

**Homework Assignment No. 1**

This homework assignment is due in class on Wednesday, January 19, 2005.

The following transistor parameters should be used unless otherwise stated.

**MOSFETS**

| MOSFET Parameter | n-channel | p-channel | units                    |
|------------------|-----------|-----------|--------------------------|
| $K'$             | 24        | 8         | $\mu\text{A}/\text{V}^2$ |
| $V_{T0}$         | 0.75      | -0.75     | V                        |
| $\gamma$         | 0.8       | 0.4       | $\text{V}^{0.5}$         |
| $\phi$           | 0.6       | 0.6       | V                        |
| $\lambda$        | 0.01      | 0.02      | $\text{V}^{-1}$          |

$$C_{\text{ox}} = 0.7\text{fF}/\mu\text{m}^2$$

$$\text{LD(NMOS)} = 0.45\mu\text{m}$$

$$\text{LD(PMOS)} = 0.6\mu\text{m}$$

$$n^+ \text{ diffusion to p-well (junction, bottom)} = 0.33\text{fF}/\mu\text{m}^2$$

$$n^+ \text{ diffusion sidewall (junction, sidewall)} = 0.9\text{fF}/\mu\text{m}$$

$$p^+ \text{ diffusion to substrate (junction, bottom)} = 0.38\text{fF}/\mu\text{m}^2$$

$$p^+ \text{ diffusion sidewall (junction, sidewall)} = 1.0\text{fF}/\mu\text{m}$$

$$n\text{-channel to bulk (junction, bottom)} = 0.1\text{fF}/\mu\text{m}^2$$

$$n\text{-channel to bulk (junction, sidewall)} = 0.3\text{fF}/\mu\text{m}$$

$$p\text{-channel to bulk (junction, bottom)} = 0.1\text{fF}/\mu\text{m}^2$$

$$p\text{-channel to bulk (junction, sidewall)} = 0.3\text{fF}/\mu\text{m}$$

**BJTS**

| BJT Parameter | NPN | PNP (lateral) | units |
|---------------|-----|---------------|-------|
| $\beta$       | 100 | 50            | A/A   |
| $V_t$         | 26  | 26            | mV    |
| $I_S$         | 10  | 10            | fA    |
| $\phi_B$      | 0.8 | 0.8           | V     |
| $V_{AF}$      | 100 | 50            | V     |

|              | $C_{jE0}$ | $C_{jC0}$ | $C_{jS0}$ | n   | $\phi_B$ | $t_F$ |
|--------------|-----------|-----------|-----------|-----|----------|-------|
| Vertical NPN | 100fF     | 1000fF    | 2000fF    | 0.5 | 0.8V     | 0.5ns |
| Lateral PNP  | 80fF      | 500fF     | 2000fF    | 0.5 | 0.8V     | 5ns   |

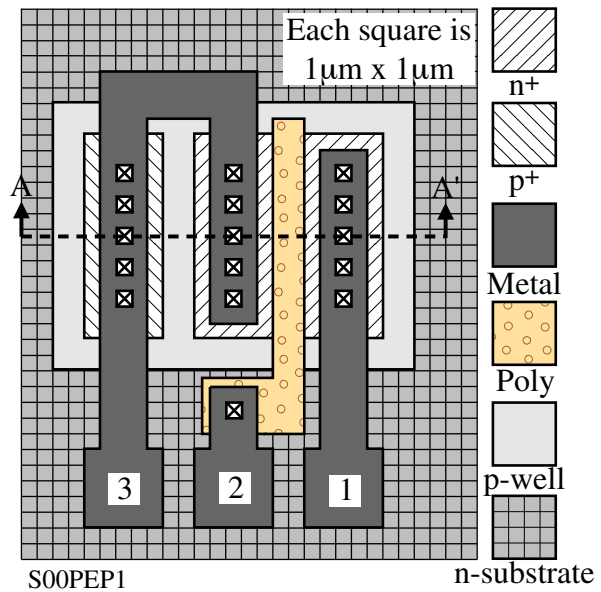
Problem 1 - (10 points)

A top view of a MOS transistor is shown.

(a) Identify the type of transistor (NMOS or PMOS) and its value of W and L.

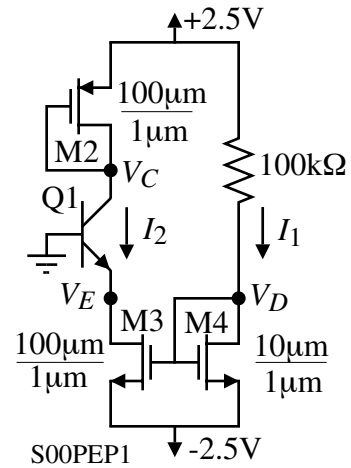
(b.) Draw the cross-section A-A' approximately to scale.

(c) Assume that dc voltage of terminal 1 is 5V, terminal 2 is 3V and terminal 3 is 0V. Find the numerical value of the capacitance between terminals 1 and 2, 2 and 3, and 1 and 3. Assume that the voltage dependence for pn junction capacitances is -0.5 (this is called MJ in SPICE).



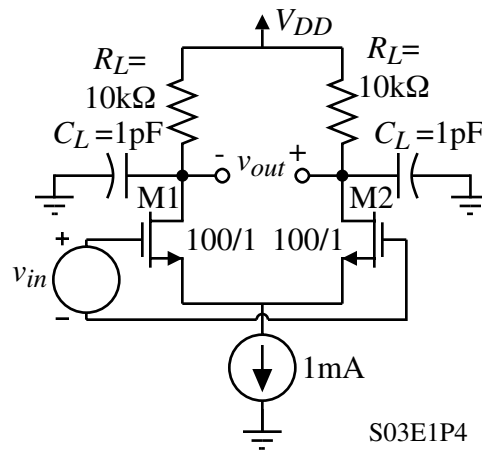
Problem 2 - (10 points)

Find the numerical values of  $I_1$ ,  $I_2$ ,  $V_D$ ,  $V_E$ , and  $V_C$  to within  $\pm 5\%$  accuracy.



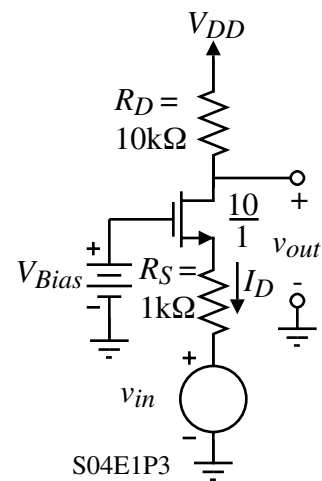
Problem 3 - (10 points)

Find the numerical values of all roots and the midband gain of the transfer function  $v_{out}/v_{in}$  of the differential amplifier shown. Assume that  $K_N' = 110\mu A/V^2$ ,  $V_{TN} = 0.7V$ , and  $\lambda_N = 0.04V^{-1}$ . The values of  $C_{gs} = 0.2pF$  and  $C_{gd} = 20fF$ .



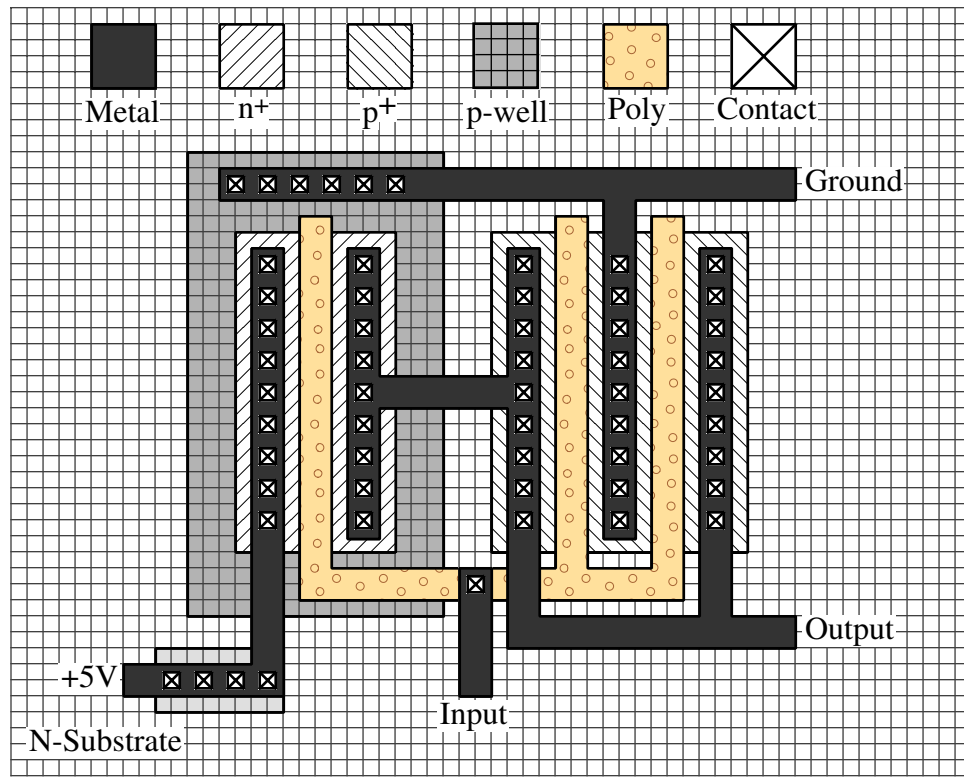
Problem 4 - (10 points)

Find the voltage transfer function of the common-gate amplifier shown. Identify the numerical values of the small-signal voltage gain,  $v_{out}/v_{in}$ , and the poles and zeros. Assume that  $I_D = 500\mu A$ ,  $K_N' = 100\mu A/V^2$ ,  $V_{TN} = 0.5V$ , and  $K_P' = 50\mu A/V^2$ ,  $V_{TP} = -0.5V$ ,  $\lambda \approx 0V^{-1}$ ,  $C_{gs} = 0.5pF$  and  $C_{gd} = 0.1pF$ .



Problem 5 - (10 points)

Draw the electrical schematic using the proper symbols for the transistors. Identify on your schematic the terminals that are +5V, ground, input, and output. Label the transistors on the layout as M1, M2, etc. and determine their W/L values. Assume each square in the layout is 1 micron by 1 micron. Find the area in square microns and periphery in microns for the source and drain of each transistor.



S01PEP1