**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 invertingop amp circuit shown in figure 2. Figure 2: The inverting amplifier.

At first, use *R*1 1kand *R*2 33k. Derive the gain formula *AV= R1/R2* and experimentally verify the gain for a 100Hz sine wave. Also calculate and measure the gain with *R*1 10kand *R*2 100k. 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 non-inverting amplifier shown in figure 3 with *R*1 1kand *R*2 33k. For your report, derive and experimentally verify the gain relation

$$A\_{V}= \frac{R\_{1}+ R\_{2}}{R\_{1}}$$

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Figure 3: The non-inverting 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.)

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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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 figure7. Sketch the input and output waveforms for a1kHz sine wave, triangle wave, and square waveinput as for the integrator. For your report,include your sketches and show that the outputwaveform is indeed the derivative of the inputwaveform.



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.