HW3

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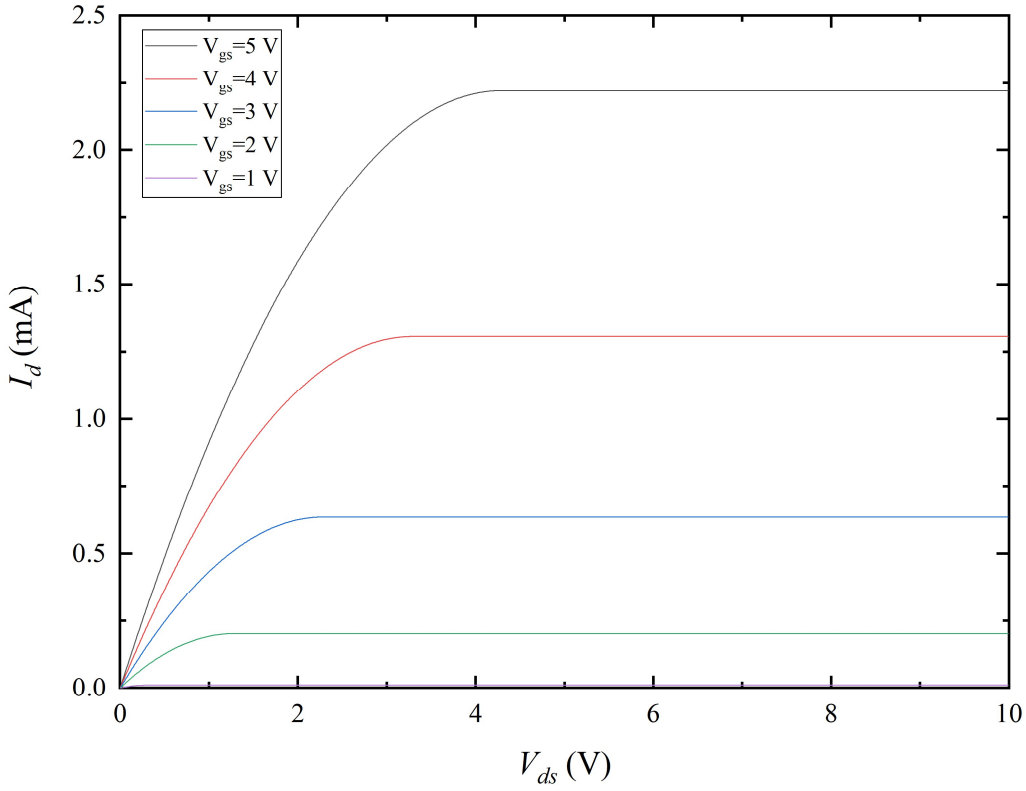
20194072

Exercise 2.1)



[Figure 1] This graph is that V_{ds} vs I_d at V_{gs} = 1 V to V_{gs} = 5 V, with different saturation voltage.

Linear region: $I_d = (240\ \mu\text{AV}^{-2})[V_{gs} - (0.7\ \text{V}) - V_{ds}/2]V_{ds}$

Saturation: $I_d = (120\ \mu\text{AV}^{-2})[V_{gs} - (0.7\ \text{V})]^2$ at $V_{ds} = V_{gs} - (0.7\ \text{V})$

Exercise 2.2)

In figure (a), $I_{d1} = (\beta/2)(V_{DD} - V_t - V_{DS}/2)V_{DS}$ where β is determined by W/L.

For upper MOS in figure (b), $I_{d2,u} = \beta(V_{DD} - V_t - V_1/2)V_1$.

Similarly, for lower MOS in figure (b), $I_{d2,l} = \beta[V_{DD} - V_1 - V_t - (V_{DS} - V_1)/2](V_1 - V_{DS})$.

Finally, $I_{d2,u} = I_{d2,l}$ implies $V_1 = (V_{DD} - V_t) - \sqrt{(V_{DD} - V_t)^2 - (V_{DD} - V_t - V_{DS}/2)V_{DS}}$.

and we can determine the fact, $I_{d2} = (\beta/2)(V_{DD} - V_t - V_{DS}/2)V_{DS}$ by obtained V_1, so that $I_{d1} = I_{d2}$.

Exercise 2.3)

Body effect reduces the current of the figure (b), because the voltage between source and body in figure (b) will increase the threshold voltage of MOS. Therefore, we can determine that $I_{d1} > I_{d2}$.

