5–4 Assume that the field current of the generator in Problem 5–2 has been adjusted so that it supplies rated voltage when loaded with rated current at unity power factor.

a. What is the torque angle δ of the generator when supplying rated current at unity power factor?

b. What is the maximum power that this generator can deliver to a unity power factor load when the field current is adjusted to the current value?

c. When this generator is running at full load with unity power factor, how close is it to the static stability limit of the machine?

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5–2 A 480-V, 200-kVA, 0.8 power factor lagging, 60-Hz, two-pole Y-connected synchronous generator has a synchronous reactance of 0.4 Ω and an armature resistance of 0.04 Ω. At 60 Hz, its friction and windage losses are 6 kW, and its core losses are 4 kW. The field circuit has a DC voltage of 200 V, and the maximum I_F is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω. The OCC of this generator is shown in Figure P5–1.

➢ Let $X_S = 0.3\ \Omega$.

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a) At the rated load w/ unity PF, use (2-29), $P = \sqrt{3} V_{LL} I_L \cos\theta$ to find the line current magnitude $I_A = I_L = \dfrac{P}{\sqrt{3} V_{LL} \cos\theta} = \dfrac{200\times10^3 (0.8)}{\sqrt{3}(480)0.8}$ $\Rightarrow I_L = I_A = 240.5626$ A.

With a unity PF $\Rightarrow \theta_I = 0°$ (assuming $\overline{V}_\phi = 480/\sqrt{3}\angle 0° = 277.127\angle 0°$ (V_{rms})).

Per (5-9), $\overline{E}_A = 277.127\angle 0° + (240.5626\angle 0°)(0.04 + j0.3)$

$\Rightarrow \overline{E}_A = 295.693\angle 14.127°$ V_{rms}.

The torque angle δ is the angle between the phase voltage $\overline{V}_\phi$ & induced voltage $\overline{E}_A$

$\Rightarrow$ **δ = 14.127°.**

b) Per (5-19), $P_{max} = \dfrac{3V_\phi E_A}{X_S} = \dfrac{3(277.127)295.693}{0.3}$

$\Rightarrow$ **P_{max} = 819,448.5 W = 819.45 kW.**

c) In terms of torque angle, **δ= 14.127°** at a unity PF is far less than the δ= 90° torque angle limit.

In terms of power, at a unity PF per (5-19),

$$P = \frac{3V_\phi E_A \sin\delta}{X_S} = \frac{3(277.127)295.693\sin 14.127°}{0.3} \Rightarrow \mathbf{P = 200{,}004.45\ W = 200\ kW}$$

which is far smaller (~24.4%) than $\mathbf{P_{max} = 819.45\ kW}$.