36 AC Circuits

36.1 AC Sources and Phasors

1. The figure shows emf phasors A, B, and C.
   a. What is the instantaneous value of the emf? "\( r \)\"x\( r \)xis \( r \)\ol{c} of \( r \)\.
      \[ \text{A} \quad \text{B} \quad \text{C} \]
      \[ \begin{array}{c}
          60 \sqrt{ } & -100 \sqrt{ } & 80 \sqrt{ } \\
        \end{array} \]
   b. At this instant, is the magnitude of the emf increasing, decreasing, or holding constant?
      \[ \text{A} \quad \text{B} \quad \text{C} \]
      \[ \text{dec.} \quad \text{dec.} \quad \text{inc.} \]

2. Draw a phasor diagram for the following emfs.
   a. \((100 \text{V}) \cos \omega t\) at \(\omega t = 240^\circ\)  
   b. \((400 \text{V}) \cos \omega t\) at \(t = \frac{1}{3}T\)  
   c. \((200 \text{V}) \cos \omega t\) at \(t = 0\)

3. The current phasor is shown for a 10 Ω resistor.
   a. What is the instantaneous resistor voltage \(v_R\)?
      \[ i = -4A \quad V = iR = 40 \text{V} \]
   b. What is the peak resistor voltage \(V_R\)?
      \[ i_p = 5A \quad V = iR = 50 \text{V} \]
4. The peak current through a resistor is 4.0 A. What is the peak current if:
   a. The resistance $R$ is doubled?
      \[ I = \frac{V}{R} \quad R \uparrow 2x \quad I \uparrow 2x \]  
      \( 2 \text{ A} \)  
   
   b. The peak emf $\varepsilon_0$ is doubled?
      \[ I \uparrow 2x. \]  
      \( 8 \text{ A} \)  
   
   c. The frequency $\omega$ is doubled?
      \[ (4 \text{ A}) \quad \text{No effect}. \]

36.2 Capacitor Circuits

5. The peak current through a capacitor is 4.0 A. What is the peak current if:
   a. The peak emf $\varepsilon_0$ is doubled?
      \[ V = \frac{1}{2x} \quad X_C = \frac{1}{\omega C} \quad \varepsilon_0 = \frac{1}{\omega C} \quad \varepsilon \uparrow 2x \quad I \uparrow 2x \]  
      \( 8 \text{ A} \)  
   
   b. The capacitance $C$ is doubled?
      \[ C \uparrow 2x \Rightarrow I \uparrow 2x. \]  
      \( 8 \text{ A} \)  
   
   c. The frequency $\omega$ is doubled?
      \[ \omega \uparrow 2x \Rightarrow I \uparrow 2x \]  
      \( 8 \text{ A} \)  

6. Current and voltage graphs are shown for a capacitor circuit with $\omega = 1000 \text{ rad/s}$.
   a. What is the capacitive reactance $X_C$?
      \[ V = \frac{1}{X_C} \quad X_C = \frac{10V}{10 \text{ mA}} = 1 \text{ k} \Omega. \]
   
   b. What is the capacitance $C$?
      \[ X_C = \frac{1}{\omega C} = 1 \text{ k} \Omega \]
      \[ C = 10^{-6} \text{ F} = 1 \mu\text{F} \]
7. A 13 μF capacitor is connected to a 5.5 V/250 Hz oscillator. What is the instantaneous capacitor current \( i_C \) when \( E = -5.5 \) V?

[Diagram showing capacitor and waveforms]

\[ \text{Leading 90° out of phase, so } i = 0 ! \]

8. Consider these three circuits.

[Diagram showing three circuits with labeled capacitances]

Rank in order, from largest to smallest, the peak currents \((I_C)_1\) to \((I_C)_3\) provided by the emf.

Order: 3, 1, 2

Explanation:

9. Consider these four circuits.

[Diagram showing four circuits with labeled frequencies and capacitances]

Rank in order, from largest to smallest, the capacitive reactances \((X_C)_1\) to \((X_C)_4\).

Order: 2, 1 = 3, 4

Explanation:

\[ X_C = \frac{1}{\omega C} \]
36.4 Inductor Circuits

14. The peak current passing through an inductor is 4.0 A. What is the peak current if:
   a. The peak emf $\mathcal{E}_0$ is doubled?
      \[ V = I \omega L \]
   b. The inductance $L$ is doubled?
      \[ V = I \omega L \]
   c. The frequency $\omega$ is doubled?
      \[ V = I \omega L \]

15. Current and voltage graphs are shown for an inductor circuit with $\omega = 1000$ rad/s.
   a. What is the inductive reactance $X_L$?
      \[ X_L = \frac{V}{I} = \frac{10 \text{ V}}{10 \text{ mA}} = 1 \text{ k}\Omega \]
   b. What is the inductance $L$?
      \[ X_L = \omega L = 1000 \text{ rad/s} \cdot L \]
      \[ L = \frac{X_L}{\omega} = \frac{1 \text{ k}\Omega}{1000 \text{ rad/s}} = 1 \text{ H} \]

16. Consider these four circuits.

   \[ \begin{array}{cccc}
   \text{1} & \text{2} & \text{3} & \text{4} \\
   \text{100 Hz} & \text{100 Hz} & \text{50 Hz} & \text{200 Hz} \\
   \mathcal{E}_0 & \mathcal{E}_0 & \mathcal{E}_0 & \mathcal{E}_0 \\
   2 \mu\text{H} & 1 \mu\text{H} & 4 \mu\text{H} & 2 \mu\text{H} \\
   \end{array} \]

   Rank in order, from largest to smallest, the inductive reactances $(X_L)_1$ to $(X_L)_4$.
   
   Order: \( 4, 1, 3, 2 \)
   
   Explanation:
   \[ X_L = \omega L \].
36.5 The Series RLC Circuit

17. The resonance frequency of a series RLC circuit is 1000 Hz. What is the resonance frequency if:
   a. The resistance $R$ is doubled?
      $\omega_0 = \frac{1}{\sqrt{LC}}$
      
   b. The inductance $L$ is doubled?
      
   c. The capacitance $C$ is doubled?
      
   d. The peak emf $\varepsilon_0$ is doubled?
      
   e. The frequency $\omega$ is doubled?

18. For these combinations of resistance and reactance, is a series RLC circuit in resonance (Yes or No)? Does the current lead the emf, lag the emf, or is it in phase with the emf?

<table>
<thead>
<tr>
<th>$R$</th>
<th>$X_L$</th>
<th>$X_C$</th>
<th>Resonance?</th>
<th>Current?</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 $\Omega$</td>
<td>100 $\Omega$</td>
<td>50 $\Omega$</td>
<td>No</td>
<td>$i$ lag, $L$ dominates</td>
</tr>
<tr>
<td>100 $\Omega$</td>
<td>50 $\Omega$</td>
<td>100 $\Omega$</td>
<td>No</td>
<td>$i$ lead, $C$ dominates</td>
</tr>
<tr>
<td>100 $\Omega$</td>
<td>75 $\Omega$</td>
<td>75 $\Omega$</td>
<td>Yes</td>
<td>in phase</td>
</tr>
</tbody>
</table>

19. In this series RLC circuit, is the emf frequency less than, equal to, or greater than the resonance frequency $\omega_0$? Explain.

$\sqrt{\text{leads } i}$, $\underline{\text{inductor dominates}}$

$\omega_L$ is "too big"

$\omega > \omega_0$
20. The resonance frequency of a series RLC circuit is greater than the emf frequency. Does the current lead or lag the emf? Explain.

\[ \omega_L \text{ is too small } (\omega < \omega_0) \]

\[ \frac{1}{\omega C} \text{ is too big. } C \text{ decreases } V \text{ lag } i. \]

\[ i \text{ leads } V, \text{ or } \mathcal{E} \]

21. Consider these four circuits. They all have the same resonance frequency \( \omega_0 \).

Rank in order, from largest to smallest, the maximum currents (\( I_{\text{max}} \)) of (1) to (4).

Order: 4, 1, 2, 3

Explanation:

Smaller \( R \), \( i \)

22. The current in a series RLC circuit lags the emf by 20°. You cannot change the emf. What two different things could you do to the circuit that would increase the power delivered to the circuit by the emf?

Voltage leads \( i \), \( \text{inductor dominates} \)

You could decrease \( L \)

or decrease \( C \)
36.6 Power in AC Circuits

23. An average power dissipated by a resistor is 4.0 W. What is \( P_{\text{avg}} \) if:
   a. The resistance \( R \) is doubled?
   \[
   P = \frac{V^2}{R} \quad R \uparrow 2 \times, \quad P \downarrow 2 \times \quad (2 \text{W})
   \]
   b. The peak emf \( E_0 \) is doubled?
   \[
   V \uparrow 2 \times, \quad V \uparrow 4 \times, \quad P \uparrow 4 \times \quad (16 \text{W})
   \]
   c. Both are doubled simultaneously?
   \[
   (8 \text{W})
   \]

24. Consider these three circuits.

Rank in order, from largest to smallest, the average powers \( P_1 \) to \( P_3 \) delivered by the three emfs.

Order: \( 3, 1, 2 \)
Explanation: