KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

EE 306

Solved-HW # 3: Transformers

4-14

(a) $a = \frac{4800}{240} = 20$

$$Z_{E2} = \frac{1}{a^2} Z_{E1} = \frac{1}{(20)^2}(120 + j300) = 0.3 + j0.75\ \Omega$$

(b) $V_2 = 230\angle 0^\circ \quad V$

$$I_{2,rated} = \frac{10{,}000}{240}\angle -\cos^{-1}1 = 41.67\angle 0^\circ \quad A$$

$$V_1 = aV_2 + \frac{I_2}{a} Z_{E1}$$

$$= 20(230\angle 0^\circ) + \left(\frac{41.67}{20}\angle 0^\circ\right)(120 + j300)$$

$$= 4600\angle 0 + 2.083\angle 0^\circ (120 + j300)$$

$$= 4890\angle 7.3^\circ \quad V$$

4-15

$V_2 = 230\angle 0^\circ \ V$

$I_2 = \frac{75{,}000}{(230)(0.85)}\angle -\cos^{-1}0.85 = 383.63\angle -31.8^\circ \ A$

$a = \frac{2300}{230} = 10$

(a) $E_1 = aV_2 + \frac{I_2}{a}(a^2R_2 + ja^2X_2)$

$= 10(230\angle 0) + \left(\frac{383.63\angle -31.8^\circ}{10}\right)(10)^2(0.003 + j0.0065)$

$= 2322.9 + j15.1 = 2322.97\angle 0.37^\circ \ V$

~~$I_1 = \frac{I_2}{a} + E_1\left(\frac{1}{R_c} + \frac{1}{jX_m}\right) = \frac{383.63}{10}\angle -31.8^\circ + E_1\left(\frac{10^{-3}}{4.5} + \frac{10^{-3}}{j1}\right)$~~

$= 33.14 - j22.54 = 40.08\angle -34.2^\circ \ A$

(b) $V_1 = E_1 + I_1(R_1 + jX_1) = 2322.97\angle 0.37^\circ + (40.08\angle -34.2^\circ)(0.3 + j0.45)$

$= 2347.5 + j29.78 = 2347.7\angle 0.73^\circ \ V$

(c) $P_1 = V_1 I_1 \cos\theta\Big]_{I_1}^{V_1} = (2347.7)(40.08)\cos(0.73 + 34.2)$

$= 77.15 \ kW$

$PF = \cos(0.73^\circ + 34.2^\circ) = 0.82$ lagging

4-21

(a) $P_{out} = (10)(0.8) = 8\ kW = 8000\ W$

$P_{in} = P_{out} + P_{core} + P_{cu}$

$= 8000 + 150 + 250 = 8400\ W$

$\eta = \frac{P_{out}}{P_{in}} = \frac{8000}{8400} 100\% = 95.2\%$

(b) $P_{out} = (\frac{3}{4})(10{,}000)(1.0) = 7500\ W$

$P_{in} = 7500 + 150 + (\frac{3}{4})^2(250) = 7190.6\ W$

$\eta = \frac{7500}{7190.6} 100\% = 96.3\%$

(c) $P_{out} = (\frac{1}{2})(10{,}000)(0.6) = 3000\ W$

$P_{in} = 3000 + 150 + (\frac{1}{2})^2(250) = 3212.5\ W$

$\eta = \frac{3000}{3212.5} 100\% = 93.4\%$

4-24

$$a = \frac{2400}{240} = 10$$

$$I_{1,rated} = \frac{50{,}000}{2400} = 20.8\ A$$

$$R_{C2} = \frac{V_{oc}^2}{P_{oc}} = \frac{(240)^2}{450} = 128\ \Omega$$

$$G_{C2} = \frac{1}{R_{C2}} = 0.0078\ S$$

$$Y_{o2} = \frac{I_{oc}}{V_{oc}} = \frac{5}{240} = 0.02083\ S$$

$$B_{m2} = \sqrt{Y_{o2}^2 - G_{C2}^2} = \sqrt{(0.02083)^2 - (0.0078)^2} = 0.0193\ S$$

$$X_{m2} = \frac{1}{B_{m2}} = 51.8\ \Omega$$

$$R_{E1} = \frac{P_{sc}}{I_{sc}^2} = \frac{600}{(20.8)^2} = 1.39\ \Omega$$

$$Z_{E1} = \frac{V_{sc}}{I_{sc}} = \frac{55}{20.8} = 2.64\ \Omega$$

$$X_{E1} = \sqrt{Z_{E1}^2 - R_{E1}^2} = \sqrt{(2.64)^2 - (1.39)^2} = 2.24\ \Omega$$

(a) $V_2 = 220\angle 0^\circ$

$$I_2 = 156\angle -\cos^{-1} 0.8 = 156\angle -36.9^\circ$$

$$V_1 = aV_2 + \frac{I_2}{a}(R_{E1} + jX_{E1}) = 10(220\angle 0^\circ) + \left(\frac{156}{10}\angle -36.9^\circ\right)(1.39 + j\,2.24)$$

$$= 2238.4\angle 0.4^\circ$$

$$V.R. = \frac{V_1 - aV_2}{aV_2} = \frac{2238.4 - 2200}{2200}100\% = 1.7\ \%$$