

1.

The internal generated voltage E_A of a **2-pole, Δ -connected, 60 Hz**, three phase synchronous generator is 14.4 kV, and the terminal voltage V_T is 12.8 kV. The synchronous reactance of this machine is $4\ \Omega$, and the armature resistance can be ignored.

- (a) If the torque angle of the generator $\delta = 18^\circ$, how much power is being supplied by this generator at the current time?
- (b) What is the power factor of the generator at this time?
- (c) Sketch the phasor diagram under these circumstances.
- (d) Ignoring losses in this generator, what torque must be applied to its shaft by the prime mover at these conditions?

Tip for (d): consider conservation of power

$$(a) \quad P = \frac{3V_\phi E_A}{X_s} \sin \delta = \frac{3 \times 12.8 \times 10^3 \times 14.4 \times 10^3}{4} \times \sin 18^\circ = 42.72 \text{ MW}$$

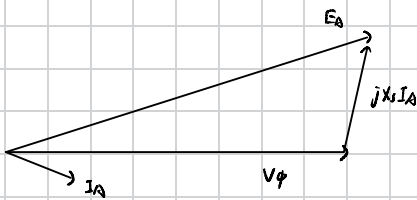
$$(b) \quad E_A = V_\phi + jX_s I_A$$

$$I_A = \frac{E_A - V_\phi}{jX_s}$$

$$I_A = \frac{14.4 \times 10^3 \angle 18^\circ - 12.8 \times 10^3 \angle 0^\circ}{j \times 4} = 1135 \angle -11.37^\circ \quad \Rightarrow \theta = 11.37^\circ$$

$$\cos(-11.37^\circ) = 0.98 \quad \text{lagging}$$

(c)



$$(d) \quad P_{conv} = 3 E_A \cdot I_A \cdot \cos(\delta + \theta) = 3 \times 14.4 \times 10^3 \times 1135 \times \cos(18^\circ + 11.37^\circ) \\ = 42.72 \text{ MW}$$

no losses:

$$T_{app} = \frac{P_{conv}}{\omega_m} = \frac{42.72 \times 10^4}{2\pi \times 60} = 113318 \text{ N}\cdot\text{m}$$