

ECE 320 - Homework #5

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

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

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

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 $V_1 = 5V$. Determine I_b , I_c , V_b , and V_c .

$$V_b = 0.7V$$

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

$$V_c = 0.2V$$

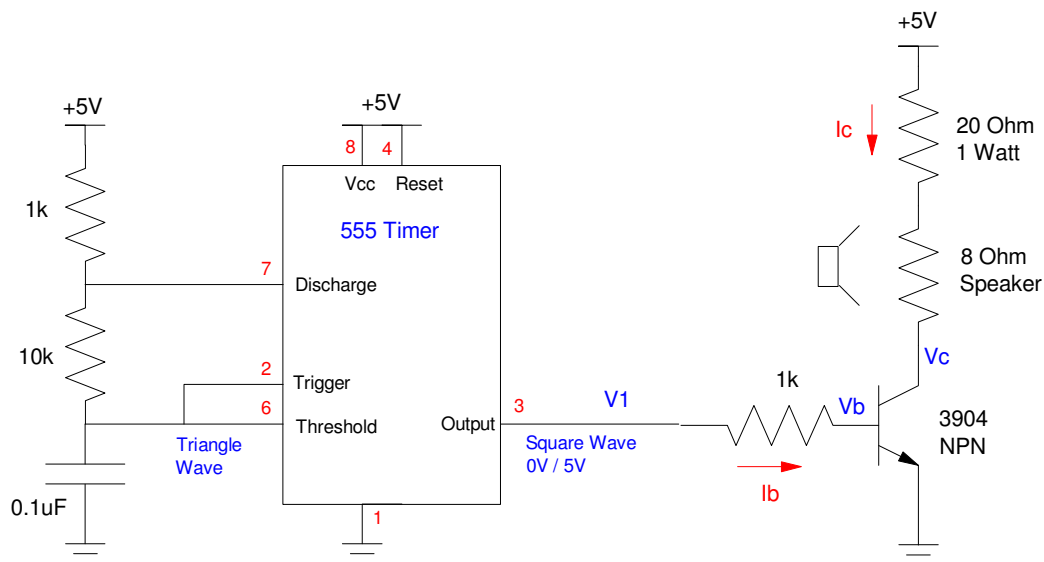
the transistor is saturated

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

Assume $V_1 = 0V$. Determine I_b , I_c , V_b , and V_c .

