# EECS 105 – Microelectronic Devices and Circuits

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### Homework Assignment # 4, Due February 16, 2001

Unless stated otherwise, use the following parameters in the problems
n-channel MOSFET:

$\mu_n C_{ox}$=50μA/V$^2$, $V_{TOn}$=1.0V, $\gamma_n$=0.6V$^{1/2}$, $\lambda_n$=(0.1/L)V$^{-1}$ *(L in μm)*, $\phi_p$=-0.42V

p-channel MOSFET:

$\mu_p C_{ox}$=25μA/V$^2$, $V_{TOp}$=-1.0V, $\gamma_p$=0.6V$^{1/2}$, $\lambda_p$=(0.1/L)V$^{-1}$ *(L in μm)*, $\phi_n$=0.42V

**4.1 PN Junction**

For a PN junction with $N_d=10^{15}$cm$^{-3}$ and $N_a=10^{17}$cm$^{-3}$

a) calculate the built-in potential $\phi_B$ of the PN junction
b) calculate the junction depth in thermal equilibrium
c) Derive the relationship between the junction depth and the applied reverse voltage, assuming that all of the voltage is dropped on the low doping side

**4.2 MOSFET Characteristics**

For MOSFETs (a), (b), (c), (d) with terminal voltages in Figure 4.2, determine (1) the operating region (cutoff, triode, or saturation) and (2) the drain current $I_D$.

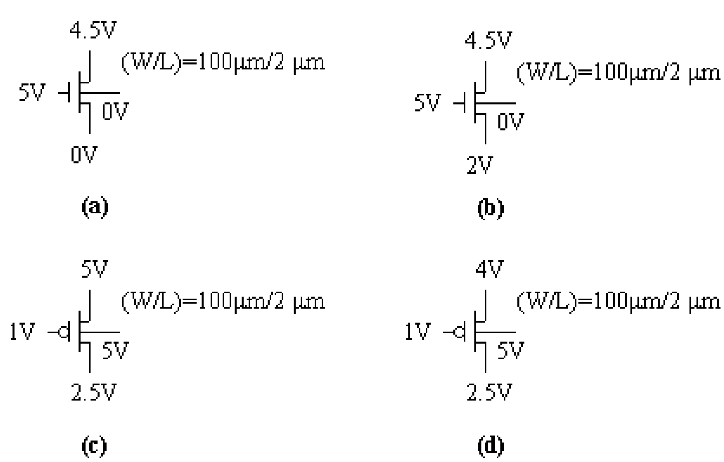
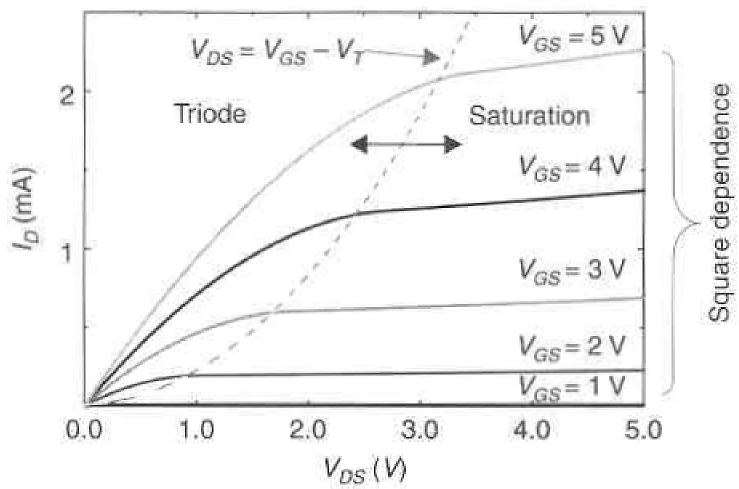



Figure 4.2

**4.3 MOS Parameter Estimation**

Consider the I-V characteristics of a NMOS transistor (W=100μm, L=20μm). Estimate the algebraic parameter ***KP*** in the SPICE model equations (pp 239)

a) Estimate KP from slope at $V_{ds}$=0V
b) Estimate KP from data with $V_{ds}=V_{ds\_max}$ =5V




**4.4 Large Signal Model v.s. Small Signal Model**

Consider an amplifier with a resistive load

a) Find an expression for the large signal voltage $V_{out}$, assuming the MOSFET is in the triode region
b) If $V_{in}$=3V, find $V_{out}$ and $I_{out}$ (current flow through the MOSFET)
c) Linearize the resulting equation to find $\Delta V_{out}/\Delta V_{in}$ ($V_{in}=V_{in0}+/\Delta V_{in}$, $V_{out}=V_{out0}+/\Delta V_{out}$, ignore products such as $\Delta V_{out}\times\Delta V_{in}$)
d) Instead linearize MOS equation alone to get model in Figure 4.22, find $g_m$, and $r_o$
e) Substitute the model in d) for the MOS circuit symbol and solve for small signal $V_{out}/V_{in}$