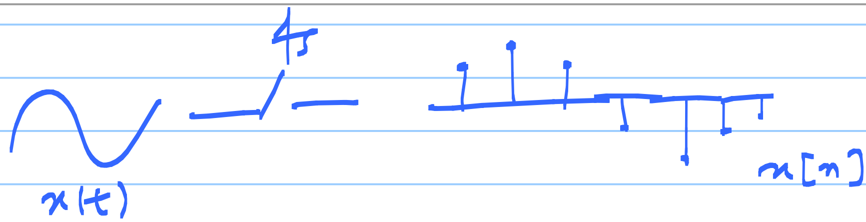
ECE 614 – Lecture 10

Note Title 9/27/2012



* $\boxed{\text{PSS}}$

$\Rightarrow f_s = 100\,\text{MHz}$, 10 ns

STB
↳ Ac

PSTB → break the loop using CMDM probe

PAC

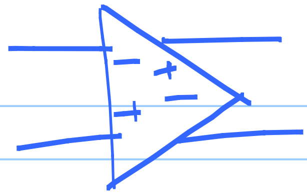
$h(t) \overset{\mathcal{Z}}{\longleftrightarrow} H(z)$

$x[n] \longrightarrow X(z) \rightarrow X(e^{j\omega})$

DTFT

Behavioral modeling

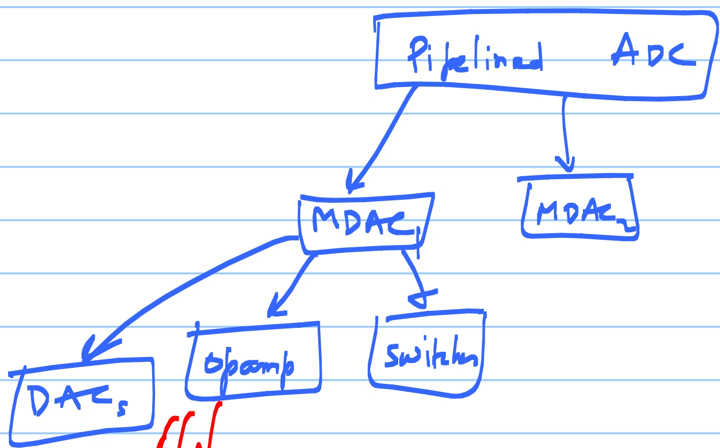
$\boxed{\text{Verilog-A}}$



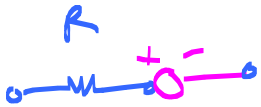
Macromodel

(VCCS
VCVS)

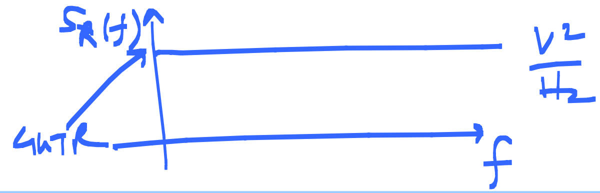
* Config view → switch subcircuit schematic views

