Lab 6: Op Amps

Purpose:
Introduce students to the design of and use of common operational amplifier (Op Amp) circuits.

Equipment and Components:
1) Prototyping board, Multimeter, Power supply, Function (Signal) Generator
2) Resistors: Resistors: 10 kΩ and others depending upon your design
3) OPA27GP (Single Opamp)

Procedure:
Download the datasheet for OPA27GP from Texas Instrument’s website (or google it). Copy the first page with the pin diagram in your lab-book. Make sure that you understand where to apply the positive & negative power supplies, the positive & negative signal inputs, and where the output is taken.

![Fig. 1: Inverting Op Amp Circuit](image)

1. Calculation:
Design the following circuits (find Rs) using an OPA27GP op-amp (or equivalent) with power supply voltages of \( V^+ = 15 \text{ V} \) and \( V^- = -15 \text{ V} \), \( R_f=10 \text{ kΩ} \). Draw circuit diagrams of each, showing the opamp pin numbers so that you will be able to follow it while constructing the circuits using PSpice and on your proto-board.

A) Inverting amplifier with a voltage gain of 10.
B) Non-inverting amplifier with a gain of 11.
2. Simulation:

Using Multisim (or LTSpice), simulate the above designs. You can leave the output open or use the equivalent circuit for the probe as shown in Fig. 1 (use R_L=1M\Omega and C_L=20 pF).

(In Multisim Place Component->Master Database->Analog->OpAmp->OPA27GP)

1) First perform DC sweep of Vs from -5 to 5 V. DC sweep will help us verify that the design is working as expected.

2) Next configure the voltage source with sine wave of V_{peak to peak}=2 V (V_{amp} or V_{peak}=1 V) at frequency=1 kHz (end time=0.01 s, max time step t_{max}=1e-6). Perform Transient analysis and observe the output.

Please include the results of both DC sweep and Transient Analysis in your lab book.

3. Experiment:

Power Supply

To create +15 V and -15 V power supplies, connect two floating power supplies in series and use the common node as the reference (ground) point for the circuit (please see the picture shown in the Appendix). Make sure that you first measure the output of the power supplies to ensure V_+ = 15 V and V_- = -15V using Multimeter before connecting them to your circuit. Be careful when you connect the power supplies (high voltage on wrong pins will destroy the op amp). Turn up the voltage slowly from 0 to 15 V.

Always power down your circuit before working on your circuit or making adjustments to your existing circuit.

Function Generator

Set the function generator to output sine wave of V_{pp}=2 V (V_{amp}=1 V) at frequency=1 kHz and phase=0°. In order to calibrate the display and values, you must set specify the type of load that the generator will be driving. On the function generator, set the output impedance as follows.

[Output Menu => Load Impedance => 50 Ω, Load, or High Z]

50 Ω is used for normal AC operations, Load does not back out the Source Resistor, and High Z is used for “open circuit” type connections. You should use the High Z for this lab.

Carefully assemble the op amp circuit on your breadboard. Connect the power supply only after assembling and carefully checking your circuit and making sure that the connections are correct. You can use oscilloscope to make the measurements.
Cables

Make sure that you use regular co-ax cable from the function generator to your circuit (and not the probes). When you want to measure the output of your circuit using the oscilloscope, use the probes when possible.

Measurements

1) Measure the output voltage for both the designs and calculate the voltage gain. Remember that

\[
\text{Voltage Gain} = \frac{\text{Output Voltage Amplitude}}{\text{Input Voltage Amplitude}}. 
\]

Tabulate the results of calculation, simulation and experiment for the gain in your lab book.

4. Conclusion

Discuss your general op-amp observations. Including issues related to rail voltages, opamp response, and a comparison of calculated values, simulated values, and experimental values.
Appendix

*How to connect the dual power supply to your op-amp:*

Please make sure that all the grounds in the circuit as well as the ones from the oscilloscope, function generator, and the power supply are connected together as a single ground.