$V_{DD} = 1(V)$ $V_{Tn} = |V_{Tp}| = 0.26$ (1)

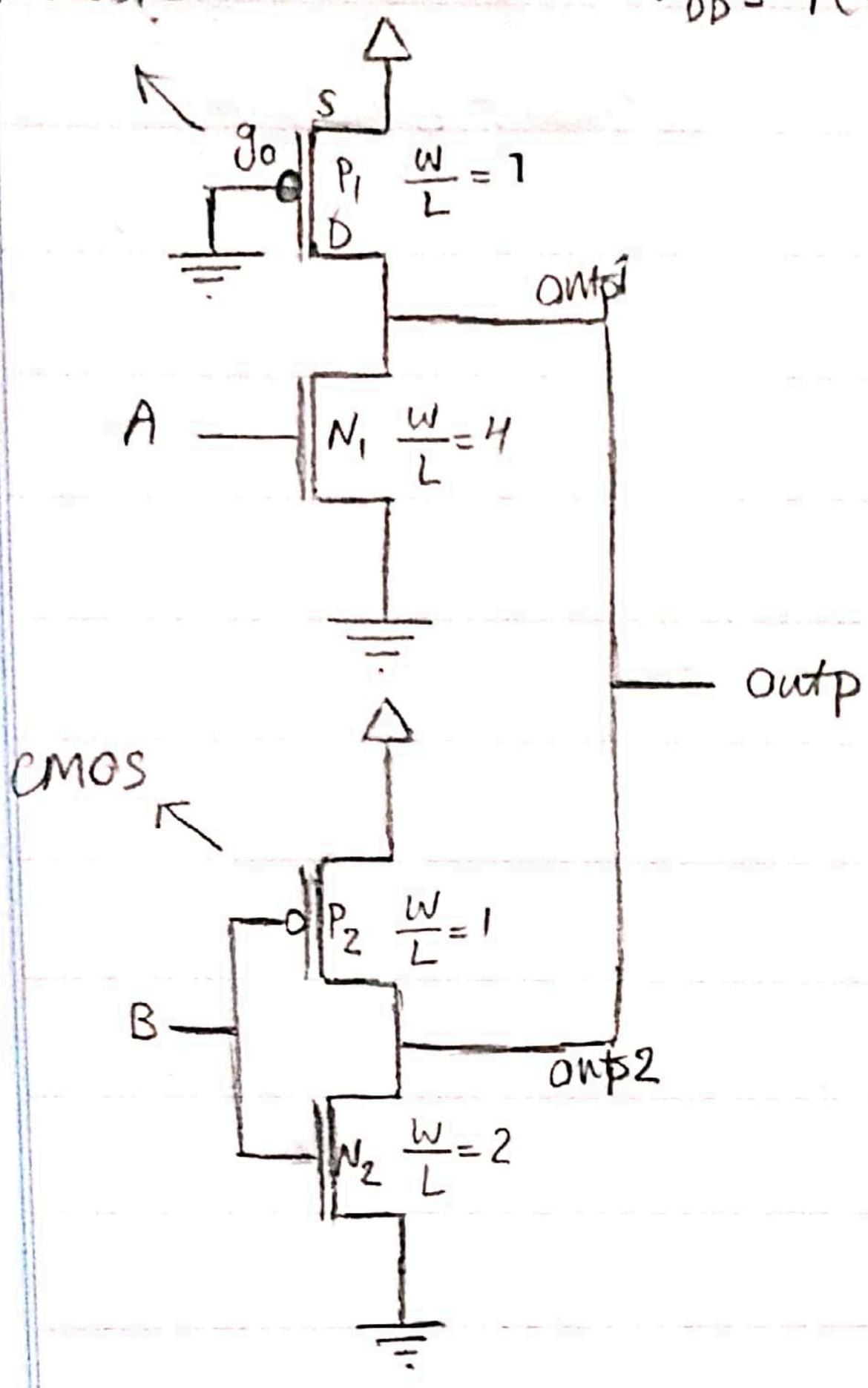
تعداد حالات :

$A=0$, $B=0$ State 1

$A=0$, $B=1$ State 2

$A=1$, $B=0$ State 3

$A=1$, $B=1$ State 4



$B=0 \rightarrow out_{P2} = V_{DD}$

$B=V_{DD} \rightarrow out_{P2} = 0\ (V)$

$\Big\} \rightarrow$ CMOS

$A=0 \rightarrow$ NMOS : off $\rightarrow$ $V_{max_{outp}} = V_{DD} - V_t$

$out_1 = V_{DD} - V_t$

$A=1 \rightarrow$ NMOS : ON $\rightarrow$ $V_{outp} = V_{min}$

$I_{DD}\ (sat) = I_{D_n}\ (triode)$

$$I_{DP}(sat) = \frac{1}{2} K_p' \underbrace{\left(\frac{W}{L}\right)_p}_{1} \left(\overbrace{V_{DD} - V_{outp}}^{V_{GS_p}} - V_t\right)^2 \quad ①$$

$$I_{Dn}(triode) = K_n' \underbrace{\left(\frac{W}{L}\right)}_{4} \left[\left(\overbrace{V_{DD}}^{V_{GS_n}} - V_t\right) \overbrace{V_{outp}}^{V_{DS_n}} - \frac{V_{DS_n}^2}{2}\right] \quad ②$$

①, ② $\Rightarrow$ $V_{min} = V_{outp}$

State 1: $B = 0 \rightarrow outp_2 = V_{DD}$

$A = 0 \rightarrow outp_1 = V_{DD} - Vt$

$[P_1 \& P_2 \Rightarrow ON \ , N_1 \& N_2 \Rightarrow off] \Rightarrow outp = \underline{V_{DD} = 1 (V)}$

$V_{outp} = V_{outp_1} + V_{outp_2} = 2V_{DD} - Vt$

State 2: $B = 1 \rightarrow outp_2 = 0$

$A = 0 \rightarrow outp_1 = V_{DD} - V_t$

$V_{outp} = V_{outp_1} + V_{outp_2} = 0 + V_{DD} - V_t = V_{DD} - V_t$

$[P_1 \& N_2 \Rightarrow ON \ , P_2 \& N_1 \Rightarrow off] \Rightarrow outp = \frac{V_{DD}}{2} + 0 = \underline{0.5 (V)}$

State 3: $B = 0 \rightarrow outp_2 = V_{DD}$

$A = 1 \rightarrow outp_1 = V_{min}$

$V_{outp} = V_{outp_1} + V_{outp_2} = V_{DD} + V_{min}$

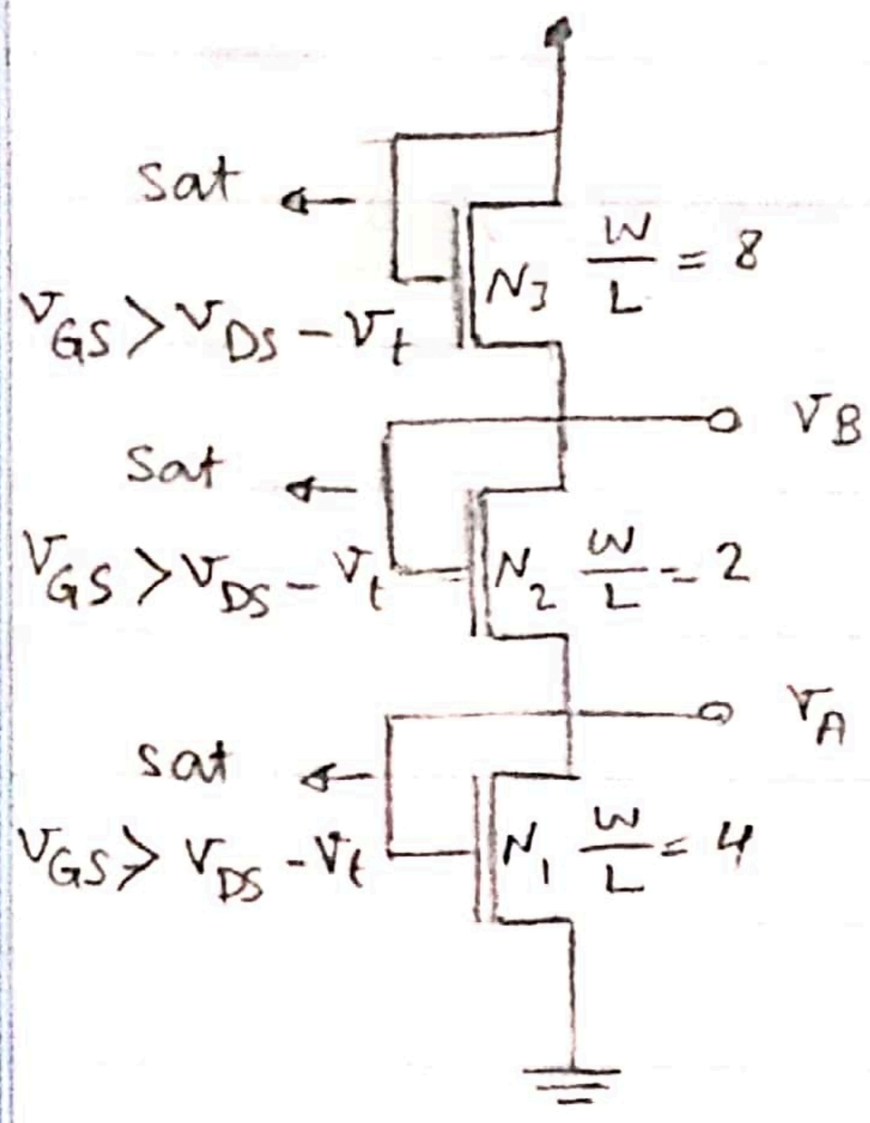
$[P_1 \& P_2 \& N_1 \Rightarrow ON \ , N_2 \Rightarrow off] \Rightarrow outp = \frac{V_{DD}}{2} + \left(\frac{V_{DD}}{2} - V_{Tn}\right) = \underline{0.74 (V)}$

