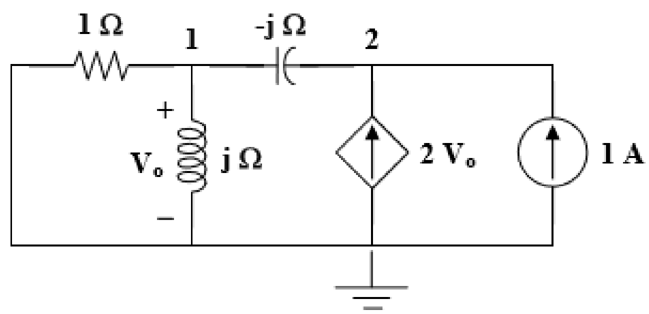
Chapter 11, Solution 15.

To find $\mathbf{Z}_{eq}$, insert a 1-A current source at the load terminals as shown in Fig. (a).



(a)

At node 1,

$$\frac{\mathbf{V}_o}{1} + \frac{\mathbf{V}_o}{j} = \frac{\mathbf{V}_2 - \mathbf{V}_o}{-j} \longrightarrow \mathbf{V}_o = j\mathbf{V}_2 \qquad (1)$$

At node 2,

$$1 + 2\mathbf{V}_o = \frac{\mathbf{V}_2 - \mathbf{V}_o}{-j} \longrightarrow 1 = j\mathbf{V}_2 - (2+j)\mathbf{V}_o \qquad (2)$$

Substituting (1) into (2),

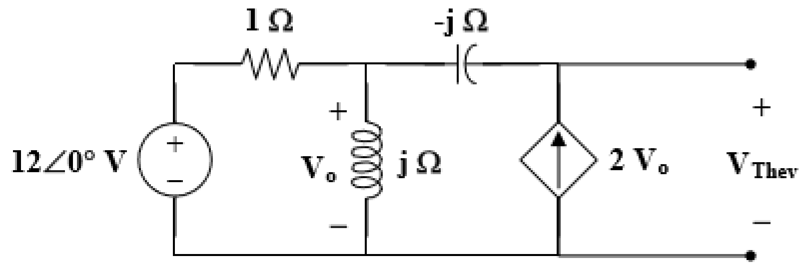
$$1 = j\mathbf{V}_2 - (2+j)(j)\mathbf{V}_2 = (1-j)\mathbf{V}_2$$

$$\mathbf{V}_2 = \frac{1}{1-j}$$

$$\mathbf{Z}_{eq} = \frac{\mathbf{V}_2}{1} = \frac{1+j}{2} = 0.5 + j0.5$$

$$\mathbf{Z}_L = \mathbf{Z}_{eq}^* = \mathbf{[0.5 - \mathit{j}0.5]\ \Omega}$$

We now obtain $\mathbf{V}_{Thev}$ from Fig. (b).



(b)

$$-2\mathbf{V}_o + \frac{\mathbf{V}_o - 12}{1} + \frac{\mathbf{V}_o}{j} = 0$$

$$\mathbf{V}_o = \frac{-12}{1 + j}$$

$$-\mathbf{V}_o - (-j \times 2\mathbf{V}_o) + \mathbf{V}_{Th} = 0$$

$$\mathbf{V}_{Thev} = (1 - j2)\mathbf{V}_o = \frac{(-12)(1 - j2)}{1 + j}$$

$$P_{max} = \frac{\left[\left[\dfrac{V_{Thev}}{0.5 + j0.5 + 0.5 - j0.5}\right]\right]^2}{2} 0.5 = \frac{\left(\dfrac{12\sqrt{5}}{\sqrt{2}}\right)^2}{2(2x0.5)^2} 0.5$$

$$= \mathbf{90\ W}$$

Chapter 11, Solution 23.

Using Fig. 11.54, design a problem to help other students to better understand how to find the rms value of a waveshape.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Determine the rms value of the voltage shown in Fig. 11.54.

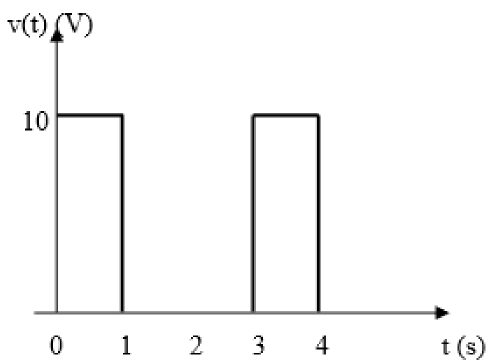


Figure 11.54 For Prob. 11.23.

