28-1-13

Lec 8

Noise

* Statistical form of representation

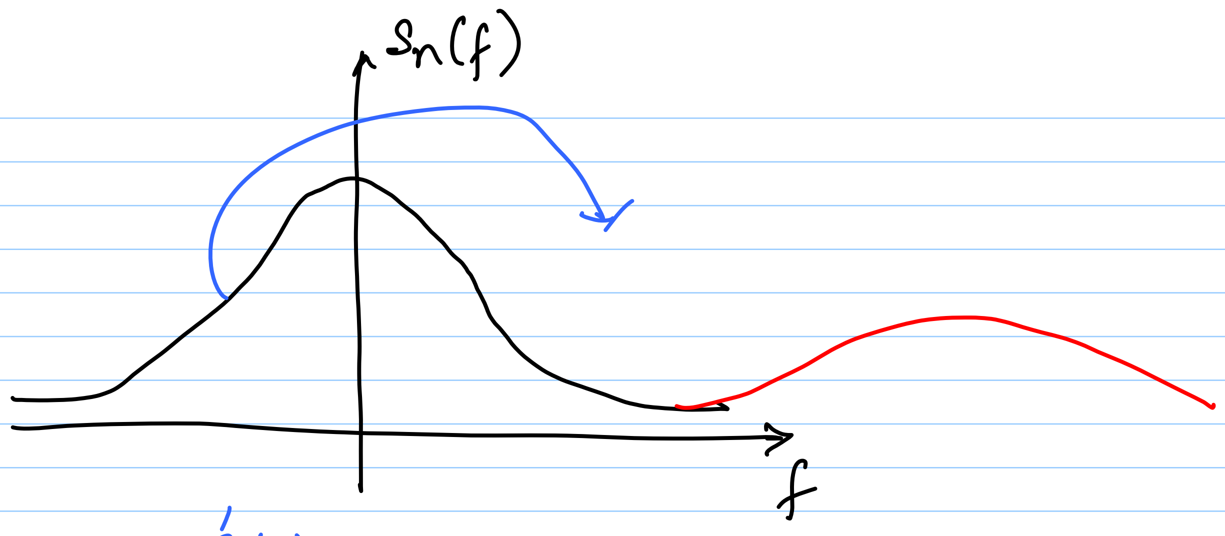
$\overline{v_n^2}$ & $\overline{i_n^2}$

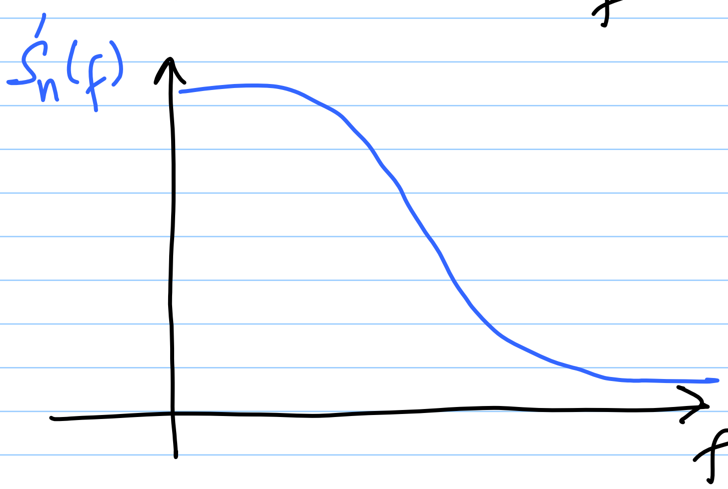
* rms value should be smaller than desired signal

→ small-signal analysis

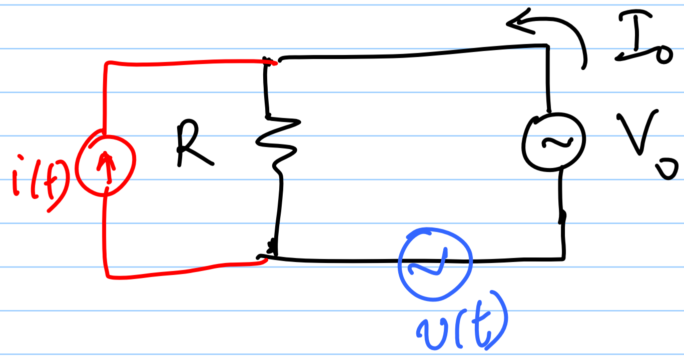
* very often noise is broadband

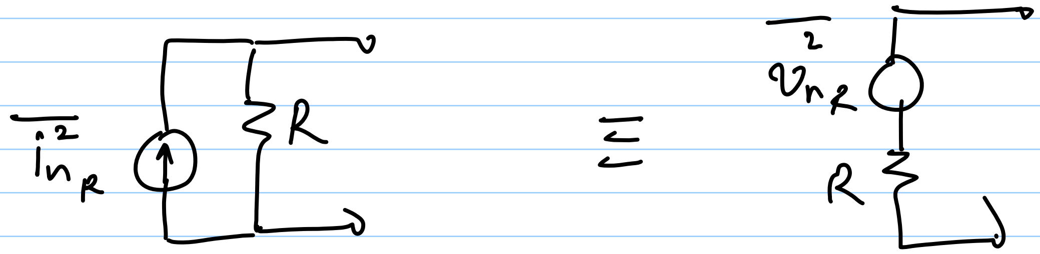
→ useful to look @ freq. domain



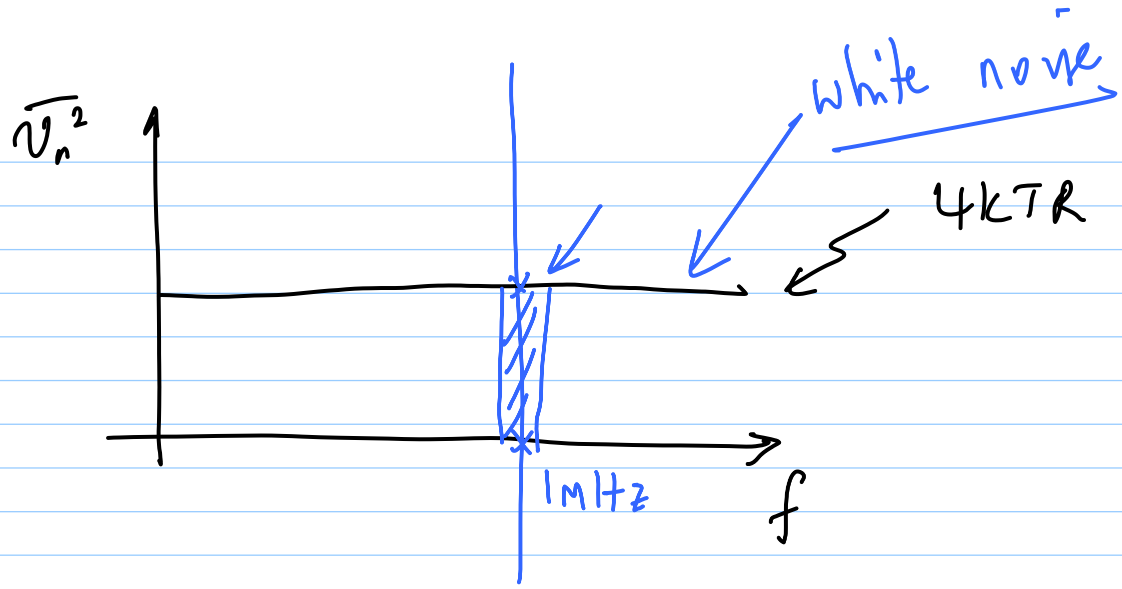


1) Resistors →



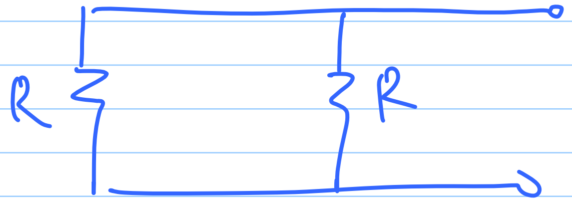


$$\frac{\overline{v_{n_R}^2}}{\Delta f} = 4kTR \quad V^2/Hz \qquad \Bigg| \qquad \frac{\overline{i_{n_R}^2}}{\Delta f} = \frac{4kT}{R} \quad A^2/Hz$$

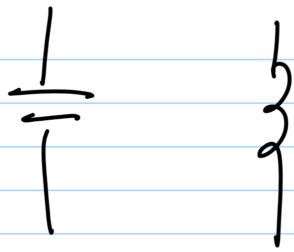


$$\overline{v_n^2}\Big|_{1MHz} = 4kTR \left(\frac{V^2}{Hz}\right) \times 1(Hz)$$

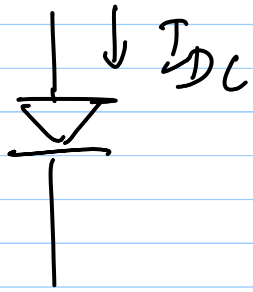
$$= 4kTR \quad (V^2)$$



$$\frac{2\,\overline{i_n^2}}{\Delta f} = \frac{8kT}{R}$$

2) 

noiseless elements

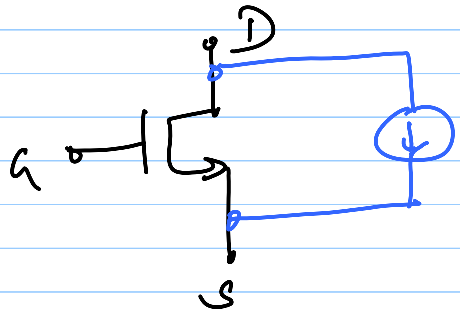
3) 

Shot noise

* white noise
* depends on I_{DC}

$$\overline{i_{n_D}^2} = 2q\,I_{DC}\,\Delta f$$

4) **MOSFET** — depends on op-point



$$\frac{\overline{i_{n_d}^2}}{\Delta f} = \frac{4KT}{R_{DS}} \simeq 4KT\, g_{d_0}$$

a) thermal noise — white in nature

i) triode region — like a resistor

$$R_{DS} = \frac{1}{\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_T)} = \frac{1}{g_{d_0}}$$

(ii) **Sat. region**

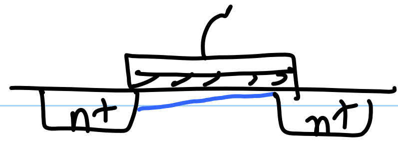
$$\overline{i_{n_d}^2} = 4KT \times \left(\frac{2}{3}\right) \cdot g_m \Delta f$$

$$= \frac{8KT}{3} g_m \Delta f$$

$$g_m = \mu_n C_{ox}\left(\frac{W}{L}\right)(V_{gs} - V_T) = g_{d_0}$$

(iii) OFF region : $\overline{i_{nd}^2} = 0$

b) Flicker noise



$$\overline{i_{n_{1/f}}^2} = \frac{k}{f} \cdot \frac{g_m^2}{WLC_{ox}} \cdot \Delta f$$

* Pmos better than nmos ?