Digital I.C

Assignment

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1 $\quad W/L = 2 \quad \mu_n = 350 cm^2/V\cdot s$

from (2.11)

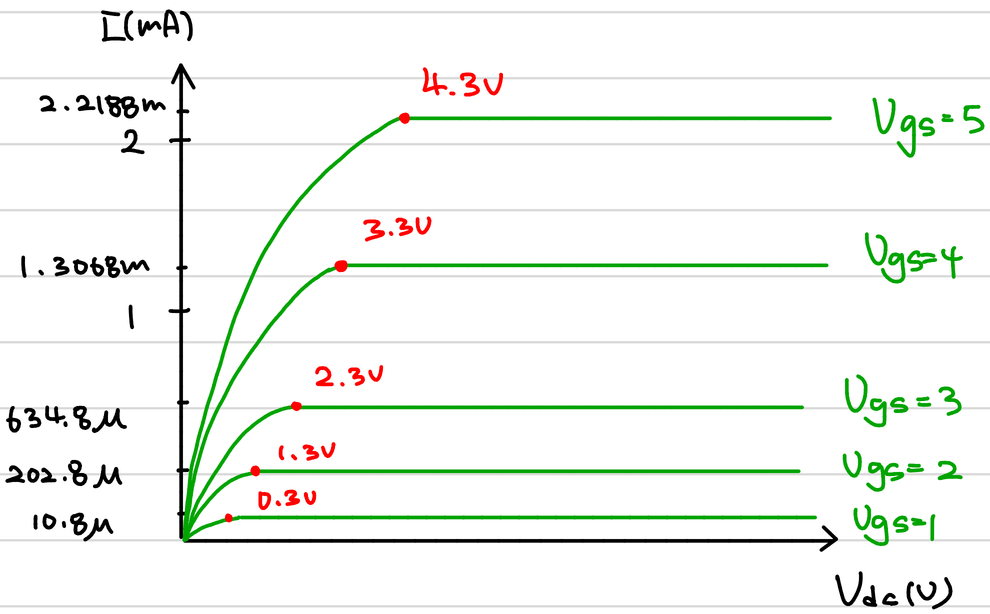
$$\beta = \mu_n C_{ox} \frac{W}{L} = 350 \left(\frac{3.9 \times 8.85 \times 10^{-14}}{100 \times 10^{-8}} \right) \cdot 2 = 240 \ \mu A/V^2$$

$$I_{ds} = \begin{cases} 0 & V_{gs} < V_{th} \\ \beta \left(V_{gs} - V_{th} - \frac{V_{ds}}{2} \right) V_{ds} & V_{gs} > V_{th},\ V_{ds} < \overset{0.3}{V_{dsat}} \\ \frac{1}{2}\beta \left(V_{gs} - V_{th} \right)^2 & V_{gs} > V_{th},\ V_{ds} > V_{dsat} \end{cases}$$

$\hookrightarrow$ $V_{gs} = 1 \rightarrow 10.8\mu A$ $\quad V_{gs} = 2 \rightarrow 202.8\mu A$

$V_{gs} = 3 \rightarrow 634.8\mu A$ $\quad V_{gs} = 4 \rightarrow 1.3068\ mA$

$V_{gs} = 5 \rightarrow 2.2188 mA$



2 in (a) $V_{gs} = V_{DD}$ linear region

① $I_{DS1} = \beta_1 \left(V_{GS} - V_{th} - \frac{V_{DS}}{2}\right) V_{DS} = \beta_1 \left(V_{DD} - V_{th} - \frac{V_{DS}}{2}\right) V_{DS}$

② top TR $I_{DS2} = \beta_2 \left(V_{DD} - V_1 - V_{th} - \frac{V_{DS} - V_1}{2}\right)(V_{DS} - V_1)$

$$= \beta_2 \left(V_{DD} - V_{th} - \frac{V_{DS} + V_1}{2}\right)(V_{DS} - V_1)$$

③ bottom TR $I_{DS2} = \beta_2 \left(V_{DD} - V_{th} - \frac{V_1}{2}\right) V_1$

$$\therefore \left(V_{DD} - V_{th} - \frac{V_{DS} + V_1}{2}\right)(V_{DS} - V_1) = \left(V_{DD} - V_{th} - \frac{V_1}{2}\right) V_1$$

$$\rightarrow V_1 = (V_{DD} - V_{th}) - \underbrace{\boxed{\sqrt{(V_{DD} - V_{th})^2 - \left(V_{DD} - V_{th} - \frac{V_{DS}}{2}\right) V_{DS}}}}_{= k}$$

$$\beta_2 \left(\frac{V_{DD} - V_{th}}{2} + \frac{k}{2}\right)(V_{DD} - V_{th} - k)$$

$$= \frac{\beta_2}{2}\left[(V_{DD} - V_{th})^2 - k^2\right] = \frac{\beta_2}{2}\left(V_{DD} - V_{th} - \frac{V_{DS}}{2}\right) V_{DS}$$

$$\beta_1 = \frac{\beta_2}{2} \qquad \therefore I_{DS1} = I_{DS2}$$

#3. a)에서는 $V_{sb}=0$ 이기 때문에 body effect가 없다

하지만 b)의 top TR의 경우 V_s가 V_1이기 때문에 $V_{sb}>0$이

되어 I_{DS2}가 감소한다. $\therefore I_{DS1} > I_{DS2}$

permittivity of free space

$= 8.85\times10^{-14}$ F/cm

#4. $C_{permicron} = C_{ox} L = \frac{\varepsilon_{ox}}{t_{ox}} L$ → Length $= 90\times10^{-9}$m

↳ thickness of oxide

$= 16\times10^{-4}\mu m$

$= \frac{8.85\times10^{-14}\,(F/\cancel{cm})}{16\times10^{-4}\,(\mu m)}\, 90\times10^{-7}\,(\cancel{cm}) = 1.94\,fF/\mu m$

#5 unit size diffusion contact $= 4\lambda \times 5\lambda$

$1\lambda = 0.3\mu m$ $\therefore$ area $= 0.12\times0.15 = 1.8\mu m^2$

from 2.21) $C_{dB(0V)} = (1.8\mu m^2)(0.42fF/\mu m^2)$

$+ (5.4\mu m)(0.33fF/\mu m) = 2.54fF$

from 2.22) $C_{dB(1V)} = (1.8\mu m^2)(0.42fF/\mu m^2)\left(1+\frac{5}{0.98}\right)^{-0.44}$

$+ (5.4\mu m)(0.33fF/\mu m^2) + \left(1+\frac{5}{0.98}\right)^{-0.12}$

$= 1.78fF$

Additional example

$V_g = 1.8V$ $V_t = 0.4V$ $V_d < 1.4V$ Length= 180nm

$V_s = 0$ 이라 가정

① $V_{gs} > V_{th}$

② $V_{gs} - V_{th} = 1.4V > V_{ds}$

linear region

∴ Potential