F. Y. B. Tech Academic Year 2020-21

Trimester: **Subject:** Basics of Electrical and Electronics Engineering

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Roll No: **109054.** **Batch : I3**

Experiment No: 8

Name of the Experiment: Finding Resonant Frequency of series R-L-C circuit

Performed on: 11th February 2022

Submitted on: 15th February 2022

Aim : Finding Resonant Frequency of series R-L-C circuit

Objective

To understand the resonance in series R-L-C circuit and to find out resonant frequency of given R-L-C circuit

Components and equipment required

Components	Specifications
Signal Generator	Audio frequency range
AC Ammeter	0-1 A
R-L-C circuit board	Component values given below

Theory

In the series R-L-C circuit, when inductive reactance X_L equals the capacitive reactance X_C circuit is called as series resonance circuit. Circuit behaves like a resistive circuit and the resulting current is in phase with the applied voltage. Circuit power factor is unity. At resonance, the equivalent impedance of the circuit consists of only resistive components due to cancelling out the reactive components. At this condition circuit draws the maximum current shown in Fig.4 due to minimum impedance of the circuit as shown in

Fig.3. As X_L is directly proportional to frequency and X_C is inversely proportional to frequency, we can obtain the resonance of any R-L-C circuit by varying its frequency. The frequency, at which this condition occurs, is known as resonance frequency f_r of that circuit. The magnitude of the resonating frequency can be calculated using eq.(1)

$$f_r = \frac{1}{2\pi\sqrt{LC}} \tag{1}$$

During series resonance, voltage magnification is observed. Voltage across the capacitor or inductor is multiple times the supply voltage. This can be observed using the term Q factor or Quality factor of the circuit which is given by eq. (2)

