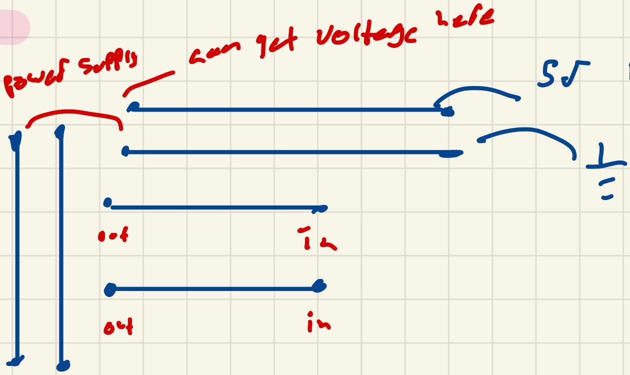
LAB 1

In this lab we mainly got accustomed to the lab equipment and built some simple circuits

1.



2. a) Fig 1 => we measured 5 volts (5.07) across the resistor with ground connection and ϕ volts without!

— No reference point to measure the voltage w/

b) Fig 3 => .46 milliamps in the closed circuit

c) Voltage : 5.06

$$\frac{V_1}{V_2} = \frac{5.07}{5.06}$$

$$\frac{V}{I} = \frac{5.07}{46 \times 10^{-3}} = 11021.74 \text{ ohms}$$

3) figure 5 =>

$$V_{rx} = \frac{R_1}{R_1 + R_2} \times V_{in}$$

$$2.5V = \frac{10k\,\text{ohms}}{20\,k\text{ohms}} \times 5 \text{ volts}$$

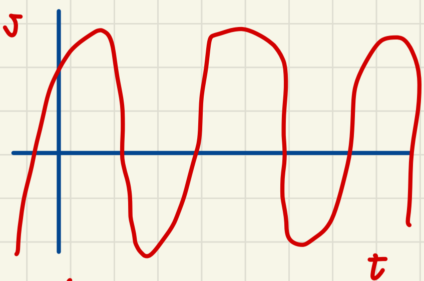
we got $\underline{2.48 V}$ → very similar measurements

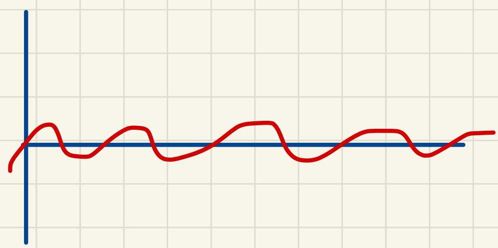
4. $V_{rx} = \frac{R_1}{R_1 + R_2} \times V_{in}$

If $R_1 >> R_2$ then taking the limit of the equation should give $V_{out} = 1$

If $R_2 >> R_1$ the taking the limit V_{out} will approach $\emptyset$.

5)





with out terminato

Peak to Peak = 1.96 V

f = 1.244 KHz

with terminator

Peak to Peak = 220 mV

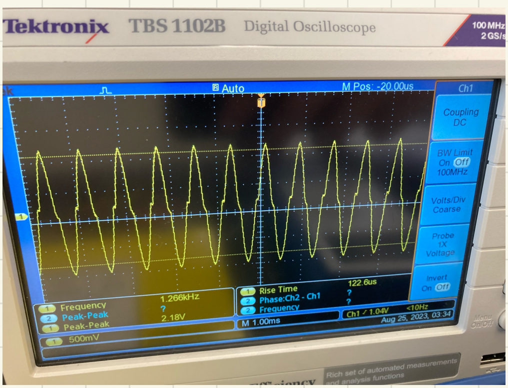
f = 2.252 kHz

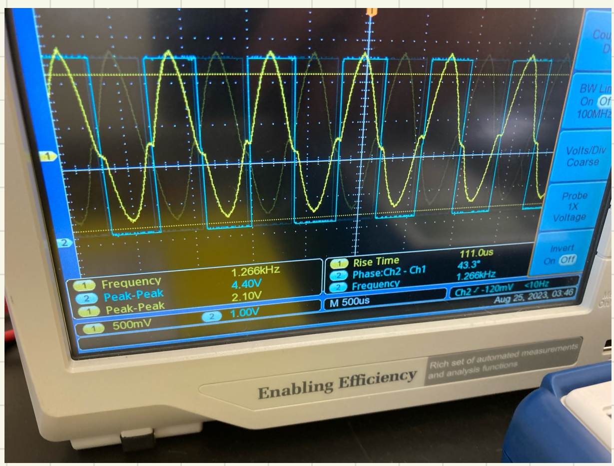
- much lower Peak to peak voltage with the terminator due to its acting like a resistor in the circuit

