EE3123 Tutorial 2 (Solution)
AC Power Circuits and Components II

Name: **Student No.:**

Q1

An ideal transformer with $N_1 = 1000$ and $N_2 = 250$ is connected with an impedance Z_{22} across winding 2. If $V_1 = 1000\,\underline{/0^\circ}$ V and $I_1 = 5\,\underline{/-30^\circ}$ A, determine V_2, I_2, Z_2, and the impedance Z'_2, which is the value of Z_2 referred to the primary side of the transformer.

Solution

$$\overline{V}_2 = \frac{N_2}{N_1}\overline{V}_1 = \frac{250}{1000}(1000\angle 0^\circ) = 250\angle 0^\circ\,\text{V} \;\leftarrow$$

$$\overline{I}_2 = \frac{N_1}{N_2}\overline{I}_1 = \frac{1000}{250}(5\angle -30^\circ) = 20\angle -30^\circ\,\text{A} \;\leftarrow$$

$$\overline{Z}_2 = \frac{\overline{V}_2}{\overline{I}_2} = \frac{250\angle 0^\circ}{20\angle -30^\circ} = 12.5\angle 30^\circ\,\Omega$$

$$\overline{Z}_2' = \overline{Z}_2\left(\frac{N_1}{N_2}\right)^2 = (12.5\angle 30^\circ)\left(\frac{1000}{250}\right)^2 = 200\angle 30^\circ\,\Omega \;\leftarrow$$

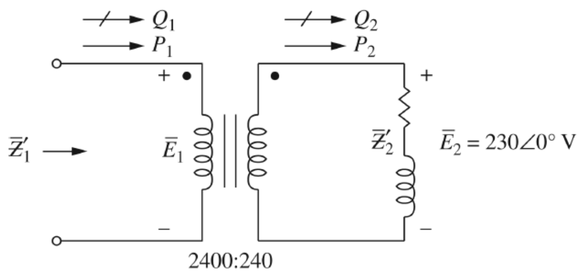
Also $\overline{Z}_2' = \overline{V}_1/\overline{I}_1 = (1000\angle 0^\circ)/(5\angle -30^\circ) = 200\angle 30^\circ\,\Omega \;\leftarrow$

Q2

A single-phase 100-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 60 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.

Solution



(a) $E_1 = \frac{N_1}{N_2} E_2 = \frac{2400}{240}(230) = 2300\,\text{V}$

(b) $\bar{S}_2 = \bar{E}_2 \bar{I}_2^*; \bar{I}_2 = \left(\frac{\bar{S}_2}{\bar{E}_2}\right)^* = \left[\frac{60\times 10^3 \angle \cos^{-1} 0.8}{230\angle 0°}\right]^* = 260.9\angle -36.87°$

$$\bar{Z}_2 = \frac{\bar{E}_2}{\bar{I}_2} = \frac{230\angle 0°}{260.9\angle -36.87°} = 0.8817\angle 36.87°\,\Omega$$

$$= 0.705 + j.529\,\Omega$$

(c) $\bar{Z}_1' = \left(\frac{N_1}{N_2}\right)^2 \bar{Z}_2 = 100\bar{Z}_2 = 88.17\angle 36.87°\,\Omega$

(d) $P_1 = P_2 = 60(0.8) = 48\,\text{kW}$

$Q_1 = Q_2 = 48\tan(36.87°) = 36\,\text{kVAR}$

Q3

A single-phase step-down transformer is rated 13 MVA, 66 kV/11.5 kV. With the 11.5 kV winding short-circuited, rated current flows when the voltage applied to the primary is 5.5 kV. The power input is read as 100 kW. Determine R_{eq1} and X_{eq1} in ohms referred to the high-voltage winding.

Solution

Rated current magnitude on the 66-kV side is given by

$$I_1 = \frac{13{,}000}{66} = 197.0\,\text{A}$$

$$I_1^2 R_{eq\,1} = (197.0)^2 R_{eq\,1} = 100\times 10^3$$

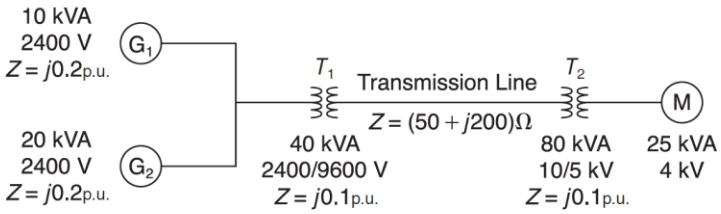
$$\therefore R_{eq\,1} = 2.58\,\Omega \quad \leftarrow$$

$$Z_{eq1} = \frac{5.5\times 10^3}{197.0} = 27.9\,\Omega$$

Then $X_{eq\,1} = \sqrt{Z_{eq\,1}^2 - R_{eq\,1}^2} = \sqrt{(27.9)^2 - (2.58)^2} = 27.8\,\Omega \quad \leftarrow$

Q4

For the system shown below, draw an impedance diagram in per unit by choosing 100 kVA to be the base kVA and 2400 V as the base voltage for the generators.



Solution

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

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

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

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

For the transmission-line zone, base impedance $= \dfrac{(9600)^2}{100\times 10^3}$

$$\therefore\ \bar{Z}_{LINE} = (50 + j200)\frac{100\times 10^3}{(9600)^2} = (0.054 + j0.217)\,\text{pu}$$

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

The impedance diagram for the system is shown below: