SENSOR AND ALARM SYSTEM

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GOAL

Design and build a circuit that senses change in light (through the use of a photoresistor in a Wheatstone bridge), amplifies that output (Schmitt Trigger/Comparator), sends ‘high’ or ‘low’ signal (Schmitt Trigger/Comparator), and sends an alarm (LED).

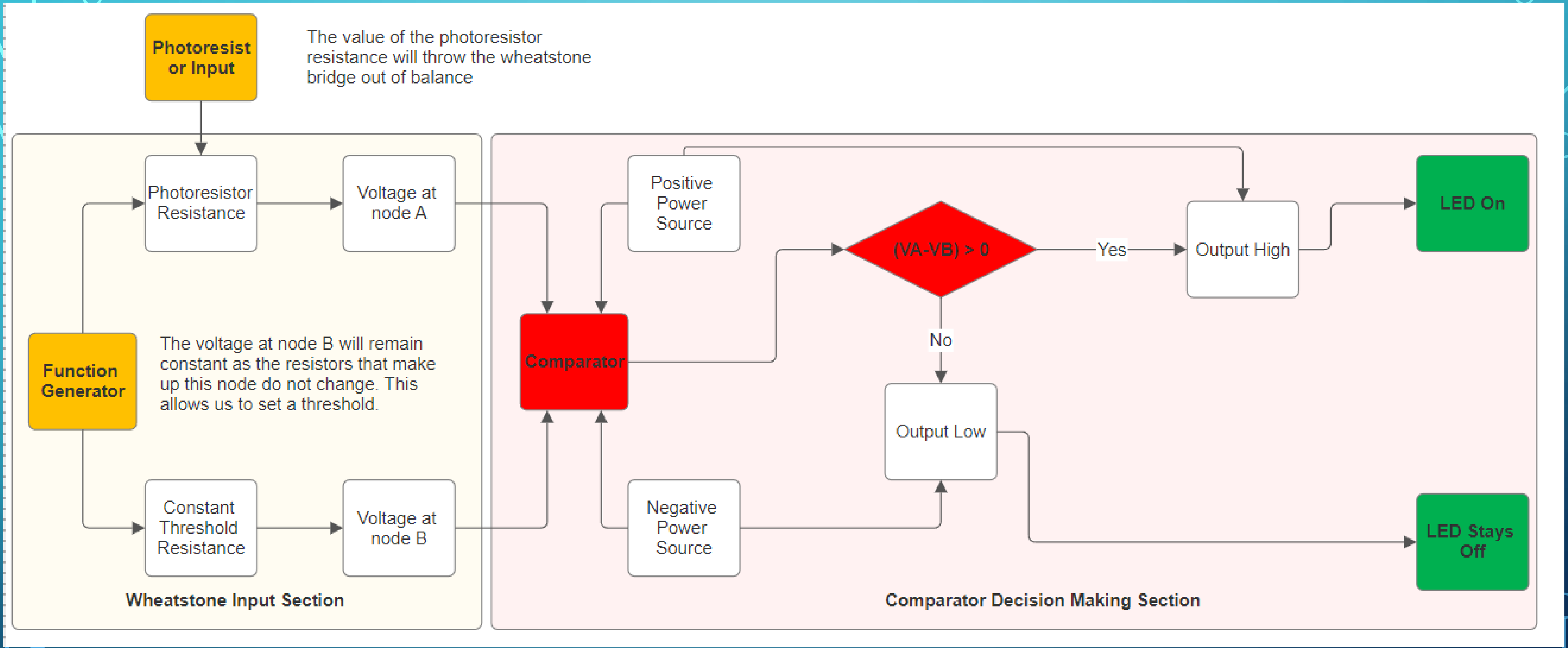


DIAGRAM USING COMPARATOR

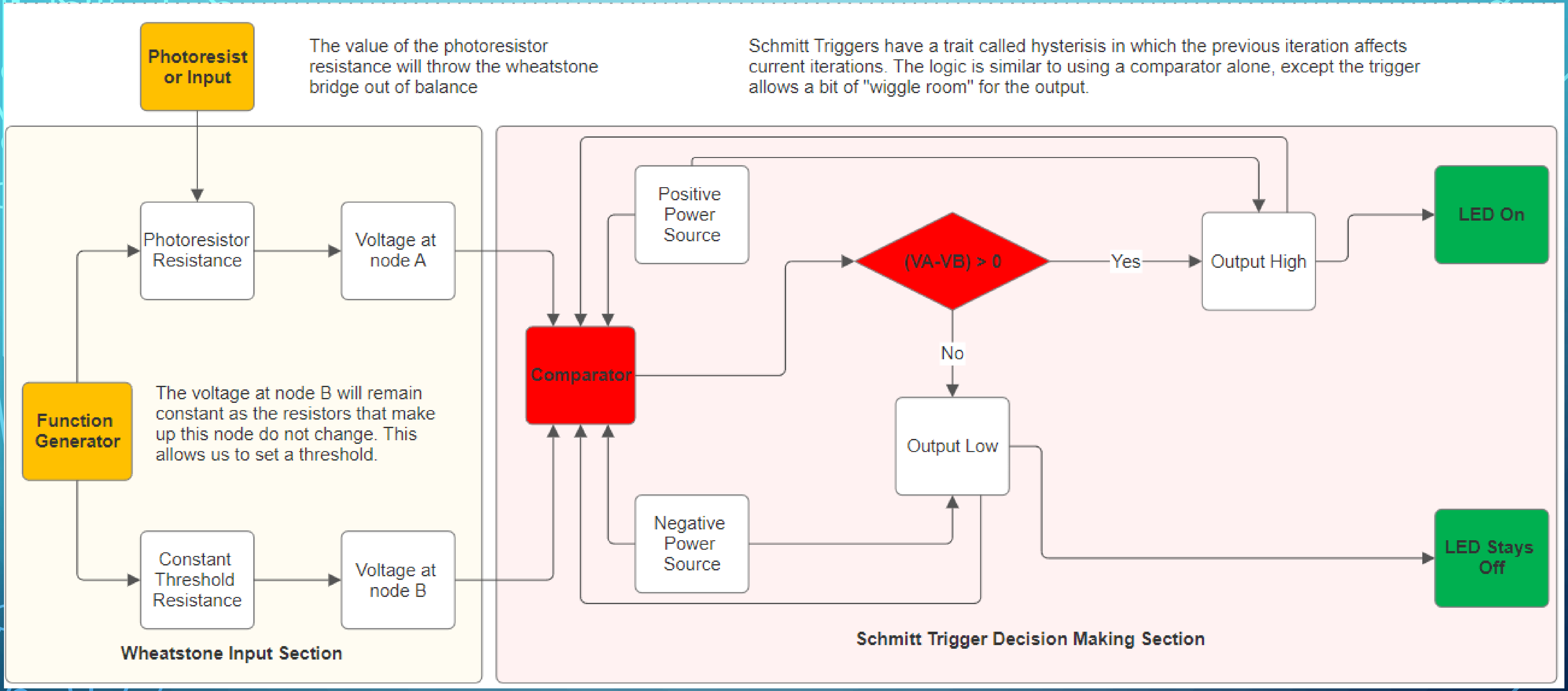


DIAGRAM USING SCHMITT TRIGGER

MATHEMATICAL ANALYSIS (COMPARATOR)

With a low resistance....

Finding VA and VB

$Rp = 1k \mid R1 = R2 = R3 = 1.2k$

$VA = 5 - VRp = 5 - \left(\frac{5 * 1k}{1.2k+1k}\right) = 2.727V$

$VB = 5 - VR2 = 5 - \left(\frac{5 * 1.2k}{1.2k + 1.2k}\right) = 2.5V$

Inserting into Comparator

$Vout = \begin{cases} V_{s+} \; when \; (VA - VB) > 0 \\ V_{s-} \; when (VA - VB) < 0 \end{cases}$

$VA - VB = 0.228 > 0, thus \; Vout = 5V$

$Von = 5V$

Von is Vout when the light is on!

With a high resistance....

