Chapter 16

1. a. $\mathbf{Z}_T = R \parallel X_L = \dfrac{(1\text{ k}\Omega \angle 0°)(4\text{ k}\Omega \angle 90°)}{1\text{ k}\Omega + j4\text{ k}\Omega} = \mathbf{970.87\ \Omega \angle 14.04° = 941.87\ \Omega + j235.53\ \Omega}$

b. $$\frac{1}{\mathbf{Z}_T} = \frac{1}{\mathbf{X}_L} + \frac{1}{\mathbf{X}_C} + \frac{1}{\mathbf{R}} = \frac{1}{20\text{ k}\Omega \angle 90°} + \frac{1}{12\text{ k}\Omega \angle -90°} + \frac{1}{6\text{ k}\Omega \angle 0°}$$
$$= 50 \times 10^{-6} \angle -90° + 83.33 \times 10^{-6} \angle 90° + 166.67 \times 10^{-6} \angle 0°$$
$$= -j50 \times 10^{-6} + j83.33 \times 10^{-6} + 166.67 \times 10^{-6}$$
$$= 166.67 \times 10^{-6} + j33.33 \times 10^{-6}$$
$$= 169.97 \times 10^{-6} \angle 11.31°$$
$$\mathbf{Z}_T = \frac{1}{169.97 \times 10^{-6} \angle 11.31°} = \mathbf{5.88\ k\Omega \angle -11.31° = 5.77\ k\Omega - j1.15\ k\Omega}$$

c. 40 mH || 20 mH = 13.33 mH

$X_L = \omega L = 2\pi fL = 2\pi(10\text{ kHz})(13.33\text{ mH}) = 837.55\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC} = \frac{1}{2\pi\,(10\text{ kHz})(6\text{ nF})} = 2.65\text{ k}\Omega$$

$$\mathbf{Z}_T = \mathbf{X}_L \parallel \mathbf{X}_C = \frac{(837.55\ \Omega \angle 90°)(2.65\text{ k}\Omega \angle -90°)}{j837.55\ \Omega - j2.65\text{ k}\Omega}$$
$$= \mathbf{1.23\ k\Omega \angle 90° = j1.23\ k\Omega}$$

2. a. $$\frac{1}{\mathbf{Z}_T} = \frac{1}{\mathbf{X}_L} + \frac{1}{\mathbf{X}_C} + \frac{1}{\mathbf{R}} = \frac{1}{8\ \Omega \angle 90°} + \frac{1}{4\ \Omega \angle -90°} + \frac{1}{12\ \Omega \angle 0°}$$
$$= 0.125 \angle -90° + 0.25 \angle 90° + 0.083 \angle 0°$$
$$= -j0.125 + j0.25 + 0.083$$
$$= 0.083 + j0.125 = 150.05 \times 10^{-3} \angle 56.416°$$
$$\mathbf{Z}_T = \frac{1}{150.05 \times 10^{-3} \angle 56.416°} = \mathbf{6.66\ \Omega \angle -56.42° = 3.68\ \Omega - j5.55\ \Omega}$$

b. $\mathbf{Z}_T = \mathbf{-j4\ k\Omega = 4\ k\Omega \angle -90°}$

c. $$\frac{1}{\mathbf{Z}_T} = \frac{1}{\mathbf{R}_1} + \frac{1}{\mathbf{X}_L} + \frac{1}{\mathbf{X}_C} + \frac{1}{\mathbf{R}_2} = \frac{1}{1.2\text{ k}\Omega \angle 0°} + \frac{1}{3.2\text{ k}\Omega \angle 90°} + \frac{1}{4.6\text{ k}\Omega \angle -90°} + \frac{1}{3.6\text{ k}\Omega \angle 0°}$$
$$= 833.33 \times 10^{-6} \angle 0° + 312.5 \times 10^{-6} \angle -90° + 217.39 \times 10^{-6} \angle 90° + 277.78 \times 10^{-6} \angle 0°$$
$$= 1.111 \times 10^{-3} - j312.5 \times 10^{-6} + j217.39 \times 10^{-6}$$
$$= 1.111 \times 10^{-3} - j95.11 \times 10^{-6} = 1.115 \times 10^{-3} \angle -4.89°$$
$$\mathbf{Z}_T = \frac{1}{1.115 \times 10^{-3} \angle -4.89°} = \mathbf{896.86\ \Omega \angle 4.89° = 893.6\ \Omega + j76.45\ \Omega}$$

3. I. $\mathbf{Y}_T = \dfrac{1}{R} \angle 0° = \dfrac{1}{6.8\ \Omega} \angle 0° = \mathbf{147.06\ mS \angle 0° = 147.06\ mS}$

II. $\mathbf{Y}_T = \dfrac{1}{X_L \angle 90°} = \dfrac{1}{2\text{ k}\Omega} \angle -90° = \mathbf{5\ mS \angle -90° = -j5\ mS}$

III. $\mathbf{Y}_T = \dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{X_C \angle -90°} = \dfrac{1}{2\ \text{k}\Omega} = \angle 90° = \mathbf{500\ \mu S \angle 90°} = \mathbf{\mathit{j}500\ \mu S}$

4. I. a. $\mathbf{Z}_T = \dfrac{(10\ \Omega \angle 0°)(60\ \Omega \angle 90°)}{10\ \Omega + j60\ \Omega} = \mathbf{9.86\ \Omega \angle 9.46°}$

b. $\mathbf{Y}_T = \dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{9.86\ \Omega \angle 9.46°} = \mathbf{0.10\ S \angle -9.46°}$

c. $0.10\ \text{S} \angle -9.46° = 0.1\ \text{S} - j0.02\ \text{S} = G - jB_L$
$G = \mathbf{0.1\ S}$
$B_L = \mathbf{0.02\ S}$

d. –

II. a. $22\ \Omega \parallel 2.2\ \Omega = 2\ \Omega$
$\mathbf{Z}_T = \dfrac{(2\ \Omega \angle 0°)(6\ \Omega \angle -90°)}{2\ \Omega - j6\ \Omega} = \dfrac{12\ \Omega \angle -90°}{6.32\ \Omega \angle -71.57°} = \mathbf{1.90\ \Omega \angle -18.43°}$

b. $\mathbf{Y}_T = \dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{1.90\ \Omega \angle -18.43°} = \mathbf{0.53\ S \angle 18.43°}$

c. $0.53\ \text{S} \angle 18.43° = 0.5\ \text{S} - j0.17\ \text{S} = G + jB_C$
$G = \mathbf{0.5\ S}$
$B_C = \mathbf{0.17\ S}$

