ECE 320 - Homework #5

555 Timers, Transistors used as a Switch, Schmitt Triggers.

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.

$$V_b = 0.7V$$

The voltage drop across a silicon diode is 0.7V

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

$$\beta I_b = 430mA$$

This is a switch that can turn on a load which draws up to 430mA

$$V_c = 0.2V$$

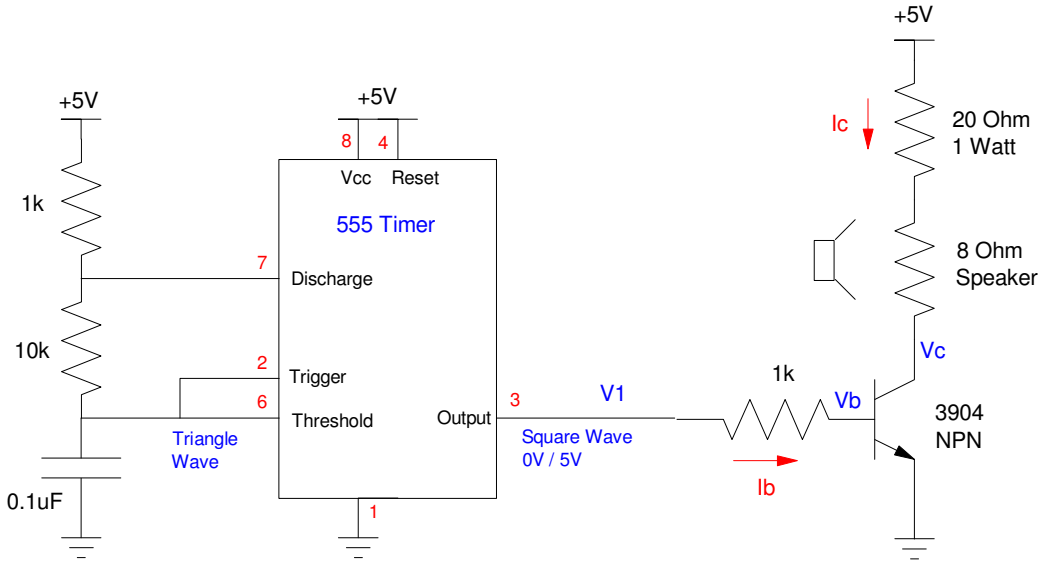
