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EE 477L HW4

Q1)

	Equation/Symbol	Constant Voltage Scaling	New Scaling
Channel Length	L	1/S	1/S
Channel Width	W	1/S	1/S
Gate Oxide Thickness	t_{ox}	1/S	1/S
Junction Depth	X_j	1/S	1/S
Power Supply	V_{DD}	1	$1/\sqrt{S}$
Threshold Voltage	V_{th}	1	$1/\sqrt{S}$
Mobility	μ	1	1
Area	WL	$1/S^2$	$1/S^2$
C_{ox}	ε_{ox}/t_{ox}	S	S
C_{gate}	$C_{ox}WL$	$1/S$	$1/S$
k	$\mu C_{ox}\frac{W}{L}$	1	1
I_{DS}	$\frac{k}{2}(V_{GS}-V_{th})^2$	1	$1/S^{3/2}$
R_{on}	V_{DS}/I_{DS}	1	$\sqrt{S}$
Power	$P = V_{DS} * I_{DS}$	1	$1/S^2$
Power Density	$Power/Area$	S^2	1
Delay	$R_{on} * C_{gate}$	1	$1/\sqrt{S}$
Energy Consumption	$Power * Delay$	1	$1/S^{5/2}$

NAME	Constant Volt Scaling	New scaling
Area	$1/s \times 1/s = 1/s^2$	same
Cox	Given ε_{ox} is a constant $t_{ox} = 1/s$, So Cox scales by S	same
C_{gate}	$S \times 1/s^2 = 1/s$	same
K	$s \times 1/s = 1$	same
IDS	∵ V_{GS}, V_{th} and k remain unchanged, so I_{DS} is scaling by 1	$V_{GS} - V_{th}$ is $1/\sqrt{s}$, So $I_{DS} = 1/s^{3/2}$
Ron	1	$1/\sqrt{s} \,/\, 1/s^{3/2}$ $= 1/s^{1/2} \,/\, 1/s^{3/2}$ $= \sqrt{s}$
Power Density	Power is constant, So it's scales by S^2	$1/s^2$
Power	all factors are constants, so 1	$V_{DS} = 1/\sqrt{s}$, $I_{DS} = 1/s^{3/2}$ $V_{DS} / I_{DS} = 1/s^2$
Delay	1	$1/\sqrt{s}$
Energy consumption	1	$1/s^2 / 1/\sqrt{s} = 1/s^{5/2}$

Q2)

a) $V_T = V_{T0} + \gamma\left(\sqrt{|2\phi_F - V_{SB}|} - \sqrt{2\phi_F}\right)$

$= 0.5V + 0.52\left(\sqrt{1.1 - 0.25} - \sqrt{1.1}\right)$

$= 0.434V$

$V_{GS} = V_G - V_S - V_T = 0.316V$

$I_{DS} = k' \cdot (W/L)/2 \cdot (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$

where $V_{DS} = 0.45V$,

$\therefore 20 \times 10^{-6} = \frac{200 \times 10^{-8} (W/L)}{2} (0.316)^2 + (1 + 0.06 \times 0.9)$

$\boxed{W/L \simeq 1.95}$

b) $I_D = k' \cdot (W/L)/2 \cdot (V_{GS})^2 (1 + \lambda V_{DS})$

where $V_T = 0.5V$

$V_{GS} = 1.3 - 0 - 0.5 = 0.8V$

$V_{DS} = 0.5 - 0 = 0.5V$

$$ID = \frac{200 \times 10^{-6} \times 1.95}{2} (0.8)^2 (1 + 0.06 \times 0.5)$$

$$\boxed{= 128.54\ \mu A}$$

Q3)

- velocity Saturation
  - As effective chennel length decrease, lateral electric field increase, causing the carrier velocity to saturate.

- Mobility Degradtion
  - strong vertical eletric fields causedby large V_{GS} lead carrier scattering near the surface. reduce mobility.

- threshold voltage Reduction
  - In short MOSFETs, a Portion of the deletion charge is supported by the source and drain junctions, reducing the gate's control and lowing the threshold voltage.

- DIBL
  - In small geometries, the Potential barrier between source and drain is lowered as the drain voltage increases, may cause leakage current at low gate voltages

· Punch - through

- occurs when the depletion regions of the source and drain overlaps, lead to a sharp increase in drain current

· Hot carrier Effect

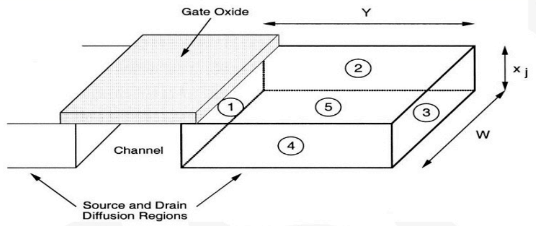
- High electric fields in short channel devices give rise to energetic carriers that can be injected into the gate oxide, causing degradation of the oxide and shifting the threshold Volt.

Q4)

Parameter measurement are used to experimentally determine key MOSFET characteristics / factors,

these measurements can provide accurate device behavior, ensuring that circuit simulations closely reflect real world performance

Q5)



p-Substrate => N_A
p^+-Channel-stop => $10.N_A$ or higher

Junction	Area	Type
1	$W.X_j$	n^+/p
2	$Y.X_j$	n^+/p^+
3	$W.X_j$	n^+/p^+
4	$Y.X_j$	n^+/p^+
5	$W.Y$	n^+/p

With the diagram given above,

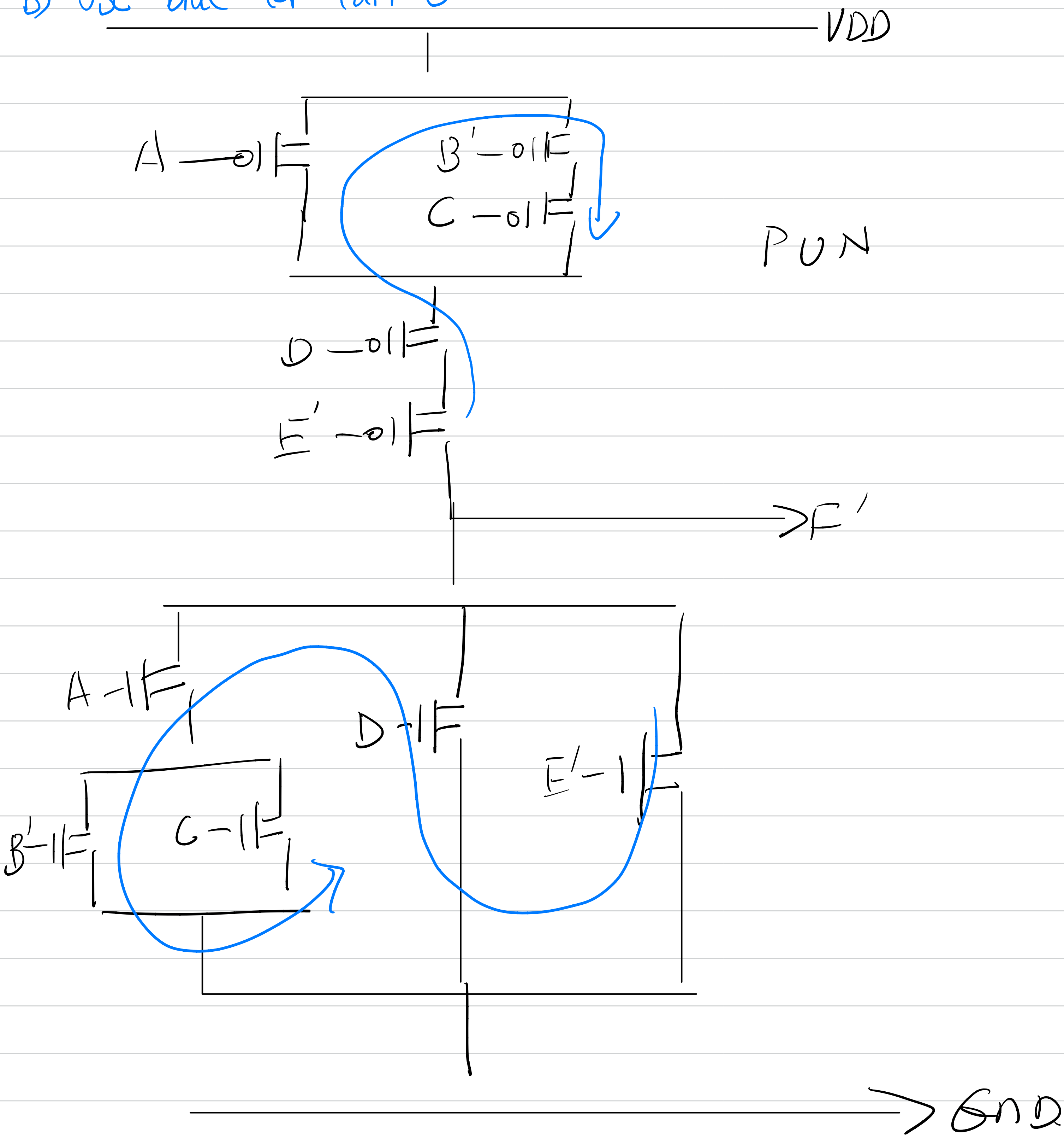
C_{db} = junction 1 + 3 + 5 or $C_{j1} + C_{j3} + C_{j5}$

C_{sb} = junction 2+4 or $C_{j2} + C_{j4}$

Q6)

a) $F' = A(B'+C) + D + E'$

b) use blue for part b



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