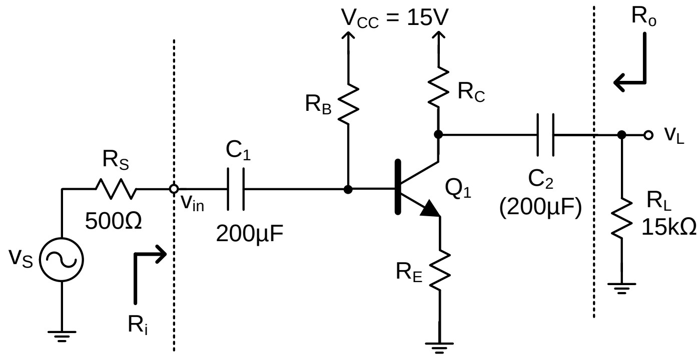
EECE 2412 – Homework 8 – Fall 2016

Due: Wednesday, November 16, 2016

1) Carefully read all sections in chapter 4 of the textbook and review lecture slide sets 15-20 before attempting to work on this design problem. Consider the amplifier below at room temperature (300K). Design for an overall inverting gain around $A_{vs} = v_L/v_S = -20$ with a collector current of up to 8mA to limit the power consumption with V_{CC} = 15V. Assume that $R_S = 500\Omega$ and $R_L = 15K\Omega$. The amplifier should be able to provide a peak-to-peak output signal swing of 10V without distortion. During your hand calculations, assume that a Q2N2222 transistor with $\beta = 200$ and a forward base-emitter voltage drop of 0.7V is available. You may select any values for the shown resistors with the exception of the given values of R_S and R_L.
   a) Analyze the circuit and show your equations as well as calculation results to select the component values that result in the specified voltage gain at midband frequencies.
   b) Derive an equation for the input resistance (R_i) at midband frequencies, and use this equation to satisfy the design requirement of $R_i > 5k\Omega$.
   c) What is the expected value of the output resistance (R_o) at midband frequencies based on hand calculations?
   d) Set up the circuit as shown below in PSPICE using the Q2N2222 model for the BJTs. Run a DC simulation and verify that your operating point agrees with your hand calculation results. Submit a print-out of the schematic in which the DC voltages and currents are displayed.
   e) Run an AC simulation with a logarithmic frequency sweep from 1Hz to 100MHz and 20 points per decade. Verify with an AC simulation that your voltage gain A_{vs} agrees with your hand calculation with reasonable error. Submit the plot of the voltage gain (as a ratio, not in dB) vs. frequency in which the midband voltage gain should be labeled.
   f) Verify that your simulated input resistance is reasonably close to your calculated value in part b) by inserting an ideal AC voltage source (without R_S, but with the coupling capacitor C_1) directly at the amplifier input (v_{in}). Run an AC simulation with a logarithmic frequency sweep from 1Hz to 100MHz and 20 points per decade. Afterwards, plot the absolute value of the ratio of the test voltage source and its AC current at the terminal vs. frequency in order to obtain the plot of $Z_{in} = |v_{test}/i_{test}|$ vs. frequency. Submit this plot with a label to show the input impedance for midband frequencies.
   g) Verify that your simulated output resistance is reasonably close to your calculated value in part c). First keep R_S but replace v_s with a short-circuit to ground. Next, remove resistor R_L and place an AC test voltage source at node v_L in the figure (in lieu of R_L). Then, run an AC simulation with a logarithmic frequency sweep from 1Hz to 100MHz and 20 points per decade. Afterwards, plot the absolute value of the ratio of the test voltage source and its AC current at the terminal vs. frequency in order to obtain the plot of $Z_{out} = |v_{test}/i_{test}|$ vs. frequency. Submit this plot with a label to show the output impedance for midband frequencies.
   h) Reinsert R_L and v_s to revert to the same configuration as in the figure below, and select the input voltage amplitude for v_s of V_s = 250mV. Specify a 100kHz frequency for the sinusoidal input. Run a transient simulation with a duration of 50µs and a step size of 0.1µs. Verify that the output voltage amplitude V_L is equal to $A_{vs} \times V_s$ and undistorted. Place labels to show the peak-to-peak output voltage swing. Submit plots of the source and output voltages vs. time. Compare the voltage gains from the transient simulation, AC simulation, and hand calculations.



2) Problem 5.3 on page 335 in the textbook.

3) Problem 5.23 on page 336 in the textbook.