$$Q = \frac{\omega L}{R} = \frac{\sqrt{L}}{R\sqrt{C}} \tag{2}$$

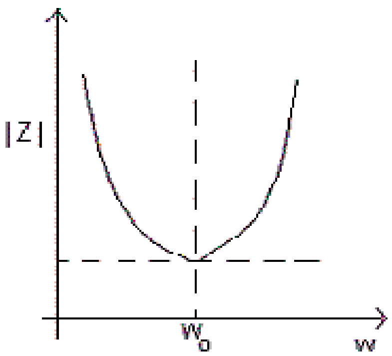


Fig.2: Impedance vs frequency

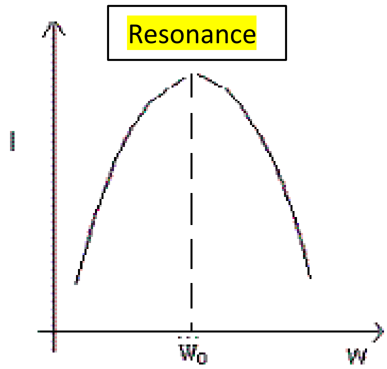
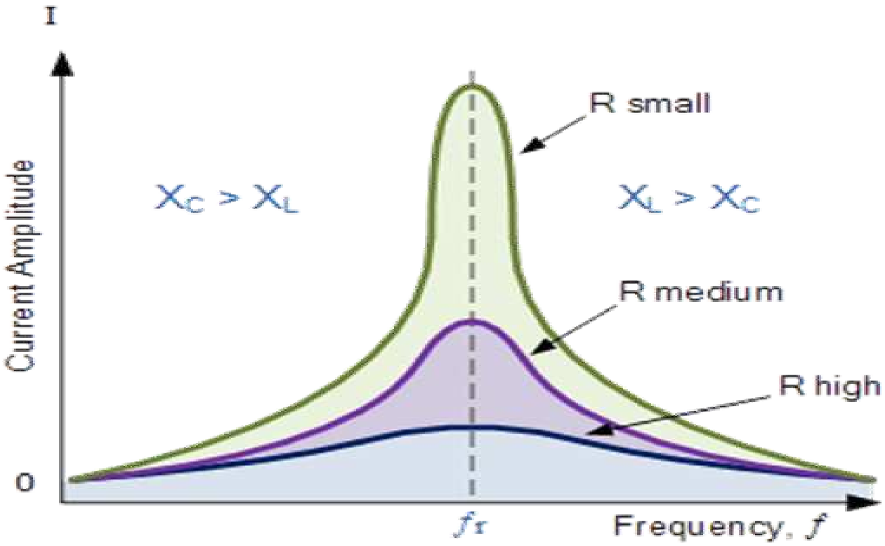
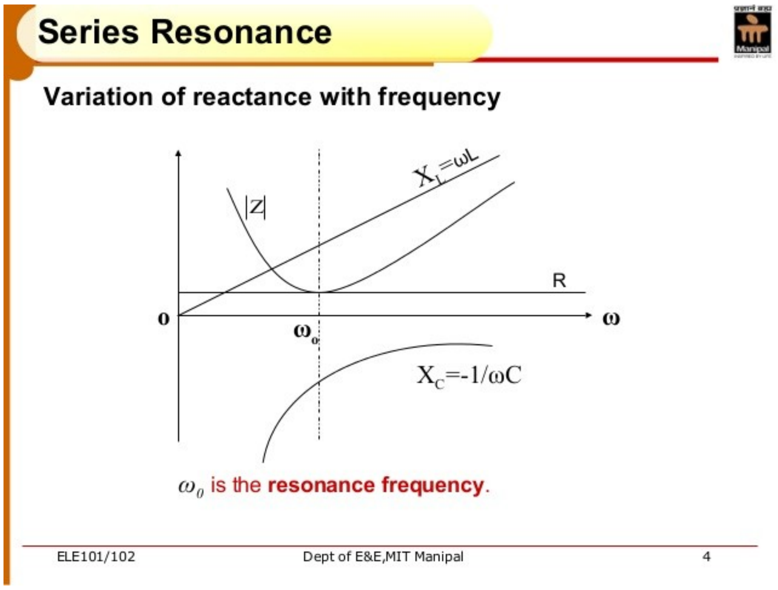


Fig.3: Current vs frequency





Procedure

1) Connect the circuit as shown in Fig.1
2) Give 5V peak to peak amplitude sinusoidal input from the signal generator.
3) Change the frequency and obtain the maximum current in the circuit. Vary frequency from 800 Hz to 2800Hz. Note down this reading at resonant frequency.
4) Adjust frequencies for six equally spaced readings above and below the resonant frequency and note down corresponding current values on AC ammeter.

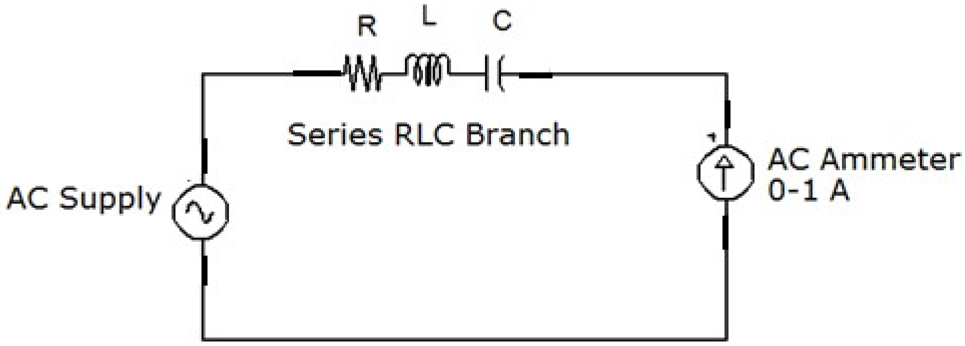


Fig. 1: Series R-L-C Circuit

Observations

1) **Components used in the series circuit:**
   i) $L = 10$ mH ii) $C = 1$ μF iii) $R = 30\ \Omega$

