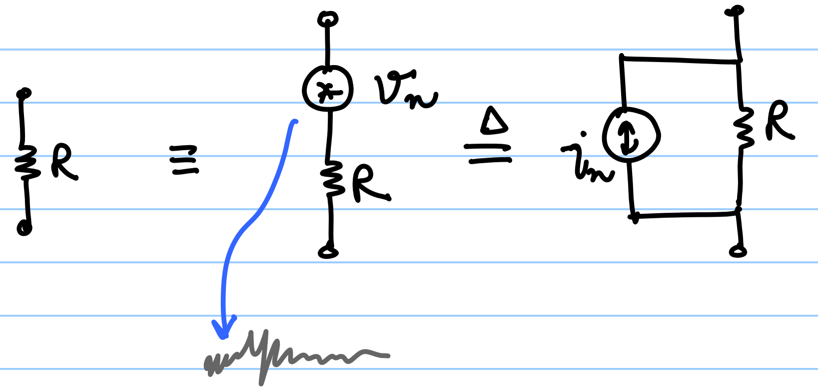
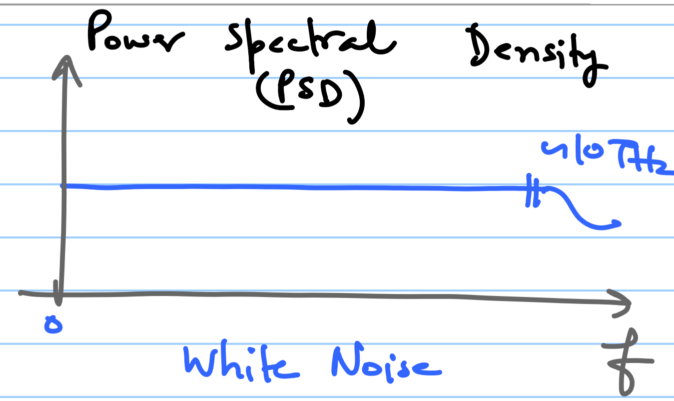
ECE 517 - Lecture 18

Note Title 3/23/2017



$$\overline{v_n^2} = 4KTR$$

mean square noise voltage $\equiv 4kT\,R\,\Delta f$



White Noise

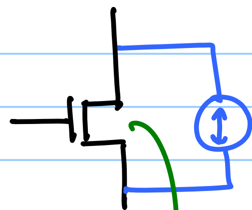
Thermal Noise

Thermal Noise $\propto T$

CUTOFF

TRIODE

SAT

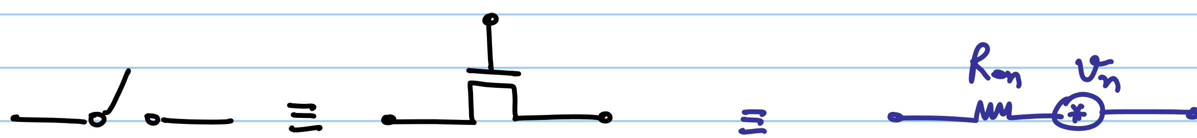


$$\overline{I_n^2} = 4KT\gamma g_m$$

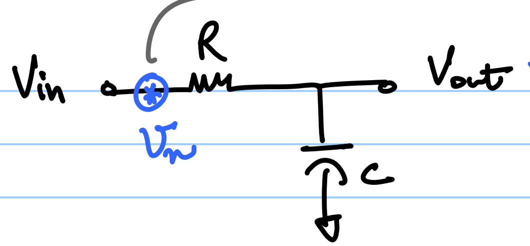
$$g_m = f\left(\frac{W}{L}, I_D\right)$$

$\gamma \rightarrow$ Technology dependent parameter, $\gamma = \begin{cases} \frac{2}{3} & \text{for long channel} \\ > \frac{2}{3}, & \text{short channel} \end{cases}$

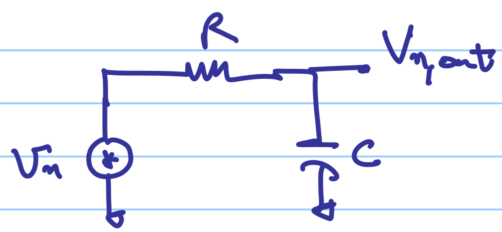
$$\rightarrow \frac{8}{3} KT g_m$$



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

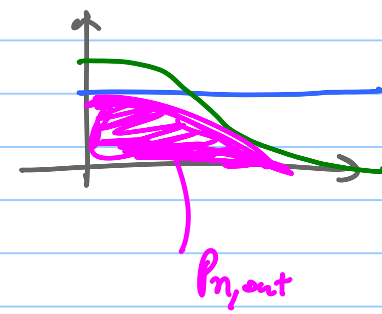


$$\propto 4kT\cancel{R} \cdot \frac{1}{2\pi \cancel{R} C} \propto \frac{kT}{C}$$



$$P_{n,out} = \int_0^\infty 4kTR \cdot \left| \frac{1}{1 + j2\pi f RC} \right|^2 \cdot df$$

$$= \frac{kT}{C}$$



$$V_{n,out,rms} = \sqrt{P_{n,out}} = \boxed{\sqrt{\frac{kT}{C}}}$$

C	$V_{n,rms} = \sqrt{\frac{kT}{C}}$
0.1 pF	200 µV
1 pF	64 µV
10 pF	20 µV
100 pF	6.4 µV

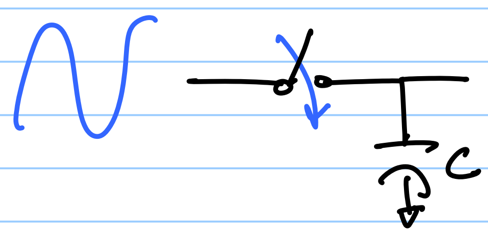
$N = 10$ bits

$V_{FS} = 1\,V$

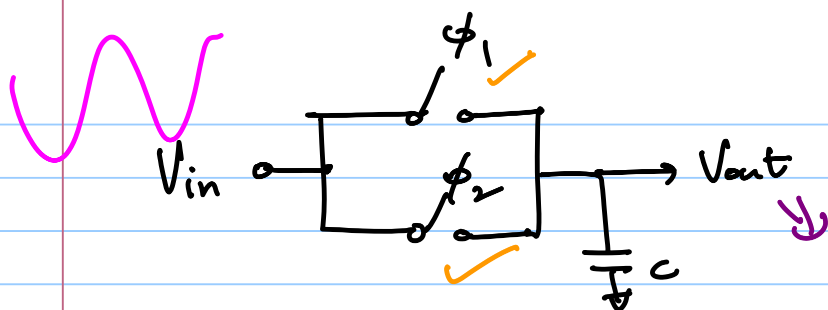
$$V_{LSB} = \frac{1}{2^{10}}\,V \simeq 1\,mV$$

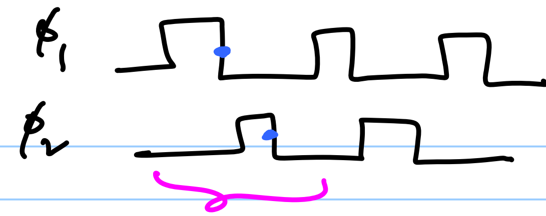
$N = 16$ bits

$$V_{LSB} = \frac{1}{2^{16}}\,V = \frac{1}{64}\,mV \simeq 0.02\,mV$$



$$\Rightarrow \quad v_{n,rms} = \sqrt{\frac{kT}{C}}\;V$$



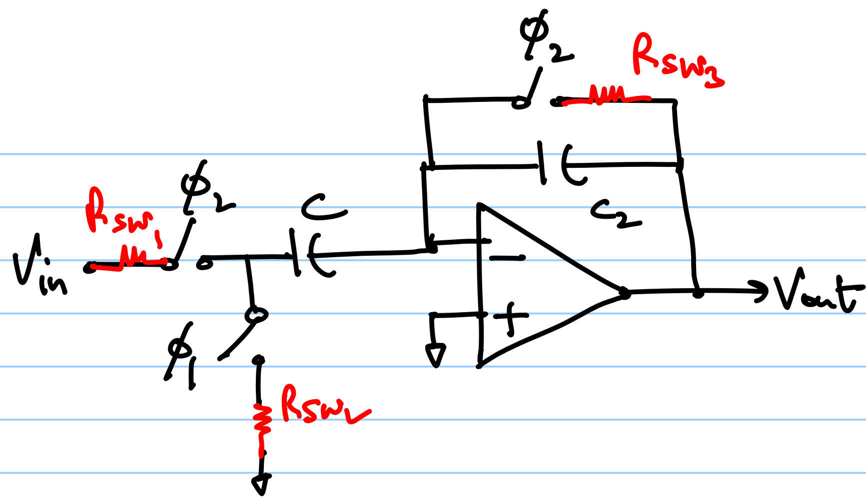


$V_{n_1} + V_{n_2}$ ← two noise voltages are not correlated

$$V_{n,rms} = \sqrt{V_{n_1,rms}^2 + V_{n_2,rms}^2}$$

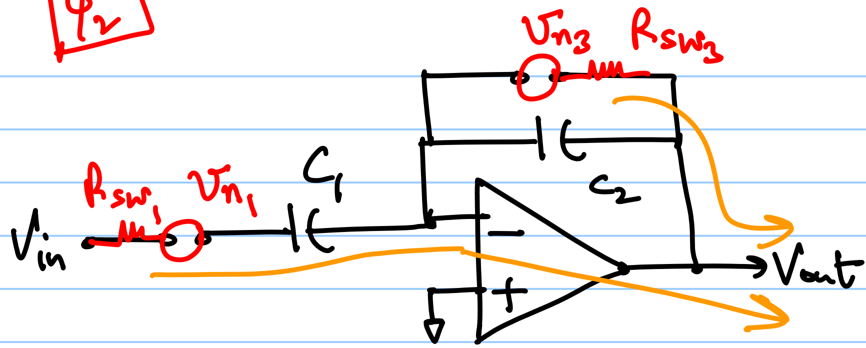
$$= \sqrt{\frac{kT}{C} + \frac{kT}{C}} = \frac{kT}{C}\sqrt{2}$$

can't add two noise voltages,
can only add their power



ϕ_2
R_{sw_3}
ϕ_2
R_{sw_1}
C
C_2
V_{in}
V_{out}
ϕ_1
R_{sw_2}

$\boxed{\phi_2}$

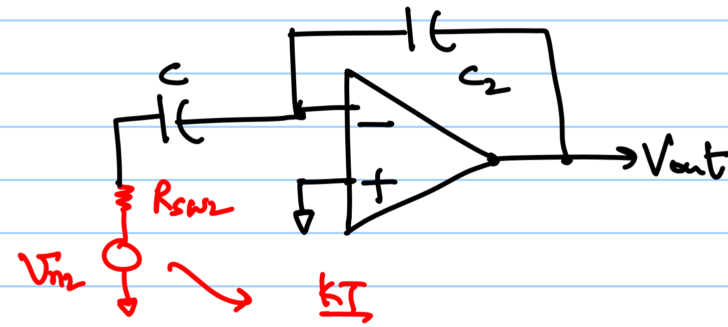


$R_{s_1} \Rightarrow \frac{KT}{C_1}$ mean square noise

$\hookrightarrow \frac{KT}{C_1}\left(\frac{C_1}{C_2}\right)^2$

$R_{s_3} \Rightarrow \frac{KT}{C_2} \longrightarrow \frac{KT}{C_2}$

$\boxed{\phi_1}$



$\frac{KT}{C_2}$

$R_{sw_2} \Rightarrow \frac{KT}{C_2}\left(\frac{C_1}{C_2}\right)^2$

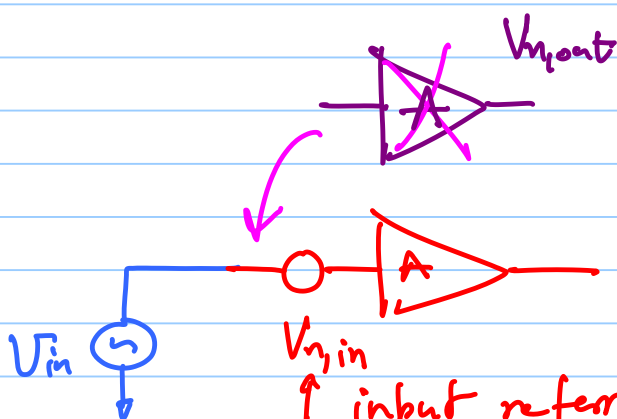
$$\text{Total output noise} = \frac{2kT}{C_1}\left(\frac{C_1}{C_2}\right)^2 + \frac{kT}{C_2}$$

$$\text{Input referred noise} = \frac{\text{Total output Noise}}{(\text{gain})^2}$$

$$G = \frac{C_1}{C_2}$$

$$= \frac{\frac{2kT}{C_1}\left(\frac{C_1}{C_2}\right)^2 + \frac{kT}{C_2}}{\left(C_1/C_2\right)^2} = \frac{kT}{C_1}\left[2 + \frac{C_2}{C_1}\right]$$

$$= \frac{kT}{C_1}\left[2 + G^{-1}\right]$$



↑ input referred noise

$$G = 2 \longrightarrow \underline{V_{n,in} = \sqrt{2.5\,\frac{kT}{C_1}}} \text{ for gain of 2.}$$

SAR ADC ⇒ Successive Approximation Register