Department of Electrical and Computer Engineering, Cornell University

ECE 3150: Microelectronics

Spring 2016

Homework 6 **Due on March 10, 2016 at 7:00 PM**

Suggested Readings:

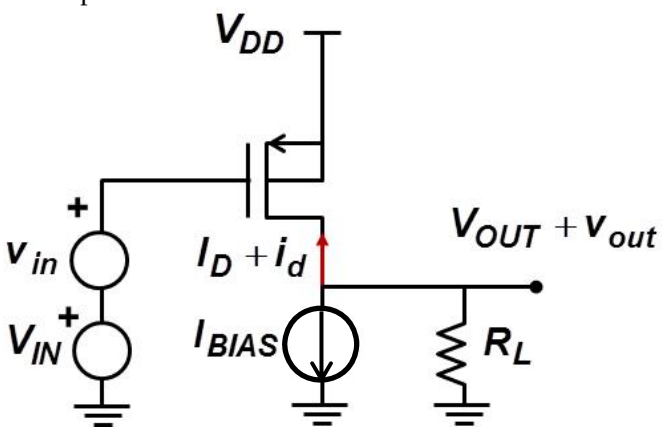
a) Lecture notes

Important Notes:

1) MAKE SURE THAT YOU INDICATE THE UNITS ASSOCIATED WITH YOUR NUMERICAL ANSWERS. OTHERWISE NO POINTS WILL BE AWARDED.
2) Unless noted otherwise, always assume room temperature.

Problem 5.1: (A PFET Amplifier driving a load)

Consider the following PFET amplifier circuit:



Assume:

$W = 150\ \mu\text{m}$
$L = 15\ \mu\text{m}$
$\mu_p C_{ox} = 50\ \mu A/V^2$
$\lambda_p = .067\ 1/V$
$V_{DD} = 2.5\,V$
$R_L = 10\ \text{k}\Omega$
$I_{BIAS} = 100\mu\text{A}$
$V_{TP} = -0.5\,V$

a) What should be the value of V_{IN} such that $V_{OUT} = 0\,V$?

b) Draw a small signal model of the entire circuit.

c) Find and expression for and calculate the numerical value of the small signal gain at the bias value calculated in part (a):

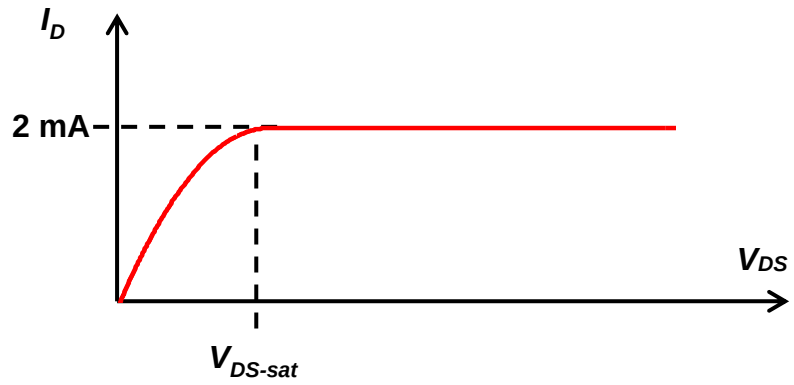
$$A_v = \frac{v_{out}}{v_{in}} = ?$$

d) What are the maximum and minimum values of the output voltage such that the PFET remains in saturation?

e) What are the maximum and minimum values of the input voltage such that the PFET remains in saturation?

Problem 5.2: (A NFET former exam problem)

A NFET (of unknown gate material) has the $I_D - vs - V_{DS}$ curve shown below for $V_{GS} = 4\,V$ and $V_{BS} = 0\,V$. The threshold voltage V_{TN} of the device is 1 V when $V_{BS} = 0\,V$.



Assume:

$W = 25\ \mu\text{m}$

$L = 10\ \mu\text{m}$

$\varepsilon_{ox} = 3.45 \times 10^{-13}$ F/cm

$t_{ox} = 10^{-6}$ cm

$\lambda_n = 0$

$N_a = 10^{17}\ 1/\text{cm}^3$

a) What is the drain-to-source voltage at which the device saturates when $V_{GS} = 4\,V$?

b) What is the electron mobility (cm^2/V-s) in the channel?

c) What is the inversion layer sheet charge density (in C/cm^2) in the FET channel at the source end when $V_{GS} = 4\,V$ and $V_{DS} = 1V$ and $V_{BS} = 0\,V$?

d) What is the inversion layer sheet charge density (in C/cm^2) in the FET channel at the drain end when $V_{GS} = 4\,V$ and $V_{DS} = 1V$ and $V_{BS} = 0\,V$?

e) For the same bias conditions as in parts (c) and (d), what is the drift velocity of electrons (cm/s) near the source end?

f) For the same bias conditions as in parts (c) and (d), what is the drift velocity of electrons (cm/s) near the source end?

g) What is the inversion layer sheet charge density (in C/cm^2) in the FET channel at the source end when $V_{GS} = 4\,V$ and $V_{DS} = 5\,V$ and $V_{BS} = 0\,V$?

h) What is the inversion layer sheet charge density (in C/cm^2) in the FET channel at the drain end when $V_{GS} = 4\,V$ and $V_{DS} = 5\,V$ and $V_{BS} = 0\,V$?

i) Now suppose $V_{GS} = 4\,V$ and $V_{DS} = 5\,V$ and $V_{BS} = -5\,V$. Find the FET current (in Amps).