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ECE210 Lab 5 Report
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Introduce and define concepts

Buffer Amplifier - Serves as an interface between two circuits with different impedance levels, and helps maintain the signal as it passes from one circuit to another.
https://www.electricity-magnetism.org/buffer-amplifiers/

Inverting Amplifier - An op-amp circuit with a negative gain, due to its function inverting the input (switching signs) as its output.
https://www.utmel.com/blog/categories/amplifiers/what-is-an-inverting-amplifier

Summing Inverter Amplifier - An inverting amplifier circuit with multiple inputs connected in parallel.
https://www.electrical4u.com/summing-amplifier/

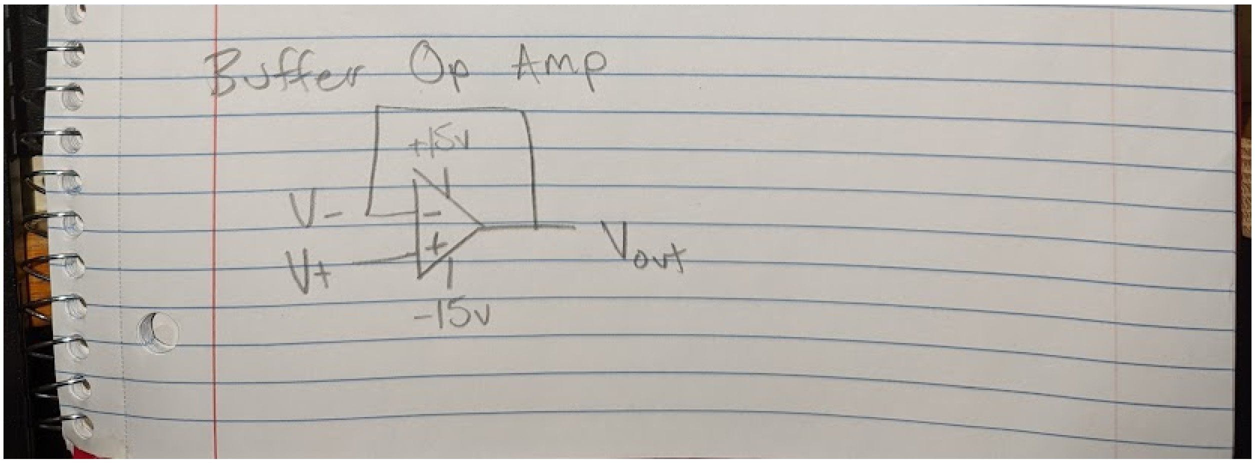
Open loop gain - The total gain of the Op Amp circuit
Closed loop feedback - The gain of a negative feedback circuit. This is usually not device specific.
https://toshiba.semicon-storage.com/us/semiconductor/knowledge/faq/linear_opamp/what-are-open-loop-and-closed-loop-gains-of-an-op-amp.html

Motivation for experiment

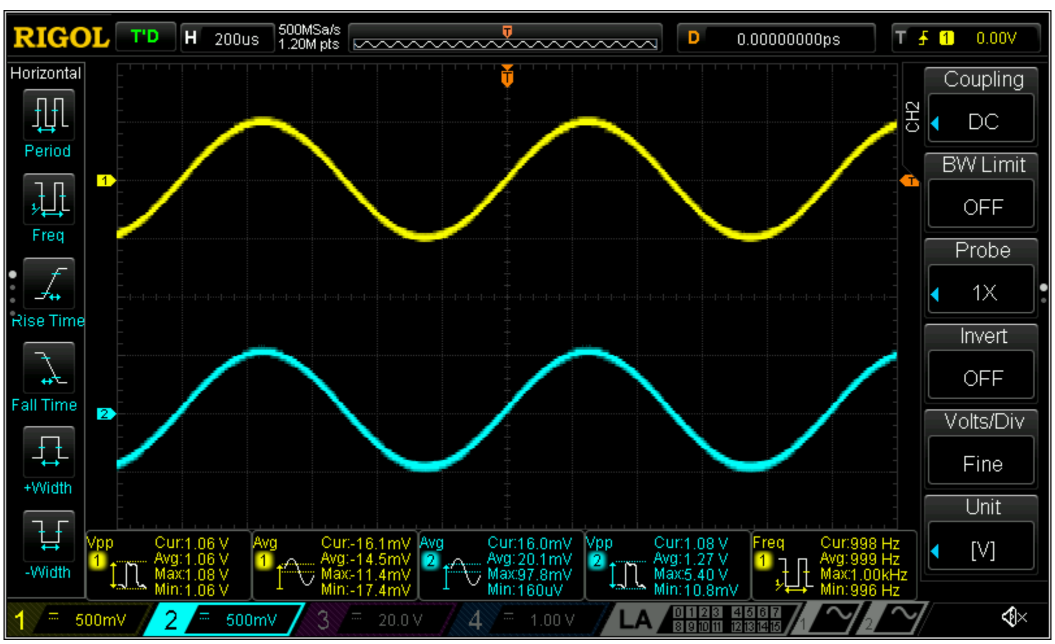
In this lab, we are working and experimenting with different Op-Amp circuits. These include the Buffer Amplifier, the Inverting Amplifier, and the Summing Inverter Amplifier. (defined above) In order to experiment with each of these circuits, we must configure our breadboard to match the instructions provided in the lab. If done correctly, we will have a working Op-Amp circuit in which we can measure the voltage and current passing through. More specifically, our focus is to measure things like Voltage gain, the inputs of circuits, and their outputs. Being more hands on and seeing the values will help us understand more about these specific circuits.

BUFFER AMPLIFIER

1 - Experimental diagram



Plot of Buffer Amplifier



Analysis

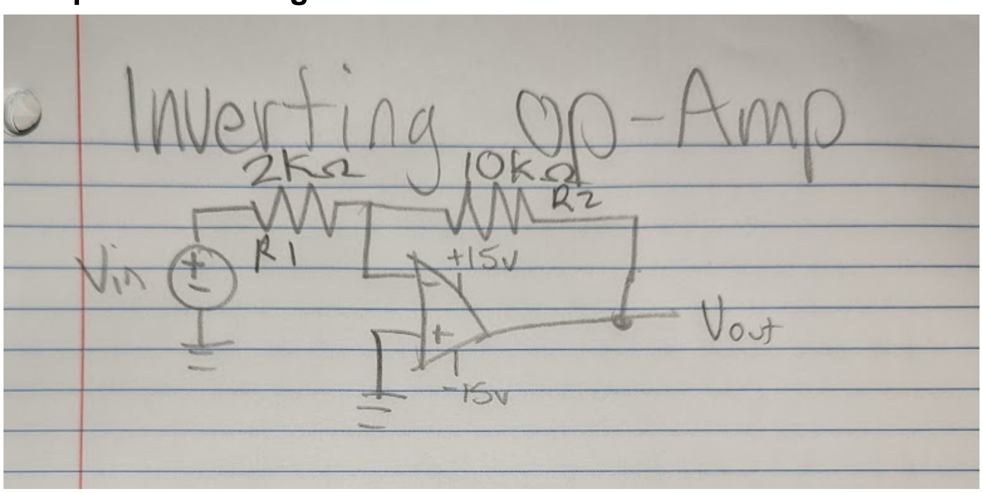
Calculation - $Vout \ = \ V+ \quad --> \quad Vout \ = \ 1.08V$

% error = (1.06-1.08)/1.08 * 100 = 1.85%

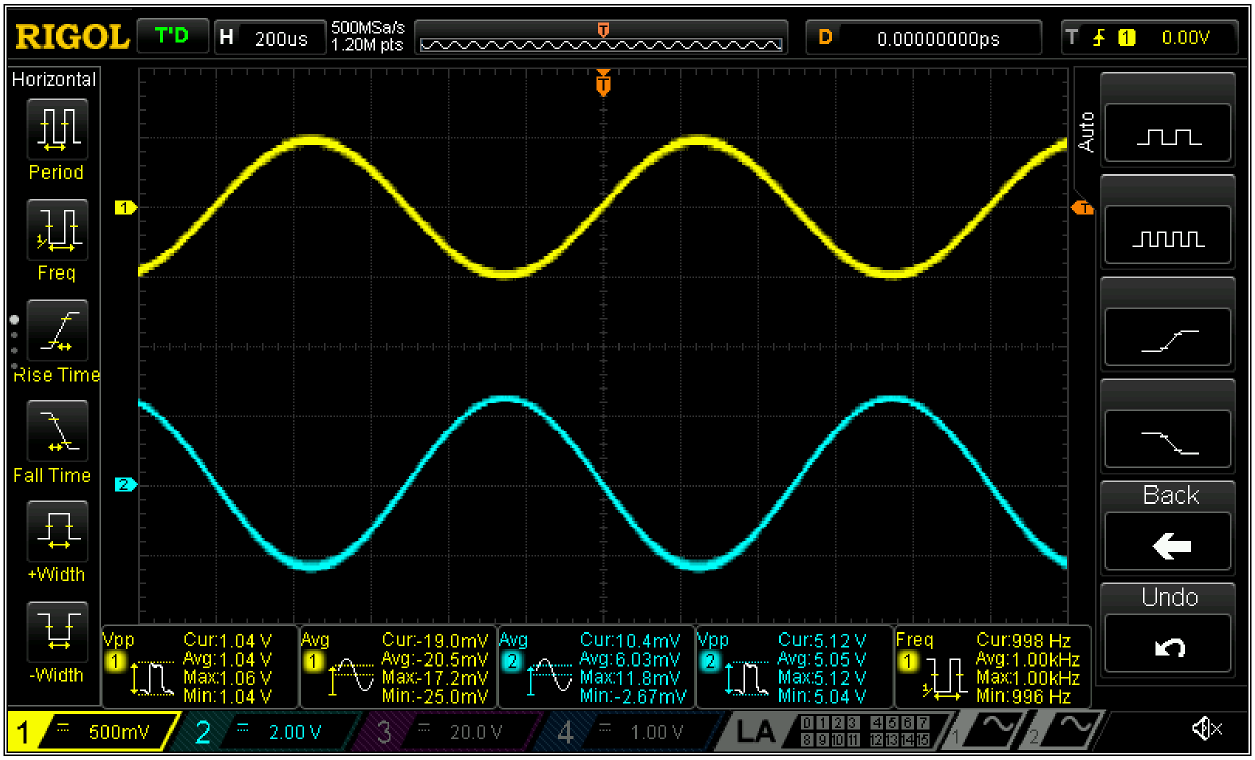
Here, the input(blue) and the output(yellow) are portrayed. From observation, we can see that these sinusoidal waves appear identical, which is expected in a Buffer Amplifier. The input Vpp reads 1.08V, and the output Vpp reads 1.06V. These values are not EXACT, but they are very close. This small margin of error (1.85%.) could result from a loose connection in the circuit, or just resistors not being exactly the correct resistance which caused the voltage drop. Nonetheless, these measurements support the claim that the input and output should be identical in a Buffer Amplifier.

INVERTING AMPLIFIER

2- experimental diagram



Plot of inverting amplifier



Analysis

Calculation - $Vout = \frac{-R2}{R1} \times Vin$ $-->$ -10k/2k * 1.04 = -5.2, Vout = 5.2V

Voltage gain $\rightarrow \frac{Vout}{Vin} = \frac{5.12V}{1.04V} = 4.92x\ gain$

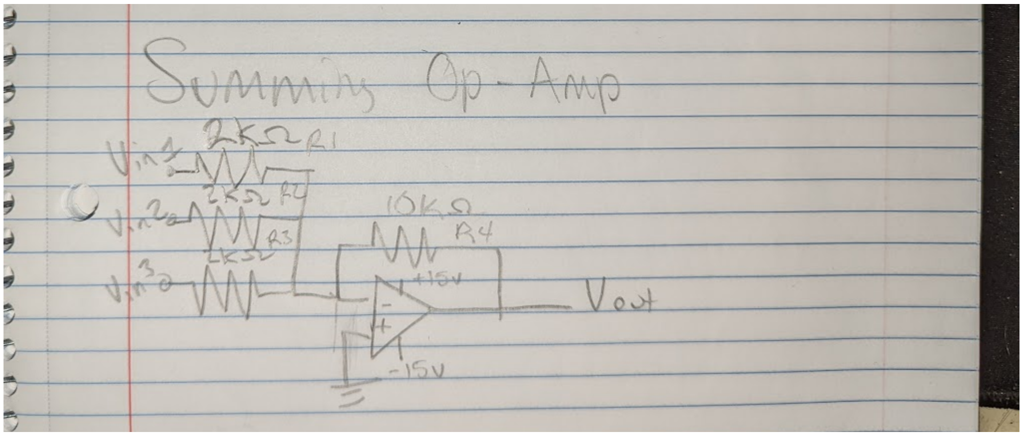
% error Vout = (5.12-5.2)/5.2 * 100 = 1.5% error

% error Gain = (4.92-5)/5 * 100 = 1.6% error

Both the input(blue) and output(yellow) are displayed in the plot. By observation, it is clear to see that these waves are reflections of one another. This display would make sense, as the circuit we were working with was an INVERTING Amplifier. The oscilloscope measures the input voltage at 5.12V, and the output voltage at 1.04V. Our percent error of 1.5 % falls within expected, considering the resistors not being exactly the correct resistance. Our estimated gain of 5x is very close to the measured value of 4.92, yielding a percent error of 1.6% which is exactly as expected, seeing as our Vout % error is about the same, the error would come from the same resistors

SUMMING INVERTING AMPLIFIER

3- experimental diagram



Plot of summing inverting amplifier

Analysis

$$Vgain = \frac{Vout}{Vin} --> \frac{14.2V}{1V} = 14.2x\ gain$$

Theoretical gain = -R4(Vin1/R1 + Vin2/R2 + Vin3/R3) = -10k(1V/2k + 1V/2k + 1V/2k) = 15x gain
% error = (14.2-15)/15 * 100 = 5.33 % error

Again, this plot accurately represents the signals of a summing inverter amplifier because the output wave is the inverse of the input wave. From the oscilloscope, we can see that the input voltage is 1V, and the output is 14.2V, comparing this to our theoretical gain, we get an error percentage of 5.33 which is a little high, but not unexplainable, the errors in each of the resistors again can stack up and cause a value that differs about this much from perfect.

Conclusion

Overall our experiment was a success, we demonstrated the various ways that you can use an operational amplifier to modify the output voltage. The three ways we covered included a Buffer Amplifier, Inverting Amplifier, and Summing Inverting amplifier each serving their own unique functions:
The Buffer amplifier can be used to maintain signal integrity when transferring output from one circuit to another
The Inverting amplifier, just as the name suggests, inverts the signal, in this configuration it also amplifies the output. This is useful in applications where you need to reverse a signal
Finally, the Summing inverting amplifier gives an easy way to add inputs together and combine them into one signal, this is useful where you need to combine signals together.
The discrepancies are within range or error as we would expect. The average resistor has a resistance variance of about 10% so in each of our experiments we remained below that threshold, for buffer amplifier we had a % error of 1.85%, for inverting amplifier we had a percent error of 1.6% and for summing inverting amplifier we had an error of 5.33%, all well within the 10% variance coming just from the resistors.
This lab was successful in showing us the intricacies of Op-Amps and their wide range of useful functions.