ECE 320 - Homework #5

555 Timers, Transistors used as a Switch, Schmitt Triggers. Due Monday, Sept 27th

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

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

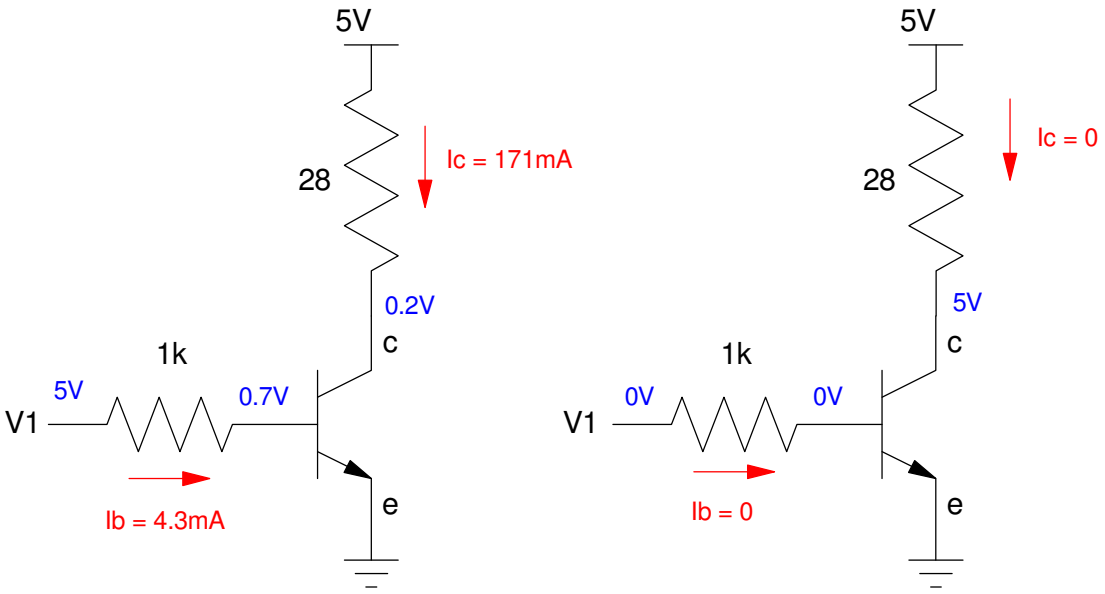
Assume a thermistor with

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

Transistor Switch

1) For the circuit shown below

- Assume V1 = 5V. Determine Ib, Ic, Vb, and Vc.
- Assume V1 = 0V. Determine Ib, Ic, Vb, and Vc.

