VE320 Homework 8

In the following problems, assume the semiconductor and oxide in the MOS system are silicon and silicon dioxide, respectively, and assume the temperature is T=300 K unless otherwise stated.

1.

A p-channel MOSFET has the following parameters: $k_p' = 0.10$ mA/V^2, $W/L = 15$, and $V_T = -0.4$ V. Calculate the drain current I_D for (a) $V_{SG} = 0.8$ V, $V_{SD} = 0.25$ V; (b) $V_{SG} = 0.8$ V, $V_{SD} = 1.0$ V; (c) $V_{SG} = 1.2$ V, $V_{SD} = 1.0$ V; and (d) $V_{SG} = 1.2$ V, $V_{SD} = 2.0$ V.

2.

Consider a p-channel MOSFET with the following parameters: $k_p' = 0.12$ mA/V^2 and $W/L = 20$. The drain current is 100 μA with applied voltages of $V_{SG} = 0$, $V_{BS} = 0$, and $V_{SD} = 1.0$ V. (a) Determine the V_T value. (b) Determine the drain current I_D for $V_{SG} = 0.4$ V, $V_{SB} = 0$, and $V_{SD} = 1.5$ V. (c) What is the value of I_D for $V_{SG} = 0.6$ V, $V_{SB} = 0$, and $V_{SD} = 0.15$ V?

3.

An NMOS device has the following parameters: n$^+$ poly gate, $t_{ox} = 400$ Å, $N_a = 10^{15}$ cm^{-3}, and $Q_{ss}' = 5 \times 10^{10}$ cm^{-2}. (a) Determine V_T. (b) Is it possible to apply a V_{SB} voltage such that $V_T = 0$? If so, what is the value of V_{SB}?

4.

Consider an ideal n-channel MOSFET with a width-to-length ratio of $(W/L) = 10$, an electron mobility of $\mu_n = 400$ cm^2/V-s, an oxide thickness of $t_{ox} = 475$ Å, and a threshold voltage of $V_T = +0.65$ V. (a) Determine the maximum value of source resistance so that the saturation transconductance g_{ms} is reduced by no more than 20 percent from its ideal value when $V_{GS} = 5$ V. (b) Using the value of r_s calculated in part (a), how much is g_{ms} reduced from its ideal value when $V_{GS} = 3$ V?

5.

Assume that the subthreshold current of a MOSFET is given by

$$I_D = 10^{-15} \exp\left(\frac{V_{GS}}{(2.1)V_t}\right)$$

over the range $0 \le V_{GS} \le 1$ volt and where the factor 2.1 takes into account the effect of interface states. Assume that 10^6 identical transistors on a chip are all biased at the same V_{GS} and at $V_{DD} = 5$ V. (a) Calculate the total current that must be supplied to the chip at $V_{GS} = 0.5, 0.7,$ and 0.9 V. (b) Calculate the total power dissipated in the chip for the same V_{GS} values.

6.

A silicon MOSFET has parameters $N_a = 4 \times 10^{16}$ cm^{-3}, $t_{ox} = 12$ nm $= 120$ Å, $Q'_{ss} = 4 \times 10^{10}$ cm^{-2}, and $\phi_{ms} = -0.5$ V. The transistor is biased at $V_{GS} = 1.25$ V and $V_{SB} = 0$. (a) Calculate ΔL for (i) $\Delta V_{DS} = 1$ V, (ii) $\Delta V_{DS} = 2$ V, and (iii) $\Delta V_{DS} = 4$ V. (b) Determine the minimum channel length L such that $\Delta L/L = 0.12$ for $V_{GS} = 1.25$ V and $\Delta V_{DS} = 4$ V.

7.

Consider an n-channel silicon MOSFET. The parameters are $k'_n = 75$ μA/V^2, $W/L = 10$, and $V_T = 0.35$ V. The applied drain-to-source voltage is $V_{DS} = 1.5$ V. (a) For $V_{GS} = 0.8$ V, find (i) the ideal drain current, (ii) the drain current if $\lambda = 0.02$ V^{-1}, and (iii) the output resistance for $\lambda = 0.02$ V^{-1}. (b) Repeat part (a) for $V_{GS} = 1.25$ V.

8.

The initial parameters of an n-channel MOSFET are $k'_n = 0.15$ mA/V^2, $L = 1.2$ μm, $W = 6.0$ μm, and $V_T = 0.45$ V. The device operates over a voltage range of 0 to 3 V. Assume a constant-field scaling factor of $k = 0.65$, but assume the threshold voltage is constant. (a) Determine the maximum drain current in the (i) original device and (ii) scaled device. (b) Determine the maximum power dissipation in the (i) original device and (ii) scaled device.

9.

The parameters of an n-channel MOSFET are $N_a = 2 \times 10^{16}$ cm^{-3}, $L = 0.70$ μm, and $t_{ox} = 8$ nm $= 80$ Å. The diffused junction radius is $r_j = 0.30$ μm. The designed threshold voltage is to be $V_T = 0.35$ V taking into account the shift due to short-channel effects. What is the equivalent long-channel threshold voltage?

10.

An n-channel MOSFET has parameters of $N_a = 3 \times 10^{16}$ cm^{-3}, $W = 2.2$ μm, and $t_{ox} = 8$ nm $= 80$ Å. Neglecting short-channel effects, calculate the shift in threshold voltage due to narrow-channel effects. Assume the fitting parameter is $\xi = \pi/2$.