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 Ω, and the armature resistance can be ignored.

(a) If the torque angle of the generator $\delta = 18°$, 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) $P = \frac{3V_\phi E_A}{X_s} \sin\delta = \frac{3 \times 12.8\times10^3 \times 14.4\times10^3}{4} \times \sin 18° = 42.72\ MW$

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

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

$I_A = \frac{14.4\times10^3 \angle 18° - 12.8\times10^3 \angle 0°}{j \times 4} = 1135 \angle -11.37° \quad \Rightarrow \theta = 11.37°$

$\cos(-11.37°) = 0.98$ lagging

(c)

(d) $P_{conv} = 3E_A \cdot I_A \cdot \cos(\delta + \theta) = 3 \times 14.4\times10^3 \times 1135 \times \cos(18° + 11.37°)$

$= 42.72\ MW$

no losses:

$T_{app} = \frac{P_{conv}}{\omega_m} = \frac{42.72\times10^6}{2\pi \times 60} = 113318\ N\cdot m$