Lecture 9 8/2/2016

Transit frequency:

$$\omega_T = \frac{g_m}{C_{gs}} = \frac{3}{2}\,\mu_n \frac{\overbrace{(V_{GS}-V_T)}}{L^2}$$

Bias @ large $V_{GS}-V_T$ in h.f. circuits

$$\frac{3}{4}\,\frac{v_{SAT}}{L}$$

velocity saturated.

MOS transistor mismatch

$$\left.\begin{aligned} I_D &= \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{GS} - V_T)^2 \\ &= \frac{k_n}{2} (V_{GS} - V_T)^2 \end{aligned}\right\} \text{Saturation region}$$

Random mismatch: Current factor k_n & threshold voltage V_T randomly distributed.

$V = I \cdot \underline{\underline{R}}$ std deviation of $\frac{\Delta R}{R_0}$ ← Mean value

$i = \underline{C} \cdot \frac{dv}{dt}$ " of $\frac{\Delta C}{C_0}$

$I = \frac{k_n}{2}(V_{GS} - V_T)^2$ std deviation of $\frac{\Delta k_n}{k_{n0}}$ ← Mean value

std deviation of ΔV_T

std deviation of $\frac{\Delta k_n}{k_{n_0}}$ $\quad \sigma_{k_n} = \sigma\left(\frac{\Delta k_n}{k_{n_0}}\right) = \frac{A_\beta}{\sqrt{WL}}$

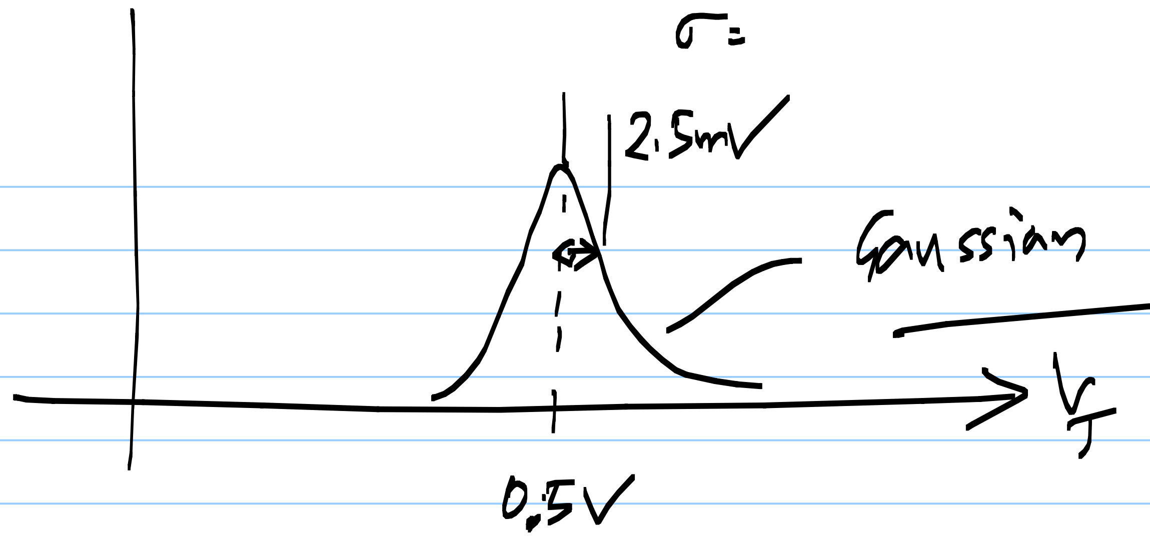
$k_n \equiv \beta_n$

std deviation of V_T : $\sigma_{V_T} = \sigma\left(V_T\right) = \frac{A_{V_T}}{\sqrt{WL}}$

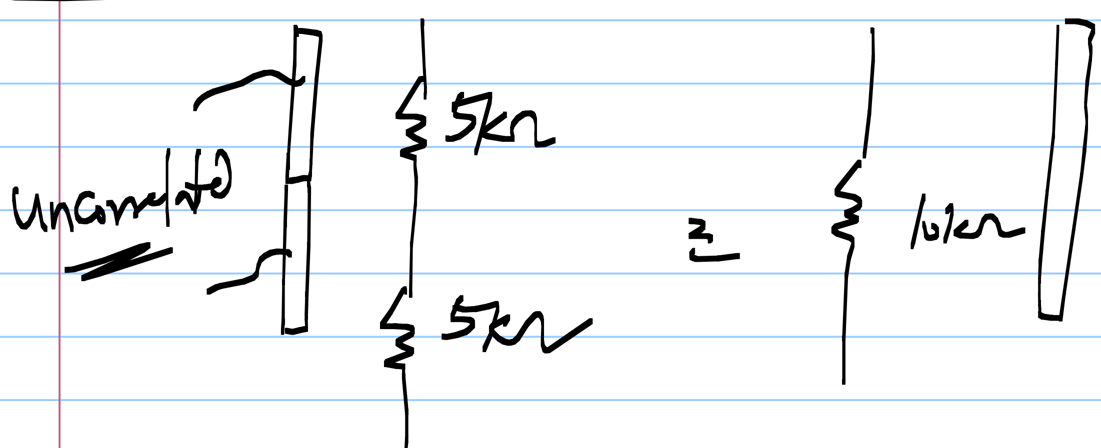
$A_\beta \left\{\equiv A_c, A_k\right\}$: $(\%) \cdot \mu m$

A_{V_T} : $\frac{mV \cdot \mu m}{\quad}$

$$\left.\begin{array}{l} A_{V_T} : 5mV \cdot \mu m \\ \frac{10\mu m}{0.4\mu m} : \end{array}\right\} \sigma_{V_T} = 2.5mV$$

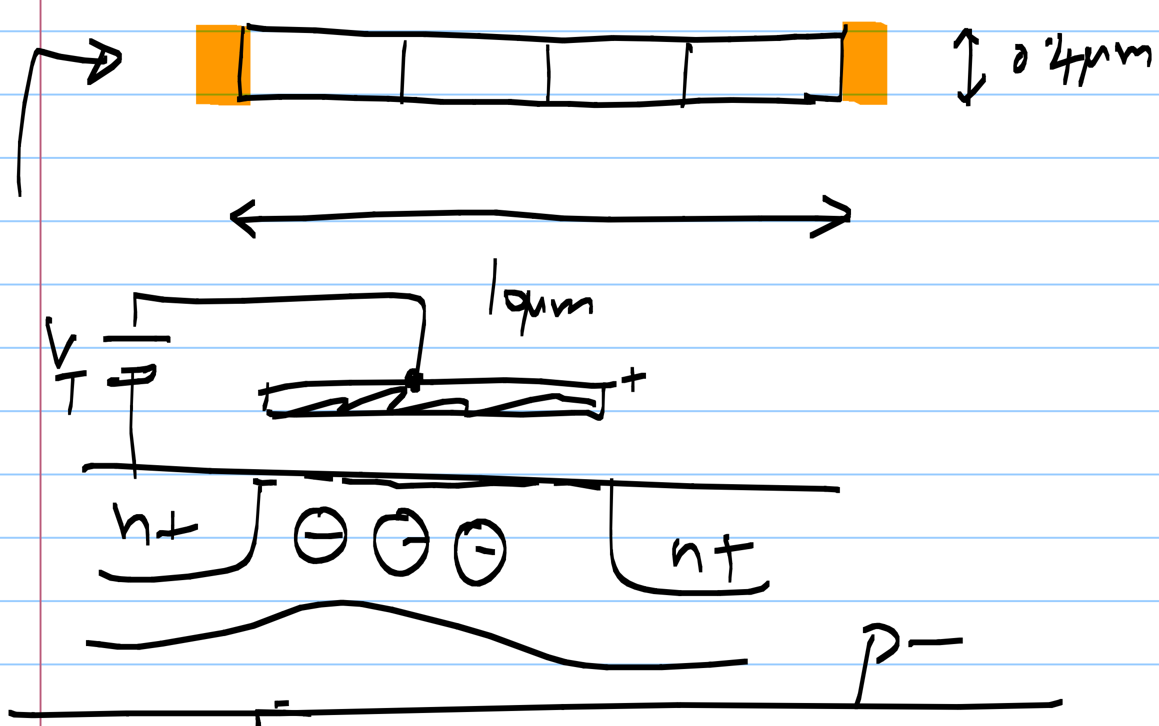


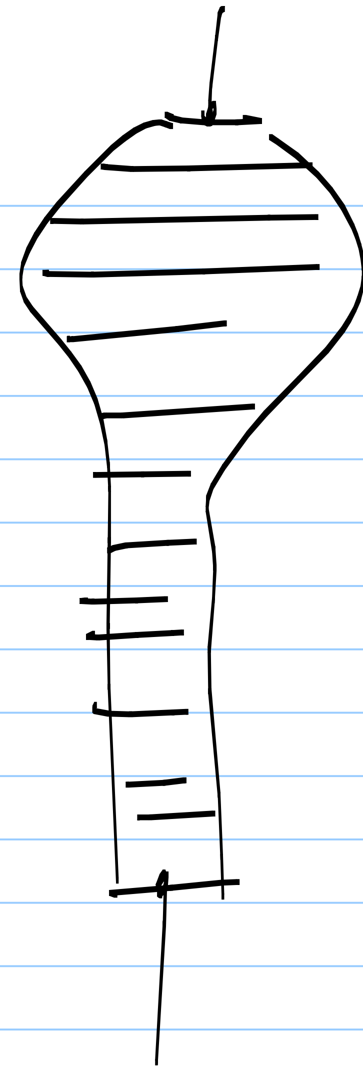
$\sigma =$
2.5mV
Gaussian
V_T
0.5V

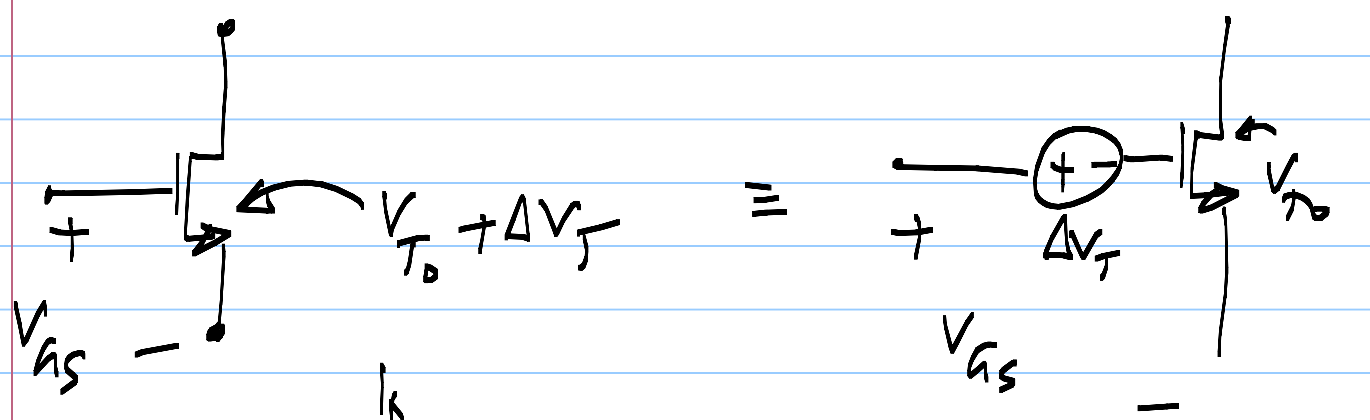


Uncorrelated
5kΩ
5kΩ
≈
10kΩ

$$\frac{10\mu m}{0.4\mu m}$$