Solution

$$V_{rms}^2 = \frac{1}{T}\int_0^T v^2(t)dt = \frac{1}{3}\int_0^1 10^2\,dt = \frac{100}{3}$$

V_{rms} = **5.7735 V**

Chapter 11, Solution 51.

(a) $\mathbf{Z}_T = 2 + (10 - j5) \parallel (8 + j6)$

$$\mathbf{Z}_T = 2 + \frac{(10 - j5)(8 + j6)}{18 + j} = 2 + \frac{110 + j20}{18 + j}$$

$$\mathbf{Z}_T = 8.152 + j0.768 = 8.188\angle 5.382°$$

pf = cos(5.382°) = **0.9956 (lagging)**

(b) $$\mathbf{S} = \mathbf{V}\,\mathbf{I}^* = \frac{|\mathbf{V}|^2}{\mathbf{Z}^*} = \frac{(16)^2}{(8.188\angle -5.382°)}$$

$$\mathbf{S} = 31.26\angle 5.382°$$

$P = S\cos\theta =$ **31.12 W**

(c) $Q = S\sin\theta =$ **2.932 VAR**

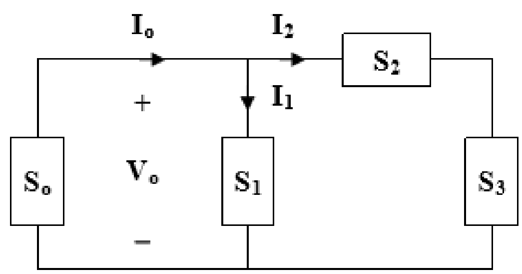
(d) $S = |\mathbf{S}| =$ **31.26 VA**

(e) $\mathbf{S} = 31.26\angle 5.382° =$ **(31.12+j2.932) VA**

(a) 0.9956 (lagging, (b) 31.12 W, (c) 2.932 VAR, (d) 31.26 VA, (e) [31.12+j2.932] VA

Chapter 11, Solution 61.

Consider the network shown below.



$$\mathbf{S}_2 = 1.2 - j0.8 \text{ kVA}$$

$$\mathbf{S}_3 = 4 + j\frac{4}{0.9}\sin(\cos^{-1}(0.9)) = 4 + j1.937 \text{ kVA}$$

Let $\mathbf{S}_4 = \mathbf{S}_2 + \mathbf{S}_3 = 5.2 + j1.137$ kVA

But $\mathbf{S}_4 = \mathbf{V}_o\,\mathbf{I}_2^*$

$$\mathbf{I}_2^* = \frac{\mathbf{S}_4}{\mathbf{V}_o} = \frac{(5.2 + j1.137)\times 10^3}{100\angle 90^\circ} = 11.37 - j52$$

$$\mathbf{I}_2 = 11.37 + j52$$

Similarly, $\mathbf{S}_1 = \sqrt{2} - j\frac{\sqrt{2}}{0.707}\sin(\cos^{-1}(0.707)) = \sqrt{2}(1 - j)$ kVA

But $\mathbf{S}_1 = \mathbf{V}_o\,\mathbf{I}_1^*$

$$\mathbf{I}_1^* = \frac{\mathbf{S}_1}{V_o} = \frac{(1.4142 - j1.4142)\times 10^3}{j100} = -14.142 - j14.142$$

$$\mathbf{I}_1 = -14.142 + j14.142$$

$$\mathbf{I}_o = \mathbf{I}_1 + \mathbf{I}_2 = -2.772 + j66.14 = \mathbf{66.2\angle 92.4^\circ\ A}$$

$$\mathbf{S}_o = V_o I_o^*$$

$$\mathbf{S}_o = (100\angle 90^\circ)(66.2\angle -92.4^\circ)\ VA$$

$$\mathbf{S}_o = \mathbf{6.62\angle{-2.4^\circ}\ kVA}$$

66.2∠92.4° A, 6.62∠–2.4° kVA

Chapter 11, Solution 69.

