Department of Electrical Engineering
Indian Institute of Technology, Kanpur

EE 210 **Assignment #3** **Assigned: 28.1.25**

1. Assume an n-channel MOSFET (NMOS) is operated with its source grounded. Device specification: V_{TN0} = 1 V, $2\phi_F$ = 0.6 V, and γ = 0.4 $V^{1/2}$. Determine its threshold voltage V_{TN}, with the body tied to i) ground, ii) –1 V, and iii) –5 V. What would happen if the body were tied to a positive potential?

2. An NMOS has the following specifications: V_{TN0} = 0.7 V, k'_N = 40 μA/V^2, W = 20 μm, and L = 1 μm. Neglect body effect.
   a) Neglecting λ, determine the drain current if V_{GS} = 2 V and V_{DS} is i) 1 V and ii) 5 V.
   b) Now assume λ = 0.1 V^{-1}, and repeat part a).

3. An NMOS has the following specifications: V_{TN0} = –1 V, k'_N = 40 μA/V^2, W = 20 μm, L = 1 μm, $2\phi_F$ = 0.6 V, and γ = 0.4 $V^{1/2}$. It is operated with its gate and source tied together at ground potential, the drain at 0.5 V, and the body connected to a variable voltage source V_B. Neglect channel length modulation effect.
   a) If V_B = 0 V, state with justification whether the device is operating in the non-saturation or saturation mode. Determine the drain current for this case.
   b) Now, if V_B is varied, then determine the value of V_B, at which the change over of the mode of operation will take place, i.e., it will change from non-saturated to saturated or vice versa. What is the drain current at this change over point?
   c) Also, determine the value of V_B at which the drain current would go to zero.

4. An NMOS transistor has parameters W = 10 μm, L = 1 μm, k'_N = 194 μA/V^2, λ = 0.024 V^{-1}, t_{ox} = 8 nm, ϕ_F = 0.3 V, V_{TN0} = 0.6 V, and $N_A = 5 \times 10^{15}$ cm^{-3}. Derive and sketch the complete small-signal equivalent circuit for this device with V_{GS} = 1 V, V_{DS} = 2 V, and V_{SB} = 1 V. Use V_0 = 0.7 V, and $C_{sb0} = C_{db0}$ = 20 fF. Overlap capacitance from gate to source and gate to drain is 0.2 fF/μm.

5. Use the device data of Problem 4 to calculate the frequency of unity current gain of this transistor with V_{DS} = 3 V, V_{SB} = 0 V, and V_{GS} = 1 V, 1.5 V, and 2 V. Also, for each case, determine the theoretically possible maximum value of f_T.