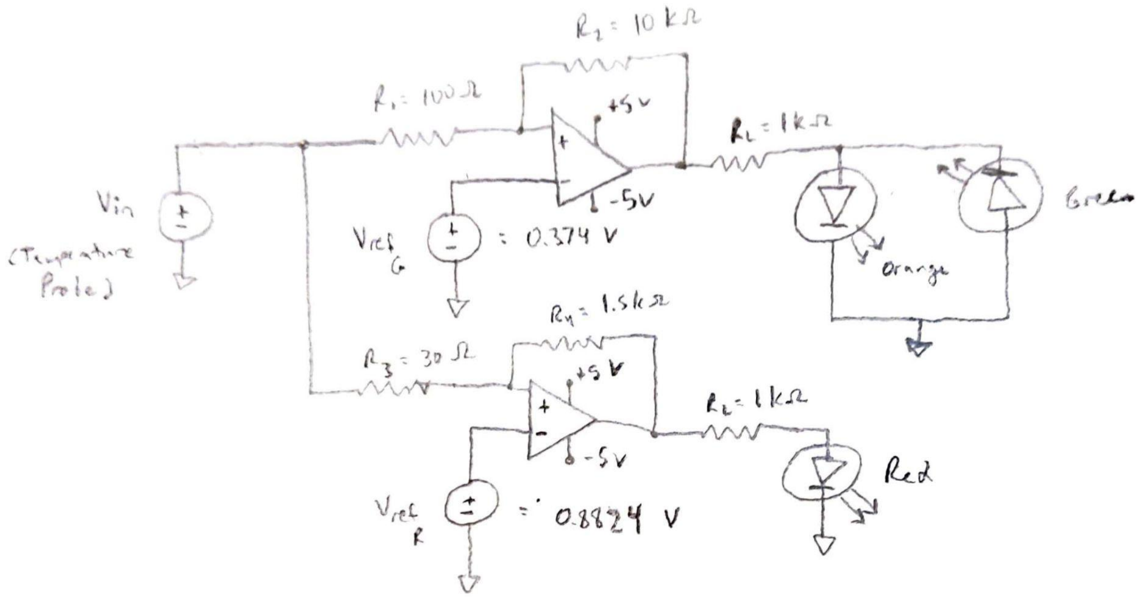
EE 230 Lab 4 - Design Lab 1 - Temperature Indicator Circuit

