ECE 321 - Homework #2

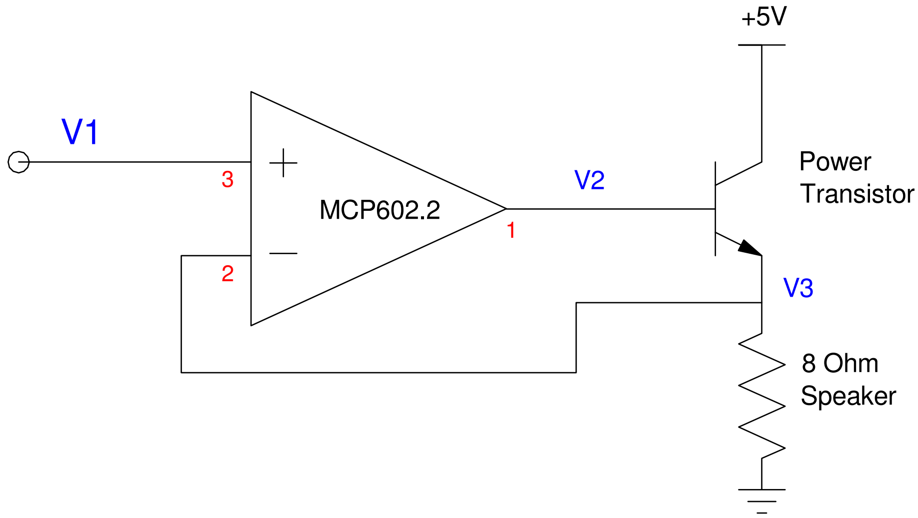
Push-Pull Amplifiers & Tmperature Sensors. Due Monday, April 12th

Please make the subject "ECE 321 HW#2" if submitting homework electronically to Jacob_Glower@yahoo.com (or on blackboard)

Push-Pull Amplifiers

1) Assume you only have access to a +5V power supply. Design a push-amplifier to drive an 8-Ohm speaker

- Input: 0..5V analog signal, capable of 22mA
- Output: 8 Ohm speaker
- Relationship: Y = X