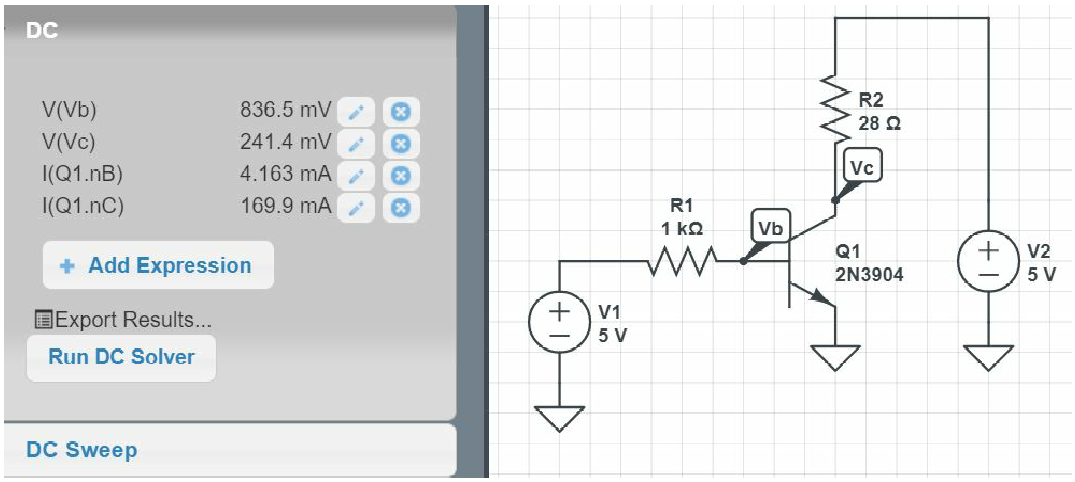


2) Using CircuitLab, determine {Ib, Ic, Vb, and Vc} for

- V1 = 0V
- V1 = 5V

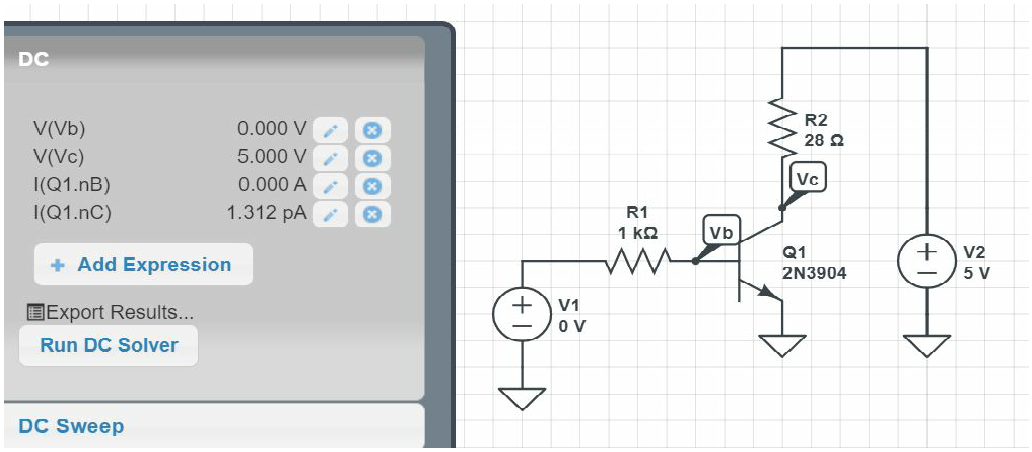
V1 = 5V

- The transistor is saturated (Vc = 0.241V)
- 100 Ib > Ic (saturated)



V1 = 0V

- The transistor is off (current = 0)



3) Simulate the circuit with the 555 timer in CircuitLab.

- What frequency should you hear at the speaker?