$$I_b = I_c = 0$$

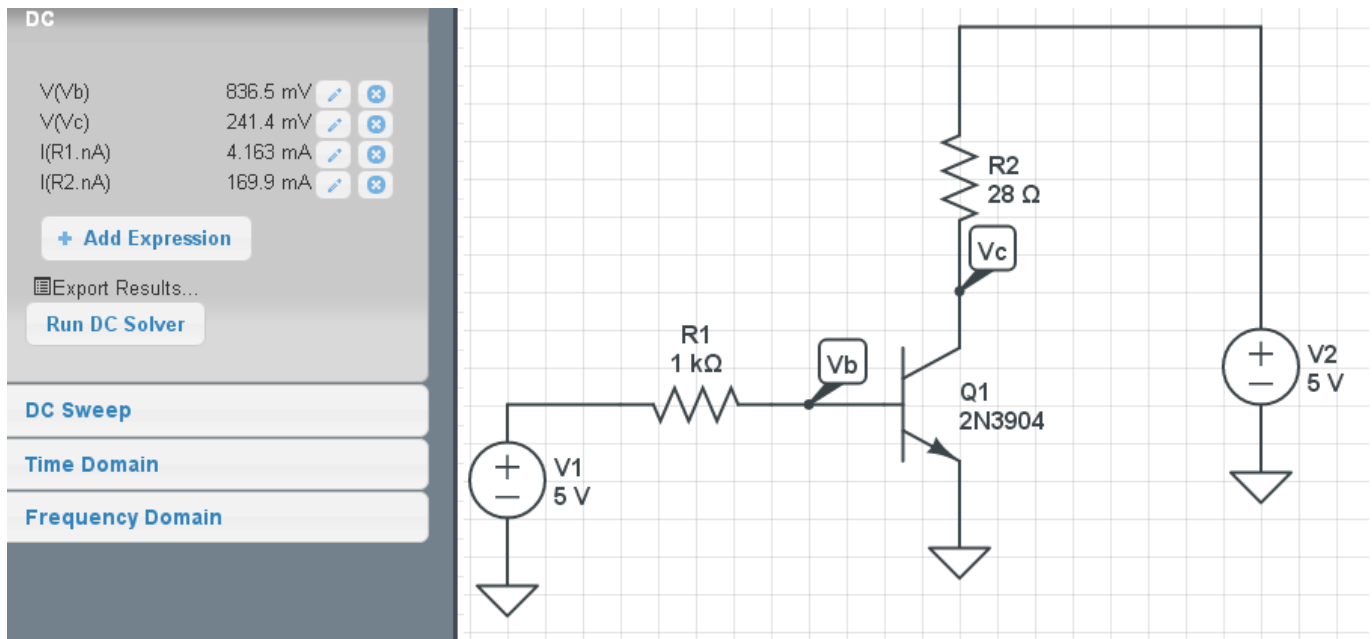
$$V_c = 5V$$



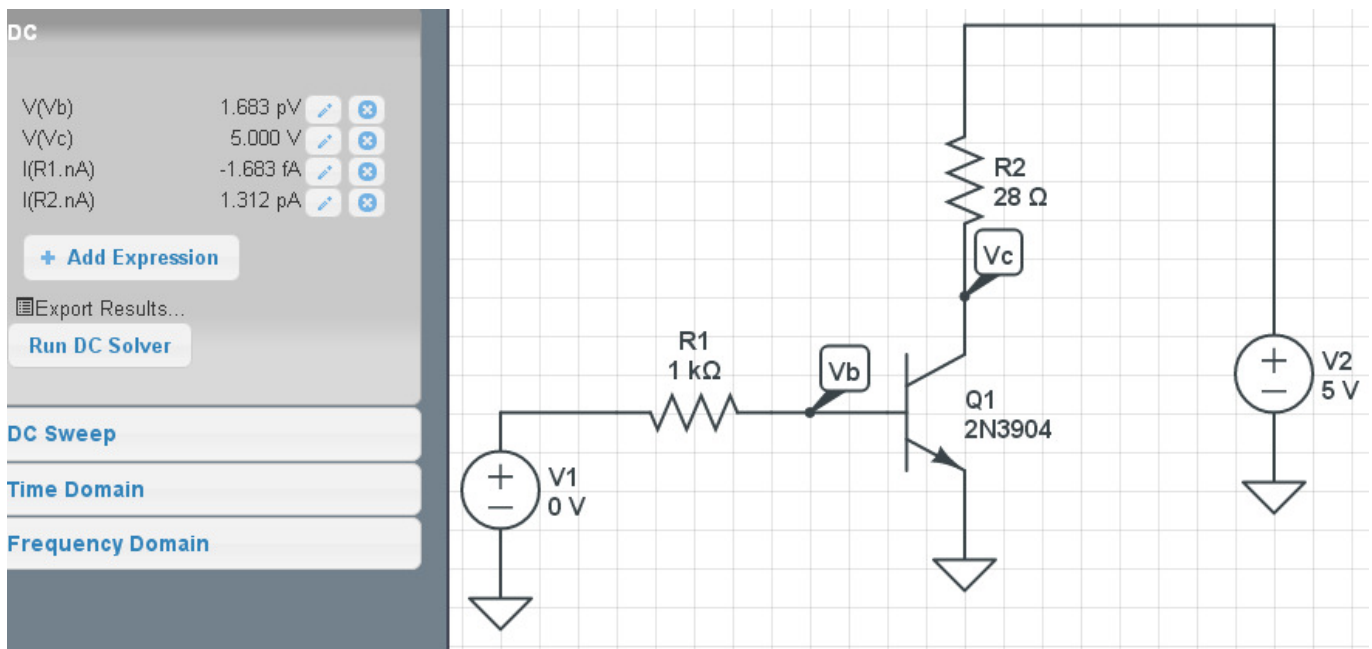
2) Using CircuitLab, determine $\{I_b, I_c, V_b, \text{ and } V_c\}$ for

- $V_1 = 0V$
- $V_1 = 5V$

Is the transistor turning on ($V_c = 0.2V$) and off ($I_c = 0$)?



