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)

$\beta = 100$ $\min(|V_{ce}|) = 0.2V$ $\max(I_c) = 200mA$
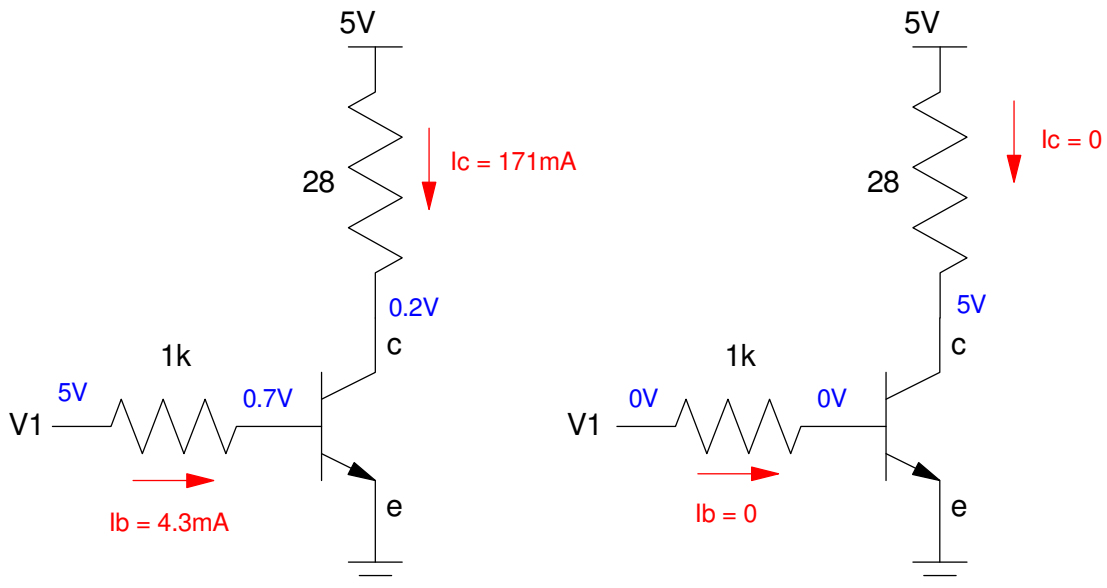
Assume a thermistor with

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

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)

DC Sweep

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

  • What frequency should you hear at the speaker?