III. a. $\dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{3\ \text{k}\Omega \angle 0°} + \dfrac{1}{6\ \text{k}\Omega \angle 90°} + \dfrac{1}{9\ \text{k}\Omega \angle -90°}$
$= 0.333 \times 10^{-3} \angle 0° + 0.167 \times 10^{-3} \angle -90° + 0.111 \times 10^{-3} \angle 90°$
$= 0.333 \times 10^{-3} - j0.056 \times 10^{-3}$
$= 0.34 \times 10^{-3} \angle -9.55°$
$\mathbf{Z}_T = \dfrac{1}{0.34 \times 10^{-3} \angle -9.55°} = \mathbf{2.94\ k\Omega \angle 9.55°}$

b. $\mathbf{Y}_T = \dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{2.94\ \text{k}\Omega \angle 9.55°} = \mathbf{0.34\ mS \angle -9.55°}$

c. $0.34\ \text{mS} \angle -9.55° = 0.333 \times 10^{-3}\ \text{S} - j0.056 \times 10^{-3}\ \text{S} = G - jB_L$
$G = \mathbf{0.333\ mS}$
$B_L = \mathbf{0.056\ mS}$

5. I. a. $\mathbf{Z}_T = 4.7\ \Omega + j8\ \Omega = \mathbf{9.28\ \Omega \angle 59.57°}$

b. $\mathbf{Y}_T = \dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{9.28\ \text{k}\Omega \angle 59.57°} = \mathbf{0.108\ S \angle -59.57°}$

c. $0.108\ \text{S} \angle -54.57° = 54.7\ \text{mS} - j93.12\ \text{mS} = G - jB_L$

G = **54.7 mS**
B_L = **93.12 mS**

II. a. $\mathbf{Z}_T = 33\ \Omega + 20\ \Omega - j70\ \Omega = 53\ \Omega - j70\ \Omega =$ **87.80 Ω ∠ −52.87°**

b. $\mathbf{Y}_T = \dfrac{1}{87.80\ \Omega \angle -52.87°} =$ **11.39 mS ∠ 52.87°**

c. 11.39 mS ∠ 52.87° = 6.88 mS + j9.08 mS = $G + jB_C$
G = **6.88 mS**
B_C = **9.08 mS**

III. a. $\mathbf{Z}_T = 200\ \Omega + j500\ \Omega - j600\ \Omega = 200\ \Omega - j100\ \Omega =$ **223.61 Ω ∠ −26.57°**

b. $\mathbf{Y}_T = \dfrac{1}{223.61\ \Omega \angle -26.57°} =$ **4.47 mS ∠ 26.57°**

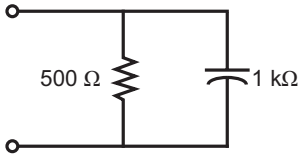
c. 4.47 mS ∠ 26.57° = 4 mS + j2 mS = $G - jB_C$
G = **4 mS**
B_C = **2 mS**

6. I. a. $R_1 \parallel R_2 = \dfrac{1\ \text{k}\Omega}{2} = 500\ \Omega$

$X_{C_1} \parallel X_{C_2} = \dfrac{2\ \text{k}\Omega \angle -90°}{2} = 1\ \text{k}\Omega \angle -90°$

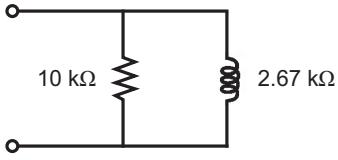
$\mathbf{Y}_T = \dfrac{1}{500\ \Omega \angle 0°} + \dfrac{1}{1\ \text{k}\Omega \angle -90°}$
$= 2 \times 10^{-3}\ \text{S} + 1 \times 10^{-3}\ \text{S} \angle 90°$
$=$ **2 mS + j1 ms**

b.



II. a. $\mathbf{Y}_T = \dfrac{1}{10\ \text{k}\Omega \angle 0°} + \dfrac{1}{4\ \text{k}\Omega \angle 90°} + \dfrac{1}{8\ \text{k}\Omega \angle 90°}$
$= 100 \times 10^{-6} + 250 \times 10^{-6} \angle -90° + 125 \times 10^{-6} \angle -90°$
$= 100 \times 10^{-6} + 375 \times 10^{-6} \angle -90°$
$=$ **100 μS − j375 μs**

b.

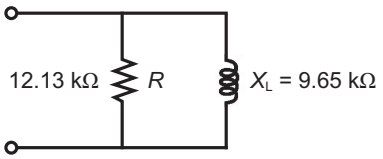


7. a. $X_L = 2\pi fL = 2\pi(2\ \text{kHz})(470\ \text{mH}) = 5.91\ \text{k}\Omega$
$\mathbf{Z}_T = 4.7\ \text{k}\Omega + j5.91\ \text{k}\Omega = 7.55\ \text{k}\Omega \angle 51.51°$

$$\mathbf{Y}_T = \frac{1}{\mathbf{Z}_T} = \frac{1}{7.55\ \text{k}\Omega \angle 51.51°} = \mathbf{132.45\ \mu S \angle -51.51°}$$
$$= \mathbf{82.43\ \mu S - j103.67\ \mu S} = G - jB_L$$

b. $G = 82.43\ \text{mS} = \frac{1}{R} \Rightarrow R = \frac{1}{82.43\ \text{mS}} = \mathbf{12.13\ k\Omega}$

$B_L = 103.67\ \mu\text{S} = \frac{1}{X_\text{L}} \Rightarrow X_\text{L} = \frac{1}{103.67\ \mu\text{S}} = \mathbf{9.65\ k\Omega}$



c. $R = \mathbf{12.13\ k\Omega}$

$X_\text{L} = 2\pi fL = 9.65\ \text{k}\Omega$, $\text{L} = \frac{9.65\ \text{k}\Omega}{2\pi(2\ \text{kHz})} = \mathbf{767.92\ mH}$

d. Both have resistance and inductive components.

