Bangladesh University of Engineering and Technology
Department of Electrical and Electronic Engineering

EEE270 – Electrical Drives and Instrumentation Sessional

Experiment 05

Observation of starting characteristic and dc current vs ac current characteristic curve (V curve) of a synchronous motor

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Evaluation Form:

IMPORTANT! You must complete this experiment during your scheduled lab period. All work for this experiment must be demonstrated to and verified by your lab instructor *before the end* of your scheduled lab period.

STEP	DESCRIPTION	MAX	SCORE
1	Pre-Lab	5	
2	Data Collection Part A	5	
3	Report Part A	5	
4	Data Collection Part B	5	
5	Report Part B	5	
	Total	25	

Signatureof Evaluator: ____

Academic Honesty Statement:

IMPORTANT! Please carefully read and sign the Academic Honesty Statement, below. *You will not receive credit for this lab experiment unless this statement is signed in the presence of your llab instructor.*

"Insigningthisstatement,Iherebycertifythattheworkonthisexperimentismyownand that I have not copied the work of any other student (past or present) while completing this experiment. I understand that if I fail to honor this agreement, I will receive a score of ZERO for this experiment and be subject to possible disciplinary action."

Name:____LabGroup: Date: ____________

Student ID__________________Signature: ____

Contents

Pre-lab Study

Before attempting this lab, please do the following:

1. Reading Assignment:
    - Reference : Chapter 5, page 280-285,Electric Machinery Fundamentals-Stephen J Chapman
    - Read the lab-sheet BEFORE coming to class.

2. Draw the equivalent circuit of a synchronous motor. Also sketch the phasor diagram of synchronous motor operating at lagging power factor.

3. i) What effect does change in field current have on synchronous motor? Sketch the effect in phasor diagram.

    ii) What is over excited and under excited mode?

Experiment 5: Observation of dc current vs ac current characteristic curve (V curve) for the synchronous motor

1 Lab Overview

At the end of this lab, you will be able to

- Obtain starting characteristic of synchronous motor
- Observe how a synchronous motor can act as a variable inductance or capacitance
- Obtain the dc current vs ac current characteristic curve for the synchronous motor

2 Theory

A synchronous motor is an AC motor where the rotation of the rotor (or shaft) is synchronized with the frequency of the supply current. That is, the rotation period of the rotor is equal to the rotating field of the machine it is inside of. The speed of rotation is controlled strictly by the number of pole pairs and the frequency of the applied power. The synchronous motor makes use of the rotating magnetic field. However, the torque developed does not depend on the induction currents in the rotor. Briefly, the principle of operation of the synchronous motor is as follows:

− A multiphase source of AC is applied to the stator windings and a rotating magnetic field is produced.
− A direct current is applied to the rotor windings and a fixed magnetic field is produced.
− The motor is so constructed that these two magnetic fields react upon each other causing the rotor to rotate at the same speed as the rotating magnetic field.
− If a load is applied to the rotor shaft, the rotor will momentarily fall behind the rotating field but will continue to rotate at the same synchronous speed.

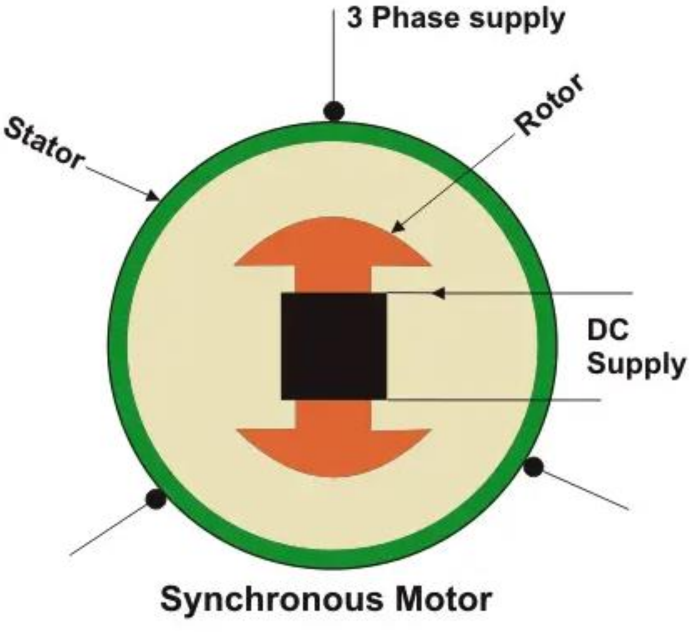

Figure 2.1: Construction of synchronous motor

The falling behind is analogous to the rotor being tied to the rotating field with a rubber band. Heavier loads will cause stretching of the band so the rotor position lags the stator field but the rotor continues at the same speed. If the load is made too large, the rotor will pull out of synchronism with the rotating field and, as a result, will no longer rotate at the same speed. The motor is then said to be overloaded.

