VLSI Design : Quiz-1

Monsoon 2024, IIIT Hyderabad (Instructor: Prof. Abhishek Srivastava)

Date : 28^{th} Aug, 2024, Duration : 1 Hour, Max. Marks : 10

Instructions:

- Clearly write your assumptions (if any)
- Use of own hand-written notes on 1 A4 sheet (both sides) is allowed
- Calculators are allowed

1. Derive the input voltage expression for which the static current drawn by the CMOS inverter is maximum? Given: $K_n = K_p$ (where, $K = \mu C_{ox}\frac{W}{L}$), V_{T_n} = 0.55 V, V_{T_p} = -0.65 V, $\mu_n C_{ox}$ = 220 μA/V^2, $(\frac{W}{L})_n$ = 10. What is the value of this maximum current for the given parameters? [2]

2. Consider a CMOS inverter. You are given that VDD = 3.0 V, V_{T_n} = 0.5 V, V_{T_p} = -0.7 V, μ_n = 450 cm^2/Vs, and μ_p = 250 cm^2/Vs. The n and p channel transistors have the same channel length and gate oxide capacitance per unit area and overall capacitance at inverter output is C_L.

   (a) Derive the expression for the time (τ_r) taken to charge the output from 0 V to $VDD - |V_{T_p}|$ with the input voltage equal to V_{T_n} for which n channel transistor is considered as off. [3]

   (b) Derive the expression for the time (τ_f) taken to discharge the output from VDD to V_{T_n} with the input voltage equal to $VDD - |V_{T_p}|$ for which p channel transistor is considered as off. [3]

   (c) Find the ratio $\frac{W_p}{W_n}$ such that $\tau_r = \tau_f$. [2]

   Hints:

   i. Identify the mode of operation for the range of output values and use corresponding current equations

   ii. **These substitutions might help in simplification:**

$$V_1 = V_{T_n} + |V_{T_p}|; V_2 = VDD - V_{T_n} - |V_{T_p}|$$

$$\frac{1}{ay^2 + by} = \frac{1}{b}\left(\frac{1}{y} - \frac{a}{ay + b}\right)$$

$$\int \frac{dy}{ay + b} = \frac{1}{a} ln(ay + b)$$

$$\int \left(\frac{1}{y} - \frac{a}{ay + b}\right) dy = ln\frac{y}{ay + b}$$

Good luck !!