American International University- Bangladesh

Department of Electrical and Electronic Engineering

EEE 2208: Electrical Machines 2 Laboratory

Title: The split phase induction motor II.

Introduction:

The single-phase induction motor which is equipped with an auxiliary winding displaced in magnetic position from, and connected in parallel with a main running winding is called split phase induction motor.

In this experiment our objectives are:

1) To learn the basic motor wiring connections.
2) To observe the starting and running operation of the split-phase motor.
3) To measure the starting and operating characteristics of the split-phase motor under load and no-load conditions.
4) To study the power factor and efficiency of the split-phase motor.

Theory and Methodology:

Capacitor-Start Motors:

In these motors, the necessary phase difference between I_s and I_m is produced by connecting a capacitor in series with the starting winding as shown in **Fig. 36.10**. The capacitor is generally of the electrolytic type and is usually mounted on the outside of the motor as a separate unit as shown in **Fig. 36.11**.

The capacitor is designed for extremely short-duty service and is guaranteed for not more than 20 periods of operation per hour, each period not to exceed 3 seconds. When the motor reaches about 75 percent of full-load speed, the centrifugal switch *S* opens and cuts out both the starting winding and the capacitor from the supply, thus leaving only the running winding across the lines.

As shown in **Fig. 36.12**, current I_m drawn by the main winding lags the supply voltage V by a large angle whereas I_s leads V by a certain angle. The two current are out of phase with each other by about 180° (for a 200 W, 50 Hz motor) as compared to nearly 30° for a split-phase motor.

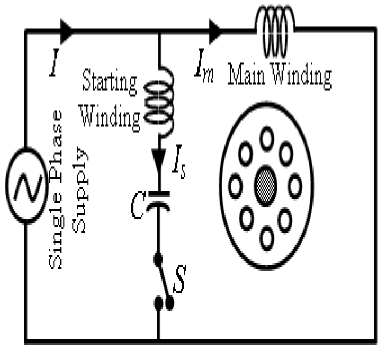


Fig. 36.10

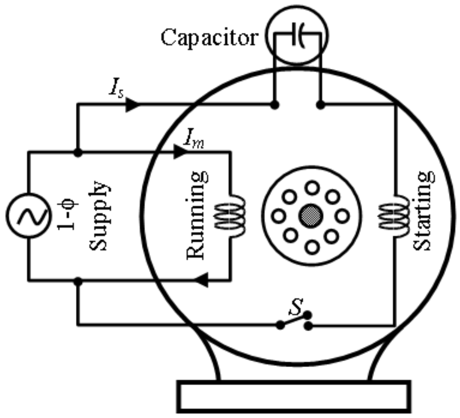


Fig. 36.11

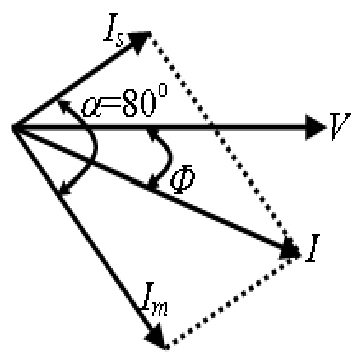


Fig: 36.12

Their resultant current *I* is small and is almost in phase with *V* as shown in Fig. 36.12.
Since the torque developed by a split-phase motor is proportional to the *sine* of the angle between I_s and I_m, it is obvious that the increase in the angle (from 30° to 80°) alone increases the starting torque to nearly twice the value developed by a standard split-phase induction motor. Other improvement in motor design have made it possible to increase the starting torque to a value as high as 350 to 450 percent.

Typical performance curve of such a motor is shown in **Fig. 36.13**.

