ECE 311, ELECTRONIC CIRCUITS

LAB 1: opertaional amplifer

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1 Problem or objective

The objective of this lab is to show that we have studied the different aspects or characteristics of the operational amplifier. The fundamental amplifier building blocks using commercially available operational amplifiers are inverting, non-inverting, and voltage-follower. In this lab, we will go over the operational amplifier in great detail, from the schematic diagram to an analysis of the operational amplifier.

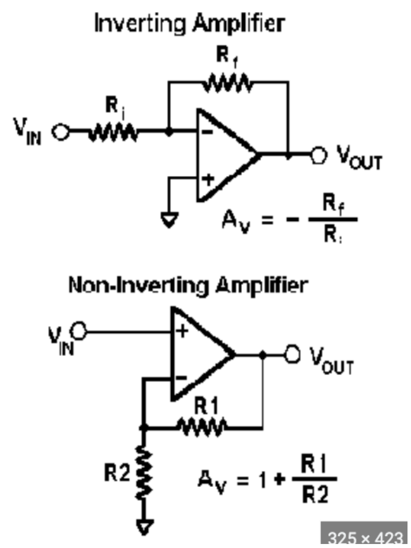
2 Abstract

We used online software called LTI Spice, which has how-to videos on YouTube. This software has allowed us the opportunity to investigate an operational amplifier with an inverting amplifer, another with a non-inverting amplifer, and the final circuit with a voltage follower. The simulation just demonstrated the effects of a different amplifier on the circuit or input signal. We avoid simulations because they can be misleading, so we had to perform an actual lab to verify our findings from the simulation and compare them.

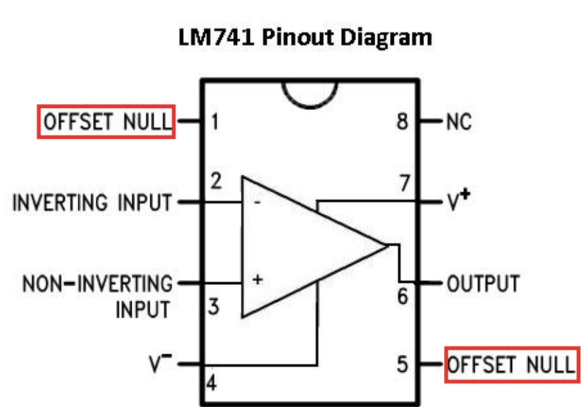
3 operational amplfiers background

An operational amplifier is an integrated circuit (IC) that amplifies the difference in voltage between two inputs. There are rules associated with using an operational amplifier such that there will be no current entering either input of the opamp. Second, the difference between the inputs will be zero because there is no current in them. An open circuit will provide a very large gain for the operational amplifier. The open loop gain of an operational amplifier, or op amp, is the output voltage divided by the difference between the noninverting and inverting inputs of the amplifier, as shown in equation 1. The typical gain of an op amp ranges from 104 to 105 or higher. It's also critical to note that an open-circuit operational amplifier will not have any feedback because the circuit is an open circuit, thus there is no feedback.

the Amplifier gain is simply the ratio of the output divided-by the input. Gain has no units as its a ratio, but in Electronics it is commonly given the symbol "A", for Amplification. Then the gain of an amplifier is simply calculated as the "output signal divided by the input signal".The amplifier gain is the output divided by the input ratio. Gain has no units; it is simply a ratio of output voltage to input voltage. In order to manipulate the gain, negative feedback can be given via two resistors, R3 and R4. These resistors are placed in a closed loop with amplification from the output to the input signal. This will allow a small amount of current to be received via the input again.



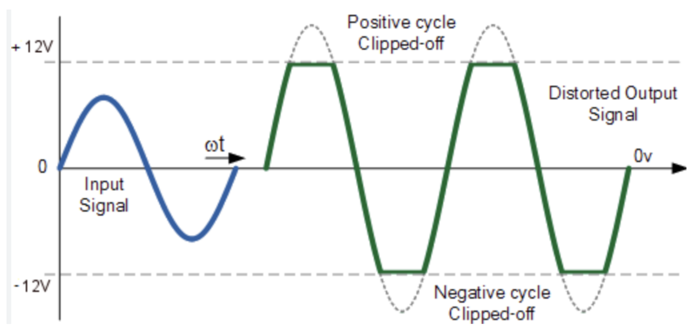
as you can see I have included a photo illustration demonstrating the inverting and non inverting gain.



