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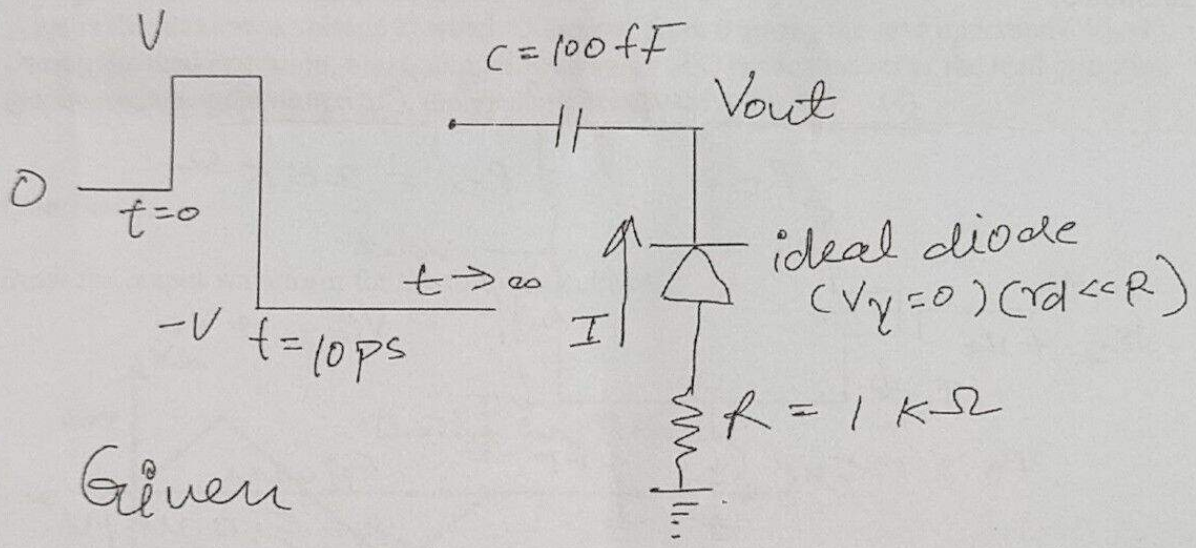
Department of Electronics and Communication Engineering
Indian Institute of Technology, Roorkee
End-Term Examination (9th June 2023)
ECN 102: Fundamentals of Electronics

Maximum Marks: 57 65
Time: 3 hours
Open notes exam

Note:
Only handwritten notes are allowed (Printed notes/photocopies/books not allowed).
Write your name and Enrollment number on each page of the question paper.
Please mention the names of all your nearest neighbors on the first page of the Answer sheet.
You must solve all the parts of the question in the serial order (else the question would not be evaluated)

Question 1:



Given

$V_{out}(0^-) = 0$

$RC = 100ps$

a) What is the value of the voltage Vout at t = 5ps? (2)
b) What is the value of Vout at t = 10ps+ ? (3)
c) What is the value of current I at t = 10ps+ ? (3)
d) What is the value of I at t → ∞ ? (2)
e) What is the value of Vout at t=20ps? (3)

Question 2:

a) The length of a long channel MOSFET is doubled, its threshold voltage (V_{th}) will increase/decrease/remain constant. (2)

b) The vertical (transverse) electric field in the gate dielectric near the source edge of the channel is smaller/larger/equal to that of the in the gate dielectric near the drain edge of the channel. Consider that the MOSFET operates in a saturation regime. (3)

c) If the channel length of a long channel MOSFET is **doubled**:

i. The saturation drain voltage ($V_{D_{sat}}$) increases/decreases/remains unchanged. (3)

