ECE 320 - Homework #5

555 Timers, Transistors used as a Switch, Schmitt Triggers. Due Monday, February 13th

Please submit as a hard copy or submit on BlackBoard

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

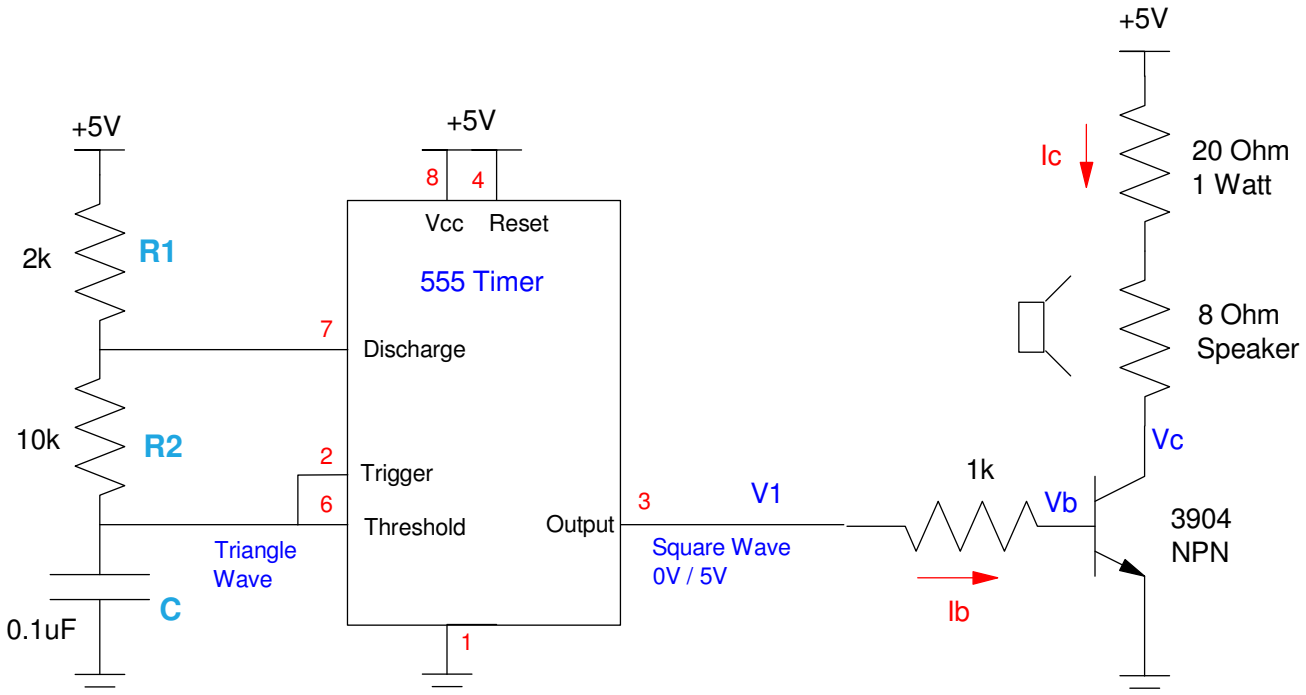
$$R = 1000 \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right) \Omega$$