8. $\mathbf{Z}_T = \frac{\mathbf{V}}{\mathbf{I}}$, $\mathbf{V} = (0.7071)(24\ \text{V}) \angle -40° = 16.97\ \text{V} \angle -40°$

$\mathbf{I} = (0.7071)(6\ \text{mA}) \angle 30° = 4.243\ \text{mA} \angle 30°$

$\mathbf{Z}_T = \frac{16.97\ \text{V} \angle -40°}{4.243\ \text{mA} \angle 30°} = 4\ \text{k}\Omega \angle -70°$

$\mathbf{Y}_T = \frac{1}{\mathbf{Z}_T} = \frac{1}{4\ \text{k}\Omega \angle -70°} = 250 \times 10^{-6}\ \text{S} \angle 70°$

$= 85.51 \times 10^{-6}\ \text{S} + j234.92 \times 10^{-6} = G + jB_C$

$G = \frac{1}{R} \Rightarrow R = \frac{1}{85.51 \times 10^{-6}\ \text{S}} = \mathbf{11.69\ k\Omega}$

$B_C = \frac{1}{X_C} \Rightarrow \frac{1}{234.92 \times 10^{-6}\ \text{S}} = \mathbf{4.26\ k\Omega}$

$X_C = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega X_C} = \frac{1}{(10{,}000\ \text{rad/s})(4.26\ \text{k}\Omega)}$

$C = \mathbf{23.47\ nF}$

9. a. $\mathbf{Y}_T = \frac{1}{10\ \Omega \angle 0°} + \frac{1}{20\ \Omega \angle 90°} = 0.1\ \text{S} - j0.05\ \text{S} = \mathbf{111.8\ mS \angle -26.57°}$

b. –

c. $\mathbf{E} = \mathbf{I}_s/\mathbf{Y}_T = 2\ \text{A} \angle 0°/111.8\ \text{mS} \angle -26.57° = \mathbf{17.89\ V \angle 26.57°}$

$\mathbf{I}_R = \frac{E \angle \theta}{R \angle 0°} = 17.89\ \text{V} \angle 26.57°/10\ \Omega \angle 0° = \mathbf{1.79\ A \angle 26.57°}$

$$\mathbf{I}_L = \frac{E\angle\theta}{X_L\angle 90°} = 17.89\text{ V}\angle 26.57°/20\ \Omega\angle 90° = \mathbf{0.89\text{ A}\angle -63.43°}$$

f. $P = I^2R = (1.79\text{ A})^2\ 10\ \Omega = \mathbf{32.04\text{ W}}$

g. $F_p = \frac{G}{Y_T} = \frac{0.1\text{ S}}{111.8\text{ mS}} = \mathbf{0.894\text{ lagging}}$

h. $e = \mathbf{25.30\sin(377t + 26.57°)}$
$i_R = \mathbf{2.53\sin(377t + 26.57°)}$
$i_L = \mathbf{1.26\sin(377t - 63.43°)}$
$i_s = \mathbf{2.83\sin 377t}$

10. a. $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(60\text{ Hz})(0.13\ \mu\text{F})} = 20.4\text{ k}\Omega$

b. $\mathbf{Y}_T = \frac{1}{10\text{ k}\Omega\angle 0°} + \frac{1}{20.4\text{ k}\Omega\angle -90°} = 0.1\text{ mS}\angle 0° + 0.049\text{ mS}\angle -90°$
$= \mathbf{0.111\text{ mS}\angle 26.10°}$

c. $\mathbf{E} = \frac{\mathbf{I}_s}{\mathbf{Y}_T} = \frac{2\text{ mA}\angle 20°}{0.111\text{ mS}\angle 26.10°} = \mathbf{18.02\text{ V}\angle -6.1°}$
$\mathbf{I}_R = \frac{\mathbf{E}}{\mathbf{Z}_R} = \frac{18.02\text{ V}\angle -6.1°}{10\text{ k}\Omega\angle 0°} = \mathbf{1.80\text{ mA}\angle -6.1°}$
$\mathbf{I}_C = \frac{\mathbf{E}}{\mathbf{Z}_C} = \frac{18.02\text{ V}\angle -6.1°}{20.4\text{ k}\Omega\angle -90°} = \mathbf{0.883\text{ mA}\angle 83.90°}$

d. –

e. $\mathbf{I}_s = \mathbf{I}_R + \mathbf{I}_C$
$2\text{ mA}\angle 20° = 1.80\text{ mA}\angle -6.1° + 0.883\text{ mA}\angle 83.90°$
$= (1.79\text{ mA} - j0.191\text{ mA}) + (0.094\text{ mA} + j0.878\text{ mA})$
$= 1.88\text{ mA} + j0.687\text{ mA}$
$2\text{ mA}\angle 20° \cong 2\text{ mA}\angle 20.07°$

f. $P = I^2R = (1.80\text{ mA})^2\ 10\text{ k}\Omega = \mathbf{32.4\text{ mW}}$

g. $F_p = \frac{G}{Y_T} = \frac{0.1\text{ mS}}{0.111\text{ mS}} = \mathbf{0.9\text{ leading}}$

h. $\omega = 2\pi f = 377\text{ rad/s}$
$\boldsymbol{i_s = 2.83\times 10^{-3}\sin(\omega t + 20°)}$
$\boldsymbol{i_R = 2.55\times 10^{-3}\sin(\omega t - 6.57°)}$
$\boldsymbol{i_C = 1.25\times 10^{-3}\sin(\omega t + 83.44°)}$
$\boldsymbol{e = 25.48\sin(\omega t - 6.57°)}$

