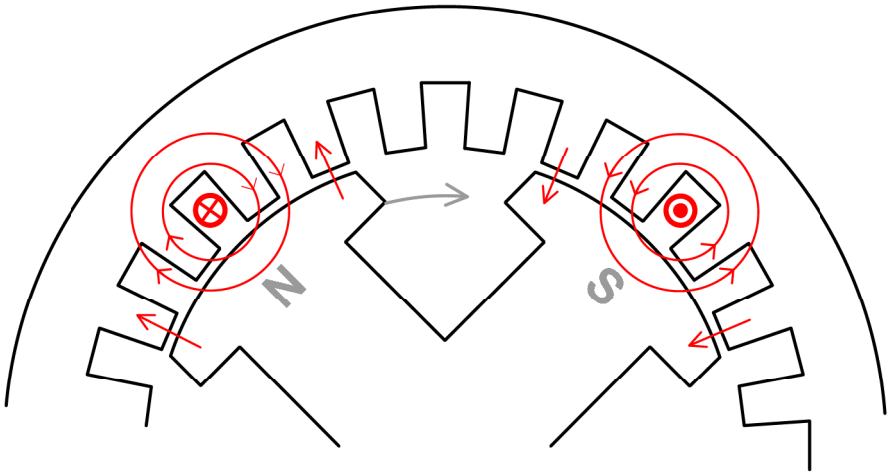
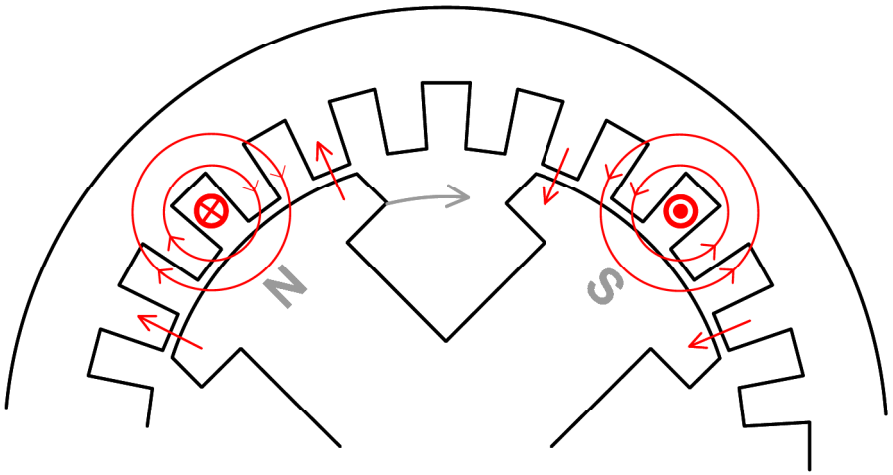
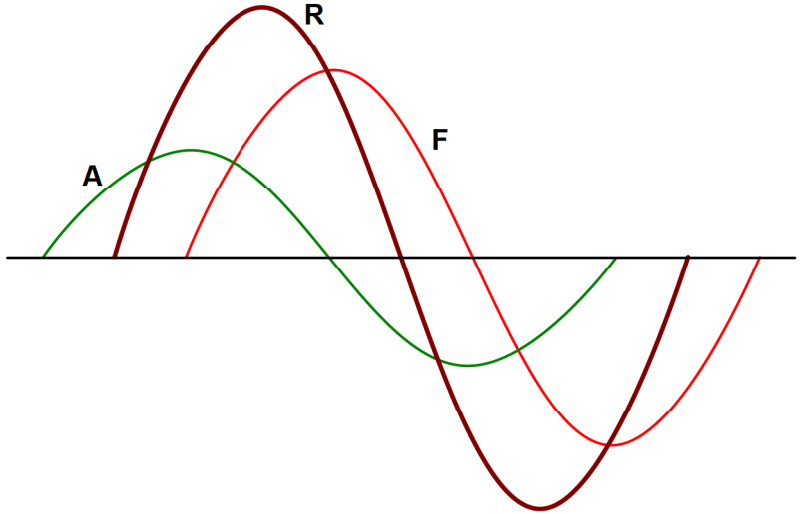
Armature Reaction



- Armature reaction is the mmf produced by the armature current in the field system.
- Due to the effect of armature reaction, voltage induced in the winding is affected.
- Armature reaction depends on the power factor of the load that is connected to the alternator

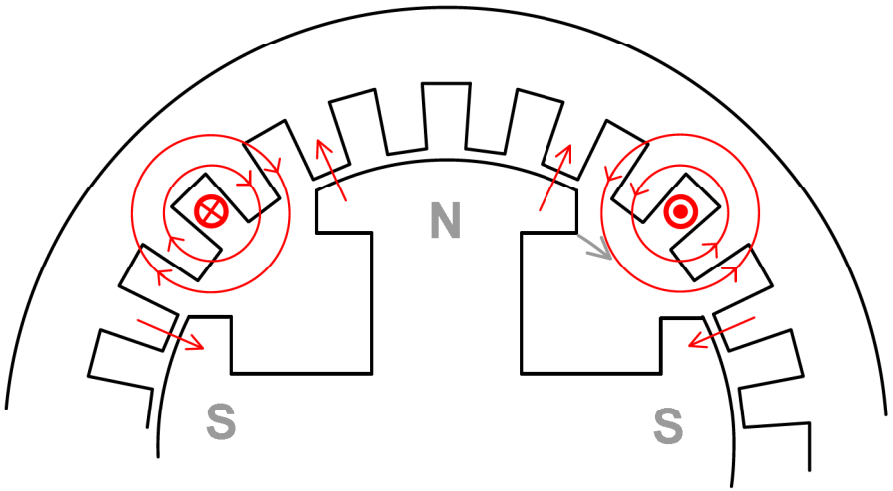
Armature Reaction with UPF Load

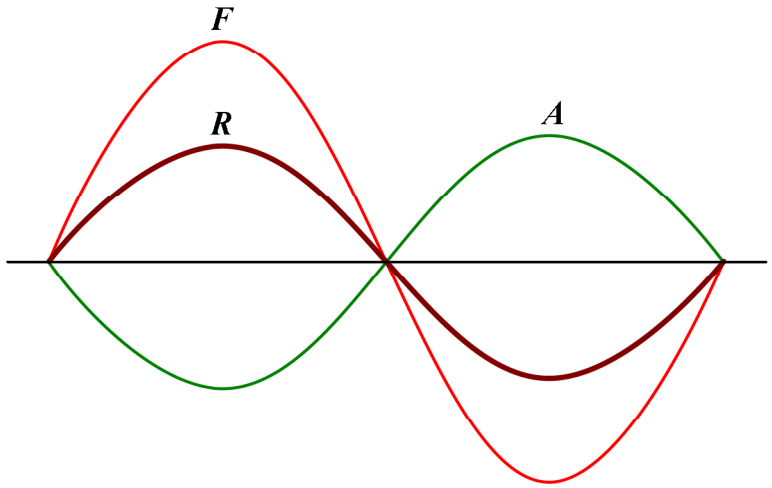




F *– Main field,* ***A*** *– Armature reaction mmf,* ***R*** *– Resultant field*

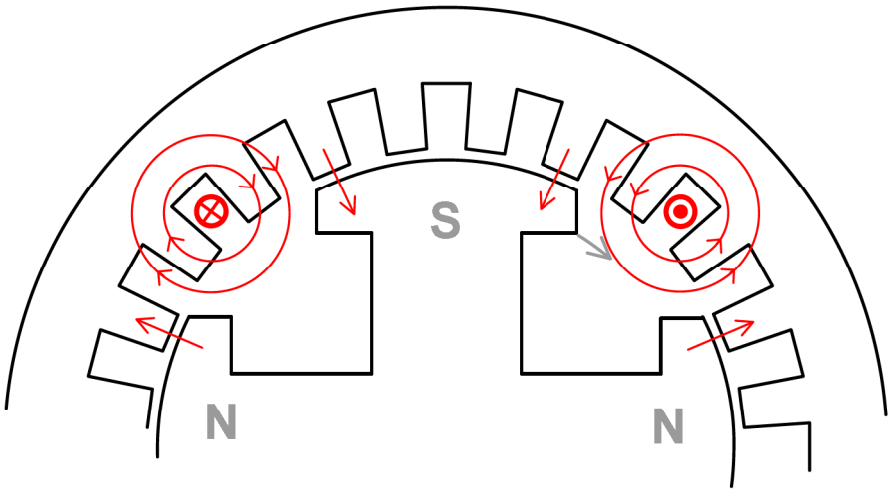
Armature Reaction at ZPF lag

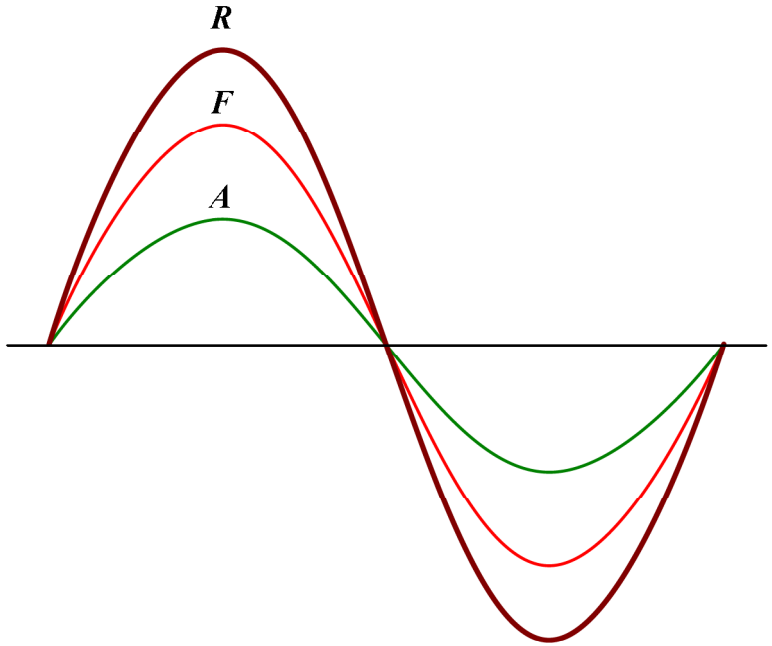




F *– Main field,* ***A*** *– Armature reaction mmf,* ***R*** *– Resultant field*

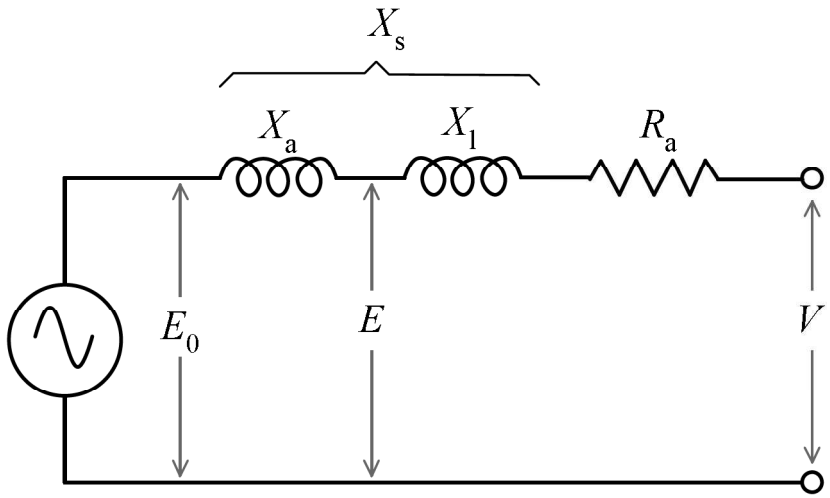
