AC Circuits - Operational Amplifiers
Chemistry 243 - Experiment 3
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 op amp circuits to measure photocurrent;
2) Detect frequency modulated light with a photodiode;
3) Detect fluorescence emission and observe phase-shifted signals.

This lab experience builds on what we have done so far with op amps and signal modulation. Previously, you have used an LED and a photodiode operated in *photovoltaic mode*, in which the flow of current out of the photodiode is restricted by a load resistor and a voltage builds up. The advantage of this mode of operation is a low amount of dark current, but it is highly non=linear and not very fast.

To address these problems, you can operate the photodiode in *photoconductive mode* instead. In this mode of operation, an op amp circuit called a *current-to-voltage amplifier* or *transimpedance amplifier* is used to produce a voltage that's proportional to the resistance of a feedback resistor times the amount of photocurrent produced by the photodiode.

Today, you will set up a simple transimpedance amplifier and use it to detect a frequency-modulated signal from an LED, and also the signal from fluorescence stimulated by the light from that LED. Since the current from the photodiode is relatively small, we will use a simple non-inverting amplifier (made from a second op amp in series with the output of the first) to amplify the signal into the hundreds of millivolts range. The signal from the fluorescence detected with the photodiode will still be relatively small, but should be detectable on the digital oscilloscopes (somewhere between 20 and 100 mV, with the high end being pretty tough to reach). The result may also be noisy, so keep in mind that the oscilloscopes can do some software averaging to give you a more stable signal and make the peak-to-peak voltage easier to read.

Part 1: Construction of the Current-to-Voltage Amplifier

Construct the following circuit on the solderless breadboard.

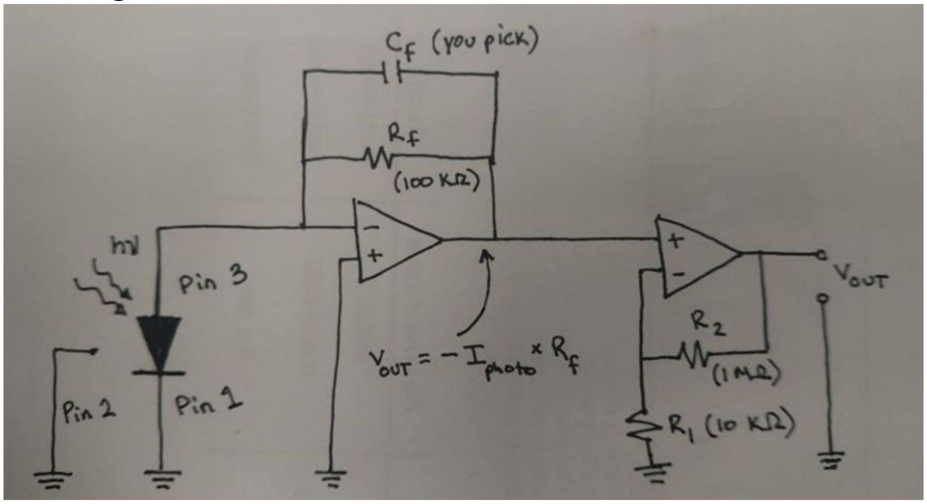

Figure 1. The voltage follower is the simplest op amp circuit made by connecting the inverting input and output pins of the op amp with a wire. This circuit is often used as a "buffer" to avoid impedance mismatches between voltage sources and measurement equipment or other parts of the circuit.

The two op amps will be on the breadboard already, as will their power supply wires and a voltage divider. You will need to add the photodiode and the appropriate resistors and capacitors.The resistors in the diagram seem to work pretty well, but the capacitor you use will impact the circuit to a smaller extent. Try it without the capacitor in the circuit, and then try a few of the options you can find in the lab to see which one works best.

Test your circuit and your choice of capacitor with a pulsed blue LED at a frequency in the 10 kHz range. Expand the range to higher and lower frequencies to figure out a good

Once you are satisfied that your circuit detects light, arrange the blue LED so that it is at a 90 degree angle to the detector and there is no signal when the light is on. You may want to use a dark piece of paper or some other physical barrier to accomplish this.

Obtain a fluorescence cuvette and fill it with DI water. Place it in the beam path and see how much scattered light reaches your detector. This is your background signal. Next, obtain a fluorescein solution (which has an excitation maximum very close to the maximum intensity wavelength of the blue LED). Record the intensity of your signal at several fluorescein concentrations and convince yourself that you have built a working (although admittedly crude) fluorometer.