Lab 3: Operational Amplifiers Part 1

ECEN 325 - 511

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Date Performed: September 28, 2021

Due Date: October 5, 2021

Purpose

The purpose of this lab was to be able to understand the fundamentals of amplifiers. There was the hands-on experience of making inverting and noninverting amplifiers, using the op-amps available.

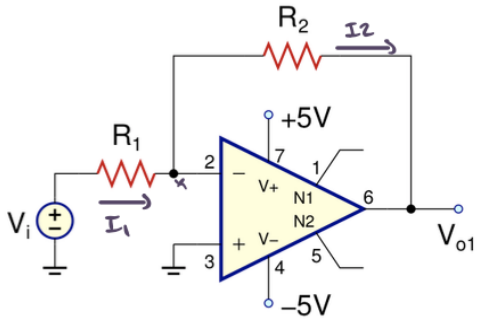
Calculations

1. Read the datasheet for the UA741 opamp and write down the typical values of the following parameters:

Supply Voltage	5V to 15 V -5V to -15 V
Input Offset Voltage	1mV
Voltage Gain	106dB
Power Consumption	50mW
Output Resistance	75Ω
Bandwidth	1MHz
Input Resistance	2MΩ
Input Offset Current	20nA
Slew Rate	0.5V/μs

2. Derive voltage gains
   Circuit A:

Circuit A :



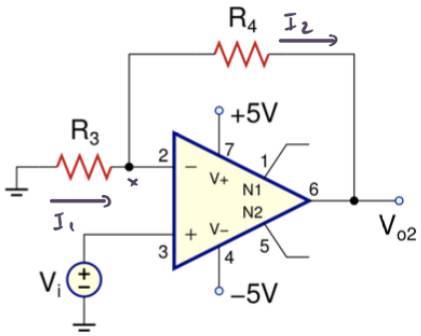
$V_x = 0$ and $I_1 = I_2$

$$\frac{V_i - V_x}{R_1} = \frac{V_x - V_{o1}}{R_2}$$

$$\frac{V_{o1}}{V_i} = \frac{-R_2}{R_1}$$

Circuit B:

Circuit B:



$V_x = V_i$

node: $\frac{V_i}{R_3} + \frac{V_i + V_{o2}}{R_4} = 0$

$V_i\left(1/R_3 + R_4\right) - V_{o2}/R_4 = 0 \Rightarrow$

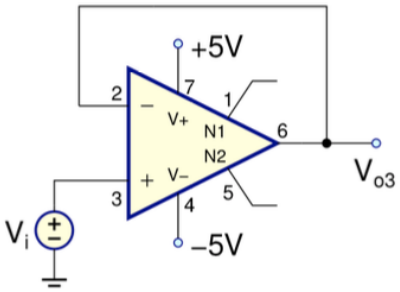
$V_i\left(\frac{1}{R_3+R_4}\right) = \frac{V_{o2}}{R_4}$

$= \frac{V_{o2}}{V_i} = \frac{R_4}{R_3+R_4}$

$$\boxed{\frac{V_{o2}}{V_i} = 1 + \frac{R_4}{R_3}}$$

Circuit C:

circuit C:



$V_x = V_i$

$V_{o3} = V_i$

$$\boxed{\frac{V_{o3}}{V_i} = 1}$$

3. f R1 = R3 = 10kΩ, find R2 and R4 such that $V_{o1}/V_i = -3$ and $V_{o2}/V_i = 6$.

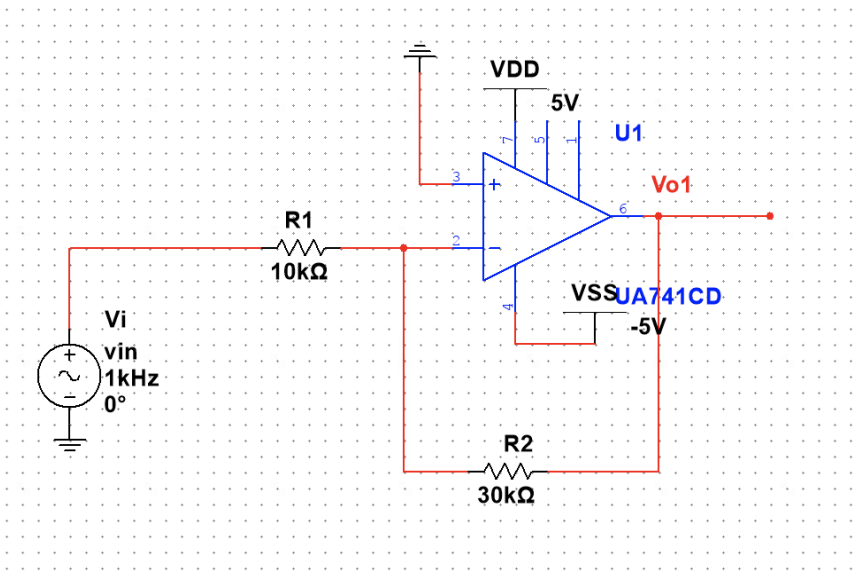
3) $\frac{V_{o1}}{V_i} = \frac{-R_2}{R_1} = -3 = \frac{-R_2}{10k} =$ $\boxed{R_2 = 30\,k\Omega}$

$\frac{V_{o2}}{V_i} = 1 + \frac{R_4}{R_3} = 6 = 1 + \frac{R_4}{10k} =$ $\boxed{R_4 = 50\,k\Omega}$

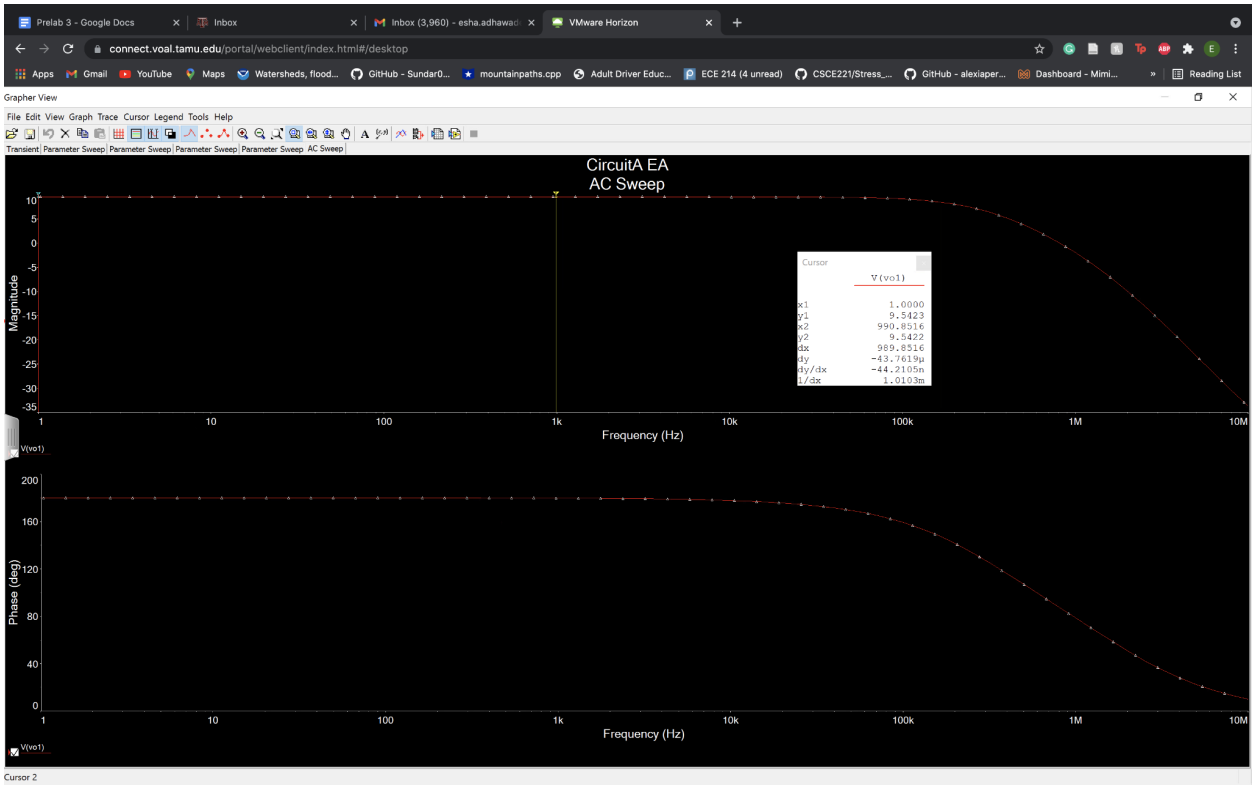
Simulations (on Multisim)

