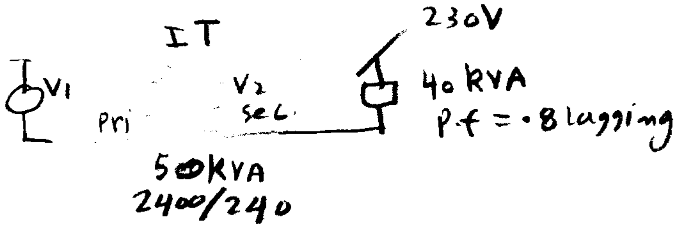
EE 240
solution set #3

(4.2) A single-phase 50-kVA, 2400/240-volt, 60-Hz distribution transformer is used as a step-down transformer. The load, which is connected to the 240-volt secondary winding, absorbs 40 kVA at 0.8 power factor lagging and is at 230 volts. Assuming an ideal transformer, calculate the following: (a) primary voltage, (b) load impedance, (c) load impedance referred to the primary, and (d) the real and reactive power supplied to the primary winding.



a) $V_1 = \frac{2400}{240}(230) = 2300\ V$

b) $S_2 = V_2 I_2^*$ $\quad I_2 = \left(\frac{40\times10^3 \angle \cos^{-1}.8}{230 \angle 0}\right)^* = 173.9 \angle -36.87^\circ$

$Z_2 = \frac{V_2}{I_2} = 1.322 \angle 36.87^\circ\ \Omega$

c) $Z_2' = a^2 Z_2 = \left(\frac{2400}{240}\right)^2 Z_2 = 132.25 \angle 36.87^\circ$

d) $P_1 = P_2 = (40)(.8) = 32\ KW$ $\quad Q_1 = Q_2 = 32 \tan 36.87^\circ$

$= 24.\ KVars.$

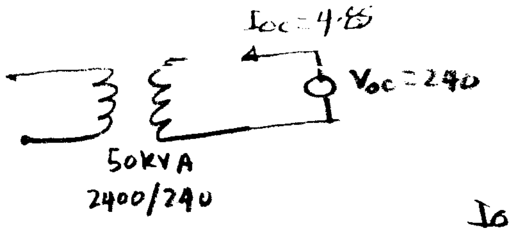
EE 740
solution set #3

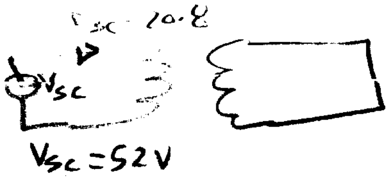
Section 4.2

④.4 The following data are obtained when open-circuit and short-circuit tests are performed on a single-phase, 50-kVA, 2400/240-volt, 60-Hz distribution transformer.

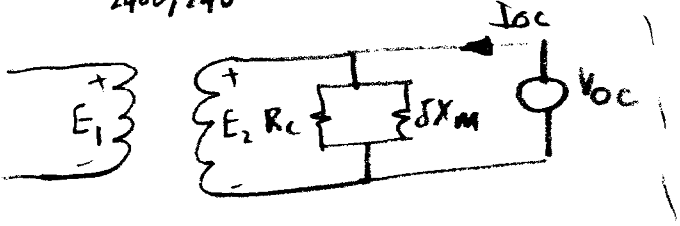
	VOLTAGE (volts)	CURRENT (amperes)	POWER (watts)
Measurements on low-voltage side with high-voltage winding open	240	4.85	173
Measurements on high-voltage side with low-voltage winding shorted	52.0	20.8	650

(a) Neglecting the series impedance, determine the exciting admittance referred to the high-voltage side. (b) Neglecting the exciting admittance, determine the equivalent series impedance referred to the high-voltage side. (c) Assuming equal series impedances for the primary and referred secondary, obtain an equivalent T-circuit referred to the high-voltage side.

