ECE 321 - Quiz #2 - Name ______________________

Push-Pull Amplifiers, Temperature Sensors. Calculators, Matlab permitted.

1) Push-Pull Amplifier: Voltage Output. Assume ideal silicon diodes and ideal silicon transistors with

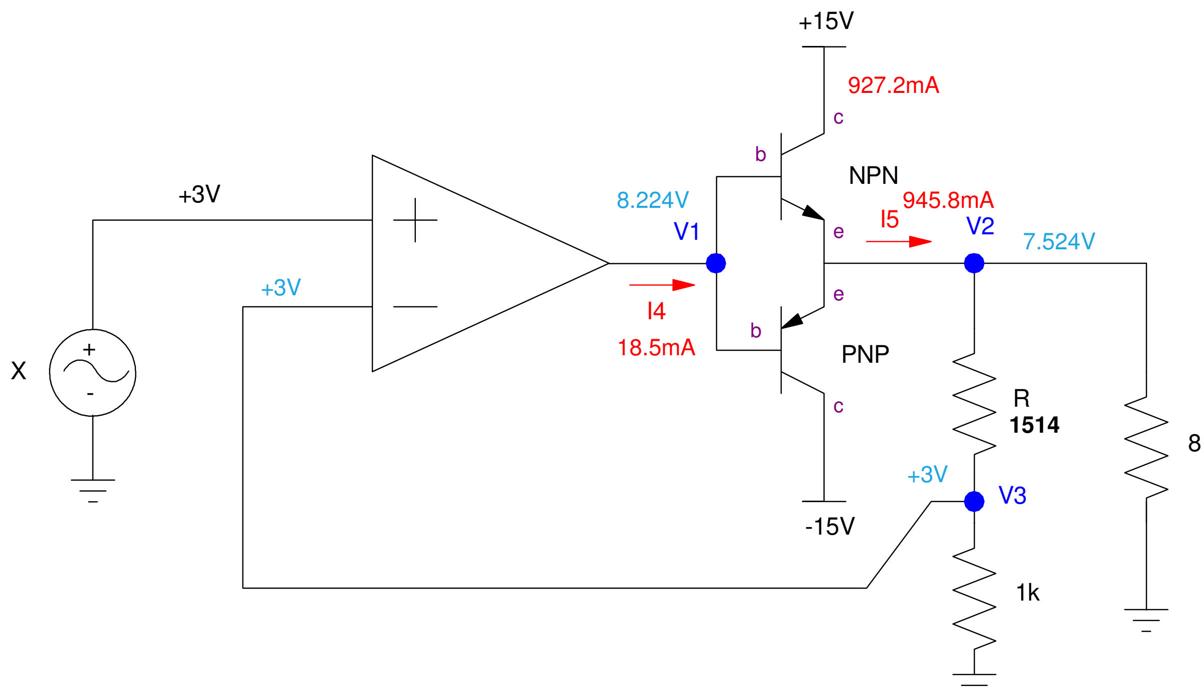
- Vbe = 0.7V
- Current gain = β = 50
- Vce(sat) = 0.2V

Also assume that

- All voltages are limited to -15V to +15V.
- R = 1000 + 100 * (your birth month) + (your birth day). For example, May 14th gives R = 1514 Ohms

Determine the voltages and currents wen X = +3V.

R 1000 + 100*Mo + Day	V1	V2	V3	I4	I5
1514	**8.224V** V2 + 0.7V	**7.524V** (1 + R/1k) V3	**3V** Vp = Vm	**18.5mA**	**945.8mA**



$$V_3 = V_m = V_p = 3V$$

$$V_2 = \left(1 + \frac{1514}{1000}\right) V_3 = 7.524V$$

$$V_1 = V_2 + 0.7V = 8.224V$$

$$I_5 = \left(\frac{V_2}{R+1000}\right) + \left(\frac{V_2}{8}\right) = 945.8mA$$

$$I_4 = \left(\frac{1}{\beta+1}\right) I_5 = 18.5mA$$

2) Push-Pull Amplifier: Voltage Output. Assume ideal silicon diodes and ideal silicon transistors with