Finding VA and VB

$Rp = 2k \mid R1 = R2 = R3 = 1.2k$

$VA = 5 - VRp = 5 - \left(\frac{5 * 2k}{1.2k+2k}\right) = 1.875V$

$VB = 5 - VR2 = 5 - \left(\frac{5 * 1.2k}{1.2k + 1.2k}\right) = 2.5V$

Inserting into Comparator

$Vout = \begin{cases} V_{s+} \; when \; (VA - VB) > 0 \\ V_{s-} \; when \; (VA - VB) < 0 \end{cases}$

$VA - VB = -0.625 < 0, thus \; Vout = -5V$

$Voff = -5V$

Voff is Vout when the light is off!

MATHEMATICAL ANALYSIS (SCHMITT TRIGGER)

With a low resistance....

Finding VA and VB

$Rp = 1k \mid R1 = R2 = R3 = 1.2k VA = 5 - VRp \; = 5 - \left(\frac{5 * 1k}{1.2k + 1k}\right) = 2.727V$

$VB = 5 - VR2 \; = \; 5 - \left(\frac{5 * 1.2k}{1.2k + 1.2k}\right) = 2.5V$

Inserting into Comparator

$$Vout = \begin{cases} V_{s+} \; when \; \frac{(VA-VB)}{2} > 0 \\ V_{s-} \; when \; \frac{(VA-VB)}{2} < 0 \end{cases}$$

$VA - VB = 0.228 > 0, \; thus \; Vout = 2.5V$

$Von = 2.5V$

Von is Vout when the light is on!

With a high resistance....

Finding VA and VB

$Rp = 2k \mid R1 = R2 = R3 = 1.2k VA = 5 - VRp \; = 5 - \left(\frac{5 * 2k}{1.2k + 2k}\right) = 1.875V$

$VB = 5 - VR2 \; = \; 5 - \left(\frac{5 * 1.2k}{1.2k + 1.2k}\right) = 2.5V$ Inserting into Comparator

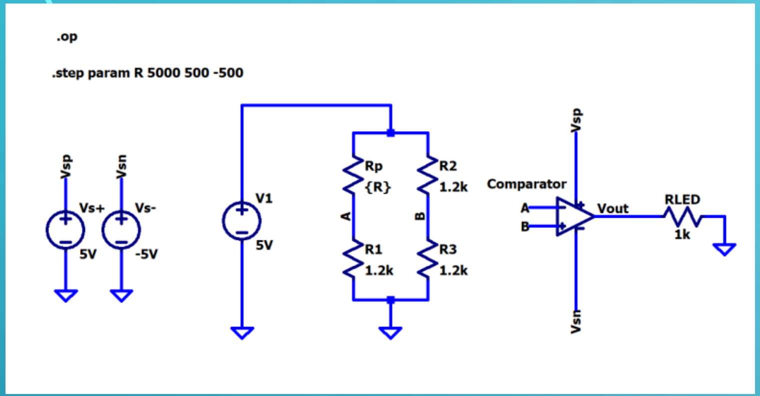
$$Vout = \begin{cases} V_{s+} \; when \; \frac{(VA-VB)}{2} > 0 \\ V_{s-} \; when \; \frac{(VA-VB)}{2} < 0 \end{cases}$$

$VA - VB = -0.625 < 0, \; thus \; Vout = -2.5V$

$Voff = -2.5V$

Voff is Vout when the light is off!

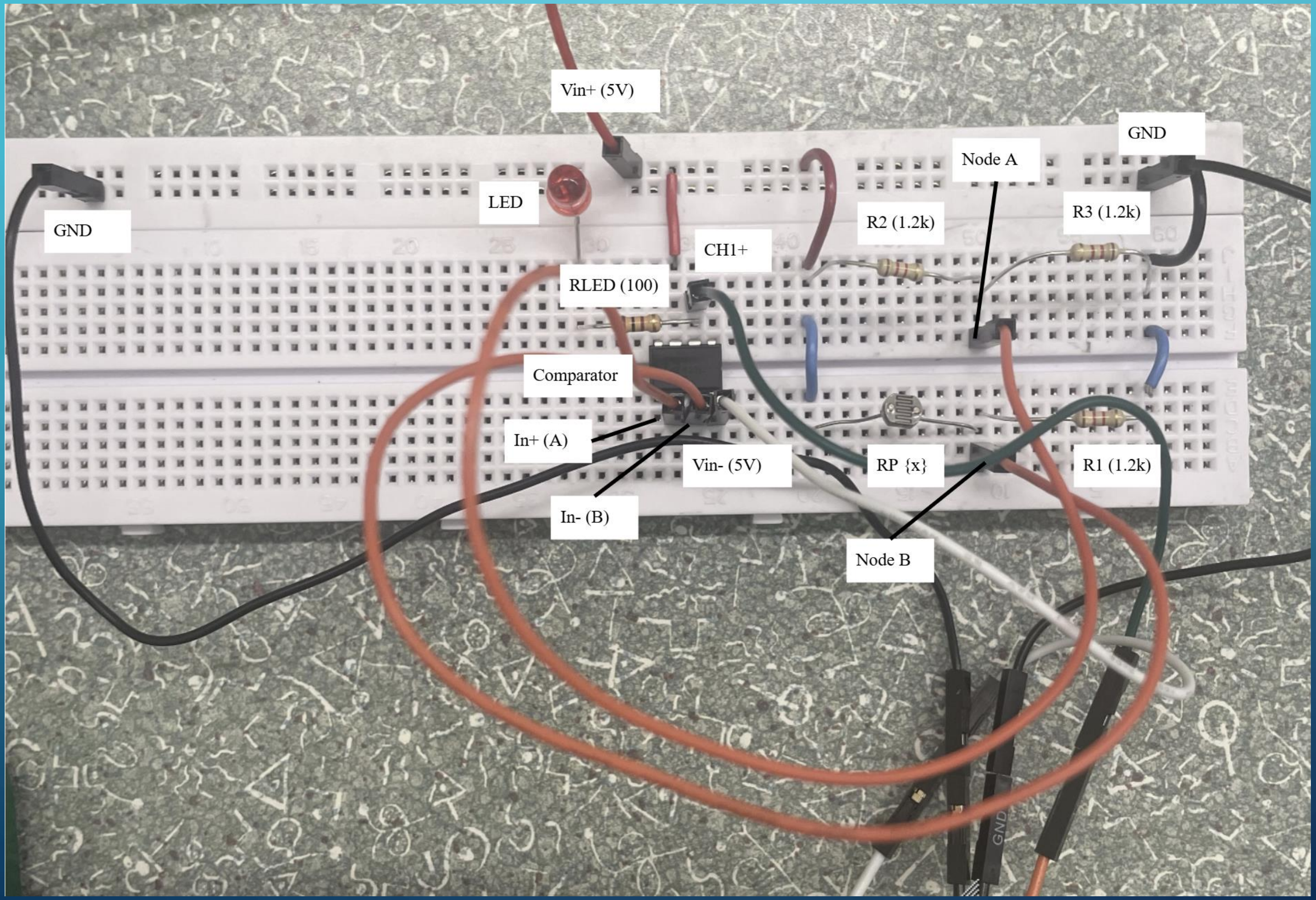
CIRCUIT SCHEMATIC/SIMULATION- COMPARATOR



