PROBLEM SET #6

Issued: Tuesday, Feb.28, 2012

Due: Tuesday, March.6, 2012, 6:00 p.m. in the EE 140 homework box in 240 Cory

1. (a) For the two current mirror circuits shown in Fig. PS6.1-1, determine the size of M_4 to achieve the minimum output voltage $2V_{ov,\,M1}$. Then determine the I_{out} percent difference from I_{REF} for the two circuits when the output voltage is $2V_{ov,\,M1}$. Assume $\lambda \neq 0$, $\gamma = 0$.

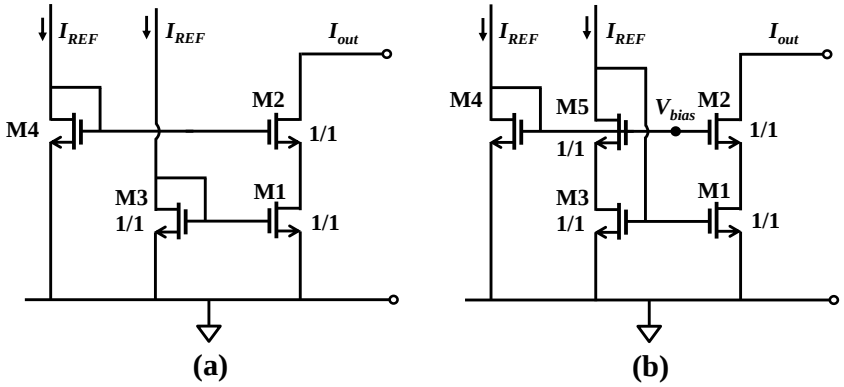


Fig. PS6.1-1

(b) A resistively-biased high-swing cascode current source with only one I_{REF} is shown in Fig. PS6.1-2(a). Determine all transistor sizes and the value of R_b in this circuit that yield $I_{out}=I_{REF}=250\mu A$ with a minimum output voltage $V_{OMIN}=0.5V$.Assume $V_{t0}=0.7V$, $k'=110\mu A/V^2$, $\gamma = 0.4$, $\lambda = 0$, $2|\varphi_f|=0.7$.

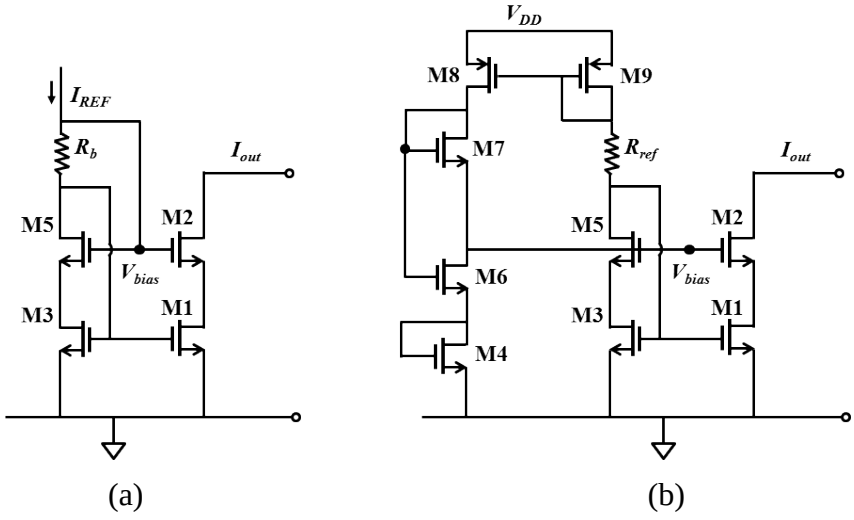


Fig PS6.1-2

(c) Fig. PS6.1-2(b) now presents a self-biased V_{bias} generator that generates its own I_{REF}. Determine the sizes of all transistors and the value of R_{ref} that yield $I_{out}=I_{REF}=250\mu A$ and a minimum output voltage $V_{OMIN}=0.5V$ for $V_{DD}=3V$. Assume $V_{t0,n}=0.7V$, $V_{t0,p}=-0.7V$, $k_n'=110\mu A/V^2$, $k_p'=50\mu A/V^2$, $\gamma = 0.4$, $\lambda = 0$, $2|\varphi_f|=0.7$ and $M_9=M_7=M_2=M_1$.

