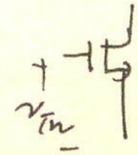
Problem - 1



$$i_o = \alpha_1 v_{in} + \alpha_2 v_{in}^2$$

$$\alpha_1 = \left(\frac{\partial i_o}{\partial v_{in}}\right)_{v_{in}=0}$$

$$\alpha_2 = \frac{\partial^2 i_o}{\partial v_{in}^2} \times \frac{1}{2}$$

1) THD $\rightarrow$ HD_2

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th})^2$$

$$\frac{\partial I_D}{\partial V_{GS}} = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th}) = g_m \rightarrow \alpha_1$$

$$\frac{\partial^2 I_D}{\partial V_{GS}^2} = \mu_n C_{ox}\frac{W}{L} \longrightarrow \alpha_2 = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}$$

$$\therefore HD_2 = \frac{1}{2}\frac{\alpha_2}{\alpha_1}V_{peak} = \frac{1}{2}\frac{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}}{\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th})}$$

$$= \frac{1}{4(V_{GS}-V_{th})}$$

2)
$$\left.\begin{aligned} S_{out} &= (g_m V_{in})^2 R_L \\ N_{out} &= \left(4KT\frac{\gamma}{\alpha}g_m\right)\cdot R_L \end{aligned}\right\} \frac{S_{out}}{N_{out}} = \frac{g_m}{4KT\frac{\gamma}{\alpha}}V_{in}^2$$

3)
$$W/L \uparrow \times 2 \rightarrow g_m = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D} \uparrow \times \sqrt{2}$$

$$= \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{th}) \uparrow \times \sqrt{2}$$

$$\therefore (V_{GS}-V_{th}) \downarrow \times \frac{1}{\sqrt{2}}$$

- g_m increased by a factor of $\sqrt{2}$ $\Rightarrow$ $(S/N)_{out} \uparrow \times \sqrt{2}$
- $(V_{GS}-V_{th})$ decreased by a factor of $\sqrt{2}$ $\Rightarrow$ $HD_2 \uparrow \times \sqrt{2}$
- Noise power $\Rightarrow$ $N_{out} \uparrow \times \sqrt{2}$