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### VLSI Design : Quiz-1

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

Date : 28<sup>th</sup> Aug, 2024, Duration : 1 Hour, Max. Marks : 10

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#### Instructions:

- Clearly write your assumptions (if any)
  - Use of own hand-written notes on 1 A4 sheet (both sides) is allowed
  - Calculators are allowed
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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,  $\mu_n C_{ox} = 220 \mu\text{A/V}^2$  and  $(\frac{W}{L})_n = 10$ . What is the value of this maximum current for the given parameters? [2]  $V_{DD} = 1.8\text{V}$
2. Consider a CMOS inverter. You are given that  $V_{DD} = 3.0$  V,  $V_{T_n} = 0.5$  V,  $V_{T_p} = -0.7$  V,  $\mu_n = 450 \text{ cm}^2/\text{Vs}$ , and  $\mu_p = 250 \text{ cm}^2/\text{Vs}$ . 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 ( $\tau_r$ ) taken to charge the output from 0 V to  $V_{DD} - |V_{T_p}|$  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 ( $\tau_f$ ) taken to discharge the output from VDD to  $V_{T_n}$  with the input voltage equal to  $V_{DD} - |V_{T_p}|$  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:

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

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

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

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

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Good luck !!