MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Stuff

6.301 Solid State Circuits

Fall Term 2010 | Issued : Nov. 6, 2010
Problem Set 7 | Due : Friday, Nov. 12, 2010

Suggested Reading: Read as many of the following as you can. All of the recommended references are on reserve at Barker Library.

1. Lundberg sections 30 and 33–36.
2. Grebene sections 7.3 and (skim) 9.
3. Gray and Meyer sections 6.2–6.4 and 10.3.

Problem 1: A basic operational amplifier circuit with an NPN input stage is shown on the next page. Calculate the following amplifier parameters.

(a) Input Bias Current.

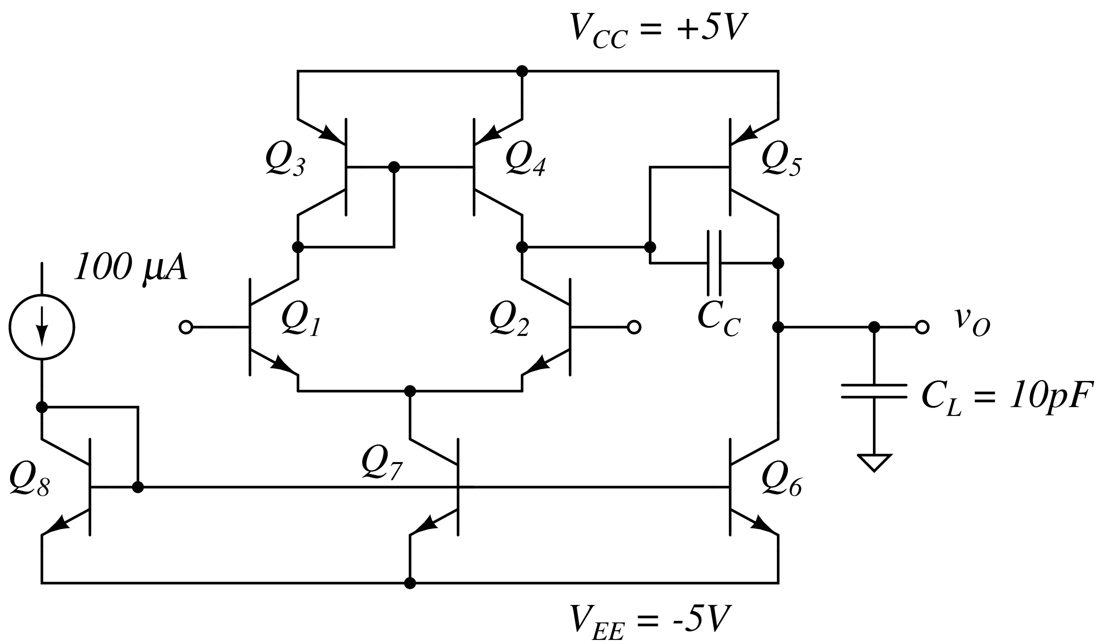
(b) DC Small-Signal Differential Gain.

(c) Common-Mode Rejection Ratio.

