# ECE 321 - Homework #5

DC Analsis of Transtor Amplfiers, 2-Ports, CE Amplifiers. Due Monday, May 4th

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
- $\beta$=200

Change R1 and R2 to their Thevenin equivalent (Rb and Vb)

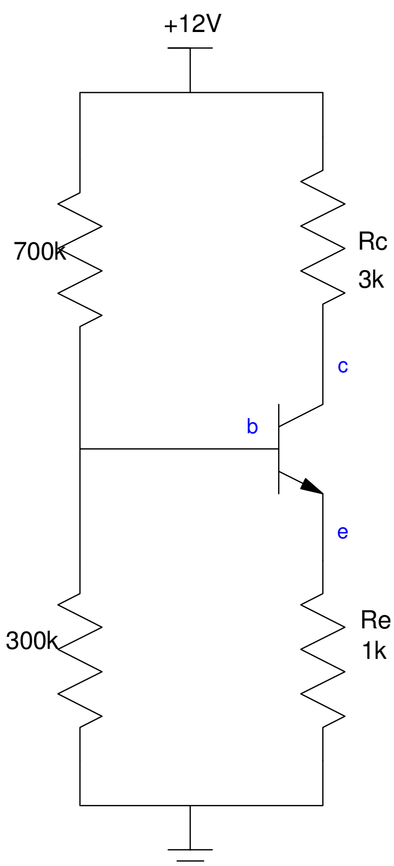
$$R_b = 700k || 300k = 210k$$

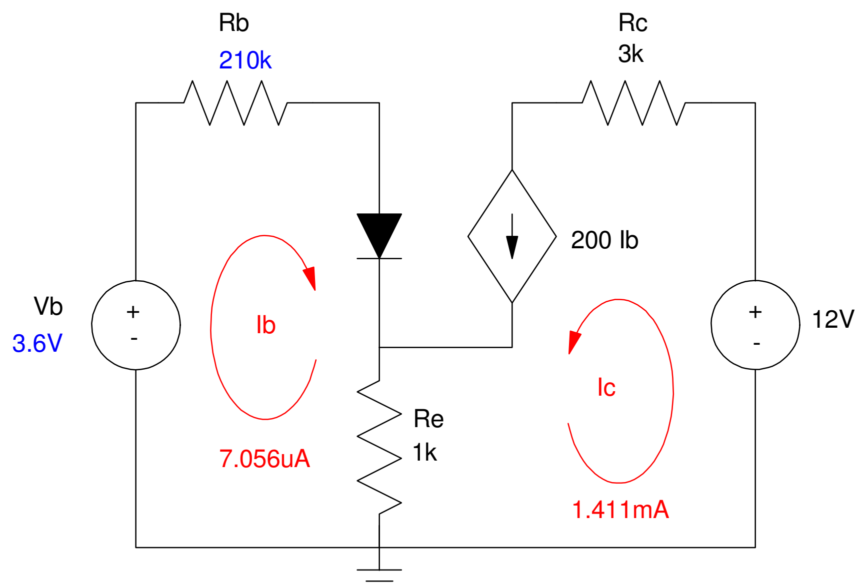
$$V_b = \left(\frac{300k}{300k+700k}\right) 12V = 3.6V$$

Find Ib

$$I_b = \left(\frac{3.6V - 0.7V}{210k + (1+\beta)1k}\right) = 7.056\mu A$$

$$V_{ce} = 12 - 3k \cdot I_c - 1k(I_c + I_b) = 6.348V$$



2) Modify this circuit so that

- The Q-point is stabilized for variations in $\beta$, and
- The Q-point is Vce = 6.0V

To stabilize the Q-point

$$(1+\beta)R_e = 210k >> R_b$$

Let Rb = 20k

$$V_{ce} = 6V = 3k \cdot I_c + 1k(I_c + I_b)$$

$$I_c = 1.498\mu A$$

$$I_b = 7.491\mu A$$

$$V_b = R_b I_b + 0.7 + R_e(I_c + I_e)$$

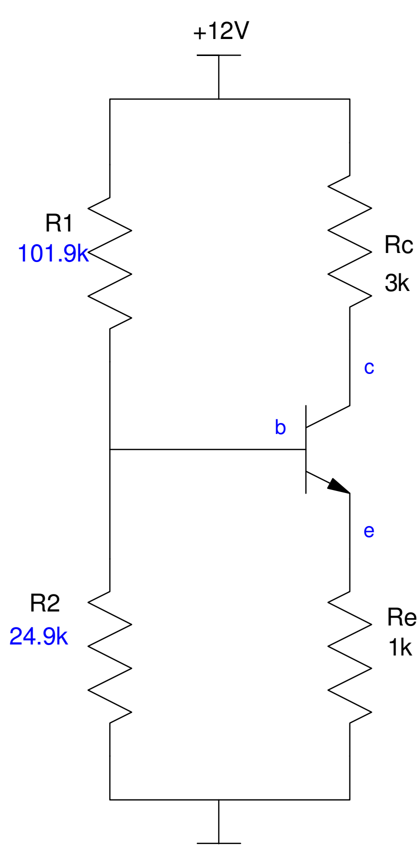
$$V_b = 2.355V$$

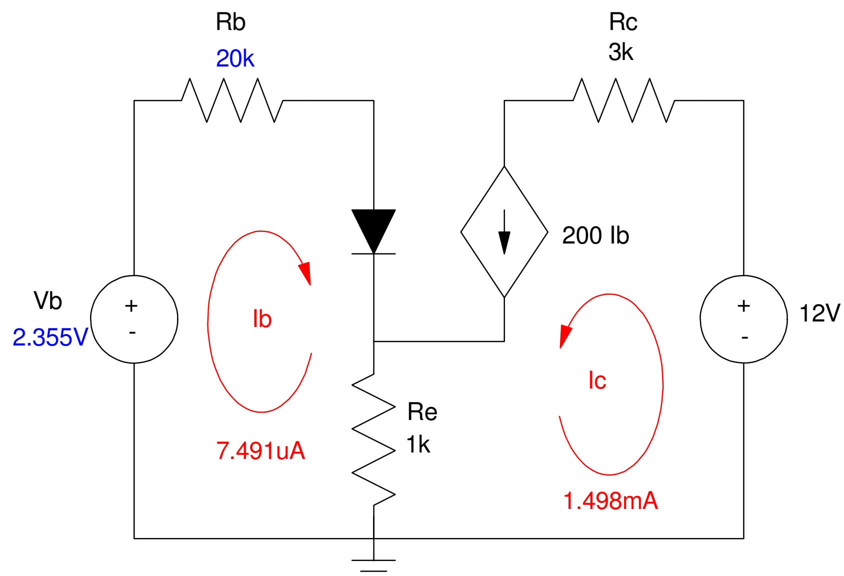
Solveing for R1 and R2

$$\left(\frac{R_1 R2}{R_1 + R_2}\right) = 20k$$

$$\left(\frac{R_2}{R_1 + R_2}\right) 12V = 2.355V$$

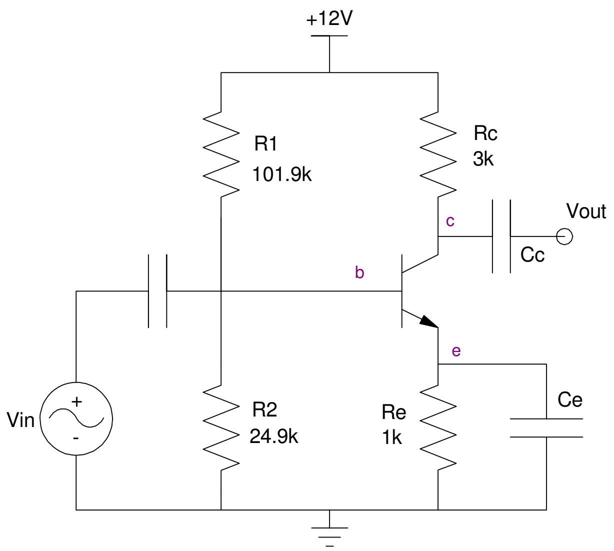
R1 = 101.9k    R2 = 24.88k

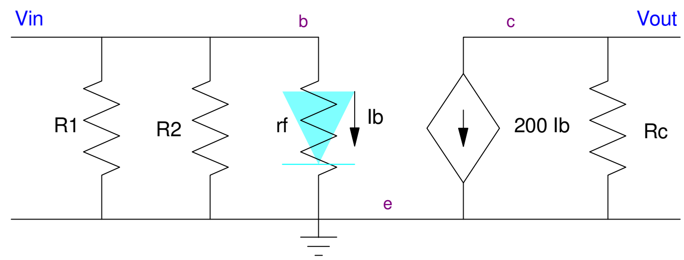


**From this point on, use the circuit you designed for problem #2**

3) Draw the small-signal model for the circuit of problem #2. From this, determine the 2-port model for the Common Emitter amplifier




$$r_f = \left(\frac{0.052}{I_b}\right) = \left(\frac{0.052}{7.491\mu A}\right) = 6942$$

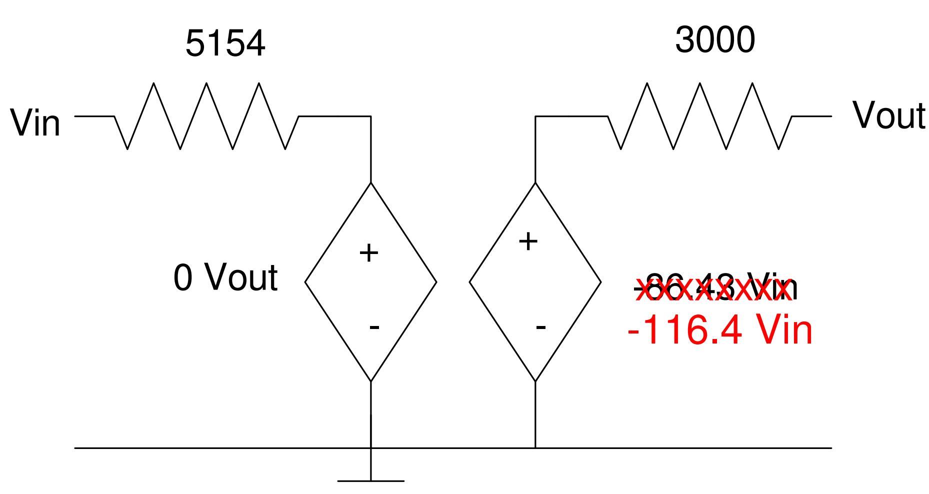
This gives:

Ai = 0

$$R_{in} = R_1 || R_2 || r_f = 5154\Omega$$

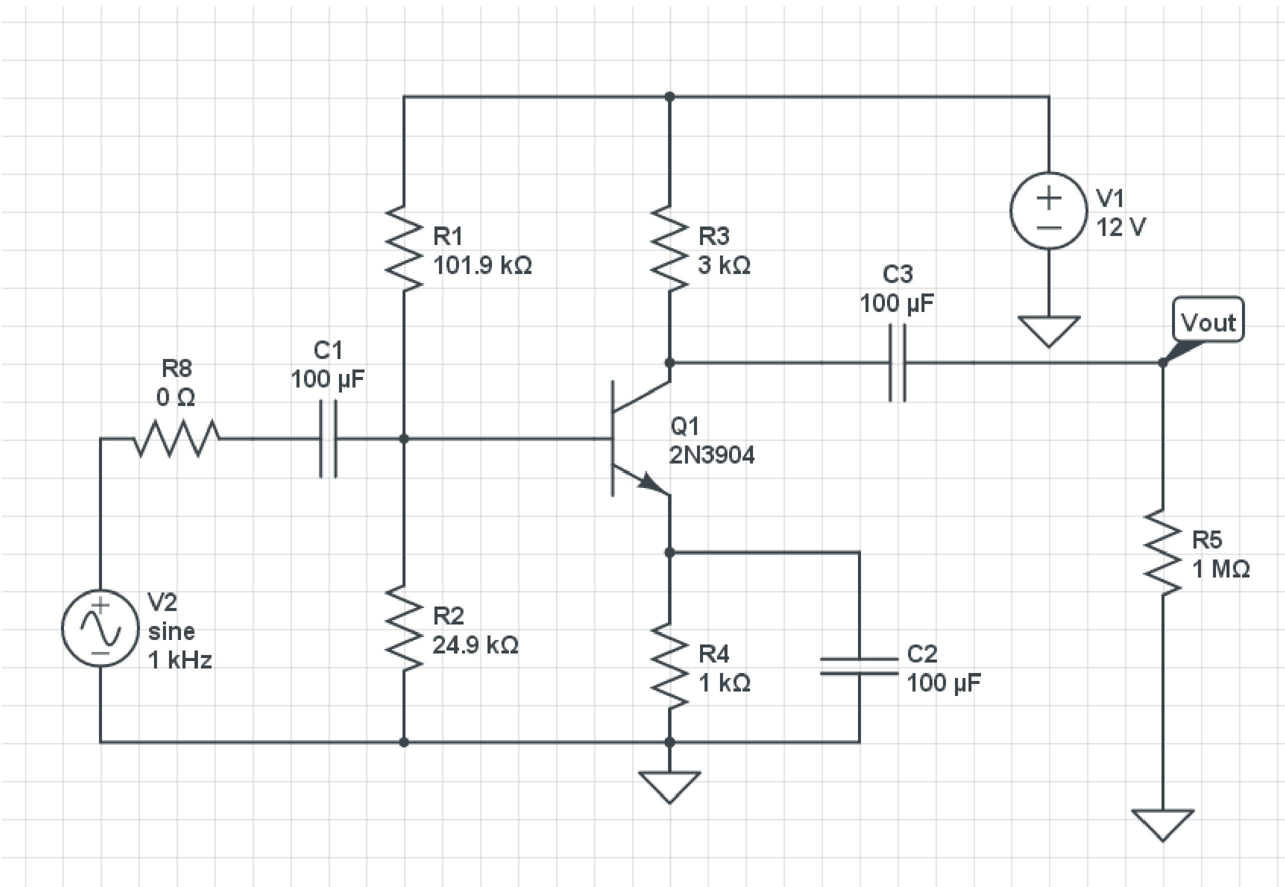
$$A_o = -\frac{\beta R_c}{r_f} = -116.4$$

$$R_{out} = 3k$$



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

- Rin
- Rout
- Ao




Ao = 162.1

- R5 = 1M
- R8 = 0
- Measured Vout: 162.1mV (meaning Ao = 162.1 vs. -116.4 computed )

Rout: Reduce R5 to 3k. This should drip the output by 1/2

- Vout = 83.4mV.

$$V_{out} = 83.4mV = \left(\frac{3000}{3000+R_{out}}\right)162.1mV$$

$$R_{out} = \left(\frac{83.4mV}{162.1mV-83.4mV}\right)3k = 3179\Omega$$ ( vs 3000 computed )

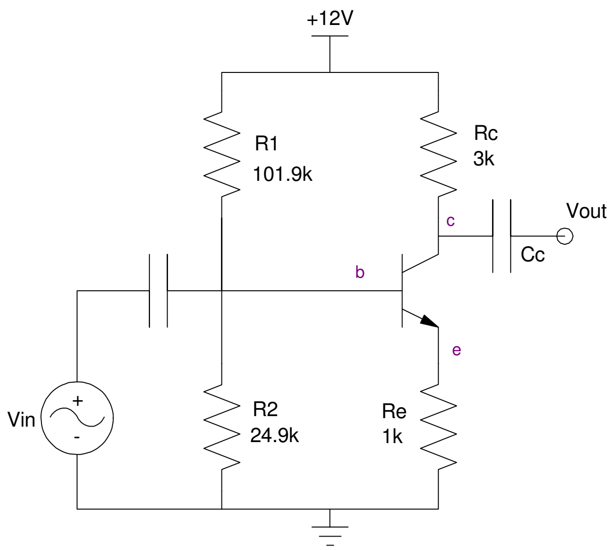
Rin: Rout = 10M, increase R8 to equal Rin (5154). Measure Vout

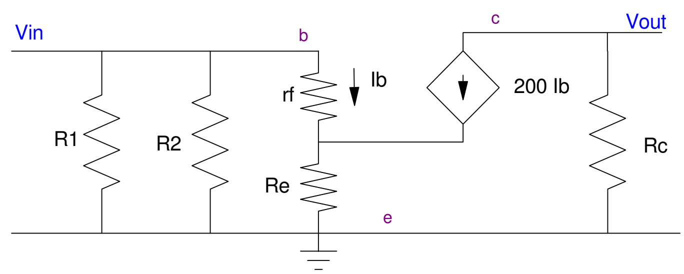
- Vout = 51.32mV

$$V_{out} = 51.32mV = \left(\frac{5154}{5154+R_{in}}\right)162.1mV$$

$$R_{in} = \left(\frac{51.32mV}{162.1mV-51.32mV}\right)5154 = 2388\Omega$$ ( vs. 5154 computed )

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




Ai: 0

Rin: Apply 1V to Vin, compute the current

$$R_{in} = R_1 || R_2 || (r_f + (1+\beta)R_e)$$

$$R_{in} = 18.25k\Omega$$

Rout: 3k

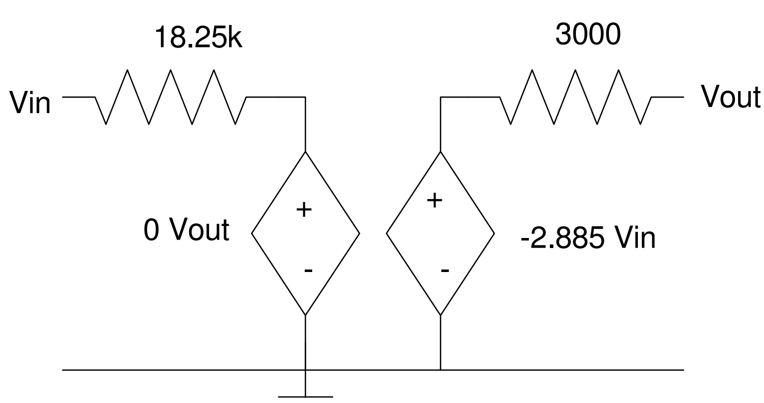
Aout: Apply 1V to the input

$$I_b = \frac{1V}{r_f + [1+\beta]R_e} = 4.809\mu A$$

$$I_c = 200 I_b = 961.8\mu A$$

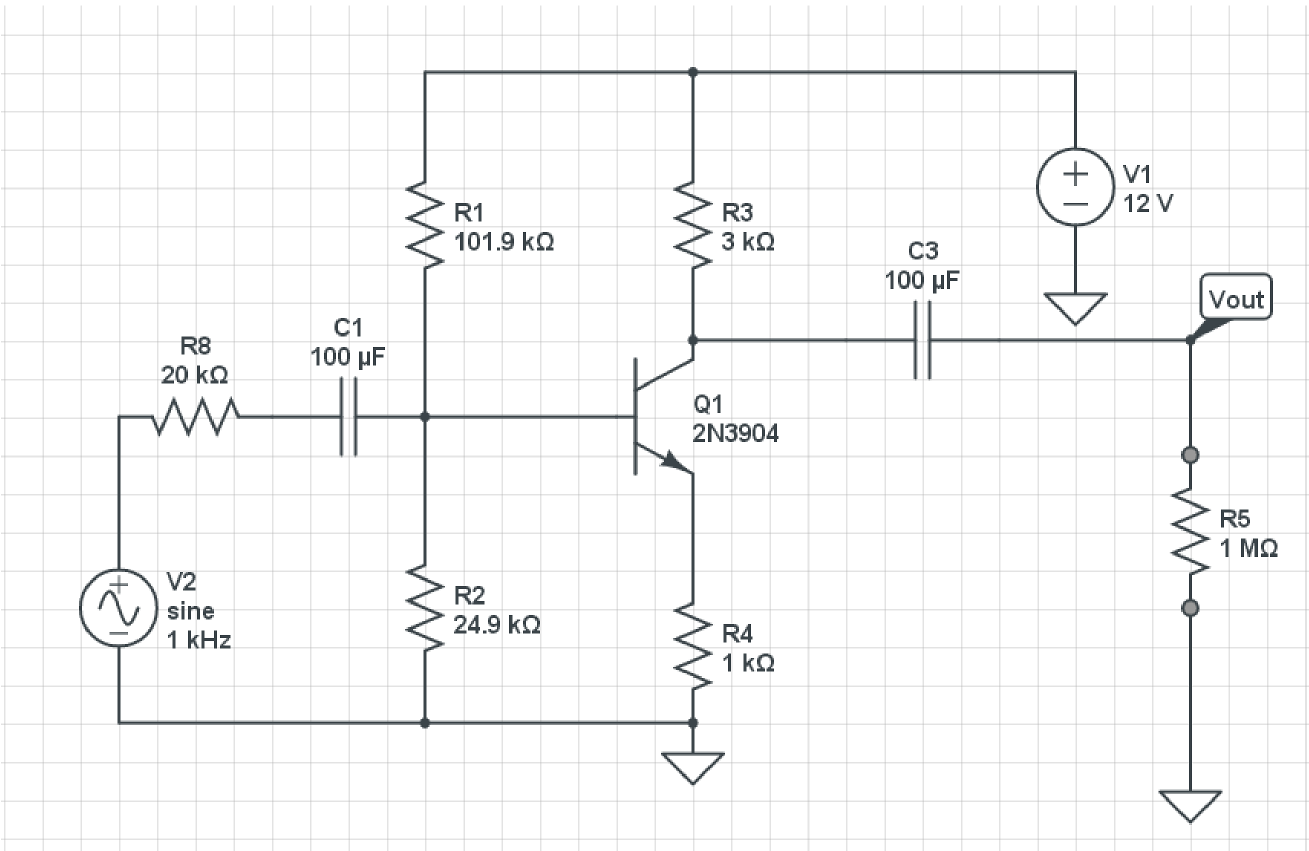
$$V_{out} = -R_c I_c = -2.885$$

Aout = -2.885



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

- Rin
- Rout
- Ao




Ao: R8 = 0, R5 = 1M

- Ao = -2.914 ( vs. 2.885 computed )

Rout: R8 = 0, R5 = 3k

- Ao = 1.464mV
- $R_{out} = \left(\frac{1.464mV}{2.914mV - 1.464mV}\right) 3000 = 3029\Omega$ ( vs. 3000 computed )

Rin: R8 = 20k, R5 = 1M

- Rout = 1.364mV
- $R_{in} = \left(\frac{1.364mV}{2.914mV - 1.364mV}\right) 20k = 17.6k\Omega$ ( vs. 18.25k computed )

Sample Calculation: Rin

$$\left(\frac{R_{in}}{R_{in} + 20k}\right) 2.914mV = 1.364mV$$

Solve for Rin and you get the previous equation