SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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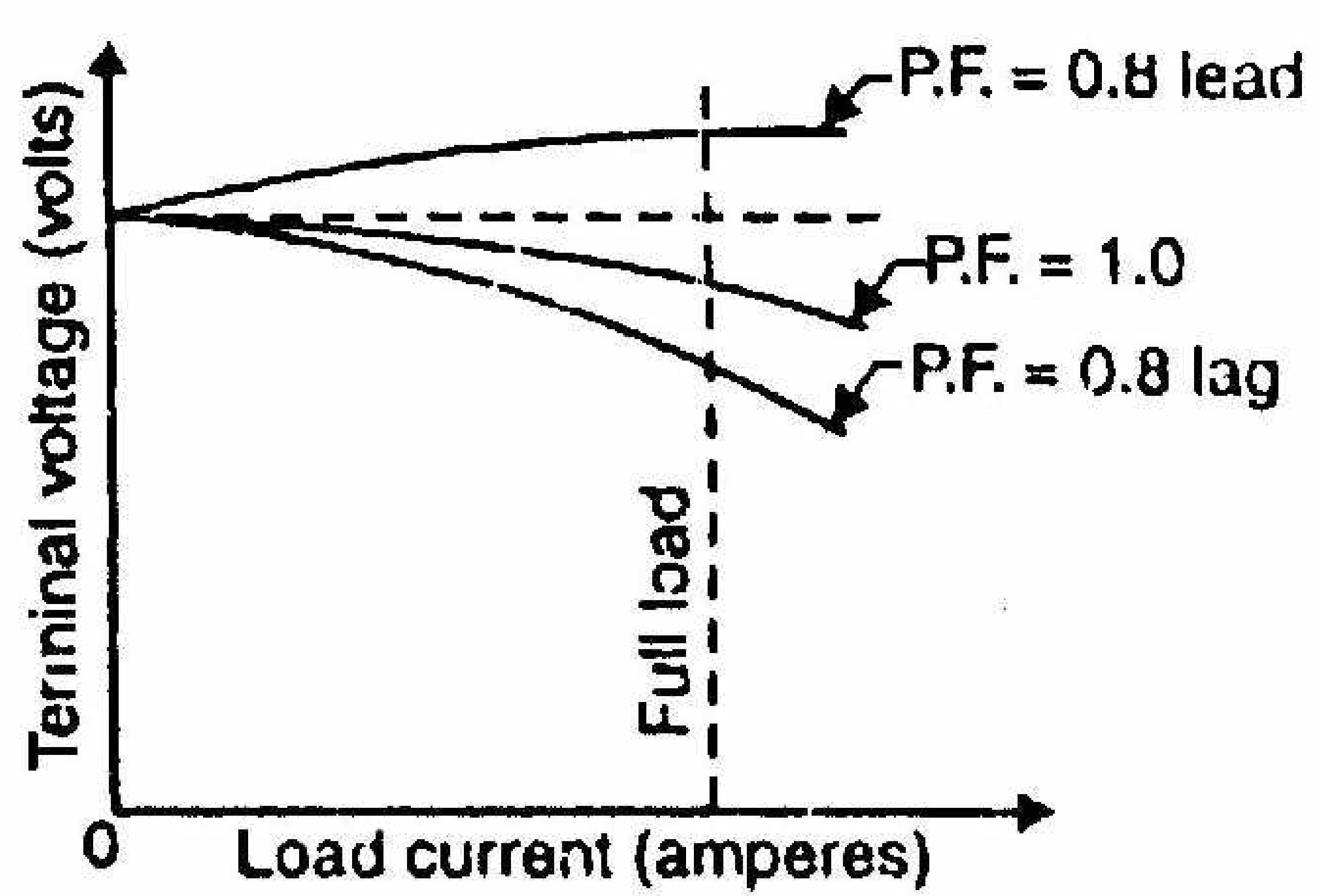
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 19EE401 SYNCHRONOUS AND INDUCTION MACHINES