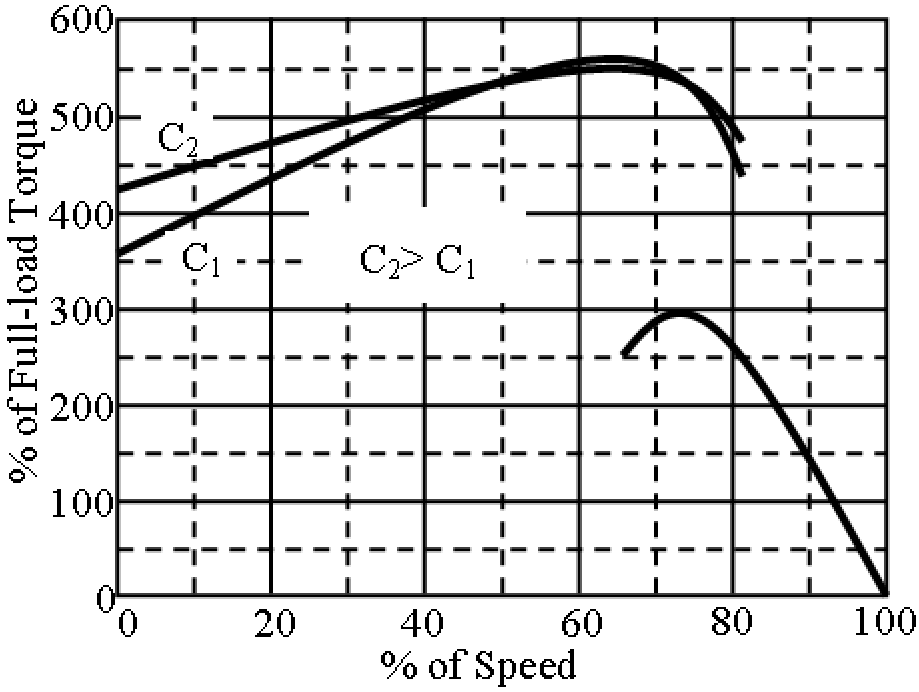


Fig. 36.13

Pre-Lab Homework:

Study about capacitor start motor.

Apparatus:

INSTRUMENTS AND COMPONENTS

DESCRIPTION	MODEL
Capacitor- Start Motor	8251
AC Ammeter	8425
AC Voltmeter	8426
Single-Phase Wattmeter	8431
Electrodynamometer	8911
Power Supply	8821
Hand Tachometer	8920
Connection Leads	8941
Timing Belt	8942

Precautions:

High voltages are present in this Laboratory Experiment! Do not make any connections with the power on! The power should be turned off after completing each individual measurement!

Experimental Procedure:

Part A:

1. Power Supply was adjusted for an output of 150V AC to perform the Procedures in this Laboratory Experiment.

   a) Connected the AC Voltmeter across Power Supply terminals 4 and N.

   b) Turned on the Power Supply and adjusted for an output of 150V AC as indicated by the voltmeter. Did not touch the voltmeter output control for the remainder of this Laboratory Experiment unless told to do so.

   c) Turned off the Power Supply.

2.
   a) Connected terminals 1 and 2 of the main winding of the Capacitor-Start Motor, to terminals A and N of the pre-adjusted 150V AC output of the Power Supply.

   b) Turned on the Power Supply switch for no longer than 10 seconds.

   c) Did the motor growl?
      ☑ Yes ☐ No

   d) Did the motor turn?
      ☑ Yes ☐ No

3.
   a) Loosened the top screws of the motor module's front panel and lowered the panel.

   b) Turned on the Power Supply switch for no longer than 10 seconds.

   c) Took hold of the motor shaft and spin it.

   d) Did the motor turn?
      ☑ Yes ☐ No

   e) What determined the direction of rotation of the motor?

   f) Returned the front panel of the module to its normal position.

4.

a) Disconnected the main winding, terminals 1 and 2, from the Power Supply.

b) Connected the auxiliary winding, terminals 3 and 4, to the pre-adjusted 150V ac output of the Power Supply terminals 4 and N.

c) Turned on the Power Supply switch for no longer than 10 seconds.

d) Did the motor growl?

☑ Yes ☐ No

e) Did the motor turn?

☐ Yes ☑ No

5.

a) Connected the main winding, terminals 1 and 2, in parallel with the auxiliary winding, terminals 3 and 4.

b) Connected the parallel windings to the pre-adjusted 150V ac output of the Power Supply.

c) Turned on the Power Supply switch for no longer than 10 seconds.

d) Did the motor start?

☑ Yes ☐ No

e) Was the motor noisy?

☑ Yes ☐ No

f) Noted the direction of rotation.

6.

a) Interchanged the leads connecting the two windings in parallel.

b) Turned on the Power Supply switch for no longer than 10 seconds.

c) Noted the direction of rotation.

d) Give a rule for reversing the rotation of a split-phase motor.

7. Connected the circuit shown in Figure 1-1. The centrifugal switch was connected in series with the auxiliary winding and both windings were connected in parallel across the 150V ac power source terminals 4 and 5, was not used when the module was operated as a split-phase motor.

