BERZIET UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEE2101

Basic Electrical Engineering Lab

Experiment #:11
Series and Parallel Resonant Circuits

Prepared by: AYA BADAWI 1222065

Partners: ***leen shawakha 1221826***

malak qasem 1210484

Instructor: Dr. Jaser Sa'ed

Eng. Mohammad Deek

20I DECEMBER I 2024

Table Of Contents:

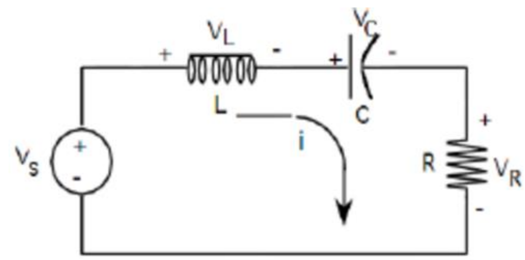
ABSTRACT

In this experiment. RLC circuits. This experiment focuses on band-pass filters aims To investigate the characteristic of the Series and Parallel Resonant Circuits .discuss the behaver of the series and parallel resonant circuits and how to find the cutoff frequencies. .we use Digital Multimeter, Oscilloscope, Function Wave Generator , Resistors, capacitors, inductors, and wires

THEORY

- Series Resonance:

The behavior of a capacitor and an inductor in a circuit changes with the frequency. At a frequency of 0 (DC), the capacitor acts as an open circuit, and the inductor behaves as a short circuit, resulting in zero output voltage. At infinite frequency, the roles reverse: the capacitor becomes a short circuit, and the inductor acts as an open circuit, but the output voltage remains zero.



However, at a certain frequency called the center frequency (f_0), the impedances of the capacitor and inductor cancel each other out because they have equal magnitudes but opposite signs. This results in the output voltage being equal to the input voltage, creating resonance in the AC circuit. Resonance occurs when the circuit's impedance is at its lowest, and the phase is zero. The sharpness of this resonance is determined by the circuit's resistance and is measured by the "Q" factor.

The resonance frequency ω_o is the frequency at which the impedances of the capacitor and inductor cancel each other out, given by $\omega_o = \frac{1}{\sqrt{LC}}$. At this frequency, the current I in the circuit is given by $I = \frac{V_R}{R}$, and the instantaneous current i is $i = I_m \cos(\omega t + \theta)$, where I_m and θ are defined by:

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

$$\theta = -\tan^{-1}\left(\frac{\omega L - \frac{1}{\omega C}}{R}\right)$$

The bandwidth B is the range of frequencies where the current amplitude is at least $\frac{1}{\sqrt{2}}$ times its maximum amplitude, given by:

$$B = \omega_2 - \omega_1 = \frac{R}{L}$$

where ω_2 and ω_1 are the -3dB frequencies, calculated as:

$$\omega_{2,1} = \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} \pm \frac{R}{2L}$$

The quality factor Q is defined as:

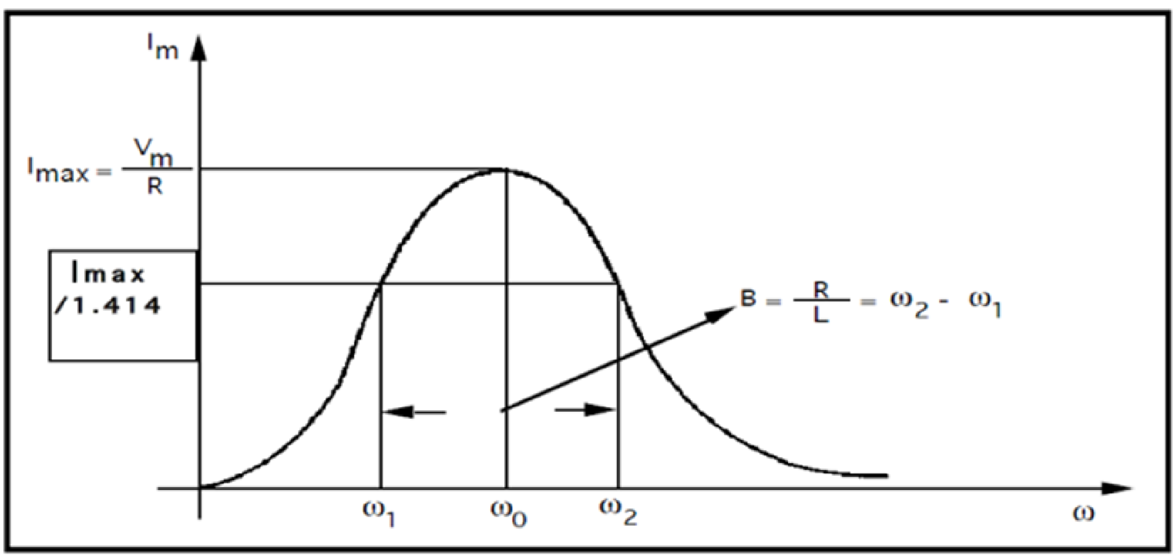
$$Q = \frac{\omega_o}{B} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

