EE-321 Lab 1 - Op-amp measurements

14th July 2005

1 Purpose

To study some of the characteristics of a "real" op-amp, and more practice with the test equipment.

The unofficial purpose is to practice using the oscilloscope and signal generators, in ways you may not have used them before, and to build a circuit that uses several external instruments and power supplies.

2 Overview

You will build several configurations of op-amp circuits, and verify that they work as expected:

- Inverting, gain = -10
- Non-inverting, gain = 11
- Differential, gain = 10

3 Parts needed

- 741 op-amp
- resistors: 10k (2), 100k (2), 1k(2)
- capacitors: .1 uf (2)
- Scope, signal generator, power supply, all on bench.
- Wire, in 3 colors, about 3 feet.

4 Procedure

4.1 Setup

Before beginning, set the equipment to reasonable settings. You must do this before making any connections to your circuit. You cannot rely on the equipment being set in any particular way when you start. Most likely, it will be set up to suit some other experiment that has nothing to do with yours, and has completely different requirements. It is possible that someone else may have set it to a mode that can damage your circuit, or even present a safety hazard. You need to set ALL controls to your needs, including those that don't apply to your work, if only to turn off features that you are not using today.

1. Scope
   (a) Set to defaults, then:
   (b) Both channel 1 and channel 2 as follows:
      i. 5 volts/division
      ii. DC coupled
      iii. 20 MHz bandwidth
      iv. Channel 1 zero to one box above center.
      v. Channel 2 zero to one box below center.
   (c) Time base to:
      i. .5 milliseconds per division
      ii. Trigger to:
         A. Channel 1
         B. DC coupled
         C. Level to 0.
   (d) "Measure" to:
      i. Channel 1 voltage p-p
      ii. Channel 2 voltage p-p
2. Signal generator
   (a) Set to defaults, then:
   (b) Frequency to 1 KHz.
   (c) Level to 1 volt p-p as measured on scope. (Channel 1)
3. Power supply
   (a) Use the fixed power supply.
   (b) Using the scope, confirm that it has no visible ripple, and that it is approximately ± 15 volts, within 1 volt.
   (c) Turn it off before moving on.

4.2 The inverting configuration

1. Build the circuit according to this schematic:

2. Have at least one other person check your circuit.

3. Make a cable to connect the power supply. Use three different colors, preferably red, yellow, and black, but use what we have in solid wire, as opposed to stranded. Twist the wires together. Use the red wire for +15 volts, the yellow wire for −15volts, and the black wire to ground. Connect it first to the breadboard, then to the power supply. Connect the black binding post to ground.

4. Connect the scope, channel 1 to input, channel 2 to output. Always put a 1K resistor in series with the scope probe. Put the resistor in the breadboard, sticking up. Clip the scope cable to the end of the resistor that sticks up.

5. Turn power on. Verify that the DC voltages at input and output are zero.

6. Connect the signal generator to the input. Verify that the input and output signals are expected, and not distorted. Turn up the scope sensitivity so the signal nearly fills the screen. Fill in the table with your measurements:

	voltage p-p	phase
input		0
output		
gain		

7. Increase the level at the signal generator until you see it clip. Note the levels just below clipping. You will probably need to change the scope sensitivity.

	voltage p-p	phase
input		0
output		
gain		

8. Increase the input level to 5 volts p-p. Note the output level and waveform. Capture the waveform on a disk, and include it in your journal.

9. Turn the level back down below clipping. Move the channel 1 scope probe to the inverting input of the op-amp ("summing node"). Observe the level and waveform. You will need to

turn the sensitivity way up, and probably switch it to AC coupling. Increase the signal so the output clips. Watch the signal at the summing node. What happens? Caputre the waveform and include it in your journal.

10. Turn power off. It is time to move on.

4.3 The non-inverting configuration

1. Modify your circuit to the following:

2. Set the input signal back to 1 volt p-p, apply it, turn power on, and verify that the output signals are as expected, and are not distorted. Fill in the table:

	voltage p-p	phase
input		
output		
gain		

3. Increase the level at the signal generator until you see it clip. Note the levels just below clipping. You will probably need to change the scope sensitivity.

	voltage p-p	phase
input		0
output		
gain		

4. Increase the input level to 5 volts p-p. Note the output level and waveform. Capture the waveform on a disk, and include it in your journal.

5. Turn power off. It is time to move on.

4.4 The differential configuration

1. Modify your circuit by adding two resistors, and disconnecting the ground the inverting input binding post, as follows:

   Try, in sequence, three possible connections for the inputs:

2. Signal generator "hot" (red) to "A", ground (black) to "B":

	voltage p-p	phase
input		
output		

gain	

3. Signal generator "hot" (red) to "B", ground (black) to "A":

	voltage p-p	phase
input		
output		

gain	

4. Signal generator "hot" (red) to both "A" and "B" together, ground (black) to ground:

	voltage p-p	phase
input		
output		

gain	

4.5 Packing up

Pack your breadboard carefully for next week. You will use it again.

5 Report

Please arrange your report in the order listed here.

5.1 Executive summary (on cover) (done individually)

On the cover, show a schematic of each configuration (3 schematics), its common name, and the gain formula. For the differential configuration, give ~~also a number that shows your measured~~ common mode rejection in decibels. the differential gain and the

5.2 More detailed summary (individually)

Based on your measurements, give formulas for gain in the inverting and non-inverting configurations.

For the differential configuration, give formulas for gain, both differential and common-mode. Answer the following questions:

What is meant by "common mode" and "differential mode"?

Give a number for your measurements for "common mode rejection" in decibels.

5.3 Journal (joint)

Your report should include a journal of what you did, with enough detail that someone else can repeat your experiment, complete with mistakes. Make a copy of the journal so both members of a team can submit it.

5.4 Analysis (individually)

Provide a manual analysis of the three configurations, using an ideal op-amp, and verify that the actual unit performs as expected.

5.5 Simulation (individually)

The simulation requirement for this lab is simple: Just run each of the three cases, verifying that it works as expected. Use a voltage controlled voltage source (type "E") with a gain of 10000. Then reduce the open loop gain and answer the question: How low can the open loop gain be and still get a closed loop gain within 5% of ideal?

gain #5 ?