ECEn 450, Winter 2010
Homework # 13
Due April 6, 5:00 pm

From the text Semiconductor Devices, Physics and Technology, do the following problems:

Chapter 6, problems 24, 25

Chapter 10, problem 19

Also complete the following problems:

13.1 Assume that the subthreshold current of a MOSFET is given by

$$I_D = 10^{-15}\exp(V_{GS}/2.1xV_T)$$

over the range $0 \leq V_{GS} \leq 1$ 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 $V_{DD} = 5$ volts. (a) Calculate the total current that must be supplied to the chip at $V_{GS} = 0.5$, 0.7, and 0.9 volts. (b) Calculate the total power dissipated in the chip for the same V_{GS} values.

13.2 Apply constant-field scaling to the ideal current-voltage relations in both the saturation and nonsaturation bias regions. (a) How does the drain current scale in each bias region? (b) How does the power dissipation per device scale in each bias region?

13.3 Consider an n-channel MOSFET with $N_A = 10^{16}$ cm^{-3} and $t_{ox} = 45$ nm. If $r_j = 0.3$ microns and L = 1 micron, determine the threshold shift due to the short channel effect.

13.4 An n-channel MOSFET is doped to $N_A = 3 \times 10^{16}$ cm^{-3} and has an oxide thickness of $t_{ox} = 80$ nm. The diffused junction radius is $r_j = 0.60$ microns. If the threshold shift due to short-channel effects is to be no more than $\Delta V_T = -0.20$ volts, determine the minimum channel length L.