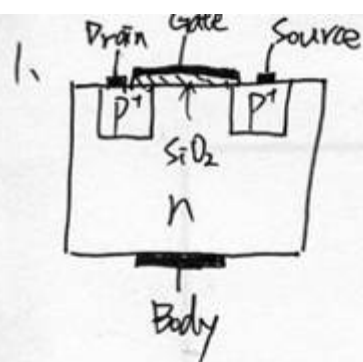
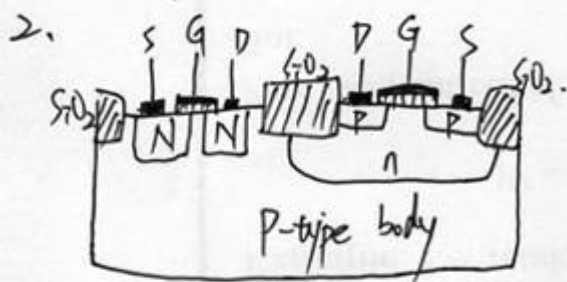




在 n structure 打入 2 處 P, 拉出導線作 Drain, Source
在 P 和 P 之間蓋上一層 SiO_2 作 Gate.



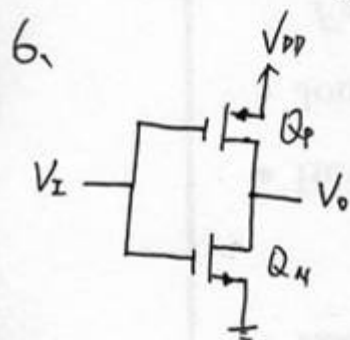
CMOS 就是把 NMOS 和 PMOS 結合在一起.
稱 Complementary MOS.

取一 P-type body 打入二小塊 N 和一大塊 N.
在大塊 n 上再打入二小塊 P, 再從 n-n 和 P-P
之間蓋上 SiO_2 再分別拉出 S, G, D 參考剖面圖

3. I_{eff} 's means channel length = L.

4. The body voltage controls I_D . thus the body acts as another gate for the MOSFET.

5. The voltage accelerates the electrons that reach the drain end of the channel and sweeps them across the depletion region into the drain. the channel length is in effect reduced.



① when $V_I = V_{DD}$ (high)

$$Q_N: V_{GSN} = V_{DD}$$

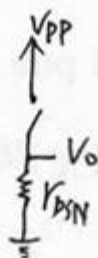
$$V_{GSN} > V_{th}$$

$\Rightarrow Q_N$ on

$$Q_P: |V_{GSP}| < |V_{th}|$$

$\Rightarrow Q_P$ off

輸出 Low



② when $V_I = 0$ (low)

$$Q_N: V_{GSN} = 0 < V_{th}$$

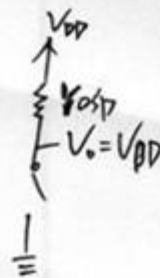
Q_N off

$$Q_P: V_{GSP} = -V_{DD}$$

$$|V_{GSP}| > |V_{th}|$$

$\Rightarrow Q_P$ on

輸出 high



$$7. (a) \hat{I}_D = \mu_n C_{ox} \frac{W}{L} [(V_{GS} - V_t) V_{DS} - \frac{1}{2} V_{DS}^2]$$

$$\mu_n C_{ox} \frac{W}{L} \doteq 1.0526 \text{ mA/V}^2$$

$$(b) Y_{DS} = \frac{V_{DS}}{\hat{I}_D} = \frac{1}{\mu_n C_{ox} \frac{W}{L} (V_{GS} - V_t)} = \frac{1}{1.05 \times 1.5} \doteq 0.634 \text{ k}\Omega$$

$$8. (a) V_{GS} \geq V_t \Rightarrow V_G \geq 4V$$

$$(b) V_{GD} \leq V_t \Rightarrow V_D \geq V_G + 1$$

$$(c) V_{GD} \geq V_t \Rightarrow V_D \leq V_G + 1$$

$$(d) I_D = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right) V_{ov}^2 \Rightarrow |V_{ov}| = 0.63V$$

$$V_{ov} = -0.63 = V_{GS} - V_t \Rightarrow V_G = 3.37V$$

$$V_D \leq V_G + 1 \Rightarrow V_D \leq 4.37V$$

$$9. I_D = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right) V_{ov}^2 \Rightarrow V_{ov} = \frac{\sqrt{I_D}}{2}$$

$$V_{GS} = V_{ov} + V_t \Rightarrow V_S = -(1 + \frac{\sqrt{I_D}}{2})$$

$$R_D = \frac{2-1}{0.5} = 2 \text{ k}\Omega$$

$$R_S = \frac{-(1 + \frac{\sqrt{I_D}}{2}) - (-2)}{0.5} = 0.88 \text{ k}\Omega$$

$$10. V_G = 8 \times \frac{2}{5} = 3.2V$$

$$\begin{cases} V_S = 4I_D \end{cases}$$

$$\begin{cases} I_D = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right) (V_G - V_S - V_t)^2 \end{cases}$$

$$I_D \doteq 0.46 \text{ mA}, V_S = 1.82V, V_D = 8 - 6I_D = 5.24V$$

$$11. (a) V_t = 0V, Q_N, Q_P \text{ cut off}$$

$$\Rightarrow \hat{I}_{PN} = \hat{I}_{DP} = 0 \text{ mA}, V_0 = 0V$$

$$(b) V_t = 2.5V \begin{cases} \hat{I}_{PN} = \frac{1}{2} K'_N \left(\frac{W_N}{L_N}\right) (V_G - V_S - V_t)^2 \\ V_S = 10I_D \end{cases}$$

$$\begin{matrix} Q_N = \text{on} \\ Q_P = \text{cut-off} \end{matrix}$$

$$\hat{I}_{PN} \doteq 0.104, V_0 = 1.04V, \hat{I}_{DP} = 0 \text{ mA}$$

$$(c) I_{DN} = 0 \text{ mA}, \hat{I}_{DP} = 0.104 \text{ mA}, V_0 = -1.04V$$