ECE 11L : Experiment 4 Report

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IV. Lab

Lab 1. Phasor of Resistive Circuits

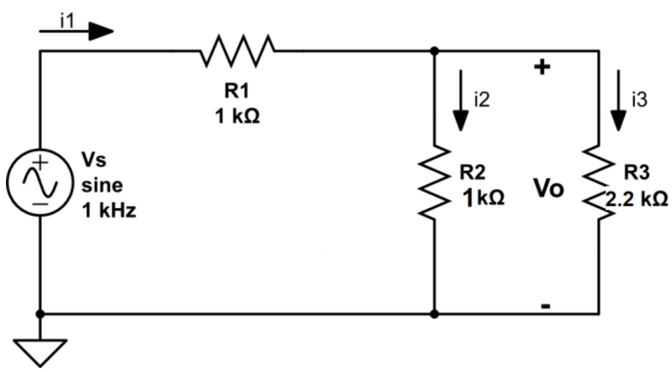
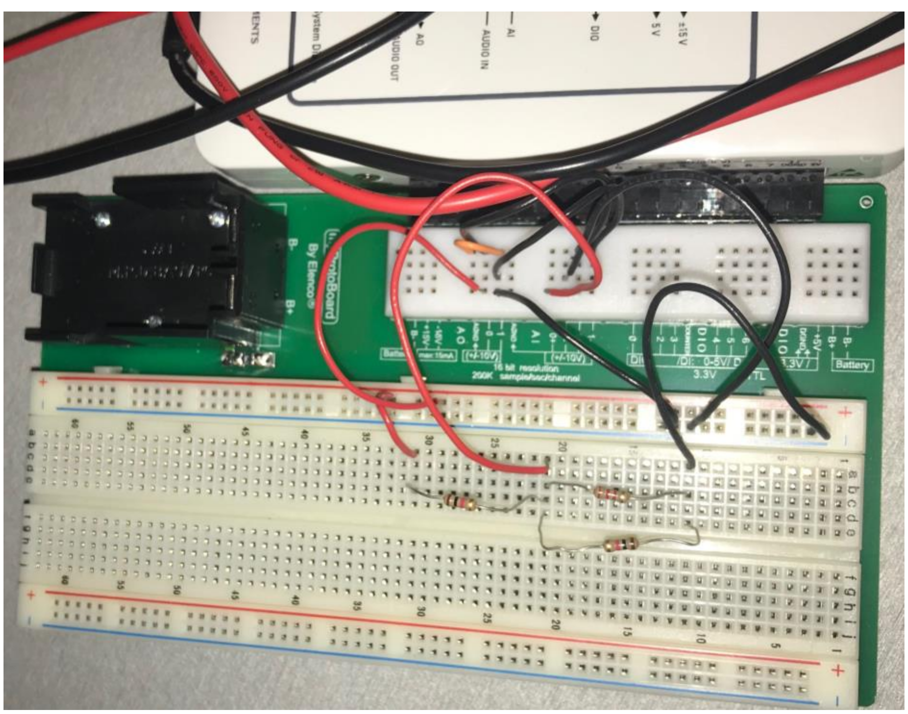


Fig.2.

(a) Build the circuit illustrated in Figure 2.



(b) If the input $V_S = sin(2\pi f t)$, where f is the frequency of the input. Derive V_o.

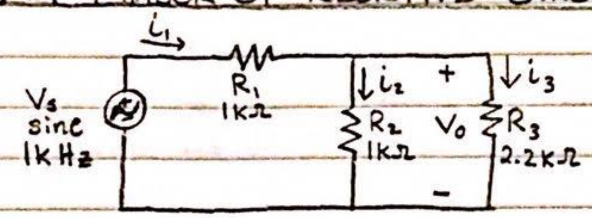
Response:

$V_o =$

Jonathan Gich

EE11L EXPERIMENT #4

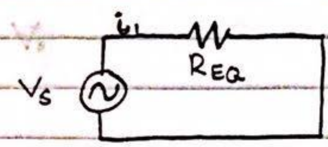
LAB #1 PHASOR OF RESISTIVE CIRCUITS



a) BUILD CIRCUIT

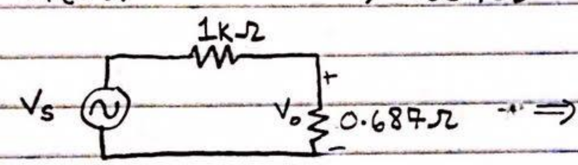
$\omega = 2\pi f$

b). If $V_s = \sin(2\pi f t)$, DERIVE V_o



$$\underbrace{\frac{1}{\frac{1}{1k} + \frac{1}{2.2k}}}_{687\Omega} + 1k = \boxed{1687\Omega}$$

$$i_1(ft) = \sin(2\pi f t) / 1687\Omega$$



USE VOLTAGE DIVIDER To SOLVE FOR V_o:

$$V_o = V_s\left[\frac{R_2}{R_1 + R_2}\right]$$

$$\boxed{V_o = \sin(2\pi f t)\left[\frac{687}{1687}\right]}$$

$$V_o = \sin(\omega t)\left[\frac{687}{1687}\right]$$

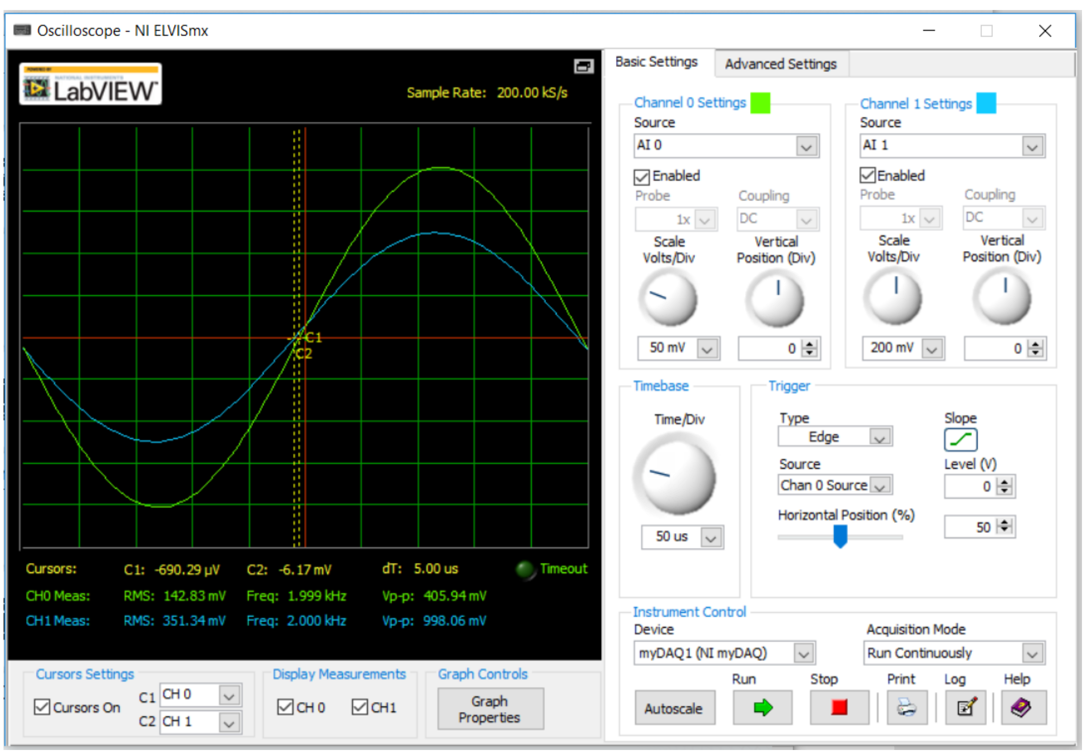
$$V_o = \sin(\omega t)[0.4074]$$

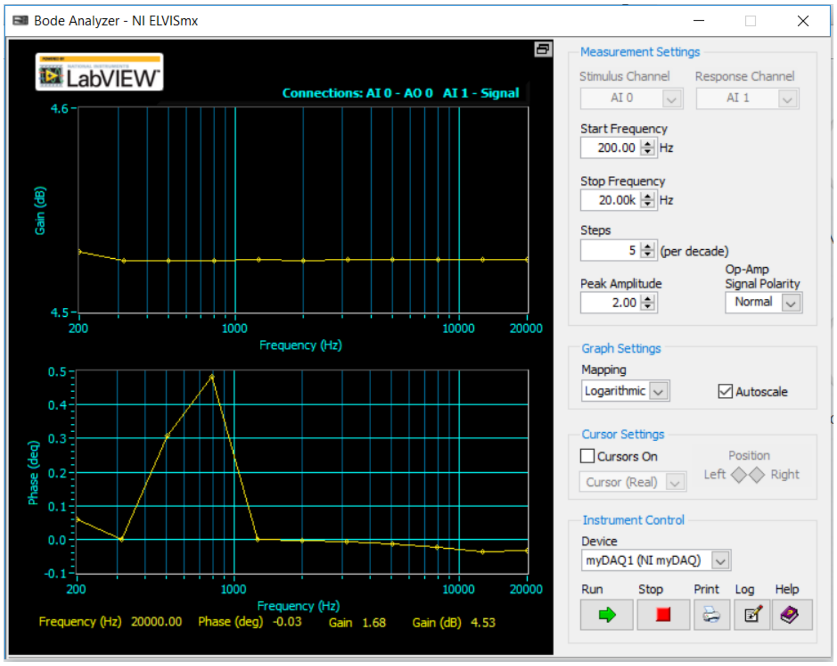
(c) Apply a sinusoidal wave to the input V_S with unity amplitude and frequency ranges from 200Hz to 20 kHz. Plot $\left|\frac{V_O}{V_S}\right|$ and $\angle\frac{V_O}{V_S}$ by selecting at least 10 - 15 frequencies within the range.

Note: In this part, please plot the frequency axis (x-axis) in log-scale. And for $|V_o/V_s|$ please use $20*\log|V_o/V_s|$, and the unit is dB now.

Response:
Please fill in measurement results below.

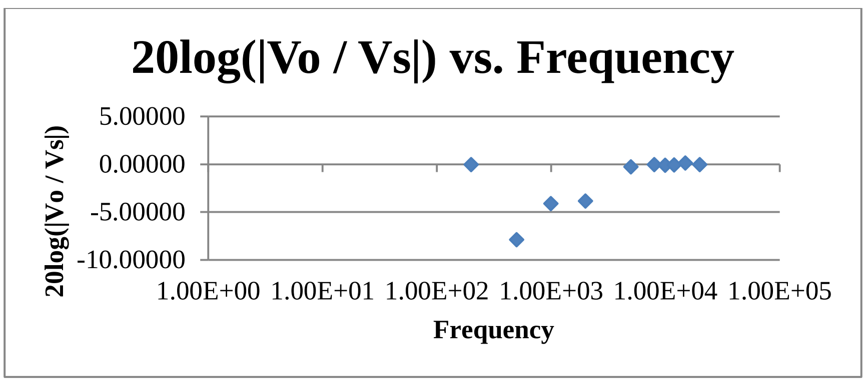
	A	B	C	D	E	F	G	H
1	f	Vo	Vs	dT (µs)	period (µs	|Vo / Vs|	20log(|Vo / Vs|	Phase Change (°)
2	2.00E+02	407.80	999.36	5	5.00E+03	0.40806	-7.78549	0.4
3	5.00E+02	406.55	999.20	4	1.99E+03	0.40688	-7.81077	0.7
4	1.00E+03	405.87	999.23	3	1.01E+03	0.40618	-7.82557	1.1
5	2.00E+03	405.87	999.02	5	505	0.40627	-7.82374	3.6
6	5.00E+03	405.73	999.36	4	200	0.40599	-7.82970	7.2
7	8.00E+03	404.70	996.28	3	125	0.40621	-7.82496	8.6
8	1.00E+04	403.33	996.49	3	100	0.40475	-7.85625	10.8
9	1.20E+04	402.98	994.32	3	85	0.40528	-7.84485	12.7
10	1.50E+04	401.83	985.87	4	65	0.40759	-7.79555	22.2
11	2.00E+04	385.11	949.90	4	50	0.40542	-7.84186	28.8