I have also included the 741 operational amplifier circuit configuration tables. These were very important in identifying how to use them in the lab. As you can see, the terminals are labeled as follows: channel 1 is the offset, channel 2 is the inverting terminal, channel 3 is the non-inverting terminal, channel 4 is the negative power source, and channel 5 is the offset null. Six is the output terminal, seven is the positive voltage, and finally eight is the not connected (NC).

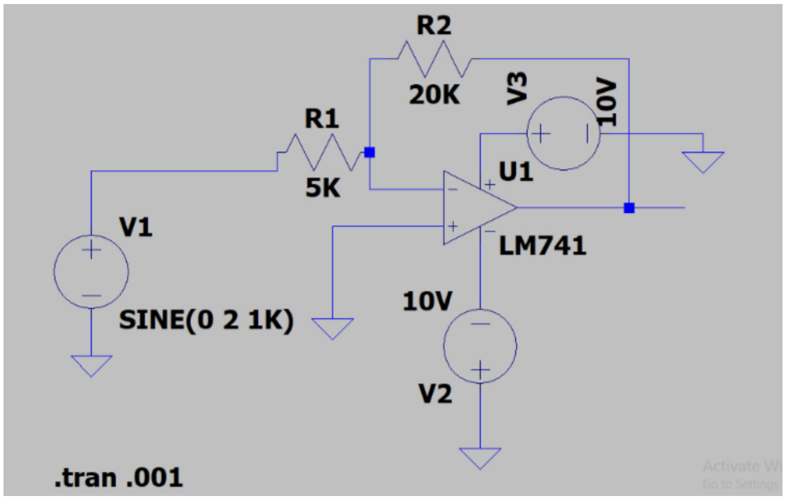
The main feature of the operational amplifer's circuit configuration is that if the power source is connected to pin 2, the signal will be inverted; if it is connected to pin 3, the signal will not be inverted and will follow the non-inverting gain.

If the voltage going inside the operational amplifier is not within the range of the input signal, this would result in clipping. Clipping is a form of wave distortion that occurs when an amplifier circuit is overdriven and attempts to deliver an output voltage beyond its maximum capacity. below is the illustration about clipping.

