CALIFORNIA STATE UNIVERSITY SACRAMENTO

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 108L

Electronics I_ Laboratory, 1 unit

Summer_ 2022

Lab - 03 Report

Submitted to

Riaz Ahmad

By

Vigomar Kim Algador

Dated: 07-31-2022

<u>TABLE OF CONTENTS</u>

INTRODUCTION:

From the last laboratory, the student learned about the basic concept of operational amplifiers which uses split power supply with plus and minus supply voltage and their input and output voltage range easily include ground in which they can have DC bias voltage ranges of zero volts. In this laboratory, the student was introduced to investigate and learn about the functionality of a single power supply operational amplifier. This will help the student get familiarize with the concept as many modern circuits are designed to operate from it. With the design circuit given to this laboratory shown in figure 1, the student must do hand calculation, do the simulation in PSpice, and construct it to a breadboard with the use of potentiometer.

Part1 – Preliminary Calculations

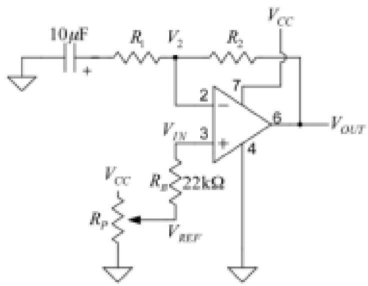

Figure 1

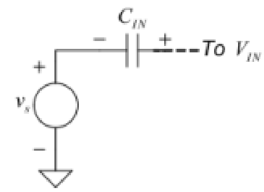

Figure 2

1. The type of amplifier shown in figure 1 is a non-inverting amplifier.

2. The value of R_P = 12kΩ.

3. The value we used for R_1 = 2.2 kΩ and R_2 = 70 kΩ.

4. The frequency f_{p1} = 7.234 Hz and it's a pole frequency.

5. DC current flows through the capacitor so, V_2= V_{out}= 2.5 V.

6. The resistance seen to ground from V_{in} is Z_{in}= 28 kΩ.

Part2 - Simulations Results

In this part of the laboratory, the student generate the circuit from the figure 1 and add the figure 2 in PSpice simulation. The student simply connected V_{REF} to a DC voltage. The student also used the values from the preliminary calculation and setting V_{REF} = 2.5 V and V_{CC} = 5V. The whole PSpice circuit is shown in figure 3.

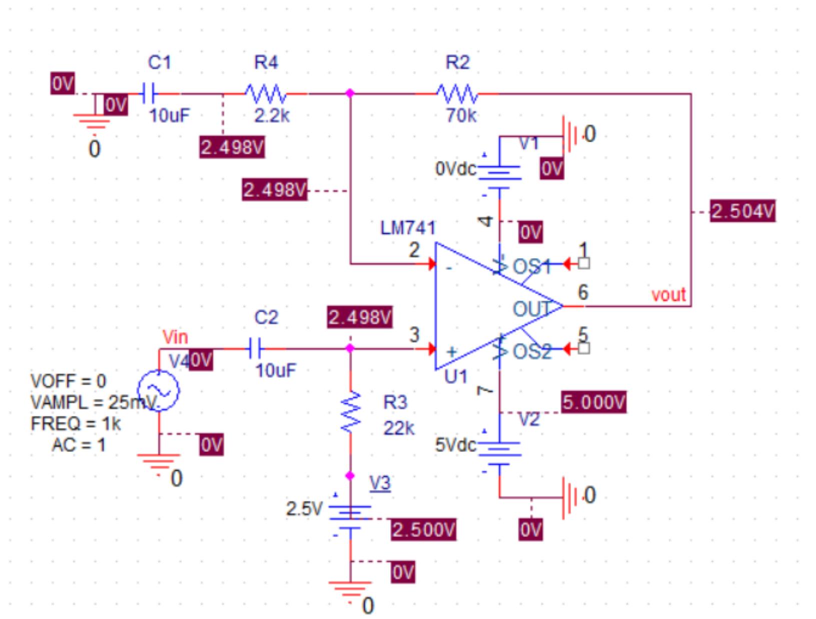

Figure 3. Circuit in PSpice simulation from figure 1 and 2.

After generating the circuit, the student run bias point and check the bias voltages at all of the nodes. With this, the student run DC sweep and sweep the value of V_{REF} from 0 to 5 volts shown in figure 4.

