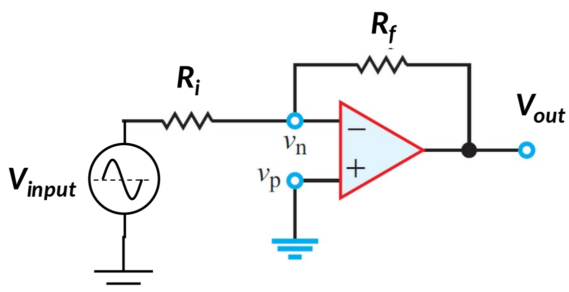
EECE 2150 - Circuits and Signals: Biomedical Applications

Lab 7

Getting started with Operational Amplifier Circuits

Part 1. Inverting Op-Amp Circuit



$$\frac{V_{out}}{V_{input}} = \frac{-R_f}{R_i}$$

Figure 1. Inverting op-amp circuit.

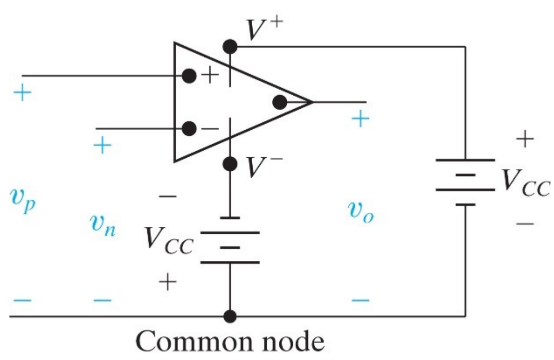


Figure 2. DC power supply connections to op-amp. Common node is ground.

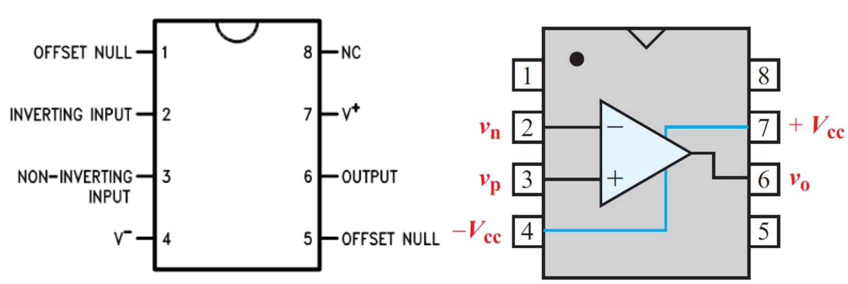


Figure 3. The 741 Op-Amp DIP package, two diagrams (the different labeling of the pins indicates commonly used terminology and are used interchangeably, i.e. v_n = inverting input, v_p = non-inverting input, $V+$¿$+Vcc$, $V-$¿$-Vcc$).

1.1 Build the circuit diagram in Figure 1 (with the power supply connections from Figure 2 and the signal connections from Figure 1!!).
- The Op Amp DIP packaging will straddle two sets of horizontal rows. Note the position of the notch. The spec sheet is on Canvas 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!*** See power supply connections shown in figure 4.
- 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 $VCC^{+¿¿}$.

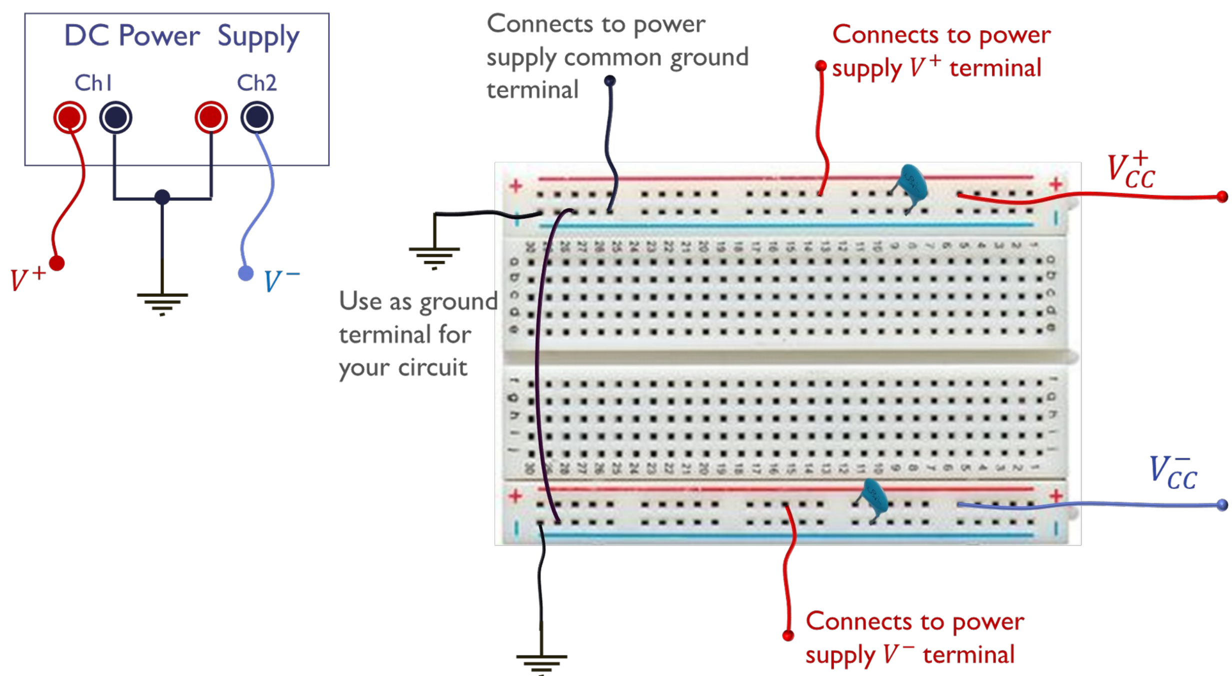


Figure 4. Block diagram showing DC power supply connections. Notice the commode node of the power supply, taken as your reference ground for the entire circuit, this includes the ground connection of the signal generator and pin (3) of the Op-Amp.

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

2.1 Build the Inverting Op-Amp circuit above on your protoboard. Make $VCC^{+¿=10V¿}$ and $VCC^{-¿=-10V¿}$.

Note that you should color code the supply voltage wires, and don't use those colors for other signals. You should use different colors for $+10V, -10V$, and Ground.

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 $G=\frac{V_{out}}{V_{¿}}=-10$. (If you don't know how to do this, check your class notes). Use resistors > $1\,k\Omega$ for now.

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

Note that the function generator will produce twice the set value of Vpp. (This is because the signal generator is designed to give the expected peak-to-peak value for a 50 Ohm load, and the load here, input resistance of the op-amp, is a much larger resistance.) You can set the signal generator to 'High Z', using the 'Utility' button, press 'utility' then choose 'output setup' and select 'High Z'. In the 'High Z' mode, the output has the same peak-to-peak as the set value.

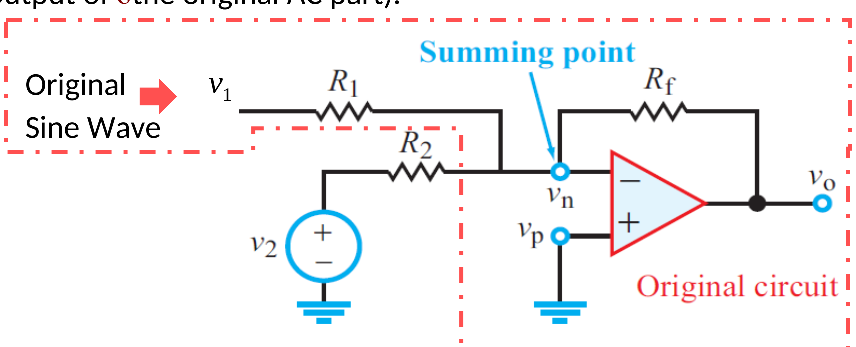
2.4 Using the oscilloscope, display the input and output signals at the same time. Measure the amplitudes of the input sine wave and the output sine wave. **Q1:** Based on these measurements, what is the gain of the system? **Q2:** Does it agree with your predicted value?

2.5 Q**3:** 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 $-1\,V\,DC$ to your output signal, v_o. You could do this with a summing inverting amplifier, where v_1 and R_1 are your original AC input voltage and resistance from parts 1 and 2. $v_2$and R_2 are a DC source and an appropriate resistor to set the DC gain to obtain a total output of ¿the original AC part).



$$v_o=\frac{-R_f}{R_1}v_1-\frac{R_f}{R_2}v_2$$

Figure 5. Summing inverting amplifier. Gains for the two inputs are $-R_f/R_1$ 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 $-10V$. **However, you can use the 10V supply to produce a $-1V$ DC at the output** by choosing your R_2value appropriately. **Q5:** Explain for your report how you did this.

3.3 ***Step 2: If you have time, 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*** $V_{¿}$ with ***0.5 V amplitude*** (center to peak) and ***1000 Hz*** frequency (no DC offset).

3.4 Based on your results in part 2, and what you know about summing amplifiers, in combination what should you measure at the circuit output? Use the oscilloscope to check this. **Q6:** What did you measure? **Q7:** Is this what you expect/why or why not?

Part 4 - For the Report:

Write a formal lab report describing what you learned in the lab, follow lab report format on Canvas.

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.**

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Last updated:8/22/2021, I. Salama, 2/23/16, N. McGruer; 8/10/15, M.Niedre.