

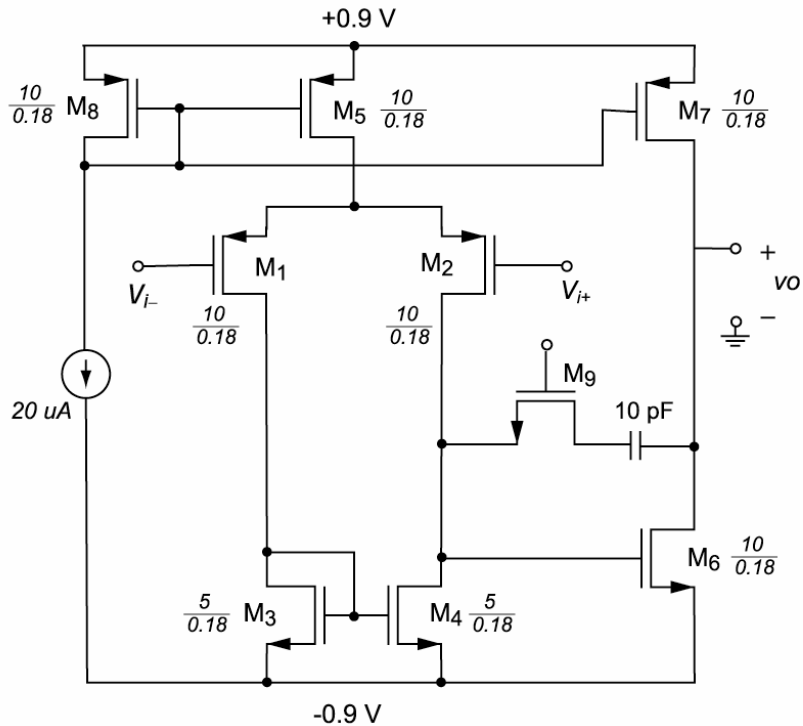
**UNIVERSITY OF CALIFORNIA AT BERKELEY**  
**College of Engineering**  
**Department of Electrical Engineering and Computer Science**

R. W. Brodersen,  
 S. Emami, and D. Sobel

**Homework #7**  
**(Due 11/24/04)**

**EECS140**  
**Fall 2004**

1. For the operational amplifier shown below:



- (a) Calculate the open-loop differential-mode voltage gain.
- (b) Calculate the unity-gain bandwidth.
- (c) Calculate the slew rate
- (d) Compare your results of (a)-(c) with HSPICE simulation results. Comment on the phase characteristics and close-loop stability of the amplifier.

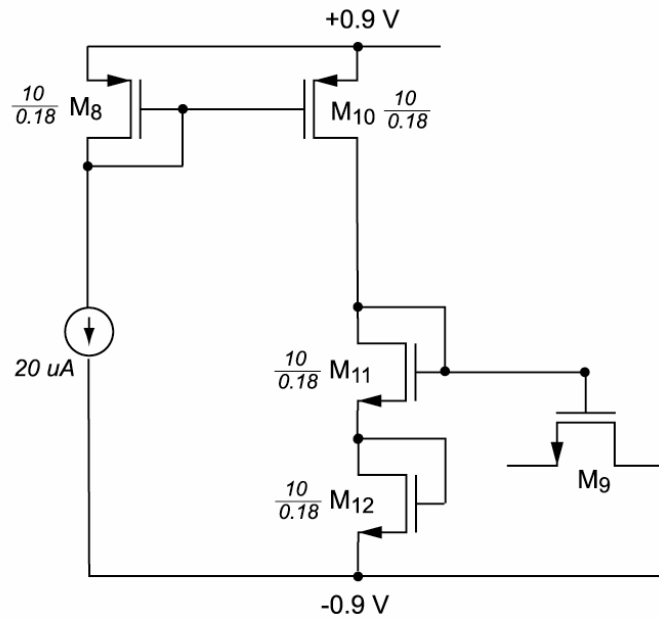
Assume that the gate of  $M_9$  is connected to the positive power supply, its bulk is tied to the negative power supply, and the  $W/L$  of  $M_9$  has been chosen to cancel the right-half-plane zero. Bulk terminal of all other transistors are connected to their respective source terminal. The Input sources have no dc voltage ( $V_{IC} = 0 V.$ ) and referred to the ground.

Use the following SPICE models. For any unspecified parameters, use the default values from HSPICE. Assume the lambda for layout rules is  $0.09 \mu\text{m}$ , and include the area and perimeter information for all transistors.

```
.model nch nmos level=1 tox=2.5n vto=0.5 kp=140e-6 lambda=0.1 gamma=0.5
+phi=0.6 capop=0 cgso=5e-10 cgdo=5e-10 cgbo=4e-10 cj=6e-4 cjsw=2e-10
```

```
.model pch pmos level=1 tox=2.5n vto=-0.5 kp=65e-6 lambda=0.15 gamma=0.5
+phi=0.6 capop=0 cgso=5e-10 cgdo=5e-10 cgbo=4e-10 cj=6e-4 cjsw=2e-10
```

2. If the circuit below is used to generate the voltage to be applied to the gate of transistor  $M_9$  of the operational amplifier of problem 1, calculate the  $W/L$  of  $M_9$  required to move the right-half-plane zero to infinity. Compare your results with HSPICE simulation results. Use the SPICE models of P#1 and tie the bulk of transistor  $M_{11}$  to the negative power supply.



3. Razavi 8.18 (page 288)

4. Razavi 8.19 (page 288)