Lab Number 2
EEE 108L – Electronics I - Laboratory

Introduction to Operational Amplifiers (One Week)

Background

The purpose of this experiment is to provide the students an introduction to operational amplifiers. The basic amplifier circuits are shown in the figures below. These circuits will be constructed using a 741or similar op-amp and ±5 V. The lab consists of three different parts:
1) Preliminary Calculations   2) Spice Simulations   3) Laboratory Experiments

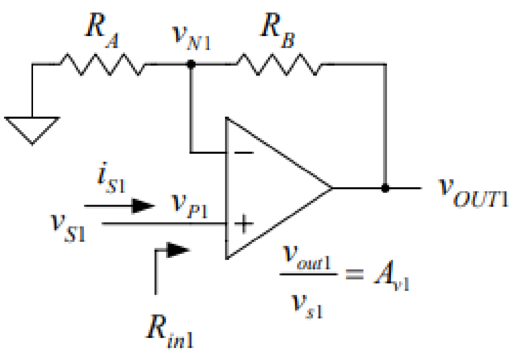


Figure 1. Non-Inverting Amplifier

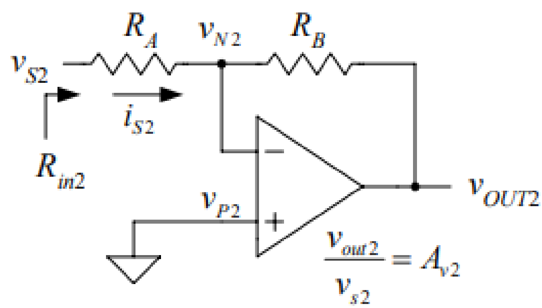
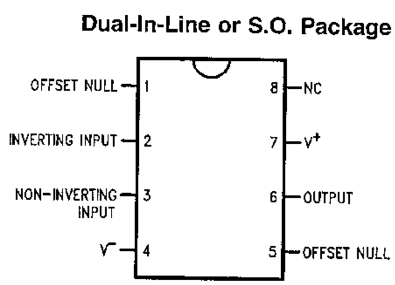
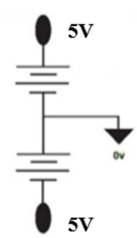


Figure 2. Inverting Amplifier





Power Supply

Preliminary Calculations:

For this lab, apply ± 5 V supplies.

1. Write an expression for the voltage gain $A_{v1} = \frac{vout}{vs1}$ in terms of R_A and R_B.
2. Select a standard resistor value for R_A such that $3.3k\Omega \leq R_A \leq 15k\Omega$ R_A and select R_B such that the gain calculated from the standard resistor values is given $A_{v1} = 3\ \frac{v}{v}$ ±10%.
3. Calculate the input resistance $R_{in1} = \frac{vs1}{is1}$ of the circuit in Figure 1.
4. Calculate the voltage V_{N1}.
5. Write an expression for the voltage gain $A_{v2} = \frac{vout2}{vs2}$ in terms of R_A and R_B.
6. Using the same value for R_A and R_B as in step1, calculate the gain Av_2.
7. Calculate the input resistance $R_{in2} = \frac{vs2}{is2}$ of the circuit in Figure 2.
8. Calculate the voltage V_{N2}.

Spice Simulations:

1. Enter the circuit of Figure 1 into PSpice. Use the resistor values determined in preliminary calculation. Use 741 model for the operational amplifier and ± 5V power supplies.
   Use input source Vsin: V_{off}=0V, V_{amp}= 0.5V, $F_{req.}$=1K and AC=1
2. Perform a DC sweep simulation in which vs_1 is swept over from −5V to +5V.
3. Identify V_{outmax} and V_{outmin} on the plot.
4. In the range for which amplifier is not saturated and is functioning as a linear amplifier, determine the slope of the transfer characteristic $\frac{\Delta Vout1}{\Delta Vs1}$.
5. Enter the circuit of Figure 2 into PSpice. Use the resistor values determined in preliminary calculation. Use 741 model for the operational amplifier and ± 5V power supplies.
6. Perform a DC sweep simulation in which vs_2 is swept from −5V to +5V.
7. Identify V_{outmax} and V_{outmin} on the plot.
8. In the range for which amplifier is not saturated and is functioning as a linear amplifier, determine the slope of the transfer characteristic $\frac{\Delta Vout2}{\Delta Vs2}$.
9. Obtain a plot of i_{s2} as a function of $v_{s2.}$
10. Determine $\frac{\Delta Vs2}{\Delta is2}$ in the linear range and compare that value with the calculated value of $R_{in2.}$
11. Are V_{outmax} and V_{outmin} are same for both circuits?
12. Consider the assumption that $V_N = V_P$. Does the assumption hold when the output is saturated?
13. For the circuit, change v_{S2} to a sine wave and observe the waveform at v_{OUT2} for:
    Amplitude: 0.5V, 1.5V and 3V. (Run Transient Analysis)
14. Discuss the three outputs plots.

Laboratory Measurements:

1. Construct the circuit of Figure 1, using the same resistor values and a ± 5V power supply.
2. Ground the node labeled v_{S1} and record v_{OUT1}.
3. Find offset voltage $V_{OS} = Vout_1/Gain$. The condition $-3mV < V_{OS} < 3mV$ should be satisfied.
4. Connect v_{S1} to an AC signal source and adjust it so that v_{S1} is a $1V_{pp}$, 1KHz triangle wave with zero DC offset.
5. Plot the waveforms of v_{S1} and v_{OUT1} and calculate the small-signal gain $\frac{vout1}{vs1}$ and compare this to the value calculated before.
6. Increase/decrease the input signal amplitude until clipping at the output is obvious, record the voltage corresponding to the positive and negative output clipping levels.
7. Verify that these are the same as v_{OUTmax} and v_{OUTmin} measured before.
8. Construct the inverting amplifier circuit of Figure 2 using the same resistors and power supply voltages as before.
9. Adjust the signal source so that v_{S2} is a $1V_{pp}$, 1KHz triangle wave with zero DC offset.
10. Plot the waveforms of v_{S2} and v_{OUT2} and calculate the small-signal gain $\frac{vout2}{vs2}$ and compare this to the value calculated before.
11. Increase / decrease the input signal amplitude until clipping at the output is obvious, record the voltage corresponding to the positive and negative output clipping levels.
12. Verify that these are the same as v_{OUTmax} and v_{OUTmin} measured before.
13. For the circuit, change v_{S2} to a sine wave and observe the waveform at v_{OUT2}.