

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science
6.301 Solid State Circuits

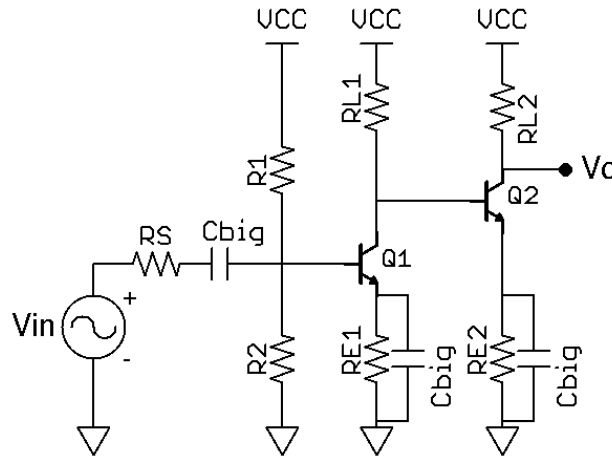
Fall 2013
Problem Set 3

Issued : Sept 18, 2013
Due : Sept 25, 2013

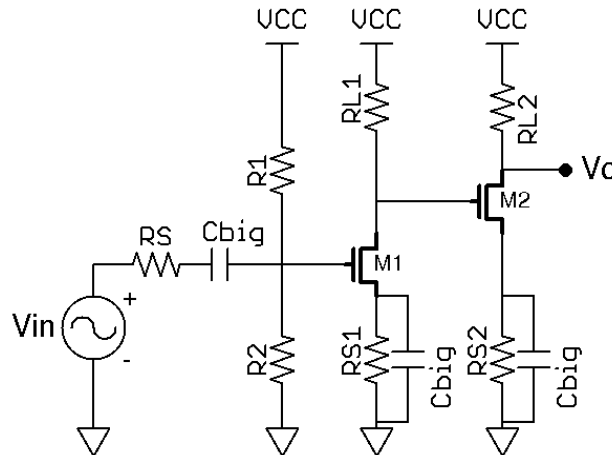
Problem 1: Cascades

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 , g_m , etc.) and labeled components. Assume $r_o = \infty$.

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

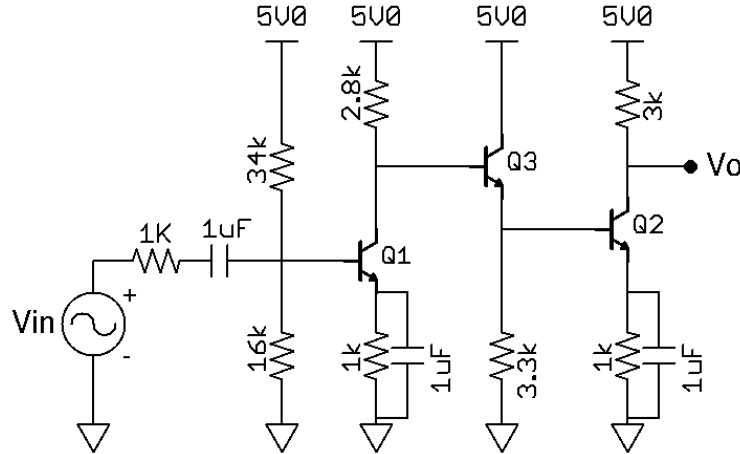


(b) Cascaded common source (CS-CS) amplifier:



Problem 2: Three transistor cascade

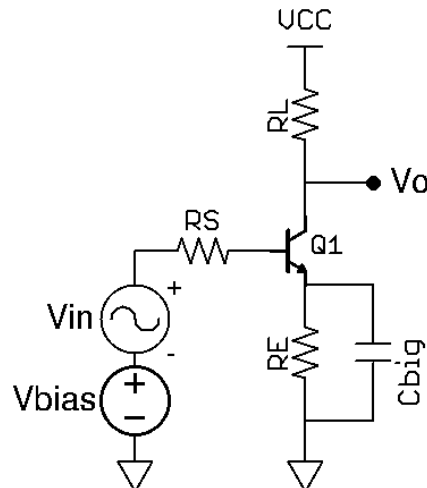
Consider this common emitter-emitter follower-common emitter (CE-EF-CE) amplifier:



- Find the midband gain, input impedance, output impedance, and power dissipation, assuming $\beta = 200$, $V_{BE} = 0.6V$, and $r_o = \infty$
- What is the largest AC input amplitude, $v_{in} = A \sin(t)$ that does not push any transistor into saturation
- Find the value of R_{L2} that permits the largest output swing
- Find the value of I_{C2} (via modifying R_{E2}) that permits the largest output swing
- Find the new midband gain in (c) and (d)

Problem 3: Looking at limits

- For the common emitter amplifier below find the maximum midband gain, a_v , in terms of V_{CEsat} , 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.

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

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

Extra Credit

So far we've told you a lot about transistors and you've probably just taken our word for it. MIT gives you lots of freedom to learn by experimentation. Here's a list of things to try out in lab before you get started on Lab 1:

- Measure the forward voltage drop across V_{BE} on a BJT.
- Use the curve tracer to see V-I curve families for BJTs and MOSFETS. Find β and V_A .
- Use the impedance analyzer to measure C_π and C_μ . Try varying the bias voltage around a reasonable range.
- Try biasing a transistor in the forward active region and see if it matches your theoretical calculation.

Take pictures and attach them to your pset for extra credit. You can get a breadboard from John Sweeny at the temporary stockroom in the 6.002 area.