UNIT-I

1. 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.

2. What are the two classification synchronous machines?

The classification synchronous machines are:

i. Cylindrical rotor type ii. Salient pole rotor type

3. What are the essential features of synchronous machine?

i. The rotor speed is synchronous with stator rotating field. ii. Varying its field current can easily vary the speed.

iii. It is used for constant speed operation.

4. Mention the methods of starting of 3-phase synchronous motor. a. A D.C motor coupled to the synchronous motor shaft.

b. A small induction motor coupled to its shaft.(pony method)

c. Using damper windings –started as a squirrel cage induction motor.

5. What are the principal advantages of rotating field system type of construction of synchronous machines?

· Form Stationary connection between external circuit and system of conditions enable the machine to handle large amount of volt-ampere as high as 500 MVA.

· The relatively small amount of power required for field system can be easily supplied to the rotating field system via slip rings and brushes.

· More space is available in the stator part of the machine for providing more insulation to the system of conductors.

· Insulation to stationary system of conductors is not subjected to mechanical stresses due to centrifugal action.

· Stationary system of conductors can easily be braced to prevent deformation.

· It is easy to provide cooling arrangement.

6. Write down the equation for frequency of emf induced in an alternator.

F = PN / 120 Hertz

Where P = No. Of poles

N = Speed in rpm.

7. What are the advantages of salient pole type of construction used for synchronous machines?

v They allow better ventilation.

v The pole faces are so shaped radial air gap length increases from the pole center to the pole tips so that flux distribution in the air gap is sinusoidal in shape which will help to

generate sinusoidal emf.

v Due the variable reluctance, the machine develops additional reluctance power, which is independent of excitation.

8. Why do cylindrical rotor alternators operate with steam turbines?

Steam turbines are found to operate at fairly good efficiency only at high speeds. The high-speed operation of rotor tends to increase mechanical losses, so the rotors should have

smooth external surface. Hence smooth cylindrical type rotors with less diameter and large axial length are used for synchronous generators driven by steam turbines with either 2 or 4 poles.

9. Which type of synchronous generators are used in Hydroelectric plants and why?

As the speed of operation is low, for hydro turbines used in hydroelectric plants, salient pole type synchronous generators are used. These allow better ventilation and also have other advantages

over smooth cylindrical type rotor.

10. What is the relation between electrical degree and mechanical degree?

Electrical degree θe and mechanical degree are related to one another by the number of poles P, the electrical machine has, as given by the following equation.

$\theta e = (P/2)\ \theta m$

11. What is the meaning of electrical degree?

Electrical degree is used to account the angle between two points in rotating electrical machines. Since all electrical machines operate with the help of magnetic fields, the electrical degree is

accounted with reference to the polarity of magnetic fields. 180 electrical degrees is accounted as

the angle between adjacent North and South poles

12. Why short-pitch winding is preferred over full pitch winding? Advantages: -

· Waveform of the emf can be approximately made to a sine wave and distorting harmonics can be reduced or totally eliminated.

· Conductor material, copper is saved in the back and front-end connections due to less coil span.

· Fractional slot winding with fractional number of slots/phase can be used which in turn reduces the tooth ripples.

· Mechanical strength of the coil is increased.

13. Write down the formula for distribution factor.

$Kd = \frac{\sin(m\beta/2)}{m\sin(\beta/2)}$ or $Kdn = \frac{\sin(mn\beta/2)}{m\sin(n\beta/2)}$

where

m - number of slots/pole/phase

β - angle between adjacent slots in electrical degree n - order of harmonics.

14. Define winding factor.

The winding factor Kw is defined as the ratio of phasor addition of emf induced in all the coils belonging to each phase winding of their arithmetic addition.

15. Why are alternators rated in kVA and not in kW?

The continuous power rating of any machine is generally defined as the power the machine or apparatus can deliver for a continuous period so that the losses incurred in the machine gives rise to a steady temperature rise not exceeding the limit prescribed by the insulation class.

