# Resonant Circuits

## Contents:

(1) Series and parallel resonance
(2) Frequency response of series and parallel resonance
(3) Quality factor of series and parallel circuit
(4) Band width
(5) Problem related to series and parallel circuit

## Resonance:

→ It means that interchange the energy in one form to another.

→ Resonance describes the energy transformation between Inductor (L) and capacitor (C).

→ For occurance of resonance in any system, two energy elements are required to store the energy in the form of electric field and magnetic field.

**Example**

R L C

R ↓ Heat Dissipating Element

L, C → Energy Storing Element

→ The circuit is said to be resonance when source current and source voltage are in same phase. Which means the imaginary component of impedance is zero. The circuit behaves like a pure resistive network.

**Example** $Z = R + jX$

$R$ ↓ Real part

$jX$ ↓ Imaginary part $\rightarrow 0$

## Condition for resonance in series and parallel circuit

- R, L and C should be present.
- $X_L = X_C$
- $\phi = 0 \rightarrow$ in same phase
- Pure resistive network
- power factor unity
- Two storing element like L and C
- Applicable only in AC circuit.

### Types of Resonance

- Series RLC
- Parallel RLC

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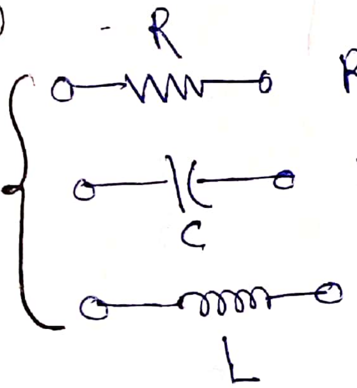


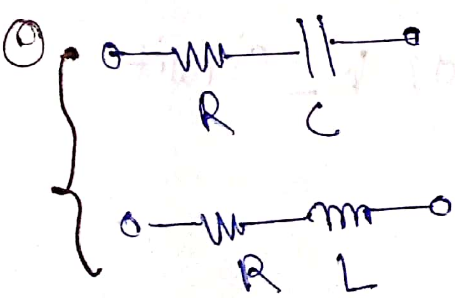

R → Resistance

$X_C = \frac{1}{jwC} = -\frac{j}{wC}$ → capacitive Reactance

Behaves as capacitive

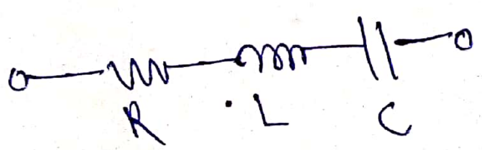
$X_L = +jwL$ → Inductive Reactance

Behaves as inductive




$Z = R + \frac{1}{jwC} = R - \frac{j}{wC}$ → RC circuit

$Z = R + jwL =$ → RL circuit



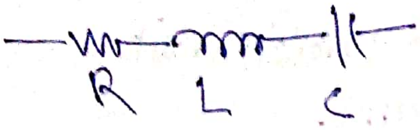

$Z = R + jwL + \frac{1}{jwC} = R + jwL - \frac{j}{wC}$

$Z = R + j(wL - \frac{1}{wC})$ or $Z = R - j(\frac{1}{wC} - wL)$

$wL > \frac{1}{wC}$ ✓ R-L

$\frac{1}{wC} > wL$ R-C

#




$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$

if $\omega L = \frac{1}{\omega C}$

$\boxed{Z = R}$ → Act as pure resistive

This condition is called resonant.

Therefore, (i) $X_L = X_C$ ← at resonant

$\omega_0 L = \frac{1}{\omega_0 C}$

$\omega_0 = \frac{1}{\sqrt{LC}}$ radian/sec

$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}} \text{ Hz}}$$

(ii)

$X_L > X_C$

$\omega L > \frac{1}{\omega C}$

$\omega^2 > \frac{1}{LC}$ ; $\omega^2$

$\omega^2 > \omega_0^2$

$\boxed{\omega > \omega_0}$ → Act as RL circuit

(iii)

$X_L < X_C$

$\omega L < \frac{1}{\omega C}$

$\omega^2 < \frac{1}{LC}$

$\omega < \frac{1}{\sqrt{LC}}$

$\boxed{\omega < \omega_0}$ → Act as RC circuit

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## Conclusion:-

$$\frac{1}{\sqrt{LC}}$$

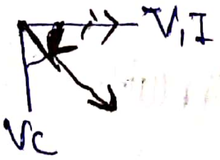
↓

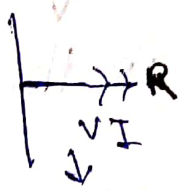
$w < w_0$ → R-C

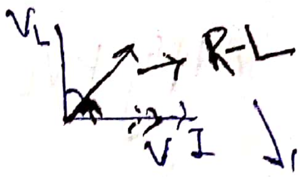
$w_0 = w$ → R

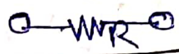
$w > w_0$ → R-L

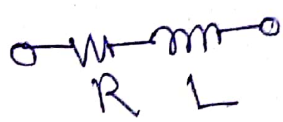
R-C ←

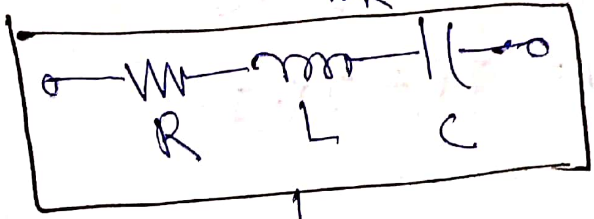


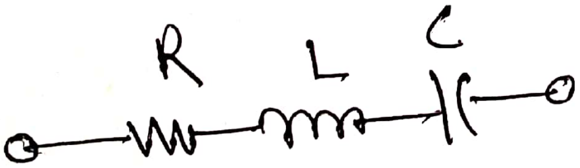



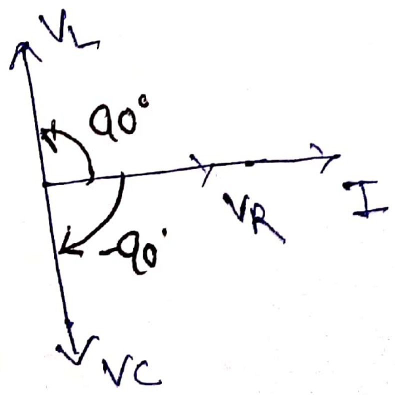




It behaves like either → R
→ R-L
→ R-C

But not → RLC

⇒




$V_R = IR$

$V = jwLI$

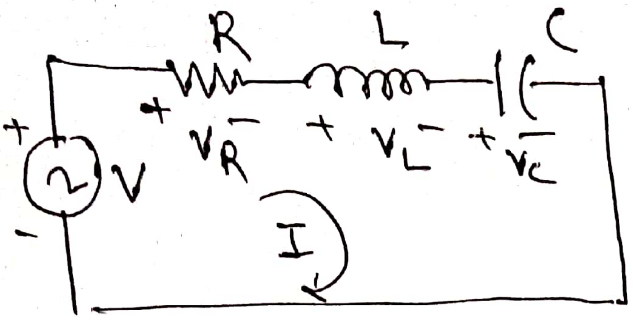
$V = -\frac{1}{jwC} I$

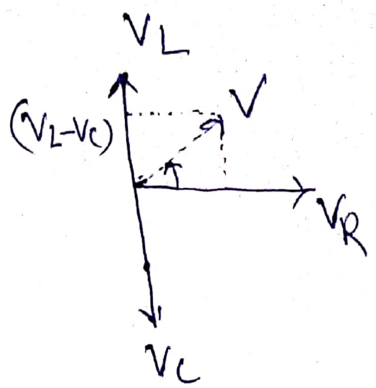
→ voltage and current in same phase → Resonance condition

→ Voltage lead by 90°

→ voltage lag by 90°

## Series RLC Resonance Circuit :




Apply KVL of given circuit

$$V = V_R + j(V_L - V_C)$$

$$V = IR + j(IX_L - IX_C)$$

$$\frac{V}{I} = R + j(X_L - X_C)$$

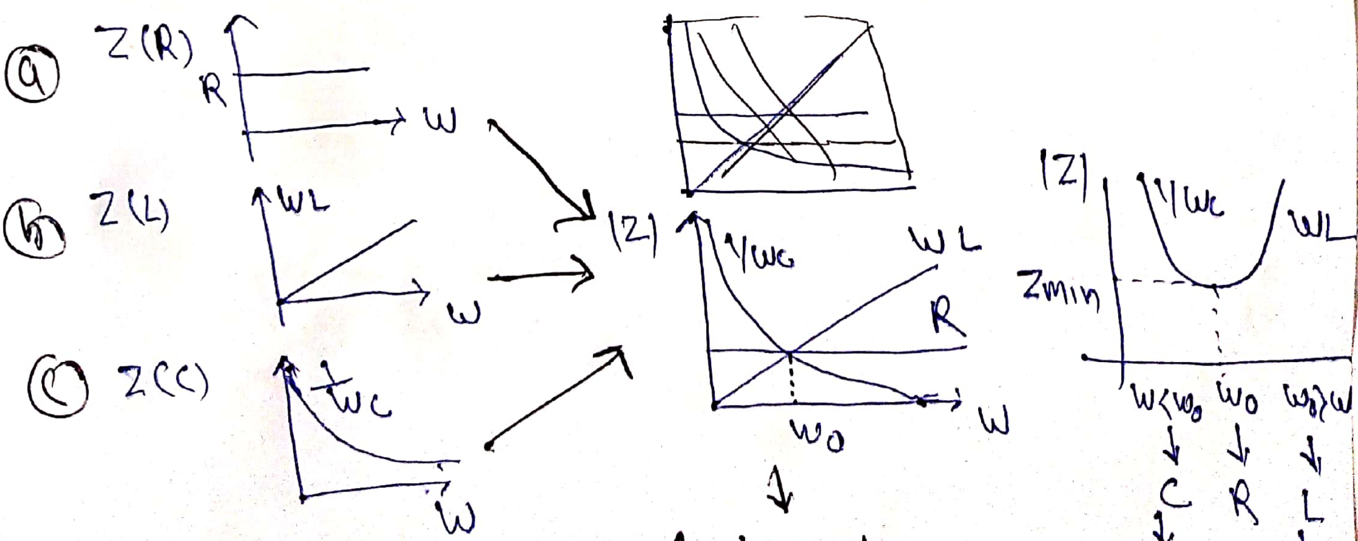
$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

$$|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

At resonance frequency $\rightarrow \omega_0$

$$\omega_0 L = \frac{1}{\omega_0 C} ;$$

$$\boxed{\omega_0 = \frac{1}{\sqrt{LC}} \text{ rad/sec}}$$




Combine of (a), (b) and (c)

Capacitive Behaviour

Inductive Behaviour