

# Lab 2: Op Amp Circuits

U.C. Davis Physics 116A

## INTRODUCTION

This lab introduces the operational amplifier or "op amp". The circuit is already constructed for you on a single IC (integrated circuit) and in this lab we will use the IC in several of its most popular configurations. For an introduction to op amps, see section 2.4 in *Bobrow*.

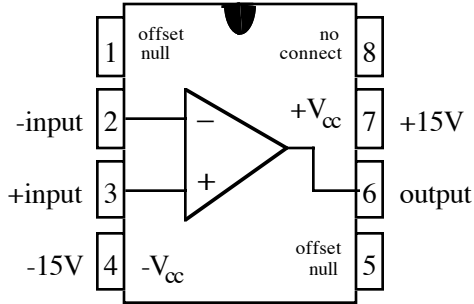


Figure 1: Pinout for the 741 op amp.

## 1. INVERTING AMPLIFIER

The pinout diagram for the LM741 op amp IC is shown in figure 1. Use this to construct the inverting op amp circuit shown in figure 2.

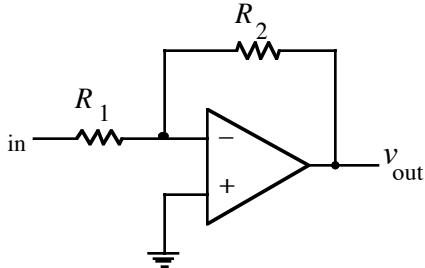


Figure 2: The inverting amplifier.

At first, use  $R_1 = 1\text{k}\Omega$  and  $R_2 = 33\text{k}\Omega$ . Derive the gain formula  $A_V = -R_2/R_1$  and experimentally verify the gain for a 100Hz sine wave. Also calculate and measure the gain with  $R_2 = 10\text{k}\Omega$  and  $R_2 = 100\text{k}\Omega$ . For your lab report, give your derivation and compare the 2 calculated and measured gains. Why is this called an inverting amp?

## 2. NONINVERTING AMPLIFIER

Construct the noninverting amplifier shown in figure 3 with  $R_1 = 1\text{k}\Omega$  and  $R_2 = 33\text{k}\Omega$ . For your report, derive and experimentally verify the gain relation

$$A_V = \frac{R_1 + R_2}{R_1}$$

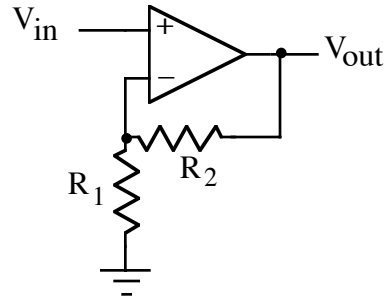


Figure 3: The noninverting amplifier.

## 3. CURRENT-TO-VOLTAGE CONVERTER

An op amp can be used to produce a voltage proportional to a given current. Construct the circuit in figure 4.

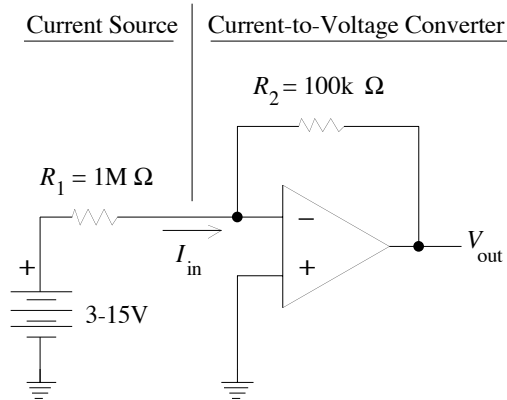


Figure 4: Current source with current-to-voltage converter.

Verify that  $V_{out} = -I_{in} R_2$  for this circuit. (That is, do the following for several voltage settings on the variable power supply: Measure the supply voltage and from this calculate  $I_{in}$ . Use the formula to calculate a theoretical  $V_{out}$  and compare this to a measured  $V_{out}$ . Include these measured values and calculations in your report along with a brief discussion of the agreement between theory and measurement.)

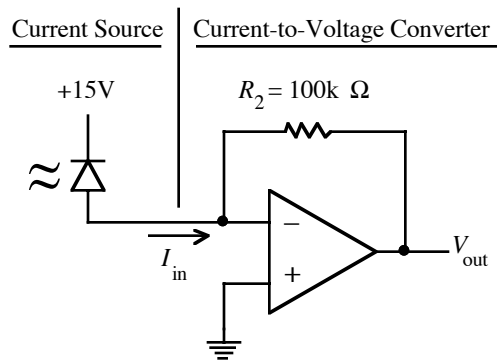


Figure 5: Photodiode with current-to-voltage converter.

Now replace the current source with a photodiode as shown in figure 5. Look at  $V_{out}$  with the oscilloscope. For your lab report, measure the intensity of light (steady and oscillating) in the room.

#### 4. INTEGRATOR

The name "operational amplifier" came from this amplifier's ability to perform mathematical operations. Two good examples of this are the integrator and differentiator which perform the operations of integration and differentiation, respectively. These are described in *Bobrow* in examples 3.7 and 3.4, respectively.

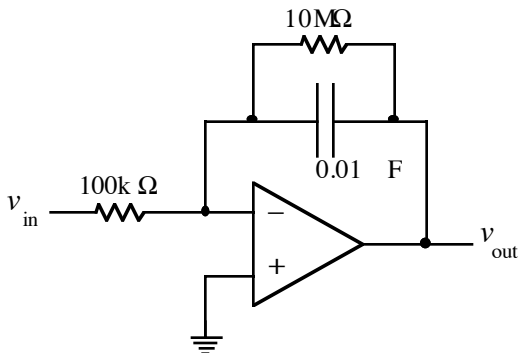


Figure 6: The op amp integrator circuit.

Construct the integrator shown in figure 6. Sketch the input and output waveforms for 1kHz sine wave, triangle wave, and square wave inputs. Try to guess what each waveform will look like ahead of time. For your report, include your sketches and show that the output waveform is indeed the integral of the input waveform.

Note that the  $10M\Omega$  resistor (a very large value) is not in the ideal integrator circuit. What is it there for? (Think about what would happen if a small DC component was present in the input waveform. What would integrating this constant do after a short time?) Try removing it

and describe what happens. Briefly discuss this in your report.

#### 5. DIFFERENTIATOR

Construct the differentiator circuit in figure 7. Sketch the input and output waveforms for a 1kHz sine wave, triangle wave, and square wave input as for the integrator. For your report, include your sketches and show that the output waveform is indeed the derivative of the input waveform.

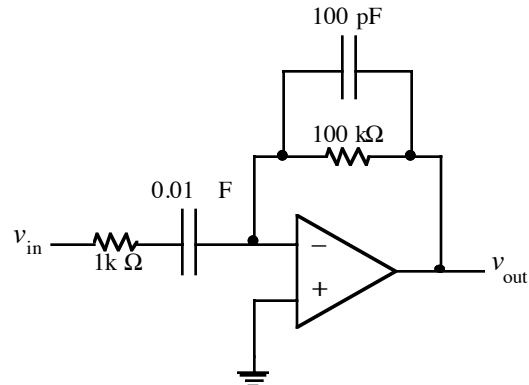


Figure 7: The differentiator amplifier circuit.

Note here that the 100 pF capacitor (a very small value) is not in the ideal amplifier. Why do you think it is here? (Think about the derivative of a square wave, for example. Could high voltages damage a chip or put a significant noise into the circuit?) Briefly discuss this in your report.