the transistor is saturated

$$I_c = \left(\frac{5-0.2}{28\Omega}\right) = 171mA$$

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

Ib = Ic = 0

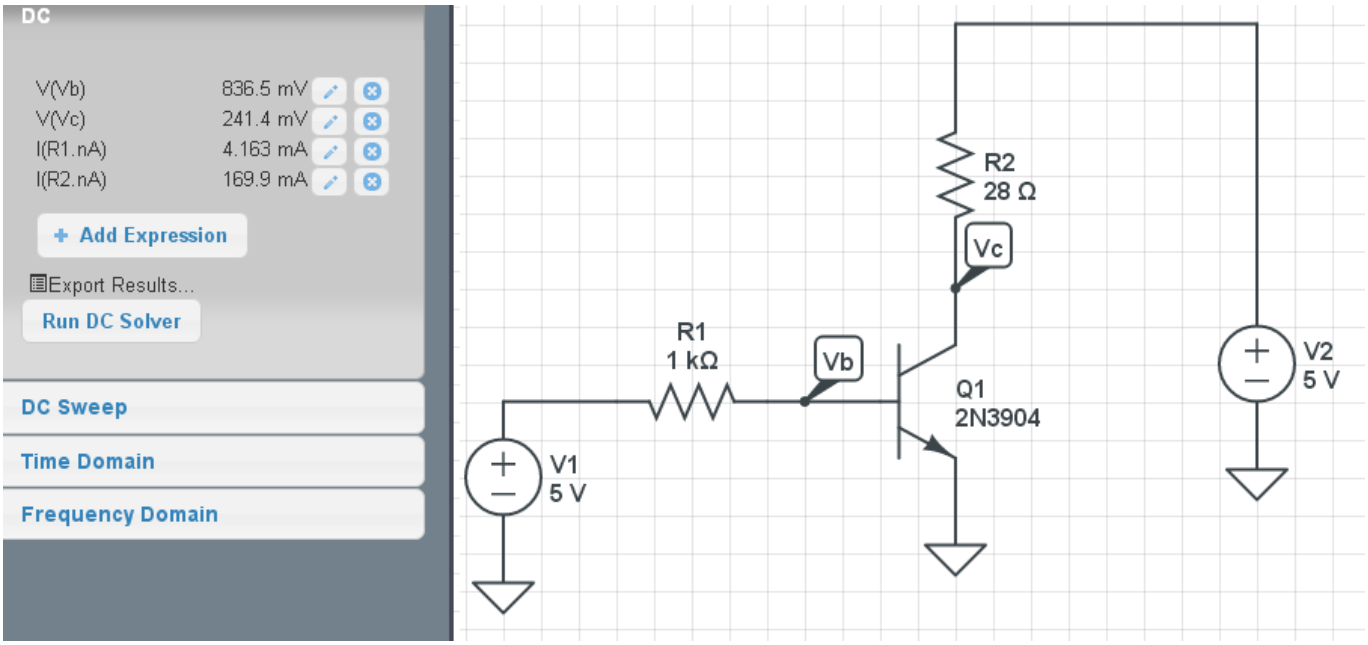
Vc = 5V



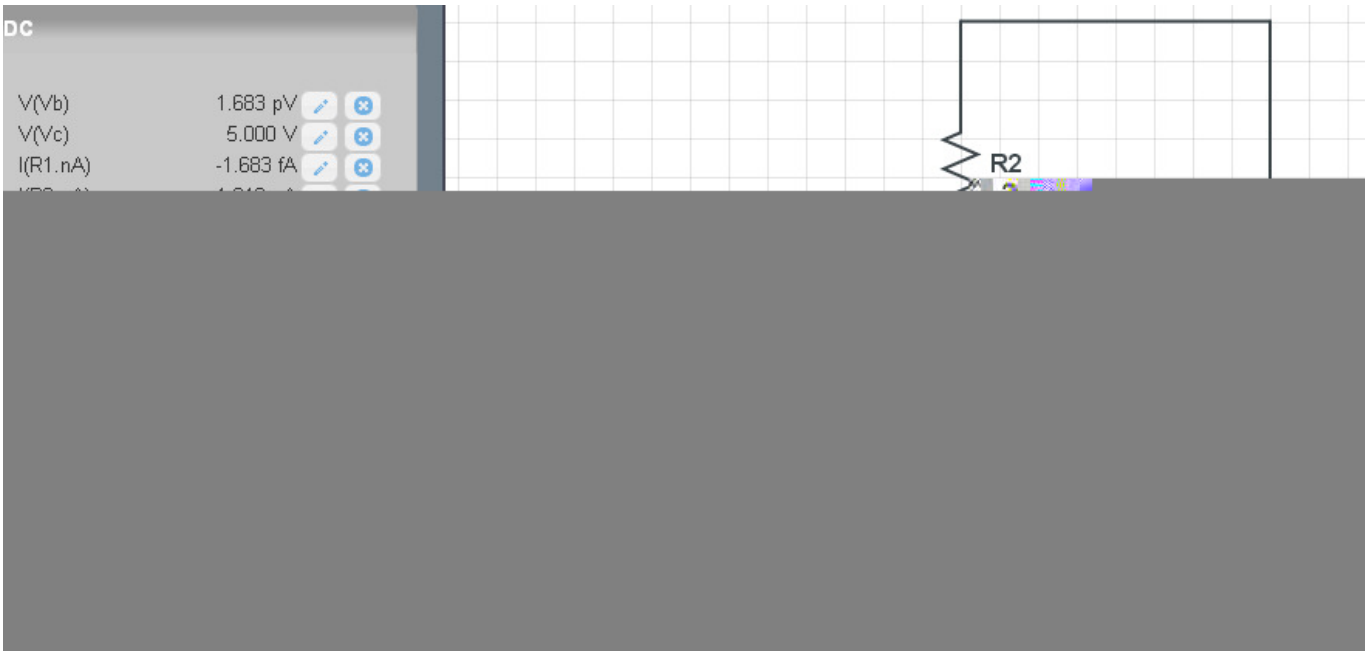
2) Using CircuitLab, determine {Ib, Ic, Vb, and Vc} for

- V1 = 0V
- V1 = 5V

Is the transistor turning on (Vc = 0.2V) and off (Ic = 0)?



