ECE 320 - Quiz #5 - Name _____

555 Timers, Transistor Switch, Comparitors, Schmitt Triggers - Fall 2021

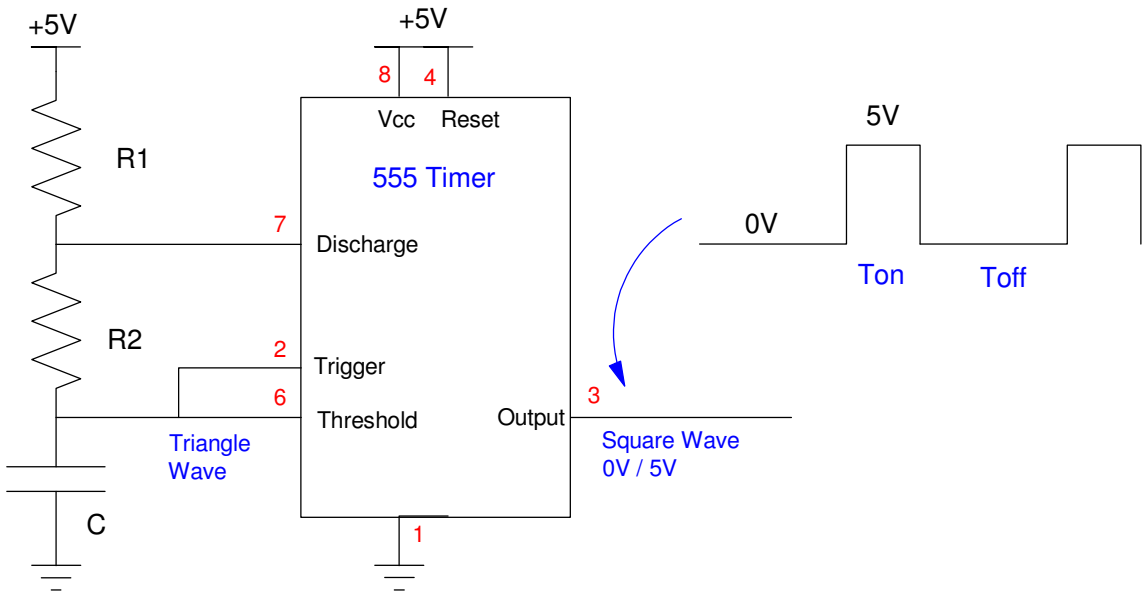
1) 555 Timers. Determine R1, R2, and C so that the 555 timer outputs a 80% duty cycle 100Hz square wave:

$$t_{on} = (R_1 + R_2) \cdot C \cdot \ln(2) = 8.0ms$$

$$t_{off} = R_2 \cdot C \cdot \ln(2) = 2.0ms$$

Let R1 be your birthday day (1000 + 100*Month + Day. May 14th would be 1514 Ohms)

R1 1000 + 100*Month + Day	R2	C
1514 Ohms	**504.7 Ohms** 1/3 * R1	**5.717 uF**



$$R_2 \cdot C \cdot \ln(2) = 2.0ms$$

$$(R_1 + R_2) \cdot C \cdot \ln(2) = 8.0ms$$

solving 2 equations for 2 unknowns:

- R1 = 1514 Ohms

$$R_1 + R_2 = 4R_2$$

$$R_2 = 504.7\Omega$$

$$C = 5.717\mu F$$

2) Transistor Switch: Design. Specify R1 and R2 so that when Vin = 5.00V,

- Ic = (100*Birth Month + Birth Day) mA. May 14th would be 514mA (0.514A)
- The transistor is saturated, and
- Ib < 25mA (the maximum output of a 555 timer)

