ECE 3150 NotesS

I-V Chars.

① cutoff: $V_{gs} < V_{tn} \Rightarrow I_{DS} \approx 0$ nMOS

$|V_{gs}| < |V_{tp}| \Rightarrow I_{DS} \approx 0$ pMOS

② linear:

$V_{GS} > V_t$ & $V_{DS} < V_{GS} - V_{tn}$

$$I_{DS} = \beta_n \left[(V_{GS} - V_{tn}) - \frac{V_{DS}}{2} \right] V_{DS}$$

$$\beta_n = \mu_n C_{ox} \frac{W_n}{L_n}, \quad C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$$

$V_{GS} - V_{tn} \Rightarrow$ gate overdrive voltage

③ Saturation Rgn

$V_{GS} > V_{tn}$ and $V_{DS} \geq V_{GS} - V_{tn}$

$$I_{DS} = \frac{\beta_n}{2} (V_{GS} - V_{tn})^2$$

$$V_{DSat} = V_{GS} - V_{tn}$$

$|V_{GS}| < |V_{tp}|$, $|V_{DS}| \geq |V_{GS}| - |V_{tp}|$

$$|I_{DS}| = \frac{\beta_p}{2} (|V_{GS}| - |V_{tp}|)^2$$

$|V_{GS}| < |V_{tp}|$, $|V_{DS}| < |V_{GS}| - |V_{tp}|$

$$|I_{DS}| = \beta_p \left[(|V_{GS}| - |V_{tp}|) - \frac{|V_{DS}|}{2} \right] |V_{DS}|$$

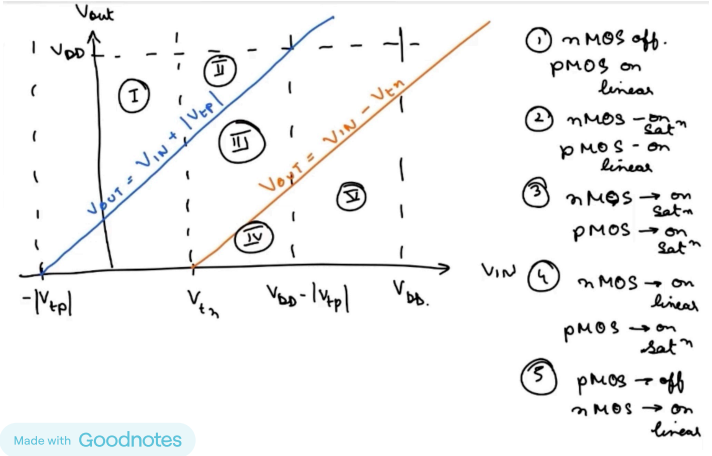
$$\beta_p = \mu_p \frac{\varepsilon_{ox}}{t_{ox}} \frac{W_p}{L_p}$$

Tripping point $V_M = \dfrac{V_{DD} - |V_{tp}| + \sqrt{\frac{\beta_n}{\beta_p}} V_{tn}}{1 + \sqrt{\frac{\beta_n}{\beta_p}}}$

$$\sqrt{\frac{\beta_n}{\beta_p}} = \frac{(1-r)V_{DD} - |V_{tp}|}{r V_{DD} - V_{tn}}$$

$NM_H = V_{OH} - V_{IH}$

$NM_L = V_{IL} - V_{OL}$



① nMOS off. pMOS on linear

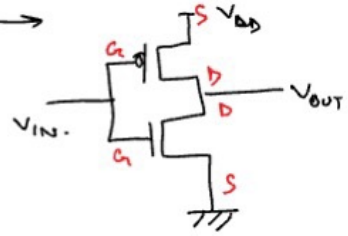
② nMOS – on sat^n pMOS – on linear

③ nMOS → on sat^n pMOS → on sat^n

④ nMOS → on linear pMOS → on sat^n

⑤ pMOS → off nMOS → on linear

M3-PB →



nMOS → (a) $V_{GS} = V_G - V_S = V_{IN} - 0 = V_{IN}$

(b) $V_{DS} = V_{OUT}$

pMOS → (a) $V_{GS} = V_G - V_S = V_{IN} - V_{DD}$

$|V_{GS}| = V_{DD} - V_{IN}$.

(b) $|V_{DS}| = V_{DD} - V_{out}$.

Resistance Diagram → end of M3-PB.