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NORTH SOUTH UNIVERSITY

Department of Mathematics & Physics

Experimental Physics

PHY-108L

Name of the Experiment: An RLC Circuit and Electrical Resonance

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Name of the Experiment: An RLC Circuit and Electrical Resonance.

Objective:

- To understand the concept of resonance in simple RLC circuit.
- To determine the resonance frequency in a parallel RLC circuit and compare this to the expected resonance value.
- To understand concepts related to resonance such as bandwidth and Q-factor.

Apparatus:

- Resister 10 kΩ
- Capacitor 10 nF
- Inductor 10 mH
- Function Generator
- Oscilloscope
- Bread Board
- Wires

Theory :

Resonance is the tendency of a system to oscillate at maximum amplitud when excited at its natural frequency. Electrical resonance occurs when the impedance or part of the circuit reaches a maximum or a minimum at a particular frequency. This is called resonant frequency and its value depends on the circuit elements involved.

Reactance of a capacitor, $X_c = \frac{1}{2\pi f c}$

Reactance of an inductor, $X_L = 2\pi f L$

At low frequency,

$$Z_L = j\omega L \text{ (small)}$$

At, high frequency, $Z_c = \frac{1}{j\omega C}$ (small)

When,

$$|Z_L| = |Z_c| ,$$

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

$$\omega = \frac{1}{\sqrt{LC}} \quad \text{and} \quad f = \frac{1}{2\pi\sqrt{LC}}$$

So, the expected resonance frequency is,

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

realme Shot by Legend T.JOY

Quality Factor:

In RLC Circuit, the ratio of resonance frequency to the difference of its neighboring frequencies so that their corresponding signal is $1/\sqrt{2}$ times of the peak value, is called Q-factor of the circuit.

$$\Delta f = f_2 - f_1$$

$$Q = \frac{f_r}{\Delta f}$$

Where f_r is the resonant frequency, and Δf the bandwidth, is the width of the range of frequencies for which the energy is at least $1/\sqrt{2}$ its peak value and Q in known as Quality Factor.

Q is measured as the "sharpness" of the resonance. For instance, when Q is large, the peak of the graph is sharp and the bandwidth is small.

For a parallel RLC circuit, assuming L and C are ideal, the Q factor is given theoretically by the equation.

$$Q = R\sqrt{\frac{C}{L}}$$

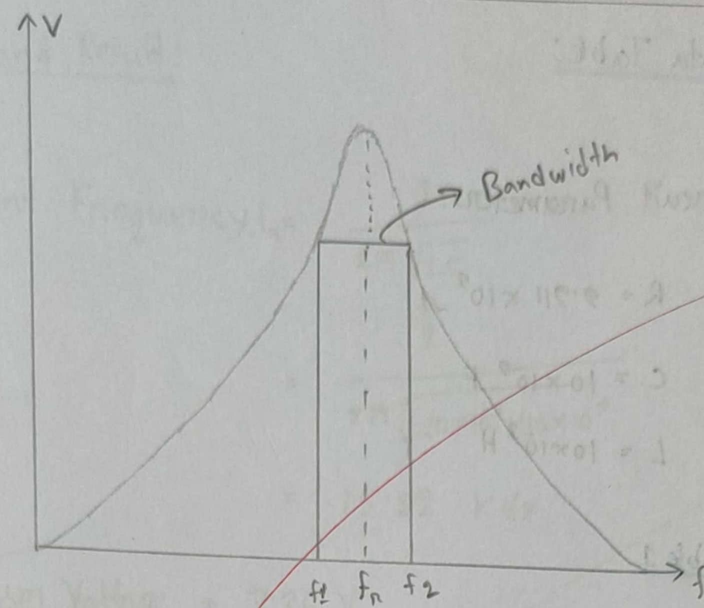
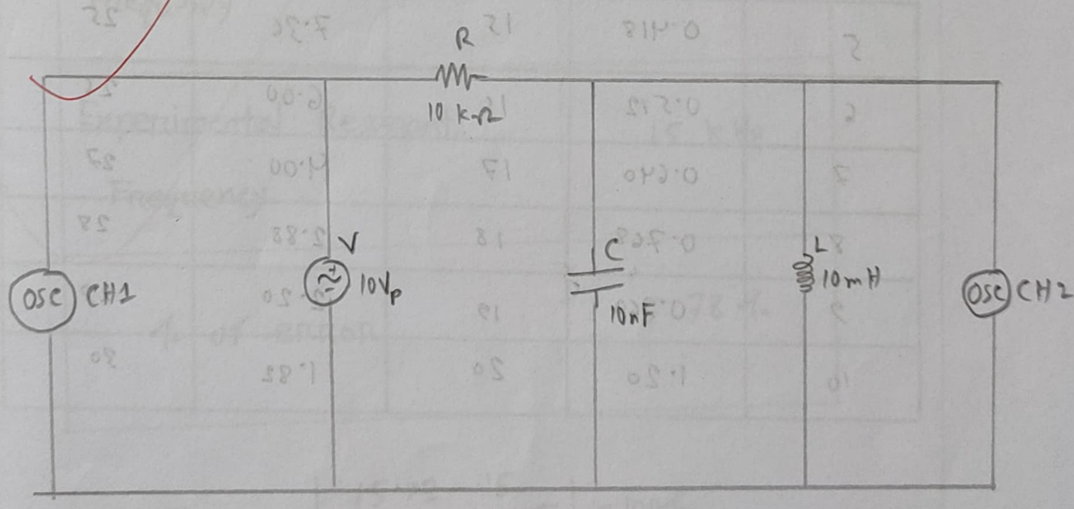


Figure: Graphical representation of resonance in RLC circuit.

