Chapter 17

1. a. $\mathbf{Z}_T = j4\ \Omega + \dfrac{(8\ \Omega\ \angle -90°)(12\ \Omega\ \angle 0°)}{-j8\ \Omega + 12\ \Omega} = \mathbf{3.69\ \Omega - \mathit{j}1.54\Omega \cong 4\Omega\ \angle -22.65°}$

b. $\mathbf{I}_s = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{14\ \text{V} \angle 0°}{4\ \Omega \angle -22.65°} = \mathbf{3.5\ A\ \angle 22.65°}$

c. $\mathbf{I}_1 = \mathbf{3.5\ A\ \angle 22.65°}$

d. $\mathbf{I}_2 = \dfrac{(8\ \Omega \angle -90°)(3.5\ \text{A}\ \angle 22.65°)}{12\ \Omega - j8\ \Omega} = \mathbf{1.94\ A\ \angle -33.66°}$

e. $\mathbf{V}_L = \mathbf{I}_s\, \mathbf{X}_L = (3.5\ \text{A} \angle 22.65°)(4\ \Omega \angle 90°) = \mathbf{14\ V\ \angle 112.65°}$

2. a. $\mathbf{Z}_T = 3\ \Omega + j6\ \Omega + 2\ \Omega \angle 0° \parallel 8\ \Omega \angle -90°$
$= 3\ \Omega + j6\ \Omega + 1.94\ \Omega \angle -14.04°$
$= 3\ \Omega + j6\ \Omega + 1.88\ \Omega - j0.47\ \Omega$
$= 4.88\ \Omega + j5.53\ \Omega = \mathbf{7.38\ \Omega\ \angle 48.57°}$

b. $\mathbf{I}_s = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{30\ \text{V} \angle 0°}{7.38\ \Omega \angle 48.57°} = \mathbf{4.07\ A\ \angle -48.57°}$

c. $\mathbf{I}_C = \dfrac{\mathbf{Z}_{R_2} \mathbf{I}_S}{\mathbf{Z}_{R_2} + \mathbf{Z}_C} = \dfrac{(2\ \Omega \angle 0°)(4.07\ \text{A}\ \angle -48.57°)}{2\ \Omega - j8\ \Omega}$
$= \dfrac{8.14\ \text{A} \angle -48.57°}{8.25 \angle -75.96°} = \mathbf{0.987\ A\ \angle 27.39°}$

d. $\mathbf{V}_L = \dfrac{\mathbf{Z}_L \mathbf{E}}{\mathbf{Z}_T} = \dfrac{(6\ \Omega\ \angle\ 90°)(30\ \text{V} \angle 0°)}{7.38\ \Omega \angle 48.57°} = \dfrac{180\ \text{V} \angle 90°}{7.38\ \Omega \angle 48.57°}$
$= \mathbf{24.39\ V\ \angle 41.43°}$

3. a. $\mathbf{Z}_T = 12\ \Omega \angle 90° \parallel (9.1\ \Omega - j12\ \Omega) = 12\ \Omega \angle 90° \parallel 15.06\ \Omega \angle -52.826°$
$= \dfrac{180.72\ \Omega \angle 37.17°}{9.10 \angle 0°}$
$= \mathbf{19.86\ \Omega\ \angle 37.17°}$

b. $\mathbf{I}_s = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{60\ \text{V} \angle 0°}{19.86\ \Omega\ \angle 37.17°} = \mathbf{3.02\ A\ \ \angle -37.17°}$

c. (CDR) $\mathbf{I}_2 = \dfrac{(12\ \Omega \angle 90°)(3.02\ \text{A} \angle -37.17°)}{j12\ \Omega + 9.1\ \Omega - j12\Omega} = \dfrac{36.24\ \text{A} \angle 52.83°}{9.1 \angle 0°}$
$= \mathbf{3.98\ A\ \angle 52.83°}$

d. (VDR) $\mathbf{V}_C = \dfrac{(12\ \Omega \angle -90°)(60\ \text{V} \angle 0°)}{9.1\ \Omega - j12\ \Omega} = \dfrac{720\ \text{V} \angle -90°}{15.06 \angle -52.826°}$

$= \mathbf{47.81\ V \angle -37.17°}$

e. $P = EI\cos\theta = (60\ \text{V})(3.02\ \text{A})\cos(37.17°)$

$= 181.20(0.797) = \mathbf{144.42\ W}$

4. a. $\mathbf{Z}_T = 2\ \text{k}\Omega \angle 0° + \dfrac{(4\ \text{k}\Omega \angle -90°)(6\ \text{k}\Omega \angle 90°)}{-j4\ \text{k}\Omega + j6\ \text{k}\Omega} + \underbrace{\dfrac{\left(\dfrac{6.8\ \text{k}\Omega}{2}\angle 0°\right)(8\ \text{k}\Omega \angle 90°)}{\dfrac{6.8\ \text{k}\Omega}{2} + j8\ \text{k}\Omega}}_{\mathbf{Z}_T'}$

$= 2\ \text{k}\Omega + \dfrac{24\ \text{k}\Omega \angle 0°}{2 \angle 90°} + \dfrac{27.2\ \text{k}\Omega \angle 90°}{\underbrace{3.4\ \text{k}\Omega + j8\ \text{k}\Omega}_{8.69\ \text{k}\Omega \angle 66.97°}}$