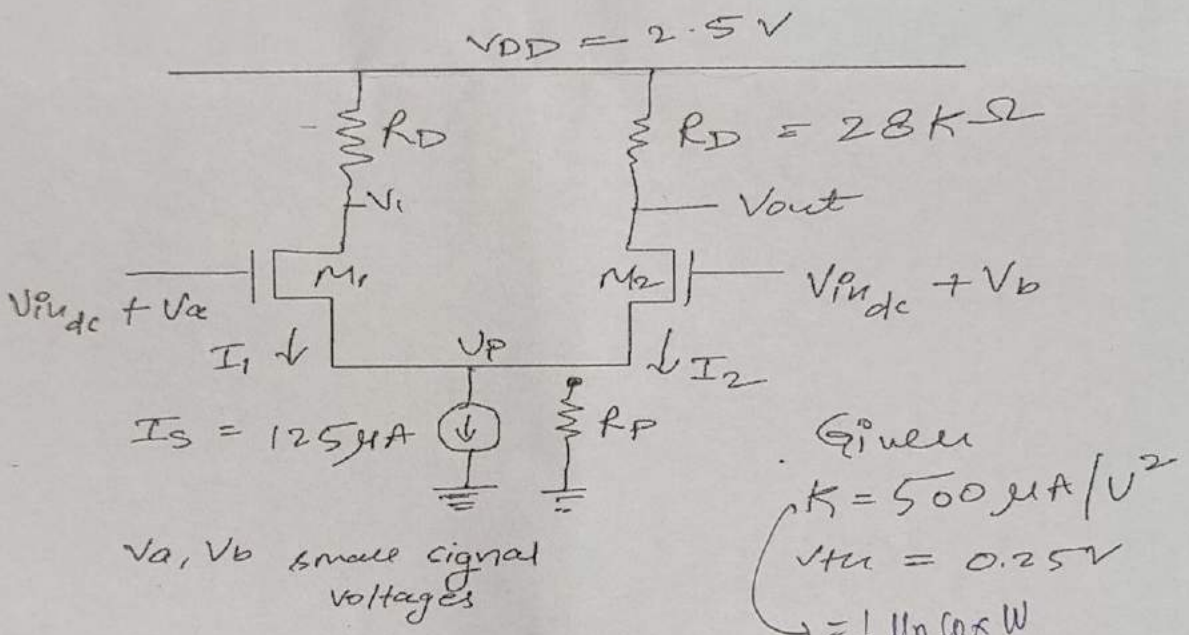
ii. The transconductance (g_m) of the MOSFET increases/decreases/remains unchanged when the device operates in the saturation region. (2)

iii. When the device operates in a linear regime its "on resistance" increases/decreases/remains unchanged. (2)

iv. When the value of $V_{GS} > V_{th}$, for an small increase in the value of V_{GS} for a MOSFET, the corresponding value of current through the body/substrate contact is ----------? (3)

v. For $V_{GS} > V_{th}$, if the overdrive voltage ($V_{GS} - V_{th}$) is doubled, the value of the vertical Electric field in the gate dielectric increases by a factor smaller than two/two/larger than two? (3)

Question 3:



a) What is the value of

1) $I_1(dc)$ (2)
2) $g_m(M1)$ (3)

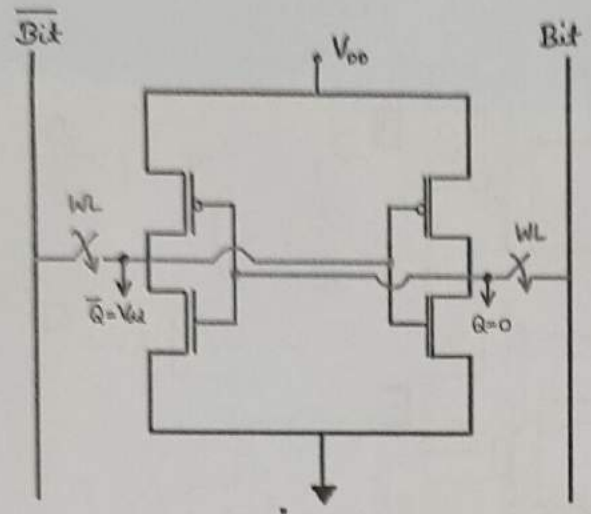
b) What is the value of differential voltage gain $\frac{V_{out}}{\left(\frac{V_a - V_b}{2}\right)}$? (3)

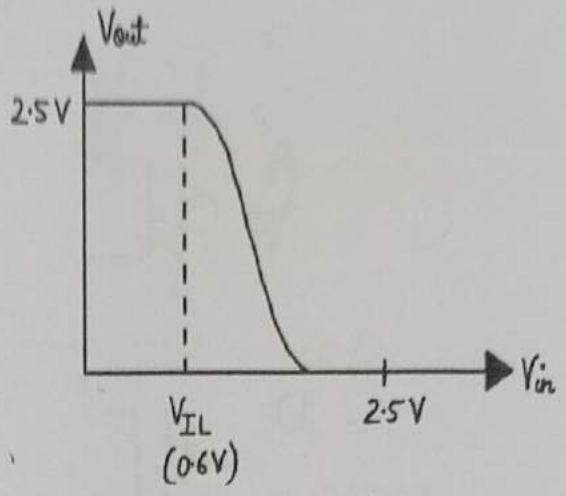
c) If the parasitic resistance R_p=10MΩ is seen across the current source I_s, What is the value of the small signal voltage V_p in differential mode? (5)

d) What is the value of differential gain while considering R_p ? (2)

c) What is the value of Common Mode gain $\frac{V_{out}}{\left(\frac{V_a+V_b}{2}\right)}$ while considering R_p? (4)

