# 5.2 Generators (cont)

Friday, 11 February 2022 3:46 PM

★ Control of Real Power

Assumption

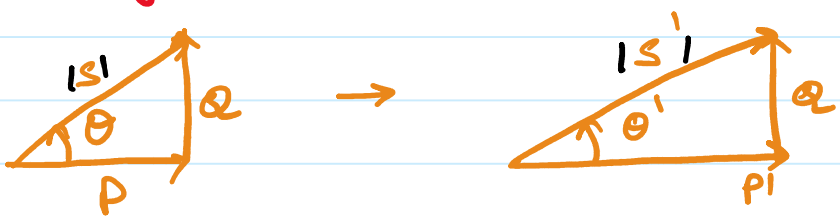
- $|E|$ and $|V|$ are unchanged

Changing the mech power input

→ changes the power angle $\delta$

→ change in current and power factor.

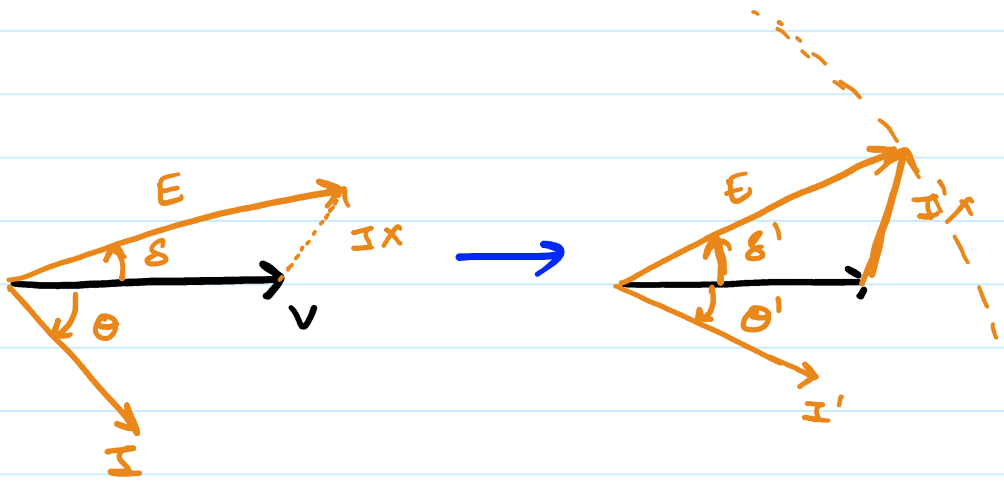
★ Changing P, Q is kept unchanged. $|S| = |V||I|$




→ If $P' > P$ → $\cos\theta' > \cos\theta$ [p.f. changes]

or $\theta' < \theta$

→ $|S'| > S$ → $I' > I$ [current changes]

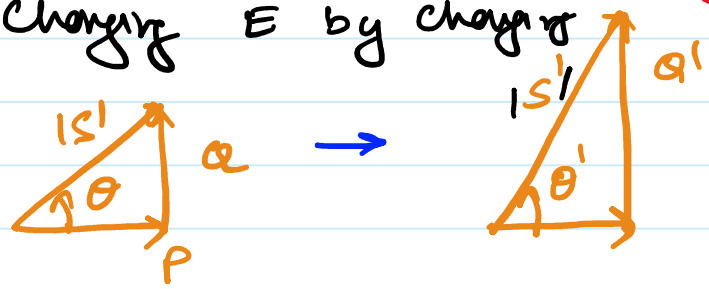


★ Control of Reactive powers.

Assumption - |V| and δ are unchanged.

P is unchanged Q is changed.

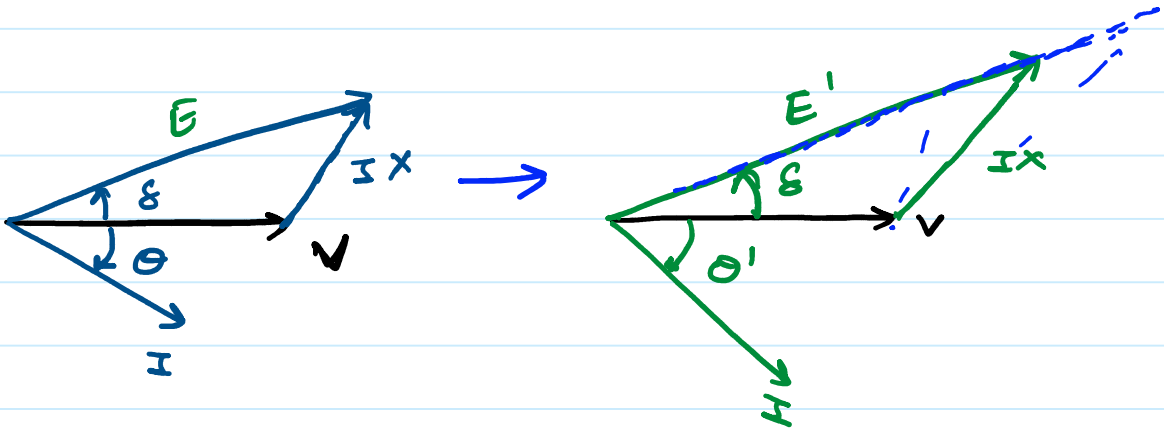
→ Changing E by changing magnetic field of rotor.




