Chapter 15

1. a. $\mathbf{I} = (0.7071)(20\text{ mA} \angle 30°)$
$= \mathbf{14.14\text{ mA} \angle 30°}$

b. $\mathbf{V} = \mathbf{IR} = (14.14\text{ mA} \angle 30°)(2\text{ k}\Omega \angle 0°)$
$= \mathbf{28.28\text{ V} \angle 30°}$

c. –

d. $v = (1.414)(28.28\text{ V}) \sin(1000t + 30°)$
$= \mathbf{40 \sin(1000t + 30°)}$

e. –

2. a. $\mathbf{V}_R = (0.7071)(24\text{ V}) \angle 20°$
$= \mathbf{16.97\text{ V} \angle 20°}$

b. $\mathbf{I} = \dfrac{\mathbf{V}_R}{\mathbf{R}} = \dfrac{16.97\text{ V} \angle 20°}{6.8\ \Omega \angle 0°} = \mathbf{2.5\text{ A} \angle 20°}$

c. –

d. $i = (1.414)(2.5\text{ A}) \sin(300t + 20°)$
$= \mathbf{3.53 \sin(300t + 20°)}$

e. –

3. a. $\mathbf{I}_L = (0.7071)(10\text{ mA}) \angle 40°$
$= \mathbf{7.071\text{ mA/}\angle 40°}$

b. $\mathbf{V}_L = \mathbf{I}_L\mathbf{X}_L = (0.7071\text{ mA} \angle 40°)(2\text{ k}\Omega \angle 90°)$
$= \mathbf{14.14\text{ V} \angle 130°}$

c. –

d. $v_L = (1.414)(14.14\text{ V}) \sin(250t + 130°)$
$= \mathbf{20 \sin(250t + 130°)}$

e. –

4. a. $X_L = \omega L = (750\text{ rad/s})(40\text{ mH}) = \mathbf{30\ \Omega}$

b. $\mathbf{V}_L = (0.7071)(200\ \mu\text{V}) \angle 90°$
$= \mathbf{141.42\ \mu V \angle 90°}$

c. $\mathbf{I}_L = \dfrac{\mathbf{V}_L}{\mathbf{X}_L} = \dfrac{141.42\ \mu\text{V} \angle 90°}{30\ \Omega \angle 90°} = \mathbf{4.71\ \mu A \angle 0°}$

d. –

e. $i_L = (1.414)(4.71\ \mu\text{A}) \sin(750t + 0°)$
$= \mathbf{6.66 \times 10^{-6} \sin 750t}$

f. –

5. a. $\mathbf{I}_L = (0.7071)(6\ \text{mA}) \angle 20°$
$= \mathbf{4.243\ mA \angle 20°}$

$\mathbf{V}_L = (0.7071)(16\ \text{V}) \angle 110°$
$= \mathbf{11.314\ V \angle 110°}$

b. $\mathbf{Z}_L = \dfrac{\mathbf{V}_L}{\mathbf{I}_L} = \dfrac{11.314\ \text{V} \angle 110°}{4.243\ \text{mA} \angle 20°} = \mathbf{2.67\ k\Omega \angle 90° = X}_L$

c. $X_L = \omega L \Rightarrow L = \dfrac{X_L}{\omega} = \dfrac{2.67\ \text{k}\Omega}{1200\ \text{rad/s}} = \mathbf{2.23\ H}$

d. –

e. –

6. a. $\mathbf{V}_C = (0.7071)(60\ \text{V}) \angle 60°$
$= \mathbf{42.43\ V \angle 60°}$

b. $\mathbf{I}_C = \dfrac{\mathbf{V}_C}{\mathbf{X}_C} = \dfrac{42.43\ \text{V} \angle 60°}{40\ \Omega \angle -90°} = \mathbf{1.061\ A \angle 150°}$

c. –

d. $i_C = (1.414)(1.061\ \text{A}) \sin(400t + 150°)$
$= \mathbf{1.5 \sin (400t + 150°)}$

e. –

7. a. $X_C = \dfrac{1}{\omega C} = \dfrac{1}{(20,000\ \text{rad/s})(0.01\ \mu\text{F})} = \mathbf{5\ k\Omega}$

b. $\mathbf{I}_C = (0.7071)(5\ \mu\text{A}) \angle -80°$
$= \mathbf{3.54\ \mu A \angle -80°}$

c. $\mathbf{V}_C = \mathbf{I}_C\mathbf{X}_C = (3.54\ \mu\text{A} \angle -80°)(5\ \text{k}\Omega \angle -90°)$
$= \mathbf{17.7\ mV \angle -170°}$

d. –

e. $v_C = (1.414)(17.7\ \text{mV}) \sin(2000t - 170°)$
$= \mathbf{25.03 \times 10^{-3} \sin (2000t - 170°)}$

f. –

8. a. $\mathbf{I}_C = (0.7071)(60\ \mu\text{A}) \angle 80°$
$= \mathbf{42.43\ \mu A \angle 80°}$

$\mathbf{V}_C = (0.7071)(24\ \text{mV}) \angle -10°$
$= \mathbf{16.97\ mV \angle -10°}$

b $\mathbf{X}_C = \mathbf{Z}_C = \dfrac{\mathbf{V}_C}{\mathbf{I}_C} = \dfrac{16.97\ \text{mV} \angle -10°}{42.43\ \mu\text{A} \angle 80°} = \mathbf{400\ \Omega \angle -90°}$

c. $X_C = \dfrac{1}{\omega C} \Rightarrow C = \dfrac{1}{\omega X_C} = \dfrac{1}{(2000\ \text{rad/s})(400\ \Omega)} = \mathbf{1.25\ \mu F}$

d. –

e. –

9. –

10. $X_L = 2\pi fL = 2\pi(1.2\ \text{kHz})(5\ \text{mH}) = \mathbf{37.7\ \Omega}$

11. $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(100\ \text{kHz})(0.02\ \mu\text{F})} = \mathbf{79.58\ \Omega}$

12. a. $\mathbf{Z}_T = \mathbf{6.8\ \Omega + j8.2\ \Omega = 10.65\ \Omega \angle 50.33°}$

b. $\mathbf{Z}_T = 2\ \Omega - j6\ \Omega + 10\ \Omega = \mathbf{12\ \Omega - j6\ \Omega = 13.42\ \Omega \angle -26.57°}$

c. $\mathbf{Z}_T = 1\ \text{k}\Omega + j3.2\ \text{k}\Omega + 5.6\ \text{k}\Omega + j6.8\ \text{k}\Omega = \mathbf{6.6\ k\Omega + j10\ k\Omega = 11.98\ k\Omega \angle 56.58°}$

13. a. $\mathbf{Z}_T = \mathbf{3\ \Omega + j4\ \Omega - j5\ \Omega = 3\ \Omega - j1\ \Omega = 3.16\ \Omega \angle -18.43°}$

b. $\mathbf{Z}_T = 1\ \text{k}\Omega + j8\ \text{k}\Omega - j4\ \text{k}\Omega = \mathbf{1\ k\Omega + j4\ k\Omega = 4.12\ k\Omega \angle 75.96°}$

c. $L_T = 247\ \text{mH}$
$X_L = \omega L = 2\pi fL = 2\pi(10^3\ \text{Hz})(247 \times 10^{-3}\ \text{H}) = 1.55\ \text{k}\Omega$
$X_C = \dfrac{1}{2\pi f\, C} = \dfrac{1}{2\pi(10^3\ \text{Hz})(0.1 \times 10^{-6}\ \text{F})} = 1.59\ \text{k}\Omega$
$= 470\ \Omega + j1.55\ \text{k}\Omega - j1.59\ \text{k}\Omega$
$= \mathbf{470\ \Omega - j40\ \Omega = 471.70\ \Omega \angle -4.86°}$

14. a. $\mathbf{Z}_T = \dfrac{\mathbf{E}}{\mathbf{I}} = \dfrac{120\ \text{V} \angle 0°}{6\ \text{A} \angle 45°} = 20\ \Omega \angle -45° = \mathbf{14.142\ \Omega - j14.142\ \Omega = R - jX}_C$

b. $\mathbf{Z}_T = \dfrac{\mathbf{E}}{\mathbf{I}} = \dfrac{80\ \text{V} \angle 130°}{20\ \text{mA} \angle 40°} = 4\ \text{k}\Omega \angle 90° = \mathbf{j4\ k\Omega = jX}_L$

c. $\mathbf{Z}_T = \dfrac{\mathbf{E}}{\mathbf{I}} = \dfrac{8\text{ kV} \angle 0°}{12\text{ A} \angle -30°} = 666.67\ \Omega \angle 30° = \mathbf{577.35\ \Omega + j333.34\ \Omega = R + jX_L}$

15. a. $\mathbf{Z}_T = 8\ \Omega + j6\ \Omega = \mathbf{10\ \Omega \angle 36.87°}$

c. $\mathbf{I} = \mathbf{E}/\mathbf{Z}_T = 100\text{ V} \angle 0°/10\ \Omega \angle 36.87° = \mathbf{10\text{ A} \angle -36.87°}$
$\mathbf{V}_R = (I \angle \theta)(R \angle 0°) = (10\text{ A} \angle -36.87°)(8\ \Omega \angle 0°) = \mathbf{80\text{ V} \angle -36.87°}$
$\mathbf{V}_L = (I \angle \theta)(X_L \angle 90°) = (10\text{ A} \angle -36.87°)(6\ \Omega \angle 90°) = \mathbf{60\text{ V} \angle 53.13°}$

f. $P = I^2R = (10\text{ A})^2\ 8\ \Omega = \mathbf{800\text{ W}}$

g. $F_p = \cos\theta_T = R/Z_T = 8\ \Omega/10\ \Omega = \mathbf{0.8\text{ lagging}}$

h. $\upsilon_R = \mathbf{113.12\ \sin(\omega t - 36.87°)}$
$\upsilon_L = \mathbf{84.84\ \sin(\omega t + 53.13°)}$
$i = \mathbf{14.14\ \sin(\omega t - 36.87°)}$

16. a. $\mathbf{Z}_T = 18\ \Omega - j29.15\ \Omega = \mathbf{34.26\ \Omega \angle -58.30°}$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(60\text{ Hz})(91\ \mu\text{F})} = 29.15\ \Omega$$

c. $$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{120\text{ V} \angle 20°}{34.26\ \Omega \angle -58.30°} = \mathbf{3.50\text{ A} \angle 78.30°}$$

$\mathbf{V}_R = (I \angle \theta)(R \angle 0°) = (3.50\text{ A} \angle 78.30°)(18\ \Omega \angle 0°) = \mathbf{63.0\text{ V} \angle 78.30°}$
$\mathbf{V}_C = (I \angle \theta)(X_C \angle -90°) = (3.50\text{ A} \angle 78.30°)(29.15\ \Omega \angle -90°) = \mathbf{102.03\text{ V} \angle -11.70°}$

f. $P = I^2R = (3.50\text{ A})^2\ 18\ \Omega = \mathbf{220.5\ W}$

g. $F_p = R/Z_T = 18\ \Omega/34.26\ \Omega = \mathbf{0.525\text{ leading}}$

h. $i = \mathbf{4.95\ \sin(377t + 78.30°)}$
$\upsilon_R = \mathbf{89.1\ \sin(377t + 78.30°)}$
$\upsilon_C = \mathbf{144.27\ \sin(377t - 11.70°)}$