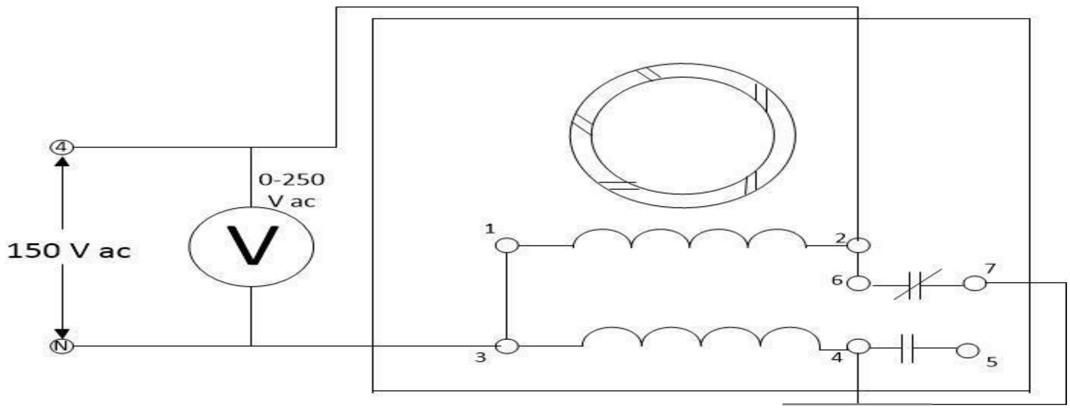


Figure 1-1

8.

a) Turned on the Power Supply switch. The output voltage control was kept at its 150V setting.

b) Did the motor start?
□ Yes □ No

c) Did the centrifugal switch operate?
□ Yes □ No

d) Estimated the starting time. Ans: 1s

e) Using Hand Tachometer measured the running speed.

f) Reduced the input voltage to 100V ac as indicated by the voltmeter and measured the running speed.

g) Returned the voltage to 100V ac and turned off the Power Supply.

9. Connected the circuit shown in Figure 1-2. Noted that both windings are connected in parallel and that the centrifugal switch was in series with the parallel connected motor windings and the 150V ac Power Supply terminals 4 and N.

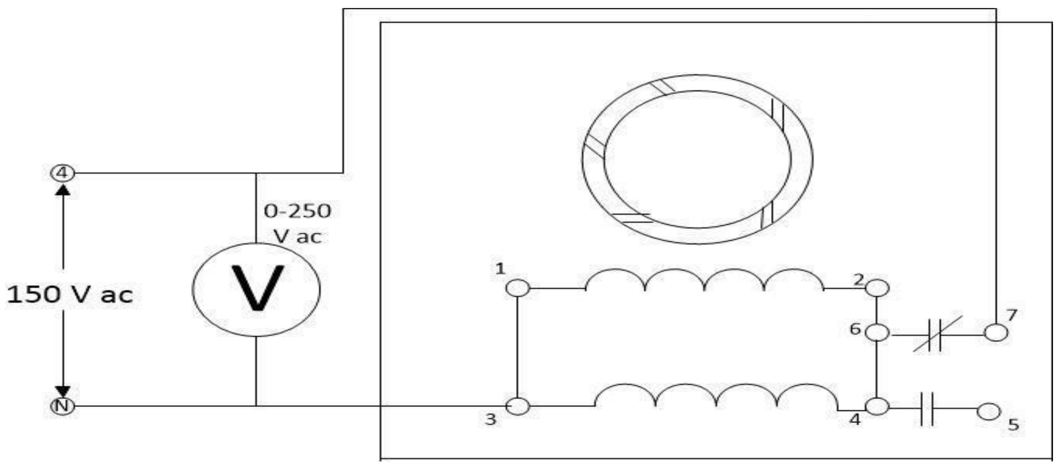


Figure 1-2

10. Before applying power to the motor-

a) Will current flow through both windings?

☑ Yes ☐ No

b) Will a starting torque be developed?

☑ Yes ☐ No

c) Will the motor start to run?

☑ Yes ☐ No

d) What will eventually happen?

11.

a) Closed the Power Supply switch and noted what happened.

b) Observed the operation of the centrifugal switch.

c) At approximately what speed does the centrifugal switch close?

d) Returned the voltage to zero and turned off the Power Supply.

Part B:

1. Using your Capacitor-Start Motor, Power Supply, AC Ammeter and AC Voltmeter connect the circuit shown in figure 10-1.
Note that the fixed 240 V ac output of the Power Supply terminals 1 and N is being used.

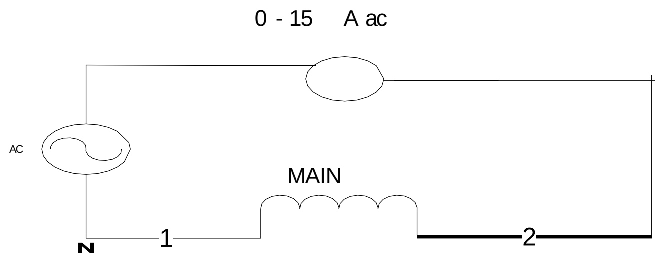


Figure 10-1

2. Turn on the Power Supply switch and measure the current through the main windings as quickly as possible -within 10 seconds.