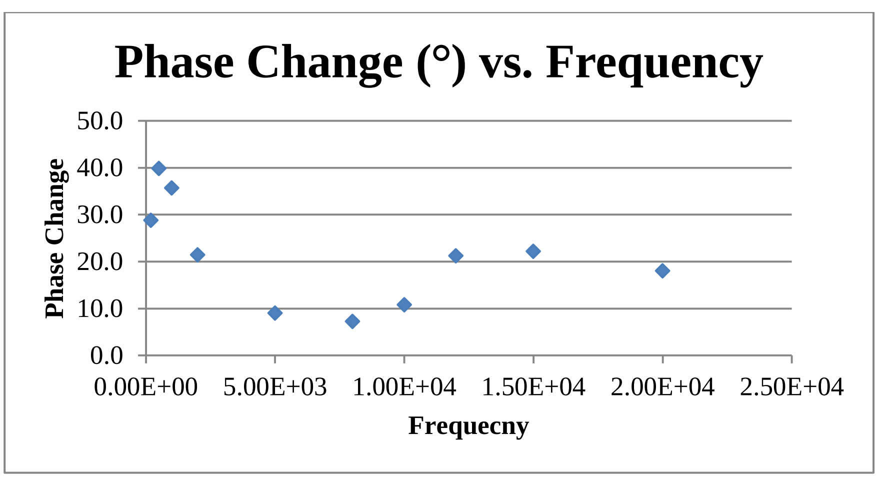


Please provide two plots here.

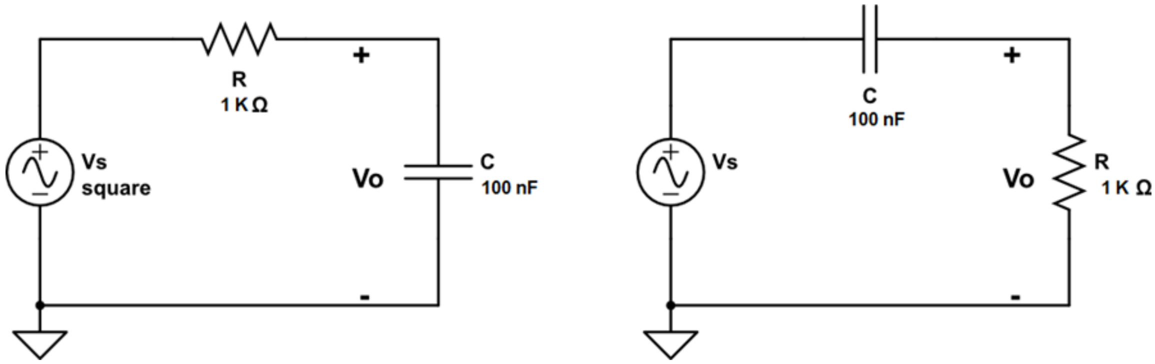
The first plot is magnitude response: $|V_o/V_s|$ v.s. frequency.



The second plot is phase response: $\angle \frac{V_O}{V_S}$ v.s. frequency.



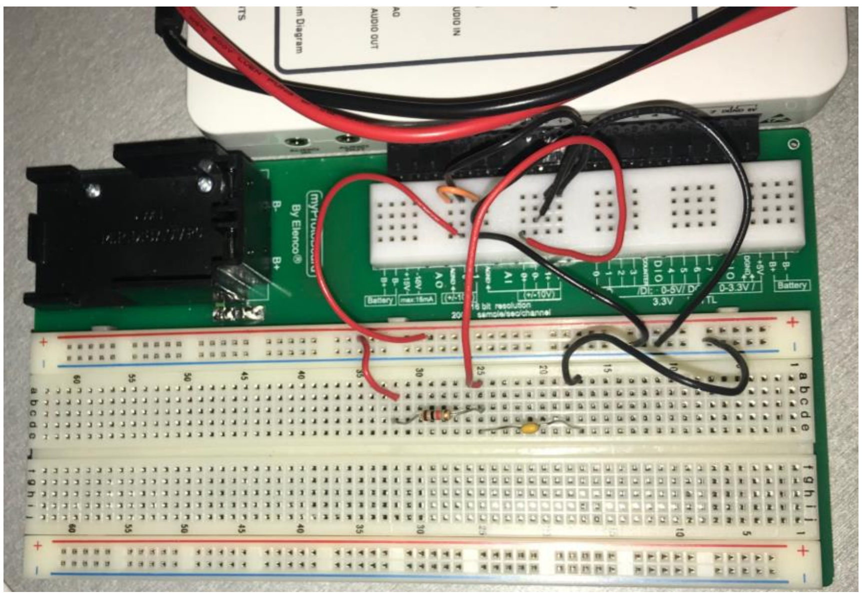
Lab 2. Time Domain and Frequency Domain Analysis of First Order Circuits
Lab 2.1 RC circuits



(a) (b)

Fig.3

(a) Build the RC circuits illustrated in Figure 3

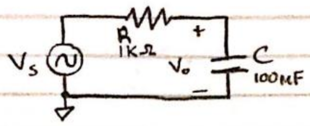


(b) Select the frequency of the square wave V_S such that $T_S > 10\,\tau$ and set the amplitude as $1V_{p\text{-}p}$ with a 0.5 V DC-offset.

Note: T_S is the period of the square wave input. τ is the time constant of *RC* circuits.

Experimentally obtained time constant was 100μs
Theoretically obtained time constant was 100μs (τ =RC=1000Ω*0.0000001F=0.0001)

LAB #2 TIME DOMAIN & FREQUENCY DOMAIN - FIRST ORDER



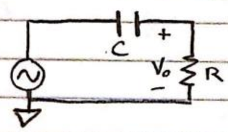
$\tau = RC$

$V_s(t) = V_R(t) + V_C(t)$

$V_C(t) = V_s(t)(1 - e^{-t/RC})$

ASSUMING: $V_s(t) = 1$ then the equation $V_C(t)$...

$V_C(t) = V_s(t)(1 - e^{-(1\times10)^6 t})$



$V_R(t) = V_s(t) - V_C(t)$

$V_R(t) = V_s(t)(e^{-t/RC})$

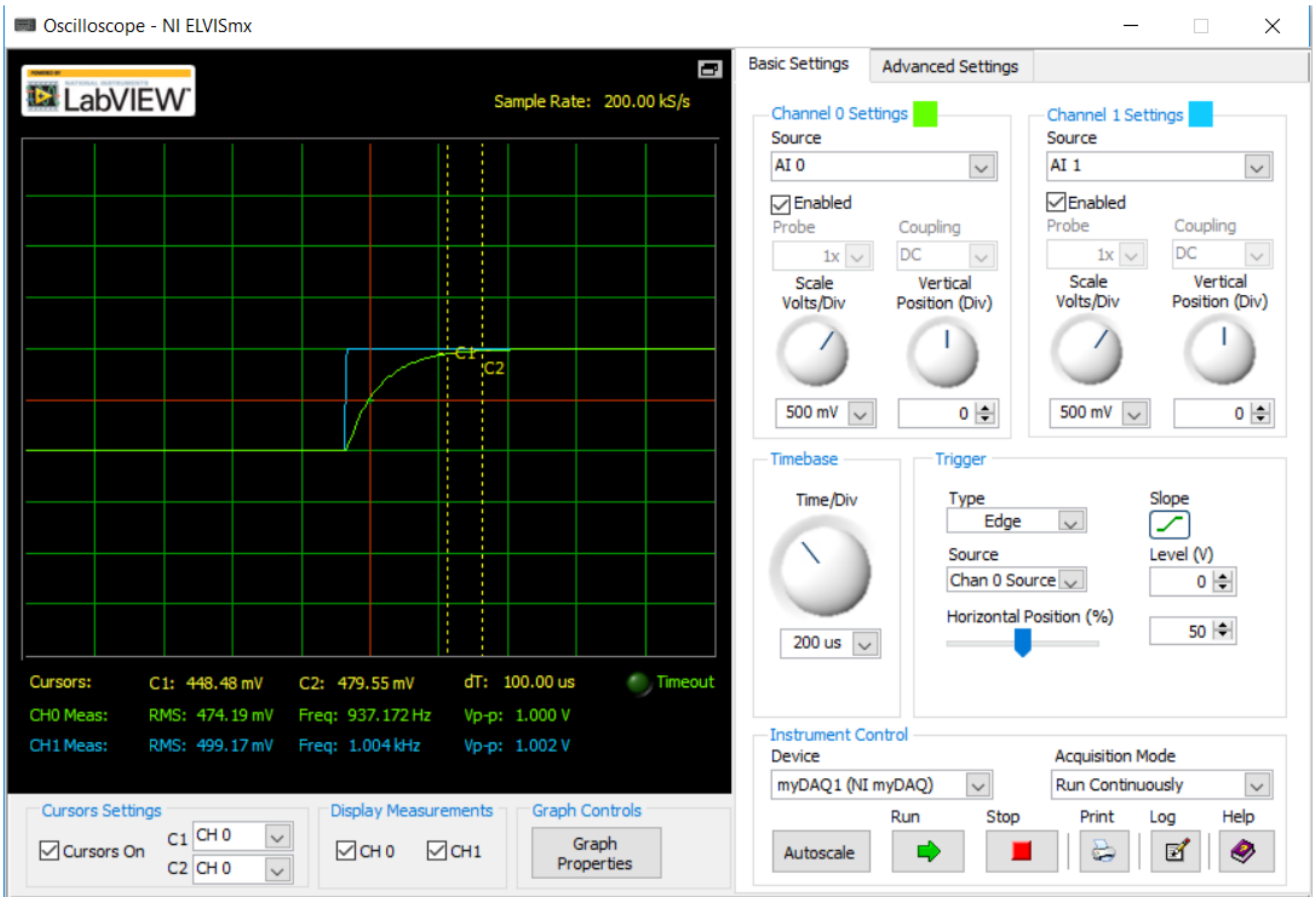
MEASURED $\tau = 100\ \mu s$ (DIFF EQ)

(c) In Figure 3(a), using the oscilloscope, plot at least one cycle of input voltage (V_S) and output voltage (V_o), and then experimentally measure τ. Compare it with the theoretical value.

Experimentally obtained time constant was 125μs
Theoretically obtained time constant was 100,000μs (τ =RC=1000Ω*0.0001F=0.1)
The experimental and the theoretical values that were obtained for the time constant were the same.