17. a. $\mathbf{Z}_T = 4\ \Omega + j6\ \Omega - j10\ \Omega = 4\ \Omega - j4\ \Omega = \mathbf{5.66\ \Omega \angle -45°}$

c. $$X_L = \omega L \Rightarrow L = \frac{X_L}{\omega} = \frac{6\ \Omega}{377\text{ rad/s}} = \mathbf{16\text{ mH}}$$

$$X_C = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega X_C} = \frac{1}{(377\text{ rad/s})(10\ \Omega)} = \mathbf{265\ \mu F}$$

d. $$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{50\text{ V} \angle 0°}{5.66\ \Omega \angle -45°} = \mathbf{8.83\text{ A} \angle 45°}$$

$\mathbf{V}_R = (I \angle \theta)(R \angle 0°) = (8.83\text{ A} \angle 45°)(4\ \Omega \angle 0°) = \mathbf{35.32\text{ V} \angle 45°}$
$\mathbf{V}_L = (I \angle \theta)(X_L \angle 90°) = (8.83\text{ A} \angle 45°)(6\ \Omega \angle 90°) = \mathbf{52.98\text{ V} \angle 135°}$
$\mathbf{V}_C = (I \angle \theta)(X_C \angle -90°) = (8.83\text{ A} \angle 45°)(10\ \Omega \angle -90°) = \mathbf{88.30\text{ V} \angle -45°}$

f. $\mathbf{E} = \mathbf{V}_R + \mathbf{V}_L + \mathbf{V}_C$
$50\text{ V} \angle 0° = 35.32\text{ V} \angle 45° + 52.98\text{ V} \angle 135° + 88.30\text{ V} \angle -45°$
$50\text{ V} \angle 0° = 49.95\text{ V} \angle 0° \cong 50\text{ V} \angle 0°$

g. $P = I^2R = (8.83\text{ A})^2\ 4\ \Omega = \mathbf{311.88\ W}$

h. $F_p = \cos\theta_T = \dfrac{R}{Z_T} = 4\ \Omega/5.66\ \Omega = \mathbf{0.707\ leading}$

i. $i = \mathbf{12.49\ \sin(377t + 45°)}$
$e = \mathbf{70.7\ \sin 377t}$
$\upsilon_R = \mathbf{49.94\ \sin(377t + 45°)}$
$\upsilon_L = \mathbf{74.91\ \sin(377t + 135°)}$
$\upsilon_C = \mathbf{124.86\ \sin(377t - 45°)}$

18. a. $X_L = \omega L = (20 \times 10^3\text{ rad/s})(0.1\text{H}) = 2\text{ k}\Omega$
$X_C = \dfrac{1}{\omega C} = \dfrac{1}{(20\times 10^3\text{ rad/s})(8200\text{ pF})} = 6.1\text{ k}\Omega$
$\mathbf{Z}_T = 1.2\text{ k}\Omega + j2\text{ k}\Omega - j6.1\text{ k}\Omega$
$= \mathbf{1.2\ k\Omega - j4.1\ k\Omega = 4.27\ k\Omega \angle -73.69°}$

b. –

c. –

d. $\mathbf{I} = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{4.24\text{ V} \angle 60°}{4.27\text{ k}\Omega \angle -73.69°} = \mathbf{0.993\ mA \angle 133.69°}$
$\mathbf{V}_R = \mathbf{IR} = (0.993\text{ mA} \angle 133.69°)(1.2\text{ k}\Omega \angle 0°) = \mathbf{1.19\ V \angle 133.69°}$
$\mathbf{V}_L = \mathbf{IX}_L = (0.993\text{ mA} \angle 133.69°)(2\text{ k}\Omega \angle 90°) = \mathbf{1.99\ V \angle 223.69°}$
$\mathbf{V}_C = \mathbf{IX}_C = (0.993\text{ mA} \angle 133.69°)(6.1\text{ k}\Omega \angle -90°) = \mathbf{6.06\ V \angle 43.69°}$

e. –

f. $\mathbf{E} = \mathbf{V}_R + \mathbf{V}_L + \mathbf{V}_C$
$4.24\text{ V} \angle 60° = 1.19\text{ V} \angle 133.69° + 1.99\text{ V} \angle 223.69° + 6.06\text{ V} \angle 43.69°$
$= (-0.822\text{ V} + j0.80\text{ V}) + (-1.44\text{ V} - j1.37\text{ V}) + (4.38\text{ V} + j\ 4.19\text{ V})$
$= 2.12\text{ V} + j3.62\text{ V}$
$\mathbf{4.24\ V \angle 60° \cong 4.20\ V \angle 59.65°}$

g. $P = I^2R = (0.993\text{ mA})^2(1.2\text{ k}\Omega) = \mathbf{1.18\ mW}$

h. $F_p = \dfrac{R}{Z_T} = \dfrac{1.2\text{ k}\Omega}{4.27\text{ k}\Omega} = \mathbf{0.281\ leading}$

i. $i = \mathbf{1.4 \times 10^{-3}\ \sin(20{,}000t + 133.69°)}$
$\upsilon_R = \mathbf{1.68\ \sin(20{,}000t + 133.69°)}$
$\upsilon_L = \mathbf{2.81\ \sin(20{,}000t + 223.69°)}$
$\upsilon_C = \mathbf{8.57\ \sin(20{,}000t + 43.69°)}$