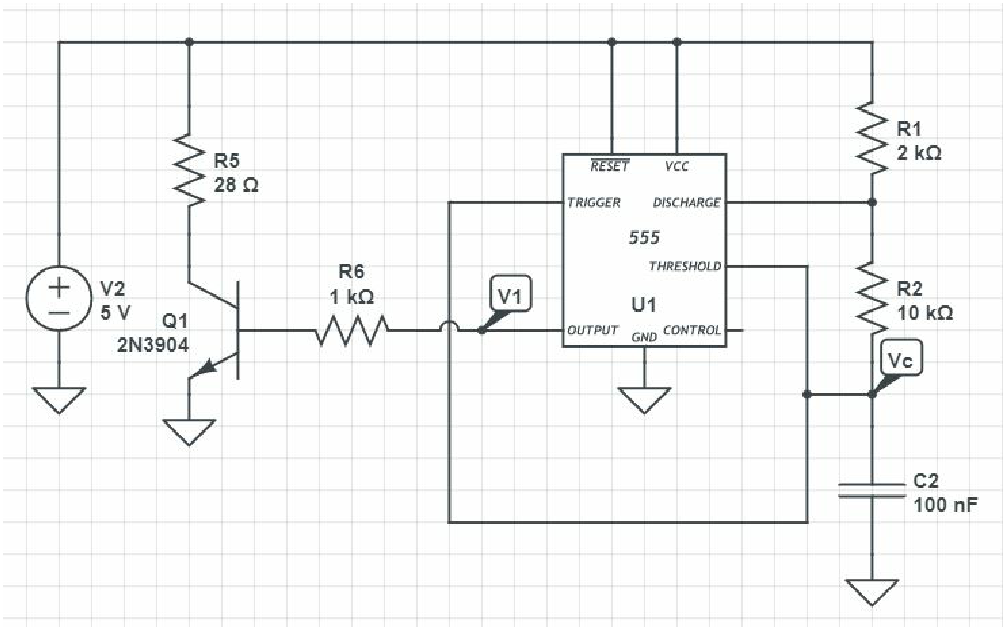
From CircutLab,

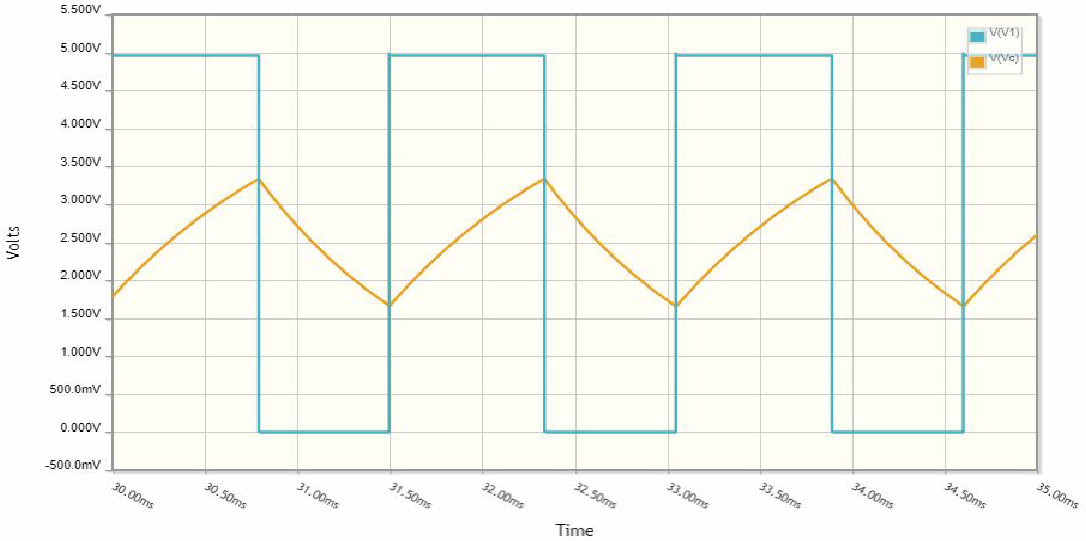
- The period is 1.6ms
- The frequency is 625Hz

The calculated frequency is

$$T = (R_1 + 2R_2) \cdot C \cdot \ln(2) = 1.525ms$$

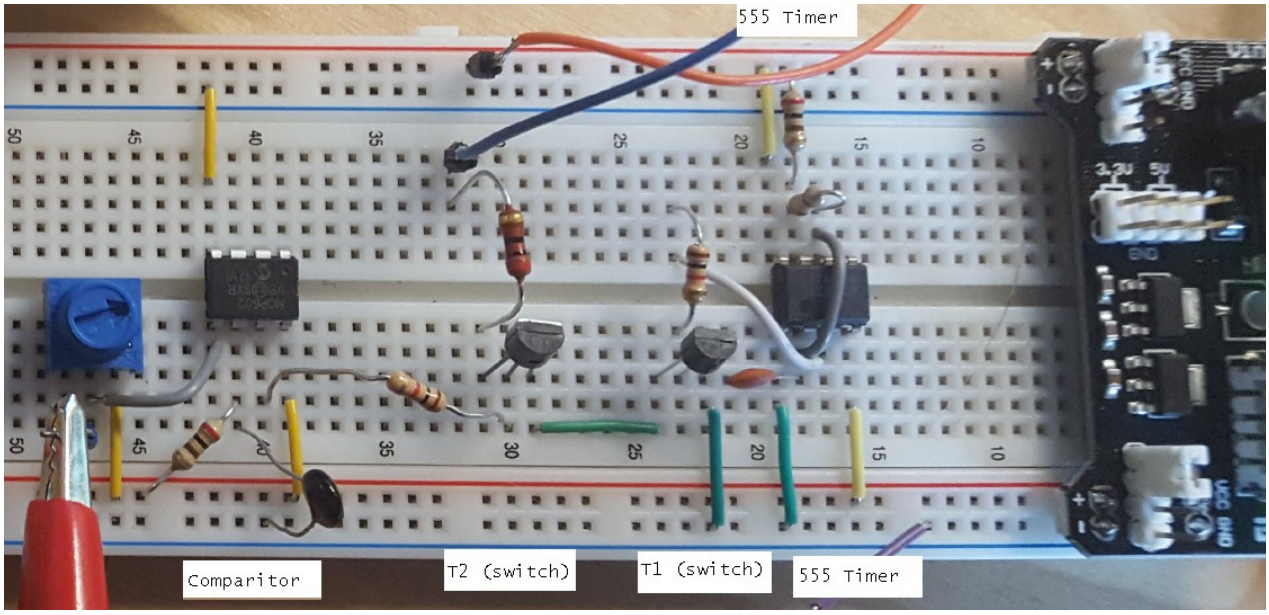
$$f = \frac{1}{T} = 656Hz$$





4) Build this circuit with your lab kits and verify

- The freqency at V1
- That the transistors is off when V1 = 0V (connect the 1k resistor to ground rather than the 555 timer)
- That the transistor is saturated when V1 = 5V (connect the 1k resistor to +5V)
- That the speaker is loud and annoying (the transistor acts as an amplifier)



Frequency at V1:

- Expected: 656Hz
- Actual: 667.2Hz

Voltage when V1 = 0V:

- Vc = 4.93V

Voltage when V1 = 5V:

- Vc = 334mV

Comparitor

Add an electronic switch to turn the speaker on and off

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

- Turn on the speaker (V2 = 5V) when T > 30C, and
- Turn off the speaker (V2 = 0V) when T < 30C

At 30C, using a 1k resistor for a voltage divider...