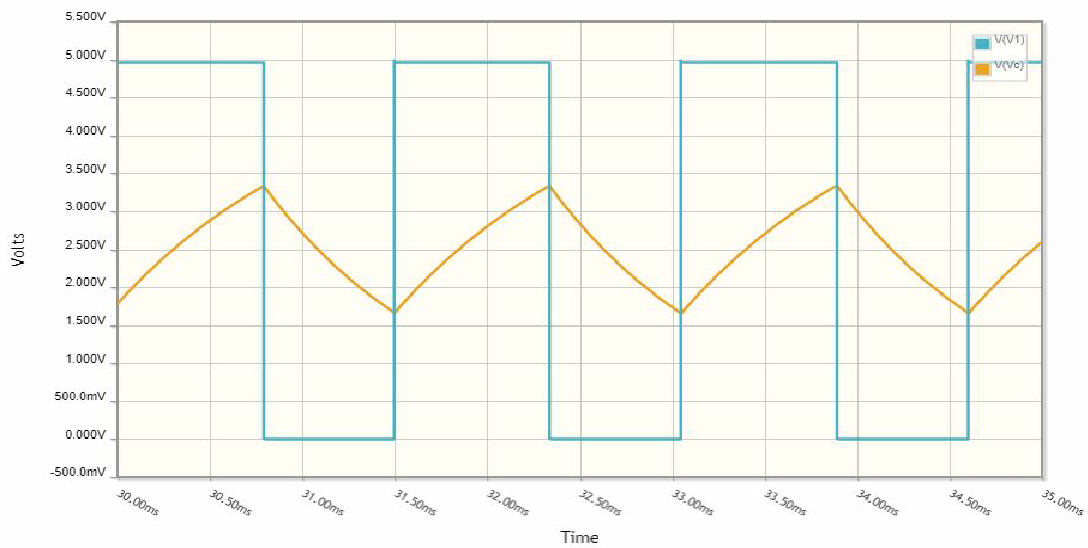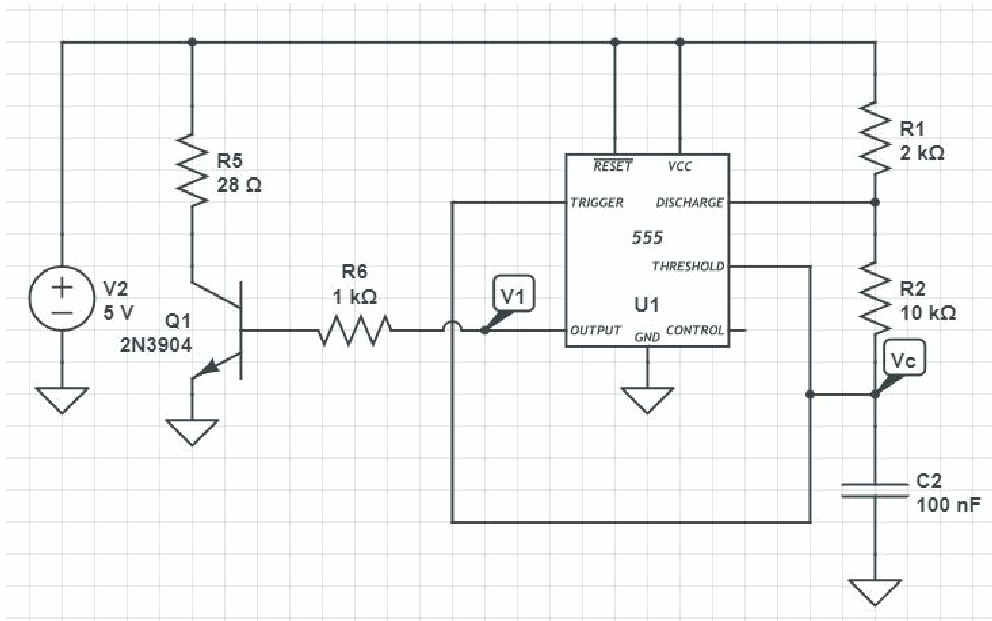From CircutLab,

  • 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)
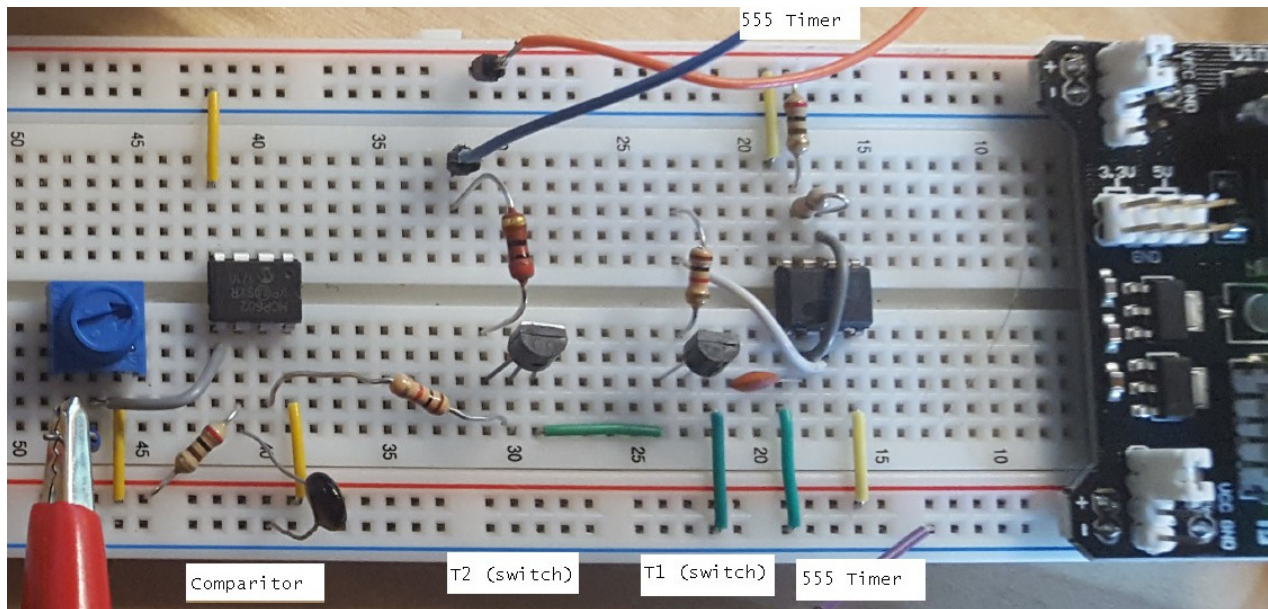
Frequency at V1:
  - Expected: 656Hz
  - Actual: 667.2Hz

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...
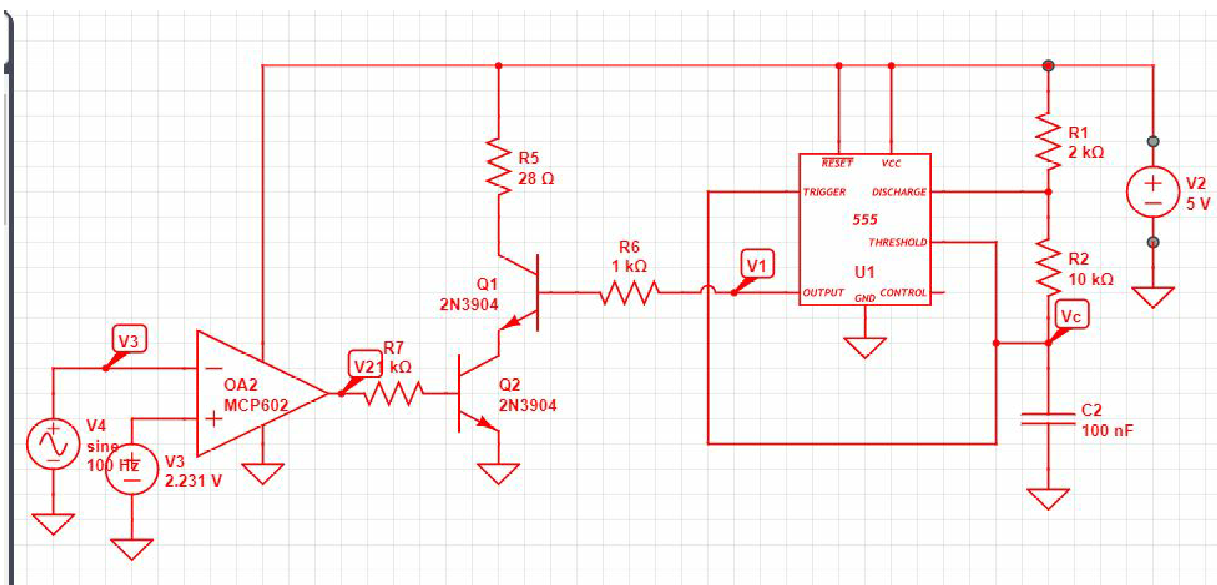   - R = 805 Ohms
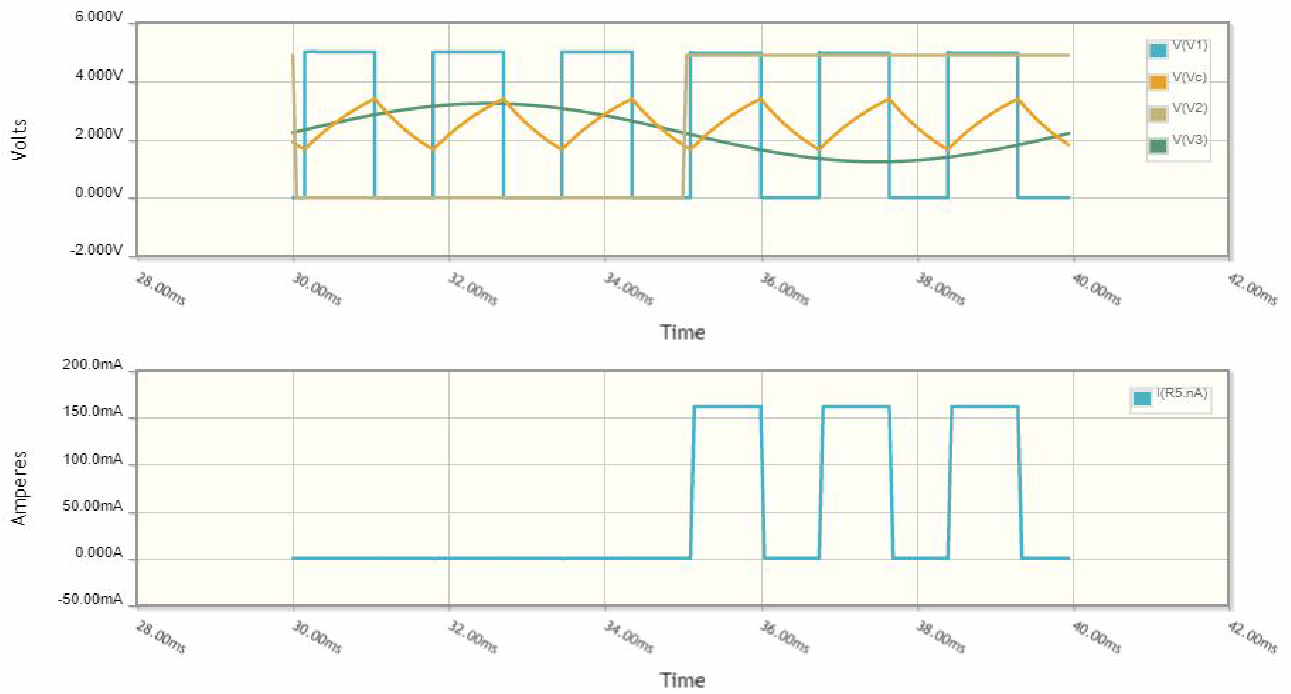   - V2 = 2.231V