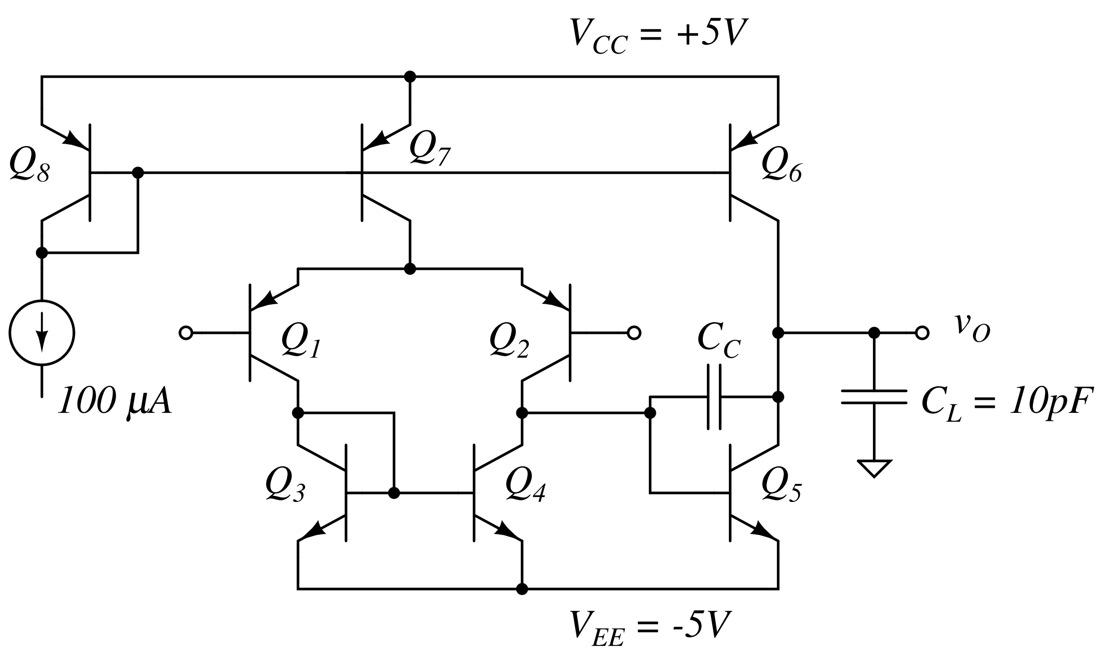
(d) Compensation capacitor size to achieve 45 degrees of phase margin for unity-gain feedback. Hint: phase margin can be found from a Bode plot as the difference between the phase and -180 degrees when the magnitude is unity. That is, for 45 degrees of phase margin, the phase of the system must be -135 degrees when the magnitude is one.

Assume the following transistor parameters:

	NPN	PNP
β	200	40
V_A	50 V	20 V
τ_F	2.5 ns	25 ns
r_b, r_c	0	0
c_μ, c_{je}, c_{cs}	0	0



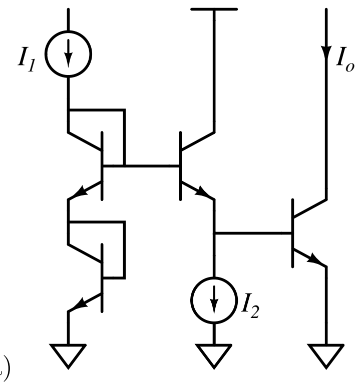
Problem 2: Repeat Problem 1 for the following PNP input operational amplifier. Create a summary table on the first page of your problem set comparing the values found in each layout.



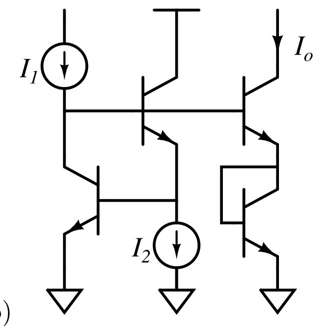
Problem 3: For each of the following circuits use the "Gilbert Principle" to determine I_o as a function of the other circuit variables. All of these circuits simplify to simple expressions.

A differential output is denoted by an I_o superimposed on an arrow, and double emitter arrows with $2A_E$ indicate that transistor has double the emitter area of the other transistors, thus its I_S is twice as large.

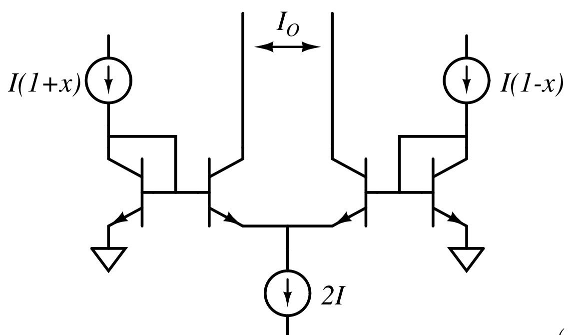
Finally, use the method of open circuit time constants to estimate the -3dB frequency for the circuit in part (a) only.



