UNIVERSITY OF LOUISIANA AT LAFAYETTE

MEASUREMENTS AND INSTRUMENTATION

MCHE 357

Lab 2

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List of Symbols

V = Voltage
L = Inductance
R = Resistance
q = Charge
q' = First derivative of charge (current)
q'' = Second derivative of charge
w_n = Natural frequency

Introduction

This lab served as an introduction to the principles of RLC circuits. These circuits contain three main devices: resistance, capacitance, and inductance. These devices are placed in series to form a circuit who's behavior can be described with a differential equation. These types of circuits are the foundation of many devices, such as radio tuners.

Theory

The three main characteristics of electrical components must be understood to analyze RLC circuits. Resistance is a quality of a component which measures the blocking of current through the device. Capacitance is the ability of a device to store charge. Inductance is the characteristic of a device that reacts to changes in current. Each of these characteristics are analogous to mechanical properties. An inductance is analogous to inertia, or mass, resistance is analogous to dampening, and capacitance is analogous to a spring. Making a circuit with all three types of devices results in a system similar to a simple mechanical vibrating system with a mass, dampener, and spring. The equation of an RLC circuit is therefore similar to the basic vibration equation, and is shown in Equation 1.

If the input to an RLC circuit is sinusoidal, the output will also be sinusoidal, but will be either out of phase or in phase with the input. Whether the output is in phase or out of phase with the input depends mainly on the natural frequency of the circuit. If the input frequency is below the natural frequency of the circuit, the output will lag the input. If the input frequency is above the natural frequency, then the output will lead the input. However, if the frequency of the input matches the natural frequency of the circuit, the output will be in phase with the input. Commonly, the inductance of an RLC circuit is constant, and the resistance will be changed via a potentiometer in order to change the amplitude of the output. The capacitance can also typically be variable, which allows the user to change the natural frequency of the system, which is what happens when tuning a radio. These variances can be useful in many circuit applications.

$$V = Lq'' + Rq' + \frac{1}{C}q \tag{1}$$

$$w_n = \sqrt{\frac{1}{LC}} \tag{2}$$

Procedure & Analysis

An RLC circuit was configured in Multisim, shown in Figure 1. The input was varied with a function generator, and the output was measured with an oscilloscope. The results from the oscilloscope were plotted at different frequencies and resistances, and are shown in Figures 2 through 8. In Figures 2 through 6, it is seen that when input frequency is held constant and the resistance changes, the amplitude changes. This result agrees with what was stated in the previous section. The input/output graphs at different frequencies were also plotted, shown in Figures 9 through 11.

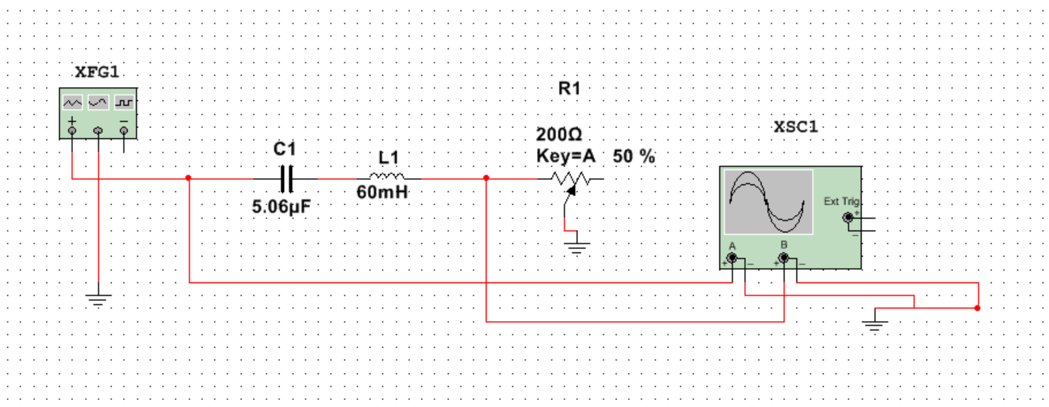


Figure 1: Multisim RLC Circuit

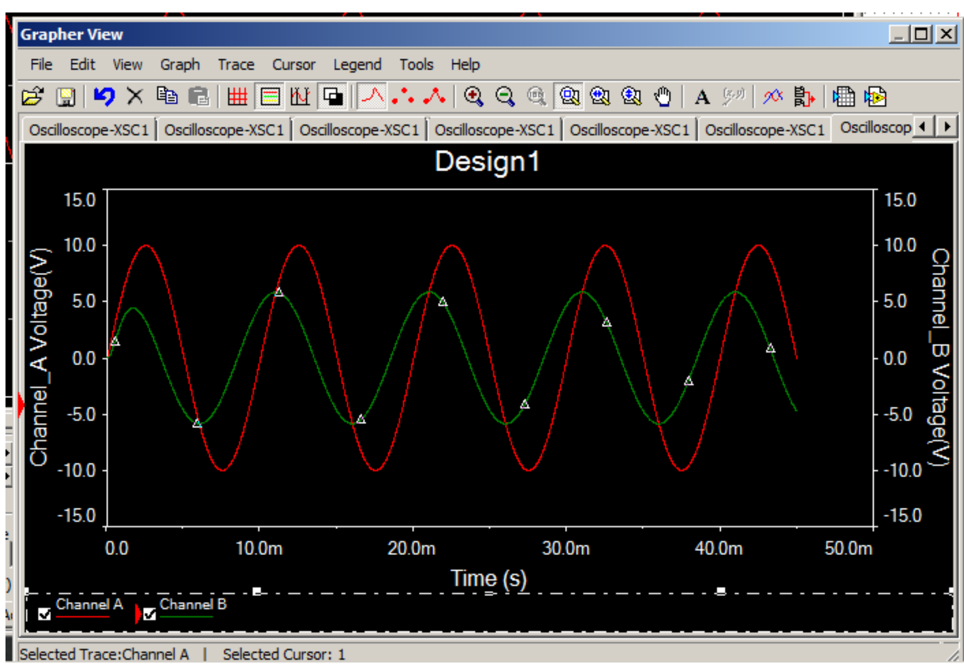


Figure 2: RLC circuit at 100 Hertz and R = 0 Ohms

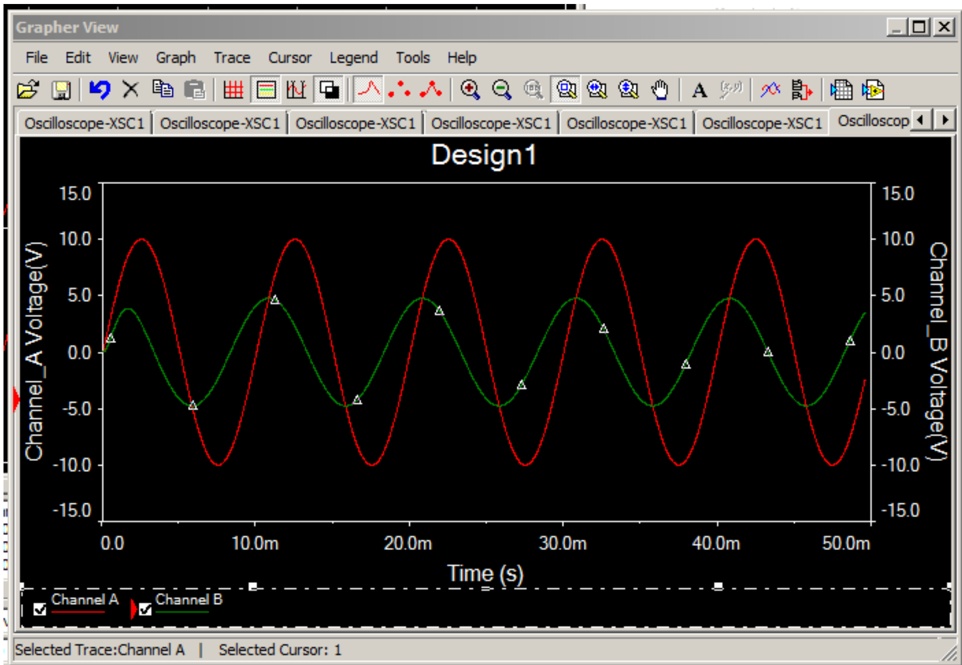


Figure 3: RLC circuit at 100 Hertz and R = 25 Ohms

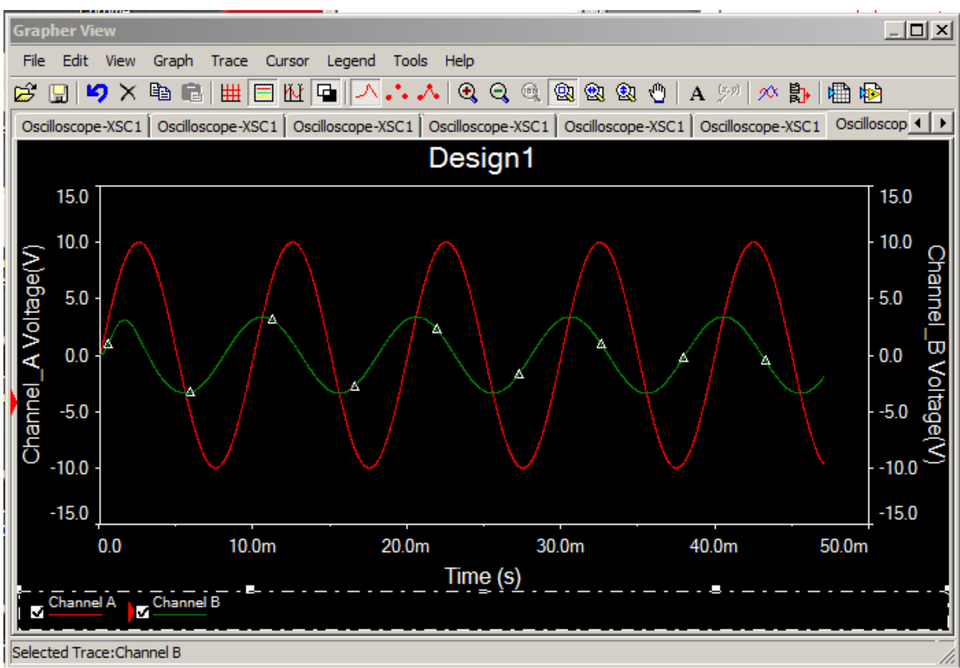


Figure 4: RLC circuit at 100 Hertz and R = 50 Ohms

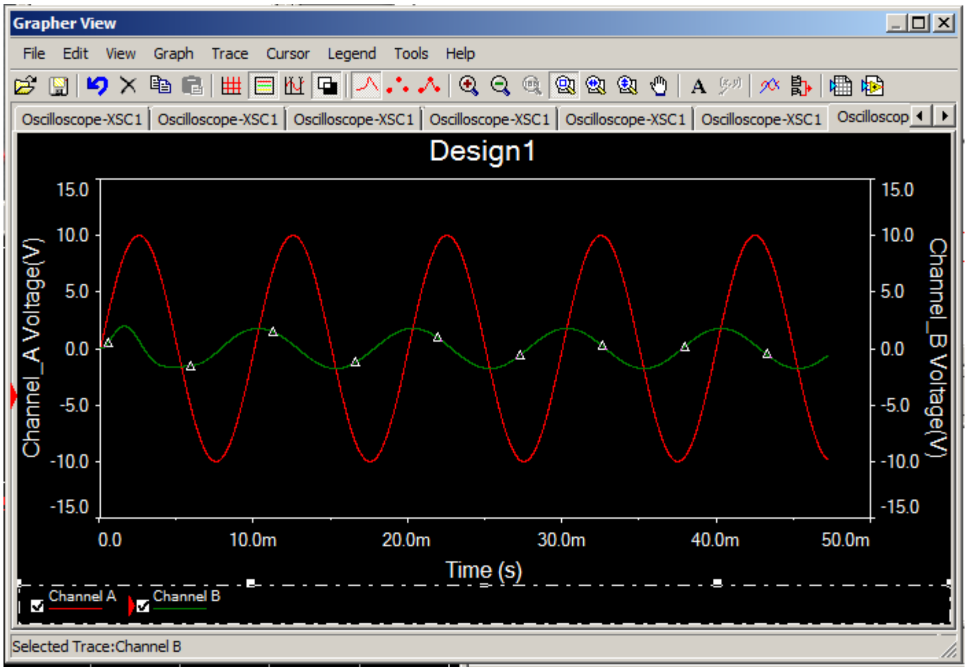


Figure 5: RLC circuit at 100 Hertz and R = 75 Ohms

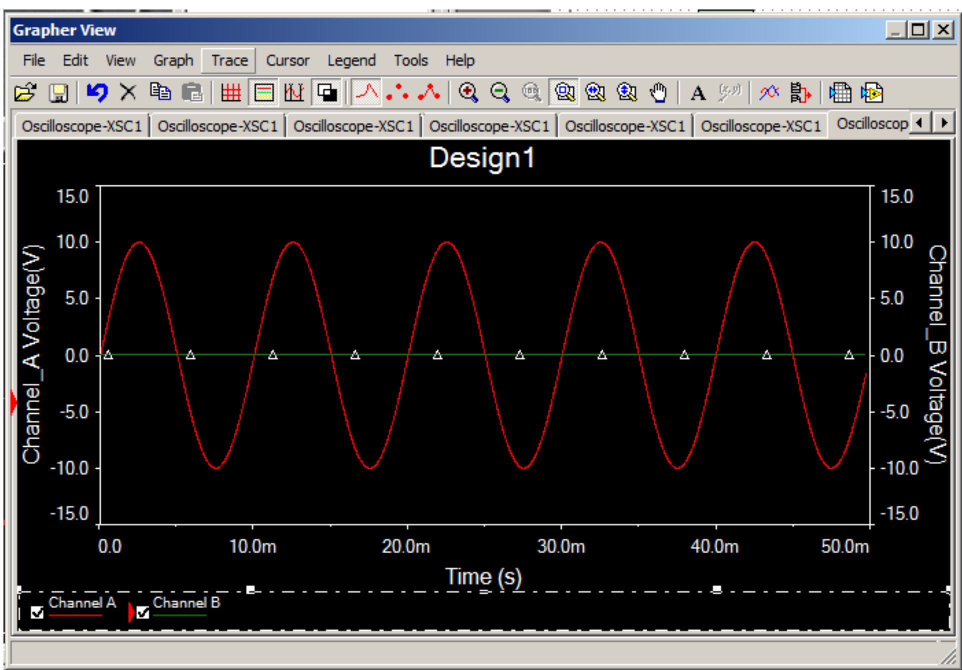


Figure 6: RLC circuit at 100 Hertz and R = 100 Ohms

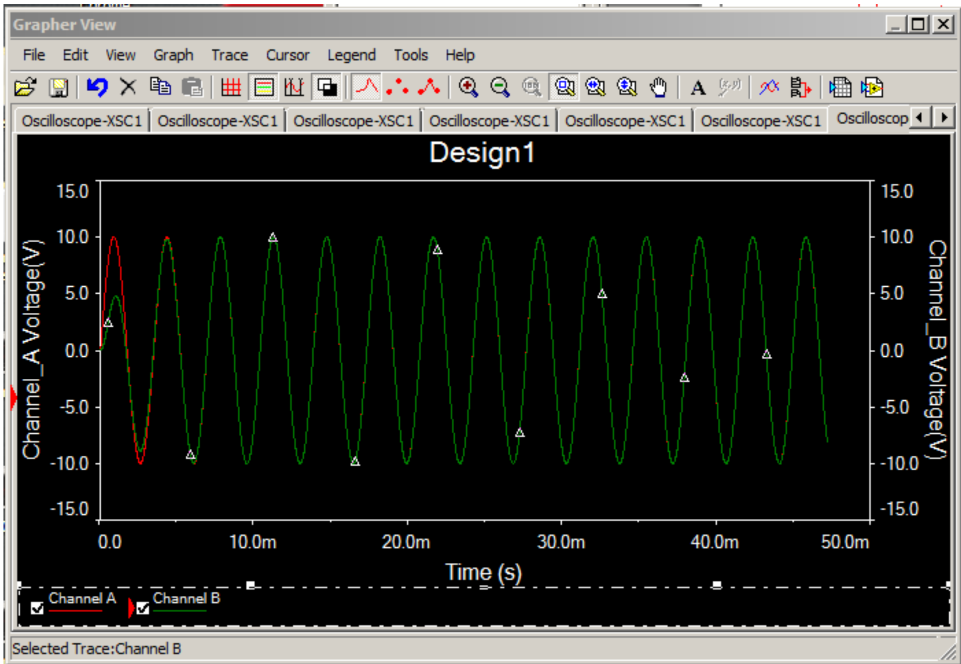


Figure 7: RLC circuit at 289 Hertz (w_n)

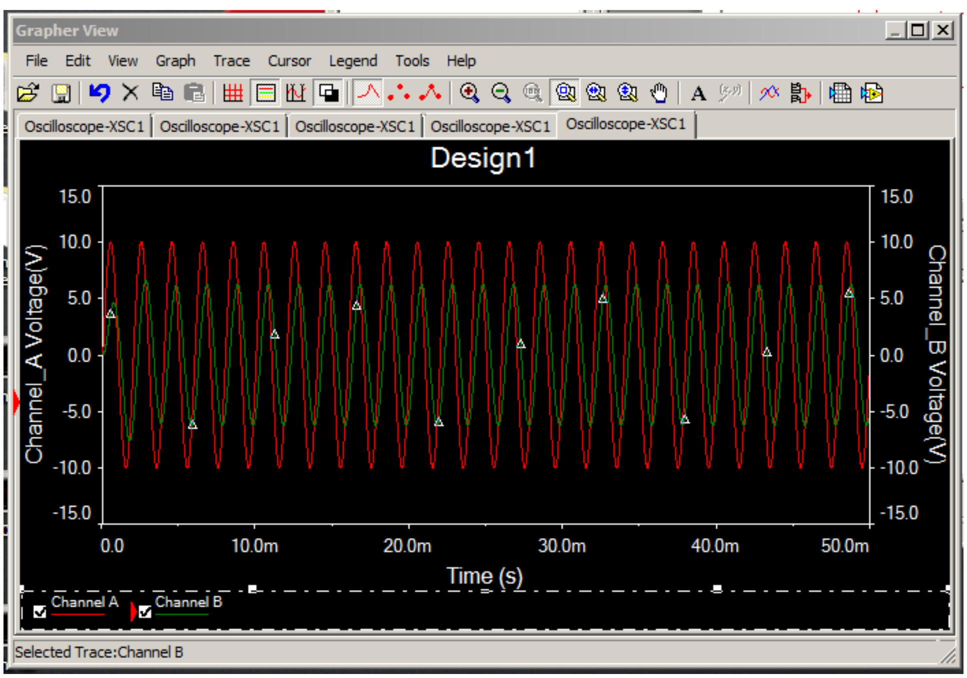


Figure 8: RLC circuit at 500 Hertz

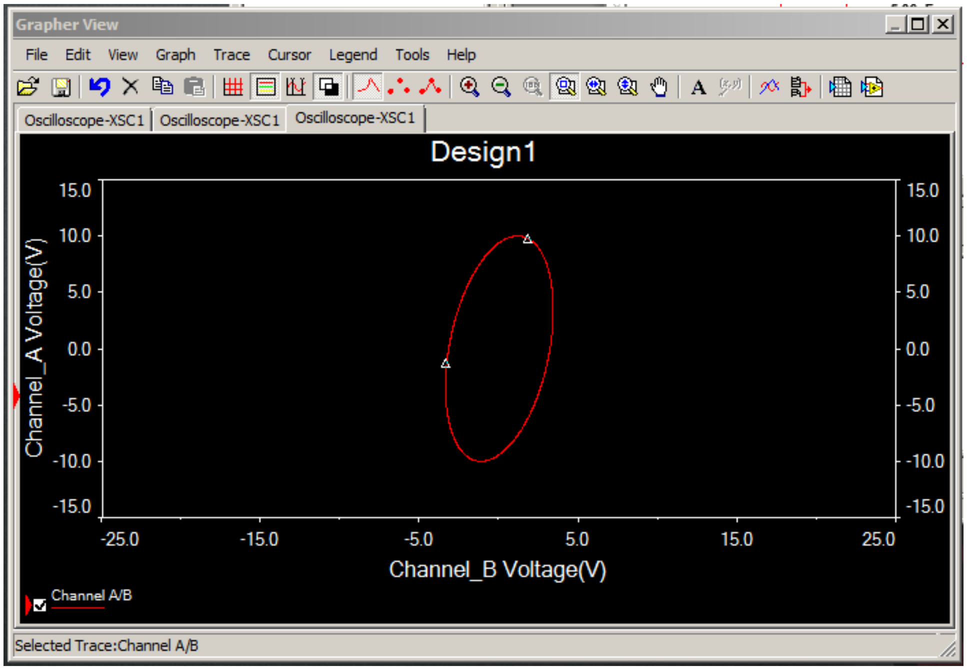


Figure 9: Input/Output at 100 Hertz

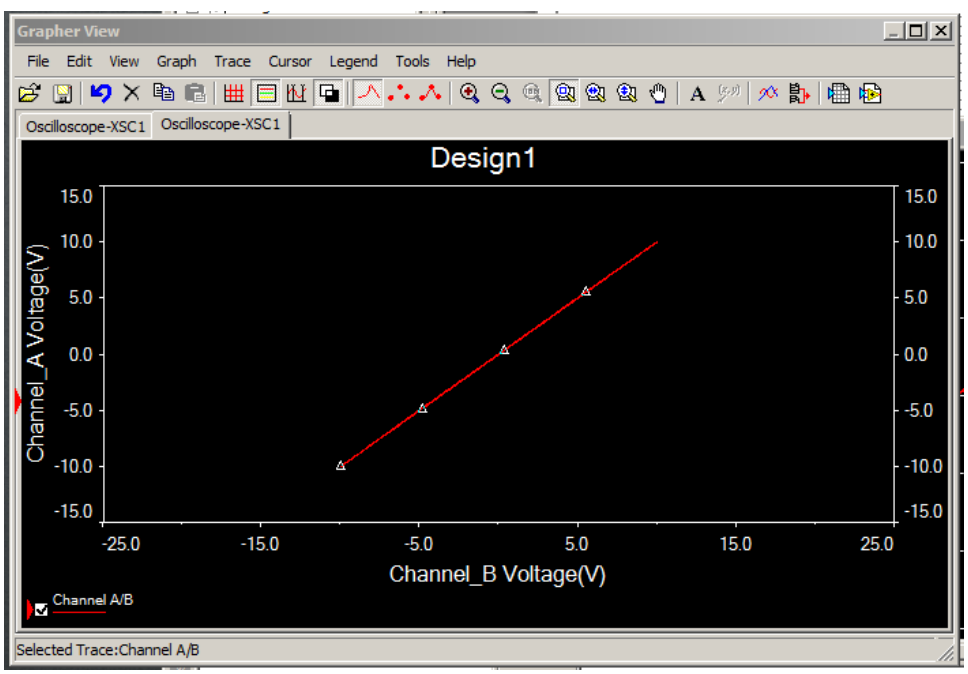


Figure 10: Input/Output at 289 Hertz (w_n)

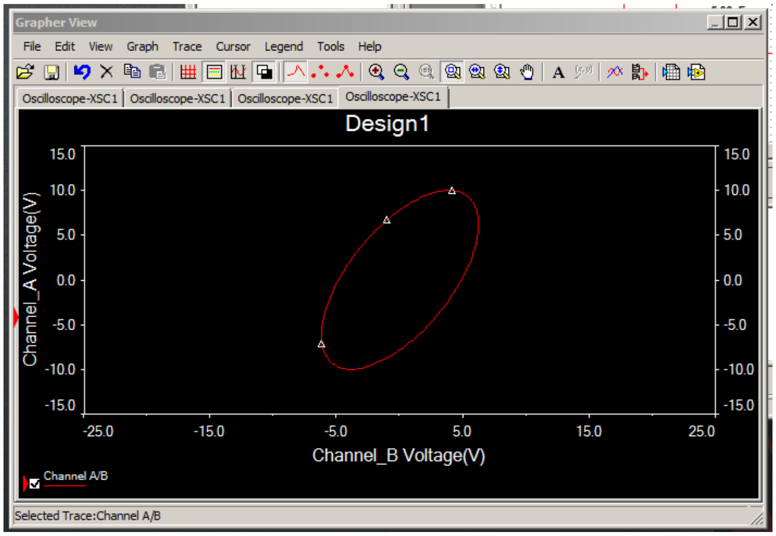


Figure 11: Input/Output at 500 Hertz

The circuit configuration created in Multisim was then created physically in the lab, as shown in Figure 12. An excel spreadsheet, shown in Figure 13, was used in this lab to aid in calculating values for resistance and capacitance that would match the available inductor for a chosen natural frequency. The values of the individual resistance varied from its denoted value slightly, as is usual with resistors.

The input to the circuit was generated with a function generator. The frequency of the input was changed and the output was measured with an oscilloscope, seen in Figures 14 through 16. The input/output graphs were also recorded at different frequencies, shown in Figures17 through 19.

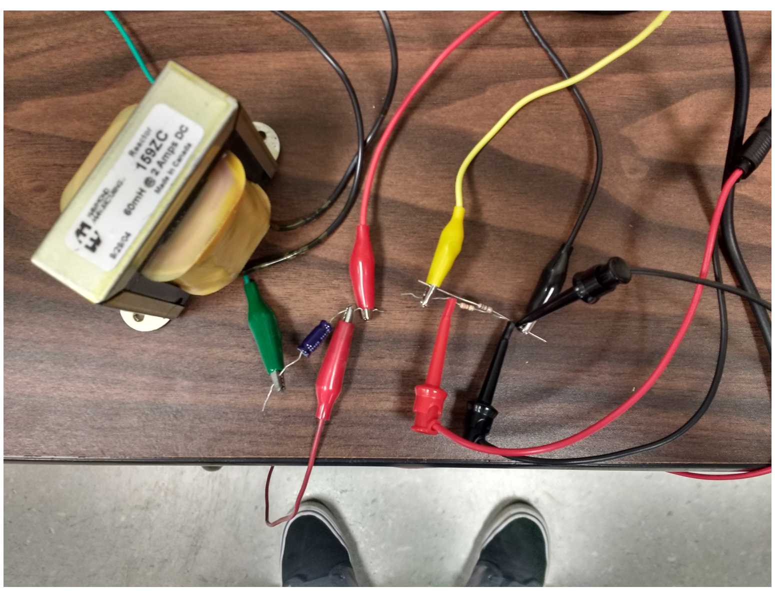
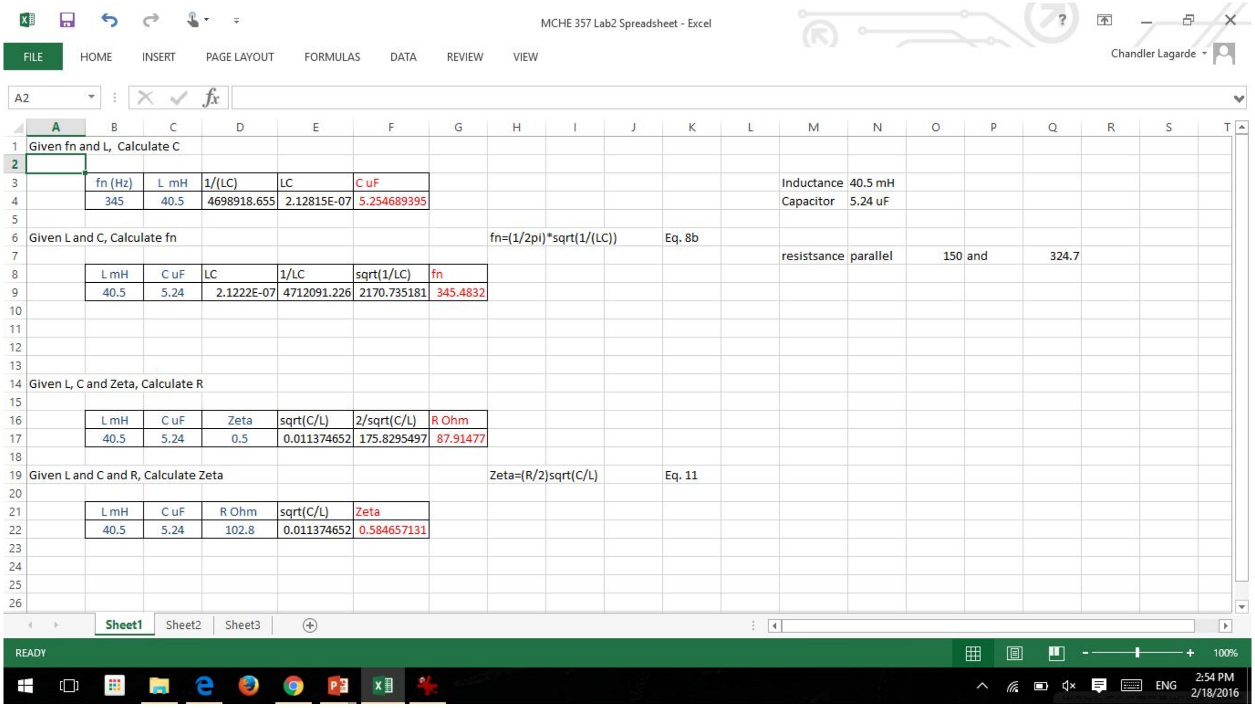


Figure 12: Physical RLC Circuit



fn (Hz)	L mH	1/(LC)	LC	C uF
345	40.5	4698918.655	2.12815E-07	5.254689395

L mH	C uF	LC	1/LC	sqrt(1/LC)	fn
40.5	5.24	2.1222E-07	4712091.226	2170.735181	345.4832

L mH	C uF	Zeta	sqrt(C/L)	2/sqrt(C/L)	R Ohm
40.5	5.24	0.5	0.011374652	175.8295497	87.91477

L mH	C uF	R Ohm	sqrt(C/L)	Zeta
40.5	5.24	102.8	0.011374652	0.584657131

Figure 13: Lab Spreadsheet

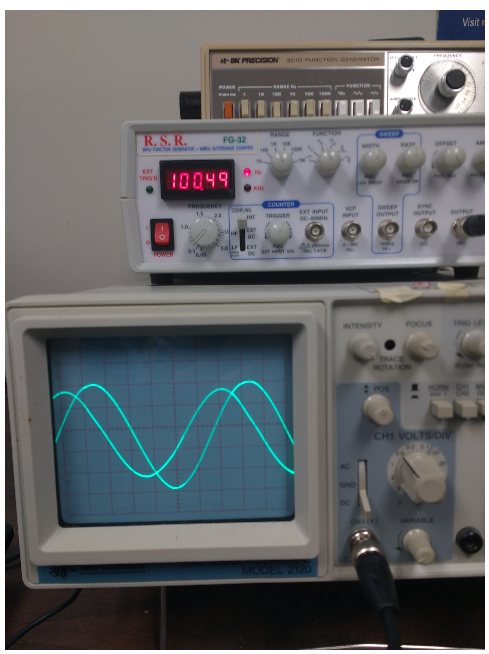


Figure 14: Oscilloscope reading at 100 Hertz

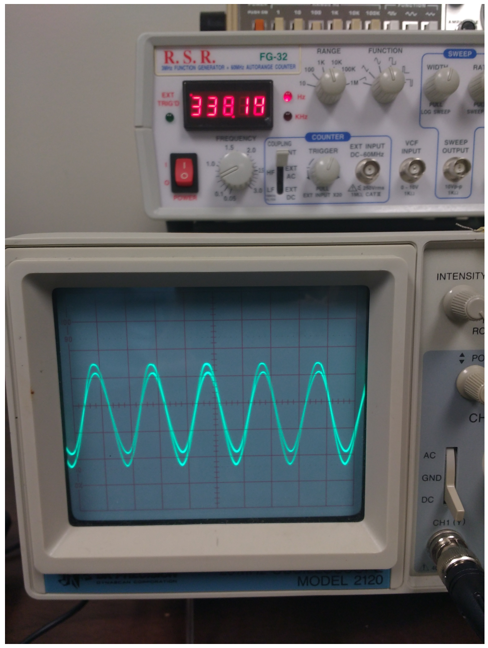


Figure 15: Oscilloscope reading at 289 Hertz (w_n)

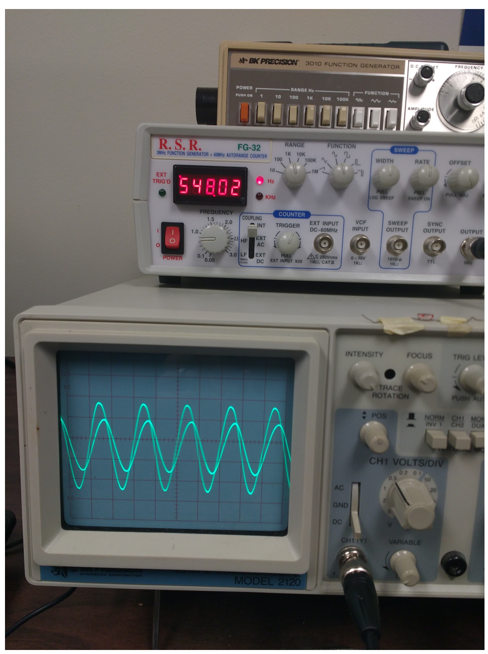


Figure 16: Oscilloscope reading at 500 Hertz

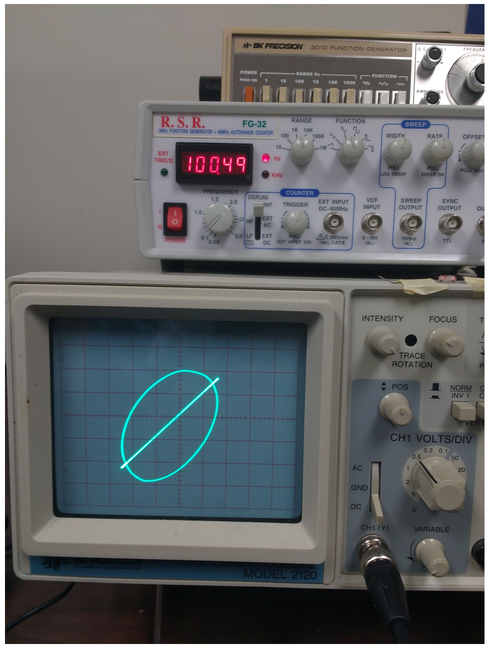


Figure 17: Oscilloscope Input/Output reading at 100 Hertz

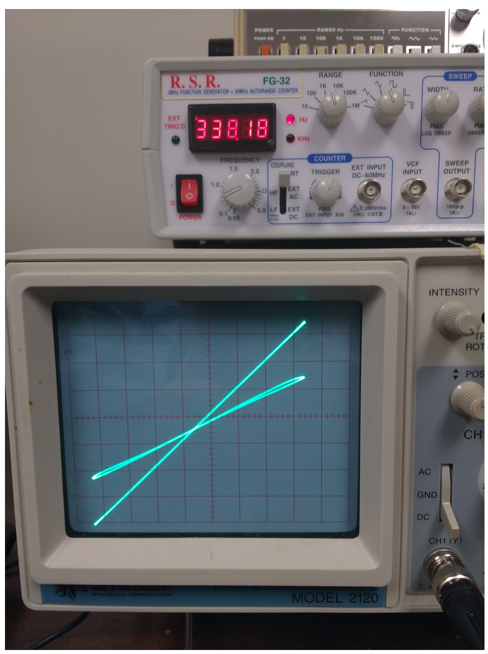


Figure 18: Oscilloscope Input/Output reading at 289 Hertz (w_n)

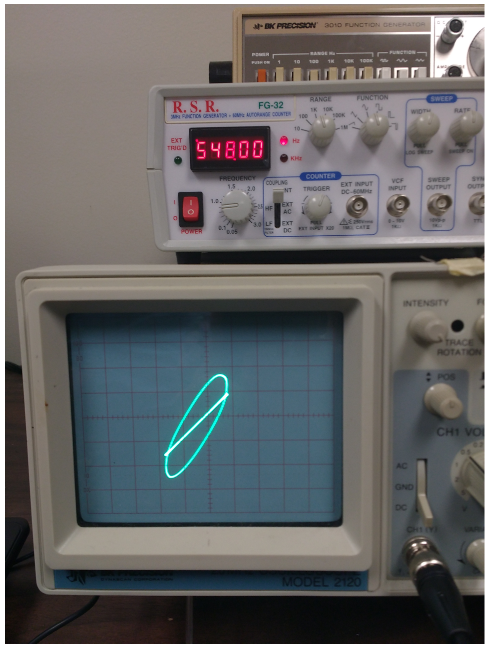


Figure 19: Oscilloscope Input/Output reading at 500 Hertz

Conclusion

This lab demonstrated the principles of basic RLC circuits. These devices include resistances, capacitors, and inductances. The effects of varying the resistance and input frequency were studied. It was noted that these circuits behave very analogously to the basic vibration system consisting of a mass, spring, and damper. It was also seen how these circuits can be used in many devices commonly used in everyday life.