UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
Department of Electrical and Computer Engineering

EXPERIMENT 2 – OPERATIONAL AMPLIFIERS

OBJECTIVES

The purpose of this lab is to introduce the operational amplifier (op-amp), and provide some experience with its applications in electronic circuits.

INTRODUCTION

An Operational Amplifier is a very high-gain, direct-coupled amplifier that uses feedback for control of its response characteristic. A direct-coupled amplifier is capable of amplifying DC as well as time varying signals. The standard symbol for an op-amp is shown below (Figure 2-1).

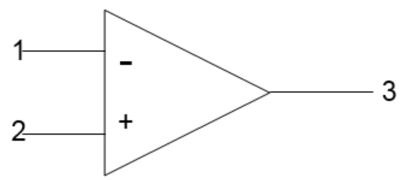

Figure 2-1 Standard symbol for operational amplifiers

The output voltage of an op-amp is the difference between the voltages applied to its input terminals multiplied by its open loop gain, A. The output voltage is positive when the voltage applied to the positive (non-inverting) input exceeds that applied to the negative (inverting) input. An ideal op-amp would have an infinite open-loop gain, requiring that the difference between V_+ and V_- be infinitesimally small in order for the output voltage to be finite. Thus, for circuit analysis purposes, this voltage difference is assumed to be zero. Furthermore, the ideal op-amp would have infinite input impedance and zero output impedance. These are, of course, the ideal characteristics for a buffer amplifier that would make it possible to drive a low impedance load with a large impedance source. For circuit analysis purposed, the current at the input terminals is assumed to be zero, while the output voltage when driving a load is assumed to be the same as the open circuit output voltage.

Operational amplifiers are versatile and useful devices. They can perform many functions, some of which are: inverting, amplification, attenuation, summing, integrating, differentiating, filtering, and signal generation (oscillators).

PRELAB

1. Study the LM741 chip layout of Figure 2-2 (look for datasheet). Describe each pin and their function if any.

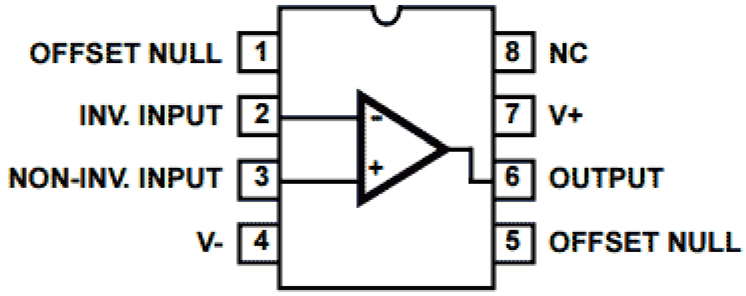

Figure 2-2 LM741 pins layout

2. Determine the transfer function, V_o/V_i and the function that the operational amplifier is performing in Figure 2-3 below for the impedance parameters listed below
   a. Z_f : resistor R = 47 kΩ Z_i : resistor R = 10 kΩ
   b. Z_f : capacitor C = 10 μF Z_i : resistor R = 1 MΩ

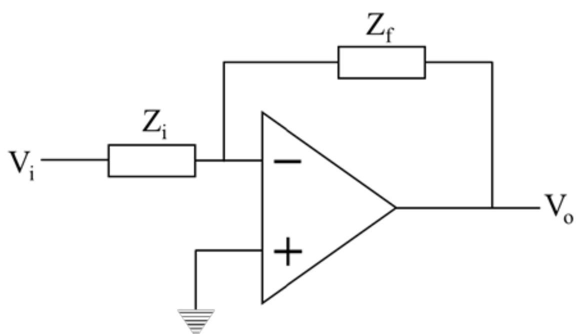

Figure 2-3 Operational amplifier circuit for part 2 of the prelab

PROCEDURE

1. Prepare the power supplies for $+V_{CC}$ and $-V_{CC}$ to ensure the proper voltages, +15V and -15V, respectively. See Figure 2-4.

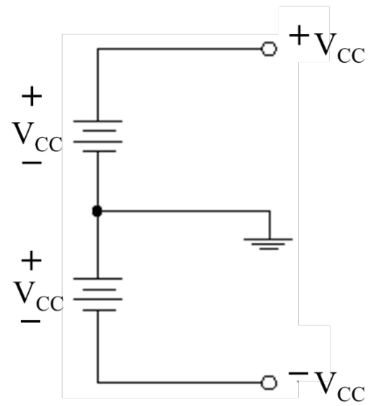

Figure 2-4 Power supplies configuration

2. Connect $+V_{CC}$ and $-V_{CC}$ to a potentiometer as shown in Figure 2-5. This will provide a variable-output DC signal source ranging from $-V_{CC}$ to $+V_{CC}$, for input to the op-amp circuit.
3. Check this circuit with a volt meter to ensure that it provides the range of voltages desired. The red voltmeter lead should be connected to the center terminal of the potentiometer and the common ground between $+V_{CC}$ and $-V_{CC}$. The way in which the power supplies are connected to each other, and to the potentiometer produces four nodes, $+V_{CC}$, $-V_{CC}$, V_{in} and ground (or reference).

