Chapter 11, Solution 85.

A regular household system of a single-phase three-wire allows the operation of both 120-V and 240-V, 60-Hz appliances. The household circuit is modeled as shown in Fig. 11.96. Calculate: (a) the currents $\mathbf{I}_1$, $\mathbf{I}_2$, and $\mathbf{I}_n$, (b) the total complex power supplied, (c) the overall power factor of the circuit.

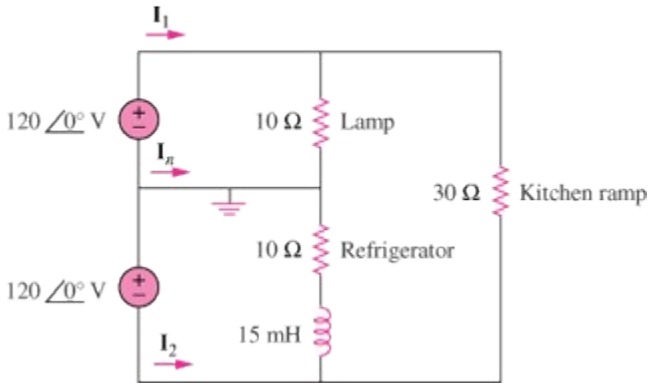
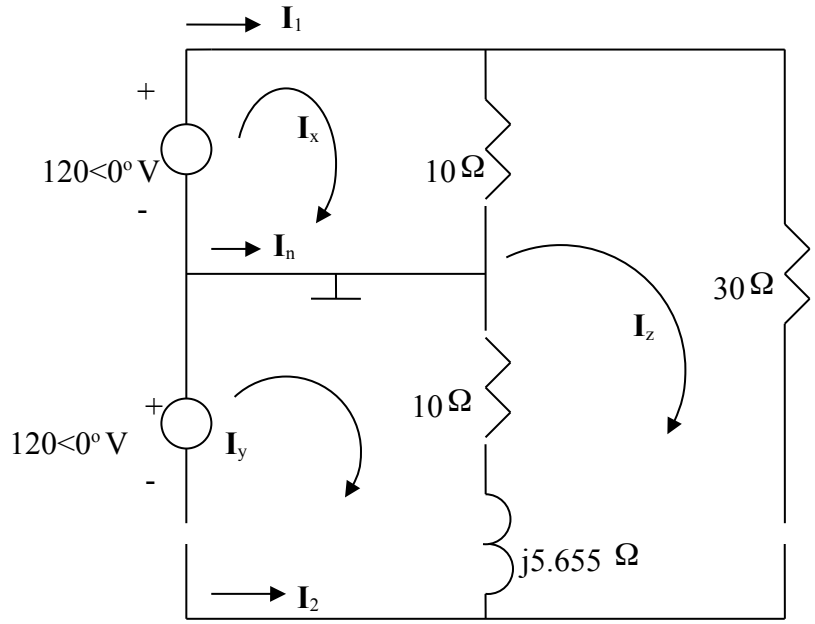


Figure 11.96
For Prob. 11.85.

Solution

(a) 15 mH $\longrightarrow$ $j2\pi x60x15x10^{-3} = j5.655$

We apply mesh analysis as shown below.



For mesh x,

$120 = 10\,\mathbf{I}_x - 10\,\mathbf{I}_z$ (1)

For mesh y,

$120 = (10+j5.655)\,\mathbf{I}_y - (10+j5.655)\,\mathbf{I}_z$ (2)

For mesh z,

$0 = -10\,\mathbf{I}_x - (10+j5.655)\,\mathbf{I}_y + (50+j5.655)\,\mathbf{I}_z$ (3)

Solving (1) to (3) gives

$\mathbf{I}_x = 20,\ \mathbf{I}_y = 17.09 - j5.142,\ \mathbf{I}_z = 8$

Thus,

$\mathbf{I}_1 = \mathbf{I}_x = \mathbf{20\ A}$

$\mathbf{I}_2 = -\mathbf{I}_y = -17.09 + j5.142 = \underline{\mathbf{17.85\angle 163.26^o\ A}} = \mathbf{17.85\angle 163.26°\ A}$

$\mathbf{I}_n = \mathbf{I}_y - \mathbf{I}_x = -2.91 - j5.142 = \underline{\mathbf{5.907\angle -119.5^o\ A}} = \mathbf{5.907\angle -119.5°\ A}$

(b) $\overline{S_1} = (120)I^*_x = 120x20 = 2400, \quad \overline{S_2} = (120)I^*_y = 2051 + j617$

$\boldsymbol{\overline{S} = \overline{S_1} + \overline{S_2} = \underline{[4.451 + j0.617]\,kVA}}$

(c) pf = P/S = 4451/4494 = **0.9904** (lagging)