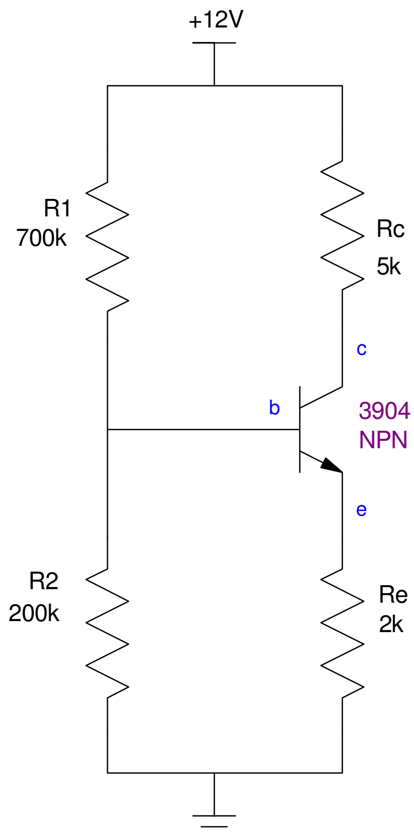
ECE 321 - Homework #5

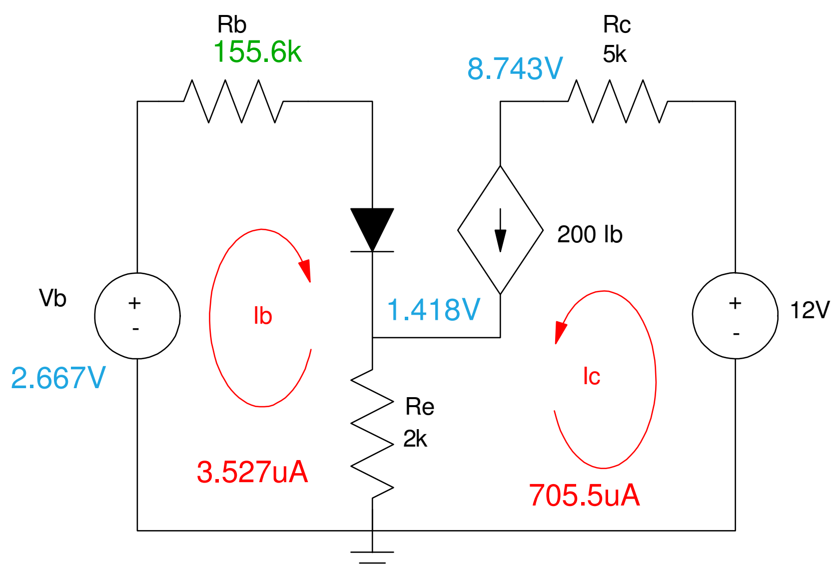
DC Analsis of Transtor Amplfiers, 2-Ports, CE Amplifiers. Due Monday, May 2nd

Please make the subject "ECE 321 HW#4" if submitting homework electronically to Jacob_Glower@yahoo.com (or on blackboard)

1) Determine the Q-point for the following transistor circuit. Assume C's are large and assume 3904 transistors:

- Vbe = 0.7V
- β=200





$$V_b = \left(\frac{R_2}{R_1+R_2}\right) 12V = 2.667V$$

$$R_b = R_1 || R_2 = 155.6k\Omega$$

$$I_b = \left(\frac{V_b - 0.7V}{R_b + (1+\beta)R_e}\right) = 3.527\mu A$$

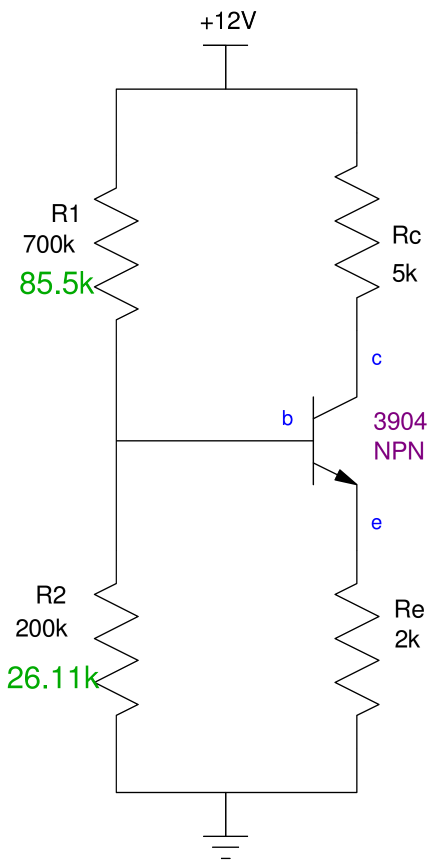
$$I_c = 200 I_b = 705.5\mu A$$

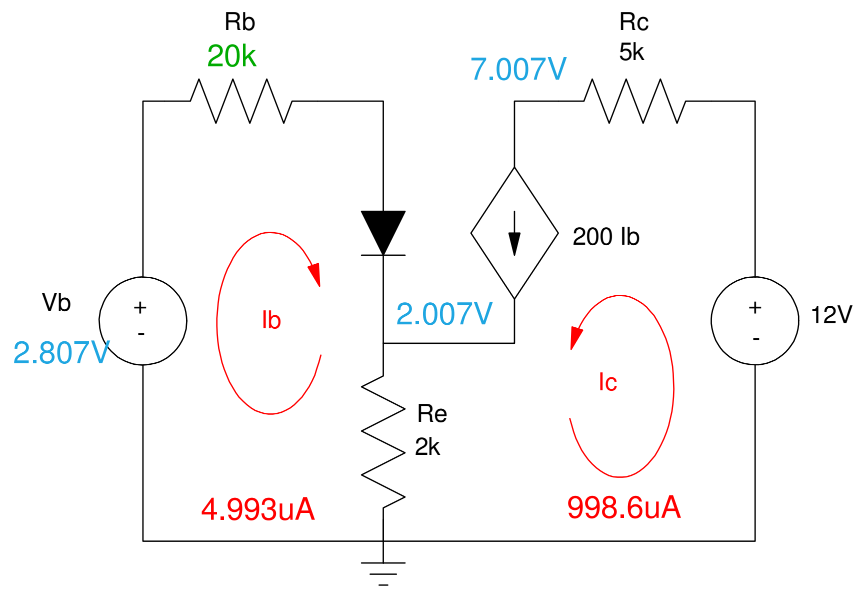
$$V_e = R_e(I_b + I_c) = 1.418V$$

$$V_c = 12V - I_c R_c = 8.473V$$

2) Modify this circuit so that

- The Q-point is stabilized for variations in , and
- The Q-point is Vce = 5.0V





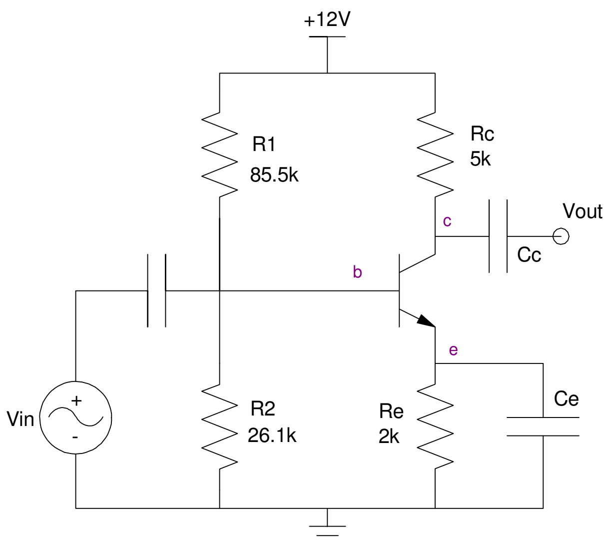
3) Draw the small-signal model for the circuit of problem #2 connected as a common emitter amplifier (below). From this, determine the 2-port model

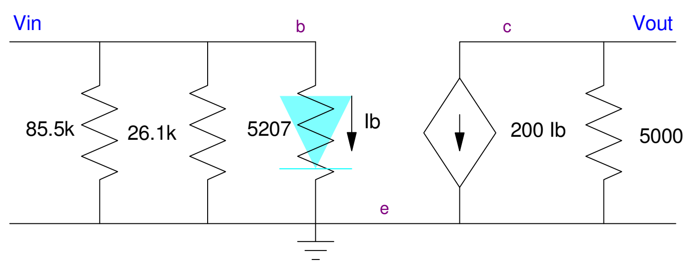
Model the diode as

$$r_f = \left(\frac{n\cdot 0.026}{I_b}\right) = \left(\frac{0.026}{4.993\mu A}\right) = 5207\Omega$$

where n depends upon the diode

- n = 1..2 in general
- n = 1.45 for 1N4004 diodes
- n = 1.00 for 3904 NPN transistors in CircuitLab (?)



