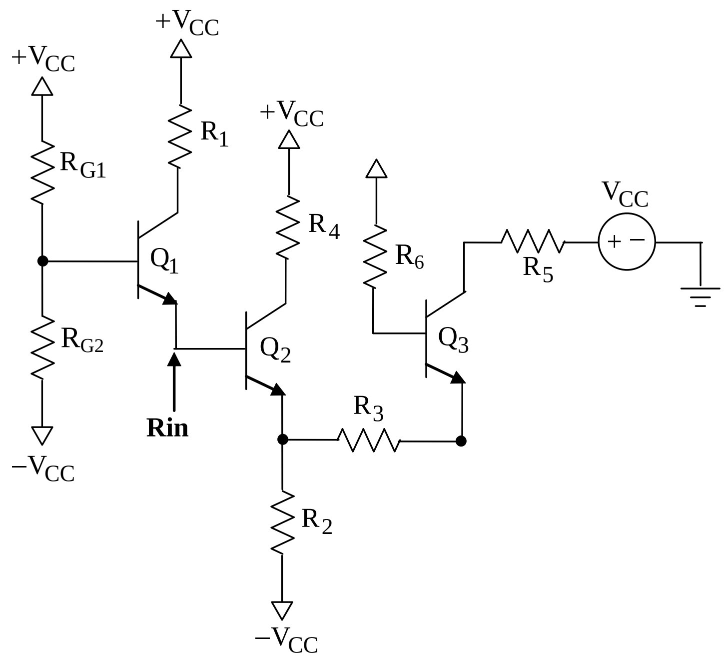
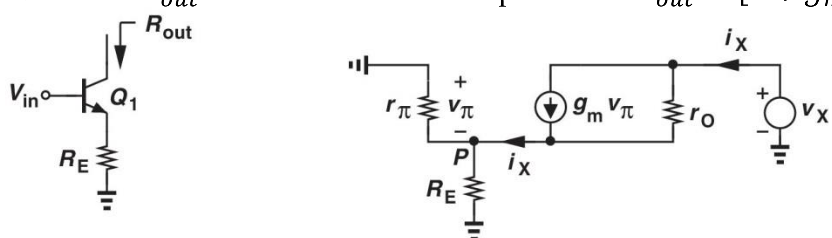
1. (a) Assume the transistors below have a finite β and an infinite Early voltage. Draw the small signal equivalent circuit (hybrid-π or model T)
(b) Write an expression for the input resistance R_{in} in the circuit shown. Your expression should include *only* real resistances (R_1, R_2, R_3, R_4, R_5, R_6, R_{G1}, R_{G2} or a subset of these) and possibly β and r_π. (Assume all transistors have the same β.)

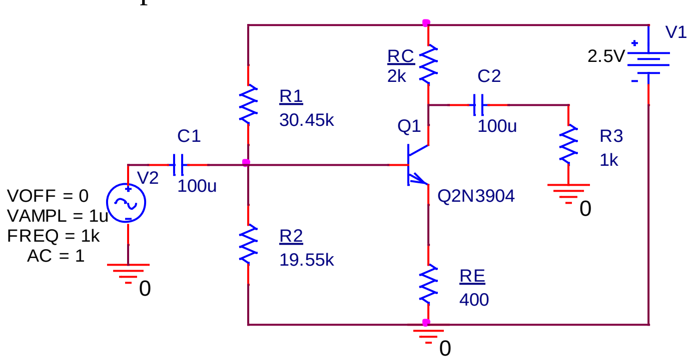


2. Derive R_{out} of the circuit below to prove that $R_{out} = [1 + g_m(R_E||r_\pi)]r_o + (R_E||r_\pi)$.



(a) (b)

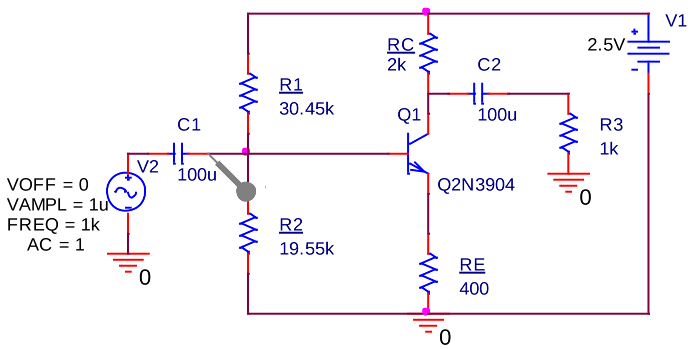
The circuit used below is from homework 4. Modify it to contain the AC source and load resistor. Use this circuit for problems 3-7.



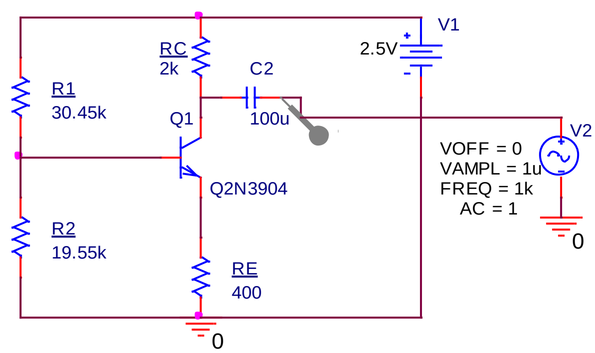
3. (continued)
Redraw the circuit using the hybrid pi model. Assume that $\beta = 125$. Assume all capacitors act as a short for the analysis. Find the following:

a. Overall gain, Vout/Vin where Vout is located above R3 and Vin is to the left of C1.
b. Rin
c. Rout (ignore the early voltage)

4. Simulate the above circuit in Pspice. Print out the following:
a. Circuit schematic
b. AC sweep that shows the results for Vout/Vin. Run the simulation from 0.1 to 1Meg.
c. Compare the value to problem 3a.
d. Place a current probe as seen in the below circuit. Run an AC sweep and measure the voltage(V2)/current probe to find Rin. The flat region is during the bandwidth. Print this graph. Compare the flat region value(Rin) to the value of 3b.



d. Remove the input. Remove R3(the load) and replace it with a voltage source. Run an AC sweep again and measure the voltage(V2)/current probe to find Rout. Print this graph. Compare the flat region value(Rout) to the value of 3c.

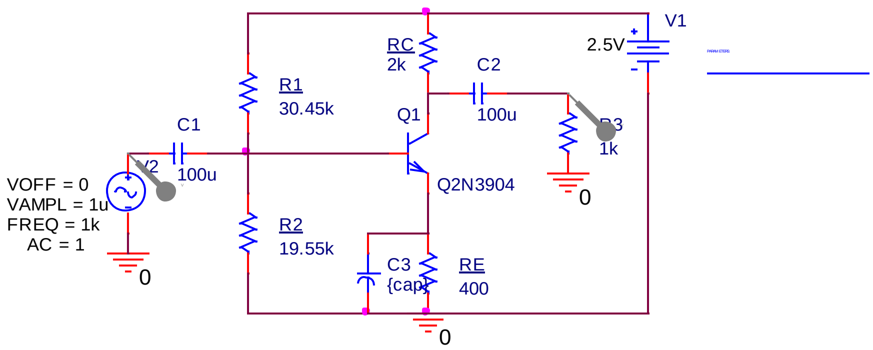


5. Make C1 into a parameter and perform a parametric AC sweep over C1 (refer to homework 4 for directions again about parametric sweeps). Vary C1 using the value list option from: 1n, 10n, 100n, 500n, 1u, 10u, 100u, 1000u.

a. Print the results of Vout/Vin.
b. What effect does C1 have on the circuit?
c. If this circuit was used to amplify voice, what value would be acceptable for C1 (20Hz-40kHz is audio range)?

6. Add a new capacitor as shown below. Change its value into a parameter and perform a parametric AC sweep over C3. Perform the AC sweep from 0.1 to 100G. Vary C2 using the value list options of: 1n, 100n, 500n, 1u, 10u, 100u, 1m.

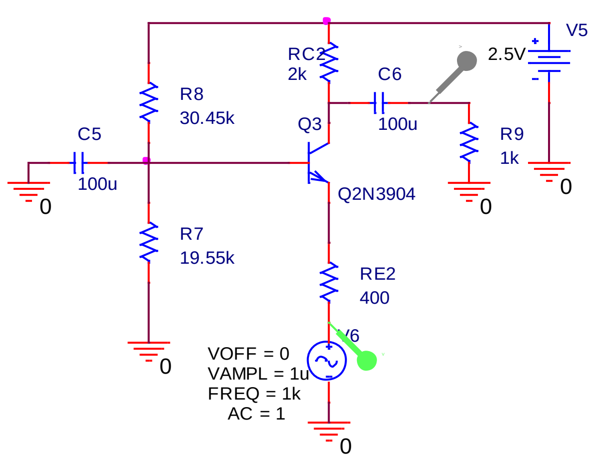
a. Print the results of Vout/Vin.
b. What effect does C3 have on the circuit? Comment on the 1pF value and what is observed.
c. If this circuit was used to amplify voice, what value would be acceptable.



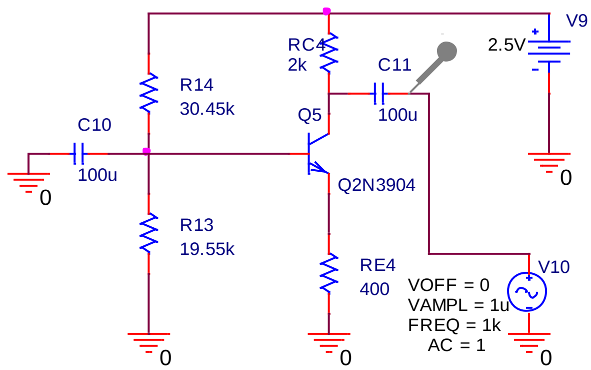
7. Set the value of C3 to 1mF.
a. Run a transient analysis and print out the circuit showing voltages and currents. Verify that these DC values are the same as from Homework 4.
b. Run an AC sweep and plot the graph of Vout/Vin. Print this plot.
c. State the gain value observed.
d. Using the method described in problem 4d and 4e, print the graphs that show Rin and Rout.

8. Draw the hybrid pi model of the circuit in problem 6. Assume that $\beta = 125$. Assume all capacitors act as a short for the analysis. Find the following:
   a. Overall gain, Vout/Vin where Vout is located above R3 and Vin is to the left of C1.
   b. Rin
   c. Rout (ignore the early voltage)
   d. Compare all these values with those found in problem 7.

9. Modify the core of the circuit again to turn the circuit into a Common Base. Run an AC sweep again and plot the graphs for:
a. Run a transient analysis on the CB amplifier below and verify that the voltages and currents have remained the same. Print this result.
b. Vout/Vin where Vout is taken at the collector and Vin is at the emitter as shown below. State the value observed for Vout/Vin.

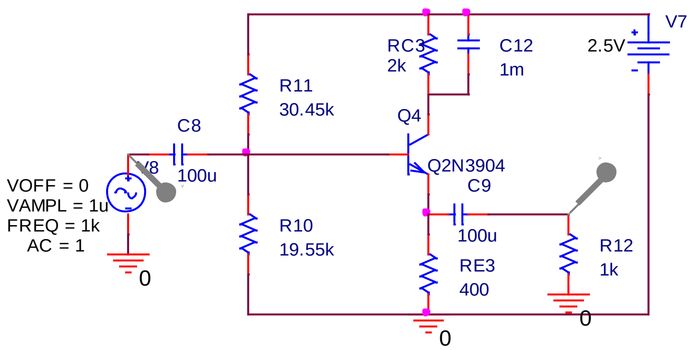


c. Find Rin by plotting V6/Current of green probe marker. Print the graph and state its observed value.
d. Find Rout with the same method as described in problem 4. The circuit for measuring Rout is shown below. Print the graph for Rout. State its observed value.



e. Comment on the values of Vout/Vin, Rin, and Rout.

10. Modify the core of the circuit again to turn the circuit into a Common Collector(shown below). Run an AC sweep again and plot the graphs desired.



a. Run a transient analysis on the CC amplifier and verify that the voltages and currents have remained the same. Print this result.
b. Run and AC sweep to obtain Vout/Vin where Vout is taken at the emitter and Vin is at the base. State the value observed for Vout/Vin.
c. Find Rin by plotting V8/(Current through C8). Print the graph and state its observed value.
d. Find Rout with the same method as described in problem 4. The circuit for measuring Rout is shown below. Print the graph for Rout. State its observed value.
e. Comment on the values of Vout/Vin, Rin, and Rout.