ECE 511 — Lecture 4

Note Title 1/31/2013

$$f_T \simeq \frac{g_m}{2\pi C_{gs}} \propto \frac{V_{ov}}{L^2}$$

open loop gain

$$g_m r_o = \frac{\beta V_{ov}}{\lambda \frac{\beta}{2} V_{ov}^2} = \frac{2}{\lambda V_{ov}} \propto \frac{L}{V_{ov}} \qquad \because \lambda \propto \frac{1}{L}$$

$$\underbrace{(g_m r_o)}\,\underbrace{f_T} \propto \frac{V_{ov}}{L^2} \cdot \frac{L}{V_{ov}} \propto \frac{1}{L}$$

gain × BW tradeoff

$L \downarrow$ mismatch increases

Short-channel devices

$$\boxed{\begin{aligned} f_T &\propto \frac{V_{ov}}{L} \\ g_m r_o &\propto \frac{L}{V_{ov}} \end{aligned}}$$

$$(g_m r_o) f_T = \text{const.}$$

L.C. $I_{D,sat} = \frac{\beta}{2}(V_{GS} - V_{THN})^2$

S.C $I_{D,sat} = \underbrace{\mu_n v_{sat}}_{\text{velocity saturation}} \frac{W}{} (V_G - V_{THN})$

Temperature effects

$$I_{D,sat} = \underbrace{\frac{\boxed{\mu_n}\,\varepsilon_{ox}}{2\,t_{ox}}}_{KP_n} \cdot \frac{W}{L}\left(V_{GS} - \boxed{V_{THN}}\right)^2$$

$\mu_n(T)$

$V_{THN}(T)$

① V_{THN}

$$V_{THN} = -V_{ms} - 2V_{fp} + \frac{Q_{bo}' - Q_{ss}'}{C_{ox}'}$$

$$\frac{\partial V_{THN}}{\partial T} = -\boxed{\frac{k}{q}}\ln\left(\frac{N_{D,poly}}{N_A}\right)$$

$0.085\ \frac{mV}{°C}$

$N_{D,poly} = 10^{20}$ & $N_A = 10^{15}$

$$\boxed{\frac{\partial V_{THN}}{\partial T} \simeq -1\,mV/°C}$$

②

$$KP(T) = KP(T_0)\left(\frac{T}{T_0}\right)^{-3/2}$$

$\mu\downarrow$

① $V_{THN}\downarrow \Rightarrow I_D\uparrow$

② $KP_n\downarrow \Rightarrow I_D\downarrow$

$$\frac{\partial I_D}{\partial T} \propto \frac{\overbrace{(V_{GS}-V_{THN})}^{V_{ov}}}{2}\cdot\frac{\partial KP_n}{\partial T} \underbrace{- KP_n\cdot\frac{\partial V_{THN}}{\partial T}}_{+ve}$$

at low $V_{GS} \Rightarrow I_D\uparrow$

at high $V_{GS} \Rightarrow I_D\downarrow$

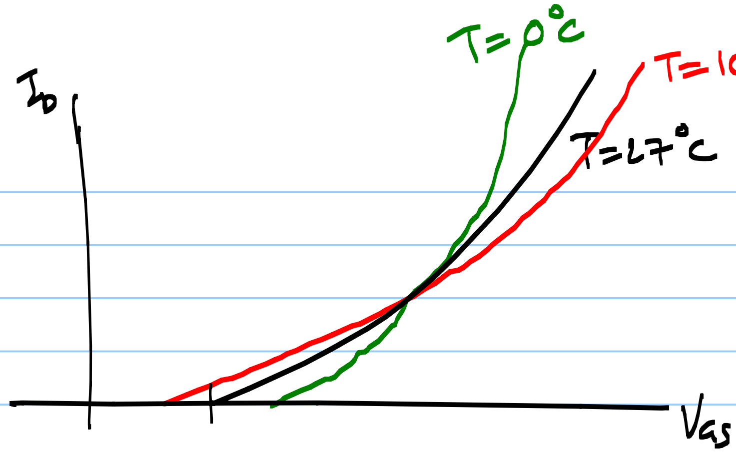

Fig 9,30