11. a. $R_1 \parallel R_2 = 220\ \Omega \parallel 120\ \Omega = 77.65\ \Omega$

$$\mathbf{X_C} \parallel \mathbf{X_L} = 60\ \Omega \angle -90° \parallel 40\ \Omega \angle 90°$$
$$= \frac{2400\ \angle 0°}{-j60 + j40} = \frac{2400\ \angle 0°}{-j20} = \frac{2400\ \angle 0°}{20 \angle -90°} = 120\ \Omega \angle 90°$$

$$\mathbf{Z}_T = (R_1 \parallel R_2) \parallel (X_C \parallel X_L)$$
$$= 77.65\ \Omega \angle 0° \parallel 120\ \Omega \angle 90°$$
$$= \frac{(77.65)(120) \angle 90°}{77.65 + j120} = \frac{9.32 \times 10^3 \angle 90°}{142.93 \angle 57.09°} = \mathbf{65.21\ \Omega \angle 32.91°}$$

b. $\mathbf{Y}_T = \dfrac{1}{\mathbf{Z}_T} = \dfrac{1}{65.21\ \Omega \angle 32.91°} = \mathbf{15.34\ mS \angle -32.91°}$

c. –

d. $\mathbf{I}_s = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{12\ \text{V} \angle 0°}{65.21\ \Omega \angle 32.91°} = \mathbf{184.02\ mA \angle -32.91°}$

e. $\mathbf{I}_C = \dfrac{\mathbf{E}}{\mathbf{X}_C} = \dfrac{12\ \text{V} \angle 0°}{60\ \Omega \angle -90°} = \mathbf{200\ mA \angle 90°}$

f. $e = (1.414)(12) \sin \omega t = \mathbf{16.97 \sin \omega t}$
$i_s = (1.414)(184.02 \times 10^{-3}) \sin(\omega t - 32.91°)$
$= \mathbf{260.02 \times 10^{-3} \sin(\omega t - 32.91°)}$

g. $F_p = \cos\theta_T = \cos 32.91° = \mathbf{0.84\ lagging}$

12. a. $\mathbf{Y}_T = \dfrac{1}{1.2\ \Omega \angle 0°} + \dfrac{1}{2\ \Omega \angle 90°} + \dfrac{1}{5\ \Omega \angle -90°}$
$= 0.833\ \text{S} \angle 0° + 0.5\ \text{S} \angle -90° + 0.2\ \text{S} \angle 90°$
$= 0.833\ \text{S} - j0.3\ \text{S} = \mathbf{0.89\ S \angle -19.81°}$
$\mathbf{Z}_T = \mathbf{1.12\ \Omega \angle 19.81°}$

b. –

c. $X_C = \dfrac{1}{\omega C} \Rightarrow C = \dfrac{1}{\omega X_C} = \dfrac{1}{(377\ \text{rad/s})(5\ \Omega)} = \mathbf{531\ \mu F}$

$X_L = \omega L \Rightarrow L = \dfrac{X_L}{\omega} = \dfrac{2\ \Omega}{377\ \text{rad/s}} = \mathbf{5.31\ mH}$

d. $\mathbf{E} = \dfrac{\mathbf{I}_s}{\mathbf{Y}_T} = \dfrac{(0.707)(3\ \text{A}) \angle 60°}{0.885\ \text{S} \angle -19.81°} = \dfrac{2.121\ \text{A} \angle 60°}{0.885\ \text{S} \angle -19.81°} = \mathbf{2.40\ V \angle 79.81°}$

$\mathbf{I}_R = \dfrac{E \angle \theta}{R \angle 0°} = \dfrac{2.397\ \text{V} \angle 79.81°}{1.2\ \Omega \angle 0°} = \mathbf{2.00\ A \angle 79.81°}$

$\mathbf{I}_L = \dfrac{E \angle \theta}{X_L \angle 90°} = \dfrac{2.397\ \text{V} \angle 79.81°}{2\ \Omega \angle 90°} = \mathbf{1.20\ A \angle -10.19°}$

$$\mathbf{I}_C = \frac{E\angle\theta}{X_C\angle -90^\circ} = \frac{2.397\text{ V}\angle 79.81^\circ}{5\,\Omega\angle -90^\circ} = \mathbf{0.48\text{ A}\angle 169.81^\circ}$$

f. $\mathbf{I}_s = \mathbf{I}_R + \mathbf{I}_L + \mathbf{I}_C$
$2.121\text{ A}\angle 60^\circ = 2.00\text{ A}\angle 79.81^\circ + 1.20\text{ A}\angle -10.19^\circ + 0.48\text{ A}\angle 169.81^\circ$
$2.121\text{ A}\angle 60^\circ \overset{\checkmark}{=} 2.13\text{ A}\angle 60.01^\circ$

g. $P = I^2R = (2.00\text{ A})^2\ 1.2\ \Omega = \mathbf{4.8\text{ W}}$

h. $F_p = \frac{G}{Y_T} = \frac{0.833\text{ S}}{0.885\text{ S}} = \mathbf{0.941\text{ lagging}}$

i. $e = \mathbf{3.39\sin(377t + 79.81^\circ)}$
$i_R = \mathbf{2.83\sin(377t + 79.81^\circ)}$
$i_L = \mathbf{1.70\sin(377t - 10.19^\circ)}$
$i_C = \mathbf{0.68\sin(377t + 169.81^\circ)}$

13. a. $X_L = \omega L = (1000\text{ rad/s})(3.9\text{ H}) = 3.9\text{ k}\Omega$,

$$X_C = \frac{1}{\omega C} = \frac{1}{(1000\text{ rad/s})(0.12\ \mu\text{F})} = 8.33\text{ k}\Omega$$

$$\mathbf{Y}_T = \frac{1}{3\text{ k}\Omega\angle 0^\circ} + \frac{1}{3.9\text{ k}\Omega\angle 90^\circ} + \frac{1}{8.33\text{ k}\Omega\angle -90^\circ}$$
$= 0.333\text{ mS}\angle 0^\circ + 0.256\text{ mS}\angle -90^\circ + 0.120\text{ mS}\angle 90^\circ$
$= \mathbf{0.333\text{ mS} - j0.136\text{ mS} = 0.36\text{ mS}\angle -22.22^\circ}$

d. $\mathbf{E} = \mathbf{I}/\mathbf{Y}_T = 3.54\text{ mA}\angle -20^\circ/0.36\text{ mS}\angle -22.22^\circ = \mathbf{9.83\text{ V}\angle 2.22^\circ}$

