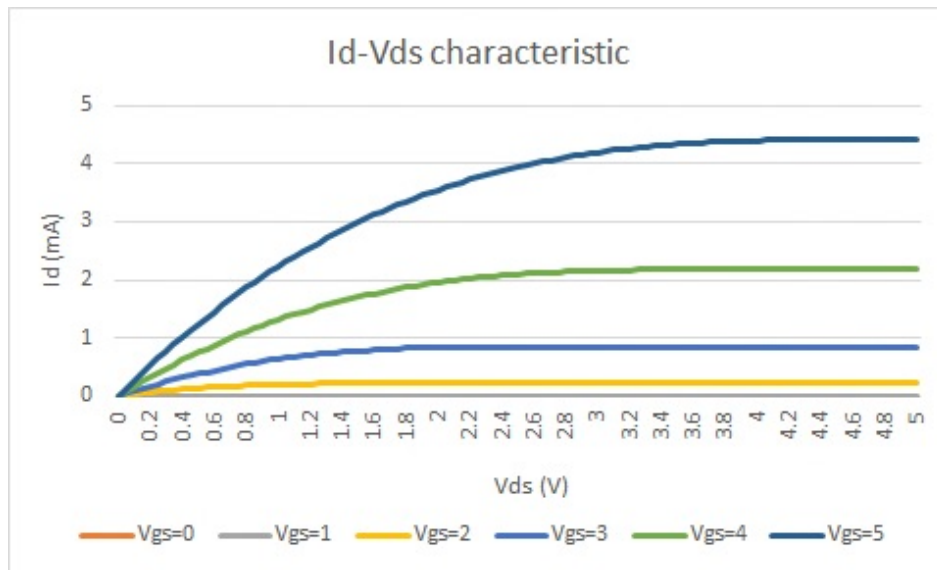


# HW #3

2.1

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$$

$$\therefore \mu_n C_{ox} \frac{W}{L} = 241.6 \mu A/V^2$$



2.2

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

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

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

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

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

$$2(kV_{DS} + V_i^2 - (V_{DS} + k)V_i) - V_{DS}^2 + 2V_{DS}V_i - 2kV_i = 0 \quad , \quad 2V_i^2 - 4kV_i + 2kV_{DS} - V_{DS}^2 = 0$$

$$\therefore V_i = \frac{2k - \sqrt{4k^2 + 2V_{DS}^2 - 4kV_{DS}}}{2} = k - \sqrt{\frac{V_{DS}^2}{2} - kV_{DS} + k^2} \quad (\because V_i < V_{DS} - V_t)$$

$\hookrightarrow$  let  $p$ .

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

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

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

$$= I_{DS1}$$

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

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2.3

From 2.2,  $V_i > 0$ ,  $V_{sb} > 0$ . Then the depletion region of channel of top TR become wider, so  $V_{th}$  increase. It causes the  $I_{bs2} < I_{bs1}$

2.4

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = \frac{3.9 \times 8.85 \times 10^{-12}}{16 \times 10^{-4} \text{ (nm)}} \times 90 \times 10^{-5} = 1.94 \text{ fF/nm}$$

2.5

$$\left\{ \begin{array}{l} \lambda = 0.3 \mu\text{m} \\ C_J = 0.42 \text{ fF}/\mu\text{m}^2 \\ M_J = 0.44 \\ CJSW = 0.33 \\ MJSW = 0.12 \\ \gamma_0 = 0.98 \end{array} \right.$$

$$\text{unit size} = 4 \times 5 \mu^2 = 1.8 \mu\text{m}^2$$

$$\text{perimeter} = 2W + 2L = 18 \mu = 5.4 \mu\text{m} \quad (\because \text{process over than } 0.35 \mu\text{m})$$

$$i) V_{DD} = 0.$$

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

$$ii) V_{DD} = 5.$$

$$\begin{aligned} C_{db} &= 1.8 \times 0.42 \text{ f} \times \left(1 + \frac{5}{0.98}\right)^{-0.44} + 5.4 \times 0.33 \text{ f} \times \left(1 + \frac{5}{0.98}\right)^{-0.12} \\ &= 1.775 \text{ fF} \end{aligned}$$

Additional

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

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