The synchronous motor is not a self-starting motor. The rotor is heavy and, from a dead stop, it is not possible to bring the rotor into magnetic lock with the rotating magnetic field. For this reason, all synchronous motors have some kind of starting device. A simple starter is another motor which brings the rotor up to approximately 90% of its synchronous speed. The starting motor is then disconnected and the rotor locks in step with the rotating field. The more commonly used starting method is to have the rotor include a squirrel cage induction winding. This induction winding brings the rotor almost to synchronous speed as an induction motor. The squirrel cage is also useful even after the motor has attained synchronous speed, because it tends to dampen rotor oscillations caused by sudden changes in loading.

Positive reactive power is needed to create the magnetic field in an alternating current motor. This reactive power has the disadvantage of producing a low power factor. Low power factors are undesirable for several reasons. Generators, transformers, and supply circuits are limited in ratings by their current carrying capacities. This means that the kilowatt load that they can deliver is directly proportional to the power factor of the loads that they supply. For example, a system can deliver only 70% of the kilowatt load at 0.7 power factor that it can deliver at unity power factor.

The synchronous motor requires considerable reactive power when it operates at no load without any DC excitation to the rotor. It acts like a three-phase inductance load on the power line. When the rotor is excited, it will produce some of the magnetism in the motor with the result that the stator has to supply less, and the reactive power drawn from the power line decreases. If the rotor is excited until it produces all the magnetism, the power line will only have to supply active power to the stator, and the power factor will be unity. As far as the power line is concerned, the synchronous motor now looks like a three-phase resistance load. If the rotor is excited still further, tending to create more magnetism than the motor needs, then the power line starts supplying negative reactive power to the stator in its attempt to keep the total flux constant. But negative reactive power corresponds to a capacitor, and the synchronous motor now looks like a three-phase capacitance load to the power line. At no-load, the synchronous motor has the property of acting like a variable inductor/variable capacitor, the value of reactance (X_L or X_C) being determined by the amount of DC current flowing in the rotor. A synchronous motor when used on the same power system with induction motors improves the overall system power factor.

3 <u>Equipment</u>

1) One ac voltmeters/multimeters (0-300V, 0-150V)
2) One ac ammeters (0-10A, 0-30V)
3) One dc voltmeter
4) One dc ammeter
5) One single phase wattmeter
6) One synchronous motor
7) One DC generator
8) Connecting Wires

4 PART A : Observation of starting characteristic of synchronous motor

4.1 Experimental set-up:

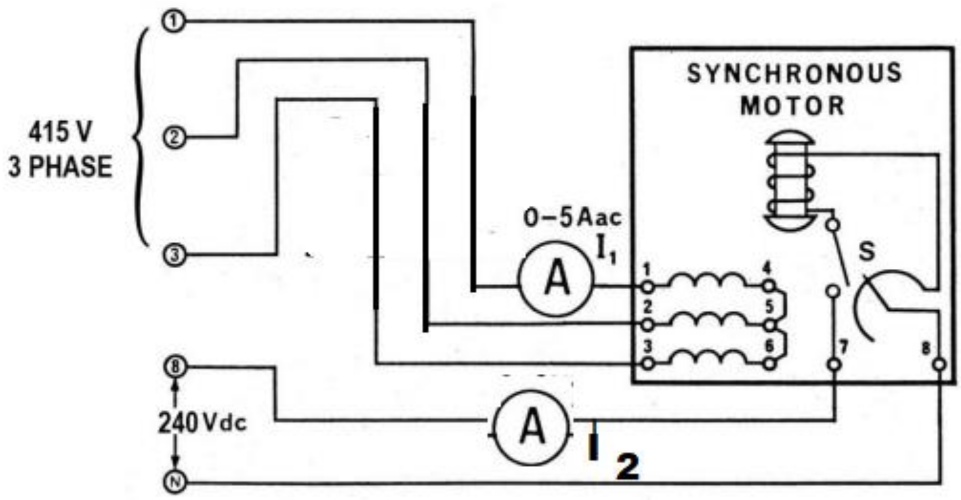

Figure 4.1: Connection diagram for observing the starting characteristic of synchronous motor

4.2 Procedure

1. Examine the front panel of the synchronous motor module.
2. Identify the three separate stator windings and observe that rotor winding is connected through toggle switch to the terminals.
3. Note down the rated current and rated voltage of stator and rotor winding, rated speed of the motor.
4. Using your Three-Phase Synchronous Motor/Generator, Power Supply and AC Ammeter, connect the circuit shown in Figure 4.1. Note that the three stator windings are wye-connected to the fixed 415 V, 3-phase output of the power supply, terminals 1, 2 and 3.
5. Turn on the only three phase AC power supply. Note that the motor starts smoothly and continues to run as an ordinary induction motor. Write down the current in AC winding.
6. Now turn off the AC power supply.
7. Now couple the synchronous motor with a DC generator. The generator will be used as load for the motor.