Assume 6144 transistors

- | Vbe | = 0.7V
- | Vce | = 0.36V when saturated
- $\beta = 200$

Ic (mA) 100*(Mo) + (Day)	Rc	min value of Rb	max value of Rb
514 mA	**9.027 Ohms**	**172 Ohms**	**1673 Ohms**

$$R_c = \left(\frac{5V - 0.36V}{514mA}\right) = 9.027\Omega$$

min value of Ib

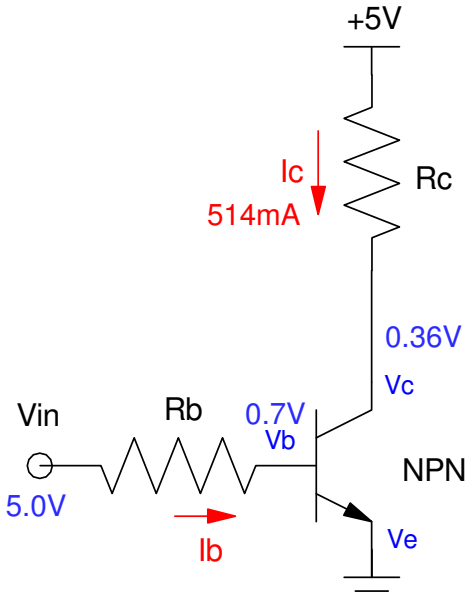
$$I_b = \frac{I_c}{\beta} = \frac{514mA}{200} = 2.570mA$$

$$R_b = \left(\frac{5V - 0.7V}{2.570mA}\right) = 1673\Omega$$

max value of Ib

$$I_b = 25mA$$

$$R_b = \left(\frac{5V - 0.7V}{25mA}\right) = 172\Omega$$



3) Darlington Pair (analysis). Assume two 6144 NPN transistors are connected as a Darlington pair.

- | Vbe | = 0.7V
- | Vce | = 0.36V when saturated
- $\beta = 200$

Let Rb be 1000 + 100(Birth Month) + Birth Day. (May 14 = 1514 Ohms). Find the currents and voltages.

Rb 1000 + 100*Mo + Day	I1	I2	I3
1514 Ohms	**2.378mA**	**8.6573mA**	**1731mA**
	V1	V2	V3
	1.4V	**0.2V**	**1.06V**