$= 2\ \text{k}\Omega + j12\ \text{k}\Omega + \underbrace{3.13\ \text{k}\Omega \angle 23.03°}_{2.88\ \text{k}\Omega + j1.22\ \text{k}\Omega}$

$= 2\ \text{k}\Omega + 7.88\ \text{k}\Omega - j12\ \text{k}\Omega + j1.22\ \text{k}\Omega$

$\mathbf{Z}_T = \mathbf{4.88\ k\Omega - \mathit{j}10.78\ k\Omega = 11.83\ k\Omega \angle -65.64°}$

b. $\mathbf{V}_2 = \dfrac{\mathbf{Z}_T'\mathbf{E}}{\mathbf{Z}_T} = \dfrac{(3.13\ \text{k}\Omega \angle 23.03°)(240\ \text{V} \angle 60°)}{11.83\ \text{k}\Omega \angle -65.64°} = \mathbf{63\ V \angle 148.67°}$

$\mathbf{I}_L = \dfrac{\mathbf{V}_2}{\mathbf{X}_{L_2}} = \dfrac{63\ \text{V} \angle 148.67°}{8\ \text{k}\Omega \angle 90°} = \mathbf{7.88\ mA \angle 58.67°}$

c. $F_p = \dfrac{R}{Z_T} = \dfrac{4.88\ \text{k}\Omega}{11.83\ \text{k}\Omega} = \mathbf{0.413\ (leading)}$

5. a. $400\ \Omega \angle -90° \parallel 400\ \Omega \angle -90° = \dfrac{400\ \Omega \angle -90°}{2} = 200\ \Omega \angle -90°$

$\mathbf{Z}' = 100\ \Omega - j200\ \Omega = 223.61\ \Omega \angle -63.43°$

$\mathbf{Z}'' = -j200\ \Omega + j600\ \Omega = +j400\ \Omega = 400\ \Omega \angle 90°$

$\mathbf{Z}_T = \mathbf{Z}' \parallel \mathbf{Z}'' = \dfrac{(223.61\ \Omega \angle -63.43°)(400\ \Omega \angle 90°)}{(100\ \Omega - j200\ \Omega) + j400\ \Omega} = \dfrac{89{,}444.00\ \Omega \angle 26.57°}{223.61 \angle 63.43°}$

$= 400\ \Omega \angle -36.86°$

$\mathbf{I} = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{100\ \text{V} \angle 0°}{400\ \Omega \angle -36.86°} = \mathbf{0.25\ A \angle 36.86°}$

b. $\mathbf{V}_C = \dfrac{(200\ \Omega \angle -90°)(100\ \Omega \angle 0°)}{100\ \Omega - j200\ \Omega} = \dfrac{20{,}000\ \text{V} \angle -90°}{223.61 \angle -63.43°} = \mathbf{89.44\ V \angle -26.57°}$

c. $P = EI\cos\theta = (100\ \text{V})(0.25\ \text{A})\cos 36.86°$

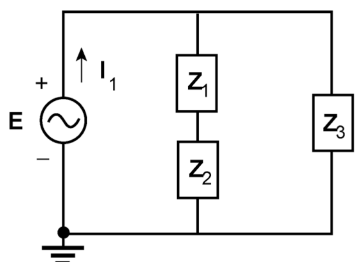
$= (25)(0.8) = \mathbf{20\ W}$

6. a. $\mathbf{I}_L = \dfrac{\mathbf{Z}_2\mathbf{I}}{\mathbf{Z}_1 + \mathbf{Z}_2} = \dfrac{(6 \angle -90^\circ)(2\text{ A} \angle 30^\circ)}{(3\ \Omega + j4\ \Omega) + (-j6\ \Omega)} = \dfrac{12\text{ A} \angle -60^\circ}{3.61 \angle -33.69^\circ} = \mathbf{3.32\ A \angle -26.31^\circ}$

b. $\mathbf{Z}_T = \mathbf{Z}_1 \parallel \mathbf{Z}_2 = (5\ \Omega \angle 53.13^\circ) \parallel (6\ \Omega \angle -90^\circ) = 8.31\ \Omega \angle -3.2^\circ$
$\mathbf{E}_T = \mathbf{I}\mathbf{Z}_T = (2\text{ A} \angle 30^\circ)(8.31\ \Omega \angle -3.2^\circ) = 16.62\text{ V} \angle 26.8^\circ$
$\mathbf{V}_C = \dfrac{(X_C \angle -90^\circ)(\mathbf{E}_T)}{X_C \angle -90^\circ + X_{L_2} \angle 90^\circ} = \dfrac{(13\ \Omega \angle -90^\circ)(16.62\text{ V} \angle 26.8^\circ)}{-j13\ \Omega + j7\ \Omega} = \mathbf{36\ V \angle 26.8^\circ}$

c. $\mathbf{V}_{ab} = \mathbf{V}_{R_1} - \mathbf{V}_C = (\mathbf{I}_L)(3\ \Omega \angle 0^\circ) - 36\text{ V} \angle 26.8^\circ$
$= (3.32\text{ A} \angle -26.31^\circ)(3\ \Omega \angle 0^\circ) - 36\text{ V} \angle 26.8^\circ = 9.96\text{ V} \angle -26.31^\circ - 36\text{ V} \angle 26.8^\circ$
$= \mathbf{31.05\ V \angle -138.34^\circ}$

7. a.



