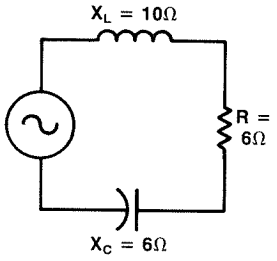
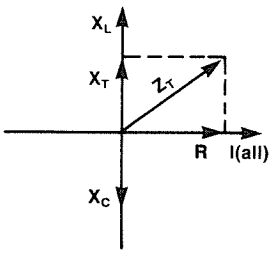
Worked-Out Examples

1. Draw a phasor diagram for this circuit showing current and impedance phasors.



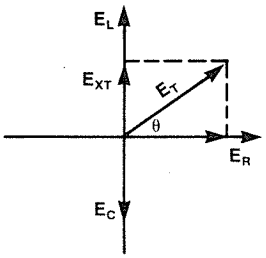
Solution:



$X_L > X_C$; therefore, X_T is plotted in phase with X_L

2. Draw voltage phasor diagrams for the circuit in Example 1. Calculate the value and sign of the phase angle.

Solution:



$$\tan \theta = \frac{E_{XT}}{E_R} = \frac{X_T}{R} = \frac{4\Omega}{6\Omega} = 0.667$$

$$\arctan 0.667 = \mathbf{33.7°}$$

The angle is rotated counterclockwise; therefore, the sign of the angle is positive.

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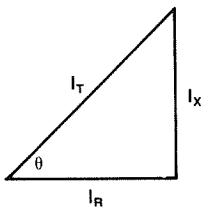
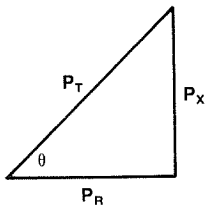
3. Draw phasor diagrams showing Pythagorean theorem relationships in parallel RLC circuits. Write equations for each solution.

Solution:

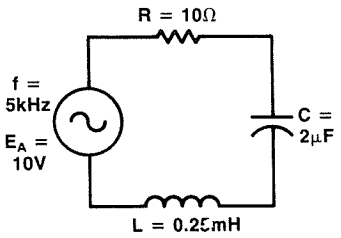




$$I_T = \sqrt{I_R^2 + I_X^2}$$
$$= \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$P_T = \sqrt{P_R^2 + P_X^2}$$
$$= \sqrt{P_R^2 + (P_L - P_C)^2}$$

4. Given the circuit and typical circuit values shown, calculate the circuit values specified.



a. X_L = _____ h. E_R = _____
b. X_C = _____ i. P_L = _____
c. X_T = _____ j. P_C = _____
d. Z_T = _____ k. P_R = _____
e. I_T = _____ l. P_X = _____
f. E_L = _____ m. P_A = _____
g. E_C = _____ n. Phase angle = _____

Solution:

a. $X_L = 2\pi fL = 6.28 \times 5 \times 10^3 \times 0.25 \times 10^{-3} = \mathbf{7.85\Omega}$

b. $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{6.28 \times 5 \times 10^3 \times 2 \times 10^{-6}} = \dfrac{1}{6.28 \times 10^{-2}} = \mathbf{15.9\Omega}$

c. $X_T = X_L - X_C = 7.85\Omega - 15.9\Omega = \mathbf{8.05\Omega}$

d. $Z_T = \sqrt{R^2 + X_T^2} = \sqrt{10^2 + 8.05^2} = \sqrt{1.65 \times 10^2} = \mathbf{12.8\Omega}$

e. $I_T = \dfrac{E_A}{Z_T} = \dfrac{10\text{VAC}}{12.8\Omega} = \mathbf{0.781A_{rms}}$

f. $E_L = I_T X_L = 0.781\text{A} \times 7.85\Omega = \mathbf{6.13VAC}$

g. $E_C = I_T X_C = 0.781\text{A} \times 15.9\Omega = \mathbf{12.4VAC}$

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h. $E_R = I_T R = 0.781A \times 10\Omega = \mathbf{7.81VAC}$