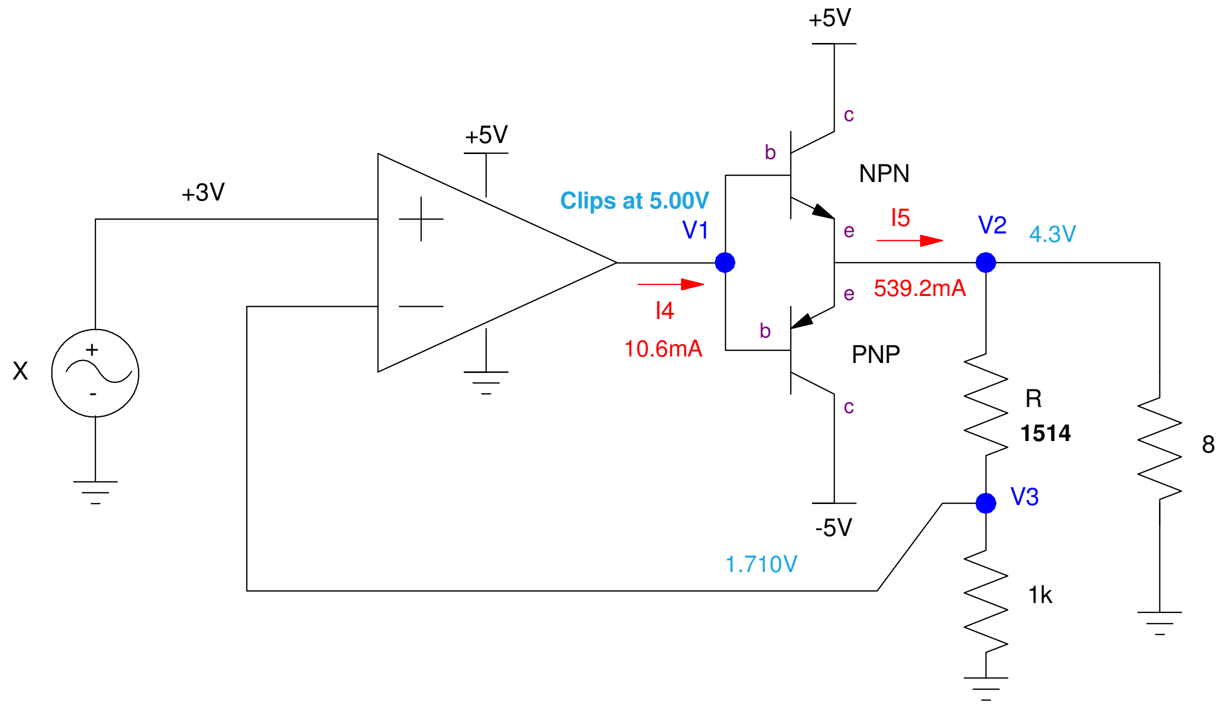
- Vbe = 0.7V
- Current gain = β = 50
- Vce(sat) = 0.2V

Also assume that

- The push-pull amplifier is fed by +5V and -5V,
- The op-amp's output is limited to 0V to +5V, and
- R = 1000 + 100 * (your birth month) + (your birth day). For example, May 14th gives R = 1514 Ohms

Determine the voltages and currents wen X = +3V.

R 1000 + 100*Mo + Day	V1	V2	V3	I4	I5
1514	**5.00V** power supply limit	**4.30V** V1 - 0.7V	**1.710V** voltage division	**10.6mA**	**539.2mA**



The op-amp *tries* to force Vp = Vm. To do this, you need the results from problem #1. (V1 = 8.22V). V1 clips at +5V due to the power supply limit, resulting in V1 = 5V.

