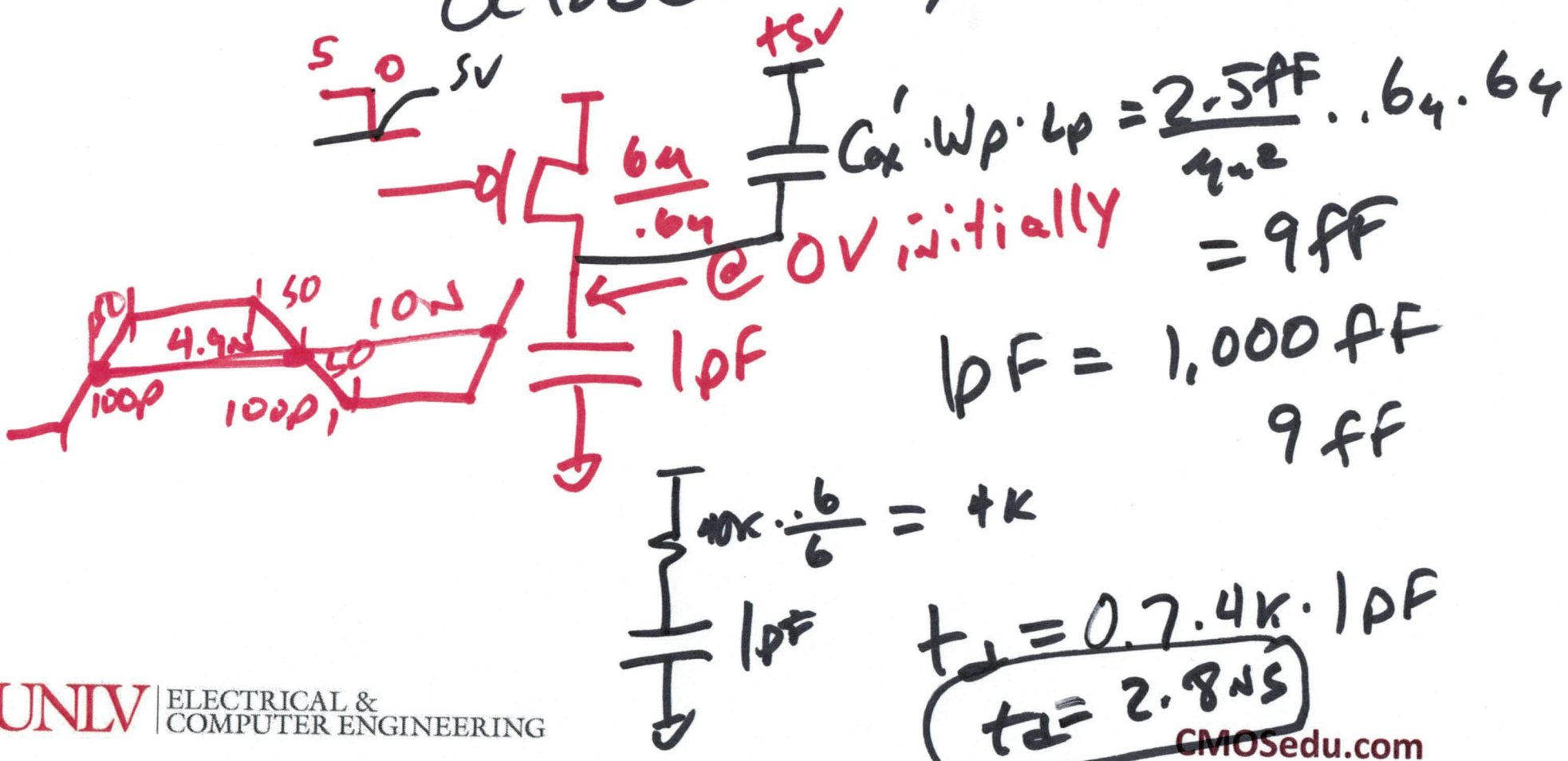
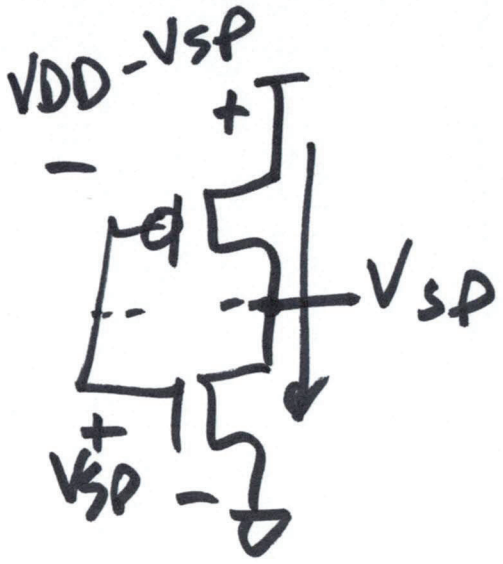
EE 421/ECG 621
Digital IC Design
Lecture 17
October 30, 2023



