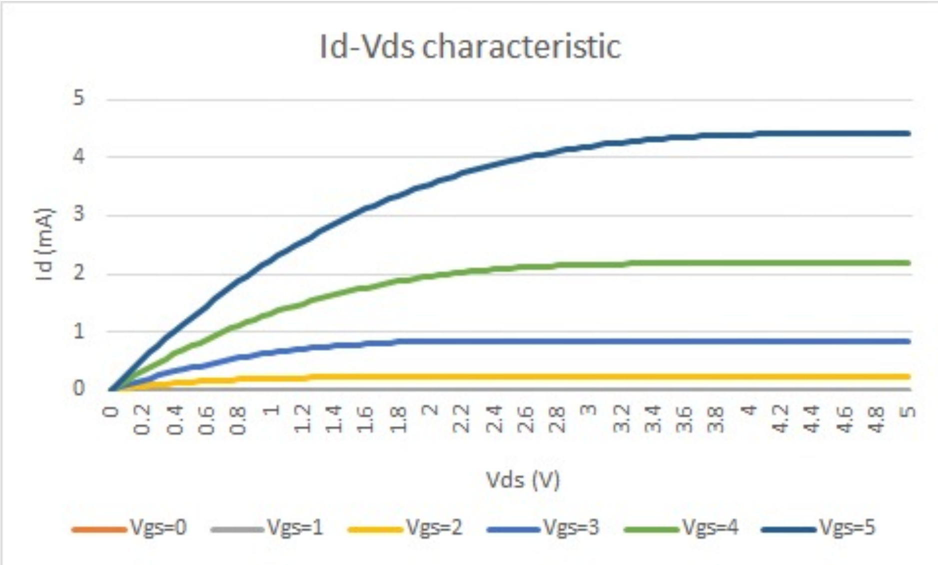
20175030 김산

HW #3

2.1

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$, $\therefore \mu_n C_{ox} \frac{W}{L} = 241.6\mu$ $[A/V^2]$



2.2

$$I_{DS1} = \frac{1}{2}\mu_n C_{ox}\frac{W}{2L}\left(2(V_{DD}-V_t)V_{DS} - V_{DS}^2\right)$$

$V_{DS} - V_1 < V_{DS}$, $V_1 < V_{DS}$, so both NMOS in (b) are in triode rigion.

$$I_{DS2} = \cancel{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}}\left(2(V_{DD}-V_t-V_1)(V_{DS}-V_1) - (V_{DS}-V_1)^2\right)$$

$$= \cancel{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}}\left(2(V_{DD}-V_t)V_1 - V_1^2\right) \quad , \text{let } V_{DD}-V_t = k.$$

$$2(k-V_1)(V_{DS}-V_1) = 2kV_{DS} + 2V_1^2 - 2(V_{DS}+k)V_1$$

$$2(kV_{DS}+V_1^2-(\cancel{V_{DS}}+k)V_1) - V_{DS}^2 + \cancel{2V_{DS}}V_1 - 2kV_1 = 0 \quad , 2V_1^2 - 4kV_1 + 2kV_{DS} - V_{DS}^2 = 0$$

$$\therefore V_1 = \frac{2k - \sqrt{4k^2 + 2V_{DS}^2 - 4kV_{DS}}}{2} = k - \underbrace{\sqrt{\frac{V_{DS}^2}{2} - kV_{DS} - k^2}}_{\text{let } p.} \quad (\because V_1 < V_{DS} - \underset{k}{V_t})$$

$$\therefore I_{DS2} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(2k(k-\cancel{p}) - (k^2+p^2-\cancel{2kp})\right)$$

$$= \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(k^2-p^2) = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(\cancel{k^2} - \left(\frac{V_{DS}^2}{2} - kV_{DS} + \cancel{k^2}\right)\right)$$

$$= \frac{1}{2}\mu_n C_{ox}\frac{W}{2L}\left(2(V_{DD}-V_t)V_{DS} - V_{DS}^2\right)$$

$$= I_{DS1}.$$

$$\therefore I_{DS1} = I_{DS2} \,//$$

2.3

From 2.2, $V_1 > 0$, $V_{sb} > 0$. Then the depletion region of channel of top TR become wider, so V_{th} increase. It causes the $I_{DS2} < I_{DS1}$ //

2.4

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9 \times 8.85 \times 10^{-12}}{16 \times \cancel{10^{-4}}\ (\mu m)} \times 90 \times \cancel{10^{-9}}^{-5} = 1.94\ fF/\mu m$$ //

2.5

$\lambda = 0.3\mu m$
$CJ = 0.42\ f/\mu m^2$
$MJ = 0.44$
$CJSW = 0.33$
$MJSW = 0.12$
$\phi_0 = 0.98$

unit size $= 4 \times 5\ \lambda^2 = 1.8\ \mu m^2$
perimeter $= 2W + 2L = 18\lambda = 5.4\ \mu m$ ($\because$ process over than $0.35\mu m$)

i) $V_{DD} = 0$.

$$C_{db} = 1.8 \times 0.42f + 5.4 \times 0.33f = 2.538\ fF$$ //

ii) $V_{DD} = 5$.

$$C_{db} = 1.8 \times 0.42f \times \left(1 + \frac{5}{0.98}\right)^{-0.44} + 5.4 \times 0.33f\left(1 + \frac{5}{0.98}\right)^{-0.12}$$

$$= 1.775\ fF$$ //

$\boxed{\text{Additional}}$

$$V(x) = V_G - V_t - \sqrt{(V_G - V_t)^2 - \frac{2I_D}{\mu_n C_{ox} W} x} = V_G - V_t - \sqrt{(V_G - V_t)^2 - \frac{2\left((V_G - V_t)V_D - \frac{1}{2}V_D^2\right)}{L} x}$$

$$= 1.4 - \sqrt{1.96 - \frac{10^9}{90}\left(2.8V_D - V_D^2\right) x}$$