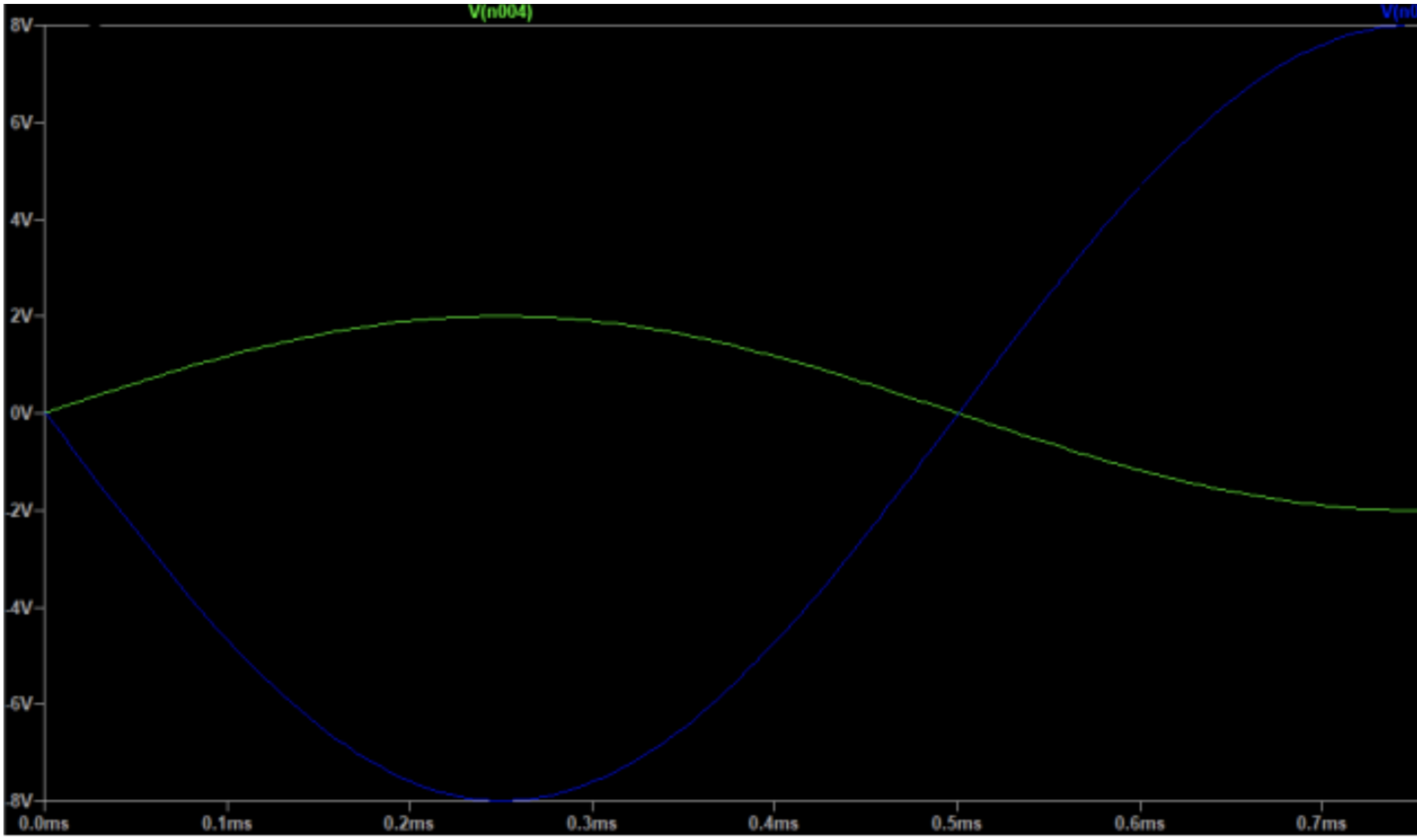


4 simulation

In the beginning of the simulation, we created an inverting operational amplifier that would output an inverting voltage four times the input voltage. Below is the schematic diagram of the first part of the simulation.

