PROBLEM SET #1A

Issued: Wednesday, Feb. 27, 2013

Due (at 8 a.m.): Monday, Mar. 18, 2013, in the EE 140/240A HW box near 125 Cory.

1. Determine the value of sensitivity S of output current to supply voltage for the circuit in Fig. PSA1.1, where $S = (V_{CC}/I_{OUT})(\partial I_{OUT}/\partial V_{CC})$.

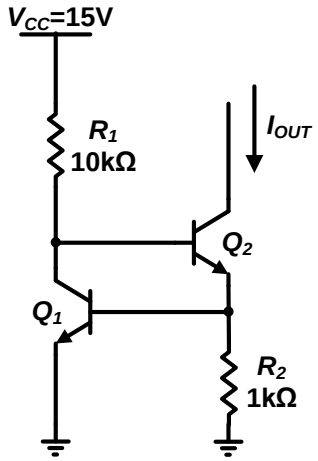

Fig. PSA1.1

2. For the circuit shown in Fig. PSA1.2, assume that $X_d = L_d = 0$, $(W/L)_2 > (W/L)_1$, and M_3 and M_4 are identical.

(a) Neglecting the body effect, calculate the bias current I_{BIAS} as a function of R, $\mu_n C_{ox}$, $(W/L)_1$, and $(W/L)_2$. Comment on how the bias current might vary with temperature.

(b) Calculate the ratio of small-signal variations in I_{BIAS} to small signal variations in V_{DD} at low frequencies. Ignore the body effect but include finite transistor r_o in this calculation.

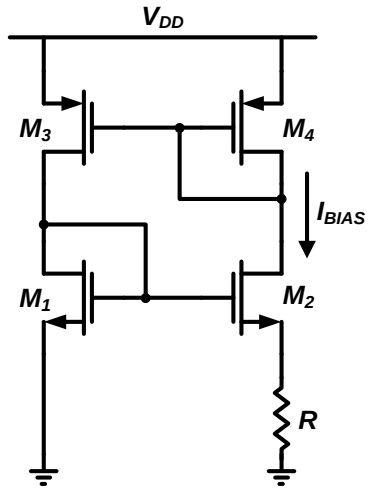

Fig. PSA1.2

3. A band-gap reference circuit is shown in Fig. PSA1.3. Assume that $\beta_F \rightarrow \infty$, $V_A \rightarrow \infty$, $I_{S1} = 1\times10^{-15}$ A, and $I_{S2} = 8\times10^{-15}$ A. Assume the opamp is ideal except for a possibly nonzero offset voltage V_{OS}.

(a) Suppose that R_2 is trimmed to set V_{OUT} equal to the target voltage for which $dV_{OUT}/dT = 0$ at $T = 25^oC$ when $V_{OS} = 0$. Find dV_{OUT}/dT at $T = 25^oC$ when $V_{OS} = 30$ mV.

(b) Under the conditions in part (a), is dV_{OUT}/dT positive or negative? Explain.

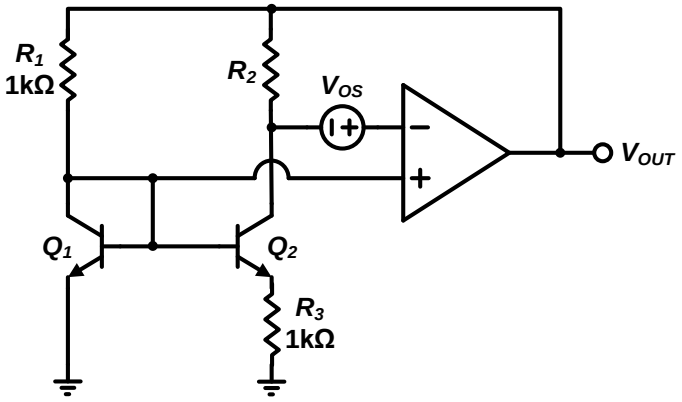

Fig. PSA1.3

4. For each of the bias reference circuits shown in Fig. PSA1.4, find the sensitivity of the bias current I_o to the supply voltage V_{CC}. For each case, give a numerical value and justification. Assume a temperature of 300K, neglect base currents, and use the data given below.

Transistors parameters:

$\beta = 100$, $r_b = 0\ \Omega$, $V_T = 26$ mV @ 300K, $V_A = 40$ V, $I_S = 10^{-17}$ A for 1X device.

Op Amp is ideal, with infinite gain and input resistance, and zero output resistance.

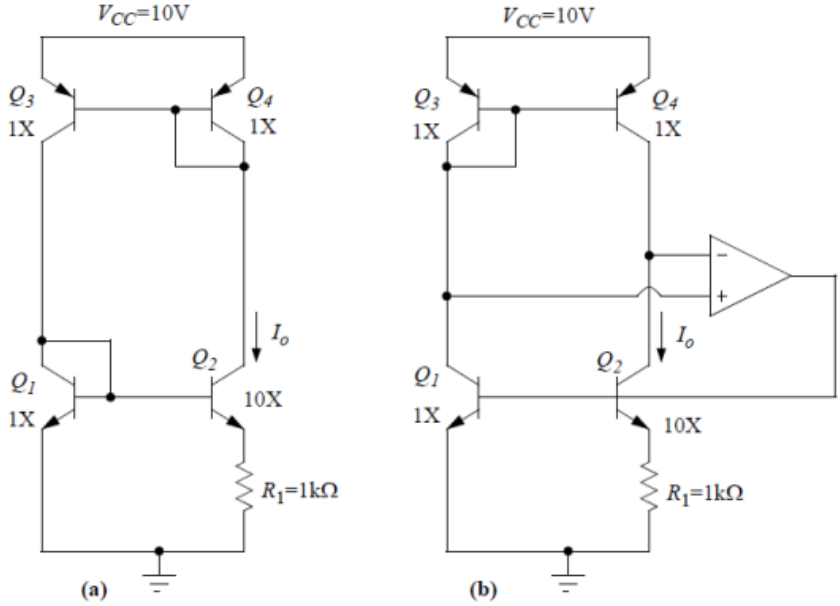

Fig. PSA1.4