Circuit A

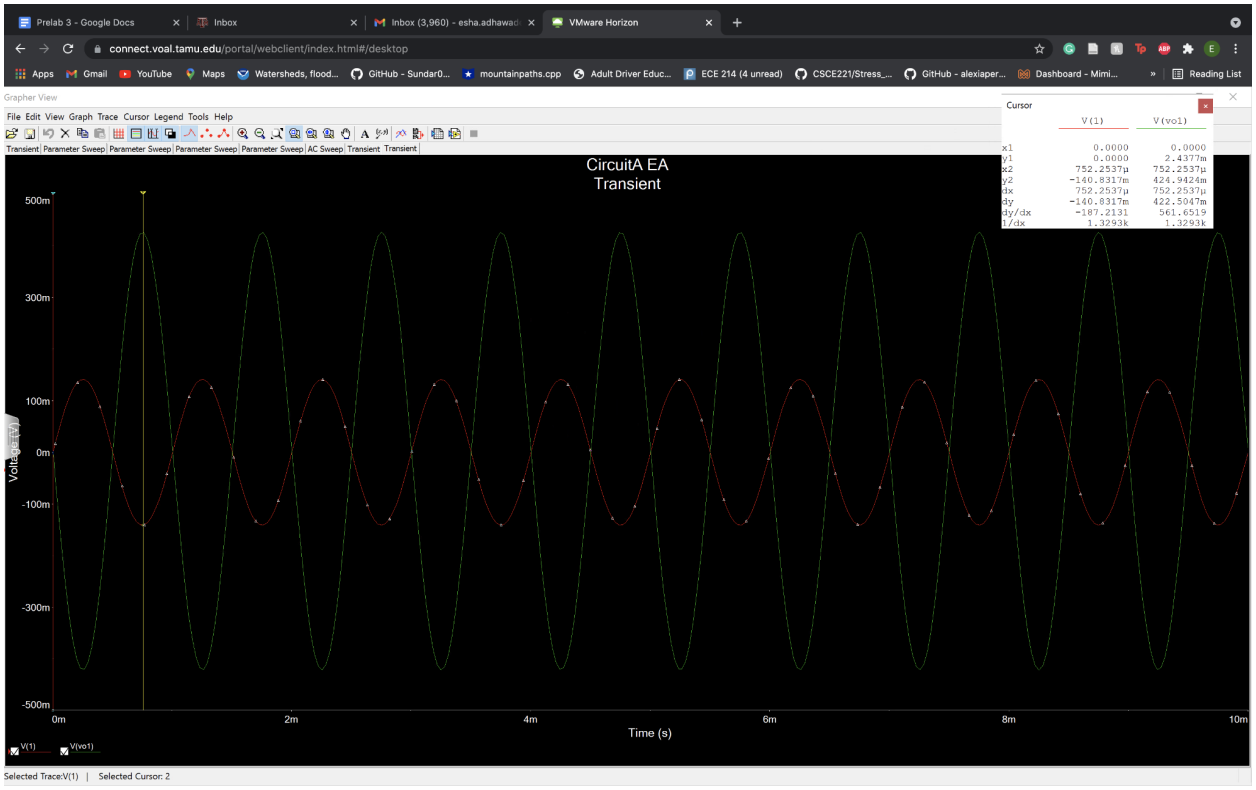
1. Schematic



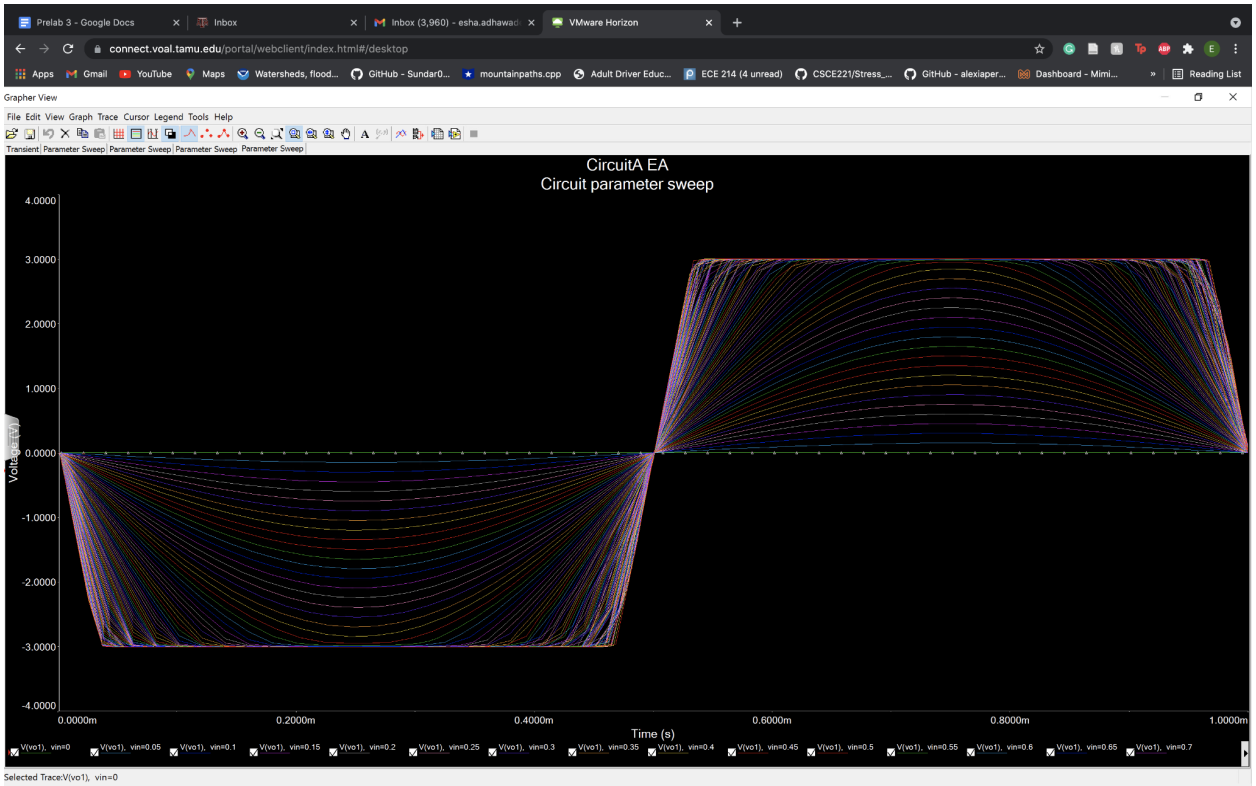
2. AC Sweep



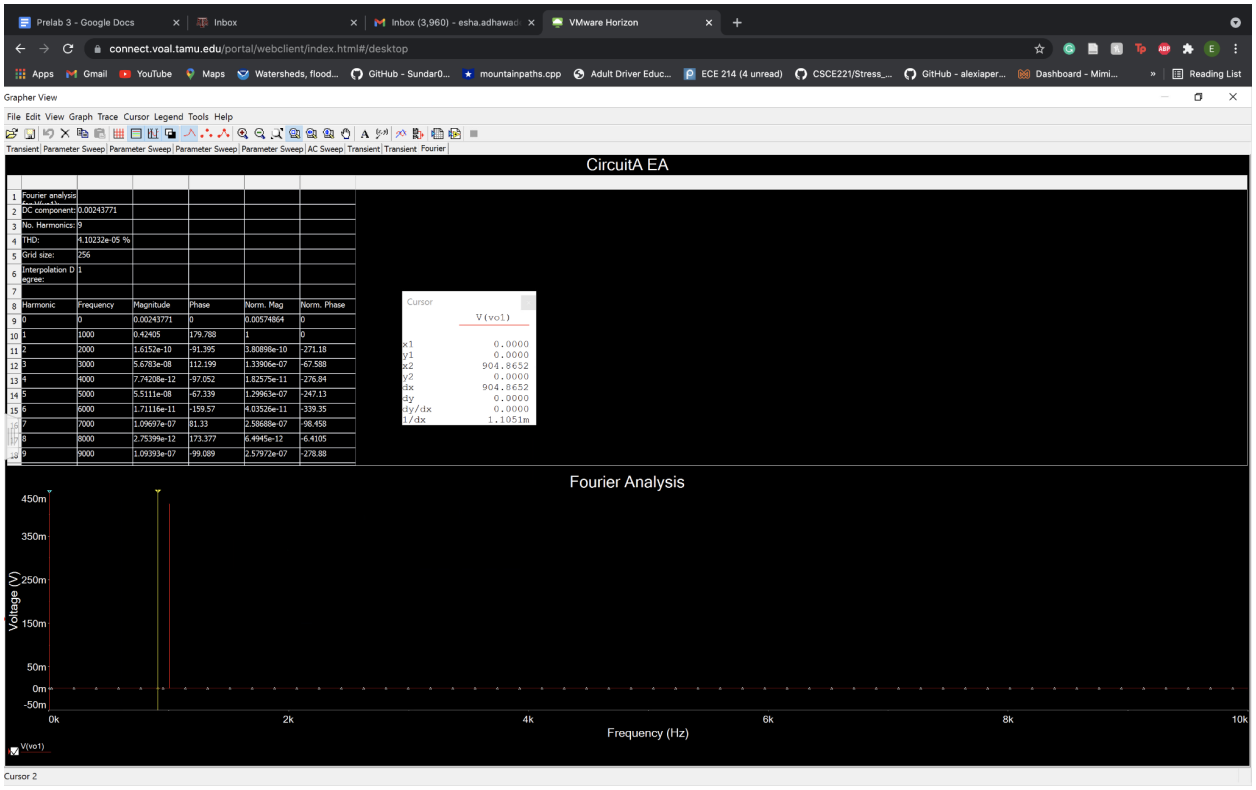
3. Transient



4. Circuit Parameter Sweep

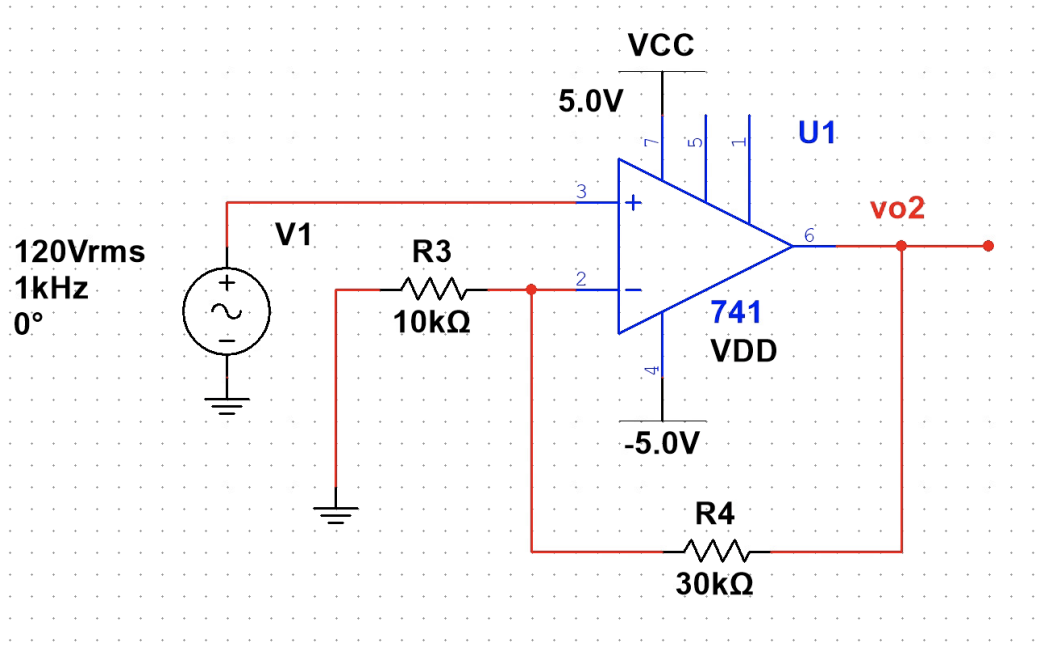


5. Fourier Simulation

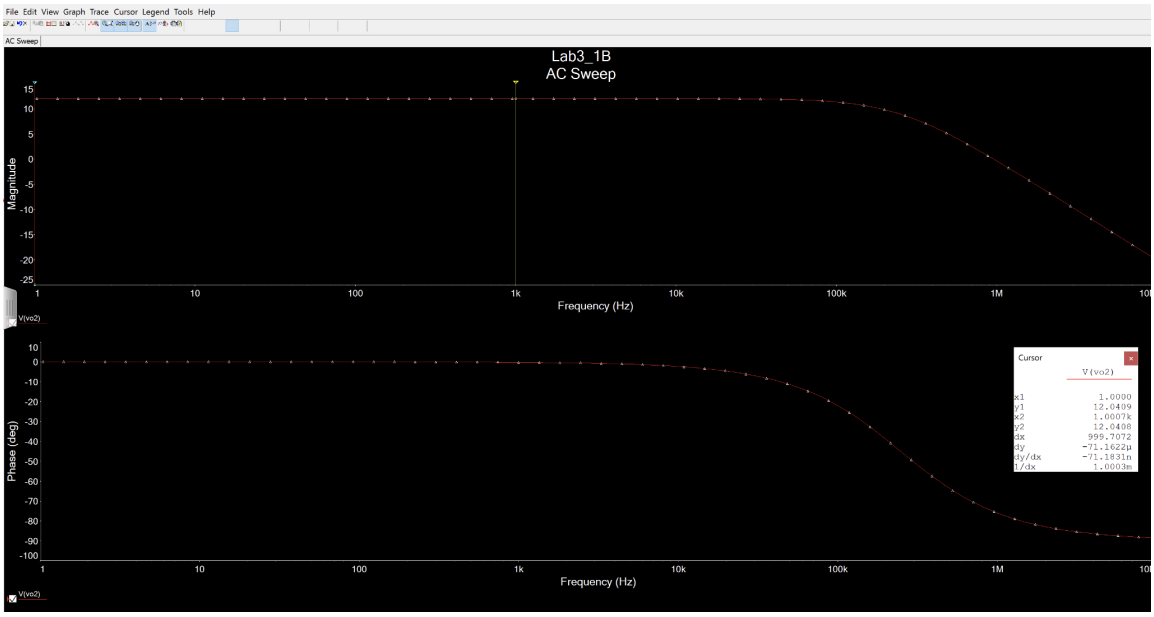


Circuit B

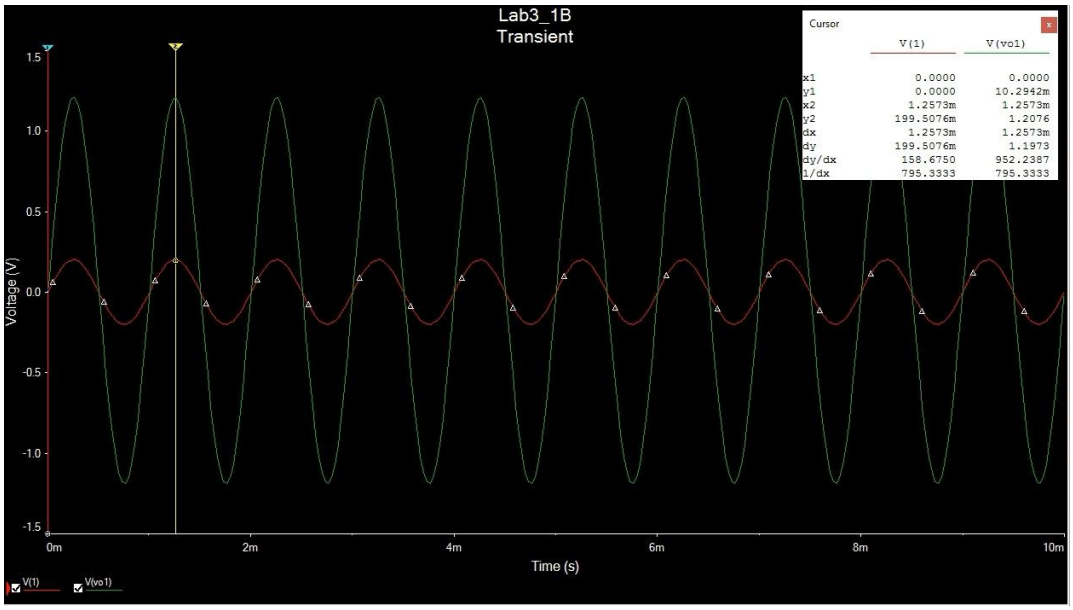
1. Schematic



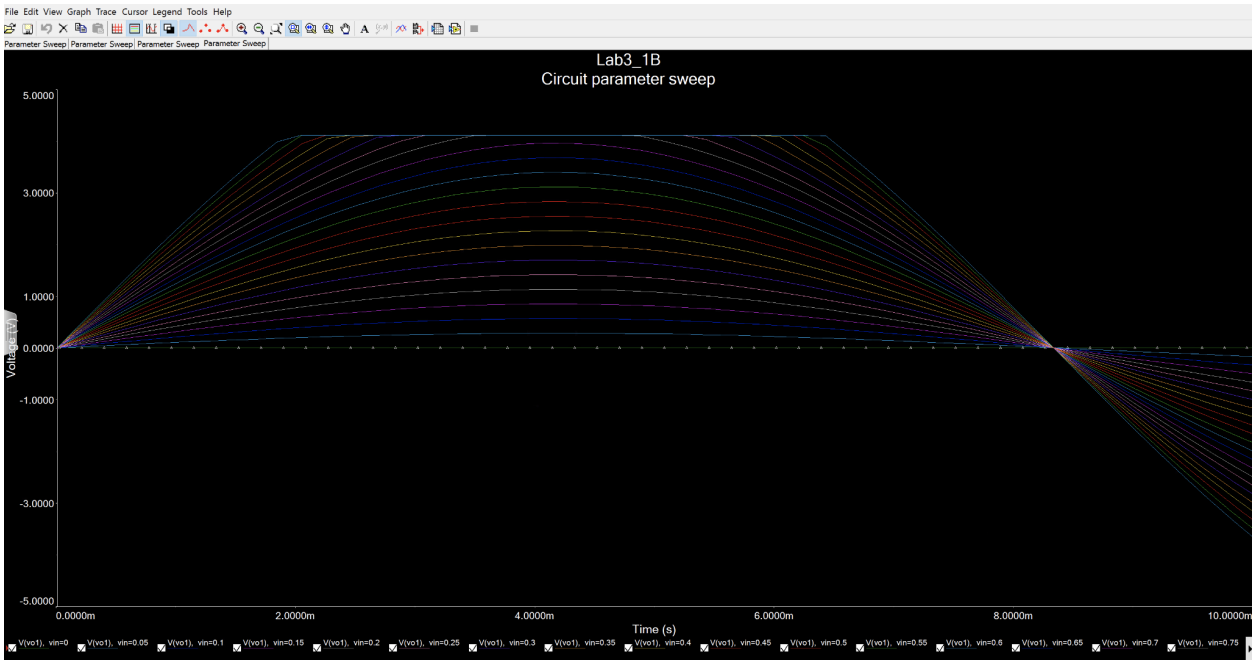
2. AC Sweep



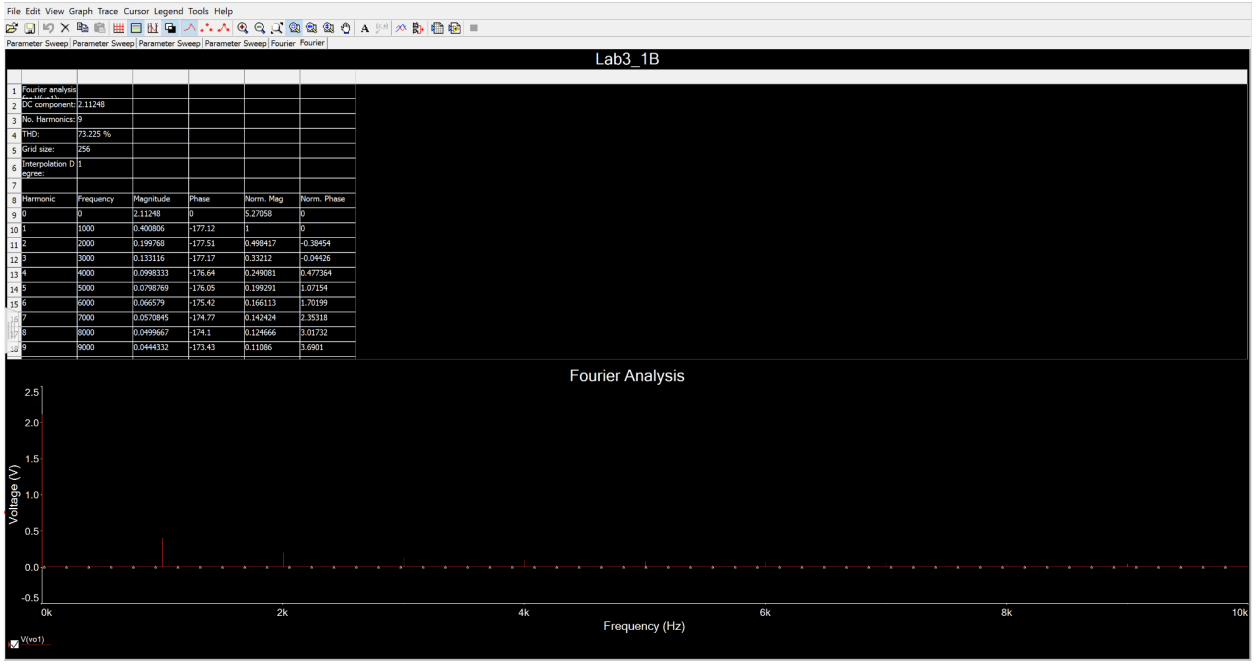
3. Transient



4. Circuit Parameter Sweep



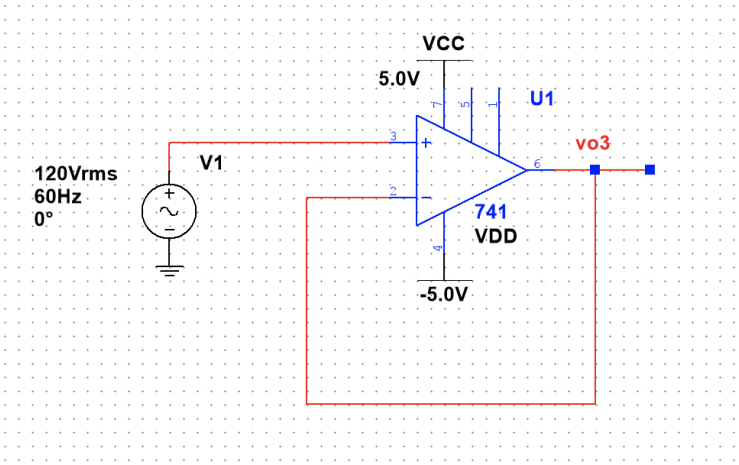
5. Fourier Simulation



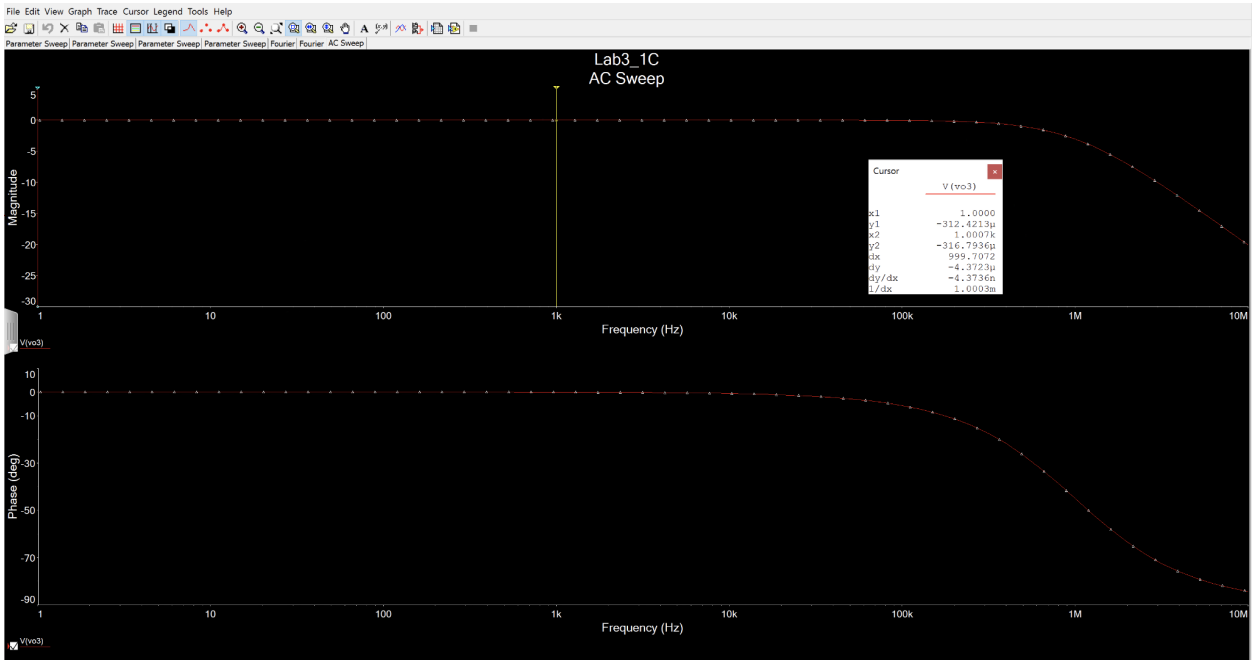
1	Fourier analysis					
2	DC component:	2.11248				
3	No. Harmonics:	9				
4	THD:	73.225 %				
5	Grid size:	256				
6	Interpolation Degree:	1				
7						
8	Harmonic	Frequency	Magnitude	Phase	Norm. Mag	Norm. Phase
9	0	0	2.11248	0	5.27058	0
10	1	1000	0.400806	-177.12	1	0
11	2	2000	0.199768	-177.51	0.498417	-0.38454
12	3	3000	0.133116	-177.17	0.33212	-0.04426
13	4	4000	0.0998333	-176.64	0.249081	0.477364
14	5	5000	0.0798769	-176.05	0.199291	1.07154
15	6	6000	0.066579	-175.42	0.166113	1.70199
16	7	7000	0.0570845	-174.77	0.142424	2.35318
17	8	8000	0.0499667	-174.1	0.124666	3.01732
18	9	9000	0.0444332	-173.43	0.11086	3.6901