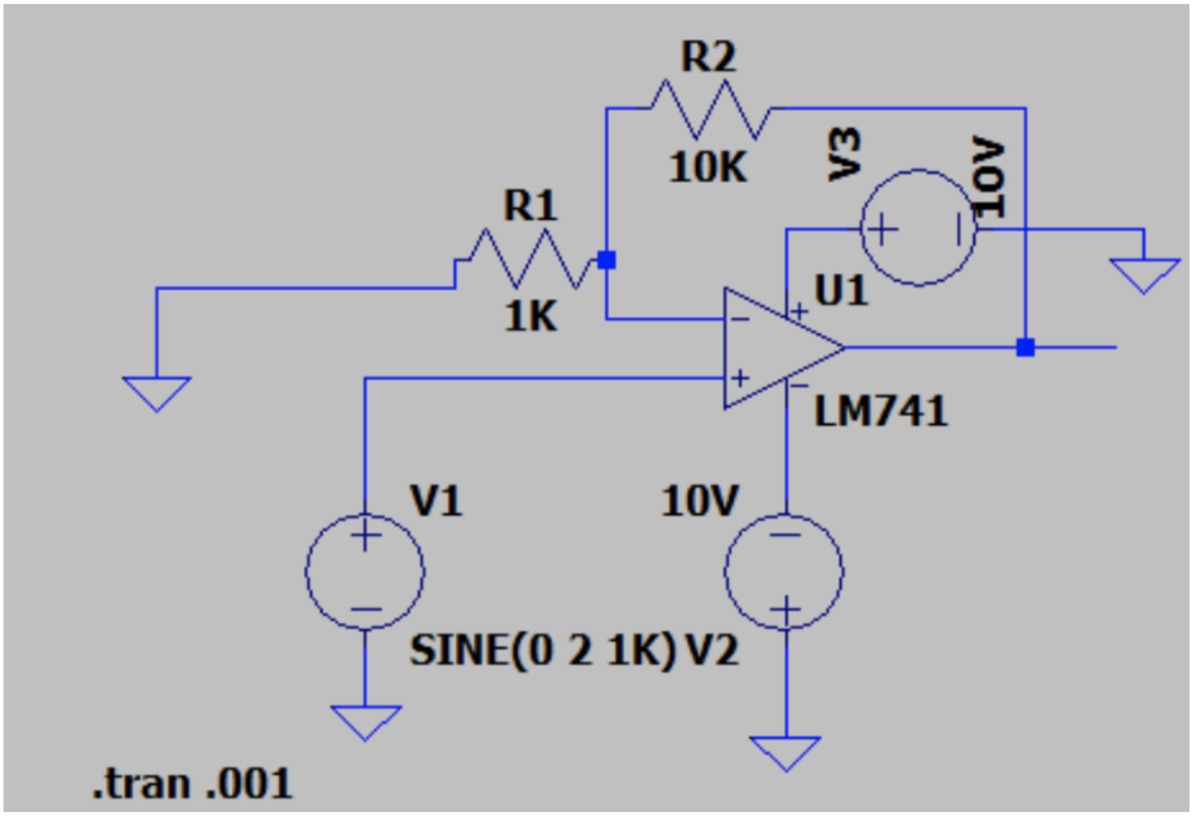


As seen in the graph, the output voltage is inverted and multiplied by four times the input voltage; the input voltage is green, while the output voltage is blue. You can verify that it is 4 times as large because 2*4 = 8, the input signal was 2, and the output signal was 8.

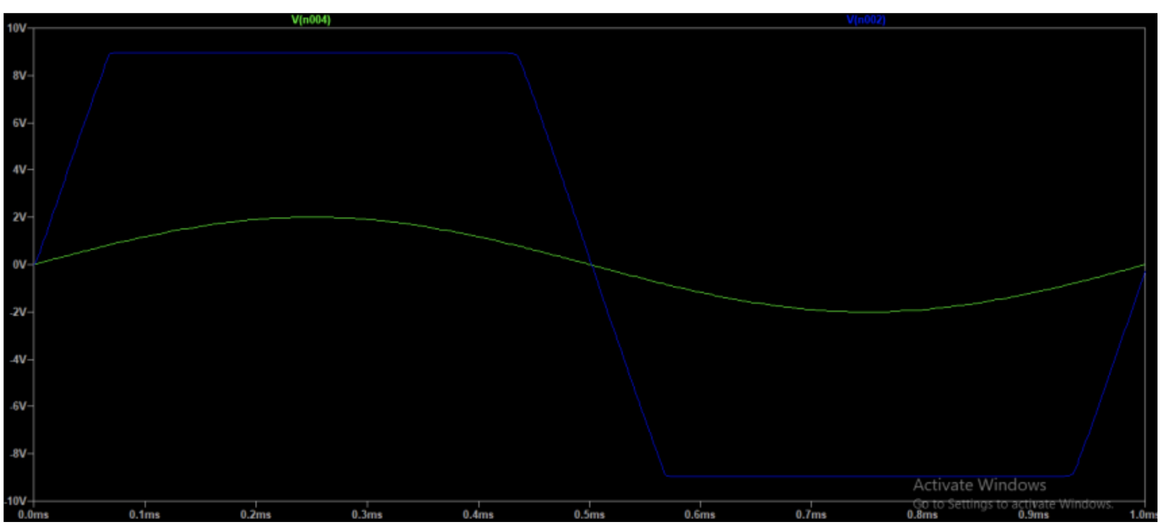


note, I do realize that my simulation chart geos of the page, but I really need to emphasis the blue line since it is not very clear.

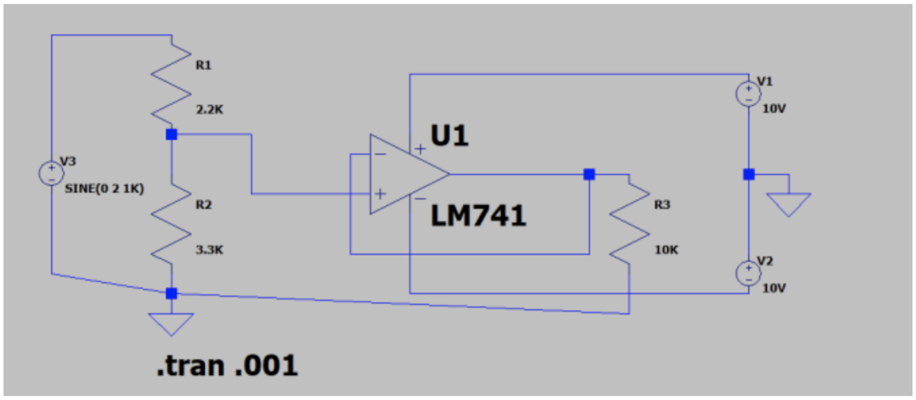
In the next part of the simulation, we output a voltage source that was about ten times greater than the input voltage. We have included the schematic below.