II YEAR /IV SEMESTER

UNIT – I SYNCHRONOUS GENERATOR

Load characteristics



Load characteristics

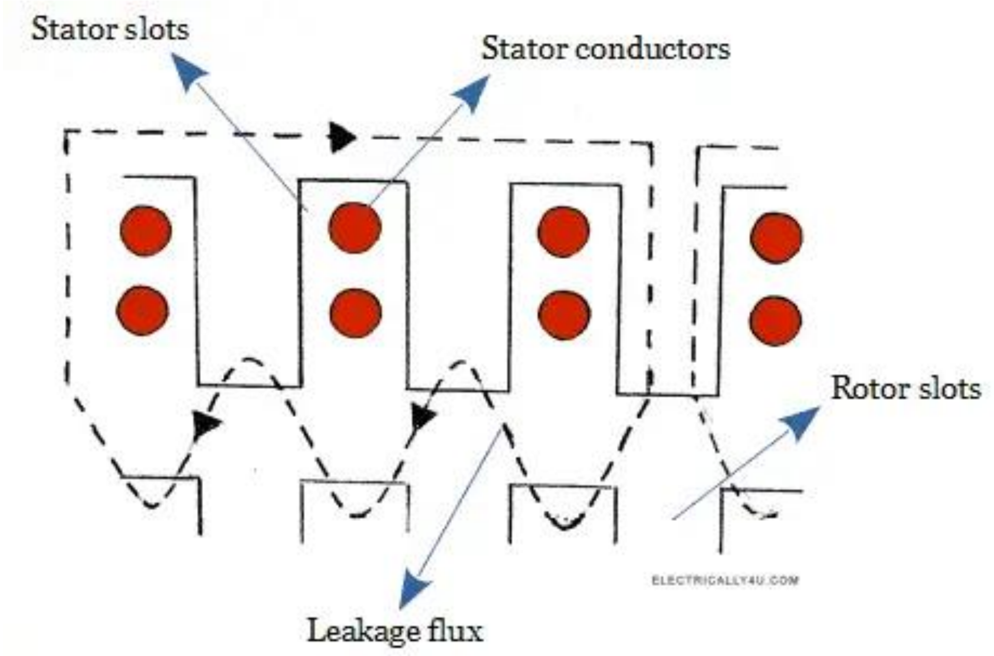
- change in terminal voltage due to armature reaction depends upon the armature current as well as power-factor of the load.
- For leading load p.f., the no-load voltage is less than the full-load voltage. Hence voltage regulation is negative in this case.
- The effects of different load power factors on the change in the terminal voltage with changes of load on the alternator are shown in Fig.
- Since the regulation of an alternator depends on the load and the load power factor, it is necessary to mention power factor while expressing regulation.

Voltage Drop due to Armature Resistance

- The armature winding resistance per phase will cause a IR_a voltage drop per phase.
- The voltage drop due to armature resistance is in phase with the armature current I. Practically, this voltage drop is negligible.

Voltage Drop due to Armature Leakage Reactance

- When current flows through armature conductors, the flux will start to flow through the armature core. Some flux will take different paths and do not cross the air gap which is called leakage flux.