$\mathbf{Z}_1 = 10\ \Omega \angle 0^\circ$
$\mathbf{Z}_2 = 80\ \Omega \angle 90^\circ \parallel 20\ \Omega \angle 0^\circ$
$= \dfrac{1600\ \Omega \angle 90^\circ}{20 + j80} = \dfrac{1600\ \Omega \angle 90^\circ}{82.462 \angle 75.964^\circ}$
$= 19.403\ \Omega \angle 14.036^\circ$
$\mathbf{Z}_3 = 60\ \Omega \angle -90^\circ$

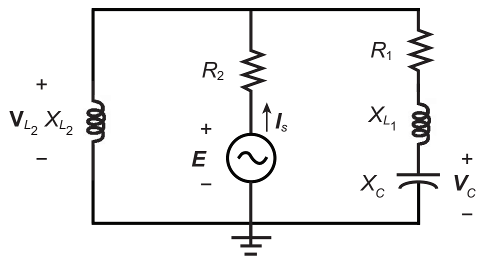
$\mathbf{Z}_T = (\mathbf{Z}_1 + \mathbf{Z}_2) \parallel \mathbf{Z}_3$
$= (10\ \Omega + 18.824\ \Omega + j4.706\ \Omega) \parallel 60\ \Omega \angle -90^\circ$
$= 29.206\ \Omega \angle 9.273^\circ \parallel 6\ \Omega \angle -90^\circ = \dfrac{1752.36\ \Omega \angle -80.727^\circ}{28.824 + j4.706 - j60}$
$= \dfrac{1752.36\ \Omega \angle -80.727^\circ}{62.356 \angle -62.468^\circ} = \mathbf{28.103\ \Omega \angle -18.259^\circ}$
$\mathbf{I}_1 = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{40\text{ V} \angle 0^\circ}{28.103\ \Omega \angle -18.259^\circ} = \mathbf{1.42\ A \angle 18.26^\circ}$

b. $\mathbf{V}_1 = \dfrac{\mathbf{Z}_2\mathbf{E}}{\mathbf{Z}_2 + \mathbf{Z}_1} = \dfrac{(19.403\ \Omega \angle 14.036^\circ)(40\text{ V} \angle 0^\circ)}{29.206\ \Omega \angle 9.273^\circ} = \dfrac{776.12\text{ V} \angle 14.036^\circ}{29.206 \angle 9.273^\circ}$
$= \mathbf{26.57\ V \angle 4.76^\circ}$

c. $P = EI \cos \theta = (40\text{ V})(1.423\text{ A})\cos 18.259^\circ$
$= \mathbf{54.07\ W}$

8. **!! $R_2 = 1\ \text{k}\Omega$**

a.



$$X_{L_1} = 2\pi fL_1 = 2\pi(5\text{ kHz})(68\text{ mH}) = 2.14\text{ k}\Omega$$
$$X_{L_2} = 2\pi fL_2 = 2\pi(5\text{ kHz})(100\text{ mH}) = 3.14\text{ k}\Omega$$
$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(5\text{ kHz})(3\text{ nF})} = 10.61\text{ k}\Omega$$

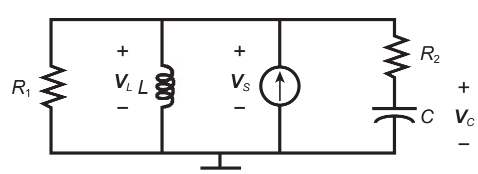
$$\mathbf{Z}_T = \mathbf{R}_2 + \mathbf{X}_{L_2} \parallel (\mathbf{R}_1 + \mathbf{X}_{L_1} + \mathbf{X}_C)$$
$$= 1\text{ k}\Omega + (3.14\text{ k}\Omega\ \angle 90°) \parallel \underbrace{\underbrace{(6.8\text{ k}\Omega + j2.14\text{ k}\Omega - j10.61\text{ k}\Omega)}_{6.8\text{ k}\Omega - j8.47\text{ k}\Omega}}_{10.86\text{ k}\Omega\ \angle -51.24°}$$

$$= 1\text{ k}\Omega + (3.14\text{ k}\Omega\ \angle 90°) \parallel (10.86\text{ k}\Omega\ \angle{-51.24°})$$
$$= 1\text{ k}\Omega + \frac{(3.14\text{ k}\Omega\ \angle 90°)(10.86\text{ k}\Omega\ \angle -51.24°)}{+j3.14\text{ k}\Omega + 6.8\text{ k}\Omega - j8.47\text{ k}\Omega}$$
$$= 1\text{ k}\Omega + \frac{34.10\text{ k}\Omega\ \angle 38.76°}{6.8 - j5.33} = 1\text{ k}\Omega + \frac{34.10\text{ k}\Omega\ \angle 38.76°}{8.64\ \angle -38°}$$
$$= 1\text{ k}\Omega + 3.95\text{ k}\Omega\ \angle 76.76°$$
$$= 1\text{ k}\Omega + 0.904\text{ k}\Omega + j3.85\text{ k}\Omega$$
$$= 1.904\text{ k}\Omega + j3.85\text{ k}\Omega$$
$$\mathbf{Z}_T = 4.3\text{ k}\Omega\ \angle 63.69°$$
$$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{10\text{ V}\ \angle 0°}{4.3\text{ k}\Omega\ \angle 63.69°} = \mathbf{2.33\ mA\ \angle{-63.69°}}$$