- the oscilliscope seems more like a voltmeter due to it outputting sinwaves of waveforms with respect to voltage as the independent variable

6) When trigger Level is outside the range of the displayed signal the graph moves and shows oscillation.

- trigger level inside of the peak to peak voltage range of the sin wave stops oscillations and almost freezes the function in place. Allowing for a much clearer image of the wave if the oscillation is happening fast.





7. for in DC the DC offset knob shift the entire function vertically

for AC the knob changes the amplitude.

8)

$$v_{out} = v \frac{R_L}{R_0 + R_L} \qquad \frac{1}{v_0} \propto \frac{1}{R_L}$$

$$\frac{1}{v_0} = \frac{1}{v} \frac{R_0 + R_L}{R_L}$$

$$\frac{1}{v_0} = \frac{R_0}{v R_L} + \frac{1}{v}$$

9)

	10 HZ	1 kHZ	100 KHZ
Sin(wave)	1.04 v	.985 v	0.02 v
Square	1.08	1.511	.005
Triangle	.794	.767	.254

10) Rise time 34.49 ns

LAB 2

In this LAB, we focused on RC circuits. We made High and Low pass filters and took measurements and did derivations accordingly

Lab 2

1) (a) circuit A

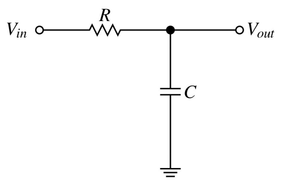


Figure 2.1: Circuit A.

Rise time = 400ns

Fall time = 424ns

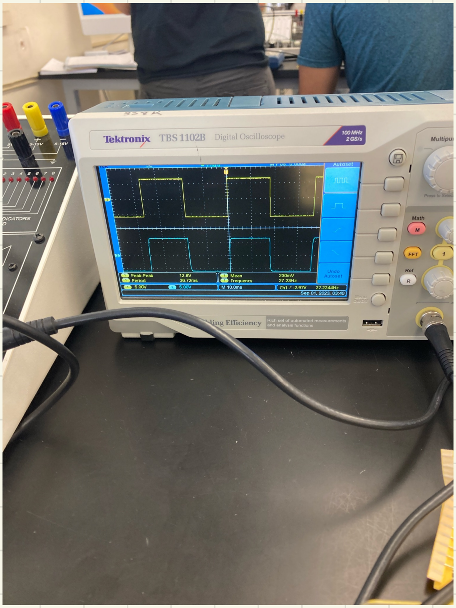
RC = 24ns

computed

measured. $\tau = RC = 10^{-4}$ seconds

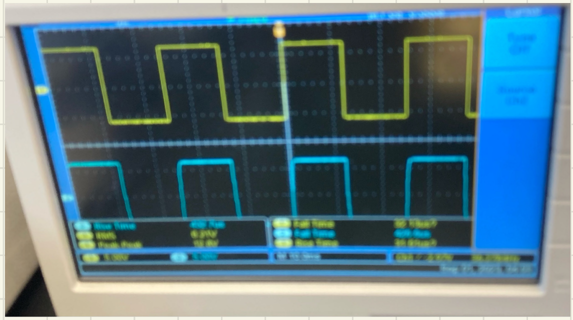
$.000024 \neq 0.0001$ seconds

a whole decimal place off but still sligutly similar

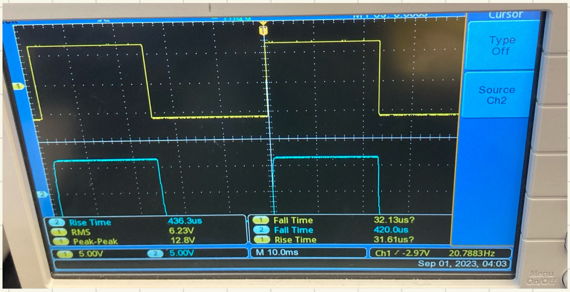


1b)