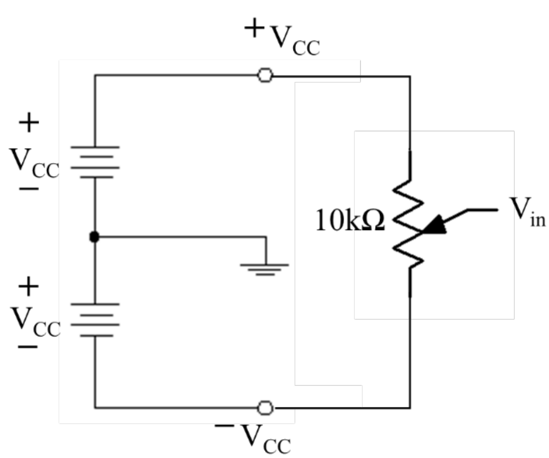

Figure 2-5 Signal source configuration (V_{in})

4. Turn the power supply off.
5. Connect the inverting amplifier circuit in Figure 2-6. Carefully measure the values of the resistors that will be used in the circuit. Check the circuit carefully.

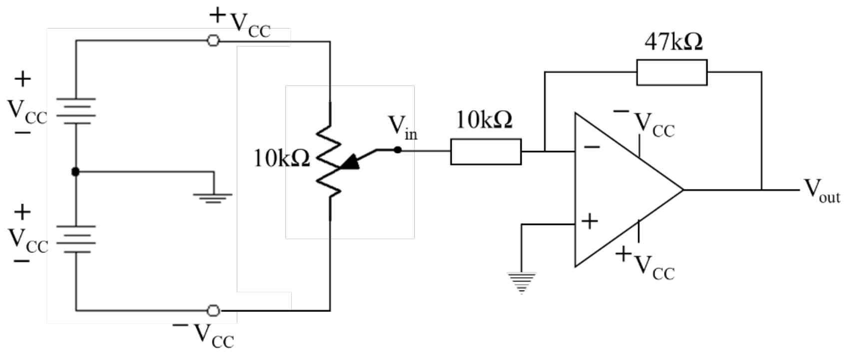

Figure 2-6 Inverting amplifier circuit

6. Turn on the power supply. Adjust the 10 kΩ potentiometer to achieve a V_{in} of 1 V. Measure V_{in} and V_{out} and verify that the actual V_{out} is consistent with the theoretical output (see part 2a of the prelab, you can also simulate the circuit).
7. If the measured V_{out} is different from the theoretic, by more than 10%, troubleshoot the circuit until is operating properly. Remember that the inverting amplifier has a negative gain.
8. Create a table with four columns labeled V_{in}, theoretical output voltage, Vout (the actual output), and percent error. Leave enough room to record 21 rows of data.
9. Turn on the power supply, adjust V_{in} to -10 V, and carefully measure V_{in} and V_{out}. Increase V_{in} from -10 V to +10 V in 1V increments, measuring V_{in} and V_{out} for each step. For each line of data, compute and record the error between theoretical output voltage and V_{out}.
10. Adjust V_{in} to 2 V, and carefully measure V_{in}, $+V_{CC}$, $-V_{CC}$, V_+(non-inv input) and V_-(inv input). Turn off the power supply.
11. By placing a 10µF capacitor in the feedback path (in Figure 2-6.) and a 1MΩ resistor at the input we obtain a circuit that performs the mathematical operation of integration, see Figure 2-7. Place a switch in the closed position (a jumper will work too) across the capacitor and adjust V_{in} to 10 V.
12. Open the switch (t=0), and observe V_{out}(t) in the oscilloscope. Observe and measure the time it takes for the output voltage to fall from 0V to -4V. Save an image of the oscilloscope trace to include in your report.

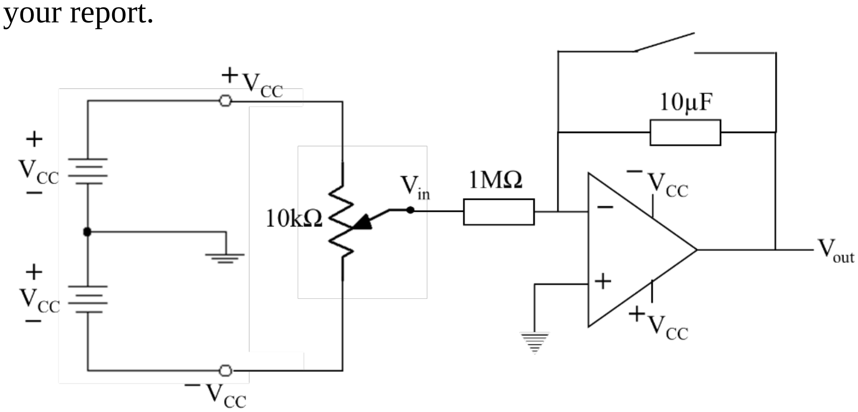

Figure 2-7 DC integrator amplifier circuit

POST-LAB

Post-Lab questions must be answered in each experiment's laboratory report.

1. For the inverting amplifier, include in your report, plots of theoretical output voltage, V_{out} (the actual output), and percent error vs. V_{in}, (i.e., three plots superimposed onto the same graph).
2. Simulate the DC integrator circuit using the same setup as in the experiment, using Multisim or PSpice. Compare the results of the simulation with those obtained in the experiment.