KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

EE 306

Solved-HW # 5: Synchronous Machines

D7-4

(a)
$$\frac{E_2}{E_1} = \frac{4.44\, k_w f_2\, N_a\, \phi_2}{4.44\, k_w f_1\, N_a\, \phi_1} = \frac{f_2\, \phi_2}{f_1\, \phi_1} = \frac{(P\, n_2/120)\, \phi_2}{(P n_1/120)\, \phi_1} = \frac{n_2\, \phi_2}{n_1\, \phi_1}$$

$$E_2 = \left(\frac{n_2}{n_1}\right)\left(\frac{\phi_2}{\phi_1}\right) E_1 = \left(\frac{1.1\, n_1}{n_1}\right)\left(\frac{0.85\, \phi_1}{\phi_1}\right) 620 = 580\ V$$

(b)
$$\frac{P n_2}{P n_1} = \frac{120\, f_2}{120\, f_1}$$

$$f_2 = \left(\frac{n_2}{n_1}\right) f_1 = \left(\frac{1.1\, n_1}{n_1}\right) 60 = 66\ Hz$$

D7-8

$$V_t = \frac{12000}{\sqrt{3}} \angle 0° = 6928 \angle 0°\ V$$

$$I_a = \frac{750{,}000}{\sqrt{3}\,(12000)(0.8)} \angle -\cos^{-1} 0.8 = 45.1 \angle -36.9°\ A$$

$$E_a = V_t + j X_s I_a = 6928 \angle 0° + (j30)(45.1 \angle -36.9°)$$

$$= 7815.6 \angle 7.96°\ V$$

$$V.R. = \frac{E_a - V_t}{V_t} = \frac{7815.6 - 6928}{6928} 100\% = 12.8\ \%$$

D7-17

$$V_t = \frac{4160}{\sqrt{3}} = 2401.8 \angle 0°$$

$$E_a = \frac{4600}{\sqrt{3}} = 2655.8 \angle -\delta$$

$$P = \frac{3 V_t E_a}{X_s} \sin\delta = \frac{(3)(2401.8)(2655.8)}{10} \sin\delta = 1,914\sin\delta$$

$$\sin\delta = \frac{1500}{1914}$$

$$\delta = 51.6°$$

ⓐ $$I_a = \frac{V_t - E_a}{jX_s} = \frac{2401.8 \angle 0° - 2655.8 \angle -51.6°}{j10} = 221.3 \angle -19.9°$$

ⓑ $$PF = \cos 19.9° = 0.94 \text{ lagging}$$

7-9

ⓐ $$S = 50 + j30 = 58.31 \angle 31° \quad MVA$$

$$\bar{I_a} = \frac{S^*}{\sqrt{3}V^*} = \frac{(58.31 \angle 31°)^*}{\sqrt{3}(13.8)} = 2,439.5 \angle -31° \; A$$

$$V_t = \frac{13.8}{\sqrt{3}} \angle 0° = 7967.4 \angle 0° \; V$$

$$E_a = V_t + jX_s I_a = 7967.4 \angle 0° + (j7.5)(2439.5 \angle -31°)$$

$$= 23,418 \angle 42° \; V_{LN} = 40,561 \; V_{LL} = 40.56 \; kV_{LL}$$

$$\delta = 42°$$

ⓑ