DIC HW#3

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1. (Ex 2.1)

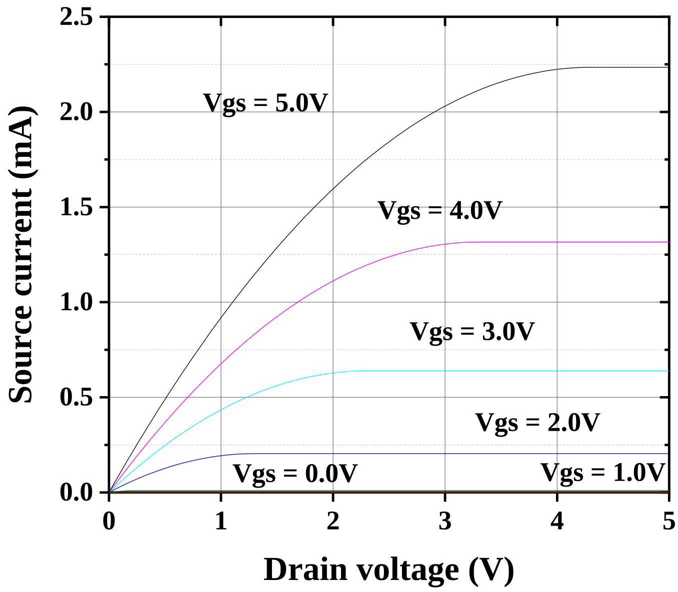
We can draw $I_d$ vs. $V_{ds}$ graph for $V_{gs}$ with this equation.(from lecture material)

| | |
|---|---|
| Subthreshold | $I_d = 0$ |
| Linear | $I_d = \beta\left(V_{gs} - V_t - \frac{V_{ds}}{2}\right)V_{ds}$ |
| Saturation | $I_d = \frac{\beta}{2}(V_{gs} - V_t)^2$ |

With,

$$\beta = \mu_n C_{OX}\frac{W}{L}$$

Then, result is here.




2. (Ex 2.2)

At their linear region,

$$I_{d2} = \mu_n C_{OX}\frac{W}{L}\left(V_{DD} - V_t - \frac{V_{DS} - V_1}{2}\right)(V_{DS} - V_1)$$

$$I_{d2} = \mu_n C_{OX} \frac{W}{L}\left( V_{DD} - V_1 - V_t - \frac{V_1}{2} \right) V_1$$

Then,

$$V_1 = V_{DD} - V_t - \sqrt{(V_{DD} - V_t)^2 - \left( V_{DD} - V_t - \frac{V_{DS}}{2} \right) V_{DS}}$$

Therefore,

$$I_{d2} = \mu_n C_{OX} \frac{W}{2L}\left( V_{DD} - V_t - \frac{V_{DS}}{2} \right) V_{DS} = I_{d1}$$

3. (Ex 2.3)

(a)에서는 source와 body에 같은 전압이 인가되었지만, (b)의 윗쪽 nmos에서는 source에 비해 body에 낮은 전압이 인가되었다. 이는 p-type인 body 부분의 reverse bias를 걸어주는 것이므로, electrostatic potential은 감소하게 되고, 그에 따라 depletion region의 두께가 증가하게 된다. 그러므로 V_th가 상승하는 것과 비슷한 결과를 얻게 되므로, 전체적인 전류의 량은 줄어들게 된다.

I_d1 > I_d2

4. (Ex 2.4)

$$C_{g/mow} = C_{ox} L \frac{1.0m}{10^{-6}\mu m} = \frac{\varepsilon_{OX}}{t_{OX}} L \frac{1.0m}{10^{-6}\mu m} = \frac{3.9\varepsilon_0}{16 \times 10^{-10} m} \times 90 \times 10^{-9} m \times \frac{1.0m}{10^6 \mu m}$$

→ $C_{g/mow} = 1.9424 \times 10^{-15}\,\mathrm{F}/\mu\mathrm{m} = 1.9424 \times \ \mathrm{fF}/\mu\mathrm{m}$

5. (Ex 2.5)

$$C_{db}(0) = (4\lambda \times 5\lambda)(0.42\,\mathrm{fF}/\mu\mathrm{m}^2) + 2 \times (4\lambda + 5\lambda)(0.33\,\mathrm{fF}/\mu\mathrm{m}^2) = 2.538\,\mathrm{fF}$$

$$C_{db}(5) = (4\lambda \times 5\lambda)(0.42\,\mathrm{fF}/\mu\mathrm{m}^2)\left(1 + \frac{5}{0.98}\right)^{-0.44} + 2 \times (4\lambda + 5\lambda)(0.33\,\mathrm{fF}/\mu\mathrm{m}^2)\left(1 + \frac{5}{0.98}\right)^{-0.12} = 1.775\,\mathrm{fF}$$

6.

$$I_d dx = \mu_n C_{ox} W (V_{gs} - V(x) - V_t) dV$$

$$I_d x = \mu_n C_{ox} W (V_{gs} - \frac{V(x)}{2} - V_t) V(x)$$

$$\frac{V(x)^2}{2} - (V_{gs} - V_t) V(x) + \frac{I_d x}{\mu_n C_{ox} W} = 0$$

$$\therefore V(x) = (V_{gs} - V_t) \pm \sqrt{(V_{gs} - V_t)^2 - \frac{2 I_d x}{\mu_n C_{ox} W}}$$

When x = 180nm, V(x) = V_ds.

$$\therefore V(x) = (V_{gs} - V_t) - \sqrt{(V_{gs} - V_t)^2 - \frac{2 I_d x}{\mu_n C_{ox} W}}$$