Response (2.1c)

(Please attached one screenshot of oscilloscope and your calculation process here)



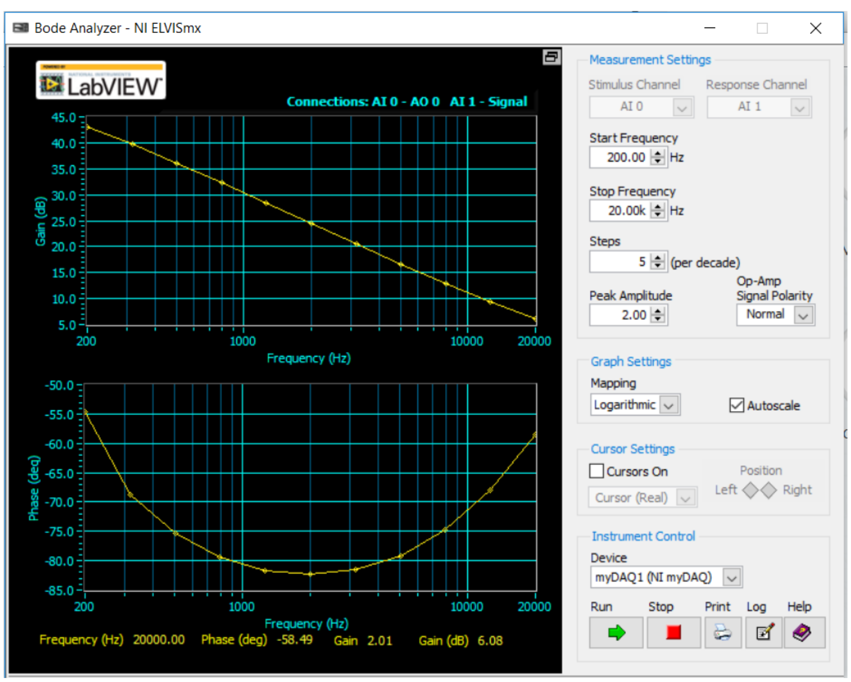
(d) In Figure 3(b), apply a sinusoidal wave to the input V_S with unity amplitude and frequency ranges from 200Hz to 20 kHz. Plot $\left|\frac{V_O}{V_S}\right|$ and $\angle\frac{V_O}{V_S}$ by selecting at least 10 - 15 frequencies within the range.

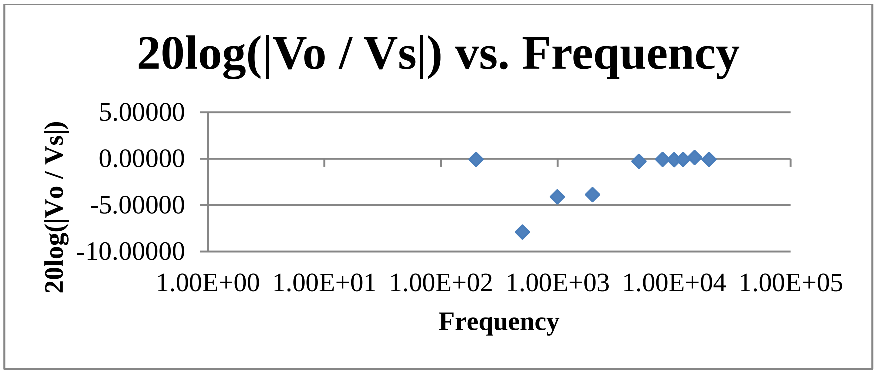
Note: In this part, please plot the frequency axis (x-axis) in log-scale. And for $|V_o/V_s|$ please use $20*\log|V_o/V_s|$, and the unit is dB now.

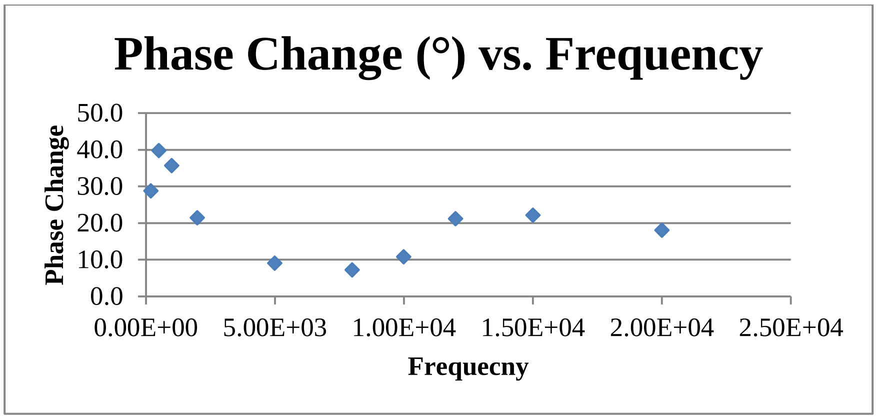
Response (2.1d)

Please fill in measurement results below.

	A	B	C	D	E	F	G	H
1	f	Vo	Vs	dT (µs)	period (µs	|Vo / Vs|	20log(|Vo / Vs|	Phase Change (°)
2	2.00E+02	992.95	1001.00	100	5.00E+03	0.99196	-0.07013	7.2
3	5.00E+02	954.96	1000.00	95	1.99E+03	0.95496	-0.40030	17.2
4	1.00E+03	853.58	1000.00	85	1.01E+03	0.85358	-1.37512	30.3
5	2.00E+03	639.37	999.44	75	505	0.63973	-3.88009	53.5
6	5.00E+03	321.81	998.46	40	200	0.32231	-9.83462	72.0
7	8.00E+03	209.31	996.17	30	125	0.21011	-13.55087	86.4
8	1.00E+04	171.37	993.56	25	100	0.17248	-15.26519	90.0
9	1.20E+04	142.59	997.15	25	85	0.14300	-16.89343	105.9
10	1.50E+04	114.46	988.32	20	65	0.11581	-18.72488	110.8
11	2.00E+04	82.74	951.37	15	50	0.08697	-21.21268	108.0

