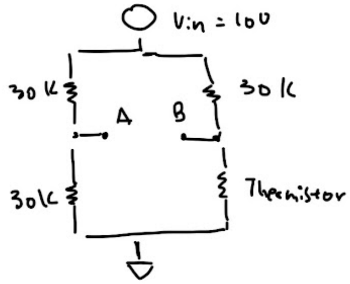
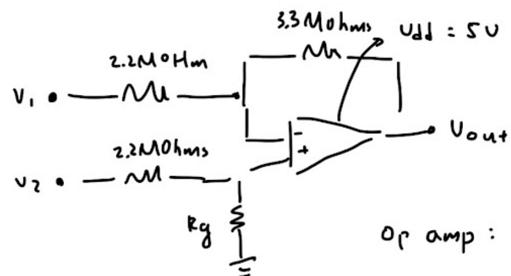
Circuit Analysis:

using thermistor NXFT15XH103FA2B025



The voltage range of this bridge is from 0V to 3,377V from the range of about 4°C to 40°C (regular environment temperatures at California)

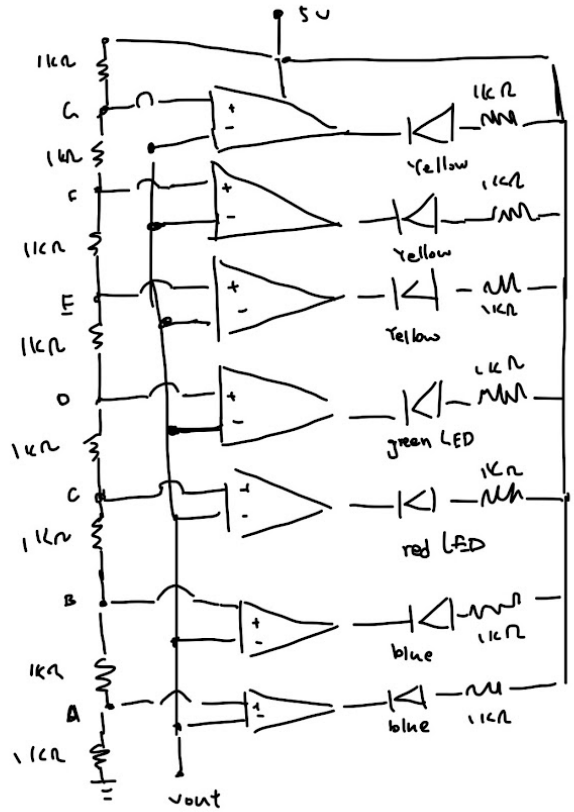
node A will be connected to V_2 while node B will be connected to V_1.



Op amp : MCP 601

then, this voltage is inputed into this op amp. It is single railed and powered by 5V and grounded. using those resistor values, we can make a gain of 1.5 $\Rightarrow \frac{3.3 \text{ Mohms}}{2.2 \text{ Mohms}} = 1.5$

The output voltage from this is called vout and goes to the next section the output ranges from 0V to 5V depending on the temperature.



This is our comparator ⇒ each of the nodes on the left A to G have increments of 0.625V. If the voltage became bigger than the voltages at the nodes, the diode at the right turns on.

The amplifiers we will be using is same as before, which is MCP601, The supply voltage range is 2.7V to 6V, and we are supplying a voltage of 5V on top.

the resistor on the left serves as voltage dividers, while the resistors on the right limit current flow through the diode.