19. a. $\mathbf{Z}_T = 30\ \Omega + j100\ \Omega - j20\ \Omega$
$= 30\ \Omega + j80\ \Omega$
$= \mathbf{85.44\ \Omega \angle 69.44°}$

b. $\mathbf{I}_s = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{40\text{ V} \angle 60°}{85.44\ \Omega \angle 69.44°} = 468.16\text{ mA} \angle -9.44°$

c. $\mathbf{V}_R = \mathbf{I}_R\mathbf{R} = \mathbf{I}_s\mathbf{R} = (468.16\text{ mA} \angle -9.44°)(30\ \Omega \angle 0°)$
$= \mathbf{14.04\ V \angle -9.44°}$

d. $F_p = \cos\theta_T = \dfrac{R}{Z_T} = \dfrac{30\ \Omega}{85.44\ \Omega} = \mathbf{0.351\ lagging}$

20. a. $\mathbf{Z}_T = 8\ \Omega + j34\ \Omega - j16\ \Omega$
$= 8\ \Omega + j18\ \Omega$
$= 19.7\ \Omega \angle 66.04°$
$\mathbf{I}_s = \mathbf{I}_L = \dfrac{\mathbf{E}_T}{\mathbf{Z}_T} = \dfrac{48\text{ V} \angle 0° - 32\text{ V} \angle 45°}{19.7\ \Omega\ \angle 66.04°}$
$= \dfrac{48\text{ V} - (22.63\text{ V} + j22.63\text{ V})}{19.7\ \Omega\ \angle 66.04°}$
$= \dfrac{25.37\text{ V} - j22.63\text{ V}}{19.7\ \Omega\ \angle 66.04°} = \dfrac{33.99\text{ V} \angle -41.729°}{19.7\ \Omega\ \angle 66.04°}$
$\mathbf{I}_L = \mathbf{1.726\ A \angle -107.77°}$

b. $\mathbf{V}_C = \mathbf{I}_C\mathbf{X}_C = \mathbf{I}_s\mathbf{X}_C$
$= (1.726\text{ A} \angle -107.77°)(16\ \Omega \angle -90°)$
$\mathbf{V}_C = \mathbf{27.62\ V \angle -197.77°}$

21. a. $\mathbf{I}_{L_1} = \mathbf{I}_s = 5\text{ mA} \angle 30°$

b. $\mathbf{Z}_T = 2\text{ k}\Omega + 3\text{ k}\Omega + j8\text{ k}\Omega + j4\text{ k}\Omega - j4\text{ k}\Omega$
$= 5\text{ k}\Omega + j8\text{ k}\Omega$
$= 9.43\text{ k}\Omega \angle 58°$
$\mathbf{V}_s = \mathbf{I}\mathbf{Z}_T$
$= (5\text{ mA} \angle 30°)(9.43\text{ k}\Omega \angle 58°)$
$= \mathbf{47.15\ V \angle 88°}$

c. $\mathbf{V}_{R_1} = \mathbf{I}\mathbf{R}_1 = (5\text{ mA} \angle 30°)(2\text{ k}\Omega \angle 0°)$
$= \mathbf{10\ V \angle 30°}$

22. 20 V (rms) $\Rightarrow$ 28.28 V (peak)
43.20 V($p - p$) $\Rightarrow$ 21.60 V (peak)

$V_{\text{scope}} = 21.60\text{ V} = \dfrac{22\ \Omega(28.28\text{ V})}{22\ \Omega + R}$
$475.20 + 21.60R = 622.16$

$$R = \frac{146.96\ \Omega}{21.60} = \mathbf{6.8\ \Omega}$$

23. a. $$V_L\,(\text{rms}) = 0.7071\left(\frac{22.8\ \text{V}}{2}\right) = 8.06\ \text{V}$$

$$X_L = \frac{V_L(\text{rms})}{I\ (\text{rms})} = \frac{8.06\ \text{V}}{1.3\ \text{mA}} = 6.2\ \text{k}\Omega$$

$$X_L = \omega L = (1000\text{rad/s})L = 6.2\ \text{k}\Omega \Rightarrow L = \frac{6.2\ \text{k}\Omega}{1000\ \text{rad/s}} = \mathbf{6.2\ H}$$

b. $$E^2 = V_R^2 + V_L^2$$

$$(22\ \text{V})^2 = V_R^2 + (8.06\ \text{V})^2$$

$$484 = V_R^2 + 64.96$$

$$V_R^2 = 419.04$$

$$V_R = \sqrt{419.04} = 20.47\ \text{V}$$

$$R = \frac{V_R(\text{rms})}{I(\text{rms})} = \frac{20.47\ \text{V}}{1.3\ \text{mA}} = \mathbf{15.75\ k\Omega}$$

c. **6.2 H**

24. a. $$V_R(\text{rms}) = 0.7071\left(\frac{8.27\ \text{V}}{2}\right) = 2.924\ \text{V}$$

$$I(\text{rms}) = \frac{V_R(\text{rms})}{R_2} = \frac{2.924\ \text{V}}{10\ \text{k}\Omega} = \mathbf{292.4\ \mu A}$$

b. $$E^2 = V_R^2 + V_C^2$$

$$(12\ \text{V})^2 = (2.924\ \text{V})^2 + V_C^2$$

$$144 = 8.55 + V_C^2$$

$$V_C^2 = 135.35$$

$$V_C = \sqrt{135.45} = 11.64\ \text{V}$$

$$X_C = \frac{V_C(\text{rms})}{I\ (\text{rms})} = \frac{11.64\ \text{V}}{292.4\ \mu\text{A}} = 39.81\ \text{k}\Omega$$

$$X_C = \frac{1}{2\pi fC} \Rightarrow C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi\,(40\ \text{kHz})(39.81\ \text{k}\Omega)} = \mathbf{100\ pF}$$