If $\theta' > Q$ $\quad \cos\theta' < \cos\theta$ [P.F. changes]

$\theta' > \theta$

→ $|S'| > |S|$ → $I' > I$ Σ current changes




★ Solving Generators

a) Find the Armature current from load parameters

b) Find the Excitation voltage E and power angle δ

$$E = V + I(R + jX)$$

c) If real power is changed → $P \rightarrow P'$

↳ |E| is unchanged

c) If real power is changed → $P \rightarrow P'$
↳ $|E|$ is unchanged.
→ New power angle
- $P' = \frac{3|V||E|}{|X|} \sin\delta'$

d) If reactive power is changed → $Q \rightarrow Q'$
↳ $\delta$ is unchanged.
→ New $|E|$
- $Q' = \frac{3|V||E'|}{|X|}\cos\delta - \frac{3|V|^2}{|X|}$

e) Find new armature current $I'$ and new power factor '$\cos\theta'$'

$$E' = V + I'(R+jX)$$
$$I' = \frac{E' - V}{R+jX}$$

(eg) 50MVA, 30KV, 3ϕ, Wye, 60Hz.
$X_s = j9\Omega$, $R = 0\Omega$.

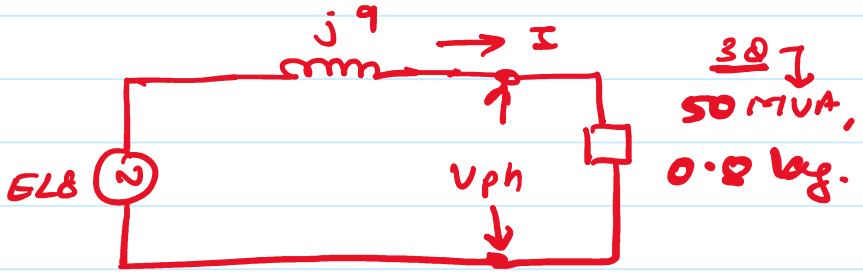
→ Rated power @ 0.8 p.f. lagging.
→ Rated terminal voltage.

→ $|S_{load}| = 50MVA$.
$\cos\theta = 0.8$ lagging.

$V_{line} = 30KV$

$V_{line} = 30kV$

$V_{ph} = \frac{30kV}{\sqrt{3}} = \frac{30\times10^3}{\sqrt{3}} \angle 0^\circ$




$|S_{3\phi}| = 3\,|V_{ph}|\,|I_{ph}|$

$|I_{ph}| = \frac{50\times10^6}{3\times\frac{30\times10^3}{\sqrt{3}}} = 962.25A.$

$\theta = 36.87^\circ$

a) $I_{ph} = 962.25\angle -36.87^\circ A$

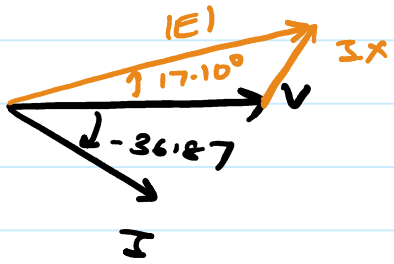
b) $E = V + I(jX)$

$= \frac{30\times10^3}{\sqrt{3}}\angle 0^\circ + 962.25\angle -36.87(j9)$

$= 23558\angle 17.10^\circ V$

$|E| = 23.558kV$

$\delta = 17.10^\circ$




→ |E| constant → Reduce torque

$P' = 25MW$

$$= \frac{3|V||E|}{|X|}\sin\delta'$$

$$25\times10^3 = \frac{3\times\frac{30\times10^3}{\sqrt{3}}\times 2355\angle\delta'}{9}$$

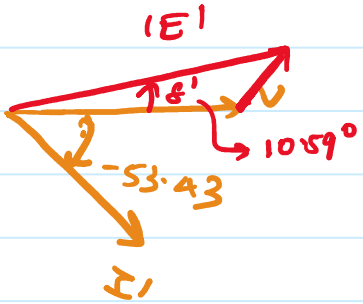
$$\sin\delta' = 0.1838 \rightarrow \delta' = 10.59^\circ$$

$$\rightarrow I' = \frac{E - V}{jX}$$

$$= \frac{|E|\angle\delta' - |V|\angle 0}{jX}$$

$$= \frac{2355\angle 10.59 - \frac{30\times10^3}{\sqrt{3}}\angle 0^\circ}{j9}$$

$$= 807.46\angle -53.43 A.$$




$|I'| = 807.46 A$

$\cos\theta' = 0.596$ lagging.

→ $|E|$ is unchanged → $P_{max}$.

$$P = \frac{3|V||E|}{|X|}\sin\delta$$

IF $\delta = 90^\circ$ $P = P_{max}$.

$$P_{max} = \frac{3\times\frac{30\times10^3}{\sqrt{3}}\times 2355\times\sin 90}{9}$$

$$= 136.02 MW$$