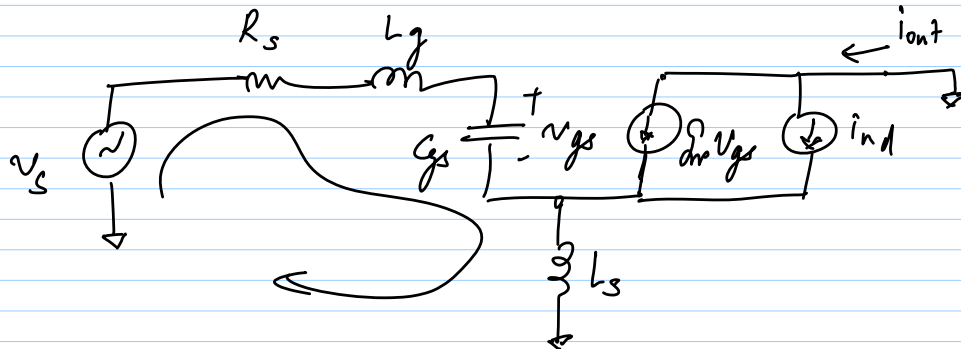


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Lec 17



Section 5.3.4 (Razavi) NF analysis

$$i_{out} = g_m v_{gs} + \bar{i}_{ind} \Rightarrow v_{gs} = \frac{1}{g_m} (i_{out} - \bar{i}_{ind})$$

$$v_s = (R_s + sL_g) \cdot sC_{gs} \cdot v_{gs} + v_{gs} + (i_{out} + sC_{gs} v_{gs}) \cdot sL_s$$

$$v_s = i_{out} \cdot sL_s$$

$$+ \frac{(L_s + L_g) s^2 C_{gs} + 1 + R_s \cdot sC_{gs}}{g_m} \cdot (i_{out} - \bar{i}_{ind})$$

$$\omega_0^2 = \frac{1}{(L_s + L_g) \cdot C_{gs}} \Rightarrow 1 + s^2(L_s + L_g)C_{gs} = 0 \text{ at } s = j\omega_0$$

$$v_s = i_{out} \left[j\omega_0 L_s + j \frac{R_s C_{gs} \omega_0}{g_m} \right]$$

$$- \bar{i}_{ind} \cdot \frac{j R_s C_{gs} \omega_0}{g_m}$$

$$\left| \frac{i_{out}}{v_s} \right| = \frac{1}{\omega_0 \left[L_s + \frac{R_s C_{gs}}{g_m} \right]}$$

$$\omega_T \cdot L_s = R_s$$

$$\frac{g_m L_s}{C_{gs}} = R_s$$

$$\left| \frac{i_{out}}{v_s} \right| = \frac{\omega_T}{2\omega_0} \cdot \frac{1}{R_s} = G_m$$

— independent of L_s, L_g & g_m $v_s = 0$ gives output noise

$$|i_{out}|_{n_1} = |\bar{i}_{ind}| \cdot \frac{R_s C_{gs}}{g_m L_s + R_s C_{gs}}$$

$$\frac{g_m L_s}{C_{gs}} = R_s$$

$$|i_{out}|_{m_1} = \frac{i_{in}}{2}$$

$$|i_{out}^2|_{m_1} = kT \delta g_m$$

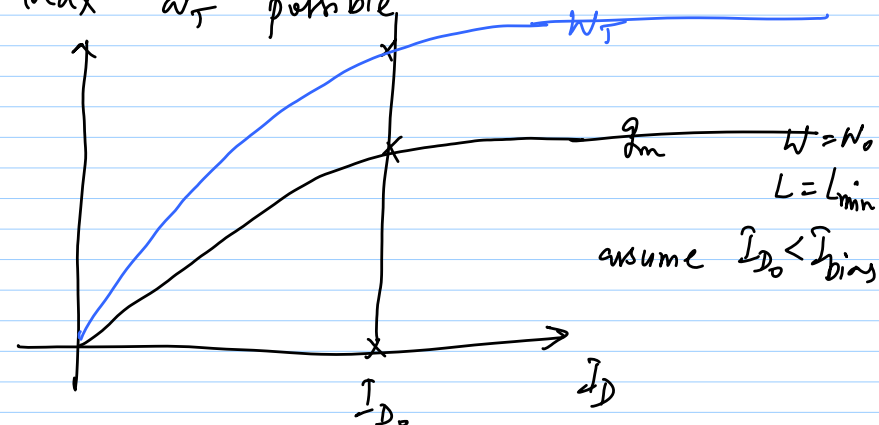
$$NF = 1 + \frac{|i_{out}|_{m_1}^2 / G_m^2}{4kTR_s}$$