Exercise 2.4)

$$C = \frac{\varepsilon_{ox} L}{t_{ox}} = \frac{(3.9 \times 8.85 \times 10^{-14}\ \text{Fcm}^{-1})(90\ \text{nm})}{(16 \times 10^{-10}\ \text{m})} = 1.94\ \text{fF}(\mu\text{m})^{-1}$$

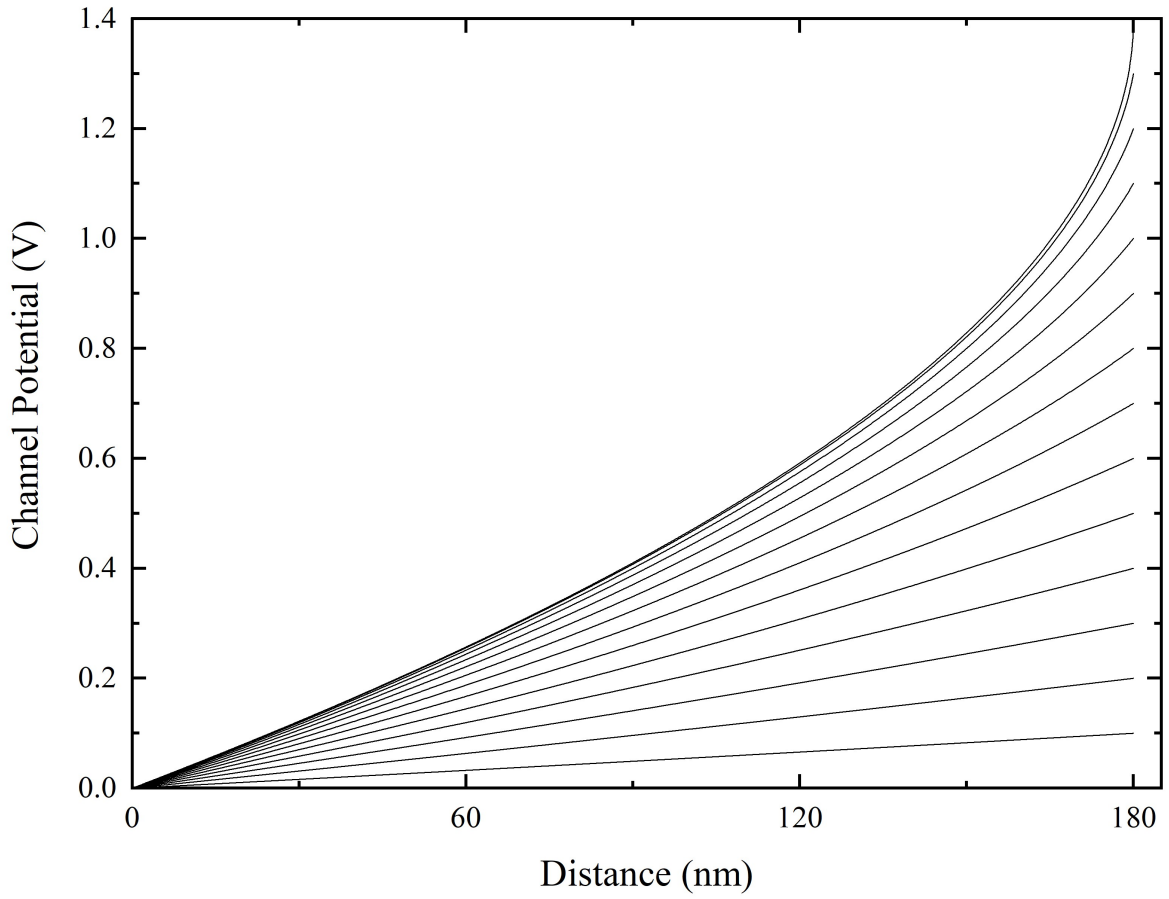
Exercise 2.5)

Its area is $4\lambda \times 5\lambda = 20\lambda$, and the perimeter is $2(4\lambda + 5\lambda) = 18\lambda$.

At 0 V, $C_{db} = (0.42)(20\lambda^2) + (0.33)(18\lambda) = 2.54\ \text{fF}$

At 5 V, $C_{db} = (0.42)(20\lambda^2)[1 + (5\ \text{V})/(0.98\ \text{V})]^{-0.44} + (0.33)(18\lambda)[1 + (5\ \text{V})/(0.98\ \text{V})]^{-0.12} = 1.78\ \text{fF}$

NMOS Potential)



[Figure 2] This graph indicates the channel potential *V(x)* vs channel distance at V_d = 0 V to V_d = 1.4 V

Since $V_g - V_t = 1.4\ \text{V}$,

The channel potential is $V(x) = 1.4\ \text{V} - \sqrt{(1.4\ \text{V})^2 - (2x)[(1.4\ \text{V})V_d - V_d^2/2]/(180\ \text{nm})}$.

The relation was found in hi2ska2/ec2018s, L9_0402.pdf