Resonance

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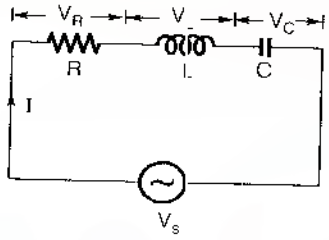
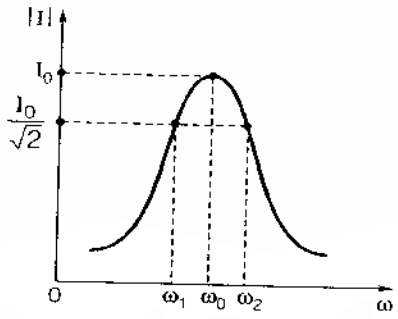
Resonance

- Resonance is the condition when the voltage across a circuit becomes in phase with the current supplied to the circuit.
- At resonance, the circuit behaves like a resistive circuit.
- Power factor of the circuit at resonance is unity.

Series Resonance





At Resonance

- $|V_L| = |V_C|$ and these are 180° out of phase
- Imaginary part of input impedance = 0

$$Z_{in}\big|_{\omega=\omega_0} = R \quad \text{.....minimum}$$

$$I\big|_{\omega=\omega_0} = \frac{V_s}{R} \quad \text{.....maximum}$$

where, $\omega_0 = \frac{1}{\sqrt{LC}}$ = Resonant frequency in rad/sec

Remember:

- For $\omega < \omega_0$, series RLC circuit behaves like an RC circuit.
- For $\omega > \omega_0$, series RLC circuit behaves like an RL circuit.
- For $\omega = \omega_0$, series RLC circuit behaves as resisitve circuit.

Bandwidth

The bandwidth of the network represent the range of the frequencies at which the current drawn by network becomes 0.707 of its maximum value.

$$\Delta\omega = (\omega_2 - \omega_1) = \frac{R}{L}$$

$$\omega_1 = \omega_0 - \frac{1}{2}\Delta\omega \quad \text{and} \quad \omega_2 = \omega_0 + \frac{1}{2}\Delta\omega$$

$$\omega_0 = \sqrt{\omega_1 \cdot \omega_2}$$

where, ω_1, ω_2 = Cut-off frequency or half power frequency

Q-factor

The quality factor of the network is a measure of sharpness of the curve for the current drawn by circuit.

$$\text{Q-factor} = 2\pi\left(\frac{\text{Maximum energy stored}}{\text{Energy dissipated per cycle}}\right)$$

$$Q_0 = \frac{\omega_0}{\Delta\omega} = \frac{1}{\omega_0 RC} = \frac{\omega_0 L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

❑ **Frequency at which voltage across capacitor is maximum**

$$f_c = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{2L^2}}$$

❑ **Frequency at which voltage across inductor is maximum**

$$f_L = \frac{1}{2\pi}\sqrt{LC - \frac{C^2R^2}{2}}$$

❑ **Selectivity**

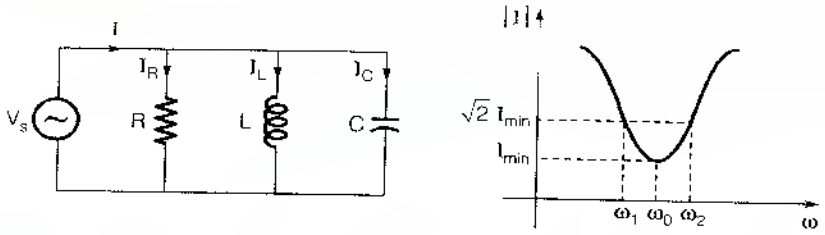
$$\text{Selectivity} = \frac{\text{Resonance frequency}}{\text{Bandwidth}} = \frac{f_0}{f_2 - f_1}$$

Feature of Series Resonance Circuit

- The resonant frequency is a geometric mean of the two half power frequency.

- The resonant frequency represent the rate at which the electrical energy stored in the capacitor is transformed to the magnetic energy stored in the inductor and vice versa.
- The quality factor represents the voltage amplification factor and must have high value for any tuned circuit.
- The quality factor of the resonant curve depends upon the numerical value of RLC components.
- For ***tuned network***, the ***quality factor*** must be ***high***, the ***bandwidth*** should be ***small*** and therefore the resistance use in the network should be small.
- Any ***series RLC*** network represents a ***band pass filter***.

Parallel Resonance



At Resonance

- $|\mathbf{I}_L| = |\mathbf{I}_C|$ and these are 180° out of phase
- Imaginary part of input impedance = 0

$$\boxed{Z_{in}\big|_{\omega=\omega_0} = R} \quad \text{.....maximum}$$

$$\boxed{\mathbf{I}\big|_{\omega=\omega_0} = \frac{V_s}{R}} \quad \text{.....minimum}$$

where, $\omega_0 = \frac{1}{\sqrt{LC}}$ = resonant frequency in rad/sec

Remember:

- For $\omega < \omega_0$ the circuit behaves like an RL circuit.
- For $\omega > \omega_0$ the circuit behaves like an RC circuit.
- For $\omega = \omega_0$ the circuit behaves like a resistive circuit.

Bandwidth

$$\boxed{\Delta\omega = (\omega_2 - \omega_1) = \frac{1}{RC}}$$

Q-Factor

$$\boxed{Q_0 = \frac{\omega_0}{\Delta\omega} = \omega_0 RC = \frac{R}{\omega_0 L} = R\sqrt{\frac{C}{L}}}$$

Feature of Parallel RLC Circuit

- The ***quality factor*** of the network represents the ***current amplification*** factor and must have a high value for any tuned circuit.
- For a ***tune network***, the ***quality factor*** should be ***high*** and therefore should have ***low bandwidth*** therefore the ***capacitance*** value is ***kept high***.
- A ***parallel RLC*** network behaves as a ***band stop filter*** or ***band reject filter***.

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