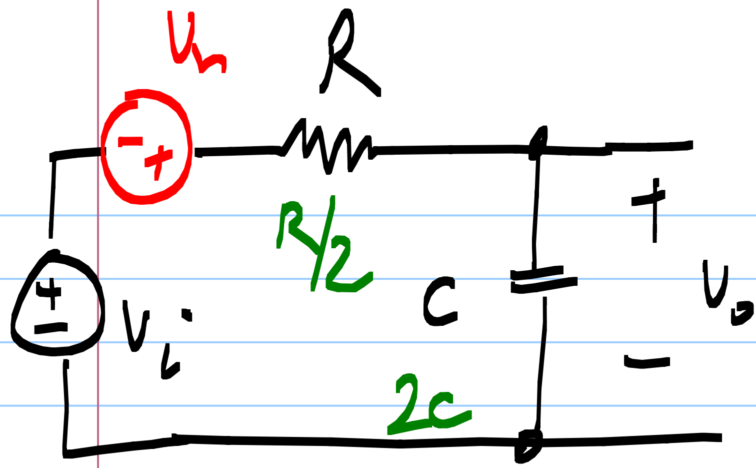
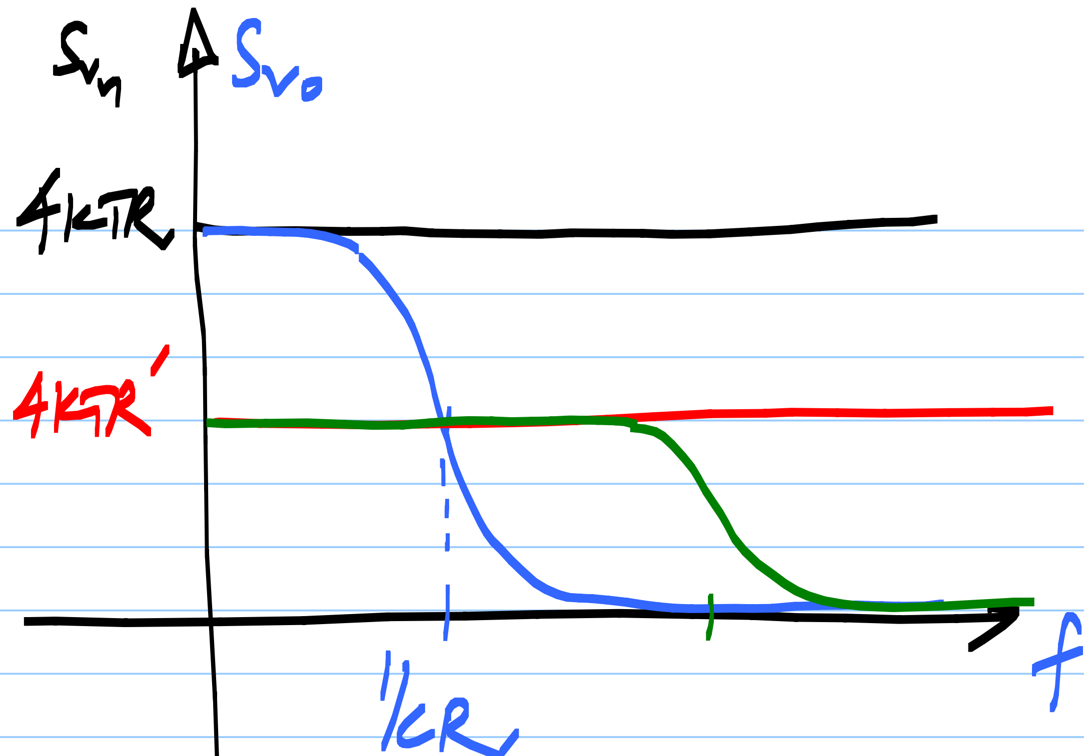




$$\frac{V_o}{V_i} = \frac{1}{1 + sCR}$$

$$\frac{V_o}{V_n} = \frac{1}{1 + sCR} \;;$$

$$S_{v_o} = S_{v_n} \frac{1}{1 + 4\pi^2 f^2 C^2 R^2}$$

$$\sigma_{V_0}^2 = \int_0^\infty \frac{4kTR}{1 + 4\pi^2 f^2 C^2 R^2}\, df = \underbrace{\frac{4kTR}{2\pi\, CR} \cdot \underbrace{\tan^{-1}(2\pi f CR)\Big]_0^\infty}_{\pi/2}}$$

