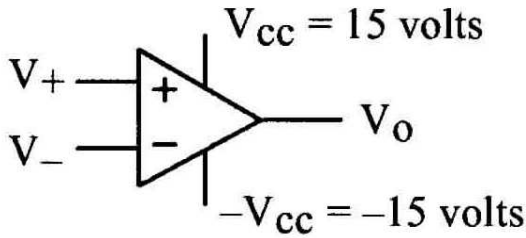


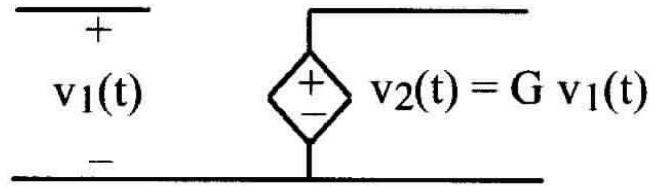
Engr 261 -- Circuits and Devices Lab
Experiment # 3 -- Controlled Voltage Sources

OBJECTIVE:

The objective of this lab is to build and analyze simple circuits containing controlled voltage sources. The lab will make use of the operational amplifier (op amp) – an integrated circuit shown in Figure 1a, to build a voltage controlled voltage source of the form shown in Figure 1b. Note that this lab will not study the inner workings of op amps.



(a) op amp



(b) voltage controlled voltage source

Figure 1

BACKGROUND:

The IC op amp is a solid-state device capable of sensing and amplifying DC and AC input signals. A typical IC op amp consists of three basic circuits, a high-input impedance differential amplifier, a high-gain amplifier, and a low-impedance output amplifier. Figure 2 shows a block diagram of an op amp. Notice that it usually requires a positive and a negative power supply. This allows the output voltage to swing positive and negative with respect to ground.

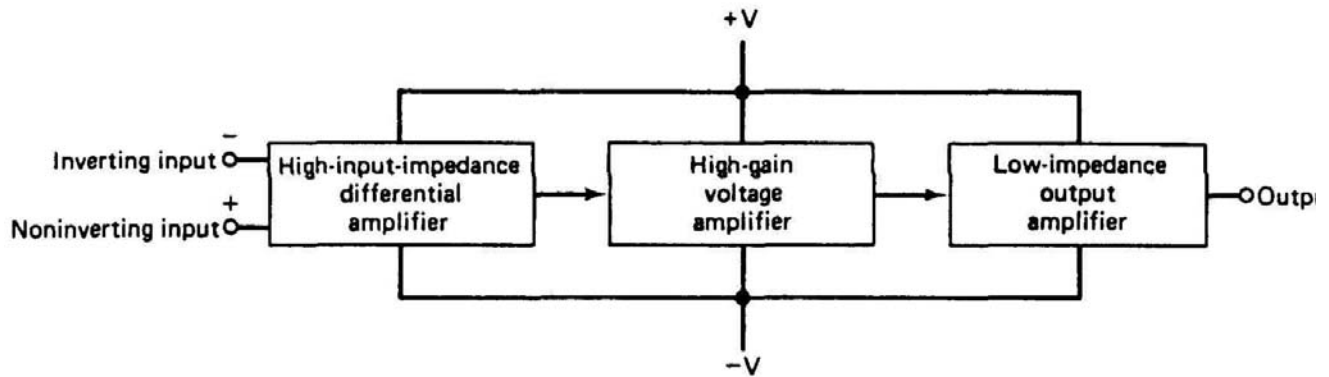


Figure 2 Block Diagram of an op amp.

The most important characteristics of an op amp are:

1. Very high input **impedance**, which produces negligible currents at the inputs,
2. Very high open-loop gain, and
3. Very low **output impedance**, so as not to affect the output of the amplifier by loading.

Power-Supply Requirements for Op Amps

Most op amps require a dual + or - power supply for proper operation. Using this type of power source allows the output of the op amp to swing positive and negative with reference to ground. This feature is particularly useful in DC circuits and special audio applications.

The simplest power source is batteries, as shown in Figure 3. Two 9-volt dry-cell batteries can be connected in series, with the common connection being reference as ground. The output will be a + or - 9 volts power supply. Although this battery supply has portability, each battery must be fresh for proper circuit operation.

