LAB 4

Three-Phase Salient Pole Synchronous Motor

SECTION NUMBER : …….

GROUP NUMBER : …….

GROUP MEMBERS :

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Connection and Motor Direction Control

OBJECTIVE

After completing this exercise, you should able to demonstrate the connection of a three-phase salient pole synchronous motor and control the direction of rotation of the motor.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
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	Reversing Switch Module	EM-3310-2C
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	Coupling	EM-3390-2A
1	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

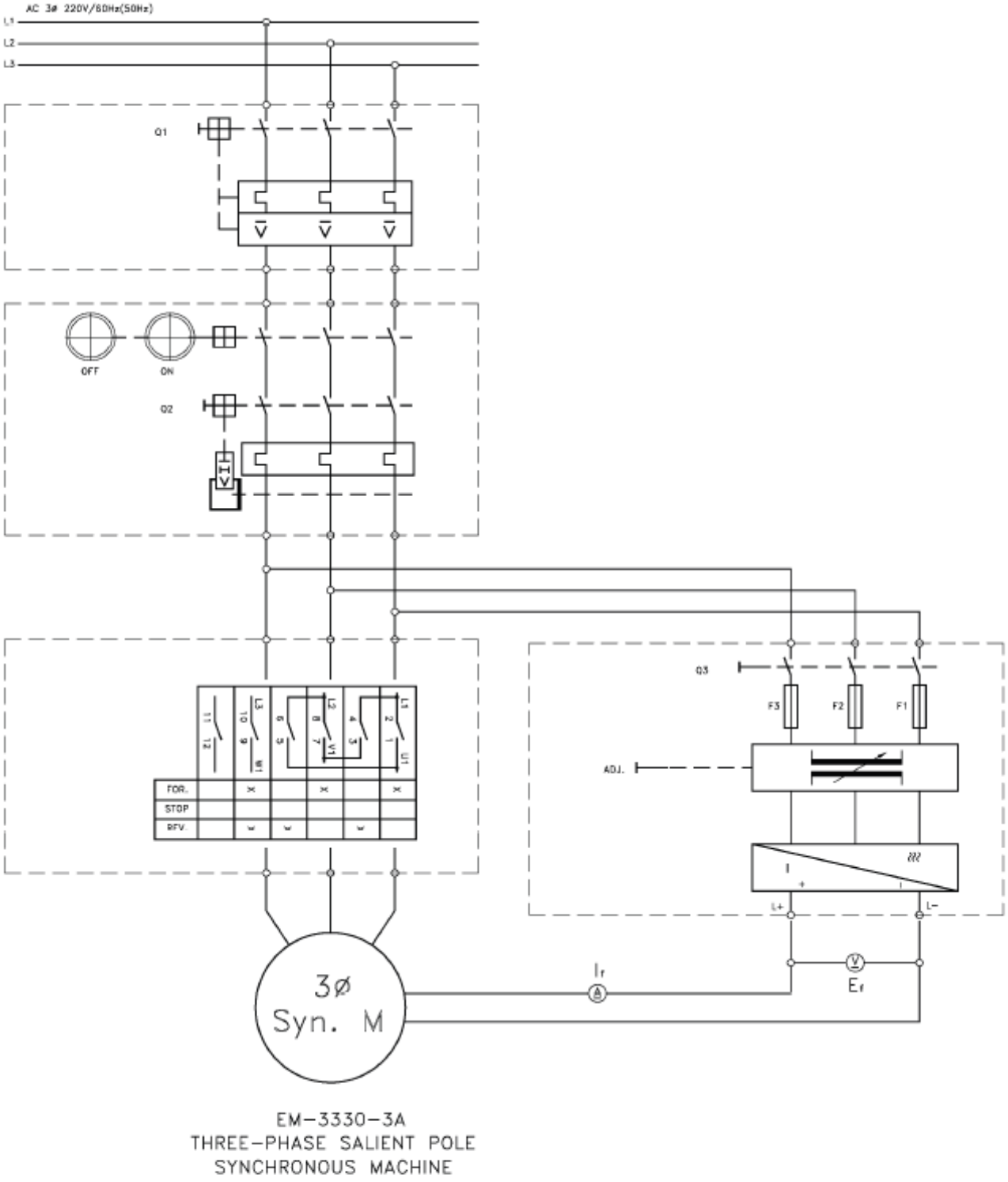

Fig. 14-1-1 Circuit diagram for rotation direction control

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. 14-1-1 and the connection diagram in Fig. 14-1-2. Have the instructor check your completed circuit.

2. On the Reversing Switch Module, set the reverse switch to the STOP position.

3. 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

5. On the Synchronous Machine Exciter Module, slowly turn the voltage control knob clockwise so that the field voltage (obtained from the Digital DCV Meter) is 60 V. Then turn off the Synchronous Machine Exciter.

6. Hold the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine and turn on the Synchronous Machine Exciter. Set the reverse switch on the Reversing Switch Module to the FOR position.

7. After 5 seconds approximately, release the start button on the panel of Three-Phase Salient Pole Synchronous Machine. The motor should rotate at the rated speed of 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power). Observe and record the direction of rotation of the motor.

   The direction of rotation = _____

8. Set the reverse switch on the Reversing Switch Module to the STOP position. Then turn off the Synchronous Machine Exciter.

9. Hold the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine. Turn on the Synchronous Machine Exciter. Set the reverse switch on the Reversing Switch Module to the REV position.

10. After 5 seconds approximately, release the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine. The motor should rotate at a speed of its rated value 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power). Observe and record the direction of rotation of the motor.

    The direction of rotation = _____

11. On the Reversing Switch Module, set the reverse switch to the STOP position.

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

13. You can couple the Digital RPM Meter to the motor for reading the motor speed.

Excitation Characteristic

OBJECTIVE

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

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	Magnetic Powder Brake Unit	EM-3320-1A
1	Brake Controller	EM-3320-1N
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	Four-pole Switch Module	EM-3310-2B
1	Digital DCA Meter	EM-3310-3A
1	Digital DCV Meter	EM-3310-3B
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
1	Connecting Leads Set	EM-3390-3A
1	Safety Bridging Plugs Set	EM-3390-4A

