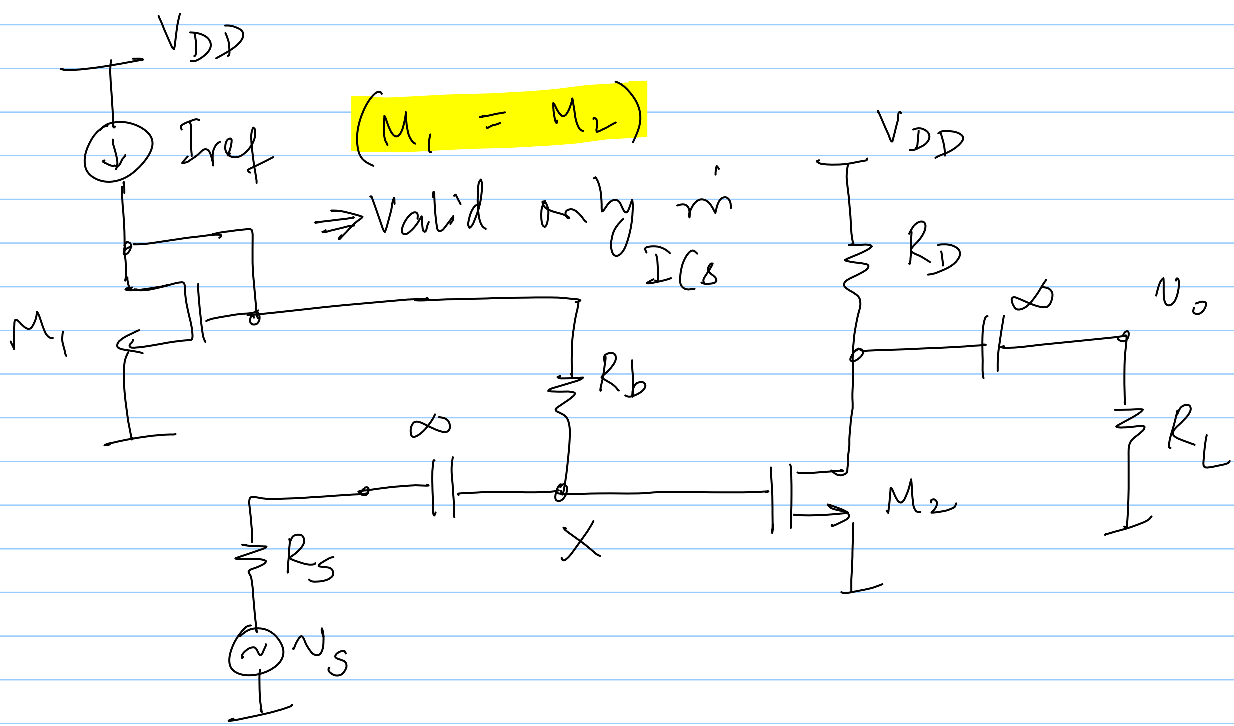
4-9-12

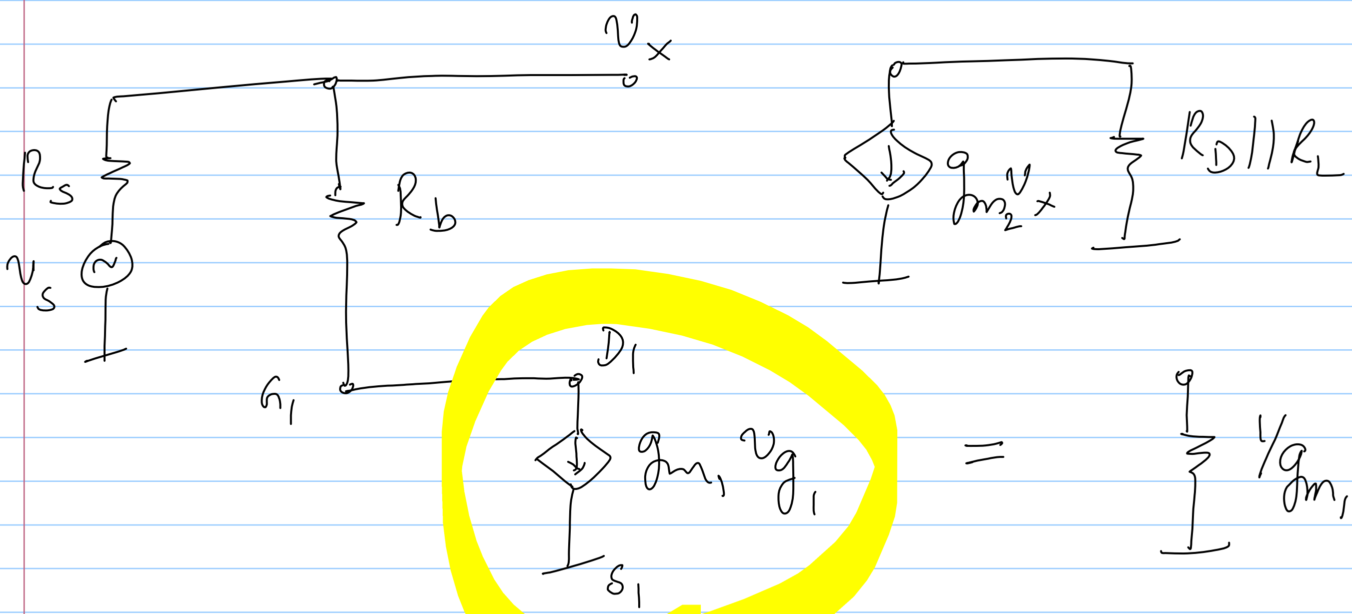
Lec 16



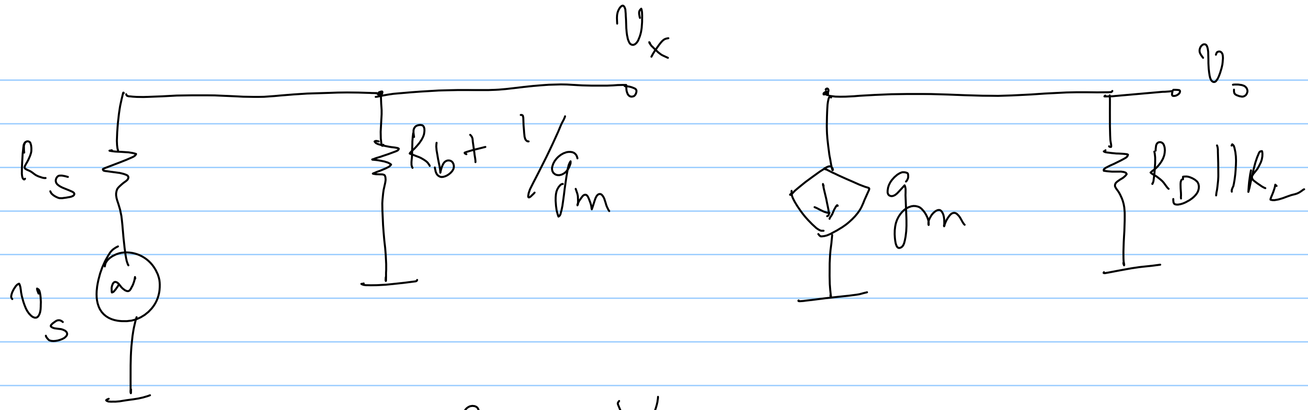
$(M_1 = M_2)$ ⇒ Valid only in ICs

$$\frac{v_x}{v_s} = ? \; ; \quad \frac{v_o}{v_s} = ?$$

Incremental eq. ckt :



$$g_{m_1} = g_{m_2} = g_m \quad (I_{D_1} = I_{D_2} = I_{ref})$$



$$\frac{v_x}{v_s} = \frac{R_b + 1/g_m}{R_s + R_b + 1/g_m}$$

$$\frac{v_o}{v_s} = -\left(\frac{R_b + 1/g_m}{R_s + R_b + 1/g_m}\right) \cdot g_m \cdot (R_D || R_L)$$

* We usually choose $R_b \gg R_s$ (as before)