V2 = V1 - 0.7V = 4.3V

V3 = 1.710V by voltage division

Note that Vp is no longer equal to Vm. The op-amp does the best it can given the power supply limitation

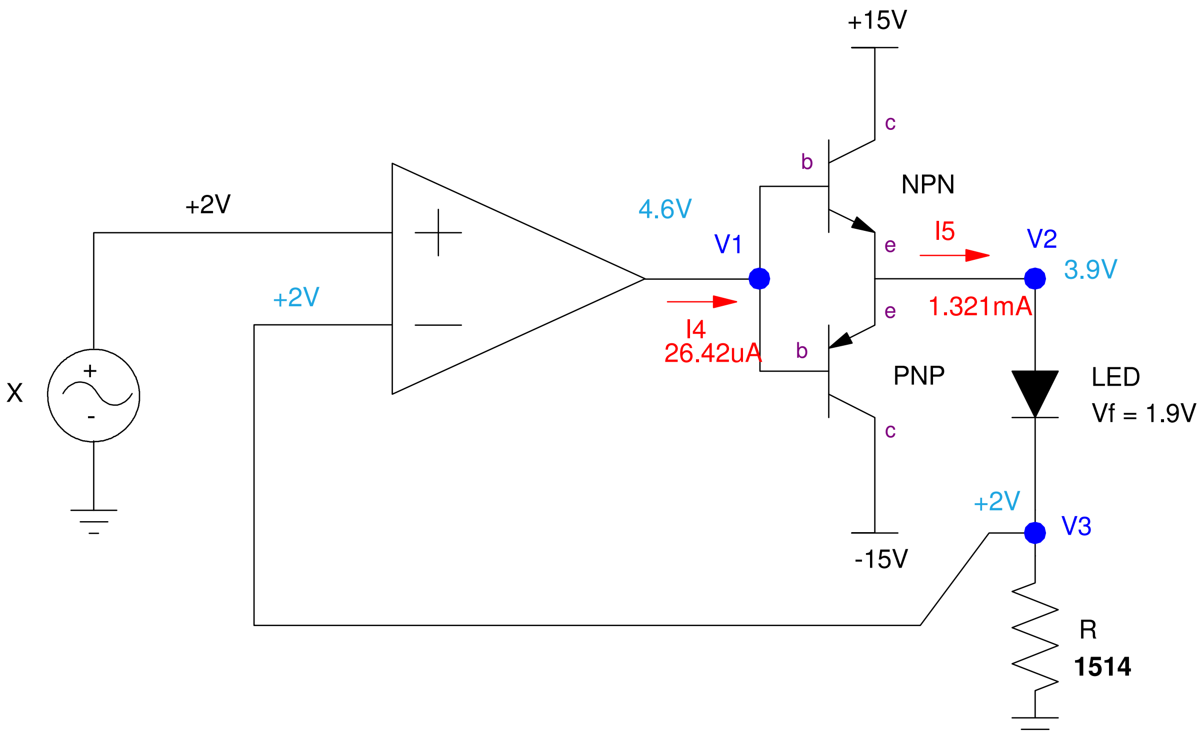
3) Push-Pull Amplifier: Current Output. Assume ideal silicon diodes and ideal silicon transistors with

- $|V_{be}| = 0.7V$
- Current gain = β = 50
- $|V_{ce}(sat)| = 0.2V$

Determine the voltages and currents wen X = +2V. Assume

- R = 1000 + 100 * (your birth month) + (your birth day). For example, May 14th gives R = 1514 Ohms

R 1000 + 100*Mo + Day	V1	V2	V3	I4	I5
1514	**4.60V** V2 + 0.7V	**3.90V** V3 + 1.9V	**2.00V** Vp = Vm	**26.42uA**	**1.321mA**



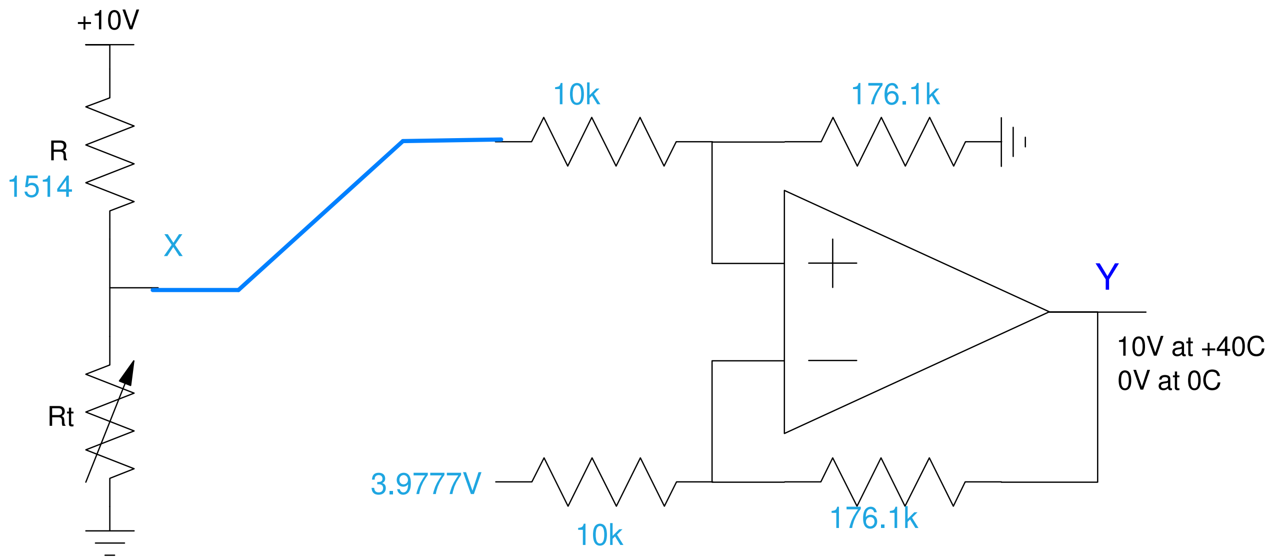
4) RTD. Assume the voltage - resistance relationship for an iron RTD temperature sensor is

$$R_t = 1000 \cdot (1 + 0.00651T)\ \Omega$$

where T is the temperature in degrees C. Design a circuit which outputs

- 0V at 0C and
- +10V at +40C

Let R = 1000 + 100 * (your birth month) + (your birth day). For example, May 14th gives R = 1514 Ohms



At 0C

- Rt = 1000 Ohms
- X = 3.9777V
- Y = 0V

At +40C

- Rt = 1261.6 Ohms
- X = 4.5453V
- Y = 10V

As X goes up, Y goes up. Connect to the + input.

Y = 0 when X = 3.9777V. Make the offset 3.9777V

The gain needed is

$$gain = \left(\frac{10V - 0V}{4.5453V - 3.9777V}\right) = 17.62$$

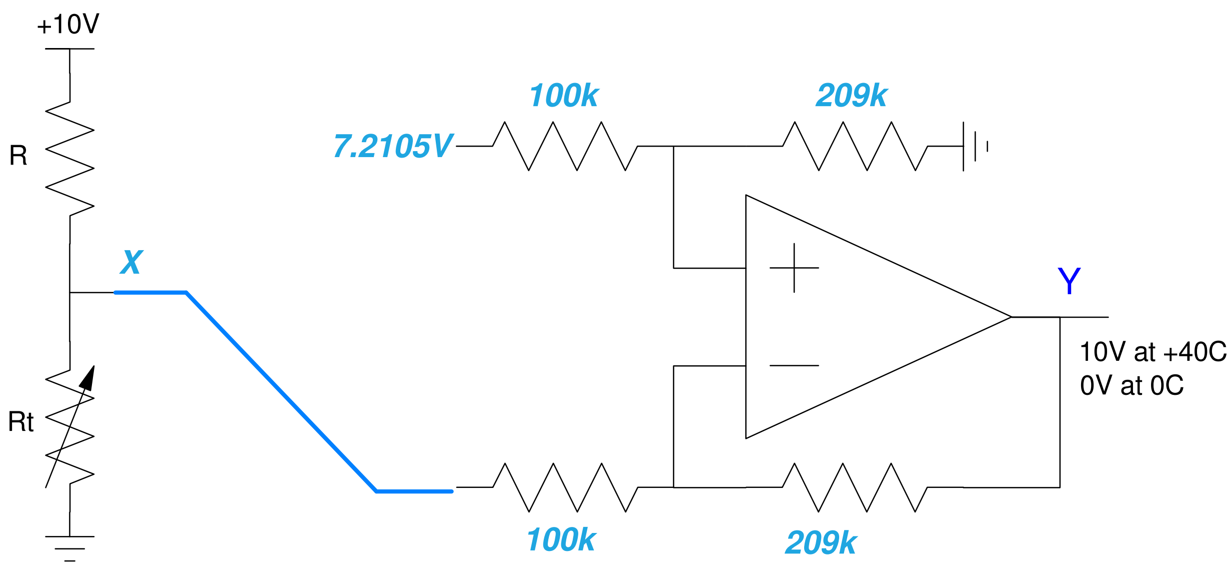
5) Thermistor. Assume the voltage - resistance relationship for a thermistor is

$$R_t = 1000 \cdot \exp\left(\frac{4440}{T+273} - \frac{4440}{298}\right)\ \Omega$$

where T is the temperature in degrees C. Design a circuit which outputs

- 0V at 0C and
- +10V at +40C

Let R = 1000 + 100 * (your birth month) + (your birth day). For example, May 14th gives R = 1514 Ohms



At 0C

- Rt = 3931.4 Ohms
- X = 7.2105V
- Y = 0V

At +40C

- Rt = 498.67 Ohms
- X = 2.4439V
- Y = 10V

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

Y = 0 when X = 7.2105V. Make the offset 7.2105V

The gain needed is

$$gain = \left(\frac{10V - 0V}{7/2105V - 2.4439V}\right) = 2.0979$$

Make the resistor ration 2.0979 : 1

6) Temperature Sensor: 555 Timer. Assume

- Ra = 500 Ohms
- R = 1000 + 100*(your birth month) + (your birthday)

Determine the frequency the 555 timer will output when

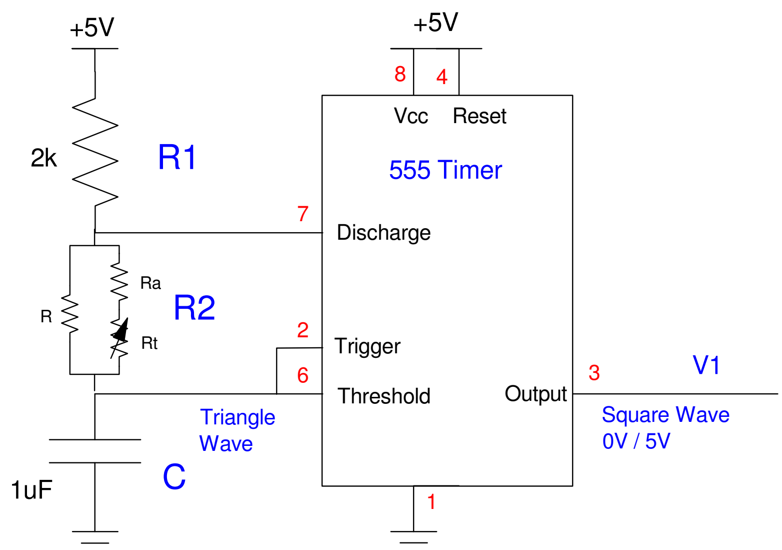
- Rt = 3320 Ohms (0C), and
- Rt = 533 Ohms (+40C)

note:

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

$$f = \frac{1}{T} \text{ Hz}$$

R 1000 + 100*Mo + Day	0C (Rt = 3320)		+40C (Rt = 533)	
1514	R2	Hz	R2	Hz
	1084 Ohms	**346 Hz**	**614 Ohms**	**446.9 Hz**



0C:

$$R_2 = \left(\frac{(R_t + R_a)R}{R_t + R_a + R}\right) = 1084.26\Omega$$

$$period = T = (R_1 + 2R_2) \cdot C \cdot \ln(2) = 2.889ms$$

$$f = \frac{1}{T} = 346Hz$$

40C

$$R_2 = \left(\frac{(R_t + R_a)R}{R_t + R_a + R}\right) = 614\Omega$$

$$period = T = (R_1 + 2R_2) \cdot C \cdot \ln(2) = 2.238ms$$

$$f = \frac{1}{T} = 446.9Hz$$