Apart from the constant loss the variable loss incurred in alternators is the copper loss, occurring in the 3-phase winding, which depends on I2R, the square of the current delivered by the generator. is directly related to apparent power delivered by the generator,Thus the alternators have only their apparent power in VA/kVA/MVA as their power rating.

16. What are the causes of changes in voltage of alternators when loaded?

· Voltage variation due to the resistance of the winding R.

· Voltage variation due to the leakage reactance of the winding X1.

· Voltage variation due to the armature reaction.

17. What is meant by armature reaction in alternators?

The interaction between flux set up by the current carrying armature conductors and the main field flux is defined as the armature reaction.

18. What do you mean by synchronous reactance?

It is the sum of the leakage reactance X1 and armature reactance Xa

$Xs = X1 + Xa$

19. What is effective resistant [Reff]?

The apparent increase in resistance of the conductor when an alternating current is flowing

through it is known as effective resistance.

20. What is synchronous impedance?

The complex addition of resistance R and synchronous reactance jXs is synchronous impedance

Zs.

$Zs = (R+jXs) = Zs\angle\theta$

Where $\theta = \tan -1(Xs/R)$

$|Zs| = \sqrt{(R2+jXs2)}$

21. What is meant by load angle of an alternator?

The phase angle introduced between the induced emf phasor E and terminal voltage phasor V during the load condition of an alternator is called load angle. The load angle increases

with increase in load. It is positive during generator operation and negative during motor

operation.

22. Define the term voltage regulation of alternator.

It is defined as the change in terminal voltage from no load-to-load condition expressed as a function or terminal voltage at load condition, the speed and excitation conditions remaining

same.

% Regulation = (E-V)/V x 100

23. What is the necessity for predetermination of voltage regulation?

Most of the alternators are manufactured with large power rating and large voltage ratings. Conduction load test is not possible for such alternators. Hence other indirect methods of

testing are used and the performance can be predetermined at any desired load currents and power

factors.

24. Why is the synchronous impedance method of estimating voltage regulation is considered as pessimistic method?

Compared to other methods, the value of voltage regulation obtained by this method is always higher than the actual value and therefore is called pessimistic method.

25. Why is the MMF method of estimating the voltage regulation is considered as the is optimistic method. optimization method?

Compared to EMF method, MMF method involves more number of complex calculation steps. Further the OCC is referred twice and SCC is referred once while predetermining the voltage regulation for each load condition. Reference of OCC takes core saturation effect. As this method requires more effort, the final result is very close to the actual value.

UNIT-1

Synchronous Generator

1. Derive the emf equation of an alternator. Explain pitch factor & distribution factor.

$$E_{ph} = 4.44 K_p K_d f \phi T_{ph} \text{ volts}$$

$K_w = K_p . K_d$ = winding factor.

$$\text{pitchfactor} = \frac{\text{Vector sum}}{\text{Arithmetic sum}} = \cos \alpha/2$$

$$K_p = \cos \frac{\alpha}{2}$$

Distribution factor (or) Breadth factor

$$K_d = \frac{\text{EMF induced in a distributed winding}}{\text{EMF induced if the winding would have bean concentrated}}$$

$$K_d = \frac{\sin \frac{m\beta}{2}}{m \sin \beta/2}$$

2. Discuss the effects of alternator on load with relevance to various powerfactors.

When load on an alternator changes, the terminal voltage V also changes. The change in V is due to the following three effects.

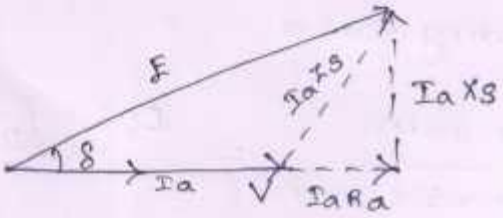
→ Voltage drop in armature resistance (Ra)

ii) voltage drop in armature leakage reactance X_L

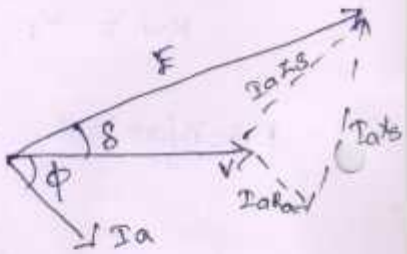
iii) voltage drop due to armature reaction.

