ECE 320 - Homework #5

555 Timers, Transistors used as a Switch, Schmitt Triggers. Due Monday, February 14th

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

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

555 Timers

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

On-Time: charge through R1 and R2

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

$$T_{on} = (10k + 20k) \cdot 0.1uF \cdot \ln(2)$$

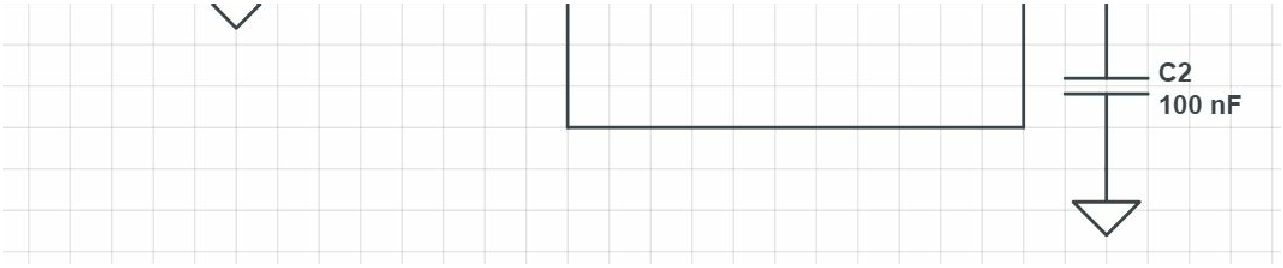
$$T_{on} = 2.079ms$$

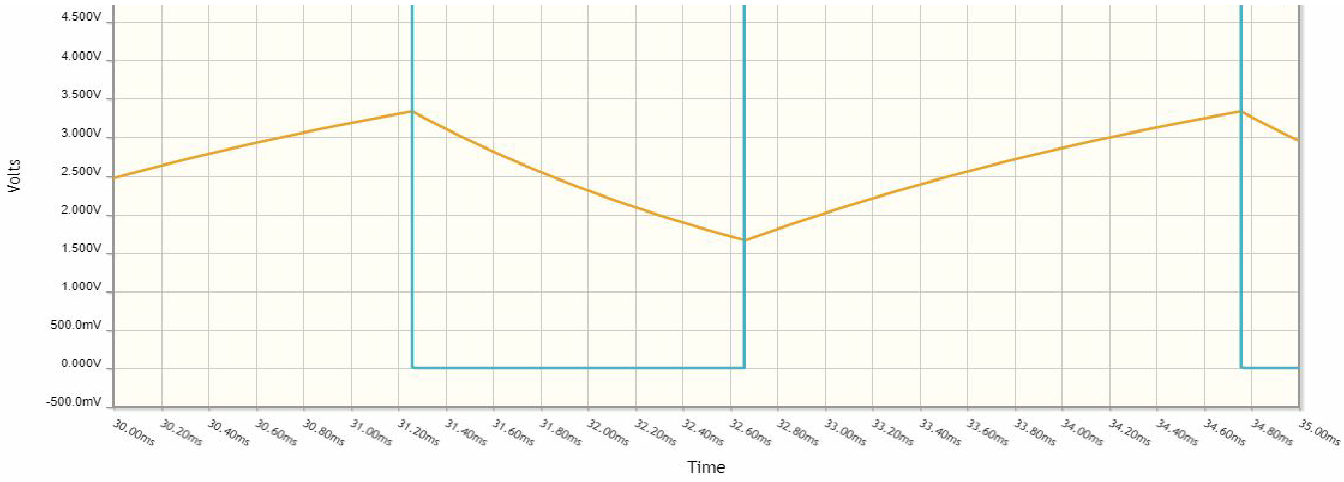
Off-Time: discharge through R2

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

$$T_{off} = 1.386ms$$

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




Volts
4.500V
4.000V
3.500V
3.000V
2.500V
2.000V
1.500V
1.000V
500.0mV
0.000V
-500.0mV
30.00ms
30.20ms
30.40ms
30.60ms
30.80ms
31.00ms
31.20ms
31.40ms
31.60ms
31.80ms
32.00ms
32.20ms
32.40ms
32.60ms
32.80ms
33.00ms
33.20ms
33.40ms
33.60ms
33.80ms
34.00ms
34.20ms
34.40ms
34.60ms
34.80ms
35.00ms
Time

Transistor Switch

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

When V2 = 0V (off)

- Vb = 0V
- Vc = 5V

When V2 = 5V

- Vb = 0.7V (ideal diode)
- Vc = 0.2V (saturated)

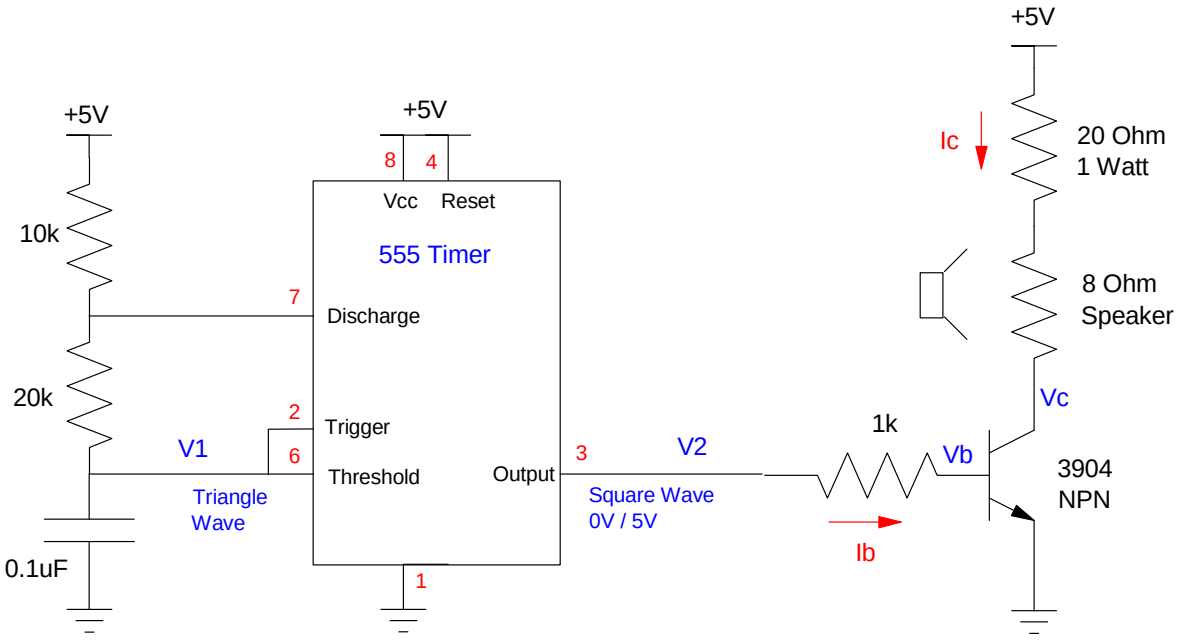
4) Verify your calculations using CircuitLab

When V2 = 0V

- Vb = 0V
- Vc = 5V

When V2 = 5V

- Vb = 0.8361V
- Vc = 0.2417V



Comparitor

Add an electronic switch to turn the speaker on and off

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

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 > 40C, and
- Turn off the speaker (V3 = 0V) when T < 40C

At 40C

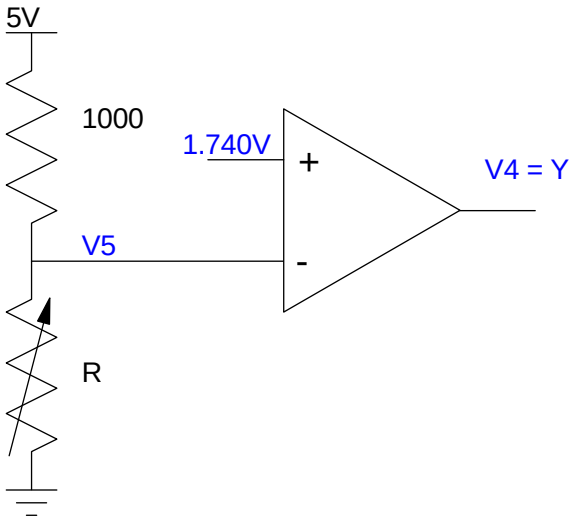
R = 533.66 ohms

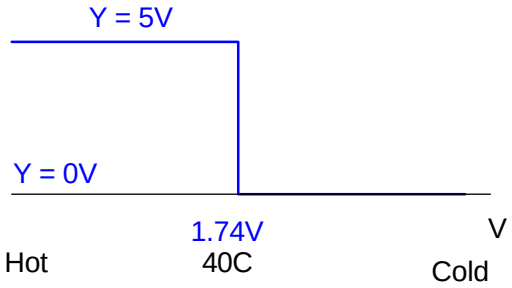
V5 = 1.740V

Make V6 = 1.740V so that the comparitor switches at 40C (create 1.740V with a voltage divider)

Connect the thermistor (V5 thermistor) to the minus input so that

- As temperature goes up, R(thermistor) goes down
- V5 goes down
- V4 goes up (V4 is 5V when it s hot)



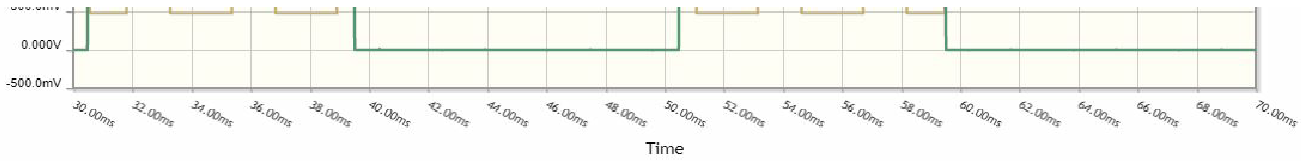


6) Simulate the comparitor in CircuitLab to verify the on / off temperature (or resitance or voltage)

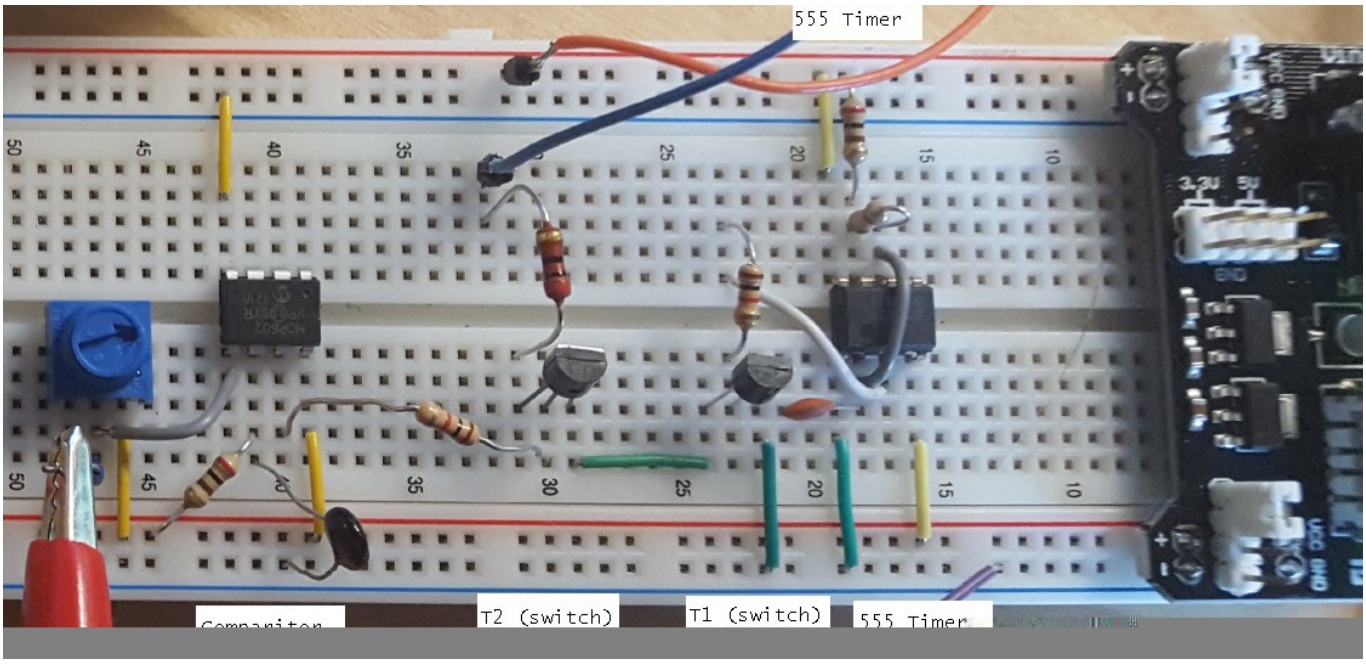
- use a voltage source (V4) to simulate the voltage at the voltage divider)

When V4 his high, the speaker plays (V3 oscillates as the transistors turn on and off with the 555 timer)

When V4 is low, the speaker is off (V3 is a constant 5.00V meaning the transistors are off)



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 comparotor, 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 > 45C, and
- Turn off the speaker (V3 = 0V) when T < 40C

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

At 40C

- R = 533.66 Ohms
- V5 = 1.74V
- V4 = 0V

At 45V

- R = 438.61 Ohms
- V5 = 1.524V
- V4 = 5V

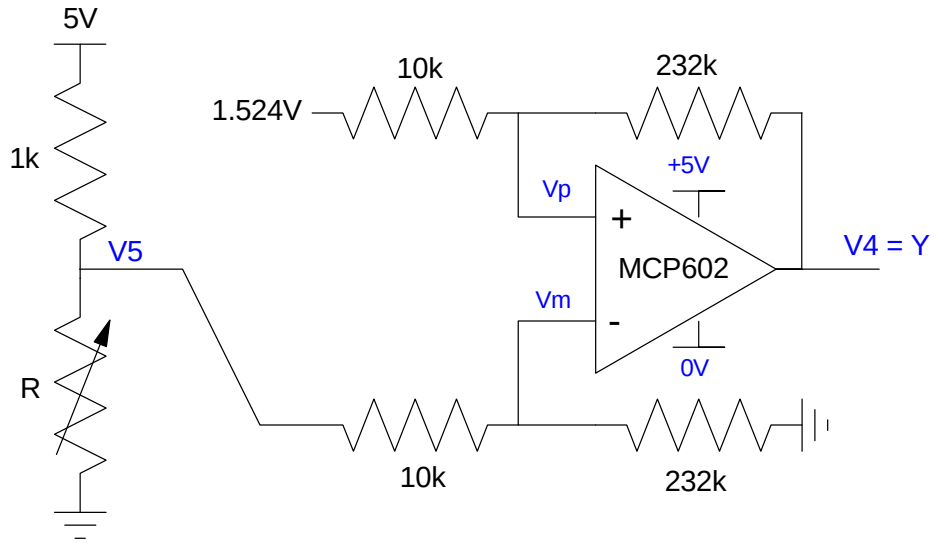
As V5 goes down, V4 goes up. Connect the voltage divider to the minus input

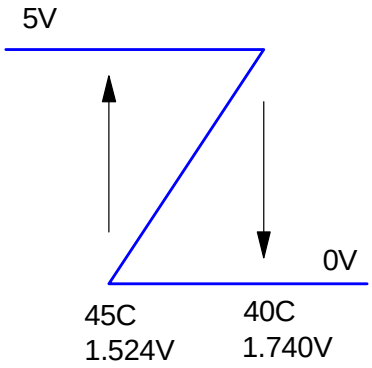
V4 is set when V5 = 1.524V. Make the offset 1.524V

The gain needed is

$$\text{gain} = \frac{\text{change in output}}{\text{change in input}} = \frac{5V - 0V}{1.74V - 1.524V} = 23.21$$

Make the resistors in a 23.31 : 1 ratio





9) Simulate the comaritor 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)


Time