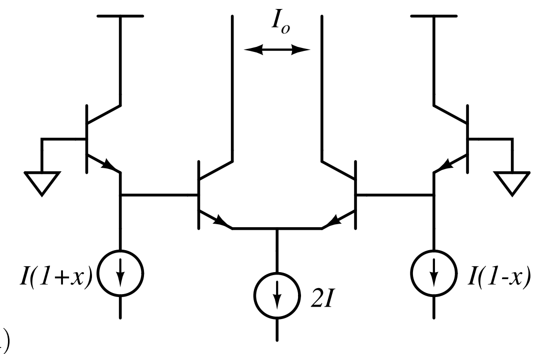
(a)



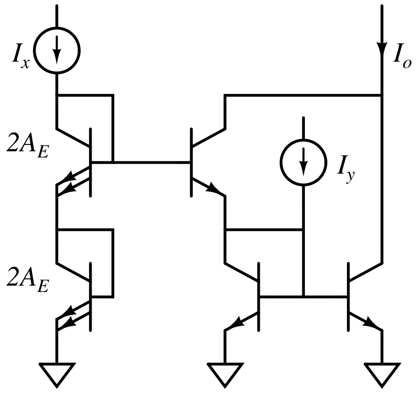
(b)



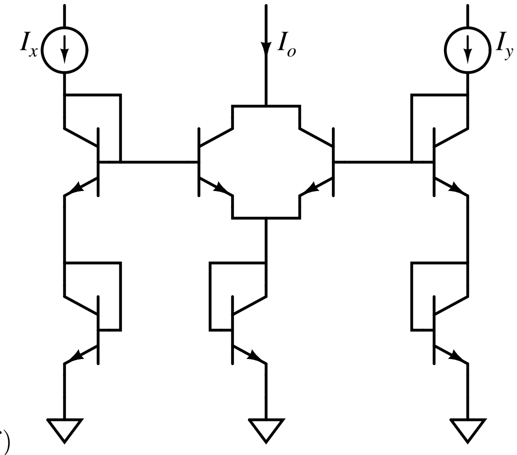
(c)



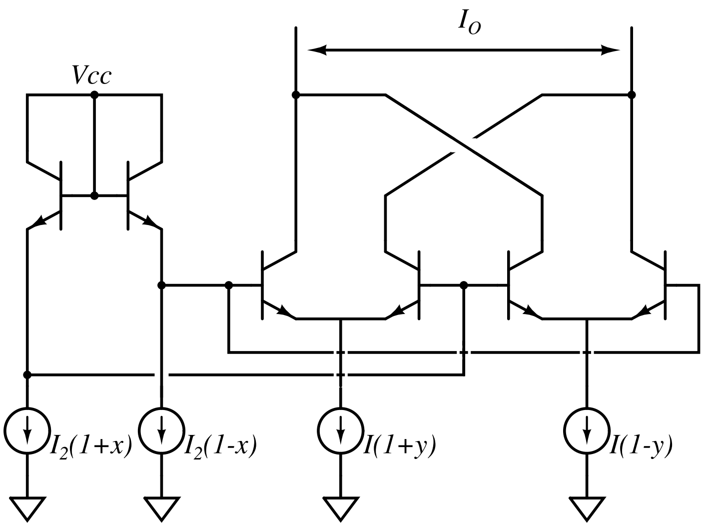
(d)



(e)



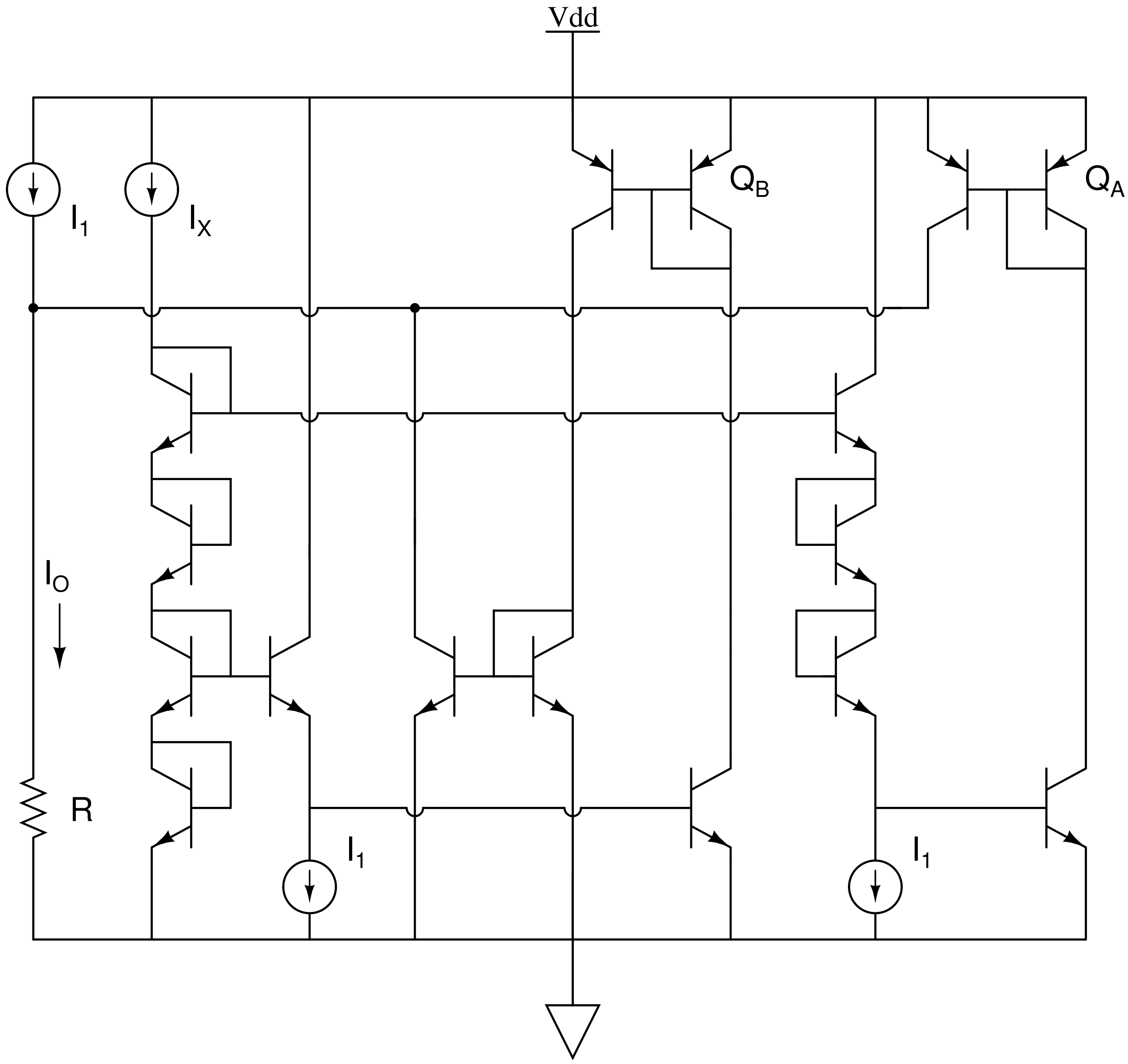
(f)



(g)

Problem 4: Find $I_o = f(I_x)$, assuming well-matched transistors, negligible base currents and I_1=1A. Also, assume Q_A and Q_B have respective emitter areas $24A_E$ and $2A_E$ while all other transistors have emitter area A_E.

What famous function does I_o approximate for small I_x?



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