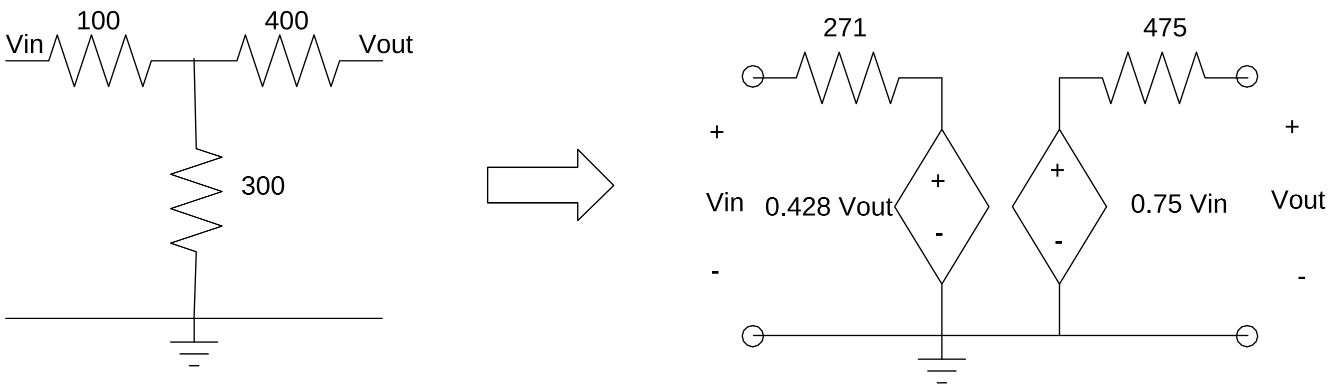
ECE 321 - Homework #5

Filters. Due Monday, November 28th

1) Find the 2-port model for the following circuit



Rin: Short Vout. Measure the voltage at the input

$$R_{in} = 100 + 300||400$$

$$R_{in} = 271$$

Ai: Set Vout = 1V. Measure Vin

$$V_{in} = \left(\frac{300}{300+400}\right) \cdot 1V$$

$$V_{in} = A_i = 0.4286$$

Rout: Shout Vin. Measure the resistance at the output

$$R_{out} = 400 + 100||300$$

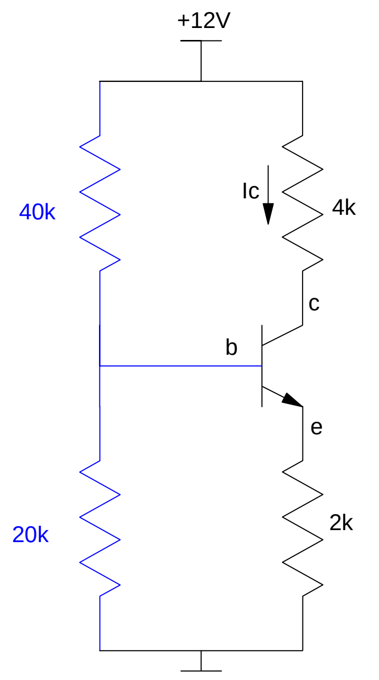
$$R_{out} = 475$$

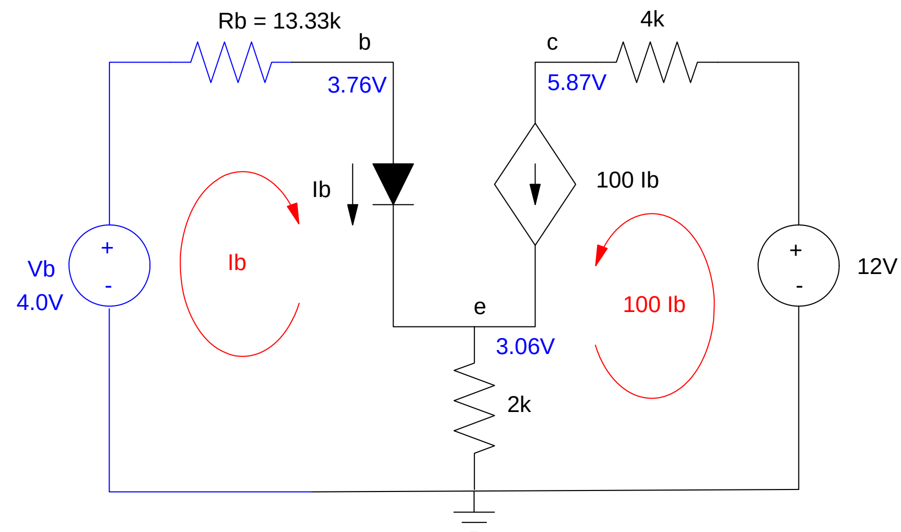
Ao: Set Vin = 1V. Measure Vout

$$V_{out} = \left(\frac{300}{300+100}\right) \cdot 1V$$

$$V_{out} = A_o = 0.75$$

2) Determine the Q-point for the following circuit. Assume $\beta = 100$.





First, redraw the circuit using the Thevenin equivalent for the 40k & 20k resistor (shown in blue)

$$R_{th} = R_b = 20k||40k = 13.33k$$

$$V_{th} = V_b = \left(\frac{20k}{20k+40k}12V\right) = 4V$$

Next, find Ib

$$-4 + 13.33k \cdot I_b + 0.7 + 2k \cdot (I_b + 100I_b) = 0$$

$$I_b = \left(\frac{4-0.7}{13.33k+101\cdot 2k}\right)$$

$$I_b = 15.33\mu A$$

The Q point is then

$$I_c = \beta I_b = 1.53mA$$

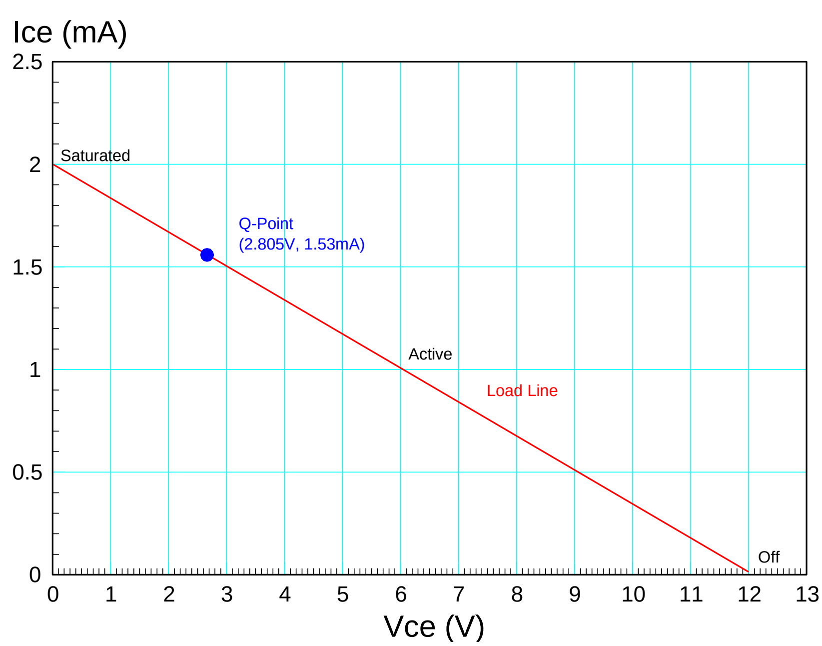
$$V_c = 12 - 4k \cdot I_c = 5.87V$$

$$V_e = 2k \cdot I_b = 3.065V$$

$$V_{ce} = 2.805V$$

Q-Point:

$$V_{ce} = 2.805V$$
$$I_c = 1.53mA$$



3) Change the previous design so that the Q-point is

- Vce = 6V
- Q-Point is stabilized for variations in β

From before

$$V_{ce} = (12 - 4k \cdot I_c) - (2k \cdot 1.01 I_c) = 6V$$

$$I_c = 996.7\mu A$$

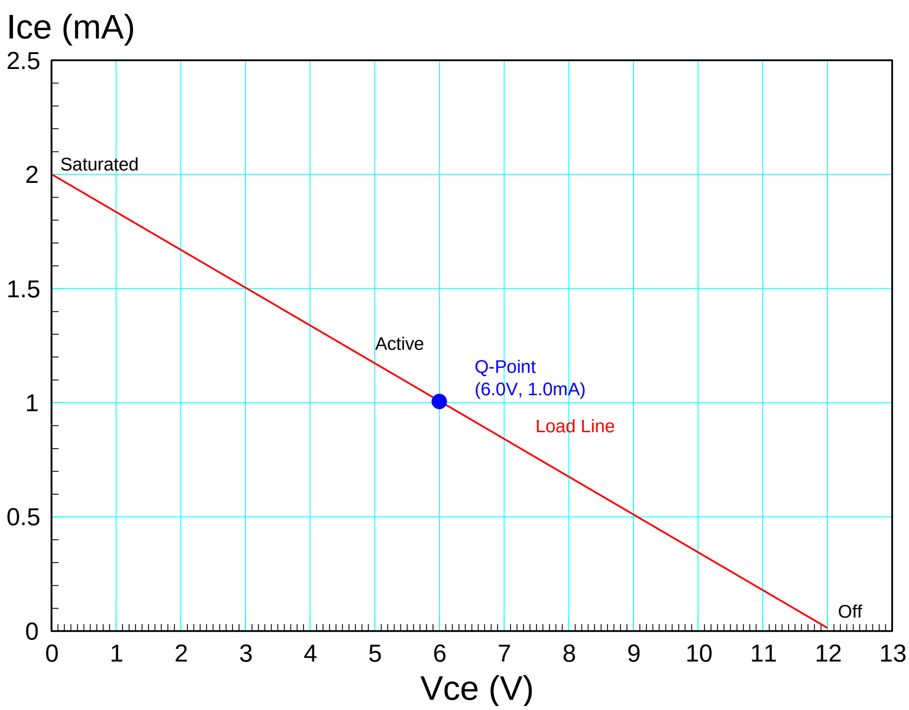
$$V_c = 8.013V$$

$$V_e = 2.013V$$

$$V_{ce} = 6.000V \qquad \text{(check)}$$

From this

$$I_b = 9.967\mu A$$



To stabilize the Q-point, let

$$(1+\beta)R_e >> R_b$$

$$202k >> R_b$$

$$R_b = 20k$$

Then

$$V_b = 0.7 + 20k \cdot I_b + 2k \cdot 101 \cdot I_b$$

$$V_b = 2.913V$$

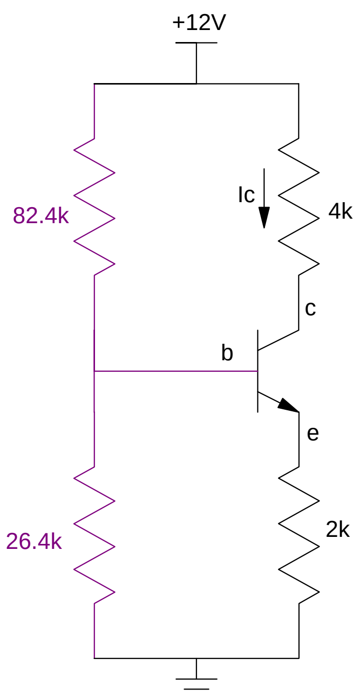
Converting back to R1 and R2

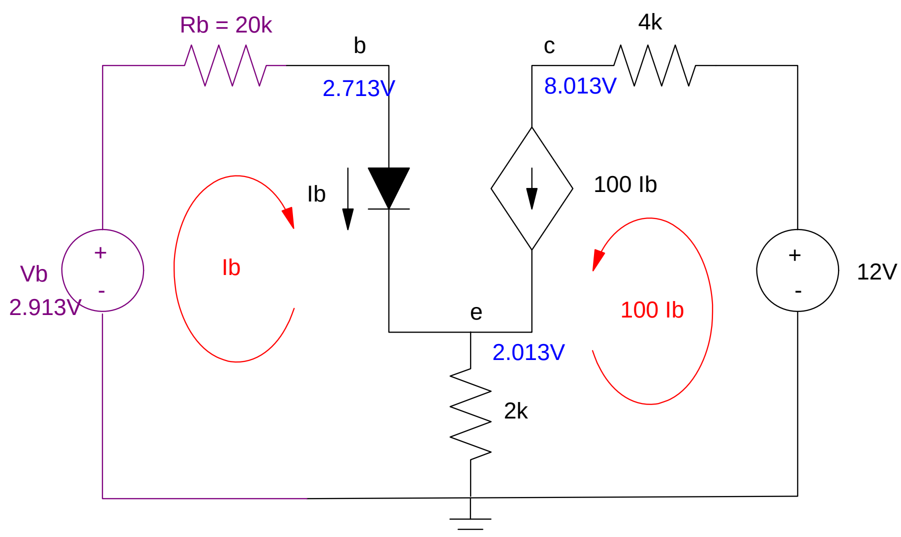
$$R_1 || R_2 = 20k$$

$$\left(\frac{R_2}{R_1+R_2}\right) 12V = 2.913V$$

$$R_1 = \left(\frac{12V}{2.913V}\right) 20k = 82.4k$$

$$R_2 = 26.41k$$





4) Specify the requirements for your ECE 321 term project.

Light to Sound: This will take the audio signal from the headphone jack and drive an 8-Ohm speaker with part of the signal traveling over a light beam.