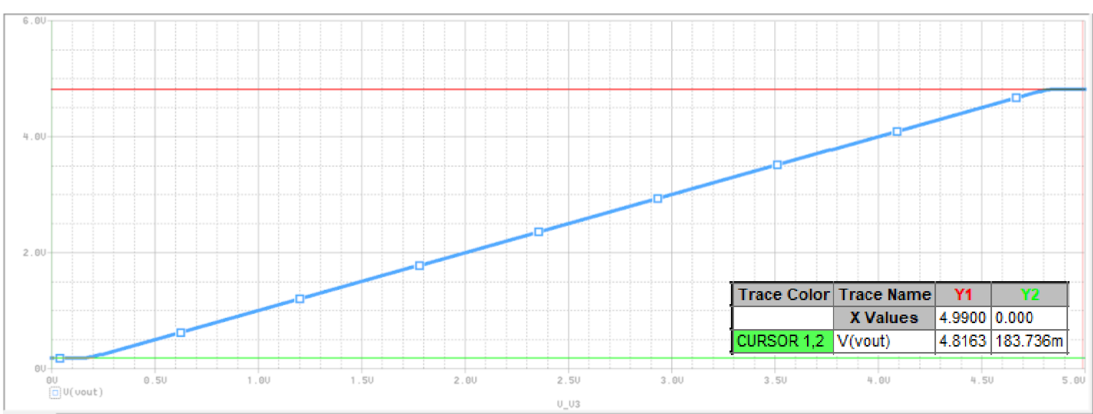

Figure 4. The graph for non-inverting amplifier from from – 5V to +5V.

From the graph, we can identify the positive clipping level as the red line which is 4.99V and the negative clipping level as the green line which is about 0V. On the other hand, the student calculated the pole frequency due to C_{IN} in which got the result f_{p2} = 0.7234 Hz with the given formula $f_{p2} = \frac{1}{2\pi C_{IN} R_B}$ where R_B = 22k ohms. After that, the student calculated 100 times the greater of $f_{p1}$and f_{p2} which the student called it as f_{p3} = 795.74 Hz. At or above this frequency, both capacitor will look like AC short circuits. Using this frequency, the student run transient simulation with V_{REF} = 2.5V and V_s equal to 50mV_{pp} sine wave.

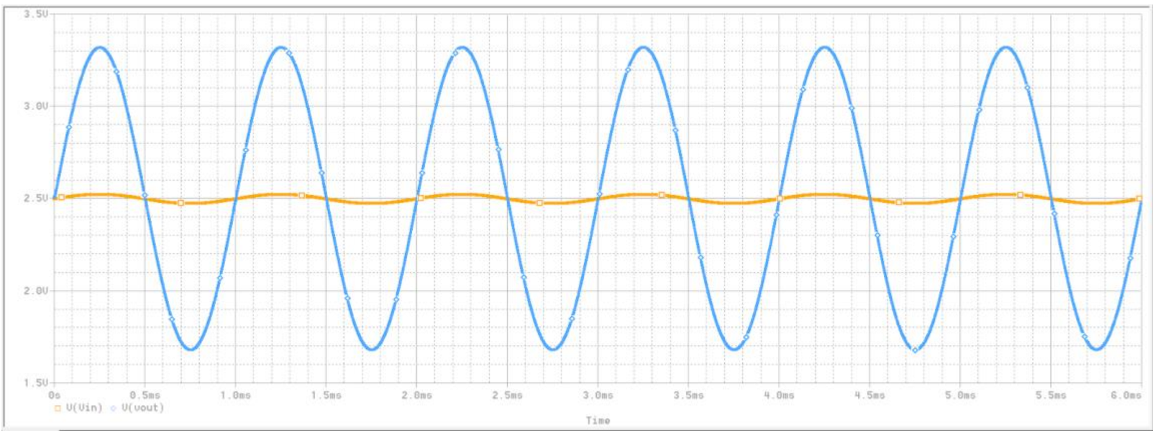

Figure 5. Simulated result with V_{in} and V_{out}

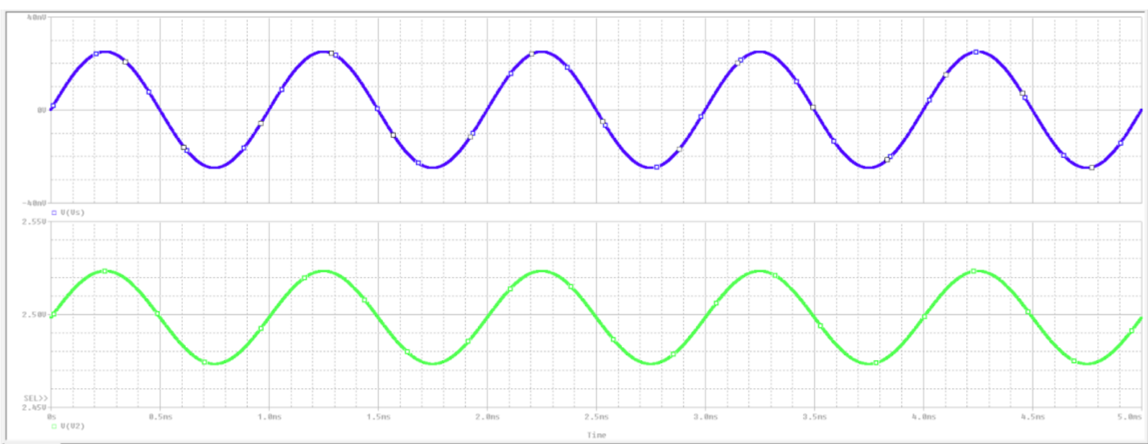
Figure 6. Simulated result for V_s and V_2

From the figure 5, we can see that V_{in} is the orange trace while V_{out} is the blue trace. Comparing the two, we can see how drastically small amplitude for V_{in} which the wave in 2.5V than the V_{out} which the amplitude is approximately 0.8V. On the other hand, the figure 6 showed the plot for V_s which is the indigo trace and V_2 which is the green trace. We can see that the amplitude for V_s is approximately 2.5 mV and V_2 is approximately 2.52 V.

Part3 - Laboratory Measurements

In this part of the laboratory, the student tasked to construct the circuit from figure 1 using an operational amplifier powered from a single +5 volt supply shown in figure 7.

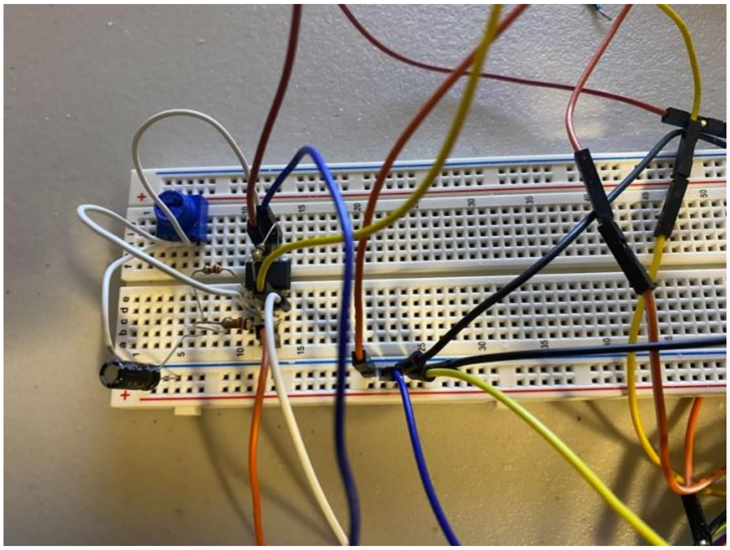

Figure 7. Circuit from figure 1 in breadboard

Using the potentiometer, the student vary V_{REF} over the range 0 to 5V and record the voltages shown in table 1.

Table 1. recorded voltages

V_{REF}	V_{IN}	V_2	V_{OUT}
1.099	1.099	1.099	1.099
1.236	1.236	1.236	1.236
1.931	1.931	1.931	1.931
2.017	2.017	2.017	2.017
2.206	2.206	2.206	2.206
3.413	3.413	3.413	3.413
3.67	3.67	3.67	3.67
4.317	4.317	4.317	4.317
4.769	4.769	4.769	4.769
4.922	4.922	4.922	4.922

In the table above, we found out that all the different voltages are the same. On the other hand, we found out that the V_{OUTmax} = 4.954 V and V_{OUTmin} = 1.001 V. After that, the student added the circuit from figure 2 and adjusted V_{REF} to +3.2V DC shown in figure 8.

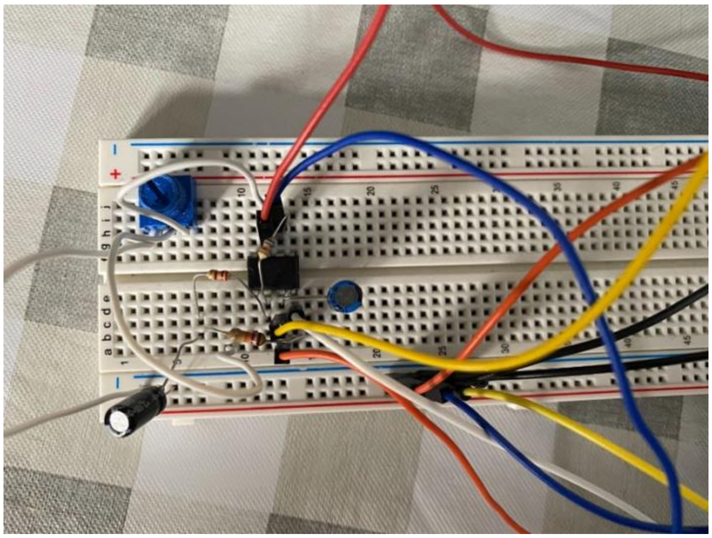

Figure 8. whole circuit with the added part from figure 2.

After, the student applied a triangle wave at V_{IN} at or above the frequency f_{p3} and then observed the V_{OUT} and determined the DC (bias) value for it shown in figure 9.

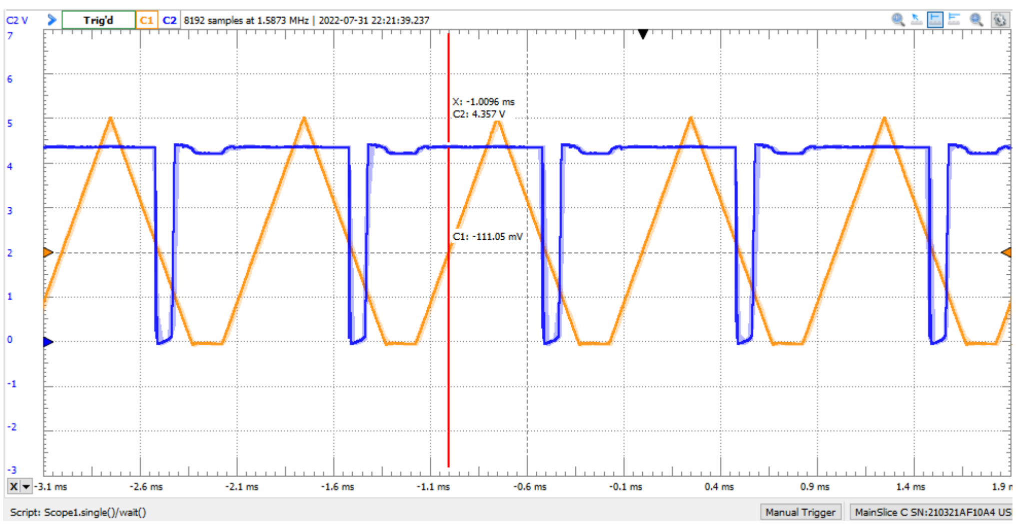

Figure 9. graph when decrease the input signal amplitude

From the graph above, the V_{IN} is the orange color that produced a triangular wave while the V_{OUT} is square-like wave. The student ran into a lot of problem with this as decreasing the signal amplitude for too much results to a line for the V_{OUT} so the graph is still clipped. The student for that the DC (bias value) of V_{OUT} is 4.357 V.

After that, the student increase the input signal amplitude until clipping becomes obvious at both maximum and minimum peaks of V_{OUT} shown in figure 10.

