CMOS DESIGN CHALLENGE

16 JAN 2015

Guidelines:

1. You don't need to do any simulations to solve any of the questions
2. State any assumptions you make while solving the problems

Submissions are expected latest by 19 Jan, midnight in .pdf

1. In any CMOS analog system, current sources play a crucial role. Hence there is a need for current references to provide a constant current to the analog system. These current references are implemented by MOS Transistors in saturation. One such configuration is a Beta Multiplier Reference (BMR) shown in the circuit below.

I_{REF1} (through M1) and I_{REF2} (through M2) are the currents provided by the reference circuit. It can be seen that currents I_{REF1} and I_{REF2} could be kept constant if the MOSFETS are long channel devices as I_D does not depend on V_{DS} when output resistance of MOS is taken to be infinite. Such circuits offer V_{DD} independent currents as long as the V_{DD} is sufficient to maintain all the four MOS in saturation.

1. Add modifications to the circuit such that it maintains a constant current independent of V_{DD} even when M_1,M_2,M_3 and M_4 are short channel devices (r_0 in finite)
2. Qualitatively explain how the circuit works after it has been modified.

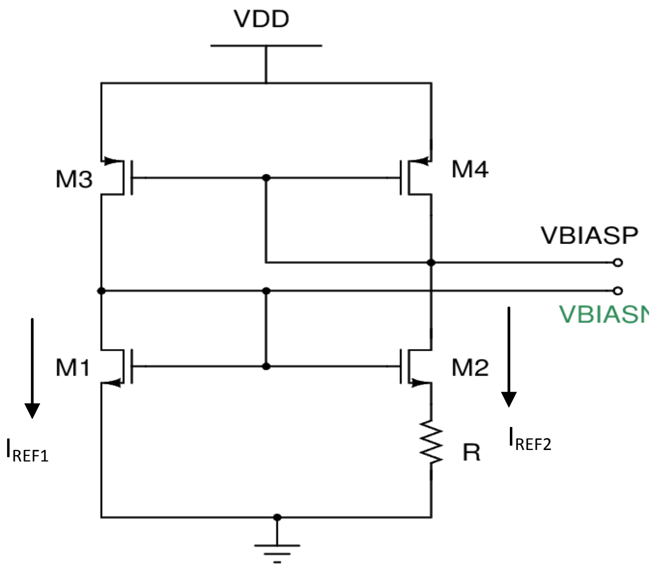

Figure 1: Beta Multiplier Reference

Assumptions to be made

$$I_D = \frac{\beta}{2}(V_{GS} - V_T)^2 \qquad \text{for long channel devices}$$

$$I_D = \frac{\beta}{2}(V_{GS} - V_T)^2(1 + \lambda V_{DS}) \quad \text{for short channel devices}$$

Hint: Modified circuit should try to maintain a constant $V_{DS.}$

2. Operational Amplifier Design.

Get the W/L ratios of the transistors M1-M8 in the figure below for the following specifications:

1. Gain ≥ 50 dB
2. 3-db Bandwidth ≥ 2 kHz
3. Unity gain bandwidth ≥ 3 MHz
4. Power ≤ 10 mW
5. C_L = 1 to 1.5 pF

Given :

$\mu_n C_{ox} = 120\mu A/V^2$

$\mu_p C_{ox} = 40\mu A/V^2$

V_{TN} = 800 mV

V_{TP} = 900 mV

V_{DD} = 5 V

$L_{min} = 1\mu m$

$\lambda n = 0.01\ V^{-1}$

$\lambda n = 0.0125\ V^{-1}$

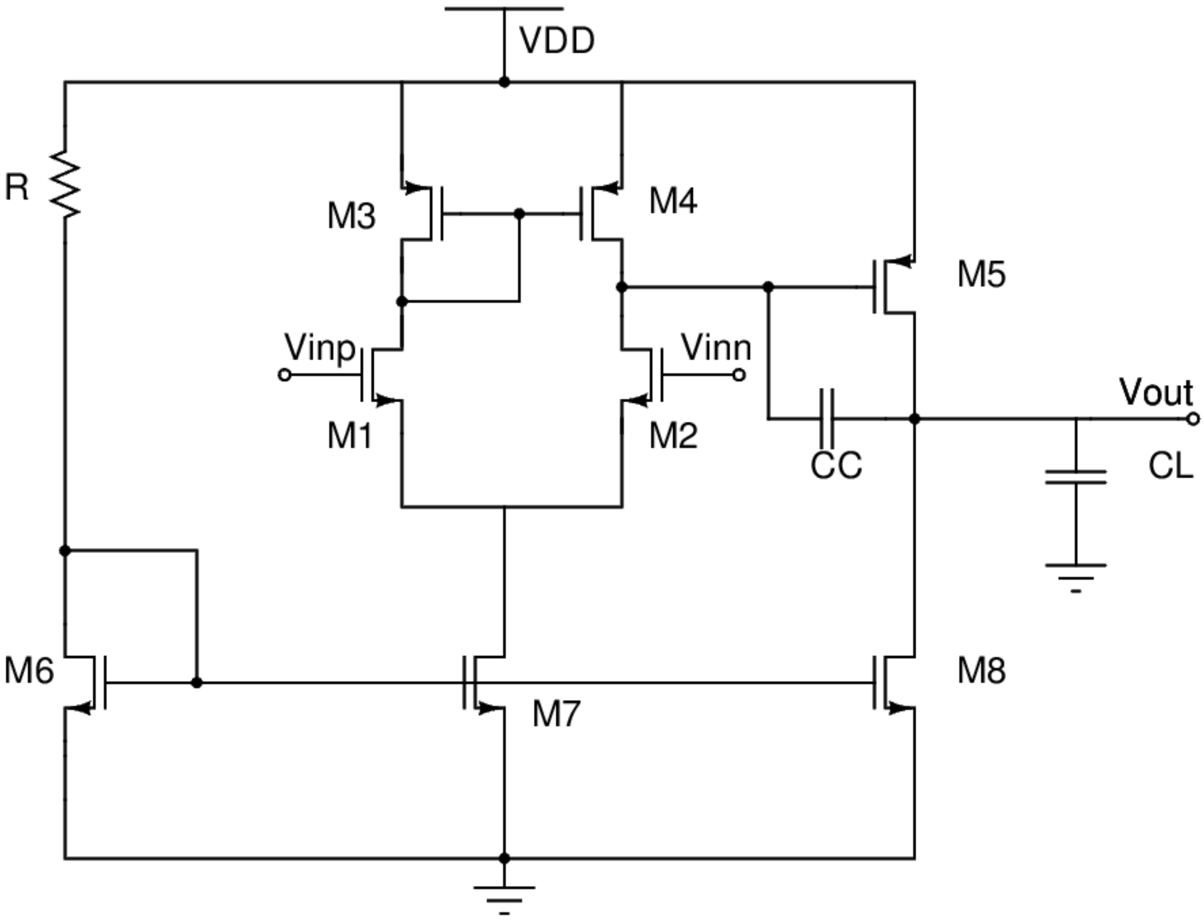

Figure 2: Opamp design