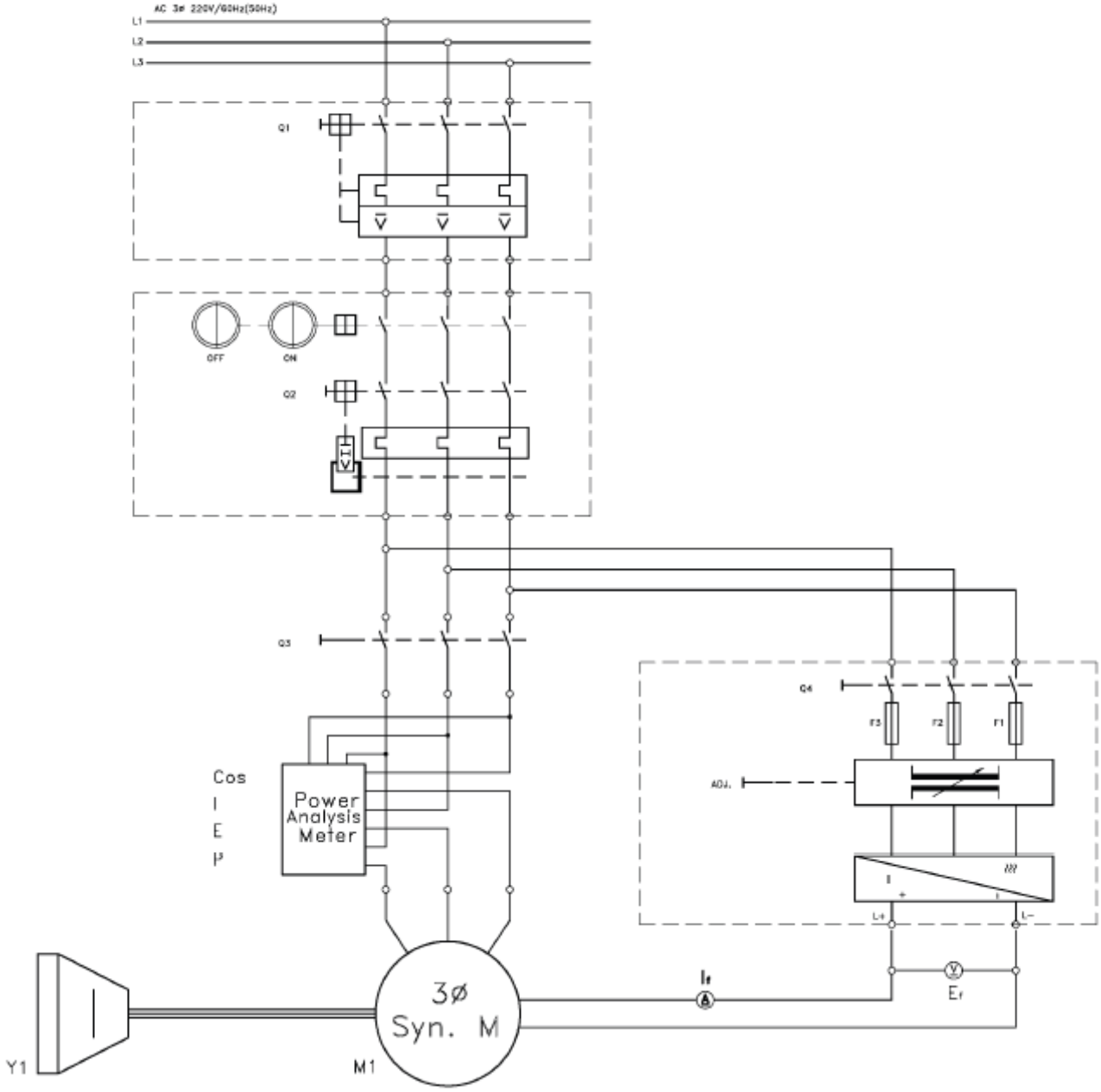

Fig. 14-2-1 Circuit diagram for excitation characteristic test

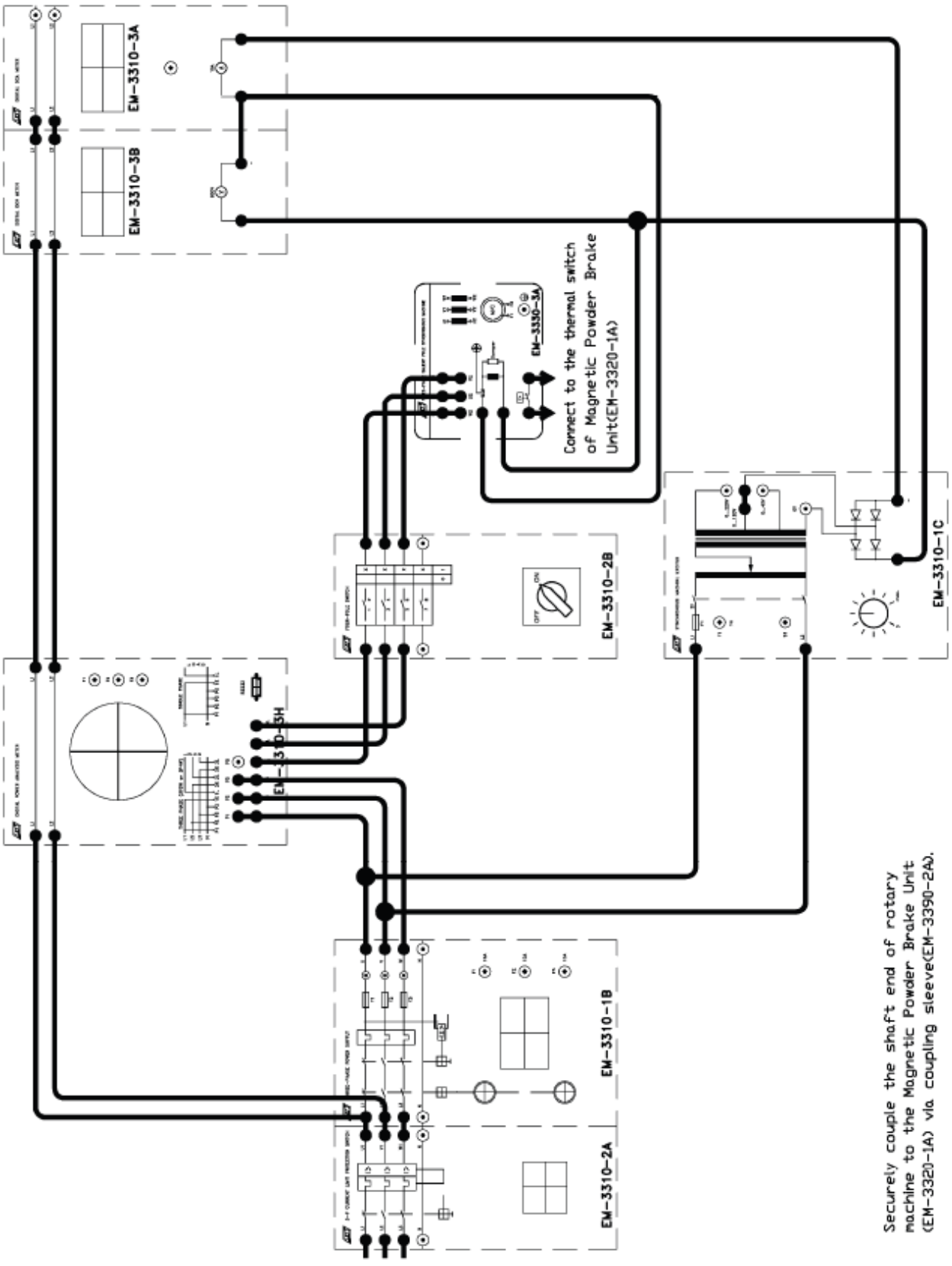

Fig. 14-2-2 Connection diagram for excitation characteristic test

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 Three-phase Salient Pole Synchronous Machine, Magnetic Powder Brake Unit, and Brake Controller on the Laboratory Table. Mechanically couple the Three-phase Salient Pole Synchronous Machine to the Magnetic Powder Brake Unit using a Coupling. Securely lock the Machine Bases together using delta screws. Install the Coupling Guard and the Shaft End Guard. Electrically connect the Brake Controller to the Magnetic Powder Brake Unit using the supplied cable.

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

2. Install the required Modules in the Experimental Frame. Construct the circuit in accordance with the circuit diagram in Fig. 14-2-1 and the connection diagram in Fig. 14-2-2. Have the instructor check your completed circuit. **Note:** The thermal switches of Three-phase Salient Pole Synchronous Motor and Magnetic Powder Brake Unit must be connected together.

   Make yourself familiar with the operation of Brake Controller by referring to the EM-3320 Operation Manual.

   Before using the Brake Controller and Magnetic Powder Brake Unit, you must first calibrate the torque display of the Brake Controller to 0 kg-m by adjusting the zero adj knob located on the rear panel of Magnetic Powder Brake Unit with the power on.

3. On the Four-Pole Switch Module, set the on-off switch to the OFF position.

4. On the Synchronous Machine Exciter Module, set the voltage control knob to the 0 position.

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

6. Slowly turn the voltage control knob on the Synchronous Machine Exciter so that the field current I_f (obtained from the Digital DCA Meter) is equal to 0.3A. Then turn off the Synchronous Machine Exciter.

