LAB 3

Three-Phase Squirrel Cage Induction Motor

SECTION NUMBER : …….

GROUP NUMBER : …….

GROUP MEMBERS : …….

…….

…….

…….

EXERCISE 12-1

Connection and Motor Direction Control

OBJECTIVE

After completing this exercise, you should be able to demonstrate the connection of a three-phase squirrel cage induction motor and control the direction of rotation of the motor.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Squirrel Cage Motor	EM-3330-3A
1	Three-phase Power Supply Module	EM-3310-1B
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Reversing Switch Module	EM-3310-2C
1	Fuse Set	EM-3310-5B
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

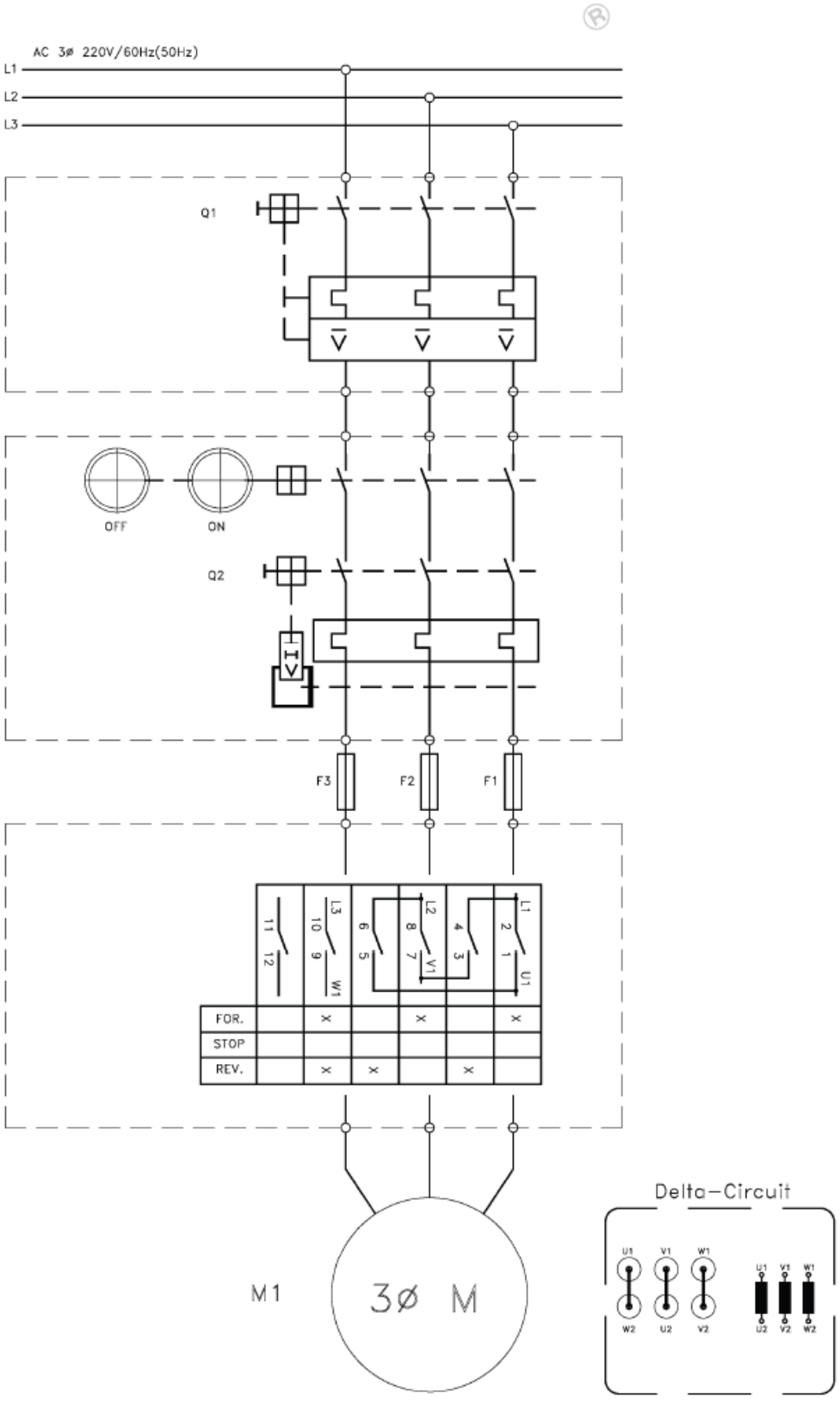

Fig. 12-1-1 Circuit diagram for rotation direction control

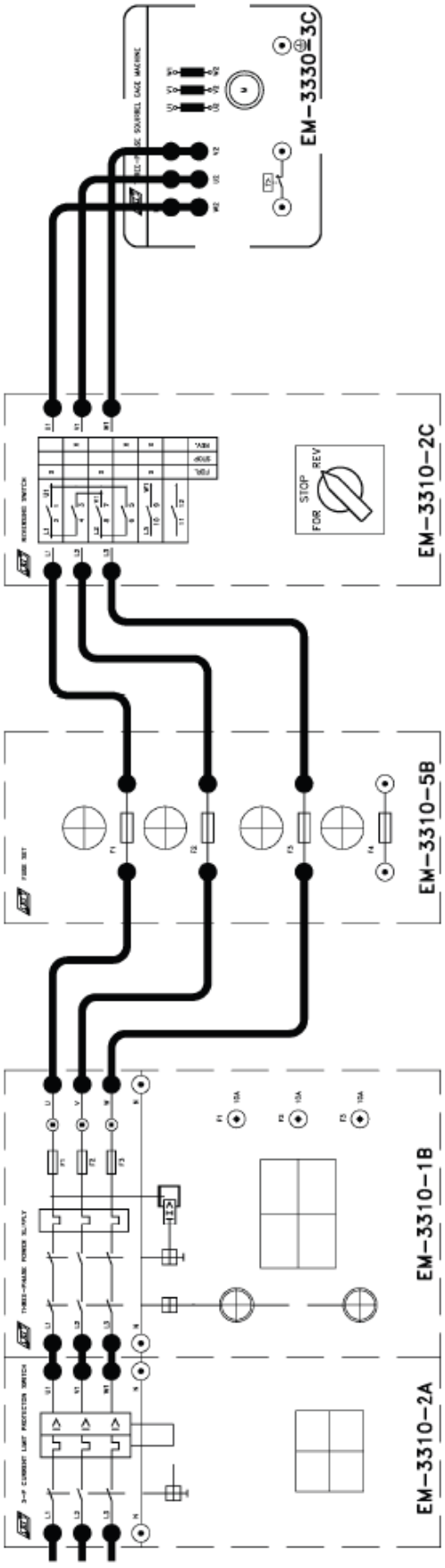

Fig. 12-1-1 Connection diagram for rotation direction control

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. Install the required Modules in the Experimental Frame. Place the Three-phase Squirrel Cage Motor on the Laboratory Table. Construct the circuit in accordance with the circuit diagram in Fig. 12-1-1 and the connection diagram in Fig. 12-1-2. Have the instructor check your completed circuit.

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

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

4. On the Reversing Switch Module, set the reverse switch to the FOR position. The motor should start running. Observe and record the direction of rotation of the motor.

   The direction of rotation = _____

5. On the Reversing Switch Module, set the reverse switch to the STOP position. The motor should stop.

6. On the Reversing Switch Module, set the reverse switch to the REV position. The motor should start running. Observe and record the direction of rotation of the motor.

