EE 230
Experiment 5
Fall 2006

Operational Amplifier Applications and Limitations

Objectives: The primary objective of this experiment is to investigate some common applications of the operational amplifier (Op Amp) and observe some of the fundamental limitations of these devices.

Equipment:
Computer with SPICE, Signal Express, GP-IB capability, and appropriate IVI drivers
HP E3631A or equivalent power supply (GP-IB Capable)
HP 33120A or equivalent signal generator (GP-IB Capable)
HP 34401A or equivalent multimeter (GP-IB Capable)
HP 54602B or equivalent oscilloscope

Parts:
741 op amp
Assortment of Resistors and Capacitors
Potentiometer
Amplified speaker
2 Photoresistors

Practical Details: The op amp used in this experiment is the μA741. It is biased with two DC power supplies. In this laboratory, use biasing voltages that are 90% of the maximum value specified in the datasheet of the device. Refer to the μA741 datasheet for specifications. Throughout the experiment and essentially all experiments in this course, it is important to verify all results on the oscilloscope prior to making any measurements with a multimeter. It is equally important to have theoretical or simulated measurement results prior to making measurements so that any discrepancies in measurements can be resolved in a timely manner in the laboratory, not in a laboratory report.

In this experiment, we will focus on two aspects of operation. One is when the operational amplifier is operating ideally. We will also try to create conditions where the operational amplifier does not operate ideally. For this experiment, you will not be expected to identify the source of the non-idealities but you will be expected to identify what conditions cause the operation to become non-ideal and what the effects of the non-ideal operation are on the performance. In the next experiment we will start looking at the source of the non-idealities and ask you to return to the all of the observed non-idealities you have found in this experiment so that you can demonstrate the source. Since everyone may have different conditions under which the non-idealities are observed, it is important that you carefully note how you created the non-idealities so that you can re-create the same situation for the next experiment. Non-idealities are due primarily to exceeding the output voltage range, exceeding the output current driving capability, exceeding the maximum rate of change that can occur at the output, or operating at frequencies that are so high that the op amp does not have adequate gain.

As a rule of the thumb, these non-idealities usually do not cause a problem if the output voltage is less than V_{DD}-2 V, the load impedance is larger than 1k Ω, and the frequency of operation is less than 10k Hz .

Part 1 Observe the Non-idealities of a 741 Op Amp

Design an inverting amplifier with a voltage gain of -10. Verify the gain by considering sinusoidal inputs, square wave inputs, and dc inputs.

After you have verified the gain, observe what happens if you

a) Keep the gain at -10, keep the frequency in the 1k Hz range, keep the output level around 20V p-p, but start decreasing the load resistance until the circuit no longer behaves as desired.
b) Keep the gain at -10, keep the load resistance large (e.g. 1k Ω), reduce the output level to around 1V p-p, and increase the frequency of the excitation until the circuit no longer behaves as desired.
c) Keep the gain at -10, keep the load resistance large (e.g. 1k Ω), keep the output level at around 20V p-p, and increase the frequency of the excitation until the circuit no longer behaves as desired.
d) Keep the gain at -10, keep the load resistance large (e.g. 1k Ω), keep the frequency around 1KHz, but start increasing the input amplitude.

Part 2 Compare the Bandwidths of Two Inverting Amplifiers

a) Use Signal Express to measure the 3 dB bandwidth for the inverting amplifier with a gain of -10 and for an inverting amplifier with a gain of -50.
b) How does the bandwidth change with gain?
c) What is the pole location for the amplifier with a gain of -10?

Part 3 Compare the Bandwidth of a Non-inverting Amplifiers to an Inverting Amplifier

a) Design a noninverting amplifier with a dc gain of +10.
b) How does the 3 dB bandwidth of the noninverting amplifier compare with that of an inverting amplifier of the same gain?

Part 4 Design an Integrator

a) Design and test an inverting integrator with an integrator unity gain frequency of approximately 2k Hz.
b) Test it with both square wave and sinusoidal inputs.
c) Make this integrator slightly lossy by placing a resistor in shunt with the feedback capacitor that is approximately 100 times as large as the resistor used in your integrator. Be sure to use non-electrolytic capacitors in the integrator.
d) What happens if this resistor is removed?

Part 5 Design an Audio Mixer

a) Design a mixer that can add two signals, one a 400 Hz sine wave and the other a 900 Hz square wave. Set the mix so that the gain from the sine wave input is -5 and the gain from the square wave input is -2. You may need to get one of your two input signals from a different bench.

b) Is it easy to verify that the mixing is correctly occurring? Why or why not?

c) Modify this mixer so that the gain on both inputs can be adjusted independently with an external light source.

d) Describe how the output sounds as you vary the gains by modulating the light into the two inputs.