EE 330 Energy Systems (Fall 2026) Quiz #7

Name KEY A

Instructions: Open book & notes (no homework). Place answers in indicated spaces and show all work for credit.

A 4.7 kVA, 120 V_{rms}, 3-phase, Δ-connected, 4-pole, 60 Hz, synchronous generator has the OCC and SCC given. The armature resistance has been found to be 0.5 Ω, and the rated field current is $I_{f,\text{rated}} = 0.6$ A. Determine the rated speed n_m, line current $I_{L,\text{rated}}$, armature/phase current $I_{A,\text{rated}}$, and rated synchronous reactance $X_{S,\text{rated}}$ for this generator.

By (4-23), $f_e = n_m P / 120 \Rightarrow n_{m,\text{rated}} = 120 f_{e,\text{rated}} / P = 120(60)/4 \quad \Rightarrow n_{m,\text{rated}} =$ **1800 RPM**.

By (2-31), $S = \sqrt{3}\, V_{LL} I_L$. Therefore, $I_{L,\text{rated}} = \dfrac{S_{\text{rated}}}{\sqrt{3}\, V_{LL}} = \dfrac{4700}{\sqrt{3}\, 120} \Rightarrow I_{L,\text{rated}} =$ **22.61289 A_{rms}**.

By (2-15), $I_L = \sqrt{3}\, I_\phi$. So, $I_{A,\text{rated}} = I_{\phi,\text{rated}} = I_{L,\text{rated}} / \sqrt{3} = 22.613 / \sqrt{3} \Rightarrow I_{A,\text{rated}} =$ **13.056 A_{rms}**.

Method 1

Using $I_{f,\text{rated}} = 0.6$ A and the OCC & SCC curves, we get $V_{T,OC} = V_{A,OC} = \boldsymbol{E_{A,OC} = 150\ V_{rms}}$ and $I_{L,SC} = 22.5\ A_{rms}$. For a Δ-connection, $I_{\phi,SC} = 22.5/\sqrt{3}$ or $\boldsymbol{I_{A,SC} = 12.9904\ A_{rms}}$. Why is $I_{A,SC} < I_{A,\text{rated}}$ slightly? Round-off error- the rated apparent power should be 4676.5 VA for these current values to agree, but was rounded to 4.7 kVA. By (5-23) & (5-24),

$$X_{S,\text{rated}} = \sqrt{\left(\frac{E_{A,OC}}{I_{A,SC}}\right)^2 - R_A^2} = \sqrt{\left(\frac{150}{12.99}\right)^2 - 0.5^2} \quad \Rightarrow \boldsymbol{X_{S,\text{rated}} = 11.536\ \Omega}.$$

Method 2

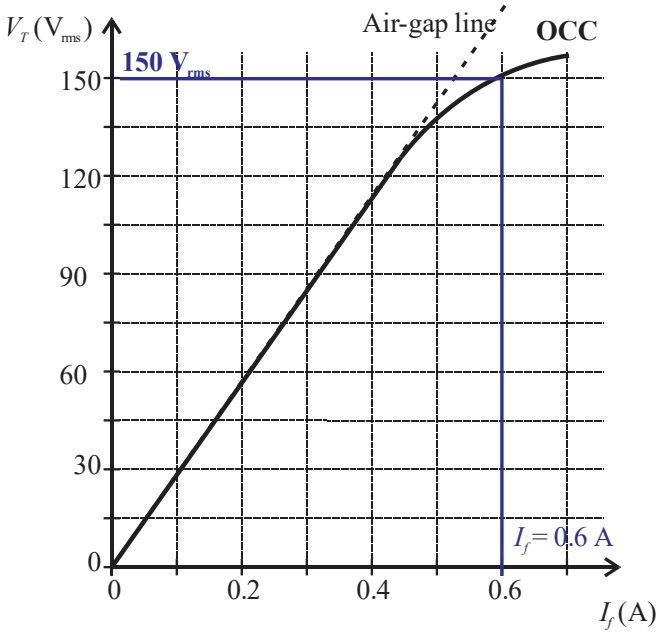
Use $I_{L,\text{rated}} = 22.6\ A_{rms}$ ($I_{A,\text{rated}} = \boldsymbol{I_{A,SC} = 13.056\ A_{rms}}$) from the specifications. Plot $I_{L,\text{rated}} = 22.6\ A_{rms}$ on the SCC to find the field current $I_f = 0.601\ A_{rms}$. For this field current, the OCC yields $V_{T,OC} = V_{A,OC} = \boldsymbol{E_{A,OC} = 151\ V_{rms}}$. Now, by (5-23) & (5-24),

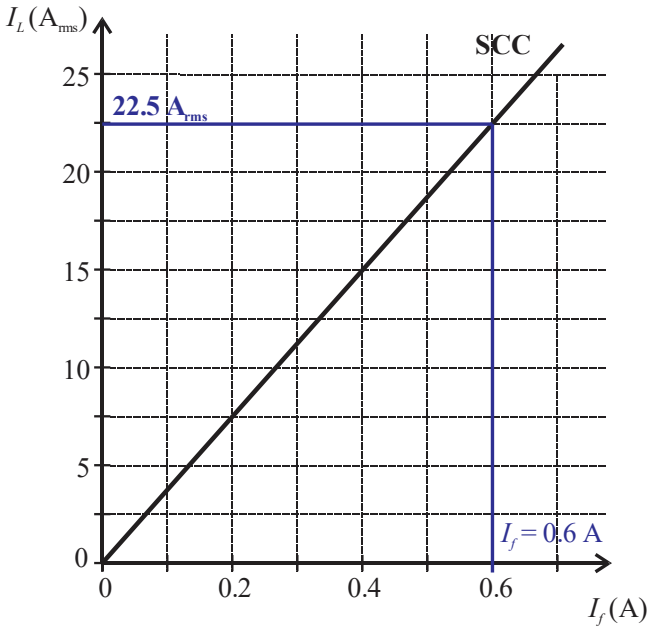
$$X_{S,\text{rated}} = \sqrt{\left(\frac{E_{A,OC}}{I_{A,SC}}\right)^2 - R_A^2} = \sqrt{\left(\frac{151}{13.056}\right)^2 - 0.5^2} \Rightarrow \boldsymbol{X_{S,\text{rated}} = 11.555\ \Omega}.$$ (small difference)

Method 1: $n_m =$ **1800 RPM** $I_{L,\text{rated}} =$ **22.5 A_{rms}** $I_{A,\text{rated}} =$ **12.99 A_{rms}** $X_{S,\text{rated}} =$ **11.536 Ω**

Method 2: $n_m =$ **1800 RPM** $I_{L,\text{rated}} =$ **22.613 A_{rms}** $I_{A,\text{rated}} =$ **13.056 A_{rms}** $X_{S,\text{rated}} =$ **11.555 Ω**

Method 1





Method 2