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

Variance

mean-squared value

$C = 10\,fF$

$C = 1\,pF$

rms value : $\sqrt{\frac{kT}{C}} = \sqrt{\frac{4 \cdot 10^{-21}}{10^{-12}}}\ V = \sqrt{40 \cdot 10^{-5}}$

$\boxed{63\,\mu V}$

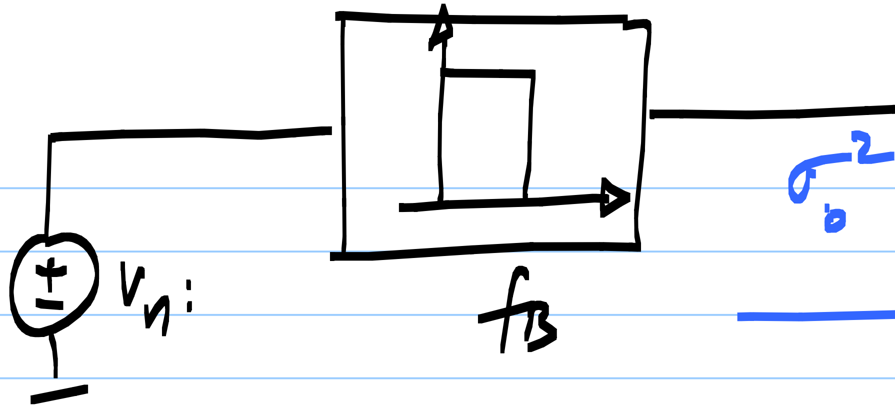
$630\,\mu V$

$$\underbrace{4kTR}\cdot\left[\frac{1}{2\pi CR}\cdot\frac{\pi}{2}\right]$$

f_{-3dB}

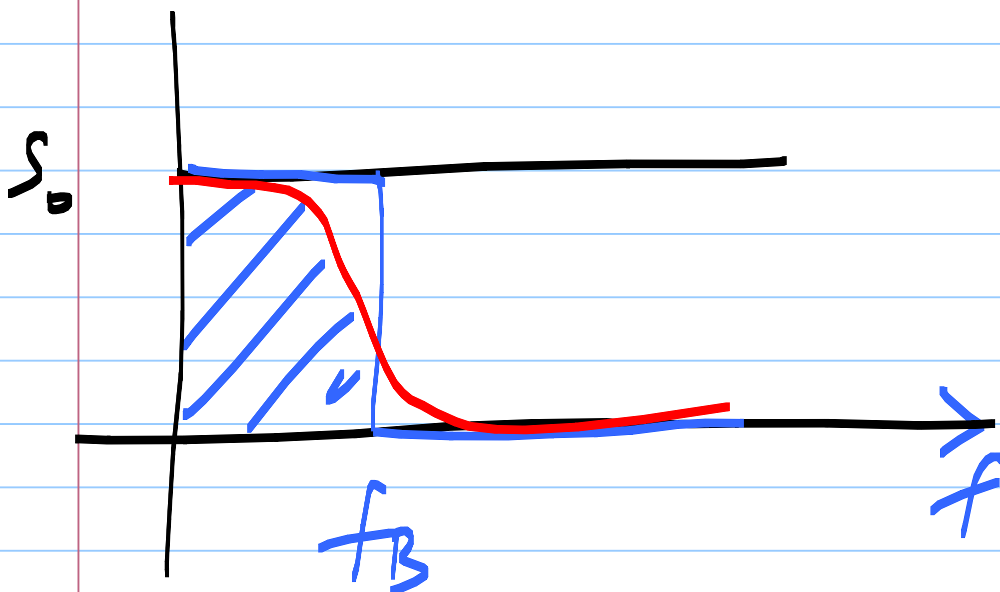
$$\left\{\underbrace{\frac{\pi}{2}\cdot f_{-3dB}}\right\}$$

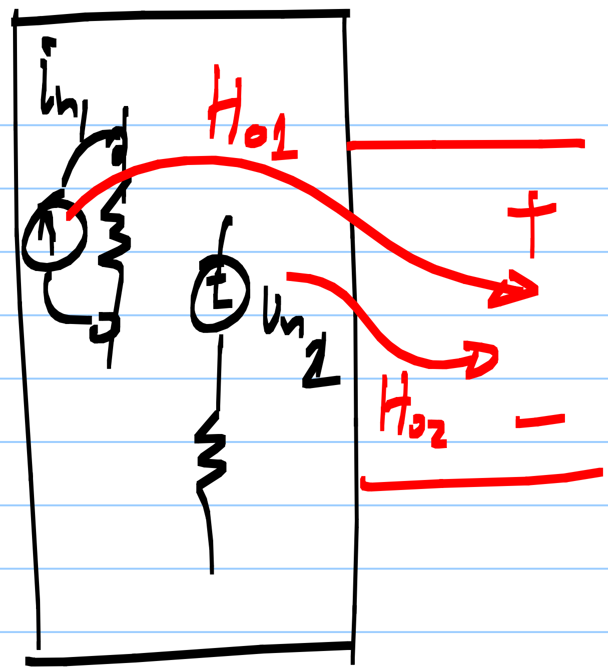
Noise BW of a 1^{st} ord. LPF



v_n: S_0.

$$\sigma_0^2 = S_0 f_B$$

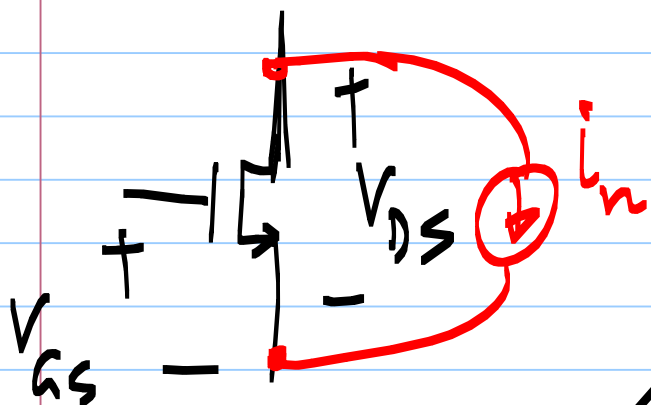




$$S_{i_{n_1}} \cdot |H_{o1}|^2 + S_{v_{n_2}} |H_{o2}|^2$$
$$+ \ldots$$

MOS transistor

$$I_D = \frac{\mu C_{ox}}{2} \frac{W}{L} \left(V_{GS} - V_T\right)^2 \quad \Bigg| \quad \begin{array}{l} V_{GS} > V_T \\ V_{DS} > V_{GS} - V_T \end{array}$$



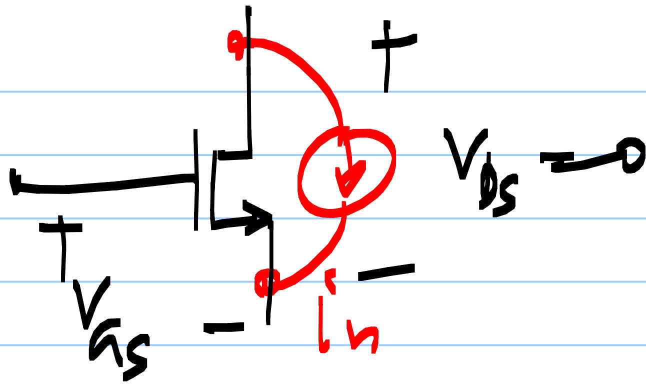
Thermal noise

$$\left. S_{i_n} = \frac{8}{3} kT \cdot g_m \right\} \text{white}$$

Noise spectral density in saturation region

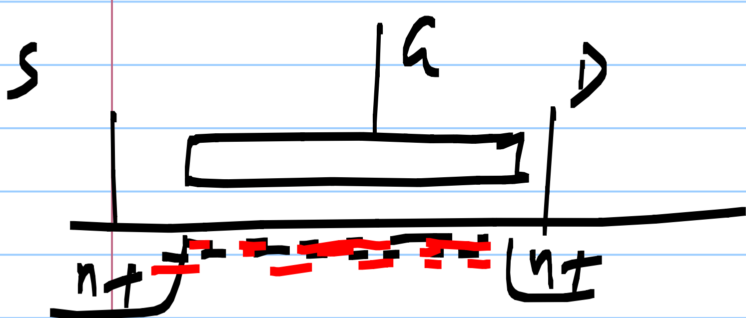
$$S_{i_R} = 4 \cdot kT \cdot \underbrace{G}_{\text{Conductance}}$$

Triode region

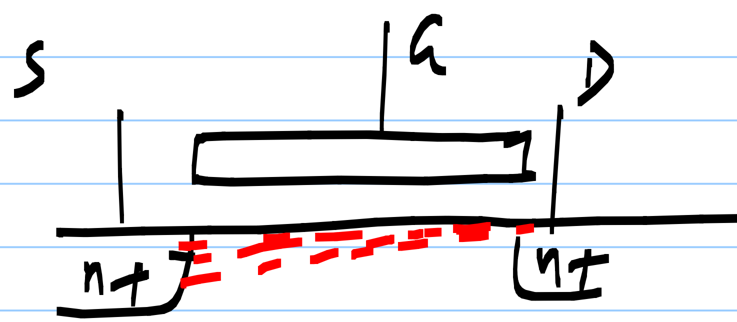


$$S_{i_n} = 4kT \cdot g_{ds}\Big|_{V_{DS}=0}$$

$V_{DS} = 0$



@ $V_{DS} = 0$



@ $V_{DS} > 0$

$$g_m \text{ (sat. region)} = \mu C_{ox}\frac{W}{L}(V_{GS}-V_T)$$

$$g_{ds}(V_{DS}=0) = \mu C_{ox}\frac{W}{L}(V_{GS}-V_T)$$

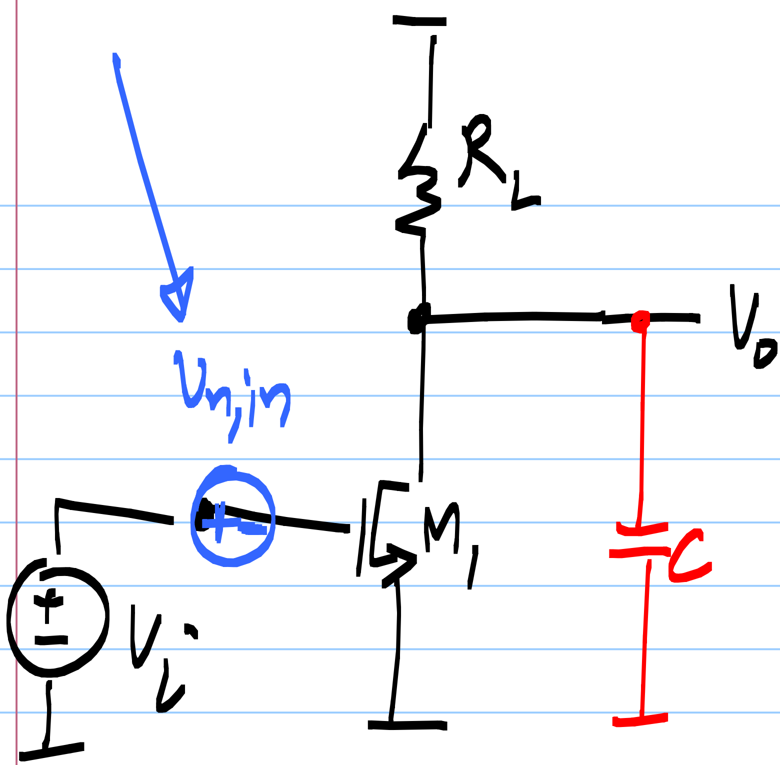
$$S_{in} = 4kT\cdot\frac{\mu|Q_I|}{L^2}$$

Inversion charge @ $V_{DS}=0$

$$C_{ox}\cdot WL\cdot(V_{GS}-V_T)$$

$$\frac{2}{3}C_{ox}WL(V_{GS}-V_T)$$

$$4kT\cdot\boxed{\mu C_{ox}\frac{W}{L}(V_{GS}-V_T)}$$

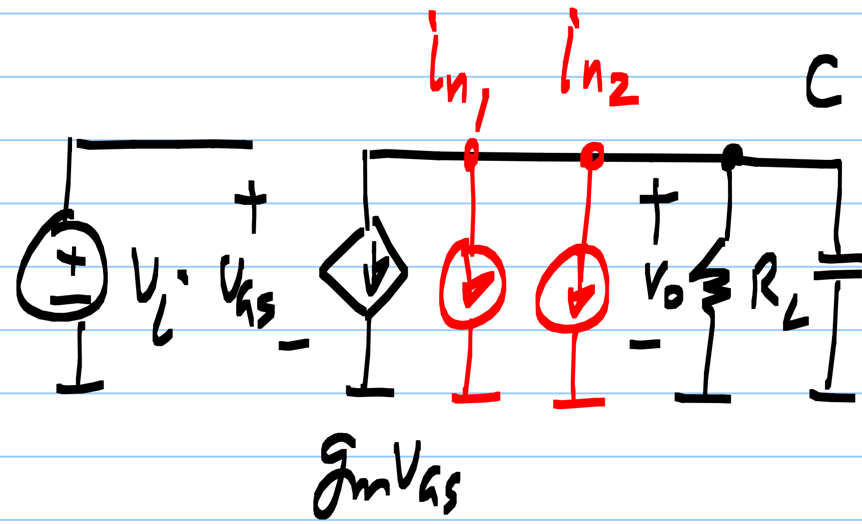


M_1 : saturation,

g_m

1. Find S_{v_o}

2. o/p loaded by C, find the integrated o/p noise (variance)



$$\frac{v_o}{i_{n_1}} = \frac{v_o}{i_{n_2}} = R_L \qquad \left[\frac{R_L}{1+sCR_L}\right]$$

from R_2 $\qquad$ from M_1

$$S_{v_o} = S_{in_1}\cdot\left|\frac{v_o}{i_{n_1}}\right|^2 + S_{in_2}\left|\frac{v_o}{i_{n_2}}\right|^2$$

$$= \frac{8}{3}kTg_m\cdot R_L^2 + \frac{4kT}{R_2}\cdot R_2^2 =$$

$$\left[\frac{8}{3}kTg_m + \frac{4kT}{R_L}\right]\left[\frac{R_L^2}{\quad}\right] = \frac{8}{3}\frac{kT}{g_m}(g_mR_L)^2\left[1+\frac{3}{2g_mR_L}\right]$$

M_1 $\qquad$ R_L

$$\sigma_{v_o}^2 = \left[\frac{8}{3} kT g_m + \frac{4kT}{R_L} \right] R_L^2 \cdot \left[\frac{1}{4 R_L C} \right]$$