$$\mathbf{I}_R = \frac{E\angle\theta}{R\angle 0^\circ} = 9.83\text{ V}\angle 2.22^\circ/3\text{ k}\Omega\angle 0^\circ = \mathbf{3.28\text{ mA}\angle 2.22^\circ}$$

$$\mathbf{I}_L = \frac{E\angle\theta}{X_L\angle 90^\circ} = 9.83\text{ V}\angle 2.22^\circ/3.9\text{ k}\Omega\angle 90^\circ = \mathbf{2.52\text{ mA}\angle -87.78^\circ}$$

$$\mathbf{I}_C = \frac{E\angle\theta}{X_C\angle -90^\circ} = 9.83\text{ V}\angle 2.22^\circ/8.33\text{ k}\Omega\angle -90^\circ = \mathbf{1.18\text{ mA}\angle 92.22^\circ}$$

g. $P = I^2R = (3.28\text{ mA})^2 3\text{ k}\Omega = \mathbf{32.28\text{ mW}}$

h. $F_p = G/Y_T = 0.333\text{ mS}/0.36\text{ mS} = \mathbf{0.925\text{ leading}}$

i. $e = \mathbf{13.9\sin(1000t + 2.22^\circ)}$
$i_R \cong \mathbf{4.64\times 10^{-3}\sin(1000t + 2.22^\circ)}$
$i_L \cong \mathbf{3.56\times 10^{-3}\sin(1000t - 87.78^\circ)}$
$i_C = \mathbf{1.67\times 10^{-3}\sin(1000t + 92.22^\circ)}$

14. a. $$\mathbf{I}_1 = \frac{(60\ \Omega\angle 90^\circ)(20\text{ A}\angle 40^\circ)}{22\ \Omega + j60\ \Omega} = \frac{120\text{ A}\angle 130^\circ}{63.91\angle 69.86^\circ} = \mathbf{18.78\angle 60.14^\circ}$$

$$\mathbf{I}_2 = \frac{(22\ \Omega\angle 0^\circ)(20\text{ A}\angle 40^\circ)}{63.91\ \Omega\angle 69.86^\circ} = \frac{440\text{ A}\angle 40^\circ}{63.91\angle 69.86^\circ} = \mathbf{6.88\angle -29.86^\circ}$$

b. $$\mathbf{I}_1 = \frac{(12\ \Omega - j6\ \Omega)(6\ \text{A} \angle 30°)}{12\ \Omega - j6\ \Omega + j4\ \Omega} = \frac{(13.42 \angle -26.57°)(6\ \text{A} \angle 30°)}{12 - j2}$$

$$= \frac{80.52\ \text{A} \angle 3.43°}{12.17 \angle -9.46°} = \mathbf{6.62\ A \angle 12.89°}$$

$$\mathbf{I}_2 = \frac{(4\ \Omega \angle 90°)(6\ \text{A} \angle 30°)}{12.17 \angle -9.46°} = \frac{24\ \text{A} \angle 120°}{12.17 \angle -9.46°} = \mathbf{1.97\ A \angle 129.46°}$$

c. $$\mathbf{I}_1 = \frac{(-j10\ \Omega + j40\ \Omega)(4\ \text{A} \angle 0°)}{+j20\ \Omega - j10\ \Omega + j40\ \Omega} = \frac{(30\ \Omega \angle 90°)(4\ \text{A} \angle 0°)}{50\ \Omega \angle 90°}$$

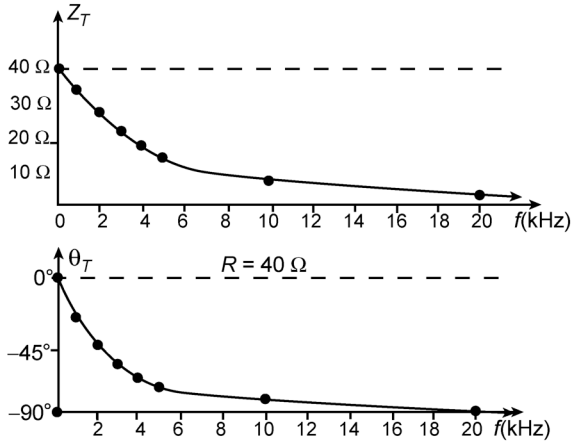
$$= \mathbf{2.4\ A \angle 0°}$$

$$\mathbf{I}_2 = \frac{(20\ \Omega \angle 90°)(4\ \text{A} \angle 0°)}{50\ \Omega \angle 90°} = \mathbf{1.6\ A \angle 0°}$$

15. a. $$\mathbf{Z}_T = \frac{(R \angle 0°)(X_C \angle -90°)}{R - jX_C} = \frac{RX_C}{\sqrt{R^2 + X_C^2}} \angle -90° + \tan^{-1} X_C/R$$

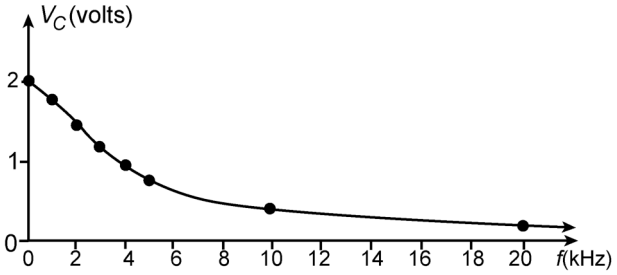
$$|Z_T| = \frac{RX_C}{\sqrt{R^2 + X_C^2}} \quad \theta_T = -90° + \tan^{-1} X_C/\text{R}$$

f	$\lvert Z_T \rvert$	θ_T
0 Hz	40.0	0.0°
1 kHz	35.74	−26.67°
2 kHz	28.22	−45.14°
3 kHz	22.11	−56.44°
4 kHz	17.82	−63.55°
5 kHz	14.79	−68.30°
10 kHz	7.81	−78.75°
20 kHz	3.959	−89.86°



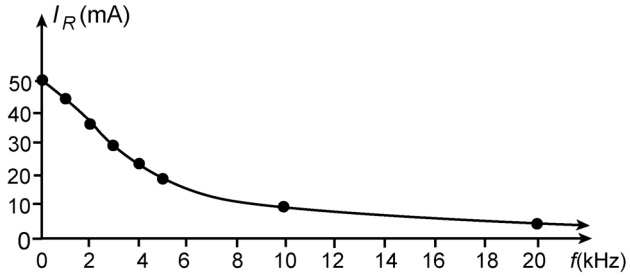
b. $$|V_C| = \frac{IRX_C}{\sqrt{R^2 + X_C^2}} = I[Z_T(f)]$$

f	$\lvert V_C \rvert$
0 kHz	2.0 V
1 kHz	1.787 V
2 kHz	1.411 V
3 kHz	1.105 V
4 kHz	0.891 V
5 kHz	0.740 V
10 kHz	0.391 V
20 kHz	0.198 V



c. $\lvert I_R \rvert = \left\lvert \dfrac{V_C}{R} \right\rvert$

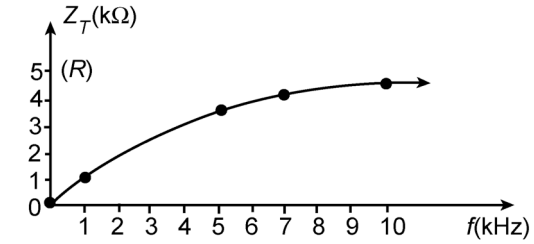
f	$\lvert I_R \rvert$
0 kHz	50.0 mA
1 kHz	44.7 mA
2 kHz	35.3 mA
3 kHz	27.64 mA
4 kHz	22.28 mA
5 kHz	18.50 mA
10 kHz	9.78 mA
20 kHz	4.95 mA

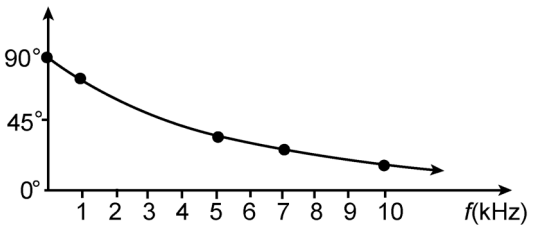


16. a. $\mathbf{Z}_T = \dfrac{\mathbf{Z}_R \mathbf{Z}_L}{\mathbf{Z}_R + \mathbf{Z}_L} = \dfrac{(R\angle 0°)(X_L \angle 90°)}{R + jX_L} = \dfrac{RX_L}{\sqrt{R^2 + X_L^2}} \angle 90° - \tan^{-1} X_L/R$

$\lvert \mathbf{Z}_T \rvert = \dfrac{RX_L}{\sqrt{R^2 + X_L^2}}$ $\theta_T = 90° - \tan^{-1} X_L/R$

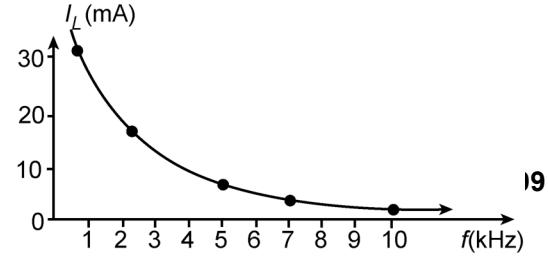
f	$\lvert Z_T \rvert$	θ_T
0 Hz	0.0 k	90.0°
1 kHz	1.22 k	75.86°
5 kHz	3.91 k	38.53°
7 kHz	4.35 k	29.6°
10 kHz	4.65 k	21.69°





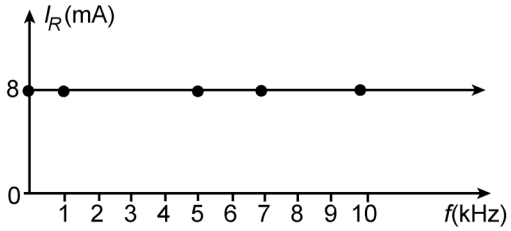
b. $\lvert I_L \rvert = \dfrac{E}{X_L}$

f	$\lvert I_L \rvert$



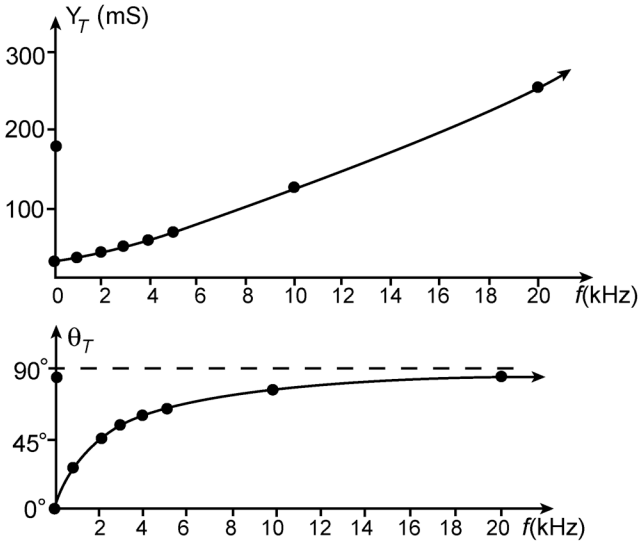
0 Hz	∞
1 kHz	31.75 mA
5 kHz	6.37 mA
7 kHz	4.55 mA
10 kHz	3.18 mA

c. $I_R = \dfrac{E}{R} = \dfrac{40\text{ V}}{5\text{ k}\Omega} = 8\text{ mA (constant)}$



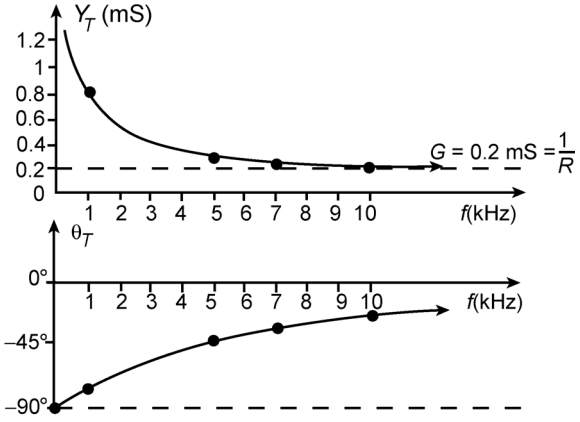
17. $\mathbf{Y}_T = \dfrac{\sqrt{R^2 + X_C^2}}{RX_C} \angle 90° - \tan^{-1} X_C/R$

f	$\lvert Y_T \rvert$	θ_T
0 Hz	25.0 mS	0.0°
1 kHz	27.98 mS	26.67°
2 kHz	35.44 mS	45.14°
3 kHz	45.23 mS	56.44°
4 kHz	56.12 mS	63.55°
5 kHz	67.61 mS	68.30°
10 kHz	128.04 mS	78.75°
20 kHz	252.59 mS	89.86°



