Alexandria University
Faculty of Engineering
Electrical Engineering Department
Fall Mid-term Exam, November 2016

جامعة الإسكندرية
كلية الهندسة
قسم الهندسة الكهربية
امتحان نصف الفصل الدراسي الأول (نوفمبر ٢٠١٦)

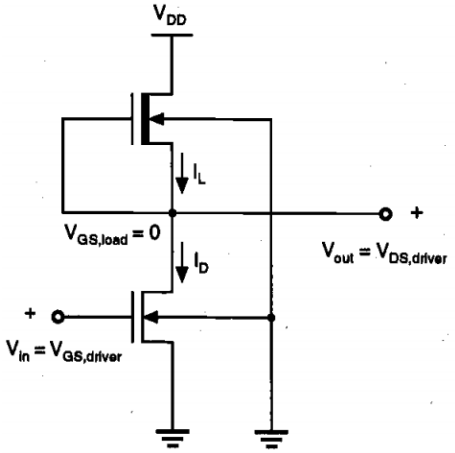
Course Title and Code Number:
Digital Integrated Circuits (EE 431)
Fourth Year (Communications and Electronics)
Time Allowed: 90 Mins

اسم المقرر والرقم الكودي له:
الدوائر المتكاملة الرقمية (EE 431)
السنة الدراسية الرابعة (اتصالات و الكترونيات)
الزمن: ٩٠ دقيقة

Answer the following questions: **(25 marks)**

Question 1: **(10 marks)**

Derive and calculate the critical voltages (V_{OL}, V_{OH}, V_{IL}, V_{IH}) and find the noise margins of the following depletion-load inverter circuit:



$V_{DD} = 5$ V
$V_{T0,driver} = 1.0$ V
$V_{T0,load} = -3.0$ V
$(W/L)_{driver} = 2,\ (W/L)_{load} = 1/3$
$k_{n,driver}' = k_{n,load}' = 25\ \mu A/V^2$
$\gamma = 0.4\ V^{1/2}$
$\phi_F = -0.3$ V

Question 2: **(10 marks)**

A CMOS technology has the following parameters:

$\mu_n C_{ox} = 120\ \mu A/V^2$
$\mu_p C_{ox} = 60\ \mu A/V^2$
$L = 0.6\ \mu m$ for both nMOS and pMOS devices

$V_{T0,n} = 0.8$ V
$V_{T0,p} = -1.0$ V
$W_{min} = 1.2\ \mu m$

Design a CMOS inverter by determining the channel widths W_n, and W_p of the nMOS and pMOS transistors, to meet the following performance specifications (**Derive** all equations you need):

- $V_{th}=1.5V$ for $V_{DD}=3V$
- Propagation delay times $\tau_{PHL} \leq 0.2$ *ns* and $\tau_{PLH} \leq 0.15$ *ns.*
- A falling delay of *0.35 ns* for an output transition from *2 V* to *0.5 V.*

Assume a combined output load capacitance of *300fF* and ideal step input.

Question 3: **(5 marks)**

Consider a uniform polysilicon line with a length *l* of *1000 μm* and a width *W* of *4 μm*. Assuming a sheet resistance value of *30 Ω/square*, a parallel plate unit area capacitance of *0.066 fF/μm²*, and a fringing field unit length capacitance of *0.046 fF/μm*. Calculate the propagation delay of the poly interconnect line using the following models:

a) Lumped RC model.
b) T model.
c) Distributed RC ladder with $N=5$.
d) Distributed RC ladder with $N=\infty$.

Good Luck

Examiner: Dr. Mohammed Morsy