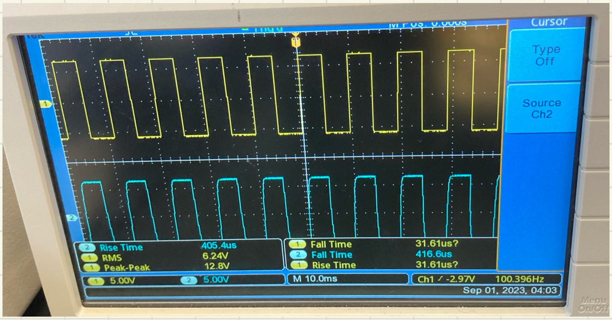
2)



1)



3)



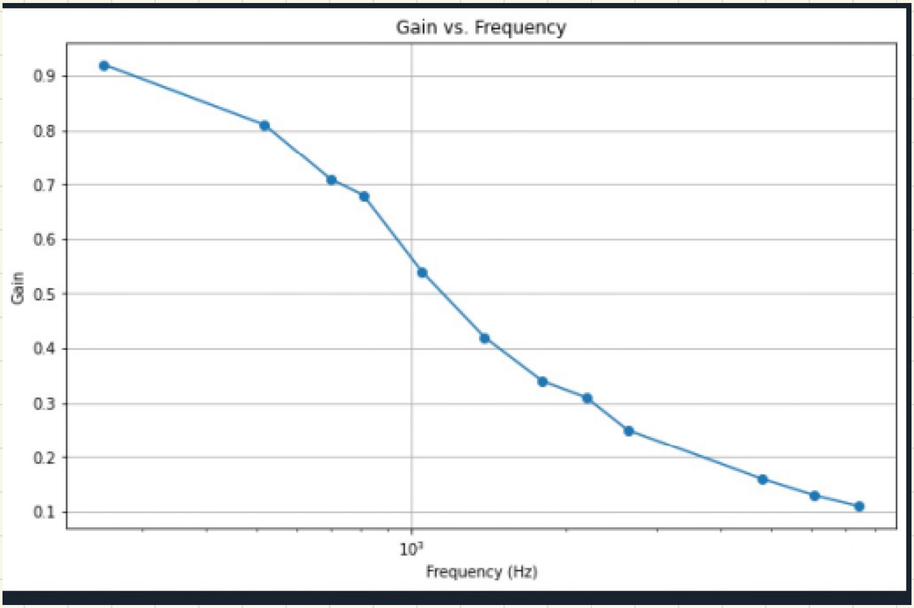
The output changes from square to it's integral because the blue line is becoming more and more a triangle wave. if you plot the derivative of a triangle wave it will give a square wave

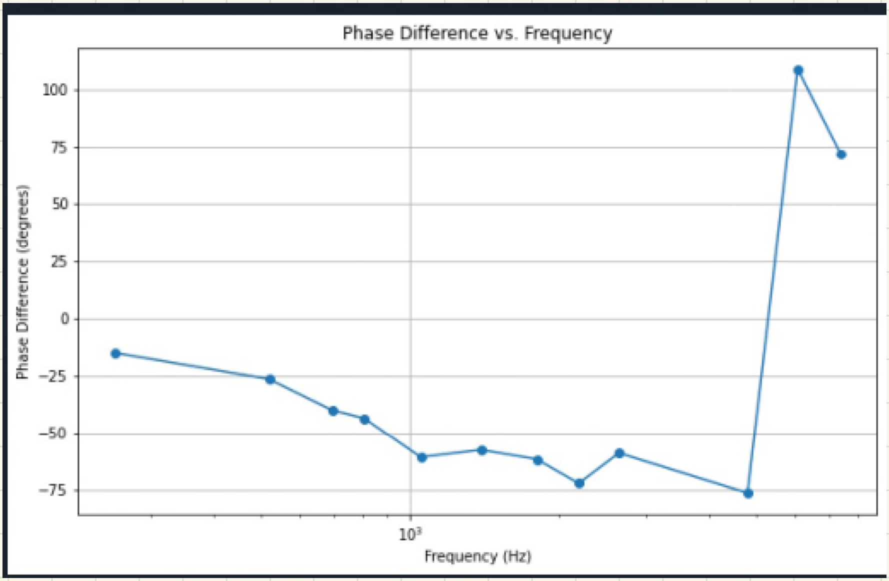
4)