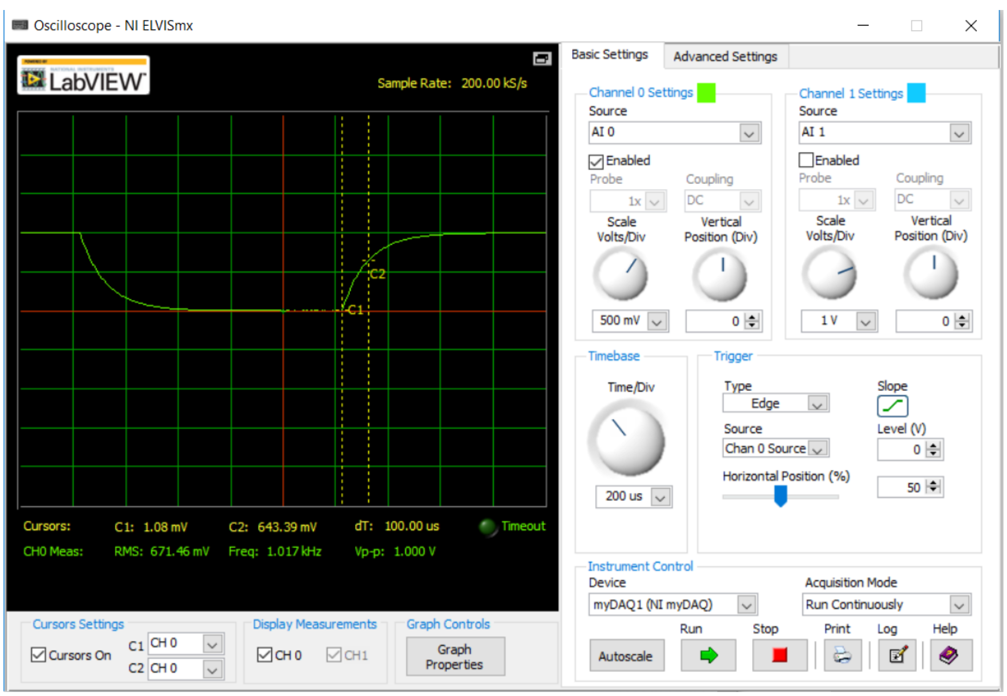






Lab 2.1 setup and experiment results:

(Please attached necessary screenshots of oscilloscope)



Lab 2.2 RL circuits

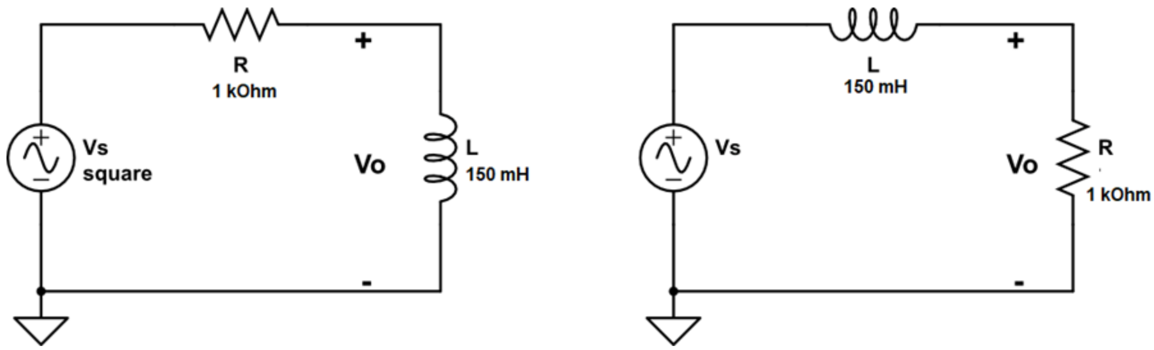
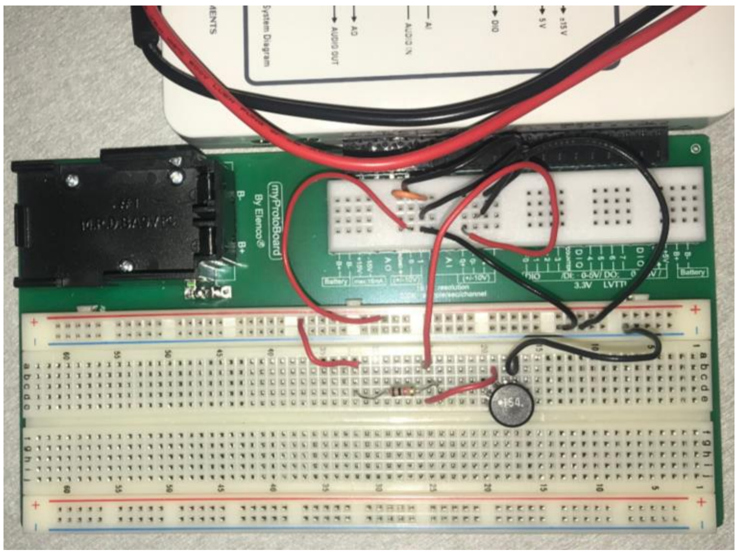


Fig.4

(a) Build the RL circuit illustrated in Figure 4



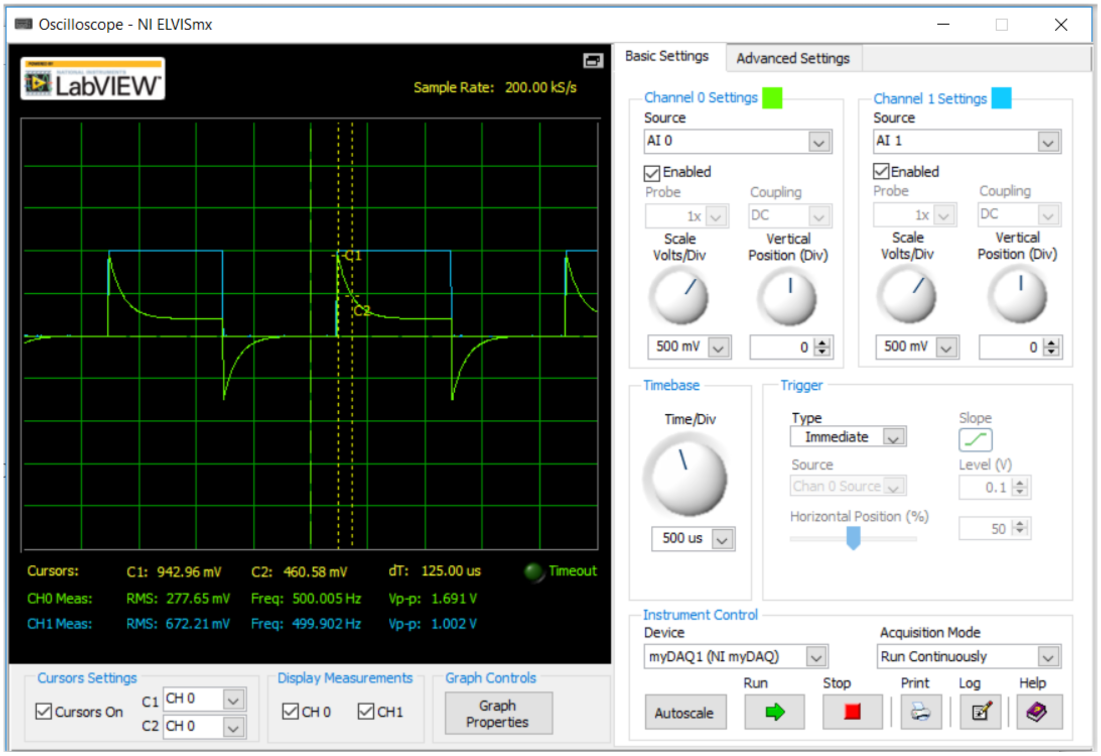
(b) Select the frequency of the square wave V_S such that the period of the square wave $T_s > 10\,\tau$ and set the amplitude as 1 $V_{p\text{-}p}$ with a 0.5 V DC-offset.

(c) Using the oscilloscope, plot at least one cycle of input and output voltage of the resistor and the capacitor, and then experimentally measure τ. Compare it with the theoretical value.

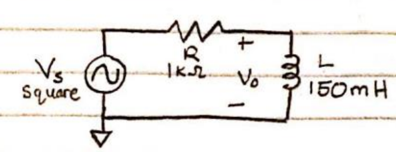
Experimentally obtained time constant was 125µs
Theoretically obtained time constant was 150µs ($\tau = L/R = 0.15H/1000\Omega = 0.00015$)
The experimental and the theoretical values that were obtained for the time constant were not the same, but very close. As seen, there was about an 18% difference between the two obtained values.

Response (2.2c)

(Please attached one screenshot of oscilloscope and your calculation process here)



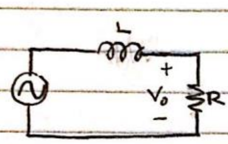
LAB #2 CONTINUED



$\tau = L/R$

$V_s(t) = V_R(t) + V_c(t)$

$V_L(t) = e^{-t(R/L)}$

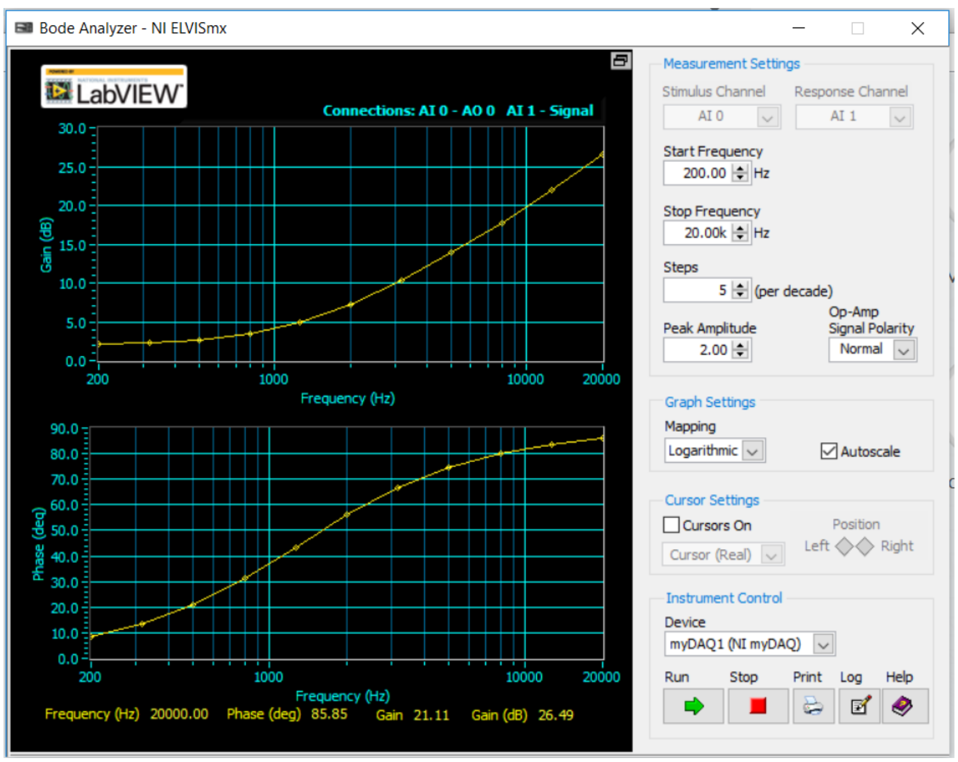


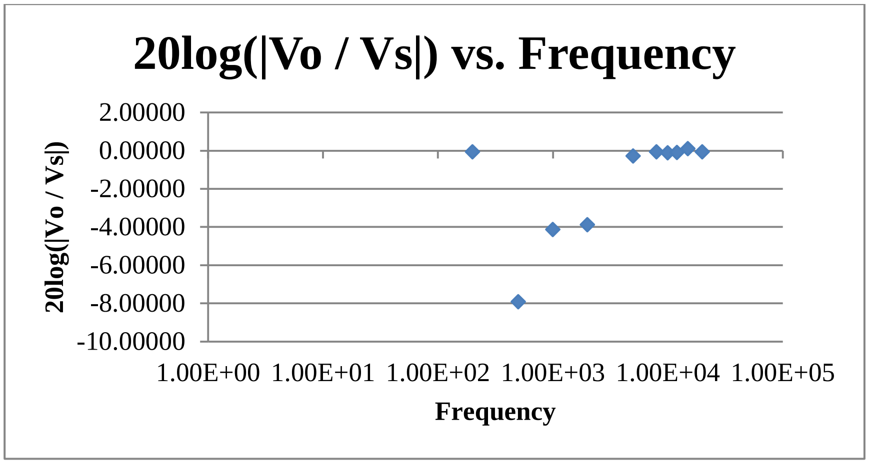
$V_R(t) = V_s(t)\left(1 - e^{-t(R/L)}\right)$