Circuit Diagram:



RLC circuit

Data Table:

Circuit Parameters:

$R = 9{\cdot}911 \times 10^{3}\ \Omega$

$C = 10 \times 10^{-9}\ F$

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

Table 1

Frequency (kHz)	Output Voltage (V) (pk-pk)	Frequency (kHz)	Output Voltage (V) (pk-pk)	Frequency (kHz)	Output Voltage (V) (pk-pk)
1	0·072	11	1·52	21	1·56
2	0·144	12	2·10	22	1·36
3	0·218	13	3·12	23	1·22
4	0·306	14	5·04	24	1·14
5	0·418	15	7·36	25	1·04
6	0·512	16	6·00	26	0·940
7	0·640	17	4·00	27	0·860
8	0·768	18	2·88	28	0·820
9	0·960	19	2·20	29	0·768
10	1·20	20	1·82	30	0·712

Calculation and Result:

Resonant Frequency, $f_r = \dfrac{1}{2\pi\sqrt{LC}}$

$= \dfrac{1}{2\pi\sqrt{10\times10^{-3}\times10\times10^{-9}}}$

$= 15.92$ KHz

Maximum Voltage $= 7.36$ V

Frequency at maximum voltage, $f_o = 15$ KHz

Table-2:

Calculated Resonant Frequency	15.92 KHz
Experimental Resonant Frequency	15 KHz
% of error	5.78 %

$$\text{Error} = \left| \frac{15.92 - 15}{15.92} \right| \times 100\%$$

$$= 5.78\%$$

Graph: Attached.

Questions and Answere:

1. Graph Attached.

2.

from the graph,

$$V_{max} = 7.36\text{ V (pk-pk)}$$

$$\therefore V_{RMS} = \frac{V_{max}}{\sqrt{2}} = \frac{7.36}{\sqrt{2}} = 5.20\text{V}$$

When, Voltage was 5.20 V

$$f_1 = 14.143\text{ kHz}$$

$$f_2 = 16.286\text{ kHz}$$

$\rightarrow$ bandwidth, $\Delta f = f_2 - f_1 = 16.286 - 14.143$

$$= 2.143\text{ kHz}$$

3.