(c)

	V_{out}/V_{in}	f	ϕ
0.68	$\frac{8.4}{12.4}$	807 HZ	-43.6°
0.81	$\frac{10}{12.4}$	519 HZ	-26.5°
0.92	$\frac{11.6}{12.4}$	253 HZ	-35.7°
0.71	$\frac{8.8}{12.4}$	696 HZ	-40.1°
0.54	6.8/12.4	1.05 KHZ	-60.8°
0.42	5.2/12.4	1.39 KHZ	-57.6°
0.34	4.7/12.4	1.8 KHZ	-61.7°
0.31	3.8/12.4	2.19 KHZ	-72.3°
0.25	3.2/12.4	2.64 KHZ	-59°
0.16	2/12.4	4.8 KHZ	-76.5°
0.13	1.6/12.4	6.06 KHZ	109°
0.11	1.4/12.4	7.4 KHZ	72°

c)


Gain vs. Frequency
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Gain
10³
Frequency (Hz)


Phase Difference vs. Frequency
100
75
50
25
0
−25
−50
−75
Phase Difference (degrees)
10³
Frequency (Hz)

2. circuit B

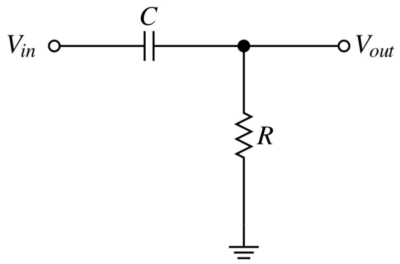


Figure 2.2: Circuit B.

a)

$R_L = 10^4$

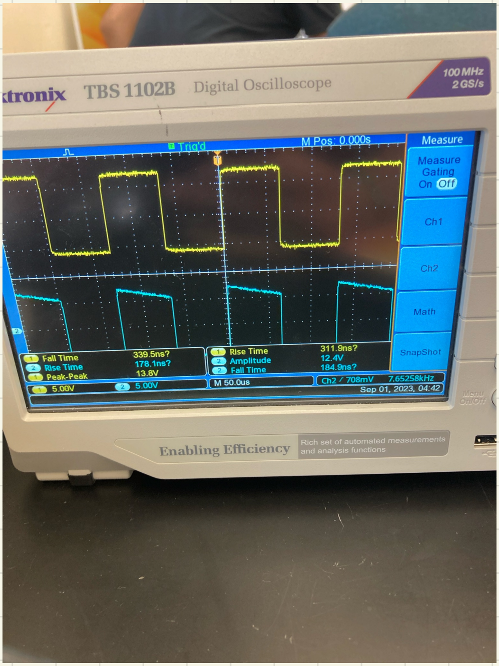
Rise ch1 = 321.4 ns

fall ch1 = 220. nS

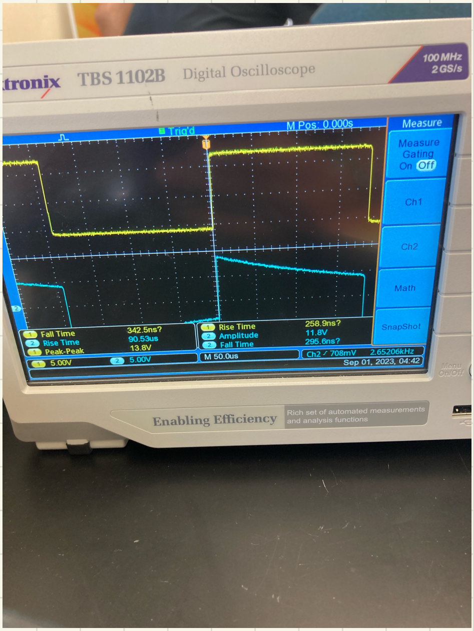
Rise ch2 = 264.3 nS

fall ch2 = 1.17 uS

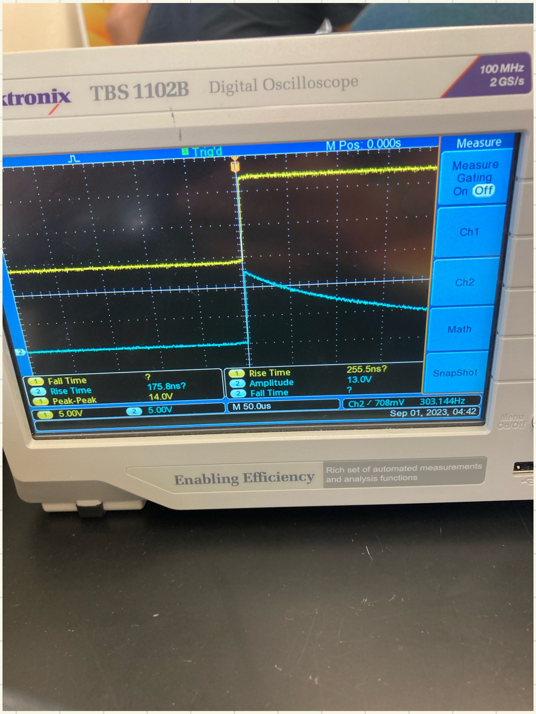
b)



①



②



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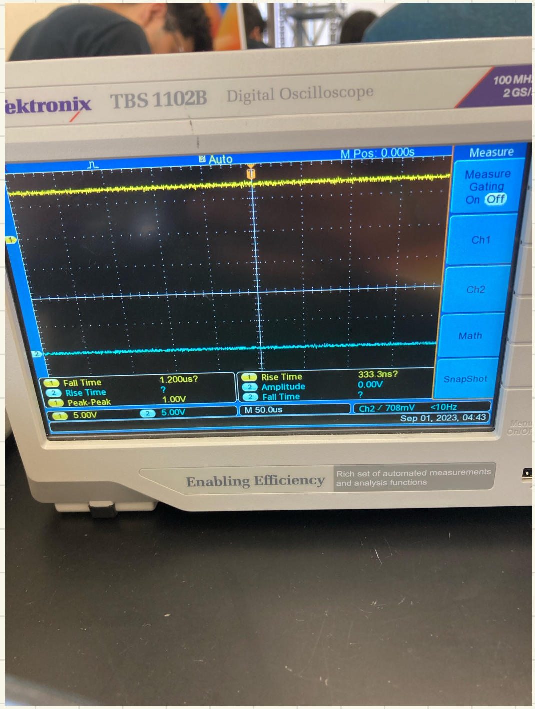
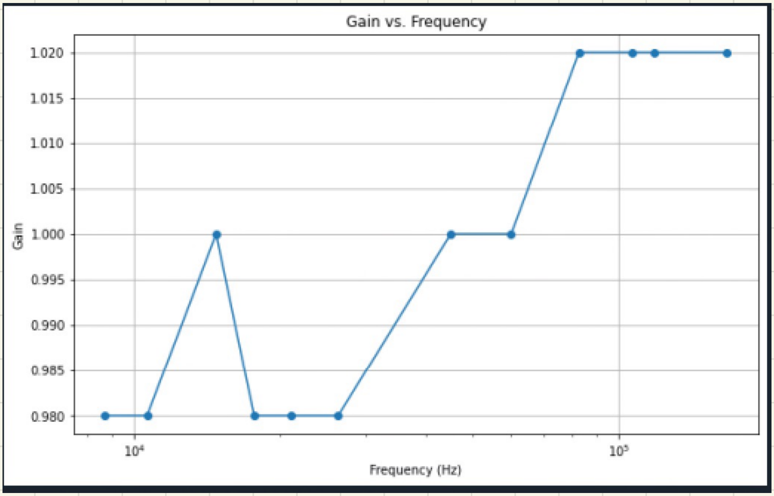