I (main winding) = 7.5A

3. a) Disconnect your leads from the main winding and connect them to the auxiliary winding terminals 3 and 4 as shown in figure 10.2.

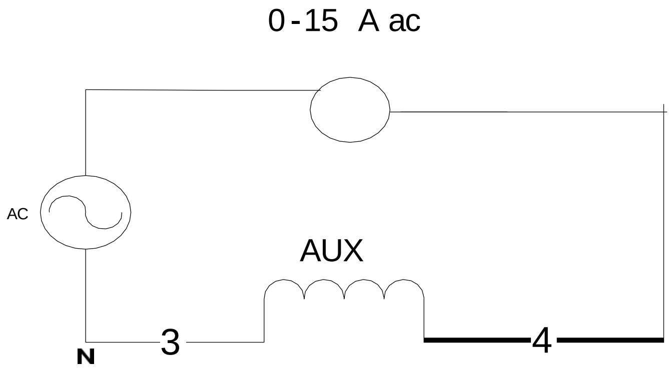
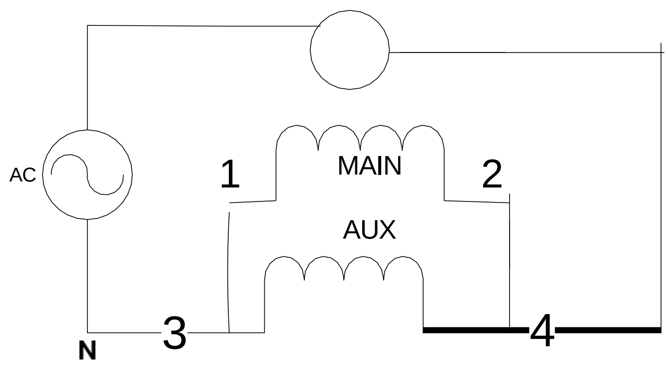


Figure 10-2

b) Repeat Procedure 2.
Note: Remember to take your measurement as quickly as possible.
I (auxiliary winding) = 6.3A

4. a) Connect both windings in parallel terminals 1 to 3 and 2 to 4 as shown in Figure 10.3.
b) Couple the Electrodynamometer to the motor with the Timing Belt.

0-15 A ac



c) Connect the Electrodynamometer to the fixed 240V ac output of the Power Supply terminals 1 and N.
d) Set the Electrodynamometer control knob at its full cw position (to provide a maximum starting load for the Capacitor-Start Motor).
e) Turn on the Power Supply switch and measure the starting current as quickly as possible- within 10 seconds.

I (starting) = 14.3 A

<u>No-load Operation</u>

5. Using your Single-Phase Wattmeter AC Ammeter and AC Voltmeter connect the circuit shown in Figure 10-4.

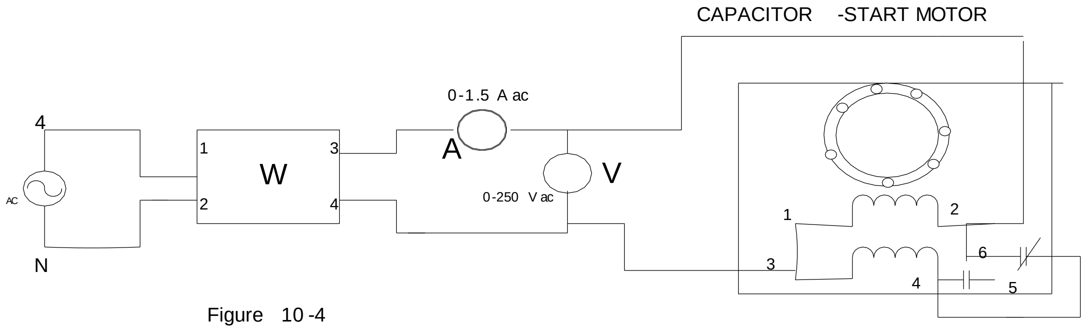


Figure 10 -4

Note that the module is wired as standard split-phase motor.

6.
a) Turn on the Power Supply and adjust for 240V ac as indicated by the voltmeter across the motor.

b) Measure and record in Table 10-1 the line current, the power and motor speed. Note and record the relative motor vibration.

