ELEC 342: Electromechanical Energy Conversion and Transmission

Homework 1

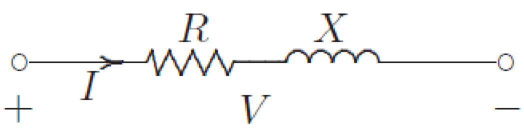
Solution of the Assignments

Assignments

Q1):

An inductive load consisting of R and X in series feeding from a 2400-V rms supply absorbs 288 kW at a lagging power factor of 0.8. Determine R and X.

Solution:



$$\theta = \cos^{-1} 0.8 = 36.87^\circ$$

The complex power is

$$S = \frac{288}{0.8}\angle 36.87^\circ = 360\angle 36.87^\circ \;\; \text{kVA}$$

The current given from $S = VI^*$, is

$$I = \frac{360 \times 10^3\angle -36.87^\circ}{2400\angle 0^\circ} = 150\angle -36.87 \;\; \text{A}$$

Therefore, the series impedance is

$$Z = R + jX = \frac{V}{I} = \frac{2400\angle 0^\circ}{150\angle -36.87^\circ} = 12.8 + j9.6 \;\; \Omega$$

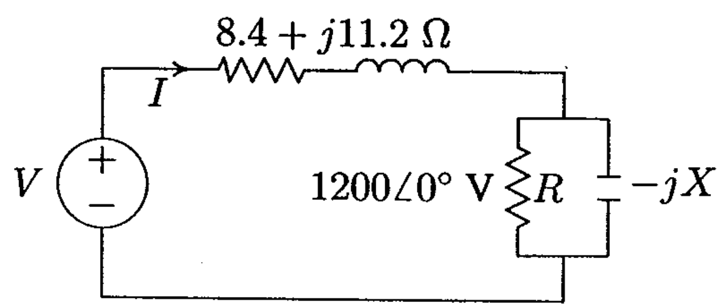
Therefore, $R = 12.8\ \Omega$ and $X = 9.6\ \Omega$.

Q2):

The load shown in Figure consists of a resistance R in parallel with a capacitor of reactance X. The load is fed from a single-phase supply through a line of impedance $8.4 + j11.2\ \Omega$. The rms voltage at the load terminal is $1200\angle 0^\circ$ V rms, and the load is taking 30 kVA at 0.8 power factor leading.

(a) Find the values of R and X.

(b) Determine the supply voltage V.



Solution:

$$\theta = \cos^{-1} 0.8 = 36.87^\circ$$

The complex power is

$$S = 30\angle{-36.87^\circ} = 24 \text{ kW} - j18 \text{ kvar}$$

(a)

$$R = \frac{|V|^2}{P} = \frac{(1200)^2}{24000} = 60 \;\; \Omega$$
$$X = \frac{|V|^2}{Q} = \frac{(1200)^2}{18000} = 80 \;\; \Omega$$

From $S = VI^*$, the current is

$$I = \frac{30000\angle 36.87^\circ}{1200\angle 0^\circ} = 25\angle 36.87 \;\; \text{A}$$

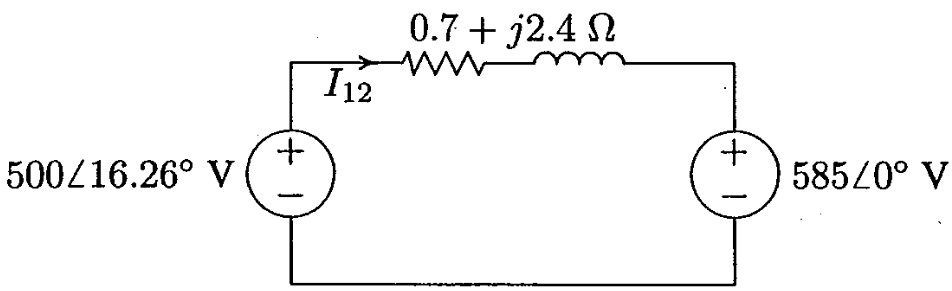
(b)

Thus, the supply voltage is

$$\begin{aligned} V &= 1200\angle 0^\circ + 25\angle 36.87^\circ(8.4 + j11.2) \\ &= 1200 + j350 = 1250\angle 16.26^\circ \;\; \text{V} \end{aligned}$$

Q3):

Two single-phase ideal voltage sources are connected by a line of impedance of $0.7 + j2.4\ \Omega$ as shown in Figure . $V_1 = 500\angle 16.26°$ V and $V_2 = 585\angle 0°$ V. Find the complex power for each machine and determine whether they are delivering or receiving real and reactive power. Also, find the real and the reactive power loss in the line.



