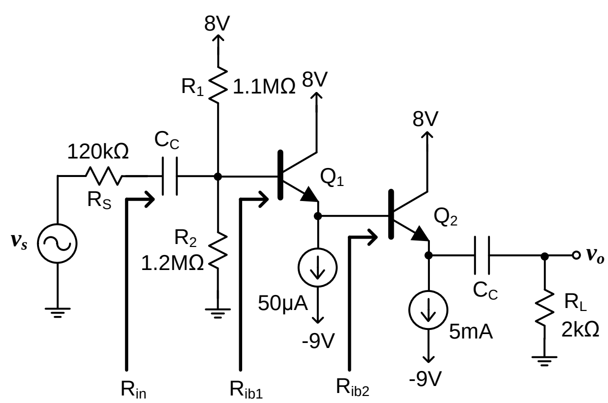
EECE 2412 – Homework 7 – Fall 2016

Due: Wednesday, November 9, 2016

1) Problem 4.51 on page 284 of the textbook. Read section 4.8 before starting to work on the problem. Make sure that you understand the small-signal equivalent circuit for the emitter-follower as well as how the parameters in the problem are derived.

2) Assume that the coupling capacitors (C_c) are short circuits for the signal in the two-stage amplifier below. Transistor Q_1 has a β of 50, transistor Q_2 has a β of 100. You can assume for both transistors that $V_{BE} = 0.7V$ and that their collector-emitter resistances (r_{ce}) are high enough to be neglected in the small-signal analysis.
   a) Find the DC emitter currents of Q_1 and Q_2 as well as the DC voltages V_{B1} and V_{B2} at their bases.
   b) With a load resistance of 2kΩ connected, determine an expression for the voltage gain from the base to the emitter of Q_2: $v_o/v_{b2} = v_o/v_{e1}$. Also find an equation for the input resistance R_{ib2} looking into the base of Q_2. Evaluate v_o/v_{b2} and R_{ib2} numerically. (Hint: Draw the small-signal equivalent circuit and consider Q_2 as an emitter-follower amplifier fed by an input voltage v_{b2} at the base.)
   c) Replace Q_2 with its input resistance R_{ib2} in the small-signal equivalent circuit, where R_{ib2} is the resistance calculated in part b). Analyze the circuit to determine the resistance (R_{ib1}) looking into the base of Q_1, the input resistance (R_{in}), and the gain ($v_{e1}/v_{b1} = v_{b2}/v_{b1}$) from the base of Q_1 to its emitter.
   d) For the case in which the amplifier is fed by a source (v_s) with a series resistance of 120kΩ, find an equation and the numerical value for the gain from the source to the base of Q_1: v_{b1}/v_s.
   e) Calculate the overall voltage gain (v_o/v_s).



3) Problem 4.58 on page 285 in the textbook under the assumption that the BJTs operate at room temperature.

4) Setup the circuit from Problem 1) in PSpice using the Q2N2222 BJT model and the same component parameters as in Problem 4.51 on page 284 of the textbook. Select $C_1 = C_2 = 1\mu F$.
   a) Run a DC simulation to verify that the BJT is operating in active mode. Inspect the DC operating point information of the BJT (as in problem 5 of homework 5), and record the transconductance parameter (GM) as well as r_π (RPI). Also notice the AC beta value of the transistor, and recalculate the voltage gain from problem 1 with the observed small-signal parameter values. Submit a print out of the schematic in which the DC voltages and currents are displayed. Also print the DC operating point information of the BJT in the output file (.out) and show your gain calculation.
   b) Run an AC simulation from 10Hz to 1GHz using a logarithmic sweep with 20 points per decade. Plot the AC voltage gain (v_o/v_s) in dB-scale vs. frequency. Label the midband frequency gain (in dB) and the 3-dB frequencies (low corner frequency and high corner

frequency) in the plot before printing it out for submission. What is the midband voltage gain as a ratio (not in dB)?

c) Set up a transient simulation with a sinusoidal input at 300kHz that has a 2V amplitude. Use a 0.01µs max. time step and a simulation time of 20µs. Plot the input and output signals vs. time, and mark the peak amplitudes in the plots. What is the gain based on the transient simulation? Does it agree with the AC gain in part b)?

d) Increase the input signal amplitude to 4V and repeat the transient simulation. Plot the input and output signals vs. time. Can you notice the distortion? Which condition is not satisfied? (What causes the distortion)?