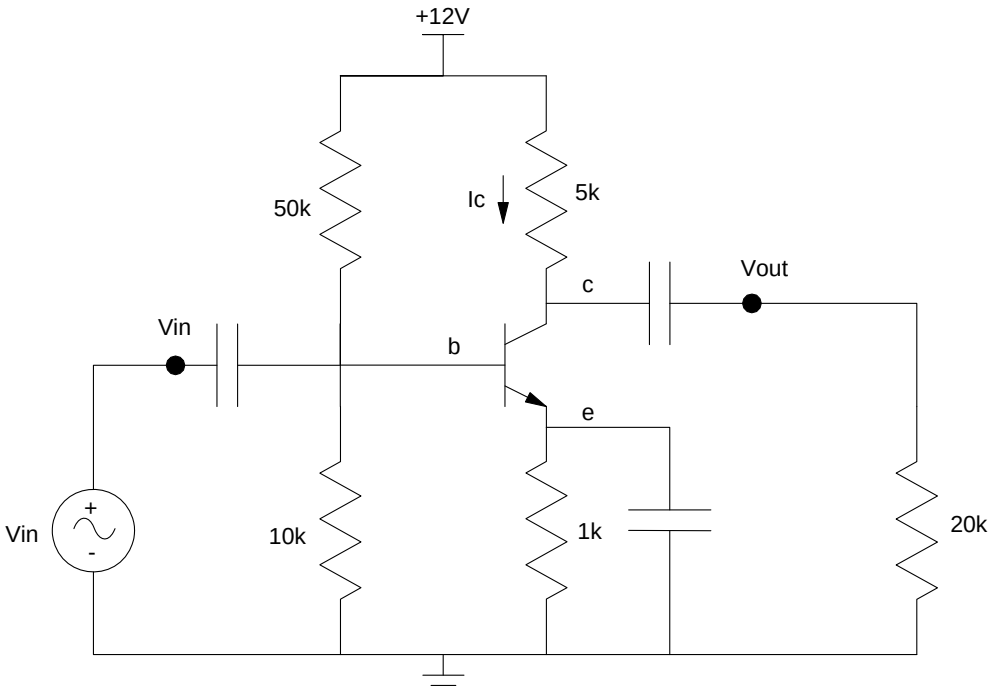
ECE 321 - Homework #4

BJT Amplifier Design. Due Monday, April 25th

For each problem, use the following circuit. Assume an ideal silicon diode with $\beta = 100$

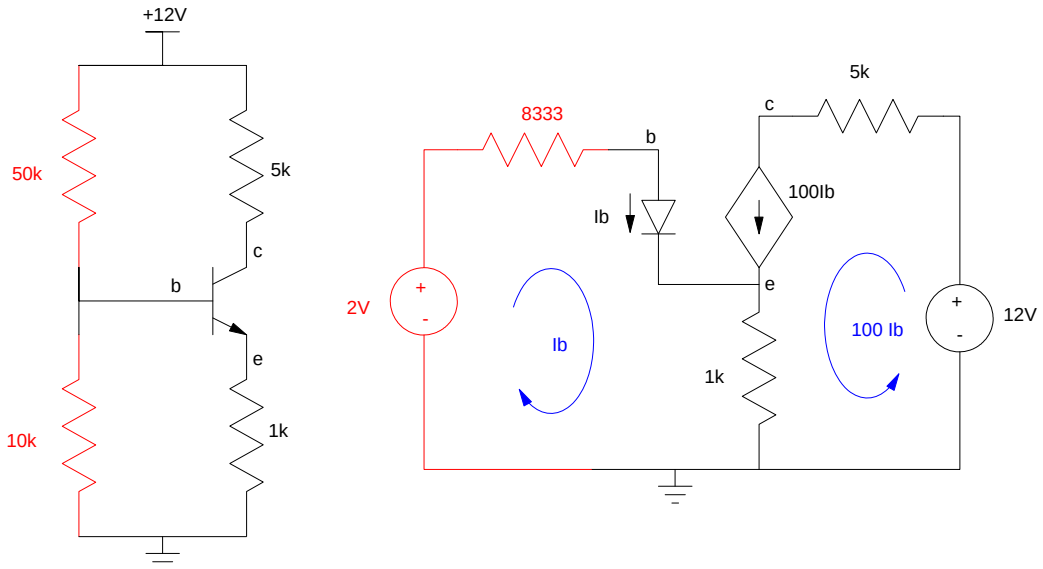


1) Determine the Q-point (Vce, Ic) for the above circuit.