V_{SP} = Switching Point

$KP_{NP} = \mu_{N,P} C'_{ox}$



$$\beta_N = KP_N \cdot \frac{W_N}{L_N}$$

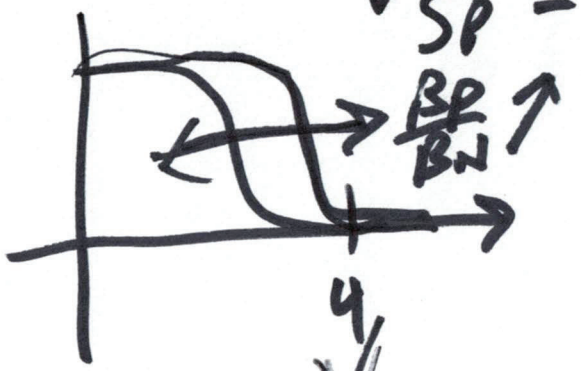
$$\beta_P = KP_P \cdot \frac{W_P}{L_P}$$

$$\frac{KP_N}{2}\frac{W_N}{L_N}\left(V_{SP} - V_{THN}\right)^2 = \frac{KP_P}{2}\frac{W_P}{L_P}\left(VDD - V_{SP} - V_{THP}\right)^2$$

$$\sqrt{\frac{\beta_N}{2}}\left(V_{SP} - V_{THN}\right) = \sqrt{\frac{\beta_P}{2}}\left(VDD - V_{SP} - V_{THP}\right)$$

$$V_{SP}\left(\sqrt{\frac{\beta_N}{2}} + \sqrt{\frac{\beta_P}{2}}\right) = \sqrt{\frac{\beta_N}{2}}V_{THN} + \sqrt{\frac{\beta_P}{2}}\left(VDD - V_{THP}\right)$$

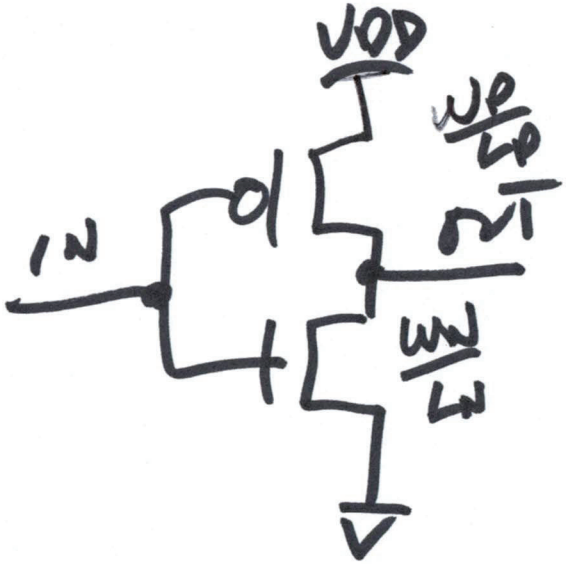
$$V_{SP} = \frac{\sqrt{\frac{B_N}{2}}\,V_{THN} + \sqrt{\frac{B_P}{2}}\,(V_{DD} - V_{THP})}{\sqrt{\frac{B_N}{2}} + \sqrt{\frac{B_P}{2}}}$$



$$V_{SP} = \frac{V_{THN} + \sqrt{\frac{B_P}{B_N}}\left(V_{DD} - V_{THP}\right)}{1 + \sqrt{\frac{B_P}{B_N}}}$$

$B_P \gg B_N$

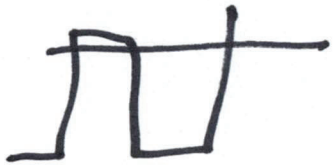
$V_{SP} \simeq V_{DD} - V_{THP}$

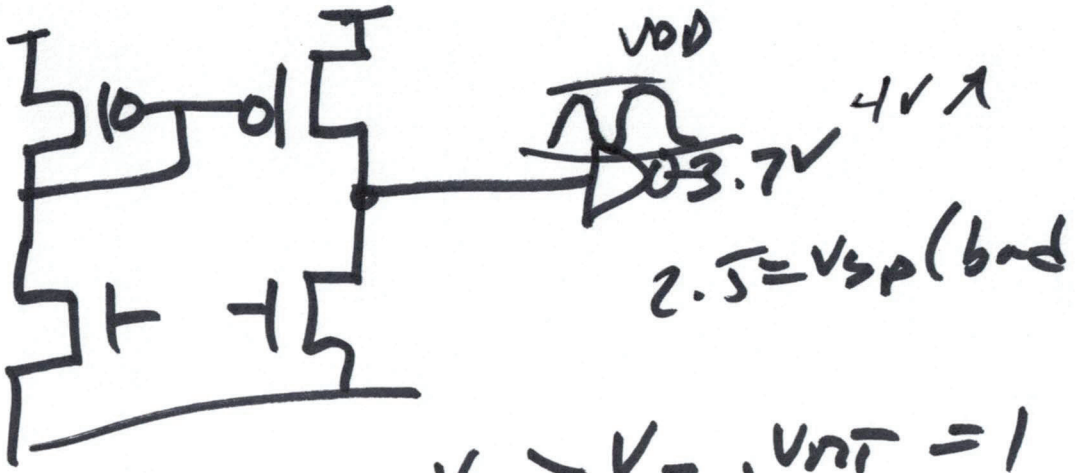


$$B_P = \frac{W_P}{L_P} \cdot K_P = \frac{W_P}{L_P} \cdot \mu_P \cdot C_{ox}'$$

$B_N \gg B_P$

$V_{SP} \to V_{THN}$

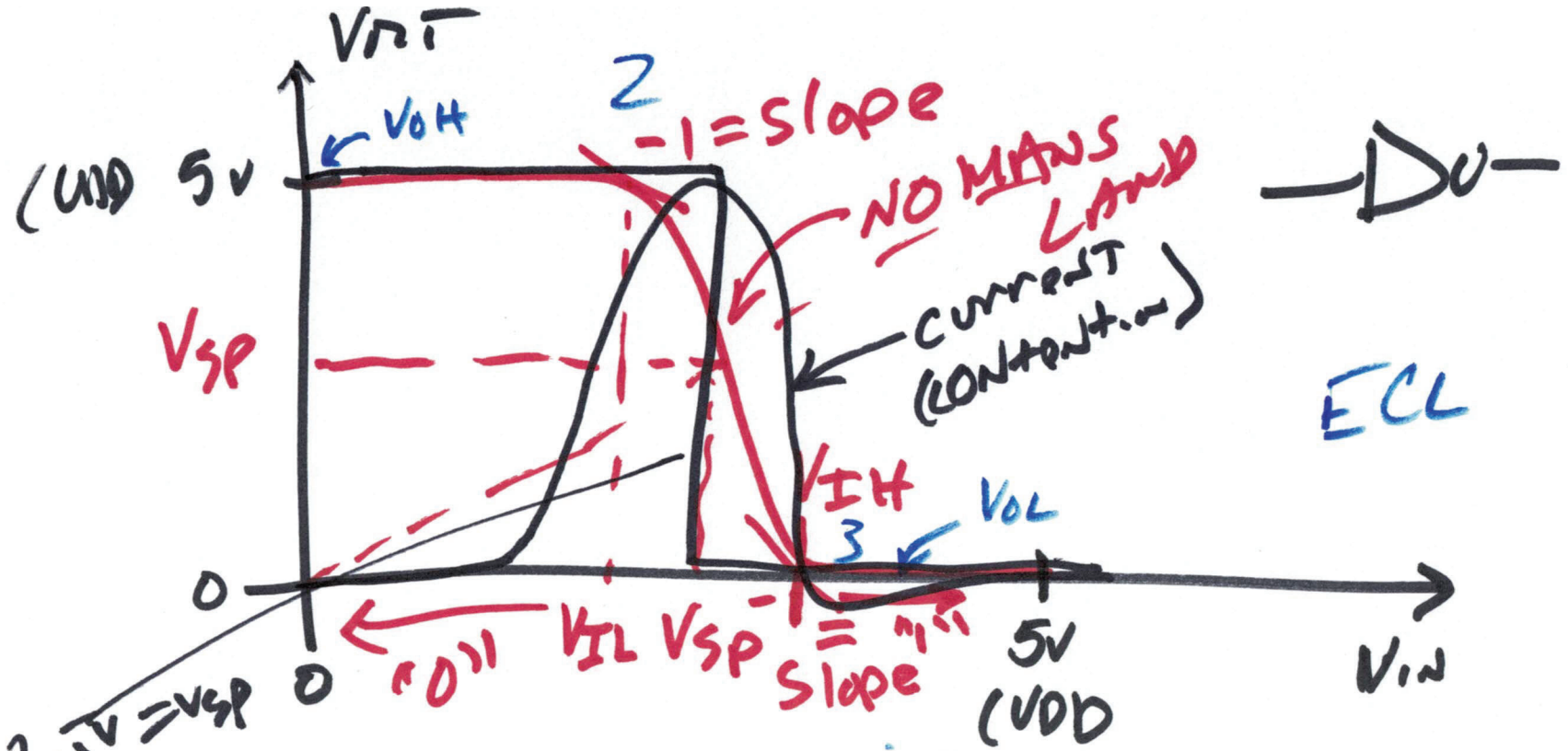


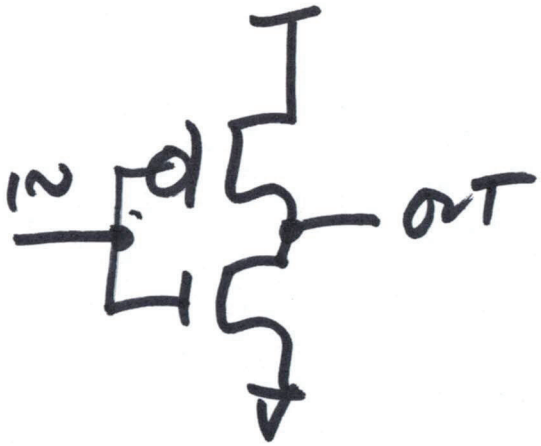


$V_+ > V_-$, $V_{OUT} = 1$

$V_+ < V_-$

$V_{OUT} = 0$





ECL

Noise Margin →

$NM_H = V_{OH} - V_{IH}$

$NM_H = 5 - 3 = 2V$

$NM_L = V_{IL} - V_{OL}$

$NM_L = 2 - 0 = 2$

$\frac{3}{2}(\frac{1}{4}\cdot.6\cdot12) = 27fF$

12/6 4

$R_N = R_P = 20k\cdot\frac{.6}{6}$

$= 40k\cdot\frac{.6}{12}$

$= 2k$

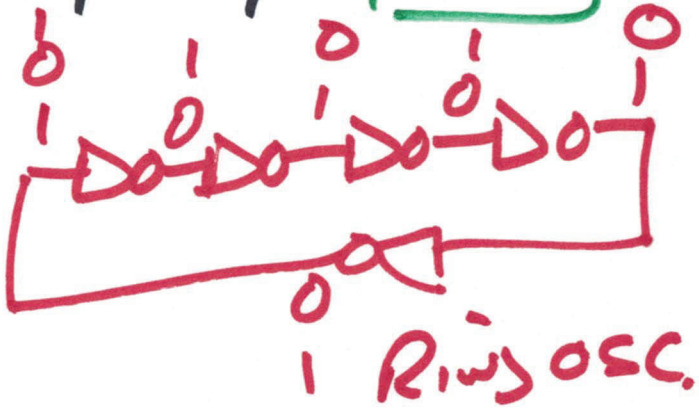
2k

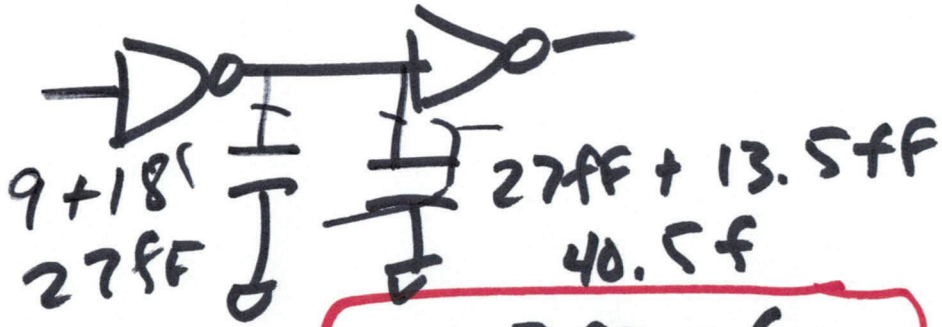
$C_{ox}\cdot L_P\cdot W_P = \frac{2.5fF}{\mu m^2}\cdot.6\cdot12_4 = 18ff$

2k

$C_{ox}\cdot L_N\cdot W_N = \frac{2.5fF}{\mu m^2}\cdot.6_4\cdot6_4 = 9ff$

$\frac{3}{2}C_{ox}\cdot L_N\cdot W_N = 13.5ff$





$67.5ff = C_{tot}$