8. Connect the rotor of the synchronous motor to the fixed 240 V dc output of the power supply, terminals 8 and N. Set the field rheostat for zero resistance (control knob turned fully cw) and close the switch S.
9. Turn on the three phase AC power supply and observe what happens. Do not leave the power on for longer than 10 seconds!
10. Does the motor vibrate or rotate smoothly?
    - Vibrates ☐
    - Rotates ☐
11. Note down the current in DC and AC ammeter.
12. Now turn off the excitation switch of rotor and turn on again after few seconds. Observe what happens.
13. Does the motor vibrate or rotate smoothly?
    - Vibrates ☐
    - Rotates ☐

14. Note down the current in DC and AC ammeter.

4.3 <u>Data Collection</u>

Rated current of rotor :
Rated voltage of rotor :
Rated current of stator winding:
Rated voltage of stator winding:
Rated speed of motor:

<u>Current readings at different conditions:</u>

	I_1	I_2
When motor runs as induction motor		
First DC, then AC source turned ON		
First AC , then DC source turned ON		

4.4 <u>Report</u>

1. Describe what happened when both stator and rotor windings are connected to power supply at the same time. Explain why that happened? What did the AC ammeter indicate?

2. Explain what happened in procedure 12-13. Is the motor running as synchronous motor?

3. Why synchronous motor cannot start by itself? Mention other methods to start a synchronous motor.

5 PART B: Obtaining DC current vs AC current characteristic curve

5.1 Experimental set-up

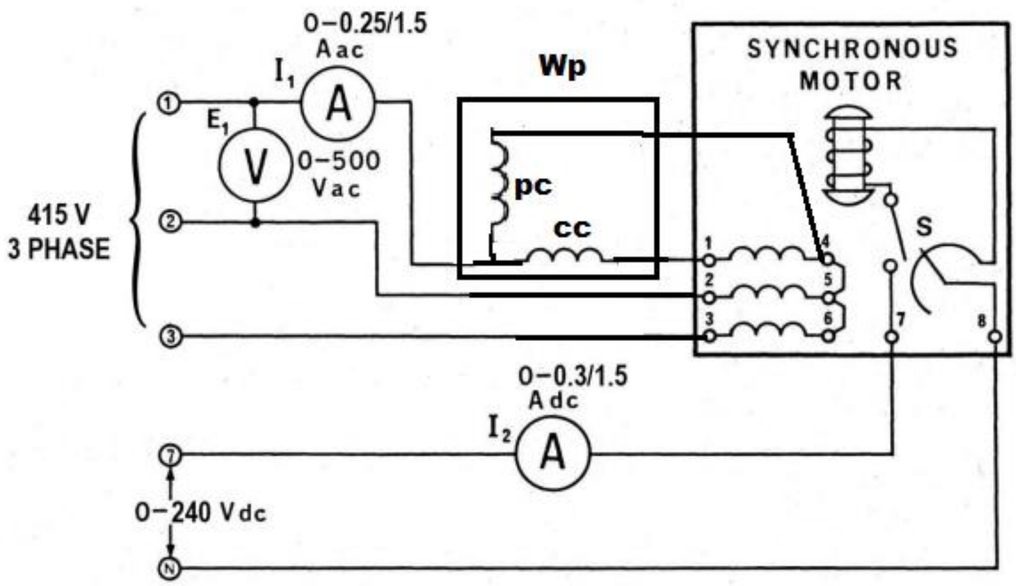

Fig. 5.1.: Connection diagram for obtaining V curve

5.2 Procedure:

1. Using your Three-Phase Synchronous Motor/Generator, Single-Phase Wattmeter, Power Supply, AC Ammeter, AC Voltmeter and DC Voltmeter/Ammeter, connect the circuit shown in Figure 5.1. Note that the stator windings are connected, through the wattmeter, to the fixed 415 V, 3-phase output of the power supply, terminals 1, 2 and 3. The rotor winding is connected, through the ammeter, to the variable 0-240 V dc output of the power supply, terminals 7 and N. The voltage adjust control knob should be at zero.
2. Open the switch S and set the field rheostat for zero resistance (knob turned fully cw)
3. With the DC excitation at zero, measure and record E1 , I1 , Wp in Table 5.3.
4. Repeat for each of the DC current values listed in Table 5.3. Take your measurements as quickly as possible when the excitation exceeds 0.4 A dc. Turn off the power supply and change ammeter ranges when the currents drop below 0.3 A dc. Remember to note the polarity of the wattmeter indications.

5. Return the voltage to zero and turn off the power supply
6. Complete Table 5.3 by calculating apparent power (remember to multiply by 1.73), active power and power factor

5.3 Data Collection

No of observation	I_2	E_1	I_1	Apparent power	W_P	Total power $=3W_p$	Power factor
1	0						
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

5.4 Report

1. Plot the recorded AC current values vs DC current values from Table 5.3

2. Plot the recorded power factors vs DC current values from Table 5.3

3. Comment on the appearance of both curve

4. A synchronous motor is sometimes called synchronous capacitor. Explain.

5. . Might a synchronous motor equally well be called a synchronous inductor?

6. Comment on the active power consumed by the motor during procedure 3-4.