b.
$$\mathbf{I}_C = \frac{\mathbf{X}_{L_2}\mathbf{I}_s}{\mathbf{X}_{L_2} + (\mathbf{R}_1 + \mathbf{X}_{L_1} + \mathbf{X}_C)} = \frac{(3.14\text{ k}\Omega\ \angle 90°)(2.33\text{ mA}\ \angle -63.69°)}{+j3.14\text{ k}\Omega + 6.8\text{ k}\Omega - j8.47\text{ k}\Omega}$$
$$= \frac{7.32\text{ mA}\ \angle 26.3°}{6.8 - j5.33} = \frac{7.32\text{ mA}\ \angle 26.3°}{8.64\ \angle -38.1°} = 0.847\text{ mA}\ \angle 64.4°$$
$$\mathbf{V}_C = \mathbf{I}_C\mathbf{X}_C = (0.847\text{ mA}\ \angle 64.4°)(10.61\text{ k}\Omega\ \angle{-90°})$$
$$= \mathbf{8.99\ V\ \angle{-25.60°}}$$

c.
$$\mathbf{V}_{L_2} = \mathbf{E} - \mathbf{I}_s\mathbf{R}_2 = 10\text{ V}\ \angle 0° - (2.33\text{ mA}\ \angle{-63.69°})(1\text{ k}\Omega\ \angle 0°)$$
$$= 10\text{ V} - 2.33\text{ V}\ \angle{-63.69°} = 10\text{ V} - (1.03\text{ V} - j2.09\text{ V})$$
$$= 8.97\text{ V} + j2.09\text{ V}$$
$$= \mathbf{9.21\ V\ \angle 13.12°}$$

9. a.



$X_L = 2\pi fL = 2\pi(10\text{ kHz})(47\text{ mH}) = 2.95\text{ k}\Omega$

$X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(10\text{ kHz})(0.01\ \mu\text{F})} = 1.59\text{ k}\Omega$

$\dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{\mathbf{R}_1} + \dfrac{1}{\mathbf{X}_L} + \dfrac{1}{\mathbf{R}_2 + \mathbf{X}_C}$

$\dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{4.7\text{ k}\Omega} + \dfrac{1}{2.95\text{ k}\Omega\angle 90°} + \dfrac{1}{1.8\text{ k}\Omega - j1.59\text{ k}\Omega}$

$= 212.77\ \mu\text{S}\ \angle 0° + 338.98\ \mu\text{S}\ \angle{-90°} + \dfrac{1}{2.40\text{ k}\Omega\angle -41.46°}$

$= 212.77\ \mu\text{S} - j338.98\ \mu\text{S} + 312.26\ \mu\text{S} + j275.88\ \mu\text{S}$

$= 525.03\ \mu\text{S} - j63.1\ \mu\text{S}$

$= 528.81\ \mu\text{S}\ \angle{-6.85°}$

and $\mathbf{Z}_T = \dfrac{1}{528.81\ \mu\text{S}\angle -6.85°} = 1.89\text{ k}\Omega\ \angle 6.85°$

$\mathbf{V}_s = (\mathbf{I})(\mathbf{Z}_T) = (8\text{ mA}\ \angle 0°)(1.89\text{ k}\Omega\ \angle 6.85°)$

$= \mathbf{15.12\ V\ \angle 6.85°}$

b. $\mathbf{V}_C = \dfrac{\mathbf{X}_C\mathbf{V}_s}{\mathbf{R} + \mathbf{X}_C} = \dfrac{(1.59\text{ k}\Omega\angle -90°)(15.12\text{ V}\angle 6.85°)}{1.8\text{ k}\Omega - j1.59\text{ k}\Omega}$

$= \dfrac{24\text{ V}\angle -83.15°}{2.40\angle -41.46°} = \mathbf{10\ V\ \angle{-41.69°}}$

c. $\mathbf{V}_L = \mathbf{V}_s = \mathbf{15.12\ V\ \angle 6.85°)}$

10. a. $\mathbf{Z}_T = 1.2\text{ k}\Omega + \dfrac{(1.2\text{ k}\Omega\angle 0°)(1.8\text{ k}\Omega\angle -90°)}{1.2\text{ k}\Omega - j1.8\text{ k}\Omega} + \dfrac{2.4\text{ k}\Omega\angle 90°}{2}$

$= 1.2\text{ k}\Omega + \dfrac{2.16\text{ k}\Omega\angle -90°}{2.16\angle -56.31°} + 1.2\text{ k}\Omega\ \angle 90°$

$= 1.2\text{ k}\Omega + 1\text{ k}\Omega\ \angle{-33.69°} + j1.2\text{ k}\Omega$

$= 1.2\text{ k}\Omega + 832.05\ \Omega - j554.70\ \Omega + j1.2\text{ k}\Omega$

$= \mathbf{2.03\ k\Omega + \mathit{j}645.30\ \Omega = 2.13\ k\Omega\ \angle 17.63°}$