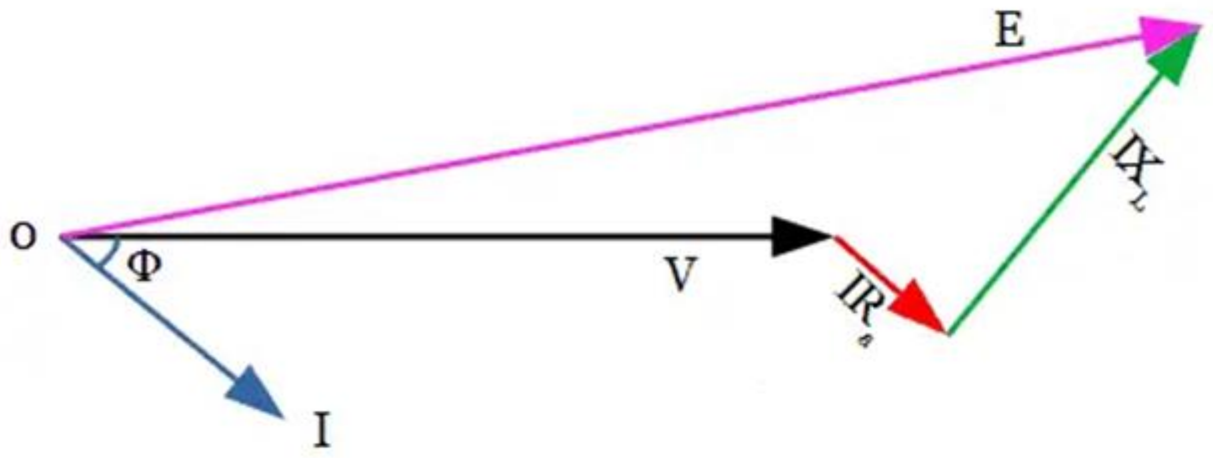


Voltage Drop due to Armature Leakage Reactance

- Here, the leakage flux depends on the current flowing through the conductor and its phase relationship with the terminal voltage. This leakage flux will set up an emf because of self-inductance. This emf is known as reactance emf, which leads the armature current I by 90^0.

Thus, the armature winding is said to possess a leakage reactance X_L. The voltage drop due to this reactance is IX_L. The generated emf has to overcome the voltage drop due to leakage reactance to give its output.

$$E = V + I (R_a + jX_L)$$



Voltage Drop due to Armature Reaction

Armature reaction is the effect of armature flux on the main field flux. The effect of the armature reaction can be seen in the DC generator as well. But compared to the DC generator, the power factor of the load in an alternator has a considerable effect on the armature reaction. Consider the following three cases.

- Unity power factor load.
- Zero power factor lagging load
- Zero power factor leading load.

The armature reaction in the alternator produces different effects such as cross magnetizing effect, demagnetizing effect, and magnetizing effect. These effects cause distortion in the main field flux, thereby affecting the generated emf.

The voltage drop due to armature reaction may be assumed as there is a presence of fictitious reactance X_a called armature reactance reaction. The voltage drop due to the armature reactance reaction is represented as IX_a.

Voltage Drop due to Armature Reaction

The leakage reactance X_L and armature reaction reactance Xa together called synchronous reactance X_S.

$$X_S = X_L + X_a$$

Thus the voltage drop in an alternator under loaded conditions is the total sum of voltage drop due to armature resistance, armature leakage reactance, and armature reaction reactance.

$$V = I R_a + j I X_L + j I X_a = I (R_a + j X_L + j X_a) = I (R_a + j (X_L + X_a))$$

$$V = I (R_a + j X_S) = I Z_S$$

Where Z_S is known as the **synchronous impedance** of an alternator.

From the discussions above, it is clear that the variation in load causes the terminal voltage of the alternator to change. It is due to the synchronous impedance of the alternator.

Phasor Diagrams of Alternator on Load

To draw the phasor diagrams, let us know the terms used in the below diagrams.

E_0 is the no-load voltage. It is the maximum voltage induced in the armature without giving any load.

E is the load voltage. It is the induced voltage after overcoming the armature reaction. E is vectorially less than the no-load voltage.

I is the armature current per phase

V is the terminal voltage. It is vectorially less than E by IZ and also vectorially less than E_0 by IZ_S.

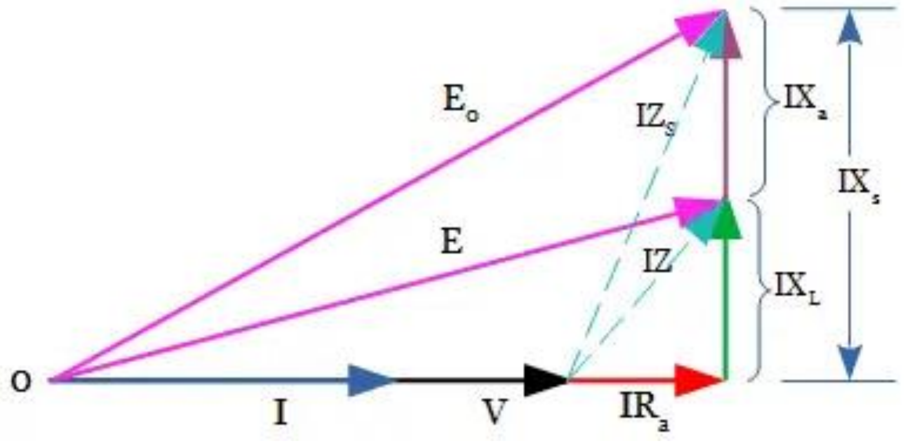
Φ is the cosine angle between terminal voltage and current.