E	I	P	SPEED	VIBRATION
V	A	W	r/min	----
210	1.8	81	1560	High
180	1.4	58	1492	Yes/Mid
120	0.9	34	1478	Yes/Low
60	0.7	31	1460	Yes/Low

c) Repeat (b) for each of the input voltages listed in the table.
d) Return the voltage to zero and turn off the Power Supply.

Full-load Operation

7.
a) Couple the Electrodynamometer to the Capacitor-Start Motor with the Timing Belt.
b) Connect the input terminals of the Electrodynamometer to the fixed 240V ac output of the Power Supply terminals 1 to N.
c) Set the Electrodynamometer control knob at its full cw position (to provide a maximum starting load for the Capacitor-Start Motor).

d) Turn on the Power Supply and adjust for 240V ac.
e) Measure and record in Table 10-1 the line current, the power and motor speed.

TORQUE	I	S	Pin	SPEED	Pout
N-m	A	VA	W	r/min	W
0.1	2	300	120	1498	15.68
0.2	2	300	140	1490	31.20
0.3	2	300	155	1480	46.50
0.4	2.1	300	155	1475	61.78

f) Repeat (e) for each of the torques listed in the table maintaining the input voltage at 240V ac.
g) Return the voltage to zero and turn off the Power Supply.

8.
a) Calculate and record in the table the apparent power (in VA) delivered to the motor for each of the listed torques.
b) Calculate and record in the table the output power Pout for each of the listed torques. Use the formula

$$Pout = 2\pi NT/60$$

9.
You will now determine the maximum starting torque developed by the CapacitorStart Motor.
a) Disconnect the Single-Phase Wattmeter, AC Ammeter and AC Voltmeter form your circuit.
b) Connect the input of your Capacitor-Start Motor to terminals 2 and N of the Power Supply (fixed 240V ac).
c) Set the Electrodynamometer control knob at its full cw position (for maximum loading).

d) Turn on the Power Supply switch and quickly measure the developed torque on the Electrodynamometer scale. Turn off the Power Supply switch.

Starting torque = 2.8 N-m

Questions for report writing:

Part A:

1. Will a single-phase Induction Motor start if only the running (main) or the starting (auxiliary) winding is excited?

   □ Yes ☑ No

2. Will such a motor run on one winding once it has been started?

   ☑ Yes □ No

3. How could you reverse the rotation of the motor?

Ans: By interchanging the leads

4. What will happen to your motor when power is applied if springs twice as stiff are used on the centrifugal switch?

Ans: The centrifugal switch will be closed after starting more rpm than normal position.

5. Explain in details the behavior of your motor in Procedure 11.

Ans: In this stage the motor started with generated torque of the starting winding. when a certain amount of speed is achieved the centrifugal switch is closed and the rotor started running by the torque created by main winding.

6. If the running winding and the auxiliary winding were connected in series, would the motor turn?

   ☑ Yes □ No

7. Does the speed of a split-phase motor change appreciably with a change in the applied voltage?

   ☑ Yes □ No

Part B:

1. From Table 10-2 state the no-load (0 N-m torque):

Ans: No load current. I=0 A

2. From Table 10-2 state the full-load (1.2 N-m torque)

Ans: Full load current I_f = 2.1 A

3. What is the approximate full-load current of your Capacitor-Start Motor?

Ans: 6.5 A

4. How much larger is the starting current than the full load operating current?

   Ans: 0.8 A

5. Based on Procedures 1, 2 and 3 explain why the starting (auxiliary) winding heats much faster than the main winding.

Ans: The heat generation is faster because the starting winding has to provide higher current.

6. Does the no-load speed of a split-phase motor change greatly with change in the applied voltage?

Ans: No

7. How many times greater is the starting torque than the normal full-load torque?

Ans: 4 times

References:

[1] B.L.Theraja, A.K.Theraja,: A textbook of Electrical Technology, Volume- II, S. Chand & company Ltd.

[2] Lab volt lab manual.

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Exp: 6

I (main winding) = 7.5 A
I (Auxi. ") = 6.3 A
I (starting) = 14.3 A

No Load:

E	I	P	Speed	Vibration
V	A	W	r/min	
210	1.8	81	1560	High
180	1.4	58	1492	yes/Mid
120	0.9	34	1478	yes/Low
60	0.7	31	1460	yes/low

Full Load:

Torque	I	S	Pin	Speed	Pout
N-m	A	VA	W	r/min	W
0.1	2		120	1498	
0.2	2		140	1490	
0.3	2		155	1480	
0.4	2.1		155	1475	

Starting torque = 2.8 N-m

17.12.2024