i. $P_L = I_T E_L = 0.781A \times 6.13V = \mathbf{4.79VAR_{rms}}$

j. $P_C = I_T E_C = 0.781A \times 12.4V = \mathbf{9.68VAR_{rms}}$

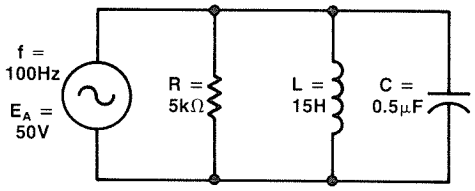
k. $P_R = I_T E_R = 0.781A \times 7.81V = \mathbf{6.1W_{rms}}$

l. $P_X = P_L - P_C = 4.79VAR - 9.68VAR = \mathbf{4.89VAR_{rms}}$

m. $P_A = \sqrt{P_R^2 + P_X^2} = \sqrt{6.1W^2 + 4.89VAR^2} = \sqrt{6.11} = \mathbf{7.82VA_{rms}}$

n. phase angle $= \arctan\left(\frac{X_T}{R}\right) = \arctan 0.805 = \mathbf{-38.8°}$

5. Given this circuit and typical circuit values shown, calculate the circuit values specified.



a. X_L = _____ h. P_R = _____

b. X_C = _____ i. P_L = _____

c. I_R = _____ j. P_C = _____

d. I_L = _____ k. P_X = _____

e. I_C = _____ l. P_A = _____

f. I_X = _____ m. Phase angle = _____

g. I_T = _____

Solution:

a. $X_L = 2\pi fL = 6.28 \times 100 \times 15 = \mathbf{9.42k\Omega}$

b. $X_C = \frac{1}{2\pi fC} = \frac{1}{6.28 \times 100 \times 0.5 \times 10^{-6}} = \frac{1}{3.14 \times 10^{-4}} = \mathbf{3.18k\Omega}$

c. $I_R = \frac{E_A}{R} = \frac{50VAC}{5k\Omega} = \mathbf{10mA_{rms}}$

d. $I_L = \frac{E_A}{X_L} = \frac{50VAC}{9.42k\Omega} = \mathbf{5.31mA_{rms}}$

e. $I_C = \frac{E_A}{X_C} = \frac{50VAC}{3.18k\Omega} = \mathbf{15.7mA_{rms}}$

f. $I_X = I_L - I_C = 5.31mA - 15.7mA = \mathbf{10.4mA}$

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g. $I_T = \sqrt{I_R^2 + I_X^2} = \sqrt{10mA^2 + 10.4mA^2} = \mathbf{14.4mA_{rms}}$

h. $P_R = I_R E_A = 10mA \times 50V = \mathbf{0.5W_{rms}}$

i. $P_L = I_L E_A = 5.31mA \times 50V = \mathbf{0.27VAR_{rms}}$

j. $P_C = I_C E_A = 15.7mA \times 50V = \mathbf{0.79VAR_{rms}}$

k. $P_X = P_L - P_C = 0.27VAR - 0.79VAR = \mathbf{0.52VAR_{rms}}$

l. $P_A = \sqrt{P_R^2 + P_X^2} = \sqrt{0.5W^2 + 0.52VAR^2} = \sqrt{0.52} = \mathbf{0.72VA_{rms}}$ or

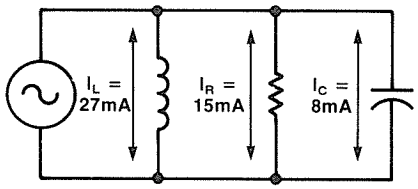
$P_A = I_T E_A = 14.4mA \times 50V = \mathbf{0.72VA_{rms}}$

m. $\tan\theta = \frac{I_X}{I_R} = \frac{10.4mA}{10mA} = \mathbf{1.04}$

$\arctan 1.04 = \mathbf{46.1°}$

Practice Problems

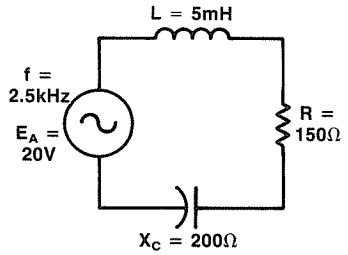
1. Draw a phasor diagram for this circuit showing voltage and current phasors.



2. Draw power phasor diagrams for the circuit in problem 1. Calculate the value and sign of the phase angle.

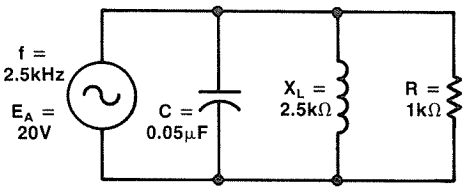
3. Draw phasor diagrams showing Pythagoren theorem relationships in series RLC circuits. Write equations for each solution.

4. Given the circuit and typical circuit values below, calculate the circuit values specified.



a. X_L = _____ g. E_C = _____
b. X_T = _____ h. P_R = _____
c. Z_T = _____ i. P_L = _____
d. I_T = _____ j. P_C = _____
e. E_R = _____ k. P_A = _____
f. E_L = _____ l. Phase angle = _____

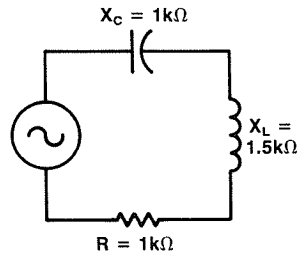
5. Given this circuit and typical circuit values shown, calculate the circuit values specified.



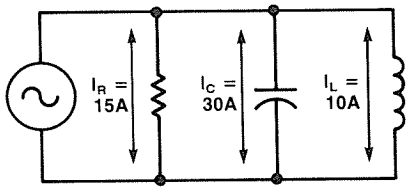
a. X_C = _____ g. P_R = _____
b. I_R = _____ h. P_L = _____
c. I_L = _____ i. P_C = _____
d. I_C = _____ j. P_X = _____
e. I_X = _____ k. P_A = _____
f. I_T = _____ l. Phase angle = _____

Quiz

1. Draw a phasor diagram for this circuit showing power and current phasors.



2. Draw a phasor diagram for this circuit showing power and voltage phasors.



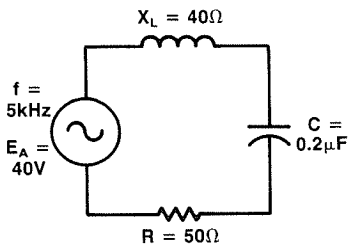
3. Calculate the value and sign of the phase angle in the circuit of Problem 1.

4. Calculate the value and sign of the phase angle in the circuit of Problem 2.

5. Calculate the value of Z_T in Problem 1.

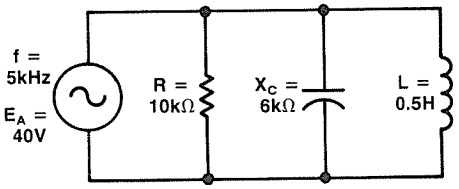
6. Calculate the value of I_T in Problem 2.

7. Given this circuit and typical circuit values shown, calculate the circuit values specified.



a. X_C = _____
b. X_T = _____
c. Z_T = _____
d. I_T = _____
e. E_R = _____
f. E_L = _____
g. E_C = _____
h. P_R = _____
i. P_L = _____
j. P_C = _____
k. P_A = _____
l. Phase angle = _____

8. Given this circuit and typical values shown, calculate the circuit values specified.



a. X_L = _____
b. I_R = _____
c. I_L = _____
d. I_C = _____
e. I_T = _____
f. P_R = _____
g. P_L = _____
h. P_C = _____
i. P_X = _____
j. P_A = _____
k. Phase angle = _____

9. In a series RCL circuit, which component will have the most voltage across it?

10. In a parallel RCL circuit, which component will have the most current through it?