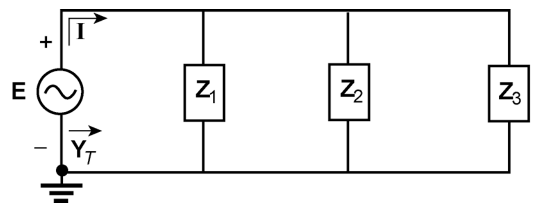
b. $\mathbf{V}_1 = \mathbf{IR}_1 = (20\text{ mA}\ \angle 0°)(1.2\text{ k}\Omega\ \angle 0°) = \mathbf{24\ V\angle 0°}$

c. $\mathbf{I}_1 = \dfrac{(1.2\text{ k}\Omega\angle 0°)(20\text{ mA}\ \angle 0°)}{1.2\text{ k}\Omega - j1.8\text{ k}\Omega} = \dfrac{2.4\text{ A}\angle 0°}{2.16\times 10^3\angle -56.31°} = \mathbf{11.11\ mA\ \angle 56.31°}$

d. $\mathbf{V}_2 = \mathbf{I(X}_{L_1} \parallel \mathbf{X}_{L_2}\mathbf{)} = (20\text{ mA}\ \angle 0°)\left(\dfrac{(2.4\text{ k}\Omega)}{2}\angle 90°\right) = \mathbf{24\ V\ \angle 90°}$

e. $\mathbf{V}_s = \mathbf{IZ}_T = (20\text{ mA}\ \angle 0°)(2.13\text{ k}\Omega\ \angle 17.63°) = \mathbf{42.60\ V\ \angle 17.63°}$

11. a.



$\mathbf{Z}_1 = 2\ \Omega - j2\ \Omega = 2.828\ \Omega \angle -45°$
$\mathbf{Z}_2 = 3\ \Omega - j9\ \Omega + j6\ \Omega$
$= 3\ \Omega - j3\ \Omega = 4.243\ \Omega \angle -45°$
$\mathbf{Z}_3 = 10\ \Omega \angle 0°$

$$\mathbf{Y}_T = \frac{1}{\mathbf{Z}_1} + \frac{1}{\mathbf{Z}_2} + \frac{1}{\mathbf{Z}_3} = \frac{1}{2.828\ \Omega \angle -45°} + \frac{1}{4.243\ \Omega \angle -45°} + \frac{1}{10\ \Omega \angle 0°}$$
$$= 0.354\ \text{S} \angle 45° + 0.236\ \text{S} \angle 45° + 0.1\ \text{S} \angle 0° = 0.59\ \text{S} \angle 45° + 0.1\ \text{S} \angle 0°$$
$$= 0.417\ \text{S} + j0.417\ \text{S} + 0.1\ \text{S}$$

$\mathbf{Y}_T = 0.517\ \text{S} + j\,0.417\ \text{S} = \mathbf{0.66\ S \angle 38.89°}$

$$\mathbf{Z}_T = \frac{1}{\mathbf{Y}_T} = \frac{1}{0.66\ \text{S} \angle 38.89°} = \mathbf{1.52\ \Omega \angle -38.89°}$$

b. $$\mathbf{V}_1 = \frac{(2\ \Omega \angle 0°)(60\ \text{V} \angle 0°)}{2\ \text{k}\Omega - j2\ \Omega} = \frac{120\ \text{V} \angle 0°}{2.828 \angle -45°} = \mathbf{42.43\ V \angle 45°}$$

c. $$\mathbf{I}_1 = \frac{\mathbf{E}}{\mathbf{Z}'} = \frac{60\ \text{V} \angle 0°}{3\ \Omega - j9\ \Omega + j6\ \Omega} = \frac{60\ \text{V} \angle 0°}{3\ \Omega - j3\ \Omega} = \frac{60\ \text{V} \angle 0°}{4.243 \angle -45°}$$
$$= \mathbf{14.14\ A \angle 45°}$$

d. $$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{60\ \text{V} \angle 0°}{1.52\ \Omega \angle -38.89°} = \mathbf{39.47\ A \angle 38.89°}$$

12. $\mathbf{Z}' = 12\ \Omega - j20\ \Omega = 23.32\ \Omega \angle -59.04°$
$R_4 \angle 0° \parallel \mathbf{Z}' = 20\ \Omega \angle 0° \parallel 23.32\ \Omega \angle -59.04° = 12.36\ \Omega \angle -27.03°$
$\mathbf{Z}'' = R_3 \angle 0° + R_4 \angle 0° \parallel \mathbf{Z}' = 12\ \Omega + 12.36\ \Omega \angle -27.03°$
$= 12\ \Omega + (11.01\ \Omega - j5.62\ \Omega)$
$= 23.01\ \Omega - j5.62\ \Omega = 23.69\ \Omega \angle -13.73°$
$R_2 \angle 0° \parallel \mathbf{Z}'' = 20\ \Omega \angle 0° \parallel 23.69\ \Omega \angle -13.73° = 10.92\ \Omega \angle -6.29°$
$\mathbf{Z}_T = R_1 \angle 0° + R_2 \angle 0° \parallel \mathbf{Z}'' = 12\ \Omega + 10.92\ \Omega \angle -6.29°$
$= 12\ \Omega + (10.85\ \Omega - j1.25\ \Omega)$
$= 22.85\ \Omega - j1.2\ \Omega = \mathbf{22.88\ \Omega \angle -3.01°}$

$$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{100\ \text{V} \angle 0°}{22.88\ \Omega \angle -3.01°} = \mathbf{4.37\ A \angle +3.01°}$$

$\mathbf{I}_{R_1} = \mathbf{I}$

$$\mathbf{I}_{R_3} = \frac{(R_2 \angle 0°)\,\mathbf{I}_s}{R_2 \angle 0° + \mathbf{Z}''} = \frac{(20\ \Omega \angle 0°)(4.37\ \text{A} \angle 3.01°)}{20\ \Omega + 23.01\ \Omega - j5.62\ \Omega} = \frac{87.40\ \text{A} \angle 3.01°}{43.38 \angle -7.44°}$$
$$= \mathbf{2.01\ A \angle 10.45°}$$

$$\mathbf{I}_4 = \frac{(R_4 \angle 0°)\,\mathbf{I}_{R_3}}{R_4 \angle 0° + \mathbf{Z}'} = \frac{(20\ \Omega \angle 0°)(2.01\ \text{A} \angle 10.45°)}{20\ \Omega + 12\ \Omega - j20\ \Omega} = \frac{40.20\ \text{A} \angle 10.45°}{32\ \Omega - j20\ \Omega} = \frac{40.20\ \text{A} \angle 10.45°}{37.74 \angle -32.01°}$$
$$= \mathbf{1.07\ A \angle 42.46°}$$

13. $R_3 + R_4 = 2.7\text{ k}\Omega + 4.3\text{ k}\Omega = 7\text{ k}\Omega$
$R' = 3\text{ k}\Omega \parallel 7\text{ k}\Omega = 2.1\text{ k}\Omega$
$\mathbf{Z}' = 2.1\text{ k}\Omega - j10\ \Omega$

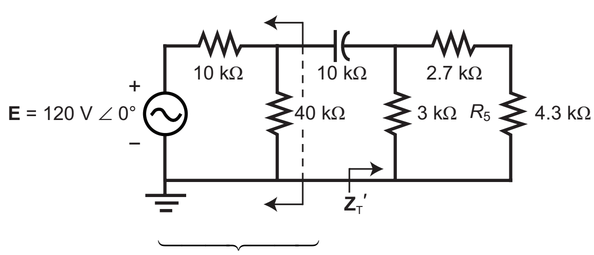
(CDR) $\mathbf{I}'\text{ (of 10 }\Omega\text{ cap.)} = \dfrac{(40\text{ k}\Omega \angle 0°)(20\text{ mA} \angle 0°)}{40\text{ k}\Omega + 2.1\text{ k}\Omega - j10\ \Omega}$
$= 19\text{ mA} \angle{+0.014°}$ as expected since $R_1 \gg \mathbf{Z}'$

(CDR) $\mathbf{I}_4 = \dfrac{(3\text{ k}\Omega \angle 0°)(19\text{ mA} \angle 0.014°)}{3\text{ k}\Omega + 7\text{ k}\Omega} = \dfrac{57\text{ mA} \angle 0.014°}{10}$
$= 5.7\text{ mA} \angle 0.014°$
$P = I^2R = (5.7\text{ mA})^2\ 4.3\text{ k}\Omega = \mathbf{139.71\ mW}$

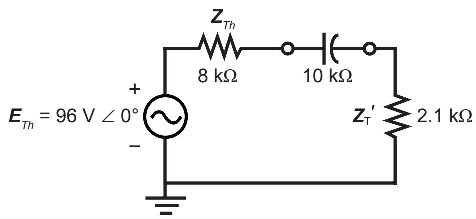
14. $\mathbf{Z}' = X_{C_2} \angle -90° \parallel R_1 \angle 0° = 2\ \Omega \angle -90° \parallel 1\ \Omega \angle 0°$
$= \dfrac{2\ \Omega \angle -90°}{1 - j2} = \dfrac{2\ \Omega \angle -90°}{2.236 \angle -63.435°}$
$= 0.894\ \Omega \angle -26.565°$
$\mathbf{Z}'' = X_{L_2} \angle 90° + \mathbf{Z}' = +j8\ \Omega + 0.894\ \Omega \angle -26.565°$
$= +j8\ \Omega + (0.8\ \Omega - j4\ \Omega)$
$= 0.8\ \Omega + j4 = 4.079\ \Omega \angle 78.69°$

$\mathbf{I}_{X_{L_2}} = \dfrac{(X_{C_1} \angle -90°)\mathbf{I}}{X_{C_1} \angle -90° + \mathbf{Z}''} = \dfrac{(2\ \Omega \angle -90°)(0.5\text{ A} \angle 0°)}{-j2\ \Omega + (0.8\ \Omega + j4\ \Omega)} = \dfrac{1\text{ A} \angle -90°}{0.8 + -j2}$
$= \dfrac{1\text{ A} \angle -90°}{2.154 \angle 68.199°} = 0.464\text{ A} \angle -158.99°$
$\mathbf{I}_1 = \dfrac{(X_{C_2} \angle -90°)\mathbf{I}_{X_{C_2}}}{X_{C_2} \angle -90° + R_1} = \dfrac{(2\ \Omega \angle -90°)(0.464\text{ A} \angle -158.99°)}{-j2\ \Omega + 1\ \Omega} = \dfrac{0.928\text{ A} \angle -248.99°}{2.236 \angle -63.435°}$
$= \mathbf{0.42\ A \angle 174.45°}$

15. a. **!! $X_C = 10\text{ k}\Omega$**



$\mathbf{E}_{\text{Th}} = \dfrac{(40\text{ k}\Omega \angle 0°)(120\text{ V} \angle 0°)}{40\text{ k}\Omega + 10\text{ k}\Omega} = 96\text{ V} \angle 0°$
$\mathbf{R}_{\text{Th}} = 10\text{ k}\Omega \parallel 40\text{ k}\Omega = 8\text{ k}\Omega$
$\mathbf{Z}_T' = 3\text{ k}\Omega \parallel (2.7\text{ k}\Omega + 4.3\text{ k}\Omega) = 3\text{ k}\Omega \parallel 7\text{ k}\Omega = 2.1\text{ k}\Omega$



$$\mathbf{I}_C = \mathbf{I}_s = \frac{\mathbf{E}_{Th}}{\mathbf{Z}_T} = \frac{96\text{ V}\angle 0°}{8\text{ k}\Omega + 2.1\text{ k}\Omega - j10\text{ k}\Omega} = \frac{96\text{ V}\angle 0°}{10.1\text{ k}\Omega - j10\text{ k}\Omega}$$

$$= \frac{96\text{ V}\angle 0°}{14.21\text{ k}\Omega\angle -44.72°} = 6.76\text{ mA }\angle 44.72°$$

$$\mathbf{I}_{R_5} = \frac{(3\text{ k}\Omega\angle 0°)(\mathbf{I}_C)}{3\text{ k}\Omega + 2.7\text{ k}\Omega + 4.3\text{ k}\Omega} = \frac{(3\text{ k}\Omega\angle 0°)(6.76\text{ mA}\angle 44.72°)}{10\text{ k}\Omega\angle 0°}$$

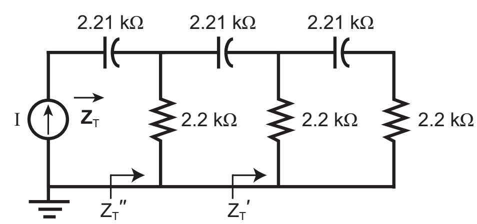
$$= \frac{20.28\text{ mA}\angle 44.72°}{10}$$

$$= 2.03\text{ mA }\angle 44.72°$$

$$P_{R_5} = I^2R = (2.03\text{ mA})^2 4.3\text{ k}\Omega$$

$$= \mathbf{17.72\text{ mW}}$$

16. a.



$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(40\text{ kHz})(1.8\text{ nF})} = 2.21\text{ k}\Omega$$

$$\mathbf{Z}_T' = (2.2\text{ k}\Omega\angle 0°) \parallel \underbrace{(2.2\text{ k}\Omega - j2.21\text{ k}\Omega)}_{3.12\text{ k}\Omega\angle -45.13°}$$

$$= \frac{6.86\text{ k}\Omega\angle -45.13°}{2.2 + 2.2 - j2.21} = \frac{6.86\text{ k}\Omega\angle -45.13°}{4.4 - j2.21}$$

$$= \frac{6.86\text{ k}\Omega\angle -45.13°}{4.92\angle -26.67°} = 1.36\text{ k}\Omega\angle -18.46°$$

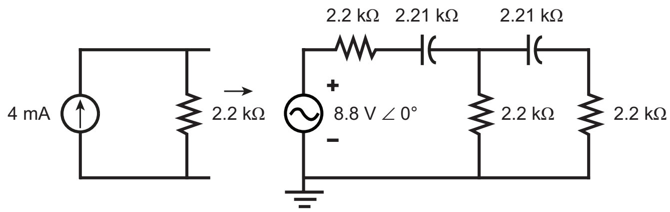
$$\mathbf{Z}_T'' = 2.2\text{ k}\Omega\angle 0° \parallel (2.21\text{ k}\Omega\angle -90° + 1.36\text{ k}\Omega\angle -18.46°)$$
$$= 2.2\text{ k}\Omega\angle 0° \parallel (-j2.21\text{ k}\Omega + 1.29\text{ k}\Omega - j0.43\text{ k}\Omega)$$
$$= 2.2\text{ k}\Omega\angle 0° \parallel \underbrace{(1.29\text{ k}\Omega - j2.64\text{ k}\Omega)}_{2.94\text{ k}\Omega\angle -63.96°}$$

$$= \frac{(2.2\text{ k}\Omega\angle 0°)(2.94\text{ k}\Omega\angle -63.96°)}{2.2\text{ k}\Omega + 1.29\text{ k}\Omega - j2.64\text{ k}\Omega}$$