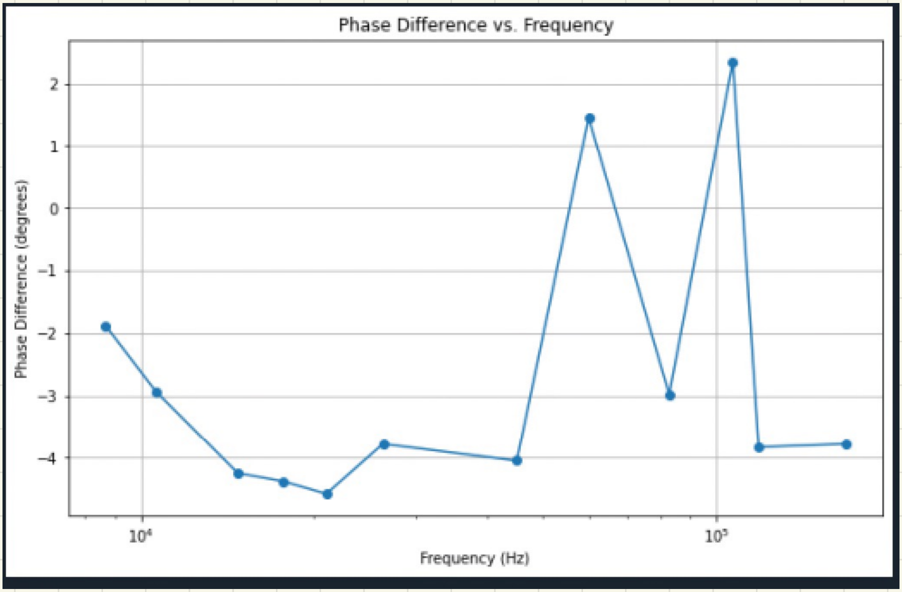
4

As we decreased the frequency you can tell channel 2 (the blue line) behaves more like the derivative bc of the spikes in the graph and the downward slope after indicate a decrease in the rate of change

(c)

f	$\frac{V_{out}}{V_{in}}$	ϕ
167.59 KHz	12/11.8 1.02	-3.78°
118.5 KHz	12/11.8 1.02	-3.83°
106.86 KHz	12/11.8 1.07	2.35°
82.82 KHz	12/11.8 1.02	-2.98°
60 KHz	1 V	1.45°
45 KHz	1	-4.05°
26.34 KHz	.98 11.8/12.2	-3.78°
21 KHz	.98 11.8/12	-4.38°
17.67 KHz	.98 12/12.2	-4.38
14.74 KHz	1 12/12	-4.25°
10.61 KHz	.98 12/12.2	-2.93°
8.68 KHz	.98 12/12.2	-1.88°


Gain vs. Frequency
1.020
1.015
1.010
1.005
1.000
0.995
0.990
0.985
0.980
Gain
10^4
10^5
Frequency (Hz)


Phase Difference vs. Frequency
2
1
0
−1
−2
−3
−4
Phase Difference (degrees)
10^4
10^5
Frequency (Hz)

Lab 2 #3)

$$Z_{tot} = R + \frac{1}{j\omega C}$$

$$V_{out} = V_{in} \times \frac{Z_{out}}{Z_{total}}$$

$$= V_{in} \cdot \frac{R}{R + \frac{1}{j\omega C}}$$

$$\frac{V_{out}}{V_{in}} = \frac{j\omega RC}{1 + j\omega RC}$$

gain as a function of frequency

phase angle

$$\frac{V_{out}}{V_{in}} = \frac{j\omega RC(1 - j\omega RC)}{(1 + j\omega RC)(1 - j\omega RC)}$$

$$= \frac{j\omega RC - (j\omega RC)^2}{1 - (j\omega RC)^2}$$

$$= \frac{j\omega RC - j^2\omega^2R^2C^2}{1 - j^2\omega^2R^2C^2}$$

$$= \underbrace{\frac{\omega^2R^2C^2}{1 + \omega^2R^2C^2}}_{\text{Real}} + \underbrace{\frac{j\omega RC}{1 + \omega^2R^2C^2}}_{\text{imaginary}}$$

$$\phi = \tan^{-1}\left(\frac{b}{a}\right)$$

continued

$$\phi = \tan^{-1}\left(\frac{\frac{wRC}{1+w^2R^2C^2}}{\frac{w^2R^2C^2}{1+w^2R^2C^2}}\right)$$

$$\phi = \tan^{-1}\left(\frac{wRC}{w^2R^2C^2}\right) = \tan^{-1}\left(\frac{1}{wRC}\right)$$ ✓