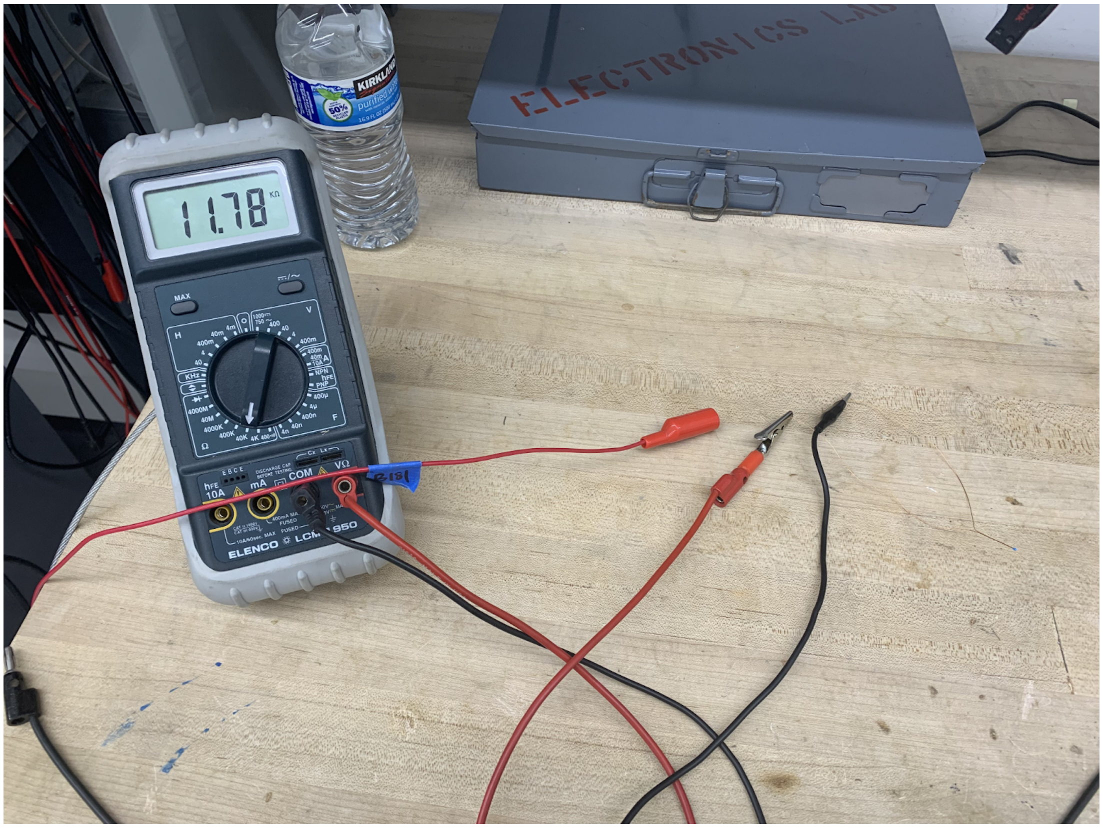
The current throgh the diode would be : $\frac{5V - V_f \text{ of diode}}{1k\Omega} = 1.5mA$

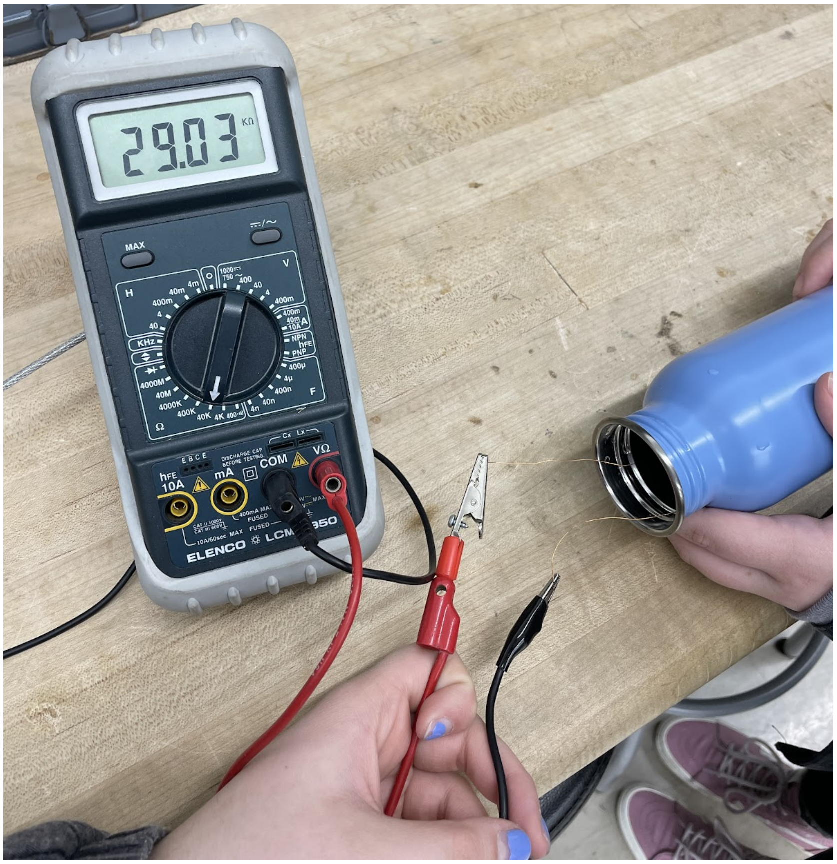
It is small enough to not break the diode