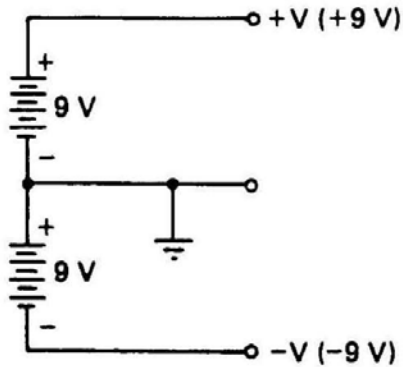


Figure 3 Battery dual power supply

Figure 3 displays the pin connection on **various IC op amp packages**. Pick the correct one for the 741 op amp that you will use in your experiment.*

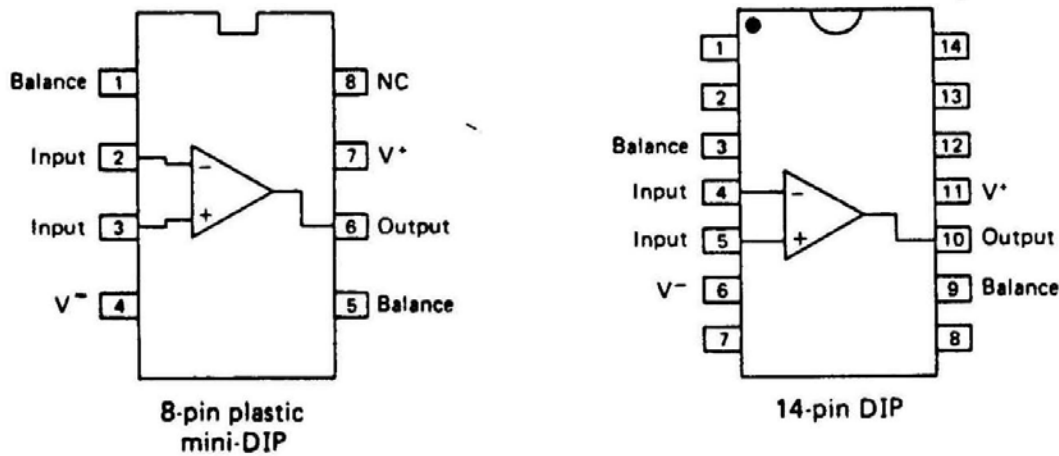


Figure 4. IC op amp packages

PRELAB:

Study and then draw the pinout diagram for a 741 op amp in the lab notebook. Focus on the 8-pin IC diagram that you will use in the lab.

* Specifications for LM 741 op amp can be downloaded from the Web site <http://www.national.com/ds/LM/LM741.pdf> of the National Semiconductor, Inc.

PART A:

1. Redraw the circuit shown in Figure 5 to show the connection of the $\pm V_{cc}$ power supplies. Also label the op amp pin numbers. Take $R=2k\Omega$.

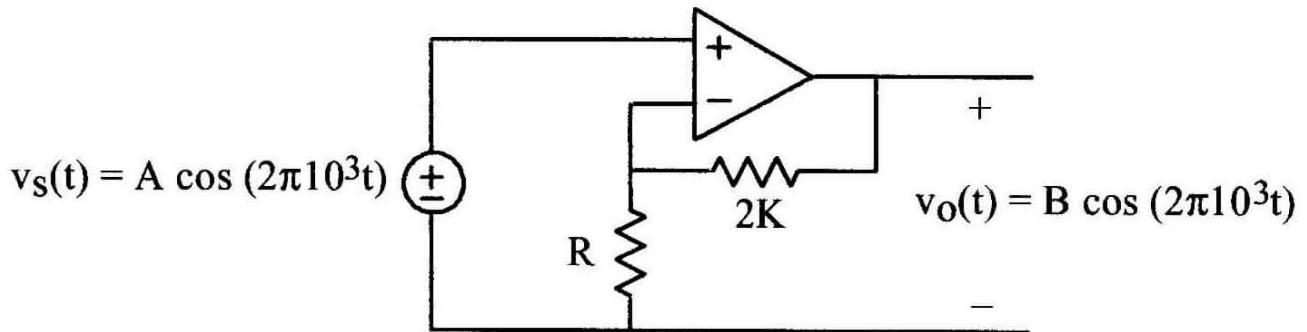


Figure 5

2. Perform a MultiSIM simulation of the circuit in Figure 5.
 - Use the 741 OP AMP in the "ANALOG" submenu icon.
 - Be sure to follow the pin diagram shown in Figure 4, with the appropriate DC voltage sources to power up your op amp.
 - For the input $v_s(t)$, use an amplitude of 5 V. You may use an oscilloscope to plot the input and output voltages.
 - Perform a "Transient" analysis, and plot the node voltages at the input and output pins.
3. Set up the circuit shown in Figure 5 with input $v_s(t)$ from the function generator, and the output $v_o(t)$ to be displayed on Channel 2 of the oscilloscope. If your circuit does not seem to function properly, troubleshoot your op-amp circuit by following the guidelines given at the end of this lab handout.**
4. Find and sketch $v_o(t)$ for inputs $v_s(t)$ with magnitudes $A = 0, 1, 2, 3, 4, 5$. Make sure to layout your circuit on your proto board to look exactly like your circuit diagram.
5. Make use of your results in part (3) to plot $v_o(t)$ as a function of $v_s(t)$.
6. Draw the controlled source circuit being implemented by the above op-amp circuit.
7. Verify that your circuit is in fact operating like a controlled voltage source - that it's voltage $v_o(t)$ is pretty much unaffected by the values of load resistors R_L in Figure 6. Use values of $R_L = 2 k\Omega, 3 k\Omega, 4 k\Omega, \dots$

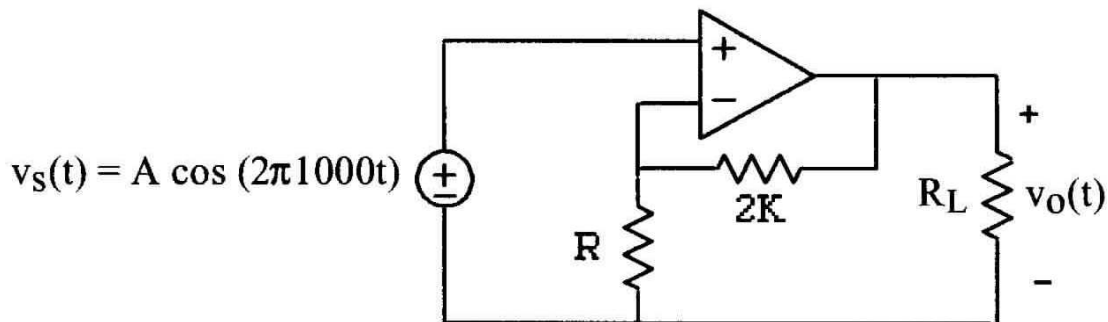


Figure 6

PART B:

1. Redraw the circuit diagram with the controlled source replaced by the op amp circuit you used in Part A (i.e., use $R=2k\Omega$ in the op-amp circuit shown in Figure 5). Be sure to show the power supplies and the pin numbers of the op amp. (Hint: See Figure 1.)

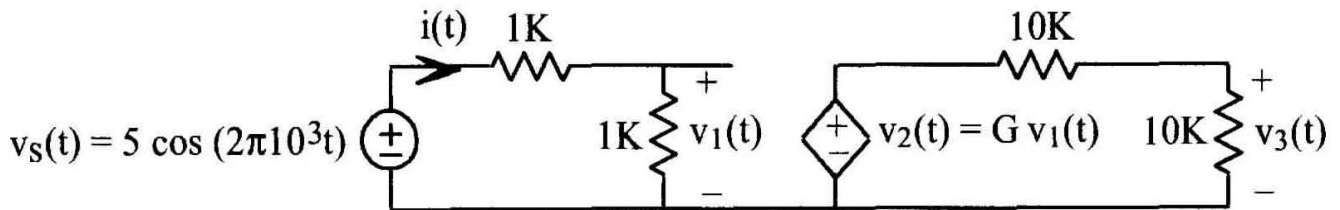


Figure 6

2. What is the gain G of your controlled source?
3. Build the circuit and measure $v_1(t)$, $v_2(t)$ and $v_3(t)$.
4. Calculate $v_1(t)$, $v_2(t)$ and $v_3(t)$.
5. Compare the amplitudes of your measured and calculated voltages in parts 3 and 4. Compute percent errors in observed values, and explain possible sources of such errors.

Laboratory Report Preparation

Prepare a **standard** laboratory notebook report using the suggested format.

**Learn to troubleshoot your op amp circuit.

To avoid frustration with your op amp circuit, check that (1) you applied voltages from the power supply to your op amp, and (2) your op amp is not blown up.

- (1) Using a multimeter, measure the voltages at the power supply terminals, and then the binding posts of your circuit, and then at the $-V$ and $+V$ pins (#4 and #7) of your chip.
- (2) Measure the voltages at three pins of your op amp chip to make sure that each **has a very small voltage** (less than 1V, preferably a few mV):
 - The inverting input (pin#2)
 - The non-inverting input (pine#3)
 - The output (pin #6)

If your read a few volts at any of these pins, ask the instructor to replace your chip. Disconnect the power supply before replacing the chip.