Circuit C

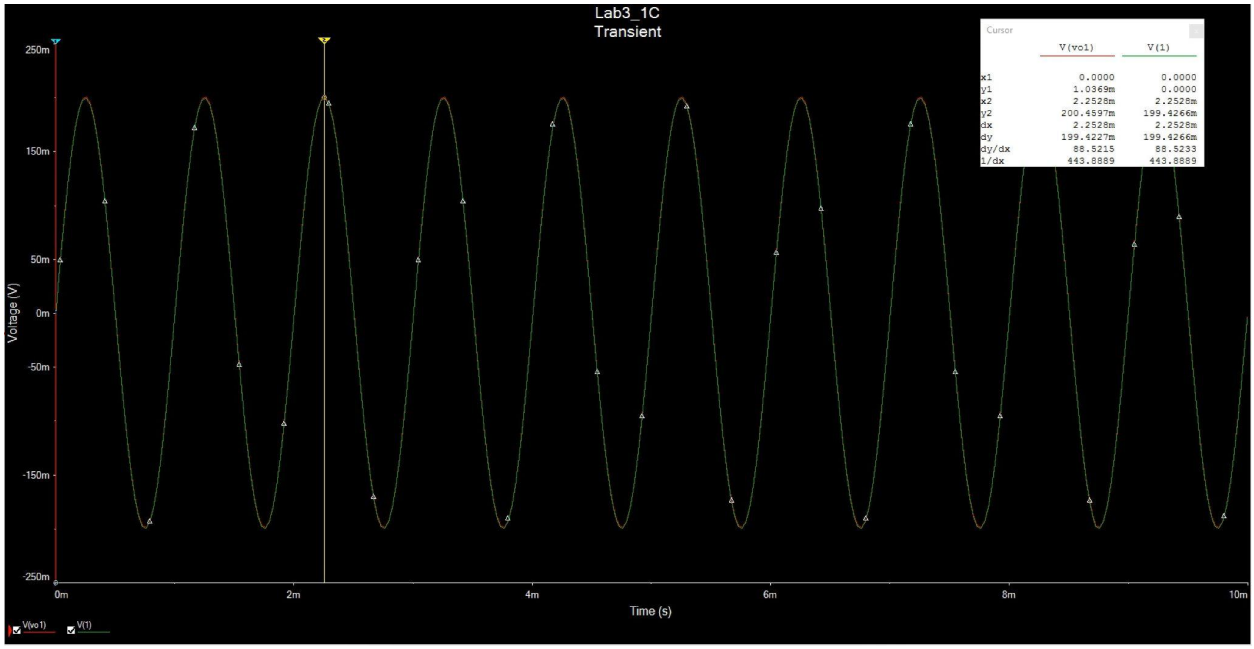
1. Schematic



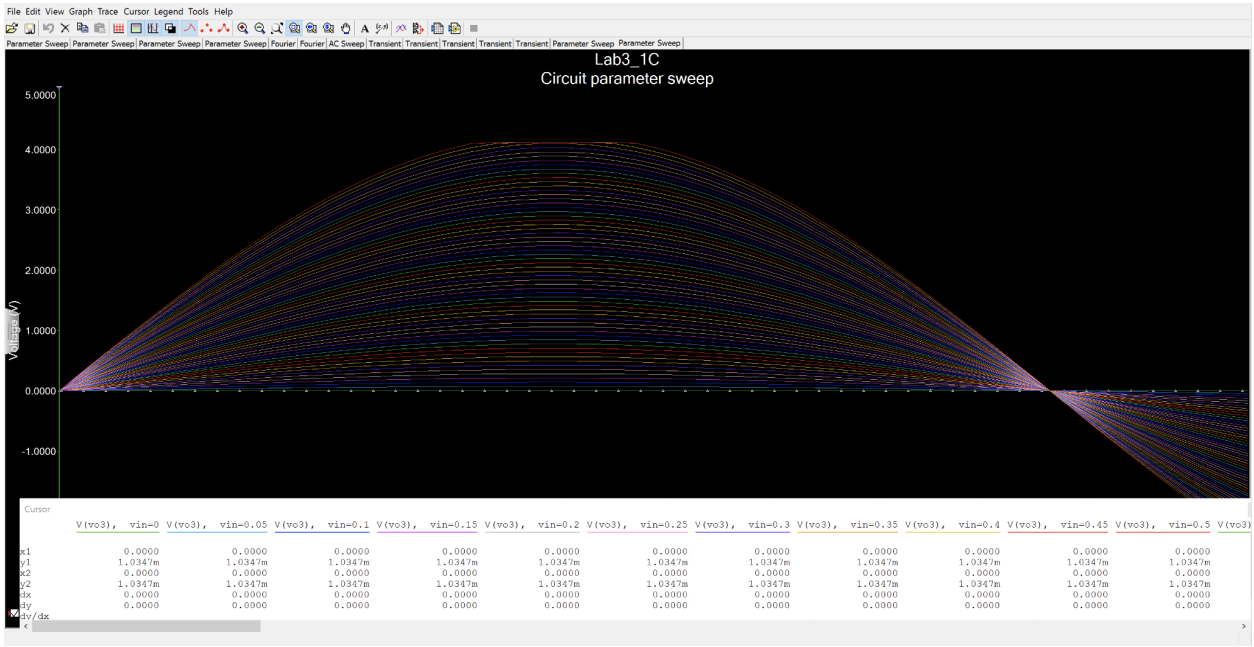
2. AC Sweep



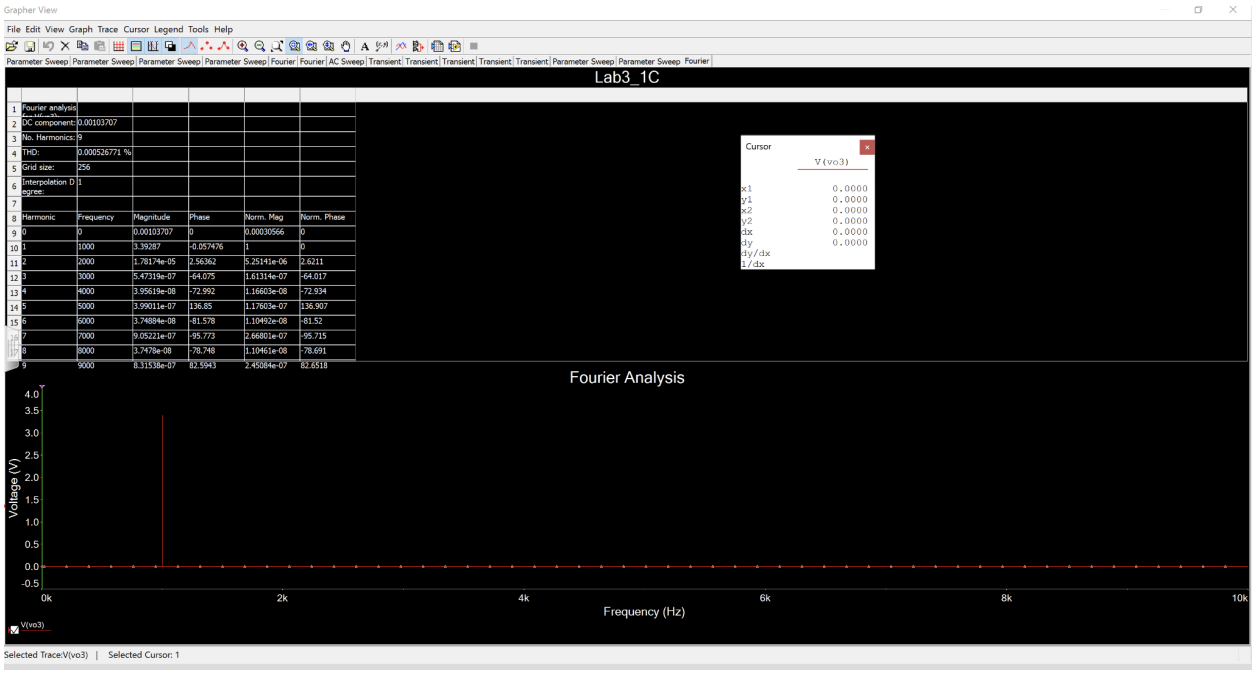
3. Transient



4. Circuit Parameter Sweep



5. Fourier Simulation



Measured Waveforms

Input Offset Current Measurement

In the data tables section...

