ELECTRICAL ENGINEERING 110L CIRCUITS MEASUREMENTS LAB

LAB 5: RESONANT CIRCUITS AND INDUCTORS

Name: Wilson Lam

UID: 203-777-389

October 25, 2012

Lab Section: EE 110L Lab 6

Lab Partners: Richard Hill

Professor: Hassan Babaie

TA: Basir-kazeruni, Sina

TABLE OF CONTENTS

OBJECTIVE

Anyone in the electrical engineer field will definitely encounter the RLC circuit in various devices. The RLC circuit is the fundamental circuit that played an important role in electronics. In this lab experiment we will cover RLC circuit, like any experience engineer, and search for frequency response, resonance, bandwidth, and quality factor. To perform the experiment theories on RLC must be discussed and applied to the RLC circuit before data can be collected. One main topic focused on this experiment is at the resonance frequency. The resonance frequency is important in our application and found when the impedance is goes to zero.

Mutual inductance is another concept that was covered in this experiment due to its importance in the universe. Everything in the universe has an inductance in which it can induce on its surrounding. To test the effect of inductance we will build a simple circuit and measure the induce current in a fellow inductor next to the powered inductor.

THEORY

In this lab we were using the following governing equations to conduct experiments, collect data, and verify principles:

Governing Equations	Equations Information
[1] $X_L = j\omega L$	Inductor's Impedance X = Impedance (Ω), ω = (rad/s), L = Inductance (H)
[2] $X_C = 1/(j\omega C)$	Capacitor's Impedance C = Capacitance (F)
[3] $\omega_R = \frac{1}{\sqrt{LC}}$ or $f_R = \frac{1}{2\pi\sqrt{LC}}$	ω_R= (rad/s) and f_R= resonant frequency (Hz) Resonant frequency occur when: - The impedance goes to zero OR - The gain is maximum
[4] Z = $[R^2+(\omega L-(\frac{1}{\omega C}))^2]^{1/2}$	Series RLC's Impedance (derive from [1] and [2] with KCL) (note: one possible form)
[5] Q = $X_{at\ resonance}/R$	Q = quality factor (unitless) X = Impedance of inductor or capacitor at resonance
[6] BW = $\omega_{Hi} - \omega_{Lo}$	BW = Bandwidth
[7] $\angle Z = tan^{-1}(\frac{\omega L - \frac{1}{\omega C}}{R}))$	Phase angle for Z (RLC circuit in series)
[8] f=1/T	f = frequency (Hz) and T = period (s)
[9] dB = 20*log(V_{in}/V_{out})	Voltage ratio to dB conversion
[10] Gain = V_{out}/V_{in}	Gain of the circuit

[11] BW = ω_{HI}-ω_{LO}	Bandwidth (ω are usually obtain from 3dB drop from maximum)
[12] Q = ω_R/(BW) = $\|\|Z_c\|\|$/R = $\|\|Z_L\|\|$/R	Quality factor of the circuit

Table 1: Governing Equations for the experiments that follow.

Kirchhoff's Current Law (KCL) –

Sum of all the current coming in equals the current going out. This law is useful when trying to setup a general equation for the circuit. This law may help with finding the impedance.

Kirchhoff's Voltage Law (KVL) –

Voltage in an enclosed loop adds up to zero. This law is useful when trying to setup a general equation for the circuit. This law may help with finding the impedance as well.

PROCEDURE

In this lab there were three main experiments that we performed and several parts that may be grouped together with the larger portion. The experiments we worked on were:

Experiment 1:
In experiment 1 the focus were on building the series RLC circuit, measuring response on each component, and re-measuring V_{out} after exchanging channel 2 connections to load.

Part A
- First setup the RLC series circuit by following the lab manual and pick C = 10nF, R = 500 Ohms, L = 3.9 mH to follow the data corresponding to our experiment. (Other values technically work as well.)
- Second prepare the oscilloscope and function generator for measurement.
- Find the resonance frequency of the circuit and use that frequency as the center data value. Choose 10 other sets of frequencies before and after the resonance for data point collection. These 20 points should include the -3dB location before and after the resonance frequency.
- Connect channel 1 of the oscilloscope to V_{in} (across functional generator) and channel 2 to V_{R_out} (across desire load).
- Begin the experiment by going through the various frequency and recording the V_{in} and V_{out}. Make sure to include the -3dB before and after the resonance frequency in the data collection.

Part B
- Exchange the current resistor for two other resistors and check to see if the resonance frequency changes. Record the data.

Part C
- This repeats the steps in part A, but make sure to switch the load to the inductor L (channel 2 is now across L).

Part D

- This repeats the steps in part A, but make sure to switch the load to the capacitor C (channel 2 is now across C).

Experiment 2:
In this part of the experiment we perform similar task to experiment 1. The circuit for this experiment is a parallel RLC circuit. R is technically in series with the parallel L and C. This experiment design is shown in the figure below.

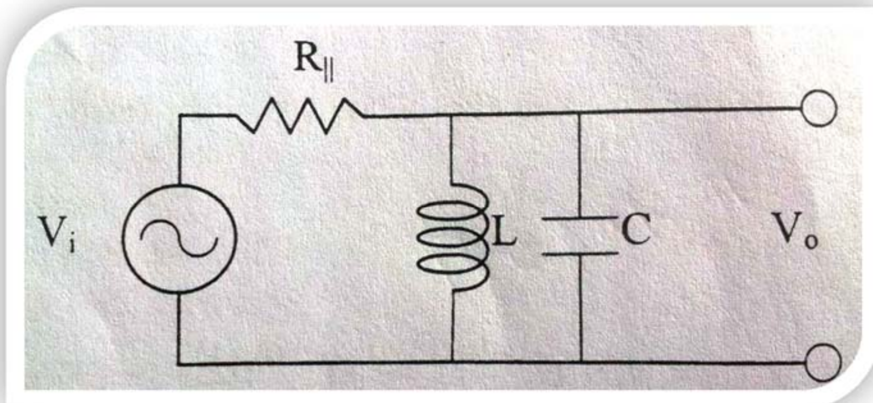

Figure 1: Diagram for experiment 2 setup.

Though this is the diagram for the setup there should be two resistors with about 2 ohms attach right after the inductor and capacitor. After that connect channel 1 across the power supply and channel 2 across:

- The inductor in the first data recording
- The capacitor in the second data recording

When the inductor or capacitor was connected the data recorded like in experiment 1 for both components.

Experiment 3:
In this part of the experiment we obtain two inductors and perform a test relating to distance. To do this we connect the inductors and the channels from the oscilloscope as shown below.

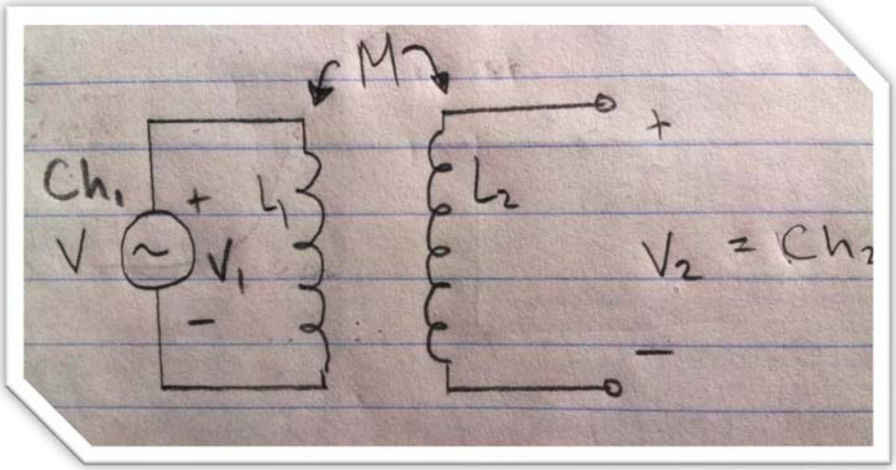

Figure 2: Experiment 3 setup for Mutual Inductance

The channel 1 will be collecting the voltage necessary so later a plot relating voltage and distance can be obtain.

DATA, DATA ANALYSIS, ERROR ANALYSIS, AND DISCUSSION

Error Analysis Equation

If the general equation is F(x1, x2,…, xn) then the error for F (identified as σ_F) would be given by the following error propagation equation:

$$\sigma_F = \sqrt{(\frac{dF}{dx_1}\sigma_{x_1})^2 + (\frac{dF}{dx_2}\sigma_{x_2})^2 + \cdots + (\frac{dF}{dx_n}\sigma_{x_n})^2}$$

Experiment 1:

Data for A – Resistor:

f (kHz)	Period (s)	Vi (V)±.05	Vo (V)±.0005	Vo/Vi ±uncertainty		dB gain ±uncertainty	
0.1	1.00E-02	2.10E+01	8.40E-02	4.00E-03	3.E-05	-4.80E+01	6.E-02
1	1.00E-03	2.10E+01	7.84E-01	3.73E-02	9.E-05	-2.86E+01	2.E-02
5	2.00E-04	2.12E+01	4.04E+00	1.91E-01	5.E-04	-1.44E+01	2.E-02
15	6.67E-05	2.06E+01	1.27E+01	6.17E-01	1.E-03	-4.20E+00	2.E-02
17	5.88E-05	**2.04E+01**	**1.42E+01**	**6.96E-01**	2.E-03	**-3.15E+00**	2.E-02
20	5.00E-05	1.96E+01	1.72E+01	8.78E-01	2.E-03	-1.13E+00	2.E-02
22	4.55E-05	1.96E+01	1.84E+01	9.39E-01	2.E-03	-5.49E-01	2.E-02
23	4.35E-05	1.98E+01	1.88E+01	9.49E-01	2.E-03	-4.50E-01	2.E-02
24	4.17E-05	1.94E+01	1.88E+01	9.69E-01	2.E-03	-2.73E-01	2.E-02
24.5	4.08E-05	1.94E+01	1.86E+01	9.59E-01	2.E-03	-3.66E-01	2.E-02

25	4.00E-05	1.94E+01	1.88E+01	9.69E-01	2.E-03	-2.73E-01	2.E-02
25.4	**3.94E-05**	**1.94E+01**	**1.90E+01**	**9.79E-01**	**3.E-03**	**-1.81E-01**	**2.E-02**
26	3.85E-05	1.96E+01	1.90E+01	9.69E-01	2.E-03	-2.70E-01	2.E-02
26.5	3.77E-05	1.96E+01	1.90E+01	9.69E-01	2.E-03	-2.70E-01	2.E-02
27	3.70E-05	1.96E+01	1.88E+01	9.59E-01	2.E-03	-3.62E-01	2.E-02
28	3.57E-05	1.96E+01	1.86E+01	9.49E-01	2.E-03	-4.55E-01	2.E-02
29	3.45E-05	1.96E+01	1.84E+01	9.39E-01	2.E-03	-5.49E-01	2.E-02
30	3.33E-05	1.96E+01	1.82E+01	9.29E-01	2.E-03	-6.44E-01	2.E-02
35	2.86E-05	2.00E+01	1.62E+01	8.10E-01	2.E-03	-1.83E+00	2.E-02
40	2.50E-05	**2.02E+01**	**1.36E+01**	**6.73E-01**	2.E-03	**-3.44E+00**	2.E-02
50	2.00E-05	2.08E+01	1.09E+01	5.24E-01	1.E-03	-5.61E+00	2.E-02
100	1.00E-05	2.12E+01	9.96E+00	4.70E-01	1.E-03	-6.56E+00	2.E-02
500	2.00E-06	2.14E+01	3.06E-01	1.43E-02	4.E-05	-3.69E+01	2.E-02

Table 2: Data collected for the resistor.

In this first experiment the channel 2 is across the resistor. The data collected are display above.

	Pre-Lab	Measured	uncertainty	Calculated	% error (%)
R (Ohms)	500	502.3	±.05	N/A	0.46
L (mH)	3.9	3.57	±.05	N/A	8.46
C (nF)	10	10.98	±.05	N/A	9.80
$W_{Resonance}$	25.49	25.4	N/A	25.42±.2	0.08

Table 3: Table have the components measured and calculated values used in the experiment.

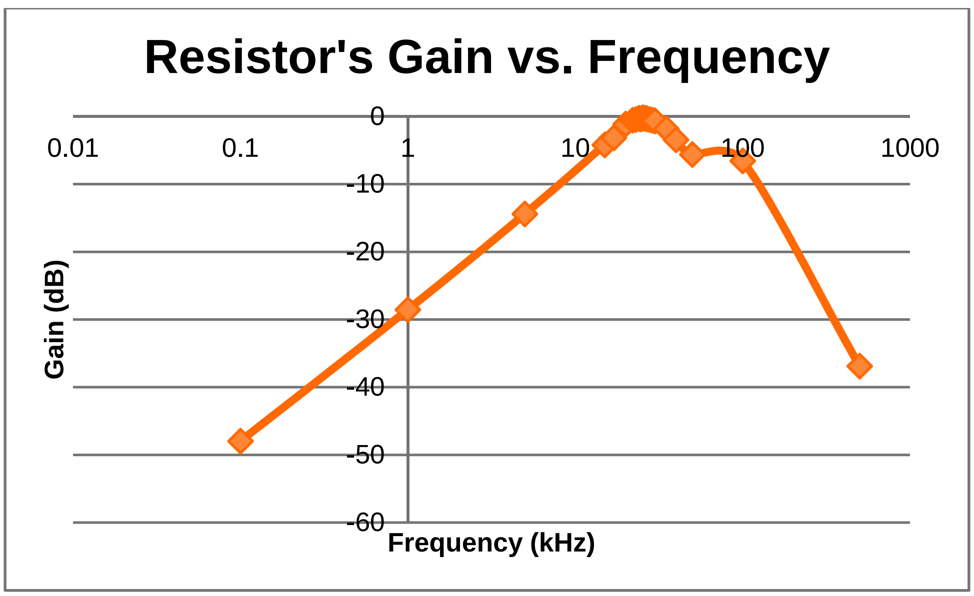

Figure 3: Graph of the resistor's gain vs. frequency. Resonance is at peak.

Data Analysis & Error Analysis

In this part of the experiment errors comes from the experimental values and were calculated using the error propagation equation. The uncertainties were listed next to the values as shown in the tables. From the value above we notice that the resonance frequency is at 25.4 kHz as we expected. The calculated value for resonance frequency was 25.42 kHz. This means that there is only a .08% error in this experiment. This part of the experiment was extremely well done. The quality factor Q can now be calculated from this. We obtain Q = 25.4/(40-17) = 0.9769.

Discussion

To pick out the resonance frequency it was not too difficult as we just look for the highest dB in the table. We also had calculated for the dB before the experiment so we know what to expect. The experiment for this resistor part was a great success. One weird thing that we notice is the horizontal line that is keeping dB almost constant at 100 kHz.

Data for B – Inductor:

f (kHz)	Period (s)	Vi (V)±.05	Vo (V)±.0005	Vo/Vi ±uncertainty		dB gain ±uncertainty	
5.116	1.95E-04	2.08E+01	8.96E-01	4.31E-02	1.E-04	-2.73E+01	2.E-02
15.24	6.56E-05	2.04E+01	8.08E+00	3.96E-01	1.E-03	-8.04E+00	2.E-02
16.97	5.89E-05	2.02E+01	9.92E+00	4.91E-01	1.E-03	-6.18E+00	2.E-02
20.06	**4.99E-05**	**1.96E+01**	**1.36E+01**	**6.94E-01**	**2.E-03**	**-3.17E+00**	**2.E-02**
22.24	4.50E-05	1.94E+01	1.66E+01	8.56E-01	2.E-03	-1.35E+00	2.E-02
23.02	4.34E-05	1.92E+01	1.74E+01	9.06E-01	2.E-03	-8.55E-01	2.E-02
24.05	4.16E-05	1.92E+01	1.84E+01	9.58E-01	2.E-03	-3.70E-01	2.E-02
24.95	4.01E-05	1.92E+01	1.92E+01	1.00E+00	3.E-03	0.00E+00	2.E-02
25.4	3.94E-05	1.90E+01	1.98E+01	1.04E+00	3.E-03	3.58E-01	2.E-02
25.99	3.85E-05	1.90E+01	2.02E+01	1.06E+00	3.E-03	5.32E-01	2.E-02
26.47	3.78E-05	1.92E+01	2.04E+01	1.06E+00	3.E-03	5.27E-01	2.E-02
27	3.70E-05	1.92E+01	2.06E+01	1.07E+00	3.E-03	6.11E-01	2.E-02
28	3.57E-05	1.92E+01	2.14E+01	1.11E+00	3.E-03	9.42E-01	2.E-02
28.97	3.45E-05	1.92E+01	2.18E+01	1.14E+00	3.E-03	1.10E+00	2.E-02
30	3.33E-05	1.92E+01	2.24E+01	1.17E+00	3.E-03	1.34E+00	2.E-02
35.11	**2.85E-05**	**1.96E+01**	**2.34E+01**	**1.19E+00**	**3.E-03**	**1.54E+00**	**2.E-02**
40.29	2.48E-05	1.98E+01	2.36E+01	1.19E+00	3.E-03	1.52E+00	2.E-02
50.8	1.97E-05	2.02E+01	2.30E+01	1.14E+00	3.E-03	1.13E+00	2.E-02
101.29	9.87E-06	2.08E+01	2.18E+01	1.05E+00	3.E-03	4.08E-01	2.E-02
194	5.15E-06	2.16E+01	2.18E+01	1.01E+00	2.E-03	8.01E-02	2.E-02
309	3.24E-06	2.16E+01	2.18E+01	1.01E+00	2.E-03	8.01E-02	2.E-02
500	2.00E-06	2.10E+01	2.10E+01	1.00E+00	2.E-03	0.00E+00	2.E-02
1000	1.00E-06	2.10E+01	2.10E+01	1.00E+00	2.E-03	0.00E+00	2.E-02
1000	1.00E-06	2.10E+01	2.10E+01	1.00E+00	2.E-03	0.00E+00	2.E-02

4911	2.04E-07	2.36E+01	2.10E+01	8.90E-01	2.E-03	-1.01E+00	2.E-02
9900	1.01E-07	2.34E+01	1.64E+01	7.01E-01	1.E-03	-3.09E+00	2.E-02
11569	8.64E-08	2.28E+01	1.54E+01	6.75E-01	1.E-03	-3.41E+00	2.E-02

Table 4: Shows the data collected for the inductor.

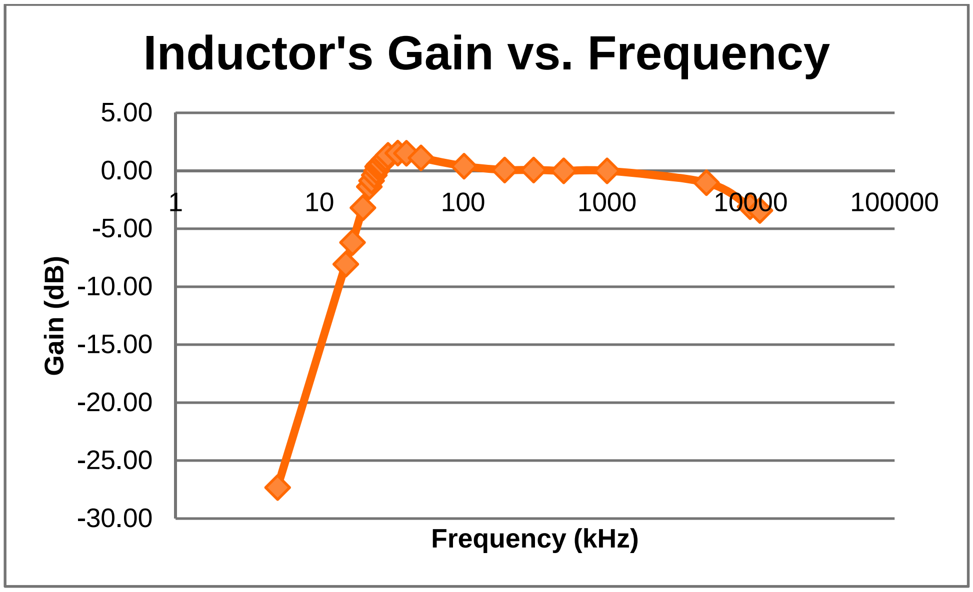

Figure 4: Graph of the inductor's gain vs. frequency. Resonance is at peak.

Data Analysis & Error Analysis

In this part of the experiment errors comes from the experimental values and were calculated using the error propagation equation. The uncertainties were listed next to the values as shown in the tables. From the value above we notice that the resonance frequency is at 35.11 kHz. The quality factor Q can now be calculated from this. We obtain Q = 35.11/(9900-20.06) = 0.0026.

Discussion

To pick out the resonance frequency it was not too difficult as we just look for the highest dB in the table. There are very important things that should be noticeable on the capacitor and inductor graphs. The inductor has a gain after close to zero after 25 kHz and the capacitor has a gain close to zero before the 25 kHz.

Data for C – Capacitor:

f (kHz)	Vi (V)±.05	Vo (V)±.0005	Vo/Vi	±uncertainty		dB gain	
0.984	2.12E+01	2.12E+01	1.00E+00	2.E-03	0.00E+00	2.E-02	0.984
3.24	2.18E+01	2.22E+01	1.02E+00	2.E-03	1.58E-01	2.E-02	3.24
5	2.16E+01	2.22E+01	1.03E+00	2.E-03	2.38E-01	2.E-02	5
7.04	2.16E+01	2.26E+01	1.05E+00	2.E-03	3.93E-01	2.E-02	7.04
10.36	2.16E+01	2.32E+01	1.07E+00	2.E-03	6.21E-01	2.E-02	10.36
15.57	2.06E+01	2.38E+01	1.16E+00	3.E-03	1.25E+00	2.E-02	15.57

18.17	2.06E+01	2.38E+01	1.16E+00	3.E-03	1.25E+00	2.E-02	18.17
18.54	2.06E+01	2.38E+01	1.16E+00	3.E-03	1.25E+00	2.E-02	18.54
18.97	2.02E+01	2.38E+01	1.18E+00	3.E-03	1.42E+00	2.E-02	18.97
19.61	2.04E+01	2.36E+01	1.16E+00	3.E-03	1.27E+00	2.E-02	19.61
19.94	**2.02E+01**	**2.36E+01**	**1.17E+00**	3.E-03	**1.35E+00**	2.E-02	**19.94**
20.75	2.00E+01	2.32E+01	1.16E+00	3.E-03	1.29E+00	2.E-02	20.75
22.13	2.00E+01	2.26E+01	1.13E+00	3.E-03	1.06E+00	2.E-02	22.13
23.04	1.96E+01	2.20E+01	1.12E+00	3.E-03	1.00E+00	2.E-02	23.04
23.46	1.96E+01	2.20E+01	1.12E+00	3.E-03	1.00E+00	2.E-02	23.46
23.95	1.98E+01	2.18E+01	1.10E+00	3.E-03	8.36E-01	2.E-02	23.95
24.5	1.98E+01	2.14E+01	1.08E+00	3.E-03	6.75E-01	2.E-02	24.5
25.16	1.96E+01	2.10E+01	1.07E+00	3.E-03	5.99E-01	2.E-02	25.16
31.3	2.00E+01	1.62E+01	8.10E-01	2.E-03	-1.83E+00	2.E-02	31.3
33.12	**2.02E+01**	**1.48E+01**	**7.33E-01**	2.E-03	**-2.70E+00**	2.E-02	**33.12**
35.95	2.04E+01	1.30E+01	6.37E-01	2.E-03	-3.91E+00	2.E-02	35.95
37.13	2.04E+01	1.22E+01	5.98E-01	1.E-03	-4.47E+00	2.E-02	37.13
38.25	2.04E+01	1.16E+01	5.69E-01	1.E-03	-4.90E+00	2.E-02	38.25
39.79	2.08E+01	1.08E+01	5.19E-01	1.E-03	-5.69E+00	2.E-02	39.79
43.77	2.08E+01	9.00E+00	4.33E-01	1.E-03	-7.28E+00	2.E-02	43.77

Table 5: Shows the data collected for the capacitor.

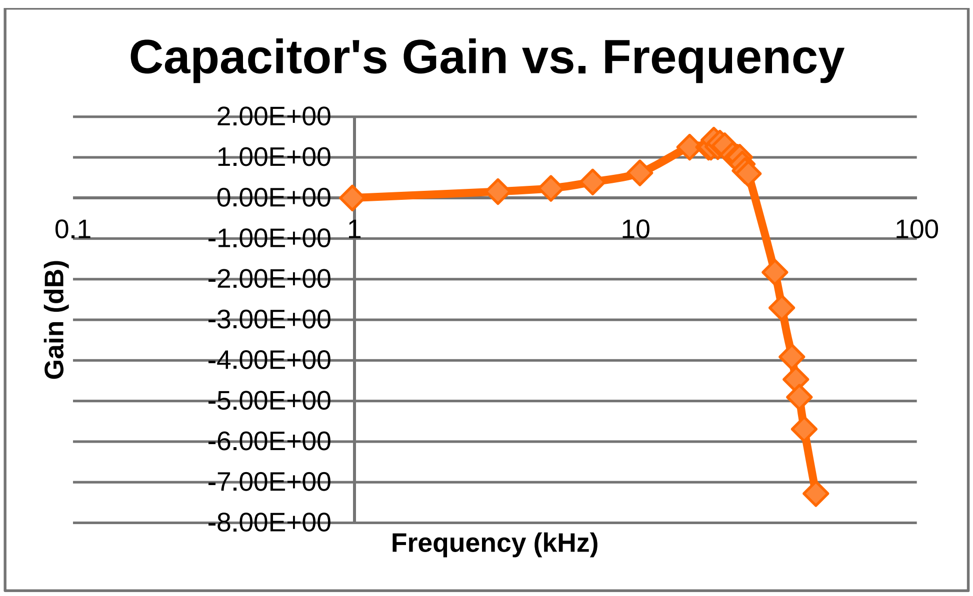

Figure 5: Graph of the capacitor’s gain vs. frequency. Resonance is at peak.

