PROBLEM SET #10

Issued: Tuesday, April 14, 2009

Due: Tuesday, April 28, 2009, **8:00 p.m.** in the EE 140 homework box in 240 Cory

1. This problem concerns the CMOS operational amplifier shown in Fig. PS10-1.

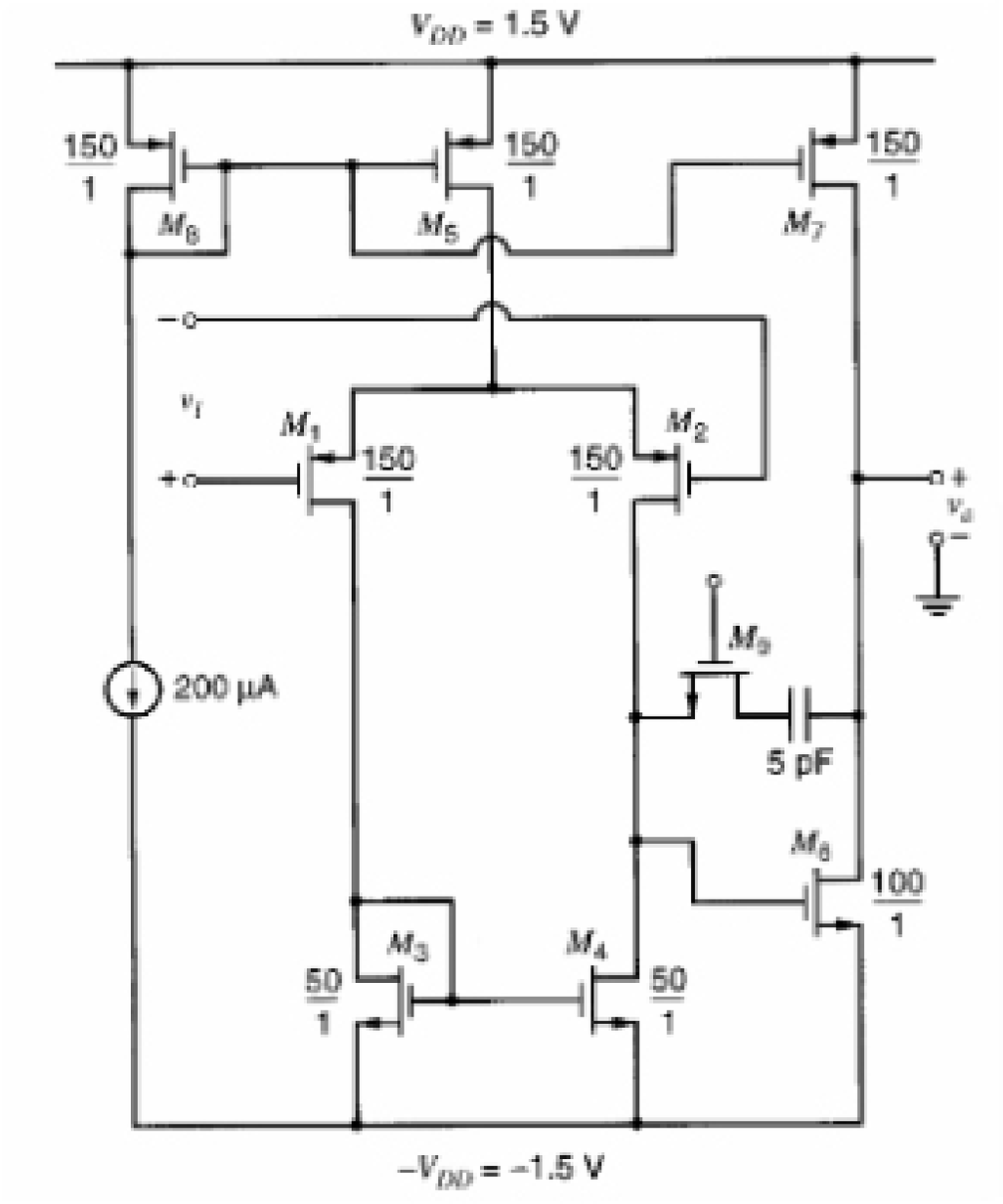

Figure PS10-1

Variable	NMOS	PMOS	Unit
X_d	0.1	0.1	μm
dX_d/dV_{ds}	0.02	0.04	μm/V
t_{ox}	80	80	A
μ	450	150	cm^2/V-s
V_T	0.7	0.7	V
γ	0	0	$V^{1/2}$

Table PS10-1

(a) Calculate the open-loop voltage gain, unity-gain bandwidth, and slew rate, for the circuit in Fig. PS10-1(a). Use the parameters of Table PS10-1. Assume that the gate of M_9 is connected to the positive power supply and that the W/L ratio of M_9 has been chosen to cancel the right half-plane zero. Compare your results with a SPICE simulation.

(b) If the circuit of Fig. PS10-1(b) is used to generate the voltage to be applied to the gate of M_9 in Fig. PS10-1(a), calculate the W/L ratio of M_9 required to move the right-half plane zero to infinity. Let V_{DD} = 1.5 V and I_5 = 200 μA. Use L = 1 um for all transistors, $W_{13} = W_{10}$ = 150 μm, and $W_{11} = W_{12}$ = 100 μm. Use Table PS10-1 for other parameters.