555 Timers

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

$$T_{on} = (R_1 + R_2) \cdot C \cdot \ln(2) = 831.8\mu s$$

$$T_{off} = R_2 \cdot C \cdot \ln(2) = 693.1\mu s$$



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

From CircuitLab

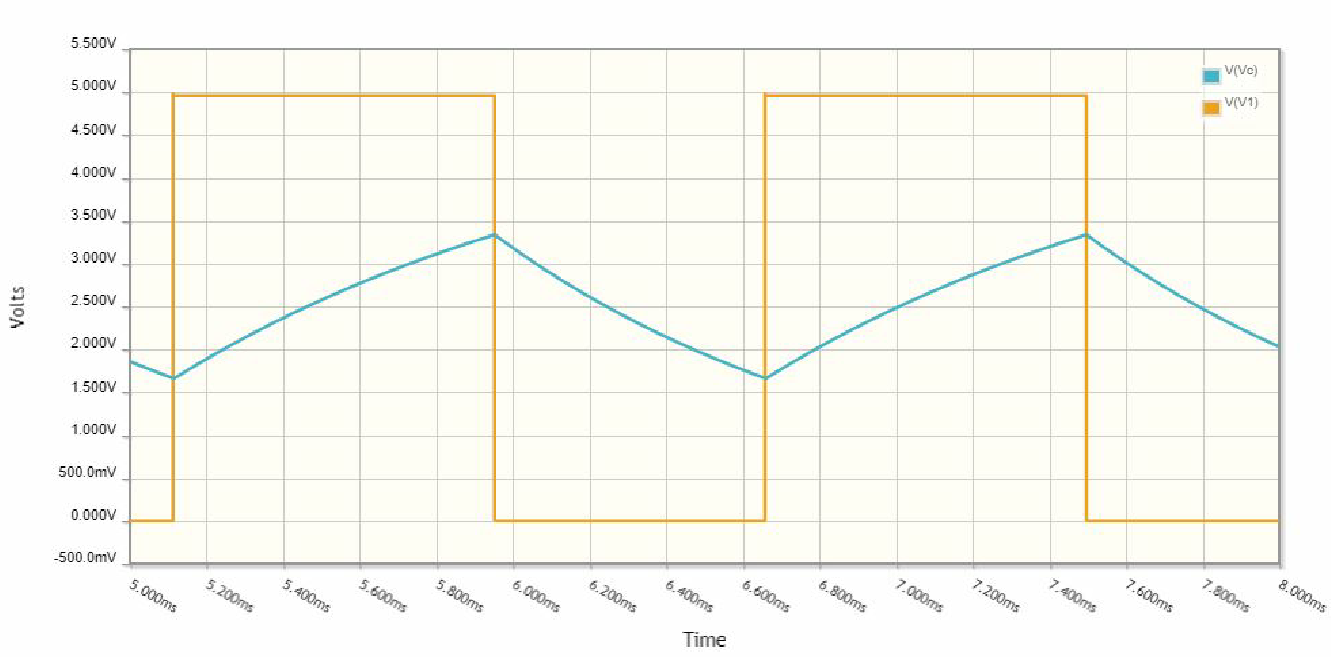
- t(on) = 11.30ms
- t(off) = 12.13ms
- t(on) = 12.84ms

