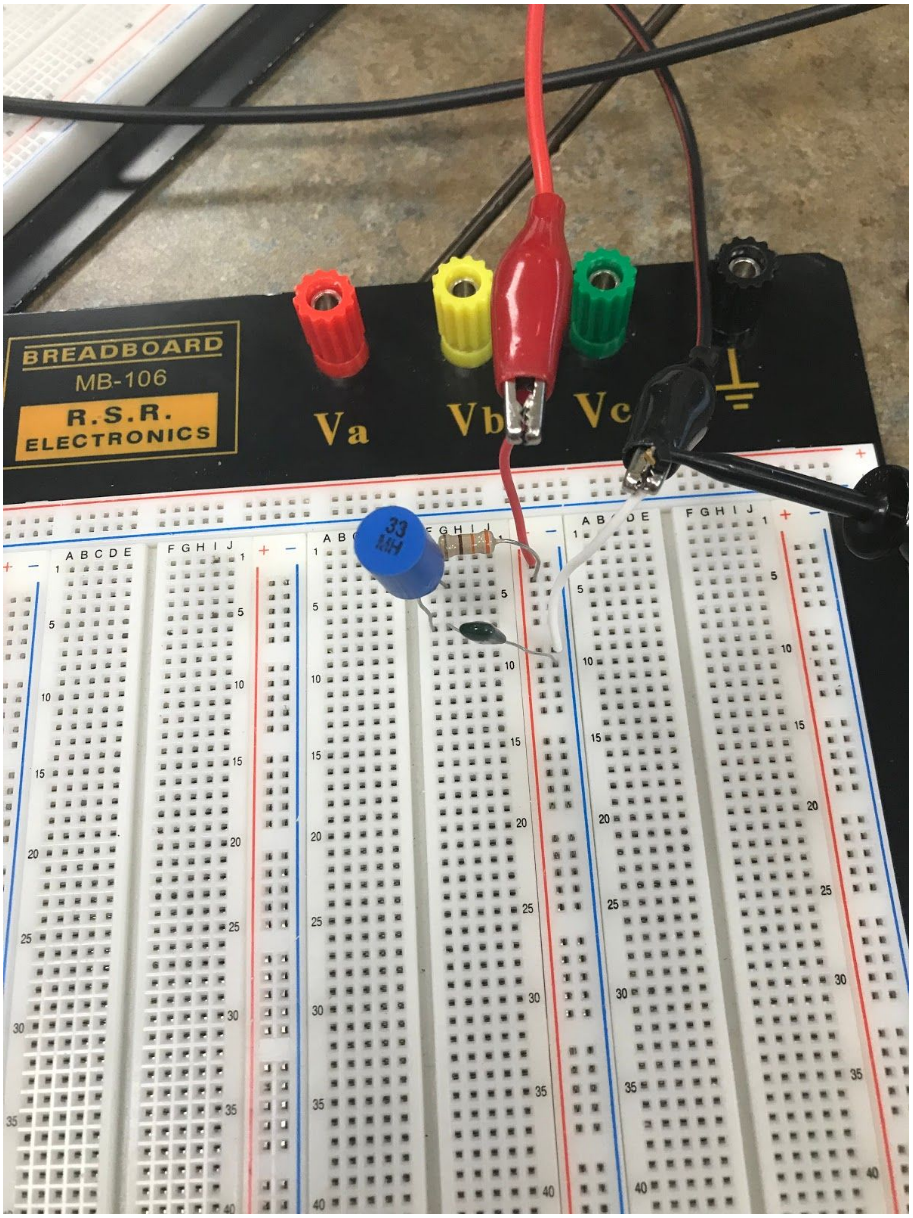
Lab 50

Thomas Buckley
Aidan O'Leary
Joshua Pinoos
Zachary Welch
The week of March 19th to 23rd 2018



Objectives:

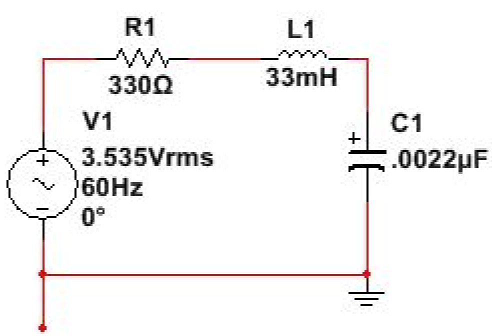
The objective of this lab is to measure the frequency of resonance in a series RCL circuit, observe the characteristics of resonance, and determine if there is a difference between the center of frequency and the resonant frequency. Another objective is to draw a frequency versus voltage graph and determine the cutoff frequencies, bandwidth, and the quality of the circuit or Q.

Materials:

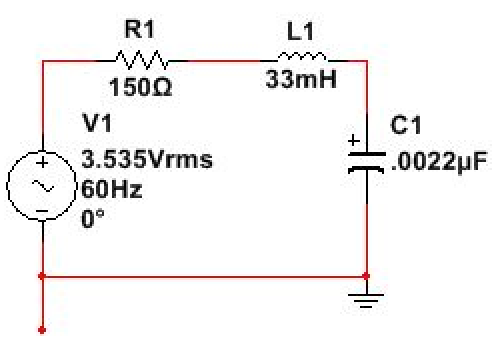
- Function generator
- Dual-trace oscilloscope
- 330 Ω resistor
- 150 Ω resistor
- 33 mH inductor
- 0.0022 µF capacitor

Procedure:

We began the lab by creating the circuit as shown in Schematic 1. Next, we connected the external trigger to Point A and set the triggering source control to EXT. We then set the function generator for 10 kHz at 5 v peak and connected Channel 2 to Point , putting the waveform in the standard position. Using the subtract function of the oscilloscope, we measured the peak voltage across the resistor and determined the phase shift between the circuit current and applied voltage. These values are shown in **Table 1.** Then **Schematic 2** was measured in the same was as **Schematic 1** and the values were put into **Table 2**.



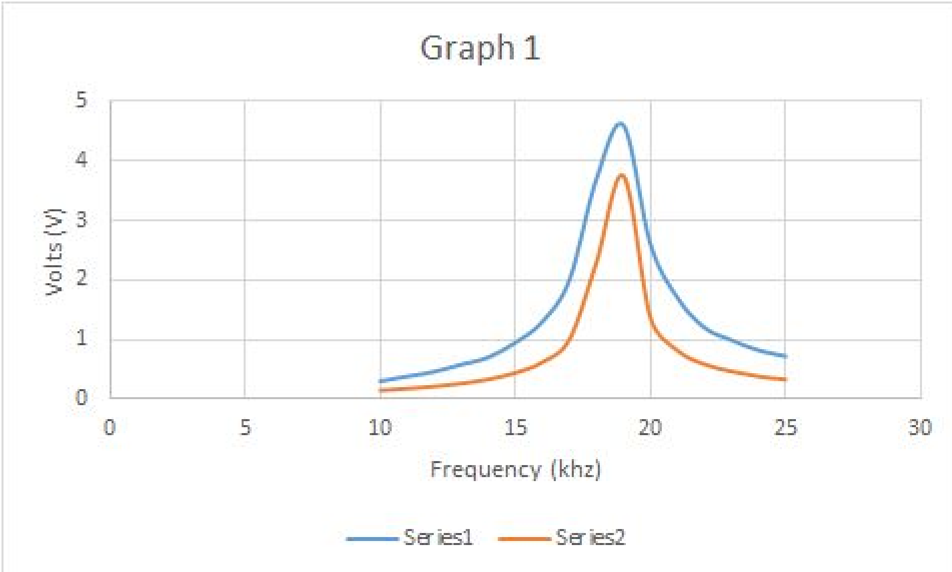
Schematic 1



Schematic 2

Table 1		Circuit 1		
Frequency	**Volts R (V) (Real)**	**Phase Angle (Degrees) (Real)**	**Volts R (V) (Sim)**	**Phase Angle (Degrees) (Sim)**
10 kHz	0.35V	0°	.30 V	-86 °
11 kHz	0.4V	2°	.38 V	-85°
12 kHz	0.4V	4°	.46 V	-84°
13 kHz	0.41V	8°	.58 V	-83°
14 kHz	0.5V	12°	.70 V	-81°
15 kHz	0.6V	12°	.95 V	-79°
16 kHz	0.8V	16°	1.3 V	-74°
17 kHz	1V	20°	2.00 V	-65°
18 kHz	1.5V	24°	3.7 V	-40°
19 kHz	2.2V	27°	4.6 V	21°
20 kHz	2.8V	0	2.6 V	58°
21 kHz	2.4V	-30°	1.7 V	70°
22 kHz	1.8V	-24°	1.2 V	75°
23 kHz	1.4V	-16°	0.99 V	78°
24 kHz	1.0V	-17°	0.82 V	80°
25 kHz	.9V	-18°	0.72 V	81°

Table 2		Circuit 2		
Frequency	**Volts R (V) (Real)**	**Phase Angle (Degrees) (Real)**	**Volts R (V) (Sim)**	**Phase Angle Degrees (Sim)**
10 kHz	0.1V	-4°	0.145 V	-88.3352°
11 kHz	0.2V	-8°	0.174V	-88.0000°
12 kHz	0.2V	-12°	0.211V	-87.5740°
13 kHz	0.2V	-4°	0.261V	-87.0000°
14 kHz	0.23V	-5°	.330V	-86.2100°
15 kHz	0.3V	-6°	0.440V	-84.9948°
16 kHz	0.4V	-6°	0.620V	-82.8983°
17 kHz	0.5V	-6°	1.000V	-78.3983°
18 kHz	0.8V	-7°	2.300V	-62.3890°
19 kHz	1.3V	10°	3.750V	41.4252°
20 kHz	2V	0°	1.360V	74.1890°
21 kHz	1.4V	-22°	0.814V	80.6337°
22 kHz	.9V	-16°	0.585V	83.2812°
23 kHz	.65V	-16°	0.465V	84.7214°
24 kHz	.5V	-8°	0.381V	85.6280°
25 kHz	.4V	9°	0.327V	86.2522°



The Bandwidth for both circuits, the larger series is the frequency for circuit 1 and the smaller series is the frequency for circuit 2.

Observation Questions:

1. The resonant frequency for both Graph 1 and Graph 2 are 18678.9hz. These were determined by using the formula and equations as shown in **Equation 1**. These values are equal because the only difference between **Schematic 1 and 2** is the resistance value, and that does not affect the output of the formula.
2. To calculate the edge frequencies, we used the equations shown in **Equation 2**. F_L= 17900.15647Hz, F_H = 19491.705903Hz
3. Next, we calculated the Bandwidth as shown in **Equation 3**.
4. We then calculated the quality as shown in **Equation 4.**
5. Next, we calculated the algebraic center of both graphs using the equation as shown in **Equation 5.**
6. Next, we calculated the geometric center frequencies using the formula and equations as shown in **Equation 6.**
7. Using the method for finding the geometric center (**Equation 6**) gave us a result much closer to resonant frequency than using the algebraic center (**Equation 5**).

Equation 1:
$Fr_1 = 1/(2\pi\sqrt{(LC)}) = 1/(2\pi\sqrt{((33*10^{-3})(.0022*10^{-6}))}) = 18678.9hz$
$Fr_2 = 1/(2\pi\sqrt{(LC)}) = 1/(2\pi\sqrt{((33*10^{-3})(.0022*10^{-6}))}) = 18678.9hz$

Equation 2:
$\omega = -(R/(2L)) + \sqrt{(R/(2L))^2 + (1/LC)} =$
$-(330/(2*.033)) + \sqrt{(330/(2*.033))^2 + (1/.033*.00000022)} = 112470$ Radians/Second OR 17900.15647Hz
$\omega = (R/(2L)) + \sqrt{(R/(2L))^2 + (1/LC)} =$
$(330/(2*.033)) + \sqrt{(330/(2*.033))^2 + (1/.033*.00000022)} = 122470$ Radians/Second OR 19491.705903Hz

Equation 3:
$F_H - F_L = 19491.705903 - 17900.15647 = 1591.55$

Equation 4:
$Q = F_R$ / Bandwidth
Q = 18678.9hz / 1591.55 = 11.7363

Equation 5:
$(f_1 + f_2)/2 = f_{center}$
(17900.15647 + 19491.705903)/2 = 18695.9hz

Equation 6:
$\sqrt{(f_1 * f_2)} = f_{center}$
$\sqrt{(17900.15647 * 19491.705903)} = 18679hz$

Discussion:

The lab was relatively easy to complete but was time consuming. The values that were recorded digitally compared to the physical values are different due to rounding errors and measuring errors making the measured values.

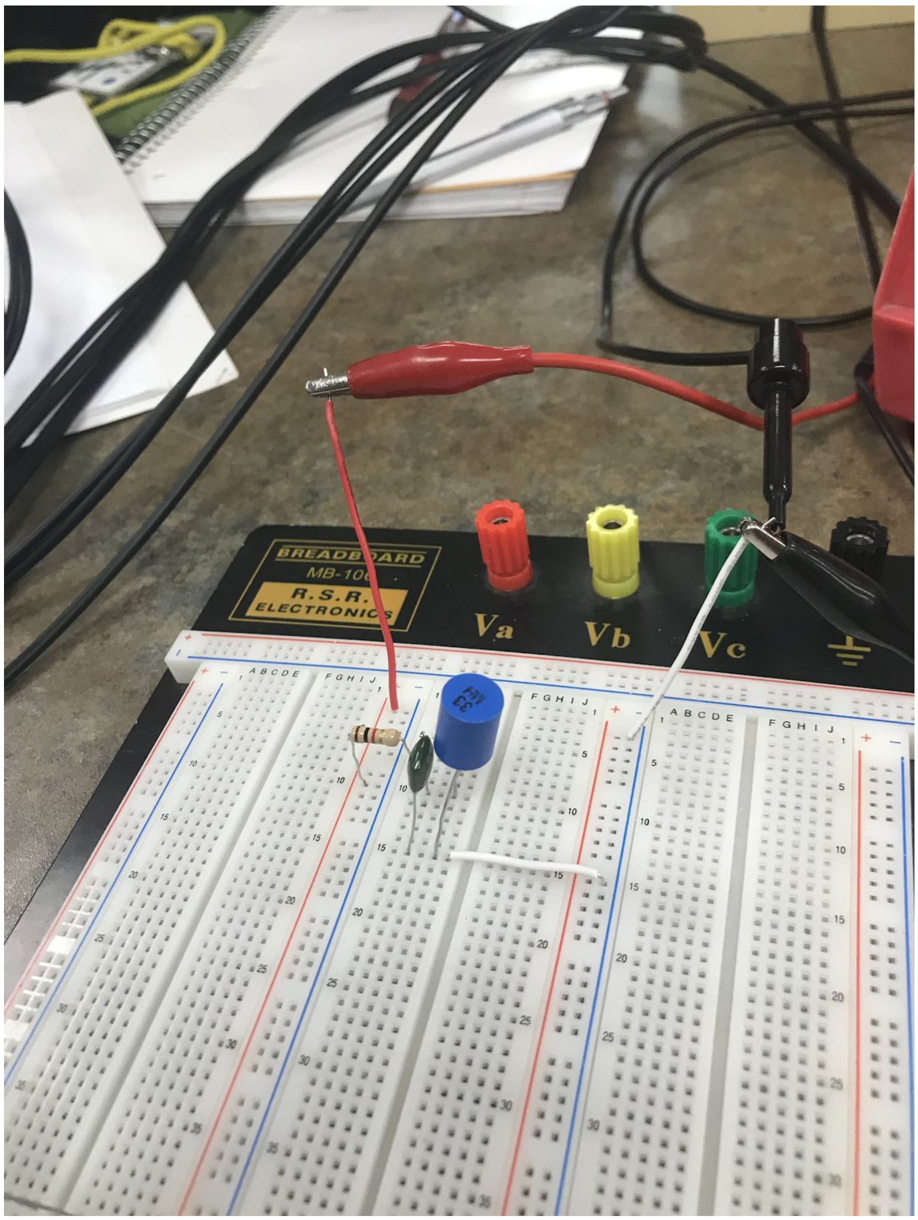
Conclusion:

The measurement of the frequency of resonance can be found by using **equation 1.**There is no difference between the center of frequency and the resonant frequency because they are both in the center of the bandpass. Cutoff frequencies can be determined by using **Equation 2,** bandwidth can be found with **Equation 3,** and quality of the circuit, or Q, can be found by using **Equation 4.**

Lab 52

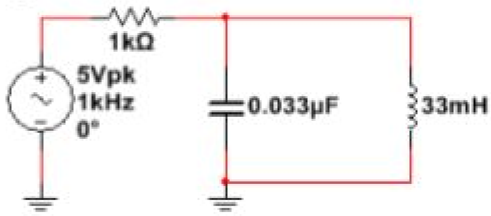
By: Thomas Buckley
Aidan O’Leary
Joshua Pinoos
Zachary Welch

The week of March 19th to the 23rd,2018



Objective: The objective of this lab is to observe the various characteristics of a parallel RLC circuit, the effect of a series resistor on bandwidth and Q, drawing a graph of frequency versus voltage on the resistor, and determining the phase angle of a parallel RLC circuit above or below the frequency of resonance.

Figure 1



Materials:

- Function generator
- Dual-trace oscilloscope
- 33 mH inductor
- 10 mH inductor
- 100 Ω resistor
- 1k Ω resistor
- 10k Ω resistor

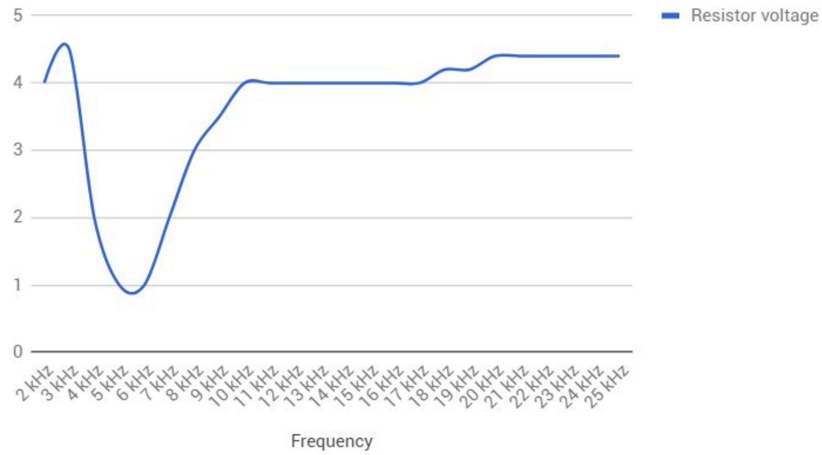
Procedure: First we constructed the circuit in **figure 1** and connected the external trigger of an oscilloscope to the applied voltage. We also inverted channel 2 and connected it to the applied voltage and connected channel 1 to measure the parallel LC portion of the circuit. Then we used the subtract function of the oscilloscope to measure the values in **Table 1** and we found that the current lagged the applied voltage until the resonant frequency (about 5 kHz) was reached and after that the current lead the applied voltage.Next we used the data from **Table 1** to create **Graph 1** and begin **Graph 3**. After that we found the upper and lower cutoff frequencies of the bell curve graph to be 9 kHz and 3.2 kHz. Since we found the upper and lower cutoff frequencies we were able to determine the bandwidth of the bell curve to be 5.8 kHz and the quality to be 0.86. Then we measured the voltages in **Table 2** and used the data to create **Graph 2** and complete **Graph 3**. After that we found that the frequency of resonance, cutoff frequencies, the bandwidth, and quality remained the same between the two sets of data. Then the 1k Ω resistor was replaced with a 100 Ω resistor and found that the bandwidth was higher and the Q was lower. The Q of the circuit was determined to be .53 and the bandwidth was 37 kHz. Next, we changed the series resistor to a 10k ohm resistor and measured the voltage across the parallel LC circuit at different frequencies. The Q of the circuit was now determined to be 5.5 using the formula F_r/Bandwidth=Q and the bandwidth was determined to be 1 kHz. Next, we replaced the series 10k ohm resistor with a 1k ohm resistor and replaced the 10mh coil with a jumper wire.

The resonant frequency was now measured to be 8.4kHz, the bandwidth was calculated to e 6.2kHz, and the q was calculated to be 1.29. All of these values are larger than the previous values.

Table 1

Frequency	Resistor voltage (V) (Real)	V_A to I_T phase angle (Degrees) (Real)	Resistor Voltage (V) (Sim)	V_A to I_T phase angle (Degrees) (Sim)
2 kHz	4v	-55.4°	4.4v	-64.8°
3 kHz	4.5v	-42.4°	3.5v	-49.1°
4 kHz	2v	-22.0°	1.7v	-21.6°
5 kHz	1v	0°	0.4v	1.8°
6 kHz	1v	17.1°	2.0vv	21.2°
7 kHz	2v	30.0°	3.1v	40.6°
8 kHz	3v	40.6°	3.6v	46.5°
9 kHz	3.5v	51.4°	3.9v	58.9°
10 kHz	4v	57.6°	4.1v	64.8°
11 kHz	4v	54.7°	4.2vv	71.2°
12 kHz	4v	61.5°	4.4v	78.1°
13 kHz	4v	66.3°	4.5v	84.2°
14 kHz	4v	72.0°	4.6v	86.2°
15 kHz	4v	58.6°	4.7v	86.0°
16 kHz	4v	81.3°	4.7v	87.1°
17 kHz	4v	65.0°	4.7v	91.5°
18 kHz	4.2v	102.0°	4.7v	91.6°
19 kHz	4.2v	69.2°	4.7v	90.0°
20 kHz	4.4v	72.0°	4.8v	90.0°
21 kHz	4.4v	76.6°	4.8v	90.9°
22 kHz	4.4v	78.3°	4.9v	91.0°
23 kHz	4.4v	75.3°	4.9v	91.0°
24 kHz	4.4v	79.0°	4.9v	85.3°
25 kHz	4.4v	81.0°	4.9v	90.0°

Lab 52 graph 1 of table 1A breadboard data



Lab 52 graph 2 of table 2A breadboard data

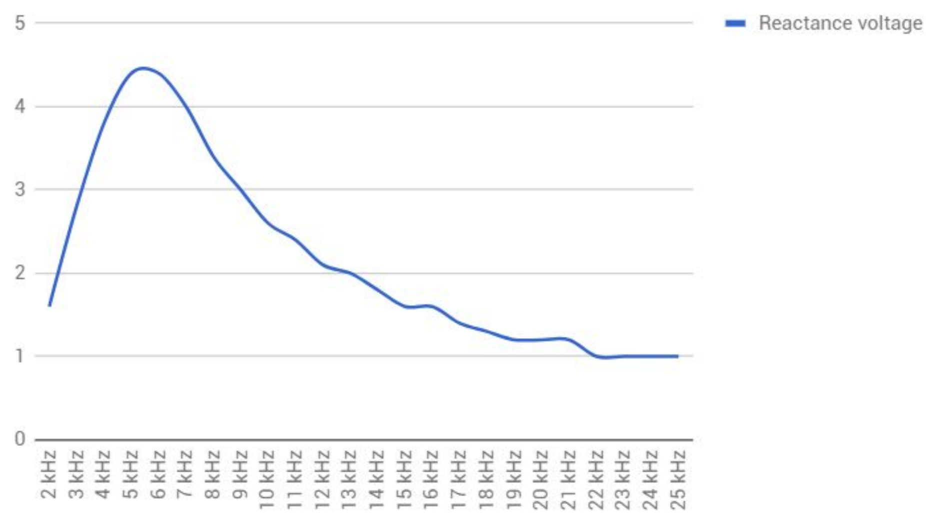


Table 3 Reactance voltage, Resistor voltage

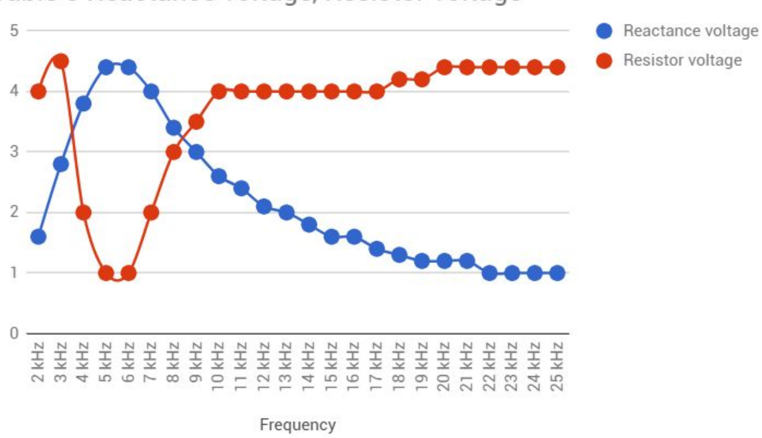


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Table 2

Frequency	Reactance voltage (Real)	VA to VLC phase angle (Real)	Reactance voltage (Sim)	Phase Angle (Sim)
2 kHz	1.6v	-55.4°	2.2v	-64.8°
3 kHz	2.8v	-42.4°	3.6v	-49.1°
4 kHz	3.8v	-22.0°	4.6v	-21.6°
5 kHz	4.4v	0°	4.9v	1.8°
6 kHz	4.4v	17.1°	4.7v	21.2°
7 kHz	4v	30.0°	4.2v	40.6°
8 kHz	3.4v	40.6°	3.6v	46.5°
9 kHz	3v	51.4°	3.0v	58.9°
10 kHz	2.6v	57.6°	2.6v	64.8°
11 kHz	2.4v	54.7°	2.2v	71.2°
12 kHz	2.1v	61.5°	1.8v	78.1°
13 kHz	2v	66.3°	1.6v	84.2°
14 kHz	1.8v	72.0°	1.4v	86.2°
15 kHz	1.6v	58.6°	1.9v	86.0°
16 kHz	1.6v	81.3°	1.8v	87.1°
17 kHz	1.4v	65.0°	1.5v	91.5°
18 kHz	1.3v	102.0°	1.4v	91.6°
19 kHz	1.2v	69.2°	1.4v	90.0°
20 kHz	1.2v	72.0°	1.2v	90.0°
21 kHz	1.2v	76.6°	1.1v	90.9°
22 kHz	1v	78.3°	1.0v	91.0°
23 kHz	1v	75.3°	1.0v	91.0°
24 kHz	1v	79.0°	0.9v	85.3°
25 kHz	1v	81.0°	0.8v	90.0°

Observation Questions:

1. When the frequency is above resonance, voltage leads current. When the frequency is below resonance, voltage lags current. At resonance, there is no phase shift between frequency and voltage.
2. At resonance, the parallel LC circuit has no impedance. When below resonance the impedance is lower, when it is higher the impedance is higher.
3. In parallel, the voltage is the same. The current of the RLC above resonance is higher, below it is lower.

Discussion:

This lab was easy to complete with no major problems,our multisim values may differ from the measured values due to errors reading the oscilloscope and we only used a 33 mH inductor so our numbers different.

Conclusion:

A parallel RLC circuit will have no phase shift between current and voltage but when frequency is above resonance voltage will lead current and when frequency is below resonance voltage will lag current**.** In a parallel RLC circuit a low value series resistor will make the quality higher and a high resistor value will make the quality low.