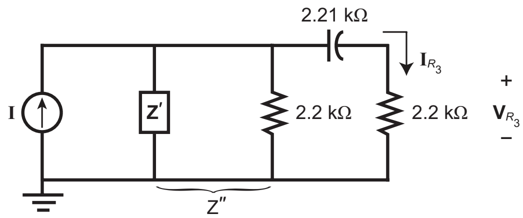
$$= \frac{6.47\text{ k}\Omega\angle -63.96°}{3.49 - j2.64} = \frac{6.47\text{ k}\Omega\angle -63.96°}{4.38\angle -37.11°}$$

$$\mathbf{Z}_T'' = 1.48\text{ k}\Omega\angle -26.85° = 1.32\text{ k}\Omega - j0.668\text{ k}\Omega$$
$$\mathbf{Z}_T = 2.21\text{ k}\Omega\angle -90° + \mathbf{Z}_T'' = -j2.21\text{ k}\Omega + 1.32\text{ k}\Omega - j0.668\text{ k}\Omega$$
$$= 1.32\text{ k}\Omega - j2.89\text{ k}\Omega = R - jX_C$$
$$= \mathbf{3.18\text{ k}\Omega\angle -65.45°}$$

b. Source conversion:



Second source conversion:



$$\left.\begin{aligned}\mathbf{Z}' &= 2.2\text{ k}\Omega - j2.21\text{ k}\Omega = 3.12\text{ k}\Omega\angle -45.13^\circ\\ \mathbf{I} &= \frac{8.8\text{ V}\angle 0^\circ}{3.12\text{ k}\Omega\angle -45.13^\circ} = 2.82\text{ mA}\angle 45.13^\circ\end{aligned}\right\}\text{source conversion}$$

$\mathbf{Z}_T'' = 2.2\text{ k}\Omega\angle 0^\circ \parallel 3.12\text{ k}\Omega\angle -45.13^\circ$

$$= \frac{(2.2\text{ k}\Omega\angle 0^\circ)(3.12\text{ k}\Omega\angle -45.13^\circ)}{2.2\text{ k}\Omega + 2.2\text{ k}\Omega - j2.21\text{ k}\Omega} = \frac{6.86\text{ k}\Omega\angle -45.13^\circ}{4.4 - j2.21}$$

$$= \frac{6.86\text{ k}\Omega\angle -45.13^\circ}{4.92\angle -26.67^\circ} = 1.39\text{ k}\Omega\angle -18.46^\circ = 1.32\text{ k}\Omega - j0.44\text{ k}\Omega$$

$$\mathbf{I}_{R_3} = \frac{(\mathbf{Z}'')(\mathbf{I})}{\mathbf{Z}'' + 2.2\text{ k}\Omega - j2.21\text{ k}\Omega} = \frac{(1.39\text{ k}\Omega\angle -18.46^\circ)(2.82\text{ mA}\angle 45.13^\circ)}{1.32\text{ k}\Omega - j0.44\text{ k}\Omega + 2.2\text{ k}\Omega - j2.21\text{ k}\Omega}$$

$$= \frac{3.92\text{ mA}\angle 26.67^\circ}{3.52 - j2.65} = \frac{3.92\text{ mA}\angle 26.67^\circ}{4.41\angle -36.97^\circ}$$

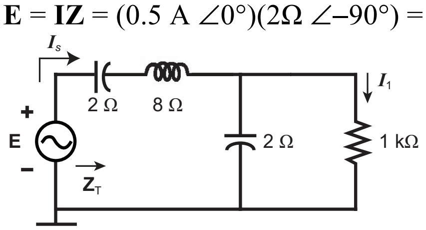
$= 0.89\text{ mA}\angle 63.64^\circ$

$\mathbf{V}_{R_3} = \mathbf{I}_{R_3}\mathbf{R}_3 = (0.89\text{ mA}\angle 63.64^\circ)(2.2\text{ k}\Omega\angle 0^\circ)$

$= \mathbf{1.96\text{ V}\angle 63.64^\circ}$

17. Source conversion:

$\mathbf{E} = \mathbf{IZ} = (0.5\text{ A}\angle 0^\circ)(2\Omega\angle -90^\circ) = 1\text{ V}\angle -90^\circ$



$\mathbf{Z}_T = -j2\ \Omega + j8\ \Omega + \underbrace{2\ \Omega\angle -90^\circ \parallel 1\ \Omega\angle 0^\circ}$

$$\frac{(2\ \Omega\angle -90^\circ)(1\ \Omega\angle 0^\circ)}{1 - j2} = \frac{2\ \Omega\angle -90^\circ}{2.24\angle -63.44^\circ}$$

$= -j2\ \Omega + j8\ \Omega + 0.89\ \Omega\angle -26.56^\circ$

$= +j6\ \Omega + 0.796\ \Omega - j0.398\ \Omega$

$= 0.796\ \Omega + j5.6\ \Omega$
$= 5.66\ \Omega\ \angle 81.91°$

$$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{1\text{ V}\angle -90°}{5.66\ \Omega\angle 81.91°} = 0.177\text{ A}\ \angle -171.91°$$

$$\mathbf{I}_1 = \frac{(2\angle -90°)(\mathbf{I}_s)}{(2\angle -90°) + 1\angle 0°} = \frac{(2\angle -90°)(0.177\text{ A}\angle -171.91°)}{1 - j2}$$

$$= \frac{354\text{ mA}\angle -261.91°}{2.24\angle -63.44°}$$

$= 158\text{ mA}\ \angle -198.47°$

$\mathbf{V}_1 = \mathbf{I}_1\mathbf{R}_1 = (158\text{ mA}\ \angle -198.47°)(1\ \Omega\ \angle 0°)$

$= \mathbf{158\ mV\ \angle -198.47°}$