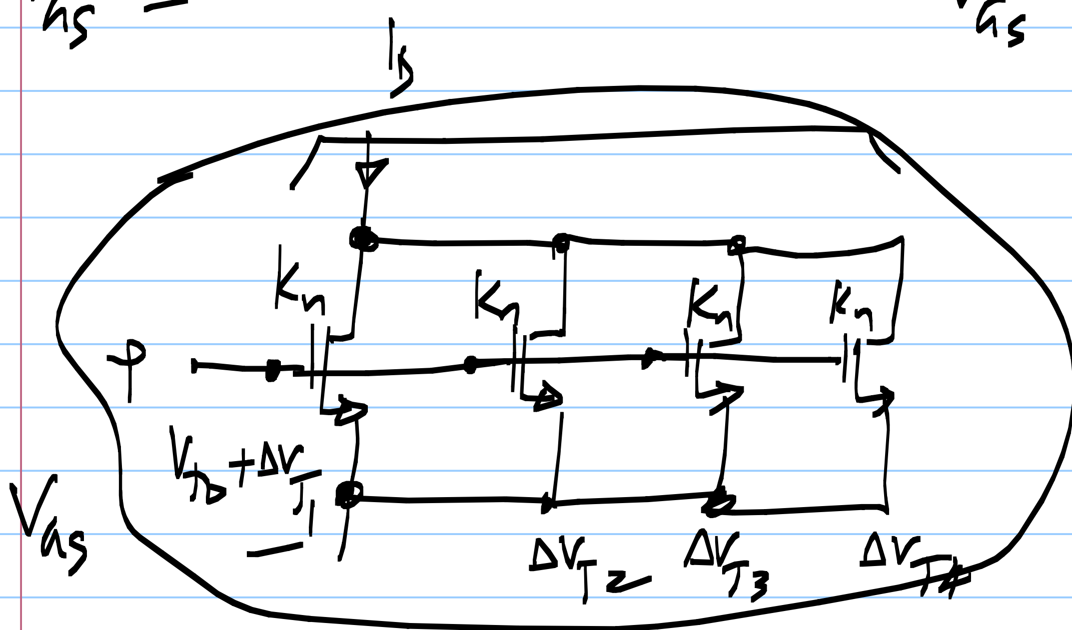






$(V_{GS} - V_T')^2$

$V_{T_0} + \underline{\underline{\boxed{\Delta V_{T_x}}}}$



$\Delta V_{T_{1 \ldots 4}} : \sigma_{V_T}$

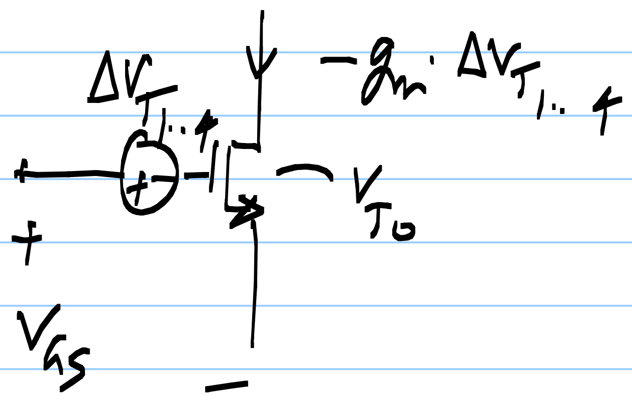
$$I_{1\ldots4} = \frac{k_n}{2}\left(V_{GS} - V_{T_0} - \Delta V_{T_{1\ldots4}}\right)^2$$

$$I_j = I_1 + I_2 + I_3 + I_4$$

$$\frac{4k_n}{2}\left(V_{GS} - V_{T_0}\right)^2$$ No mismatch

$$\frac{4k_n}{2}\left(V_{GS} - V_{T_0} - \Delta V_{T_x}\right)^2$$ w/ mismatch

$$\Delta I_D = -g_m\left(\Delta V_{T_1} + \Delta V_{T_2} + \Delta V_{T_3} + \Delta V_{T_4}\right)$$

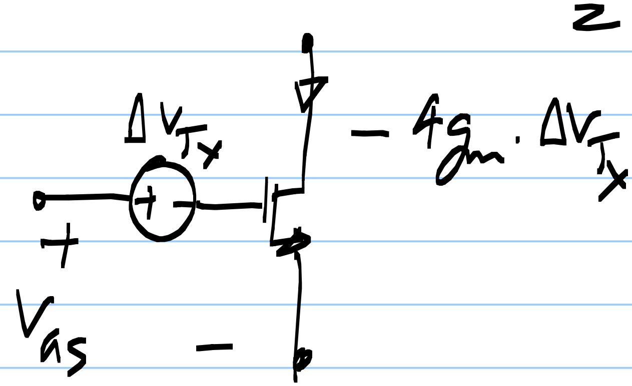


$$\Delta I_D = \overbrace{-4g_m \cdot \Delta V_{T_x}}^{1\ldots4}$$

$$\sigma^2(\Delta I_D) = g_m^2 \cdot 4\,\sigma_{V_T}^2$$

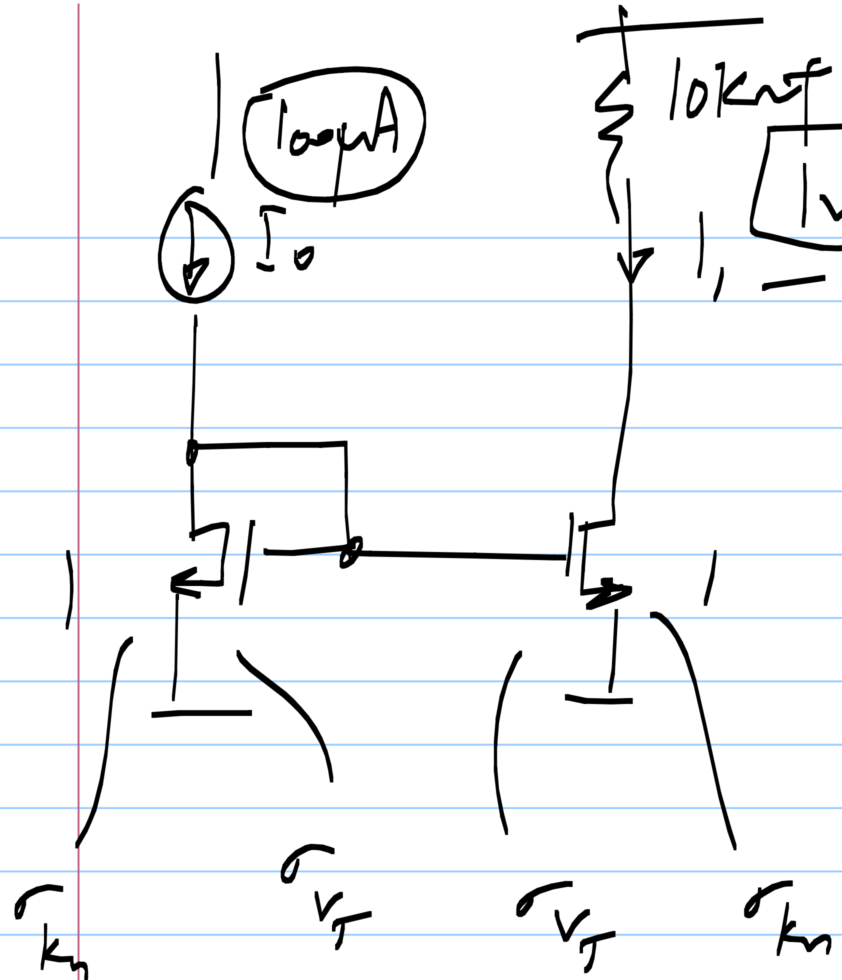
$$= 16\, g_m^2 \cdot \sigma_{V_{T_x}}^2$$

o/p drain current $= \frac{K_n}{2}\left(V_{GS} - V_{T_0}\right)^2$

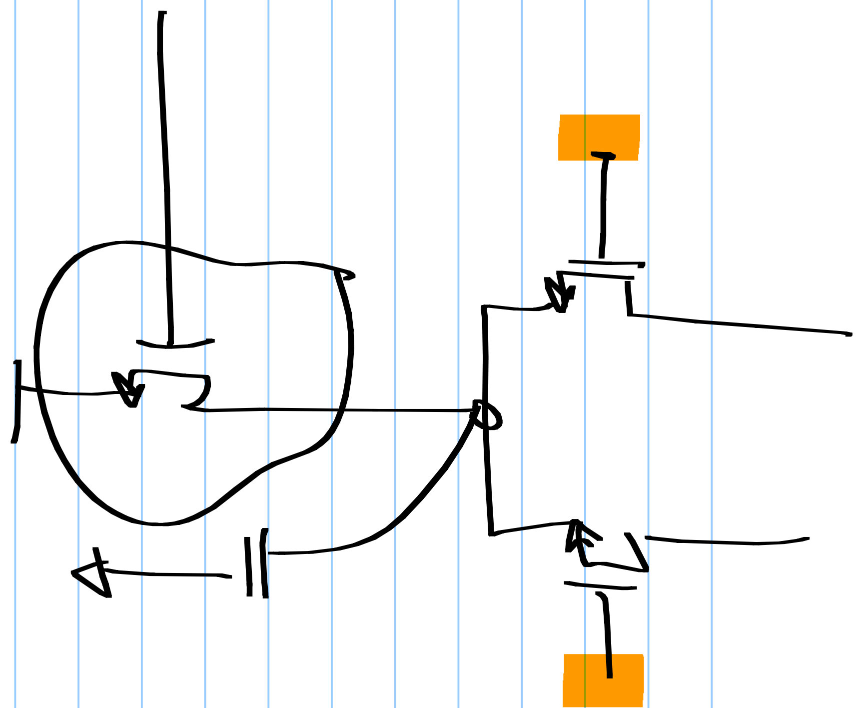


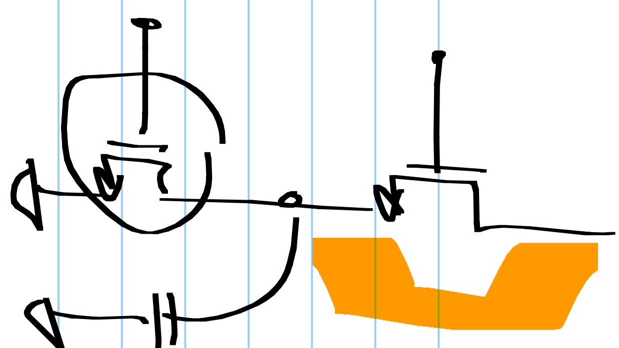
$$\sigma_{V_{T_x}}^2 = \frac{\sigma_{V_T}^2}{4}$$

$$\sigma_{V_{T_x}} = \sigma_{V_T}/2$$



$\sigma^2\left(\frac{I_1 - I_0}{I_0}\right) \sim$ in terms of σ_{V_T} & σ_{k_n}





Noise: Random noise