Question 4: SRAM memory

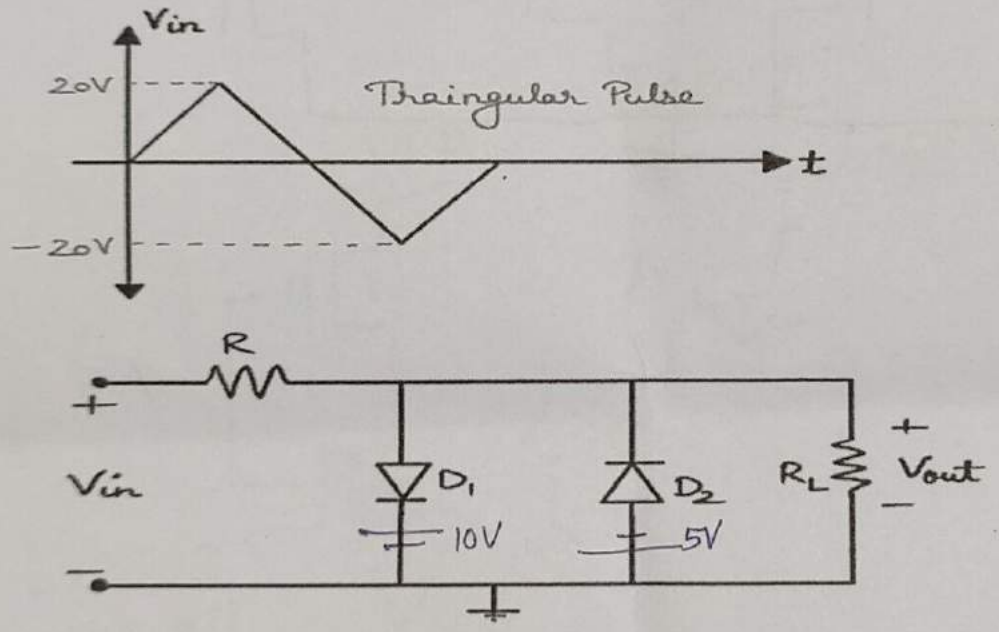




$\overline{Bit}$ and Bit lines are charged to supply voltage V_{DD} before a read operation is performed. During the read operation, the access switches close (i.e., WL = 1). What is the maximum voltage to which Q can rise from 0 during the read operation (WL=1). During the read operation, maximum allowed value of Q is such that after the read operation (access switch again turned off), the memory is restored to Q = 0V. (4)

Question 5:

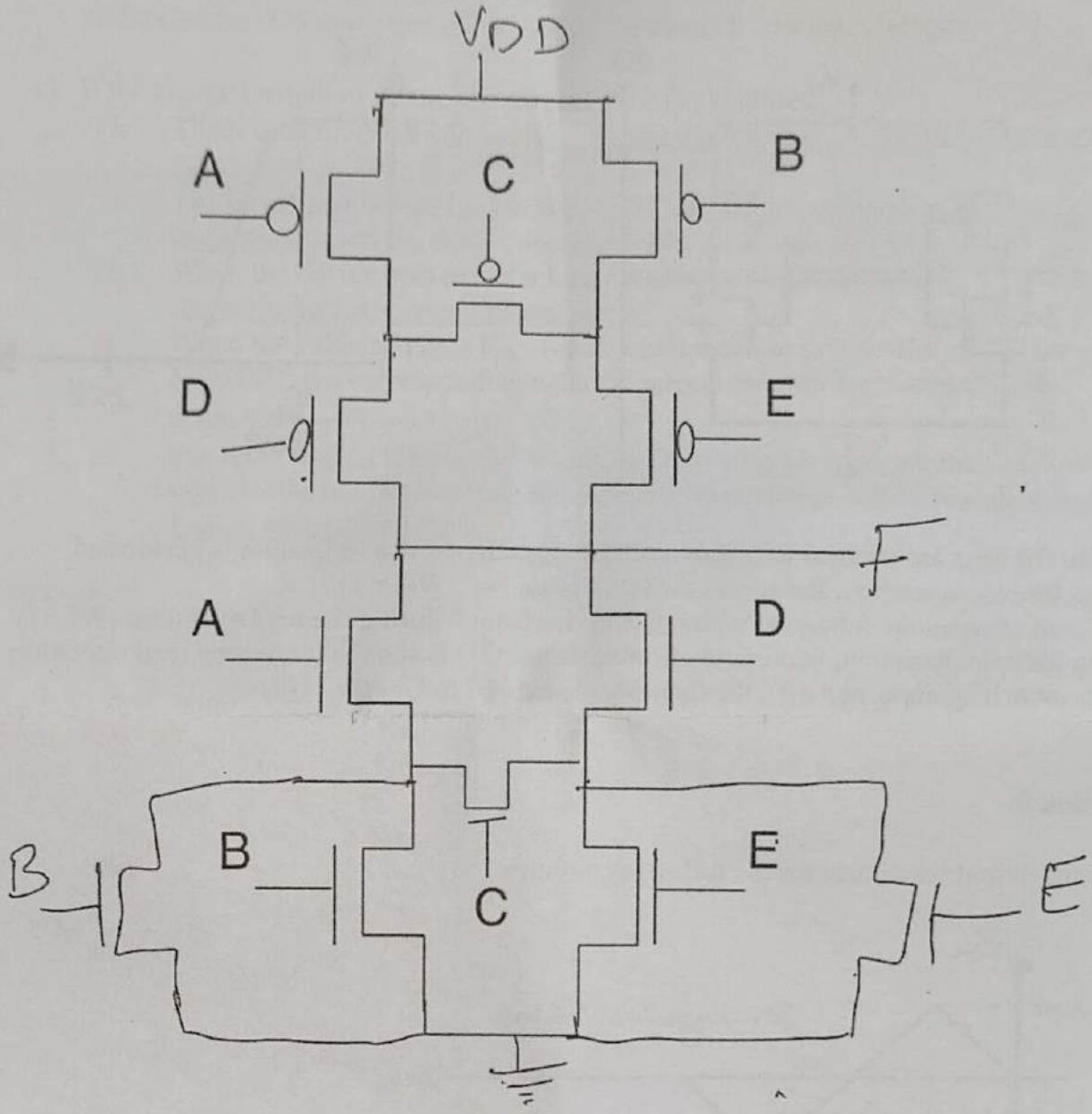
Draw the output waveform for the following circuit: (4)



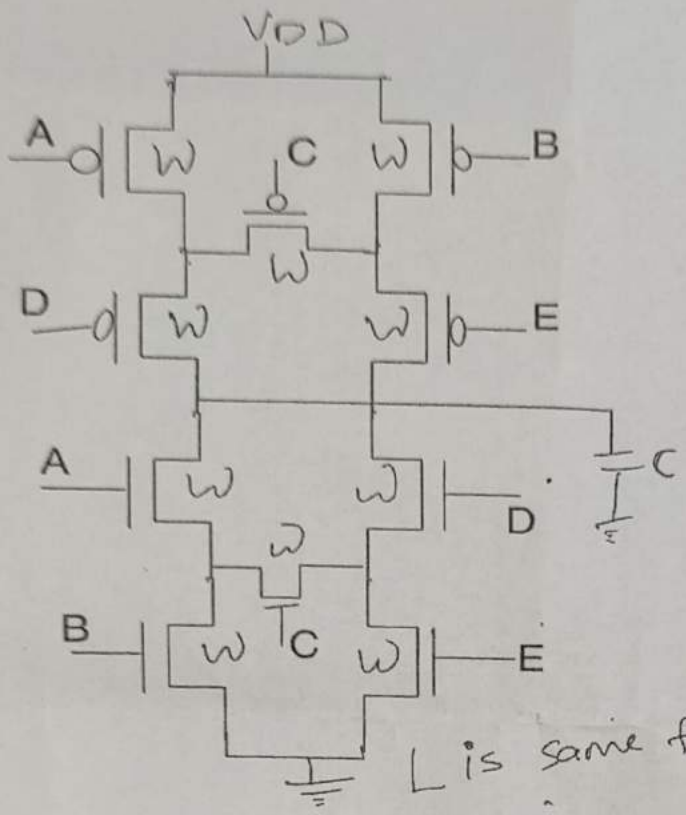
(All diodes are ideal)

Question 6:

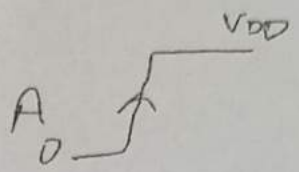
a) Write down the Boolean for F? (5)



b) Assuming that all the n-MOSFETs discharge while operating in linear regime, what is the ratio of the o/p fall delay in Case I to that of Case II? (5)



Case I



$B = V_{DD}$

$E = C = 0$

$D = V_{DD}$

Case II