$$I_1 = \left(\frac{5V-1.4V}{1514\Omega}\right) = 2.378mA$$

$$I_4 = \left(\frac{15V-1.06V}{8\Omega}\right) = 1743mA$$

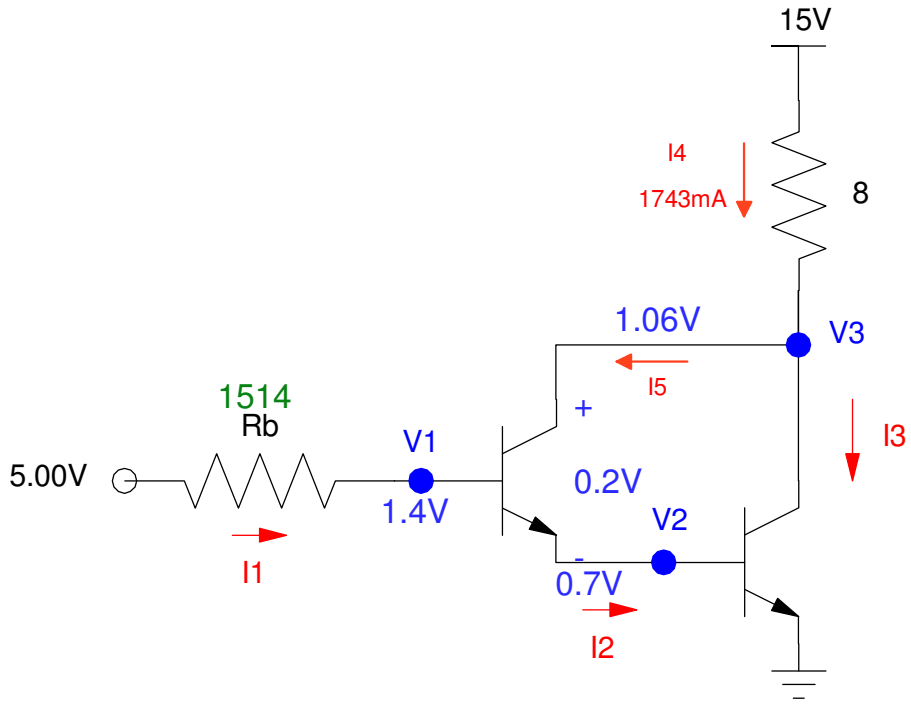
$$I_5 + I_3 = I_4 = 1743mA$$

$$I_2 = I_1 + I_5$$

$$I_3 = 200I_2$$

Solving

$$I_2 = \left(\frac{1743mA-2.378mA}{201}\right) = 8.6573mA$$

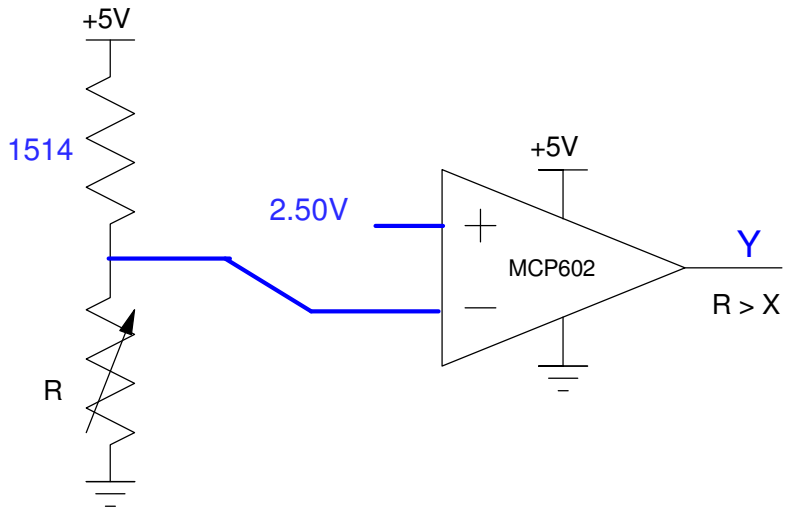


4) Comparitor: Design a circuit which output

- 0V when R > X Ohms
- 5V when R < X Ohms

where X is 1000 + 10*(Birth Month) + (Birth Day).

X = 1514 Ohms



5) Schmitt Trigger: Design a circuit which output

- 5V when R < X Ohms
- 0V when R > X + 400 Ohms
- No change for X < R < X + 400 Ohms

Let X be 1000 + 10(Birth Month) + (Birth Date).

X = 1514 Ohms

R = 1514 Ohms

- V1 = 2.50V
- Y = 5V

R = 1914 Ohms

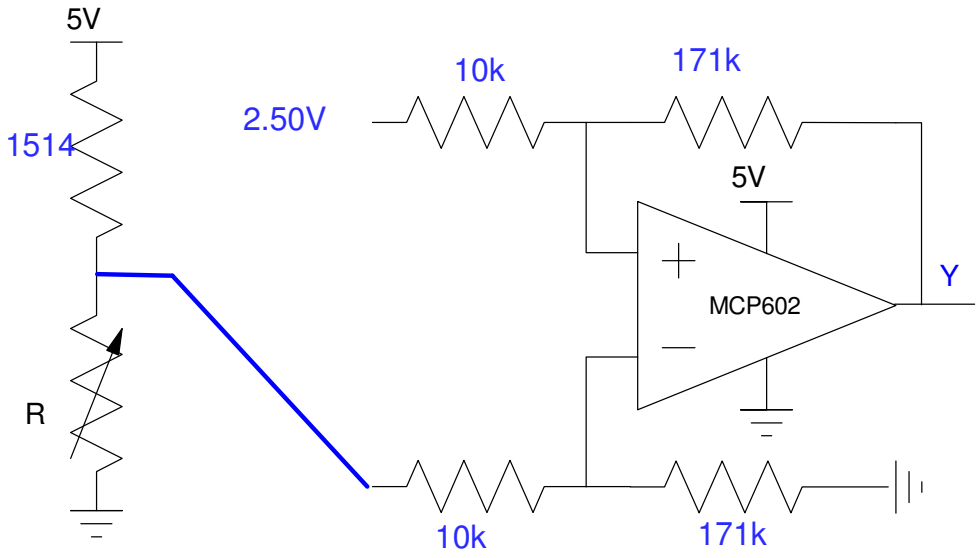
- $V_1 = \left(\frac{1914}{1914+1514}\right) = 2.792V$
- Y = 0V

As V1 goes up, Y goes down. Connect to the minus input

Y is set when V1 = 2.5V. Make the offset 2.5V

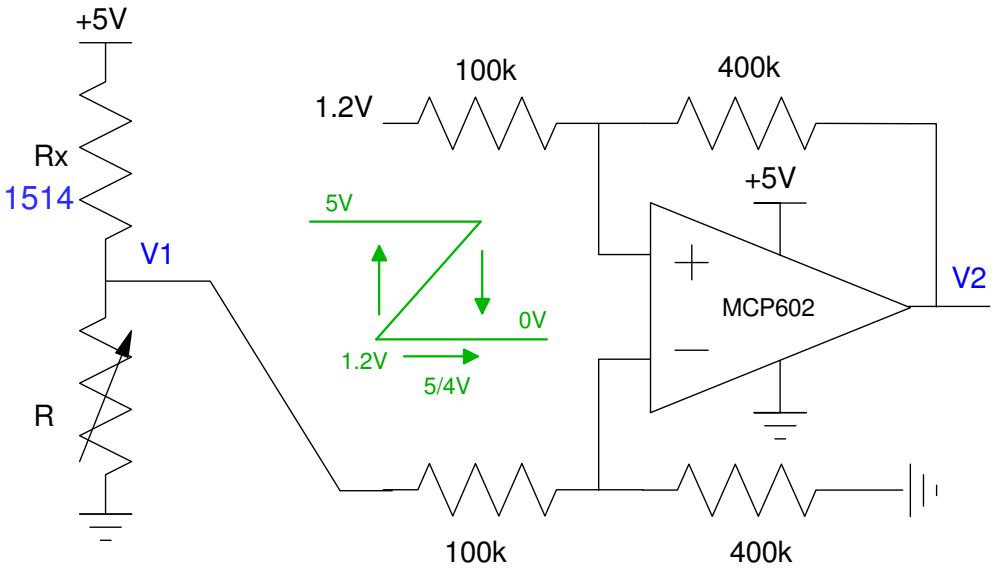
Make the gain

$$gain = \left(\frac{5v-0V}{2.792V-2.500V}\right) = 17.14$$



6) Schmitt Trigger: Analysis. Determine the voltages and resistance where the following Schmitt trigger turns on and off. Assume Rx is 1000 + 10*(Birth Month) + (Birth Day). May 14th gives Rx = 1514 Ohms.

Rx 1000 + 10*Mo + Day	On (V2 = +5V)		Off (V2 = 0V)	
1514	V1	R	V1	R
	1.2V	**478 Ohms**	**2.45V**	**1459 Ohms**



On: V2 is set when V1 = 1.2V (the offset)

$$\left(\frac{R}{R+1514}\right)5V = 1.2V$$

$$R = \left(\frac{1.2V}{5V-1.2V}\right)1514\Omega = 478.1\Omega$$

This is actually R || 500k. Removing the 500k resistor gives

$$R = 478.6\Omega$$

Off: The gain is 4

$$\left(\frac{5V}{dV}\right) = 4$$

$$dV = 1.25V$$

$$V_1 = 1.2V + 1.25V = 2.45V$$

$$R = \left(\frac{2.45V}{5V-2.45V}\right)1514 = 1454\Omega$$

removing the 500k in parallel gives

$$R = 1459\Omega$$