

# AC CIRCUITS

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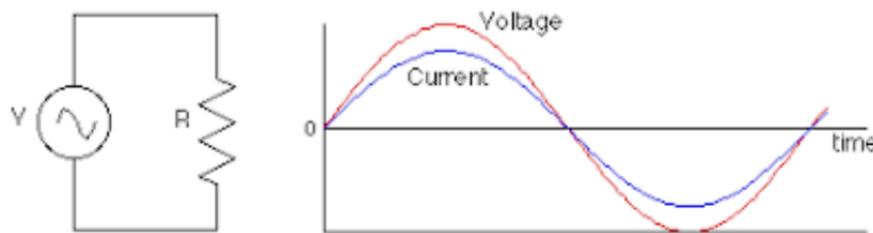
AI: Jerald Balta

P222-3659

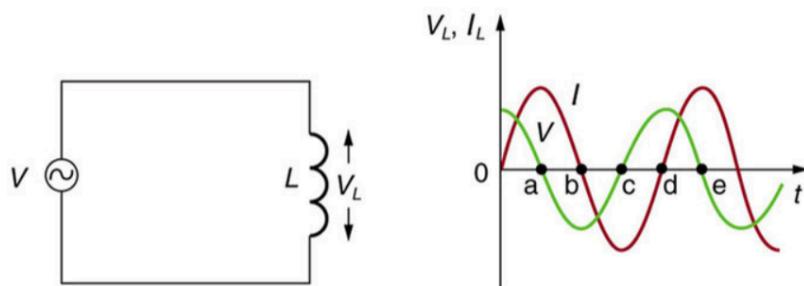
## **Introduction**

When dealing with alternating current circuits, there is a current that varies according to the frequency the alternating current is creating. This in turn changes the amount of voltage being sent through the circuit. The maximum voltage will not be at the same moment as the maximum current will be unless it is only resistance on the circuit; this phenomenon is called a phase relationship or phase angle. The phase angle differs for resistors, inductors, and capacitors.

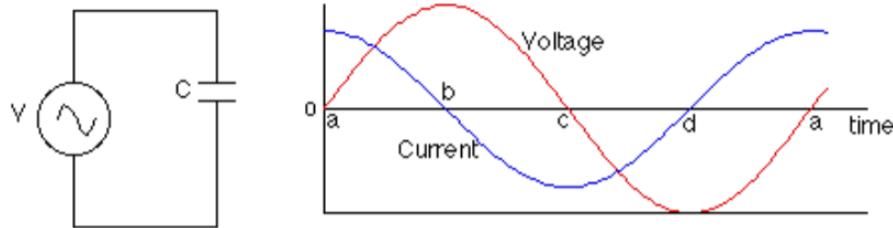
For resistors, we see no change:



For inductors, we see a voltage that leads the current at  $\pi / 2$ . Its voltage is zero when its current is max and vice versa:



For capacitors we see a voltage that lags the current at  $-\pi / 2$  where, if the voltage is at zero the current is at a maximum negative and vice versa:



These relationships and relationships of RC and RLC circuits with alternating current is what will be studied throughout this lab.

## Method

For this lab we need the following pieces of equipment:

- A BK 5 MHz Function Signal Generator
- A Differential Amplifier
- A data acquisition system
- A copy of the LoggerPro 3.15 software
- A large amount of patch cords
- A 1000 Ohm resistor (included in the plexiglass box)
- A .47 Microfarad capacitor (included in the plexiglass box)
- A 80 Millihenry inductor (included in the plexiglass box)

In order to set up the RC circuit, use the AC function generator to create a alternating current.

For this setup, a crossover frequency of 100 to 500 Hz was supposed to be made with the correct resistor, capacitor combination. A resistor of 100 ohms and .47 microfarads were chosen from using the  $f = 1 / (2 \pi R C)$  formula. Using patch cables,

connect the function generator to the resistor, the resistor

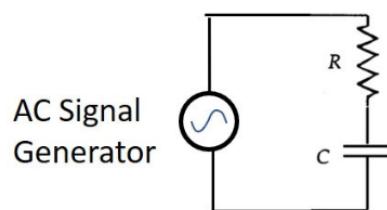


Fig. 1 – Wiring diagram for the RC Circuit

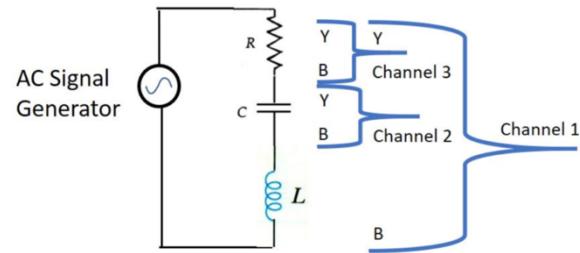
to the capacitor, and the capacitor, back to the generator closing the loop. This should look like the same as the schematic in *figure 1*. Once this is wired connect the data acquisition system where channel one blue connection will be connected before the capacitor and the yellow connection after the resistor. Channels two and three should have a cable going from the blue input to before the capacitor and after the capacitor with the yellow cable, doing the same with the resistor respectively.

The RCL circuit will be set up in a similar fashion with the same devices but also including a 10MOhm inductor. Refer to *figure 2 1* to connect the devices together. Channel one will read the voltage drop across the resistor, capacitor, and inductor beginning before the inductor with the blue patch cable and yellow

input after the resistor. Channel two will read the voltage drop across the capacitor beginning before the capacitor with the blue patch cable

and yellow input after the capacitor. *Figure 2 1*

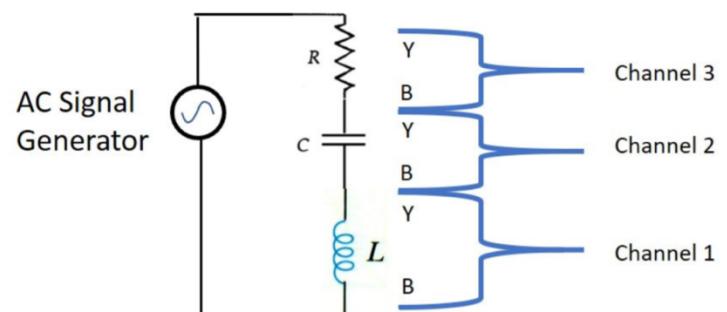
three will read the voltage drop across the resistor in the same order as the capacitor.



The final circuit will also be an RLC circuit but instead of channel one encompassing all devices, it will only read the voltage

drop across of the inductor with its blue input before the inductor and its yellow input right after the inductor (*Figure 3*

*I*).



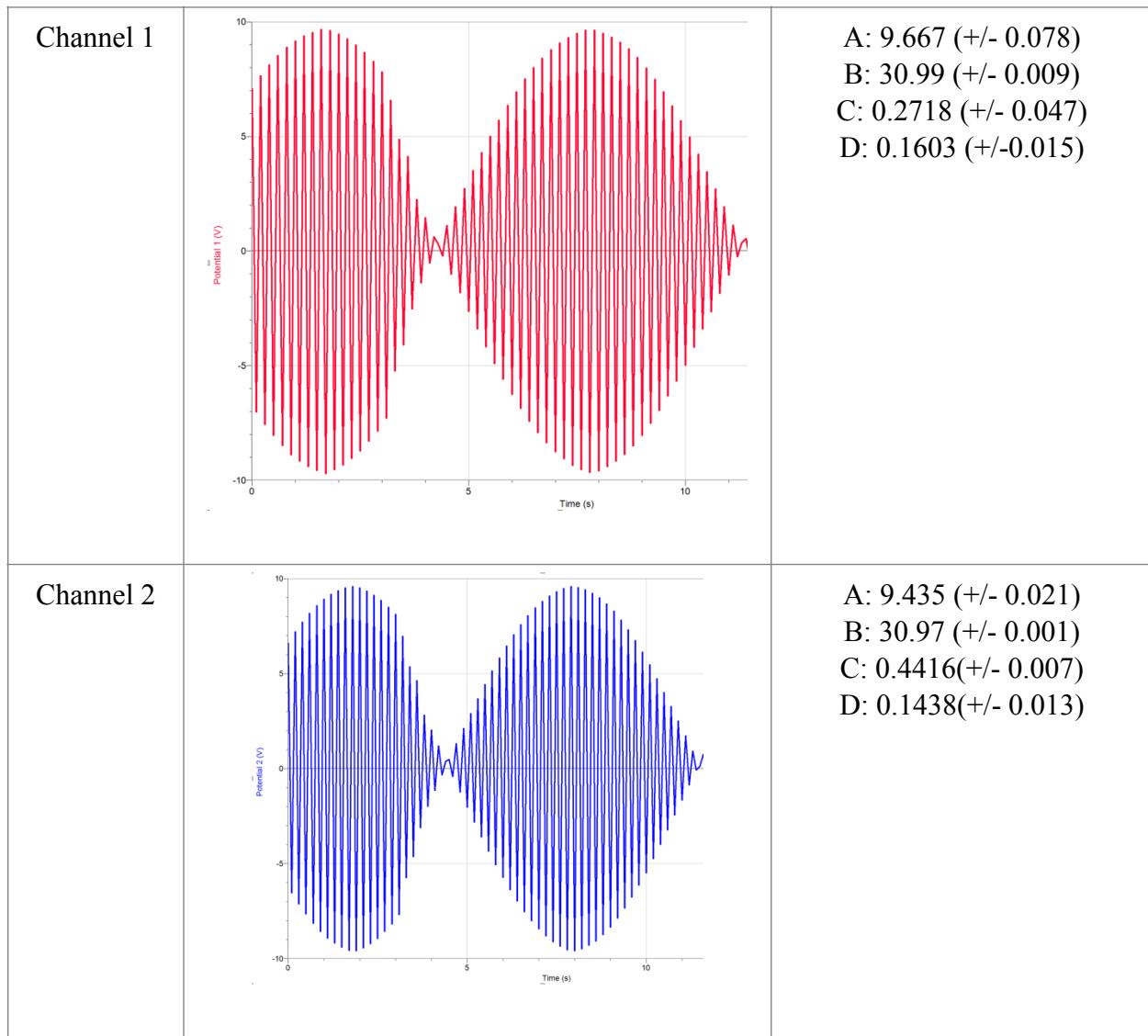
In order to collect data from these circuits, log into LoggerPro and configure the data collection rate by going under the “Experiment”,

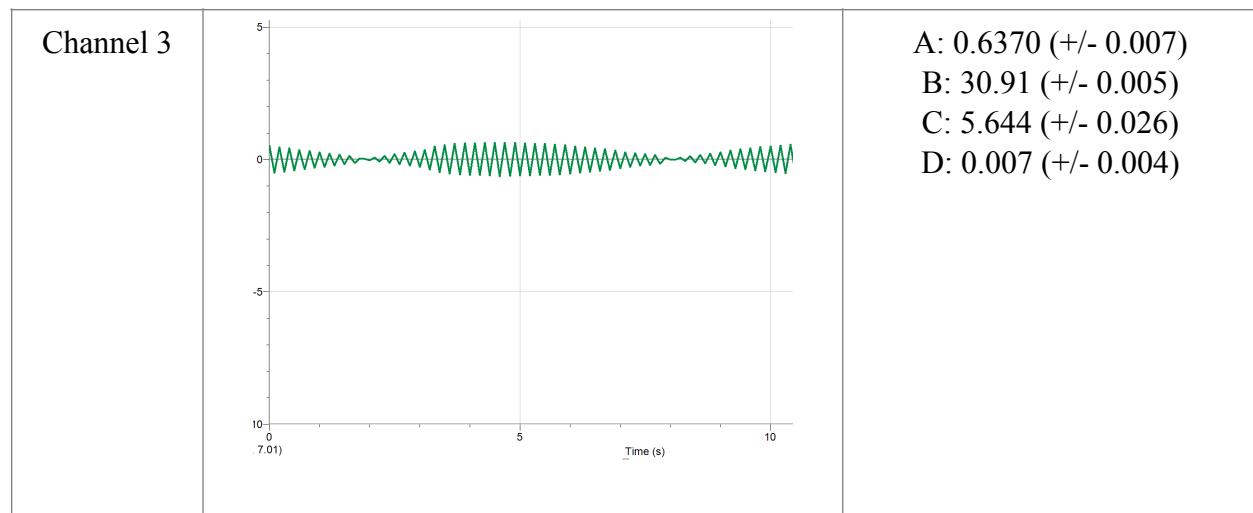
“Data Collection” tab and changing the rate to .0001 seconds, then save the changes. Begin collecting data until patterns arise from the graphs. Once the data is collected use the data fit equation ( $V = A \cos (B t + C) + D$ ) along a large amount of periods that seem to begin and end at similar frequencies or cycles. Save your data and the fit curve. Make sure to set the signal generator to create smooth sinusoidal curves. This will create error in your data if not done.

- Repeat these steps for the following frequencies of the RC circuit: 25 Hz, 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, and 2500 Hz.
- Repeat these steps for the following frequencies of the first RLC circuit: 25 Hz, 250 Hz, 338 Hz, 400 Hz, 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, and 2500 Hz (338 Hz was added to measure the resonance frequency).
- Repeat these steps for the following frequencies of the second RLC circuit: 25 Hz, 338 Hz, and 2500 Hz.