(a) Given that $\mathbf{Z} = 10 + j12$

$$\tan\theta = \frac{12}{10} \longrightarrow \theta = 50.19°$$

$\text{pf} = \cos\theta =$ **0.6402**

(b) $$\mathbf{S} = \frac{|\mathbf{V}|^2}{2\mathbf{Z}^*} = \frac{(120)^2}{(2)(10 - j12)} = 295.12 + j354.09$$

The average power absorbed $= P = \text{Re}(\mathbf{S}) =$ **295.1 W**

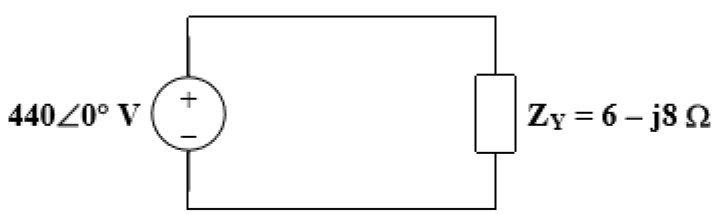
(c) For unity power factor, $\theta_1 = 0°$, which implies that the reactive power due to the capacitor is $Q_c = 354.09$

But $$Q_c = \frac{V^2}{2X_c} = \frac{1}{2}\omega C V^2$$

$$C = \frac{2Q_c}{\omega V^2} = \frac{(2)(354.09)}{(2\pi)(60)(120)^2} = \mathbf{130.4\ \mu F}$$

Chapter 12, Solution 7.

This is a balanced Y-Y system.



Using the per-phase circuit shown above,

$$\mathbf{I}_a = \frac{440\angle 0°}{6 - j8} = \mathbf{44\angle 53.13°\ A}$$

$$\mathbf{I}_b = \mathbf{I}_a\angle -120° = \mathbf{44\angle -66.87°\ A}$$

$$\mathbf{I}_c = \mathbf{I}_a\angle 120° = \mathbf{44\angle 173.13°\ A}$$

Chapter 12, Solution 11.

Given that $V_p = 240$ and that the system is balanced, $V_L = 1.7321V_p = 415.7$ V.

$I_p = V_L/|2–j3| = 415.7/3.606 = 115.29$ A and

$$I_L = 1.7321x115.29 = \mathbf{199.69\ A}.$$

Chapter 12, Solution 33.

$$\mathbf{S} = \sqrt{3}\,V_L I_L \angle\theta$$

$$S = |\mathbf{S}| = \sqrt{3}\,V_L I_L$$

For a Y-connected load,

$$I_L = I_p, \qquad V_L = \sqrt{3}\,V_p$$

$$S = 3\,V_p I_p$$

$$I_L = I_p = \frac{S}{3\,V_p} = \frac{4800}{(3)(208)} = \mathbf{7.69\ A}$$

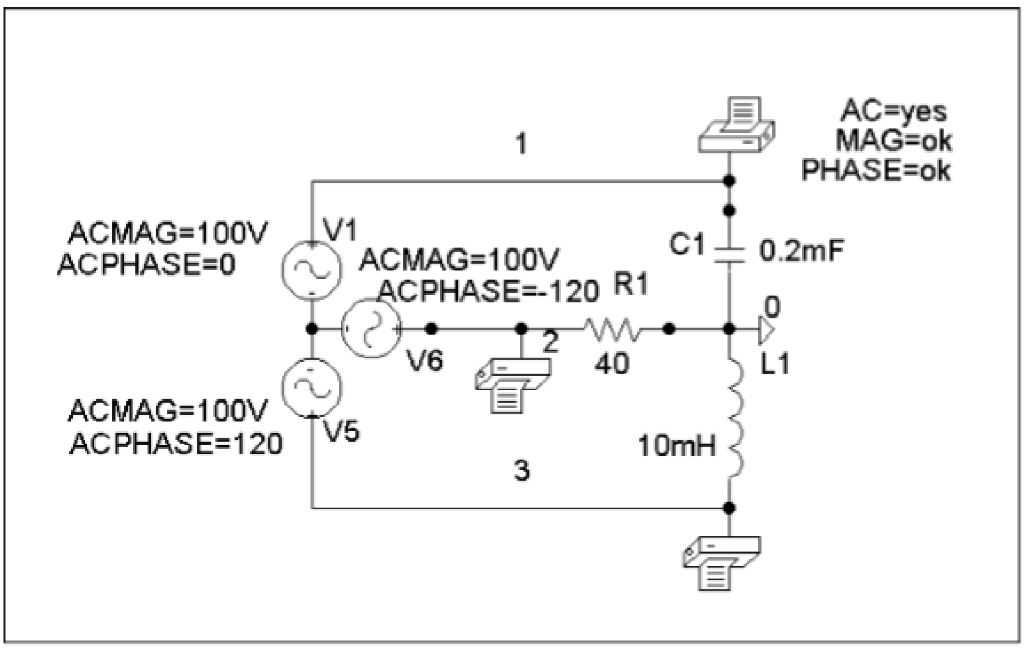
$$V_L = \sqrt{3}\,V_p = \sqrt{3} \times 208 = \mathbf{360.3\ V}$$