- R = 805 Ohms
- V2 = 2.231V

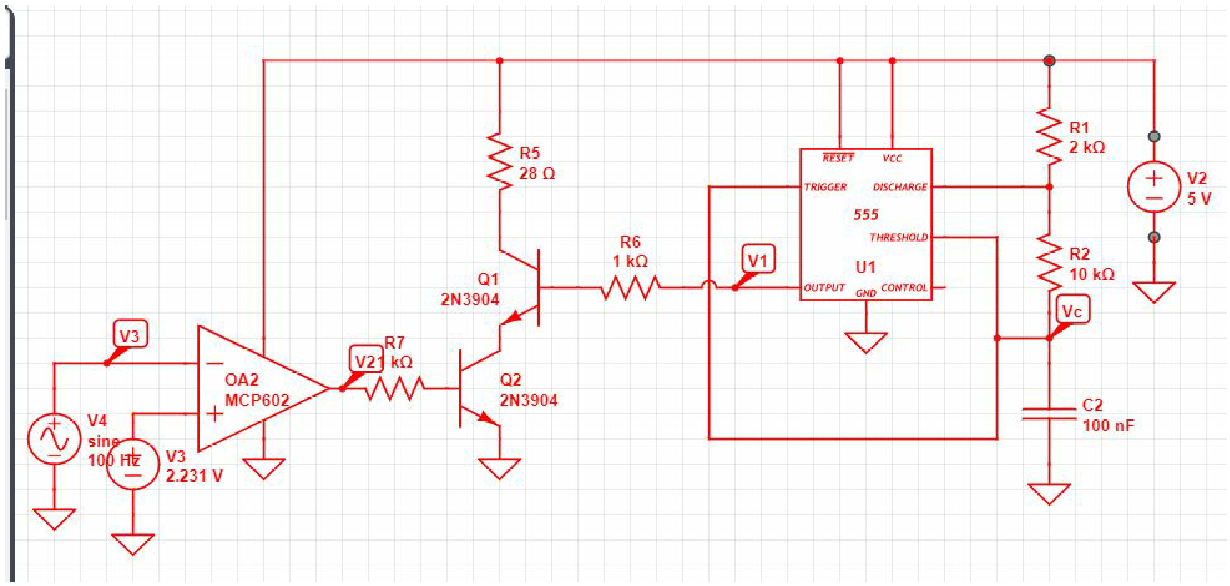
Switch on and off at 2.231V

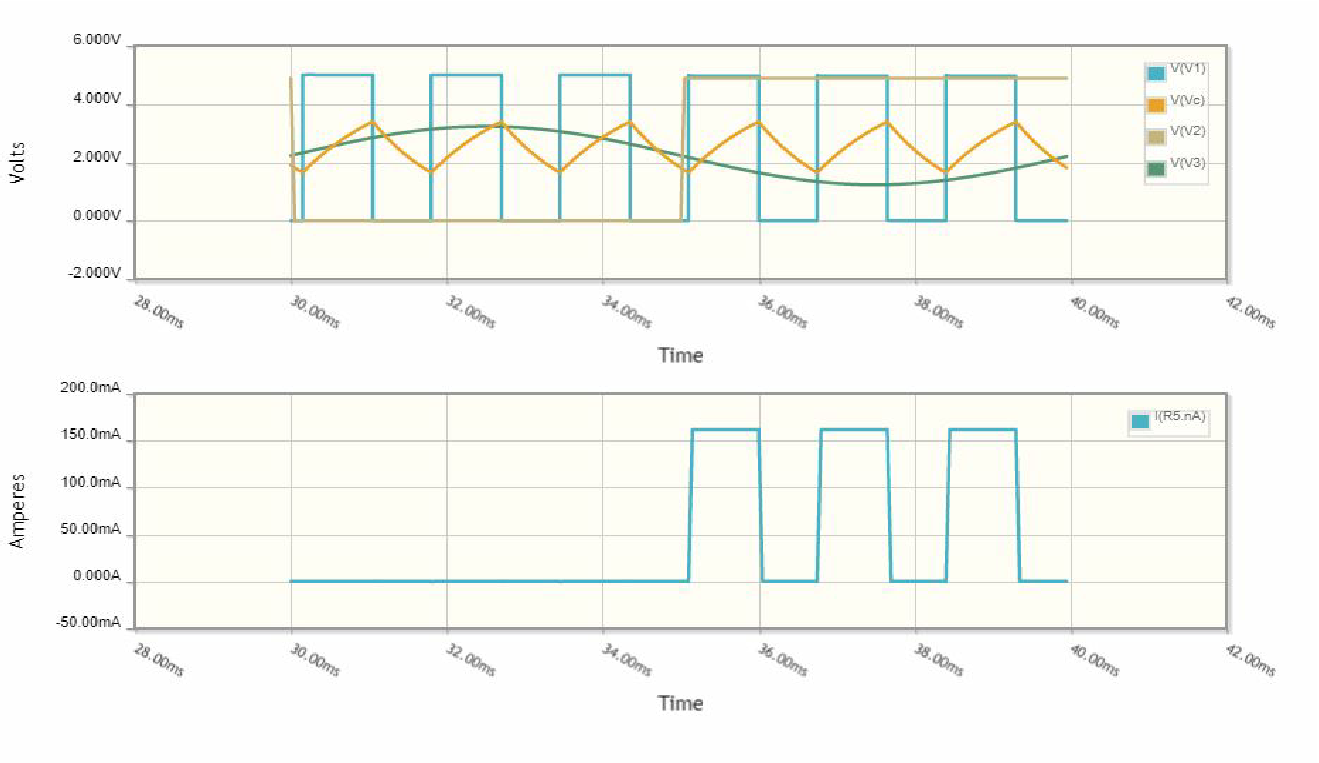
Connect to the minus input so that when T > 30C