   The direction of rotation = _____

7. On the Reversing Switch Module, return the reverse switch to the STOP position.

8. Sequentially turn off the Three-phase Power Supply and 3-P Current Limit Protection Modules.

EXERCISE 12-2

Wye-Delta Starting

OBJECTIVE

After completing this exercise, you should be able to start a three-phase squirrel cage induction motor in wye or delta.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Squirrel Cage Motor	EM-3330-3A
1	Three-phase Power Supply Module	EM-3310-1B
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Y/Δ Starting Switch Module	EM-3310-2D
1	Digital Power Analysis Meter	EM-3310-3H
	or Digital ACA Meter	EM-3310-3C
	Digital ACV Meter	EM-3310-3D
	Digital Power Factor Meter	EM-3310-3F
1	Fuse Set	EM-3310-5B
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

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. Install the required Modules in the Experimental Frame. Place the Three-phase Squirrel Cage Motor on the Laboratory Table. Construct the circuit in accordance with the circuit diagram in Fig. 12-2-1 and the connection diagram in Fig. 12-2-2. Have the instructor check your completed circuit.

2. Set the start switch on the Y/Δ Starting Switching Module to 1 (Y) position. Press the I (on) pushbutton on the Three-phase Power Supply Module to start the motor in wye.

3. Record the motor current I, motor voltage E, and power factor cos θ values displayed by the Digital Power Analysis Meter in Table 12-2-1. Turn off the Three-phase Power Supply.
4. Set the start switch on the Y/Δ Starting Switching Module to the 2 (Δ) position. Turn on the Three-phase Power Supply to start the motor in delta.

5. Record the motor current I, motor voltage E, and power factor cos θ values displayed by the Digital Power Analysis Meter in Table 12-2-1.

6. Turn off the Three-phase Power Supply.

Table 12-2-1 Measured values of I, E, and cos θ

		I (A)	E (V)	cos θ
Wye	Starting			
	Running			
Delta	Starting			
	Running			

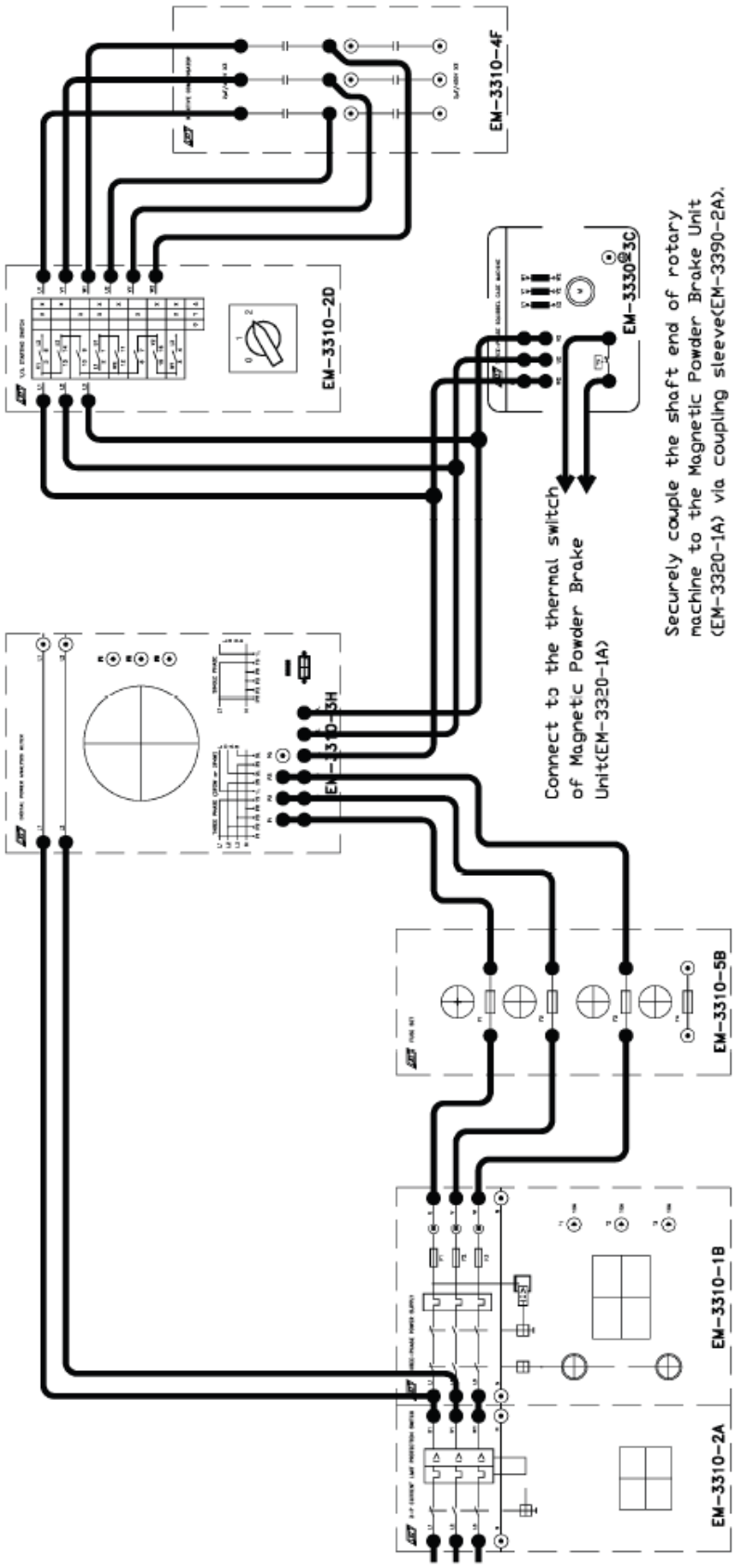

Fig. 12-3-2 Connection diagram for PF correction (2 μF capacitor)