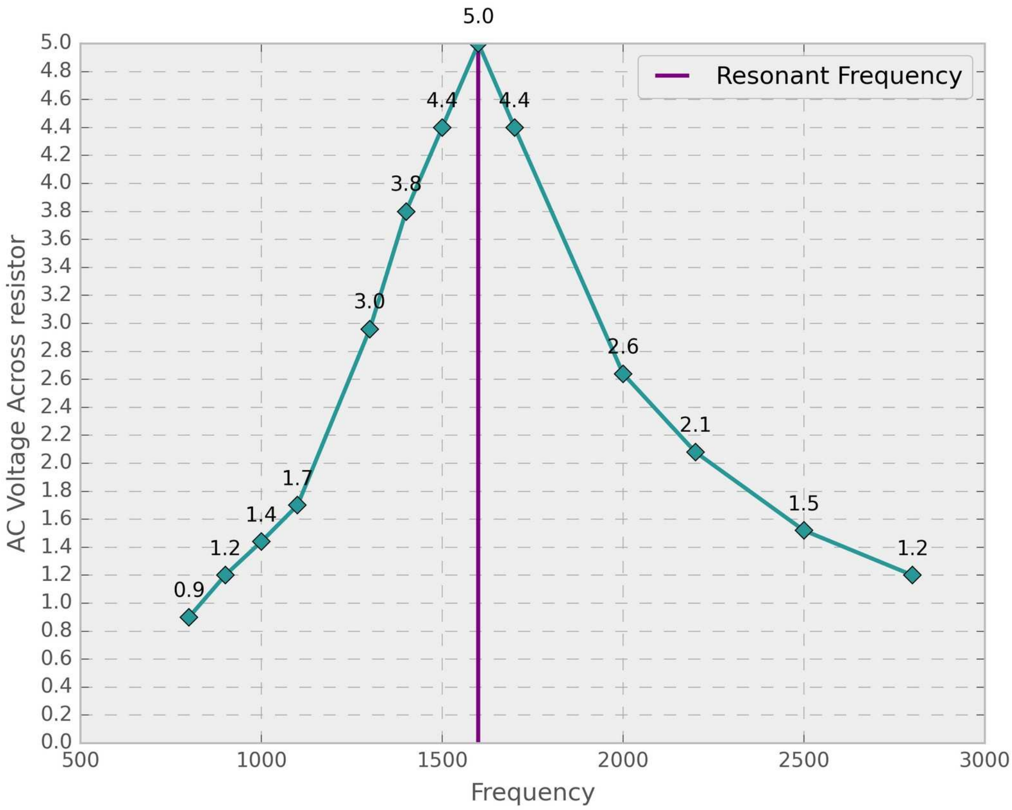
2) **Observation Table**

Sr. No	Frequency (Hz)	AC Voltage across R (V) (Proportional to theAC current in the circuit)
1	800	0.9
2	900	1.2
3	1000	1.44
4	1100	1.8
5	1300	2.96
6	1400	3.8
7	1500	4.4
8	1600	**5**
9	1700	4.4
10	2000	2.64
11	2200	2.08
12	2500	1.52
13	2800	1.2

Graph and Calculations

1) Plot graph of Current I vs. Frequency f
2) Mark resonant frequency f_r from the graph.
3) Calculate resonant frequency f_r and Q factor using eq.(1) and (2)
4)

Plot between AC Voltage and Frequency

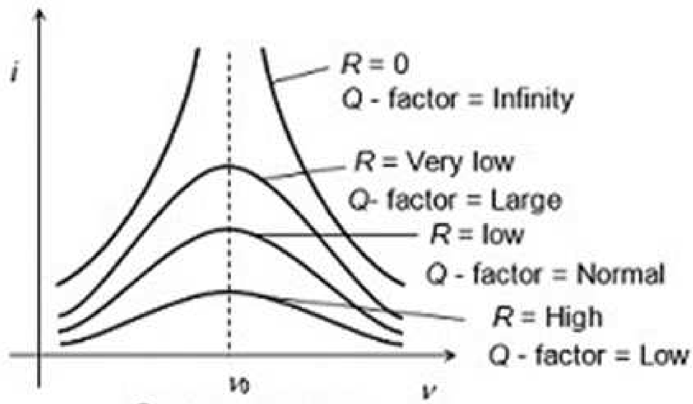


Result:

	Resonance Frequency (KHz)
Practical Value	**1.600**
Theoretical Value	**1.591**

Conclusion:

A series RLC Circuit was built and its resonance frequence was observed by measuring the voltage across the resistor for various values of input frequency. Q factor, Resonant Frequency were calculated and their concepts were understood in detail.

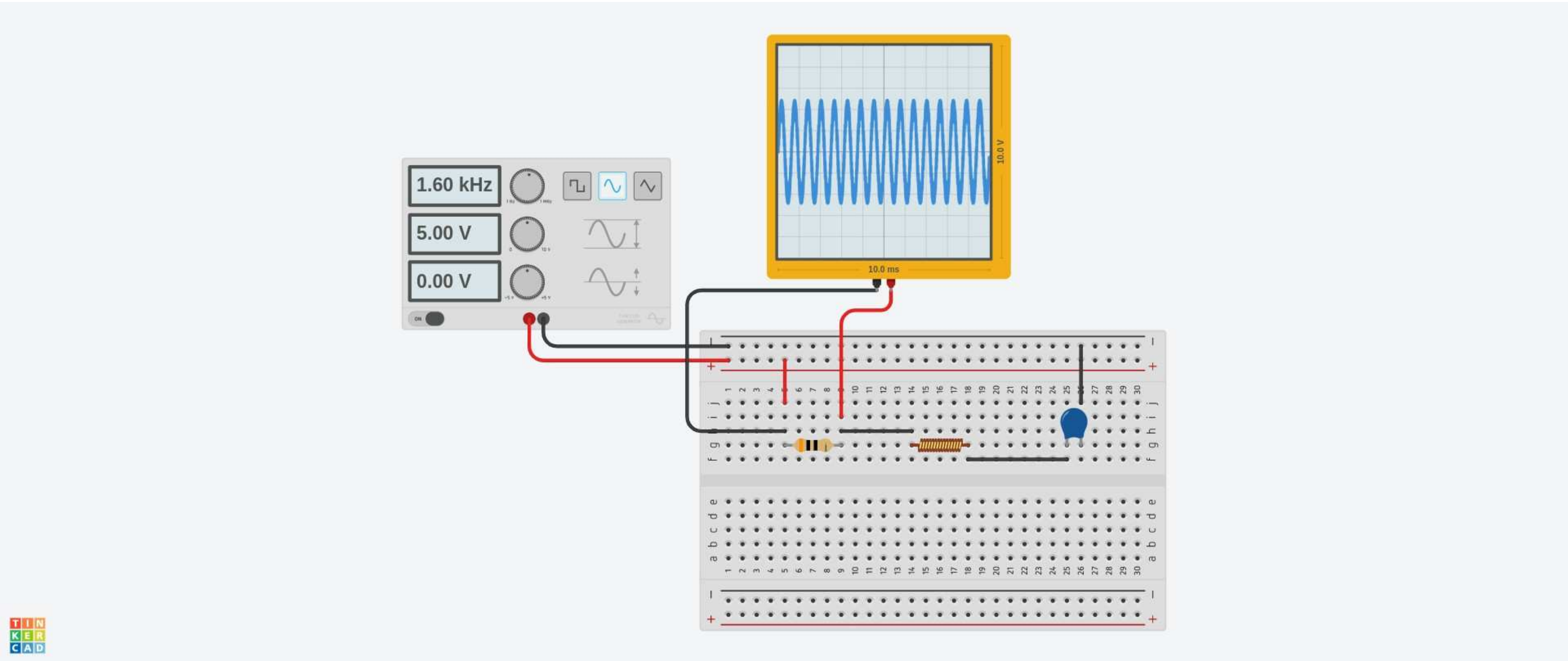


Resonance curve

Post-Lab Questions

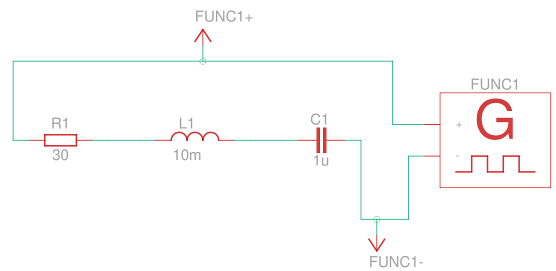
1) Derive the expression for resonance frequency.
2) Explain the reactance curves (X_L vs f and X_C vs f) for series circuit.
3) Give applications of resonant circuits.

Tinkercad Circuit



Required Components

Name	Quantity	Component
FUNC1	1	1600 Hz, 5 V, 0 V, Sine Function Generator
L1	1	10 mH Inductor
R1	1	30 Ω Resistor
C1	1	1 uF Capacitor
U1	1	1 ms Oscilloscope



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Calculations

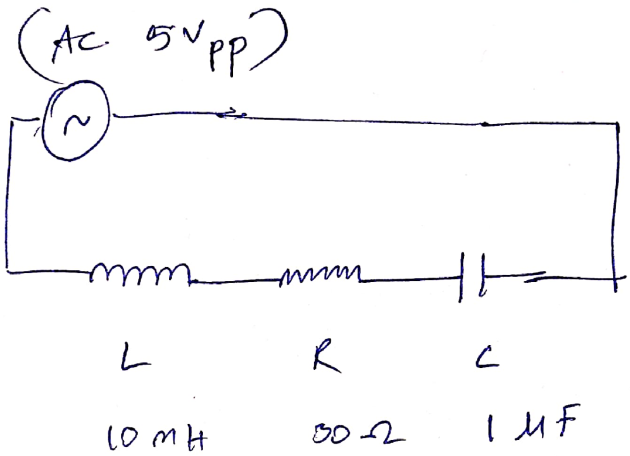
given

$R = 30\ \Omega$

$L = 10\ mH = 10 \times 10^{-3}\ H = 10^{-2}\ H$

$C = 1\ \mu F = 10^{-6}\ F$

equation (1) for Resonant frequency for these components connected in series



Therefore,

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10^{-2}\times 10^{-6}}}$$

$$= \underline{1591.5\ Hz}$$

Q factor therefore,

$$Q = \frac{\omega L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{30}\sqrt{\frac{10^{-2}}{10^{-6}}} = \frac{100}{30}$$

$$= \underline{3.3}$$

BEEE

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EXPERIMENT- 8

Post Lab Questions

Q.1. Derive expression for resonant frequency.

→ Resonance is achieved when $X_L = X_C$ in an AC circuit.