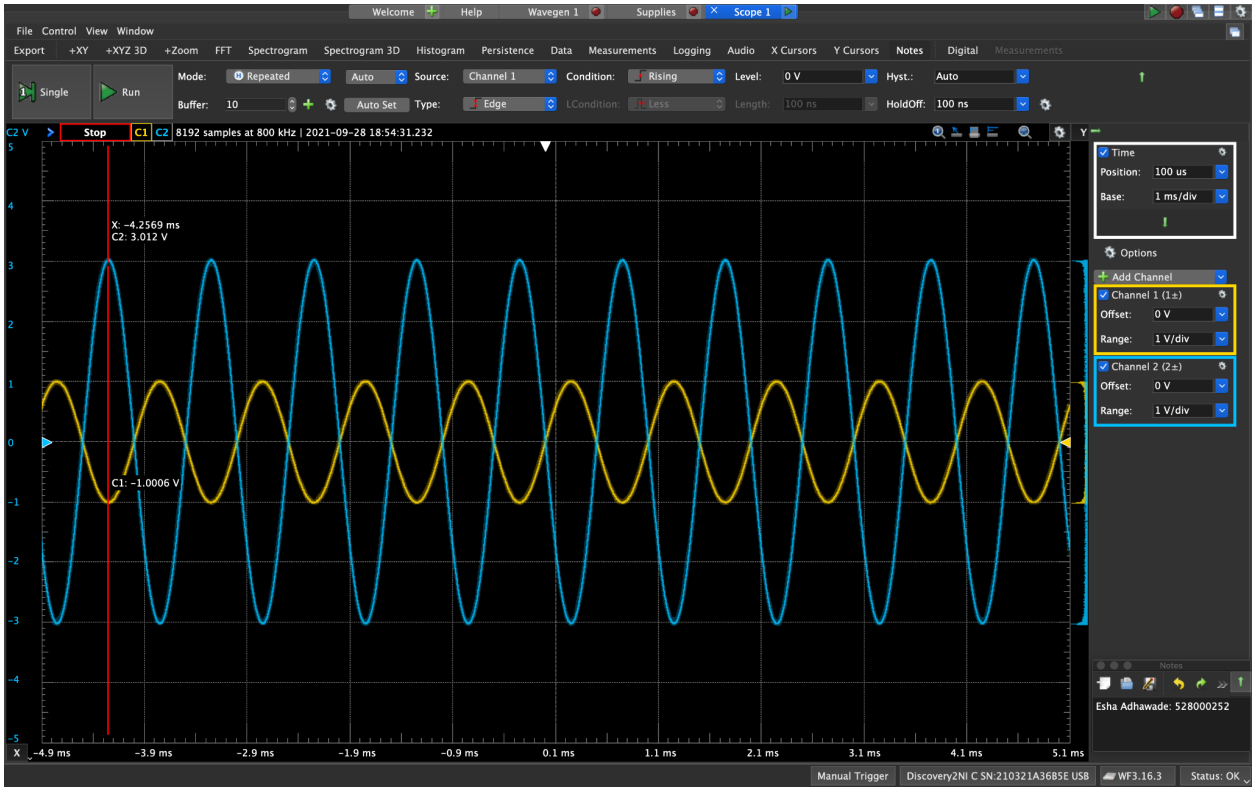
DC Offset Voltage Measurement

In the data tables section...

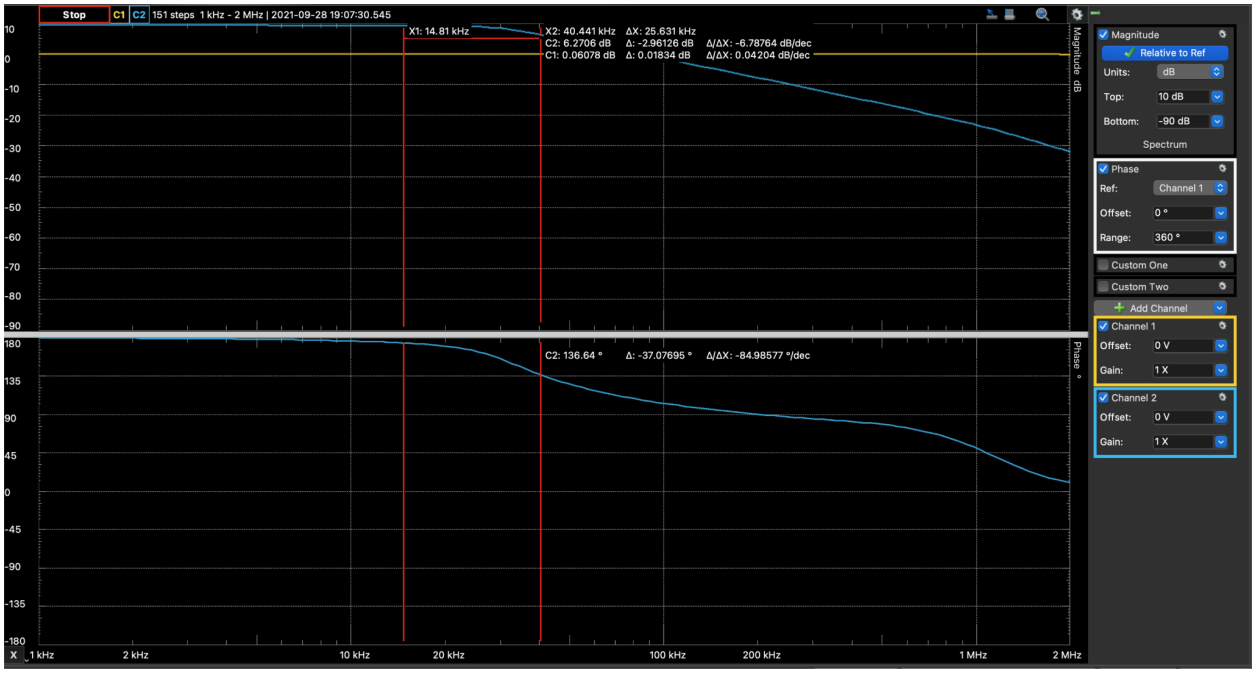
Inverting and Non-inverting Configurations