Because we are not sending in any AC signal or having any AC current, we do not need to analyze frequency and bandwidth of the op amps. However, we do need to consider the noise component. The thermistor that we have is relatively stable, so we decided we do not need a capacitor to cancel noises in the sensor.

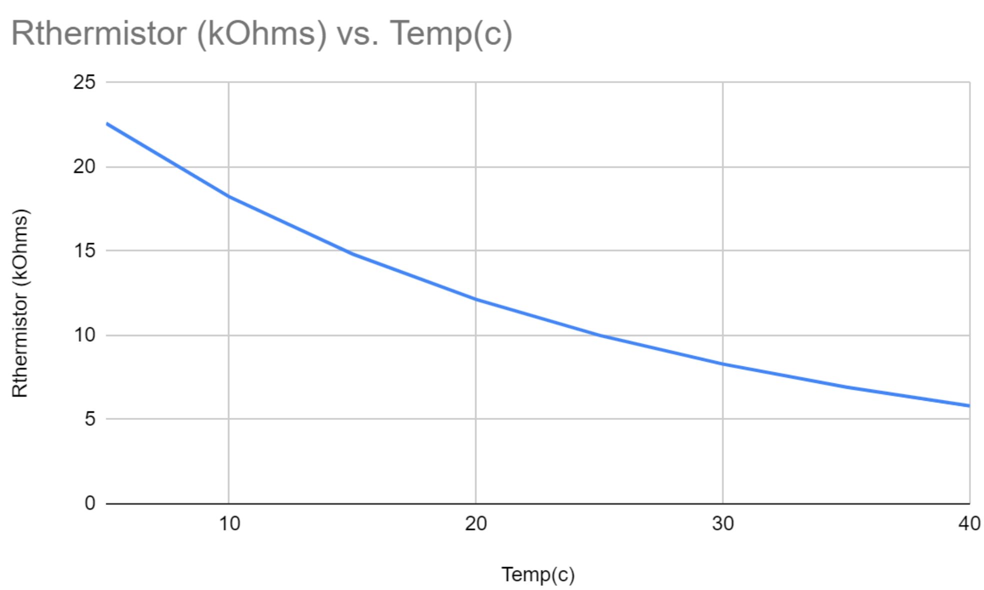
All the datasheet values are taken from [1], [2], [3], [4], [5]

Initial Testing Stage:





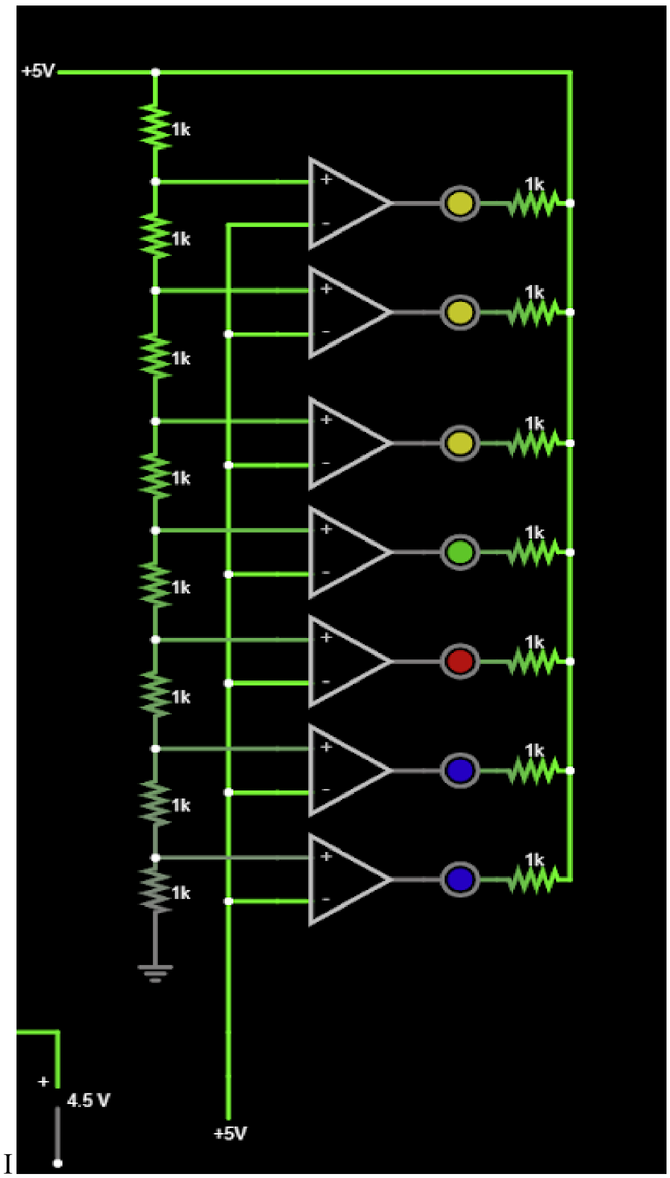
As shown above, we tested the sensor when it was at room temperature, and when the temperature rose as I squished it. We also tested the sensor in ice cold water, at about 1 degree celsius. The results align with what we would expect. Here is a graph we made from the datasheet about the thermistor's expected resistance:



Circuit Simulation:

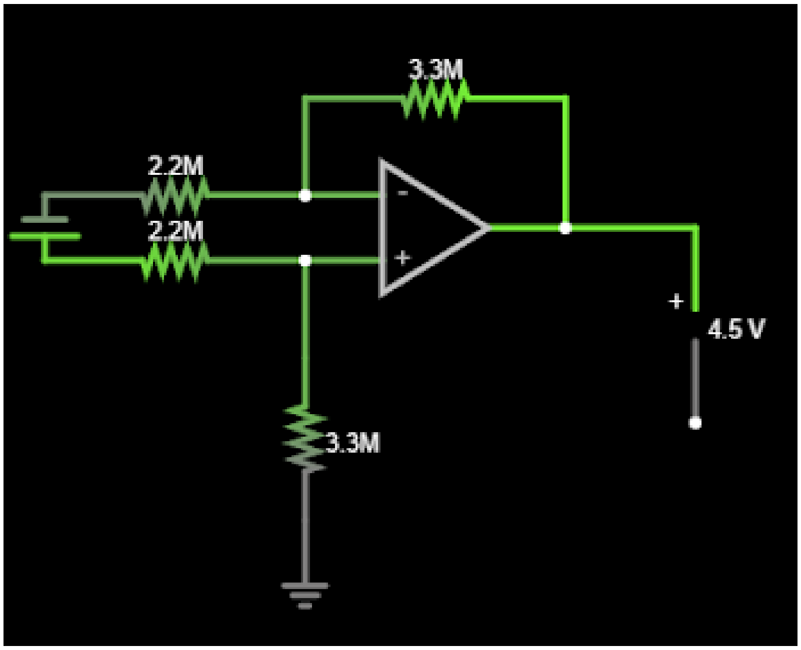
To simulate the circuit, we used the FALSTAD circuit simulator. We tested the circuit in three parts: the wheatstone bridge containing the thermistor, the interverting op amp, and the LED setup.