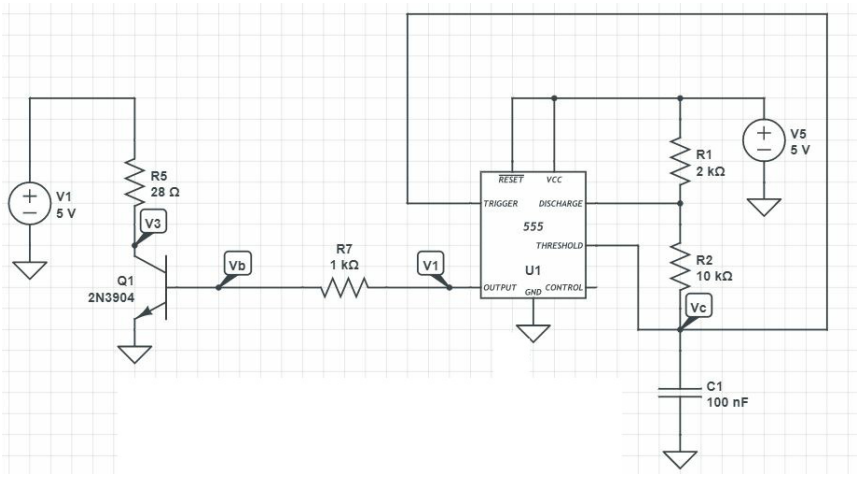
The on time is 830us

- 831.8us calculated

The off time is 710us

- 693.1us calculated





Transistor Switch

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

V1 = 0V

- Vb = 0V
- Ib = Ic = 0mA
- Vc = 5V

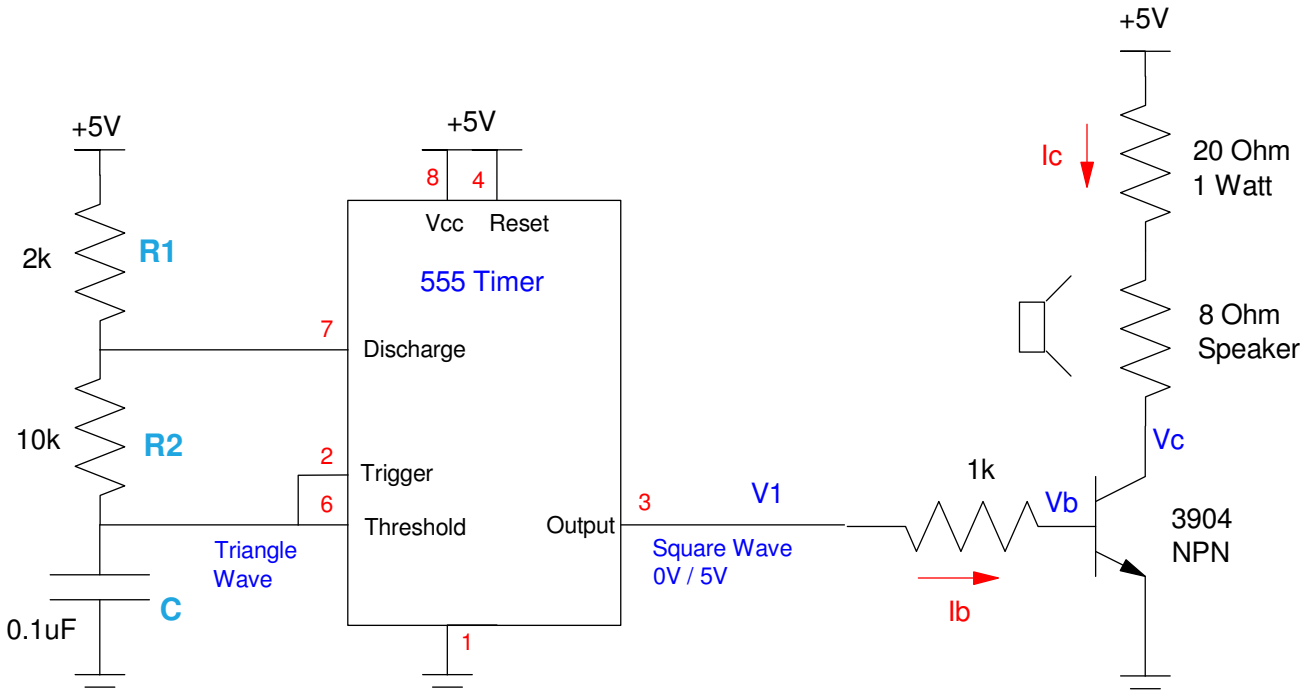
V1 = 5V

$$V_b = 0.7V$$

$$V_c = 0.2V$$

$$I_b = \left(\frac{5V-0.7V}{1k}\right) = 4.3mA$$

$$I_c = \left(\frac{5V-0.2V}{28\Omega}\right) = 153.6mA$$



4) Verify your calculations using CircuitLab

Vout = 5V (on)