Phasor diagram of a loaded Alternator

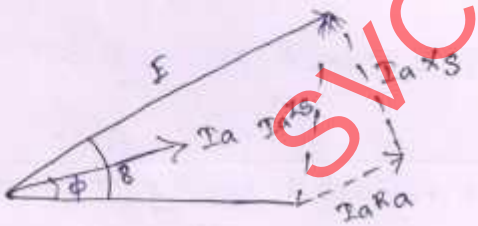
→ unity power factor



lagging power factor



Leading power factor load

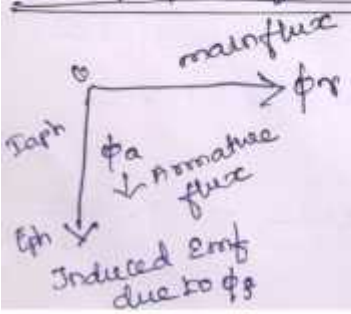


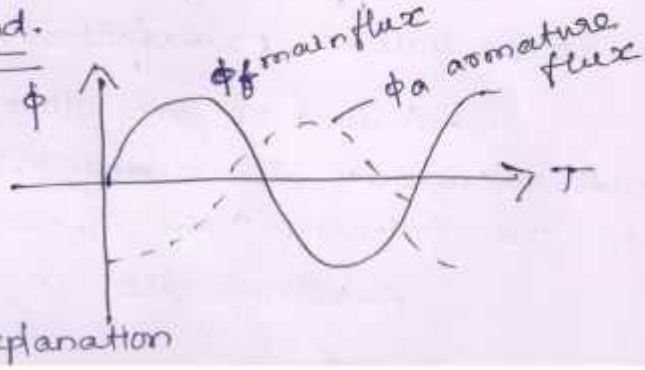
Explanation

3. what is the effect of armature reaction at different power factors on synchronous machine?

The effect of armature flux on main flux is known as the armature reaction.

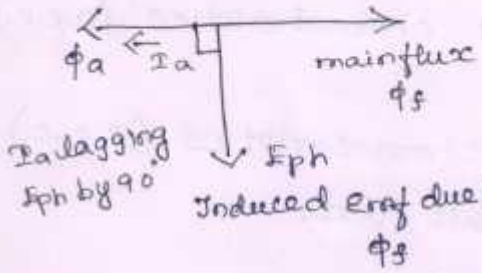
UNITY powerfactor load.

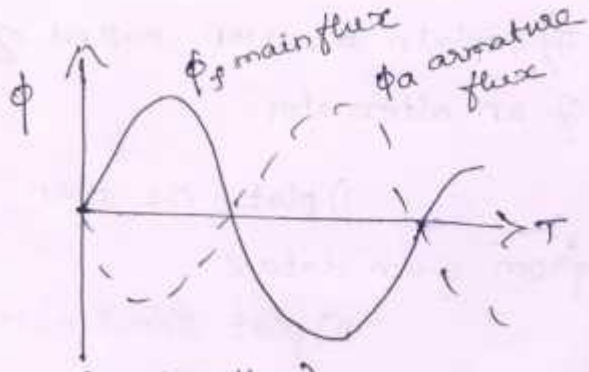




explanation

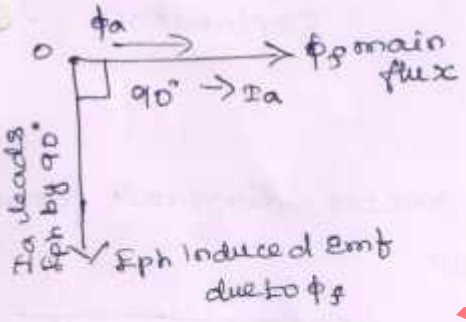
Zero lagging powerfactor load

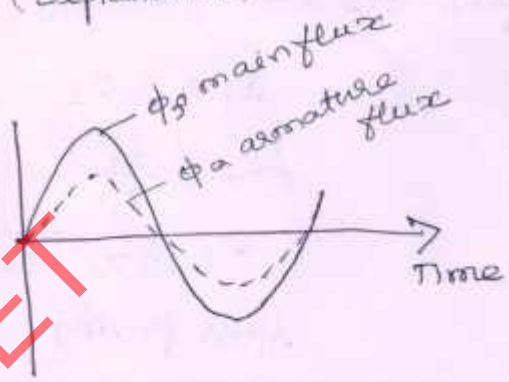




(explanation)

Zero leading powerfactor load





5) explain two reaction theory of synchronous machine. How can x_d & x_q be determined?

The two reaction theory which resolves the given armature mmfs into two mutually perpendicular components as follows

→ one component is located along the axis of salient pole rotor known as direct axis (d-axis) component.

→ other component is located 1r to the axis of salient pole rotor known as quadrature axis (q-axis) component.

$$X_{sd} = X_{ad} + X_l$$
$$X_{sq} = X_{aq} + X_l$$

diagram
explanation

$$V = E_0 - IR_a - I_d x_{sd} - I_q x_{sq}$$

7) Explain the EMF method of determining the regulation of an alternator.

1) plot the open circuit characteristics (O.C.C.) from given data.

2) plot short-circuit characteristics (S.C.C) from the data given by short circuit test.

$$E_1 = I_1 Z_s$$

$$Z_s = \frac{E_1}{I_1}$$

$$x_s = \sqrt{Z_s^2 - R_a^2}$$

Diagram
Explanation

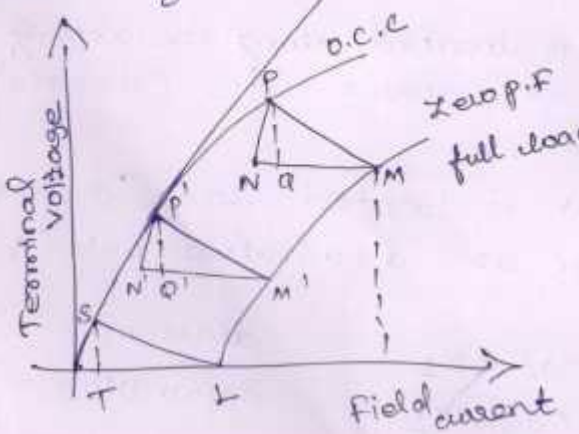
After finding R_a & x_s vector diagrams for any load power factor may be drawn.

unity power factor $\rightarrow E_0 = \sqrt{(V + IR_a)^2 + (IX_s)^2}$

lagging power factor $\rightarrow E_0 = \sqrt{(V\cos\phi + IR_a)^2 + (V\sin\phi + IX_s)^2}$

leading power factor $\rightarrow E_0 = \sqrt{(V\cos\phi + IR_a)^2 + (V\sin\phi - IX_s)^2}$

10) Describe the potier Method of determining the regulation of an alternator.



Procedure
explanation

ZPF characteristics of an alternator gives the variation of terminal voltage with field current, when the alternator is delivering its full rated current to a zero p.f. load.

This method is based on the separation of reactance due to leakage flux & armature reaction flux & therefore, it is more accurate.

8) State & explains the conditions for parallel operation of alternator.

The operation of connecting an alternator in parallel with another alternator or with common bus-bars is known as synchronizing.

Need for parallel operation:-

↑s reliability

one or more of them can be shut down.

Total load requirement cannot be met by a single alternator.

economy.

conditions for parallel operation

Terminal voltage of must be same as busbars.

frequency is same as that of busbars.

phase sequence of voltage is same as that of busbar voltage.

Synchronizing procedure — Diagram
Explanation

Three dark lamp method

Two bright & one dark lamp Method

Using synchroscope.

6) With neat sketch describe the construction & principle of operation of salient pole alternator.

construction — Diagram

- Stator
- Rotor
  - salient pole type
  - Non-salient pole type
  (features)

principle, explanation

$$N_s = \frac{120f}{P}$$