Data Analysis & Error Analysis

In this part of the experiment errors comes from the experimental values and were calculated using the error propagation equation. The uncertainties were listed next to the values as shown in the tables. From the value above we notice that the resonance frequency is at 35.11 kHz. The quality factor Q can now be calculated from this. We obtain Q = 19.94/(33.12-1) = 0.62. Dr. Babaie states that we don't necessary need to find -3dB at the low end of the frequency. In this case it becomes clear that the frequency was below to 1 kHz so there was no reason to find the -3dB location.

Discussion

Again we can see the similarity between the inductor and capacitor graphs. There are very important things that should be noticeable on the capacitor and inductor graphs. The inductor has a gain after close to zero after 25 kHz and the capacitor has a gain close to zero before the 25 kHz. Apparently the -3dB for the capacitor cannot be found as the wave generator cannot generate frequency and/or be recorded in the oscilloscope.

Experiment 2:

Data – across 2.5 Ohms Resistor

f (kHz)	Vi (V)±.05	Vo (mV)±.0005	Vo/Vi	±uncertainty	dB gain	±uncertainty
1.07	1.96E+01	4.80E+00	2.45E-04	6.E-07	-7.22E+01	2.E-02
5.13	1.76E+01	4.00E+00	2.27E-04	6.E-07	-7.29E+01	2.E-02
14.1	2.00E+01	1.12E+01	5.60E-04	1.E-06	-6.50E+01	2.E-02
17.76	1.96E+01	2.24E+01	1.14E-03	3.E-06	-5.88E+01	2.E-02
20.01	2.08E+01	3.68E+01	1.77E-03	4.E-06	-5.50E+01	2.E-02
22.06	2.08E+01	4.80E+01	2.31E-03	6.E-06	-5.27E+01	2.E-02
22.77	2.08E+01	5.28E+01	2.54E-03	6.E-06	-5.19E+01	2.E-02
24.16	2.12E+01	6.08E+01	2.87E-03	7.E-06	-5.08E+01	2.E-02
25.12	2.12E+01	6.56E+01	3.09E-03	7.E-06	-5.02E+01	2.E-02
25.37	2.12E+01	6.64E+01	3.13E-03	7.E-06	-5.01E+01	2.E-02
26.44	2.12E+01	7.12E+01	3.36E-03	8.E-06	-4.95E+01	2.E-02
27.13	2.12E+01	7.20E+01	3.40E-03	8.E-06	-4.94E+01	2.E-02
28.31	2.12E+01	7.36E+01	3.47E-03	8.E-06	-4.92E+01	2.E-02
29.89	2.08E+01	7.28E+01	3.50E-03	8.E-06	-4.91E+01	2.E-02
36.08	2.04E+01	6.56E+01	3.22E-03	8.E-06	-4.99E+01	2.E-02
40.53	2.04E+01	6.15E+01	3.01E-03	7.E-06	-5.04E+01	2.E-02
50.95	2.04E+01	5.44E+01	2.67E-03	7.E-06	-5.15E+01	2.E-02
100.58	2.04E+01	4.88E+01	2.39E-03	6.E-06	-5.24E+01	2.E-02
508	2.04E+01	4.56E+01	2.24E-03	5.E-06	-5.30E+01	2.E-02

Table 6: Shows the data collected for the 2.5 Ohm resistor.

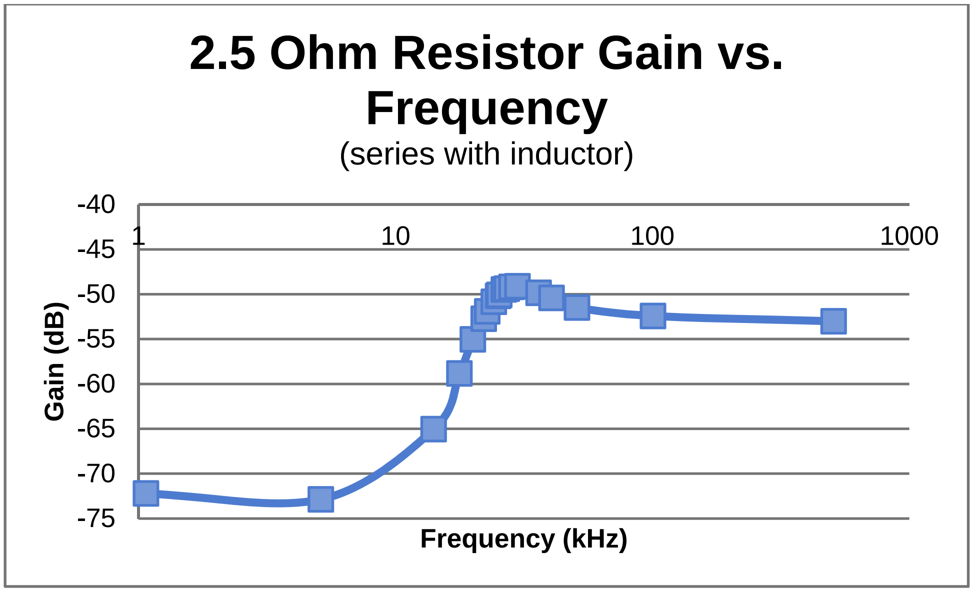

Figure 6: Graph of the resistor's gain vs. frequency. Resonance is at peak.

Data Analysis & Error Analysis

In this part of the experiment errors comes from the experimental values and were calculated using the error propagation equation. The uncertainties were listed next to the values as shown in the tables. For this experiment the 2.5 Ohm resistor was in series with the inductor so it has a similar graph to the inductor in Figure 4. The resonance for this resistor is at 29.89 kHz. It should be noticeable that there were no -3dB gain as all values are way below the -3dB.

Discussion

It seems like in this experiment we were able to find the resonance frequency pretty easily. The current could also be found by taking the voltage over the resistance. The graph for this is very similar to the one in the inductor as stated and has a low dB at the beginning frequency and a higher dB at the higher frequency. The occurrence of this resonance frequency is basically at the same location as well.

Data – across 1.8 Ohms Resistor

f (kHz)	Vi (V)±.05	Vo (mV)±.0005	Vo/Vi	±uncertainty	dB gain	±uncertainty
5.99	1.96E+01	4.40E+01	2.24E-03	6.E-06	-5.30E+01	2.E-02
15.62	2.04E+01	5.60E+01	2.75E-03	7.E-06	-5.12E+01	2.E-02
17.74	2.04E+01	6.00E+01	2.94E-03	7.E-06	-5.06E+01	2.E-02
20.28	2.08E+01	6.72E+01	3.23E-03	8.E-06	-4.98E+01	2.E-02
20.66	2.08E+01	5.12E+01	2.46E-03	6.E-06	-5.22E+01	2.E-02
21.73	2.08E+01	7.12E+01	3.42E-03	8.E-06	-4.93E+01	2.E-02
22.80	2.08E+01	7.20E+01	3.46E-03	8.E-06	-4.92E+01	2.E-02
24.00	2.12E+01	7.20E+01	3.40E-03	8.E-06	-4.94E+01	2.E-02
24.72	2.12E+01	7.12E+01	3.36E-03	8.E-06	-4.95E+01	2.E-02

25.21	2.12E+01	7.04E+01	3.32E-03	8.E-06	-4.96E+01	2.E-02
26.07	2.12E+01	6.80E+01	3.21E-03	8.E-06	-4.99E+01	2.E-02
26.89	2.12E+01	6.56E+01	3.09E-03	7.E-06	-5.02E+01	2.E-02
27.55	2.12E+01	6.24E+01	2.94E-03	7.E-06	-5.06E+01	2.E-02
28.65	2.08E+01	6.00E+01	2.88E-03	7.E-06	-5.08E+01	2.E-02
35.98	2.08E+01	3.92E+01	1.88E-03	5.E-06	-5.45E+01	2.E-02
39.39	2.08E+01	2.40E+01	1.15E-03	3.E-06	-5.88E+01	2.E-02
51.34	2.00E+01	1.36E+01	6.80E-04	2.E-06	-6.33E+01	2.E-02
100.6	2.16E+01	1.92E+01	8.89E-04	2.E-06	-6.10E+01	2.E-02
508	2.04E+01	1.12E+01	5.49E-04	1.E-06	-6.52E+01	2.E-02

Table 7: Shows the data collected for the 2.5 Ohm resistor.

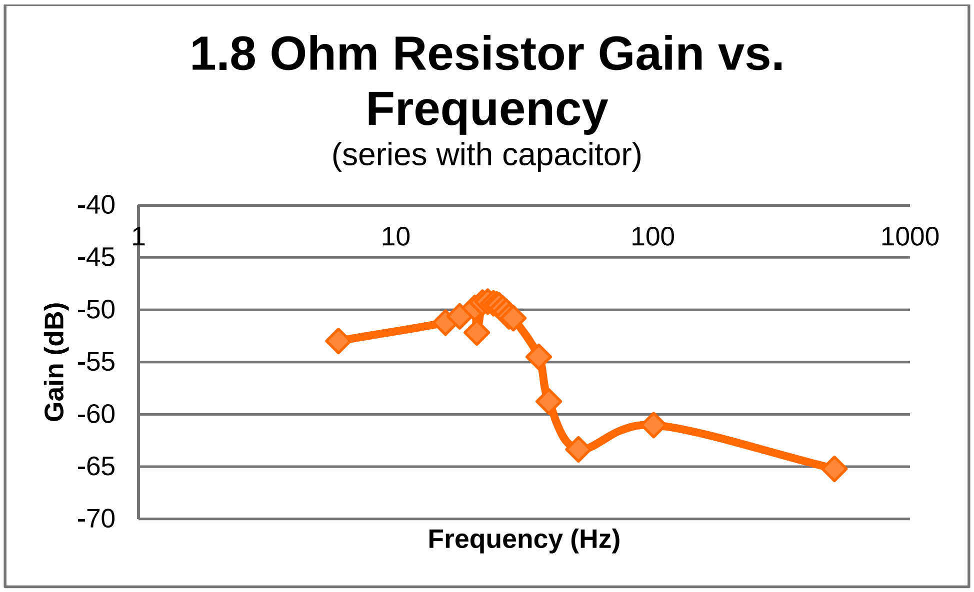

Figure 7: Graph of the resistor's gain vs. frequency. Resonance is at peak.

Data Analysis & Error Analysis

In this part of the experiment errors comes from the experimental values and were calculated using the error propagation equation. The uncertainties were listed next to the values as shown in the tables. For this experiment the 1.8 Ohm resistor was in series with the capacitor so it has a similar graph to the capacitor in Figure 5. The resonance for this resistor is at 22.80 kHz. It should be noticeable that there were no -3dB gain as all values are way below the -3dB.

Discussion

It seems like in this experiment we were able to find the resonance frequency pretty easily. The current could also be found by taking the voltage over the resistance of the 1.8 ohm resistor. The graph for this is very similar to the one in the capacitor as stated and has a high dB at the beginning frequency and a low dB at the higher frequency. The occurrence of this resonance frequency is basically at similar location.

There might have been some slight error in our mV reading since it was very difficult to do the peak to peak with such a thick noisy width. But overall it turns out pretty well.

Experiment 3:

Data

d (holes)	1/d^3	Vi (V)	Vo (mV)	M
4	1.56E-02	8.8	1640	6.32E-01
5	8.00E-03	8.2	820	3.39E-01
6	4.63E-03	8.2	500	2.07E-01
7	2.92E-03	8.2	340	1.41E-01
8	1.95E-03	8.2	240	9.92E-02
9	1.37E-03	8.2	180	7.44E-02
10	1.00E-03	8.2	140	5.79E-02
11	7.51E-04	8.2	100	4.13E-02
12	5.79E-04	8.2	100	4.13E-02
13	4.55E-04	8.2	80	3.31E-02
15	2.96E-04	8.2	80	3.31E-02

Table 8: Data for the mutual inductance tet

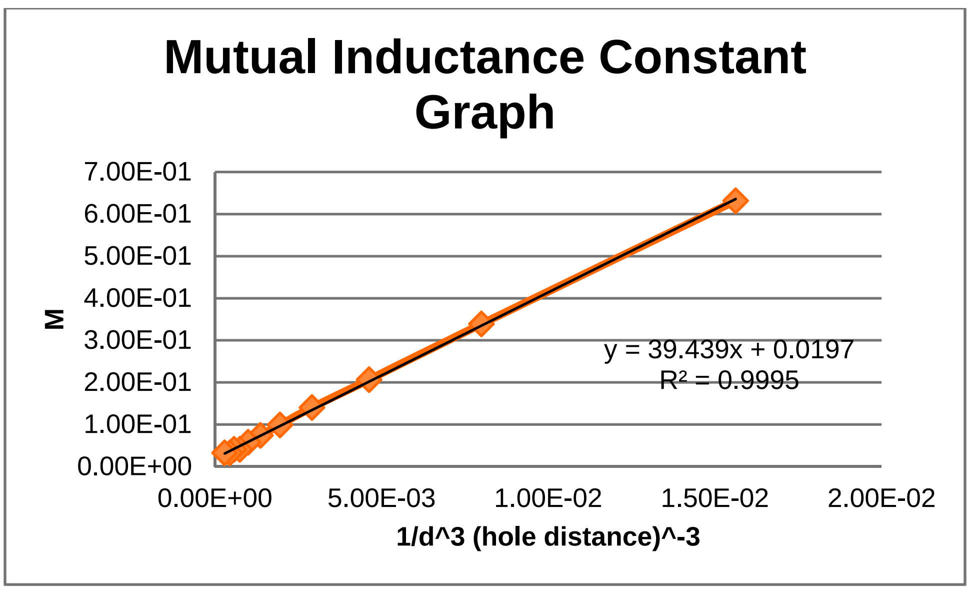

Figure 8: Mutual inductance vs. distance (hole distance)$^{-3}$ graph

Data Analysis & Error Analysis

In this part of the experiment the best fit linear line graph comes from the r^{-3} ratios. With the r^{-3} the graph has a R^2 value of .9995 which is very close to one. This means that M for mutual inductance from our data supports the $1/r^3$ theory.

Discussion

This experiment provides a really nice graph that easily tells us the results of how M varies with distance. The distances we took to measure were equal distance though this should not matter much.

There might have been some slight error in our mV reading since it was very difficult to do the peak to peak with such a thick noisy width. But overall it turns out pretty well.

CONCLUSION

In conclusion this experiment was a great success we were able to get extremely small percent error for the experiment 1. The RLC series circuit was a great success as we were able to find the Q factor and the resonance frequency for each component fine without much trouble. For the experiment 2 there was a section where we have lots of difficulties in reading the small mV reading from the oscilloscope since the graph has a huge width making it hard to measure the peak to peak. In the mutual inductance section we were able to obtain our distance relation without much trouble.

To improve in our future experiment we need a better method of measuring the peak to peak of small voltages especially for those in the mV scale. Beside that the overall experiment was a great success.