- R goes to zero
- V2 goes to zero
- Vp > Vm (and Y = 0V)

6) Simulate the comparitor 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)





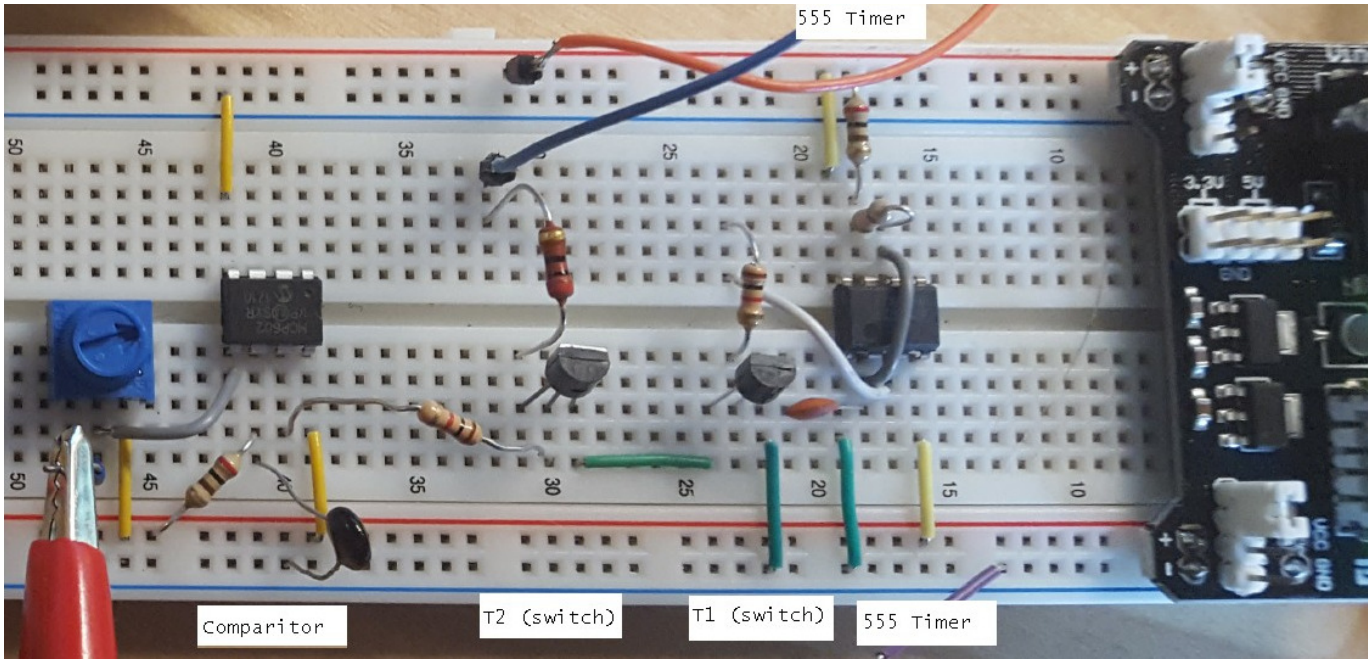
When V3 goes above 2.31V (< 30C),

- V2 goes to 0V (brown curve)
- I(speaker) = 0 (bottom curve)

When V3 goes below 2.31V

- V2 goes to 5v (brown)
- I(speaker) turns on (bottom curve)

