MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

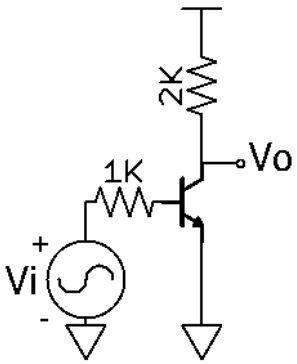
Fall 2013
Problem Set 4

Issued : Oct 1, 2013
Due : Oct 8, 2013

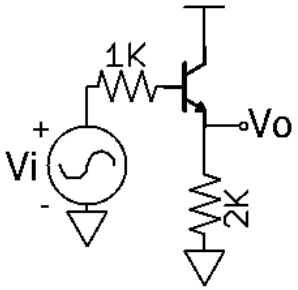
Problem 1: Building Blocks

The AC schematics for four amplifiers are shown below. For each of the amplifiers, find the midband voltage gain and the -3dB frequency using the open-circuit time-constant method. Assume $\beta = 200$, $I_C = 2.5$mA, $c_\pi = 50$pF, and $c_\mu = 2$pF. Neglect r_b and r_o.

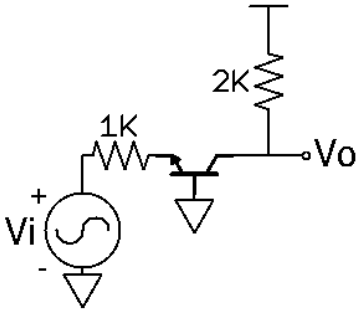
(a) Common Emitter:



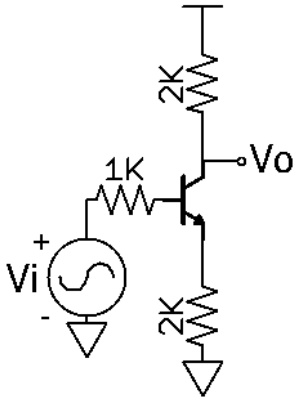
(b) Emitter Follower:



(c) Common Base:

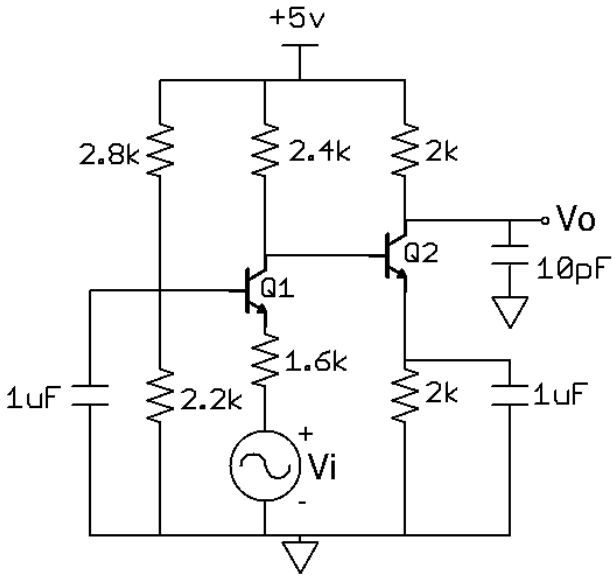


(d) C-E with Emitter Degeneration:



Problem 2: Two-transistor OCTs

For the following CB-CE amplifier, assume $V_{BE} = 0.6$v, $\beta = 200$, $c_\pi = 20$pF, and $c_\mu = 2$pF. Neglect r_b and r_o.



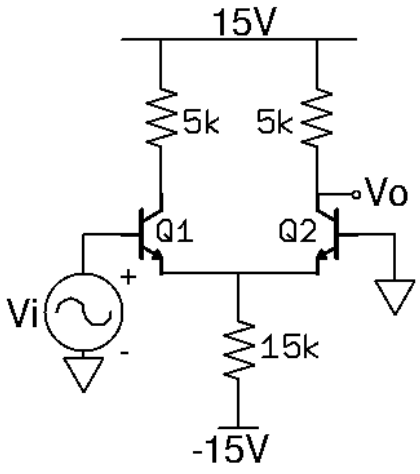
(a) Calculate the midband voltage gain.

(b) Find the -3dB frequency of the amplifier using the OCT method.

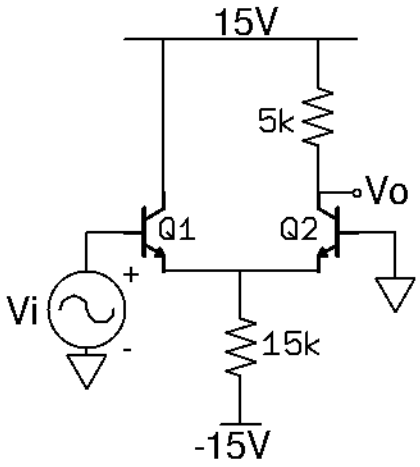
Problem 3: Emitter Coupled Pairs

For the two amplifiers shown below, find the midband voltage gain and the -3dB frequency. Why does one have more bandwidth than the other?
You may assume $V_{BE} = 0.6$v, $\beta = 200$, $c_\pi = 40$pF, $c_\mu = 4$pF, and neglect r_b and r_o.

(a) Single-ended Differential Pair

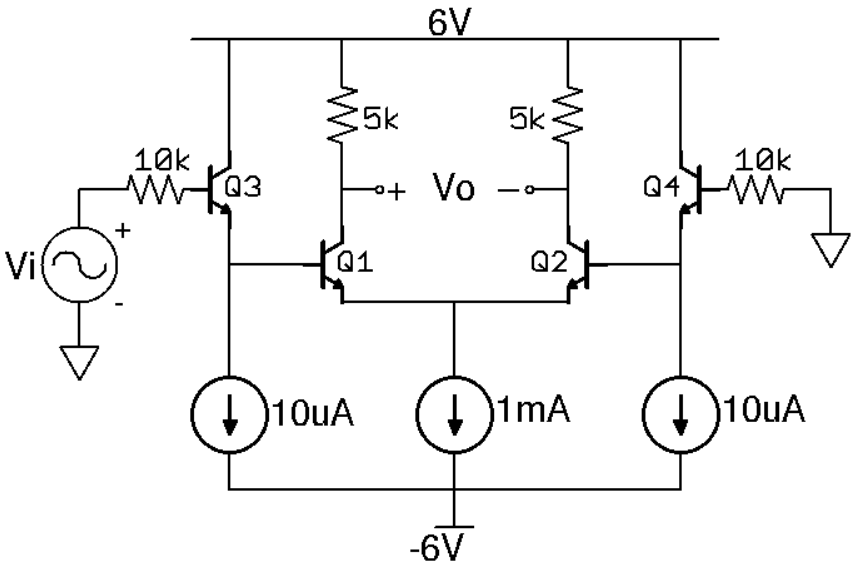


(b) EF-CB



Problem 4: Buffered Diff Pair

For the amplifier shown below, use the following data: $I_s = 0.5$fA, $\beta = 200$, $c_{\mu 0} = 0.5$pF, $c_{je} = 4$pF, and $f_T = 500$MHz at $I_C = 1$mA and $V_{CB} = 2.5$v. $m = 0.5$ and $\Psi_0 = 0.7$v for all junctions. Neglect r_b and r_o.



(a) Calculate the midband voltage gain.

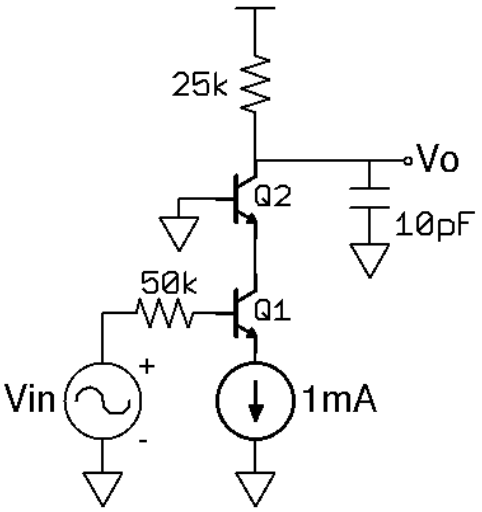
(b) Find the -3dB frequency of the amplifier using the OCT method.

(c) Verify the above results in SPICE. Turn in your SPICE input file as well as a plot showing the high-frequency roll-off.

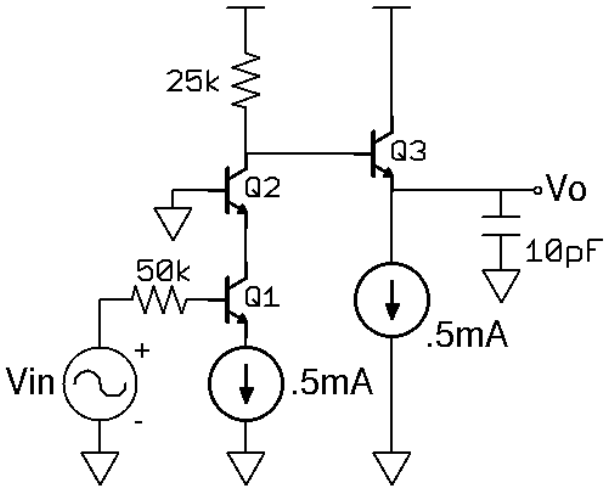
Problem 5: Cascode Cascades

Given the following AC schematics, find the midband gain and -3dB frequency using the OCT method for each amplifier. You may assume $\beta = 200$, $c_\mu = 2\text{pF}$, $c_{je} = 5\text{pF}$, and $\tau_F = 250\text{ps}$. Neglect r_b and r_o.

(a)



(b)



(c)