Group Members: Henry Shires and Nick Doty

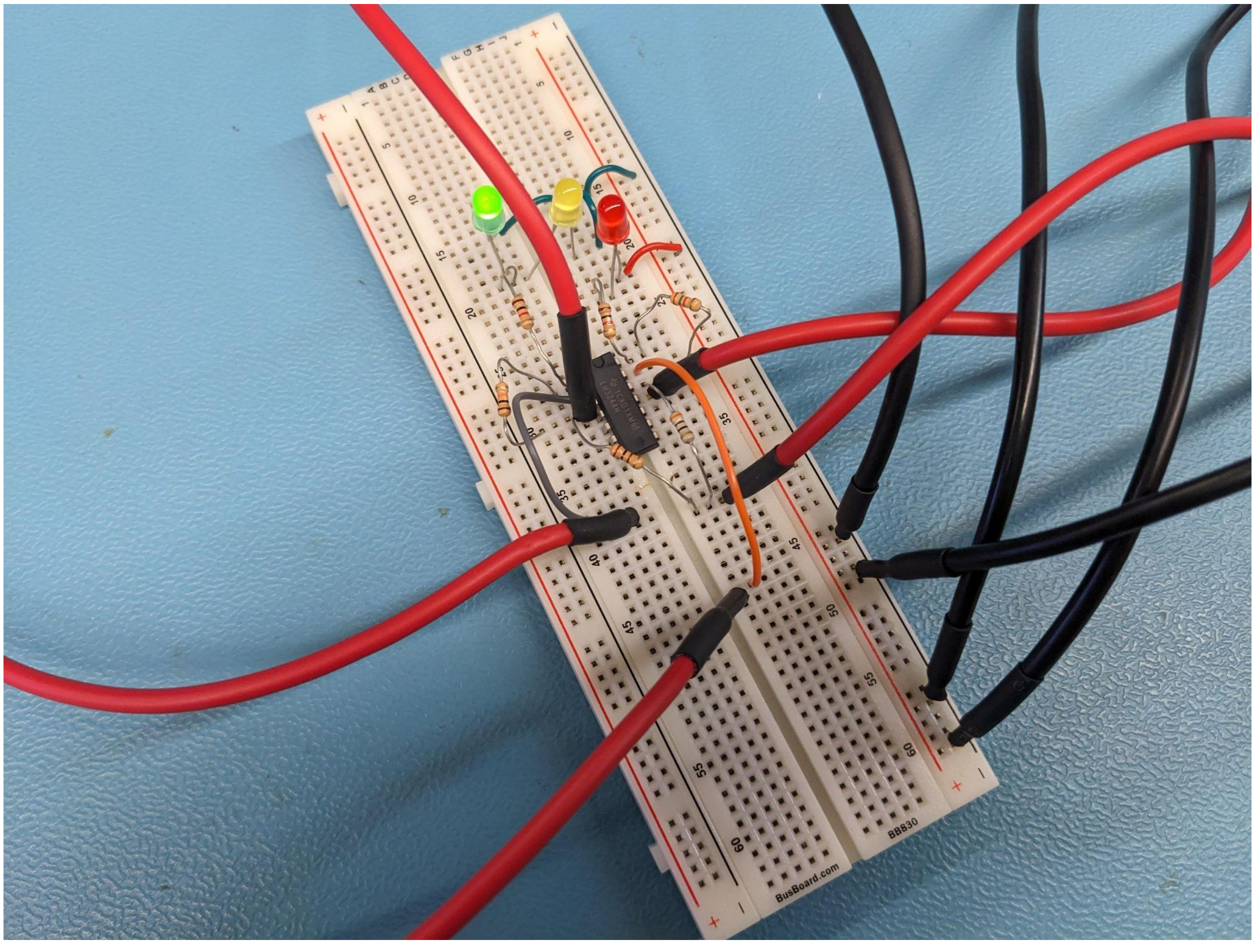
Lab Date: 9/19 to 9/26/2023

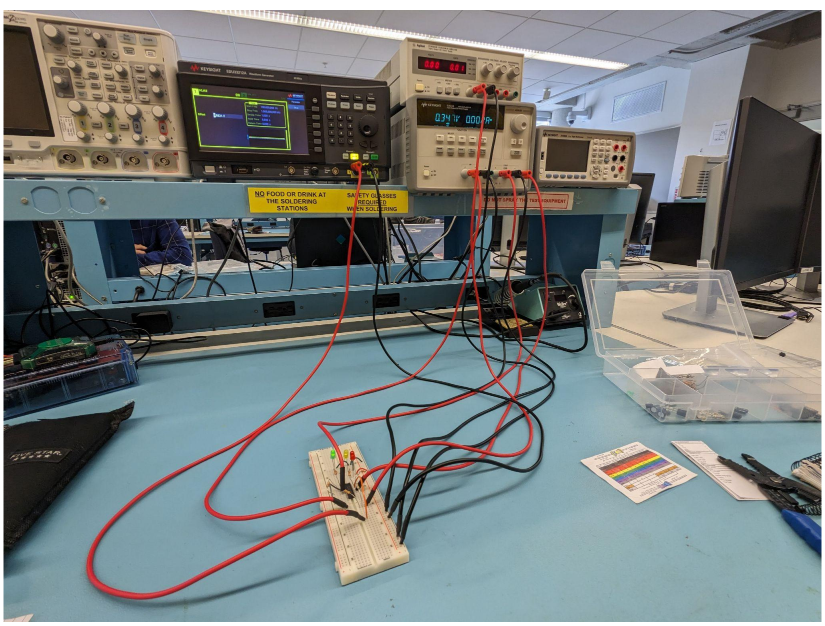
1. Our schematic of the temperature indicator circuit



Temperature Indicator Circuit

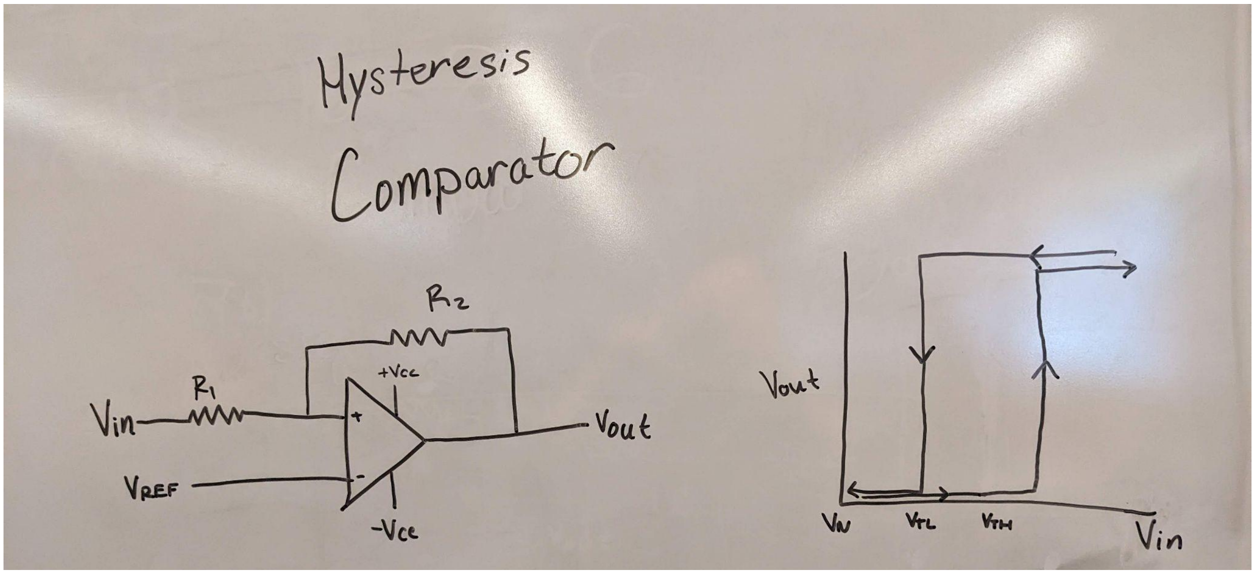
2. A photo of our built circuit and working as intended





3. Our circuit utilizes two op-amps to act as two comparators for determining if an input voltage is less than or greater than a reference voltage. Each comparator circuit is designed like a Hysteresis Comparator

to enable the signal to compare 40° C (orange and green)/100° C (red) or 0.4 V (orange and green)/1 V (red) on a temperature rise and 30° C (orange and green)/80° C (red) or 0.3 V (orange and green)/0.8 V (red) on a temperature fall according to the provided formula of the temperature sensor (vo = (10 mV/°C)*T, where T is the temperature in °C). A Hysteresis Comparator works as seen in the below sketch:



The R_2 resistor creates a positive feedback loop to enable the behavior seen in the graph to the right, plotting voltage comparisons. On the decrease of a voltage signal, the reference can be compared with a signal smaller than initially, allowing our temperature indicator to compare two separate temperatures for each LED combination.

To determine how a basic comparator circuit works, we first built the two-LED comparator hint provided in the lab. If the voltage of the input signal is less than the reference voltage, the circuit will draw current from ground through the red LED. If the voltage of the input signal is greater than the reference voltage, the circuit will behave as expected and provide a positive current towards ground through the green LED.

We modified this basic comparator to first change which LEDs are lit (green should light when the signal is LESS than the temperature threshold of 40° C and GREATER than for ORANGE). And used a quad-op amp array (LM324AN) to better organize our design on the breadboard, utilizing two of the four op amps for two comparators (orange/green and red). This allowed us to create two comparators in parallel using the same input voltage signal and two separate V_{ref} signals. Four resistors are present to utilize the Hysteresis principle and properly compare the temperature measured by the input signal and two additional resistors are to limit the LEDs as necessary.

4. To take advantage of the Hysteresis Comparator principle, we utilized an online calculator to determine the correct resistor ratios to create a feedback loop on the non-inverting terminals of each comparator's op amp (https://www.allaboutcircuits.com/tools/hysteresis-comparator-calculator/). Given our supply voltage of **±5V,** our resistor ratios are as follows:

- V_g: R_2/R_1 = 100 = **100 kΩ /10 Ω**
- V_r: R_2/R_1 = 50 = **1.5 kΩ/30 Ω**

Additionally, to properly compare rising temperatures at 0.4 V and 1 V and falling temperatures at 0.3 V and 0.8 V for green/orange and red respectively, we used the following reference voltages:

- V_{ref}red = **0.884 V**
- V_{ref}green = **0.374 V**

To limit our LEDs, each comparator used a 1 kΩ load resistor in series with the LED arrays.

The measured LED switching points resulted in the intended behavior:

- The green LED remained lit until V_{in} > ~0.4 V for increasing in temperature and V_{in} < ~0.3 V for decreasing temperature
- The orange LED lit for V_{in} > ~0.4 V when increasing in temperature and turned off when V_{in} < ~0.3 V for decreasing temperature
- The red LED lit for V_{in} > ~1 V for increasing temperature and turned off for V_{in} < ~0.8 V for decreasing temperature.

5. When we first started to design the final circuit, we chose to complete the circuit using a voltage divider to split up a single Vref signal into inputs for each comparator. We ran into issues such as the LEDs not switching on or off properly at the intended voltages. After some time, we switched to a Hysteresis comparator method and were able to get the circuit to work smoothly. Additionally, we chose to longer use the potentiometer found in the lab hint to control the varying voltage input, as using the power supply seemed to be more effective in testing.