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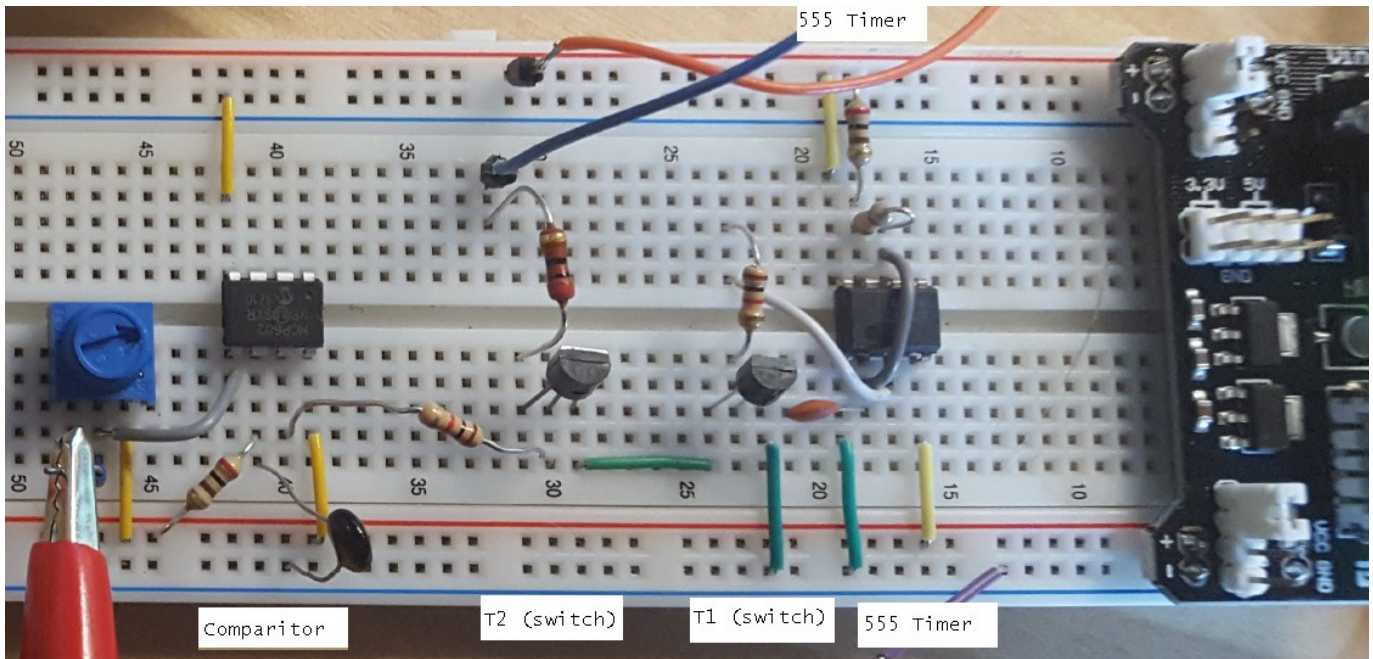   - use a voltage source (V4) to simulate the voltage at the voltage divider)

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)
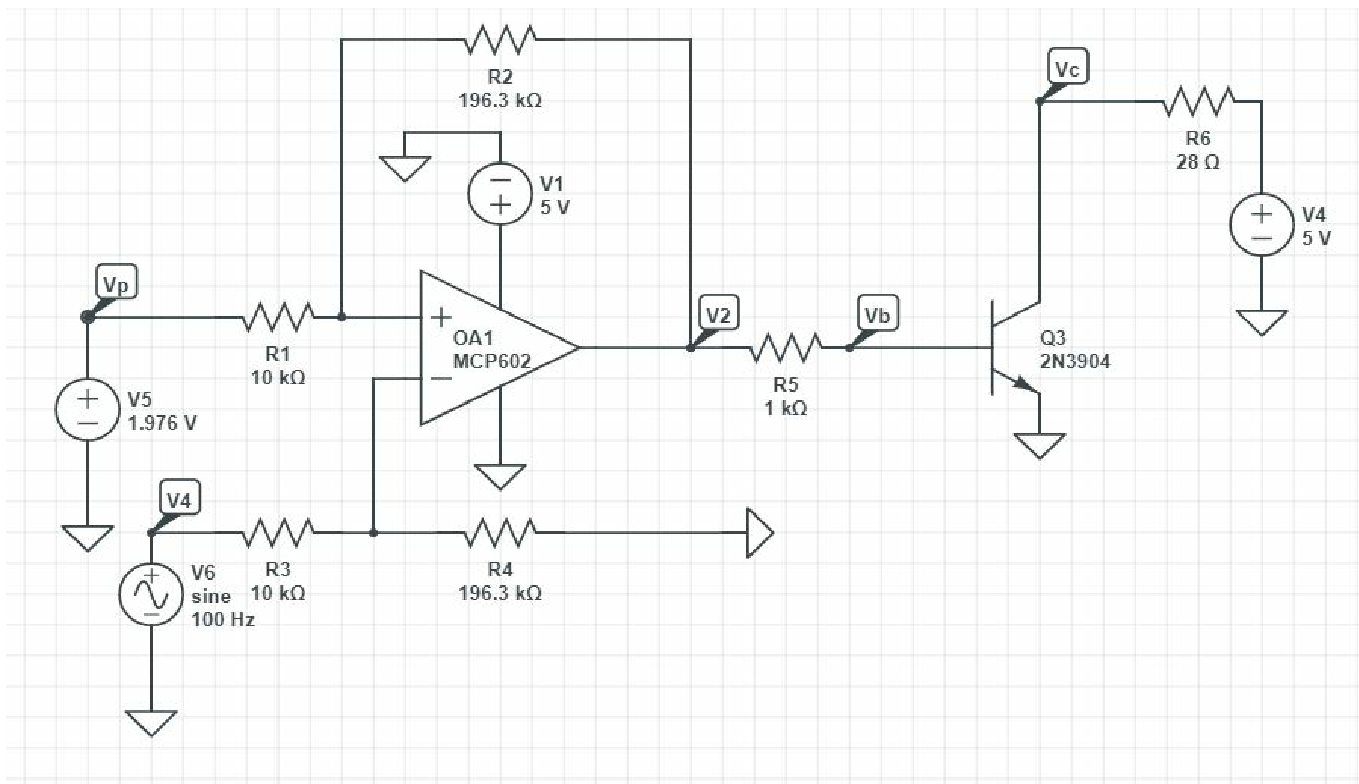
at 35C
   - R = 653 Ohms
   - V4 = 1.976V
   - V2 = 5V (on)