$\Rightarrow R_b + 1/g_m \gg R_s$

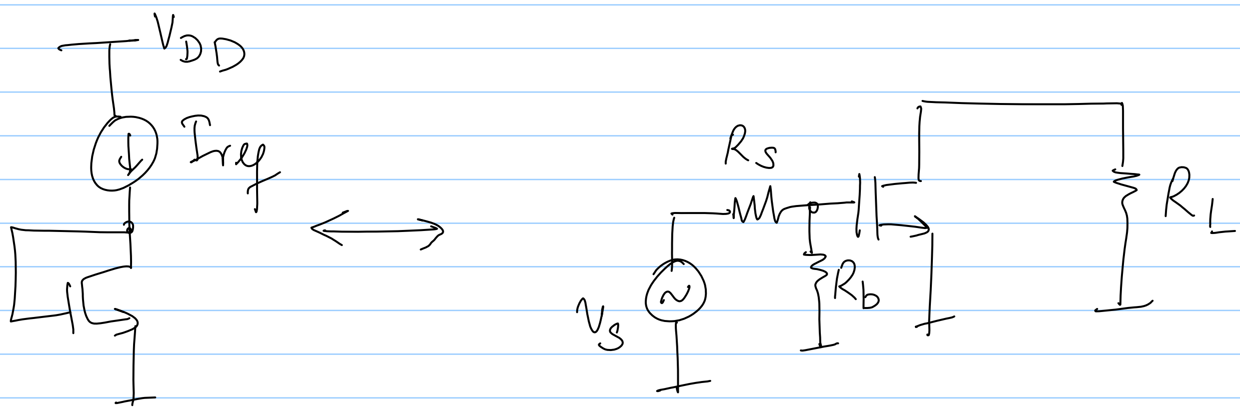
$\Rightarrow \dfrac{v_o}{v_s} \simeq -g_m (R_D || R_L)$

* Swing limits = same as before

because $\begin{cases} I_D = \text{same as before} \\ V_D = \quad " \quad\quad " \end{cases}$

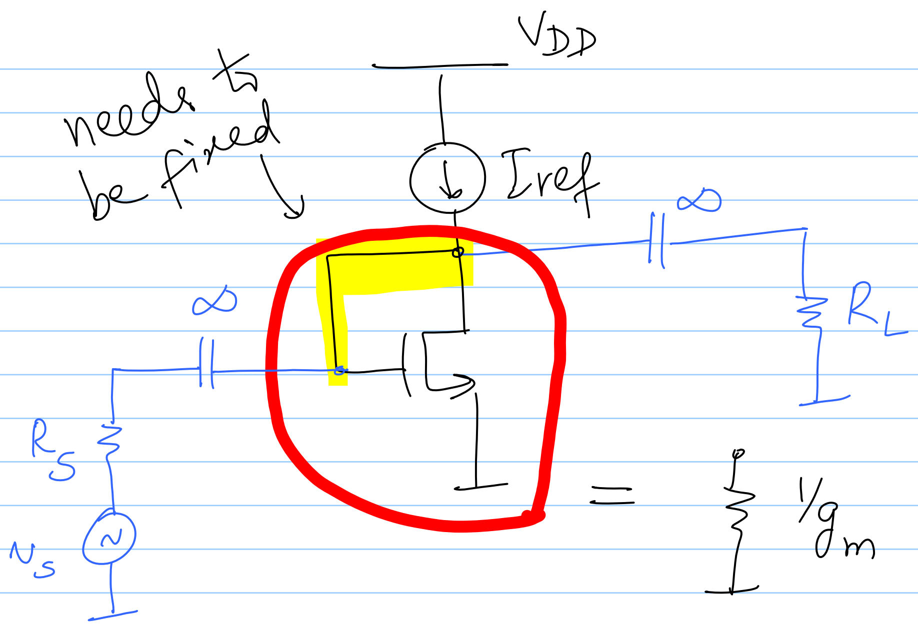
* If $V_{T_{1,2}}$ changes $\Rightarrow$ gain is constant

* Can this be done without using an extra transistor?



DC (bias)

Incremental

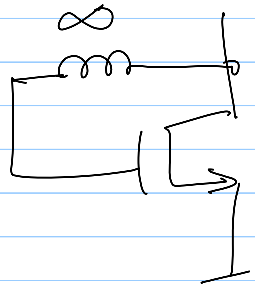


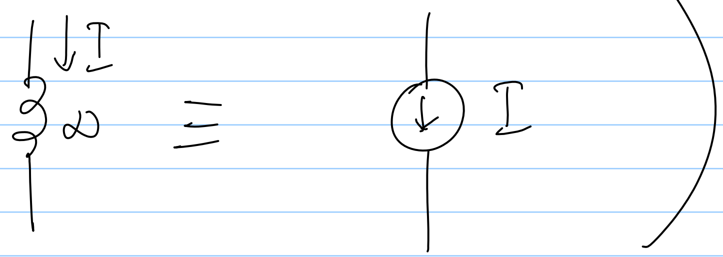
$$\text{gain} = \frac{R_L \,||\, 1/g_m}{R_L \,||\, 1/g_m + R_s}$$

not what we want!