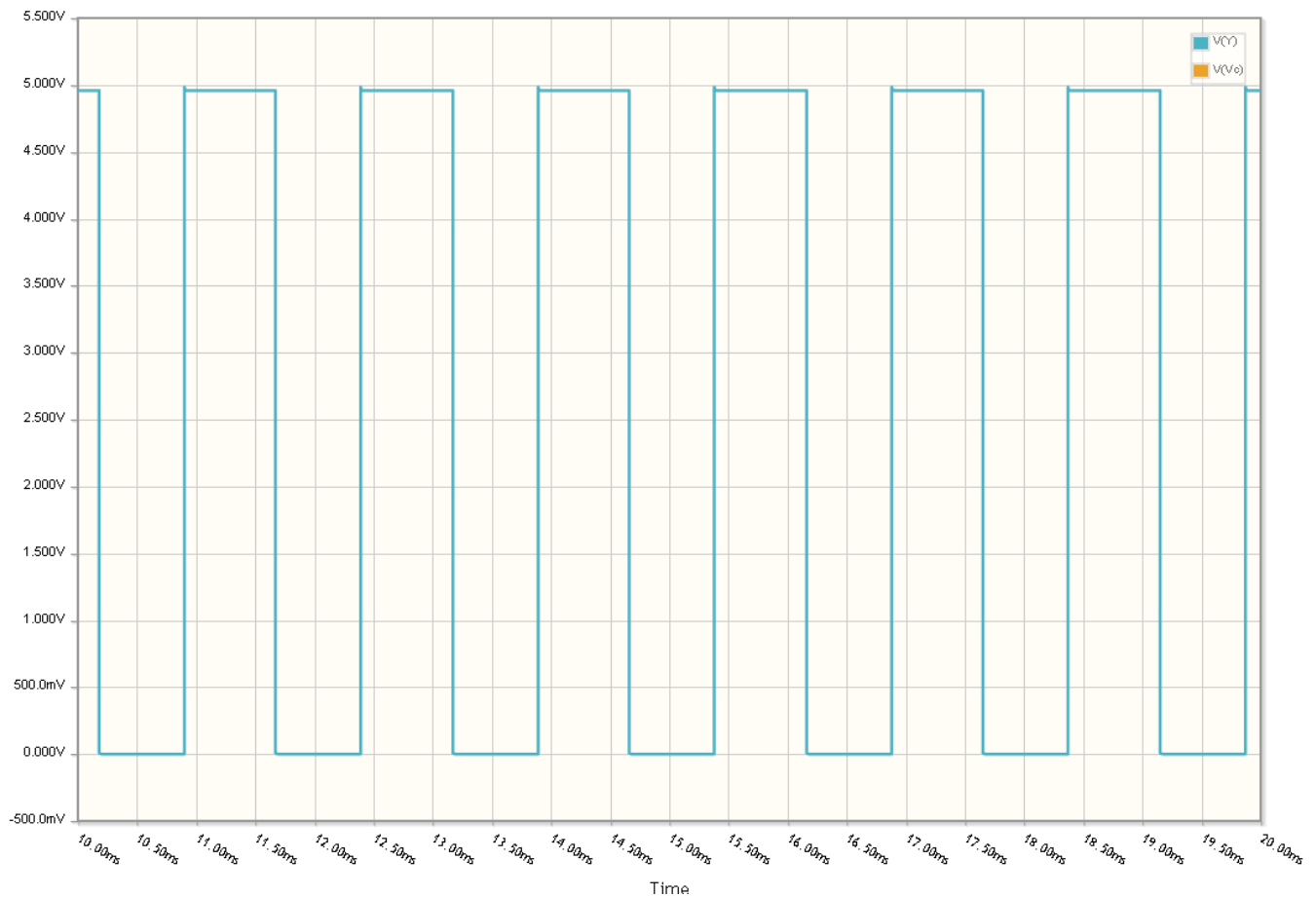
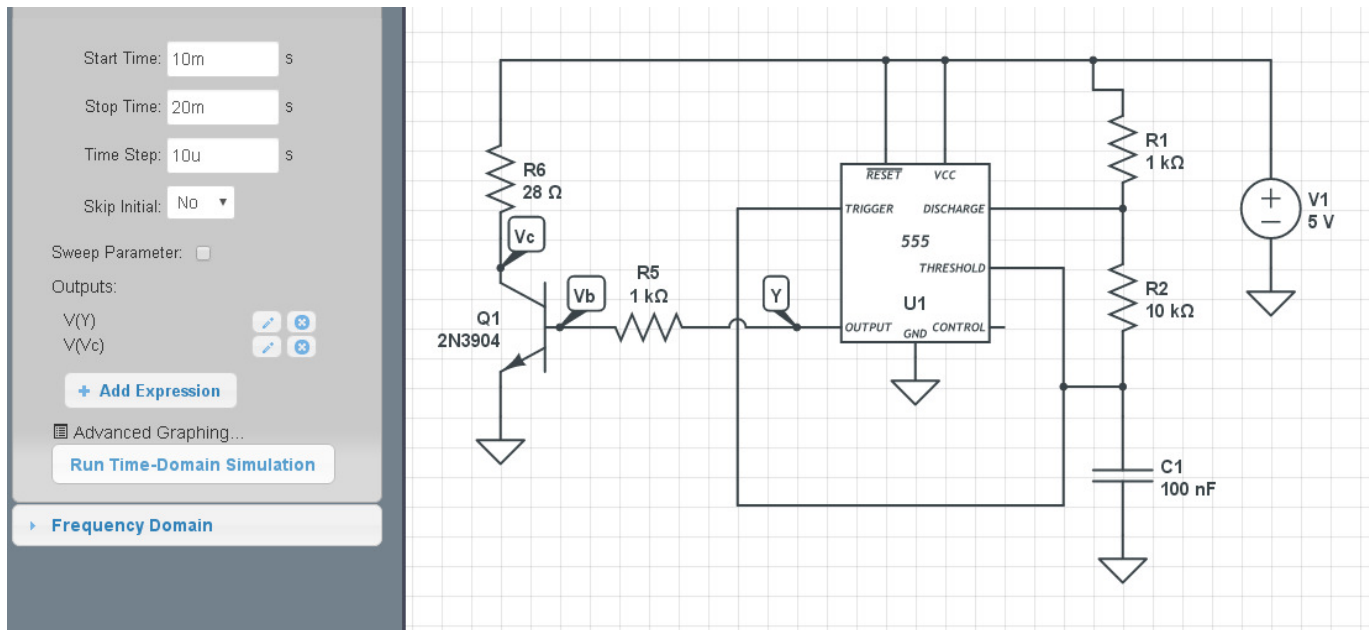
Transistor is On: ($V_{in} = 5V$, $V_{ce} = 0.241V$, $I_c = 169.6mA$)