Step 1: Redraw the circuit using the Thevenin equivalent for the 12V / 50k / 10k resistor

$$V_{th} = V_b = \left(\frac{10k}{10k+50k}\right)12V = 2V$$

$$R_{th} = R_b = 10k||50k = 8333\Omega$$



Solving for Ib:

$$-2 + 8333I_b + 0.7 + 1k(I_b + 100I_b) = 0$$

$$I_b = \left(\frac{2V-0.7V}{8333+(101)1k}\right) = 11.89\mu A$$

$$I_c = 100I_b = 1.189mA$$

Solving for Vce

$$V_e = 1k(I_b + 100I_b) = 1.201V$$

$$V_c = 12V - 5000I_c = 6.055V$$

$$V_{ce} = V_c - V_e = 4.854V$$

The Q point is

Vce = 4.854V

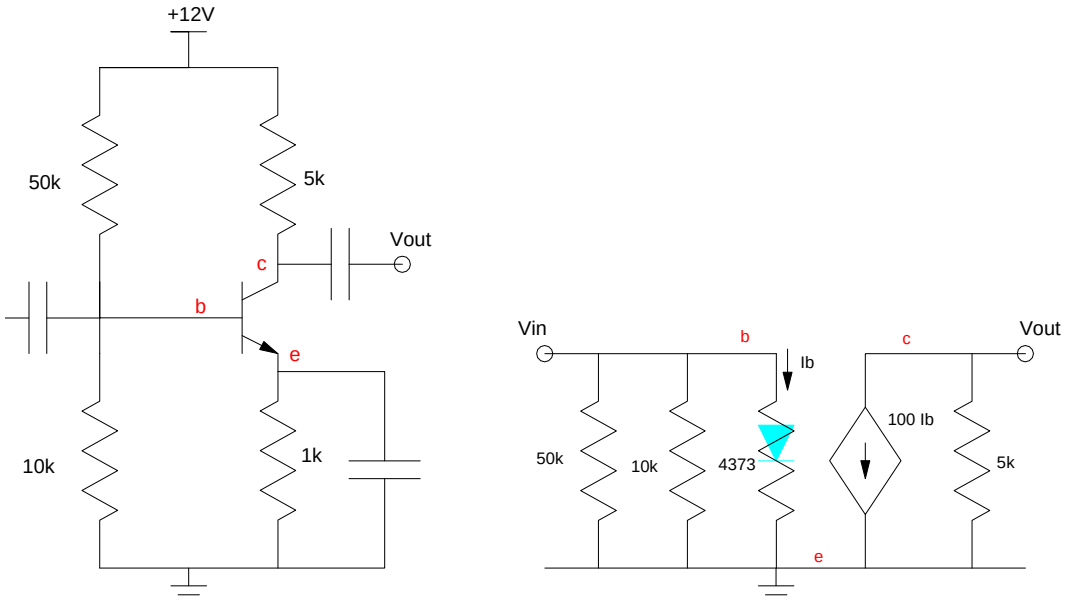
Ic = 1.189mA

2) Find the small-signal model for the transistor (i.e. resistance rf)

$$r_f = \frac{0.052}{I_{bq}} = \frac{0.052}{11.89\mu A} = 4373\Omega$$

3) Find the 2-port model from Vin to Vout.

First, redraw the circuit using the small-signal model for the transistor (the diode is replaced with rf)



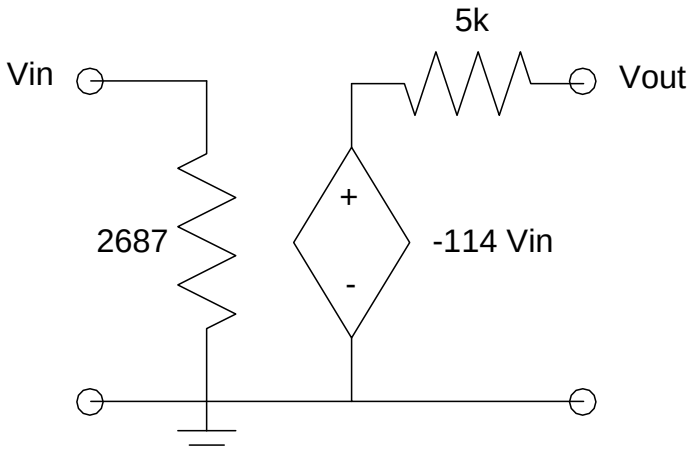
Find the 2-port parameters for the circuit to the right:

Rin: 50k || 10k || 4373 = 2867

Ai: 0

Rout: 5k

Ao: $A_o = -\frac{\beta R_c}{r_f} = -114$



4) Change the 50k and 10k resistor so that

- The Q-point is stabilized for variations in β, and
- The Q-point is Vce = 6V

For Vce = 6V

$$V_{ce} = 6V = 12 - 5k \cdot I_c - 1k(I_c + I_b)$$

$$I_c = \frac{6V}{5k+1k \cdot 1.01} = 998.3\mu A$$

$$I_b = 9.983\mu A$$

To stabilize the Q-point

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

$$101k\Omega >> R_b$$

Let Rb = 10k. Vb is then

$$V_b = R_b \cdot I_b + 0.7V + R_e(I_b + \beta I_b)$$

$$V_b = 1.808V$$

This gives 2 equations to solve for R1 and R2:

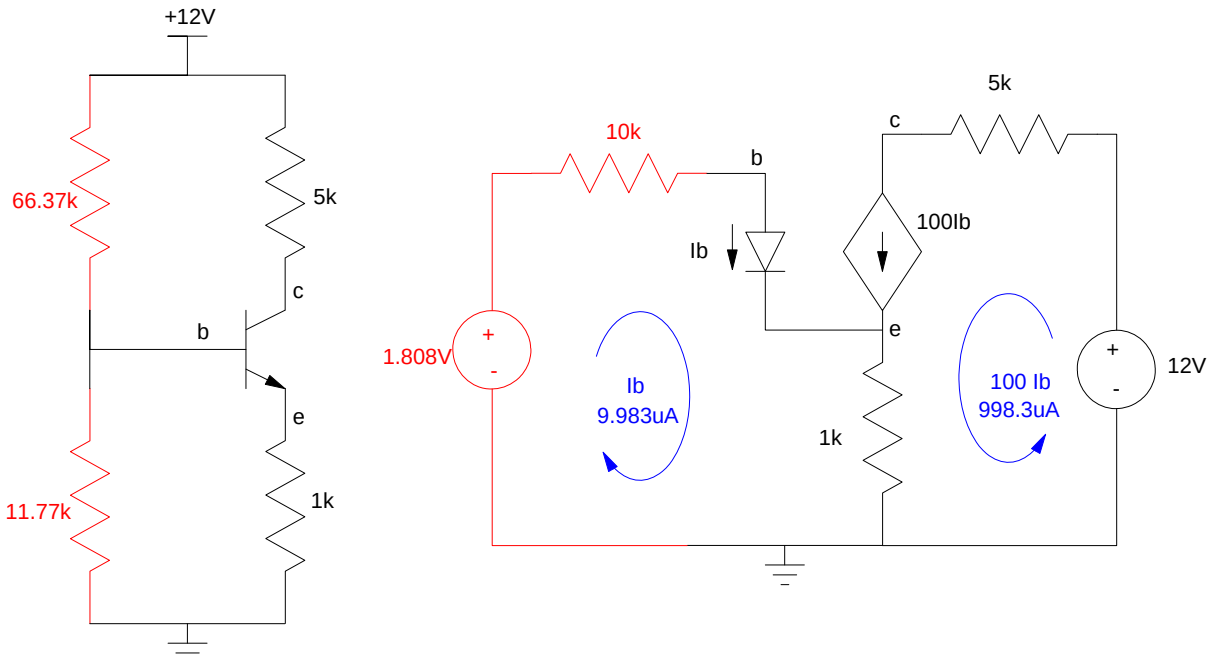
$$R_1 || R_2 = 10k$$

$$\left(\frac{R_2}{R_1+R_2}\right) 12V = 1.808V$$

This results in

R1 = 66.37k

R2 = 11.77k



Solving for R1 and R2

Problem 5-8) Term Project

Design, build, and test one section of your term project. Include

5) Requirements. What are the inputs, output, and how they relate.

6) Analysis: Give computations for resistors, etc. so that your circuit meets your requirements.

7) Test: Simulate in PartSim (or like program) to verify your analysis

8) Validation: Build your circuit in lab and collect data to verify it meets your requirements.