$$NF = 1 + g_m R_s \delta \left(\frac{\omega_0}{\omega_T} \right)^2$$

Design Procedure

$G, R_s, \omega_0, NF, |V_{DS}|, I_{bias}$

1) Max ω_T possible



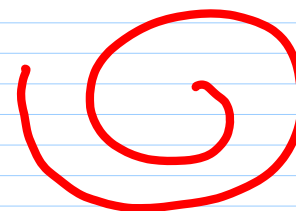
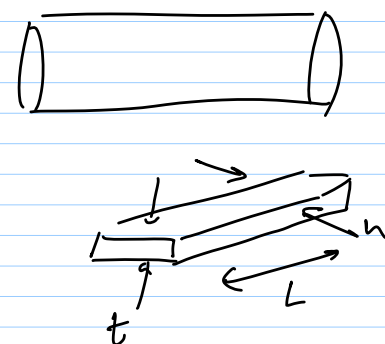
$$\omega_T L_s = R_s \Rightarrow \text{gives } L_s$$

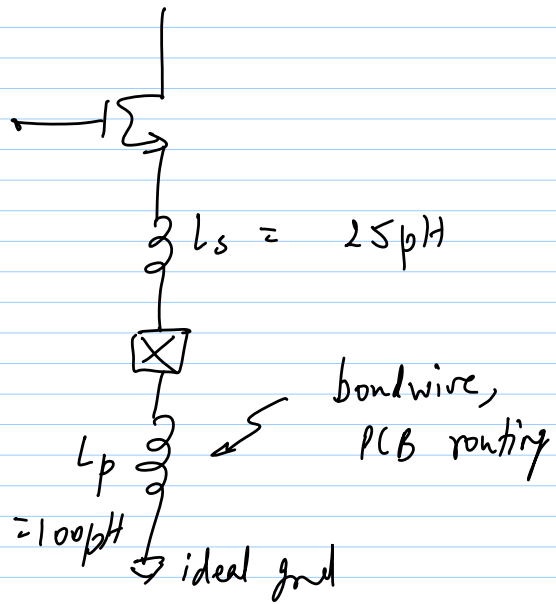
e.g. $f_T = 300 \text{ GHz}$, $R_s = 50 \Omega$

$$L_s = \frac{R_s}{\omega_T} = \frac{50}{2\pi \cdot 300 \cdot 10^9}$$

$$\approx 25 \text{ pH}$$

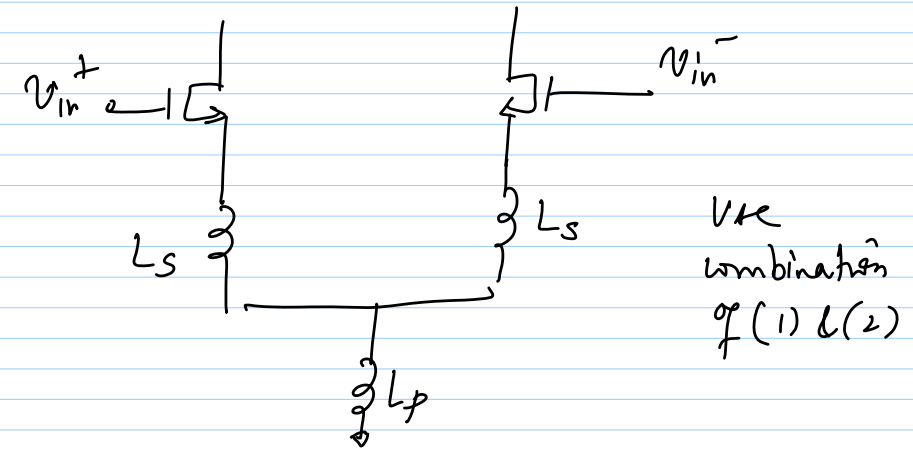
$L \sim \text{few } 100 \text{ pH} - \text{few } \text{nH}$ easily achievable in CMOS





1) $\downarrow \omega_T$ so that $L_S \gg L_P$

2) Differential structure



say $L_S = 100 \text{ pH}$ can be achieved

$$\Rightarrow f_T = 75 \text{ GHz}$$

a) $\uparrow$ Length

* linearity $\rightarrow$ b) $\downarrow I_D$ & $\uparrow W \leftarrow$
 worse

c) add C_x extra cap across L_S

* gain $\downarrow$

* noise gets worse