PROBLEM SET #6

Issued: Thursday, Feb.28, 2013

Due (at 8 a.m.): Friday, Mar. 8, 2013, in the EE 140/240A HW box near 125 Cory.

1. Consider the circuit of Fig. PS6.1, assuming $(W/L)_{1\text{-}3}$ = 40/0.5, I_{REF} = 0.3mA, λ = 0.02V^{-1}, K' = 138μA/V^2, L_D = 80nm, V_{TH0} = 0.7V, and γ = 0.

a. Determine V_b such that $V_X = V_Y$.

b. If V_b deviates from the value calculated in part (a) by 100mV, what is the ratio of I_{OUT} to I_{REF}?

c. If the circuit fed by the current source of Fig. PS6.1 changes V_P by 1V, how much do V_Y and I_{OUT} change.

d. Add a transistor to this circuit that will generate V_b to the gate of transistor M_3, while still ensuring that $V_X = V_Y$. Estimate the minimum output voltage V_P of this design.

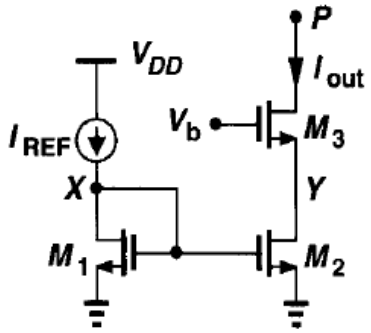

Figure PS6.1

2. The circuit of Fig. PS6.2 is designed with $(W/L)_{1,2}$ = 20/0.5, $(W/L)_{3,4}$ = 60/0.5, I_{REF} = 100μA, K' = 138μA/V^2, L_D = 80nm, V_{TH0} = 0.7V, λ = 0.02V^{-1}, 2Φ = 0.7V, and γ = 0.4V$^{1/2}$.

a. Determine V_X and the acceptable range of V_b that guarantees M_3 is biased in saturation.

b. Estimate the deviation of I_{OUT} from its nominal value if the drain voltage of M_4 is higher than V_X by 1V.

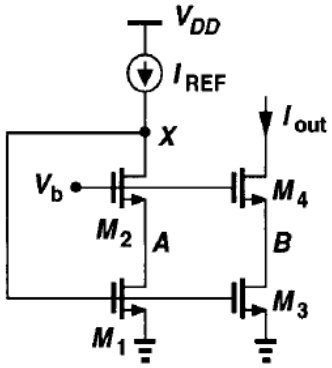

Figure PS6.2

3. Fig. PS6.3 shows a two-stage differential amplifier.

a. Calculate the DC operating points including the current flowing through each branch and DC voltage at each node. The DC value of the input nodes is set at zero. Calculate transistor small-signal parameters (i.e. g_m, r_o, C_π).

b. Draw the differential-mode and common-mode half-circuits for the amplifier and provide expressions and calculate the numerical values for the output resistance, R_{out}; gain, v_{out}/v_{in}; and high-frequency cut-off f_H.

BJT parameters:

$V_{BE(on)} = 0.7\text{V}$, $\beta = 100$, $V_A = 50\text{V}$, $V_{CC} = 6\text{V}$, $V_T = 25\text{mV}$,

$f_T = 600\text{MHz}$ at $I_C = 1\text{mA}$, $C_\mu = 0.2\text{pF}$, $C_{je} = 2\text{pF}$, $C_{cs} = 1\text{pF}$;

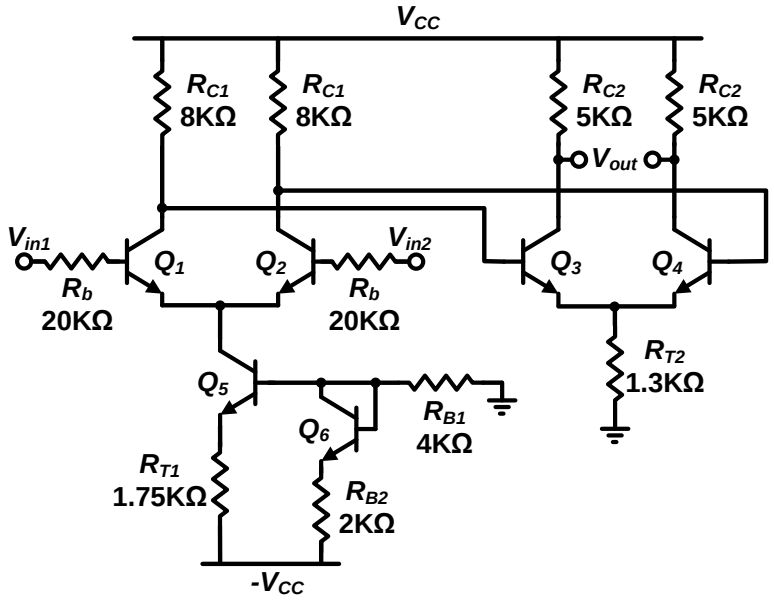

Fig. PS6.3

4. For the amplifiers shown in Fig. PS6.4, provide expressions for the gain, output resistance and high-frequency cut-off f_H, in terms of transistors small-signal parameters (i.e. g_m, g_{mb}, r_o, C_π, C_μ, C_{cs}, C_{gs}, C_{gd}, C_{db}, C_{sb}) for common-mode and differential-mode input.

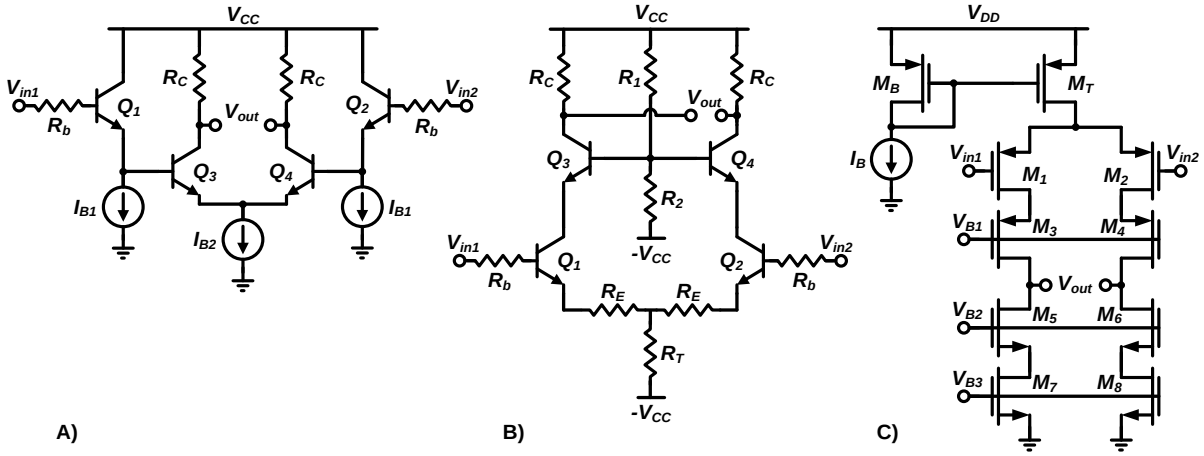

Fig. PS6.4