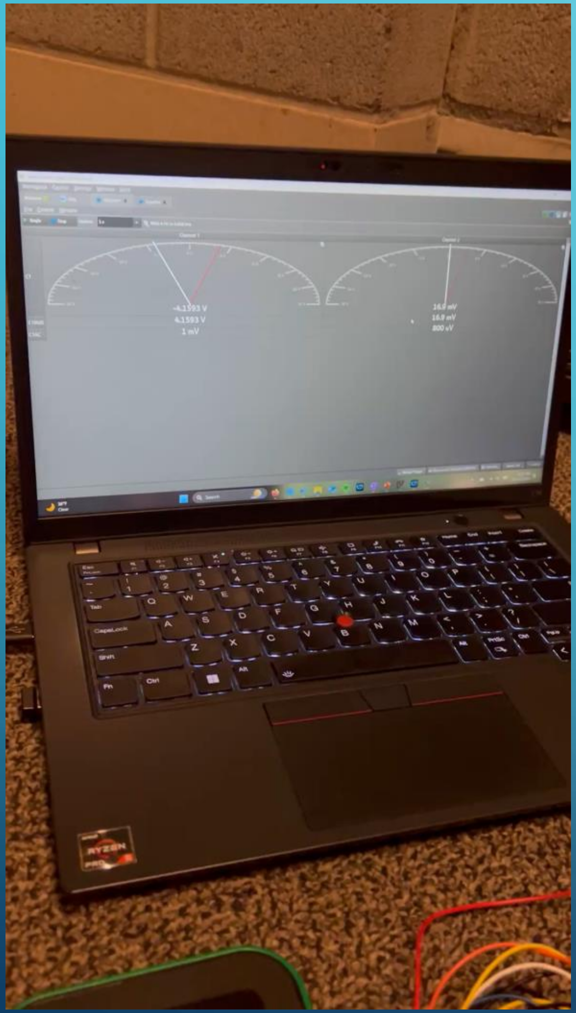
USING THE GRAPH WE SEE:
RP=2K, VOUT = -5V
RP = 1K, VOUT = 5V

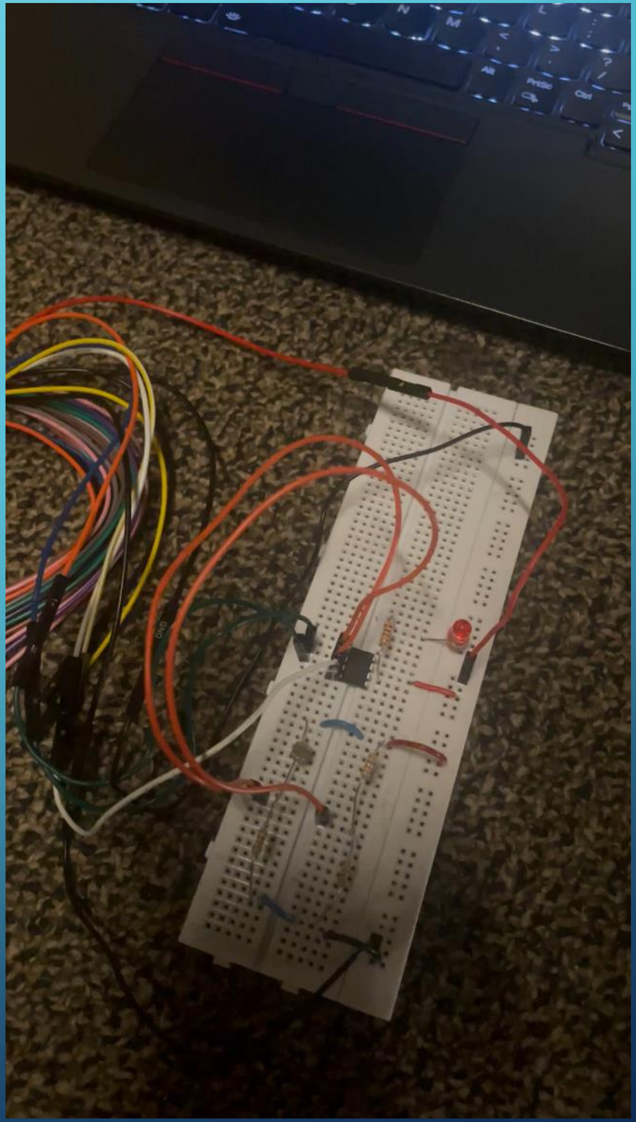
THIS MATCHES OUR MATH ANALYSIS!

EXPERIMENTAL MEASUREMENT-COMPARATOR

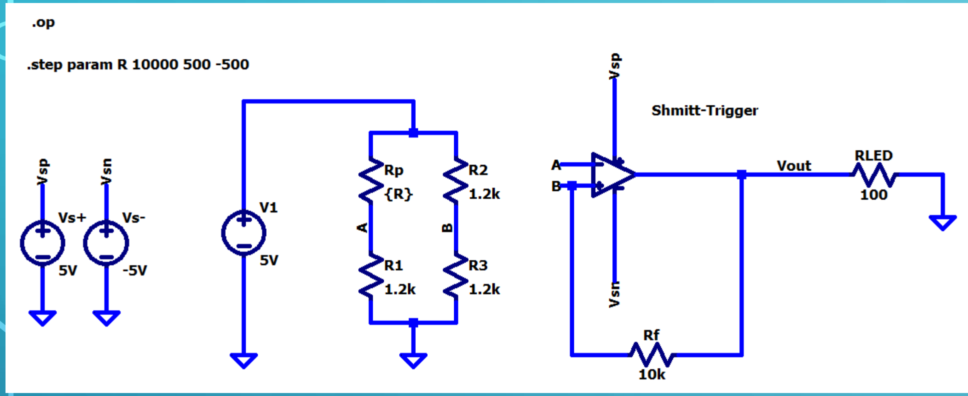


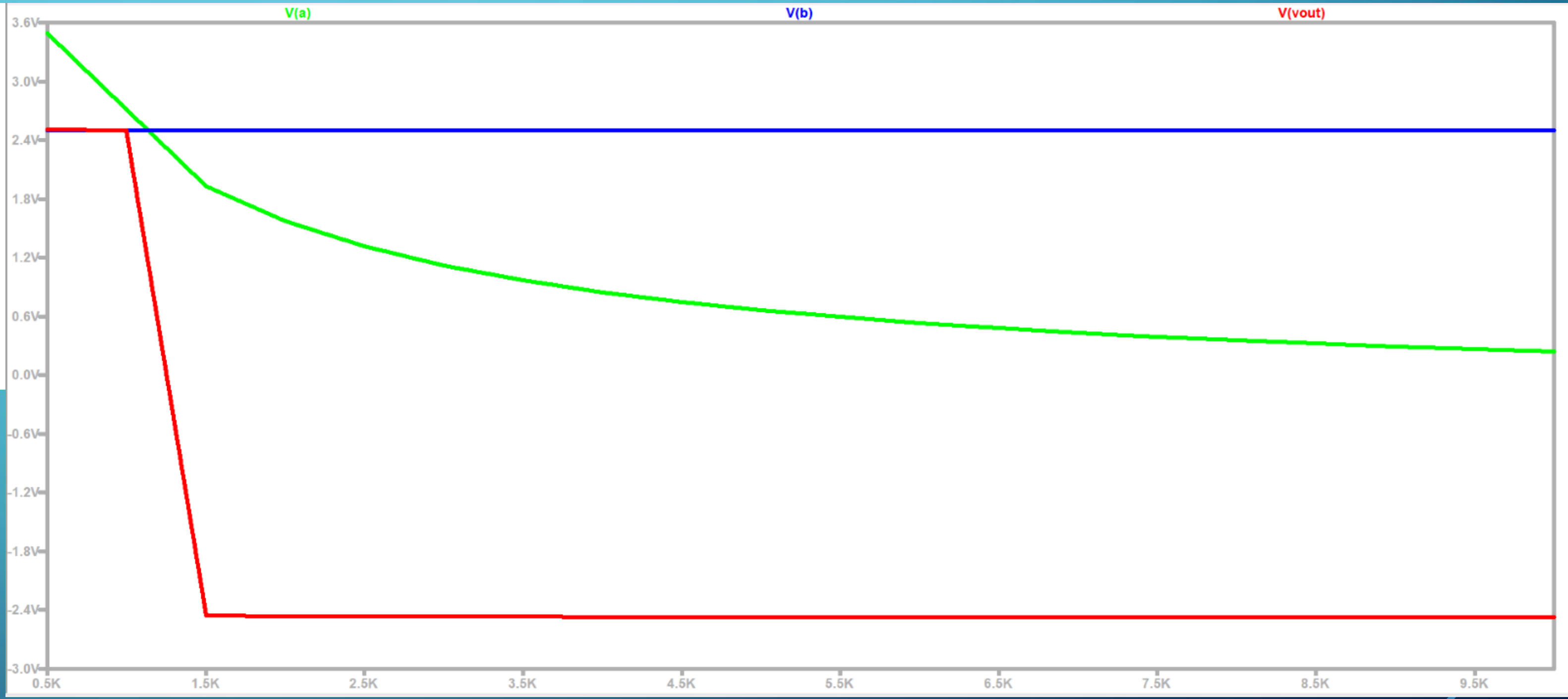
EXPERIMENTAL MEASUREMENT VIDEO-COMPARATOR





CIRCUIT SCHEMATIC/SIMULATION-SCHMITT TRIGGER

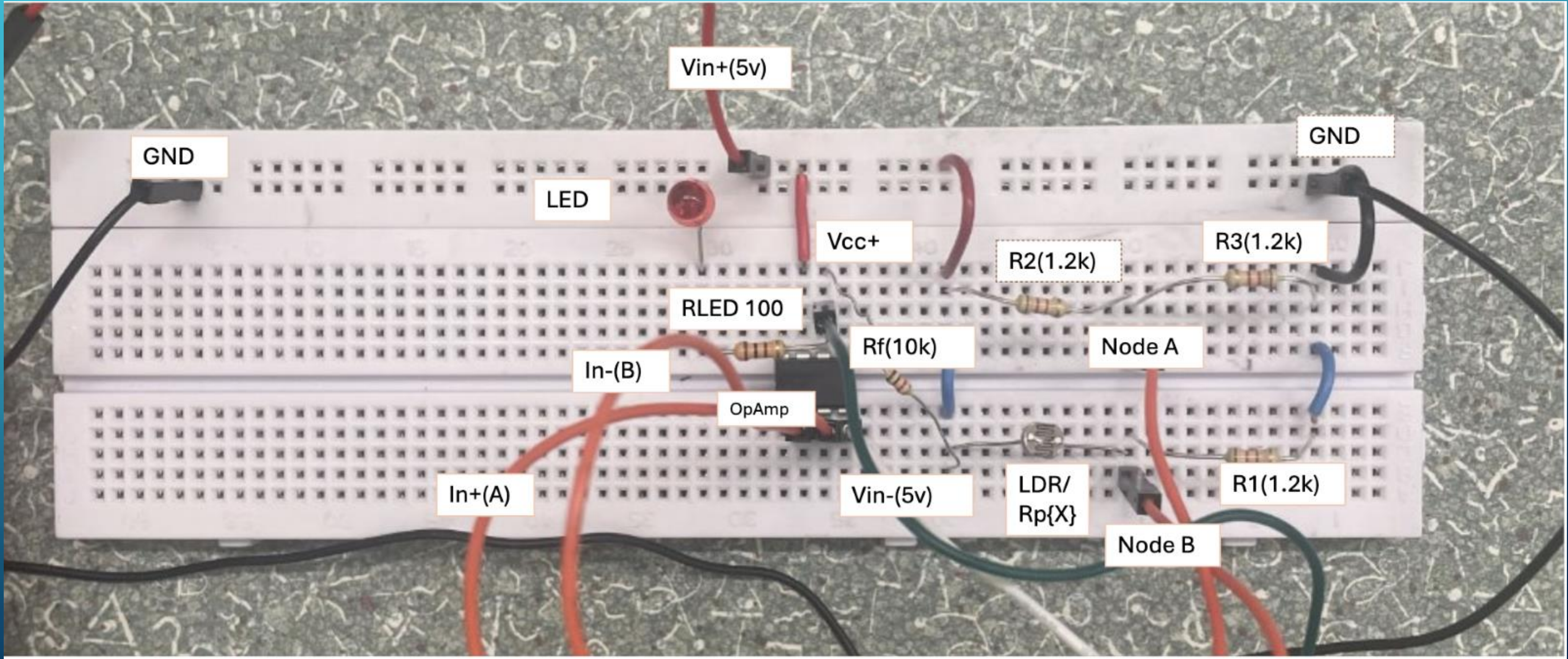




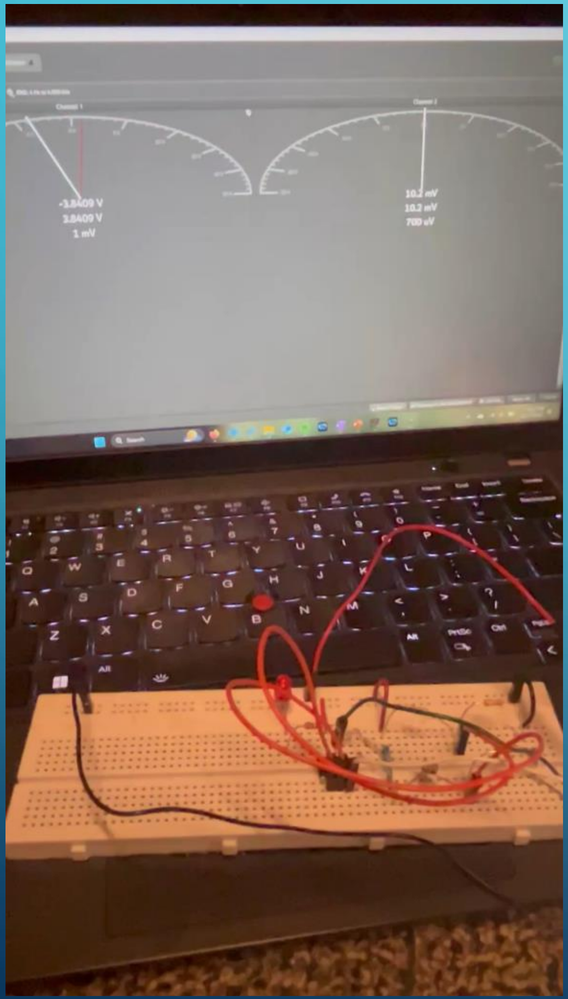
USING THE GRAPH WE SEE:
RP=2K, VOUT = -2.5V
RP = 1K, VOUT = 2.5V

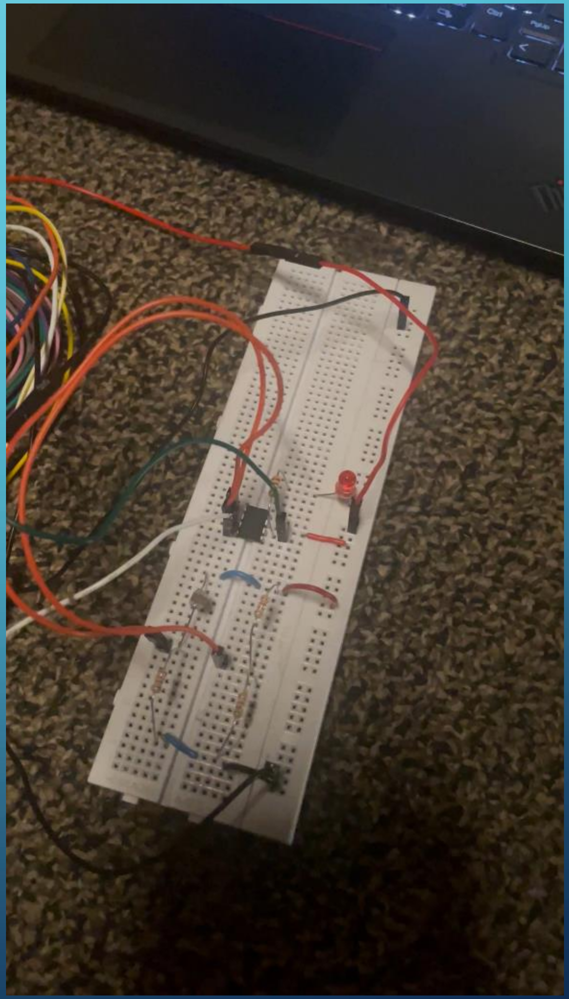
THIS MATCHES OUR MATH ANALYSIS!

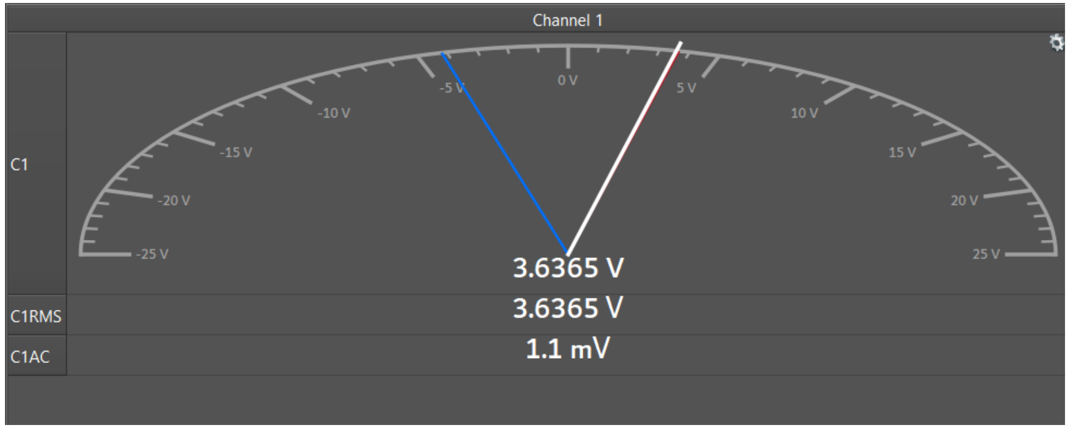
EXPERIMENTAL MEASUREMENT- SCHMITT TRIGGER

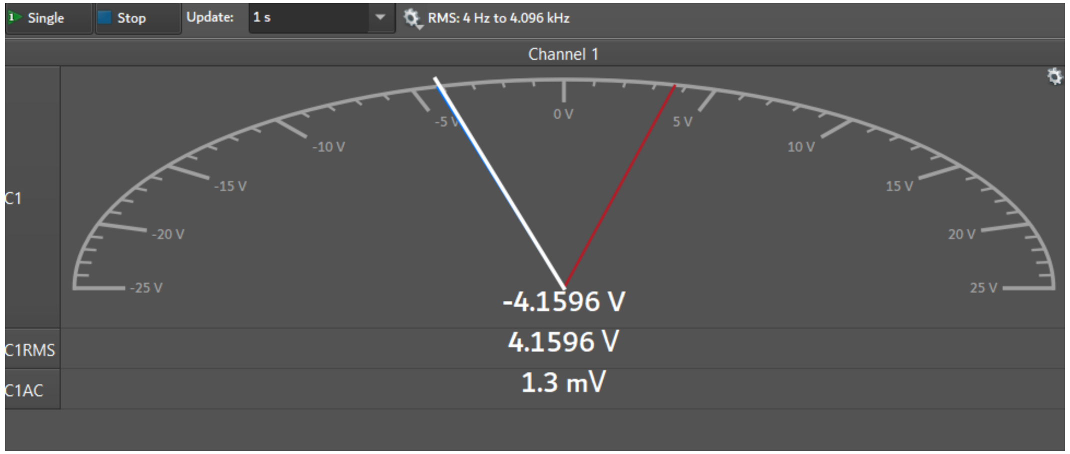


EXPERIMENTAL MEASUREMENT VIDEO- SCHMITT TRIGGER



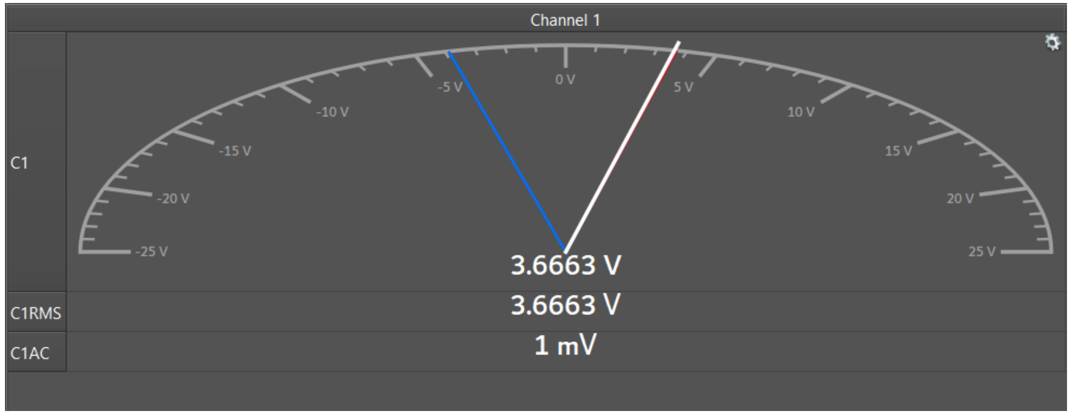


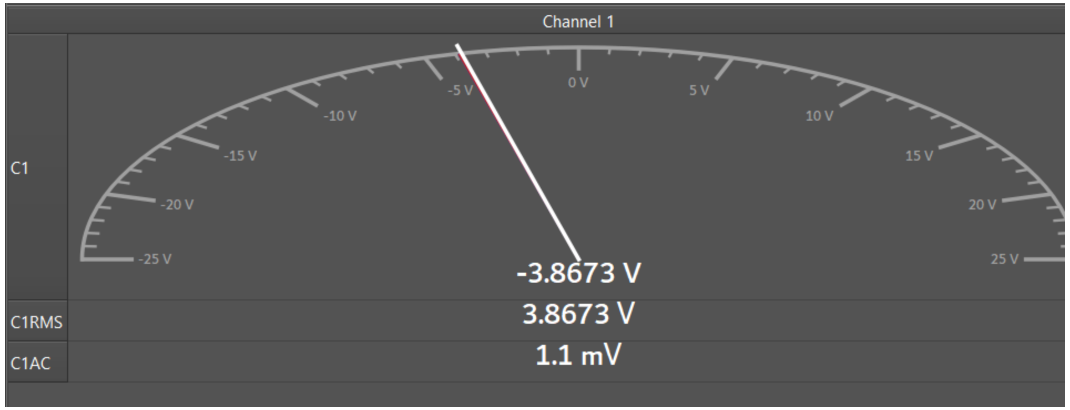




COMPARATOR MEASUREMENTS

Although not exactly the same as our simulation, the vast difference between Von (Left) and Voff (Right) shows the function of the Comparator. Internal tolerances affect Vout.





SCHMITT TRIGGER MEASUREMENTS

Although not exactly the same as our simulation, the vast difference between Von (Left) and Voff (Right) shows the function of the Schmitt Trigger. Internal tolerances affect Vout

DESIGN CHOICES

Decision Making Stage	**Pros**	**Cons**
Photoresistor	- High sensitivity to light changes, allows for a less dramatic change in light to warrant a response	- Slow response time - Hard to keep resistance constant like you can with LED
Comparator	- Pairs well with photoresistor - Part offered in class	- Doesn't manage hysteresis
Schmitt Trigger	- Good for converting sensor inputs into digital outputs - Manages hysteresis	- Unfamiliar with it - More complex than basic comparators (requires more components)
LED	- Provides clear signal when 'high' is outputted - Doesn't draw as much current as buzzer	- Need for current limiting resistor - Sensitivity to heat - Output of LED could affect input of photoresistor

UNFAMILIAR TERRITORY

- Wheatstone bridge
  - It took time to have a better understanding of how the Wheatstone bridge works and which resistor values work best with our design
  - Application of Wheatstone bridges are a part of circuit design we would not have initially considered but is very clever. We can learn more techniques in ECSE 2010 - Electric Circuits
- Schmitt Trigger
  - Schmitt triggers add on to our current understanding of Op-Amps. The concept of a threshold using feedback resistors was very interesting to work with. Decision making circuits like the Schmitt trigger are covered in more detail in ECSE 4040 - Digital Electronics.

REAL WORLD APPLICATIONS

Security System:

Light sensors can be used to stop intruders by detecting a change in light and sounding an alarm. (Example: light is let into a dark room when a window or door is opened/broken into).

Low-light technology:

In low light settings our phones and other handheld devices are able to detect when a change in lighting occurs, updating the brightness of our screens to adapt to the environment.

Commercial:

Lighting in retail stores is adjusted based on the natural lighting let in. When the sun goes down, the lig[illegible]ed on.

QUESTION

Aside from ease of use, what would change if we used a transistor instead of a comparator/Schmitt trigger?