Circuit A

Time Domain Plot

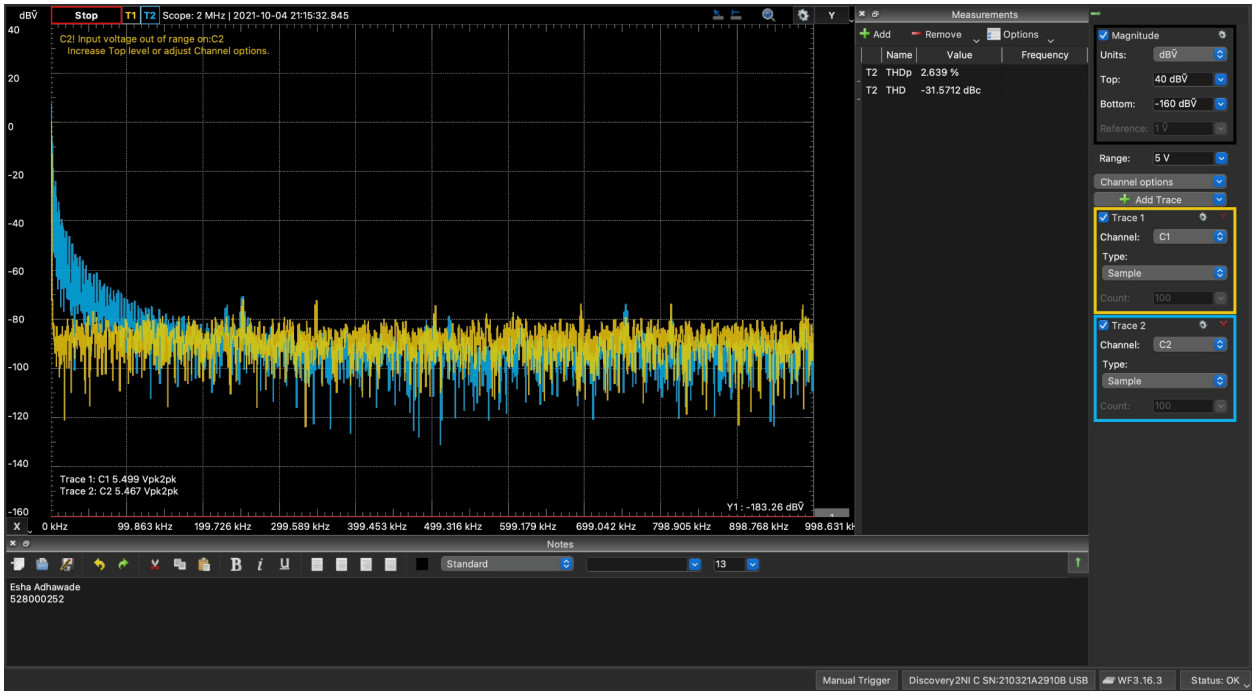


Bode Plot



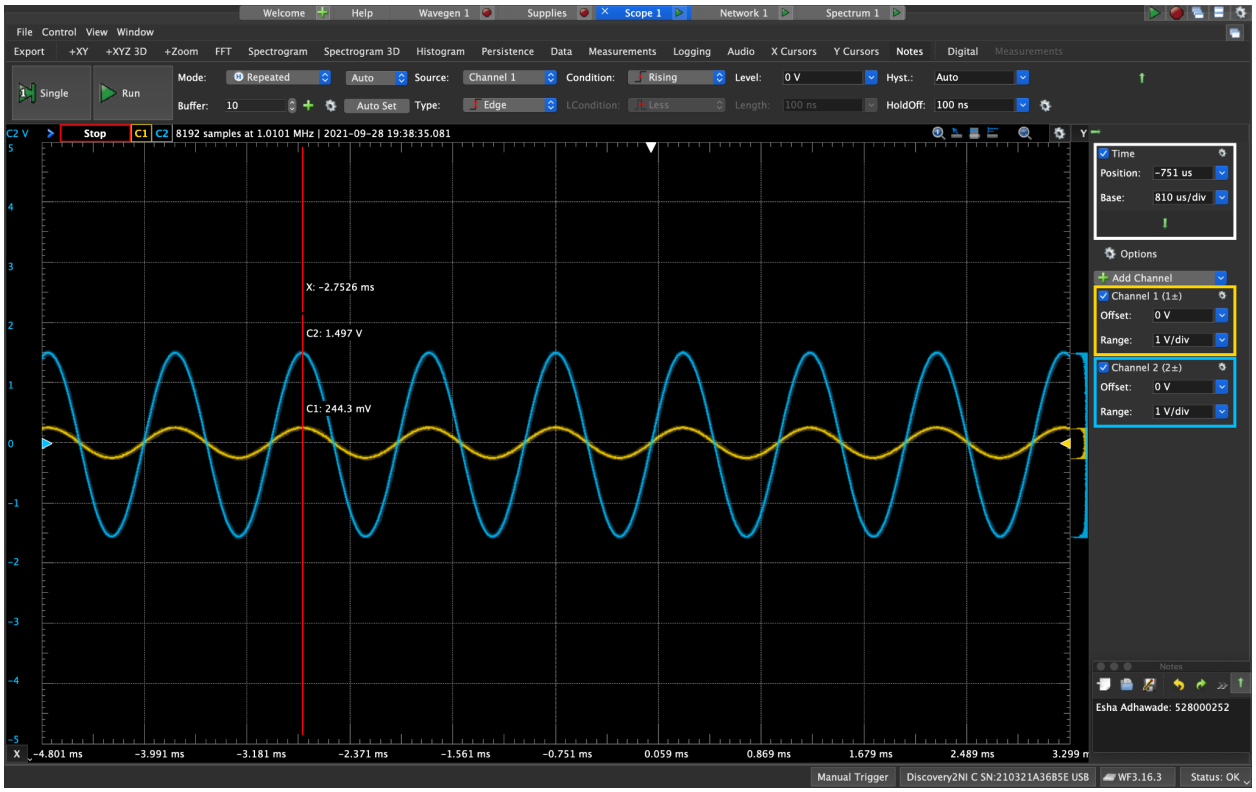
Max: 1.23 V

Total Harmonic Distortion

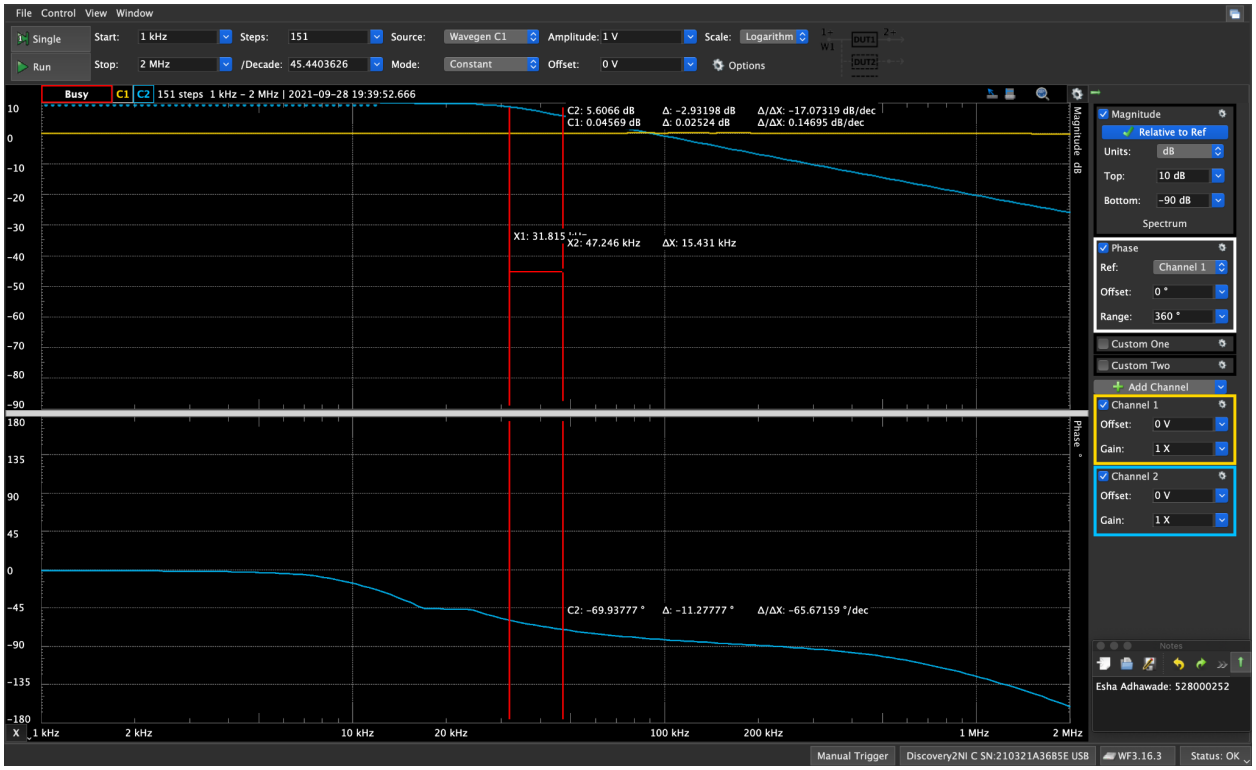


Circuit B

Time Domain Plot

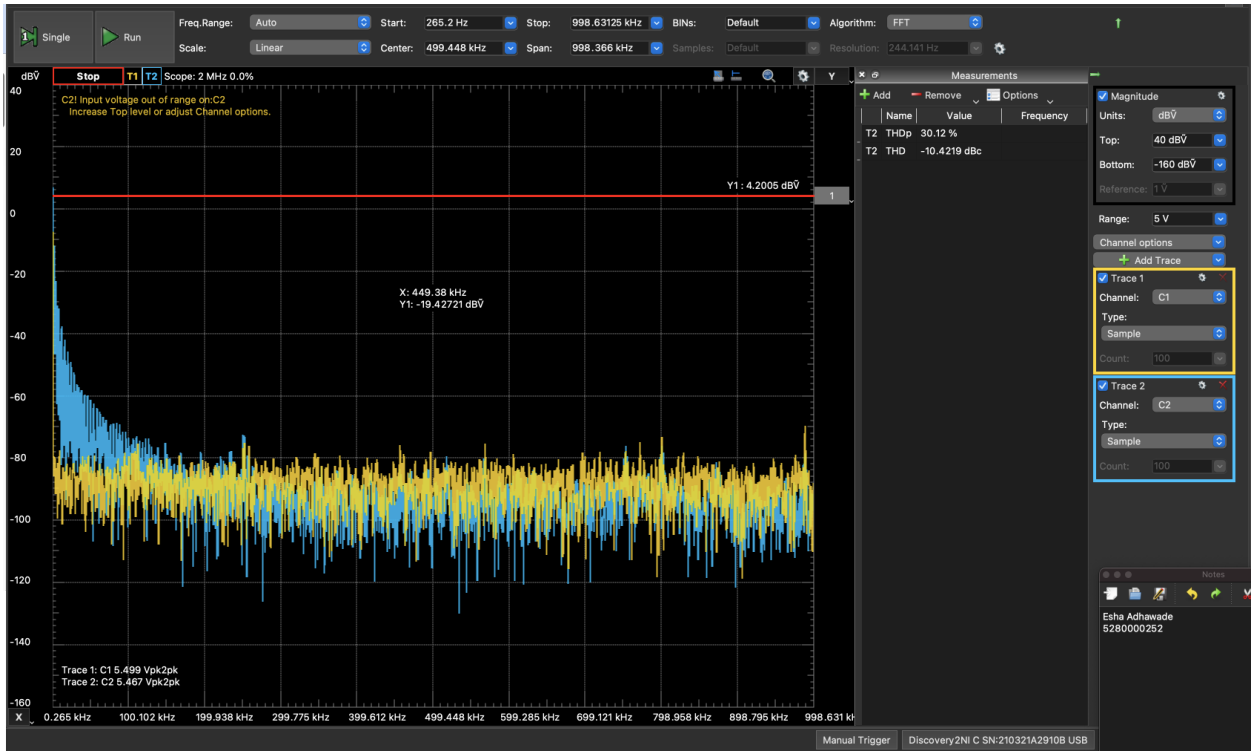


Bode Plot



Max: 0.61 V

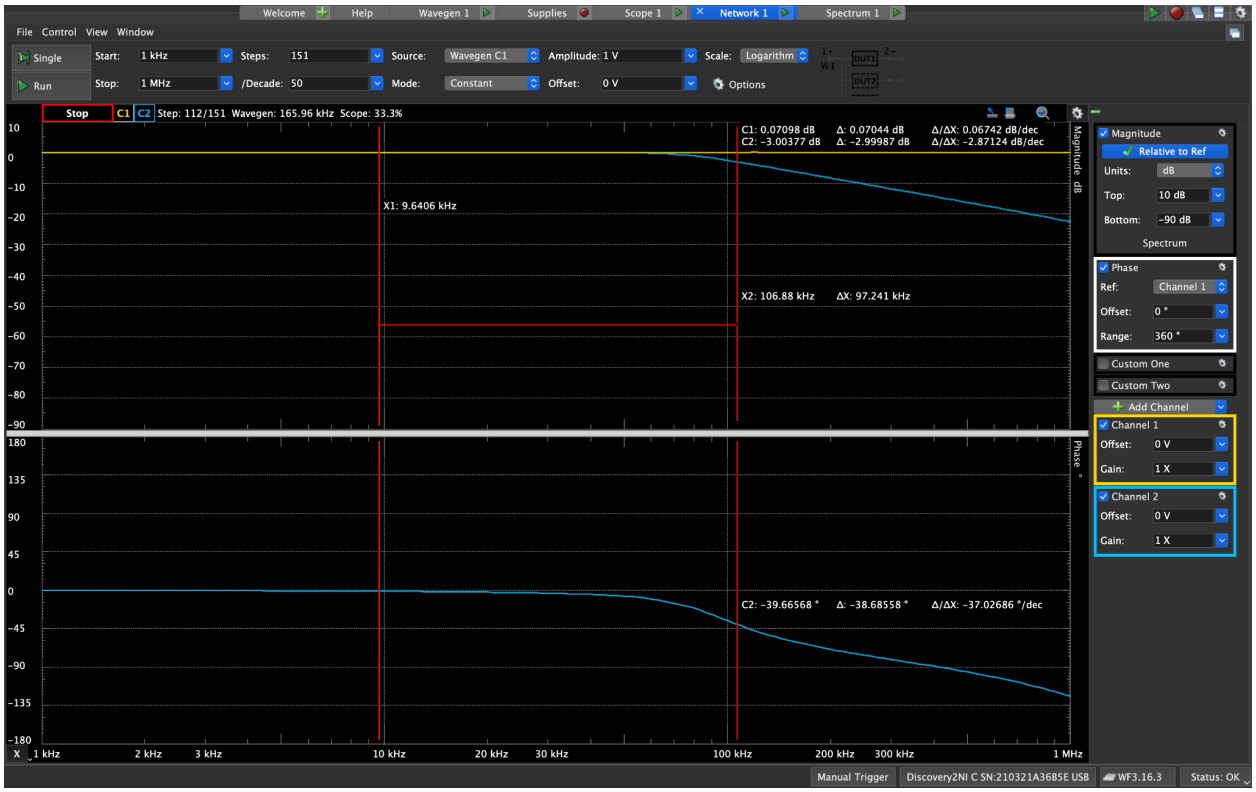
Total Harmonic Distortion



Circuit C

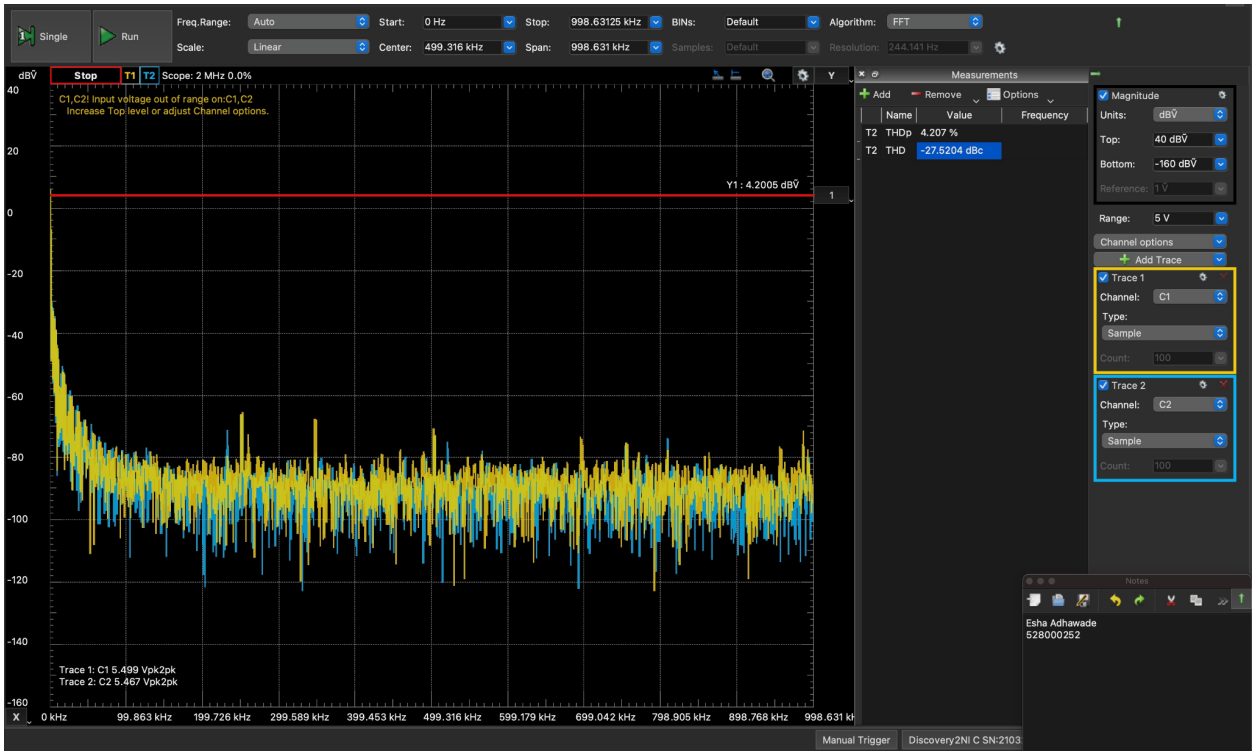
Time Domain Plot

Bode Plot



Max: 3.15 V

Total Harmonic Distortion



Data Tables

Input Offset Current Measurement

$I_1 = V_1 / R = 0.00154\ V / 100k\Omega = 1.54 \times 10^{-8}$

$I_2 = V_2 / R = 0.00439\ V / 100k\Omega = 4.39 \times 10^{-8}$

Input Offset Current: $(4.39 \times 10^{-8}) - (1.54 \times 10^{-8}) = 2.85 \times 10^{-8}$ A

DC Offset Voltage Measurement

$V_{i,\,off} = V_{o,\,off} / Gain = -0.00239 / 6 = -0.000398$ V

Inverting and Non-inverting Configurations

	Vin	**Vout**	**Voltage Gain**
Calculation Circuit A	N/A	N/A	-3
Calculation Circuit B	N/A	N/A	6
Calculation Circuit	N/A	N/A	1

C			
Simulation Circuit A	-0.14083 V	0.42494 V	-3.0174
Simulation Circuit B	0.19951 V	1.2076 V	6.05283
Simulation Circuit C	0.199426 V	0.200459 V	1.0052
Measurements Circuit A	-1.0006 V	3.012 V	-3.0102
Measurements Circuit B	.2443 V	1.497 V	6.1277
Measurements Circuit C	0.1973 V	0.1984 V	1.0056

Discussion

For lab 3, students learned about the different parameter values that can be utilized by operational amplifiers. Most of the values between the simulations and measurements, we somewhat consistent for the circuits. If there were any minor differences, that's probably because of component differences, old breadboards, or loose wires.