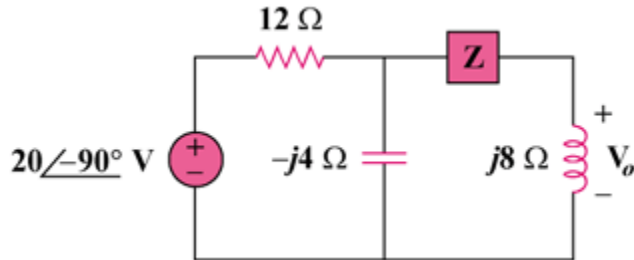


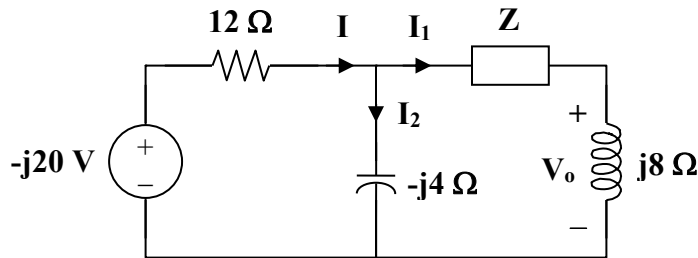
EE1002 Solution of Tutorial 9

(Questions from Alexander & Sadiku, 7th edition, Problems 9.55, 9.66, & 9.91)

- Find $\mathbf{Z}$ in the following network, given that $\mathbf{V}_o = 4\angle 0^\circ \text{ V}$



Solution



$$\mathbf{I}_1 = \frac{\mathbf{V}_o}{j8} = \frac{4}{j8} = -j0.5$$

$$\mathbf{I}_2 = \frac{\mathbf{I}_1(\mathbf{Z} + j8)}{-j4} = \frac{(-j0.5)(\mathbf{Z} + j8)}{-j4} = \frac{\mathbf{Z}}{8} + j$$

$$\mathbf{I} = \mathbf{I}_1 + \mathbf{I}_2 = -j0.5 + \frac{\mathbf{Z}}{8} + j = \frac{\mathbf{Z}}{8} + j0.5$$

$$-j20 = 12\mathbf{I} + \mathbf{I}_1(\mathbf{Z} + j8)$$

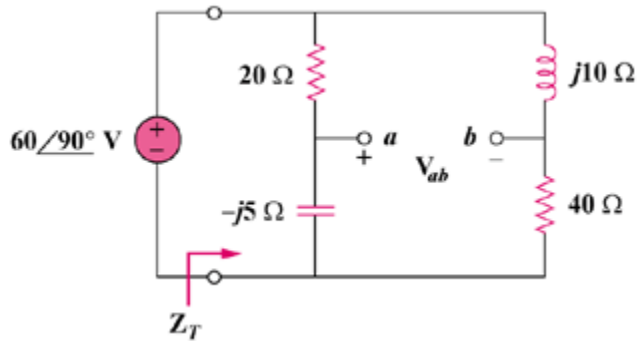
$$-j20 = 12\left(\frac{\mathbf{Z}}{8} + \frac{j}{2}\right) + \frac{-j}{2}(\mathbf{Z} + j8)$$

$$-4 - j26 = \mathbf{Z}\left(\frac{3}{2} - j\frac{1}{2}\right)$$

$$\mathbf{Z} = \frac{-4 - j26}{\frac{3}{2} - j\frac{1}{2}} = \frac{26.31\angle 261.25^\circ}{1.5811\angle -18.43^\circ} = 16.64\angle 279.68^\circ$$