25. $$P = VI\cos\theta \Rightarrow 8000\ \text{W} = (200\ \text{V})(I)(0.8)$$

$$I = \frac{8000\ \text{A}}{160} = 50\ \text{A}$$

$$0.8 = \cos\theta$$

$\theta = 36.87°$

$\mathbf{V} = 200\text{ V} \angle 0°,\ I = 50\text{ A} \angle -36.87°$

$$\mathbf{Z}_T = \frac{\mathbf{V}}{\mathbf{I}} = \frac{200\text{ V} \angle 0°}{50\text{ A} \angle -36.87°} = 4\ \Omega \angle 36.87° = \mathbf{3.2\ \Omega + j2.4\ \Omega}$$

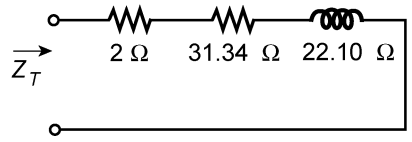
26. $P = VI\cos\theta \Rightarrow 300\text{ W} = (120\text{ V})(3\text{ A})\cos\theta$

$\cos\theta = 0.833 \Rightarrow \theta = \mathbf{33.59°}$

$\mathbf{V} = 120\text{ V} \angle 0°,\ \mathbf{I} = 3\text{ A} \angle -33.59°$

$$\mathbf{Z}_T = \frac{\mathbf{V}}{\mathbf{I}} = \frac{120\text{ V} \angle 0°}{3\text{ A} \angle -33.59°} = 40\ \Omega \angle 33.59° = \mathbf{33.34\ \Omega + j22.10\ \Omega}$$

$R_T = 33.34\ \Omega = 2\ \Omega + R \Rightarrow R = 31.34\ \Omega$



27. a. $$\mathbf{V}_1 = \frac{(2\text{ k}\Omega \angle 0°)(120\text{ V} \angle 60°)}{2\text{ k}\Omega + j8\text{ k}\Omega} = \frac{240\text{ V} \angle 60°}{8.25 \angle 75.96°} = \mathbf{29.09\text{ V} \angle -15.96°}$$

$$\mathbf{V}_2 = \frac{(8\text{ k}\Omega \angle 90°)(120\text{ V} \angle 60°)}{8.25\text{ k}\Omega \angle 75.96°} = \mathbf{116.36\text{ V} \angle 74.04°}$$

b. $$\mathbf{V}_1 = \frac{(40\ \Omega \angle 90°)(60\text{ V} \angle 5°)}{6.8\ \Omega + j40\ \Omega + 22\ \Omega} = \frac{2400\text{ V} \angle 95°}{28.8 + j40} = \mathbf{48.69\text{ V} \angle 40.75°}$$

$$\mathbf{V}_2 = \frac{(22\ \Omega \angle 0°)(60\text{ V} \angle 5°)}{49.29\ \Omega \angle 54.25°} = \frac{1.32\text{ kV} \angle 5°}{49.29\ \Omega \angle 54.25°} = \mathbf{26.78\text{ V} \angle -49.25°}$$

28. a. $$\mathbf{V}_1 = \frac{(20\ \Omega \angle 90°)(20\text{ V} \angle 70°)}{20\ \Omega + j20\ \Omega - j40} = \mathbf{14.14\text{ V} \angle -155°}$$

$$\mathbf{V}_2 = \frac{(40\ \Omega \angle -90°)(20\text{ V} \angle 70°)}{28.28\ \Omega \angle -45°} = \mathbf{28.29\text{ V} \angle 25°}$$

b. $\mathbf{Z}_T = 4.7\text{ k}\Omega + j30\text{ k}\Omega + 3.3\text{ k}\Omega - j10\text{ k}\Omega = 8\text{ k}\Omega + j20\text{ k}\Omega = 21.541\text{ k}\Omega \angle 68.199°$

$\mathbf{Z}'_T = 3.3\text{ k}\Omega + j30\text{ k}\Omega - j10\text{ k}\Omega = 3.3\text{ k}\Omega + j20\text{ k}\Omega = 20.27\text{ k}\Omega \angle 80.631°$

$$\mathbf{V}_1 = \frac{\mathbf{Z}'_T\mathbf{E}}{\mathbf{Z}_T} = \frac{(20.27\text{ k}\Omega \angle 80.631°)(120\text{ V} \angle 0°)}{21.541\text{ k}\Omega \angle 68.199°} = \mathbf{112.92\text{ V} \angle 12.432°}$$

$$\mathbf{V}_2 = \frac{\mathbf{Z}''_T\mathbf{E}}{\mathbf{Z}_T} \qquad \mathbf{Z}''_T = 3.3\text{ k}\Omega - j10\text{ k}\Omega = 10.53\text{ k}\Omega \angle -71.737°$$

$$= \frac{(10.53\text{ k}\Omega \angle -71.737°)(120\text{ V} \angle 0°)}{21.541\text{ k}\Omega \angle 68.199°} = \mathbf{58.66\text{ V} \angle -139.94°}$$

29. a. $X_L = \omega L = (1000\text{ rad/s})(20\text{ mH}) = 20\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{(1000\text{ rad/s})(39\ \mu\text{F})} = 25.64\ \Omega$$

$\mathbf{Z}_T = 30\ \Omega + j20\ \Omega - j25.64\ \Omega = 30\ \Omega - j5.64\ \Omega = \mathbf{30.53\ \Omega \angle -10.65°}$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{20\text{ V}\angle 40°}{30.53\,\Omega\angle -10.65°} = \mathbf{655.1\text{ mA}\angle 50.65°}$$

$\mathbf{V}_R = (I\angle\theta)(R\angle 0°) = (655.1\text{ mA}\angle 50.65°)(30\,\Omega\angle 0°) = \mathbf{19.65\text{ V}\angle 50.65°}$