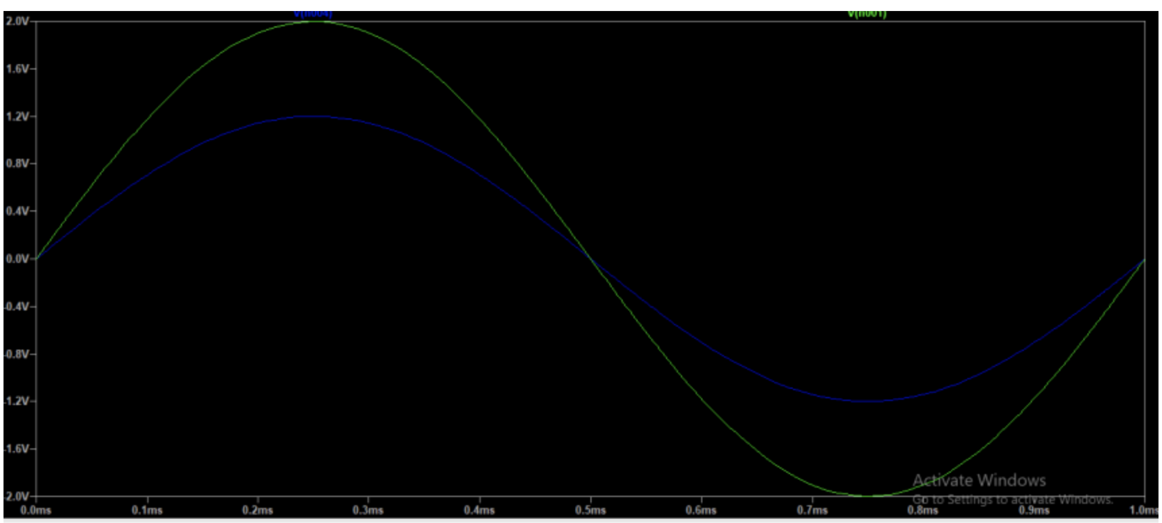
as you can see below the simulation graph have been cut off, thus their is no data above 9v, due to the clipping.



For the next part of the simulation, we have created a voltage follower that will output a voltage equal to Vr2.

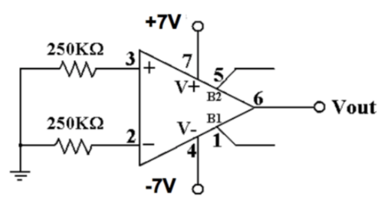


below is the waveform of the schematic noted above.



5 lab exeperment

The first part of the experiment required us to actually measure the resistance and then wire the circuit as shown below using the breadboard. Note that we have grounded the operational amplifier. I was confused about providing the operational amplifier with the +/- 7-volt power supply. We then had to collect the data using a multimeter. Below, I have also shown a figure from my notes calculating the offset current DC.



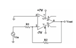
We measured the top and bottom resistors: R1 = 194 (top r = 11.83 mVmV,esistor) and R2 = 196 (bottom resistor). We then found the voltage across r1, which was R1=-11.83mv. and the voltage across r2=11.83 v.