4)

$$\frac{V_{out}}{V_{in}} = \frac{Z_{out}}{Z_{total}} = \frac{\frac{1}{jwC}}{R + \frac{1}{jwC}}$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{1+jwRC}$$ ✓

$$\phi = -\tan^{-1}(wRC)$$ ✓

Lab 3

In Lab 3 we built and observed passive filters. We made a 2 stage RC bandpass filter and two, LRC bandpass filters. We observed resonance frequencies and mostly measured the gain

Lab 3

1) 3.1 nF

1.939 KΩ = R_1

C_1 = .95 nF .98 nF

5.1 KΩ

9.96 KΩ = R_2

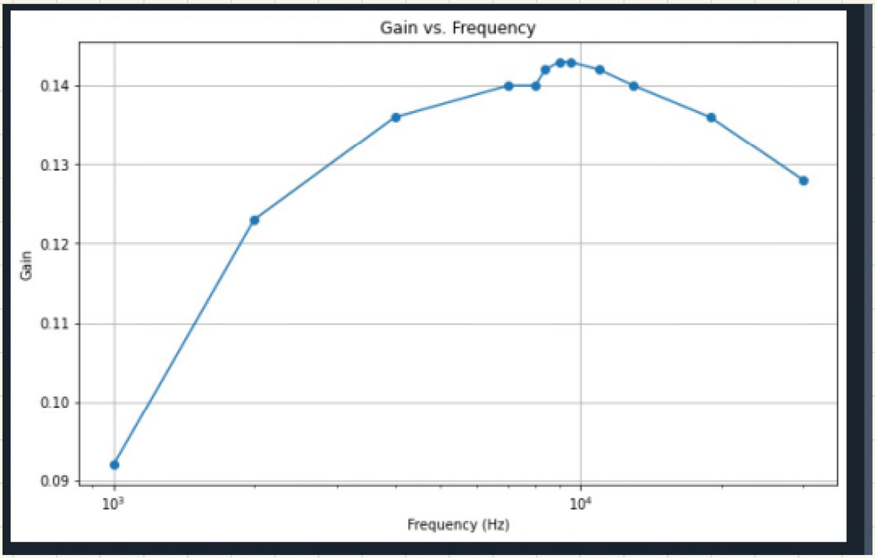
0.560 MΩ =

C_2 = 9.67 nF

Data Points

	V_{out}	V_{in}	Frequency
0.092	98 mV	1.06 V	1000 Hz
0.123	130 mV	1.06 V	2000 Hz
0.136	144 mV	1.06 V	4000 Hz
0.14	148 mV	1.06 V	7000 Hz
0.14	146 mV	1.06 V	9000 Hz
0.142	150 mV	1.06 V	8400 Hz
	152 mV	1.06 V	8700 Hz

.143	152 mV	1.06V	9000 HZ
.143	152 mV	1.06 V	9500 Hz
.142	150 mV	1.06 V	11000 HZ
.14	148 mV	1.06	13000 Hz
.136	144 mV	1.06	19000 Hz
.128	136 mV	1.06	30 KHz



2)

$$\frac{V_{intermediate}}{V_{in}} = \frac{j\omega R_1 C_1}{1 + j\omega R_1 C_1}$$ from Lab 2 (high pass)

first filter

$$\frac{V_{out}}{V_{intermediate}} = \frac{1}{1 + j\omega R_2 C_2}$$ from Lab 2 (Low Pass)

second filter

$$\text{total gain} = \frac{j\omega R_1 C_1}{1 + j\omega R_1 C_1} \times \frac{1}{1 + j\omega R_2 C_2}$$

- since $R_2 \gg R_1$ the load from the first filter will not interfere with the performance of the second filter.

3)

$R = 218.4\ \Omega$

$C = 470\ \mu F$

$L = 20\ mH$

$$\omega_0 = \frac{1}{\sqrt{LC}} = 0.01$$

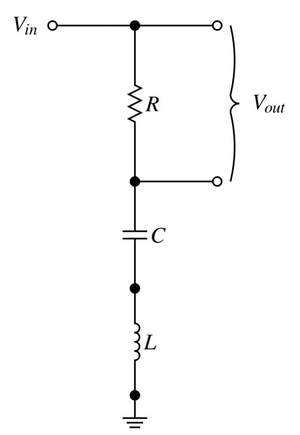


Figure 3.2: LRC Bandpass filter (Prob. 3).