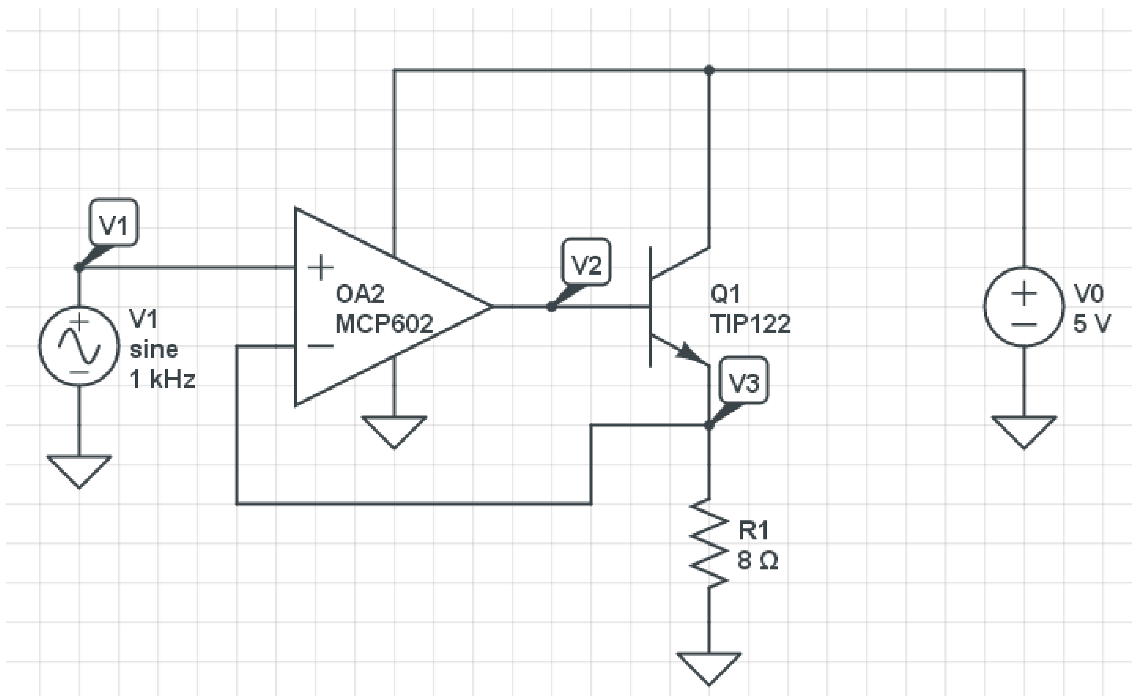


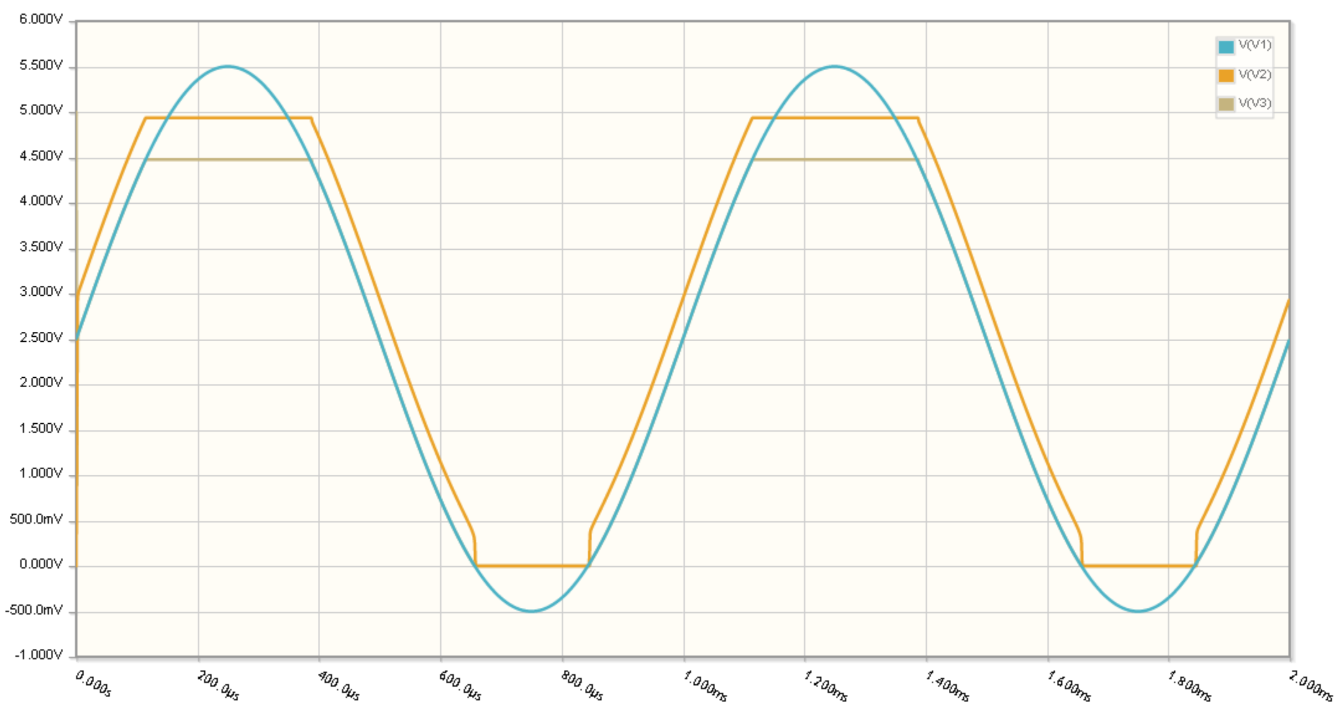
2) Simulate this design in CircuitLab. Verify

- Its operation (you can now drive an 8-Ohm speaker), and
- Its limitations (what voltage range are you able to output? 0V .. 5V?

There are a couple of ways to do this.

- DC Test: Apply constant votlages at V1 and check to see that V1 = V3.
- AC Test: Sweep the voltage in V1 and note where V1 = V3.

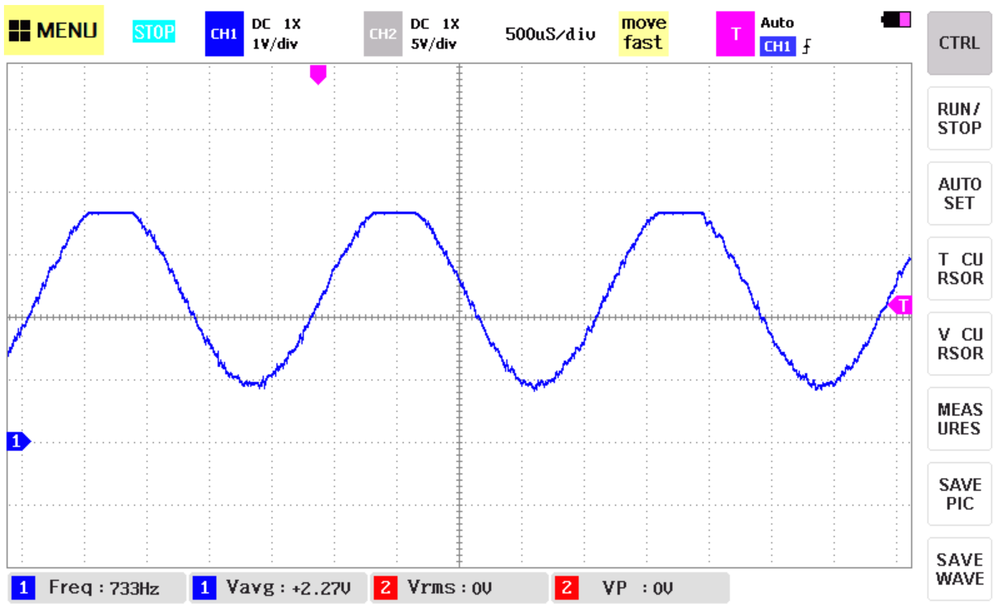




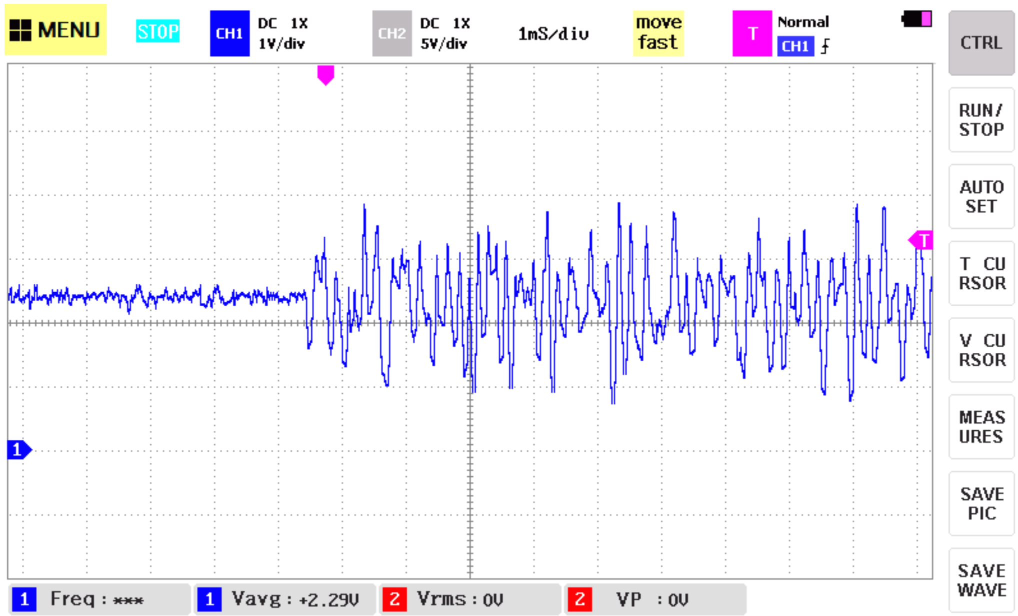
V1 = V3 for 0V < V1 < 4.5V

3) Build this circuit in hardware to amplify the output of your mixed. Verify

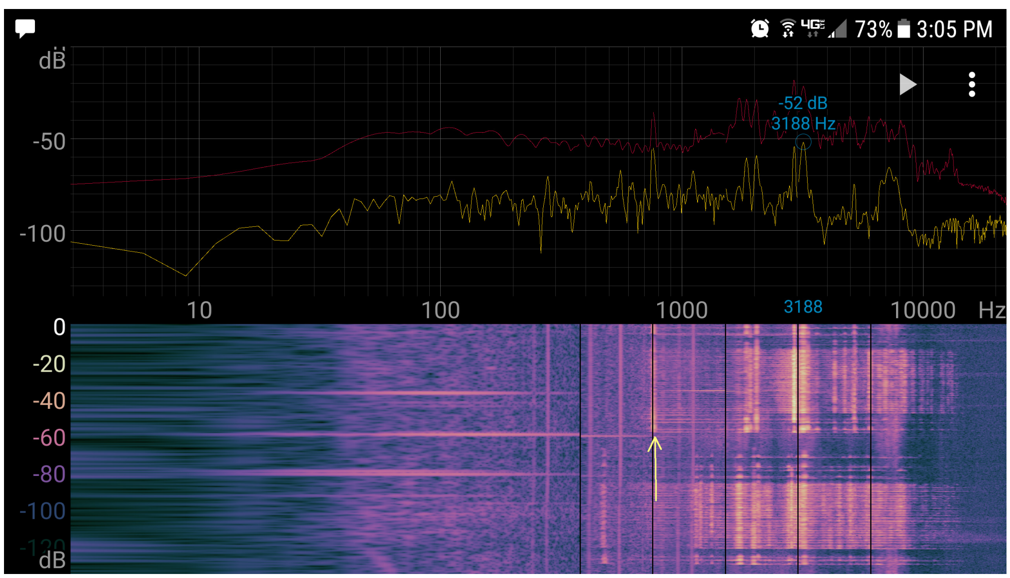
- Its operation (you can now drive an 8-Ohm speaker), and
- Its limitations (what voltage range are you able to output? 0V .. 5V?



sine wave input: Output clips at 0V and + 3.7V



Cow Bell: Time Response



Don't Fear the Reaper: Frequency Content. Cow Bell at 604Hz

Temperature Sensors

Assume you are using a thermistor where the temperature - resistance relationship is

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

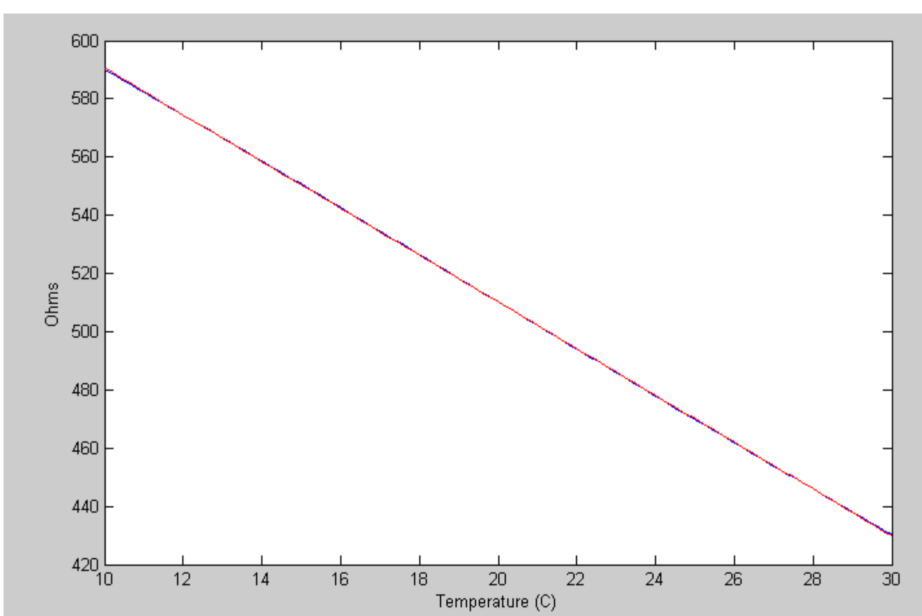
where T is the temperature in degrees C.

4) Design a linearizing circuit so that the resistance is approximately linear from 10C to +30C. Plot the resulting resitance vs. temperature relationship.

Using fminsearch and a lot of trial and error, one solution that works is

- Ra = 100
- Rb = 820.0471

```
function [ J ] = costR( Z )

   a = 100;
   b = Z(1);

   T = [10:0.1:30]';
   R = 1000 * exp(3905 ./ (T+273)  -  3905/298);

   Z = (R+a)*b ./ (R+a+b);


   B = [T, T.^0];
   A = inv(B'*B)*B'*Z;

   plot(T,Z,'b',T,B*A,'r');
   pause(0.01);

   E = Z - B*A;

   J = sum(E.^2);


   end
```



5) Using the linearizing circuit from problem 4, design a circuit which outputs

- 0V at 10C
- +5V at +30C
- Proportional in between.

Plot the resulting output voltage vs. temperature.

At 10C

- Z = 589.9731 Ohms
- Vx = 1.139V
- Vy = 0V

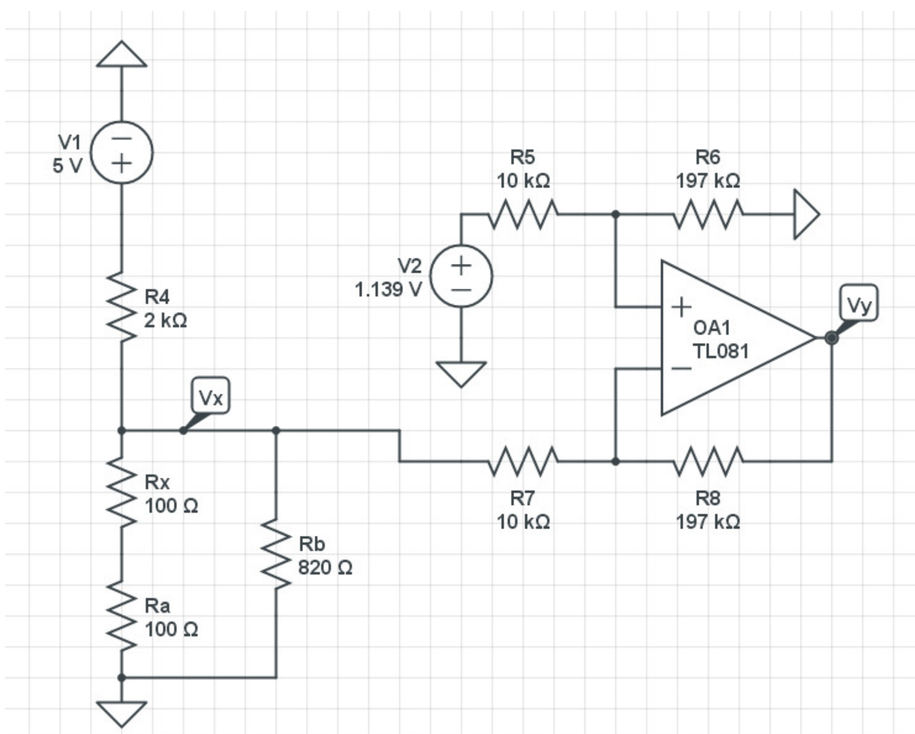
At 30C

- Z = 430.3386 Ohms
- Vx = 0.885V
- Vy = 5V

The gain is

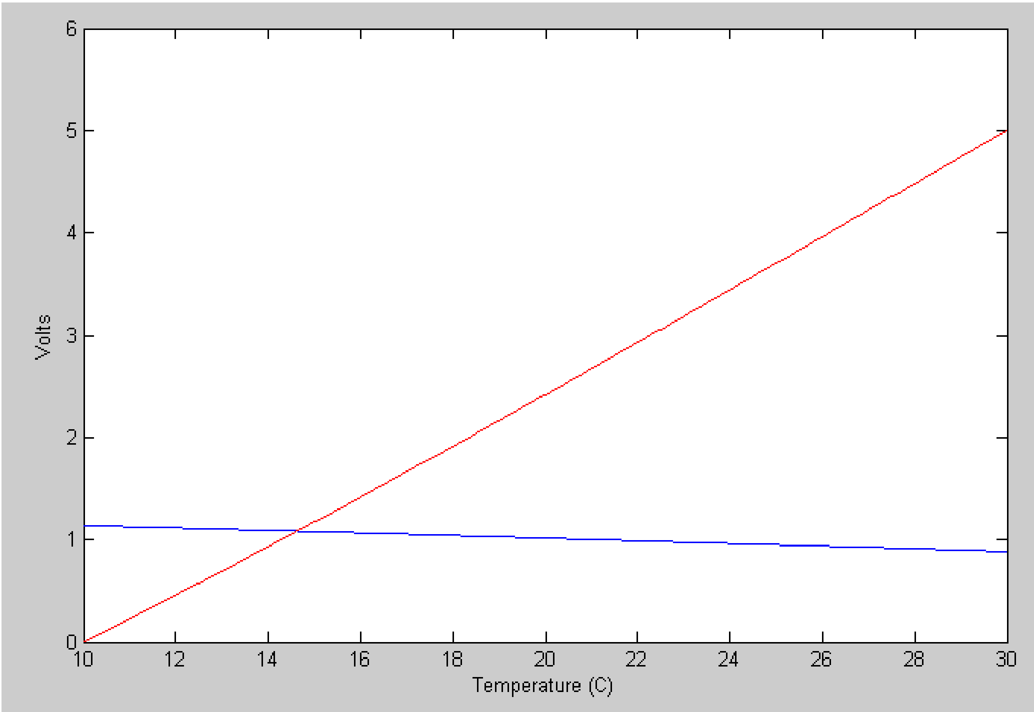
$$gain = \left(\frac{5V-0V}{0.885V-1.139V}\right) = -19.715$$

The output is 0V when Vx = 1.139V. Connect the offset to 1.139V



Plotting the votlage vs. temperature

```
    Ra = 100
    Rb = 820.0471

    T = [10:0.1:30]';
    R = 1000 * exp(3905 ./ (T+273)  -  3905/298);

    Z = (R + Ra)*Rb ./ (R + Ra + Rb);

Vx = Z ./ (Z + 2000) * 5;
Vy = 19.715*(1.139 - Vx);
plot(T,Vx,'b',T,Vy,'r')
xlabel('Temperature (C)');
ylabel('Volts');
```



Voltage at Vx (blue) and Vy (red)

6) Using the linearizing circuit from problem 4, design a 555 timer which outputs 500Hz at +10C

- Determine the frequency it outputs from 0C to +40C

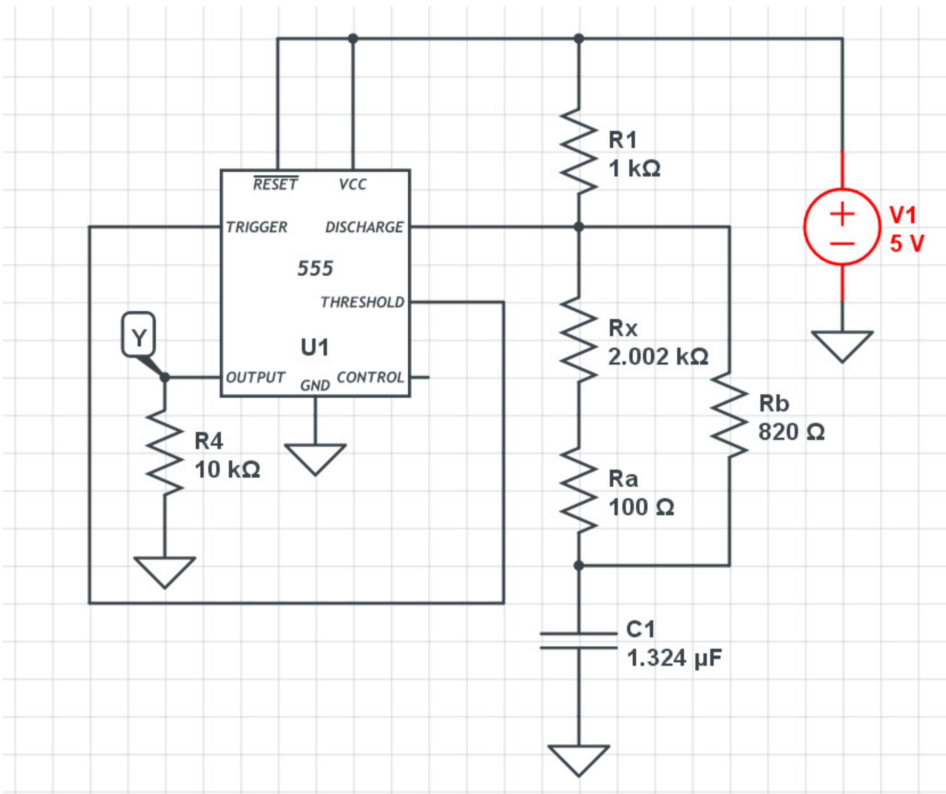
At 10C, R = 2002 Ohms, Z = 589.9731 Ohms

For 500Hz

$$2ms = (R_1 + 2R_2) \cdot C \cdot \ln(2)$$

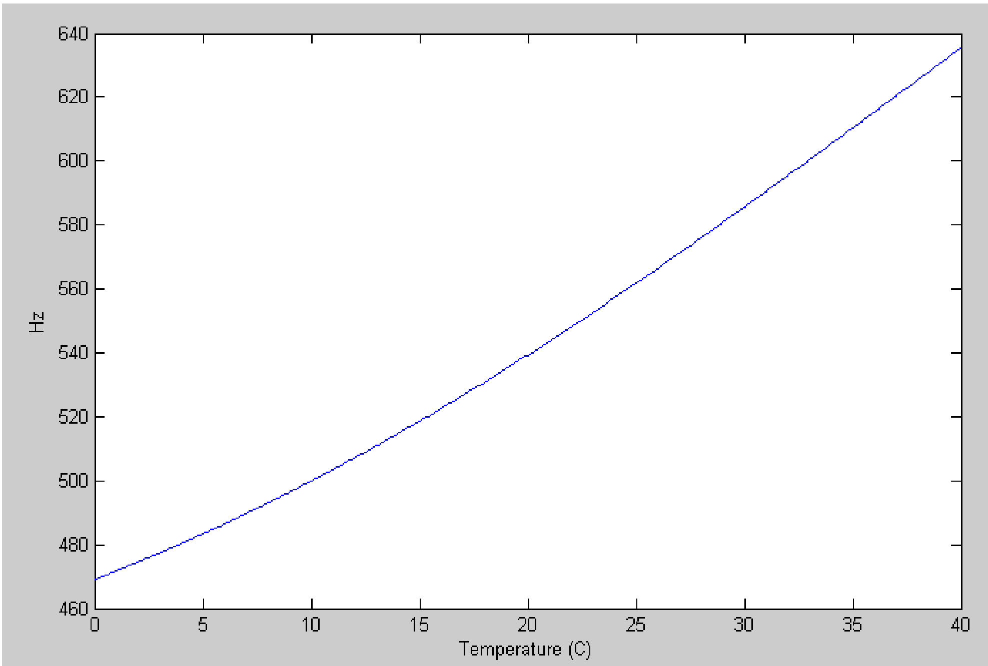
Let

- R1 = 1k
- R2 = Z = 589.9731 Ohms
- C = 1.324uF



555 timer with a lienarizing circuit for the thermistor (Rx)

```
>> T = [0:0.1:40]';
>> R = 1000 * exp(3905 ./ (T+273)  -  3905/298);
>> Ra = 100;
>> Rb = 820.0471;
>> Z = (R + Ra)*Rb ./ (R + Ra + Rb);
>> R1 = 1000;
>> C = 1.324e-6;
>> Period = (R1 + 2*Z)*C*log(2);
>> Hz = 1 ./ Period;
>> plot(T,Hz);
>> xlabel('Temperature (C)');
>> ylabel('Hz')
```



Frequency vs. Temperature for the 555 timer with a lienarizing circuit