								
I_o(A)								
E_o (V)					220			
cos θ								
P_o (W)								
N (rpm)								

Table 15-4-3 Measured values of I_f, I_o, E_o, P_o, N, and cos θ

	Switch Positions on Resistive Load and Capacitive Load Modules							
	S0=OFF	S0-S1=ON	S0-S2=ON	S0-S3=ON	S0-S4=ON	S0-S5=ON	S0-S6=ON	Shorted
I_f (A)								
I_o(A)								
E_o (V)					220			
cos θ								
P_o (W)								
N (rpm)								

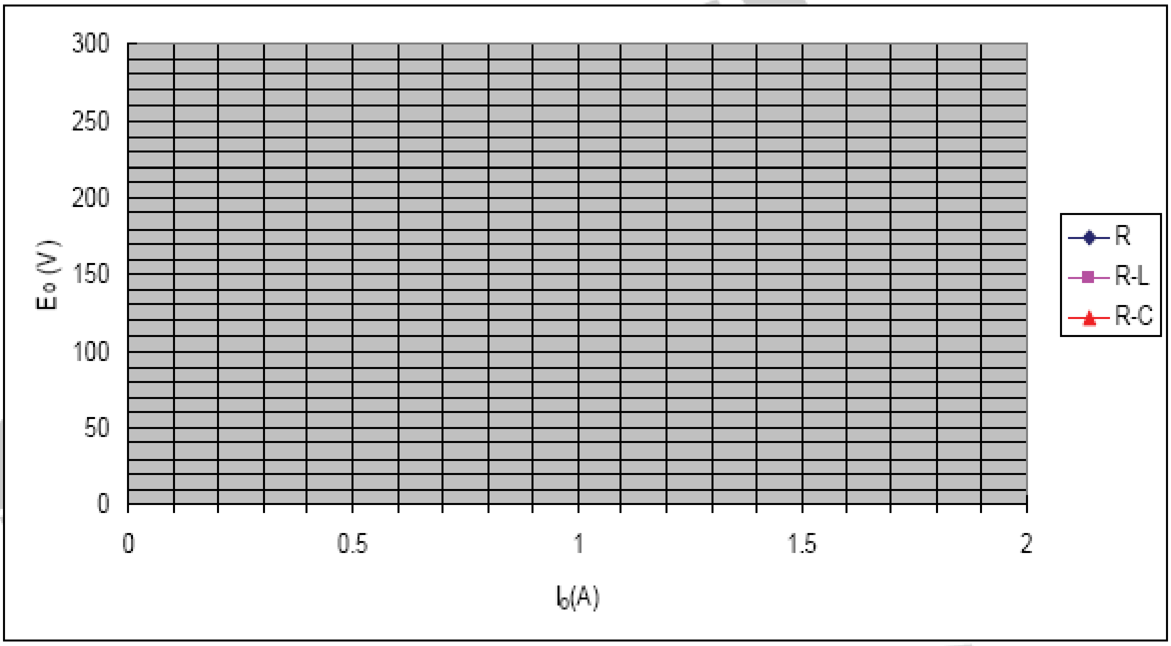

Fig. 15-4-3 The E_o vs I_o curves

Excitation Characteristic

OBJECTIVE

After completing this exercise, you should be able to demonstrate the excitation characteristic of a three-phase salient pole synchronous generator.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	DC Permanent-magnet Machine	EM-3330-1A
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	DC Power Supply Module	EM-3310-1A
1	Three-phase Power Supply Module	EM-3310-1B
1	Synchronous Machine Exciter	EM-3310-1C
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Resistive Load Module	EM-3310-4R
1	Capacitive Load Module	EM-3310-4C
1	Inductive Load Module	EM-3310-4L
2	Digital DCA Meter	EM-3310-3A
2	Digital DCV Meter	EM-3310-3B
1	Digital RPM Meter	EM-3310-3G
	or Magnetic Powder Brake Unit	EM-3320-1A
	Brake Controller	EM-3320-1N
1	Digital Power Analysis Meter	EM-3310-3H
	or Digital ACA Meter	EM-3310-3C
	Digital ACV Meter	EM-3310-3D
	Digital Three-phase Watt Meter	EM-3310-3E
	Digital Power Factor Meter	EM-3310-3F
1	Laboratory Table	EM-3380-1A
1	Experimental Frame	EM-3380-2B
	or Experimental Frame	EM-3380-2A

1	Connecting Leads Holder	EM-3390-1A
2	Coupling	EM-3390-2A
2	Coupling Guard	EM-3390-2B
1	Shaft End Guard	EM-3390-2C
1	Connecting Leads Set	EM-3390-3A
1	Safety Bridging Plugs Set	EM-3390-4A

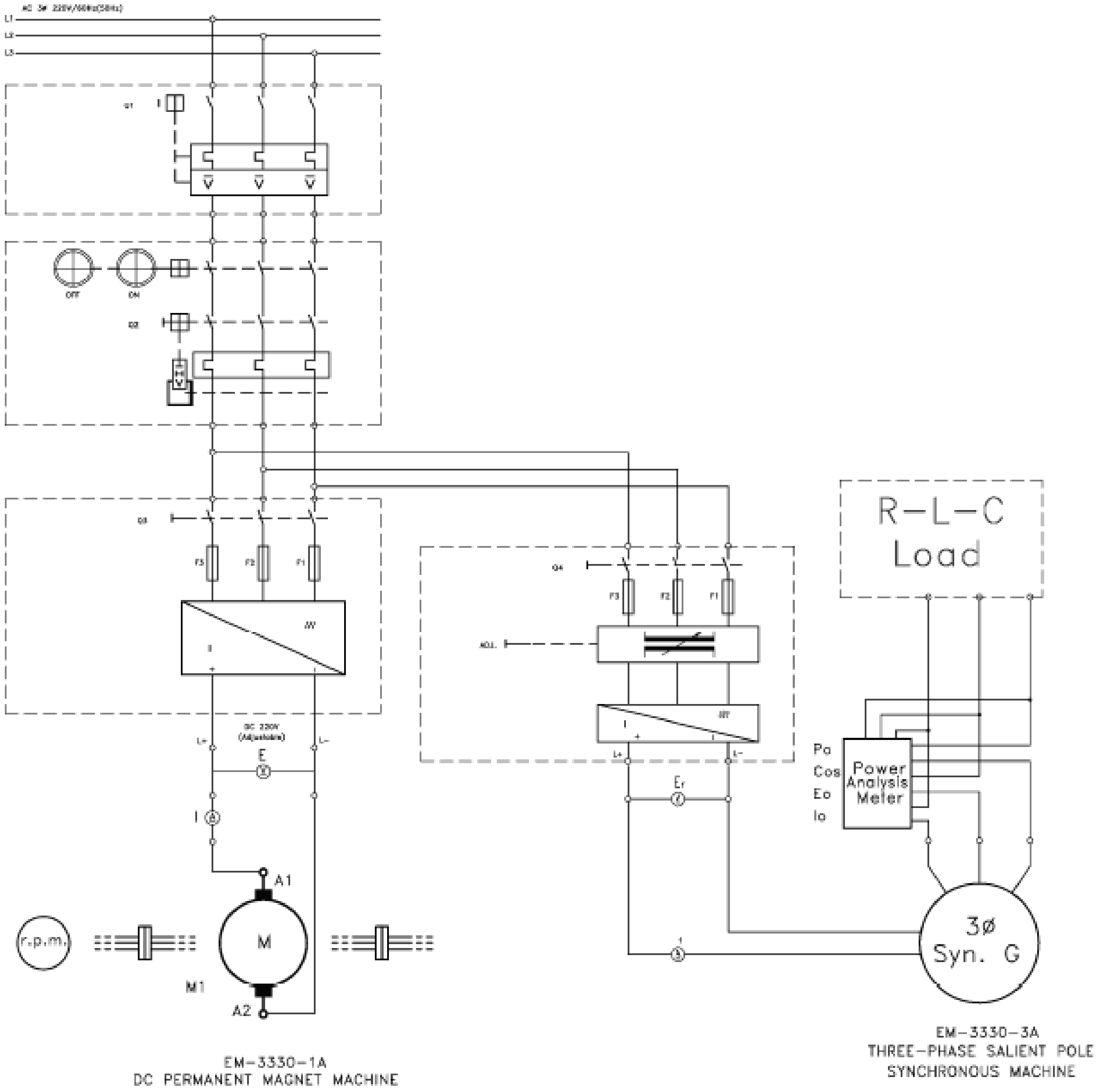

Fig. 15-5-1 Circuit diagram for excitation characteristic test

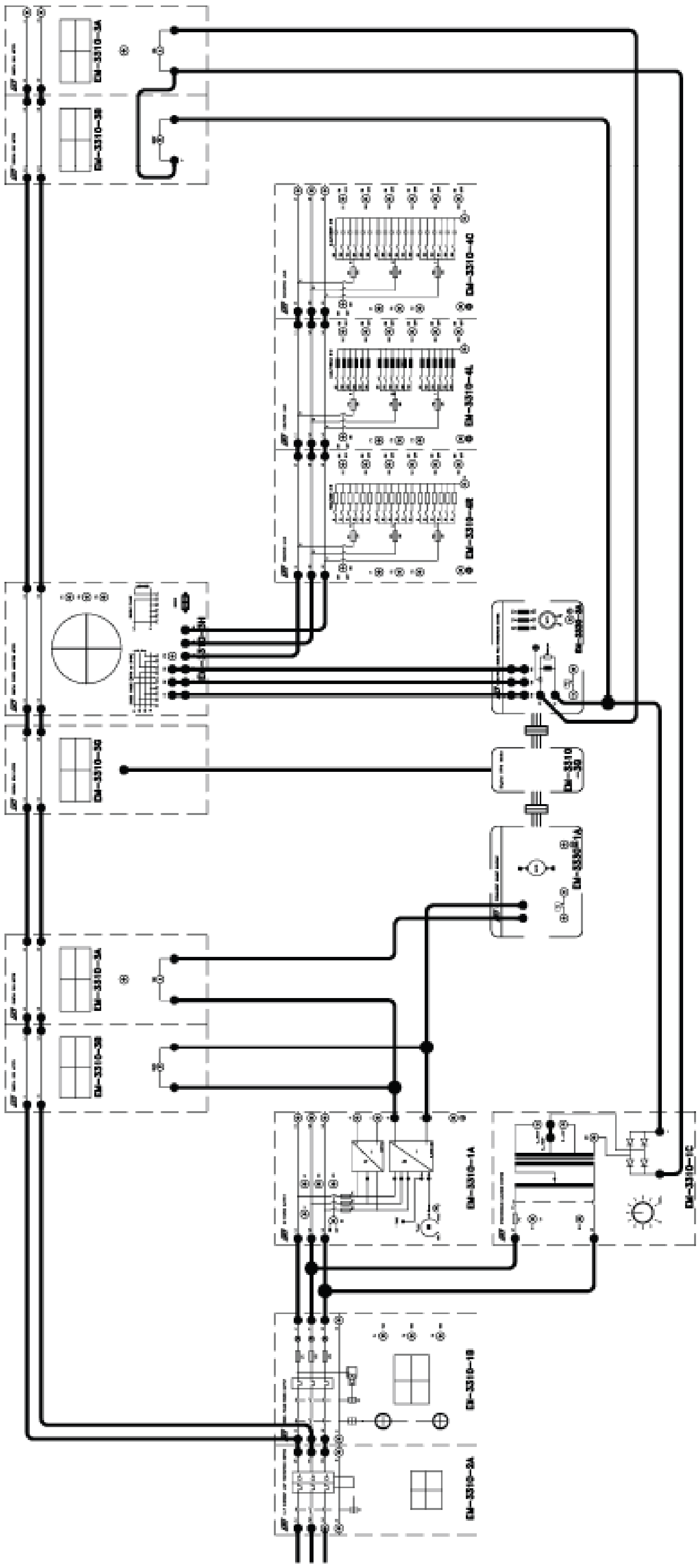

Fig. 15-5-2 Connection diagram for excitation characteristic test

PROCEDURE

CAUTION: High voltages are present in this laboratory exercise! Do not make or modify any connections with the power on unless otherwise specified! If any danger occurs, immediately press the red EMERGENCY OFF button on the Three-phase Power Supply Module.

1. Place the DC Permanent-magnet Machine, Three-phase Salient Pole Synchronous Machine, and Digital RPM Meter on the Laboratory Table. Mechanically couple the DC Permanent-Magnet (PM) Machine to the Three-phase Salient Pole Synchronous Machine and the Digital RPM Meter using Couplings. Securely lock Machine Bases using delta screws. Install the Coupling Guards and the Shaft End Guard.

2. Install the required Modules in the Experimental Frame. Construct the circuit in accordance with the circuit diagram in Fig. 15-5-1 and the connection diagram in Fig. 15-5-2. Have the instructor check your completed circuit. The synchronous generator operates in delta.

Complete this laboratory exercise as quickly as possible to avoid the rise in temperature under load condition.

3. Set the V.adj knob on the DC Power Supply Module to the min. position. Set the voltage control knob on the Synchronous Machine Exciter to the 0 position.

4. Sequentially turn on the 3-P Current Limit Protection Switch, Three-phase Power Supply, and DC Power Supply Modules.

5. On the DC Power Supply Module, press the START button and slowly turn the V.adj knob and set the prime mover to rotate at its rated speed. Maintain the speed through this exercise. **Note:** The rated speed of the prime mover (DC Permanent-magnet Machine) is 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power).

6. Turn on the Synchronous Machine Exciter.

7. Slowly turn the voltage control knob on the Synchronous Machine Exciter to increase

the output voltage up to 220 V. Maintain the output voltage through this exercise.

8. **In the laboratory excise, if the rotor of generator is locked by a load, turn off the power immediately. Note: The motor (prime mover) current must not exceed 130% of the rated current. The generator current must not exceed 130% of the rated current (0.8A x 1.3 = 1.04A) and the field current must not exceed 130% of the rated current (0.3A x 1.3 = 0.39A).**

9. On the Resistive Load Module, set the switch positions listed in Table 15-5-1. Record the generator field current I_f (obtained from the Digital DCA Meter), generator output current I_o, generator output voltage E_o, generator output power P_o, power factor cos θ (obtained from the Digital Power Analysis Meter), and generator speed N (obtained from the Digital RPM Meter) values in Table 15-5-1.

10. On the Resistive Load and the Inductive Load Modules, set the switch positions listed in Table 15-5-2. Record the generator field current I_f (obtained from the Digital DCA Meter), generator output current I_o, generator output voltage E_o, generator output power P_o, power factor cos θ (obtained from the Digital Power Analysis Meter), and generator speed N (obtained from the Digital RPM Meter) values in Table 15-5-2.

11. On the Resistive Load and the Capacitive Load Modules, set the switch positions listed in Table 15-5-3. Record the generator field current I_f (obtained from the Digital DCA Meter), generator output current I_o, generator output voltage E_o, generator output power P_o, power factor cos θ (obtained from the Digital Power Analysis Meter), and generator speed N (obtained from the Digital RPM Meter) values in Table 15-5-3.

12. Sequentially turn off the Resistive Load, Inductive Load, Capacitive Load, DC Power Supply, Synchronous Machine Exciter, Three-phase Power Supply, and 3-P Current Limit Protection Switch Modules.

13. Using the results of Tables 15-5-1 through 15-5-3, plot the I_f vs I_o curves on the graph of Fig. 15-5-3.

Table 15-5-1 Measured values of I_f, I_o, E_o, P_o, cos θ, and N

	Switch Positions on Resistive Load Module						
	S0=OFF	S0, S1=ON	S0-S2=ON	S0-S3=ON	S0-S4=ON	S0-S5=ON	S0-S6=ON
I_f (A)							
I_o (A)							
E_o (V)	220	220	220	220	220	220	220
cos θ							
P_o (W)							
N (rpm)							

Table 15-5-2 Measured values of I_f, I_o, E_o, P_o, cos θ, and N

	Switch Positions on Resistive Load and Inductive Load Modules						
	S0=OFF	S0-S1=ON	S0-S2=ON	S0-S3=ON	S0-S4=ON	S0-S5=ON	S0-S6=ON
I_f (A)							
I_o (A)							
E_o (V)	220	220	220	220	220	220	220
cos θ							
P_o (W)							
N (rpm)							

Table 15-5-3 Measured the values of I_f, I_o, E_o, P_o, cos θ, and N

	Switch Positions on Resistive Load and Capacitive Load Modules						
	S0=OFF	S0, S1=ON	S0-S2=ON	S0-S3=ON	S0-S4=ON	S0-S5=ON	S0-S6=ON
I_f (A)							
I_o (A)							
E_o (V)	220	220	220	220	220	220	220
cos θ							
P_o (W)							
N (rpm)							

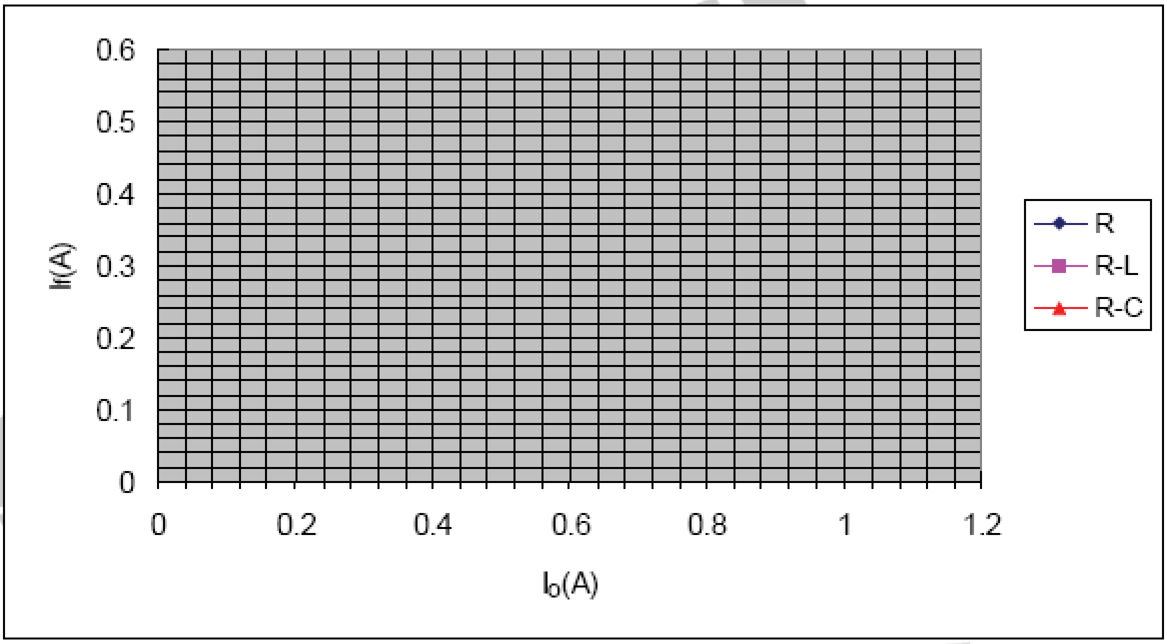

Fig. 15-5-3 The I_f vs I_o curves