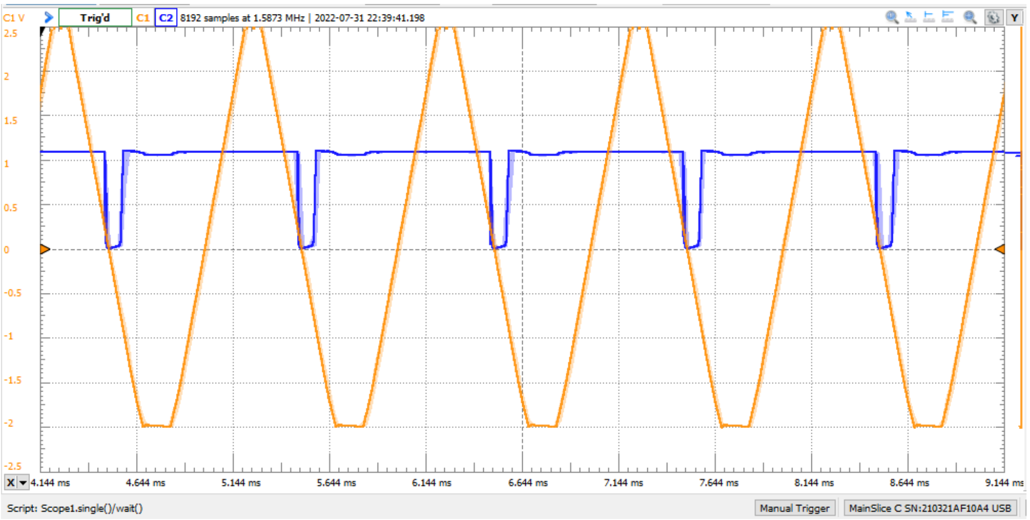

Figure 10. graph when increase the input signal amplitude

In the figure above, the color and figure for V_{IN} and V_{OUT} are the same as the figure 9. However, the V_{OUT} seems a little much smaller compare to the V_{IN}. After that, the student adjusted the V_{REF} as necessary to enable the maximum-amplitude output signal amplitude with no clipping shown in figure 11.

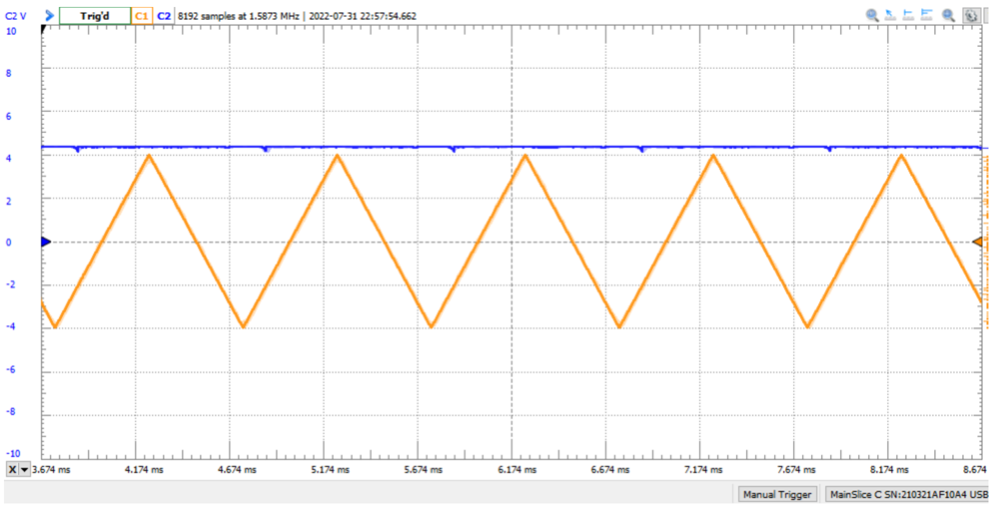

Figure 11. graph enable the maximum-amlitude output signal amplitude

For the figure above, the student was not able to generate a good wave for the V_{OUT} which shown in the blue line. However, we can see clearly the figure of triangular wave for the orange trace.

CONCLUSION:

The laboratory helps the student understand the use of single power supply operational amplifier in which mostly used in modern circuits. An example showed in figure 1 and figure 2 is a perfect example of a single power supply op-amp to work with three different methods: using hand calculations, using a simulation, and building a circuit out of breadboard. With the preliminary calculation, the student find the foundation for the values that will be used in the simulation and actual measurements. After that, the student was able to simulate using the PSpice and run different simulation and investigate the graphs and data results. On the other hand, the student built the circuit the same in figure 1 and added the figure 2. Throughout the laboratory, using a single power supply amplifier is flexible with its functionality and efficiency which is why modern circuit use this type of circuit.

APPENDIX

PRELIMINARY CALCULATIONS

4. $X_C = \frac{1}{j\omega C}$ $\quad X_C = R_1$

$$|X_C| = \frac{1}{\omega C} = \frac{1}{2\pi f C} = R_1$$

$$f = \frac{1}{2\pi R_1 C} = \frac{1}{2\pi(2.2k\Omega)(10\,uF)}$$

$$f = 7.234\ Hz$$

5. $V_{REF} = 2.5V$: $\quad V^+ = V^- = 2.5V$

No, DC current flows through capacitor

6. $R_P = \frac{12}{2} = 6k\Omega$

$$Z_{in} = (6k + 22k)\Omega$$
$$= 28\,k\Omega$$

PART 2 - SIMULATION RESULTS

4. $f_{P2} = \frac{1}{2\pi C_{IN} R_B}$ $\quad C_{IN} = 10\mu F \quad R_B = 22k\Omega$

$$f_{P2} = \frac{1}{2\pi(10\mu F)(22k\Omega)} = 0.7234\ Hz$$

5. $f_{P3} = 100(f_{P1} + f_{P2}) = 100(7.234 + 0.7234)Hz$

$$= 795.74\ Hz$$