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

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 (V2 = 5V) when T > 35C, and
- Turn off the speaker (V2 = 0V) when T < 30C

At 30C

- R = 805 Ohms
- V4 = 2.231V
- V2 = 0V (off)

at 35C

- R = 653 Ohms
- V4 = 1.976V
- V2 = 5V (on)

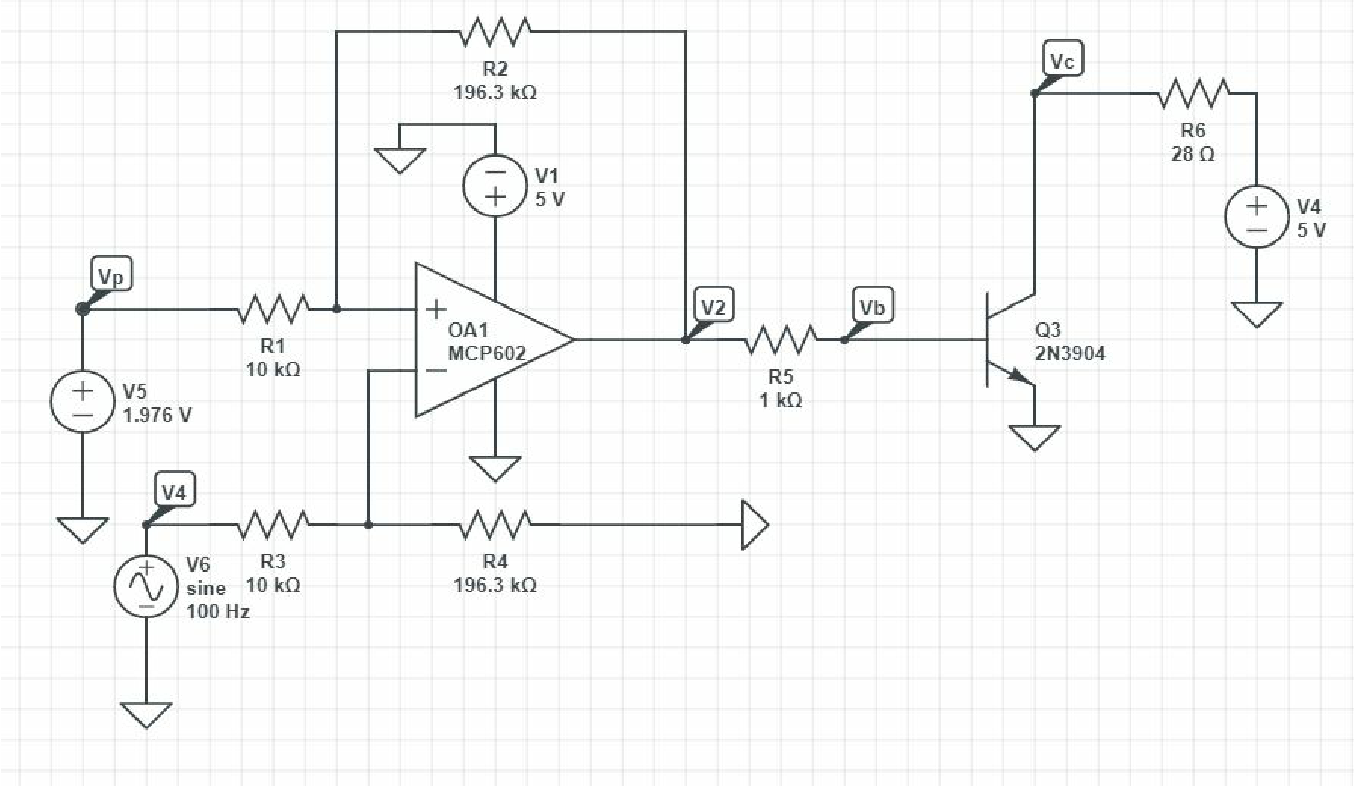
The Schmitt Trigger turns on at 1.976V. Make this the offset

V2 goes up when V4 goes down. Connect to the minus input

The gain needed is

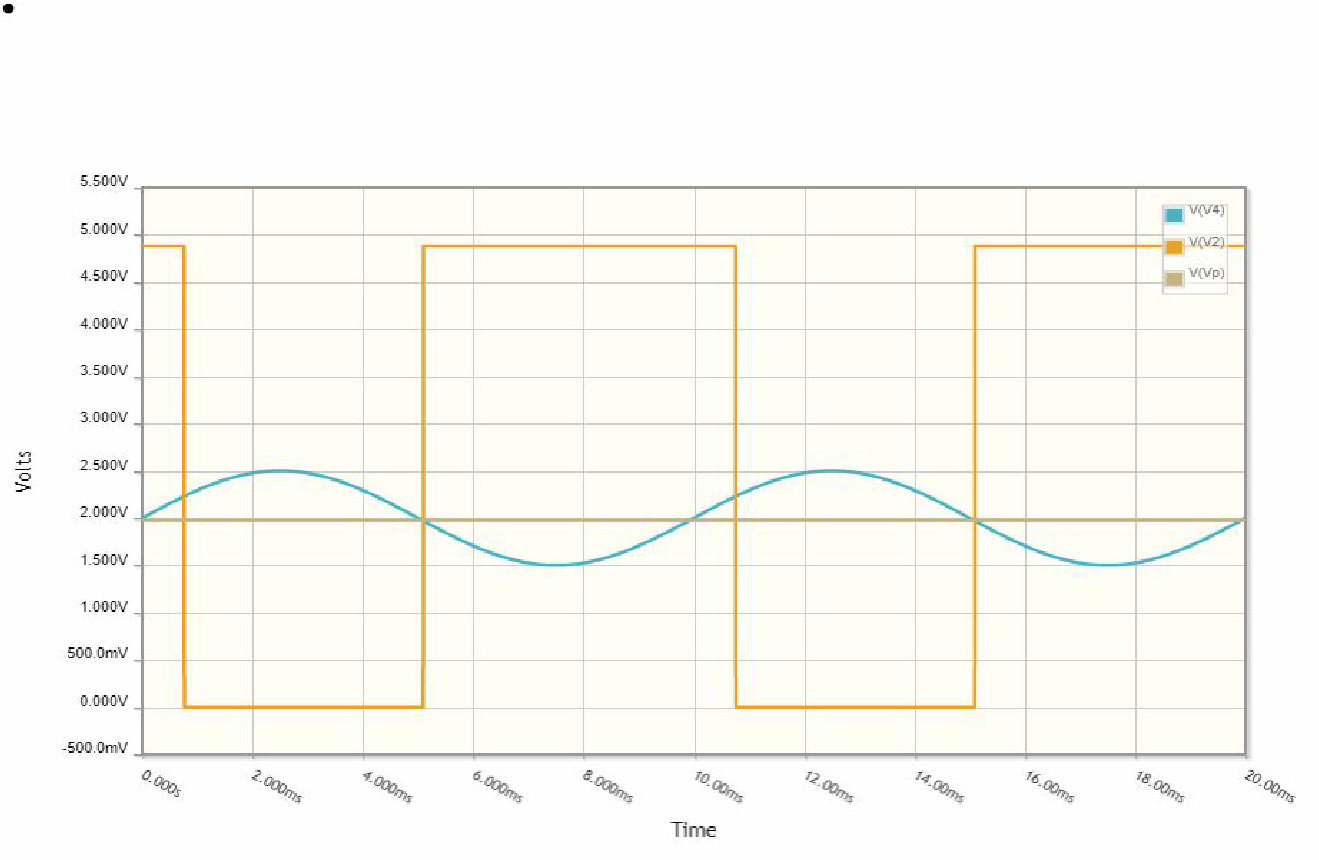
$$gain = \left(\frac{5V-0V}{2.231V-1.976V}\right) = 19.63$$

Pick resistors in a 19.63 : 1 ratio

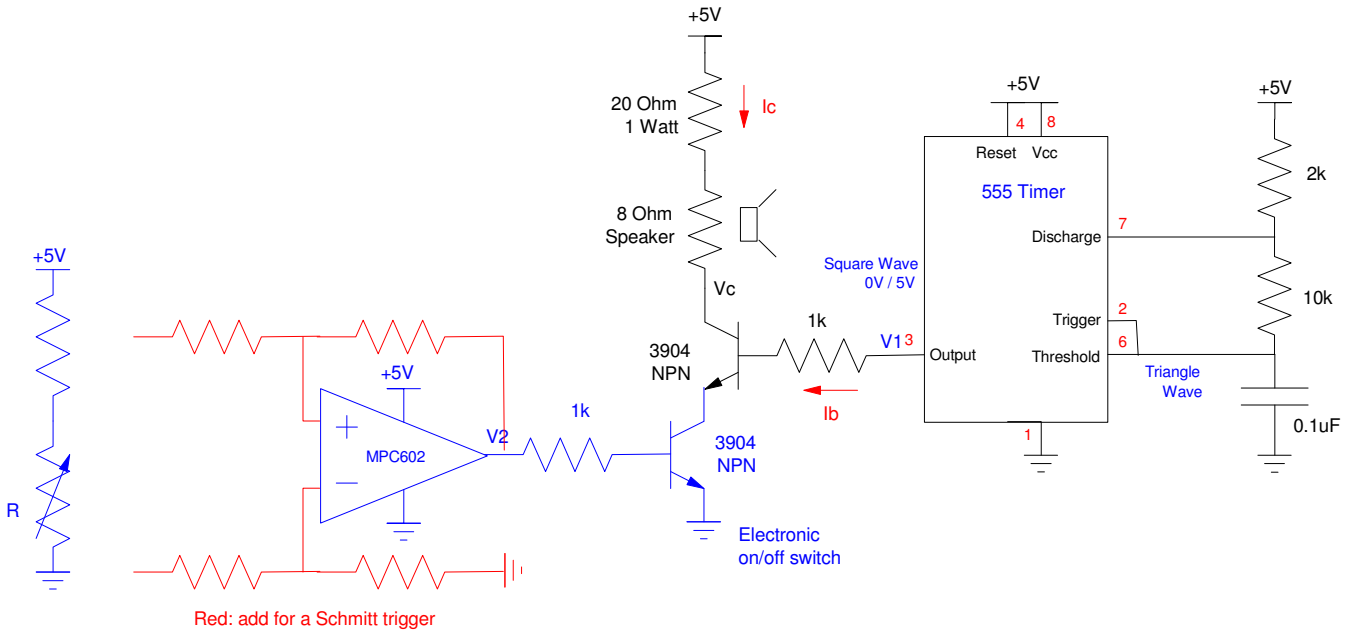


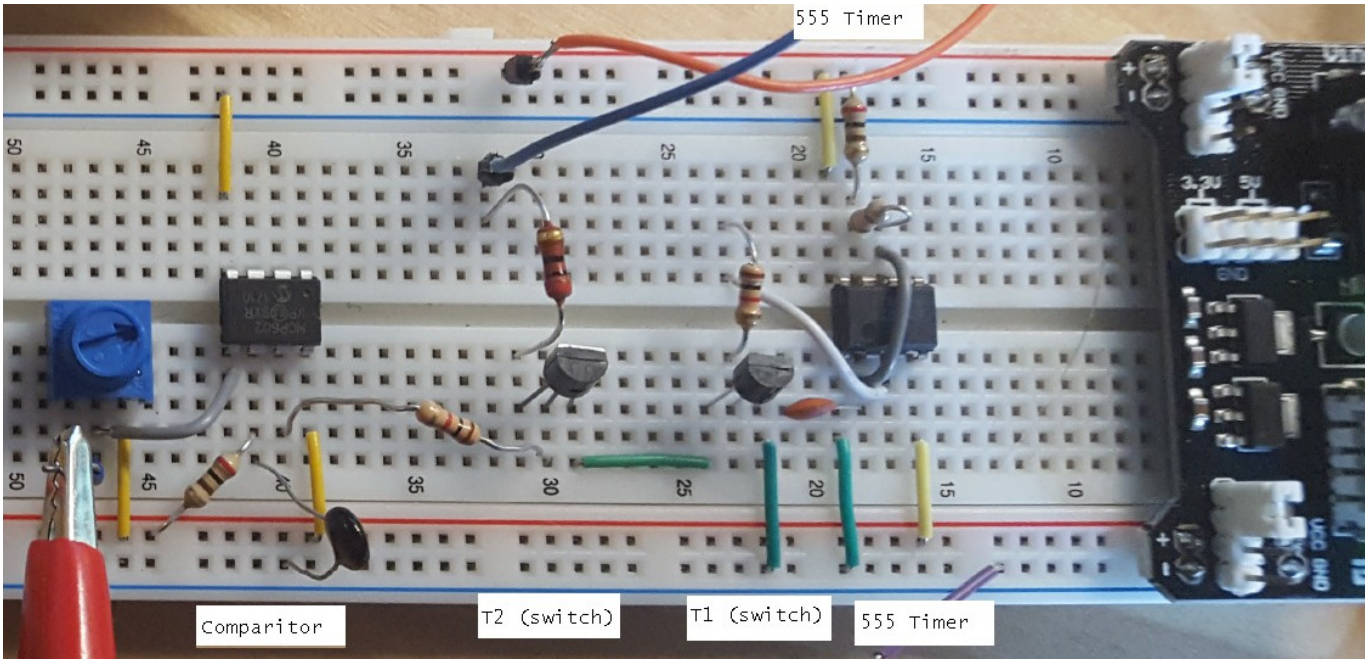
9) Simulate the comaritor in CircuitLab to verify the on / off temperature (or ressitance or voltage)

- V2 goes high (speaker on) when V4 < 1.976V
- V2 goes low (speaker off) when V4 > 2.231V



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