R·I·T

Kate Gleason
College of ENGINEERING

EEEE 281 Experiment 4: Operational Amplifiers

From: Your Name (edit) [Department (edit)]
To: Section X (edit) TA: [edit]
Date: Performed: (edit) Due: (edit)
Subject: Lab 4-Operational Amplifiers
Lab Partner(s): (edit)

Component	Percentage of Grade	Score	Comment
Report Formatting	20 %		
Hand Calculation: Inverting Op-Amp	5 %		
Hand Calculation: Non-Inverting Op-Amp	5 %		
PSPICE: Setup Conditions	5 %		
PSPICE: Data and Figures	10 %		
PSPICE: Discussion of Simulation	15 %		
Hardware: Experimental Setup	10 %		
Hardware: Experimental Data and Tables	10 %		
Hardware: Discussion of Results	20 %		
Total Score:			
Graded By:			

Abstract

The abstract section should contain a summary of what was performed in the lab and should be approximately 200 words. This should succinctly rephrase the purpose of the laboratory. It should also refer to the data collected. How many circuit topologies were investigated (2 in this lab)? What theory/data is observed for each circuit (Vin/Vout,V+/V- gain)? Was clipping observed? What voltage did it occur at?

1 Introduction and Theory

Include 1 paragraph that explains the scope of the experiment. Briefly introduce the concept of Operational Amplifiers. What was the primary purpose of the experiment? What are the standard current and voltage made for Op-Amps? Include a figure of the OpAmps; for simplicity you may use your PSPICE schematic with both OpAmps.

Figure 1.0.1: Schematic diagrams of the inverting (right) and non-inverting OpAmps used in this report. This graphic is the PSPICE schematic capture.

If the data collection has deviated in any way from the rest of your section (for example you had to come back to collect more data), explain this in a second paragraph. In particular, be sure to note if your data was acquired from a different lab than your classmates/using different equipment.

1.1 Hand Calculations: Inverting Op-Amp

- Show the key steps in the derivation of the inverting Op-Amp's gain, using proper citations to the text/course notes/etc.
- With a short discussion in text, justify the selection of the input resistor and feedback resistor to achieve the gain specified in the laboratory handout. Record the values in Table 1.1.1

Table 1.1.1: R_1 and R_f selection for the Inverting Op Amp

.

R_{in} (Ω)	R_f (Ω)

1.2 Hand Calculations: Non-Inverting Op-Amp

- Show the key steps in the derivation of the non-inverting Op-Amp's gain, using proper citations to the text/course notes/etc.
- With a short discussion in text, justify the selection of the input resistor and feedback resistor to achieve the gain specified in the laboratory handout. Record the values in Table 1.2.1.

Table 1.2.1: R_1 and R_f selection for the Non-Inverting Op Amp

.

R_{in} (Ω)	R_f (Ω)

1.3 Theory: PSPICE Simulation Summary

Begin by providing a 1 paragraph description of the PSPICE setup. Was a DC simulation used, transient simulation, etc.? Which **libraries** and **PSPICE elements** were used in the simulation? You can borrow from the text of your first tech memo here. If you do so, please be sure to cite the tech memo. Note the libraries used. You can find the information when you look at the properties of each element. There will be a reference to a ".olb" file. This is the library name.
Include a description of the Vsin supply that was added to the circuit. Specifically idenitify the values of the DC Offset, VAMPL, and, frequency selected. Explain the settings used for the transient simulation. What was the **Run to Time** value chosen to be (Note that the handout for Spring 2018 demonstrates the RunToTime parameter-how is it related to the frequency)? Why?

1.3.1 PSPICE Simulation: Inverting OpAmp

- Show the transient simulation for the inverting OpAmp
- Make sure that the input and output waves are clearly visible.
- Make the linewidth of each plot thick and clearly visible. The gain should be listed as an extracted value per the handout's tutorial.
- The figure caption should include: (i) the type of circuit (inverting opamp), (ii) the values of R1 and Rf, (iii) the peak to peak voltage of the output wave, and (iv) the resulting gain. Please edit the figure caption below.
- **A short discussion (3 sentences) of the figure should be included, tying it back to the hand calculations.**

Figure 1.3.1: Transient simulation of the inverting OpAmp. The input wave had a peak-to-peak voltage of XX, the output wave had a peak-to-peak voltage of YY, and the gain was ZZ.

1.3.2 PSPICE Simulation: Non-Inverting OpAmp

- Show the transient simulation for the non-inverting Op Amp
- Make sure that the input and output waves are clearly visible.
- Make the linewidth of each plot thick and clearly visible. The gain should be listed as an extracted value per the handout's tutorial.

- The figure caption should include: (i) the type of circuit (non-inverting opamp), (ii) the values of R1 and Rf, (iii) the peak to peak voltage of the output wave, and (iv) the resulting gain. Please edit the figure caption below.
- **A short discussion (3 sentences) of the figure should be included, tying it back to the hand calculations.**

Figure 1.3.2: Transient simulation of the non-inverting OpAmp. The input wave had a peak-to-peak voltage of XX, the output wave had a peak-to-peak voltage of YY, and the gain was ZZ.

2 Hardware Experiment: Results and Discussion

This section of the report should present what was done in hardware. A reader should be able to recreate an experiment from the detail present. One section discusses the equipment used in the experiment. The remaining sections discuss the results for each circuit.

2.1 Equipment Used in the Laboratory

Write a short paragraph to detail the equipment used in the laboratory, and specific model numbers. Ideally, you should create a table of the equipment which should be referred to in text (See Table 2.1.1 as an example). The room location where the experiment was performed should be included. Note that this should be a part of all Tech Memos, as it is an essential piece for other users to replicate your experiment. **As you will be likely using the same equipment throughout the term, once the text/tables are established, you may reuse the information with the permission of your instructor/TA. Again, cite your first lab report as a reference.**

Table 2.1.1: Equipment/Software required for Lab 4.

Item	Tool	Room
Simulation	OrCAD Capture CIS	All Open EE Labs
DC Power Supply	Agilent E3630A	09-3170
DC Power Supply	Agilent E3631A	09-3200
Multimeter	Agilent E34401A	09-3170, 09-3200
Waveform Generator	Agilent 33120A	09-3170, 09-3200
Oscilloscope	Textronix TDS2012C	09-3200
Oscilloscope	Agilent DSO 3102A	09-3170

2.2 Hardware Results: Inverting Operational Amplifier

- Include a figure showing the Oscilloscope trace for the inverting Op Amp at the Vin and Vout. Make sure the peak to peak voltage is labeled Make sure that the plot clearly shows the date that the picture was taken. Also, edit the caption below.

Figure 2.2.1: Oscilloscope trace of the inverting OpAmp. The input wave had a peak-to-peak voltage of XX, the output wave had a peak-to-peak voltage of YY, and the gain was ZZ.

- Include the measurements for V+ and V- in the table. These likely were measured on the oscilloscope as the peak-to-peak voltage measurements of the noise (since they will be close to 0). They should have been on the order of 10's of mV.
- Include measurements of the resistors used in the lab
- Include the gain.
- Summarize the results in Table 2.2.1.
- Show an oscilloscope plot that illustrates clipping in the circuit. In the figure caption, list the value of the input voltage resulting in clipping. Also, edit the caption below.v

Figure 2.2.2: Oscilloscope trace of clipping for the inverting OpAmp. The input wave had a peak-to-peak voltage of XX.

- Include 1-2 paragraphs explaining/analyzing all of the results for this section. Perform an error analysis to PSPICE.

Table 2.2.1: Table of hardware results before saturation for the inverting Op-Amp.

	Inverting Amplifier
Non-inverting input (V) (pin 3)	
Inverting input (V) (pin 2)	
R_1 (Ω)	
R_f (Ω)	
V_{in} (V) (Waveform Generator)	
V_{out} (V) (pin 6)	
$A_d = \frac{V_{out}}{V_{in}}$	

.

2.3 Hardware Results: Non-Inverting Operational Amplifier

- Include a figure showing the Oscilloscope trace for the non-inverting Op Amp at the Vin and Vout. Make sure the peak to peak voltage is labeled Make sure that the plot clearly shows the date that the picture was taken. Also, edit the caption below.

Figure 2.3.1: Oscilloscope trace of the non-inverting OpAmp. The input wave had a peak-to-peak voltage of XX, the output wave had a peak-to-peak voltage of YY, and the gain was ZZ.

- Include the measurements for V+ and V- in the table. These likely were measured on the oscilloscope as the peak-to-peak voltage measurements of the noise (since they will be close to 1).
- Include measurements of the resistors used in the lab
- Include the gain.
- Summarize the results for in Table 2.3.1.
- Show an oscilloscope plot that illustrates clipping in the circuit. In the figure caption, list the value of the input voltage resulting in clipping. Also, edit the caption below.
- Include 1-2 paragraphs explaining/analyzing all of the results for this section. Perform an error analysis.

Figure 2.3.2: Oscilloscope trace of clipping for the non-inverting OpAmp. The input wave had a peak-to-peak voltage of XX.

Table 2.3.1: Table of hardware results before saturation for the non-inverting Op-Amp.

	Non-Inverting Amplifier
Non-inverting input (V) (pin 3)	
Inverting input (V) (pin 2)	
R_1 (Ω)	
R_f (Ω)	
V_{in} (V) (Waveform Generator)	
V_{out} (V) (pin 6)	
$A_d = \frac{V_{out}}{V_{in}}$	

3 Conclusion

Provide a 1 paragraph summary of the laboratory experiment. What were the major conclusions for each part of the experiment? Also did the theory agree with the experiment? The conclusion is a revised version of the abstract. Some specific verbiage from the lab documentation lists the following points:

- Include a concise statement of conclusions commenting on differences, if any, between the ideal and simulated performance of the circuit and theory.
- Does the data agree with the hand calculations and PSPICE simulations? Why does clipping occur (discuss)? How would the voltage resulting in onset of clipping change if the power supply was adjusted to +/- 15 volts for both configurations.

4 Acknowledgments

Acknowledge **any** source of help received in the experiment/writing the report. This should certainly include your lab partner/teaching assistant/instructor. It may also include other class-

mates/study partners. State briefly what the nature of the help was.
Your report should include references to appropriate pages in the text, as well as any other sources, websites/etc. consulted in the preparation of the report.

References

[1] C.K. Alexander, and M.K.O. Sadiku, *Fundamentals of Electric Circuits, 4th Edition*, McGraw Hill, pp. xx-yy(EDIT), 2009.

[2] A. Student, *EEEE 281 Lab 1 Tech Memo*, page xx-yy, submitted Month, Day, 2015.

[3] S. Rommel, *EEEE 281 Lab 1 Lecture notes*, slides xx-yy, Spring 2015.