

Project: **Temperature Indicator**

Lab work done by _____ Tejas Agarwal _____

and _____ Sean Gordon _____

Lab work date: 3-27-2019

Report submission date: 3-27-2019

Lab Section: E

Graded by _____

Score _____

Introduction -

This design project centered around the creation of a circuit that takes the input of a temperature sensor and, in the range of 0 - 100 °C, turns on or off certain LEDs at respective temperatures. This will be built with the supplied circuitry kit.

Design Requirements -

This circuit requires three LEDs to turn on and off at specific temperatures:

- Green:
 - On as it decreases below 30 °C
 - Off as it increases above 40 °C
- Orange
 - On as it increases above 40 °C
 - Off as it decreases below 30 °C
- Red
 - On as it increases above 100 °C
 - Off as it decreases below 80 °C

Components -

This circuit will be made from three comparators (one inverting, two non-inverting), a temperature sensor that scales at 10mv/°C, and three LEDs (Green, Orange, and Red).

The comparators will be comprised of various resistors and reference voltages, listed below:

Inverting (Green):

- $R_a = 1k\Omega$ $R_b = 29k\Omega$
- $V_{ref} = 3.62v$

Non-Inverting (Orange):

- $R_a = 1k\Omega$ $R_b = 30k\Omega$
- $V_{ref} = 3.39v$

Non-Inverting (Red):

- $R_a = 1k\Omega$ $R_b = 15k\Omega$
- $V_{ref} = 8.44v$

The reference voltages will be created with an 8.44v (Red) DC supply, and two voltage dividers:

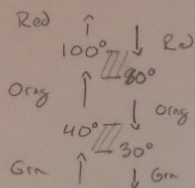
- $R_1 = 1490\Omega$ and $R_2 = 1k\Omega$, creating 3.39v (Orange)
- $R_1 = 1331\Omega$ and $R_2 = 1k\Omega$, creating 3.62v (Green)

The temperature sensor will use an LM35DZ temperature sensor, scaling at 10mv/°C.

The three LEDs will use limiting resistors valued at 680 Ω .

Notes and Written Diagram -

- Green LED requires inverting comparator.
- Orange LED requires non-inverting comparator, as does red.

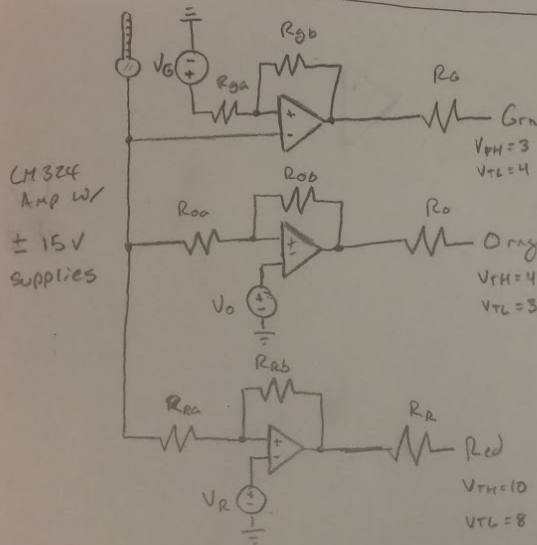


- Using 5V supply for temp. sensor.
- Sensor scales 10mV/°C *

Find voltage at °C =>
0.010 °C

$$\begin{aligned} V_{TH} &= V_{REF} \left(1 + \frac{R_a}{R_b}\right) - \frac{R_a}{R_b} V_{L+} \\ V_{TL} &= V_{REF} \left(1 + \frac{R_a}{R_b}\right) - \frac{R_a}{R_b} V_{L-} \end{aligned}$$

$$\begin{aligned} V_{TH} &= V_{REF} + \frac{R_a}{R_b} V_{L+} \\ V_{TL} &= V_{REF} + \frac{R_a}{R_b} V_{L-} \end{aligned}$$



$$\frac{R_{gb}}{R_{ga}} = \frac{15 - (-15)}{4 - 3} - 1 = 29 \Rightarrow \frac{R_{ga}}{R_{gb}} = \frac{1}{29}$$

$$V_g = 4 \left(1 + \frac{1}{31}\right) - \left(\frac{1}{31}\right)(15) = 3.62V$$

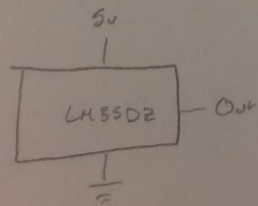
$$\frac{R_{oa}}{R_{ob}} = \frac{4 - 3}{15 - (-15)} = \frac{1}{30}$$

$$V_o = \frac{3 + \frac{1}{30}(15)}{1 + \frac{1}{30}} = 3.39V$$

$$\frac{R_{ra}}{R_{rb}} = \frac{10 - 8}{15 - (-15)} = \frac{1}{15}$$

$$V_r = \frac{8 + \frac{1}{15}(15)}{1 + \frac{1}{15}} = 8.44V$$

Temp. Sensor Setup



$R_a =$

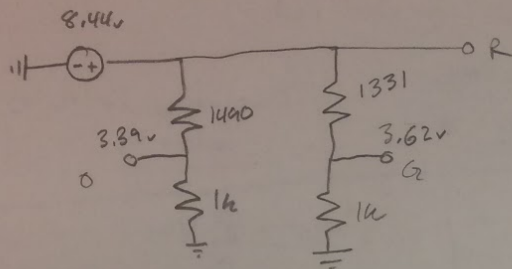
$R_o =$

$R_r =$

°C	V_o
30	3
40	4
80	8
100	10

Reference Voltages:

$$V = 8.44 \cdot \frac{1000}{1000 + R} \Rightarrow 8.44 \cdot \frac{1000}{V} - 1000 = R$$



LED limiting resistors:

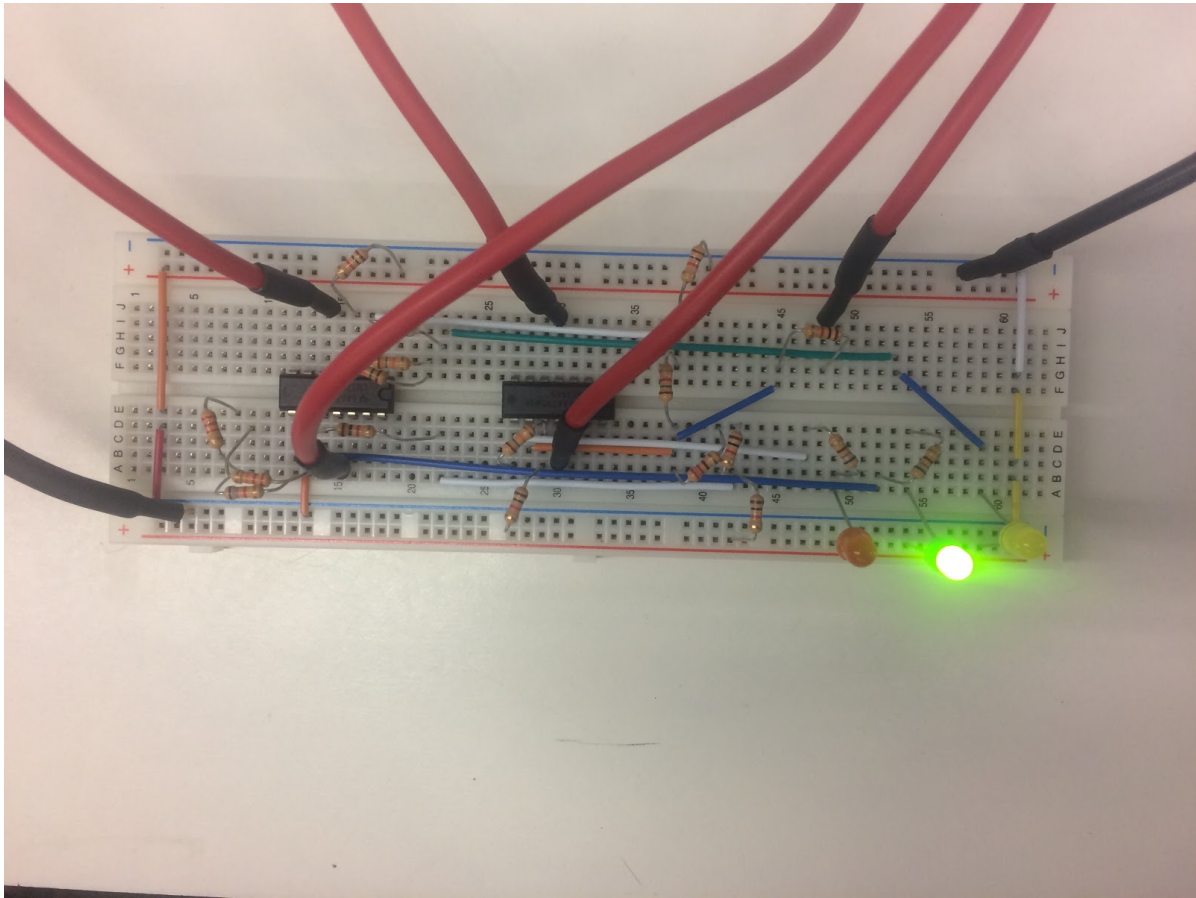
Comparator outputs 13.47V

LEDs shine brightly between 15-20mA

$$V = IR$$

$$R = \frac{V}{I} = \frac{13.47}{0.020} = \sim 680 \Omega$$

A breadboard circuit featuring a 555 timer IC. The timer is connected to a 5V supply (red wire) and ground (black wire). It has several resistors connected to its pins, including a 10k resistor on pin 1, a 10k resistor on pin 2, a 10k resistor on pin 4, and a 10k resistor on pin 5. The output of the timer (pin 3) is connected to a green LED. The circuit is powered by a 5V supply and ground.



Testing -

To test the circuit we forwent the temperature sensor in favor of a variable DC supply voltage. This was used to simulate the temperature sensor output at various voltages, as it was deemed difficult to test the circuit at one of the specified voltages of 100 °C.

The circuit was tested with the test voltage (V_t) as so:

Testing rising hysteresis:

- Start $V_t < 4v$, ensure only the green LED is lit
- Raise V_t so that $4v < V_t < 10v$, and ensure only the orange LED is lit
- Raise $V_t > 10v$, and ensure only the orange and red LEDs are lit

Testing falling hysteresis:

- Start $V_t > 10v$, ensure only the orange and red LEDs are lit
- Lower $V_t < 8$, and ensure only the orange LED is lit
- Lower $V_t < 3$, and ensure only the green LED is lit

Conclusion -

This lab was focused mainly on the usage and composition of comparators in a real-world situation. We ended up having some issues with error on the green LED, but fixed it by raising the reference voltage and raising R_{gb} , effectively shortening the range of hysteresis. Overall, the circuit planning, computation, and creation went very smoothly.