(c) Assuming that the zero has been moved to infinity, determine the maximum load capacitance that can be attached directly to the output of the circuit of Fig PS10-1(a) and still maintain a phase margin of 45°. Neglect all higher order poles except any due to the load capacitance. Use the value of W/L ratio obtained in part (b) for M_9 with the bias circuit of Fig. PS10-1(b). Ignore junction capacitance for all transistors. Use Table PS10-1 for other parameters.

2. The amplifier $a(s)$ has one real negative pole and is configured as an inverting feedback amplifier as shown in Fig. PS10-2.

(a) Calculate the DC gain of the amplifier $a(s)$ such that the static gain error of the feedback amplifier is 0.05%.

(b) Calculate the pole location such that the settling time is 10ns for 0.05% accuracy.

(c) If the open loop amplifier has a second pole that produces 60% phase margin for the feedback configuration in Figure 2, what is the new settling time? For this part you can use either analytical methods or numerical simulations.

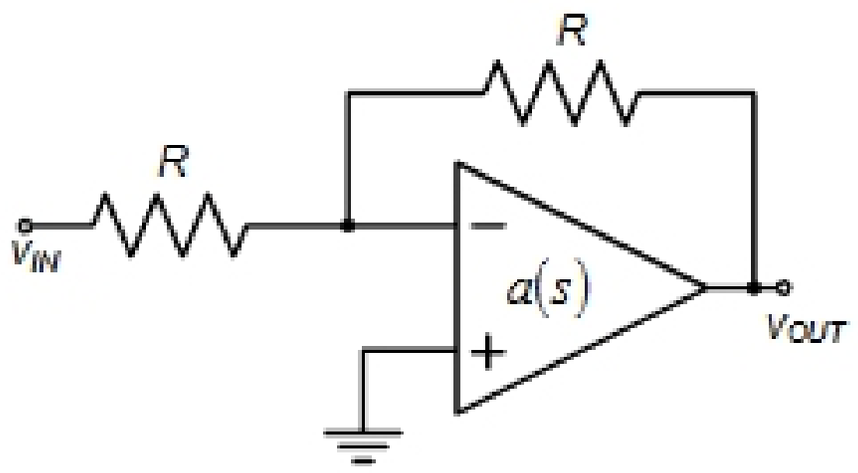

Figure PS10-2

3. Razavi, Chapter 10: Problem 10.9.

4. Razavi, Chapter 10: Problem 10.10.

5. Razavi, Chapter 9: Problem 9.3.