So $$X_L = X_C$$

$$2\pi f_r \cdot L = \frac{1}{2\pi f_r \cdot C}$$

So $$4\pi^2 \cdot f_r^2 = \frac{1}{LC}$$

$$f_r^2 = \frac{1}{4\pi^2 \cdot LC}$$

$$f_r = \sqrt{\frac{1}{4\pi^2 \cdot LC}} = \sqrt{\frac{1}{(2\pi)^2 \cdot LC}}$$

$$\boxed{f_r = \frac{1}{2\pi\sqrt{LC}}}$$

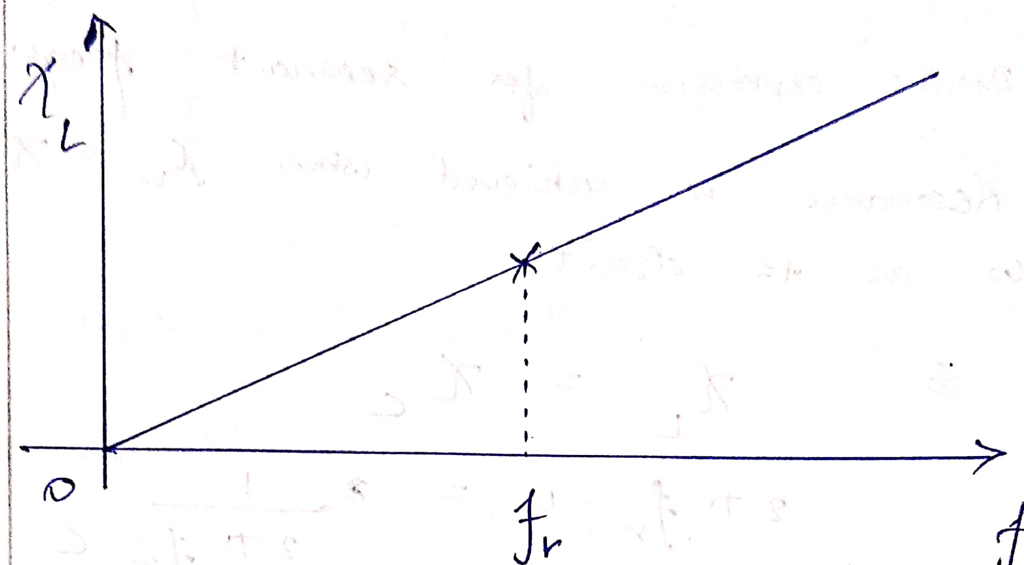
at f_r, $Z = R$,

$$I = V/R$$

$$\boxed{\omega_r = \frac{1}{\sqrt{LC}}}$$

Q.2. Explain reactance curves X_L vs f in series circuit
X_C vs f

X_L vs f ;



$$\boxed{X_L = 2\pi f \cdot L}$$

X_L therefore varies linearly with f. as given by the equation.

→ We know an inductor (—mmm—) is known to avoid large fluctuations in the circuit. This is because it produces a counter emf opposite to the direction of present emf in circuit proportional to rate of change

$$\boxed{e = -L\left(\frac{di}{dt}\right)}$$;

due to this $-$EMF, we have current flowing opposite to prevailing current for a short period of time. This reduces the value of prevailing current, and is thereby known to 'increase' the reactance X_L

$$I_L \propto \mathcal{E}_L \propto -\frac{dI_p}{dt} \propto f$$

as $f \uparrow$, $\frac{di}{dt} \uparrow$ so $I_L \uparrow$

as $I_L = -I_{Present}$,

Net I reduces, thereby $X_L \uparrow$.

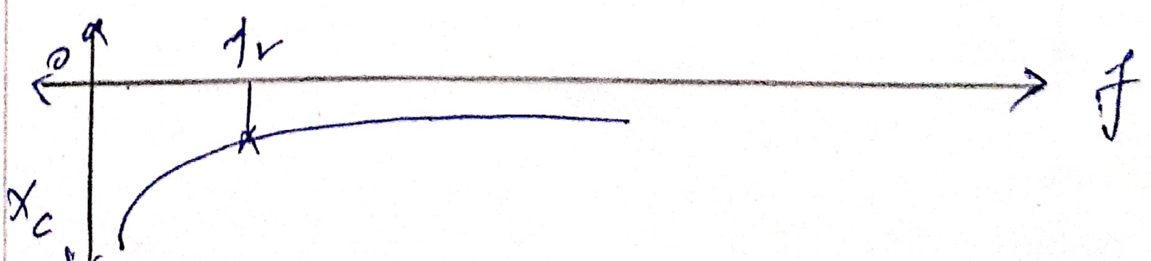
→ opposite is true for a capacitor.

A capacitor is only apparent in a circuit after charging. Changes in source voltage are reduced by using a capacitor.

as $f \uparrow$, time given to charging cap decreases, and therefore its effect on circuit reduces.

$$\boxed{X_L = \frac{1}{2\pi f C}}$$

$f \uparrow$, $X_C \downarrow$



Q.3. Give applications of resonant circuits.

→ Oscillator circuit → Radio receivers, Television sets tuning purposes.

→ Signal processing and communication systems.

→ Voltage Magnification

→ Induction Heating.

→ Filter circuits for frequencies.