MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

Midterm Quiz

October 18, 2012

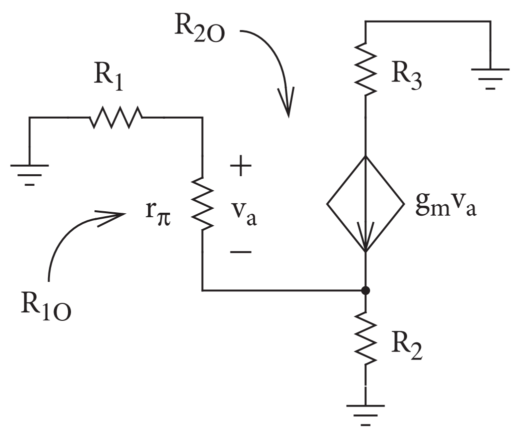
120 minutes

Room 34-303

1. This examination consists of three problems. Work all problems.
2. This examination is closed book. Calculators are allowed.
3. You will have to make reasonable approximations to do the problems quickly. You only need to calculate results within about 5% of an accurate value.
4. Please summarize your solutions in the spaces provide in this examination packet. Draw all sketches neatly and clearly where requested. Remember to label ALL important features of any sketches.
5. All problems have equal weight.
6. Make sure that your name is on this packet and on each examination booklet.

Good luck!

General equations, worst case OCT:



$$R_{10} = r_\pi \left\| \frac{(R_1 + R_2)}{1 + g_m R_2} \right.$$

$$R_{20} = \underbrace{R_1 \| [r_\pi + (\beta+1) R_2]}_{R_\|} + R_3 + \frac{g_m r_\pi R_\| R_3}{r_\pi + (\beta+1) R_2}$$

Problem 1 Inductively Loaded Emitter Follower

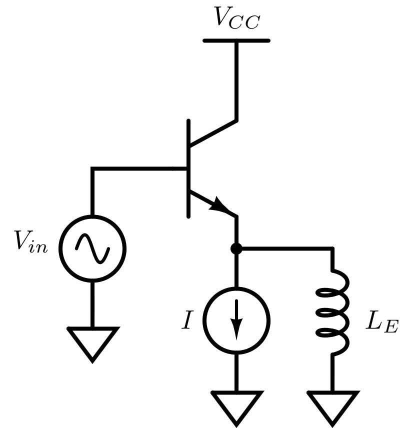


Figure 1: Inductively Loaded Emitter Follower Circuit

(a) Draw a simplified small signal model for the circuit, including only r_π, c_π, and g_m.

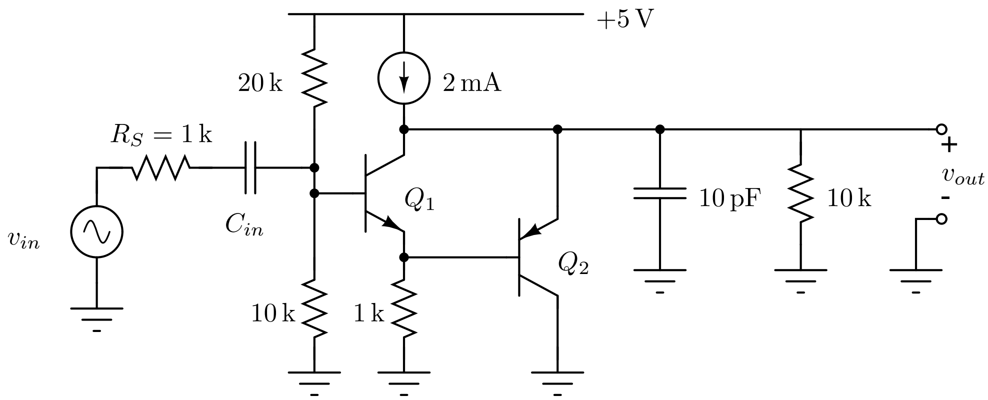
(b) Calculate the input impedance for the simplified small signal model as described in (a), and neglect higher order terms when appropriate. Justify your approximation.

(c) Show that for a specific values of L_E, the input impedance will be purely resistive. Determine the critical value for L_E in terms of transistor parameters.

(d) Sketch plots of the magnitude and phase of Z_{in} for the two cases where L_E is larger and smaller than the critical value determined above.

Problem 2 Amplifier Bandwidth

Consider the circuit below



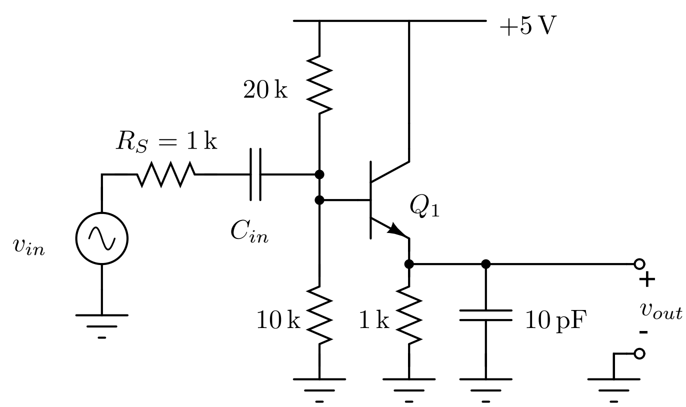
For this problem, you may assume $\beta = 100$, $v_{\text{BE}} = 0.6$ V, $c_\pi = 20$ pF, $c_\mu = 2$pF, $r_b = 0$ and $r_o = \infty$ for all transistors.

(a) Calculate the mid-band gain $v_{\text{out}}/v_{\text{in}}$.

(b) Derive the upper 3-dB frequency (ω_h) using the method of open circuit time constants.

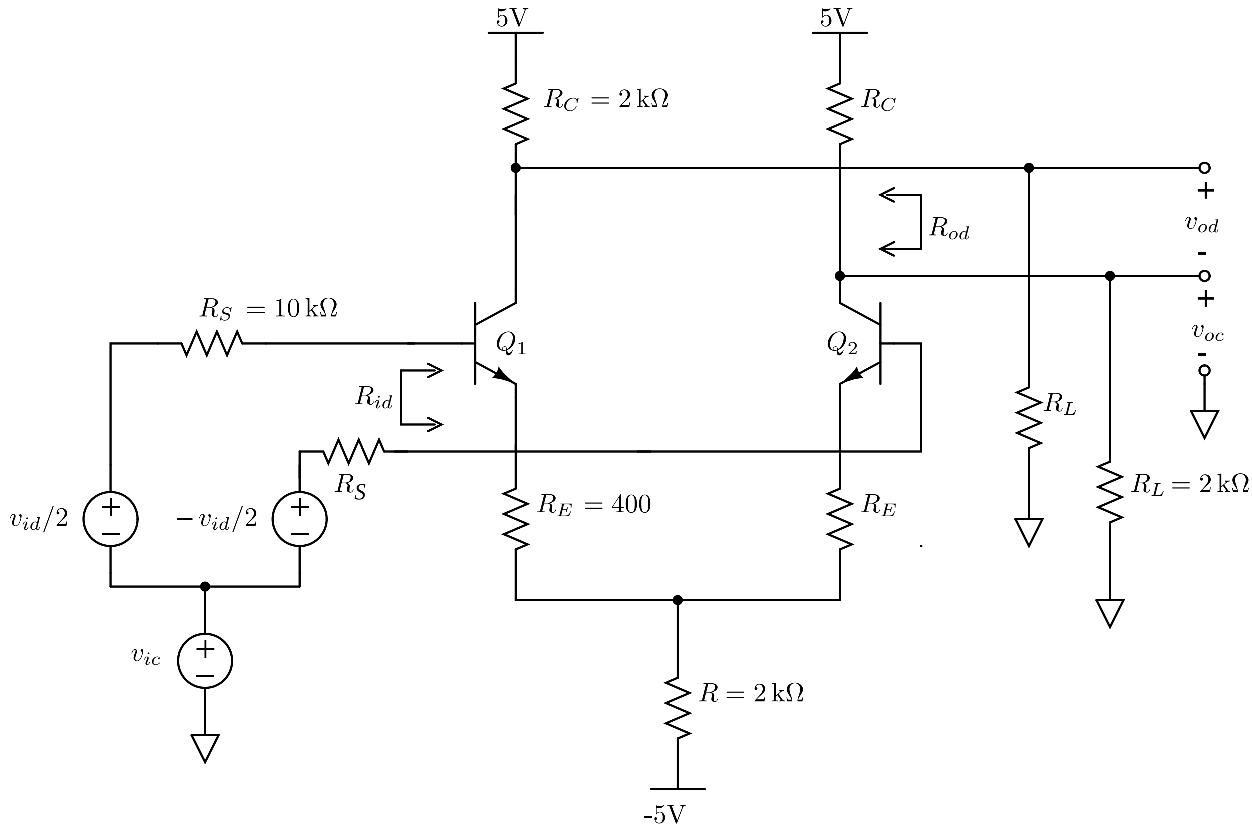
(c) How big must C_{in} be for the circuit transfer function to have a lower 3-dB frequency of at most 100 rad/sec?

(d) Now consider the modified version of the circuit below. Calculate the ω_h for this topology.



(e) Explain qualitatively (in a few sentences) the difference in bandwidth between the two topologies.

Problem 3 Differential Amplifier



Assume $\beta = 100$**,** $r_o = \infty$**,** $r_b = 0$**,** $V_{BE} = 0.6$ V **for all transistors. Ignore all parasitic capacitance.**

(a) Calculate the differential input resistance R_{id}.

(b) Calculate the differential output resistance R_{od}.

(c) Calculate the differential voltage gain $A_{vd} = v_{od}/v_{id}$.

(d) Calculate the common-mode voltage gain $A_{vc} = v_{oc}/v_{ic}$.