

**ECEn 450, Winter 2010**  
**Homework # 14**  
**Due April 13, 5:00 pm**

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

Chapter 6, problems 30, 31

Chapter 14, problem 8

Also complete the following problems:

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

14.2 An n-channel MOSFET has the following parameters:

$$\begin{array}{ll} \mu_n = 400 \text{ cm}^2/\text{V}\cdot\text{s} & t_{\text{ox}} = 50 \text{ nm} \\ L = 2 \text{ microns} & W = 20 \text{ microns} \\ V_T = +0.75 \text{ V} & \end{array}$$

Assume the transistor is biased in the saturation region at  $V_{\text{GS}} = 4 \text{ V}$ . (a) Calculate the ideal cutoff frequency. (b) Assume that the gate oxide overlaps both the source and drain contacts by 0.75 microns. If a load resistance of  $R_L = 10 \text{ k}\Omega$  is connected to the output, calculate the cutoff frequency. (Hints: the load resistance will essentially be the  $R_{\text{ds}}$  resistance for the transistor. The overlap of the gate with the drain creates the  $C_{\text{gd}}$  that goes into the calculation of the Miller capacitance. In saturation,  $C_{\text{gs}}$  is essentially just  $C_{\text{ox}}$ .)

14.3 A MOSFET has the following parameters:  $n^+$  poly gate,  $t_{\text{ox}} = 8 \text{ nm}$ ,  $N_D = 10^{17} \text{ cm}^{-3}$ , and  $Q'_{\text{SS}} = 5 \times 10^{10} \text{ cm}^{-2}$ . (a) What is the threshold voltage of this MOSFET? Is the device enhancement or depletion mode? (b) What type of implant and dose are required such that  $V_T = 0$ ?