2. Consider the simple current mirror illustrated in Fig. PS6.2. Over the process, the absolute variations of physical parameters are as follows:

Width variation:	±5%
Length variation:	±5%
k' variation:	±5%
V_T variation:	±5mV

   Assume that the drain voltages are identical, what is the minimum and maximum output current measured over the process variations given above? Assume $k' = 110\mu A/V^2$.

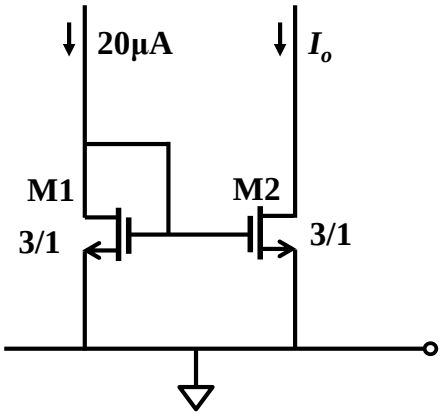


Fig. PS6.2

3. Draw the differential-mode and common-mode half-circuits for the differential amplifier in Fig. PS6.3. Use half-circuits to find the DC operating point, differential-mode gain, common-mode gain, and differential-mode input resistance for the amplifier if β_o = 100, V_{CC} = 20 V, V_{EE} = 20 V, I_{EE} = 100 μA, and R_{EE} = 600 kΩ ?

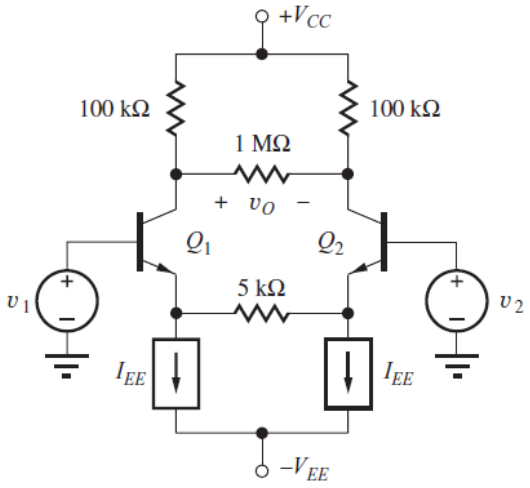
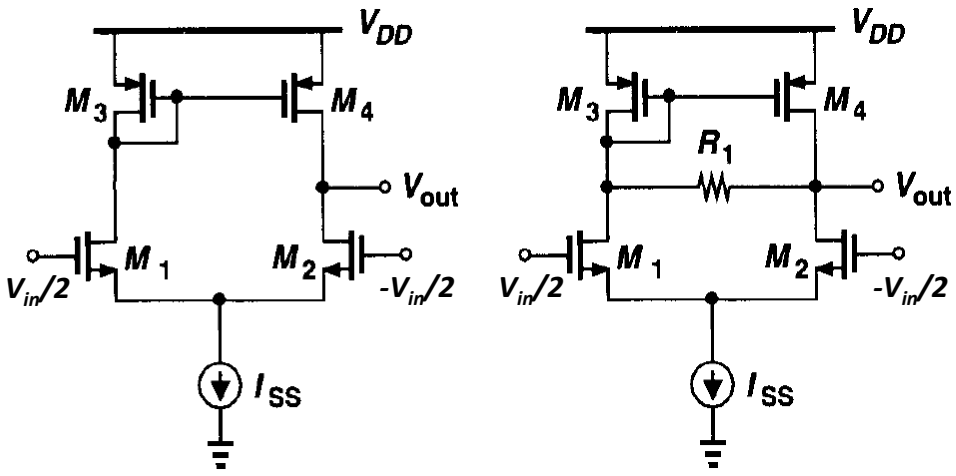


Fig. PS6.3

4. (a) For the single-ended output differential pair with active current mirror load in Fig. PS6.4(a), derive the differential gain: $A_d=g_{m1,2}(r_{o1,2} \| r_{o3,4})$, assuming $g_m r_o >> 1$.
   (b) Due to a manufacturing defect, a large parasitic resistance, R_1, has appeared in the circuit of Fig. 6.4(b). Determine an expression for the differential gain of this circuit.



(a) (b)

Fig. PS6.4