Quality Factor from graph,

$$Q = \frac{f_0}{\Delta f} = \frac{15.72\text{ kHz}}{2.143\text{ kHz}}$$

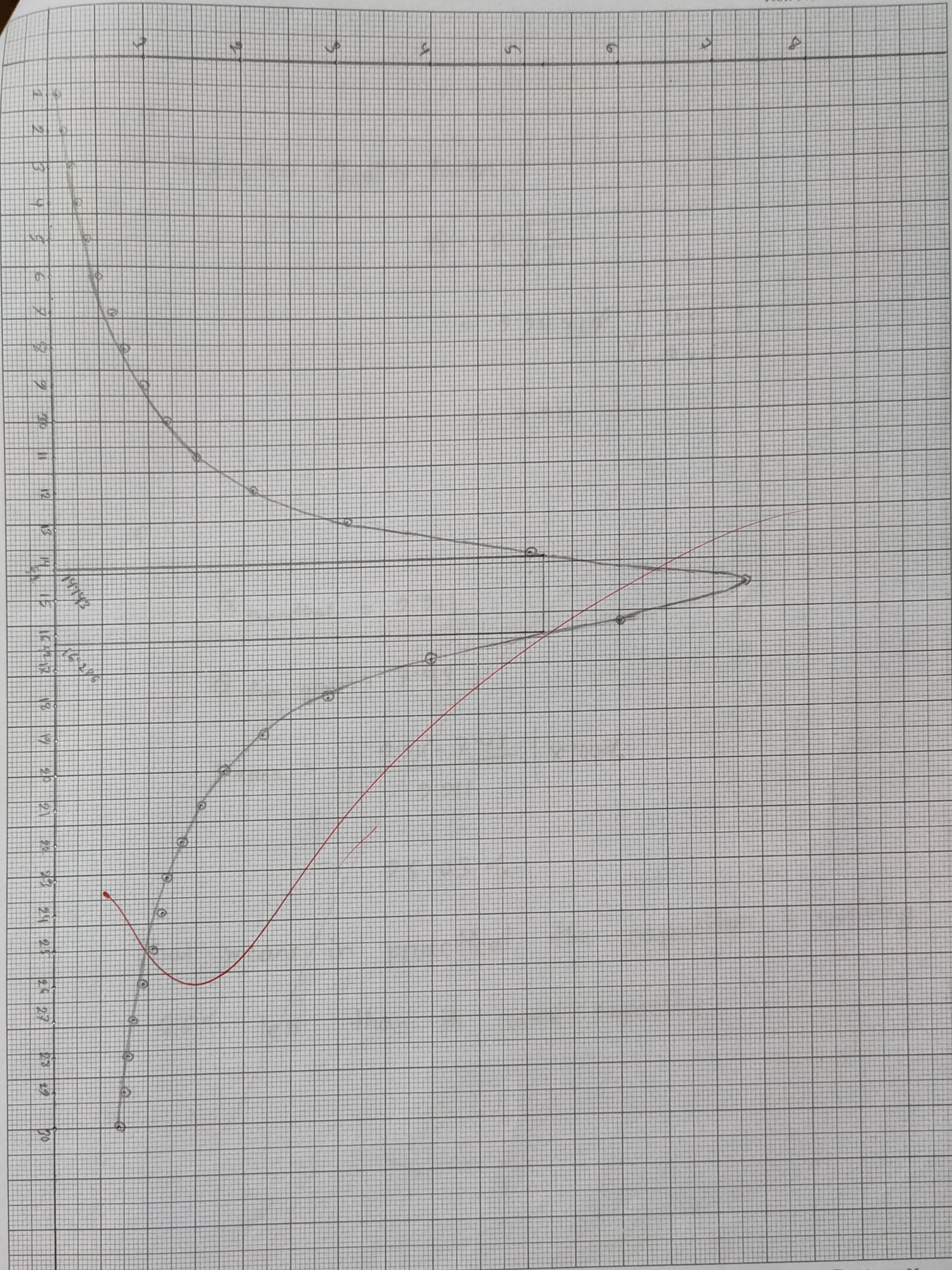
$$= 7.43$$

→ Voltage (V) (pk-pk)

Roll No. 2211424

→ Frequency (kHz)

Graph : V vs f



MICRO

N.P. 20 cm x 25 cm

4.

Theoretical Quality Factor,

$$Q = R\sqrt{\frac{C}{L}}$$

$$= 9.911 \times 10^{3} \sqrt{\frac{10\times10^{-9}\,F}{10\times10^{-3}\,H}}$$

$$= 9.911$$

5.

$Q_{Theoretical} = 9.911$

Q from graph $= 7.43$

$$\text{Error} = \left|\frac{9.911 - 7.43}{9.911}\right| \times 100\%$$

$$= 25.03\,\%$$

That means in practical the capacitor is working 25% less than its rated capacity.

Discussion:

From this experiment, we understood the concept of resonance in simple RLC circuit. We can now determine the resonance frequency in a parallel RLC circuit and compare this to the expected resonance value. As we get 25% error in this experiment. That means our capacitor is working 25%. lees than its rated capacity. We also understood the concept related to the resonance such as bandwidth and Quality factor. In this experiment, we don't face any problems. We also operate the oscilloscope smoothly this time. Finally we complete the experiment within the given time, and learnt a lot about resonance.

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Data Tables:

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R= $9.911 \times 10^3\ \Omega$

C= 10×10^{-9} F

L= 10×10^{-3} H

Table 1

Frequency (KHz)	Output Voltage (V) (pk-pk)	Frequency (KHz)	Output Voltage (V) (pk-pk)
1	72mV 0.072	16	6.00
2	0.144	17	4.00
3	0.218	18	2.88
4	0.306	19	2.20
5	0.418	20	1.82
6	0.512	21	1.56
7	0.640	22	1.36
8	0.768	23	1.22
9	0.960	24	1.14
10	1.20	25	1.04
11	1.52	26	0.940
12	2.10	27	0.860
13	3.12	28	0.820
14	5.04	29	0.768
15	7.36	30	0.712

Parika

Resonant Frequency= 15915.494 Hz

Maximum voltage= 7.36

Frequency at maximum voltage, f_0= 15 kHz

Table 2

Calculated Resonant Frequency	15.92 kHz
Experimental Resonant Frequency	15 kHz
% of error	5.78 %

Tasks and Questions:

#1: Use data obtained in Table 1 to plot output voltage vs frequency graph. Also, label the axes properly.

#2: Find the frequencies f_1 and f_2 and calculate the bandwidth. $\Delta f = f_2 - f_1$; $RMS = V_{max} \times \frac{1}{\sqrt{2}}$

#3: Quality Factor (measured from graph) = $Q = \frac{f_0}{\Delta f}$

#4: Quality Factor (theoretical) = $Q = R\sqrt{\frac{C}{L}}$

#5: Compare the theoretical value of Q factor with the experimental value. Find the % error.

Results:

Discussion: