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NORTH SOUTH UNIVERSITY

Department of Mathematics & Physics

Experimental Physics

PHY-108L.8

Name of the Experiment: **AN RLC CIRCUIT AND ELECTRICAL RESONANCE**

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Date: (i) Experiment Performed: 11 /09/2023

(ii) Report Submitted: 18 /09/2023

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Experiment 6: AN RLC CIRCUIT AND ELECTRICAL RESONANCE

1. Objectives:

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

2. Background:

Resonance is the tendency of a system to oscillate at maximum amplitude when excited at its natural frequency. Electrical resonance occurs when the impedance of 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.

The reactance of a capacitor is measured in ohms, is given by $X_c = \frac{1}{2\pi f C}$ and the reactance of an inductor is measured in ohms, given by $X_L = 2\pi f L$.

At low frequencies, the inductor caries most of the current because its impedance $Z_L = j\omega L$ is small. At high frequencies, the capacitor carries most of the current because its impedance $Z_C = \frac{1}{j\omega C}$, is small.

At some point between, when $|Z_L| = |Z_C|$, you might expect that the inductor and the capacitor would each carry half the current. However, this is not the case because we are now dealing with vector quantities. For this condition there is in fact a resonance.

The condition $|Z_L| = |Z_C|$ can be written as

$$\omega L = \frac{1}{\omega C} \text{ or } \omega = \frac{1}{\sqrt{LC}} \text{ and } f = \frac{1}{2\pi\sqrt{LC}} \qquad (1)$$

So the expected resonance frequency is given by equation 1.

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

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.

$$\Delta f = f2 - f1$$

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

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.

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

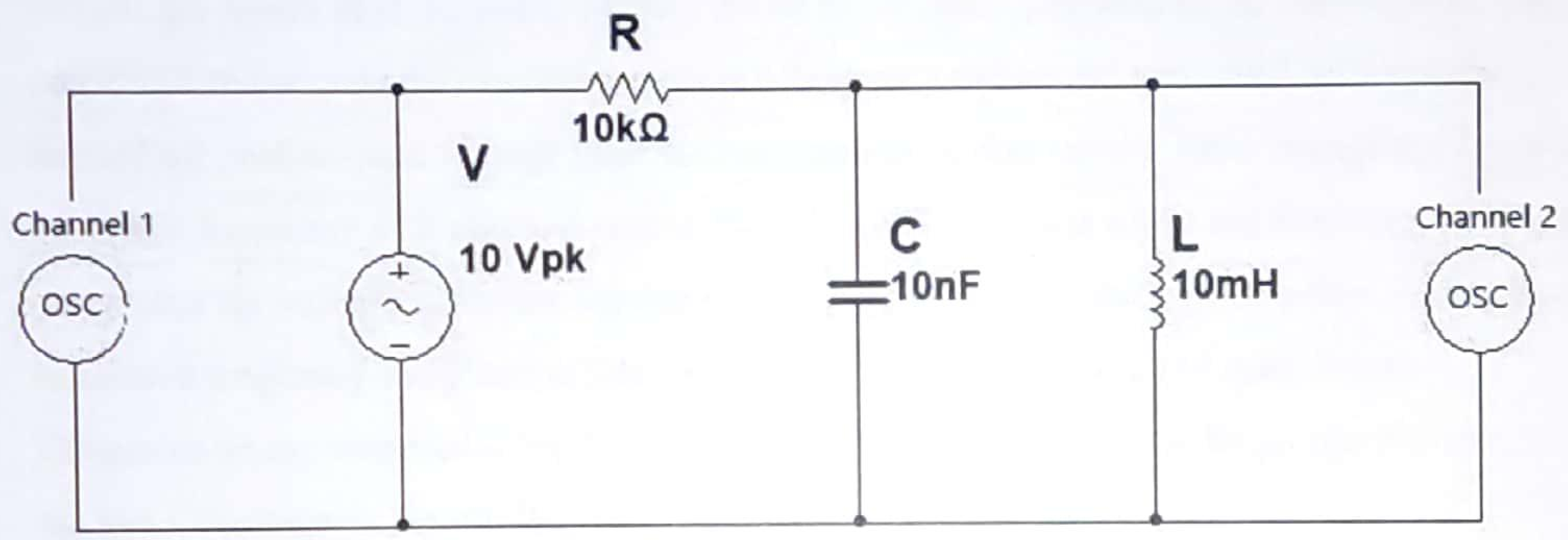

Figure 1: RLC circuit

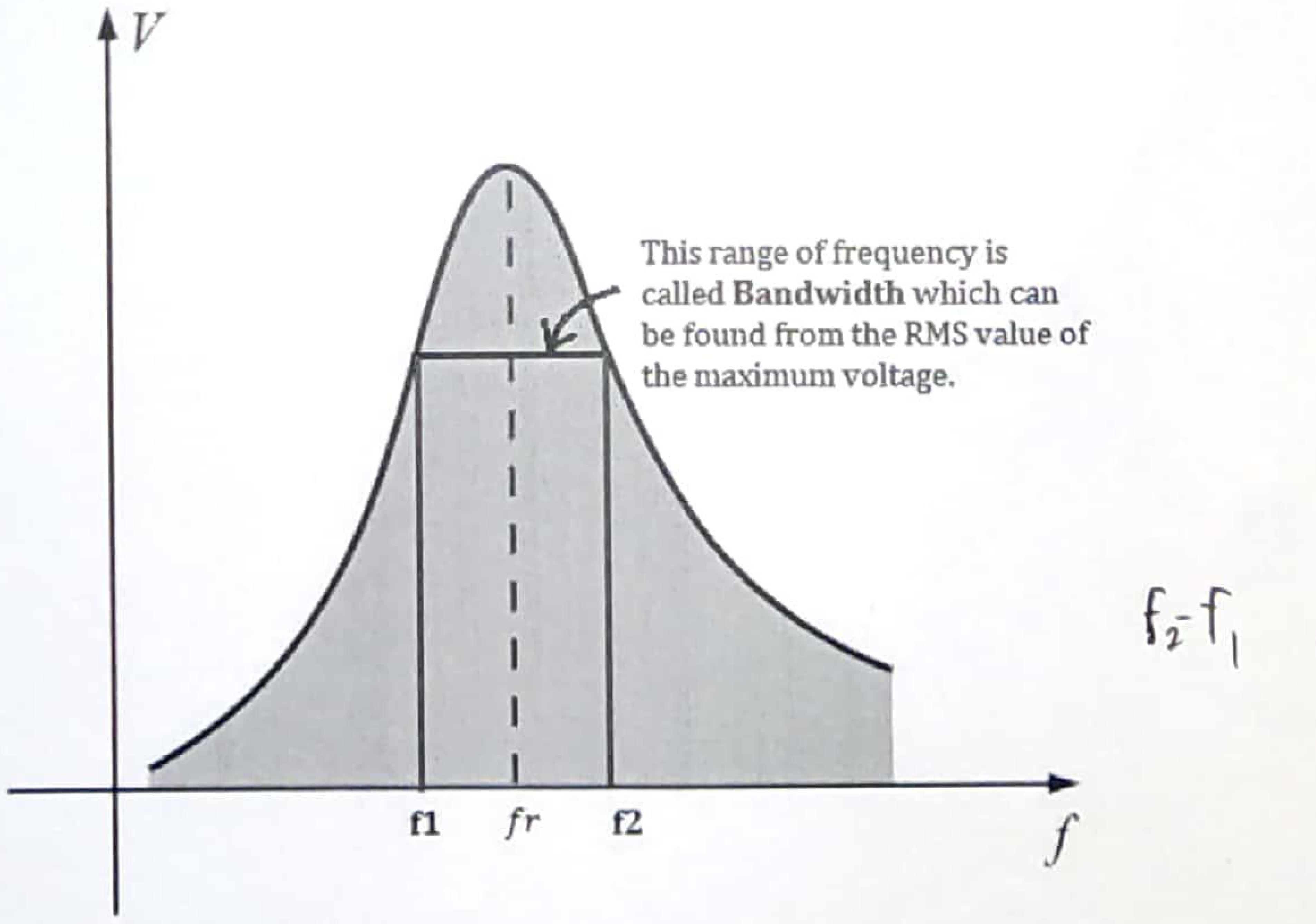

Figure 2: A Graphical representation of resonance in RLC circuit

3. Procedures and Observations:

a. Before you connect, the circuit to the function generator set the frequency to 1 kHz. Then, using the voltmeter set the function generator's output to 10 volts.

b. Connect L and C in parallel with the function generator.

c. Connect the oscilloscope's channel 1 to the signal generator, choose sine wave as an input signal, connect the oscilloscope's channel 2 to the capacitor and inductor, and observe the output signal on the oscilloscope.

d. Record the values of R, L, and C for this circuit in the space provided in the data section. Use equation 1 to compute the expected resonance frequency and record your result in data table 2.

e. Record the peak-to-peak voltage from the oscilloscope in data table 1. Now change the function generator frequency to 2 kHz and record the voltage. Then again adjust the frequency to 3 kHz and record the voltage. Continue adjusting the input frequency to each value below the expected resonance frequency computed in step 'd'. Record the voltage for each of these values.

f. Determine an experimental value for resonance frequency by finding the frequency that produces the largest voltage on the oscilloscope. Record this frequency and voltage.

Lab Report:

Date: 11.02.2023		
Name of the Students and IDs	(1) Shakil Ahmed	2221453042
	(2) Mortaza Morshed	2212697643
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Data Tables:

Circuit Parameters:

R= 9.88 kΩ

C= 10 nF

L= 10 mH

Table 1

Frequency (KHz)	Output Voltage (V) (pk-pk)	Frequency (KHz)	Output Voltage (V) (pk-pk)
1	69.6 mV	16	6.48 V
2	145 mV	17	4.20 V
3	214 mV	18	3.08 V
4	302 mV	19	2.27 V
5	378 mV	20	1.89 V
6	478 mV	21	1.62 V
7	604 mV	22	1.40 V
8	744 mV	23	1.26 V
9	904 mV	24	1.12 V
10	1.14 V	25	970 mV
11	1.54 V	26	880 mV
12	1.98 V	27	832 mV
13	2.79 V	28	768 mV
14	4.28 V	29	732 mV
15	6.96 V	30	688 mV

Resonant Frequency= 15 KHz

Maximum voltage= 6.96V

Frequency at maximum voltage, f_0= 15 KHz

Table 2

Calculated Resonant Frequency	15.91 KHz
Experimental Resonant Frequency	15 V
% of error	$\left\lvert\frac{15-15.91}{15}\right\rvert \times 100\% = 6.06\%$

Resonant frequency, $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2\times 3.1416 \times \sqrt{10\times10^{-3}\times10\times10^{-9}}}$$

$$= 15915.46 \text{ Hz}$$

$$= 15.91 \text{ KHz}$$

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.

$f_1 = 14.1\,KHz$, $f_2 = 16.65\,KHz$

band width : $\Delta f = f_2 - f_1 = (16.65 - 14.1)\,KHz = 2.55\,KHz$

#3: Quality Factor (measured from graph) = $\frac{f_0}{\Delta f} = \frac{15\,KHz}{2.55\,KHz} = 5.88$

$f_0 = 15\,KHz$, $\Delta f = 2.55\,KHz$

where $f_1 = 14.1\,KHz$ and $f_2 = 16.65\,KHz$

#4: Quality Factor (theoretical) = $R\sqrt{C/L} = 10K\sqrt{\frac{10nF}{10\,mH}} = 10$

where $R = 10K\Omega$, $L = 10\,mH$, $C = 10\,nF$

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

Q.Theoritical = 10 and Q measured = 5.88

$\%\ error = \left|\frac{10 - 5.88}{10}\right| \times 100\% = 41.2\%$

Results: The experiment was about AN RLC Circuit and Electrical Resonance. For the circuit we used $C = 10\,nF$, $L = 10\,mHz$. We are given by a table where frequency was starting from 1 to 30. After building the circuit, we found our output voltage(V). from our data table. we can see our voltage increasing from ~~1 to 15~~ and after 15 it started decreasing. We used $Q = R\sqrt{C/L}$ to find the quality factor

Discussion:

The experiment was about "AN RLC circuit and Electrical Resonance.". In this lab we used oscilloscop, capacitor, Inductor, Ressistor, wire, Breadboard. Then we buit the circuit. Then calculated the output voltage. For same frequencyes. After fill up the table our data followed theoritical rules. Thus our experiment verified.

Output voltage (V)

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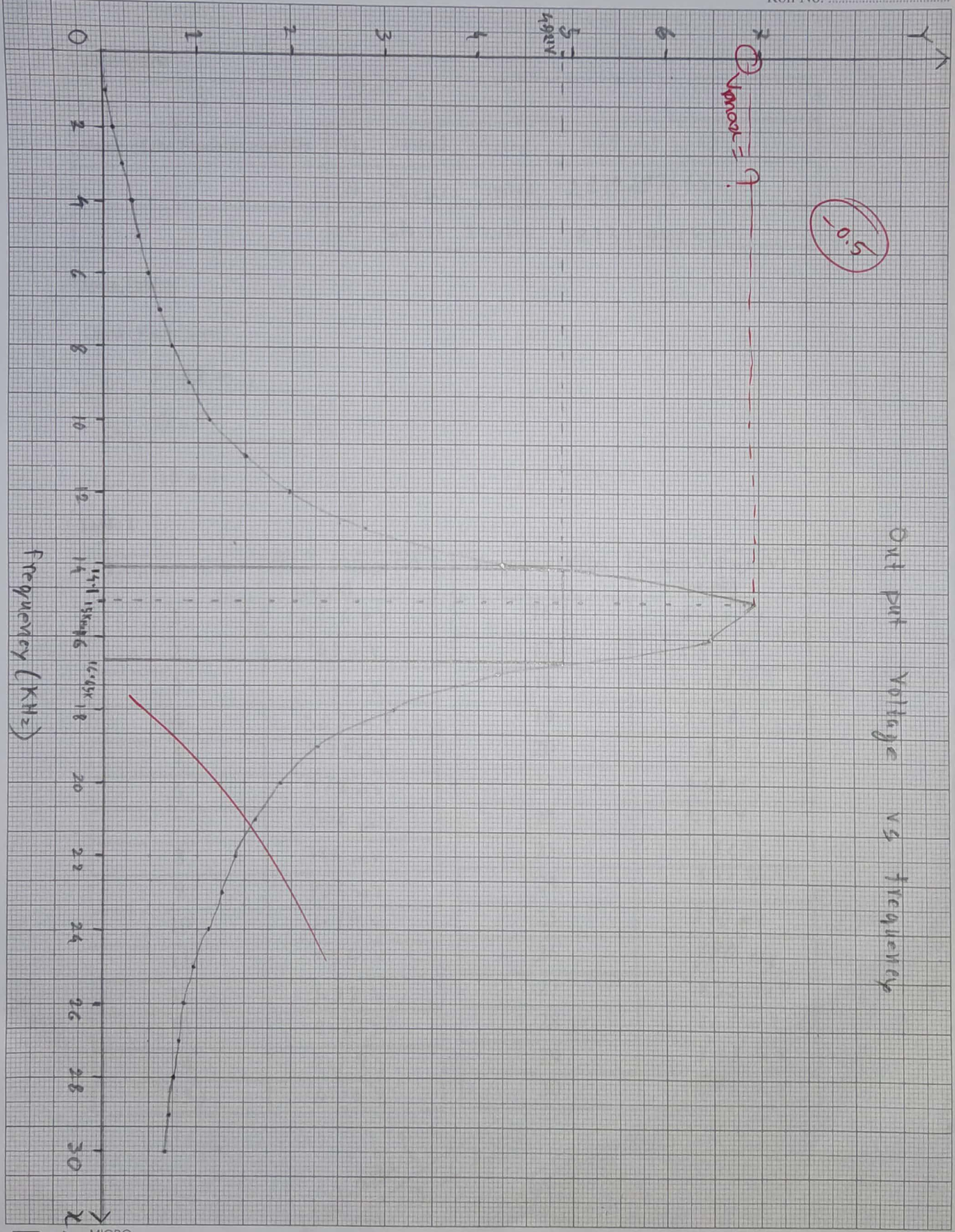

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Lab Report:

Date: 11.09.23	
Name of the Students and IDs	(1) Shakid Ahmed 2221453042
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11.09.2023

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$\frac{1}{\sqrt{2}} V_{max}$