PROBLEM SET #8

Issued: Tuesday, Nov. 3, 2015

Due (at 8 a.m.): Wednesday, Nov. 11, 2015, in the EE 140/240A HW box near 125 Cory.

1. Fig. PS8-1 presents a BJT op amp with output stage. For all transistors $|V_{BE}|$ = 0.7V, β = 100 and V_A = 200V.

(a) Determine the value of *R* such that Q_1 and Q_2 are biased with I_C = 100μA.

(b) Find the input resistance, output resistance, and voltage gain $v_o/(v_+ - v_-)$.

(c) Assuming $|V_{CEsat}| =$ 0.3V for all the transistors, find the input common-mode range

(d) For no load, what is the range of available output voltages?

(e) Assuming Q_1 or Q_2 are allowed to cut-off, find the smallest load resistance that can be driven over the range you found in part (d).

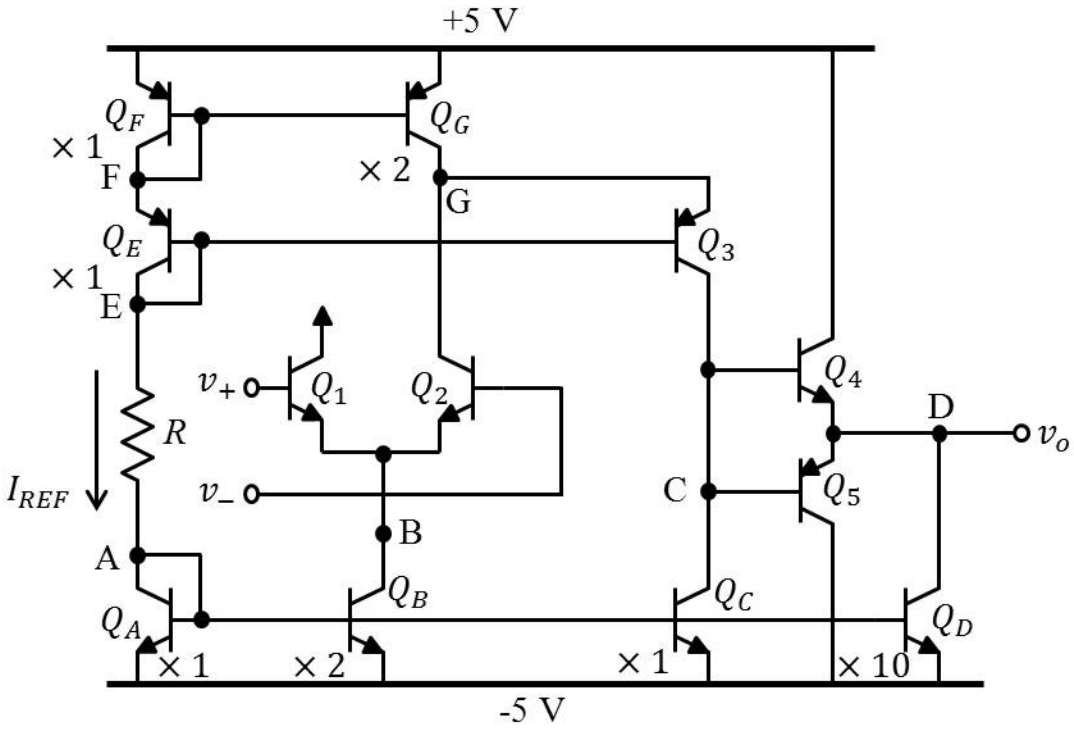

Fig. PS8-1

2. Fig. PS8-2 presents a BJT op amp with compensation capacitor C_C. All transistors have $\beta = 100$, $|V_{BE}| = 0.7\text{V}$, and $V_A = \infty$.

(a) Find the bias current I_C for each transistor.

(b) Find the voltage gain $v_o/(v_+ - v_-)$ of the amplifier with $R_L = 10\text{k}\Omega$.

(c) With R_L as in (b), find the value of C_C to obtain a 3-dB frequency of 100 Hz.

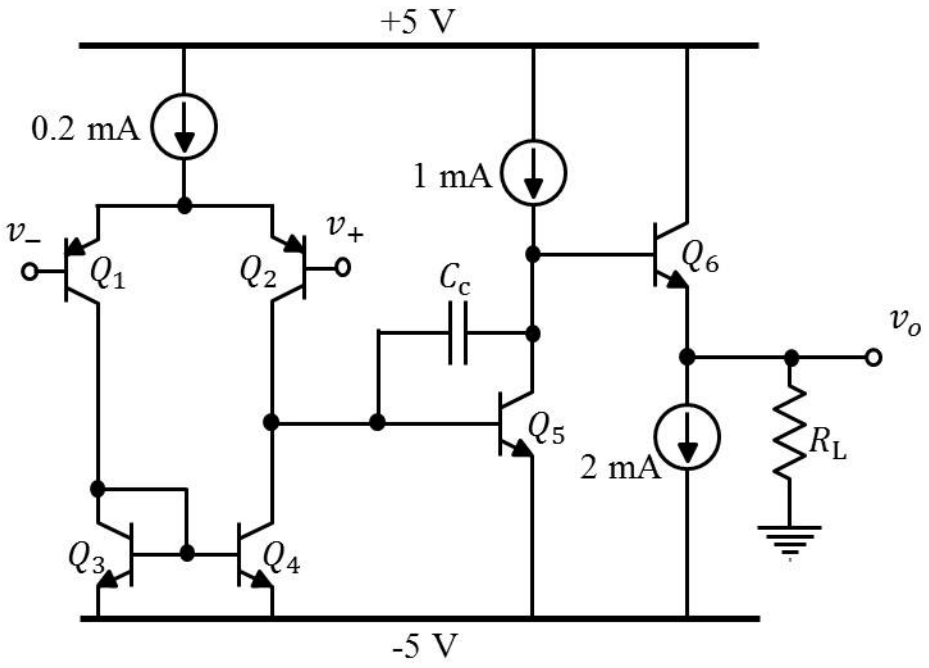

Fig. PS8-2

3. In the circuit of Fig. PS8-3, $(W/L)_{1\text{-}4}$=100μm/0.5μm, $C_1 = C_2 = 0.5\text{pF}$, $I_{SS} = 1\text{mA}$, $\mu_n = 350\text{cm}^2/\text{V/s}$, $\mu_p = 100\text{cm}^2/\text{V/s}$, $t_{ox} = 9\text{nm}$, $\varepsilon_r = 3.9$, $L_d = 0.08\mu\text{m}$, and $L_{eff} = L - 2L_d$.

(a) If a step voltage (as shown) is applied to the input of this circuit, find an expression for the time constant of its output response in terms of g_{m1-4}, r_{o1-4}, C_1 and C_2.

(b) What is the slew rate of this circuit?

(c) With a 1-V step at the input, how long does it take for I_{D2} to reach $0.1I_{SS}$? Before I_{D2} reaches $0.1I_{SS}$, you can assume that the current through C_1 and C_2 roughly equals I_{SS}.

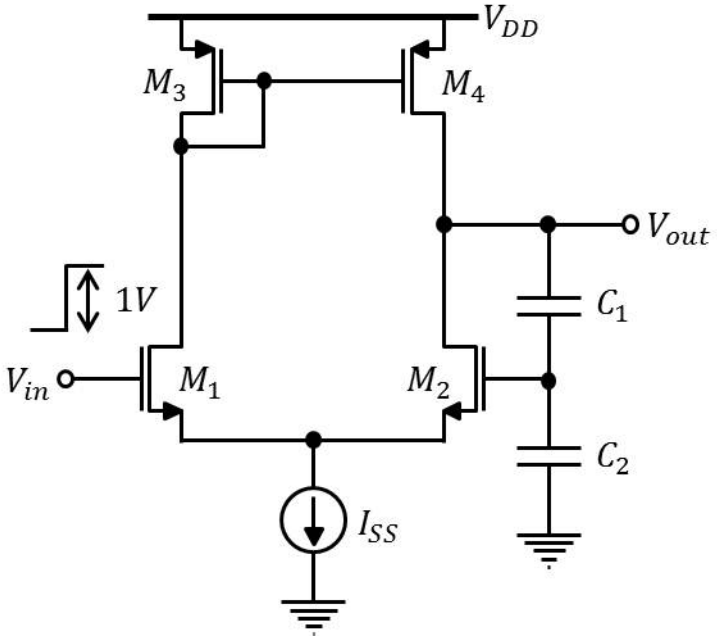

Fig. PS8-3

4. Write expressions for the low frequency closed-loop gains and poles of Fig. PS8-4 (a) and (b), where *A(s)* is the transfer function of a single pole amplifier (pole ω_{p1}) with a large low frequency gain of A_0.

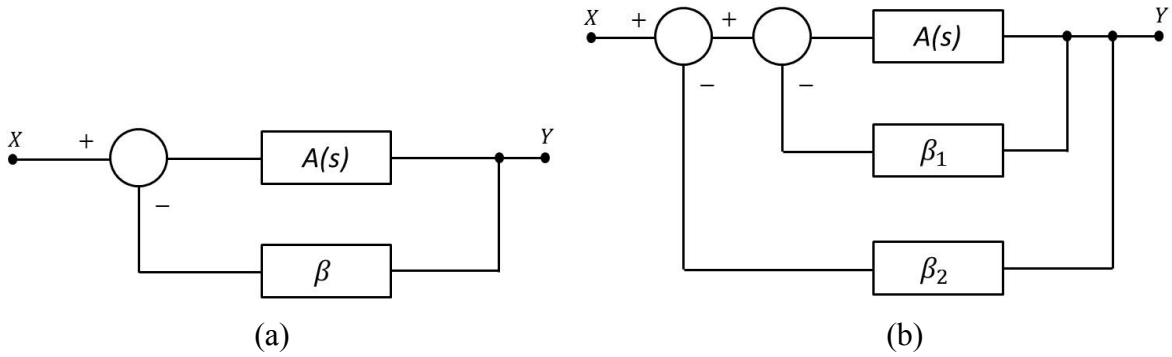

Fig. PS8-4