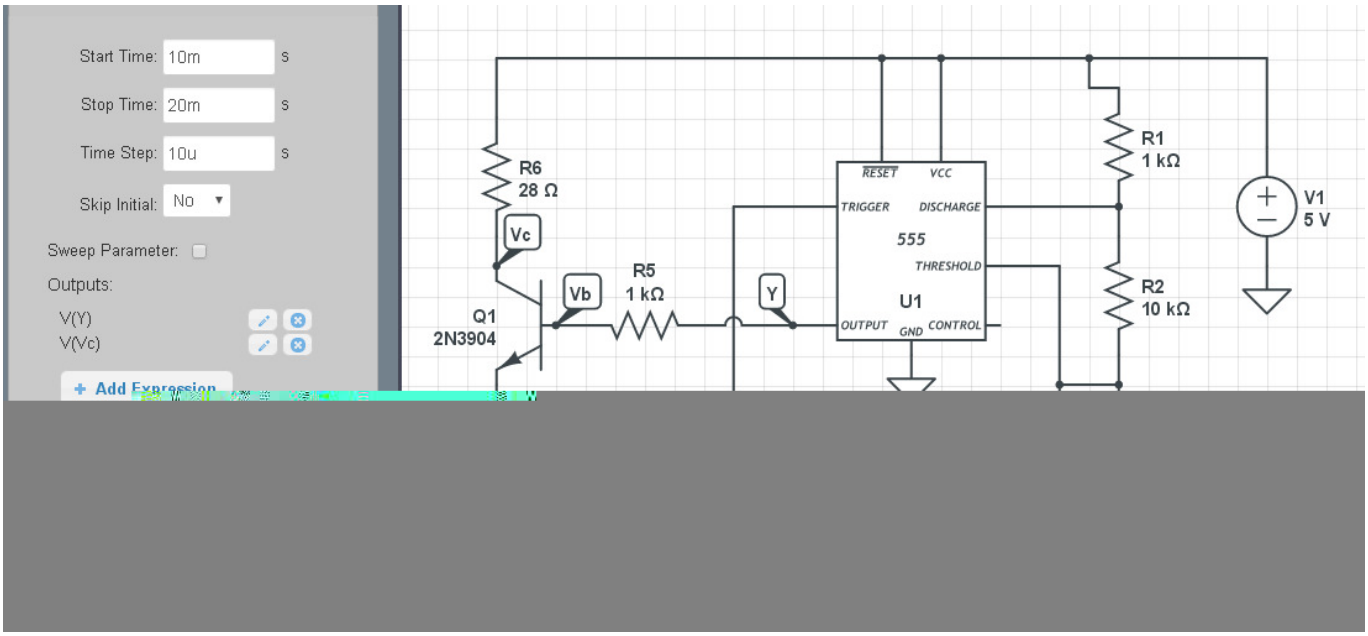
Transistor is On: (Vin = 5V, Vce = 0.241V, Ic = 169.6mA)

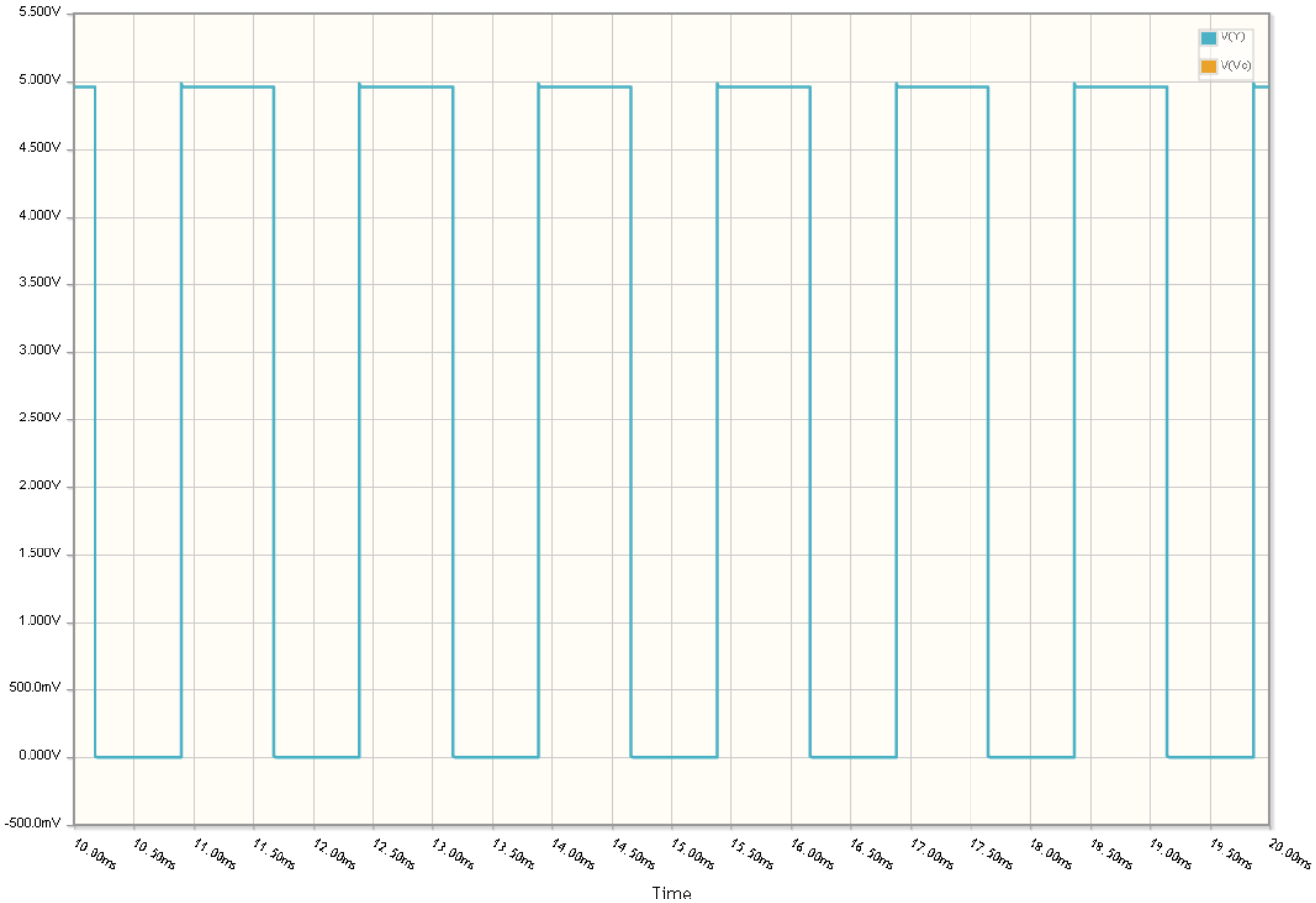


Transistor is Off: Vin = 0V, Vce = 5V, Ic = 0mA (1.31pA)

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

- What frequency should you hear at the speaker? **f = 667Hz**





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)

On:

- Vin = 4.81V
- Vb = 0.824V
- Vc = 0.117V

Off:

- Vin = 0V
- Vb = 0V
- Vc = 4.96V

Running from the 555 timer:

- f = 706.5Hz (from Piano Tuner app)

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

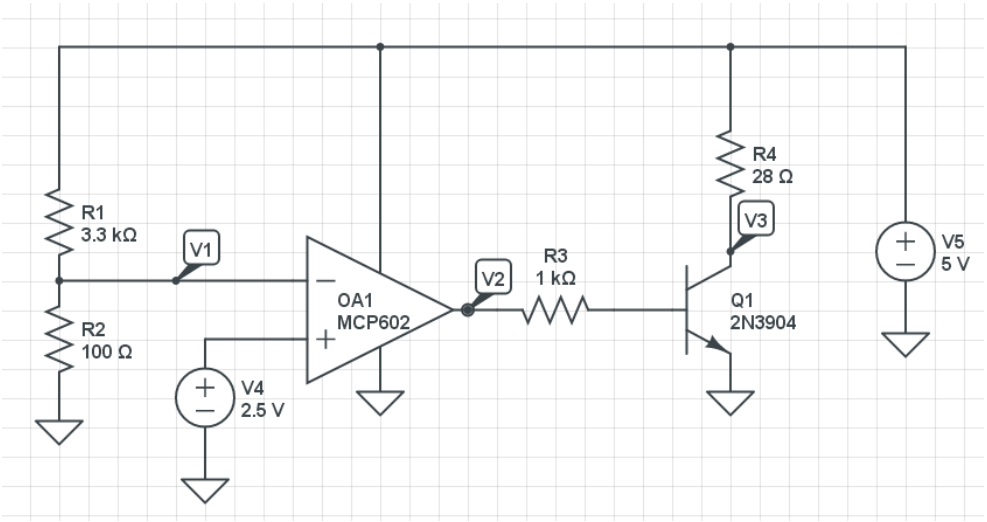
At 0C, R = 3320.12 Ohms. Assume a 3.3k resistor

