Lab Number 3

EEE 108L – Electronics I - Laboratory

Single Supply Opamps (One week)

Background

In most cases, electronic circuitry is operated with DC power supplies and the circuit remains between the most negative and most positive power supply voltages. These supply voltages are called rails. The amplifier output voltage has a similar specification called the output voltage swing (or range) and it is a function of the supply rails.
When operational amplifiers use a split power supply (i.e., plus and minus supply voltages), their input and output voltage range easily include ground, so they can have DC bias voltages of zero volts. Many modern circuits, however, are designed to operate from a single power supply. This experiment will explore the functionality of a single power supply operational amplifier.

Preliminary Calculations:

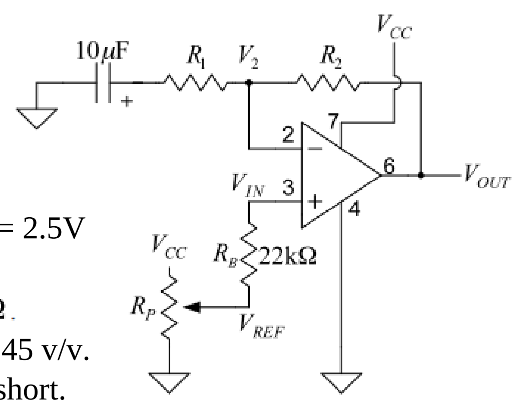

Figure 1

1. Identify the type of amplifier shown in fig.1:
2. For the amplifier Power supply, V_{CC} = 5 V V_{REF} = 2.5V
3. Choose the value of R_P between 5kΩ and 25kΩ.
4. Select R_1 and R_2, such that $2\text{k}\Omega \le (R_1 + R_2) \le 100\text{k}\Omega$. and AC gain of the amplifier is between 30 v/v and 45 v/v. under the assumption that 10uF capacitor is an AC short. Be sure to select from resistor values that are available.
5. Find frequency at which reactance $X_C = R_1$. Call it fp_1. Is it pole frequency?
6. Assuming the operational amplifier to be ideal, if V_{REF} = 2.5V, what are the DC voltages V_{out} and V_2? Hint: Does any DC current flow through the capacitor.
7. What is the resistance seen to ground from V_{IN}, if V_{REF} is positioned in the middle of the potentiometer?

SPICE Simulations:

1. Enter the circuit of Figure 1 with Figure 2 in SPICE. Since the purpose of the potentiometer is to create a variable DC voltage at V_{REF}, so in SPICE do not use the potentiometer but simply connect V_{REF} to a DC voltage source.
2. Set V_{REF}=2.5V and V_{CC}=5V. Run Bias point and check the bias voltages at all of the nodes. Do the results agree with your preliminary calculation?
3. In SPICE, run DC sweep and sweep the value of V_{REF} from 0 to 5 volts. Identify the positive and negative clipping levels at the output.
4. Calculate the pole frequency due to C_{IN}; it is given by $f_{p2} = \dfrac{1}{2\pi C_{IN} R_B}$.

5. Calculate 100 times the greater of f_{p1} and f_{p2}. Call it f_{p3}. At or above this frequency, both capacitors will look like AC short circuits.
6. Run transient simulation with V_{REF} = 2.5V and Vs equal to 50mV_{pp} (amplitude=25mV) sine wave at or above the frequency f_{p3} found earlier.
7. View the simulation results, and plot the voltages at the nodes V_S, V_{IN}, V_2, and V_{out}.
8. Find the Gain. (Use peak to peak voltage values).

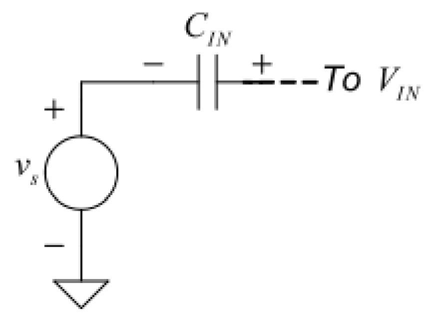

Figure 2

Laboratory Measurements:

1. Construct the circuit of Figure 1. Op-Amp is powered from a single +5 Volt supply.
2. Use potentiometer to vary V_{REF} over the range 0 to 5V (take at least 10 points), record the voltages V_{REF}, V_{IN}, V_2, and Vout. (Make a table).
3. Find V_{OUTmax} and V_{OUTmin}.
4. Add the circuit of Figure 2. Use 1uF<= C_{IN} <= 50uF. If the capacitor has polarity markings on it, be sure to connect it as shown in the figure. Adjust V_{REF} so it is equal to +3.2 volts DC. Apply a triangle wave at V_{IN} (Amplitude=10mV), at or above the frequency fp3 calculated before (1 kHz is reasonable value).
5. Observe Vout, decrease the signal amplitude if necessary, so that the signal at V_{OUT} is not clipped. Determine the DC (bias) value of Vout.
6. Increase the input signal amplitude until clipping becomes obvious at both the maximum and minimum peaks of V_{OUT}. Note the upper and lower clipping levels.
7. With V_{OUT} DC equal to +3 Volts, what is the maximum AC output signal amplitude (in V_{PP}) that has no clipping at either peak? Adjust V_{REF} as necessary to enable the maximum-amplitude output signal amplitude with no clipping.