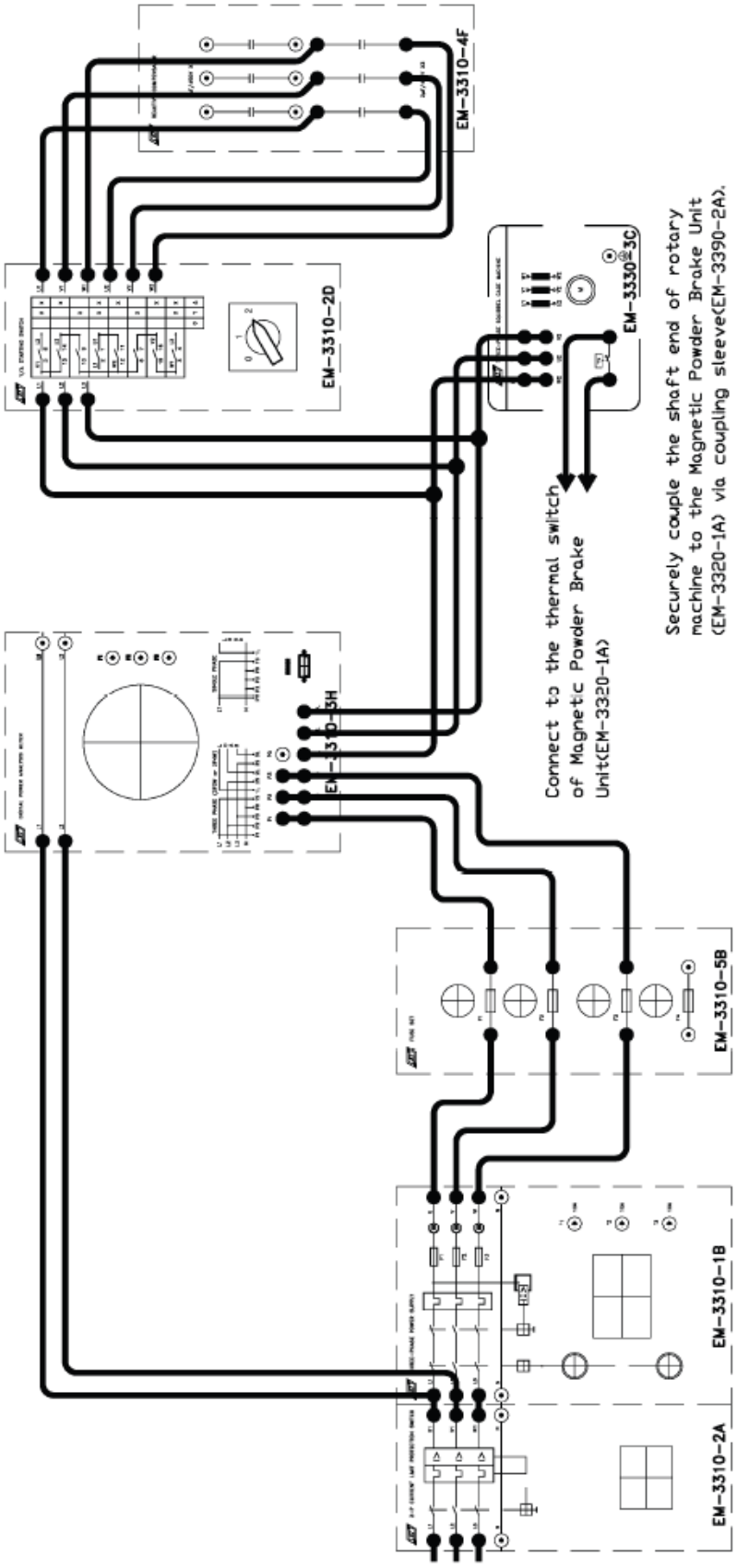

Fig. 12-3-3 Connection diagram for PF correction (3 μF capacitor)

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 Squirrel Cage Motor, Magnetic Powder Brake Unit, and Brake Controller on the Laboratory Table. Mechanically couple the Three-phase Squirrel Cage Motor 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. 12-3-1 and the connection diagram in Fig. 12-3-2. Have the instructor check your completed circuit. **Note:** The thermal switches of Single-phase Induction 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 Y/Δ Starting Switch Module, set the start switch to the 0 position. Sequentially turn on the Brake Controller, Magnetic Powder Brake Unit, 3-P Current Limit Protection Switch and Three-phase Power Supply Modules. The motor should start running under no correction condition.

4. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to 0.1 kg-m. If the Controller doesn't operate normally, reboot it by pressing the RESET button. If the rotor is locked by a heavy brake torque, release the braking by pressing the ESC or BACK button.

5. Record the motor current I, motor power P, and power factor cos θ values displayed by the Digital Power Analysis Meter in Table 12-3-1.

6. On the Y/Δ Starting Switch Module, set the start switch to the 1 (Y) position. Repeat step 5.

7. On the Y/Δ Starting Switch Module, set the start switch to the 2 (Δ) position. Repeat step 5.

8. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to 0.3 kg-m.

9. Repeat steps 5 through 7 and record the measured values in Table 12-3-2.

10. 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.

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

12. Reconstruct the circuit in accordance with the circuit diagram in Fig. 12-3-1 and the connection diagram in Fig. 12-3-3. Have the instructor check your completed circuit.

13. On the Y/Δ Starting Switch Module, set the start switch to the 0 position. Sequentially turn on the Brake Controller, Magnetic Powder Brake Unit, 3-P Current Limit Protection Switch and Three-phase Power Supply Modules. The motor should start running under no correction condition.

14. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to 0.1 kg-m.
15. Record the motor current I, motor power P, and power factor cos θ values displayed by the Digital Power Analysis Meter in Table 12-3-1.

16. On the Y/Δ Starting Switch Module, set the start switch to the 1 (Y) position. Repeat step 14.

17. On the Y/Δ Starting Switch Module, set the start switch to the 2 (Δ) position. Repeat step 14.

18. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to 0.3 kg-m.

19. Repeat steps 14 and 16 and record the measured values in Table 12-3-2.

20. 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.

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

Table 12-3-1 Measured values of I, P, and cos θ

Torque	0.1 kg-m				
	no correction	2 μF (delta)	2 μF (wye)	3 μF (delta)	3 μF (wye)
I (A)					
cos θ					
P (W)					

Table 12-3-2 Measured values of I, P, and cos θ

Torque	0.3 kg-m				
	no correction	2 μF (delta)	2 μF (wye)	3 μF (delta)	3 μF (wye)
I (A)					
cos θ					
P (W)					

EXERCISE 12-4

No-Load Characteristic

OBJECTIVE

After completing this exercise, you should be able to demonstrate the operating characteristic of a three-phase squirrel cage motor under no-load condition.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Squirrel Cage Motor	EM-3330-3A
1	Three-phase Power Supply Module	EM-3310-1B
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
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	Fuse Set	EM-3310-5B
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
	Safety Bridging Plugs Set	EM-3390-4A

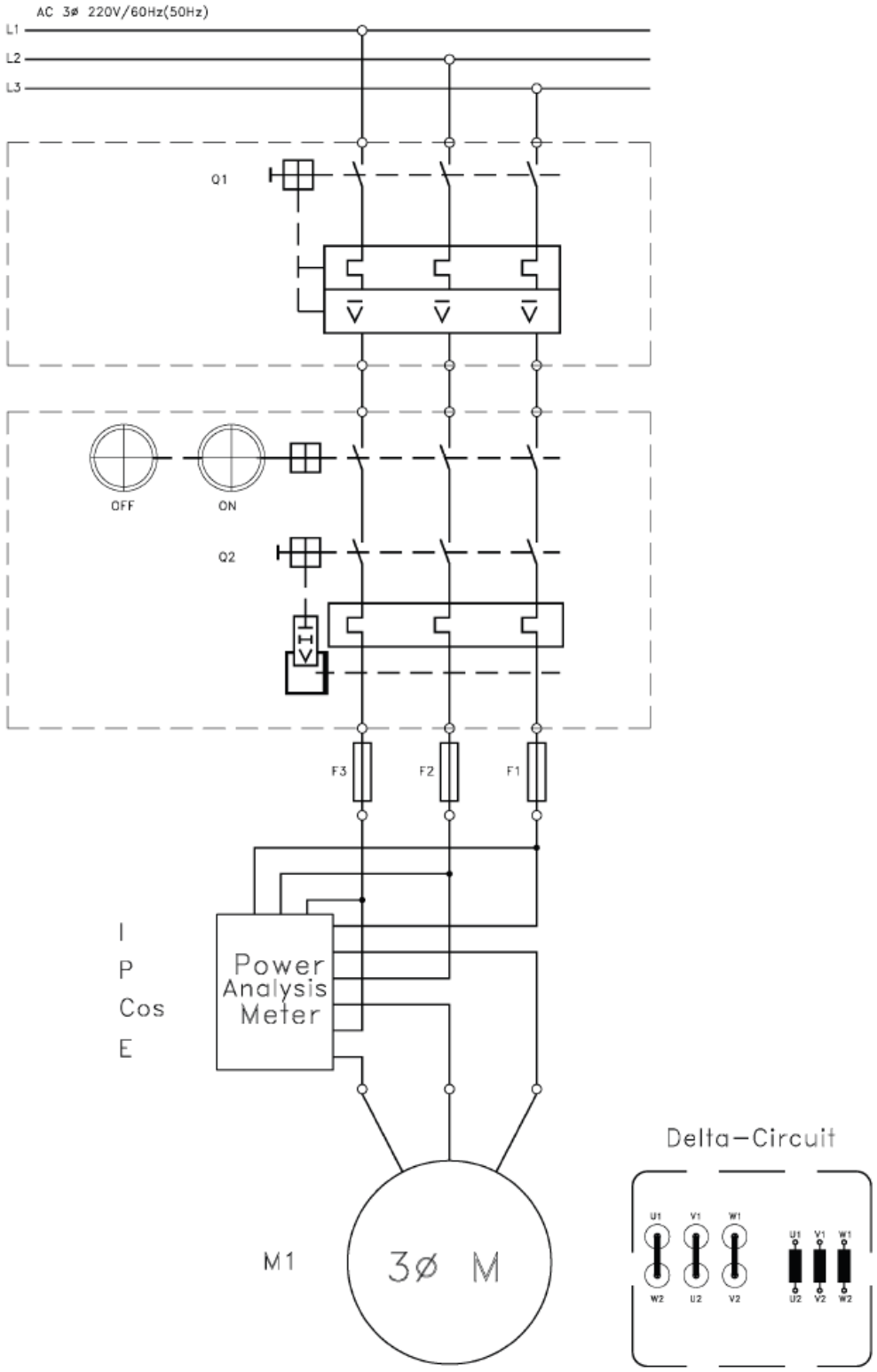

Fig. 12-4-1 Circuit diagram for no-load test

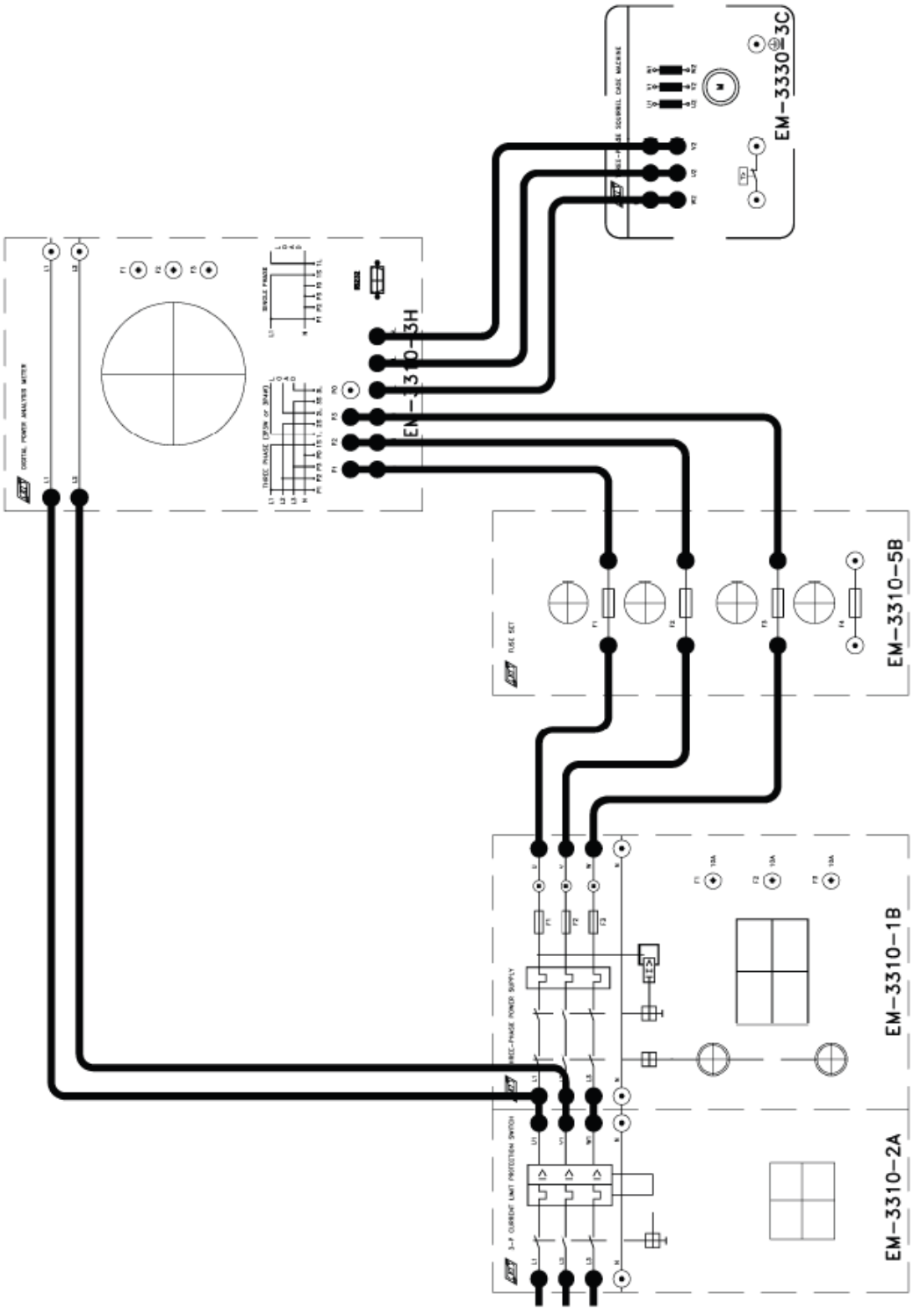

Fig. 12-4-2 Connection diagram for no-load test

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. Install the required Modules in the Experimental Frame. Place the Three-phase Squirrel Cage Motor on the Laboratory Table. Construct the circuit in accordance with the circuit diagram in Fig. 12-4-1 and the connection diagram in Fig. 12-4-2. Have the instructor check your completed circuit.

2. Sequentially turn on the 3-P Current Protection Switch and Three-phase Power Supply Modules. The motor should start running in delta.

3. Record the motor current I, motor voltage E, motor power P and power factor cos θ values displayed by the Digital Power Analysis Meter in Table 12-4-1.

4. Sequentially turn off the Three-phase Power Supply and 3-P Current Protection Switch Modules.

Table 12-4-1 Measured values of I, E, P, and cos θ

I (A)	P (W)	cos θ	E (V)

EXERCISE 12-5

Blocked-Rotor Test

OBJECTIVE

After completing this exercise, you should be able to demonstrate the blocked-rotor characteristic of a three-phase squirrel cage motor.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Squirrel Cage Motor	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	3ϕ AC/DC Power Supply	EM-3310-1D
1	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Four-pole Switch Module	EM-3310-2B
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	Fuse Set	EM-3310-5B
1	Coupling	EM-3390-2A
1	Coupling Guard	EM-3390-2B
1	Shaft End Guard	EM-3390-2C
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

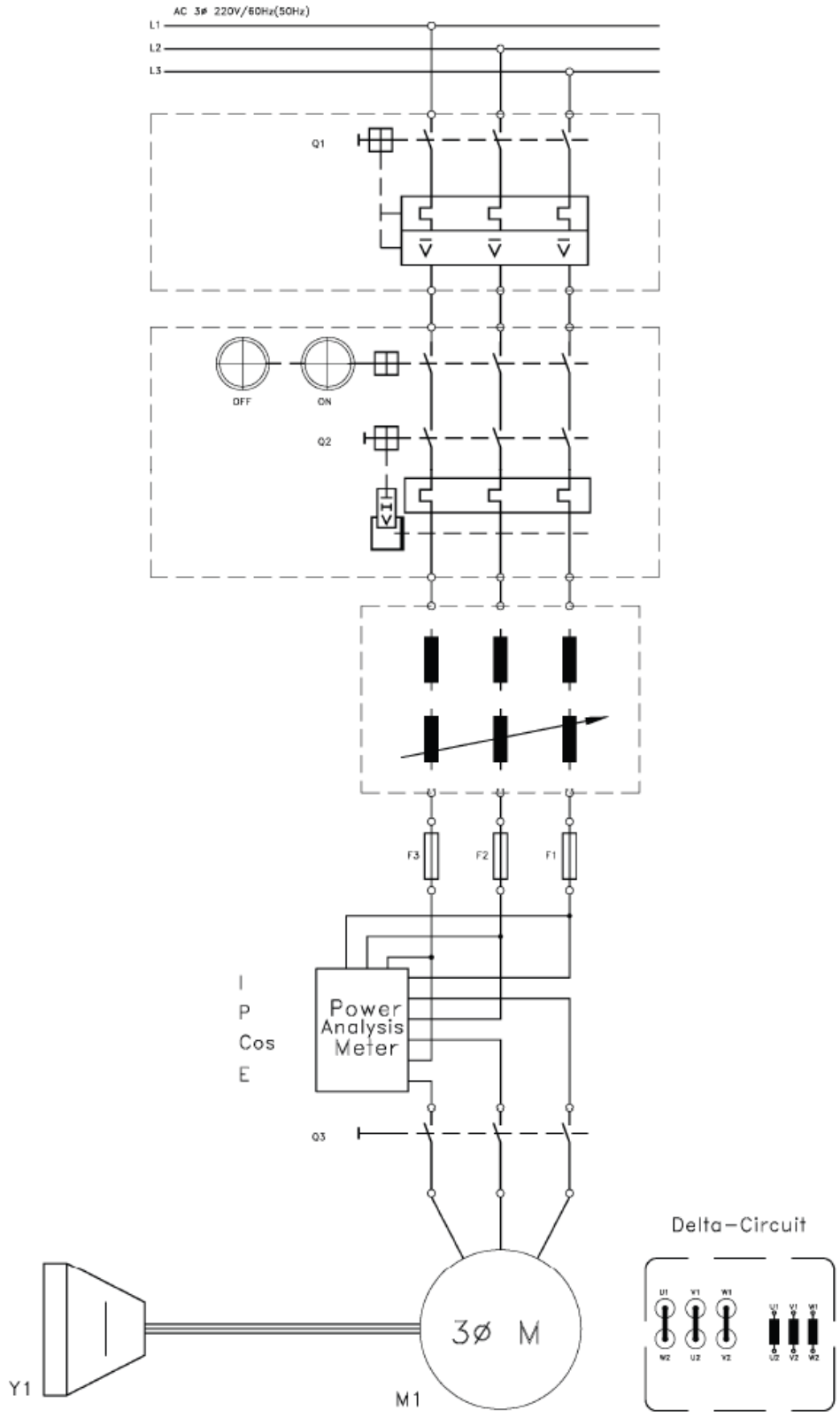

Fig. 12-5-1 Circuit diagram for blocked-rotor test

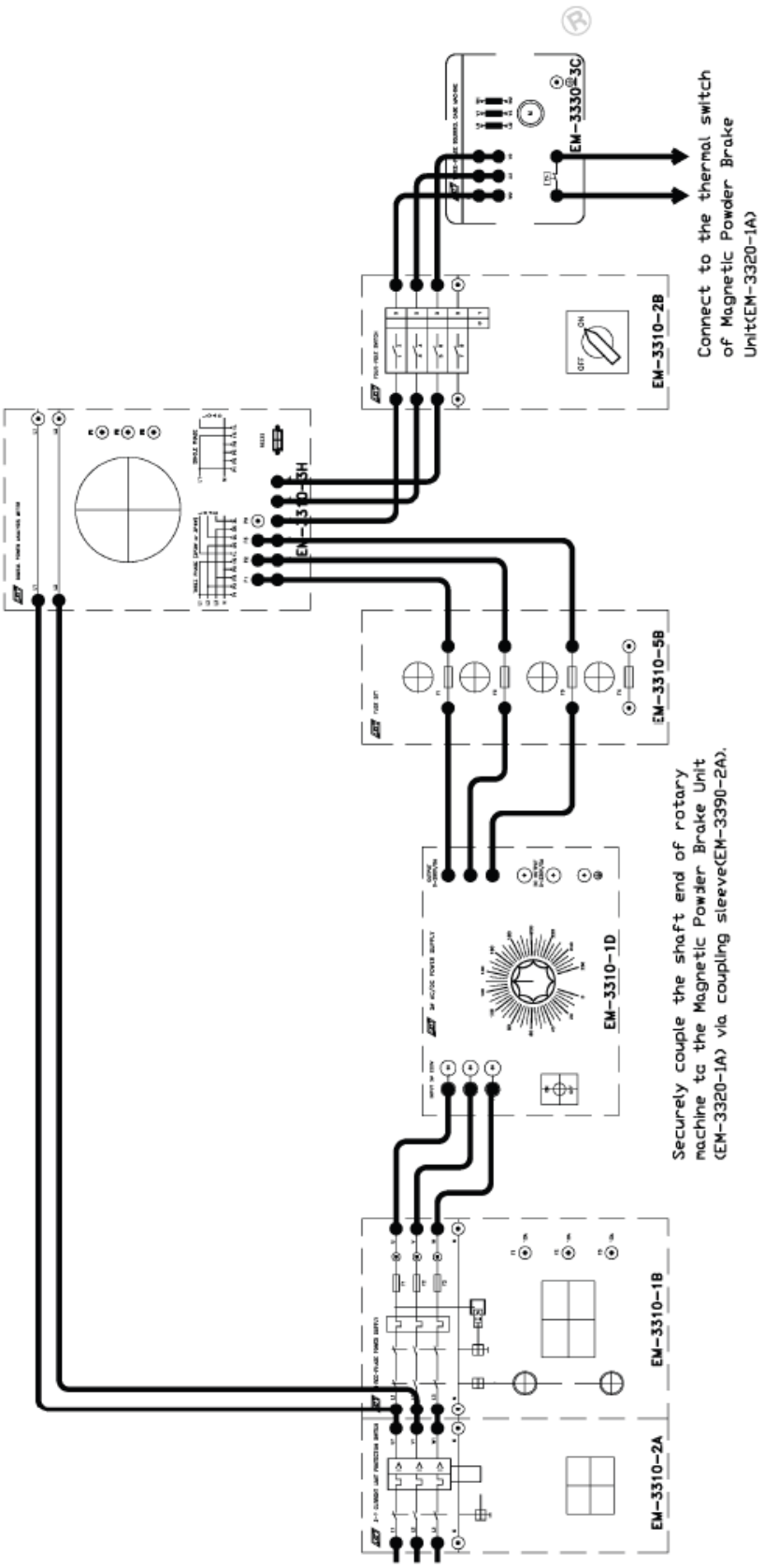

Fig. 12-5-2 Connection diagram for blocked-rotor test

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 Squirrel Cage Motor, Magnetic Powder Brake Unit, Brake Controller and 3ϕ AC/DC Power Supply on the Laboratory Table. Mechanically couple the Three-phase Squirrel Cage Motor to the Magnetic Powder Brake Unit using a Coupling. Securely lock Machine Bases together using the 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. 12-5-1 and the connection diagram in Fig. 12-5-2. Have the instructor check your circuit. **Note:** The thermal switches of Three-Phase Squirrel Cage Induction 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. Set the on-off switch on the Four-pole Switch Module to the OFF position. Sequentially turn on the Brake Controller, Magnetic Powder Brake Unit, 3-P Current Limit Protection Switch Module. Set the voltage control knob on the 3ϕ AC/DC Power Supply to the 0 position. Turn on the 3ϕ AC/DC Power Supply.

4. Manipulate the Brake Controller to operate in Mode\Open Loop\Manual mode and set the output voltage to 7V.

5. Turn on the Three-phase Power Supply. Set the on-off switch on the Four-Pole Switch Module to the ON position. The motor should start running in delta.

6. On the 3ϕ AC/DC Power Supply, Slowly turn the voltage control knob to increase the motor current I until it is equal to the rated value of 1.4 A. Record the current value in Table 12-5-1.

7. Record the motor current I, motor power P, power factor cos θ, and motor voltage E values displayed by the Digital Power Analysis Meter in Table 12-5-1.

8. Sequentially turn off the Four-pole Switch, Three-phase Power Supply, 3-P Current Limit Protection Switch Modules, Magnetic Powder Brake Unit and Brake Controller.

Table 12-5-1 Measured values of I, P, E, and cos θ

I (A)	P (W)	cos θ	E (V)
1.4			

EXERCISE 12-6

Torque-Speed Characteristic

OBJECTIVE

After completing this exercise, you should be able to demonstrate the torque-speed characteristic of a three-phase squirrel cage motor.

EQUIPMENT REQUIRED

Qty	Description	Cat. No.
1	Three-phase Squirrel Cage Motor	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	Three-pole Current Limit Protection Switch Module	EM-3310-2A
1	Digital Power Analysis Meter	EM-3310-3H
	or Digital ACA Meter	EM-3310-3C
	Digital Power Factor Meter	EM-3310-3F
1	Fuse Set	EM-3310-5B
1	Coupling	EM-3390-2A
1	Coupling Guard	EM-3390-2B
1	Shaft End Guard	EM-3390-2C
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

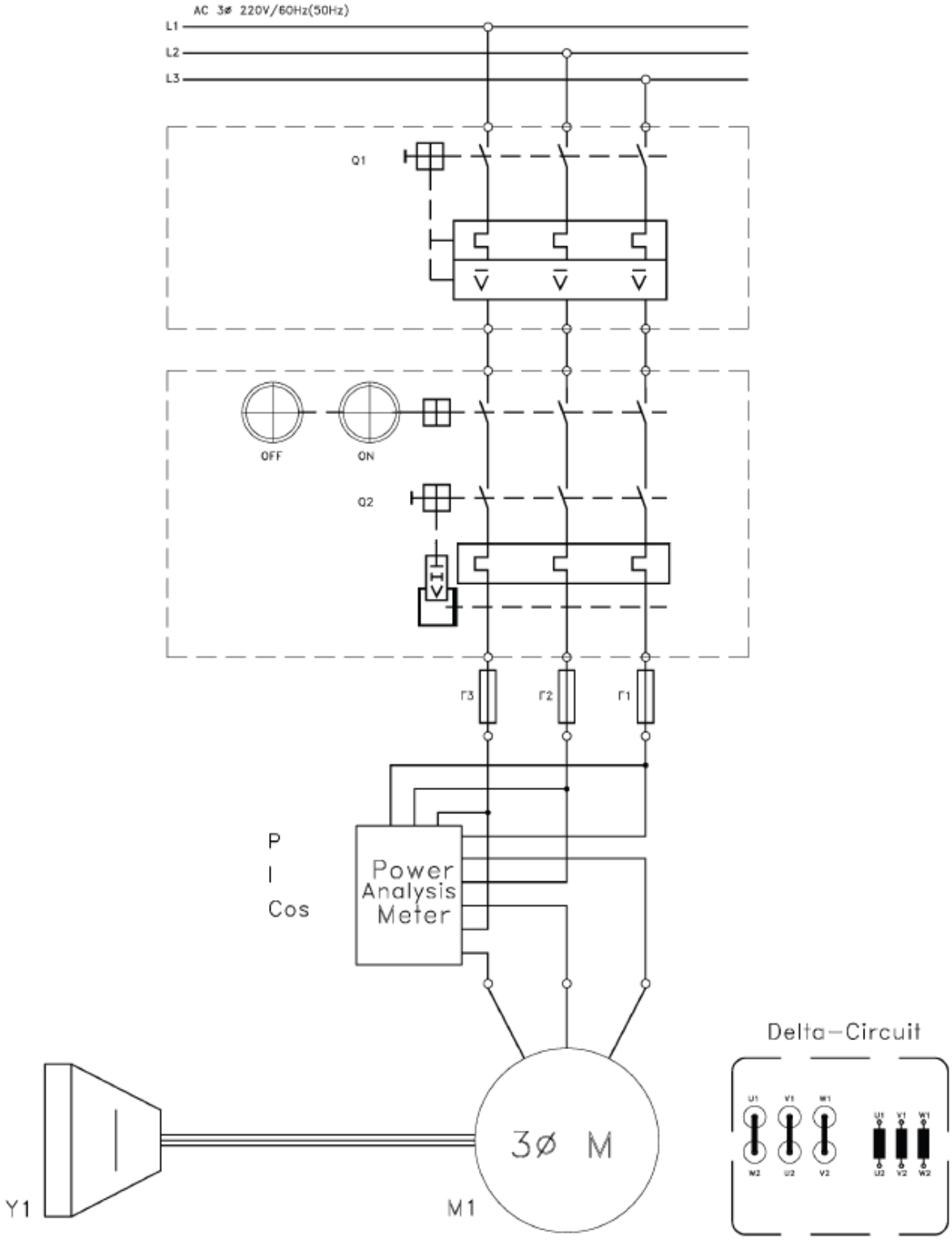

Fig. 12-6-1 Circuit diagram for torque-speed characteristic test

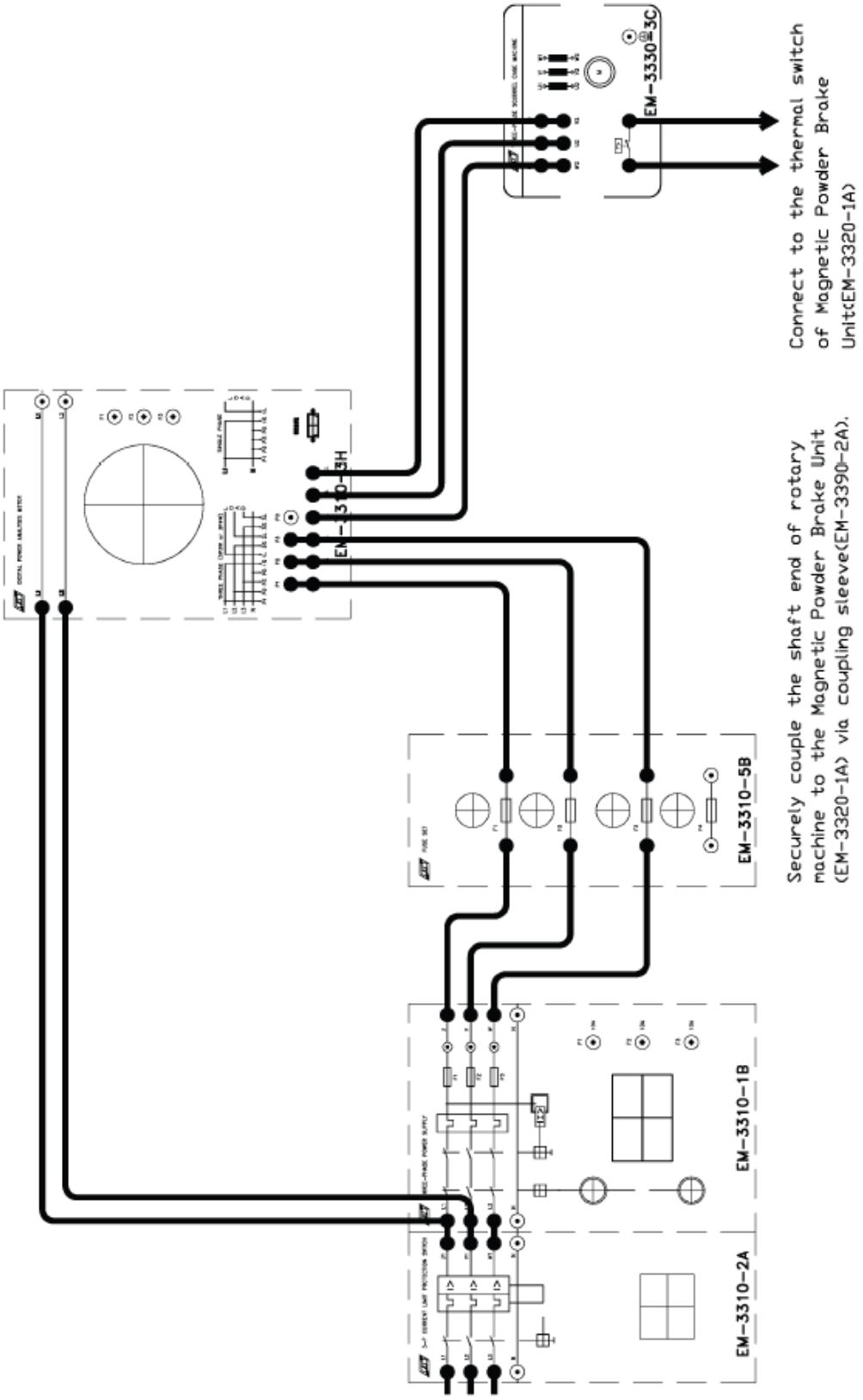

Fig. 12-6-2 Connection diagram for torque-speed characteristic test

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 Squirrel Cage Motor, Magnetic Powder Brake Unit, and Brake Controller on the Laboratory Table. Mechanically couple the Three-phase Squirrel Cage Motor 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 with the circuit diagram in Fig. 12-6-1 and the connection diagram in Fig. 12-6-2. Have the instructor check your completed circuit. **Note:** The thermal switches of Single-phase Induction 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. Sequentially turn on the Brake Controller, Magnetic Powder Brake Unit, Three-phase Power Supply and 3-P Current Limit Protection Switch Modules. The motor should start running in delta.

4. Manipulate the Brake Controller to operate in Mode\Closed Loop\Constant Torque mode and set the output torque to 0 kg-m. If the Controller doesn't operate normally, reboot it by pressing the RESET button. If the rotor is locked by a heavy brake torque, release the braking by pressing the ESC or BACK button.

5. Record the values of motor power P, motor current I, power factor cos θ (obtained from the Digital Power Analysis Meter) and the motor speed N (obtained from the Brake Controller) in Table 12-6-1.

6. 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.

7. Repeat steps 3 through 6 for other torque settings listed in Table 12-6-1. **Note:** The motor current must not exceed 130% of the rated value, 1.4 A x 1.3 = 1.82 A.

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

9. Using the results of Table 12-6-1, plot the T vs P curve on the graph of Fig. 12-6-3.

10. Using the results of Table 12-6-1, plot the I vs P curve on the graph of Fig. 12-6-4.
11. Using the results of Table 12-6-1, plot the cos θ vs P curve on the graph of Fig. 12-6-5.

12. Using the results of Table 12-6-1, plot the N vs P curve on the graph of Fig. 12-6-6.

Table 12-6-1 Measured values of P, I, N, and cos θ

T (kg-m)	0	0.05	0.1	0.15	0.2	0.25	0.3
P (W)							
I (A)							
cos θ							
N (rpm)							

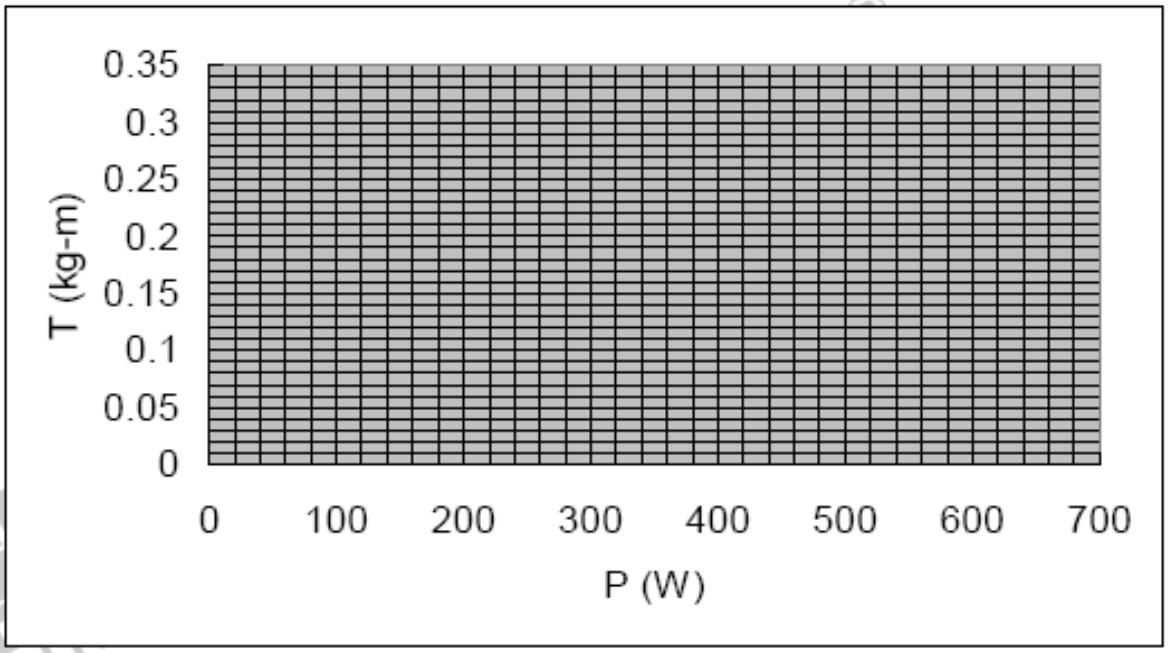

Fig. 12-6-3 The T vs P curve

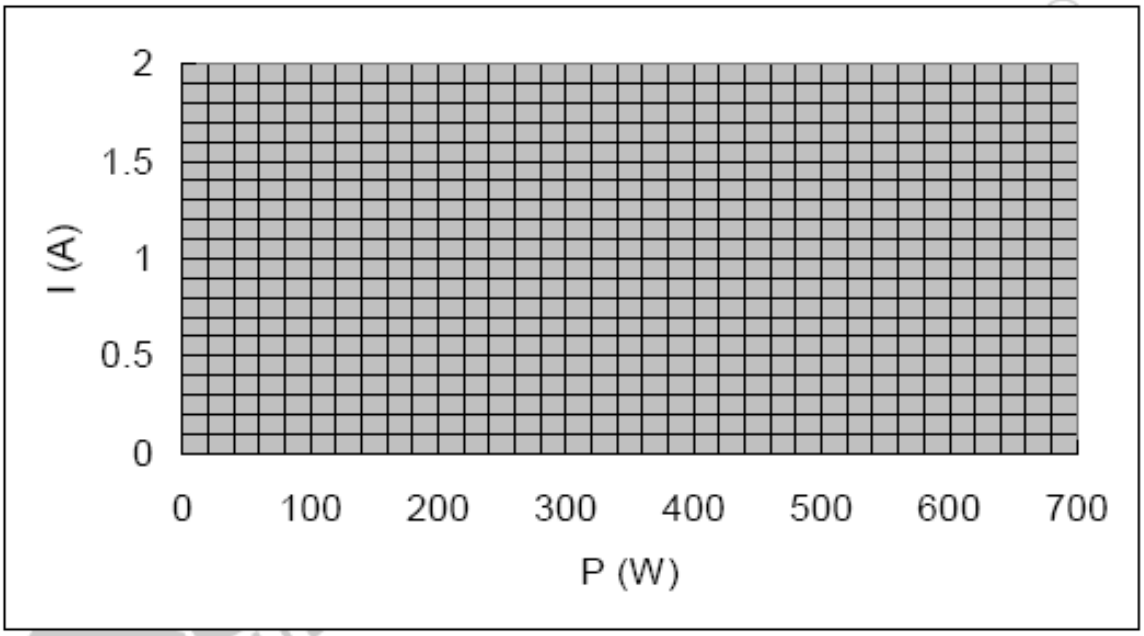

Fig. 12-6-4 The I vs P curve

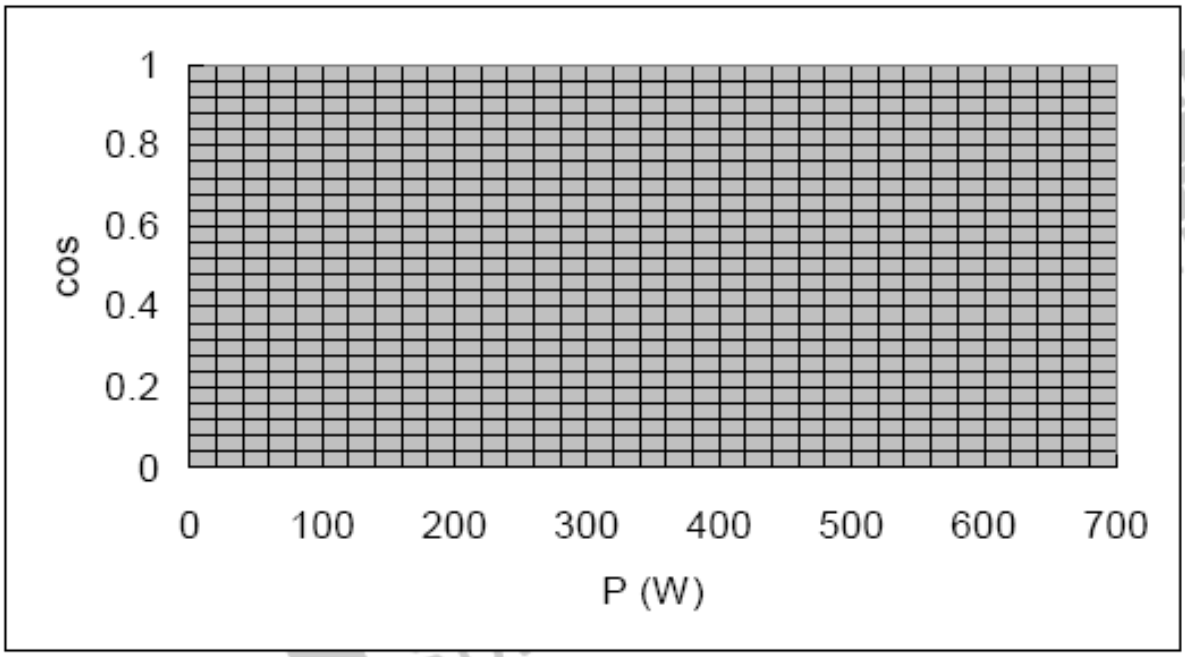

Fig. 12-6-5 The cos θ vs P curve

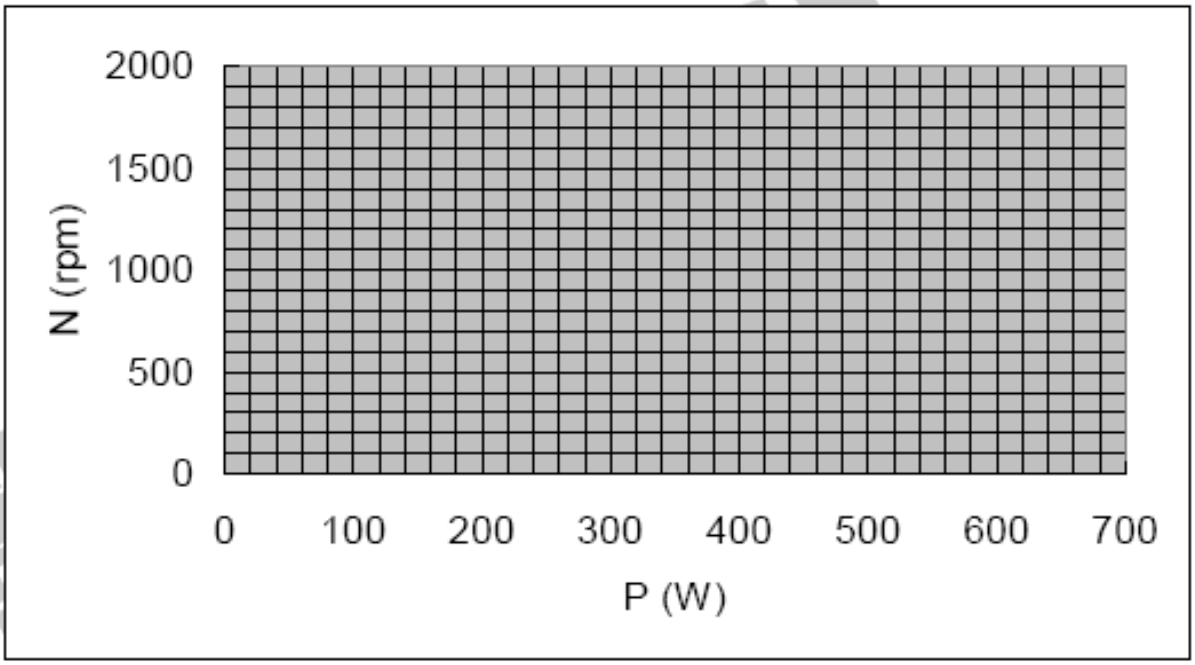

Fig. 12-6-6 The N vs P curve