Vb = 836.1mV

- vs. 700mV computed

Vc = 241.7mV

- vs. 200mV computed

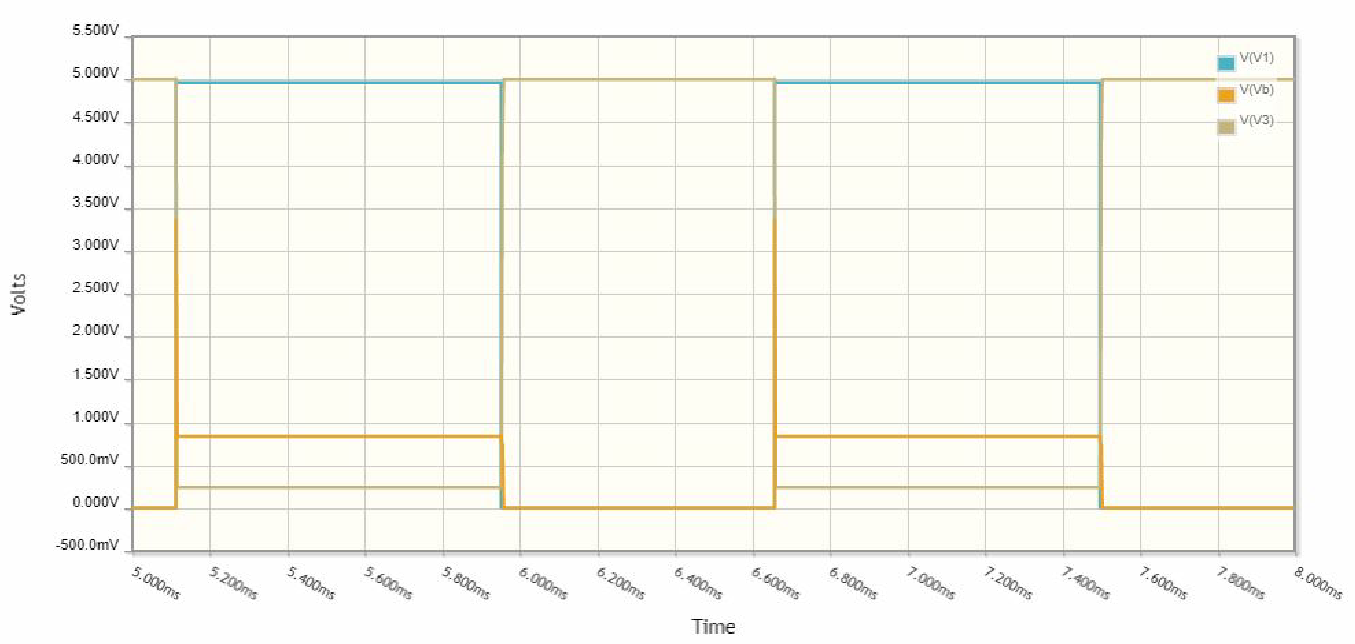
Vout = 0V

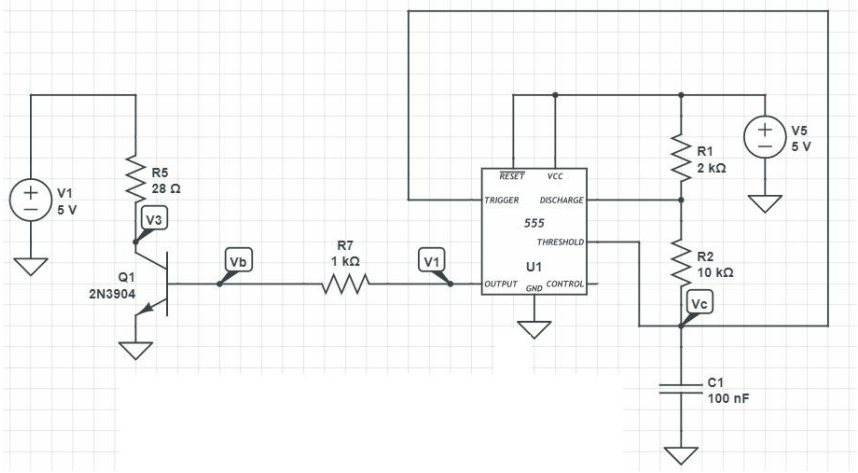
Vb = 0.00V

- vs. 0V

Vc = 5.00V

- vs 5.00V





Comparitor

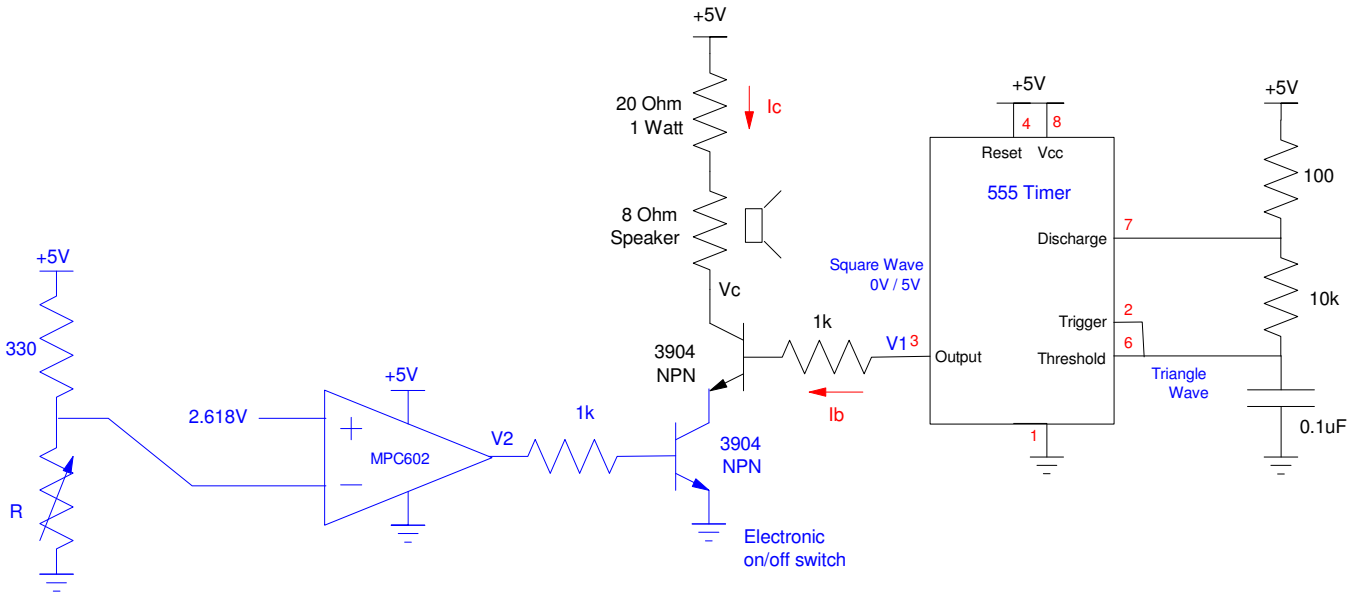
Add an electronic switch to turn the speaker on and off

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

- Turn on the speaker (V3 = 5V) when T > 50C, and
- Turn off the speaker (V3 = 0V) when T < 50C

50C corresponds to 362.7 Ohms. Assuming a 330 Ohm resistor for the voltage divider

$$V = \left(\frac{362.7}{362.7+330}\right) 5V = 2.618V$$



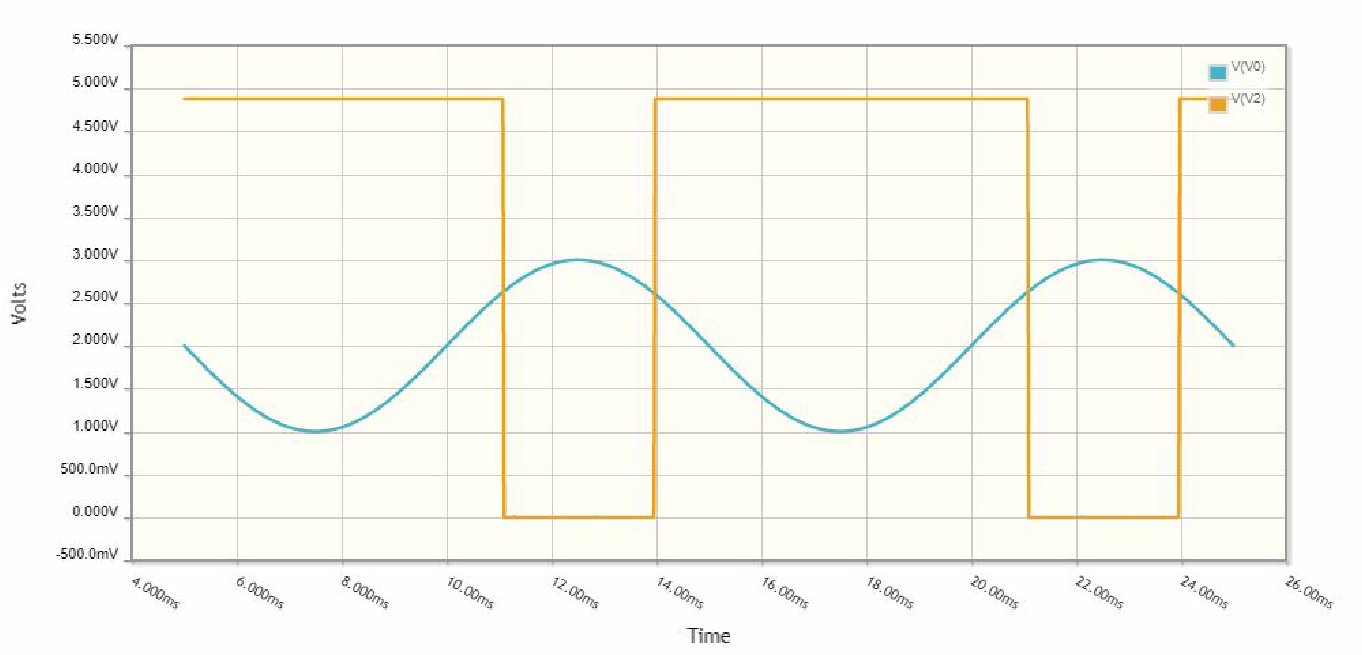
6) Simulate the comparitor in CircuitLab to verify the on / off temperature (or resitance or voltage)

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

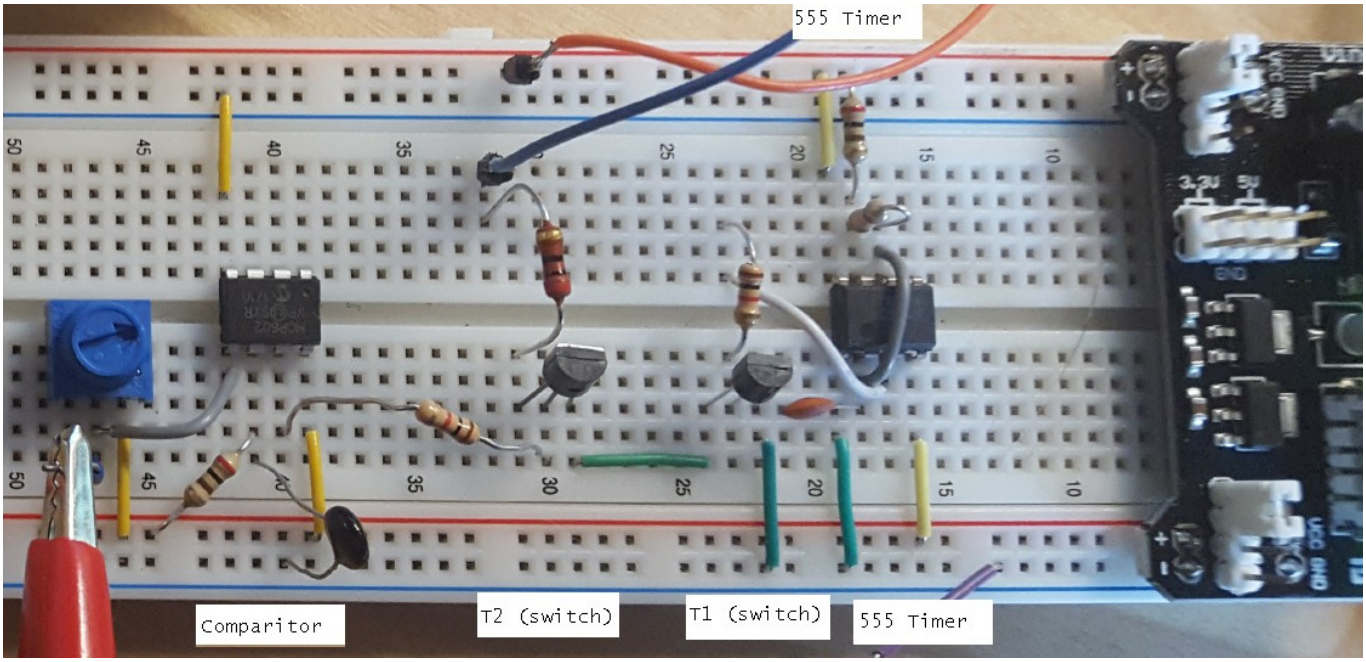
From Circuitlab

V(off) = 2.623V (vs. 2.618V computed)

V(on) = 2.610V (vs. 2.618V computed



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 comparitor, 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 > 55C, and
- Turn off the speaker (V3 = 0V) when T < 45C

55C (on)

R = 301.6 Ohms

Va = 2.388V

45C (off)

R = 438.6 Ohms

Va = 2.853V

V(on) < V(off)