$$V_1 = \left(\frac{3320}{330+3300}\right)5V = 2.5076V$$

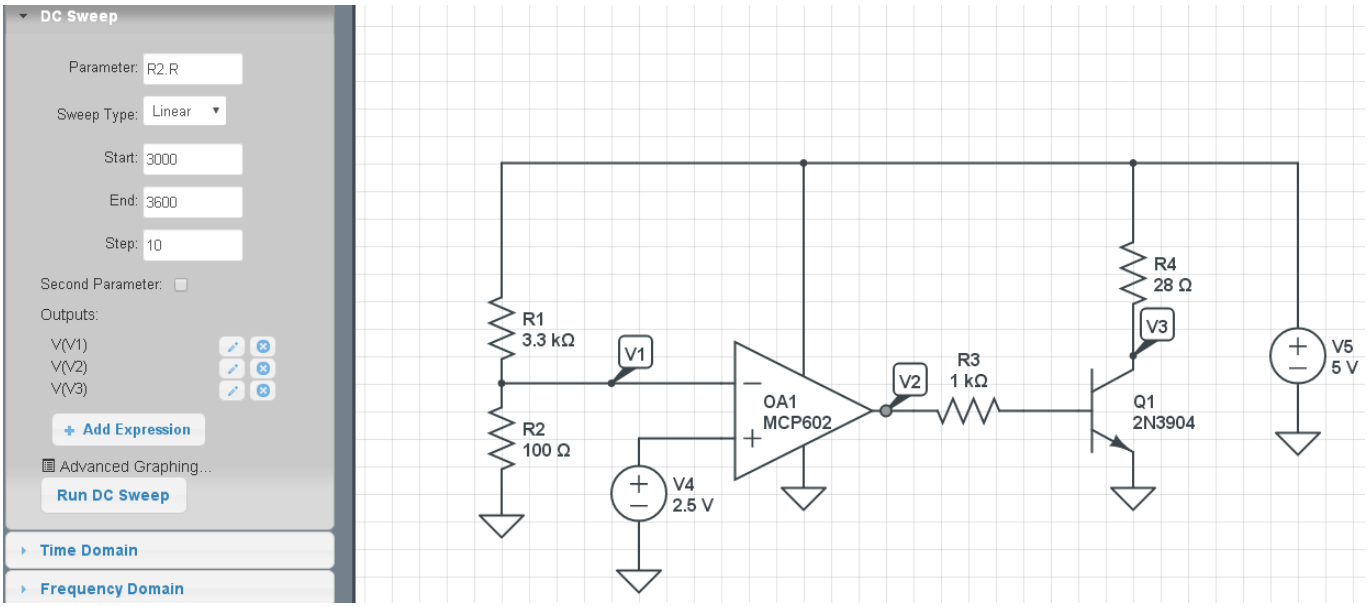
When temperature goes up

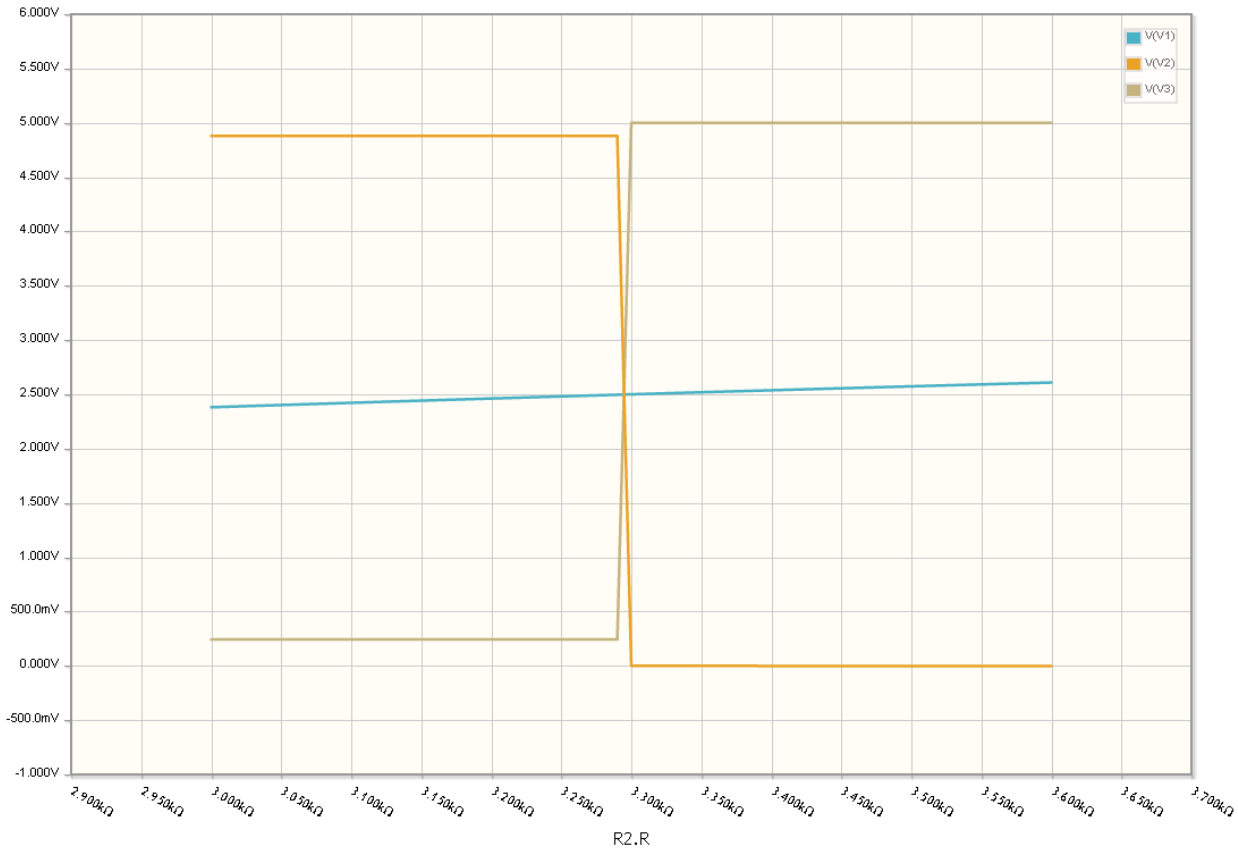
- R goes down
- V1 goes down
- V2 goes up (+5V)

This inverse relationship means conenct to the minus input.



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





The output switches at 3300 Ohms

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

- On Voltage = 1.86V
- Off Voltage = 1.84V

note: the on/off temeprature was increased since my hair dryer could output 130F but not 0F.