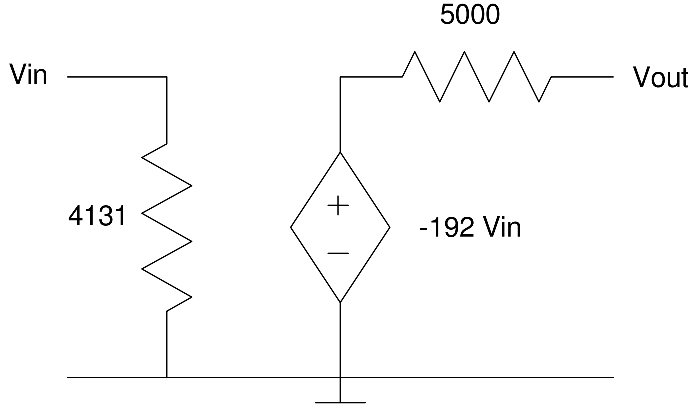


$$R_{in} = 85.5k||26.1k||5207 = 4131\Omega$$

$$A_i = 0$$

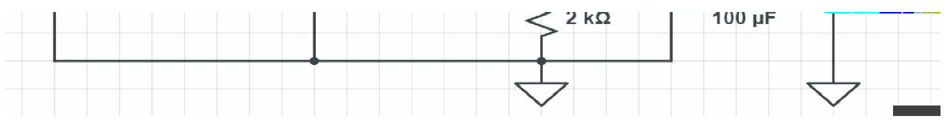
$$R_{out} = 5k$$

$$A_0 = -\left(\frac{200\cdot 5000}{5207}\right) = -192$$



4) Simulate this circuit in CircuitLab. Verify each of the 2-port parameters at 1kHz

- Rin
- Rout
- Ao



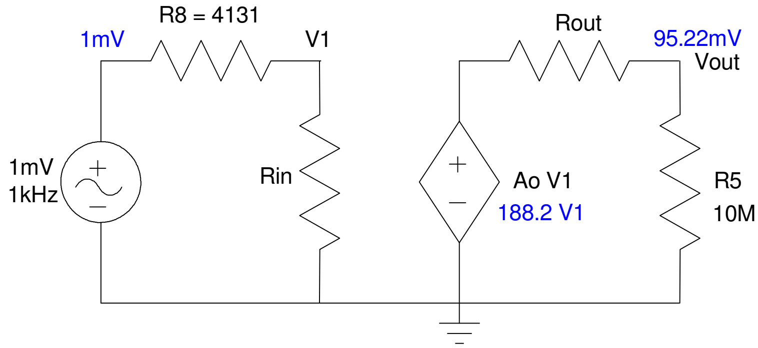
Rin

- Vin = 1mV @ 1kHz
- R8 = 4131 Ohms
- R5 = 10M
- Vout measured as 95.22mV

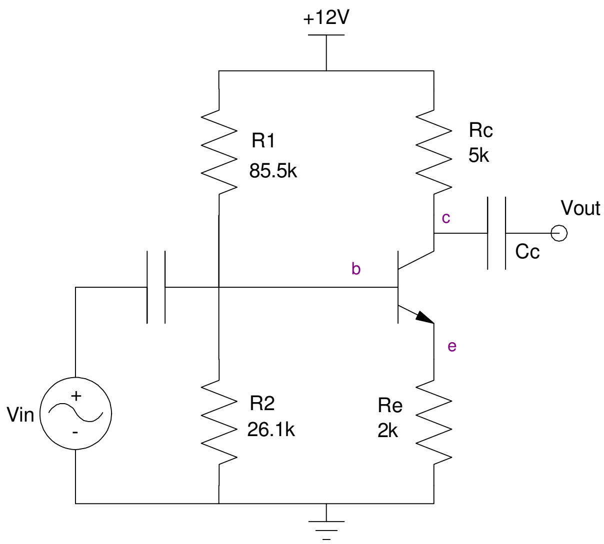
$$95.22mV = \left(\frac{R_{in}}{R_{in}+4131}\right) 188.2mV$$

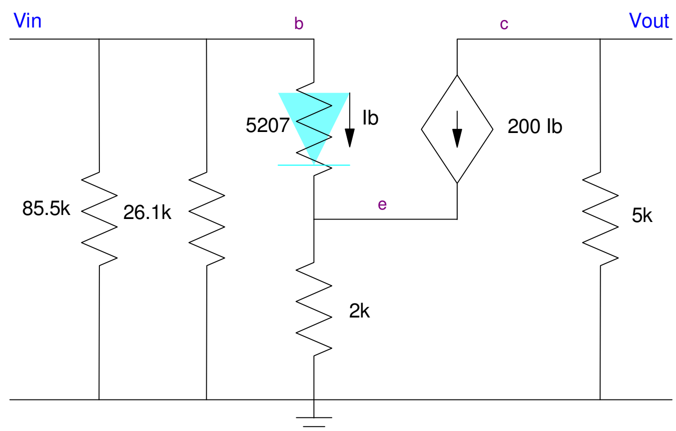
$$R_{in} = \left(\frac{95.22mV}{188.2mV - 95.22mV}\right) 4131\Omega$$

$$R_{in} = 4230\Omega$$



5) Remove Ce. Now draw the small-signal model for the circuit of problem #2. From this, determine the 2-port model for the Common Emitter amplifier





Rin: Apply 1V to Vin. Compute the current

$$I = \frac{1V}{85.5k} + \frac{1V}{26.1k} + \frac{1V}{5207 + 2k(\beta+1)} = 52.47\mu A$$

$$R_{in} = \frac{1V}{52.47\mu A} = 19.06k\Omega$$

Ain = 0

Rout = 5k

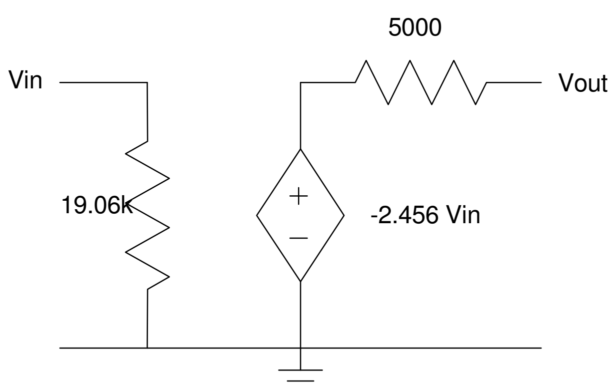
short Vin and Ib = 0

Aout: Apply 1V to Vin

$$I_b = \left(\frac{1V}{5207 + 2k(\beta+1)}\right) = 2.456\mu A$$

$$I_c = 200 I_b = 491.2\mu A$$

$$V_{out} = -5k \cdot I_c = -2.456$$



6) Simulate this circuit in CircuitLab. Verify each of the 2-port parameters at 1kHz

Same simulation as before but with Ce = 1pF (essentially not there)

Ao

- Vin = 1mV @ 1kHz
- R8 = 0
- R5 = 10M
- Vout measured as a 2.452 mVp sine wave
- Ao = 2.452 (vs. 2.456 computed)

Rout

- Vin = 1mV @ 1kHz
- R8 = 0
- R5 = 5k
- Vout measured at 1.228mV

$$R_{out} = \left(\frac{2.452-1.228}{1.228}\right)5000\Omega$$

$$R_{out} = 4984\Omega \text{ (vs. 5k computed)}$$

Rin

- Vin = 1mV @ 1kHz
- R8 = 20k Ohms
- R5 = 10M

Vout measured as 1.195mV

$$R_{in} = \left(\frac{1.195}{2.452-1.195}\right)20k\Omega$$

$$R_{in} = 19.01k\Omega \text{ (vs. 19.06k computed)}$$