Armature Reaction at ZPF Lead

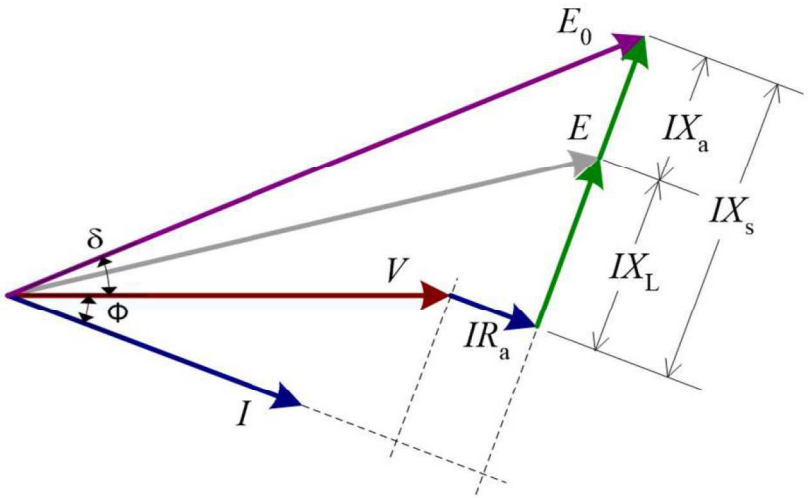




F *– Main field,* ***A*** *– Armature reaction mmf,* ***R*** *– Resultant field*

Equivalent Circuit and Phasor Diagram





R – Armature resistance

X_l – Leakage reactance

X_a – Reactance due to armature reaction

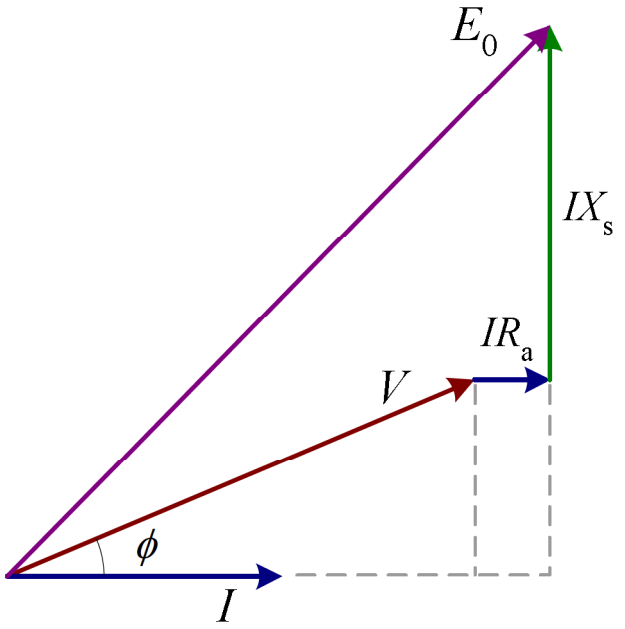
X_S – Synchronous reactance

V – Terminal voltage

E – Induced voltage

E_0 – No load voltage

Expression for No-load Voltage (Lagging PF)

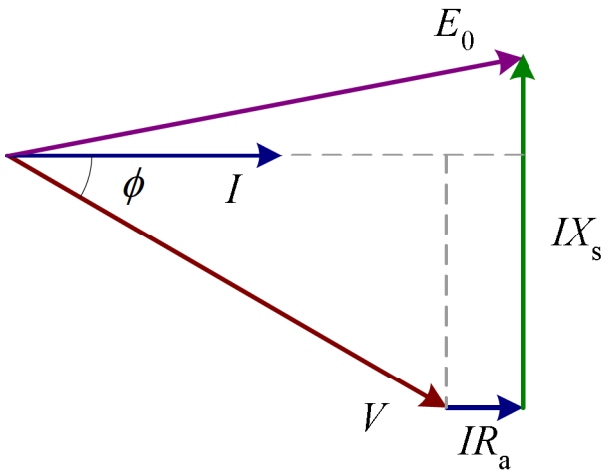


$$E_0 = \sqrt{\left(V\cos\phi + IR_a\right)^2 + \left(V\sin\phi + IX_s\right)^2}$$

$$\text{Percentage regulation} = \frac{E_0 - V}{V} \times 100$$

where V is the terminal voltage on load and E_0 is the no load voltage.

Expression for No-load Voltage (Leading PF)

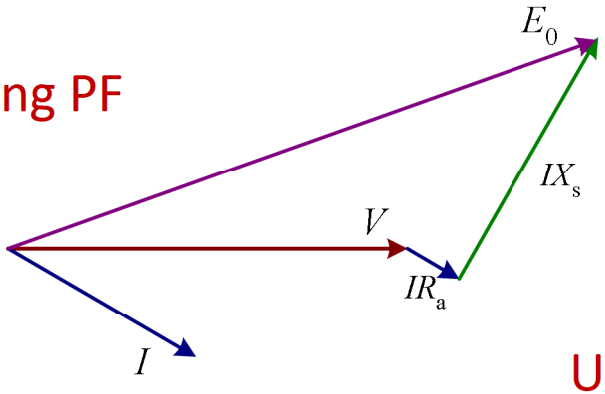


$$E_0 = \sqrt{\left(V\cos\phi + IR_a\right)^2 + \left(IX_s - V\sin\phi\right)^2}$$

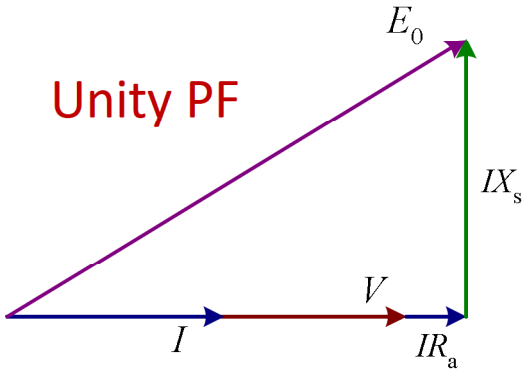
$$E_0 = \sqrt{\left(V\cos\phi + IR_a\right)^2 + \left(V\sin\phi - IX_s\right)^2}$$

Voltage regulation under different PF

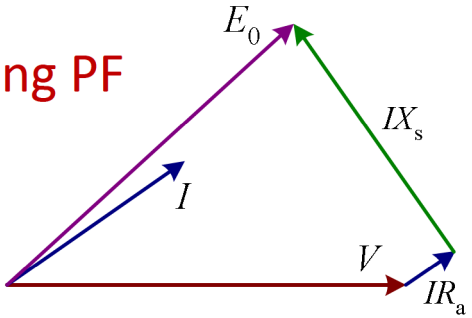
Lagging PF

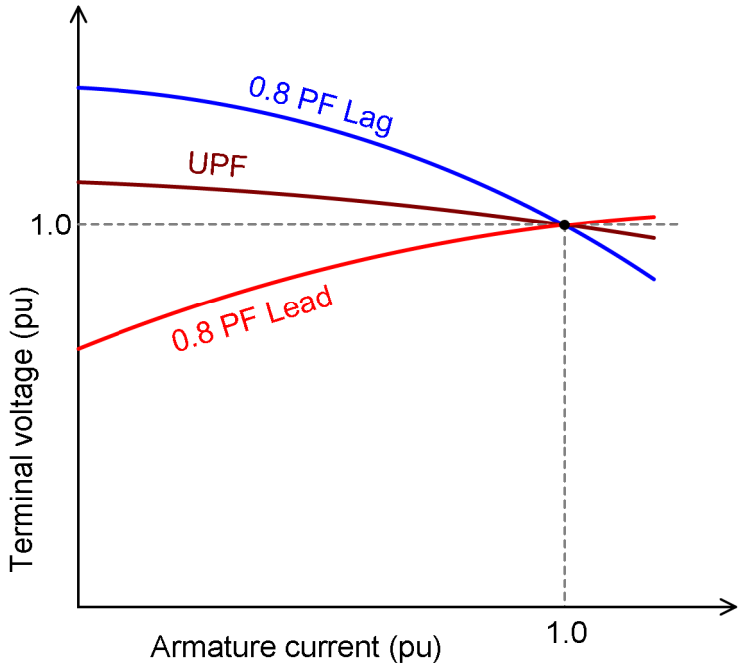


Unity PF



Leading PF





Example 1.7

A 10 MW three phase alternator has a load of 0.85 pf lag at 11 kV terminal voltage. The armature resistance is 0.1 ohm per phase and the synchronous reactance is 0.66 ohm per phase. Calculate the no-load emf (line to line).

$$\text{Per phase voltage, } V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{11000}{\sqrt{3}} = 6351 \text{ volts}$$

$$\cos\phi = 0.85$$

$$\phi = \cos^{-1}(0.85) = 31.8°$$

$$\sin\phi = 0.527$$

$$\text{Line current, } I_a = \frac{10 \times 10^6}{\sqrt{3} \times 11000 \times 0.85} = 617.5 \text{ A}$$

$$\text{No-load voltage, } E_0 = \sqrt{(V\cos\phi + I_a R)^2 + (V\sin\phi + I_a X_s)^2}$$

$$= \sqrt{(6351 \times 0.85 + 617.5 \times 0.1)^2 + (6351 \times 0.527 + 617.5 \times 0.66)^2}$$

$$= 6623 \text{ volts}$$

$$\text{Line voltage, } V_L = \sqrt{3}\, V_{ph} = \sqrt{3} \times 6623 = 11471 \text{ volts}$$