EECE 2150 - Circuits and Signals: Biomedical Applications

Lab 6 Sec 2

Getting started with Operational Amplifier Circuits

DiMarzio Section Only: Prelab: 3 items in yellow.
Reflection: Summary of what you learned, and answers to two questions in green.

Part 1. Inverting Op-Amp Circuit

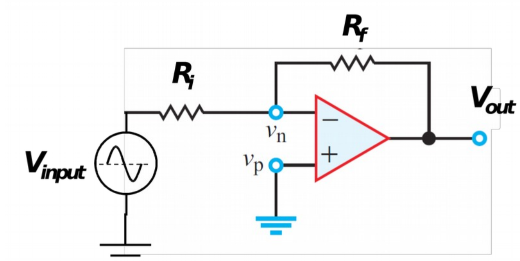


Figure 1. Inverting op-amp circuit.

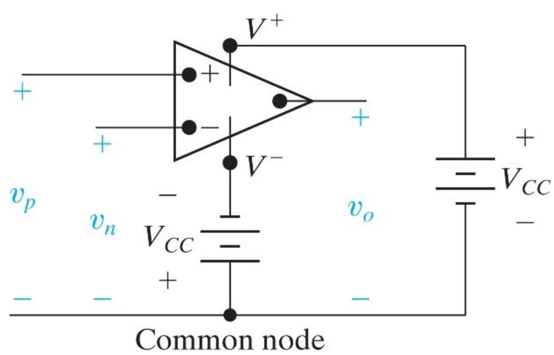


Figure 2. DC power supply connections to op-amp. Common node is ground.

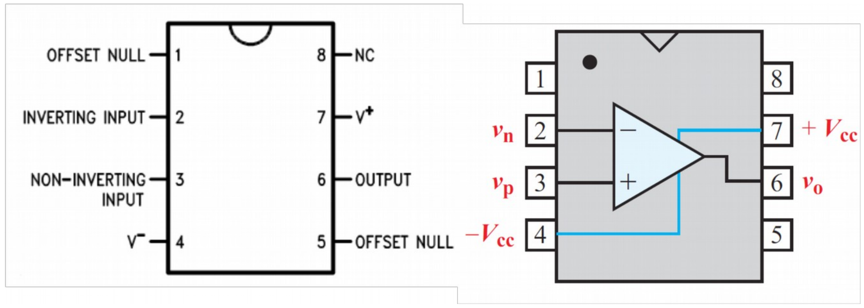


Figure 3. The 741 Op-Amp DIP package, two diagrams (the different labeling of the pins indicates commonly used terminology and are used interchangeably, i.e. v_n = inverting input, v_p = non-inverting input, V+ = +Vcc, V- = -Vcc).

1.1 <u>Draw</u> a wiring diagram for the circuit diagram in Figure 1 on the attached protoboard diagram (with the power supply connections from Figure 2 and the signal connections from Figure 1!!).

<u>Note that:</u>

- The Op Amp DIP packaging will straddle two sets of horizontal rows. Note the position of the notch. The spec sheet is on Blackboard and will be used more extensively in the next lab.
- The Op-Amp is an ***active component*** and requires +Vcc and –Vcc power to pins 7 and 4, respectively; ***otherwise it will not work!*** It may take some thought and discussion with the instructor or TAs to understand how to set this up with the power supply!
- You should use the long strips of your protoboard (buses) for the DC supply voltages. So use one for –VCC, one for ground, and one for +VCC .

Part 2. Building and Testing the Inverting Op-Amp Circuit

2.1 <u>Build</u> the Inverting Op-Amp circuit (Fig. 1 above) on your protoboard. Make $\mathbf{V_{CC}=10V}$ and $\mathbf{-V_{CC}= -10V}$.

Note: Color code the supply voltage wires, and don't use those colors for other signals. You should use different colors for +10 V, -10 V, and Ground. We will be checking your circuits for good wiring practices.

Two common wiring conventions are:

1) +Vcc = Red Ground = Black, -Vcc = Blue

2) +Vcc = Red Ground = Green -Vcc = Black

(Pick either one you like but stick to it!)

(The signal wires should be a fourth color.)

2.2. Choose your resistor values so that the circuit has a gain of $\mathbf{G = V_{out} / V_{in} = -10.}$ Use resistors > 1 kΩ for now.

2.3 Set the function generator to produce an input ***sine wave*** V_{input} with ***0.5 V amplitude*** (center to peak) and ***1000 Hz*** frequency. (no DC offset)

*Remember that the function generator will produce center-to-peak amplitude of the set value, and **not** the peak-to-peak value. This is because every time you power on the signal generator, it gives the expected peak-to-peak value for a 50 Ohm load, and the load here is a much larger resistance. Your knowledge of Thevenin equivalents and voltage dividers should help you now to understand why it behaves differently with the larger load. You can change this setting from the default if you want, or just live with it being off by a factor of two (or in other words use the displayed value as the center-to-peak amplitude, ½ of the actual peak-to-peak value).*

2.4 Using the oscilloscope, display the input and output signals of the amplifer at the same time. Measure the amplitudes of the input sine wave and the output sine wave. **Q1:** Based on these measurements, what is the gain of the system? **Q2:** Does it agree with your predicted value?

2.5 **Q3:** How can you verify that the gain is negative and not positive?

2.6 When you are convinced that the circuit is working as you intended, increase the amplitude of the sine wave input to **1.2V** center-to-peak. **Q4:** Explain in your report what happened to the output, and why.

Part 3. Summing Inverting Op-Amp Circuit

3.1 Suppose you had a basic function generator that could not produce a DC offset, but you wanted to add -1V DC to your output signal, v_o. You could do this with a summing inverting amplifier, where v_{input} and R_i are your original AC input voltage and resistance from parts 1 and 2 and v_2 and R_2 are a DC source and an appropriate resistor to set the DC gain to obtain a total output of -1V+the original AC part.

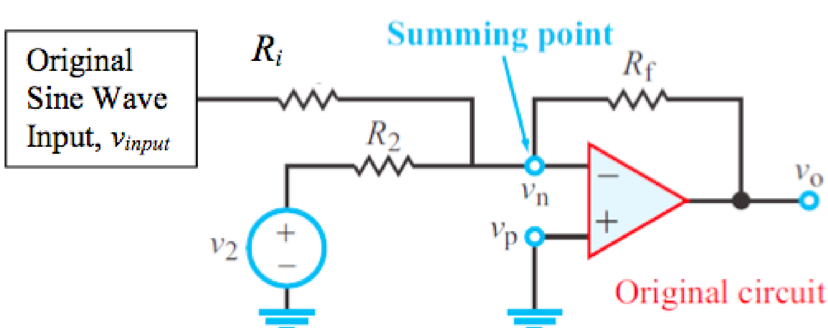


Figure 4. Summing inverting amplifer. Gains for the two inputs are R_f/R_i and R_f/R_2. The sum appears at the output.

3.2 ***Step 1: Figure out how to use the DC power supply to produce your -1V DC Offset***. Note that you are obviously using the DC power supply to power the circuit, so your DC input must be either +10 or -10 V. **However, you can use the 10V supply to produce a -1V DC output** by choosing your R_2 value appropriately. **Q5:** How can you do this, in detail ?

3.3 ***Step 2: Now modify your circuit from part 2 to add the -1V to the sinewave output***. Set the function generator to produce an input ***sine wave*** V_{input} with ***0.5 V amplitude*** (center to peak) and ***1000 Hz*** frequency (no DC offset).

3.4 Use the oscilloscope to check your result. **Q6:** Did you measure what you expect?

Part 4 – Instructions For the Lab Reflection

The lab reflection for this lab is due as per the instructions on Blackboard.

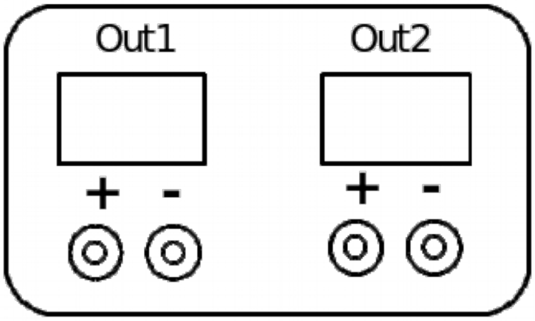
IMPORTANT: BEFORE YOU LEAVE THE LAB:

(a) **Turn off all of the equipment you have used on your workbench.**

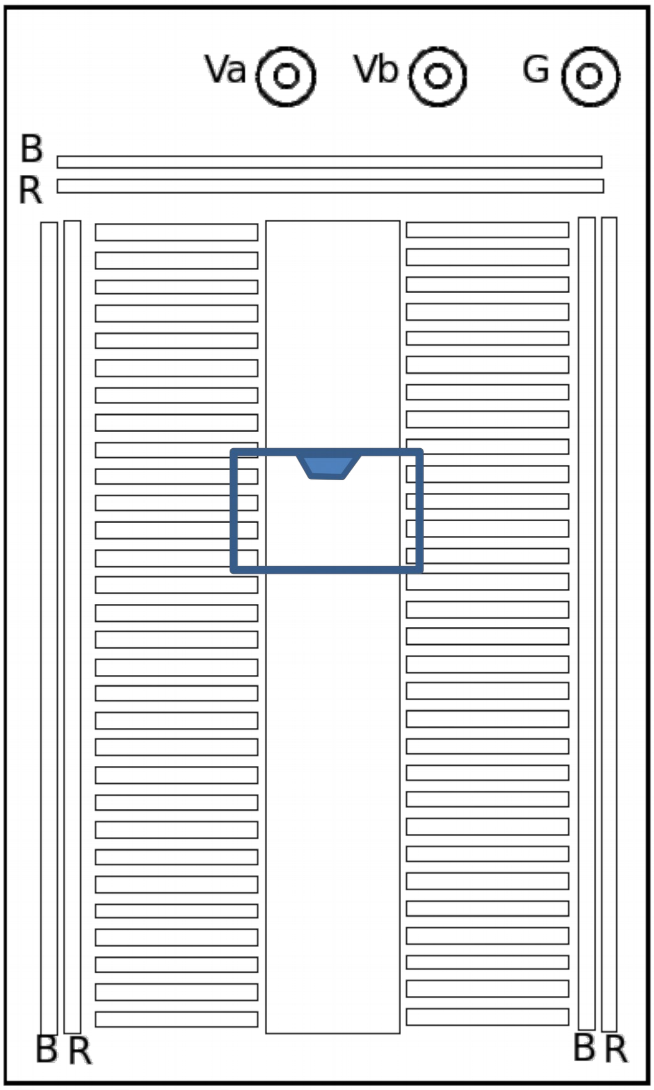
(b) **Make sure to have your notebook signed by an instructor or TA before you leave the lab.**

Department of Electrical Engineering, Northeastern University.
Last updated: 10/1/16 D. Brooks, 9/28/16, N. McGruer; 8/10/15, M.Niedre.

Power Supply

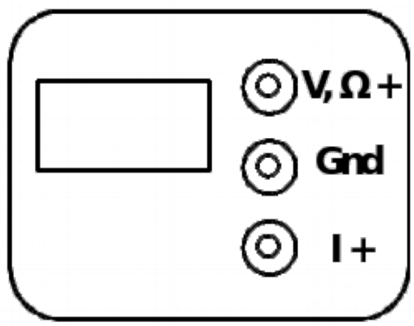


Circuit Diagram



Breadboard

Multi-meter



Function Gen.