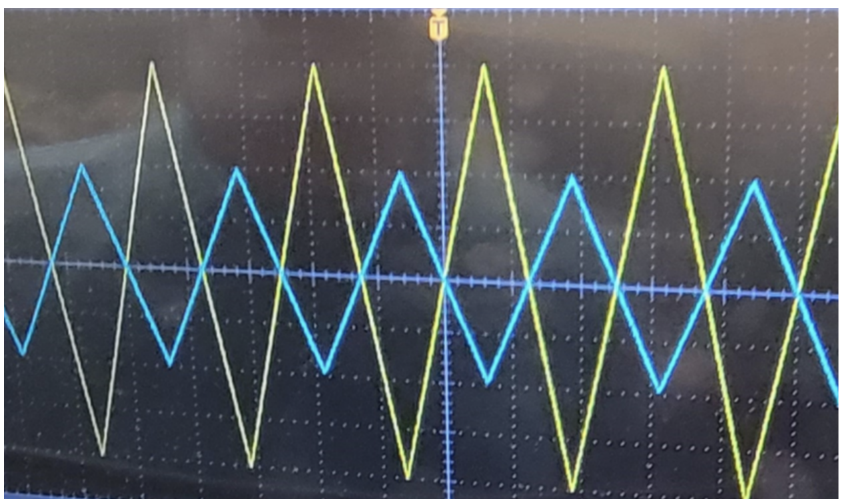
$$I = \frac{V}{R}$$

$$It = \frac{-11.83mv}{194\,k\Omega} = -5.15 * 10^{-8} A$$

$$Ib = \frac{11.83mv}{194\,k\Omega} = 5.15 * 10^{-8} A$$

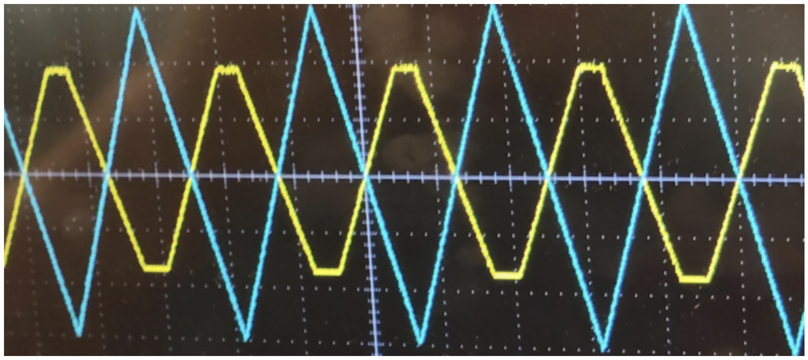
For part 2, we used the same setup but with R1 = 5 kohms and R2 = 20 kohms. We had to measure and write down the actual voltage of the resistor. We provided the op amp with +10 and -10 volts, and we then had to use the signal generator to check the waveform of the output voltages. The oscilicope had assisted us in comprehending the waveform's detailed information. We did the same thing after increasing the input voltage to +3 volts.





So the above graph shows us providing the operational amplifier with a voltage of +/-7 volts. The professor taught us how to provide the operational amplife of -7 volts. I measured the output coming out of pin 6, and have included the above graph to show what would happen.the yellow line is the output, abd blue line is the input. Vin was 1v, while the vout was about 4 times greater then the input. thus you can notice the gain is 4A.

The lab then asked us to increase the voltage to 3 volts. The gain was 4, the output had to be 4 times the input, which is 3, the output was about 12 volts, and the VC is configured to +/- 10 volts. Thus, we have noticed some clipping being done. The yellow line, on the other hand, was decalered with a value of 15 volts because it is five times as long.



6 Disussion of results

The measured input of the output current in Part 1 was 9.11 nA, while the data sheet of the op amp said that the maximum input was 200 nA.So the input current was within the range of the offset current for the op amplifier. I believe if the input current was higher than 200 nA, then the output amplifier would be fried.

The waveforms that I have received in this experiment demonstrated the design of the transient; for example, in Part 1, we saw a voltage graph versus time within the inverting configuration. The inverting configuration showed the voltage being inverted. On the other hand, the voltage follower showed two voltages: the closed voltage and the open voltage gain. These two voltages were very similar; they lagged a bit, and I believe that's why they were named voltage followers.

Not it Is it possible to get a gain of less than 1 using a non-inverting amplifier? Because the gain formula is Vout/vin = 1 + (R2/R1), the gain will never be less than 1. This is due to the non-inverting op amp's ability to produce an amplified signal that is in phase with input.

7 Conclusion

We have learned a lot about operational amplifers and their characteristics as foundation amplifier building blocks using commercially available operational amplifers. We used three types of op amps in this lab experiment: inverting, non-inverting, and voltage follower.