AC Circuits - Operational Amplifiers
Chemistry 243 - Experiment 2
Winter 2017

Pre-lab requirements and skills
1) Reading circuit diagrams; construction and use of basic circuits.
2) Use of test and measurement equipment.

In-lab objectives
1) Learn how to build basic op amp circuits and study their response to AC signals;
2) Refresher on use of test equipment including digital multimeters and oscilloscopes;
3) Learn to evaluate and troubleshoot more complex circuits.

This lab experience is intended to some of the basic concepts of electronic measurement that you encountered in Experiment 1, and also to introduce you to circuits involving operational amplifiers, which are vital to lots of chemical instrumentation. Knowledge of the basic concepts in operation amplifier circuit design and the use of these circuits will become useful as these circuits will be used in later Chemistry 243 lab experiences where you will eventually work towards building and testing a simple functioning instrument.

Part 1: Frequency Response of an Op Amp Circuit
Construct the following circuits on the solderless breadboard. Pick one first, then do the other once you've finished all steps below (if you have time). Power the op amp with roughly +10V and -10V, just make sure to keep the inputs equal and opposite. Use the square wave output from the NI VirtualBench as the voltage source:

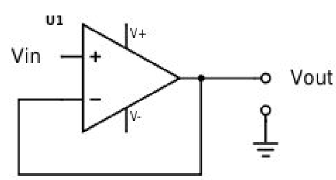

Figure 1. The voltage follower is the simplest op amp circuit made by connecting the inverting input and output pins of the op amp with a wire. This circuit is often used as a "buffer" to avoid impedance mismatches between voltage sources and measurement equipment or other parts of the circuit.

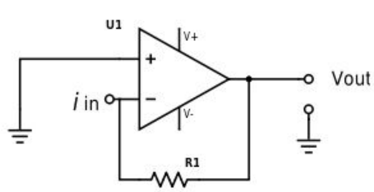

Figure 2. The current-to-voltage amplifier is used to amplify a small amount of current into a voltage that can be easily measured. The circuit obeys Ohm's law, so that the product of the input

current (times negative one) and the feedback resistor R1 is equal to the voltage out of the circuit. The choice of resistor can therefore be guided by the expected magnitude of the input current.

As in the previous Experiment, apply a sine wave to each circuit and monitor both the input (V_{source}) and output (V_{out}) signals with the oscilloscope. Vary the frequency over several orders of magnitude and examine the frequency dependence of the output voltage. Record these values in a spreadsheet and calculate the gain (Vout/Vsource) in dB using the equation gain(dB) = 20*log(Vout/Vsource). Plot this ratio vs. the frequency on the x-axis (use a log scale for this axis).

Part 2: Light Detection with a Photodiode

Get a photodiode from your instructor and create the circuit shown in Figure 3 (also see the pin diagram for the photodiode).

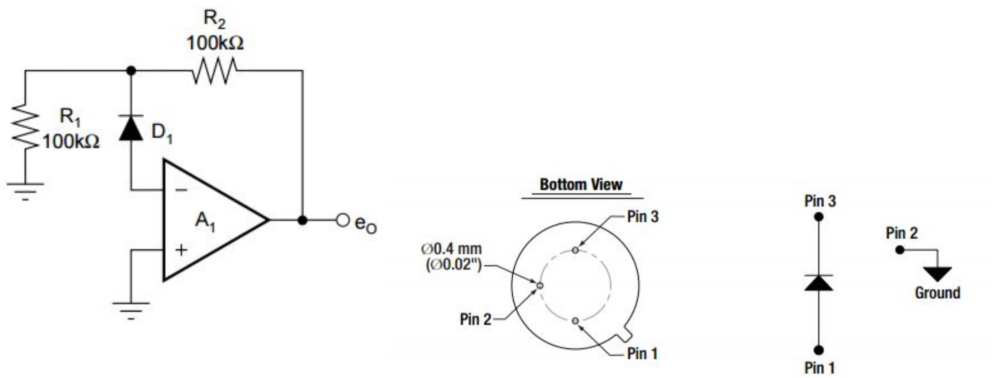

Figure 3. The current-to-voltage amplifier with the photodiode in the circuit (left) and the pin diagram for the photodiode (right).

With this circuit constructed on the breadboard, point the photodiode up at the ceiling lights and measure the voltage from the op amp with a handheld multimeter. Cover the photodiode and measure the change in signal. If it is very small or non-existent, you may want to use larger resistors for R2 and/or R1. Once you have established that your photodiode gives a light-dependent voltage, try the same experiment with a photomultiplier (if the necessary equipment is available; ask your instructor). If the photomultiplier won't be used, you can try to hook up an LED to use as a light source and see if you can detect it with the photodiode. You can do this on easy mode, using a 10V DC voltage to drive the LED and a multimeter for detection, or in hard mode (using a 10 Hz square wave from the VirtualBench and the oscilloscope as the detector) in anticipation of future experiments.