Set 2 - extra problems

Solutions to the following problem from the text book are provided here: 3.16, 3.28, 3.41 (S_{base} is 1000 MVA, not 100 MVA), 3.42

3.16 (a) $a = 2400/240 = 10$

$$R_2' = a^2 R_2 = \left(\frac{2400}{240}\right)^2 0.0075 = 0.75\ \Omega$$

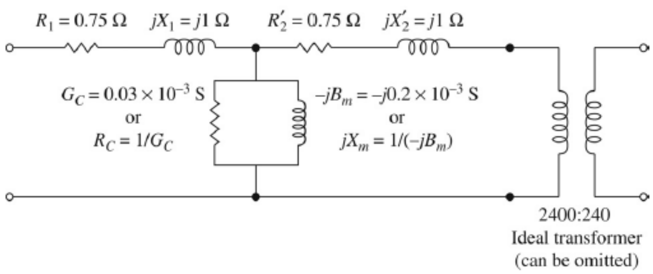
$$X_2' = a^2 X_2 = (10)^2\, 0.01 = 1.0\ \Omega$$

Referred to the HV-side, the exciting branch conductance and susceptance are given by

$$(1/a^2)0.003 = (1/100)0.003 = 0.03\times10^{-3}\ \text{S}$$

and $$(1/a^2)0.02 = (1/100)0.02 = 0.2\times10^{-3}\ \text{S}$$

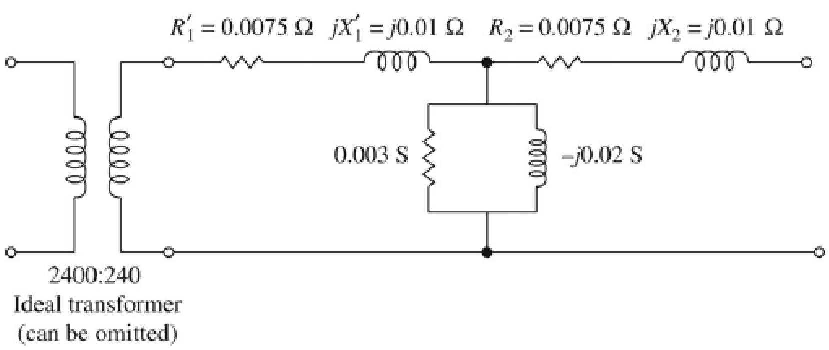
The equivalent circuit referred to the high-voltage side is shown below:



(b) $R_1' = R_1/a^2 = 0.0075\Omega$

$X_1' = X_1/a^2 = 0.01\Omega$

The equivalent circuit referred to the low-voltage side is shown below:



3.28 Eq. 3.3.11 of the text applies.

$$G_1:\ \bar{Z} = j0.2\left(\frac{2400}{2400}\right)^2\left(\frac{100}{10}\right) = j2\,\text{pu}$$

$$G_2:\ \bar{Z} = j0.2\left(\frac{2400}{2400}\right)^2\left(\frac{100}{20}\right) = j1\,\text{pu}$$

$$T_1:\ \bar{Z} = j0.1\left(\frac{2400}{2400}\right)^2\left(\frac{100}{40}\right) = j0.25\,\text{pu}$$

$$T_2:\ \bar{Z} = j0.1\left(\frac{10}{9.6}\right)^2\left(\frac{100}{80}\right) = j0.136\,\text{pu}$$

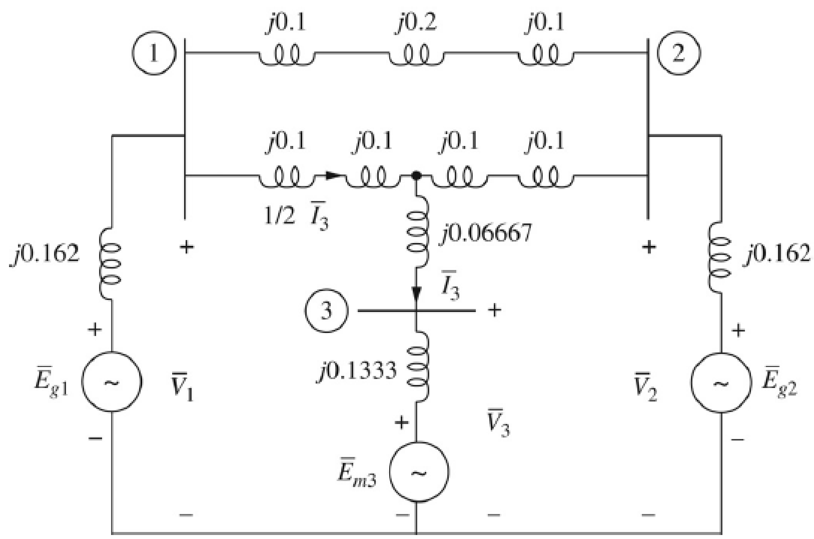
For the transmission-line zone, base impedance $= \dfrac{(9600)^2}{100\times10^3}$

$$\therefore\ \bar{Z}_{LINE} = (50 + j200)\frac{100\times10^3}{(9600)^2} = (0.054 + j0.217)\,\text{pu}$$

$$M;\ \text{kV}A = \frac{25}{100} = 0.25\,\text{pu};\ 4\,\text{kV} = \frac{4}{4.8} = 0.833\,\text{pu}$$

The impedance diagram for the system is shown below:

3.41



Per-unit positive-sequence reactance diagram

$S_{base} =$ 1000 MVA

$V_{base\ H} = 500$ kV in transmission-line Zones

$V_{base\ X} = 20$ kV in motor/generator Zones

$$X''_{g1} = X''_{g2} = 0.2\left(\frac{18}{20}\right)^2 = 0.162\,\text{pu}$$

$$X''_{m3} = 0.2\left(\frac{1000}{1500}\right) = 0.1333\,\text{pu}$$

$$X_{T1} = X_{T2} = X_{T3} = X_{T4} = 0.1\text{pu}$$

$$X_{TS} = 0.1\left(\frac{1000}{1500}\right) = 0.06667\,\text{pu}$$

$$Z_{base\ H} = (500)^2 / 1000 = 250\,\Omega$$

$$X_{line}\,50 = 50/250 = 0.2\,\text{pu}$$

$$X_{line}\,25 = 25/250 = 0.1\,\text{pu}$$

3.42 $\bar{V}_{3pu} = \dfrac{18}{20}\angle 0° = 0.9\angle 0°\,\text{pu}$

$$\bar{I}_3 = \frac{1500}{\sqrt{3}(18)(0.8)}\angle\cos^{-1}0.8 = 60.14\angle 36.87°\,\text{kA}$$

$$I_{base\,X} = \frac{1000}{20\sqrt{3}} = 28.87\,\text{kA}$$

$$\bar{I}_3 = \frac{60.14}{28.87}\angle 36.87° = 2.083\angle 36.87°\ \text{pu}$$

$$\bar{V}_1 = \bar{V}_2 = \bar{V}_3 + \bar{I}_3\left(j\times_{T5}\right) + \frac{1}{2}\bar{I}_3\left(jX_{Line25} + jX_{T3}\right)$$

$$= 0.9\angle 0° + \left(2.083\angle 36.87°\right)\left[j\left(0.06667 + \frac{0.1+0.1}{2}\right)\right]$$

$$= 0.7454\angle 21.88°\,\text{pu}$$

$$V_1 = V_2 = 0.7454(20) = 14.91\,\text{kV}$$