The maximum values in the circuit are:

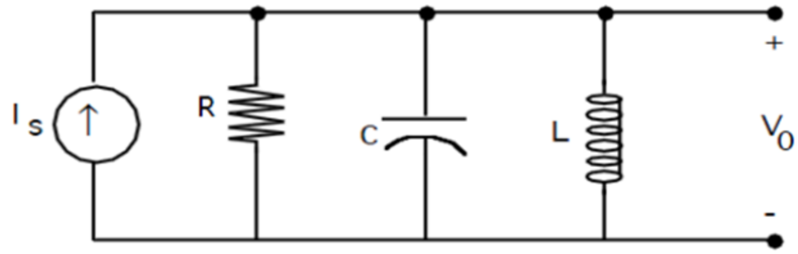
1. V_R occurs at $\omega = \omega_o$
2. V_L occurs at $\omega_o\sqrt{1 - \frac{R^2C}{2L}}$
3. V_C occurs at $\omega_o\sqrt{1 - \frac{R^2C}{2L}}$

The bandwidth β is also given by:

$$\beta = \omega_{c2} - \omega_{c1} = \frac{R}{L}$$



- Parallel Resonance:



resonance of a parallel RLC circuit is more complex than that of a series RLC circuit. However, the resonant frequency for both circuit types converges to the same expression when the circuit's resistance is small. In a parallel RLC circuit, one way to define the resonant frequency is as the frequency at which the circuit's impedance is at its maximum.

In the special case where the resistances of the inductor and capacitor are negligible, the concept of admittance simplifies the analysis. Resonance in this circuit can also be defined as the frequency at which the voltage and current are in phase, resulting in a unity power factor.

Given that the current $I_s = I_m \cos(\omega t + \theta)$, the voltage $V_o = V_m \cos(\omega t + \theta)$ can be expressed as:

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

$$\theta = -\tan^{-1}\left(R\left(\omega C - \frac{1}{\omega L}\right)\right)$$

Key points include:

- The resonance frequency is:

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

- The -3dB frequencies are:

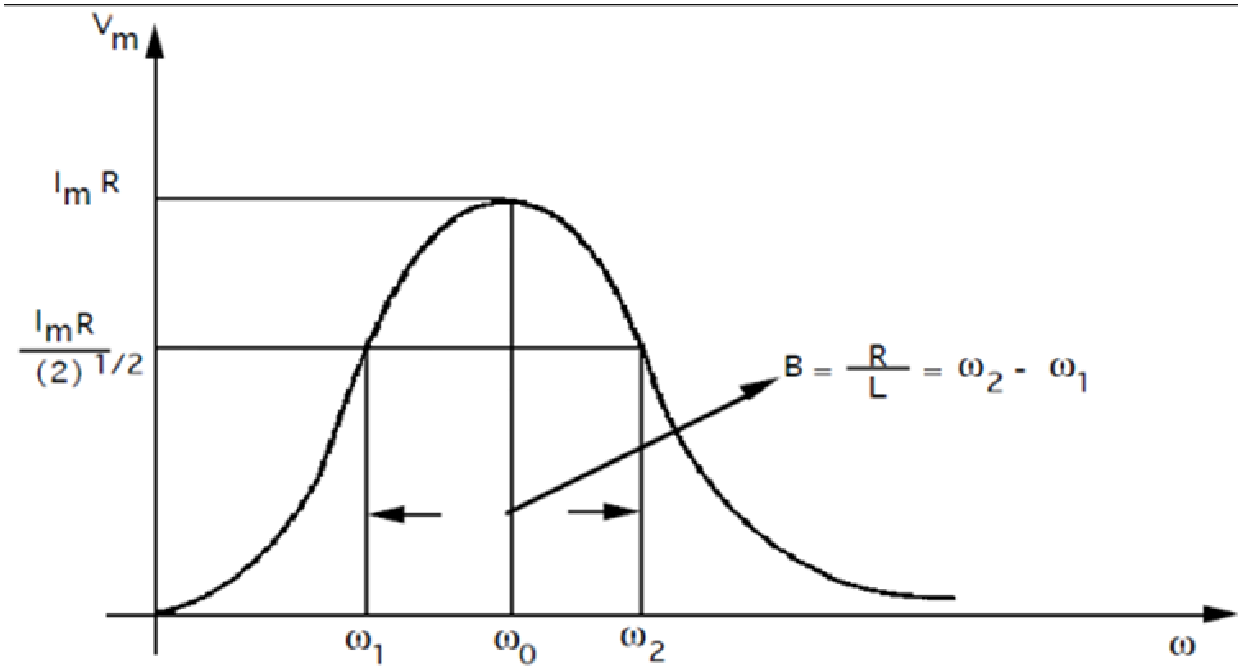
$$\omega_{2,1} = \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}} \pm \frac{1}{2RC}$$

- The bandwidth is:

$$\beta = \omega_2 - \omega_1 = \frac{1}{RC}$$

- The quality factor is:

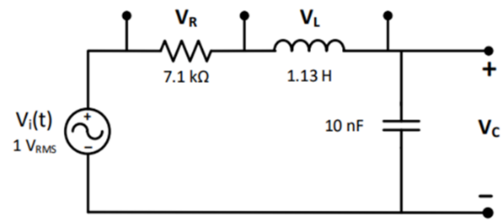
$$Q = \frac{\omega_o}{\beta} = R\sqrt{\frac{C}{L}}$$



PROCEDURE

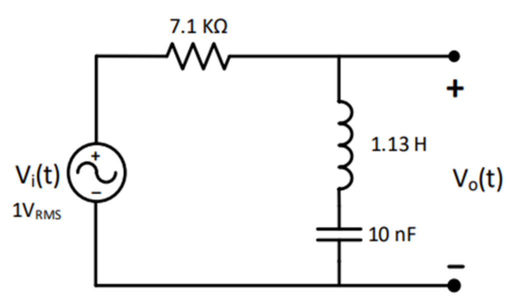
- **Part A) Impedance and resonance:**

In this circuit, an RMS input voltage was applied in series with a 7.1 kΩ resistor, a 1.13 H inductor, and a 10 nF capacitor. The frequency was varied between 30 Hz and 80 kHz. when f increase VR and VL increase. VC at first increase (when c charge). When c discharge VC decrease



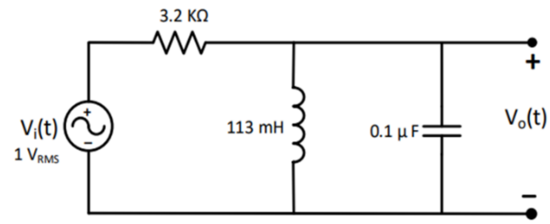
- **PART B) Series Resonant Circuits:**

In this circuit, an RMS input voltage was applied in series with a 7.1 kΩ resistor, a 1.13 H inductor, and a 10 nF capacitor. The frequency was varied between 100 Hz and 20 kHz. At both the lowest (100 Hz) and highest (20kHz) frequencies, the output voltage was observed to be nearly the same as the input voltage, indicating maximum output. As the frequency increased, the output voltage gradually decreased, reaching nearly zero at the center frequency. After passing the center frequency, the output voltage began to rise again, reaching a maximum at the cutoff frequencies fc1 and fc2 , which were measured using the formula Vmax/ sqrt 2 . These measurements were taken using both an oscilloscope and a digital multimeter.



- **PART C) Parallel Resonant Circuits:**

A 1-volt RMS input voltage was connected in parallel with a 3.2 kΩ resistor, a 113 mH inductor, and a 0.1 μF capacitor. The output voltage was measured across the capacitor. At both the lowest (15 Hz) and highest (10 kHz) frequencies, the output voltage was minimal, nearly zero. As the frequency increased, the output voltage gradually rose until it reached a peak at the center frequency. After this point, the output voltage began to decrease. The two cutoff frequencies (fc1 and fc2} were identified by measuring the voltage at V max\sqrt2. The data were recorded using both an oscilloscope and a digital multimeter.



SIMULATION AND DATA ANALYSIS AND CACULATIONS

- Part A: Impedance and resonance:

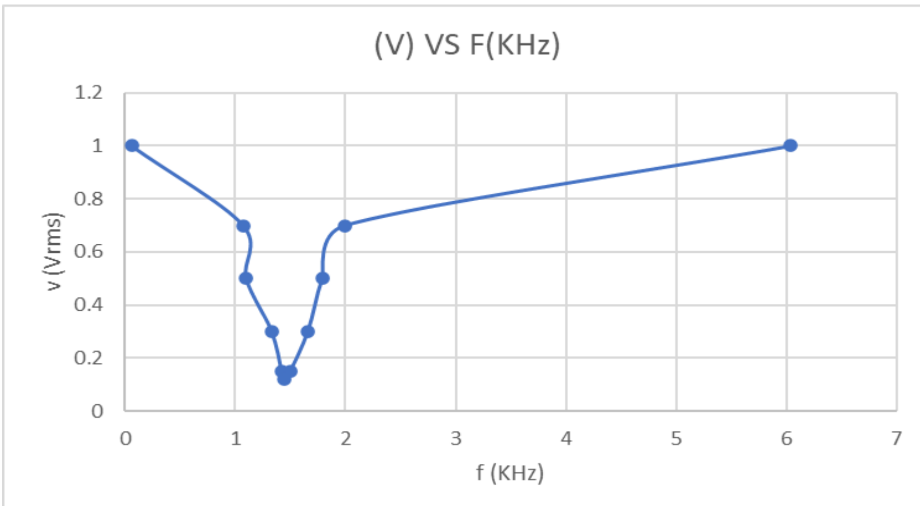
f[Hz]	30	400	700	1k	1.2 k	1.5 k	2k	2.5k	3.5k	6k	80k
VR[VRMS]	0.18	0.2	0.384	0.63	0.742	0.958	0.72	0.529	0.282	0.046	0.314
VL[VRMS]	0.001	0.71	0.252	0.59	0.77	1.33	1.5	1.371	1.16	0.959	0.152
VC[VRMS]	0.988	1.37	1.48	1.33	1.417	1.425	0.784	0.48	0.189	0.015	0.002

As the frequency increases:

The Capacitor Behaves as a short circuit, And the Inductor Behaves as an open circuit.

- PART B) Series Resonant Circuits:

$V_o[V_{rms}]$	Vmax	Vmax / √2	0.5	0.3	0.15	Vmin	0.15	0.3	0.5	0.7	1
f[kHz]	0.06	f_{c1} 1.07	1.1	1.33	1.42	f_0 1.44	1.5	1.66	1.79	f_{c2} 2	6.04



B =R/L=7100/1.13 =6283

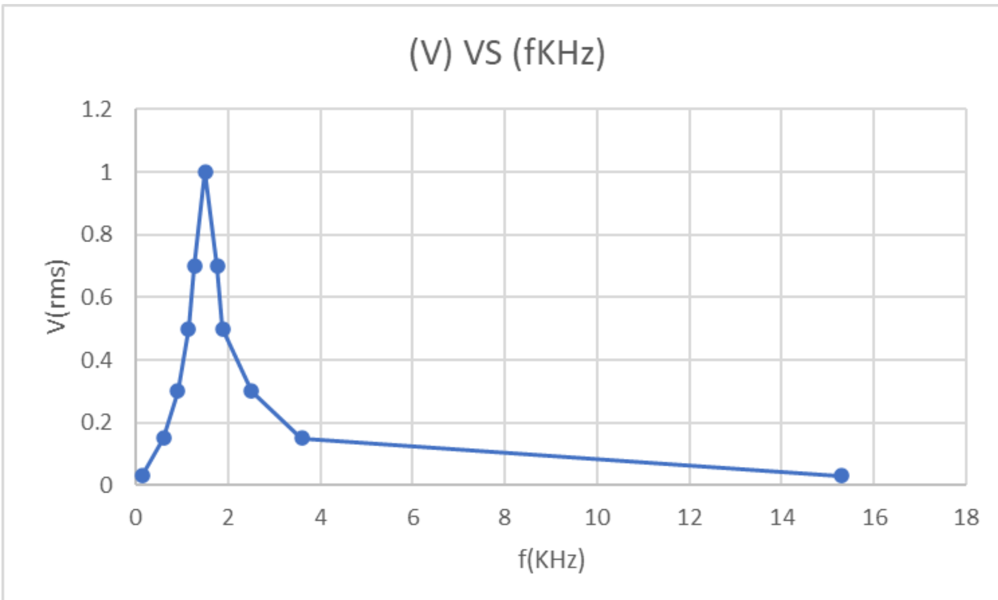
For the cutoff frequencies we can see when the voltage reaches (0.707V) the frequencies are (F1 = 1.07kHz, F2 =2kHz) which are the same as the value we calculated theoretically, and for the

resonance frequency we can see that at the lowest point in the curve the frequancy is (Fo= 1.44kHz) which is close to what we calculated theoretically.

Then we changed the value of the resistor then simulated the circuit as shown we got the curve of the voltage for the inductor and capacitor which is similar to the curve when the resistor was (7.1k ohm) but the difference will be in the values of the cutoff frequencies but not the resonance frequency

• PART C) Parallel Resonant Circuits:

$V_o[V_{rms}]$	0.03	0.15	0.3	0.5	Vmax / √2	Vmax	Vmax / √2	0.5	0.3	0.15	0.03
f[kHz]	0.135	0.6	0.907	1.14	f_{c1} 1.27	f_0 1.505	f_{c2} 1.76	1.88	2.5	3.6	15.31



B=1/RC = 3125

For the cutoff frequencies we can see when the voltage reaches (0.707V) the frequencies are (F1 = 1.27kHz, F2 =1.76kHz) which are the same as the value we calculated theoretically, and for the resonance frequency we can see that at the highest point in the curve the frequency is (Fo= 1.505kHz) which is close to what we calculated theoretically.

the behavior of the voltage is the same the only difference will occur on the cutoff frequencies and on the resonance frequency when changing the inductor and R value.

CONCLUSION

we studied the resonance frequencies and cutoff frequencies for an RLC circuit and how to find each one of them using the graph.

REFEERENCES

1)lab manual.

2)data was taken during exp:

Experiment 11 - Data Tables:

Part A: Impedance and resonance

For the circuit of figure 11.5

Table 11.1

f [Hz]	30	400	700	1 k	1.2 k	1.5 k	2 k	2.5 k	3.5 k	6 k	80 k
V_R [V_{RMS}]	0.18	0.2	0.384	0.63	0.772	0.958	0.72	0.529	0.282	0.076	0.314
V_L [V_{RMS}]	0.8	0.71	0.252	0.59	0.77	1.33	1.5	1.371	1.160	0.959	0.152
V_C [V_{RMS}]	0.988	1.37	1.48	1.33	1.417	1.425	0.784	0.48	0.189	0.045	0.002

Part B: Series Resonant Circuits

For the circuit of figure 11.6

For R = 7.1 kΩ

Table 11.2

Vo [V_{RMS}]	V_{max}	$V_{max}/\sqrt{2}$	0.5	0.3	0.15	V_{min}	0.15	0.3	0.5	$V_{max}/\sqrt{2}$	V_{max}
f [kHz]	0.066	f_{c1} 1.07	1.1	1.33	1.42	f_0 1.44	1.5	1.66	1.79	f_{c2} .2	6.04

Part C: Parallel Resonant Circuits

For the circuit of figure 11.7

For R = 3.2 kΩ

Table 11.4

Vo [V_{RMS}]	0.03	0.15	0.3	0.5	$V_{max}/\sqrt{2}$	V_{max}	$V_{max}/\sqrt{2}$	0.5	0.3	0.15	0.03
f [kHz]	0.135	0.60	0.907	1.14	f_{c1} 1.27	f_0 1.505	f_{c2} 1.76	1.88	2.5	3.6	15.3