UNIT II
SYNCHRONOUS MOTOR
PART A

1. Name the methods of starting a synchronous motors
   - By an extra 3 phase induction motor
   - By providing damper winding in pole shoes
   - By operating the pilot exciter as a dc motor

2. **What is the effect on speed if the load is increased on a 3 phase synchronous motor?**

The speed of operation remains constant from no load to maximum load if the motor operated constant frequency supply.

3. **Why a synchronous motor is called as constant speed motor?**

Synchronous motor work on the principle of force developed due to the magnetic attraction established between the rotating magnetic field and the main pole feed. Since the speed of rotating magnetic field is directly proportional to frequency the motor operates at constant speed.

4. **What is the phasor relation between induced emf and terminal voltage of a 3 phase synchronous motor?**

The rotating magnetic field is initially established by the prime source of supply V. The main field then causes an emf (e) to get induced in the 3 phase winding. Hence when the machine operates as a synchronous motor the emf phasor always lags the terminal voltage phasor by the load/torque angle.

5. **What are V and inverted V curves of synchronous motor?**

The variation of magnitude of line current with respect to the field current is called V curve. The variation of power factor with respect to the field current is called inverted V curve.

6. **What happens when the field current of a synchronous motor is increased beyond the normal value at constant input?**

Increase in emf causes the motor to have reactive current in the leading direction. The additional leading reactive current causes the magnitude of line current, accompanied by the decrease in power factor.

7. Distinguish between synchronous phase modifier and synchronous condenser

A synchronous motor used to change the power factor or power factor in the supply lines is called synchronous phase modifier. A synchronous motor operated at no load with over excitation condition to draw large leading reactive current and power is called a synchronous condenser.

8. **How the synchronous motor can be used as synchronous condenser?**

Synchronous motor is operated on over excitation so as to draw leading reactive current and power from the supply lines. This compensates the lagging current and power requirement of the load making the system power factor to become unity. The motor does the job of capacitors and hence called as synchronous condenser.

9. **Mention the methods of starting of 3-phase synchronous motor.**
   - A D.C motor coupled to the synchronous motor shaft.
   - A small induction motor coupled to its shaft
   - Using damper windings as a squirrel cage induction motor.

10. **What is meant by hunting of synchronous motor?**

When the load applied to the synchronous motor is suddenly increased or decreased, the rotor oscillates about its synchronous position with respect to the stator field. This action is called hunting.

11. **Write important differences between a 3-phase synchronous motor and a 3-phase induction motor.**
   - Synchronous motor is a constant speed motor whereas induction motor speed will decrease on load.
   - Synchronous motor requires A.C and D.C supplies whereas induction motor requires only A.C supply.
   - Synchronous motor can be worked under various power factors such as lagging, leading and unity. But induction motor can be run with lagging power factor only.

12. What could be the reasons if a 3-phase synchronous motor fails to start?

It is usually due to the following reasons

- Voltage may be too low.
- Too much starting toad.
- Open circuit in one phase or short circuit.
- Field excitation may be excessive.

13. **How does a change of excitation affect its power factor?**

When the excitation is reduced, the motor draws a lagging current and when the excitation is increased, the armature current is leading the applied voltage. It may also happen for some value of excitation, that current may be in phase with the voltage i.e. power factor is unity.

14. What is phase swinging?

Phase swinging is otherwise called as hunting. When the load on the synchronous motor is varying or the supply frequency is pulsating the speed of the machine will fluctuate causing vibration on the rotor, which is called hunting or phase swinging.

15. What is meant by pull out torque?

When the load on the motor is increased, the load angle is also increased, i.e. the rotor goes on progressively falling back in phase and draws more current. If we increase the load further, then the motor pulls out of synchronism and stops. The torque developed at pull out point is called pull out torque.

16. Under which condition a synchronous motor will fail to pull in to step?

- No field excitation.
- Excessive load.
- Excessive load inertia.

17. **How will you reverse the direction of rotation of a 3-phase synchronous motor?**

By Inter changing two phases of the 3-phase supply connections the direction of rotation can be reversed.

18. Write the applications of synchronous motor.

- Used for power factor improvement in sub-stations and in Industries.
- Used in industries for power applications-
- Used for constant speed drives such as motor -generator set, pumps and compressors.

19. Give some merits and demerits of synchronous motor Merits

- This motor runs at constant speed (synchronous speed) even at full load.
- Can be operated with leading power factor, for power factor improvement.

Demerits

- Two sources of supply are necessary
- Since damper-winding resistance is low, it take large currents, from supply mains.

20. Why a synchronous motor is a constant speed motor?

It runs always with a constant speed called synchronous speed N =120 f/P. where f is the supply frequency and P is the no- of poles.

21. **How the synchronous motor is made self-starting?**

By providing damper windings in the pole face's, it will start and run like a squirrel cage induction motor.

22 State the characteristic features of synchronous motor.

- the motor is not inherently self-starting
- The speed of operation is always in synchronous with the supply frequency irrespective of load conditions
- The motor is capable of operating at any power factor.

23. In what way synchronous motor is different from other motors?

All dc and ac motors work on the same principle. Synchronous motor operates due to magnetic locking taking place between stator and rotor magnetic fields.

24. **Why a 3-phase synchronous motor will always run at synchronous speed?**

Because of the magnetic coupling between the stator poles and rotor poles the motor runs exactly at synchronous speed.

25. **What are the uses of damper winding in synchronous motor?**

- Starting of synchronous motor

- Reduce the Oscillations

26. Explain "phase Spread" in the armature winding.

In order to obtain the better-wave shape the coil are not concentrated or bunched in one slot, but are distributed in a number of slots to form polar groups under each pole. This is called phase spread. The winding so obtained is known as distributed winding.

27. What is an exciter?

The field windings of an alternator are excited by means of direct current from some external source. For this purpose D.C generator is used. This D.C generator is called as exciter.

28.Why a synchronous motor is a constant speed motor?

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29. **How the synchronous motor is made self-starting?**

By providing damper windings in the pole face's, it will start and run like a squirrel cage induction motor.

30.What happens when the field current of a synchronous motor is increased beyond the normal value at constant input?

Increase in emf causes the motor to have reactive current in the leading direction. The additional leading reactive current causes the magnitude of line current, accompanied by the decrease in power factor.

PART-B

1. Draw the phasor diagram of a synchronous motor.
2. Explain the significance of V and inverted V curves
3. Discuss the following (i) Constant excitation circle.(ii) Constant power circle. 4. Derive the mechanical power developed per phase of a synchronous motor.
5. A 5kW,3 phase Y-connected 50 Hz,440 V, cylindrical rotor synchronous motor operates at rated condition with 0.8 pf leading. The motor efficiency excluding field and stator losses is 95% and Xs=2.5 Ω. Calculate (i)Mechanical power developed (ii)armature current (iii)back emf (iv)power angle (v)maximum or pull out torque of the motor.
6. The input to an 11000 V, 3 phase star connected synchronous motor is 60 A. the effective resistance and synchronous reactance per phase are respectively 1Ω and 30 Ω. Find(i) The power supplied to the motor (ii)stator copper loss/phase (iii) Induced emf for a power factor of 0.8 leading
7. Explain V-curves and inverted V-curves.
8. Explain the various starting methods of a synchronous motor
9. Explain effect of changing field current excitation at constant load. (i)Under excitation (ii) Normal excitation (iii) Over excitation
10. A synchronous motor having 40% reactance and negligible resistance is to be operated at rated voltage at UPF,0.8 pf lag and 0.8pf lead. What are the values of induced emf.
11. A 75 kW, 400V, 4 pole, 3 phase, star connected synchronous motor has a resistance and synchronous reactance per phase of 0.04Ω and 0.4 Ω respectively. Compute for full load 0.8pf lead the open circuit emf per phase and gross mechanical power developed. Assume an efficiency of 92.5%. (May 2014)
12. A 2000V, 3 phase, 4 pole, star connected synchronous motor runs at 1500rpm. The excitation is constant and corresponding to an open circuit voltage of 2000V. The resistance is negligible in comparison with synchronous reactance of 3.5Ω /ph. For an armature current of 200A.Determine (i) power factor (ii) power input (iii) torque developed.
13. Derive an expression for the maximum torque developed per phase of a synchronous motor
14. Explain how synchronous motor can be used as a synchronous condenser. Draw the phasor diagram.
15. Describe the principle of operation of synchronous motor.