MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

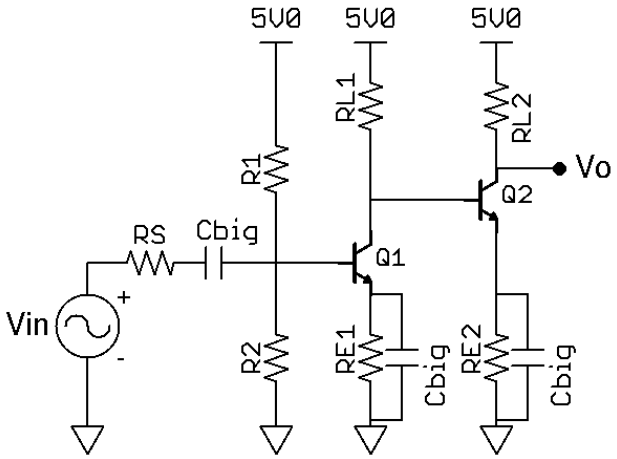
Fall 2013 — Issued : Sept 18, 2013

Problem Set 3 — Due : Sept 25, 2013

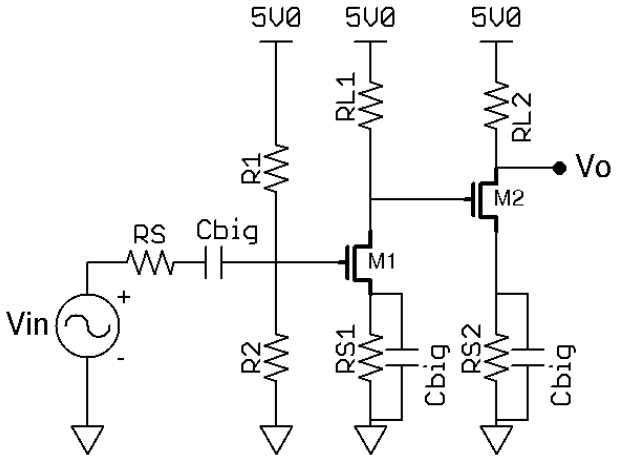
Problem 1: Cascades

For the following circuits find the midband gain, input impedance (not including R_s), and output impedance in terms of transistor small-signal parameters (r_π, gm, etc.) and labeled components. Assume $r_o = \infty$.

(a) Cascaded common emitter (CE-CE) amplifier:

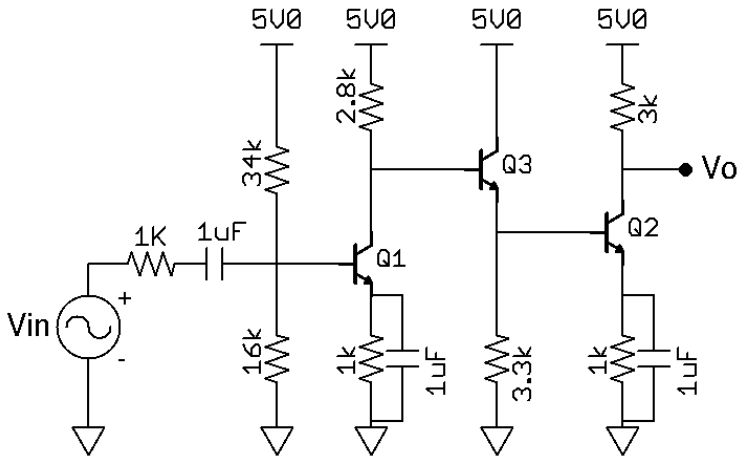


(b) Cascaded common source (CS-CS) amplifer:



Problem 2: Three transistor cascade

For this common emitter-emitter follower-common emitter (CE-EF-CE) amplifier:



(a) Find the midband gain, input impedance, output impedance, and power dissipation, assuming $\beta = 200$, $V_{BE} = 0.6V$, and $r_o = \infty$

(b) What is the largest AC input amplitude, $v_{in} = A\sin(t)$ that does not push any transistor into saturation

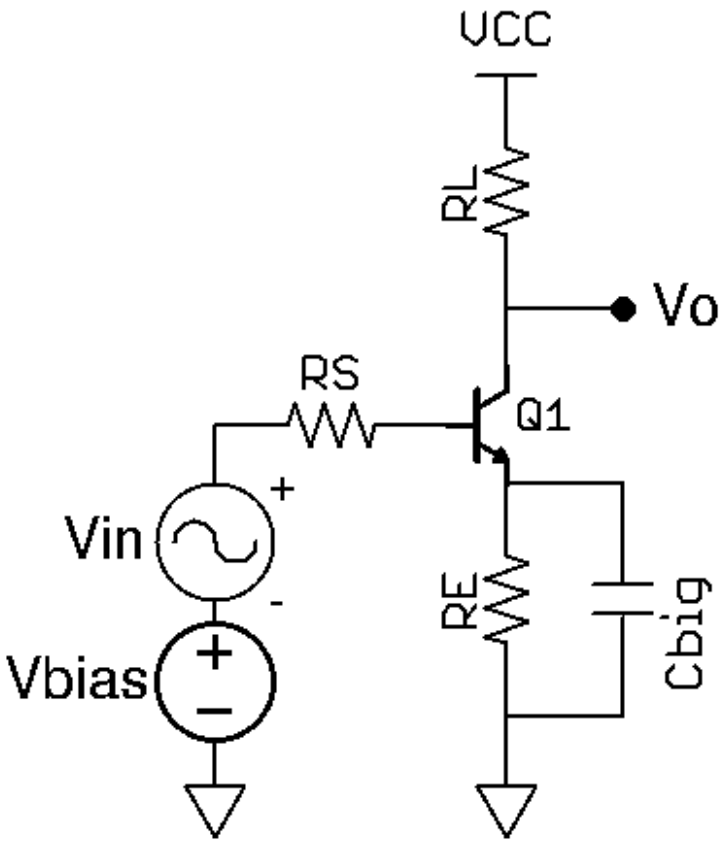
(c) Find the value of R_{L_2} that permits the largest output swing

(d) Find the value of I_{C_2} (via modifying R_{E_2}) that permits the largest output swing

(e) Find the new midband gain in (c) and (d)

Problem 3: Looking at limits

(a) For the common emitter amplifier below find the maximum midband gain, a_v, in terms of $V_{CE_{sat}}$, V_{BE}, and any labels in the schematic.



(b) What is the maximum output swing (before saturating) for an amplifier configured with maximum midband gain?

(c) Given an AC input that is symmetric about ground, find the midband gain that permits the maximum output swing.

Problem 4: More transfer function review

For the following transfer functions find the 3 dB bandwidth (the frequency at which the magnitude of the frequency response is .707 of the DC gain) in hertz. For A_1, A_2, and A_4 find the 10-90% risetime.

$$A_1(s) = \frac{1}{\tau s + 1} \quad A_2(s) = \frac{10}{(\tau s + 1)^2}$$

$$A_3(s) = \frac{100}{(\tau s + 1)^M} \quad A_4(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

Problem 5: Frequency Domain Jungle Gym

For the following transfer functions, sketch the pole-zero plot, the bode plot, and the step response.

$$A_1(s) = \frac{1}{s^2} \quad A_2(s) = \frac{20}{s^2 + 2s + 1} \quad A_3(s) = \frac{10}{s^2 + s + 1}$$

$$A_4(s) = \frac{s+1}{s+2} \quad A_5(s) = \frac{s+2}{s+1} \quad A_6(s) = \frac{s-1}{s+1}$$