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

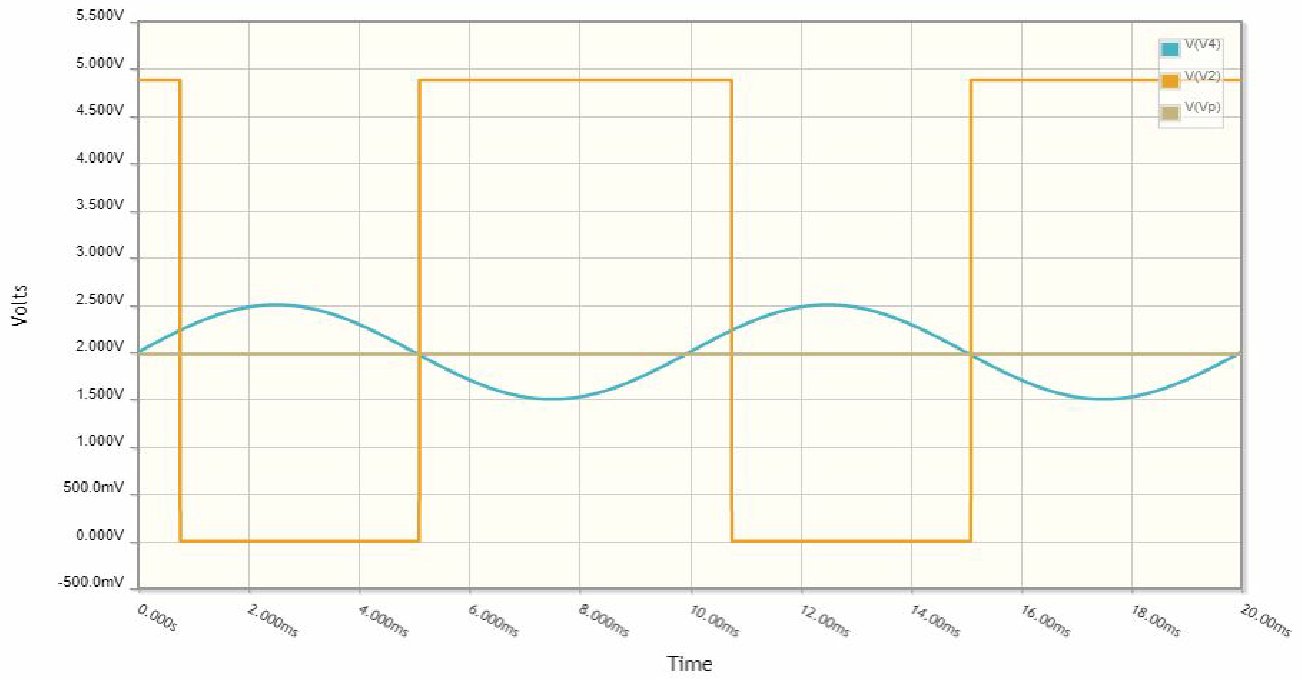$$gain = \left(\frac{5V - 0V}{2.231V - 1.976V} \right) = 19.63$$

