

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

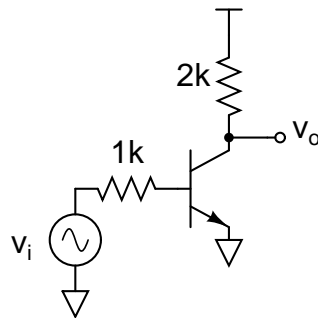
Spring Term 2003  
Problem Set 4

Issued : February 28, 2003  
Due : Friday, March 7, 2003

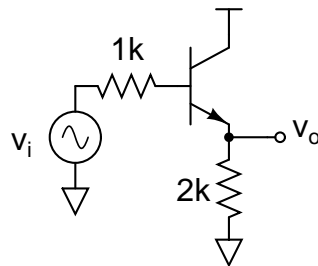
---

**Problem 1:** The AC schematics for four amplifiers are shown below. For each of the amplifiers, find the small-signal mid-band voltage gain and the  $-3$  dB frequency using the open-circuit time-constant method. Assume  $\beta=200$ ,  $I_C=1\text{mA}$ ,  $c_\pi=20\text{pF}$ , and  $c_\mu=2\text{pF}$ . Neglect  $r_b$  and  $r_o$  for this problem.

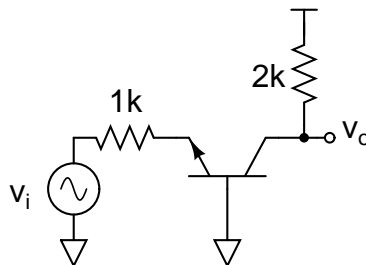
(a) Common-Emitter:



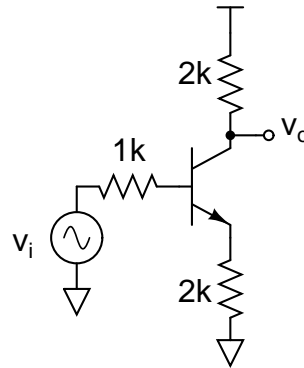
(b) Emitter-Follower:



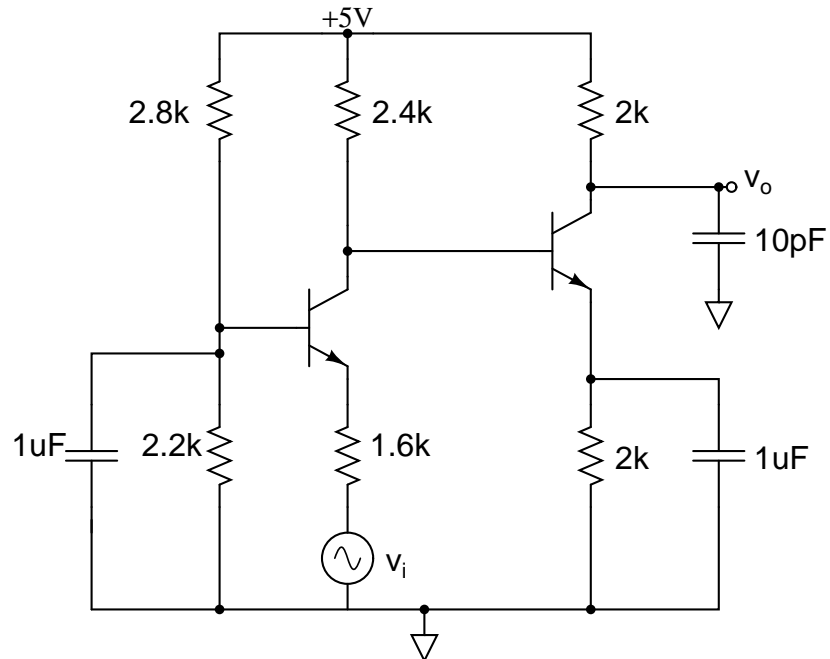
(c) Common-Base:



(d) CE with emitter degeneration:

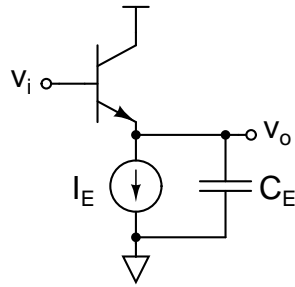


**Problem 2:** For the following CB-CE amplifier, assume that  $V_{BE,ON}=0.6V$ ,  $\beta=200$ ,  $c_{\pi}=20pF$ , and  $c_{\mu}=2pF$  for both transistors. Neglect  $r_b$  and  $r_o$ .



- Calculate the midband small-signal voltage gain.
- Estimate the  $-3$  dB frequency of the circuit gain using the OCT method.

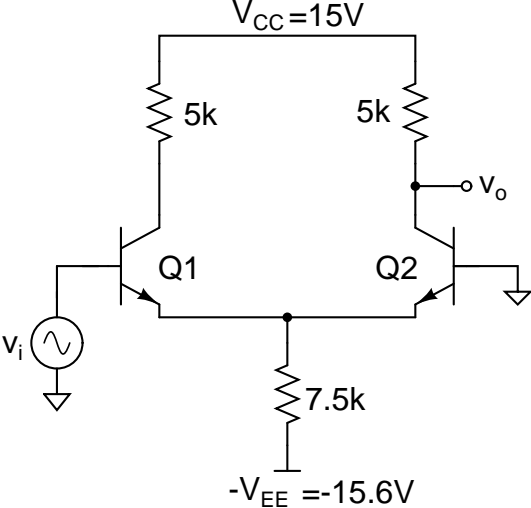
**Problem 4:** In recitation, a capacitively loaded EF such as the one shown below was discussed.



- (a) Find the incremental input impedance. For simplicity, neglect  $c_\mu$  in the small-signal model.
- (b) Show that for sufficiently small values of  $C_E$ , the input impedance has a negative real part. Determine the critical value of  $C_E$  in terms of transistor parameters.
- (c) Why could a negative input impedance be a bad thing?

**Problem 5:** For each of the two amplifiers shown below, assume that  $V_{BE,ON}=0.6V$ ,  $\beta=200$ ,  $c_{\pi}=20pF$ , and  $c_{\mu}=2pF$  for both transistors. You may neglect  $r_b$  and  $r_o$ . Find the small-signal midband voltage gain and the  $-3$  dB frequency.

(a) Single-ended Differential Amplifier:



(b) EF-CB:

