**Lab – Electronic Filters**

**Objectives**

-To learn about RC circuits and RLC circuits

-To learn about low pass and high pass filters

-To learn about resonance

**Pre-Lab:**

1. What is an electronic filter and what is the difference between a low pass and high pass filter?
2. What is meant by the cut-off frequency of a filter?
3. In electronics, what is meant by the term *Resonance*?

**Equipment**

Measuring Equipment: Instek 1052-U Digital Oscilloscope, BK Precision 4012 A Function Generator; Powered Breadboard, jumper wires, BNC (Bayonet Neill–Concelman) cables

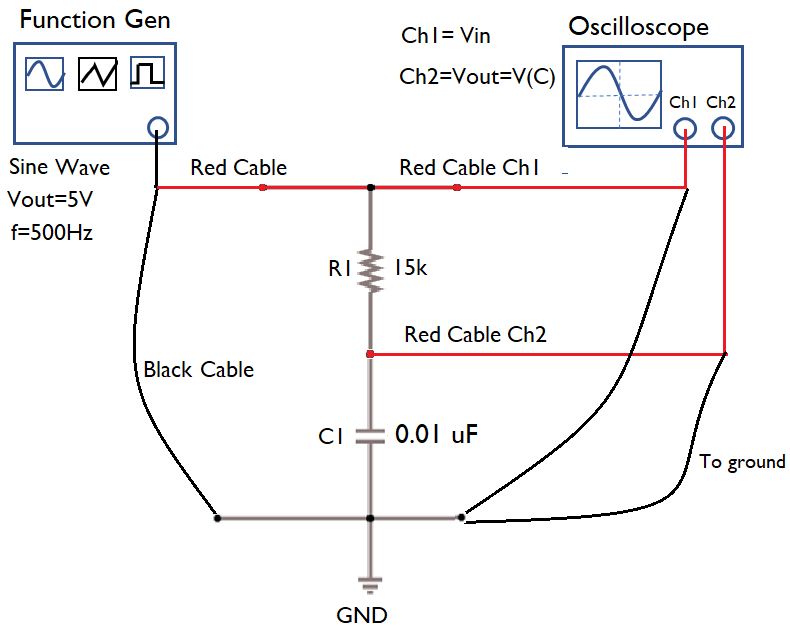
Resistors: Two10k Ohm, one 15k Ohm, one 1k Ohm

Capacitor: 0.01F; 0.1F

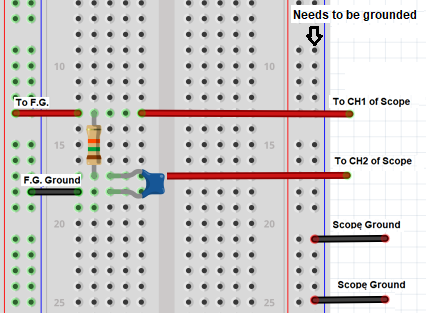
Inductor: 100mH

**Activity 1 – RC Circuit as a Low Pass Filter**

Wire up the circuit below on your breadboard.



*Figure 1a – Low Pass Filter Circuit Schematic*

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*Figure 1b – Low Pass Filter Circuit on a breadboard1*

[[1]](#endnote-1)

1. Set the Function Generator: Sine Wave, f= 500 Hz; Output Level: 5V-peak.

2. Measure the amplitude of the output signal, Vout. Make a table in your notebook as shown below and record this value in the table.

3. Repeat steps1 and 2 for frequencies: 50, 100, 1.0k, 10k, and 100k Hz

When looking at Vout be sure to adjust the volts/div knob on CH2 on scope so that the waveform fits most of the screen. Also adjust time/div knob so that you clearly see a few peaks of the sine shape.