First, we simulated the LED setup. This includes seven op amps and LEDs connected in parallel. This voltmeter setup allows the LEDs to turn on incrementally. We tested at multiple various input voltages. An input voltage smaller than 0.625V turns none of the LEDs on and an input voltage greater than 4.375V turns on all the LEDs, demonstrating how the circuit performs as desired for our desired input range. Additionally, none of the voltages or currents across this system were too great or out of control. In the figure below, a 5V input lights up 7 of the 7 lights, as desired.



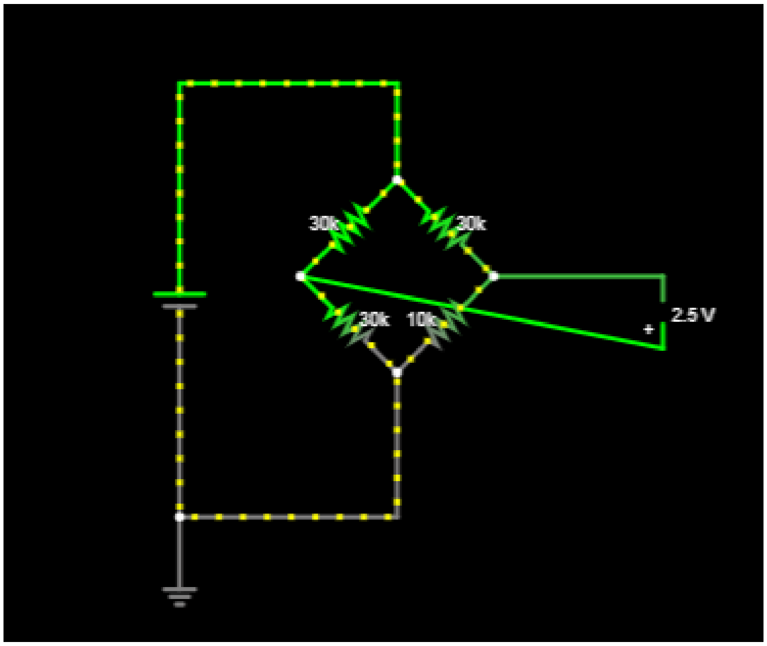
We decided to use 7 LEDs with different colors to represent the range of 4-40 degrees C. The first two blue LEDs represent the range from about 0-15 degrees C. The red LED represents a temperature above roughly 10 degrees C and the green LED represents a temperature above roughly 15 degrees C. The first yellow LED turns on at about 20 degrees C, with the remaining lights incrementing up to 40 degrees C.

Amplifier Stimulation:



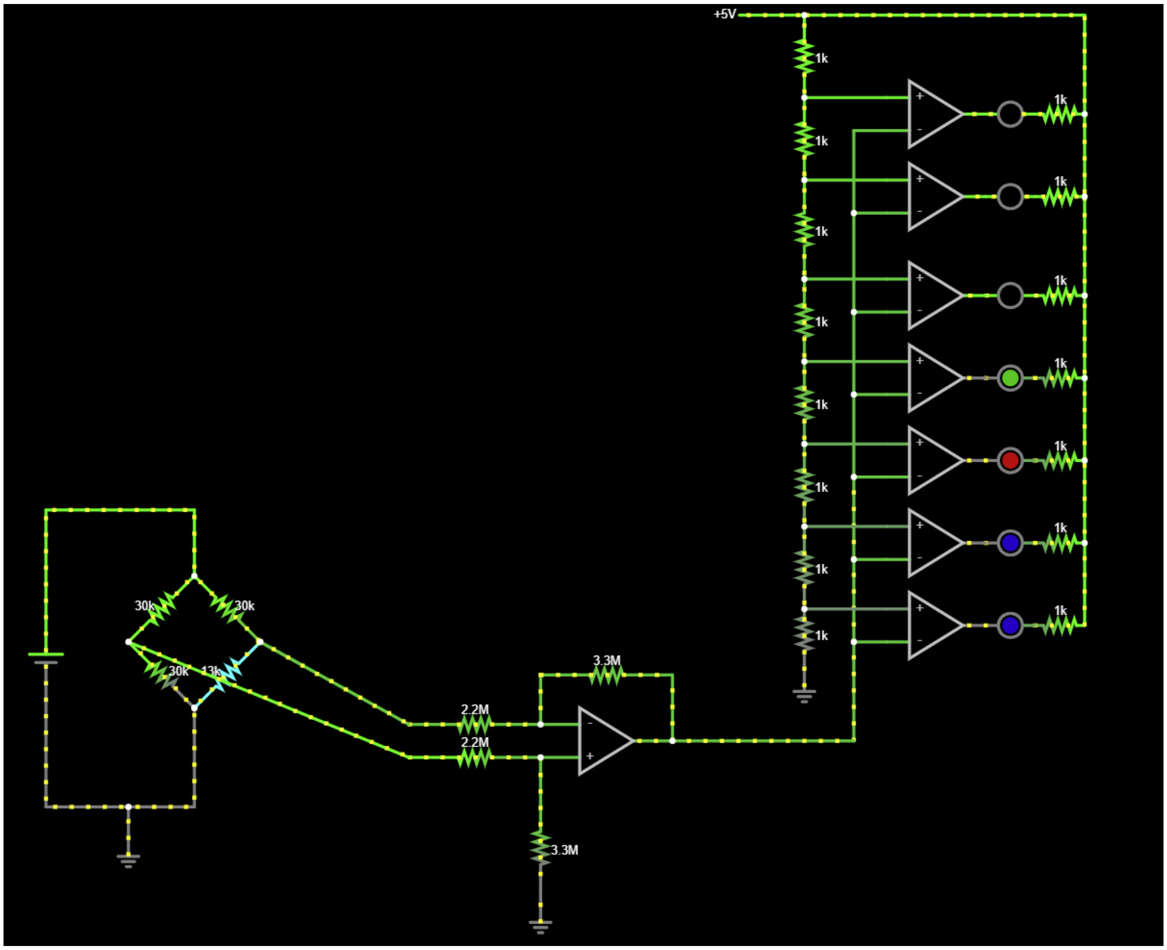
To connect the output from the wheatstone bridge to the input of the LEDs, we used a differential op amp with a gain of 1.5 (3.3/2.2). This converts the 0-3.3776V output to a desired 0-5V input for the LEDs (corresponding to 4C to 40C). We used two 2.2MOhm resistors and two 3.3MOhms resistors and an op amp (MCP601). The simulation was successful because the output voltage is exactly 1.5 times the input voltage. We input a voltage of 3V and it outputs a voltage of 4.5V.

Wheatstone Bridge Simulation:



Using a wheatstone bridge, we have a different voltage output from 0 to 3.37V from the wheatstone bridge, that will be fed straight into the amplifier shown above.

Completed stimulation:



When we connect the last two systems together, they work as anticipated. A resistor value of about 13 kOhms, which corresponds to about 17 degrees C, turns on 4 of the 7 lights total.

Because the resistance of the thermistor does not change linearly with temperature, we do not have a particularly linear representation of the lights corresponding to temperature (however, it is pretty close). Instead, we can represent our temperature and voltage using this graph: