ECE 320 - Homework #5

555 Timers, Transistors used as a Switch, Schmitt Triggers. Due Monday, February 14th

Assume a 3904 transistor (NPN) and 3906 (PNP) ($0.04 each)

$$\beta = 100 \qquad \min(|V_{ce}|) = 0.2V \qquad \max(I_c) = 200mA$$

Assume a thermistor with

$$R = 1000 \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right) \ \Omega$$

555 Timers

1) Determine the on and off times for the voltage at V2 for following 555-timer circuit

On-Time: charge through R1 and R2

$$T_{on} = (R_1 + R_2) \cdot C \cdot \ln(2)$$

$$T_{on} = (10k + 20k) \cdot 0.1uF \cdot \ln(2)$$

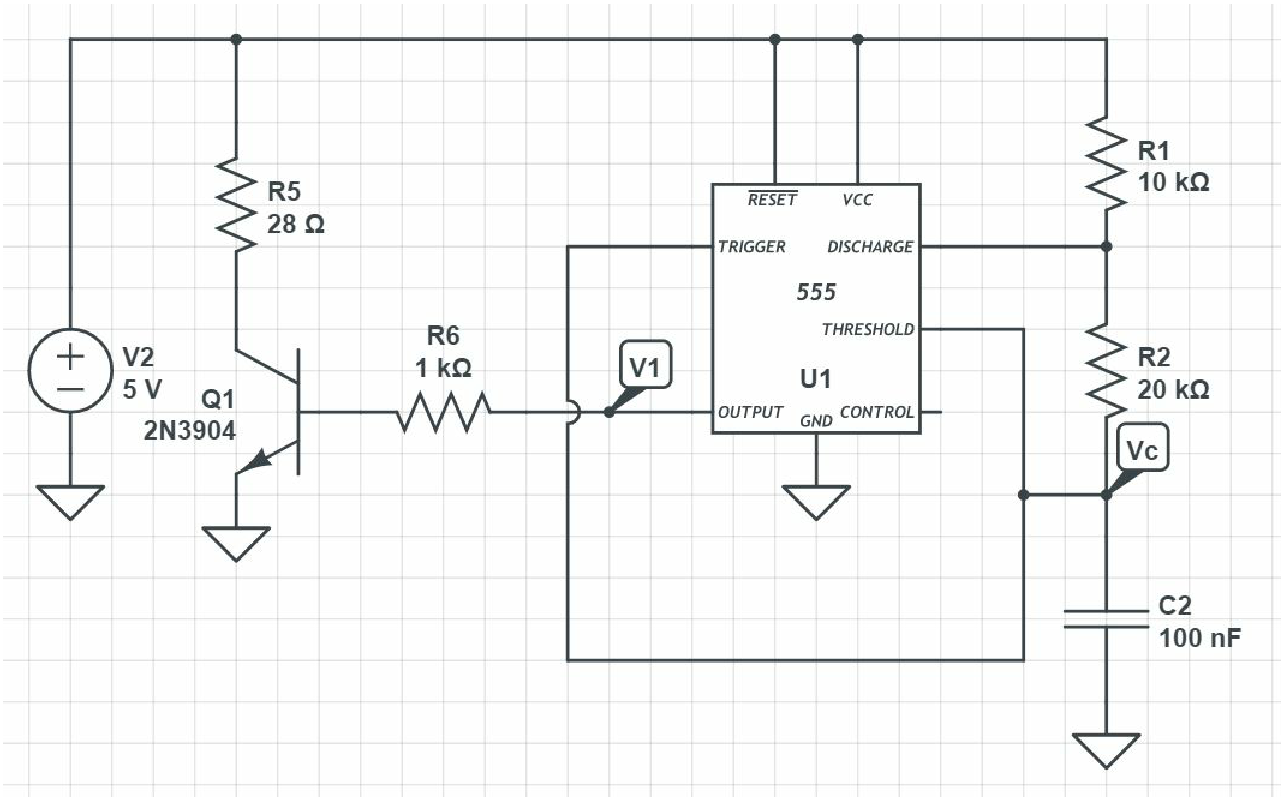
$$T_{on} = 2.079ms$$

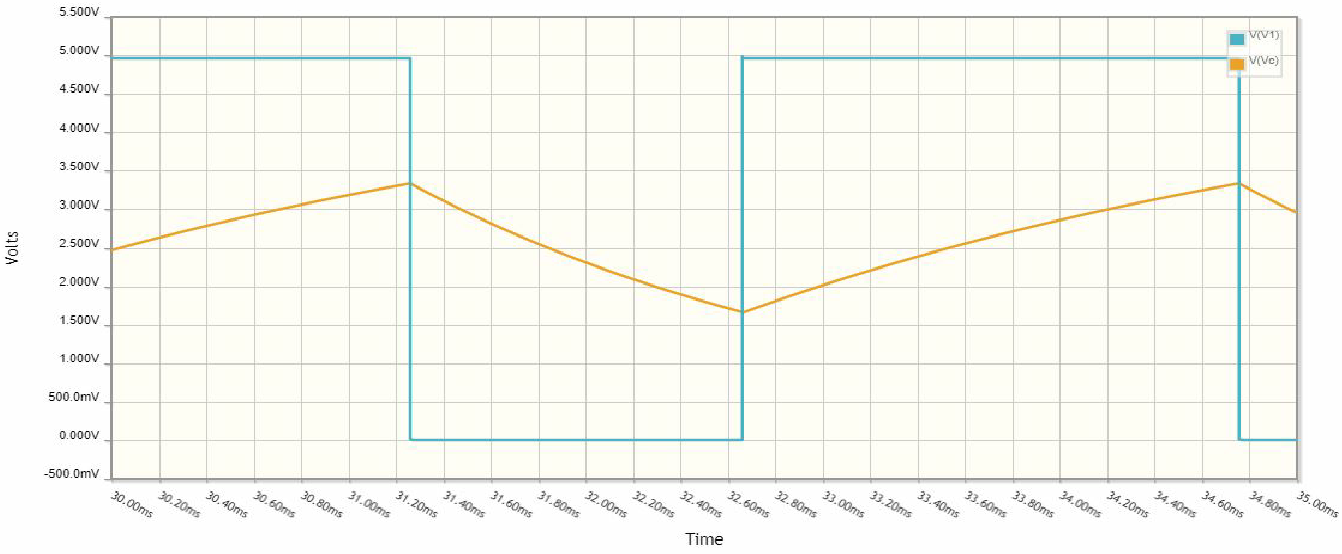
Off-Time: discharge through R2

$$T_{off} = R_2 \cdot C \cdot \ln(2)$$

$$T_{off} = 1.386ms$$

2) Simulate this circuit in CircuitLab and verify the on and off times





555 Timer Output at Vc (orange) and Vout (blue)

	On-Time	Off-Time
Calculated	2.079 ms	1.386 ms
Simulated	2.08 ms	1.41 ms

Transistor Switch

3) Determine the voltages {Vb, Vc} and currents {Ib, Ic} when

When V2 = 0V (off)

- Vb = 0V
- Vc = 5V

When V2 = 5V

- Vb = 0.7V (ideal diode)
- Vc = 0.2V (saturated)

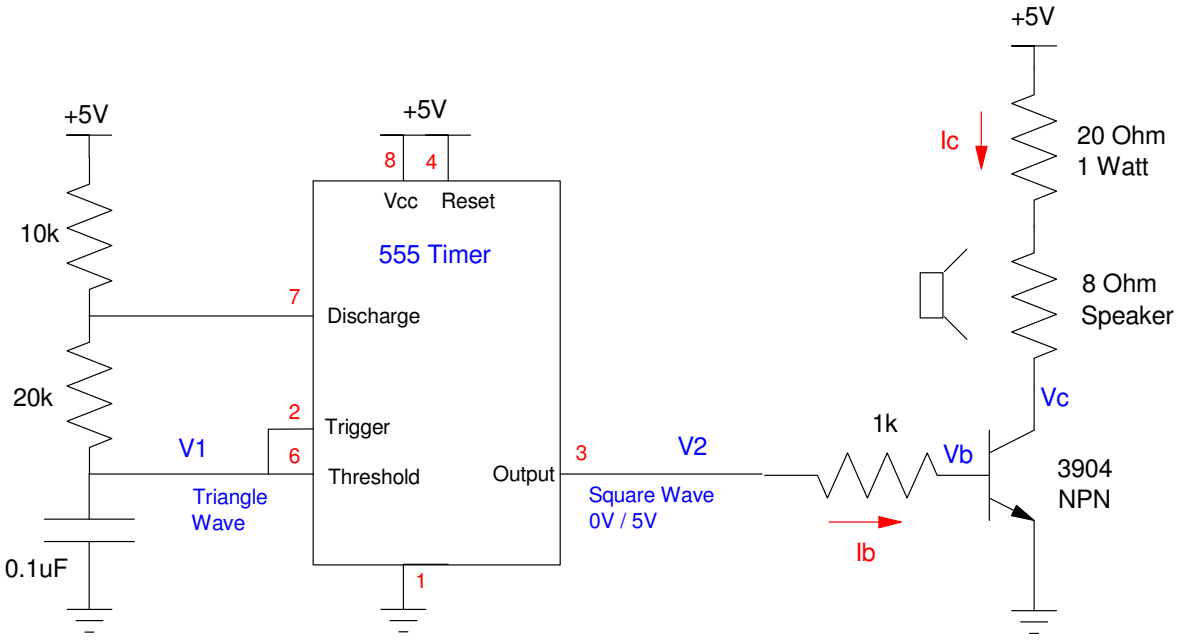
4) Verify your calculations using CircuitLab

When V2 = 0V

- Vb = 0V
- Vc = 5V

When V2 = 5V

- Vb = 0.8361V
- Vc = 0.2417V



Comparitor

Add an electronic switch to turn the speaker on and off

$$R = 1000 \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right) \Omega$$

5) Design a comparitor (shown in blue - don't add the red resistors (they are for a Schmitt trigger)) to

- Turn on the speaker (V3 = 5V) when T > 40C, and
- Turn off the speaker (V3 = 0V) when T < 40C

At 40C

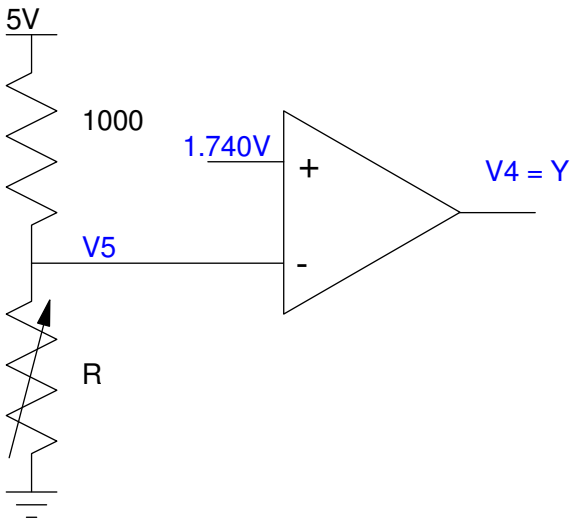
R = 533.66 ohms

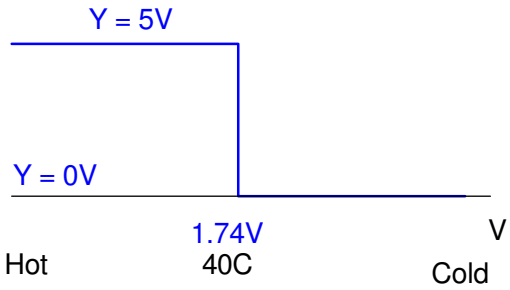
V5 = 1.740V

Make V6 = 1.740V so that the comparitor switches at 40C (create 1.740V with a voltage divider)

Connect the thermistor (V5 thermistor) to the minus input so that

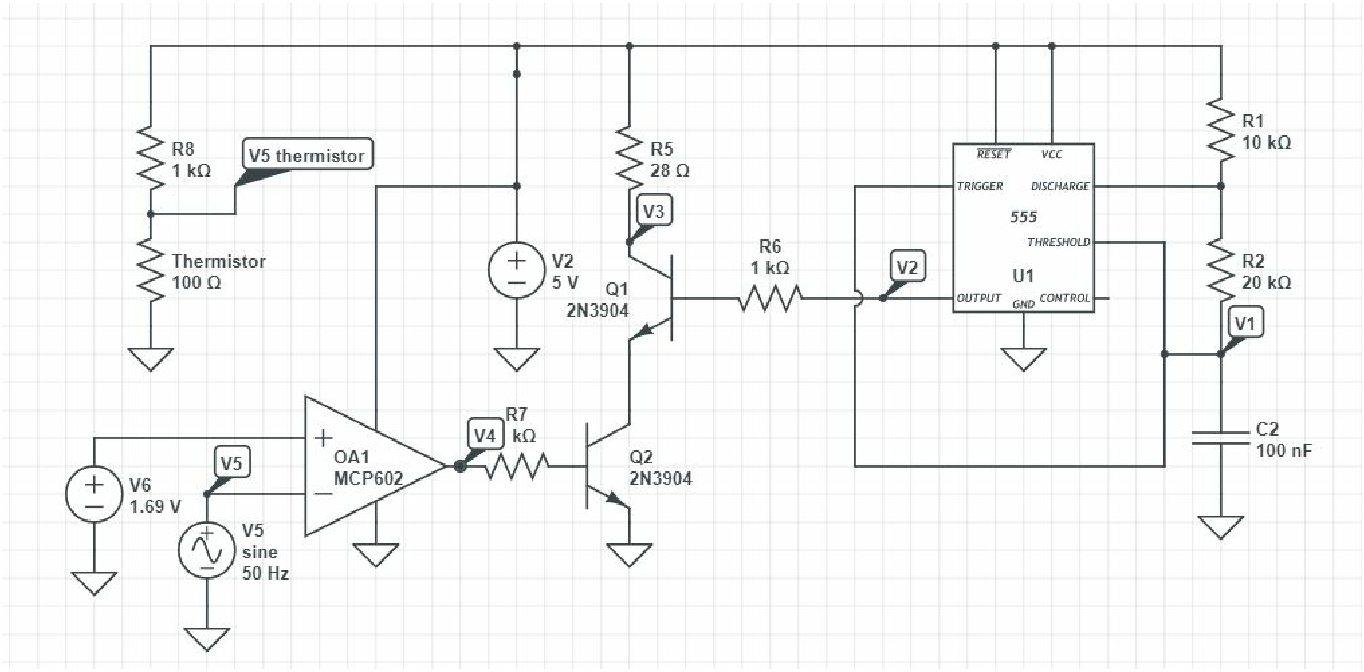
- As temperature goes up, R(thermistor) goes down
- V5 goes down
- V4 goes up (V4 is 5V when it's hot)





6) Simulate the comparitor in CircuitLab to verify the on / off temperature (or resitance or voltage)

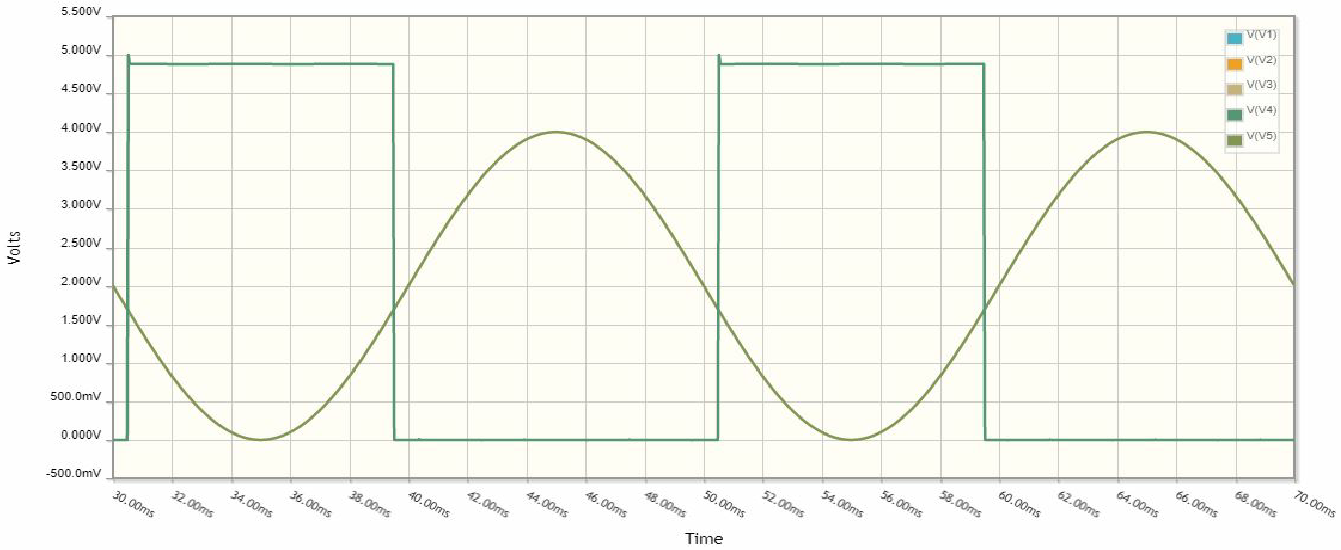
- use a voltage source (V4) to simulate the voltage at the voltage divider)



Schematic for a temperature alarm with a comparitor.
Note: V5 is replaced with V5 Thermistor in hardware

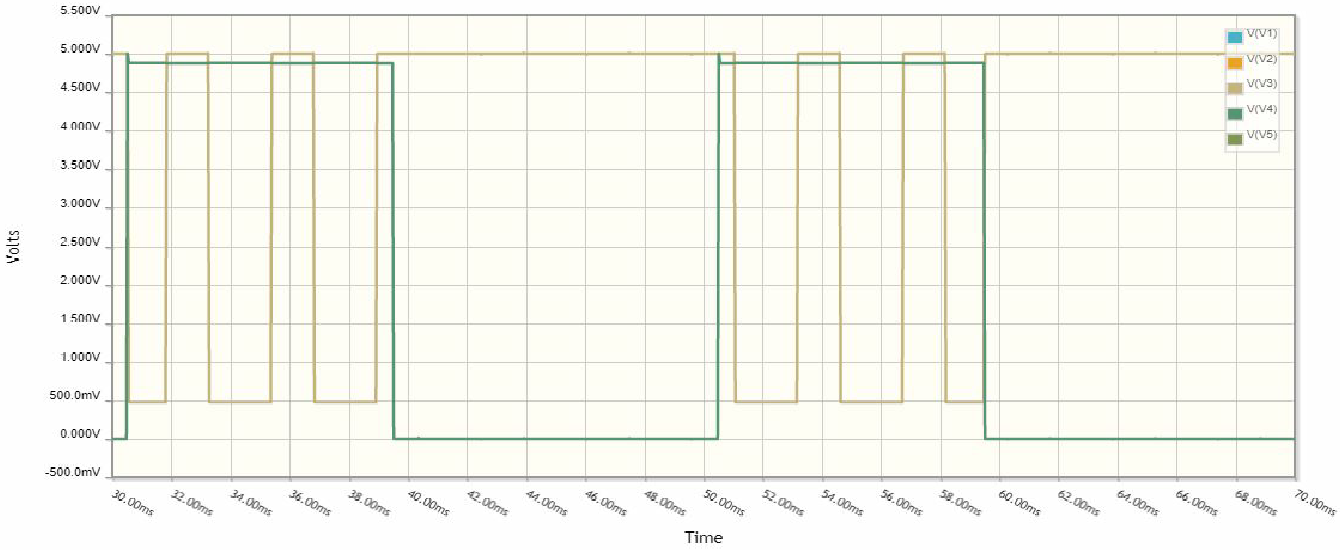
Replace V5 with a sine wave to simulate temperature going up and down

- When V5 goes below 1.69V (should be 1.74V), V4 goes high (turning on the switch)
- When V5 goes above 1.69V, V4 goes low (turning off the switch)

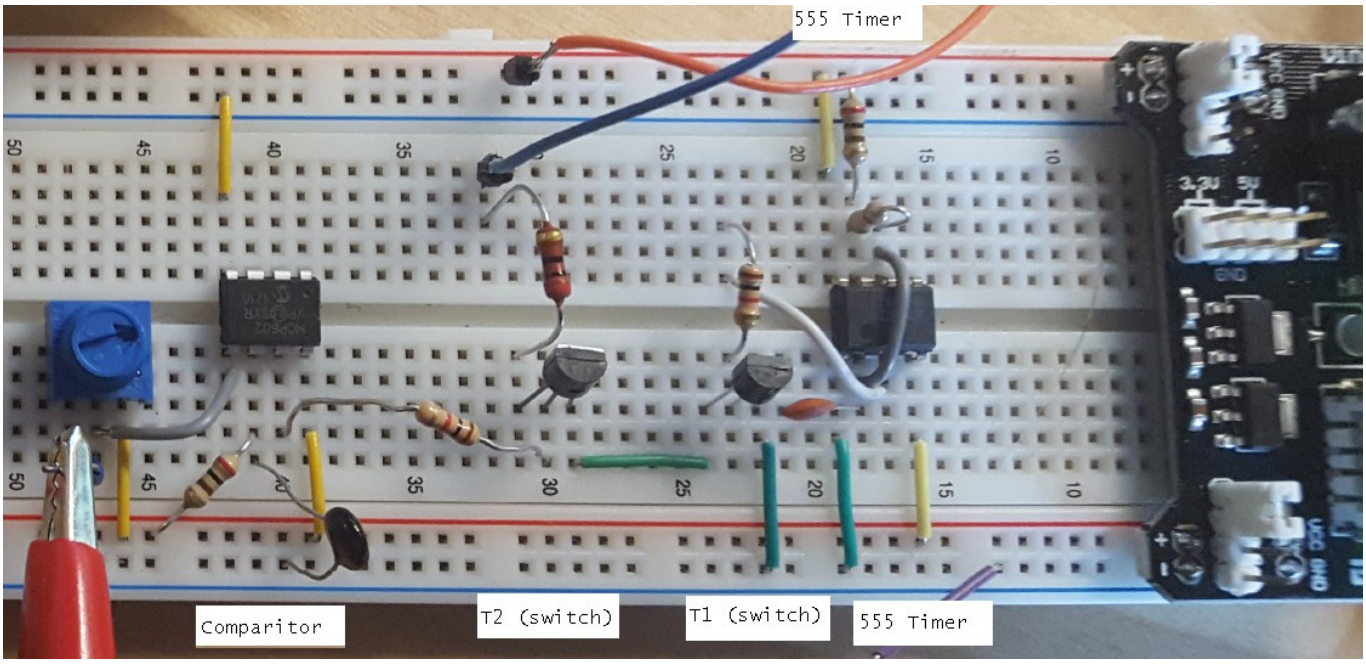


When V4 his high, the speaker plays (V3 oscillates as the transistors turn on and off with the 555 timer)

When V4 is low, the speaker is off (V3 is a constant 5.00V meaning the transistors are off)



7) Build this circuit and verify it's on and off temperature (or voltage or ressistance. Replace R with a potentiometer for test purposes)



Vp = 2.00V (set with a potentiometer)

- Turns on at 1.99V
- Turns off at 2.08V

Note that for a comparotor, V(on) = V(off) (approximately)

Schmitt Trigger

Add an electronic switch to turn the speaker on and off

8) Design a Schmitt Trigger (modify section in blue) to

- Turn on the speaker (V3 = 5V) when T > 45C, and
- Turn off the speaker (V3 = 0V) when T < 40C

$$R = 1000 \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right) \Omega$$

At 40C

- R = 533.66 Ohms
- V5 = 1.74V
- V4 = 0V

At 45V

- R = 438.61 Ohms
- V5 = 1.524V
- V4 = 5V

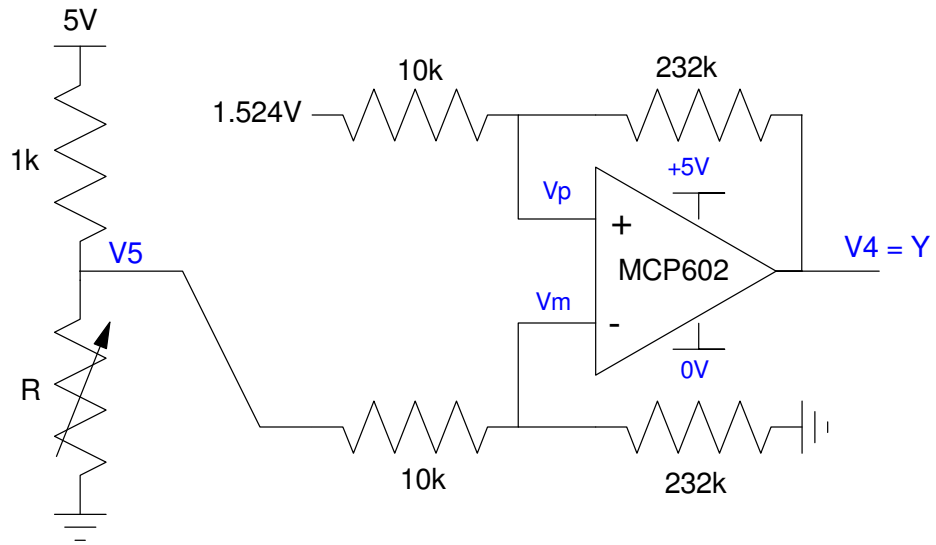
As V5 goes down, V4 goes up. Connect the voltage divider to the minus input

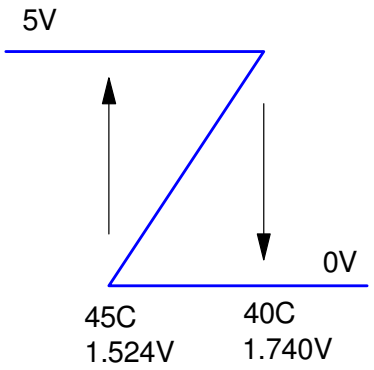
V4 is set when V5 = 1.524V. Make the offset 1.524V

The gain needed is

$$gain = \left(\frac{\text{change in output}}{\text{change in input}}\right) = \left(\frac{5V-0V}{1.74V-1.524V}\right) = 23.21$$

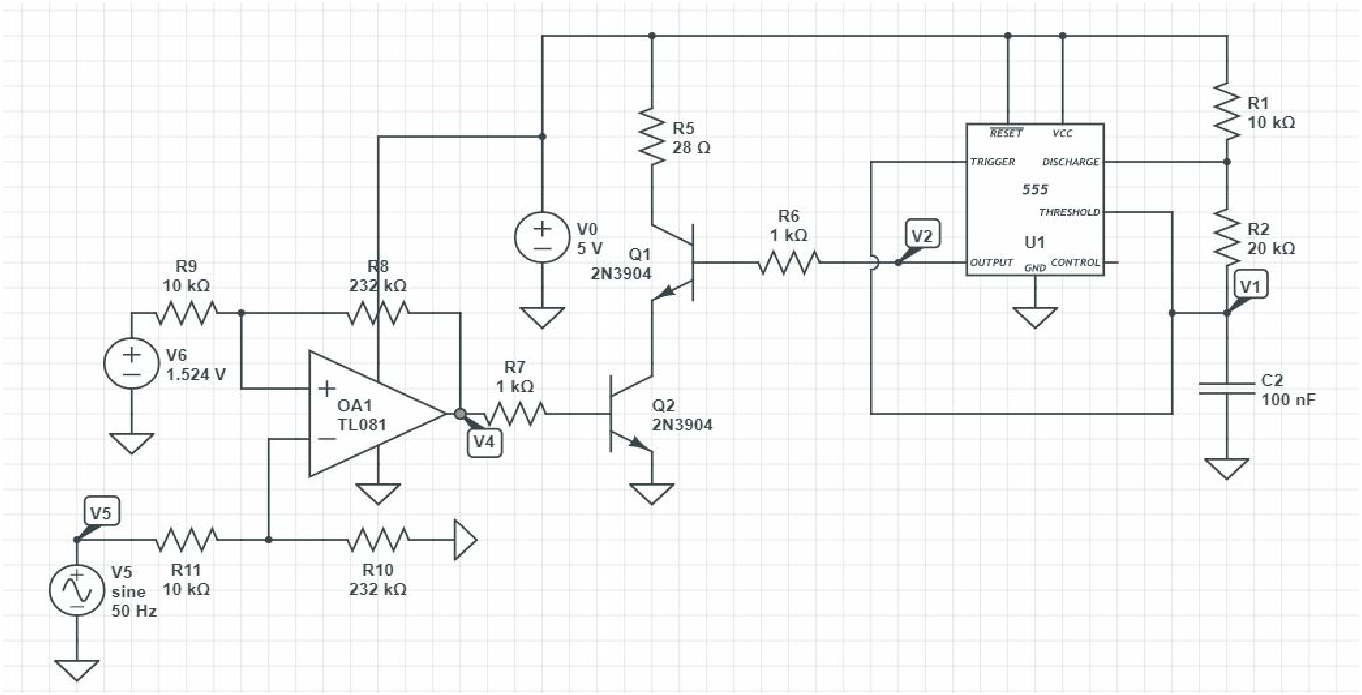
Make the resistors in a 23.31 : 1 ratio

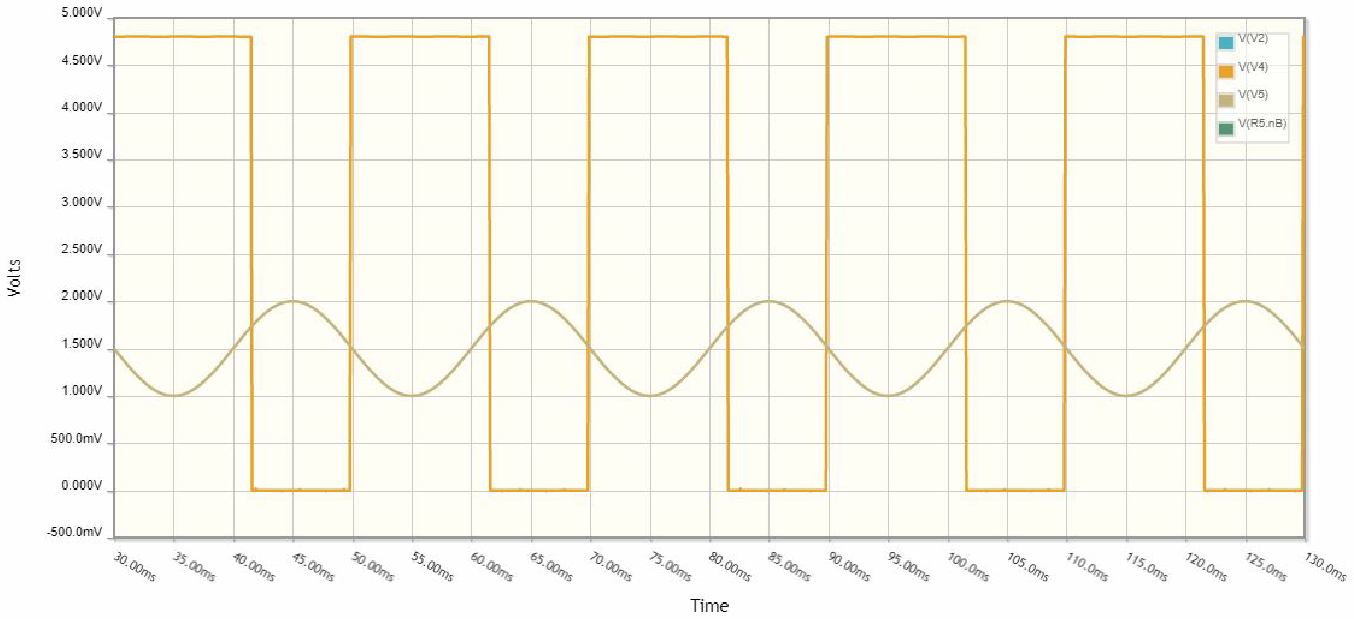




9) Simulate the comaritor in CircuitLab to verify the on / off temperature (or ressitance or voltage)

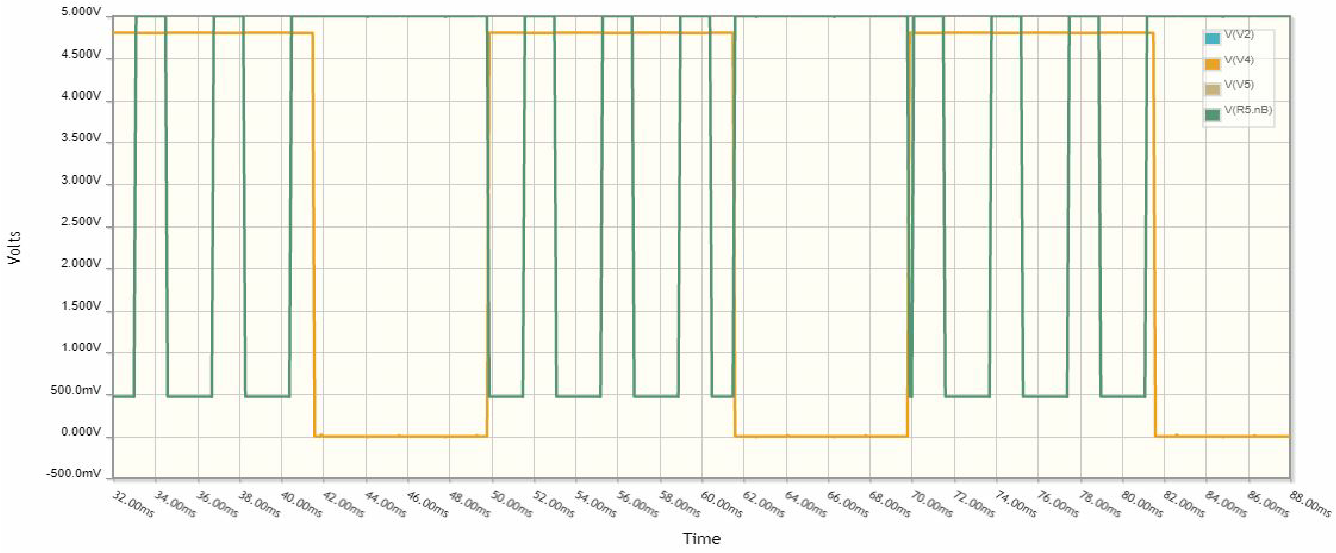
- use a voltage source (V4) to simulate the voltage at the voltage divider)





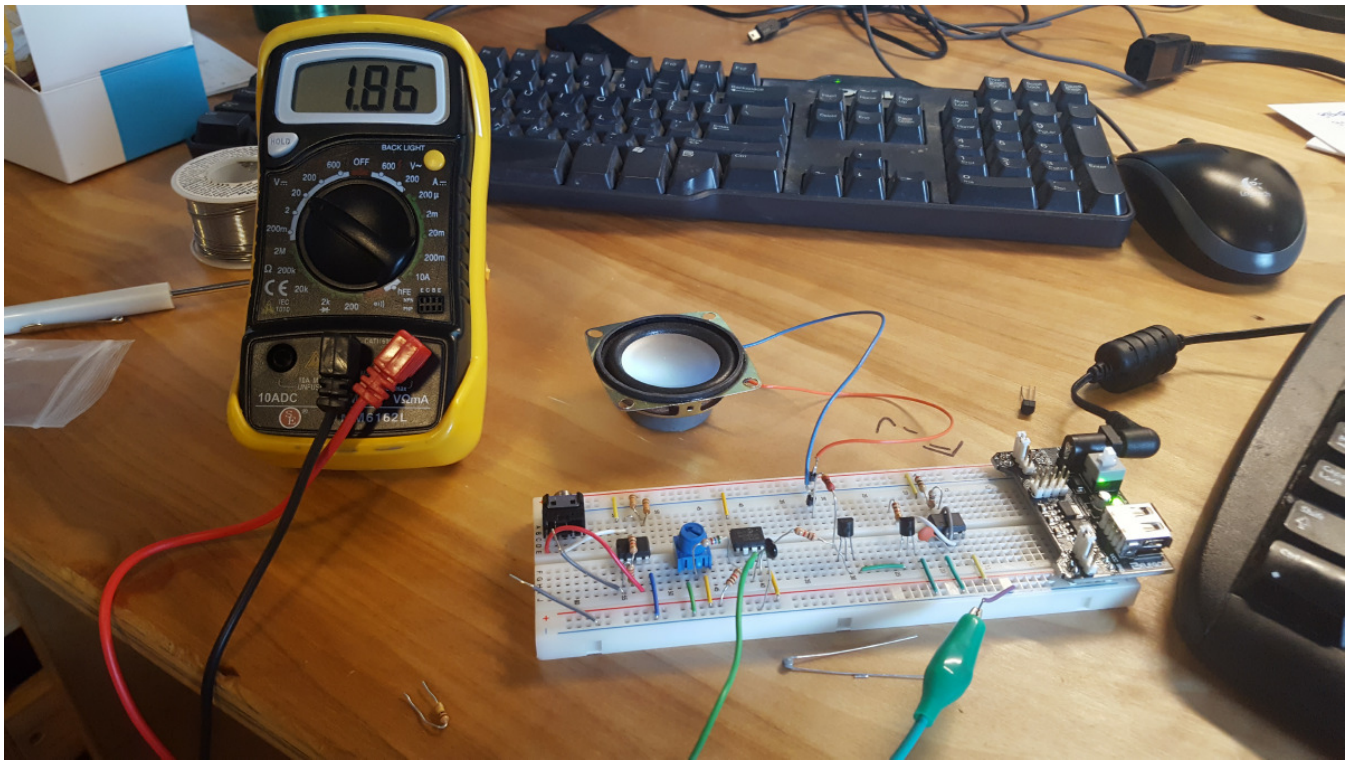
On Voltage: 1.531V

Off Voltage: 1.741V



- When V4 = 5V, the transistor is on (speaker plays)
- When V4 = 0V, the transistor is off (speaker is off)

10) Build this circuit and verify it's on and off temperature (or voltage or ressistance. Replace R with a potentiometer for test purposes)



Vp set to 2.00V with a potentiometer

- Turns on at 1.98V
- Turns off at 2.26V