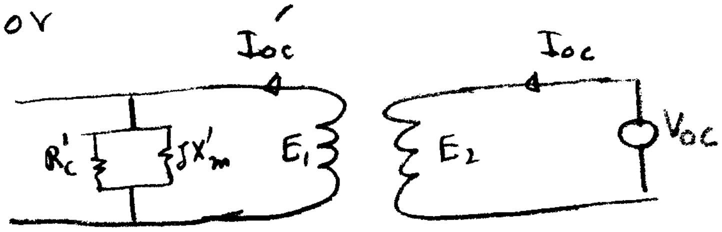




a)



or



$$E_1 = \left(\frac{2400}{240}\right)(240) = 2400\angle 0^\circ$$

$$I'_{oc} = \left(\frac{240}{2400}\right)(I_{oc}) = \left(\frac{1}{10}\right)(4.85) = 0.485$$

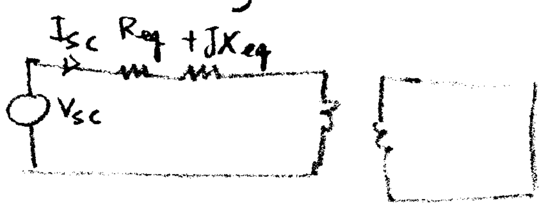
$$R_c = \frac{E_1^2}{P_c} \qquad G_c = \frac{1}{R_c} = 3.003 \times 10^{-5}\ \mho$$

$$|Y_c| = \left|\frac{I'_{oc}}{E_1}\right| = \frac{0.485}{2400} = 2.02 \times 10^{-4}\ \mho$$

$$B_m = \sqrt{Y_c^2 - G_c^2} = 1.998 \times 10^{-4}\ \mho \qquad B_M = \frac{1}{X_M}$$

4.4) cont.

b)



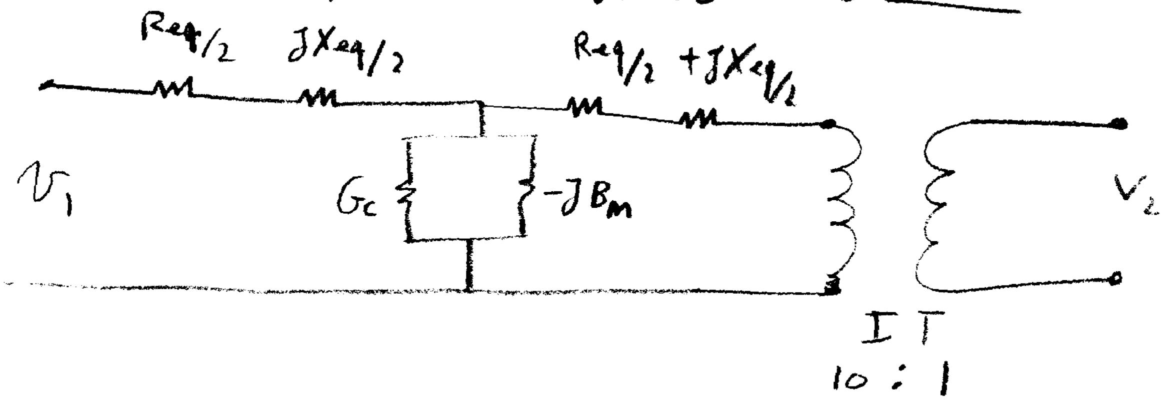
$$R_{eq} = \frac{P_{sc}}{I_{sc}^2} = \frac{650}{20.8} = 1.502 \ \Omega$$

$$Z_{eq} = \left| \frac{V_{sc}}{I_{sc}} \right| = \frac{52}{20.8} = 2.5 \ \Omega$$

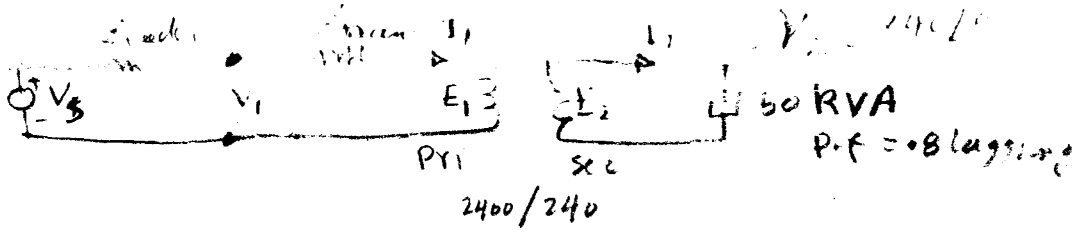
$$X_{eq1} = \sqrt{Z_{eq1}^2 - R_{eq1}^2} = \sqrt{(2.5)^2 - (1.502)^2} = 1.998 \ \Omega$$

$$Z_{eq1} = R_{eq1} + jX_{eq1} = 1.502 + j1.998 = 2.5 \underline{/53.07^\circ}$$

c)



4.6 A single-phase 50-kVA, 2400/240-volt, 60-Hz distribution transformer is used as a step-down transformer at the load end of a 2400-volt feeder whose series impedance is (0.5 + j3.0) ohms. The equivalent series impedance of the transformer is (1.5 + j2.0) ohms referred to the high-voltage (primary) side. The transformer is delivering rated load at 0.8 power factor lagging and at rated secondary voltage. Neglecting the transformer exciting current, determine (a) the voltage at the transformer primary terminals, (b) the voltage at the sending end of the feeder, and (c) the real and reactive power delivered to the sending end of the feeder.



$$I_2 = \left(\frac{S_2}{V_2}\right)^* = \frac{50\times10^3}{240} \angle -\cos^{-1} .8 = 208.3 \angle -36.87^\circ \text{ A}$$

$$I_1 = \frac{N_2}{N_1} I_2 = \frac{1}{10}(208.3 \angle -36.87^\circ) = 20.83 \angle -36.87^\circ$$

$$V_1 = I_1(Z_{trans}) + E_1 = 2450 \angle .34^\circ \text{ volts}$$

b)

$$V_s = I_1(Z_{feeder}) + V_1 = 2496 \angle 1.338^\circ \text{ V}$$

c)

$$S_s = V_s I_1^* = (2496 \angle 1.338^\circ)(20.83 \angle 36.87^\circ) = 40.85\times10^3 + j32.16\times10^3$$

P_s = 40.85 KW

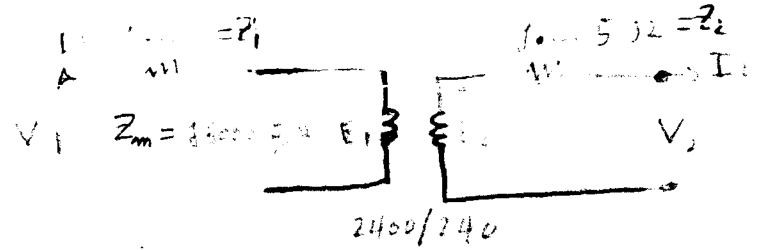
Q_s = 32.16 KVars.

} Delivered

Section 4.3

(4.7) Using the transformer ratings as base quantities, work Problem 4.5 in per-unit.

(4.5) A single-phase 50-kVA, 2400/240-volt, 60-Hz distribution transformer has a 1-ohm equivalent leakage reactance and a 5000-ohm magnetizing reactance referred to the high-voltage side. If rated voltage is applied to the high-voltage winding, calculate the open-circuit secondary voltage. Neglect I^2R and G_c^2V losses. Assume equal series leakage reactances for the primary and referred secondary.



p.u [illegible]

$S_b = 50$ kVA

$V_{b1} = 2400$ V

$V_{b2} = 240$

$Z_{b1} = \dfrac{(2400)^2}{50 \times 10^3} = 115.2\ \Omega$

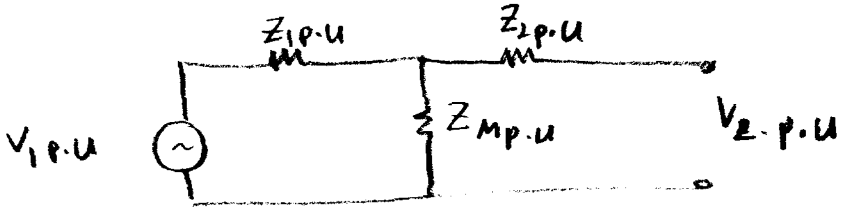
$Z_{b2} = \dfrac{(240)^2}{50 \times 10^3} = 1.152\ \Omega$

r_1

$Z_{1\,p.u} = \dfrac{j.5}{115.2} = j.00434$

$Z_{2\,p.u} = \dfrac{j.005}{1.152} = j.00434$

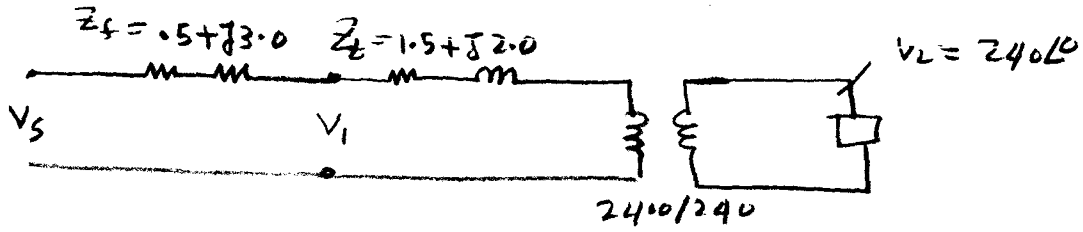
$Z_{m\,p.u} = \dfrac{j5000}{115.2} = j43.40$ p.u



$$V_{2\,p.u} = 1\angle 0 \left(\frac{j43.4)}{j(43.4 + 4.34 \times 10^{-3})} = 0.9999\angle 0 \right.$$

$$V_2 = V_{2\,p.u}\, V_{Base\,2} = 239.98\angle 0 \quad \text{Volts.}$$

(4.8) Using the transformer ratings as base quantities, work Problem 4.6 in per-unit.



$S_b = 50$ kVA

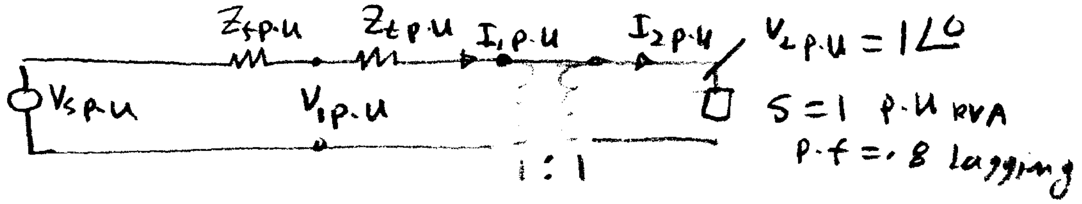
$V_{b1} = 2400$ V

$V_{b2} = 240$ V

$$Z_{b1} = \frac{(2400)^2}{50\times10^3} = 115.2\ \Omega$$

$$Z_{f\,p.u} = \frac{.5 + j3.0}{115.2} = 4.34\times10^{-3} + j.026 \quad p.u\ \Omega$$

$$Z_{t\,p.u} = \frac{1.5 + j2}{115.2} = 0.013 + j0.01736 \quad p.u\ \Omega$$



$$V_{1\,p.u} = I_{1\,p.u}(Z_{t\,p.u}) + V_{2\,p.u}$$

$$I_{1\,p.u} = I_{2\,p.u} = 1\ \angle -36.87^\circ$$

a) $V_{1\,p.u} = 1.021\angle .34^\circ$ p.u V $\quad V_1 = (1.021\angle .34)2400 = 2450\angle .34^\circ$ ✓

b) $V_{s\,p.u} = I_{1\,p.u}(Z_{f\,p.u}) + V_{1\,p.u} = 1.040\angle 1.338^\circ$ p.u V

$V_s = (1.040)\angle 1.338\ (2400) = 2496\angle 1.338^\circ$ Volts

c) $P_{s\,p.u} = V_{s\,p.u}\, I^{*}_{s\,p.u} = 0.817 + j\,0.643$ p.u

$P_s = (0.817)(50) = 40.85$ kW

$Q_s = (0.643)(50) = 32.15$ kVars