Solution:

$$I_{12} = \frac{500\angle 16.26° - 585\angle 0°}{0.7 + j2.4} = 42 + j56 = 70\angle 53.13° \ \ \text{A}$$

$$\begin{aligned} S_{12} = V_1 I_{12}^* &= (500\angle 16.26°)(70\angle{-53.13°}) = 35000\angle{-36.87°} \\ &= 28000 - j21000 \ \ \text{VA} \\ S_{21} = V_2 I_{21}^* &= (585\angle 0°)(-70\angle{-53.13°}) = 40950\angle{-53.13°} \\ &= -24570 + j32760 \ \ \text{VA} \end{aligned}$$

From the above results, since P_1 is positive and P_2 is negative, source 1 generates 28 kW, and source 2 receives 24.57 kW, and the real power loss is 3.43 kW. Similarly, since Q_1 is negative, source 1 receives 21 kvar and source 2 delivers 32.76 kvar. The reactive power loss in the line is 11.76 kvar.

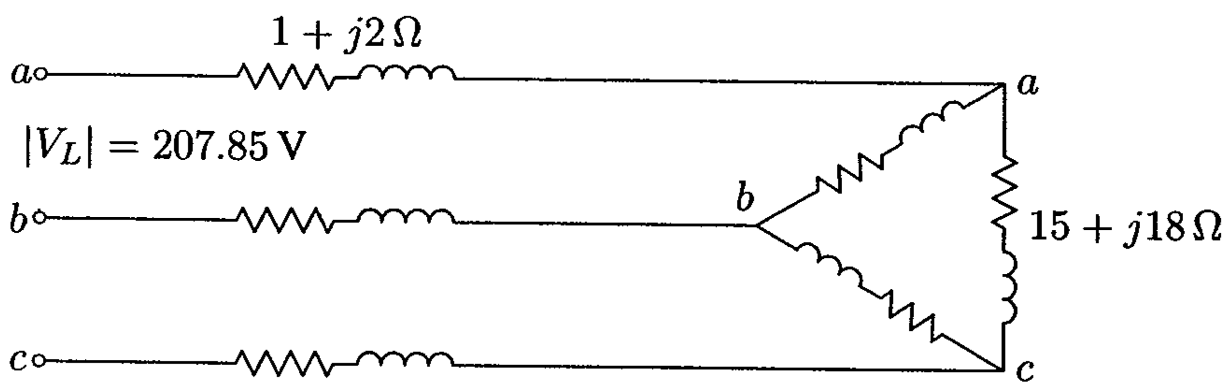
Q4):

A balanced delta connected load of $15 + j18\ \Omega$ per phase is connected at the end of a three-phase line as shown in Figure . The line impedance is $1 + j2\ \Omega$ per phase. The line is supplied from a three-phase source with a line-to-line voltage of 207.85 V rms. Taking V_{an} as reference, determine the following:

(a) Current in phase a.

(b) Total complex power supplied from the source.

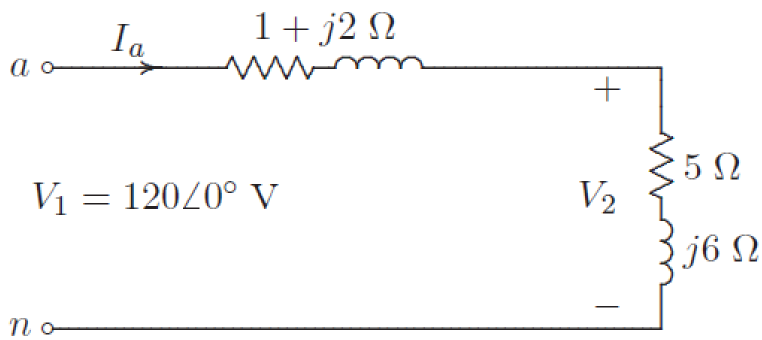
(c) Magnitude of the line-to-line voltage at the load terminal.



Solution:

$$V_{an} = \frac{207.85}{\sqrt{3}} = 120 \ \ \text{V}$$

Transforming the delta connected load to an equivalent Y-connected load, result in the phase 'a' equivalent circuit, shown in Figure ·



The per phase equivalent circuit

(a)

$$I_a = \frac{120\angle 0°}{6 + j8} = 12\angle{-53.13°} \ \ \text{A}$$

(b) The total complex power is

$$S = 3V_{an}I_a^* = (3)(120\angle 0°)(12\angle 53.13°) = 4320\angle 53.13° \ \text{VA}$$
$$= 2592 \ \text{W} + j3456 \ \text{Var}$$

(c)

$$V_2 = 120\angle 0° - (1 + j2)(12\angle{-53.13°} = 93.72\angle{-2.93°} \ \ \text{A}$$

Thus, the magnitude of the line-to-line voltage at the load terminal is $V_L = \sqrt{3}(93.72) = 162.3$ V.