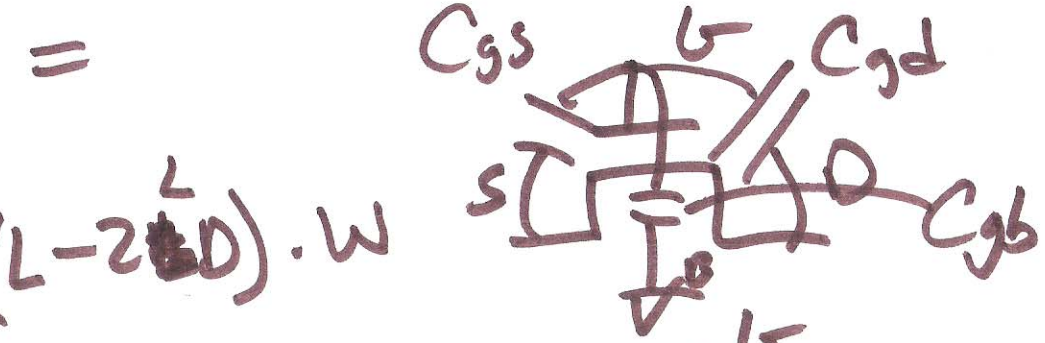
EE 421 / ECG 621
Digital IC Design

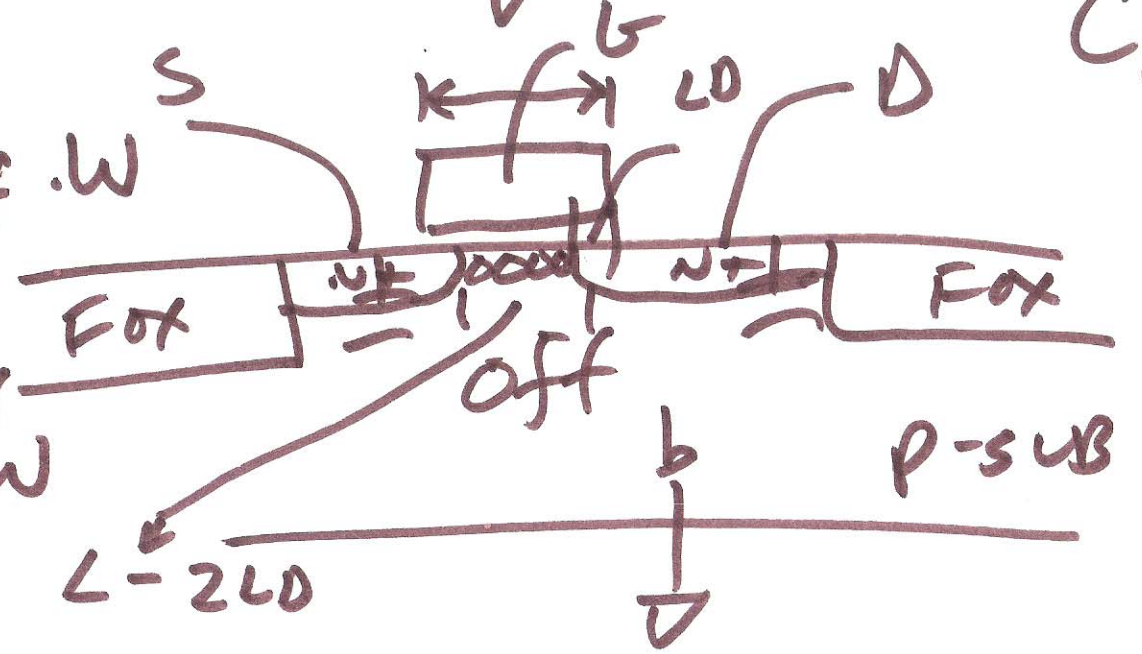
$C_{gb} =$



$\frac{\epsilon_{ox}}{t_{ox}} \cdot (L - 2LD) \cdot W$

$= \frac{\epsilon_{ox}}{t_{ox}} \cdot L_{eff} \cdot W$

$= C_{ox} \cdot L_{eff} \cdot W$



$C_{gd} = CGDO \cdot W$

$= \frac{\epsilon_{ox}}{t_{ox}} \cdot LD \cdot W$

$= C_{ox}' \cdot LD \cdot W$

$= C_{gs}$

$= CGSO \cdot W$

off

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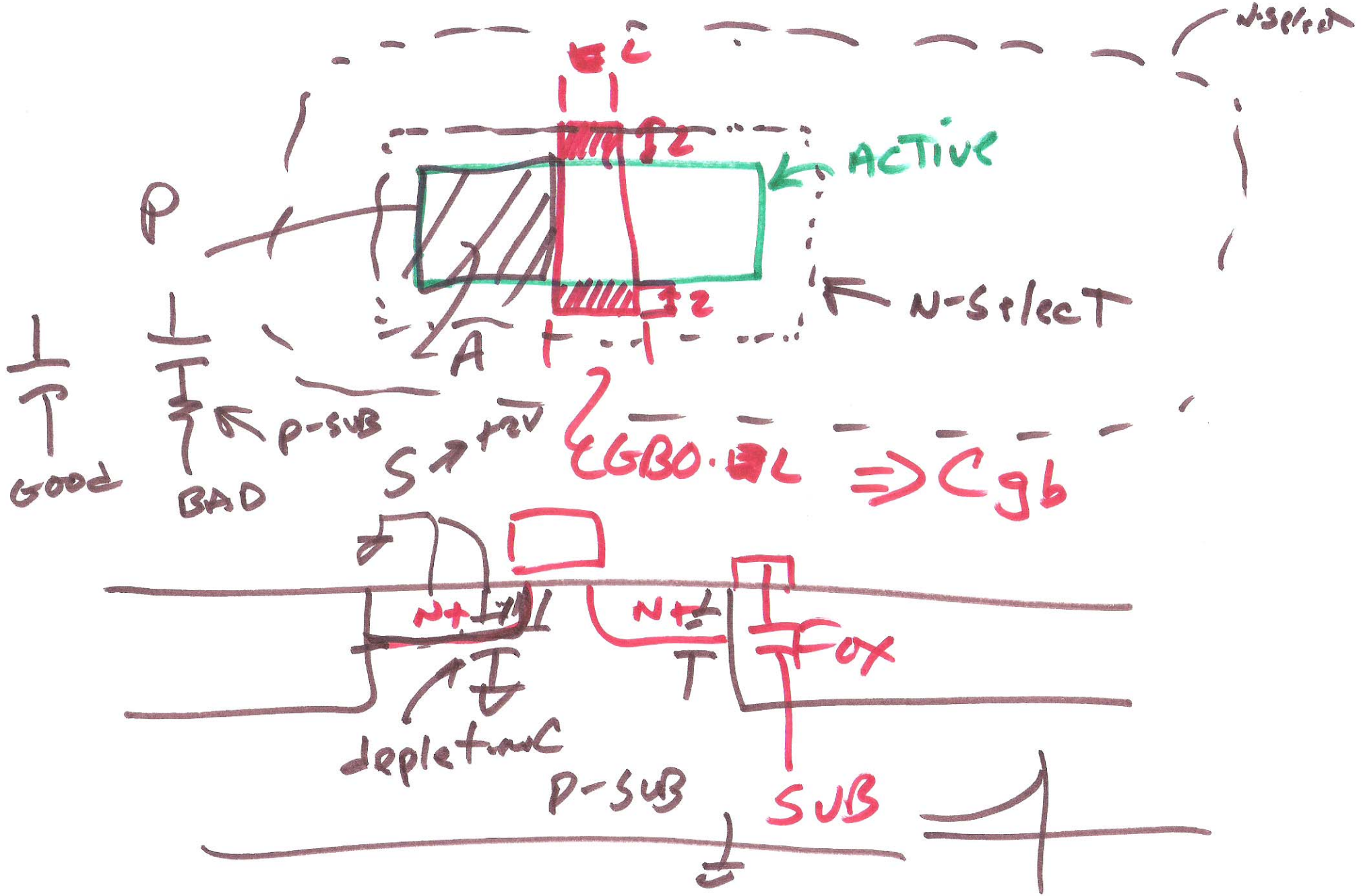
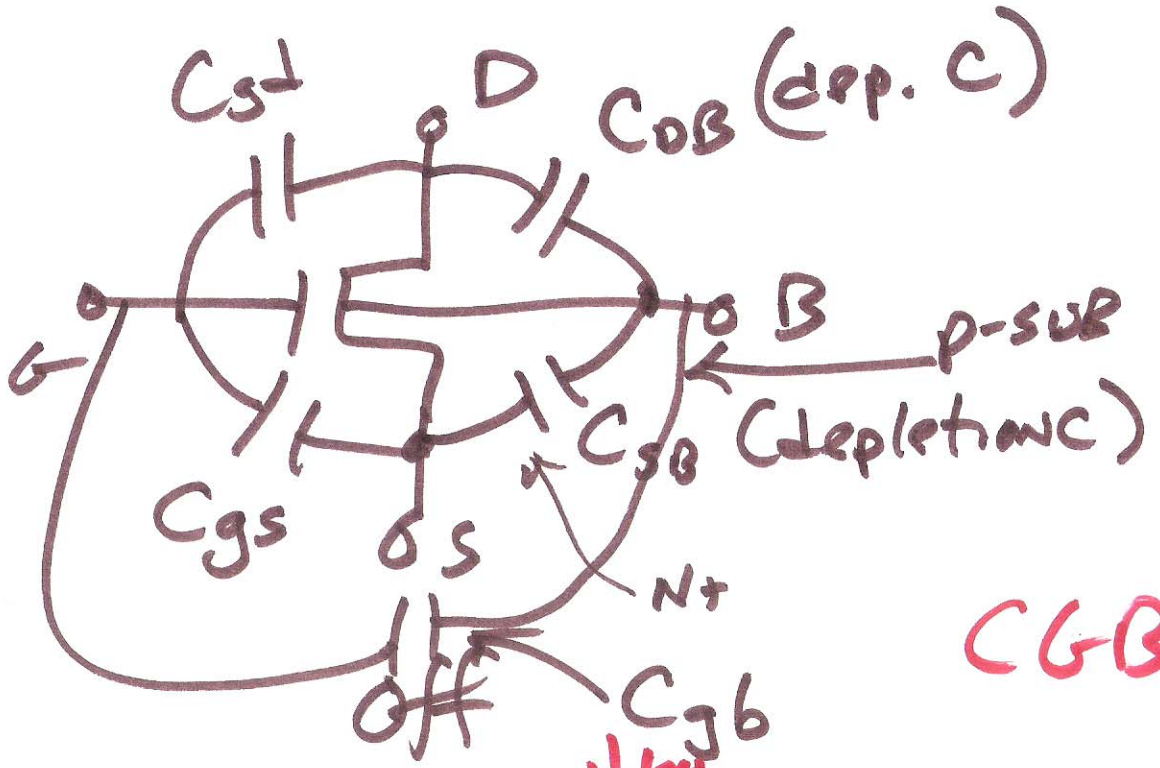
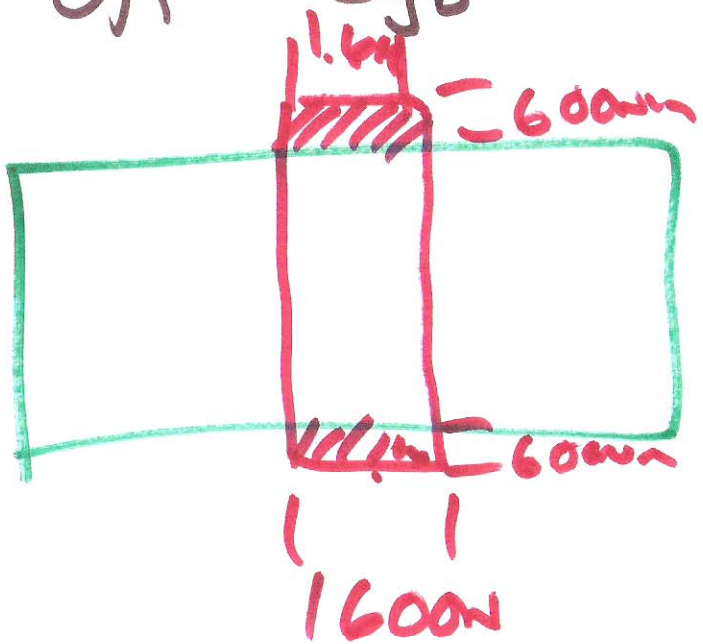
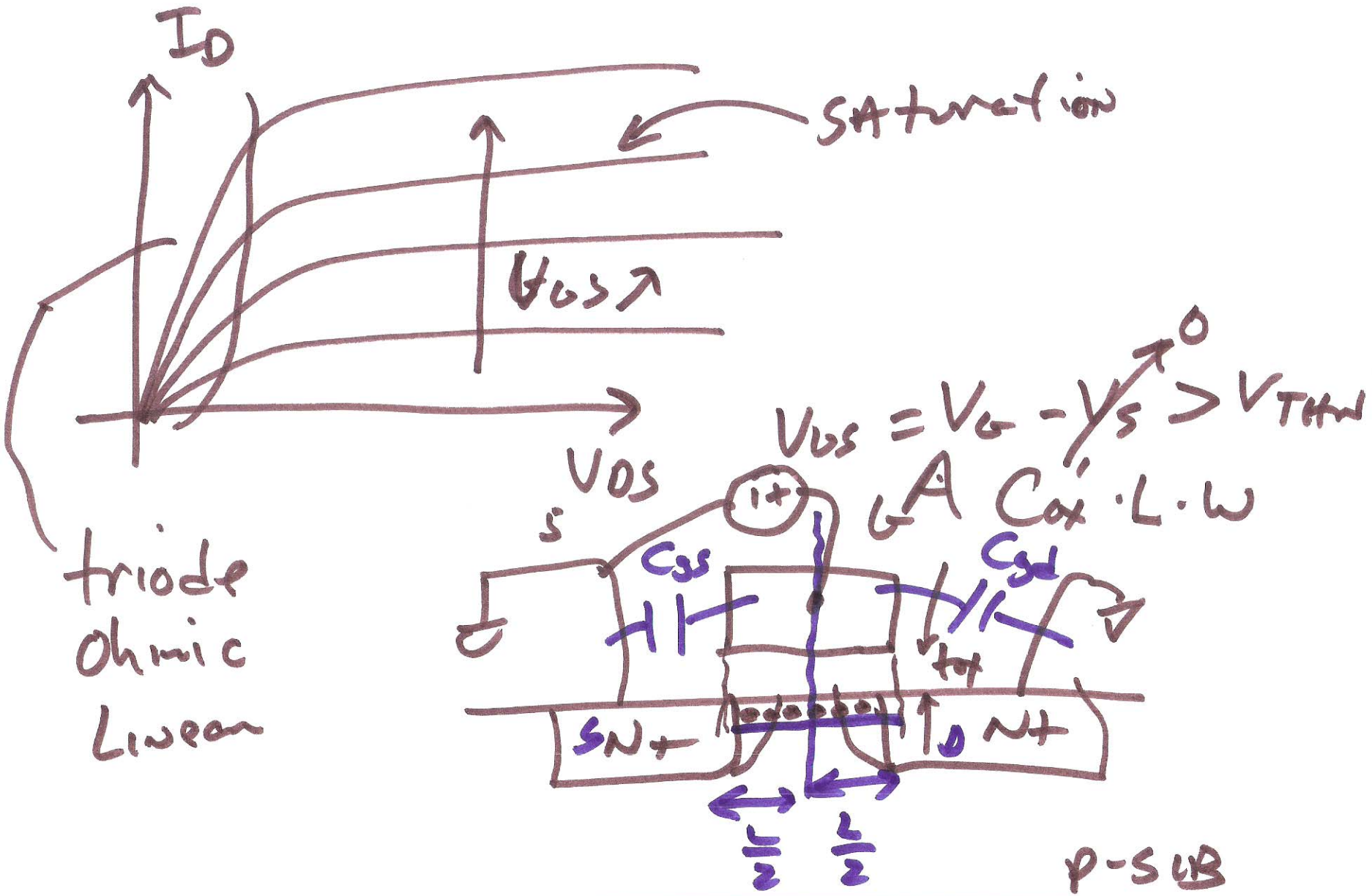
1)


N-Select
L
W
ACTIVE
P
A
N-SelecT
P-SUB
GOOD
BAD
S
CGBO·WL ⇒ Cgb
N+
N+
FOX
depletion
P-SUB
SUB


Csd
D
CDB (dep. C)
G
B
p-sub
Cgs
S
CSB (depletion C)
N+
CGBO
CGB


1.6um
600nm
600nm
1600N

Poly1 → sub



$$C_{gs} = C_{gd} = C_{ox}' \cdot W \frac{L}{2}$$

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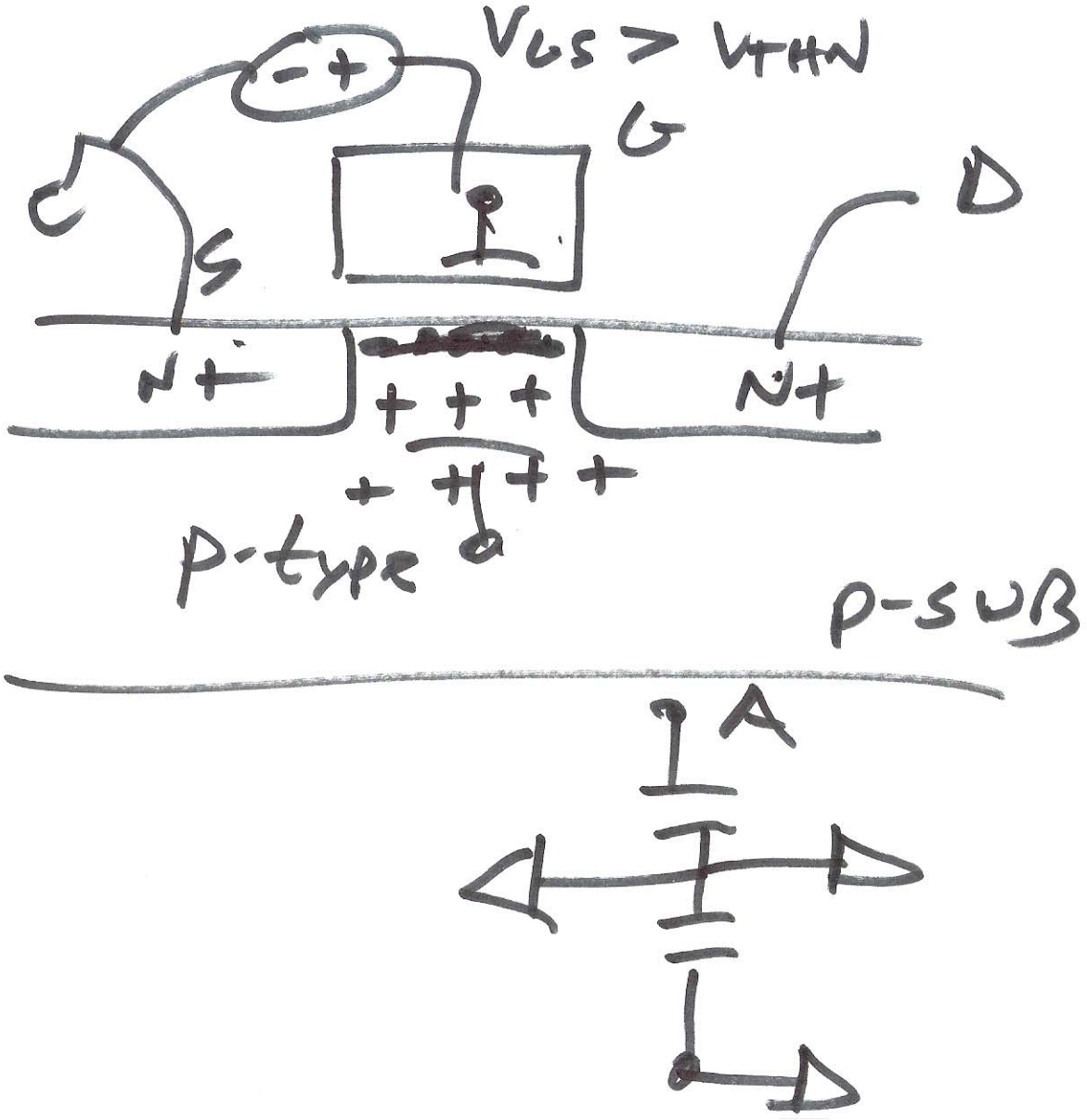

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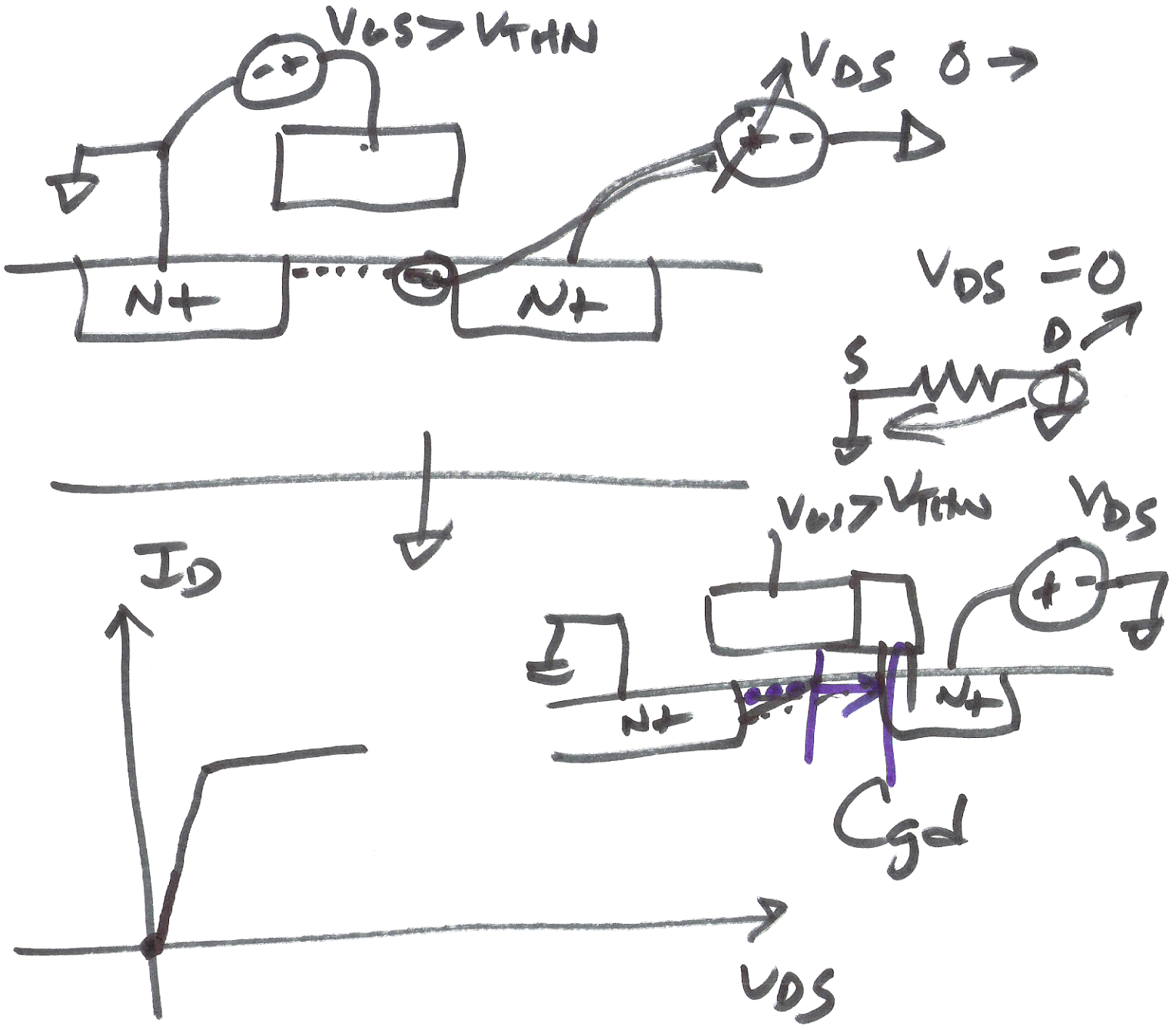
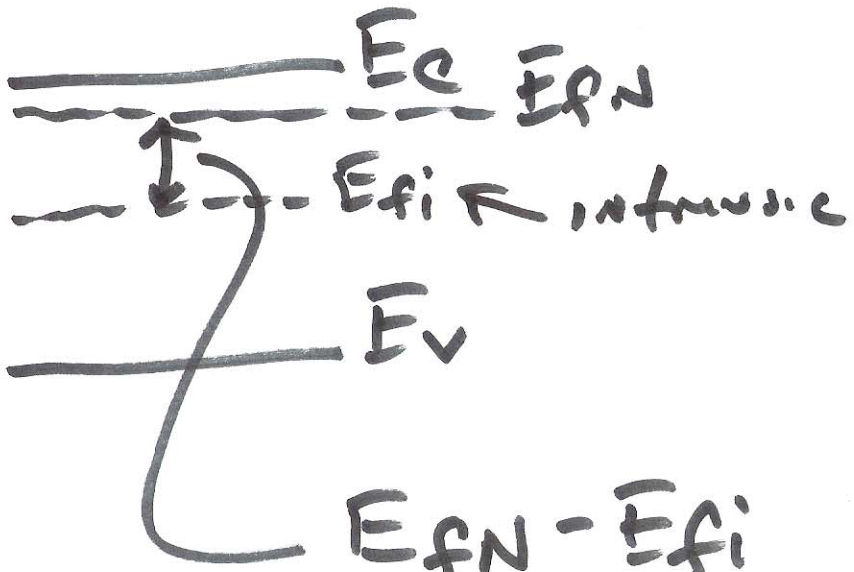
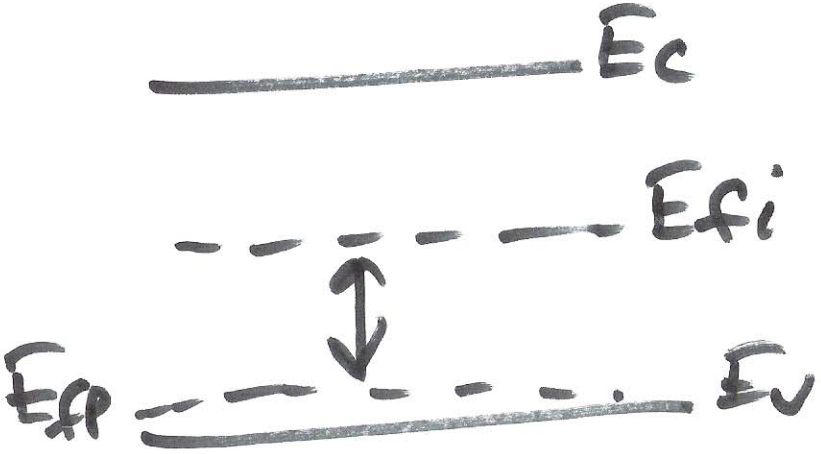

VGS > VTHN
VDS 0 →
N+
N+
VDS = 0
S
D
VGD > VTHN
VDS
ID
N+
N+
Cgd
VDS

N-type (N_D, Atoms/cm³)



$$E_{fN} - E_{fi} = kT \cdot \ln \frac{N_D}{n_i}$$

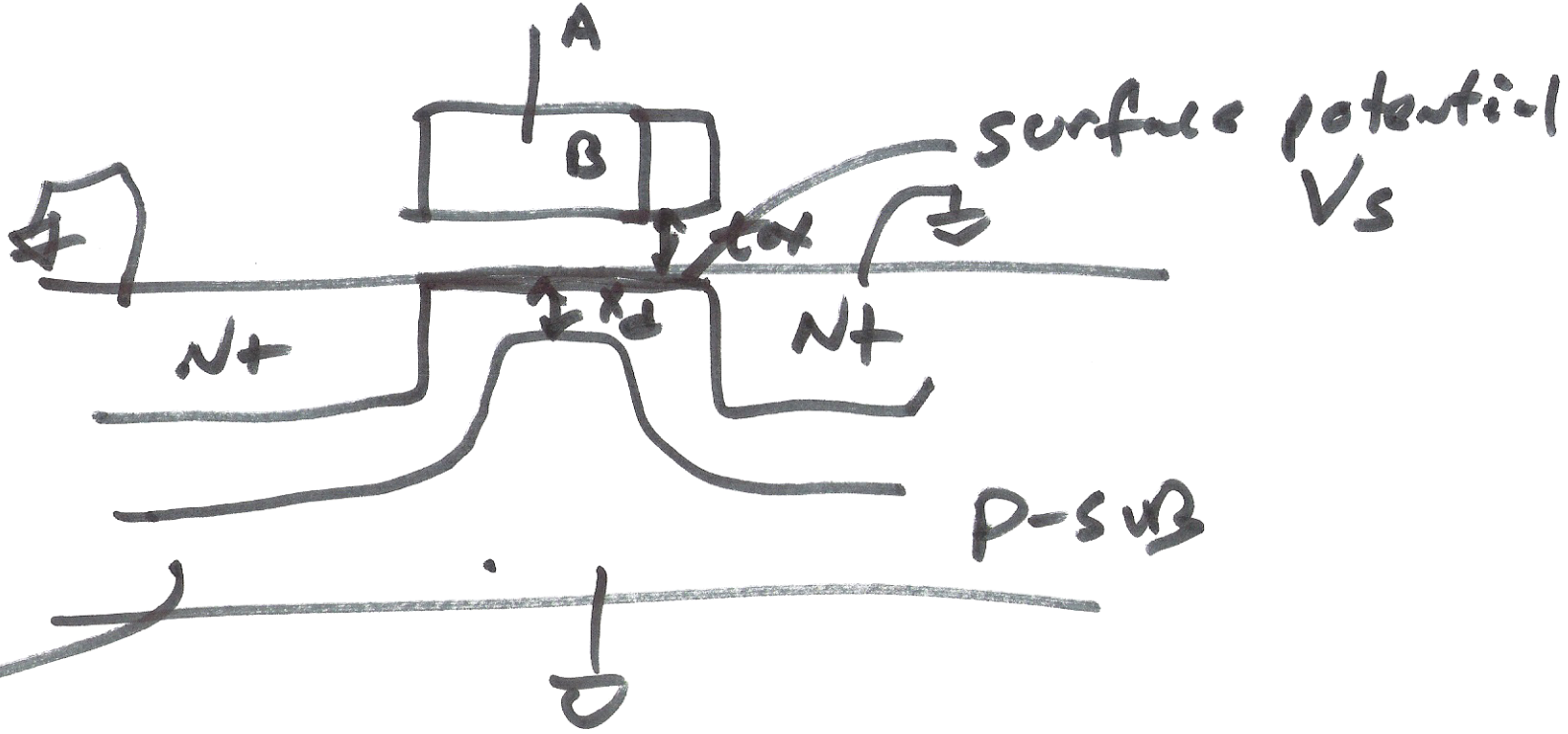
P-type (N_A)



$$E_{fi} - E_{fp} = kT \ln \frac{N_A}{n_i}$$

$$E_{fN} - E_{fp} = kT \ln \frac{N_D N_A}{n_i^2}$$

$$V_{bi} = \frac{E_{fN} - E_{fp}}{q} = \frac{kT}{q} \ln \frac{N_D N_A}{n_i^2}$$



$$-\frac{kT}{q}\ln\frac{N_A}{n_i} \quad X_d = \sqrt{\frac{2\varepsilon_{si}\,|V_s - V_{fp}|}{q\,N_A}}$$

$$= V_{fp}$$

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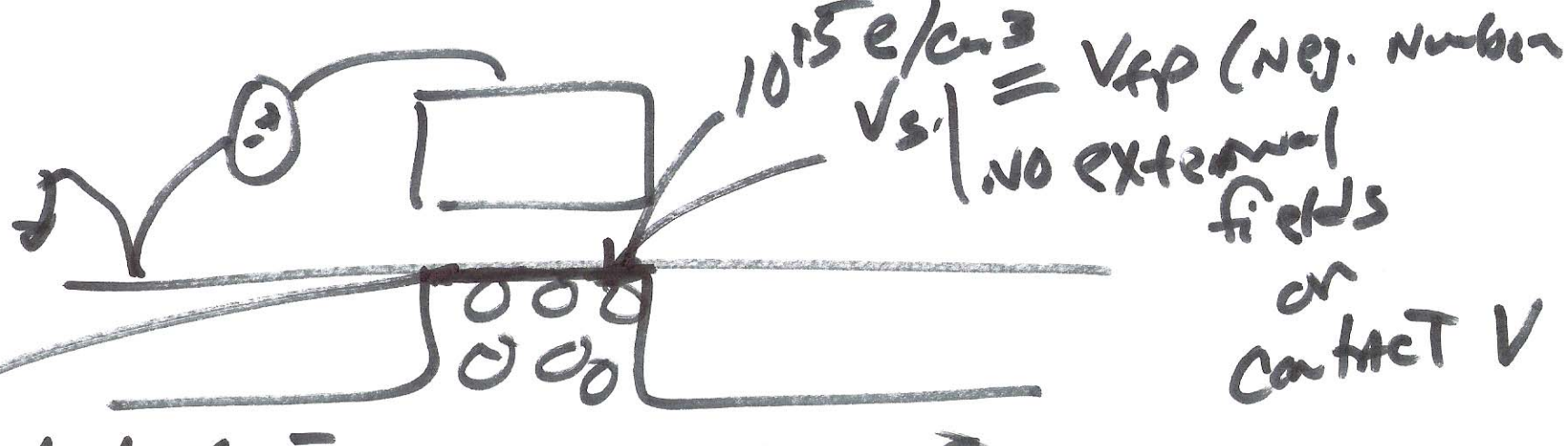

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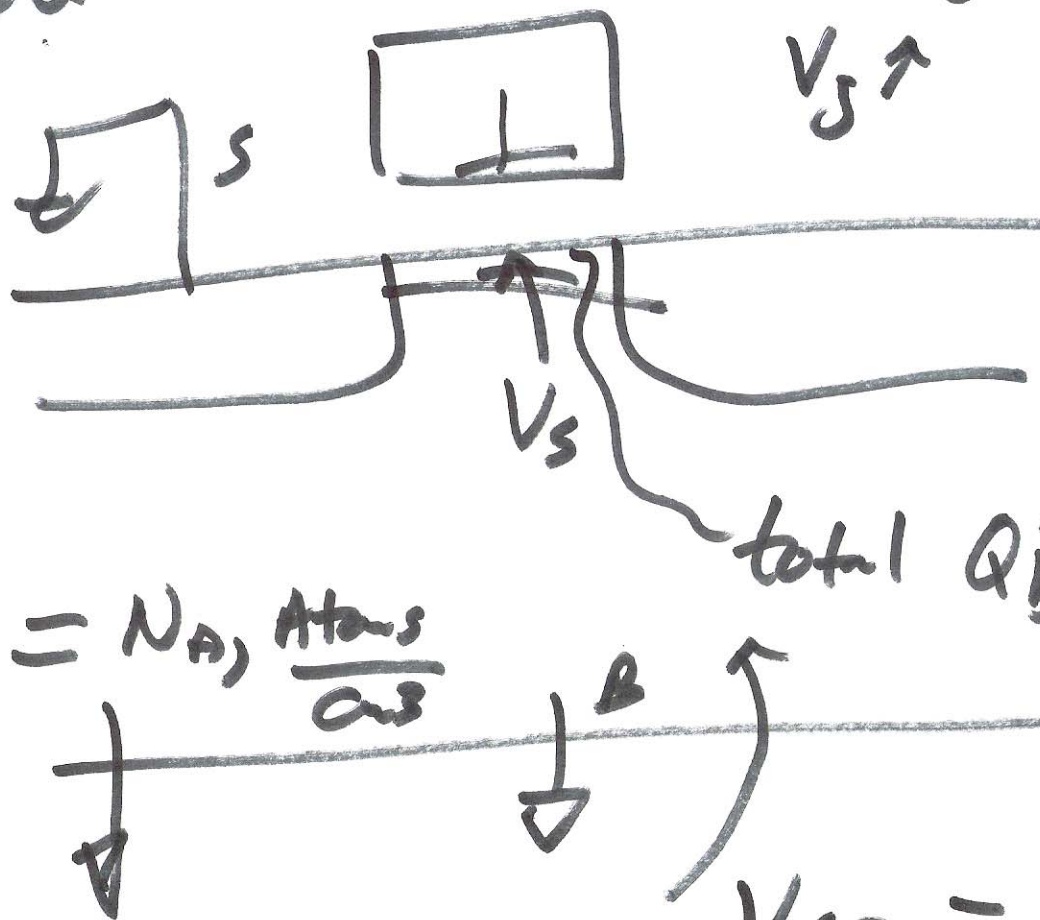
$CV = Q$

NO V_J $V_S = V_{FP}$ (NEG)

$V_J \uparrow$ $V_S = 0$

$V_S = -V_{FP}$ (POS)



$V_{FP} = -.3V$

$P = N_A$, Atoms / cm^3

$$V_{FP} = -\frac{kT}{q} \ln \frac{N_A}{n_i}$$

$$\frac{1}{T} \quad V_{TH} \cdot C_{ox}' = Q_i'$$

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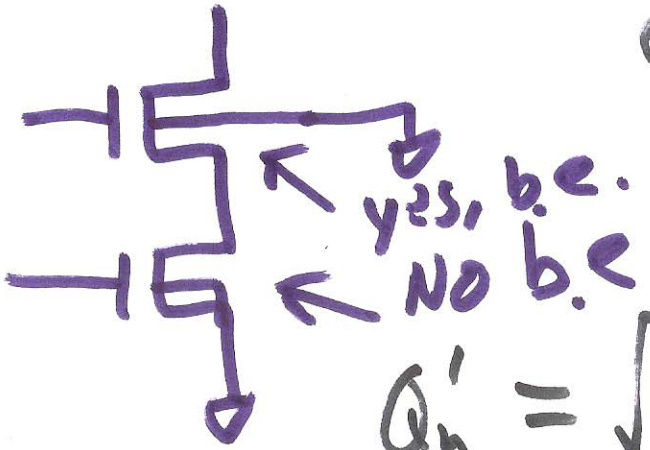
$$Q_b' = \sqrt{2\epsilon_{si} \cdot qN_A |V_S - V_{fp}|}$$

@ V_{THN} $\quad V_S = -V_{fp}$

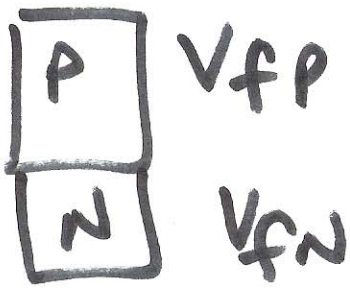
$$|V_S - V_{fp}| = 2V_{fp}$$

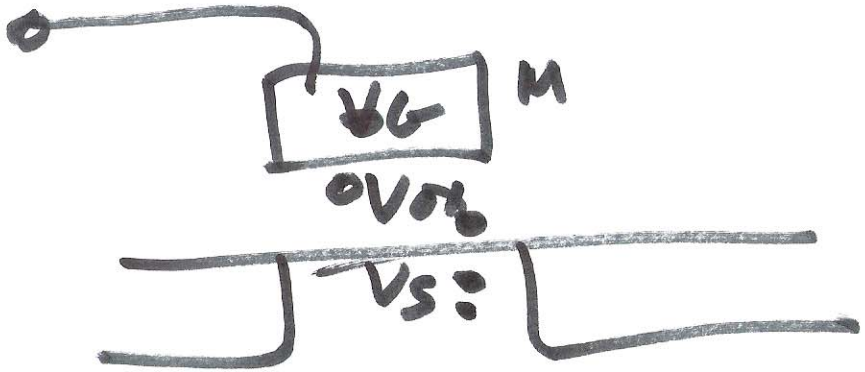


$$Q_b' = \sqrt{2qN_A\epsilon_{si}|2V_{fp}|}$$

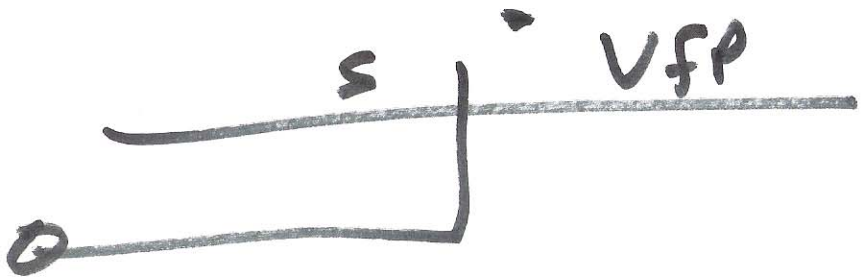
body effect $(V_S - V_B \neq 0)$

$$Q_b' = \sqrt{2qN_A\epsilon_{si}|-2V_{fp} + V_{SB}|}$$





$$V_{fp} - V_{fN} = V_{bi}$$



$$(V_G - V_{ox}) + (V_{ox} - V_s) + (V_s - V_{fp}) = 0$$

$$V_{MS} = V_G - V_{fp}$$

$CV = Q$

$$V_{THN} = \frac{Q_b' - Q_{ss}'}{C_{ox}'} - 2V_{fp}$$

With contact potentials

$$V_{THN} = \frac{Q_b' - Q_{ss}'}{C_{ox}'} - 2V_{fp} - V_{ms}$$

$V_m - V_s = V_{ms}$

V_{ms}: contact potential diff

$N_{D,poly}$

$$V_{ms} = \frac{KT}{q} \ln \frac{N_{D,poly}}{n_i} - \frac{KT}{q} \ln \frac{N_A}{n_i}$$