connect to the minus input

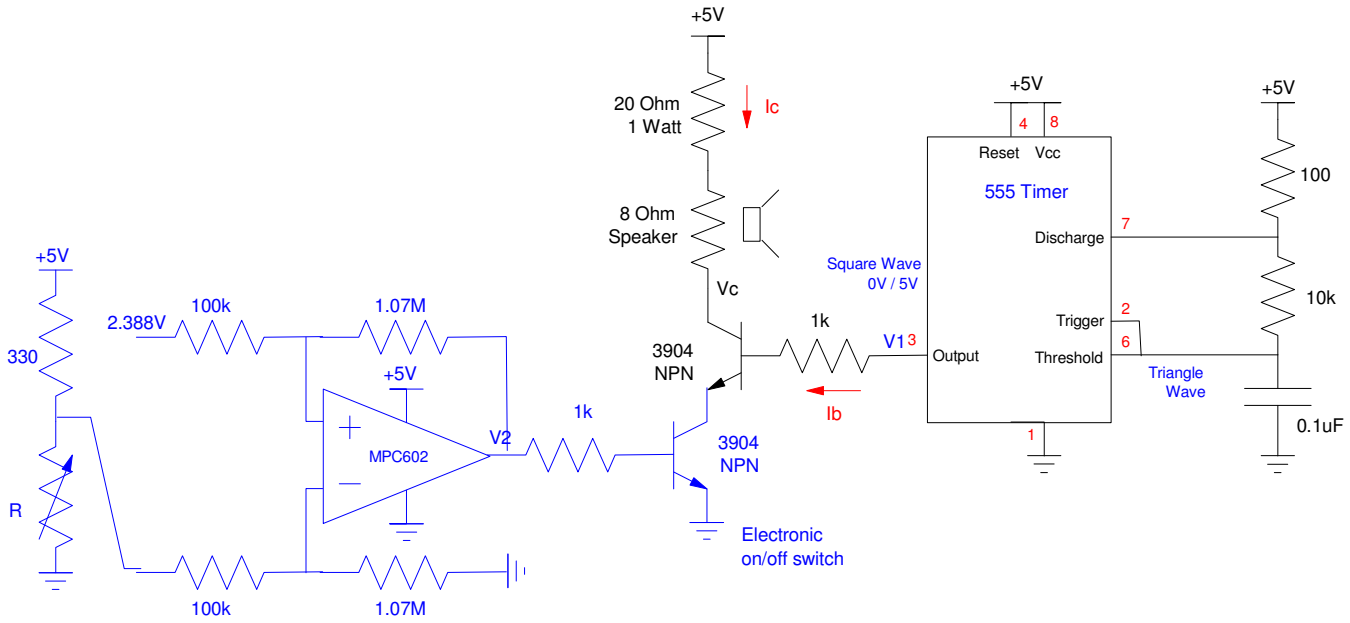
V(on) = 2.388V

make the offset 2.388V

Gain:

$$gain = \left(\frac{5V-0V}{2.853V-2{,}388V}\right) = 10.74$$

Pick the resistors in a 10.74 : 1 ratio



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

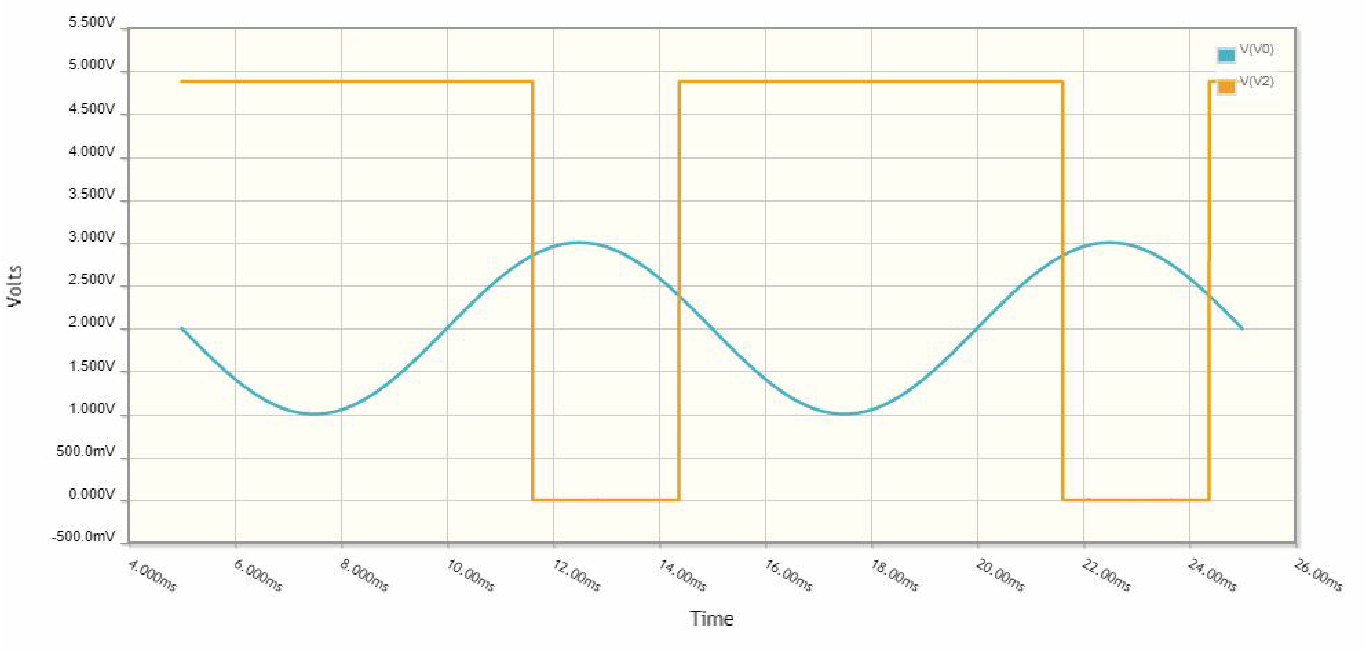
- use a voltage source (V4) to simulate the voltage at the voltage divider)