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

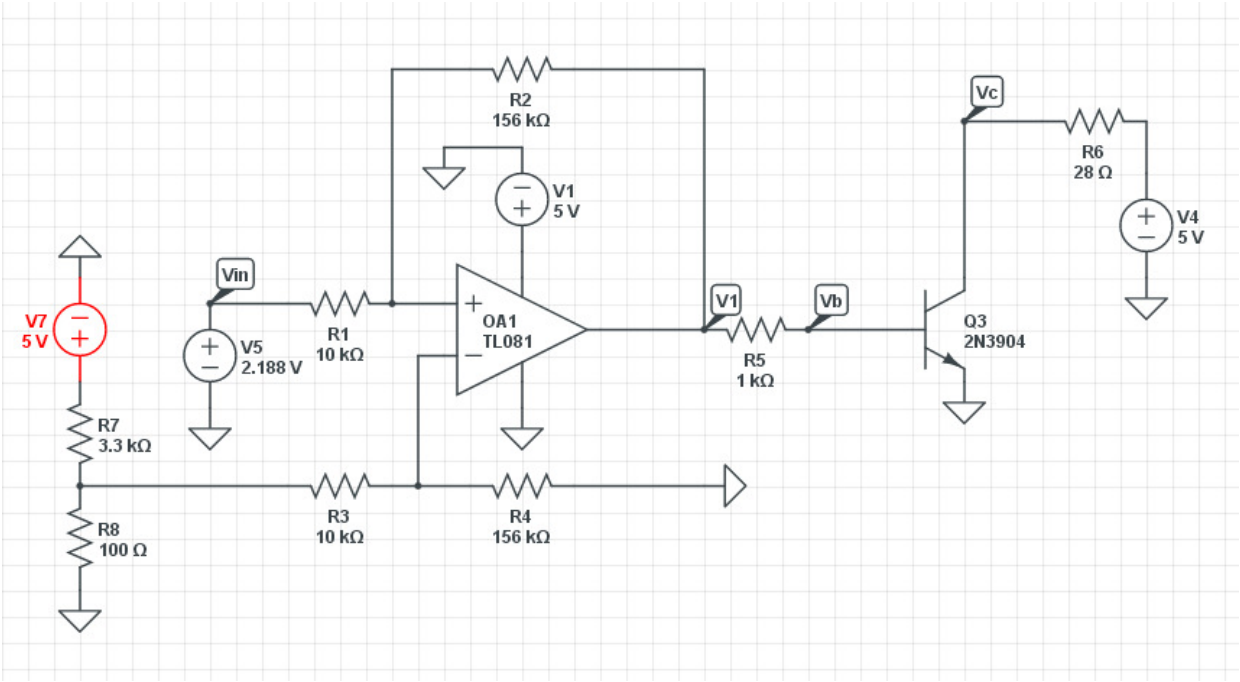
0C: (off)

- R = 3320
- V1 = 2.5076V

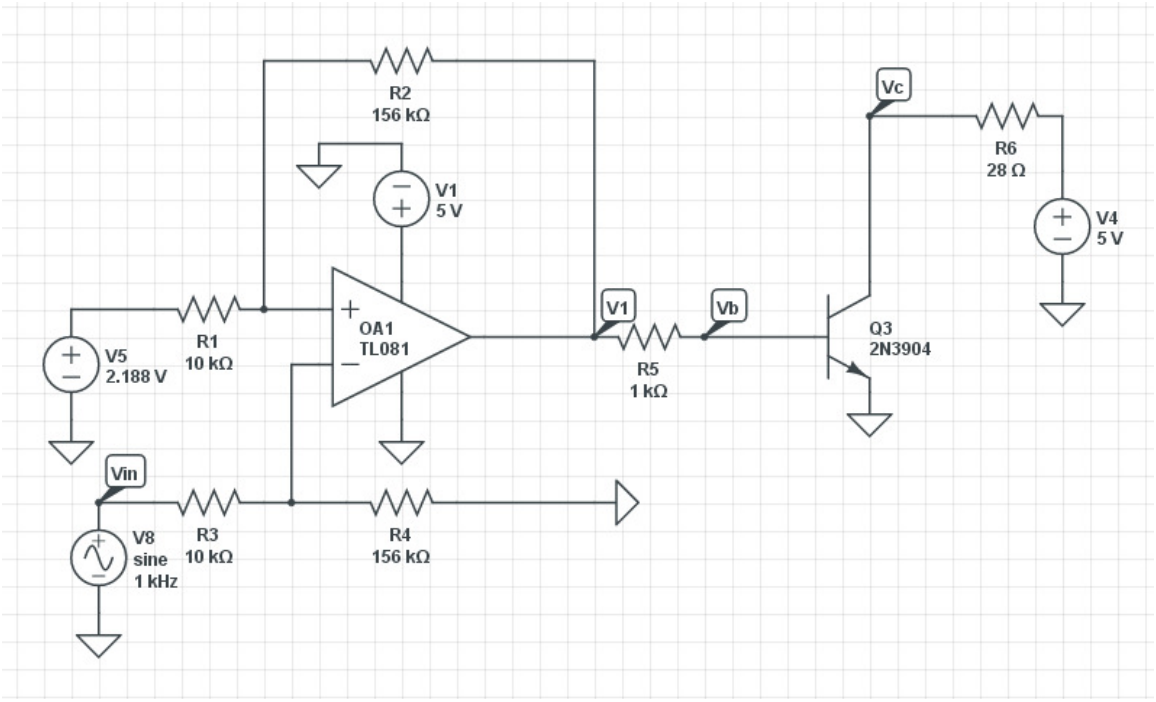
5C: (on)

