ELEC 244
Lab 1 - Op-amps

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John Doe, Mary Smith

1 Objective

In this lab, we worked on understanding the workings of both breadboards and Op-Amps. We learned how to wire and set up a breadboard for future use, a well as initialize an Op-Amp in your circuit. Experimental values were compared to calculated ones through the use of the oscilloscope. We learned how to create an inverting amplifier and how the values are gated by the DC offset as well as the power supply. Fiially,zen preparation for the lab next week, we assembled a circuit containing two microphones and a speaker in order to transmit and amplify external signals coming in the form of audio waves.

2 Materials

- Breadboard
- 741 Op Amp
- NI Virtual Bench
- $10\,\Omega$ Resistor
- $100\,\Omega$ Resistor
- $10\,\mathrm{k}\Omega$ Resistor (2)
- $100\,\mathrm{k}\Omega$ Resistor
- $0.1\,\mu\mathrm{F}$ Capacitor
- Dynamic Microphone
- Telephone handset

3 Test Description

3.1 The 741 Op Amp

After learning about the Op Amp, we compared open and closed loop configurations, and understood the concepts of DC offset amplification and clipping. By creating simple circuits in this format, we familiarized ourselves with the pins on the 741 Op Amp, and creating functional circuits that would not blow out the device.

3.2 The Inverting Configuration

In this smaller section of the lab, we focused on the functions of closed loop inverting amplifier configurations of the Op Amp. We learned about topics such as clipping and the slew rate, and how the internal properties of the Op Amp effect the output signal in comparison to the expected output.

3.3 Transducer Amplifiers

As the name implies, in this section we used what we knew about Op Amps to create an amplifier that worked on the audio signals created by a dynamic microphone. These signals were first viewed by the Virtual Bench, until the voltage was amplified to an acceptable level. Then, this circuit was attached to the circuit for a phone handset, to show that the Op Amp amplified the audio signal as well.

3.4 Pre-Lab Calculations and Schematics

Before the lab, there we no calculations to be done, just some setup for the breadboard. To power all of the terminals we needed to set up the power bus, by connecting it to all 3 of the power rails as seen in Fig ??. After the power was properly connected, we noted the proper connections for the Interface Board connectors, which would be needed in the lab.

4 Results and Discussion

After setting up the Op-Amp into an open-loop response configuration in Part A for Experiment 4.1, we produced a 2 V_{pp}, 20 Hz sine wave. We measured the voltage output from the Op-Amp and observed a max voltage of 14.4 V and a minimum voltage of -13.6 V. We then connected a 100 Ω resistor between v_{OUT} and ground. This caused the voltage to drop dramatically because the resistor itself has a significant voltage drop. We now observed a max voltage of 3.12 V and a minimum voltage of -1.64 V. After removing the 100 Ω resistor, we set the function generator to produce a square wave of the same frequency. We observed that v_{OUT} becomes a square wave as well. We also noted some slew-rate limiting, where the slope of v_{OUT} does not change as quickly as v_{IN} when switching between high and low voltages. Furthermore, we noticed that v_{OUT} exhibited 0.79V of DC offset despite the fact that the function generator was set to 0 DC offset. We hypothesized that this DC offset arises from the Op-Amp affecting the input voltage so that it is not perfectly magnified, thus yielding a nonzero DC offset.

Overall, using an open-loop response configuration is not ideal due to the fact that distortions in the circuit are highly magnified. For example, the small DC offset in the Op-Amp was magnified to nearly a full volt, which caused clipping in the output signal (where the larger amplitude portions of the signal are cut off due to the limitations of the Op-Amp's power supply.)

We then built an inverting amplifier in Part A of Experiment 4.2 using 10 $k\Omega$ resistors for R_1 and the feedback resistor R_F. We then set the function generator to produce a 1 V_{pp}, 100 Hz sine wave and observed the following output from CH 2 in Fig 1.
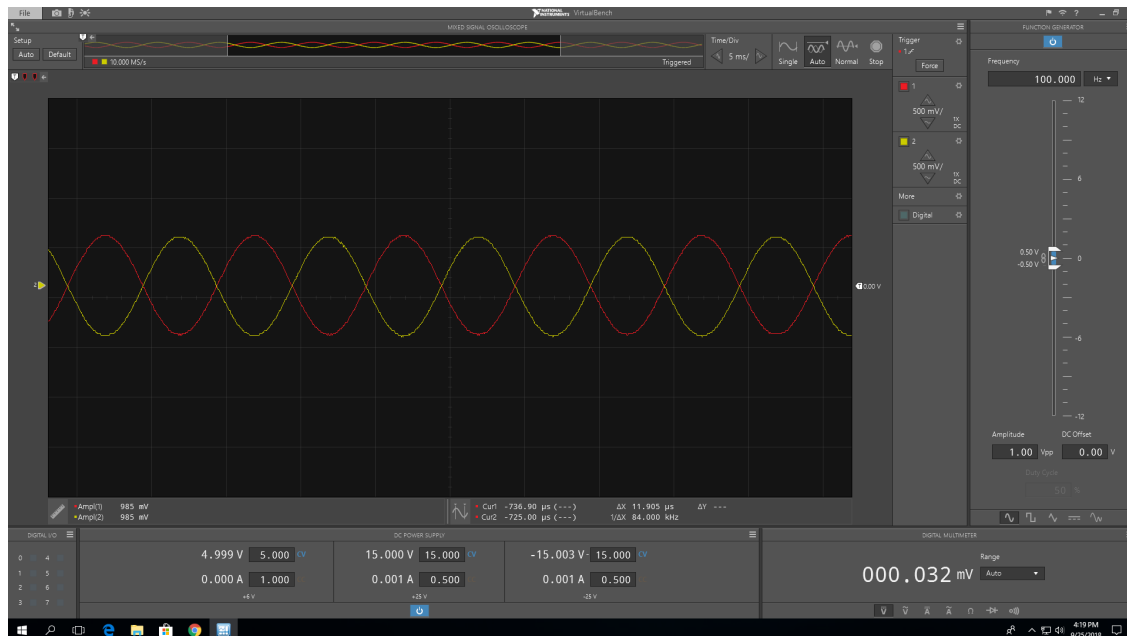

Figure 1: OpAmp Output in Response to 1 V_{pp}, 100 Hz sine wave

We then replaced the 10 $k\Omega$ resistor with a 100 $k\Omega$ resistor. The gain then became approximately 10 because $\frac{R_F}{R_1} = \frac{100k\Omega}{10k\Omega} = 10$. We then started to increase the amplitude of the input and noticed that clipping

began to occur when $|V_{IN}| = 3$. This is the same amplitude as Experiment 1.1 because we didn't change the power supply to the Op-Amp; thus, the op-amp is limited to a 30 V range ($+=15$ V).

We then reduced the input amplitude so that $|V_{OUT}| = 20V$. We then began to increase the input frequency. We noticed that the peak-to-peak voltage of v_{OUT} decreased to 10 V at 33 kHz.

We then set the function generator to produce a triangle and a square wave. We observed that the output to the triangle wave was also a triangle wave with no DC offset. However, when we inputted a square wave, we observed a 4V DC offset on the output (the waveform was square as well).

5   References

https://www.ece.rice.edu/ dpr2/elec240/lab4/

6   Conclusion

6.1   4.1: The 741 Op Amp

6.1.1   Part A: Powering Up the 741 Op Amp

The first part of this lab was simply connecting the Op Amp to the breadboard and understanding the pins on the Op Amp. The

7   Errors

Your text here

Note (To be deleted): Briefly list sources of error and discuss how to eliminate or deal with them