$$\mathbf{Z} = (2.798 - j16.403) \Omega$$

2. For the following circuit, calculate Z_T and V_{ab} .

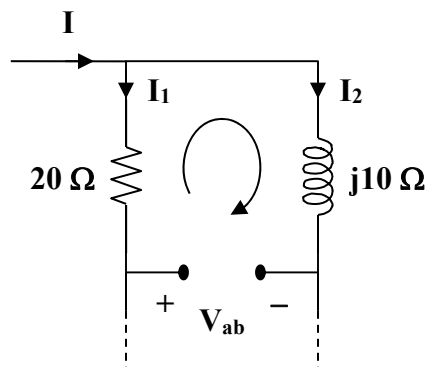


Solution

$$Z_T = (20 - j5) \parallel (40 + j10) = \frac{(20 - j5)(40 + j10)}{60 + j5} = \frac{170}{145}(12 - j)$$

$$Z_T = 14.069 - j1.172 \, \Omega = 14.118 \angle -4.76^\circ$$

$$I = \frac{V}{Z_T} = \frac{60 \angle 90^\circ}{14.118 \angle -4.76^\circ} = 4.25 \angle 94.76^\circ$$



$$I_1 = \frac{40 + j10}{60 + j5} I = \frac{8 + j2}{12 + j} I$$

$$I_2 = \frac{20 - j5}{60 + j5} I = \frac{4 - j}{12 + j} I$$

$$V_{ab} = -20I_1 + j10I_2$$

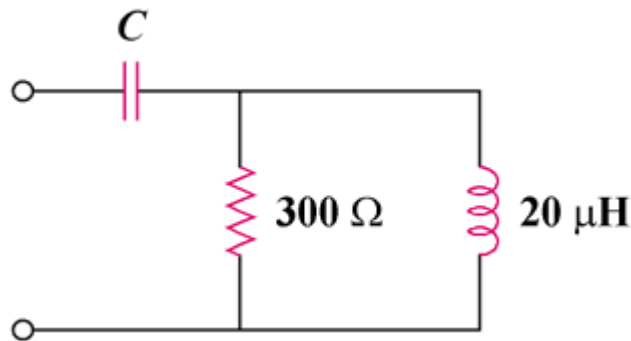
$$V_{ab} = \frac{-(160 + j40)}{12 + j} I + \frac{10 + j40}{12 + j} I$$

$$V_{ab} = \frac{-150}{12 + j} I = \frac{(-12 + j)(150)}{145} I$$

$$V_{ab} = (12.457 \angle 175.24^\circ)(4.25 \angle 97.76^\circ)$$

$$V_{ab} = 52.94 \angle 273^\circ \text{ V } (52.94 \angle 270^\circ \text{ V is more accurate})$$

3. The following figure shows a parallel combination of an inductance and a resistance. If it is desired to connect a capacitor in series with the parallel combination such that the net impedance is resistive at 10 MHz, what is the required value of C ?



Solution

$$\begin{aligned} Z_{in} &= \frac{1}{j\omega C} + R \parallel j\omega L \\ Z_{in} &= \frac{-j}{\omega C} + \frac{j\omega LR}{R + j\omega L} \\ &= \frac{-j}{\omega C} + \frac{\omega^2 L^2 R + j\omega LR^2}{R^2 + \omega^2 L^2} \end{aligned}$$

To have a resistive impedance, $\text{Im}(Z_{in}) = 0$.

Hence,

$$\begin{aligned} \frac{-1}{\omega C} + \frac{\omega LR^2}{R^2 + \omega^2 L^2} &= 0 \\ \frac{1}{\omega C} &= \frac{\omega LR^2}{R^2 + \omega^2 L^2} \\ C &= \frac{R^2 + \omega^2 L^2}{\omega^2 LR^2} \end{aligned}$$

where $\omega = 2\pi f = 2\pi \times 10^7$

$$C = \frac{9 \times 10^4 + (4\pi^2 \times 10^{14})(400 \times 10^{-12})}{(4\pi^2 \times 10^{14})(20 \times 10^{-6})(9 \times 10^4)}$$

$$C = \frac{9 + 16\pi^2}{72\pi^2} \text{ nF}$$

$$C = \mathbf{235 \text{ pF}}$$