Transistor is Off: $V_{in} = 0V$, $V_{ce} = 5V$, $I_c = 0mA$ (1.31pA)

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

- What frequency should you hear at the speaker? $f = 667\text{Hz}$



4) Build this circuit with your lab kits and verify

- The frequency at V1
- That the transistor is off when $V_1 = 0V$ (connect the 1k resistor to ground rather than the 555 timer)
- That the transistor is saturated when $V_1 = 5V$ (connect the 1k resistor to +5V)
- That the speaker is loud and annoying (the transistor acts as an amplifier)

On:

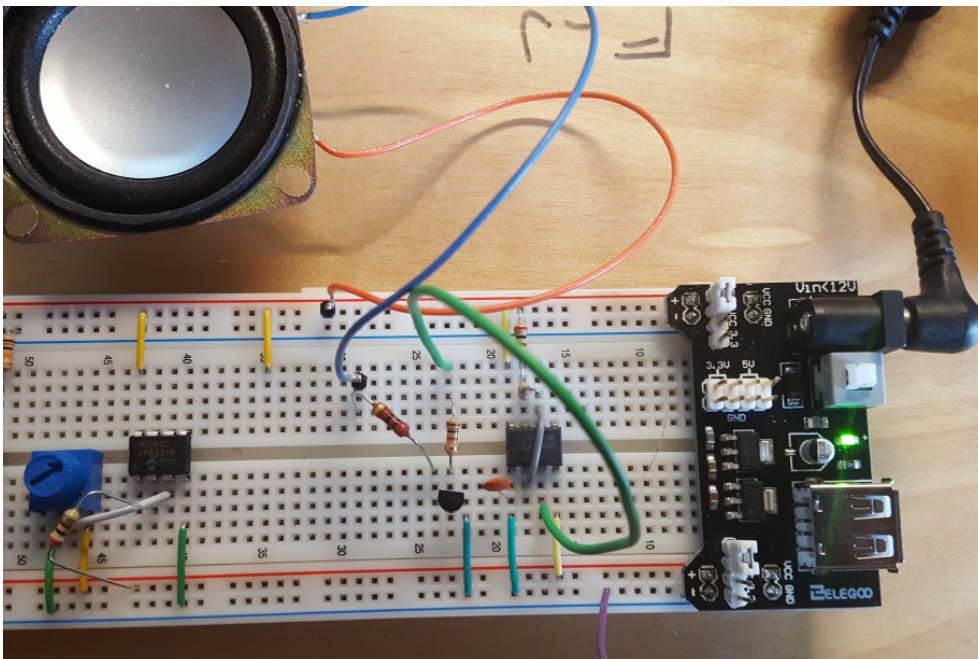
- $V_{in} = 4.81V$
- $V_b = 0.824V$
- $V_c = 0.117V$

Off:

- $V_{in} = 0V$
- $V_b = 0V$
- $V_c = 4.96V$

Running from the 555 timer:

- $f = 706.5Hz$ (from Piano Tuner app)



Comparator

Add an electronic switch to turn the speaker on and off

5) Design a comparator (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

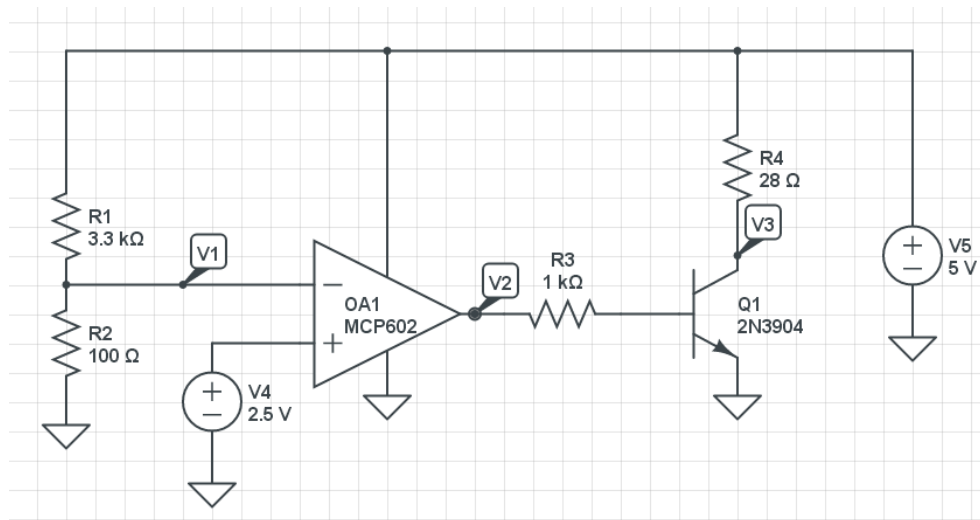
At 0C, R = 3320.12 Ohms. Assume a 3.3k resistor

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

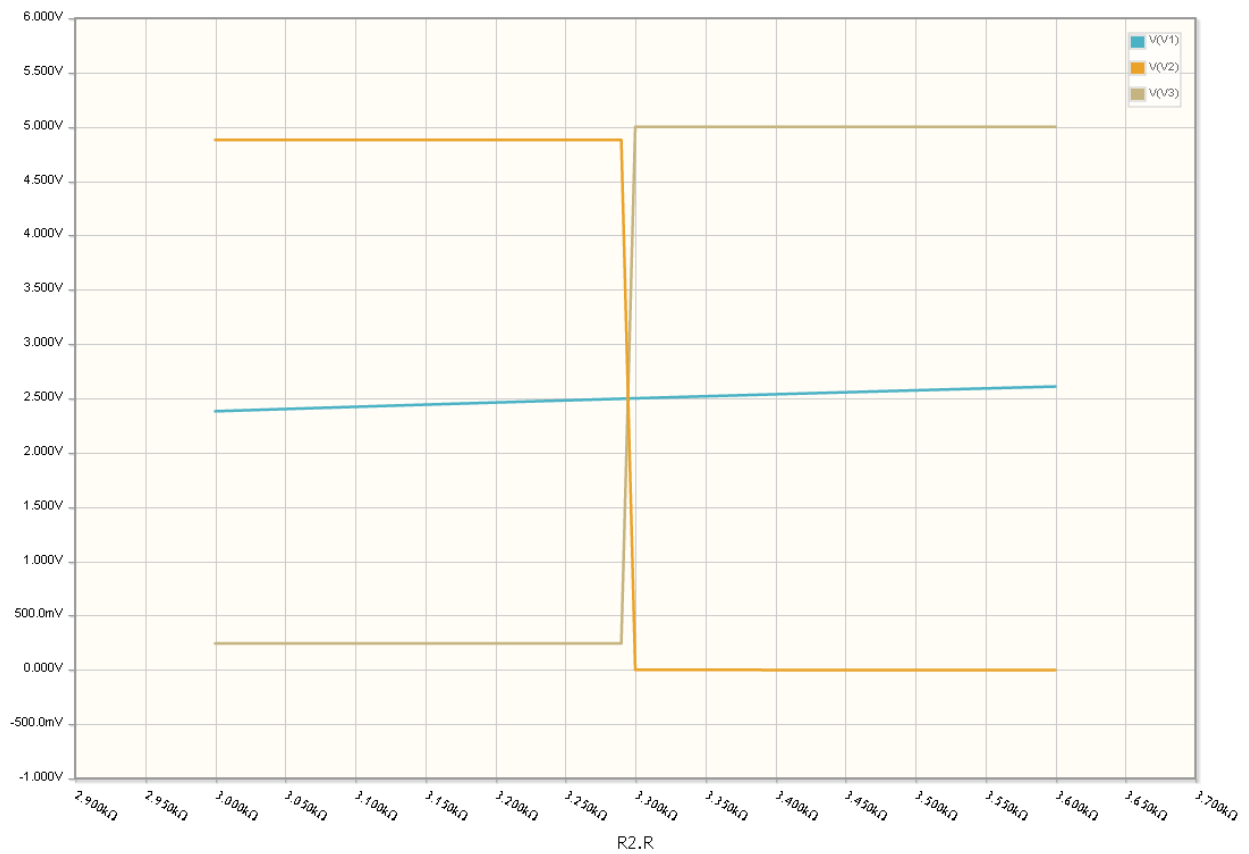
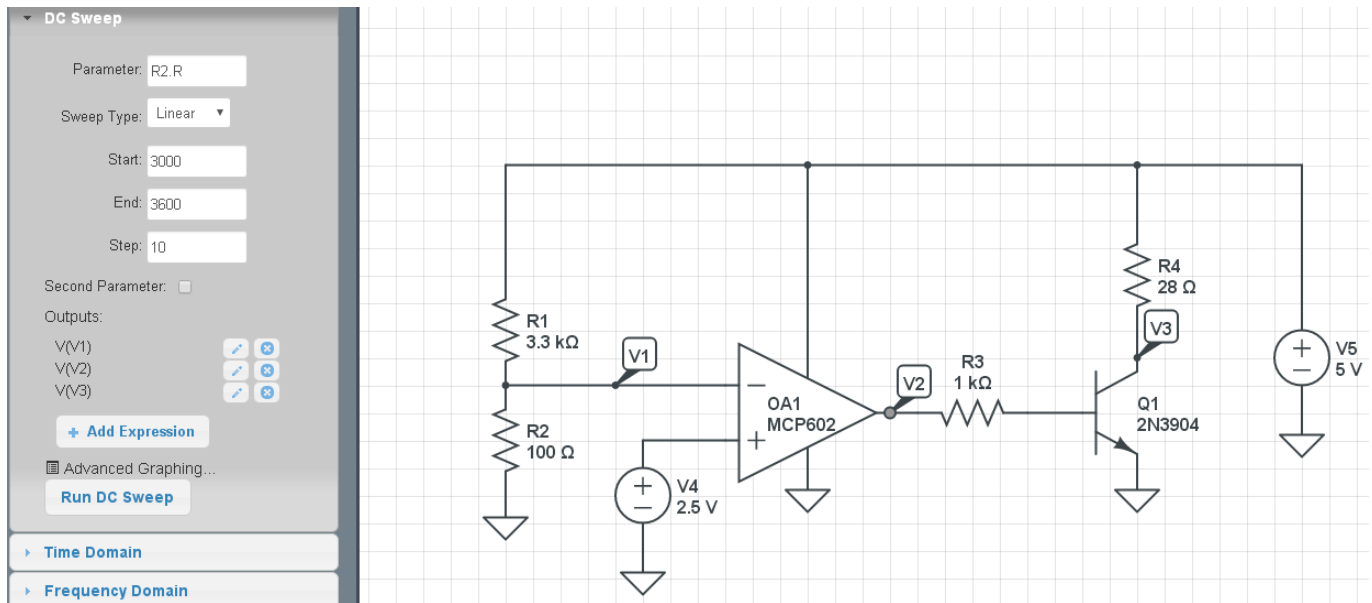
When temperature goes up

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

This inverse relationship means connect to the minus input.



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

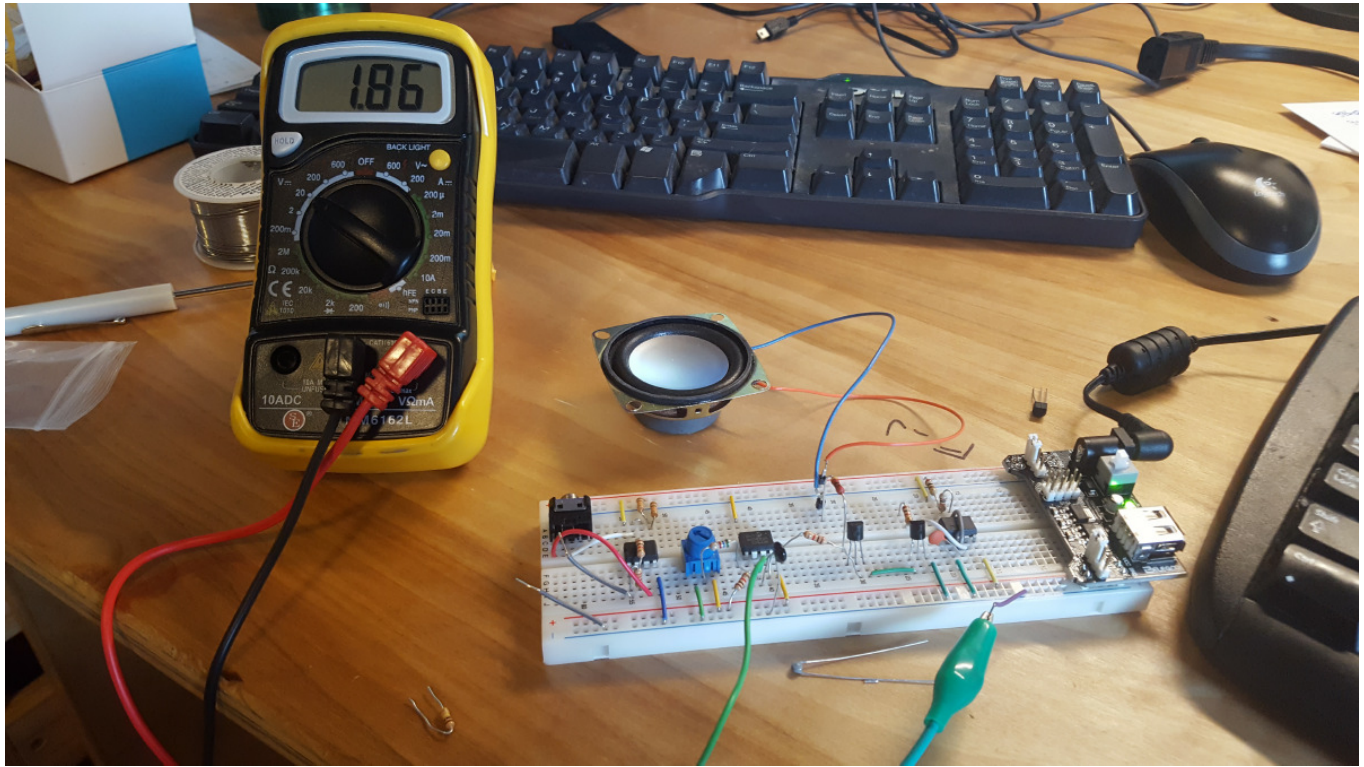


The output switches at 3300 Ohms

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

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

note: the on/off temperature 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 ($V_2 = 5V$) when $T < 0C$, and
- Turn off the speaker ($V_2 = 0V$) when $T > 5C$

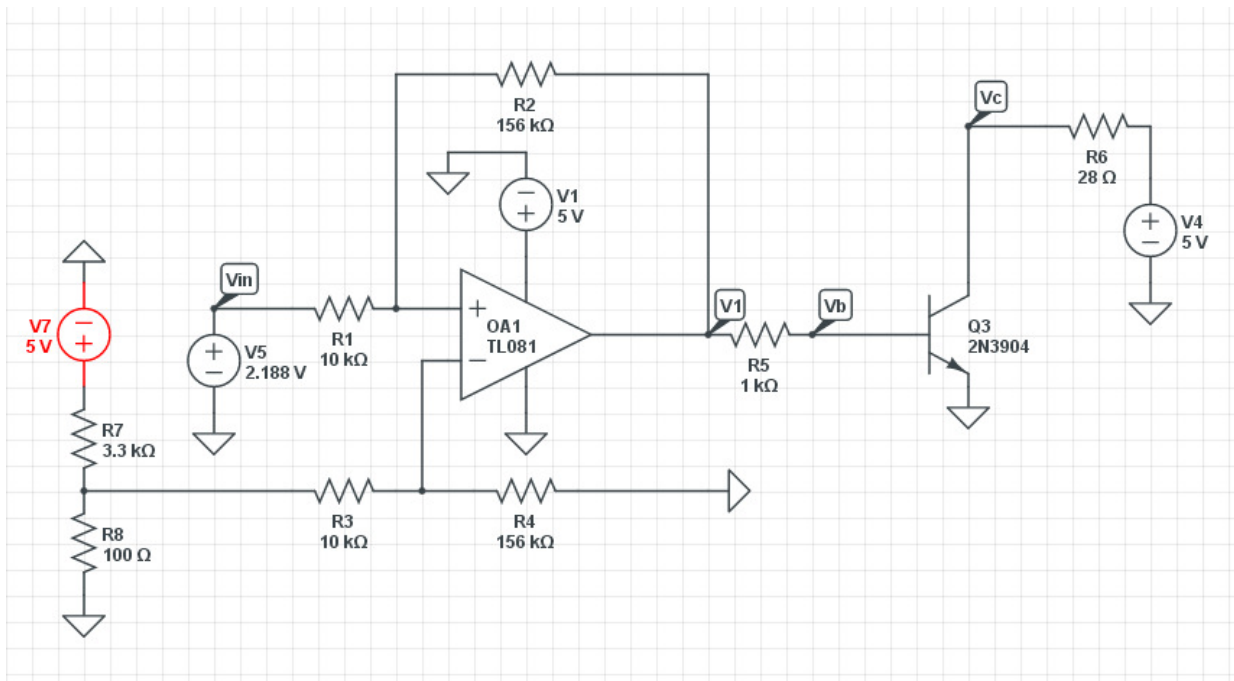
0C: (off)