18. $Y_T = \dfrac{1}{Z_T}$ (use data of Prob. 36), $\theta_{T_Y} = -\theta_{T_Z}$

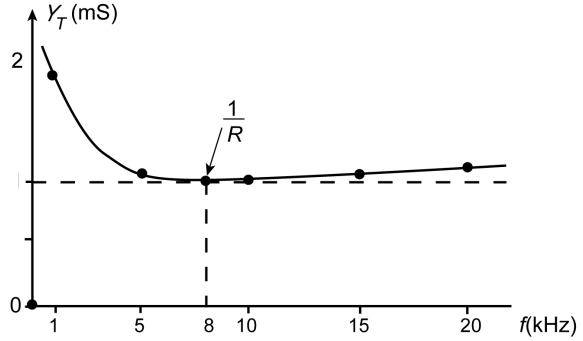
f	Y_T	θ_T
0 Hz	∞	–90.0°
1 kHz	0.82 mS	–75.86°
5 kHz	0.256 mS	–38.53°
7 kHz	0.23 mS	–29.6°
10 kHz	0.215 mS	–21.69°



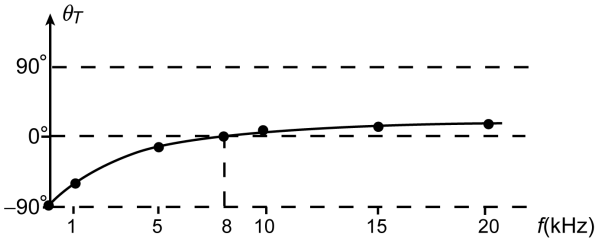
19. a. $\mathbf{Y}_T = G\angle 0° + B_L\angle -90° + B_C\angle 90°$

$= \sqrt{G^2 + (B_C - B_L)^2}\ \angle \tan^{-1}\dfrac{B_C - B_L}{G}$

f	$\lvert Y_T\rvert$
0 Hz	$X_L \Rightarrow 0$, $Z_T = 0$, $Y_T = \infty$
1 kHz	1.86 mS
5 kHz	1.02 mS
10 kHz	1.00 mS
15 kHz	1.02 mS
20 kHz	1.04 mS

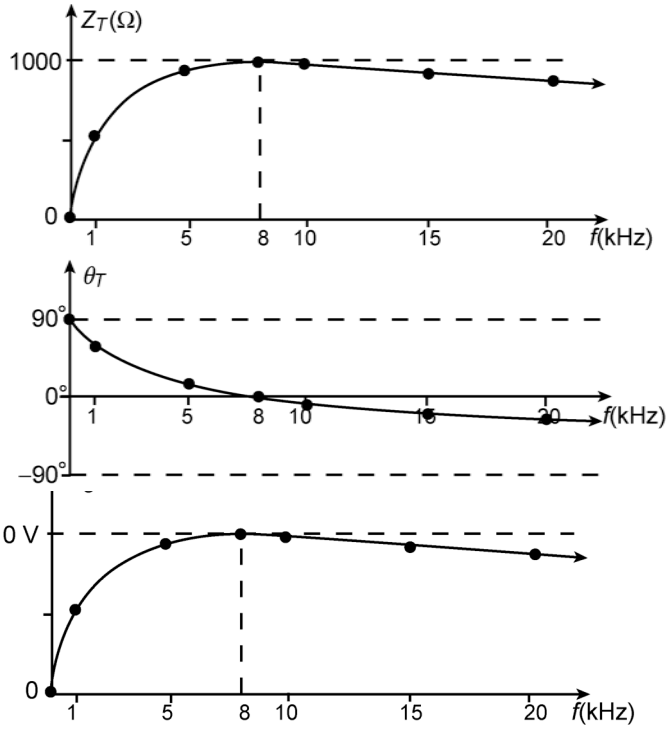


f	$\lvert\theta_T\rvert$
0 Hz	−90.0°
1 kHz	−57.51°
5 kHz	−12.63°
10 kHz	+1.66°
15 kHz	+9.98°
20 kHz	+16.54°



b. $Z_T = \dfrac{1}{Y_T}, \theta_{T_Z} = -\theta_{T_Y}$

f	Z_T	θ_T
0 kHz	0.0	90.0°
1 kHz	537.63	57.52°
5 kHz	980.39	12.63°
10 kHz	1 k	−1.66°
15 kHz	980.39	−9.98°
20 kHz	961.54	−16.54°

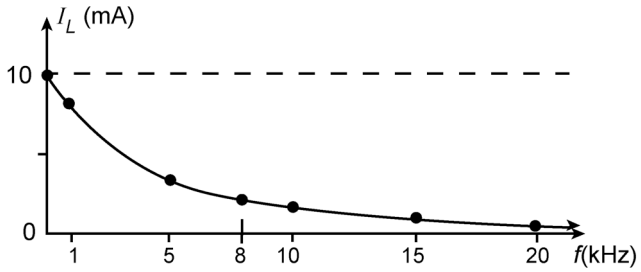


c. $V_C(f) = I[Z_T(f)]$

f	$\lvert V_C\rvert$
0 kHz	0.0 V
1 kHz	5.38 V
5 kHz	9.80 V
10 kHz	10 V
15 kHz	9.80 V
20 kHz	9.62 V

d. $I_L = \dfrac{V_L(f)}{X_L} = \dfrac{V_C(f)}{X_L}$

f	I_L
0 kHz	10.0 mA
1 kHz	8.56 mA
5 kHz	3.12 mA
10 kHz	1.59 mA
15 kHz	1.04 mA
20 kHz	0.765 mA