- As it says we couldn't get this circuit to show any data on the oscilliscope, I think the circuit could be essentially short circuiting due to the capacitor not being charged up and then driving the current.

Since $V_{in} = V_R + V_{LC}$

$$V_R = V_{LC} - V_{in}$$

We can use these voltages to find V_R as a function of frequency by plotting

4)

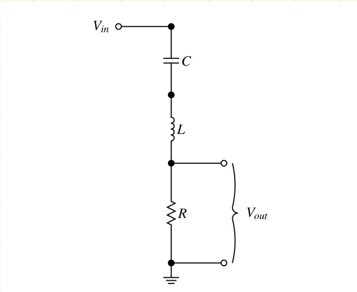


Figure 3.3: LRC Bandpass filter (Prob. 4).

Resonance frequency = 1800 KHz

1.8 KHz $V_{in} = 10.2V$, $V_{out} = 8.8V$

200 Hz $V_{in} = 10.4V$, $V_{out} = 8V$

32.5 KHz $V_{in} = 10.2V$, $V_{out} = 7.2V$

115 KHz $V_{in} = 10.2V$, $V_{out} = 3.4V$

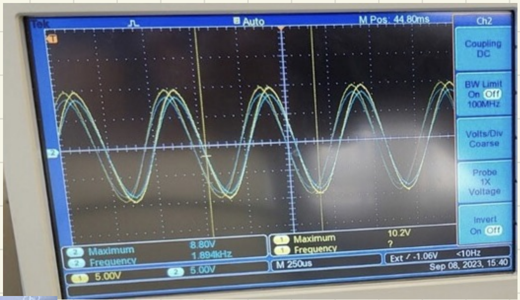
$R_{eq} = R_1 + R_2$

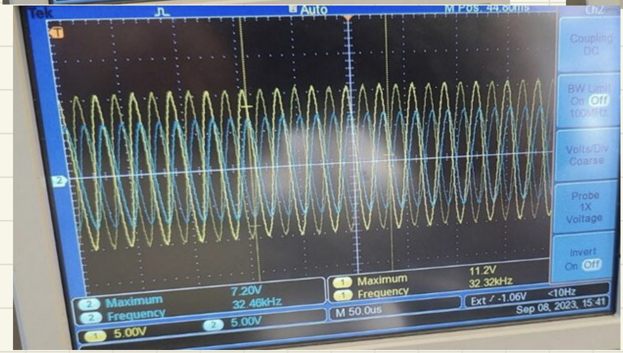
$= 102.6\Omega + 100.2\Omega$

$C = 8.18 \mu F$

$L = 1 \times 10^{-3} H$

4 different wave forms





5)

$R = 500\,\Omega, 100\,\Omega$

$C = 8.18\,\mu F$

$L = 0.001\,H$

$\omega_0 = \dfrac{1}{2\pi\sqrt{LC}} = 1.76\,kHz$ for both $100\,\Omega$ and $500\,\Omega$ resistor

resonance

- If you want sharper resonance you need higher resistance.

6)

$L = 0.001\,H$

$C = 8.18\,\mu F$

$R = 500\,\Omega$

$\dfrac{V_{out}}{V_{in}}$

$Z_C = \dfrac{-1}{j\omega C}, \quad Z_L = j\omega L$

$\dfrac{1}{Z_{box}} = \dfrac{1}{Z_C} + \dfrac{1}{Z_L} = \dfrac{-\omega^2 LC + 1}{j\omega L}$

$Z_{box} = -j\omega L / 1 - \omega^2 LC$

$$Z_{total} = R + \frac{-j\omega L}{1-\omega^2 LC}$$

$$\frac{V_{out}}{V_{in}} = \frac{Z_{box}}{Z_{total}} = \frac{-j\omega L/(1-\omega^2 LC)}{R - j\omega L/(1-\omega^2 LC)}$$

$$= \frac{-j\omega L}{R(1-\omega^2 LC)+j\omega L}$$

$$= \frac{\omega L}{\omega^2 RLC - \omega L + R}$$ ✓

$$Q = \frac{(1.76 \times 10^3) \times 10^{-7}}{500\,\Omega} = 3.52$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = 1.76 \times 10^{3} \text{ rad/s}$$