$\mathbf{V}_C = (655.1\text{ mA}\angle 50.65°)(25.64\,\Omega\angle -90°) = \mathbf{16.80\text{ V}\angle -39.35°}$

b. $\cos\theta_T = \dfrac{R}{Z_T} = \dfrac{30\,\Omega}{30.53\,\Omega} = \mathbf{0.983\text{ leading}}$

c. $P = I^2R = (655.1\text{ mA})^2\,30\,\Omega = \mathbf{12.87\text{ W}}$

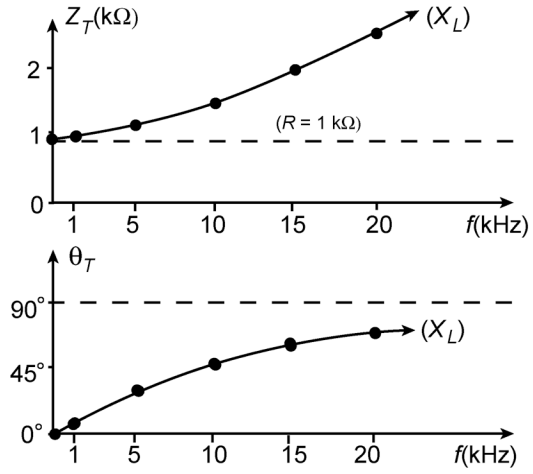
f. $\mathbf{V}_R = \dfrac{(30\,\Omega\angle 0°)(20\text{ V}\angle 40°)}{\mathbf{Z}_T} = \dfrac{600\text{ V}\angle 40°}{30.53\,\Omega\angle -10.65°} = \mathbf{19.66\text{ V}\angle 50.65°}$

$\mathbf{V}_C = \dfrac{(25.64\,\Omega\angle -90°)(20\text{ V}\angle 40°)}{30.53\,\Omega\angle -10.65°} = \mathbf{16.80\text{ V}\angle -39.35°}$

g. $\mathbf{Z}_T = \mathbf{30\,\Omega - j5.64\,\Omega} = R - jX_C$

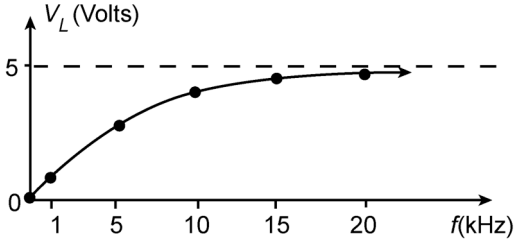
30. a. $\mathbf{Z}_T = \sqrt{R^2 + X_L^2}\,\angle\tan^{-1}X_L/R$

f	Z_T	θ_T
0 Hz	1.0 kΩ	0.0°
1 kHz	1.008 kΩ	7.16°
5 kHz	1.181 kΩ	32.14°
10 kHz	1.606 kΩ	51.49°
15 kHz	2.134 kΩ	62.05°
20 kHz	2.705 kΩ	68.3°



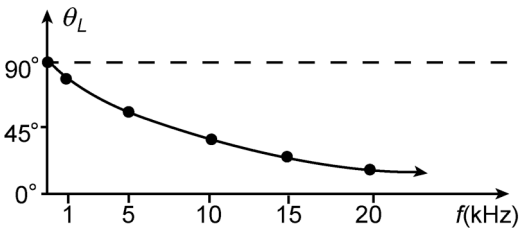
b. $V_L = \dfrac{X_L E}{Z_T}$

f	V_L
0 Hz	0.0 V
1 kHz	0.623 V
5 kHz	2.66 V
10 kHz	3.888 V
15 kHz	4.416 V
20 kHz	4.646 V



c.

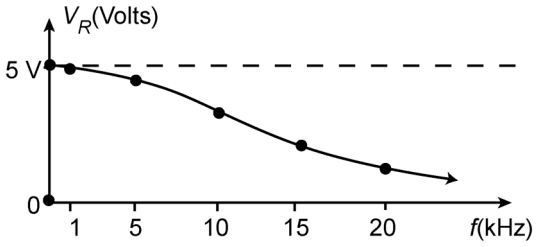
f	$\theta_L = 90° - \tan^{-1}X_L/R$
0 Hz	90.0°
1 kHz	82.84°



5 kHz	57.85°
10 kHz	38.5°
15 kHz	27.96°
20 kHz	21.7°

d.

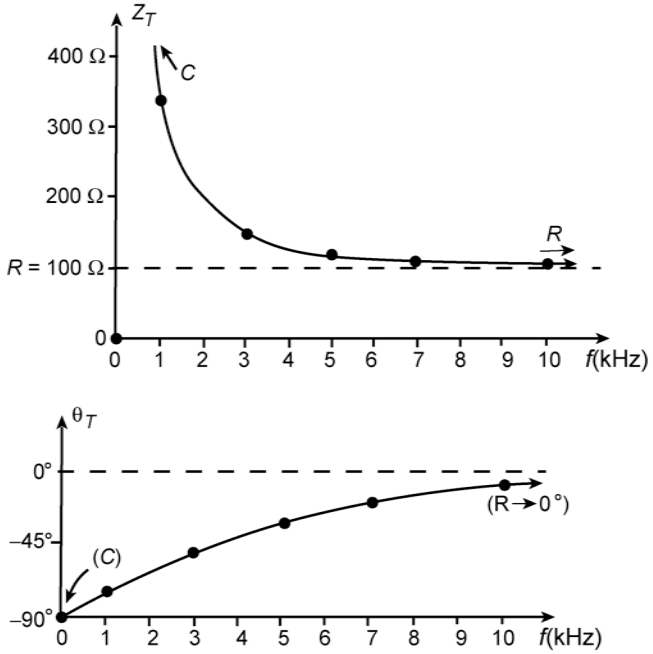
f	$V_R = RE/Z_T$
0 Hz	5.0 V
1 kHz	4.96 V
5 kHz	4.23 V
10 kHz	3.11 V
15 kHz	2.34 V
20 kHz	1.848 V