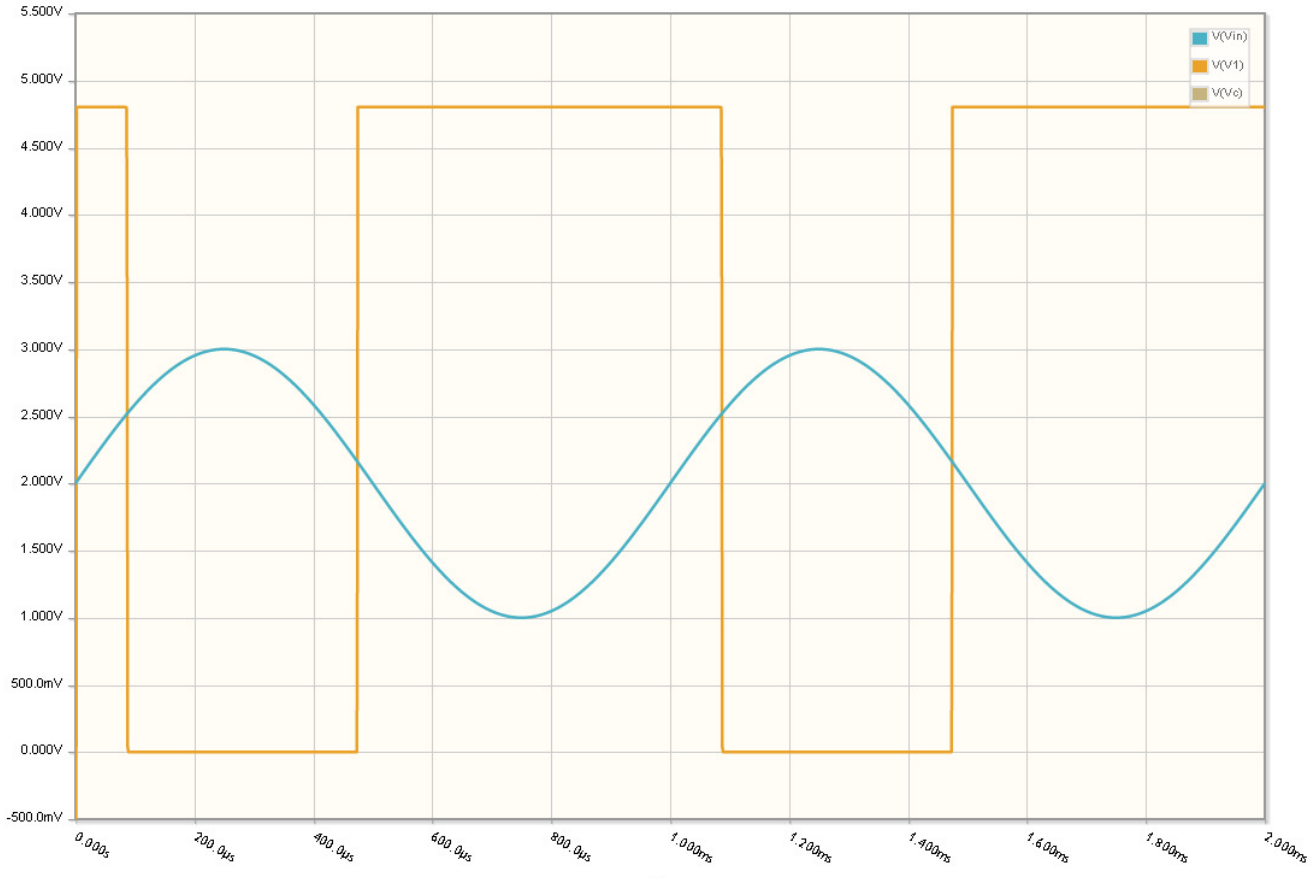
- R = 2567 ohms
- V1 = 2.1877V

gain = 15.63



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





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

- On Voltage: 1.68V
- Off Votlage: 1.86