7. Hold the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine. Turn on the Synchronous Machine Exciter. Set the on-off switch on the Four-Pole Switch Module to the ON position.

8. After 5 seconds approximately, release the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine. The motor should rotate at the rated speed of 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power).

9. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to each of the torque settings listed in Table 14-2-1. If the Controller doesn't operate normally, reboot it by pressing the RESET button. **If the rotor of motor is locked by a heavy brake torque, turn off the power immediately.**

10 Record the values of the power factor cos θ, motor current I, motor voltage E, and power P displayed by the Digital Power Analysis Meter in Table 14-2-1.

11. Manipulate the Brake Controller to release the braking. That is to say, release the braking by pressing the ESC or BACK button on the Brake Controller.

12. Repeat steps 3 through 11 for other settings of the field current I_f listed in Table 14-2-1. **Note:** The motor current must not exceed 130% of the rated current,1.17A x 1.3 = 1.521A.

13. Sequentially turn off the Three-phase Power Supply, 3-P Current Limit Protection Switch modules, Magnetic Powder Brake Unit and Brake Controller.

Table 14-2-1 Measured values of cos θ, I, E, and P

T (kg-m)		0	0.05	0.1	0.15	0.2	0.25
I_f=0.15A	cos θ						
	I (A)						
	E (V)						
	P (W)						
I_f=0.3A	cos θ						
	I (A)						
	E (V)						
	P (W)						
I_f=0.45A	cos θ						
	I (A)						
	E (V)						
	P (W)						

Load Characteristic

OBJECTIVE

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

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Salient Pole Synchronous Machine	EM-3330-3A
1	Magnetic Powder Brake Unit	EM-3320-1A
1	Brake Controller	EM-3320-1N
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	Four-pole Switch Module	EM-3310-2B
1	Digital DCA Meter	EM-3310-3A
1	Digital DCV Meter	EM-3310-3B
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
1	Coupling	EM-3390-2A
1	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