31. a. $\mathbf{Z}_T = \sqrt{R^2 + X_C^2}\ \angle -\tan^{-1} X_C/R$

$|Z_T| = \sqrt{R^2 + X_C^2}$, $\theta_T = -\tan^{-1} X_C/R$

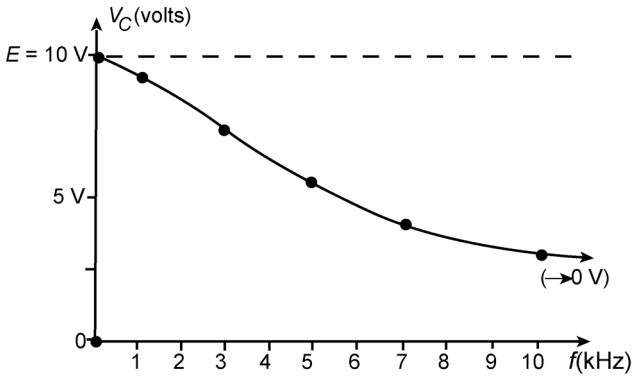
f	$\lvert\boldsymbol{Z}_T\rvert$	θ_T
0 kHz	∞ Ω	–90.0°
1 kHz	353.1 Ω	–73.55°
3 kHz	150.80 Ω	–48.46°
5 kHz	120.78 Ω	–34.11°
7 kHz	111.09 Ω	–25.82°
10 kHz	105.58 Ω	–18.71°



b. $$\mathbf{V}_C = \frac{(X_C \angle -90°)(E \angle 0°)}{R - jX_C} = \frac{X_C E}{\sqrt{R^2 + X_C^2}} \angle -90° + \tan^{-1} X_C/R$$

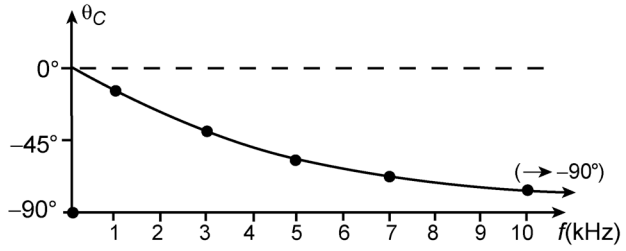
$$|V_C| = \frac{X_C E}{\sqrt{R^2 + X_C^2}}$$

f	$\lvert V_C \rvert$
0 Hz	10.0 V
1 kHz	9.59 V
3 kHz	7.49 V
5 kHz	5.61 V
7 kHz	4.36 V
10 kHz	3.21 V



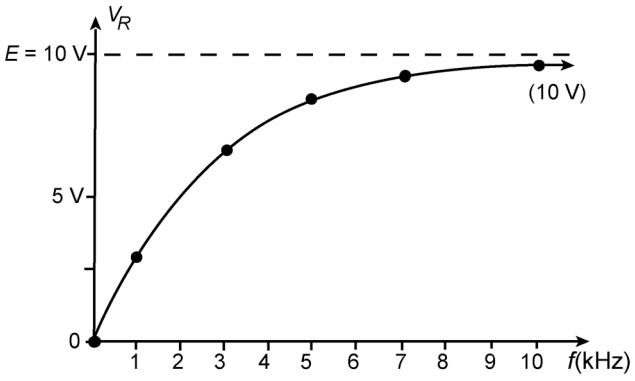
c. $\theta_C = -90° + \tan^{-1} X_C/R$

f	θ_C
0 Hz	0.0°
1 kHz	−16.45°
3 kHz	−41.54°
5 kHz	−55.89°
7 kHz	−64.18°
10 kHz	−71.29°



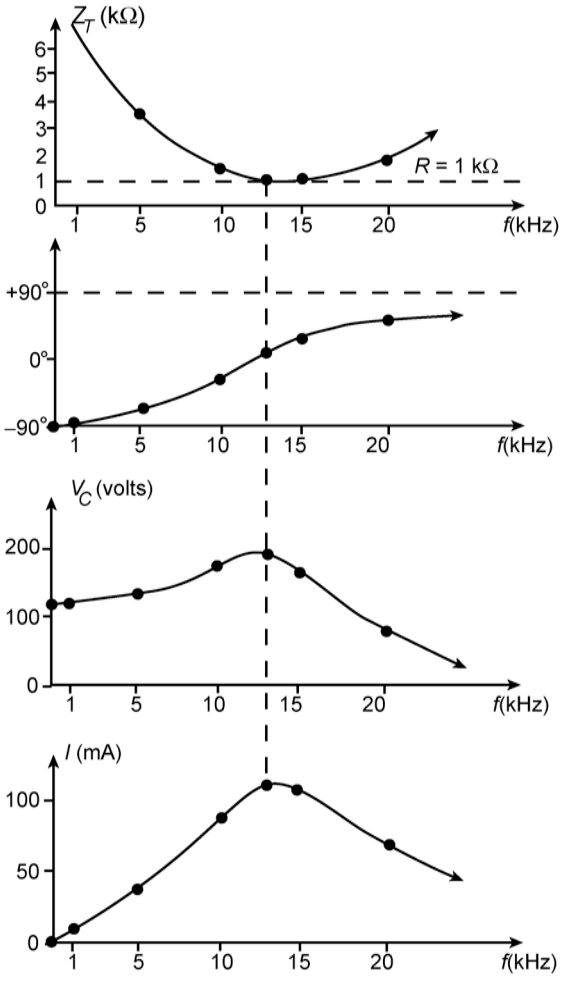
d. $$|V_R| = \frac{RE}{\sqrt{R^2 + X_C^2}}$$

f	$\lvert V_R \rvert$
0 Hz	0.0 V
1 kHz	2.83 V
3 kHz	6.63 V
5 kHz	8.28 V
7 kHz	9.00 V
10 kHz	9.47 V