4. Determine Vout/Vin for each frequency. Neatly sketch the table below in your notebook.

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency (Hz) | Vin | Vout | Vout/Vin |
| 50 |  |  |  |
| 100 |  |  |  |
| 500 |  |  |  |
| 1.0k |  |  |  |
| 10.0k |  |  |  |
| 100k |  |  |  |

**Analysis**

5. Make a plot of Vout/Vin vs Freq.

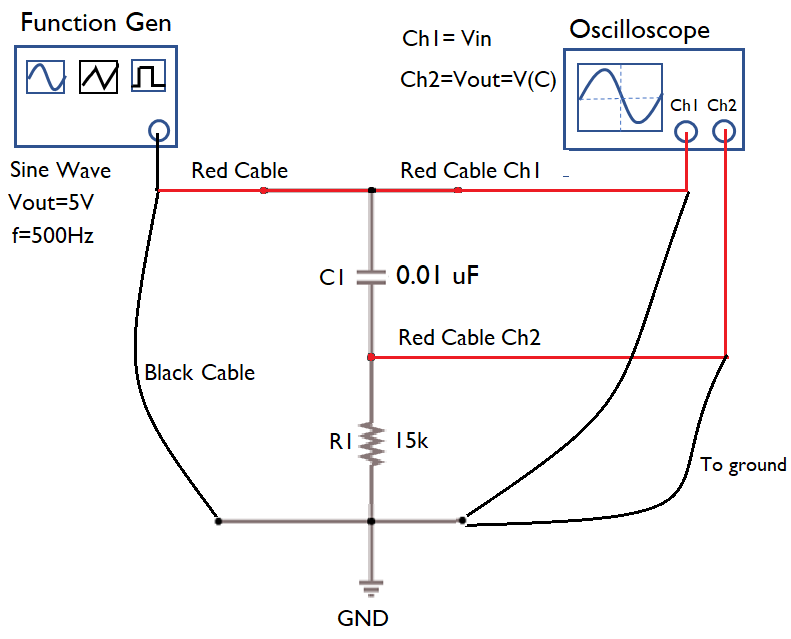
6. *f(3 db)* is defined as the frequency where Vout/Vin= 0.7.

(1)

Question: How does the theory compare to experiment results?

**Activity 2 - RC Circuit as a High Pass Filter**

Wire up the circuit below.



*Figure 2 – High Pass Filter Circuit*

1. Determine Vout/Vin for each frequency.

Neatly sketch the table below in your notebook.

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency (Hz) | Vin | Vout | Vout/Vin |
| 50 |  |  |  |
| 100 |  |  |  |
| 500 |  |  |  |
| 1.0k |  |  |  |
| 10.0k |  |  |  |
| 100k |  |  |  |

**Analysis**

2. In Excel, make a plot of Vout/Vin vs Freq.

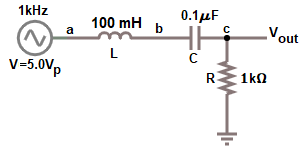
3. *f(3db)* is defined as the frequency where Vout/Vin= 0.7.

Theoretically,

Question: How does the theory compare to experiment results?

**Activity 3 - RLC Circuits and Resonance**

Wire up the circuit below. Use the multimeter to measure the resistor and capacitor values and record these values in your notebook. The inductance (L) of the inductor is 100 mH ± 10%



*Figure 3 -RLC Circuit2*

Use the values of L and C in the circuit to determine the resonant frequency (fR).

(2)

1. Use Ch1 of the oscilloscope to observe the input voltage to the circuit. Connect the red probe cable from the function generator to point ‘**a**’ on the circuit diagram and the black probe cable to ground. Connect a BNC cable from Ch1 of the oscilloscope to point ‘**a’** on the circuit. Make sure the red cable from the scope is connected to point ‘**a**’ and the black cable to ground.
2. Use Ch2 of the oscilloscope to observe the voltage across the resistor (or Vout). Connect the red cable to point ‘**c**’ on the circuit and the black cable to ground.
3. Turn on the function generator and set the frequency to about 1kHz and adjust the output knob on the F.G. so that input voltage (Ch1) reads about 10 Vpp. Do not the change the amplitude of the function generator signal for the rest of the experiment.
4. Vary the F.G. frequency and note how the voltage across the resistor (Ch2) changes. Set the F.G. frequency to 100 Hz to start and change it as indicated in the table below. Record the Vpp voltage of the output signal in each case. Use the data table to determine (approximately) the frequency where you get maximum voltage. This is resonance.

|  |  |
| --- | --- |
| **Function Generator Frequency** | **Voltage Out** |
| 100 |  |
| 400 |  |
| 800 |  |
| 1200 |  |
| 1600 |  |
| 2000 |  |
| 2400 |  |
| 2800 |  |
| 3400 |  |
| 3800 |  |
| 4200 |  |
| 5000 |  |

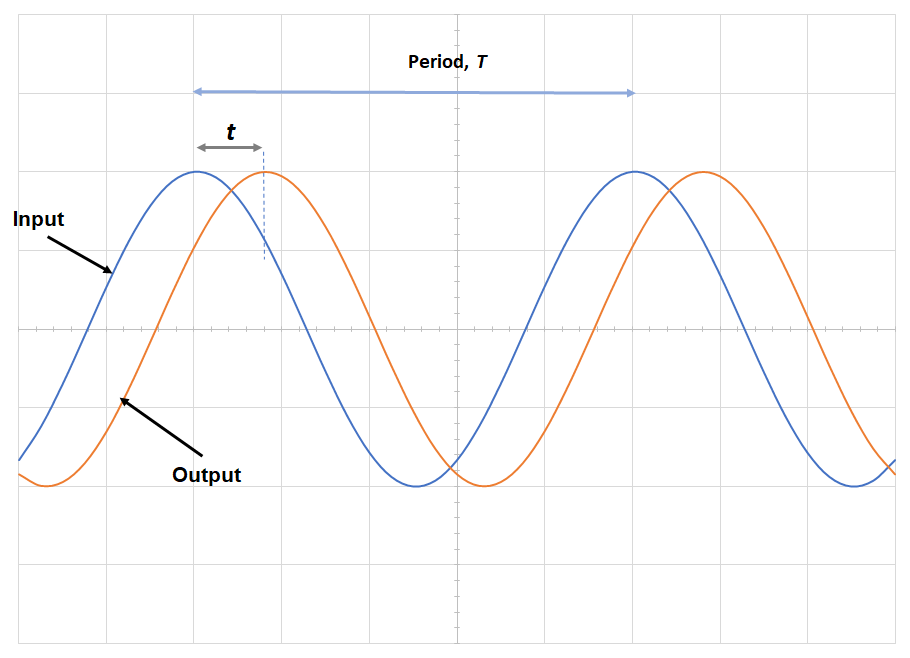
**Analysis**

1. In Excel, make a scatter graph of Voltage vs. Frequency.
2. Determine the resonant frequency from the scatter graph. The resonant frequency is characterized by having the largest value of Vout.

**Question:** How do the calculated (from equation 2) and measured frequencies compare- similar or very different?

1. Set the frequency of the input signal to 4500 Hz. On the oscilloscope, overlay the input signal (Ch1) and output signal (Ch2) and measure the phase angle.

To determine the phase angle between the input and output waves you will need to find the time difference, t, as shown in the diagram below. The value of t tells you by how much one signal lags the other. In the diagram below, for example, the output signal lags the input signal by 80 msecs. Note: 1 division on the scope grid is equivalent to 100 msecs.



100 mS/div

*Figure 4 -Oscilloscope screen showing the input and output signals*

Use the ‘Cursors’ feature on the oscilloscope to determine the phase angle.

You can measure *t* by determining the time that an input signal peak occurs and then determining the time when the peak of the output signal occurs and subtracting those two numbers. The phase angle (q) is determined from the equation below,

where is the phase angle, *T* is the period and *t* is the time lag between the input and output signal.

**Question:** How does the phase angle change when you change the frequency of the signal from 4500 Hz to the resonant frequency?

***Observations***

Describe what happens to the phase between the input and output signals when you vary the FG frequency above and below the resonant frequency.

1. 1 These images were created with Fritzing (<https://fritzing.org>)

   2 All Schematic diagrams were created with Falstad circuit simulator (https://falstad.com/circuit/) [↑](#endnote-ref-1)