Section 1 – Salinity Circuit

Water is a poor insulator but impurities in water can serve as conductors and make water more conductive. One common impurity is salt. Salt ionizes in water, forming sodium and chlorine ions. In the presence of an electric potential, the charged ions will move in opposite directions to cancel out the potential, creating a current. Up to a point, as salt concentration increases, the conductivity of water also increases. Using this property, we can create a circuit to determine the salinity of a certain water sample. The water sample can act as a resistor in a non-inverting op-amp circuit. Keeping all other circuit components (R­i and Vi) constant, the output voltage will change based on the salinity of the sample.

In order to decide on the values of the other circuit components, you will need to get an estimate of the range of resistances of salt water. Create different concentrations of salt water and measure their resistances using a multimeter. What factors (other than salinity) might affect your resistance measurements? Are you able to get stable readings? Why?

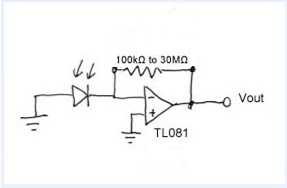
Create an op-amp circuit that relates salinity to voltage. If the multimeter was giving you fluctuating resistance measurements earlier, how can you make sure that you get stable output voltages? Calibrate your circuit using different known salinities.

Section 2 – Turbidity Circuit

Turbidity is a measure of the haziness of water. There are many different ways to quantify turbidity. One common method is to measure the amount of incident light that passes straight through (180 degrees) the turbid solution. Another method is to measure the amount of light that is reflected 90 degrees from the incident light. We will use both methods to create our turbidity circuit.

From the methods used to measure turbidity, it should be clear that the color of the solution should not affect turbidity. For example, a solution of distilled water and a solution of distilled water dyed green both should have turbidities of essentially zero. Turbidity is solely concerned with the presence of particles in the solution that disturb the passage of light. Considering this, what type of emitter and light sensor (photodiode) should your turbidity meter use?

Photodiodes generate current so you will need to build a transimpedance amplifier that converts that current to voltage readings. Derive the equation for the gain of the circuit. What value for the feedback resistor should you use (the Light Current versus Irradiance plot in the data sheet might help)? If the circuit is noisy or unstable, it might help to put a small capacitor (1pF to 10pF) in parallel with the resistor.



Apply different light intensities to the photodiode and check the output of the transimpedance amplifier on the scope. Compare the actual output with the expected output. Is the circuit working properly?

Build two amplifier circuits, one to measure transmittance and the other to measure 90-degree reflection. You might want to build a rig on which to mount the photodiodes, emitter, and cuvette since slight changes in their relative positions can affect your readings.

Create solutions of different turbidities to calibrate your meter. You can find their turbidities using a laboratory turbidity meter. Create a calibration curve that relates turbidity to the ratio of your transmittance and 90-degree reflection voltages.

Section 3 – pH Circuit

You will be working with pH probes when building your pH circuit. This website provides useful information about the probes: http://www.explainthatstuff.com/how-ph-meters-work.html. Basically, pH probes consist of two electrodes: a glass electrode and a reference electrode. The glass electrode consists of an ion-permeable glass container that has been filled with neutral solution and that contains a metal (typically silver) wire. The reference electrode is a wire of the same metal material. Both electrodes are immersed in the test solution. If the test solution is not neutral, there will be ion exchange between the test and neutral solution and between the metal wire and neutral solution of the glass electrode. The amount of ion exchange will be different, creating a potential difference between the reference and glass electrodes.

The potential difference is on the order of millivolts so the probe needs a non-inverting amplifier. Take several readings from the probe and estimate how much gain your amplifier should have and the component values of your amplifier circuit. Now try connecting the probe to your amplifier circuit. What results do you get? Are they what you expect? Do they change with pH?

Instead of connecting the probe directly to the amplifier, try adding a buffer (follower circuit) between the probe and non-inverting amplifier. Do your results match your expectations? If they don’t, try measuring the voltage output from the follower circuit.

Create a calibration curve that relates pH to output voltage.

Why do you think using a buffer was important in this situation? Hint: the current between the two wires inside the pH probe has to run through a glass membrane.

Section 4 – Pressure Circuit

Same as in the old op-amps lab; the pressure sensor has a pressure range of 0 – 50 kPa, which will measure up to about 15 feet underwater, probably good enough for the final project