- $R = 3320$
- $V_1 = 2.5076V$

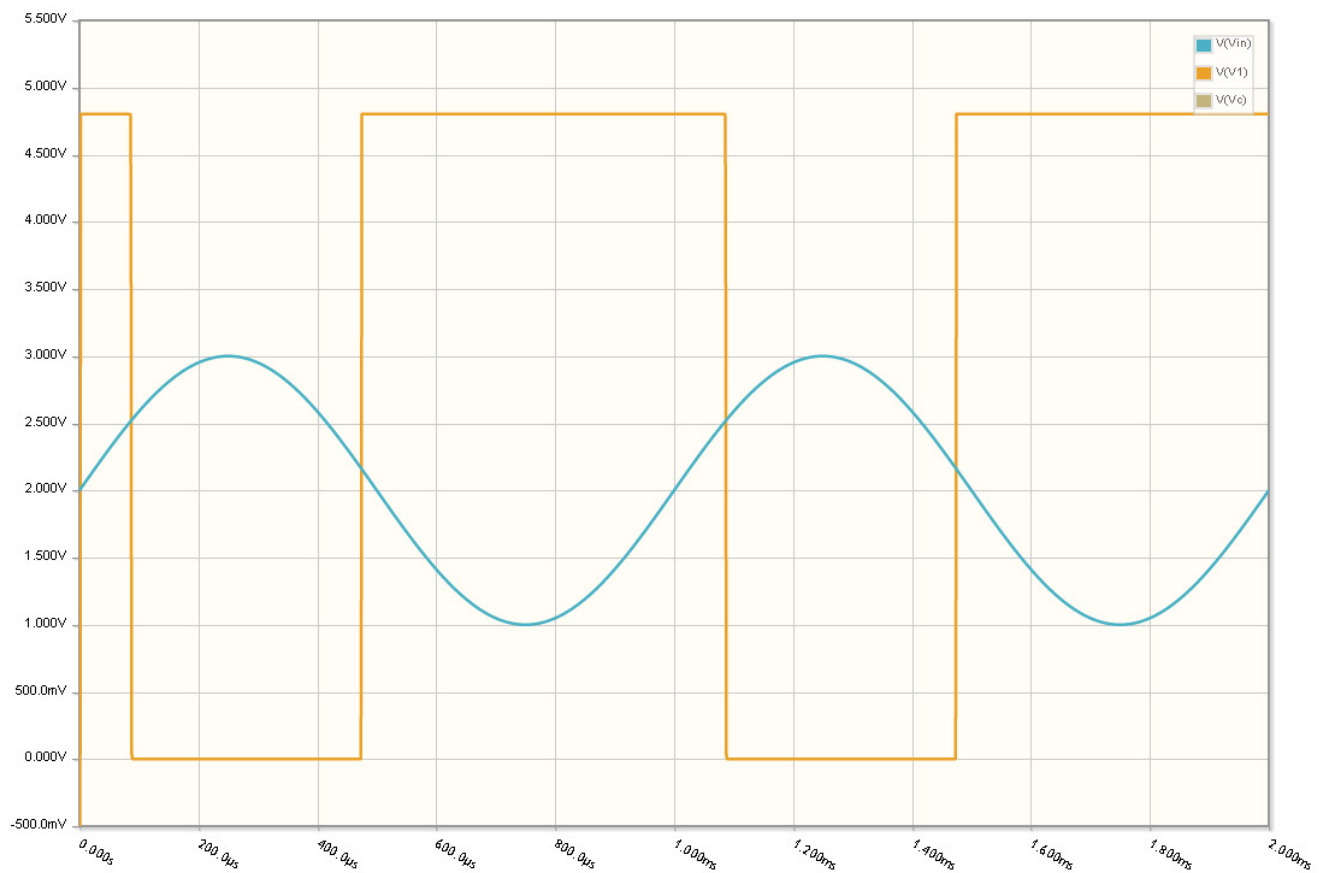
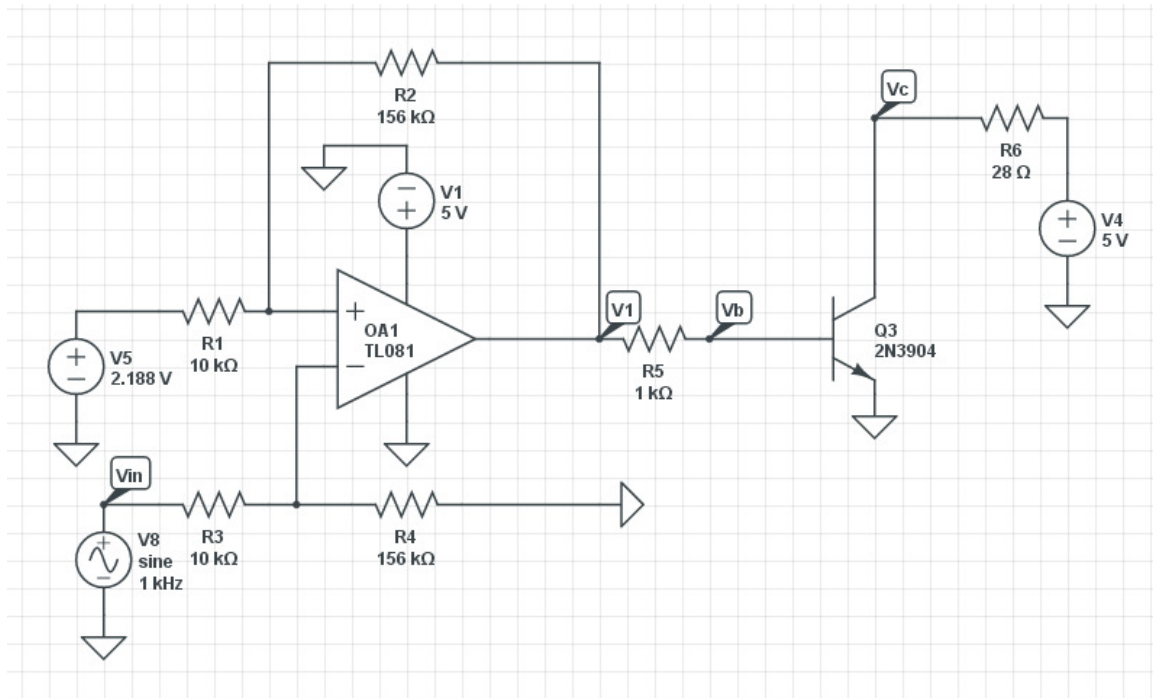
5C: (on)

- $R = 2567$ ohms
- $V_1 = 2.1877V$

gain = 15.63



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



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

- On Voltage: 1.68V
- Off Voltage: 1.86