Chapter 12, Solution 59.

The schematic is shown below. In the AC Sweep box, we set Total Pts = 1, Start Freq = 60, and End Freq = 60. After simulation, we obtain an output file which includes

FREQ	VM(1)	VP(1)
6.000 E+01	2.206 E+02	–3.456 E+01
FREQ	VM(2)	VP(2)
6.000 E+01	2.141 E+02	–8.149 E+01
FREQ	VM(3)	VP(3)
6.000 E+01	4.991 E+01	–5.059 E+01

i.e. V_{AN} = $\mathbf{220.6\angle{-34.56°}}$, V_{BN} = $\mathbf{214.1\angle{-81.49°}}$, V_{CN} = $\mathbf{49.91\angle{-50.59°}}$ **V**



Chapter 12, Solution 71.

(a) If $\mathbf{V}_{ab} = 208\angle 0°$, $\mathbf{V}_{bc} = 208\angle\text{-}120°$, $\mathbf{V}_{ca} = 208\angle 120°$,

$$\mathbf{I}_{AB} = \frac{\mathbf{V}_{ab}}{\mathbf{Z}_{Ab}} = \frac{208\angle 0°}{20} = 10.4\angle 0°$$

$$\mathbf{I}_{BC} = \frac{\mathbf{V}_{bc}}{\mathbf{Z}_{BC}} = \frac{208\angle\text{-}120°}{10\sqrt{2}\angle\text{-}45°} = 14.708\angle\text{-}75°$$

$$\mathbf{I}_{CA} = \frac{\mathbf{V}_{ca}}{\mathbf{Z}_{CA}} = \frac{208\angle 120°}{13\angle 22.62°} = 16\angle 97.38°$$

$$\mathbf{I}_{aA} = \mathbf{I}_{AB} - \mathbf{I}_{CA} = 10.4\angle 0° - 16\angle 97.38°$$

$$\mathbf{I}_{aA} = 10.4 + 2.055 - j15.867$$

$$\mathbf{I}_{aA} = 20.171\angle\text{-}51.87°$$

$$\mathbf{I}_{cC} = \mathbf{I}_{CA} - \mathbf{I}_{BC} = 16\angle 97.83° - 14.708\angle\text{-}75°$$

$$\mathbf{I}_{cC} = 30.64\angle 101.03°$$

$$P_1 = |\mathbf{V}_{ab}||\mathbf{I}_{aA}|\cos(\theta_{V_{ab}} - \theta_{I_{aA}})$$

$$P_1 = (208)(20.171)\cos(0° + 51.87°) = \mathbf{2.590}\ \boldsymbol{kW}$$

$$P_2 = |\mathbf{V}_{cb}||\mathbf{I}_{cC}|\cos(\theta_{V_{cb}} - \theta_{I_{cC}})$$

But $\mathbf{V}_{cb} = \text{-}\mathbf{V}_{bc} = 208\angle 60°$

$$P_2 = (208)(30.64)\cos(60° - 101.03°) = \mathbf{4.808}\ \boldsymbol{kW}$$

(b)

$$P_T = P_1 + P_2 = 7398.17\ \text{W}$$

$$Q_T = \sqrt{3}\,(P_2 - P_1) = 3840.25\ \text{VAR}$$

$$\mathbf{S}_T = P_T + jQ_T = 7398.17 + j3840.25\ \text{VA}$$

$$S_T = |\mathbf{S}_T| = \mathbf{8.335}\ \boldsymbol{kVA}$$