Pick resistors in a 19.63 : 1 ratio
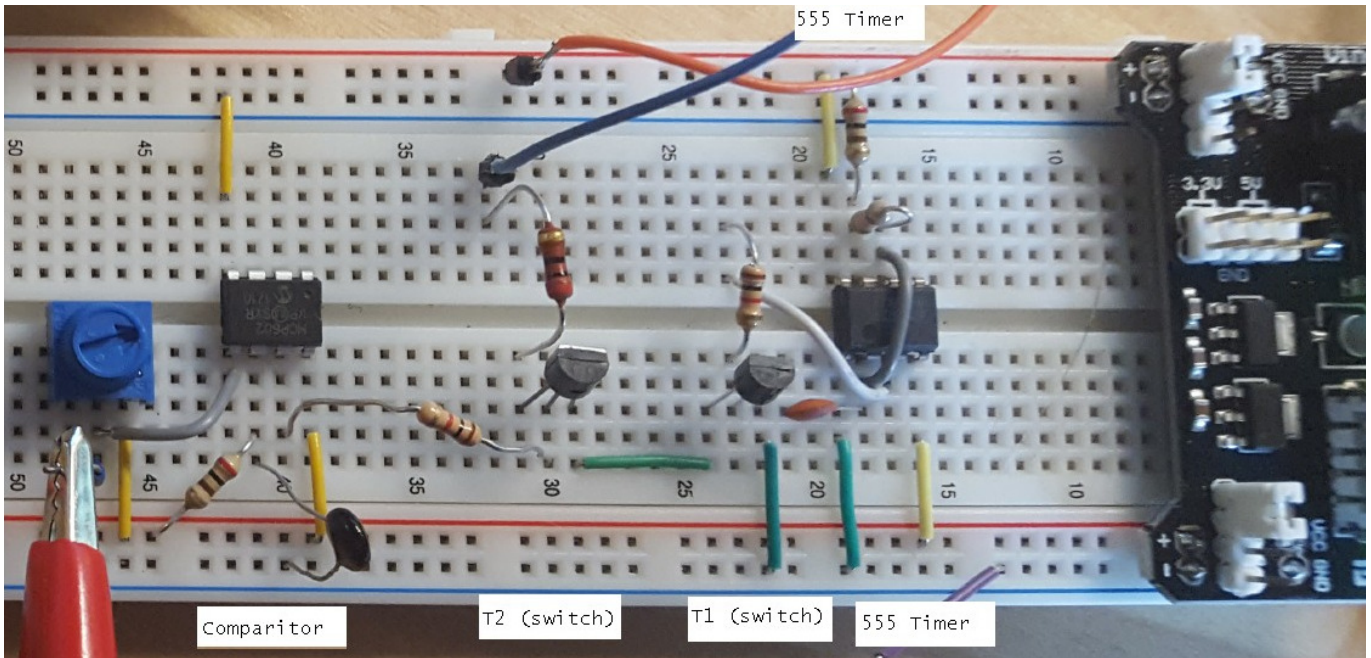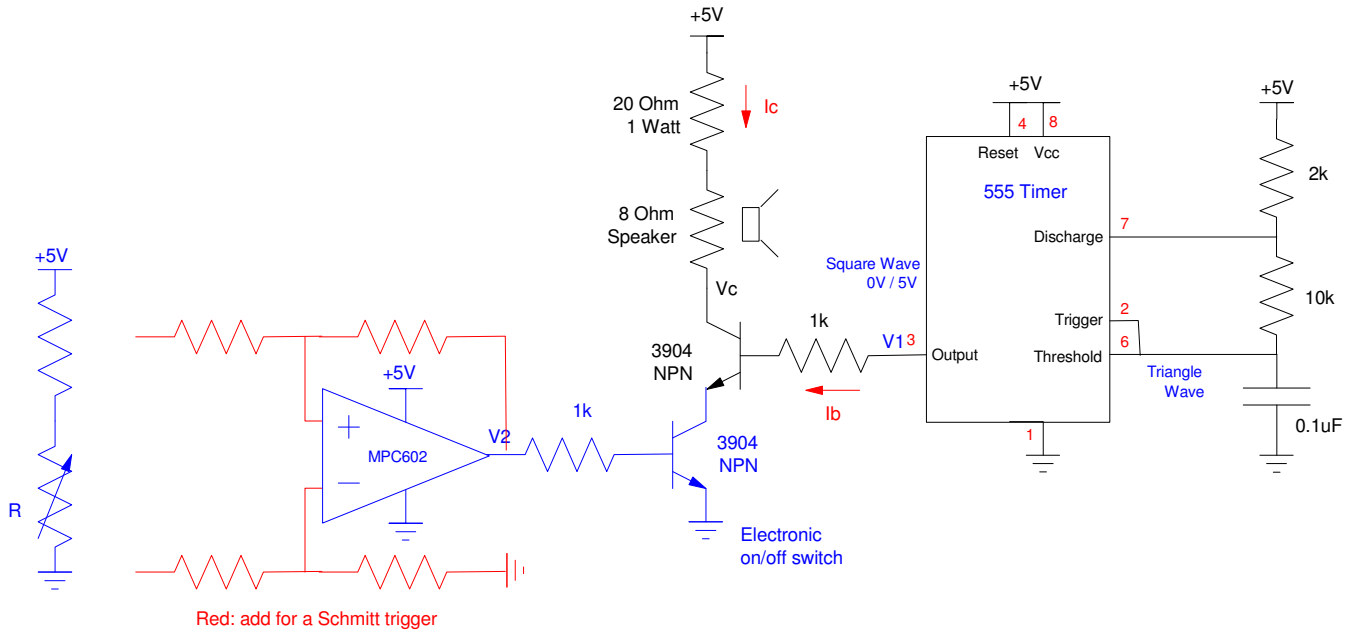
9) Simulate the comaritor in CircuitLab to verify the on / off temperature (or ressitance or voltage)
   - V2 goes high (speaker on) when V4 < 1.976V
   - V2 goes low (speaker off) when V4 > 2.231V

   •

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

+5V

20 Ohm
1 Watt

Ic

8 Ohm
Speaker

Vc

Square Wave
0V / 5V

+5V

+5V

4 8

Reset   Vcc

555 Timer

Discharge

7

2k

+5V

1k

V1 3

3904
NPN

Output

Trigger

2

10k

Threshold

6

Triangle
Wave

+5V

V2

1k

MPC602

3904
NPN

Ib

1

0.1uF

R

Electronic
on/off switch

Red: add for a Schmitt trigger

555 Timer

Comparitor

T2 (switch)

T1 (switch)

555 Timer

Vp set to 2.00V with a potentiometer
- Turns on at 1.98V
- Turns off at 2.26V