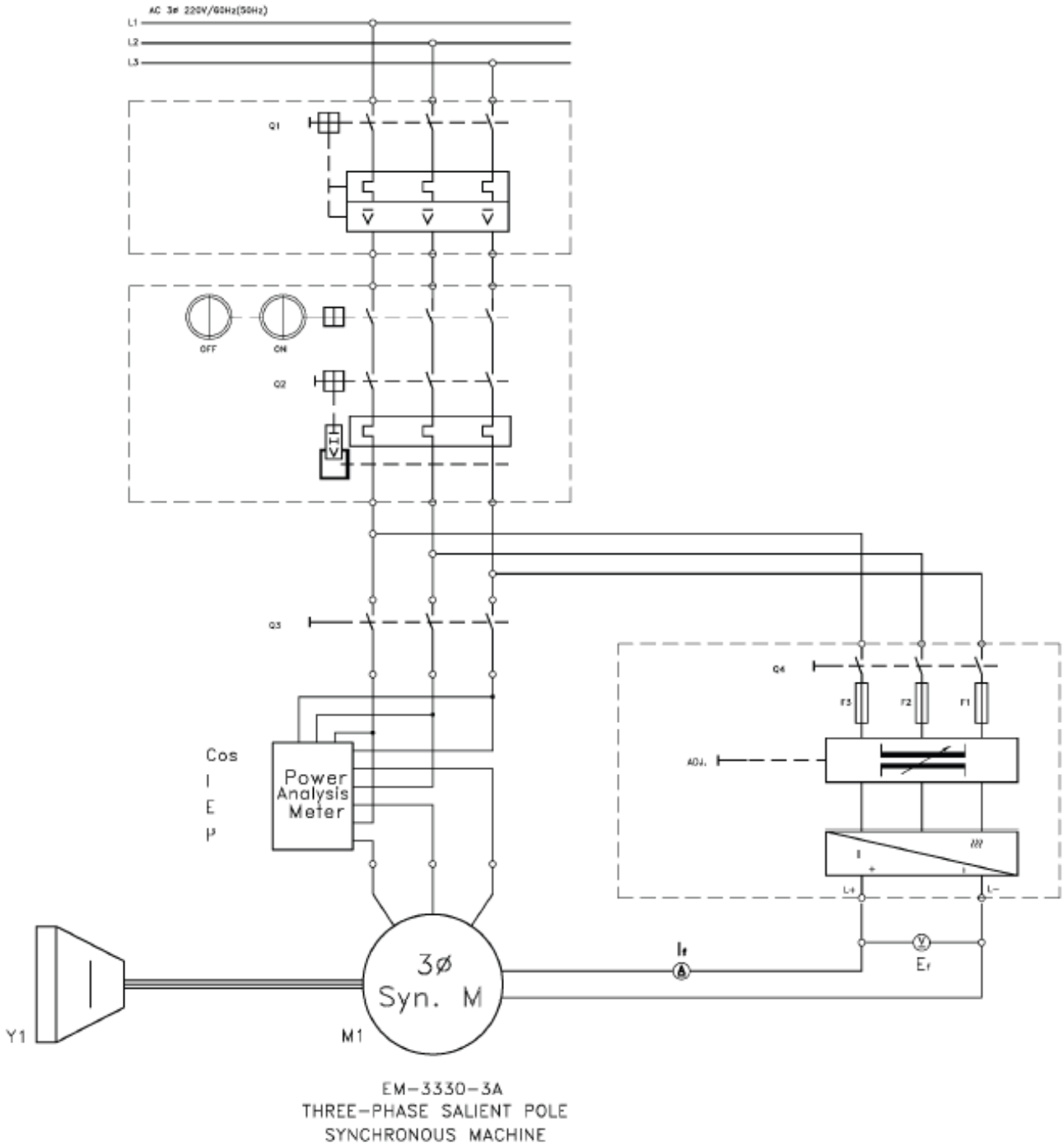

Fig. 14-3-1 Circuit diagram for load characteristic test

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 Three-phase Salient Pole Synchronous Machine, Magnetic Powder Brake Unit, and Brake Controller on the Laboratory Table. Mechanically couple the Three-phase Salient Pole Synchronous Machine to the Magnetic Powder Brake Unit using a Coupling. Securely lock Machine Bases together using delta screws. Install the Coupling Guard and the Shaft End Guard. Electrically connect the Brake Controller to the Magnetic Powder Brake Unit using the supplied cable.

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

2. Install the required Modules in the Experimental Frame. Construct the circuit in accordance the circuit diagram in Fig. 14-3-1 and the connection diagram in Fig. 14-3-2. Have the instructor check your completed circuit. **Note:** The thermal switches of Three-phase Salient Pole Synchronous Motor and Magnetic Powder Brake Unit must be connected together.

   Make yourself familiar with the operation of Brake Controller by referring to the EM-3320 Operation Manual.

   Before using the Brake Controller and Magnetic Powder Brake Unit, you must first calibrate the torque display of the Brake Controller to 0 kg-m by adjusting the zero adj knob located on the rear panel of Magnetic Powder Brake Unit with the power on.

3. On the Four-Pole Switch Module, set the on-off switch to the OFF position.

4. On the Synchronous Machine Exciter Module, set the voltage control knob to the 0 position.

5. Sequentially turn on the Brake Controller, Magnetic Powder Brake Unit, 3-P Current Limit Protection Switch, Three-phase Power Supply, and Synchronous Machine Exciter Modules.

6. Slowly turn the voltage control knob on the Synchronous Machine Exciter so that the field current I_f (obtained from the Digital DCA Meter) is equal to 0.4 A. Then turn off the Synchronous Machine Exciter.

7. Hold the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine. Turn on the Synchronous Machine Exciter. Set the on-off switch on the Four-Pole Switch Module to the ON position.

8. After 5 seconds approximately, release the synchronizing button on the panel of Three-Phase Salient Pole Synchronous Machine. The motor should rotate at its rated speed of 1,800 rpm for 60-Hz power (1,500 rpm for 50-Hz power).

9. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to each of the torque settings listed in Table 14-3-1. If the Controller doesn't operate normally, reboot it by pressing the RESET button. **If the rotor of motor is locked by a heavy brake torque, turn off the power immediately.**

10. Record the motor current I, motor voltage E, power P, and power factor cos θ values displayed by the Digital Power Analysis Meter in Table 14-3-1.

11. Manipulate the Brake Controller to release the braking. That is to say, release the braking by pressing the ESC or BACK button on the Brake Controller.

12. Repeat steps 3 through 11 for other settings of the field current I_f listed in Table 14-3-1. **Note:** The motor current must not exceed 130% of the rated current,1.17A x 1.3 = 1.521A.

13. Sequentially turn off the Three-phase Power Supply, 3-P Current Limit Protection Switch modules, Magnetic Powder Brake Unit and Brake Controller.

14. Plot I vs If curves at different torque settings in Fig. 14-3-3 using the results of Table 14-3-1

Table 14-3-1 Measured values of cos θ, I, E, and P

T (kg-m)		I_f=0.4A	I_f=0.35A	I_f=0.3A	I_f=0.25A	I_f=0.2A	I_f=0.15A	I_f=0.1A	I_f=0.05A
0	cos θ								
	I (A)								
	E (V)								
	P (W)								
0.05	cos θ								
	I (A)								
	E (V)								
	P (W)								
0.1	cos θ								–
	I (A)								
	E (V)								
	P (W)								
0.15	cos θ							–	–
	I (A)								
	E (V)								
	P (W)								

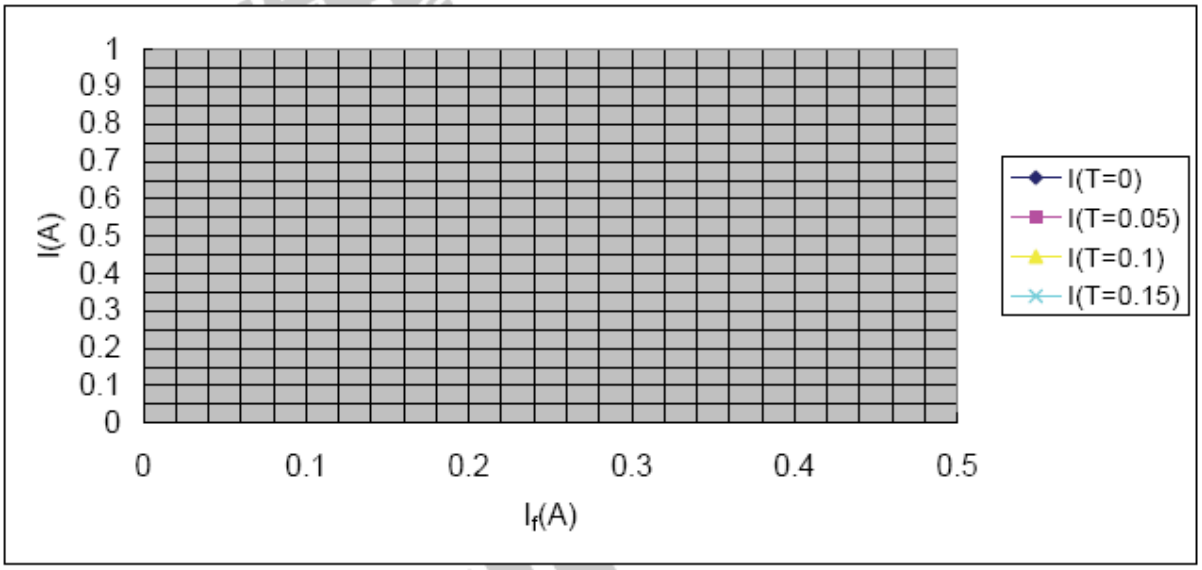

Fig. 14-3-3 I vs I_f curves