32. a. $\mathbf{Z}_T = \sqrt{R^2 + (X_L - X_C)^2}\,\angle \tan^{-1}(X_L - X_C)/R$

f	Z_T	θ_T
0 Hz	$\infty\ \Omega$	−90.0°
1 kHz	$19.31 \times 10^3\ \Omega$	−87.03°
5 kHz	$3.40 \times 10^3\ \Omega$	−72.91°
10 kHz	$1.21 \times 10^3\ \Omega$	−34.33°
15 kHz	$1.16 \times 10^3\ \Omega$	+30.75°
20 kHz	$1.84 \times 10^3\ \Omega$	+56.99°



b. $|V_C| = \dfrac{X_C E}{Z_T}$

f	$\lvert V_C \rvert$
0 Hz	120 V
1 kHz	120.62 V
5 kHz	136.94 V
10 kHz	192.4 V
15 kHz	133.45 V
20 kHz	63.29 V

c. $|\ I\ | = \dfrac{E}{Z_T}$

f	I
0 Hz	0.0 mA
1 kHz	6.21 mA
5 kHz	35.29 mA
10 kHz	99.17 mA
15 kHz	103.45 mA
20 kHz	65.22 mA

33. a. $X_C = \dfrac{1}{2\pi f C} = R \Rightarrow f = \dfrac{1}{2\pi RC} = \dfrac{1}{2\pi(220\ \Omega)(0.47\ \mu\text{F})} = \mathbf{1.54\ kHz}$

b. Low frequency: X_C very large resulting in large Z_T
High frequency: X_C approaches zero ohms and Z_T approaches R

c. $f = 100$ Hz: $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(100\ \text{Hz})(0.47\ \mu\text{F})} = 3.39\ \text{k}\Omega$

$Z_T \cong X_C$

$f = 10$ kHz: $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(10\ \text{kHz})(0.47\ \mu\text{F})} = 33.86\ \Omega$

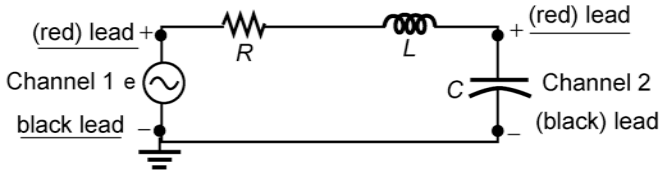
$Z_T \cong R$

d. –

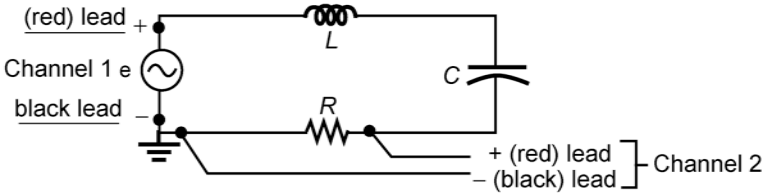
e. $f = 40$ kHz: $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(40\ \text{kHz})(0.47\ \mu\text{F})} = 8.47\ \text{k}\Omega$

$\theta = -\tan^{-1}\dfrac{X_C}{R} = -\tan^{-1}\dfrac{8.47\ \Omega}{220\ \Omega} = \mathbf{-2.2°}$

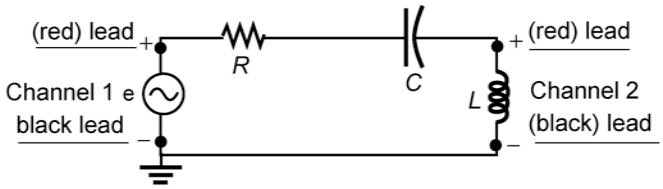
34. a.



b.



c.



35. (I): (a) $\theta_{\text{div.}} = 0.8$ div., $\theta_T = 4$ div.

$\theta = \dfrac{0.8\ \text{div.}}{4\ \text{div.}} \times 360° = 72°$

v_1 leads v_2 by 72°

(b) v_1: peak-to-peak = (5 div.)(0.5 V/div.) = **2.5 V**

$$V_1(\text{rms}) = 0.7071\left(\frac{2.5\text{ V}}{2}\right) = \mathbf{0.88\text{ V}}$$

v_2: peak-to-peak = (2.4 div.)(0.5 V/div.) = **1.2 V**

$$V_2(\text{rms}) = 0.7071\left(\frac{1.2\text{ V}}{2}\right) = \mathbf{0.42\text{ V}}$$

(c) T = (4 div.)(0.2 ms/div.) = 0.8 ms

$$f = \frac{1}{T} = \frac{1}{0.8\text{ ms}} = \mathbf{1.25\text{ kHz}} \text{ (both)}$$

(II): (a) $\theta_{\text{div.}} = 2.2$ div., $\theta_T = 6$ div.

$$\theta = \frac{2.2\text{ div.}}{6\text{ div.}} \times 360° = 132°$$

v_1 leads v_2 by 132°

(b) v_1: peak-to-peak = (2.8 div.)(2 V/div.) = **5.6 V**

$$V_1(\text{rms}) = 0.7071\left(\frac{5.6\text{ V}}{2}\right) = \mathbf{1.98\text{ V}}$$

v_2: peak-to-peak = (4 div.)(2 V/div.) = **8 V**

$$V_2(\text{rms}) = 0.7071\left(\frac{8\text{ V}}{2}\right) = \mathbf{2.83\text{ V}}$$

(c) T = (6 div.)(10 μs/div.) = 60 μs

$$f = \frac{1}{T} = \frac{1}{60\ \mu\text{s}} = \mathbf{16.67\text{ kHz}}$$