Input (X):

- 100mVp sine wave,
- Capable of driving 10mA
- 100 - 1kHz

Output (Y):

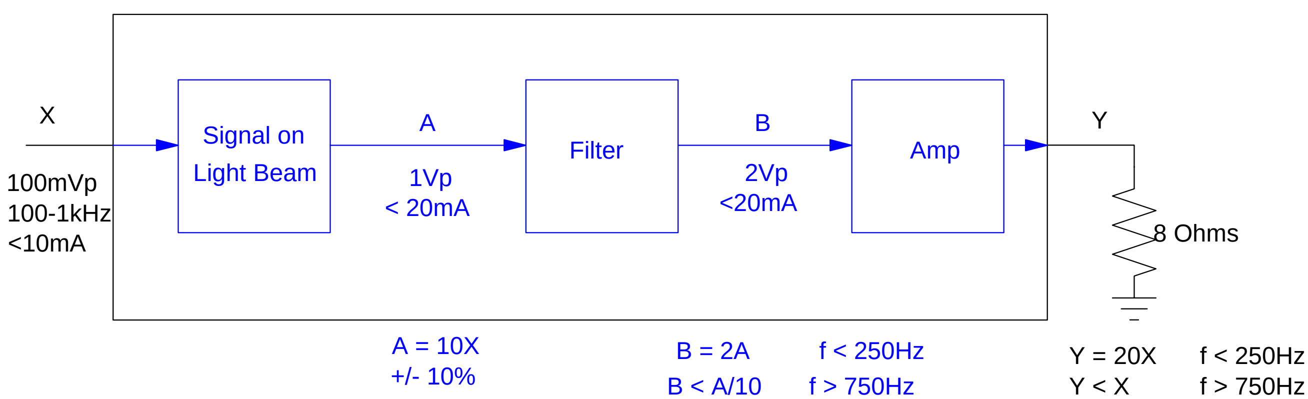
- Voltage across an 8 Ohm speaker

Relationship:

- Y = 20X, f < 250Hz
- Y < X f > 750 Hz

All parameters have +/- 10% tolerance.

Part of the audio signal must travel on a light beam



5) Break down your term project into 2 or more sections which include

Signal on a Light Beam:

Input

- 100mVp Sine Wave
- 100-1kHz
- <10mA

Output:

- 1Vp Sine Wave,
- Capable of 20mA

Relationship:

- Y = 10X

Filter:

Input

- 1Vp Sine Wave
- 100-1kHz
- Capable of 20mA

Output:

- 2Vp Sine Wave,
- Capable of 20mA

Relationship:

- Y = 2X f < 250Hz
- Y < 0.1X f > 750Hz

Amplifier

Input

- 2Vp Sine Wave,
- Capable of 20mA
- 100-1kHz

Output:

- 8 Ohm Speaker

Relationship:

- Y = X

note: All parameters are +/- 10% tolerance.

note: 100-1kHz makes it easier to test: you only have to check the gain at 100, 250, 750, and 1000 Hz. It might work outside this range but that's outside the requirements (and does not need to be tested).