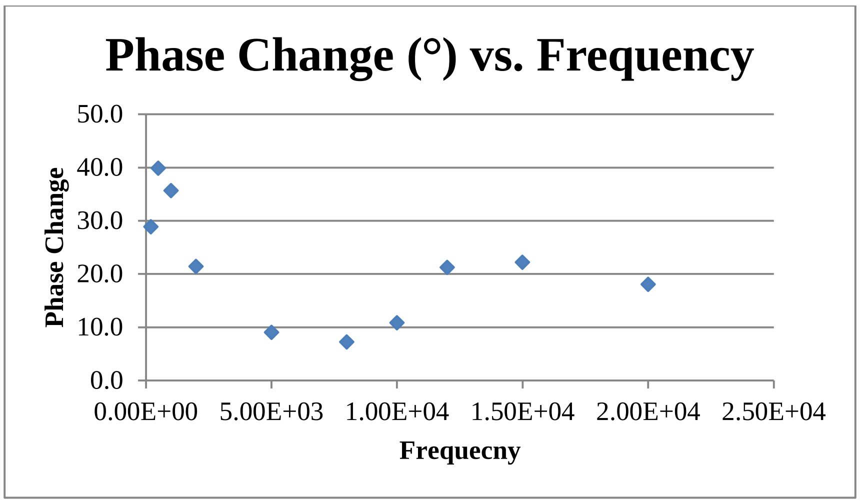
(d) Apply a sinusoidal wave to the input V_S with unity amplitude and frequency ranges from 200Hz to 20 kHz. Plot $\left|\frac{V_O}{V_S}\right|$ and $\angle\frac{V_O}{V_S}$ by selecting at least 10-15 frequencies within the range.

Note: In this part, please plot the frequency axis (x-axis) in log-scale. And for $|V_o/V_s|$ please use 20*log | V_o/V_s |, and the unit is dB now.

	A	B	C	D	E	F	G	H	I
1	f	Vo	Vs	dT (µs)	period (µs	|Vo / Vs|	20log(|Vo / Vs	Phase Change (°)	
2	2.00E+02	992.95	1001.00	400	5.00E+03	0.99196	-0.07013	28.8	
3	5.00E+02	401.94	1000.00	220	1.99E+03	0.40194	-7.91678	39.8	
4	1.00E+03	622.29	1001.00	100	1.01E+03	0.62167	-4.12883	35.6	
5	2.00E+03	639.37	999.44	30	505	0.63973	-3.88009	21.4	
6	5.00E+03	967.72	1000.00	5	200	0.96772	-0.28501	9.0	
7	8.00E+03	982.44	990.61	2.5	125	0.99175	-0.07193	7.2	
8	1.00E+04	985.71	998.45	3	100	0.98724	-0.11154	10.8	
9	1.20E+04	987.34	997.81	5	85	0.98951	-0.09162	21.2	
10	1.50E+04	979.49	967.39	4	65	1.01251	0.10797	22.2	
11	2.00E+04	939.92	947.44	2.5	50	0.99206	-0.06922	18.0	




20log(|Vo / Vs|) vs. Frequency
2.00000
0.00000
-2.00000
-4.00000
-6.00000
-8.00000
-10.00000
20log(|Vo / Vs|)
1.00E+00 1.00E+01 1.00E+02 1.00E+03 1.00E+04 1.00E+05
Frequency


Phase Change (°) vs. Frequency
50.0
40.0
30.0
20.0
10.0
0.0
Phase Change
0.00E+00 5.00E+03 1.00E+04 1.50E+04 2.00E+04 2.50E+04
Frequecny

Response (2.2d)

Discussion: (*This part needs detailed report*)

In cases of resistive circuits (Lab 1), *RC* (Lab 2.1.d), *RL* (Lab 2.2.d) circuits, what effect do you observe? For example, what is the gain, phase response looks like. What are other circuit behaviors we can observe?

Note: here, we define gain = $\left|\frac{V_O}{V_S}\right|$, and phase = $\angle\frac{V_O}{V_S}$

Response:

When comparing the three different circuits it is evident that there is a significant difference between each experimental setup.

The Resistive Circuit:

a) The gain is fairly constant with a zero slope. Gain is always positive within given frequencies.
b) The Phase shows a slight spike in the lower ranges of frequency (300-1100 Hz) and flattens out after the small spike. Phase wavers around a phase of zero at higher frequencies.

The RC Circuit:

c) The gain shows a negative slope with constant slope. Lower frequency has a correlation with higher values of gain. Gain is always positive within given frequencies.
d) The Phase shows a U-like curve pattern centered at about 2000 Hz. The Minimum point of the bowl shape is at about -83 degrees. Phase is always negative within given frequencies.

The RL Circuit:

e) The gain shows a positive trend, having lower gain at lower frequencies, and higher gain at higher frequencies. The slope is however slightly arched, which indicates that it is not a constant slope, possibly exponential if a regression was calculated. Gain is always positive within given frequencies.
f) The Phase shows an S-like pattern centered at about 2000 Hz. Phase is always positive within given frequencies.

Some sources of error were propagated from the precision of the instrumentation that was used to collect our data. The myDAQ's most precise measurements were measured at 5μs. Most of the samples of data that were recorded required more precise measurements than were allowed on the device. As a result, some data was estimated with precision beyond that of 5μs.