20. a. $R_p = \dfrac{R_s^2 + X_s^2}{R_s} = \dfrac{(20\ \Omega)^2 + (40\ \Omega)^2}{20\ \Omega} = \mathbf{100\ \Omega}\ (R)$

$X_p = \dfrac{R_s^2 + X_s^2}{X_s} = \dfrac{2000\ \Omega}{40} = \mathbf{50\ \Omega}\ (C)$

b. $R_p = \dfrac{R_s^2 + X_s^2}{R_s} = \dfrac{(2\ \text{k}\Omega)^2 + (8\ \text{k}\Omega)^2}{2\ \text{k}\Omega} = \mathbf{34\ k\Omega}\ (R)$

$X_p = \dfrac{R_s^2 + X_s^2}{X_s} = \dfrac{(2\ \text{k}\Omega)^2 + (8\ \text{k}\Omega)^2}{8\ \text{k}\Omega} = \mathbf{8.5\ k\Omega}\ (L)$

21. a. $R_s = \dfrac{R_p X_p^2}{X_p^2 + R_p^2} = \dfrac{(8.2\ \text{k}\Omega)(20\ \text{k}\Omega)^2}{(20\ \text{k}\Omega)^2 + (8.2\ \text{k}\Omega)^2} = \mathbf{7.02\ k\Omega}$

$X_s = \dfrac{R_p^2 X_p}{X_p^2 + R_p^2} = \dfrac{(8.2\ \text{k}\Omega)^2(20\ \text{k}\Omega)}{467.24\ \text{k}\Omega} = \mathbf{2.88\ k\Omega}$

$\mathbf{Z}_T = \mathbf{7.02\ k\Omega - }\boldsymbol{j}\mathbf{2.88\ k\Omega}$

b. $R_s = \dfrac{R_p X_p^2}{X_p^2 + R_p^2} = \dfrac{(68\ \Omega)(40\ \Omega)^2}{(40\ \Omega)^2 + (68\ \Omega)^2} = \mathbf{17.48\ \Omega}$

$X_s = \dfrac{R_p^2 X_p}{X_p^2 + R_p^2} = \dfrac{(68\ \Omega)^2(40\ \Omega)}{6224\ \Omega^2} = \mathbf{29.72\ \Omega}$

$\mathbf{Z}_T = \mathbf{17.48\ \Omega + }\boldsymbol{j}\mathbf{29.72\ \Omega}$

22. a. $C_T = 2\ \mu\text{F}$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi(10^3\ \text{Hz})(2\ \mu\text{F})} = 79.62\ \Omega$

$X_L = \omega L = 2\pi(10^3\ \text{Hz})(10\ \text{mH}) = 62.8\ \Omega$

$\mathbf{Y}_T = \dfrac{1}{220\ \Omega \angle 0°} + \dfrac{1}{79.62\ \Omega \angle -90°} + \dfrac{1}{62.8\ \Omega \angle 90°}$

$= 4.55\ \text{mS} \angle 0° + 12.56\ \text{mS} \angle 90° + 15.92\ \text{mS} \angle -90°$

$= \mathbf{4.55\ mS - }j\mathbf{3.36\ mS = 5.66\ mS \angle -36.44°}$

$\mathbf{E} = \mathbf{I}/\mathbf{Y}_T = 1\text{ A} \angle 0°/5.66\text{ mS} \angle -36.44° = \mathbf{176.68\ V \angle 36.44°}$

$\mathbf{I}_R = \dfrac{E \angle \theta}{R \angle 0°} = 176.68\text{ V} \angle 36.44°/220 \angle 0° = \mathbf{0.803\ A \angle 36.44°}$

$\mathbf{I}_L = \dfrac{E \angle \theta}{X_L \angle 90°} = 176.68\text{ V} \angle 36.44°/62.80 \angle 90° = \mathbf{2.813\ A \angle -53.56°}$

b. $F_p = G/Y_T = 4.55\text{ mS}/5.66\text{ mS} = \mathbf{0.804\ lagging}$

c. $P = I^2R = (0.803\text{ A})^2\ 220\ \Omega = \mathbf{141.86\ W}$

f. $\mathbf{I}_s = \mathbf{I}_R + 2\mathbf{I}_C + \mathbf{I}_L$

$$\text{and } \mathbf{I}_C = \frac{\mathbf{I}_s - \mathbf{I}_R - \mathbf{I}_L}{2}$$

$$= \frac{1\text{ A} \angle 0° - 0.803\text{ A} \angle 36.44° - 2.813\text{ A} \angle -53.56°}{2}$$

$$= \frac{1 - (0.646 + j0.477) - (1.671 - j2.263)}{2} = \frac{-1.317 + j1.786}{2}$$

$\mathbf{I}_C = -0.657 + j0.893 = \mathbf{1.11\ A \angle 126.43°}$

g. $\mathbf{Z}_T = \dfrac{1}{\mathbf{Y}_T} = \dfrac{1}{5.66\text{ mS} \angle -36.44°} = 176.7\ \Omega \angle 36.44°$

$= \mathbf{142.15\ \Omega + }j\mathbf{104.96\ \Omega} = R + jX_L$

23. $P = VI \cos\theta = 3000\text{ W}$

$$\cos\theta = \frac{3000\text{ W}}{VI} = \frac{3000\text{ W}}{(100\text{ V})(40\text{ A})} = \frac{3000}{4000} = 0.75\text{ (lagging)}$$

$$\theta = \cos^{-1} 0.75 = 41.41°$$

$$\mathbf{Y}_T = \frac{\mathbf{I}}{\mathbf{E}} = \frac{40\text{ A} \angle -41.41°}{100\text{ V} \angle 0°} = 0.4\text{ S} \angle -41.41° = 0.3\text{ S} - j0.265\text{ S} = G_T - jB_L$$

$$G_T = 0.3\text{ S} = \frac{1}{20\ \Omega} + \frac{1}{R'} = 0.05\text{ S} + \frac{1}{R'}$$

$$\text{and } R' = \frac{1}{0.25\text{ S}} = 4\ \Omega$$

$$X_L = \frac{1}{B_L} = \frac{1}{0.265\text{ S}} = \mathbf{3.74\ \Omega}$$