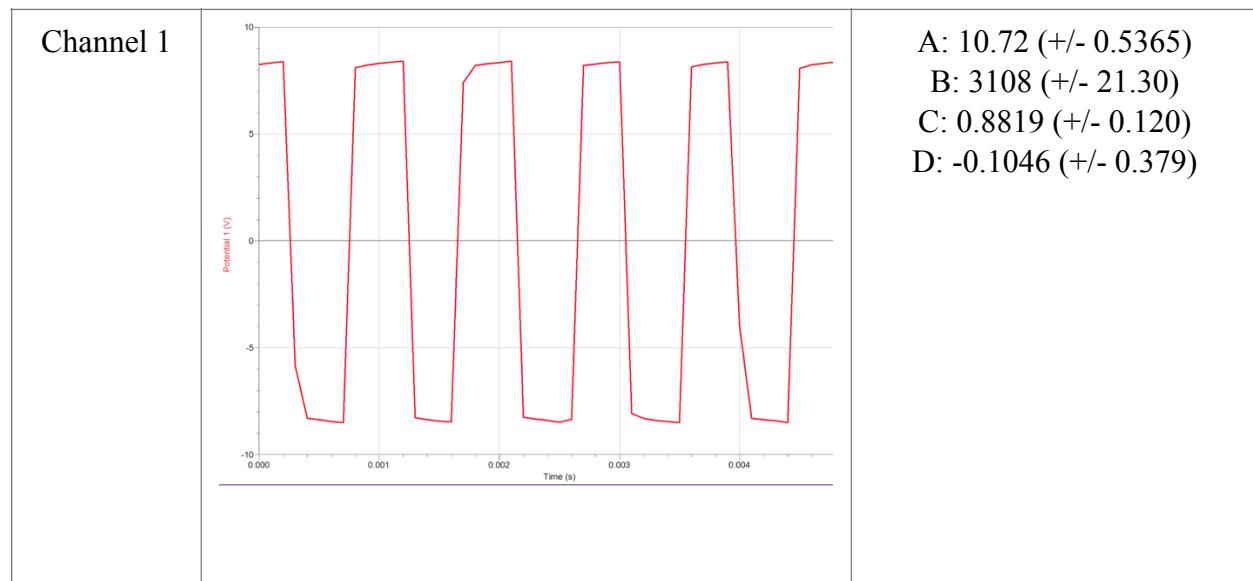
## Results

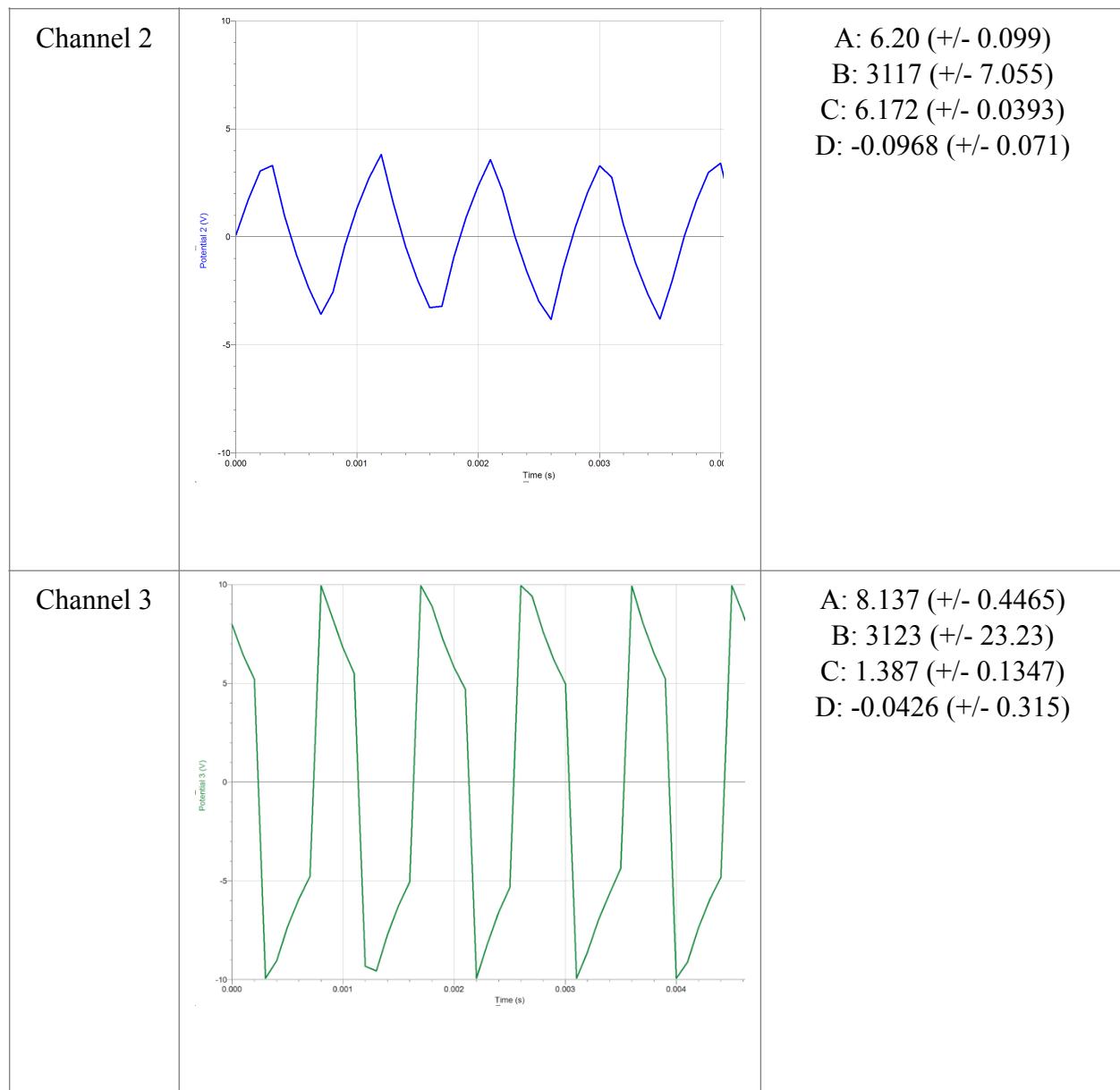
RC circuit 25 Hz:



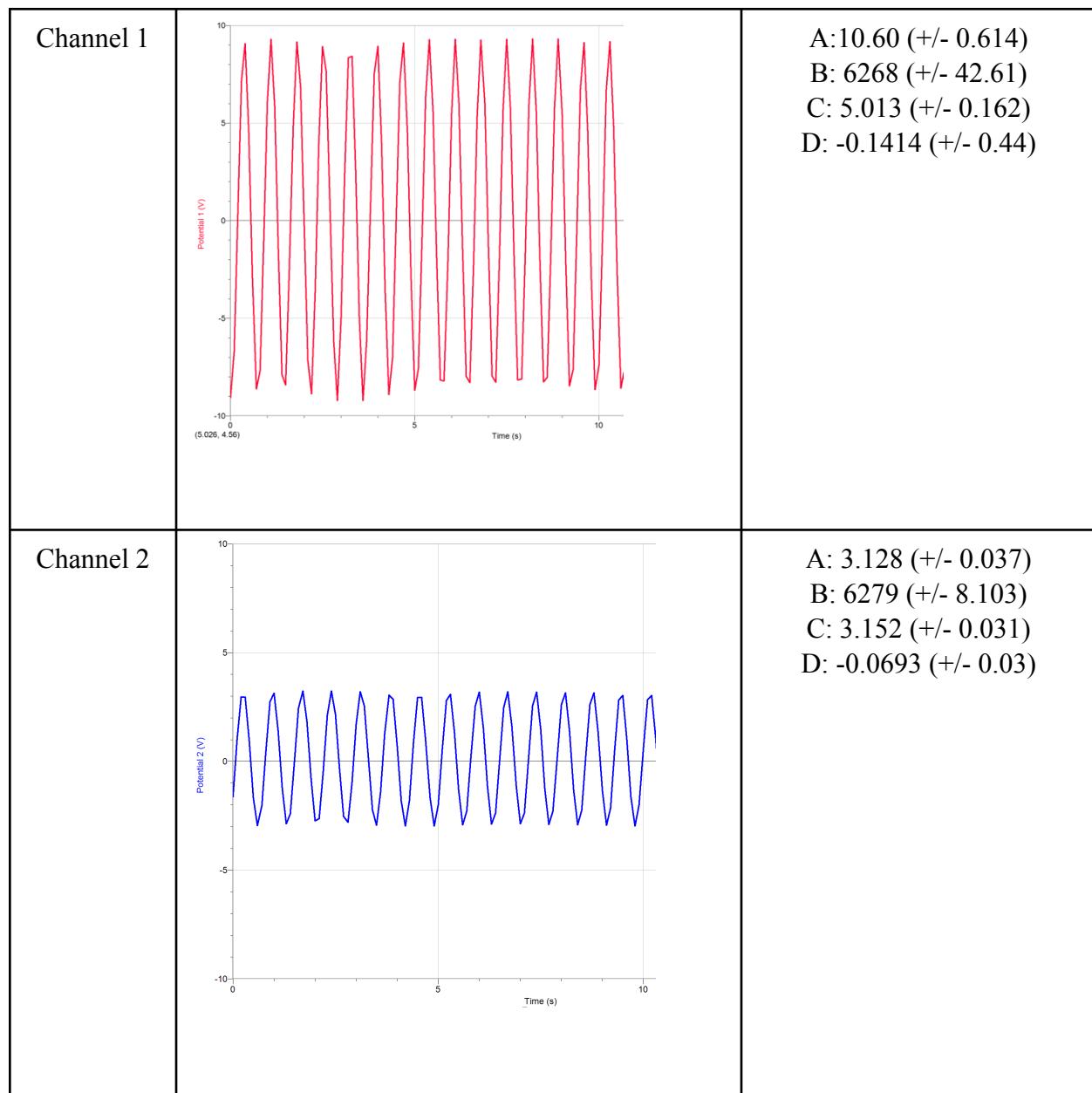


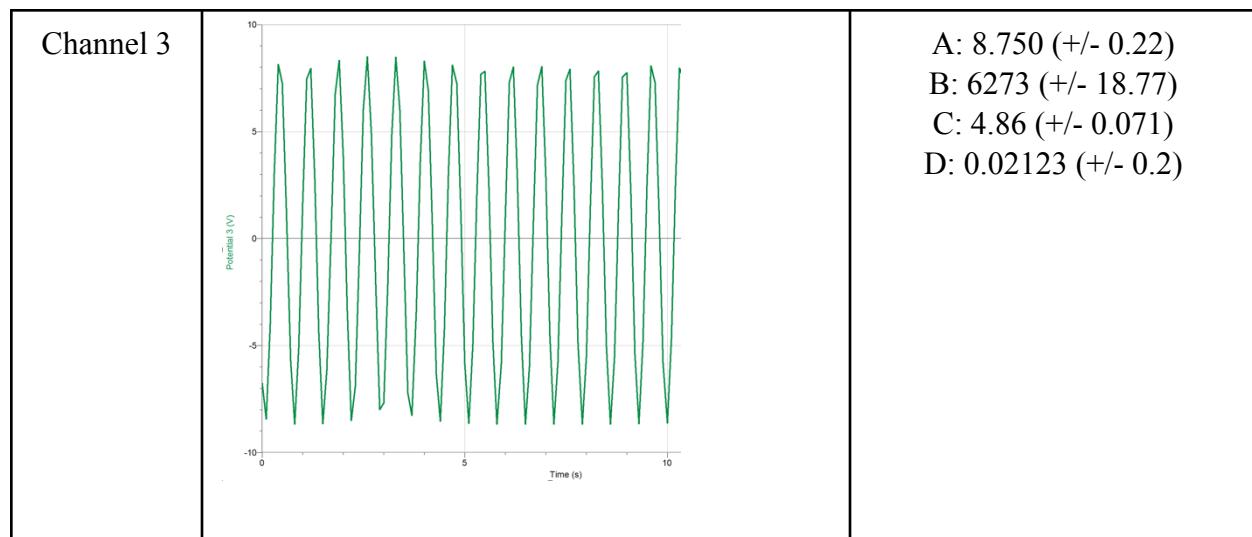
RC circuit 500 Hz:



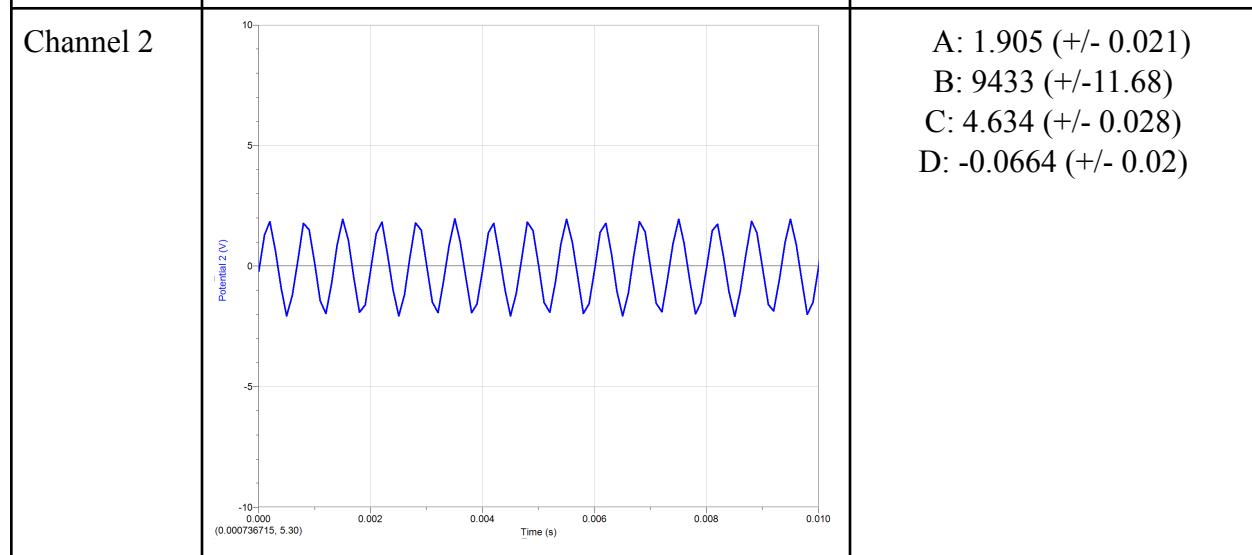
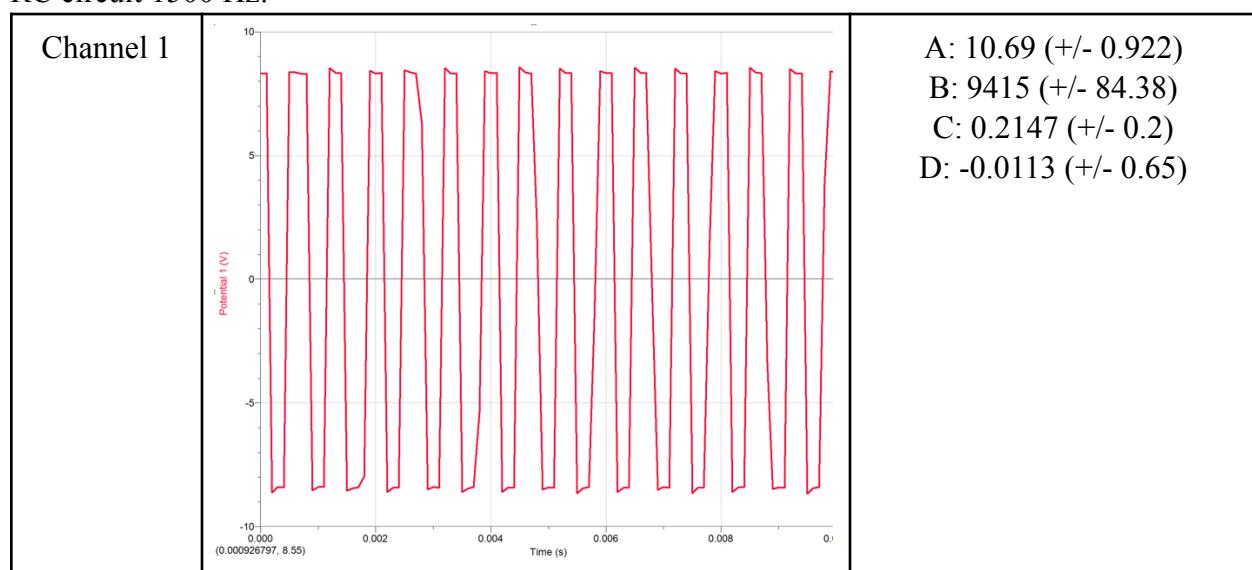


RC circuit 1000 Hz:

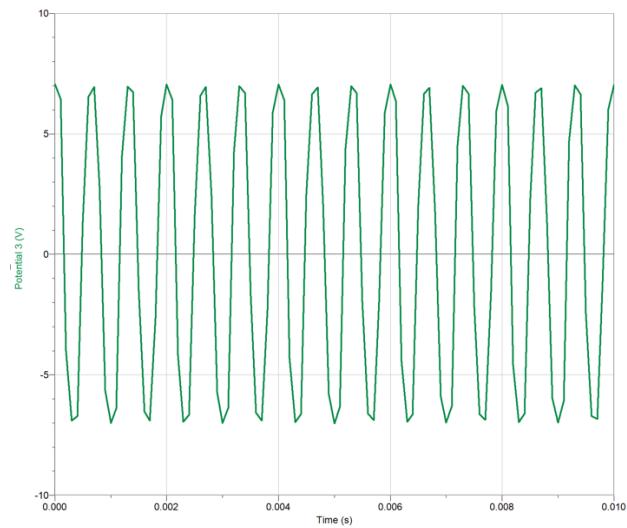




RC circuit 1500 Hz:



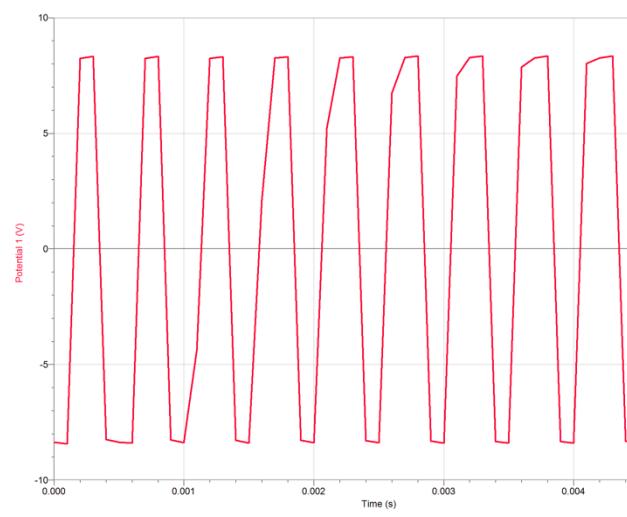
Channel 3



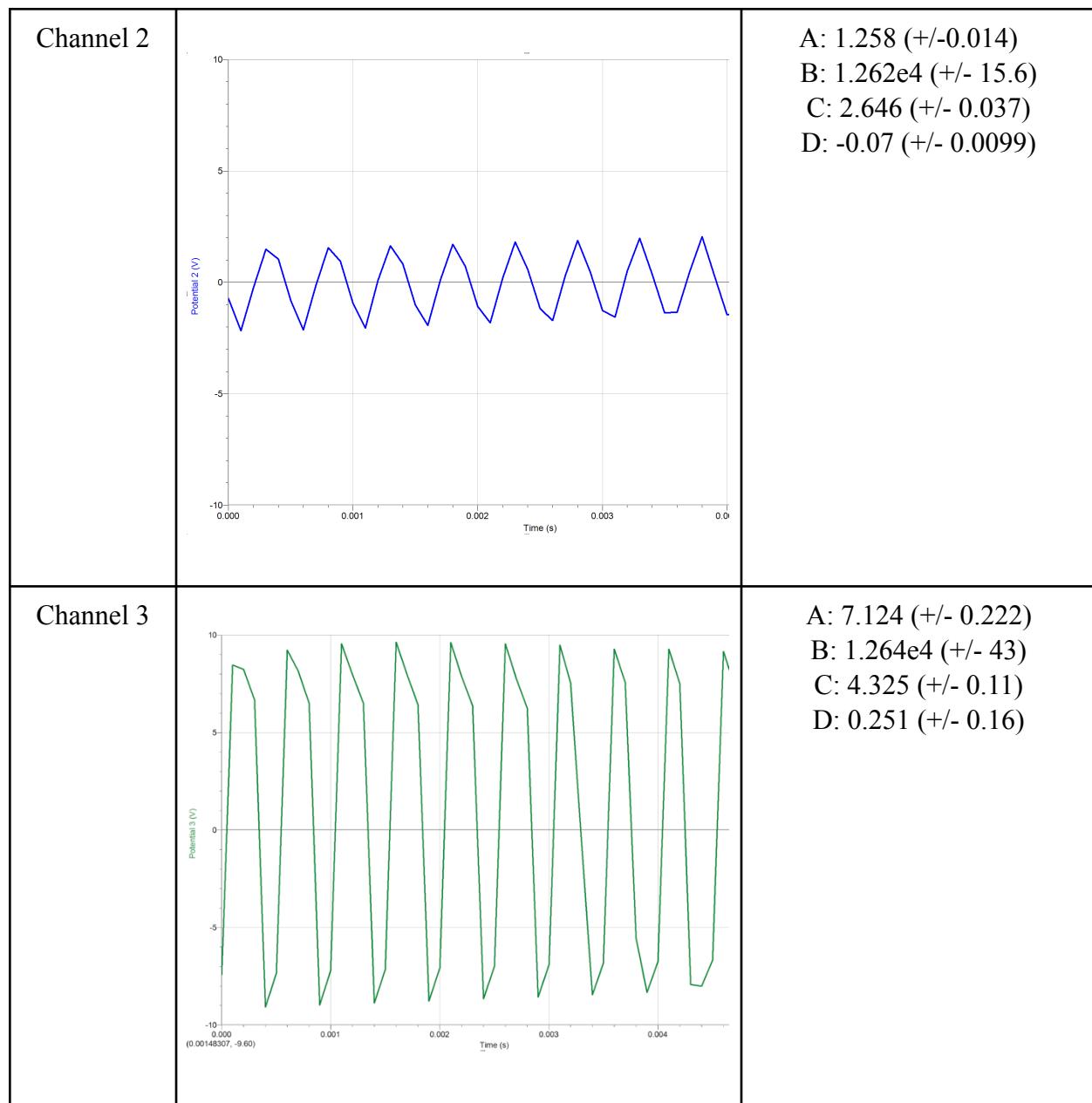
A: 8.015 (+/- 0.025)  
B: 9430 (+/- 30.82)  
C: 0.056 (+/- 0.073)  
D: -0.0101 (+/- 0.18)

RC circuit 2000 Hz:

Channel 1

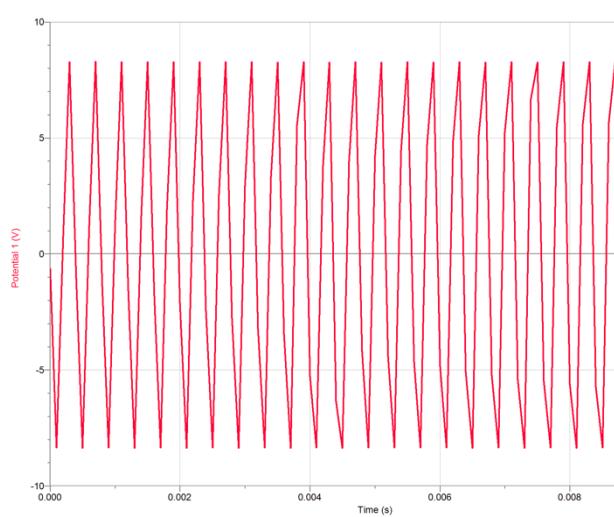


A: 10.72 (+/- 0.737)  
B: 1.269e4 (+/- 96.5)  
C: 4.646 (+/- 0.237)  
D: 1.021 (+/- 0.525)



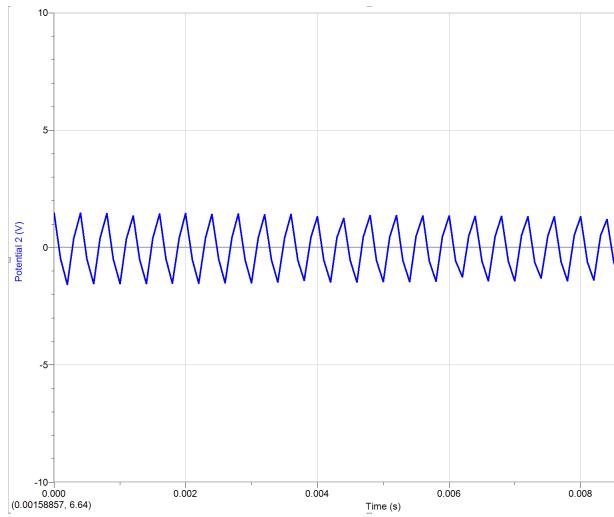
RC circuit 2500 Hz:

Channel 1



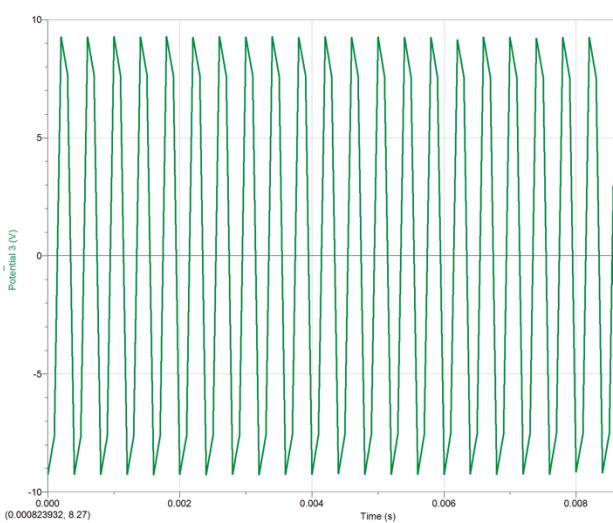
A: 9.495 (+/- 0.763)  
B: 27.77 (+/- 0.008)  
C: 2.988 (+/- 0.022)  
D: 0.1580 (+/- 0.05)

Channel 2



A: 2.622 (+/- 1.455)  
B: 25.72 (+/- 0.438)  
C: 5.875 (+/- 1.401)  
D: 0.3527 (+/- 1.03)

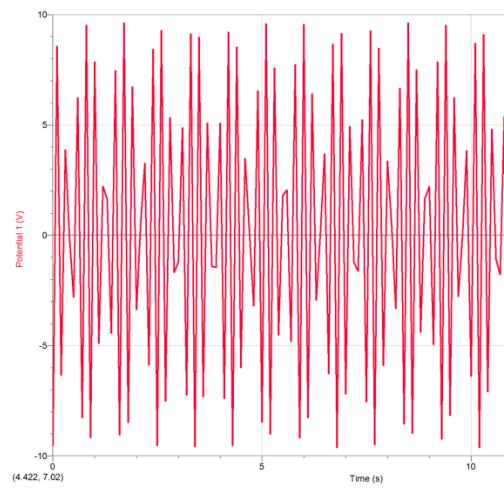
Channel 3



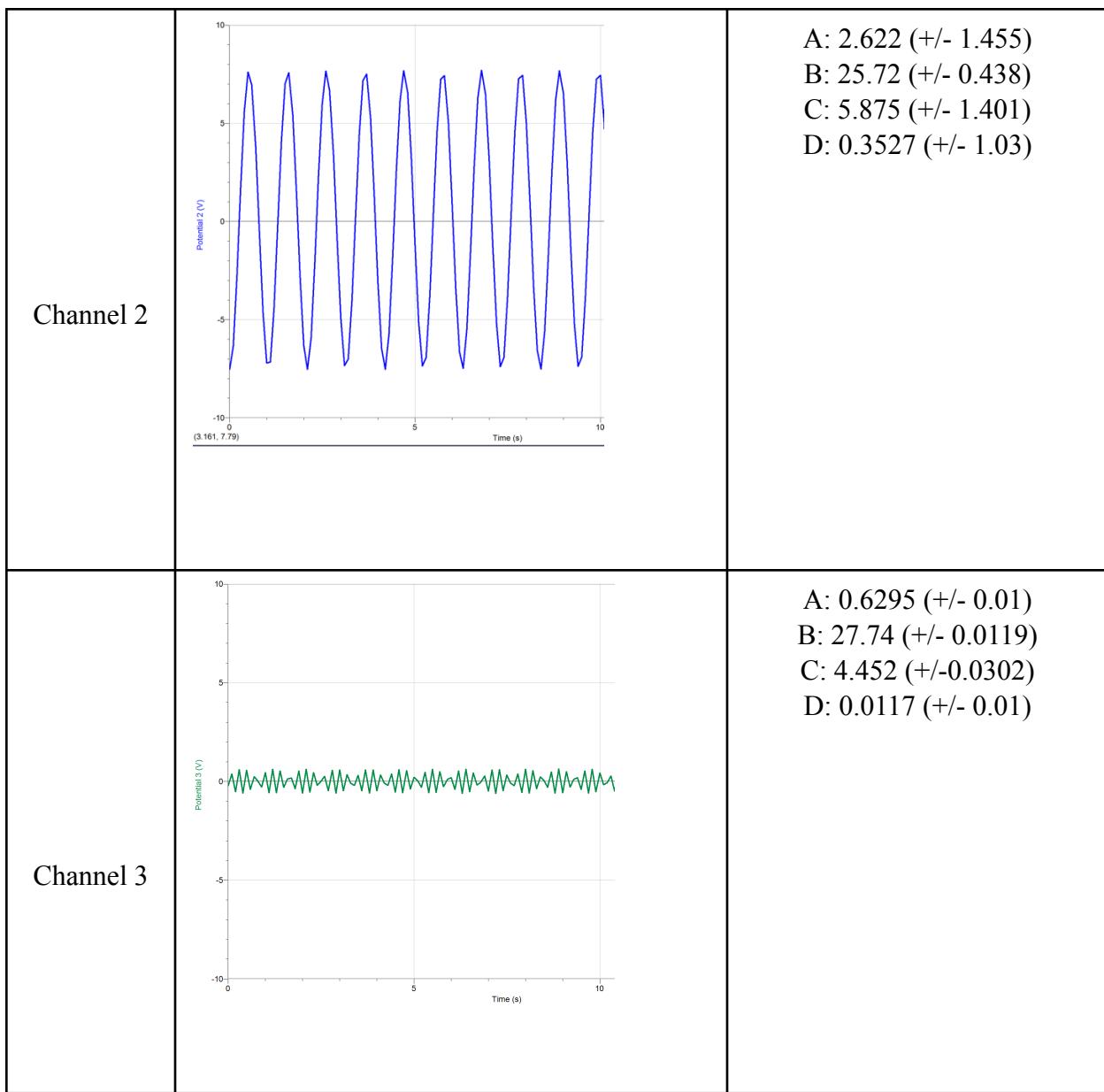
A: 0.6295 (+/- 0.01)  
B: 27.74 (+/- 0.0119)  
C: 4.452 (+/- 0.0302)  
D: 0.0117 (+/- 0.01)

RLC Circuit 1 25 Hz:

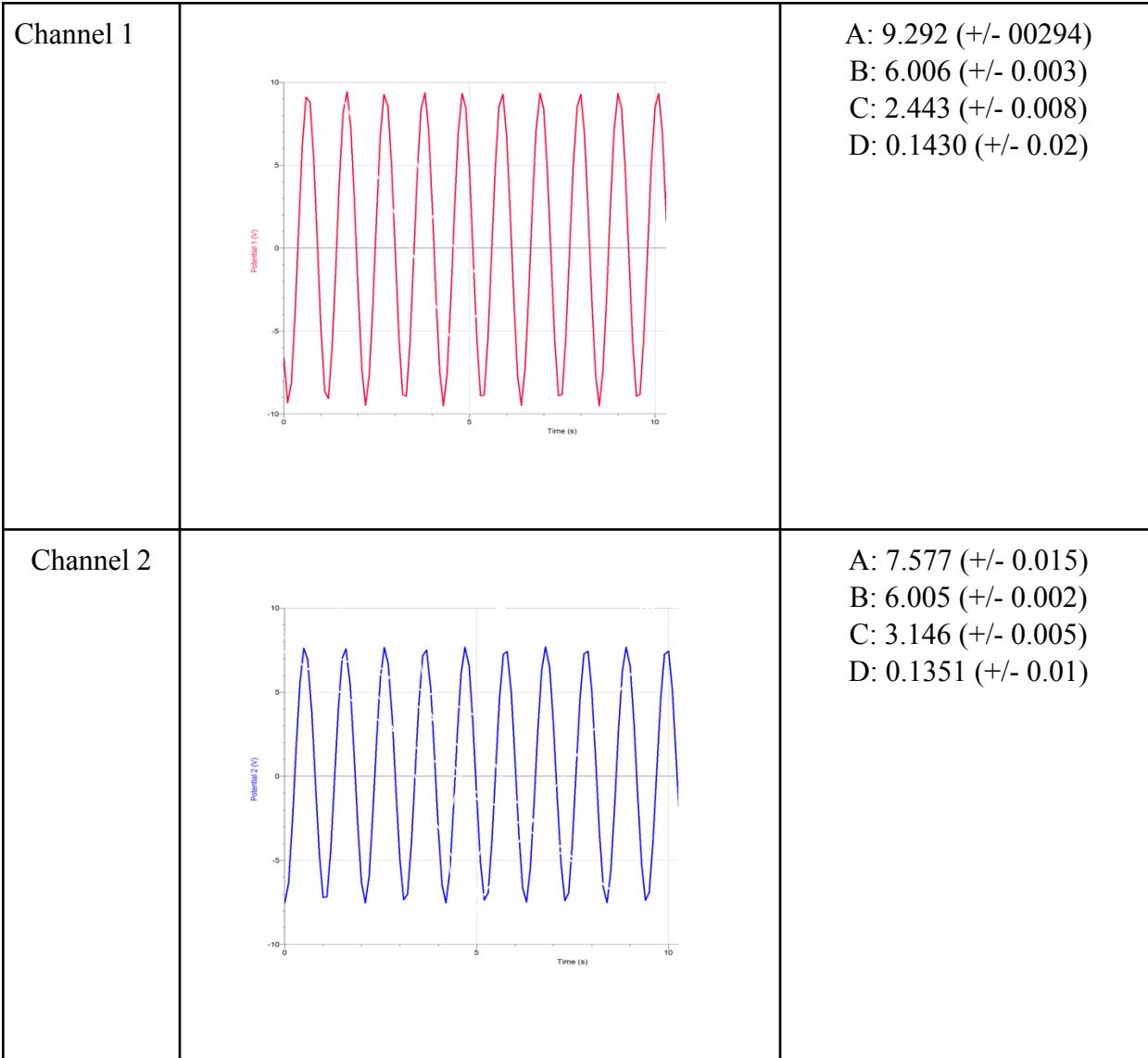
Channel 1



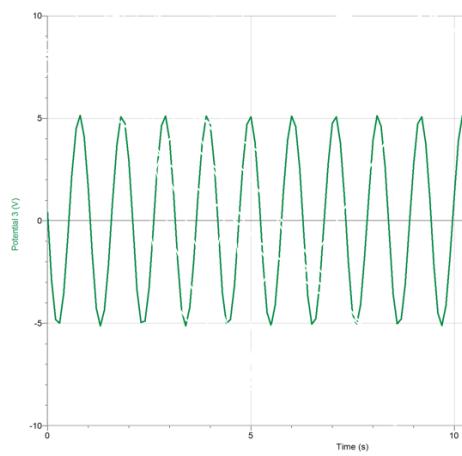
A: 9.495 (+/- 0.763)  
B: 27.77 (+/- 0.008)  
C: 2.988 (+/- 0.022)  
D: 0.1580 (+/- 0.05)



RLC Circuit 1 250 Hz:



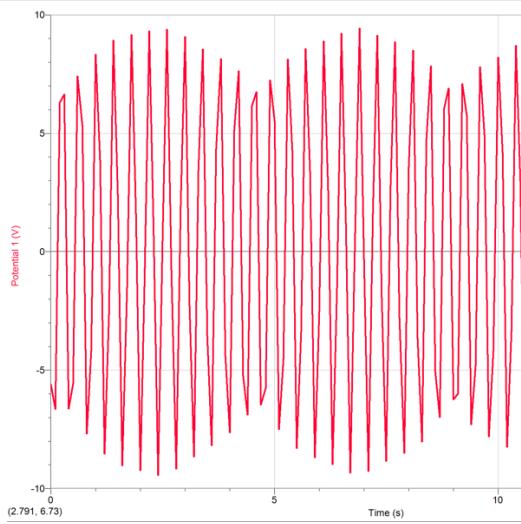
Channel 3



A: 5.211 (+/- 0.023)  
B: 6.005 (+/- 0.005)  
C: 1.565 (+/- 0.012)  
D: 0.0064 (+/- 0.02)

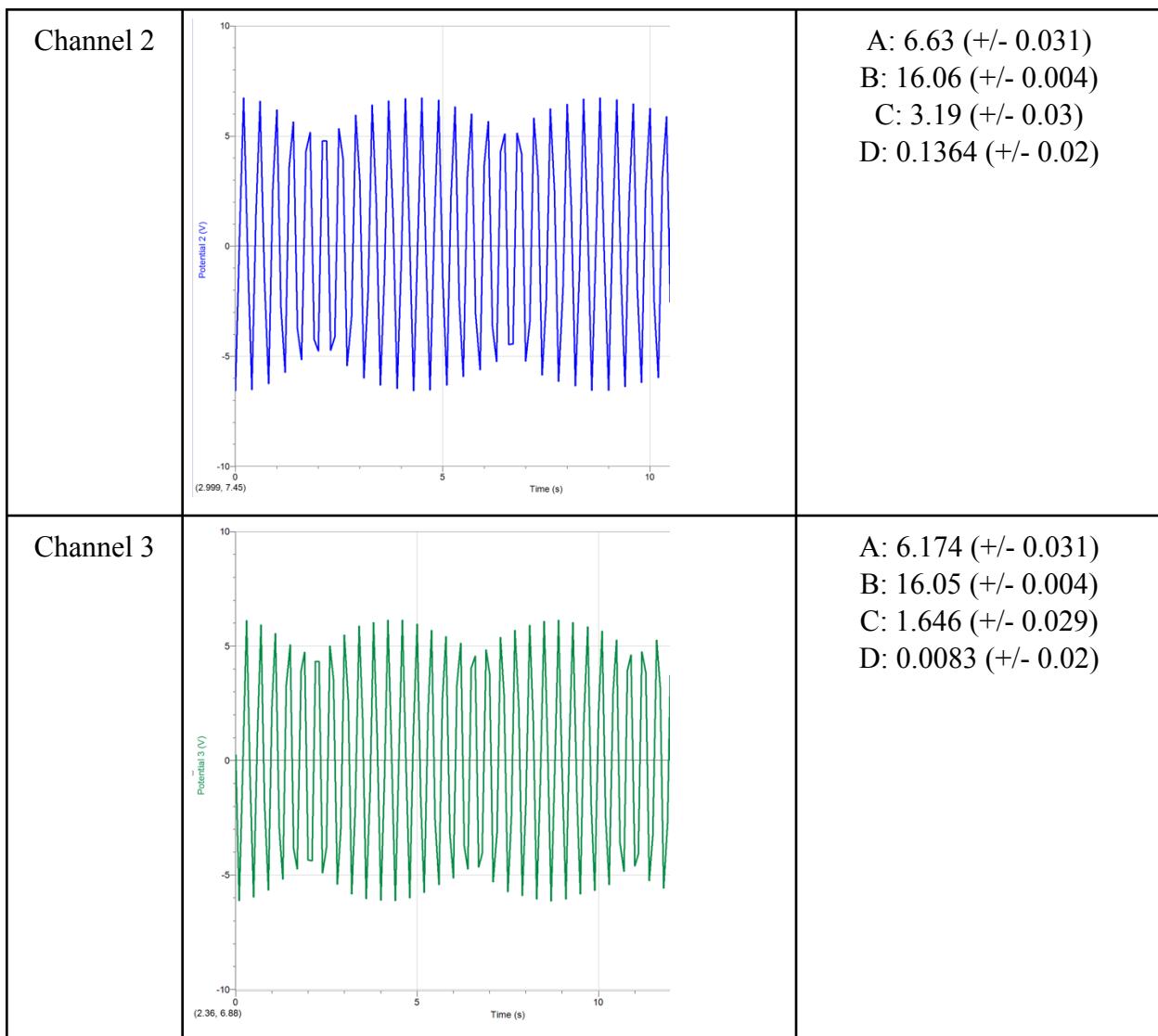
RLC circuit 1 338 Hz:

Channel 1

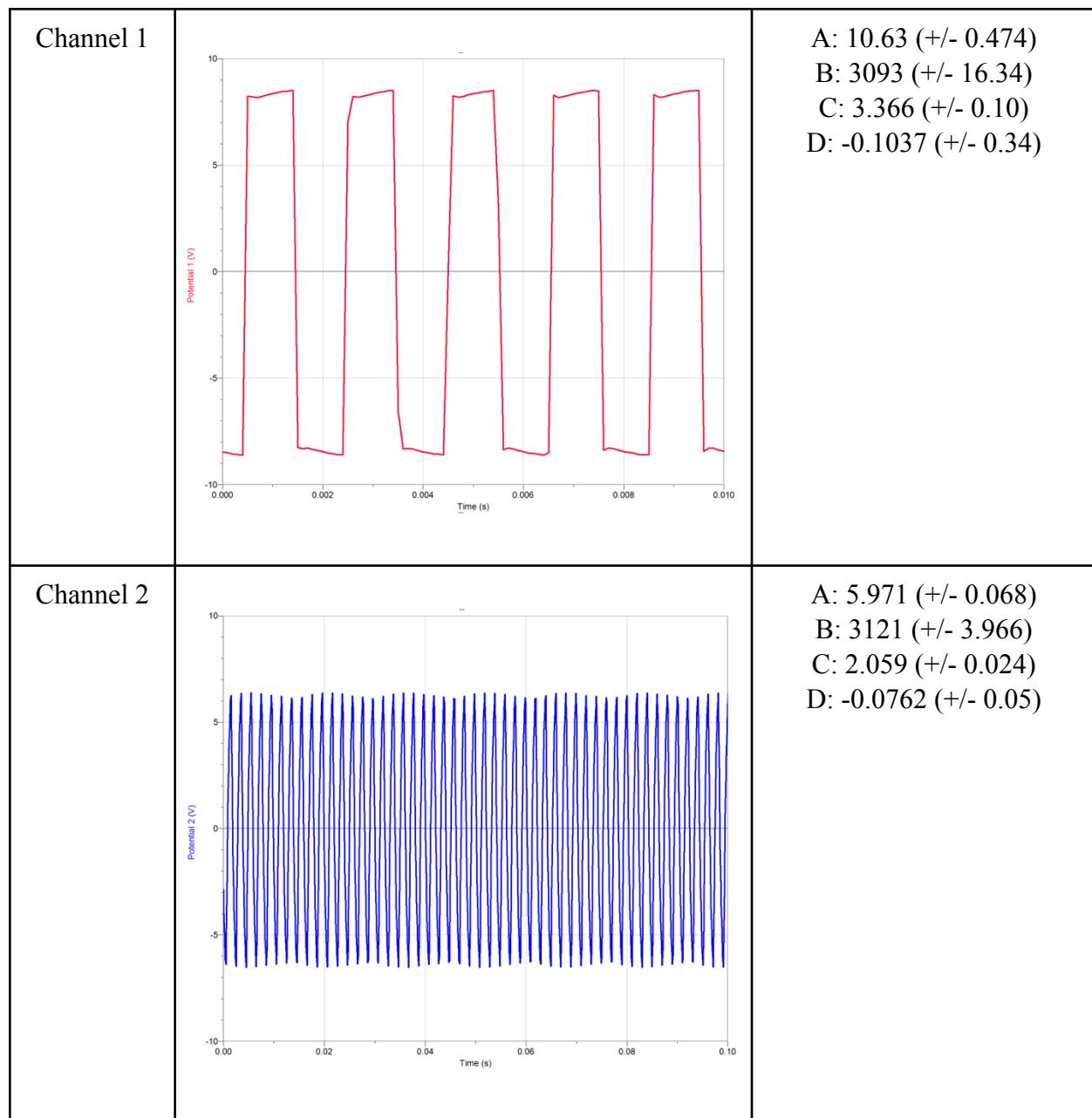


A: 9.211 (+/- 0.043)  
B: 16.05 (+/- 0.004)  
C: 2.365 (+/- 0.027)  
D: 0.1432 (+/- 0.03)

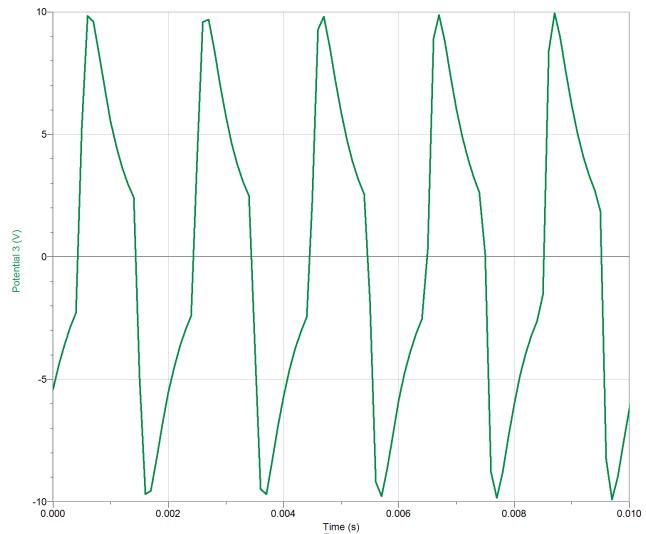
(2.791, 6.73)



RLC circuit 1 500 Hz:



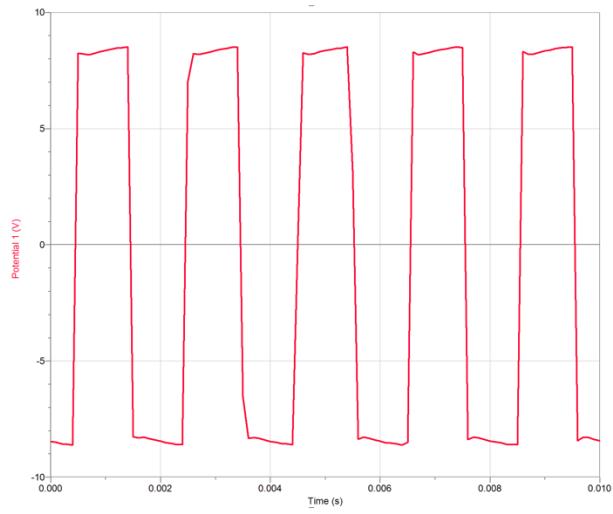
Channel 3



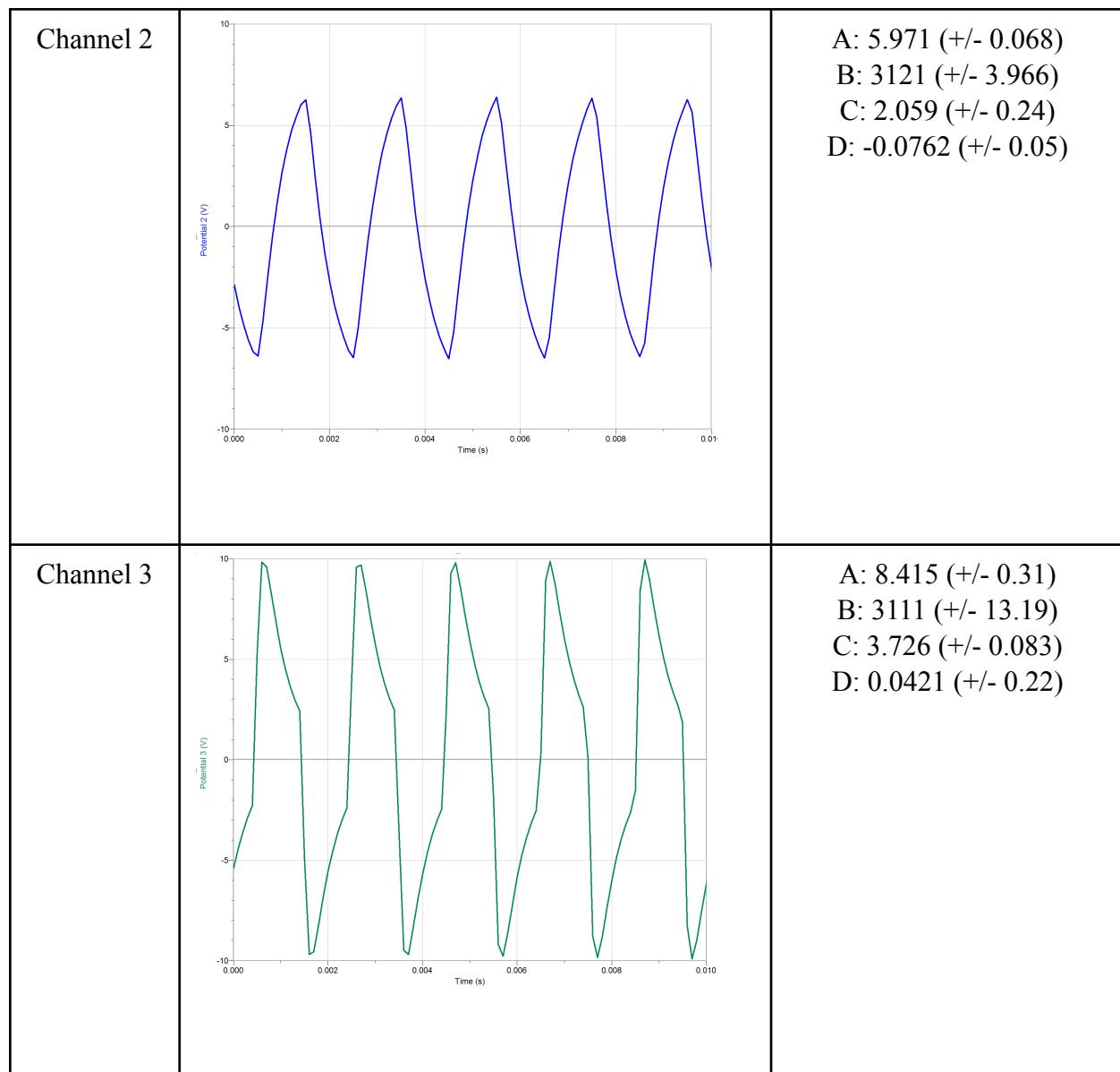
A: 8.415 (+/- 0.031)  
B: 3111 (+/- 13.19)  
C: 3.726 (+/- 0.083)  
D: 0.0421 (+/- 0.22)

RLC circuit 1 750 Hz:

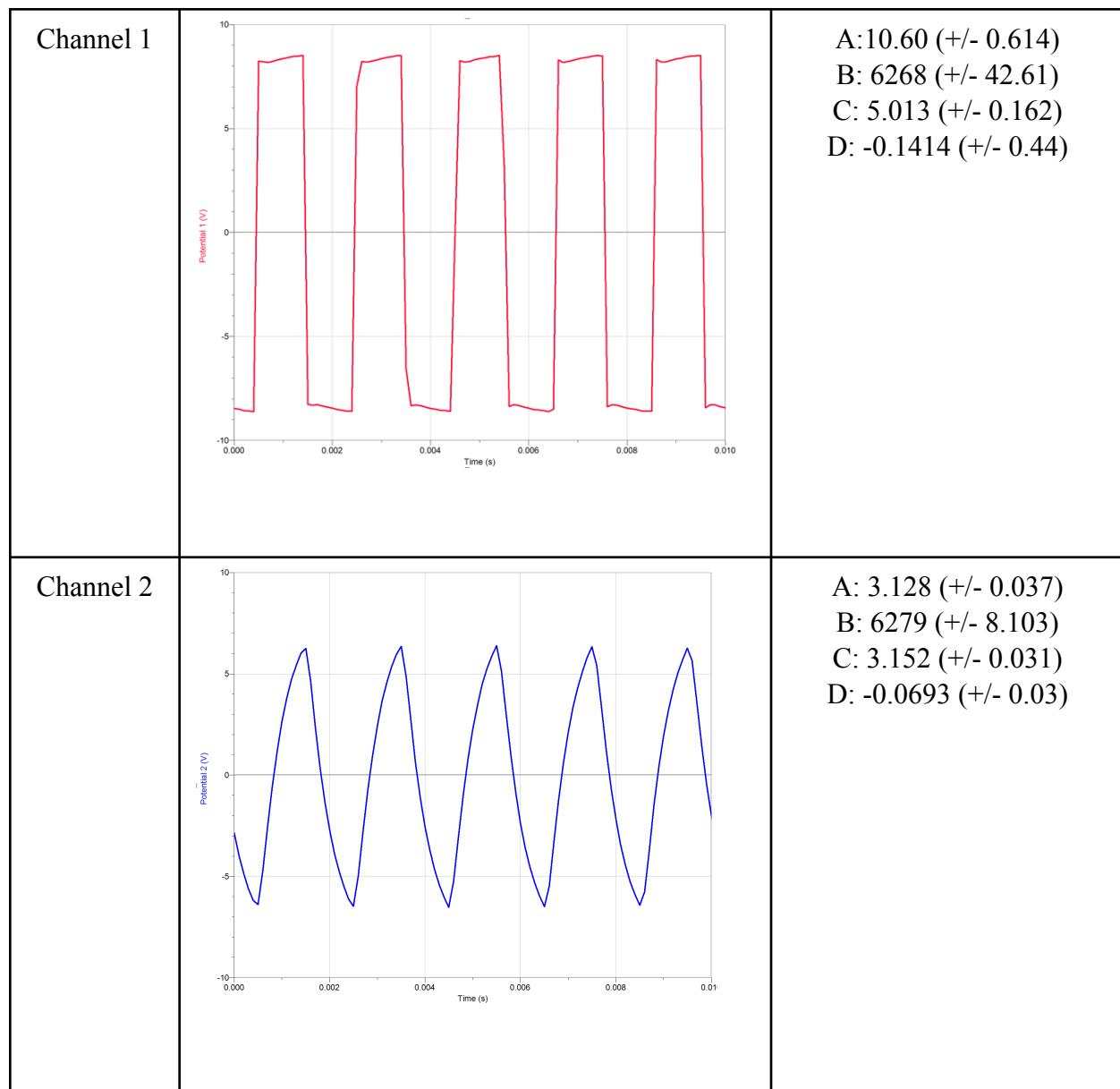
Channel 1

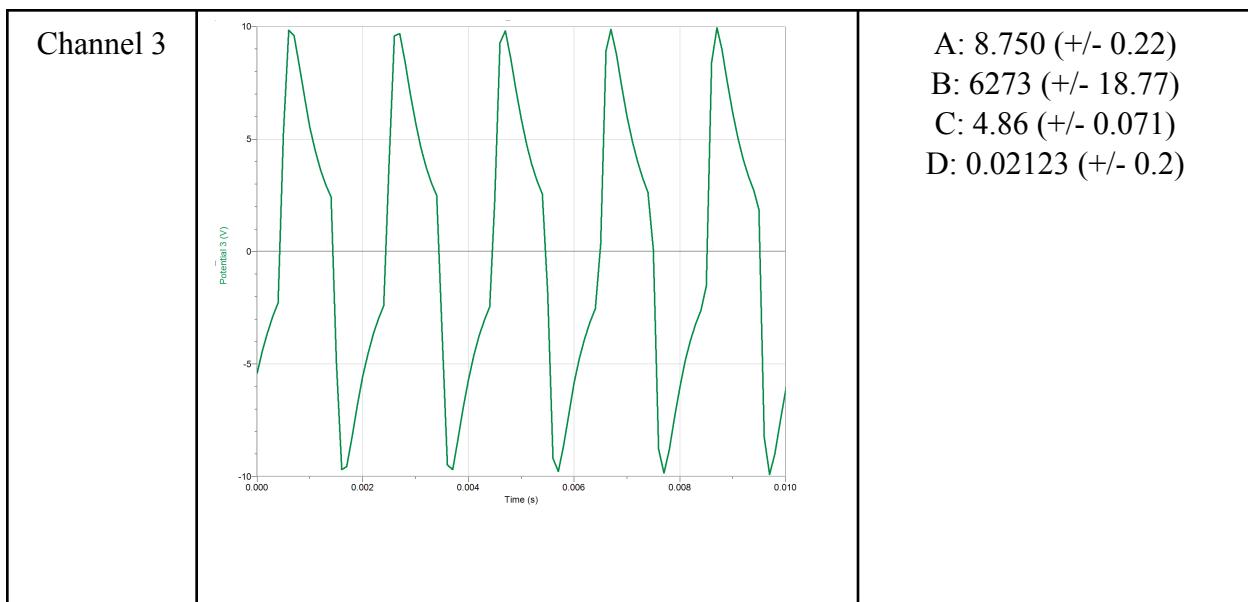


A: 10.63 (+/- 0.474)  
B: 3093 (+/- 16.34)  
C: 3.366 (+/- 0.10)  
D: -0..1037 (+/- 0.3)

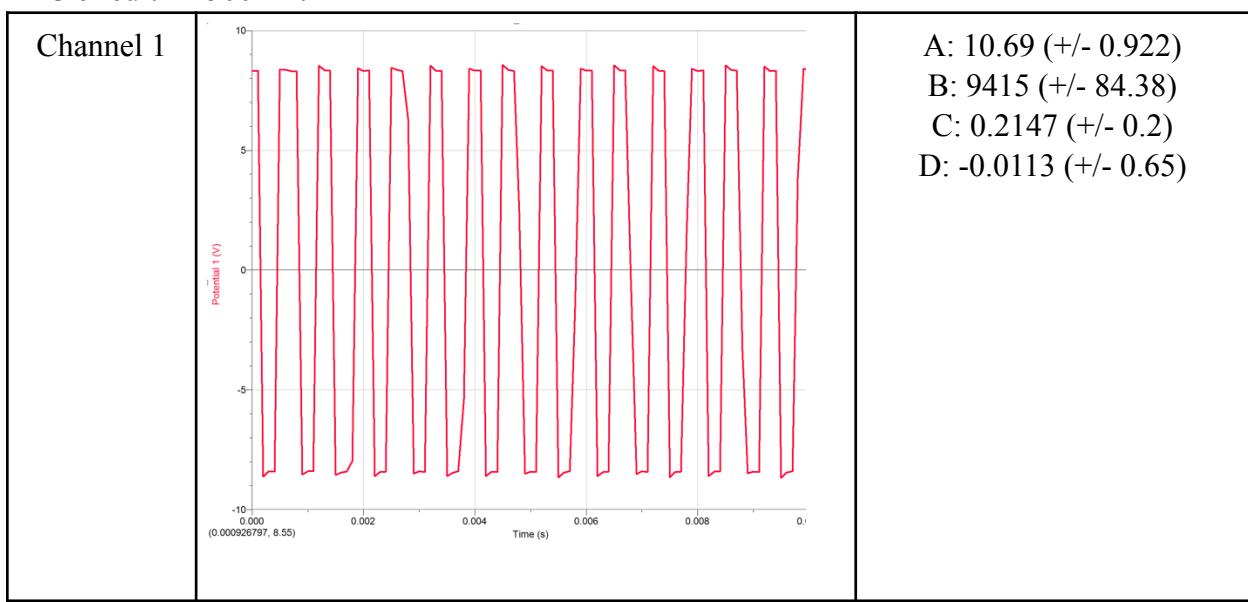


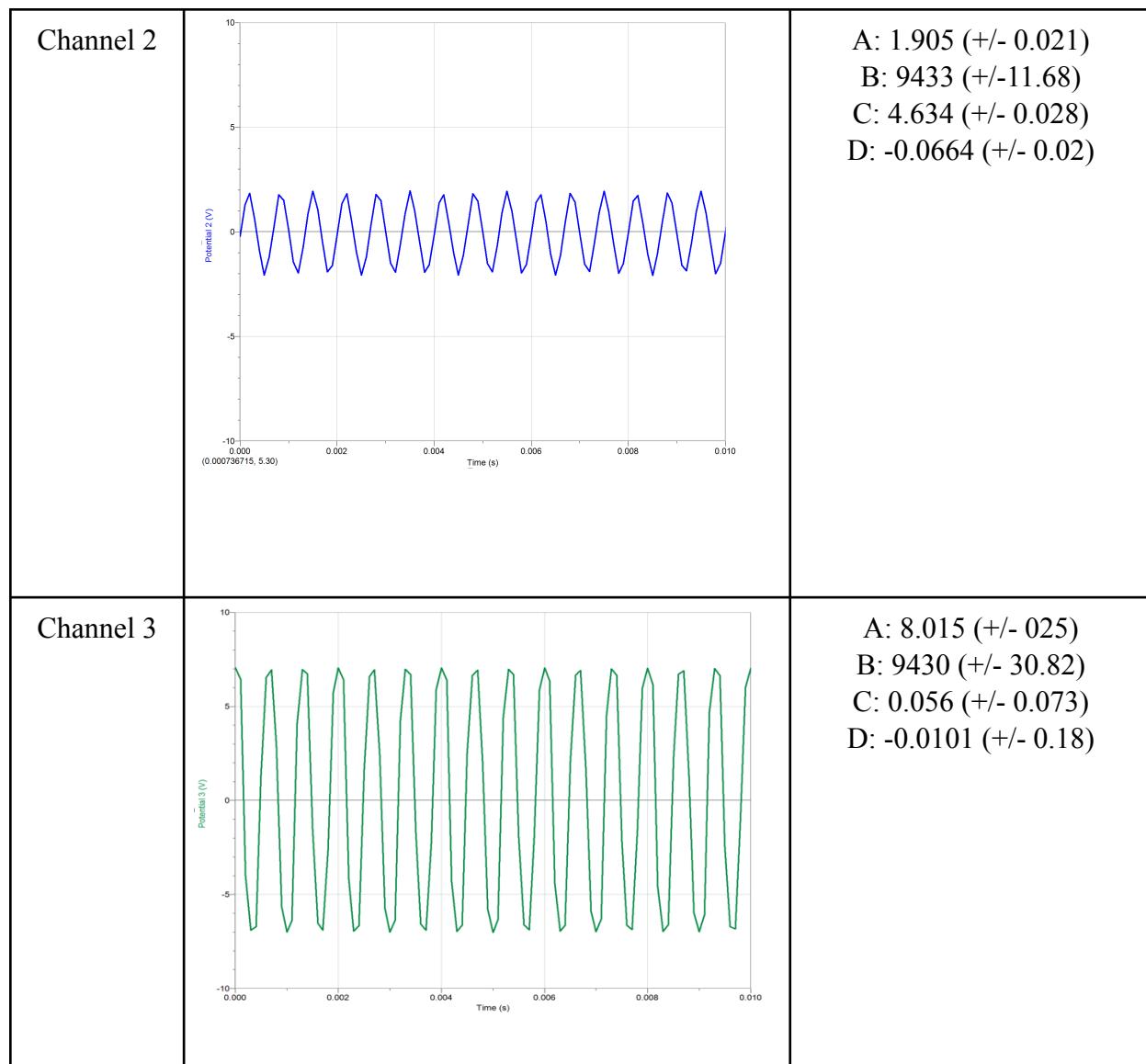
RLC circuit 1 1000 Hz:



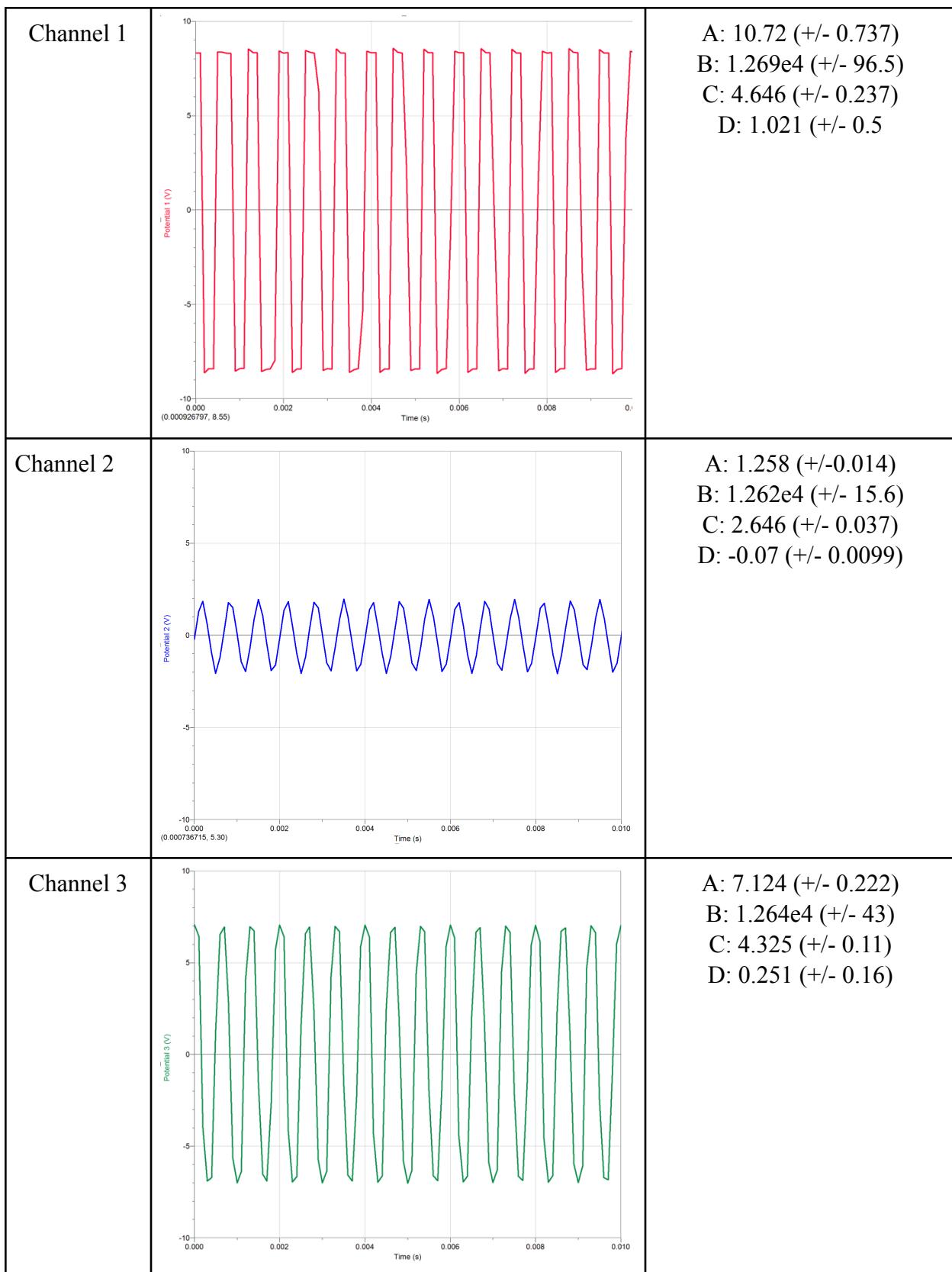


RLC circuit 1 1500 Hz:

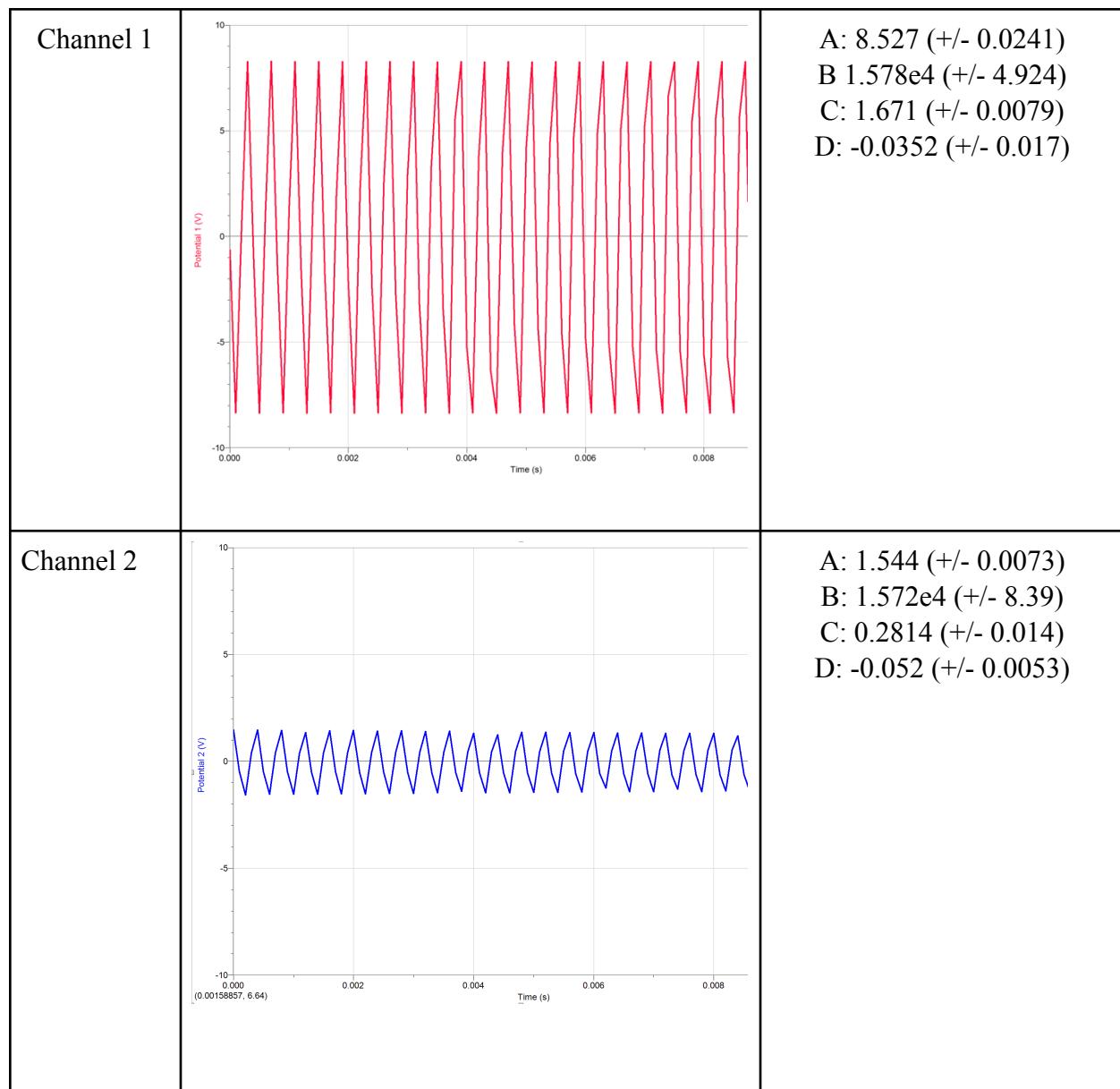


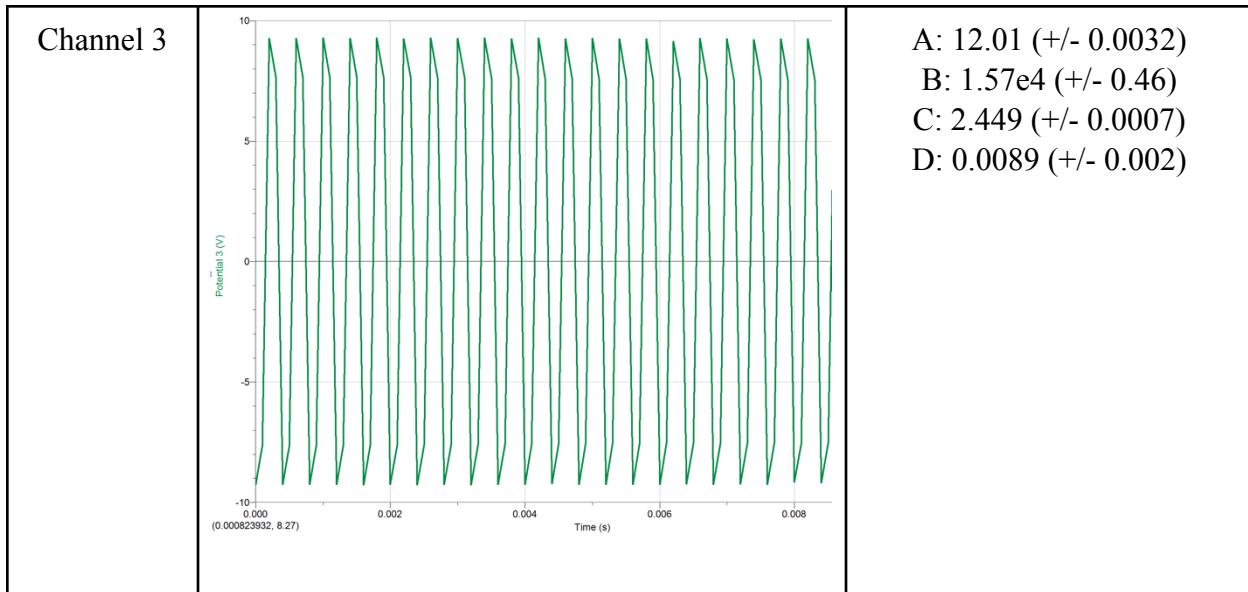


RLC circuit 1 2000 Hz:



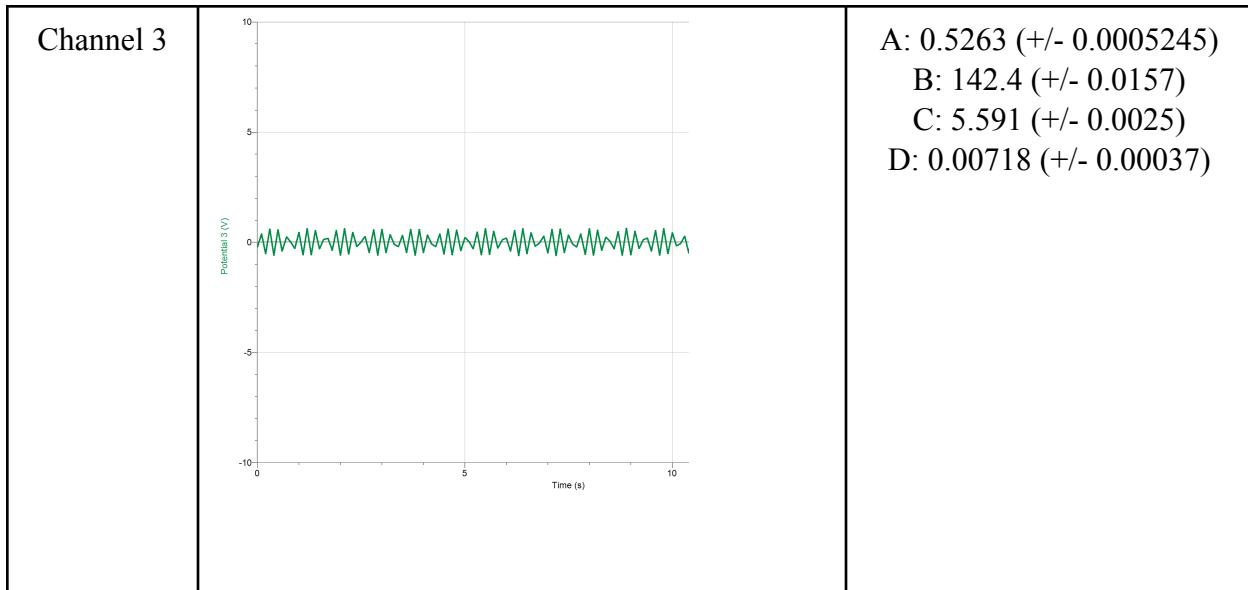
RLC circuit 1 2500 Hz:



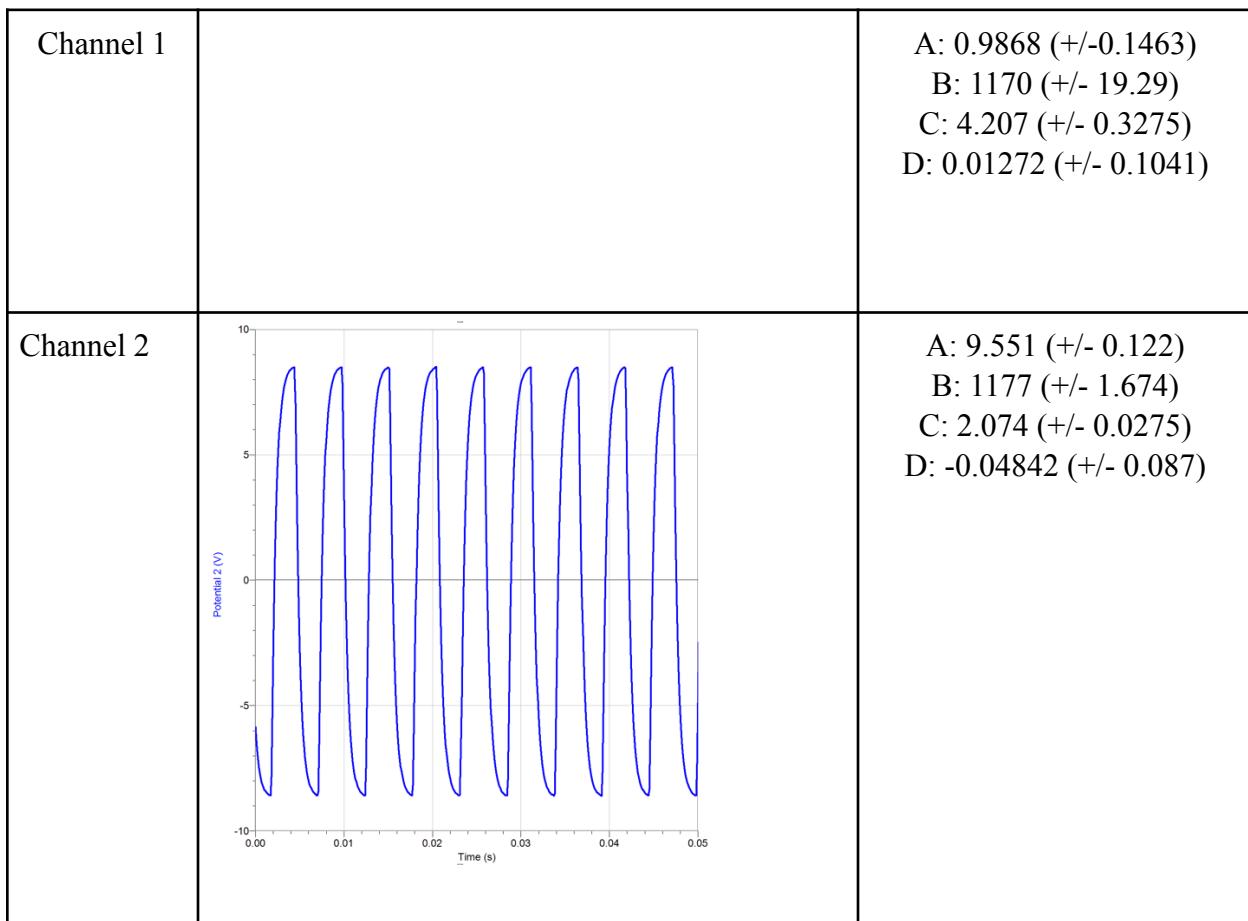


RLC circuit 2 25 Hz:

Channel 1		A: 0.098 (+/- 0.0003) B: 142.4 (+/- 0.041) C: 5.732 (+/- 0.0065) D: 0.01344 (+/- 0.00018)
Channel 2		A: 8.252 (+/- 0.0026) B: 142.4 (+/- 0.005) C: 4.1111 (+/- 0.0008) D: -0.1958 (+/- 0.0018)

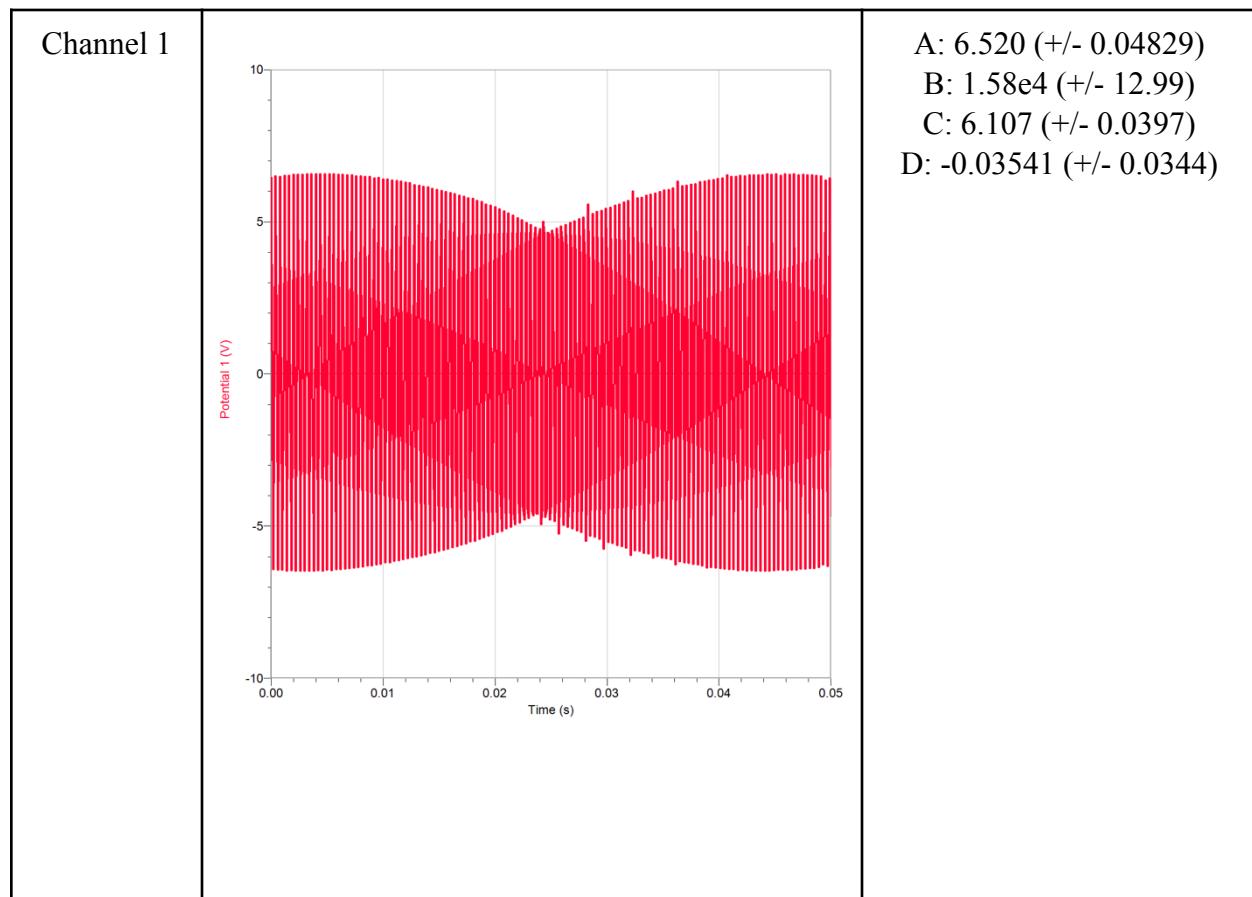


RLC circuit 2 338 Hz:

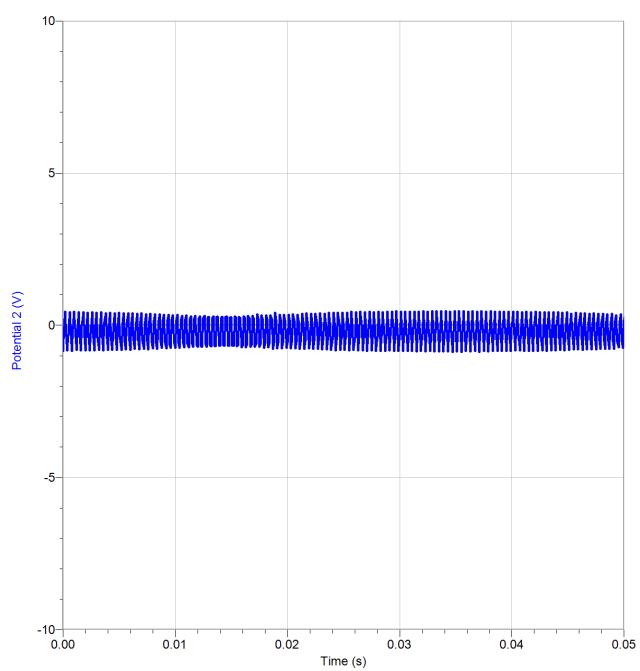


Channel 3		A: 4.965 (+/- 0.2235) B: 1172 (+/- 5.907) C: 3.704 (+/- 0.1014) D: 0.03352 (+/- 0.1591)
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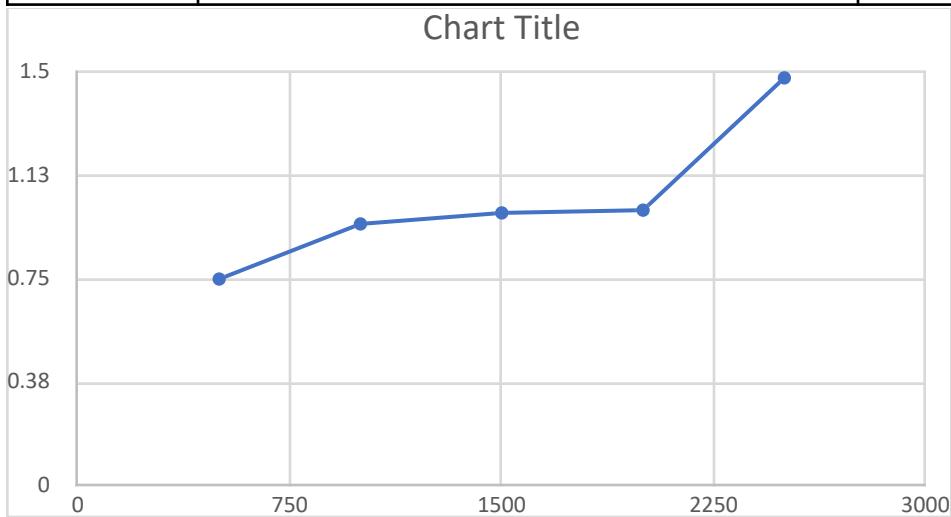
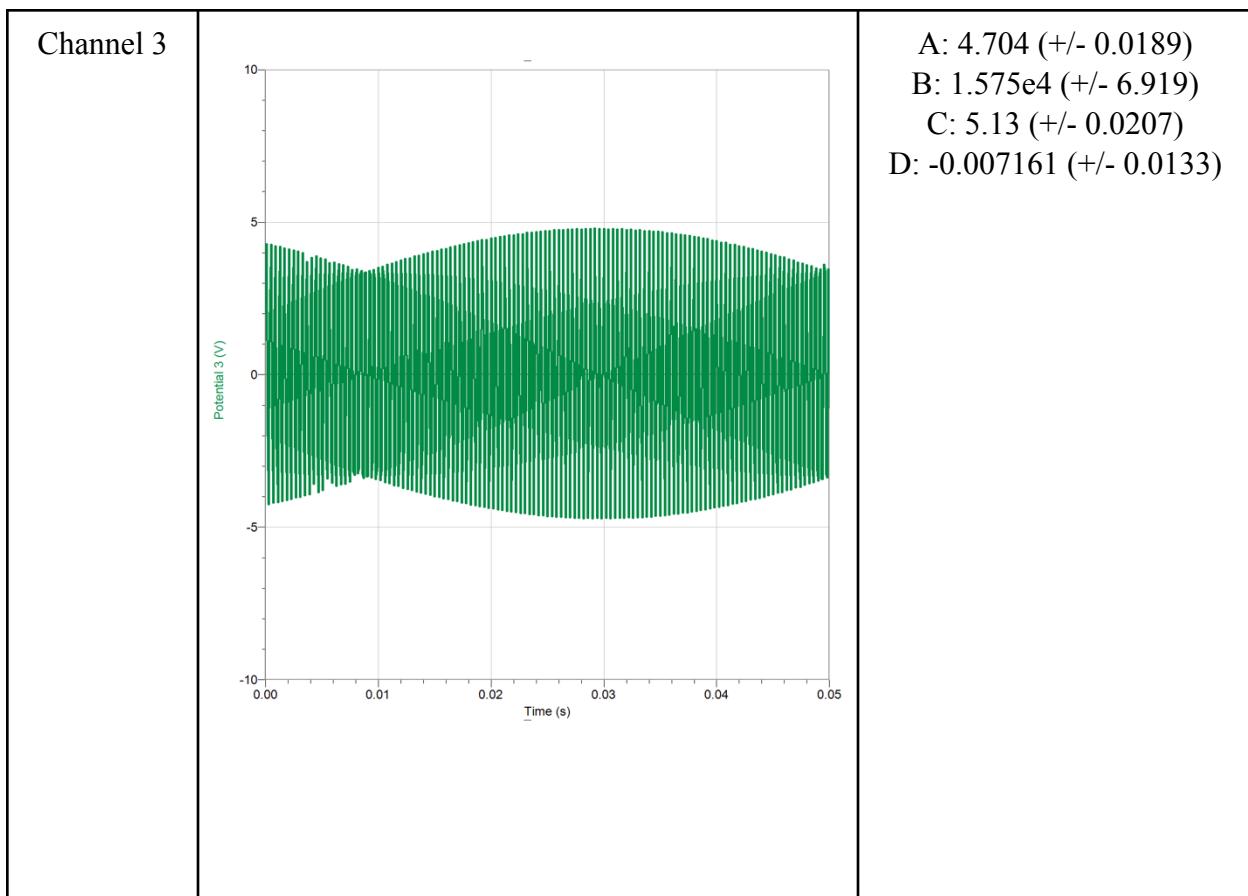
RLC circuit 2 2500 Hz:



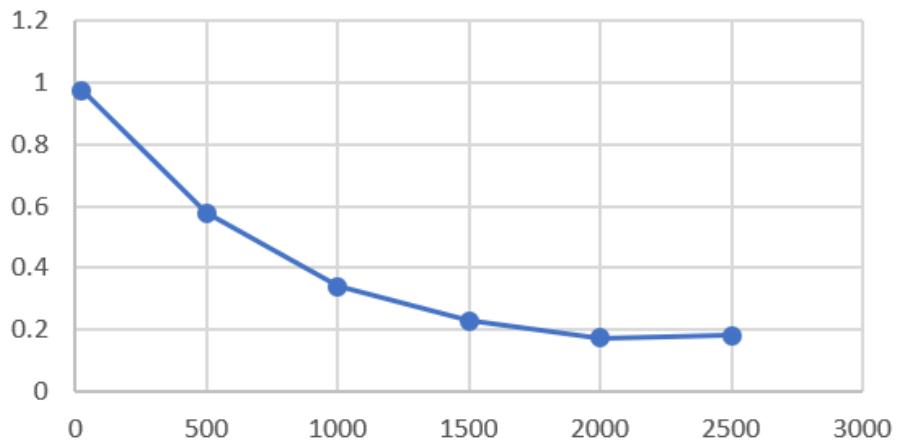
Channel 2



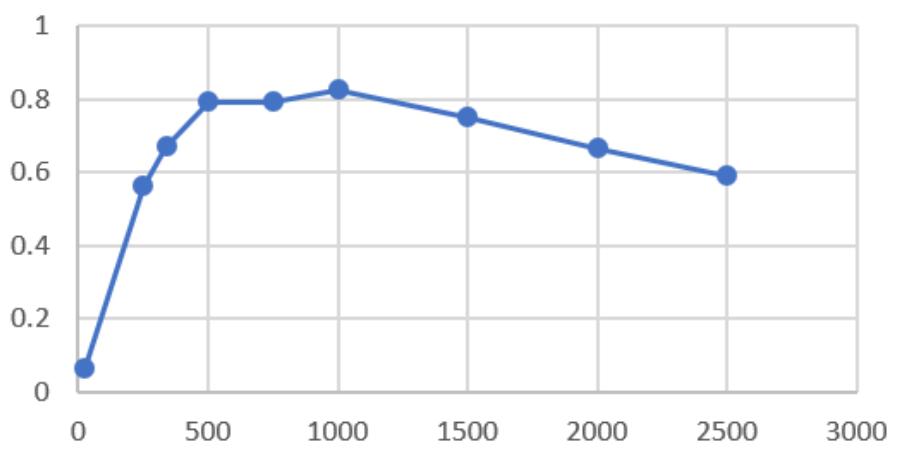
A: 0.6672 (+/- 0.005721)  
B: 1.58e4 (+/- 15.2)  
C: 3.33 (+/- 0.0462)  
D: -0.1973 (+/- 0.0041)

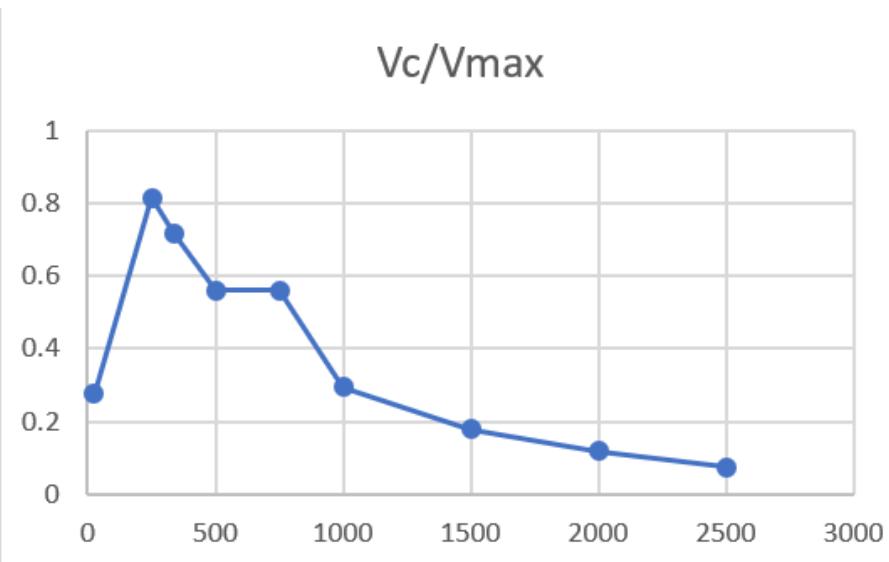


$V_c/V_{max}$



$V_r/V_{max}$





## Analysis

When analyzing the RCL circuit one graph and some graphs related to other experiments it is evident that the setting to create curved sinusoidal AC current was not set. This created error in data collection. Once this error is clear and is forgotten when trying to interpret the graphs, it is much clearer that these results were not technically incorrect with what was predicted. It was unexpected that the maximum voltage values did not add up to be equal to the total maximum voltage drop throughout all of these experiments.

When analyzing the  $V_c / V_{max}$  of the RC circuit over time it is clear that this ratio would decrease the higher the frequency exponentially which proves our hypothesis on this certain relationship. There is some substantial error once the frequency exceeds 2000Hz and is an abnormality which can be seen to happen throughout the rest of these experiments. In the  $V_r / V_{max}$  graph we can see the same dip in the curve once it seems to meet its peak at about .8 and then begins to linearly drop.

This same relationship is noticed when analyzing the  $V_c/V_{max}$  graph for the RLC circuit. Only that here the dip corresponds to a plateau between 500 and 750Hz at about .6V. It was interesting

to observe how the majority of the voltage drops in these experiments was a result of the inductor and not the resistors that is in series with the rest of these devices though mathematically according to the laws earlier described, this makes sense.

## **Conclusion**

Although this lab will not be graded, I still consider it successful as although the data collected was not correctly interpreted by our input devices, There was much beauty to what was collected and this lab was most helpful in understanding how different devices vary in voltage drops through time. Phase angles will always be created when creating circuits with such devices and their graphs will be aesthetically pleasing when the bigger picture is seen.

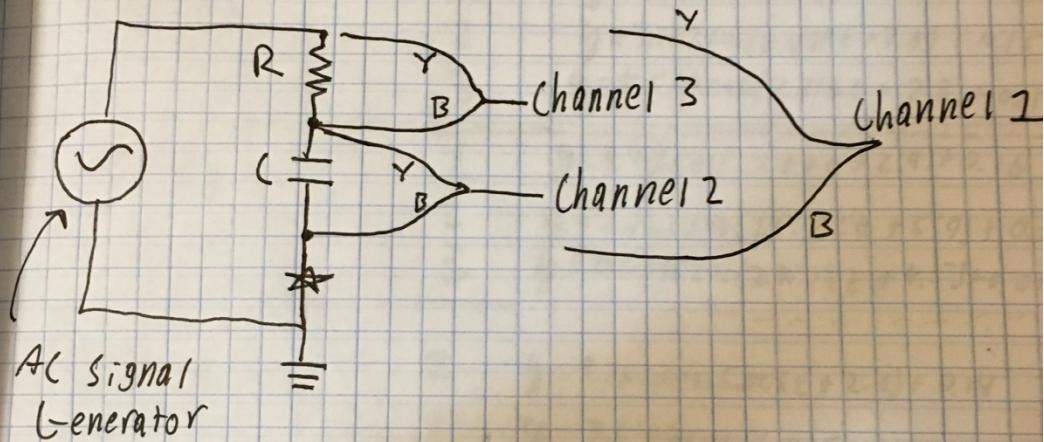
## Appendix

Exp. #: 10

Date: 11/7/19  
Course/Section: P222-3662

### AC Circuits Lab

#### - Experimental Set-Up:



↳  $\star$  = spot where inductor to be added following  
RL circuit analysis

## Data/Observations:

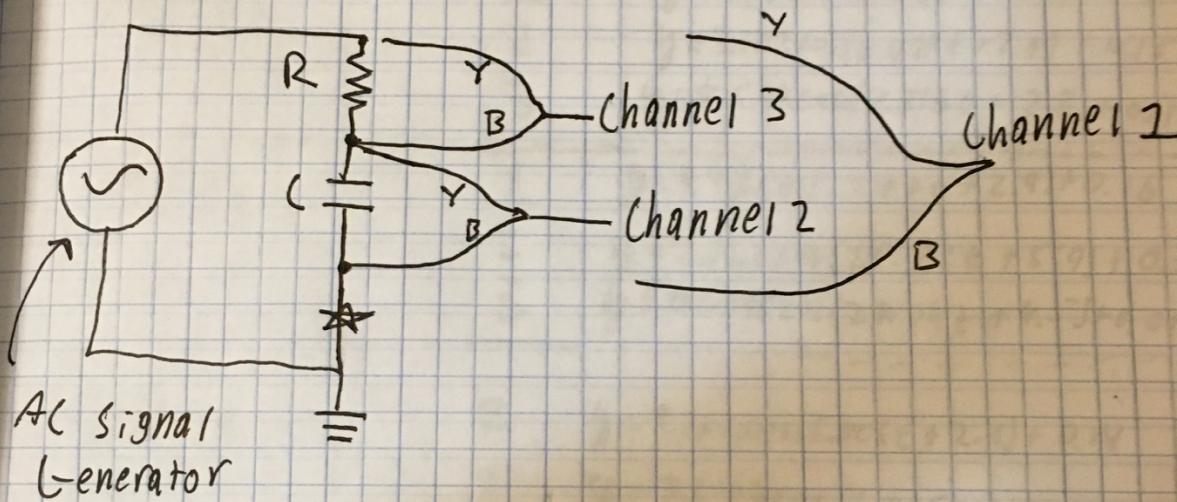
<u>Frequency</u>	<u>Channel</u>	<u>Curve Fit Eqn</u>
<del>RL</del> 25 Hz	1 2 3	$y = 9.484 \cos(30.96t + 0.38) + 0.1509$ $y = 9.435 \cos(30.97t + 0.44) + 0.14$ $y = 0.637 \cos(30.91t + 5.64) + 0.0074$
1000 Hz	1 2 3	$y = 9.116 \cos(8.833t + 2.7) + 0.18$ $y = 3.102 \cos(8.829t + 3.9) + 0.15$ $y = 8.539 \cos(8.816t + 2.3) + 0.012$
<del>RL</del> 25 Hz	1 2 3	$y = 9.495 \cos(27.77t + 2.9) + 0.16$ $y = 2.622 \cos(25.72t + 8.9) + 0.35$ $y = 0.6295 \cos(27.74t + 4.5) + 0.012$
250 Hz	1 2 3	$y = 9.262 \cos(6.006t + 2.4) + 0.14$ $y = 7.577 \cos(6.005t + 3.1) + 0.14$ $y = 5.211 \cos(6.005t + 1.6) + 0.0064$
338 Hz	1 2 3	$y = 9.211 \cos(16.05t + 2.4) + 0.14$ $y = 6.63 \cos(16.06t + 3.19) + 0.14$ $y = 6.174 \cos(16.05t + 1.6) + 0.0083$

Exp. #: 10

Date: 11/7/19  
Course/Section: P222-3662

## AC Circuits Lab

### - Experimental Set-Up:



↳  $\star$  = spot where inductor to be added following  
RL circuit analysis