* We want to decouple D & G for incr. picture

1)

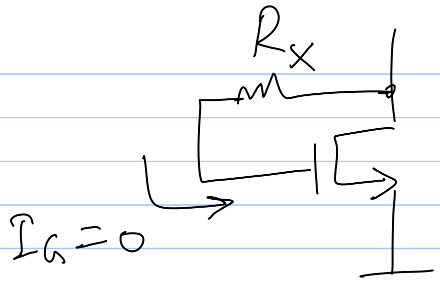




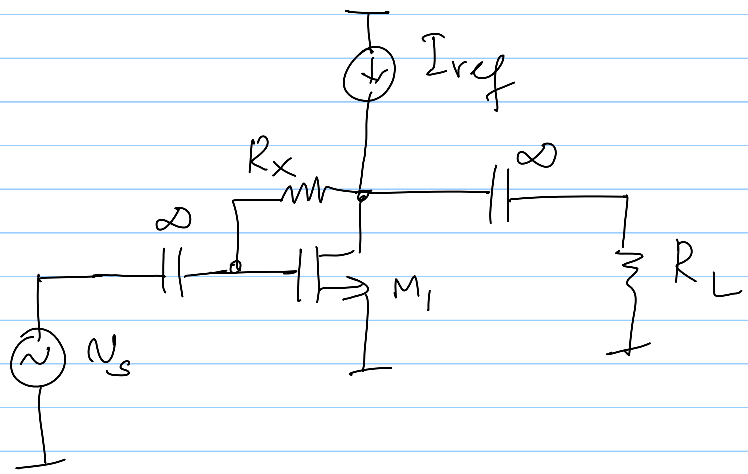
here $I = 0$

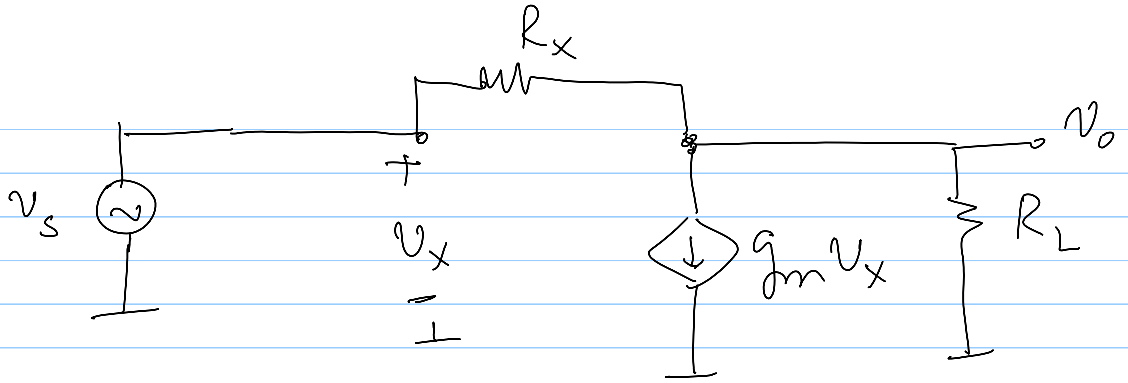
⇒ Impractical (L in ICs are very large)

2)



* R_X is very large
* voltage drop across R_X is zero





$$v_x = v_s$$

$$\frac{v_s - v_o}{R_x} = g_m v_s + \frac{v_o}{R_L}$$

$$v_s (G_x - g_m) = v_o (G_x + G_L)$$

$$\Rightarrow \quad \frac{v_o}{v_s} = \frac{G_x - g_m}{G_x + G_L}$$

$$\frac{v_o}{v_s} = -\frac{g_m}{G_L}\left[\frac{1 - G_x/g_m}{1 + G_x/G_L}\right]$$

* $g_m > G_L$ for large gain

* $G_x << G_L \Rightarrow G_x << g_m$

$\therefore$ R_x = large $\Rightarrow R_x >> R_L \Rightarrow$ gain $\approx -g_m R_L$

* <u>Swing limits</u> = <u>lower</u>

→ I_D = same as before ⇒ cut off limit is the same

→ voltage across $R_x = 0$; $V_D = V_G$