V(off) = 2.852V

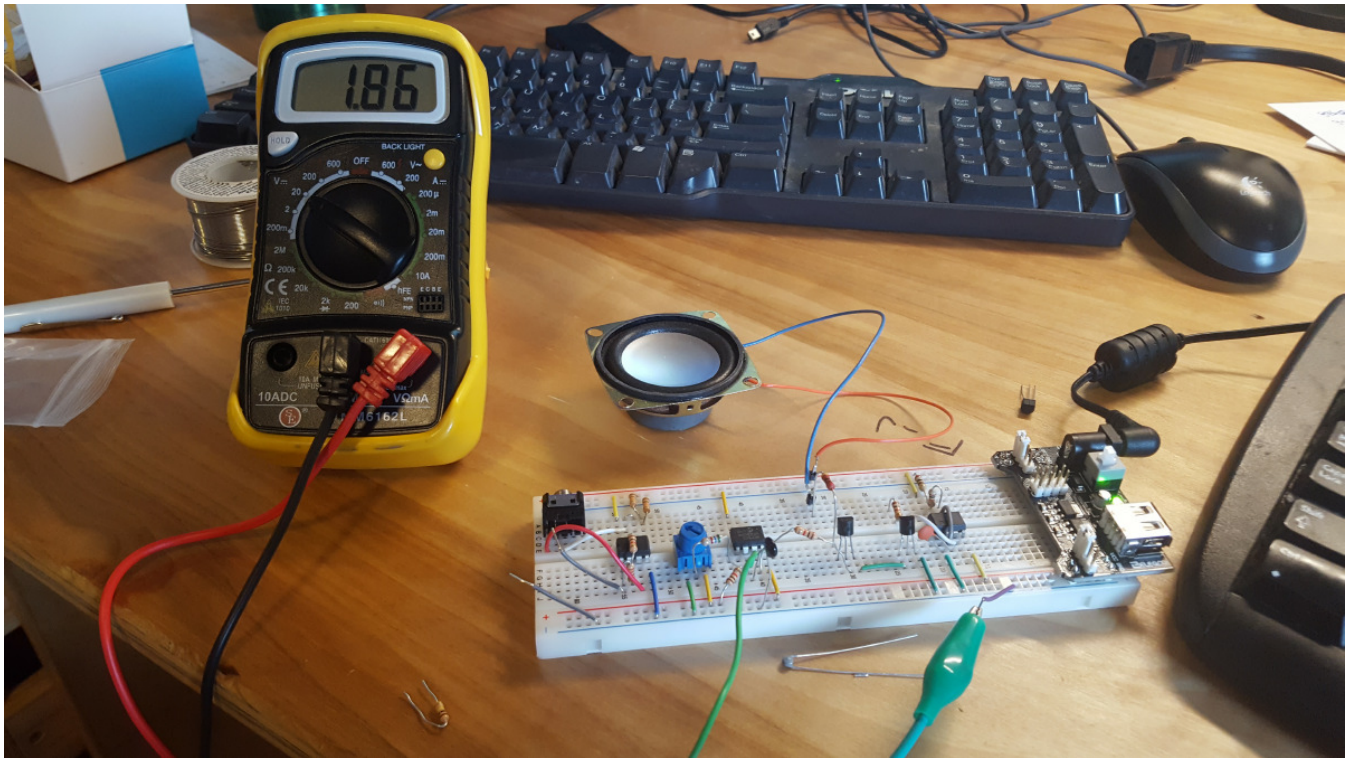
vs. 2.853V computed

V(on) = 2.349V

vs. 2.388V computed



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