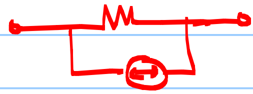


Transistor-level
behavioral
verilog-A
Schematic VL

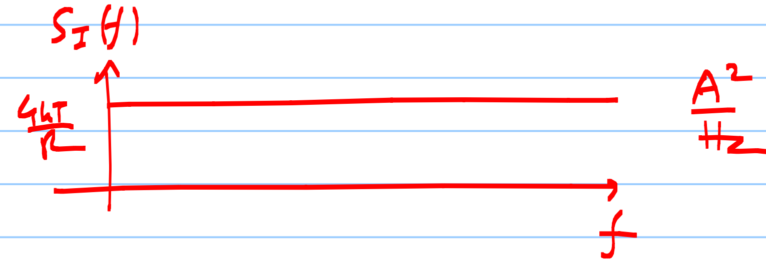


$$\overline{V_n^2} = 4kTR$$





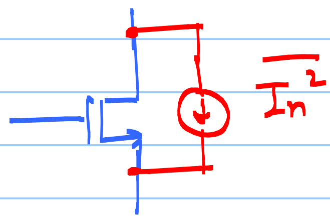
$$\overline{I_n^2} = \frac{4kT}{R}$$

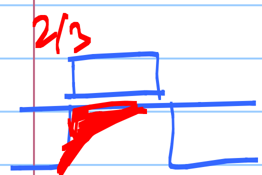


long-channel MOSFET

⇒ In saturation

$\overline{I_n^2}$ ⇒ thermal noise current contributed by the channel



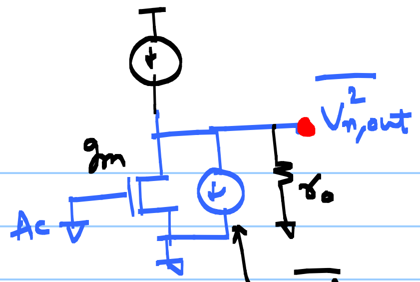


$$\overline{I_n^2} = 4KT\gamma \, g_m$$

γ → $\frac{2}{3}$ for long-channel

≃ 2.5 for a submicron process

has a dependence on V_{DS}



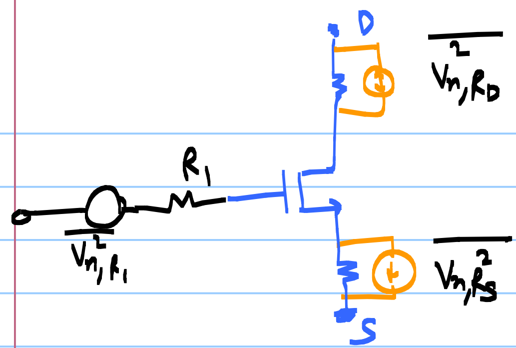
$$\overline{I_n^2} = 4kT\gamma g_m$$

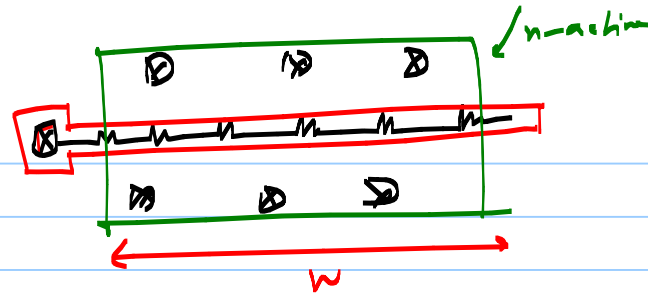
$$\overline{V_{n,out}^2} = \overline{I_n^2} \cdot r_{out}^2$$

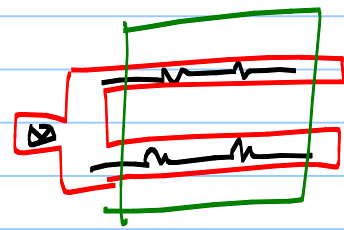
$$= 4kT\gamma g_m r_o^2$$

$$= \frac{8}{3} kT g_m r_o^2$$

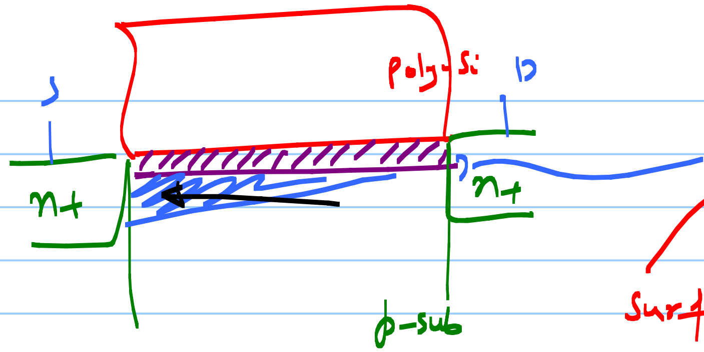
$g_m \downarrow$

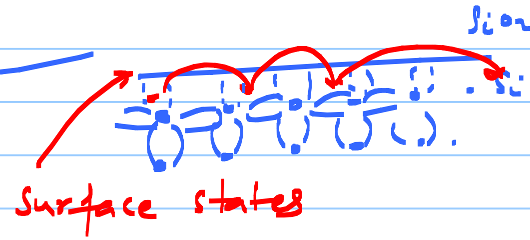


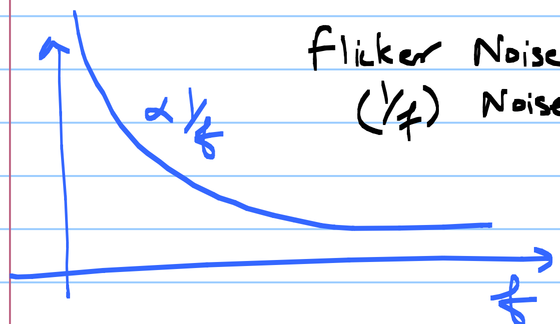




Use multi finger
layout for
Large W

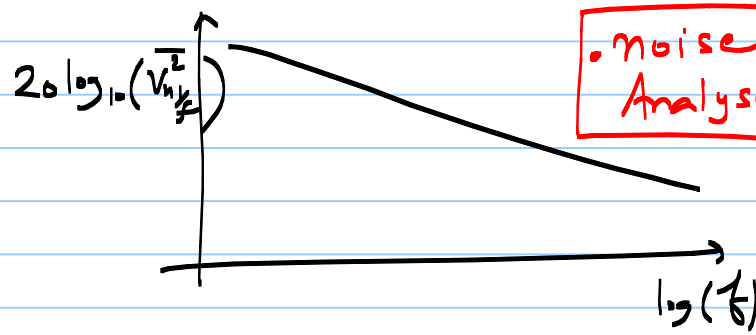




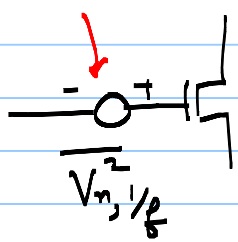


Flicker Noise

(1/f) Noise



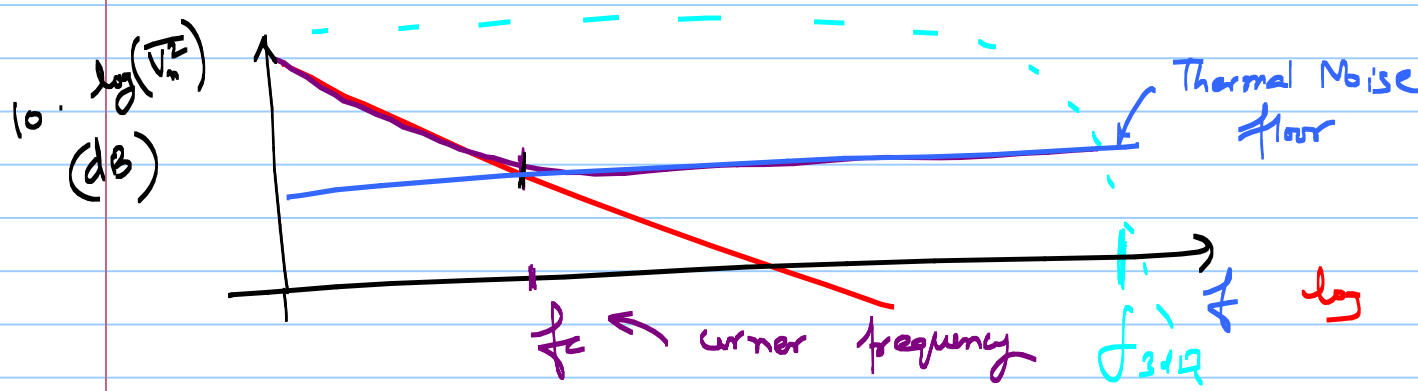
$\boxed{\text{• noise Analysis}}$

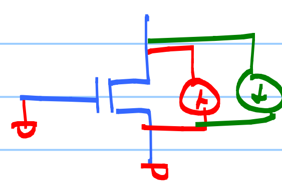


$$\overline{V_{n,1/f}^2} = \frac{K}{C_{ox} W L} \cdot \frac{1}{f} \propto \frac{1}{\text{Area}} \cdot \frac{1}{f}$$

* for PMOS due to the buried channel the flicker noise is smaller

$$K_p < K_n$$





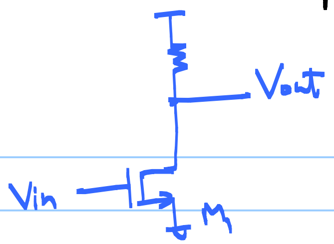
$$\overline{I_n^2} = 4KT\left(\frac{2}{3}g_m\right) = \frac{K}{C_{ox}WL}\cdot\frac{1}{f_c}\cdot g_m^2$$

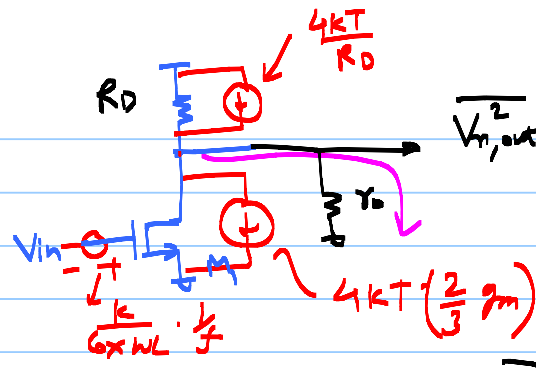
$$\Rightarrow f_c = \frac{K}{C_{ox}WL}\cdot g_m\,\frac{3}{8KT}$$

Sub/μm CMOS

⇒ 500k → 1MHz

Total Output Noiα

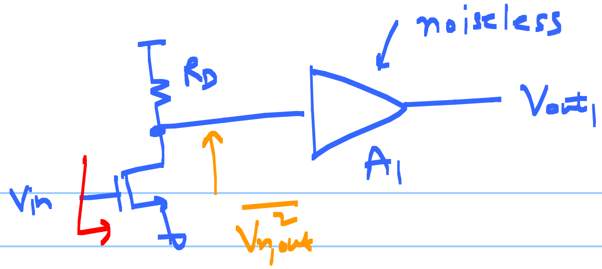




$i_d = g_m v_{gs}$

$R_D << r_o$

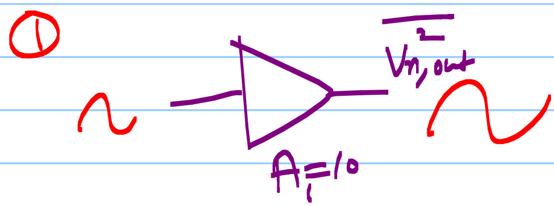
$$\overline{V_{n,out}^2} = \Bigg[\underbrace{4kT\left(\frac{2}{3}g_m\right)}_{\overline{I_{n_1}^2}} + \underbrace{\frac{K_N}{C_{ox}WL}\cdot\frac{1}{f}\,g_m^2}_{g_m^2\cdot\overline{V_{n_{1/f}}^2}} + \underbrace{\frac{4kT}{R_D}}_{\overline{I_{nR}^2}} \Bigg]\cdot R_D^2$$

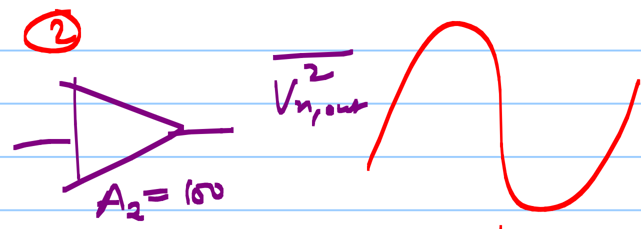


$\Leftarrow A_1^2 \cdot \overline{V^2_{n,out}} \Leftarrow$ The circuit is noisier @ the output

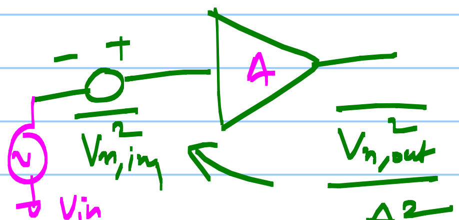
A_1^2

SNR ← remains the same

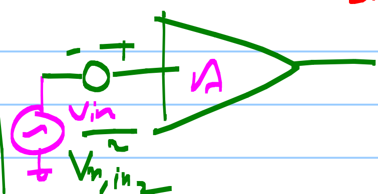




SNR is 10X



$$\frac{\overline{V^2_{n,out}}}{A^2}$$



V_p

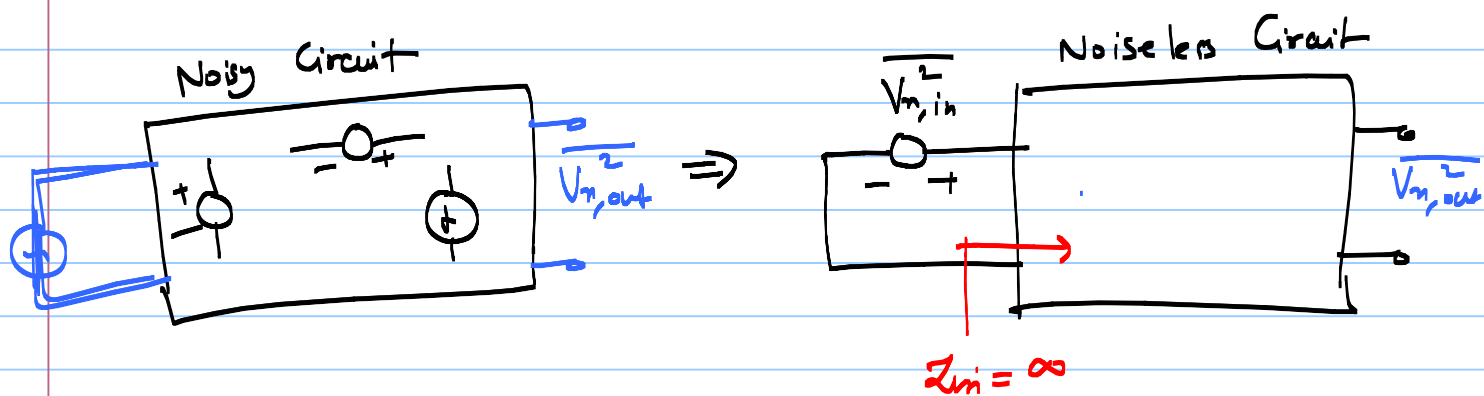
$$SNR = 10 \cdot \log_{10}\left(\frac{\left(\frac{V_p}{\sqrt{2}}\right)^2}{\overline{V^2_{n,in}}}\right) = 20\log\left(\frac{\frac{V_p}{\sqrt{2}}}{\overline{V_{n,in}}}\right)$$

input referred noise

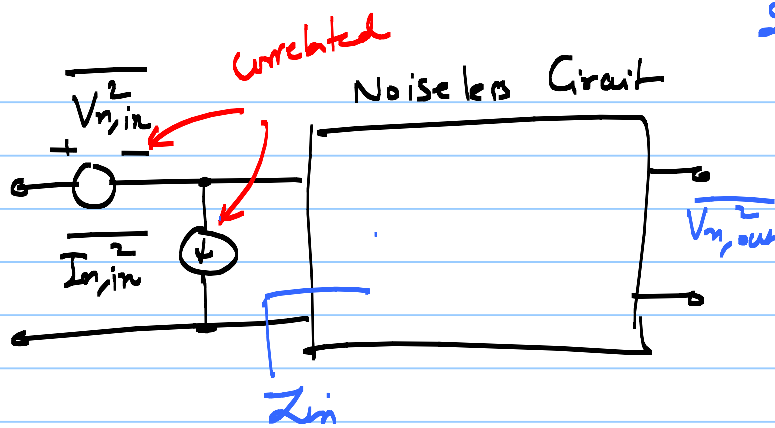
Input-referred Noise

$$\overline{V_{n,in}^2} = \frac{\overline{V_{n,out}^2}}{A_v^2}$$

fictitious quantity



* Necessary and sufficient representation of any linear 2-port circuit



$\Leftarrow$ Superposition of the effects of $\overline{V_{n,in}^2}$ & $\overline{I_{n,in}^2}$