The impedances are given by

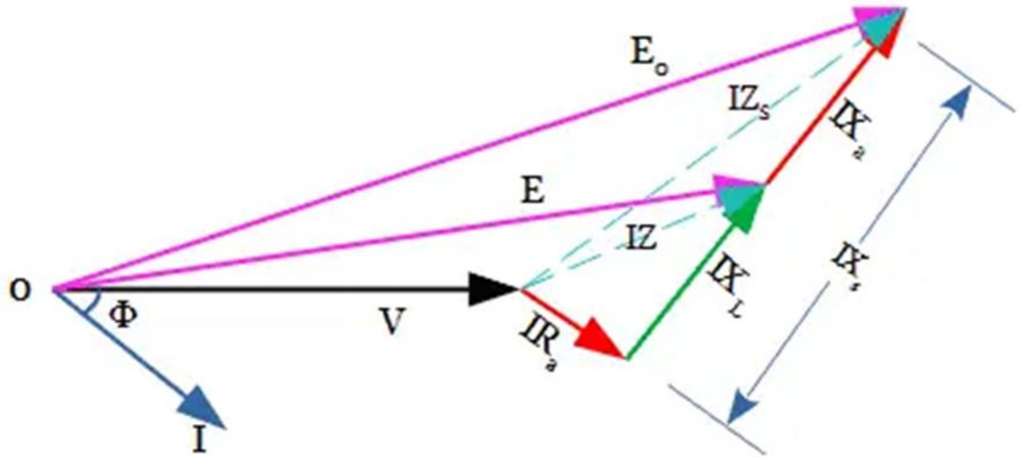
$$Z = R_a + jX_L = \sqrt{(R_a^2 + X_L^2)}$$

$$Z_S = R_a + jX_S = \sqrt{(R_a^2 + X_S^2)}$$

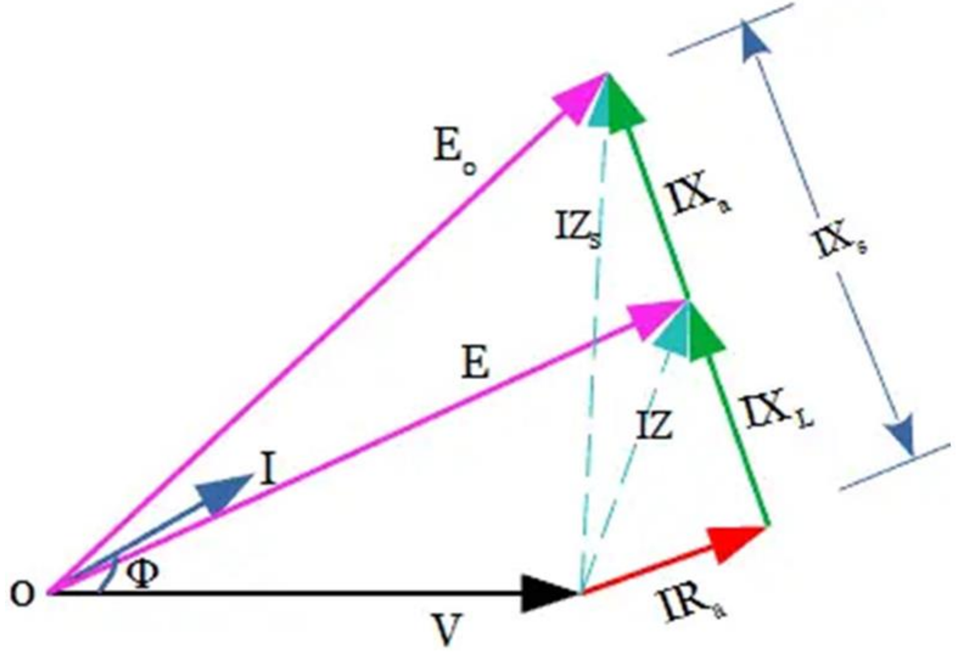
where X_L is the leakage reactance, X_a is the armature reaction reactance and X_S is the synchronous reactance and Z_S is the synchronous impedance.



Unity Power Factor Load



Lagging Power Factor Load



Leading Power Factor Load

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THANK YOU