State 4: $B = 1 \rightarrow outp_2 = 0$

$A = 1 \rightarrow outp_1 = V_{min}$

$V_{outp} = V_{outp_1} + V_{outp_2} = 0 + V_{min} = V_{min}$

$[P_1 \& N_1 \& N_2 \Rightarrow ON \ , P_2 \Rightarrow off] \Rightarrow outp = \left(\frac{V_{DD}}{2} - V_{Tn}\right) + 0 = \underline{0.24 (V)}$



$K'_n = 206\ (\mu A/V^2)$ (2)

$V_B = V_{DD} - V_t = 1 - V_t$

$V_A = V_B - V_t = 1 - 2V_t$

$$I_{D_n}(sat) = \frac{1}{2} k'_n \left(\frac{W}{L}\right)(V_{GS} - V_t)^2$$

$$I_{Dn_1}(sat) = \frac{1}{2} \times 200 \times 10^{-6} \times 8 \times (1 - V_B - V_t)^2 = 0$$

$$I_{Dn_2}(Sat) = \frac{1}{2} \times 200 \times 10^{-6} \times 2 \times (V_B - V_A - V_t)^2 = 0$$

$$I_{Dn_3}(Sat) = \frac{1}{2} \times 200 \times 10^{-6} \times 4 \times (\overbrace{V_A - V_t}^{1 - 3V_t})^2 =$$

$$I_D = 0.4 \times 10^{-3} \times (1 + 9V_t^2 - 6V_t) = 0.4 + 3.6V_t^2 - 2.4V_t$$

$V_{GD} = 0 \Rightarrow V_{GS} = V_{DS} \rightarrow$ Sat

$I = \frac{V}{R} \Rightarrow V \propto \frac{W}{L}$ and $I \propto \frac{W}{L} \Rightarrow$ با استفاده از $\frac{W}{L} \propto R$

$\rightarrow R_{N1} = R_{N2} = R_{N3} \rightarrow V_A = \frac{2V_{DD}}{3}$ and $V_B = \frac{V_{DD}}{3} \rightarrow V_A = \frac{2}{3}$ and

$V_B = \frac{1}{3}$

$$K_n = 200\mu \longrightarrow I_{N_1} = I_{N_2} = I_{N_3} = k_n [V_{GS} - V_{Tn}]^2$$

$$= 200\mu \left[\frac{1}{3} - 0.26\right]^2 = 7.075 \times 10^{-6}$$