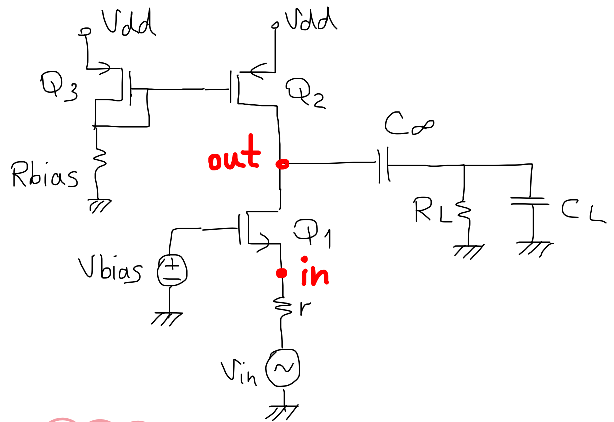
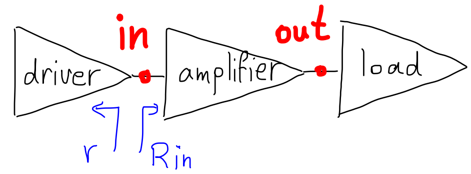
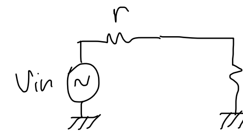
* Input and output resistances of the common gate amplifier :





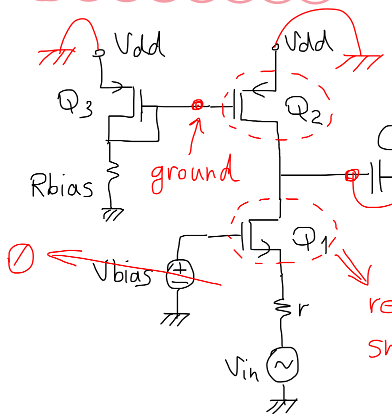


$+ V_{in} \dfrac{R_{in}}{r+\cancel{R_{in}}}$
$-$

$r \gg R_{in} \Rightarrow \dfrac{R_{in}}{r} \ll 1$

* AC analysis :

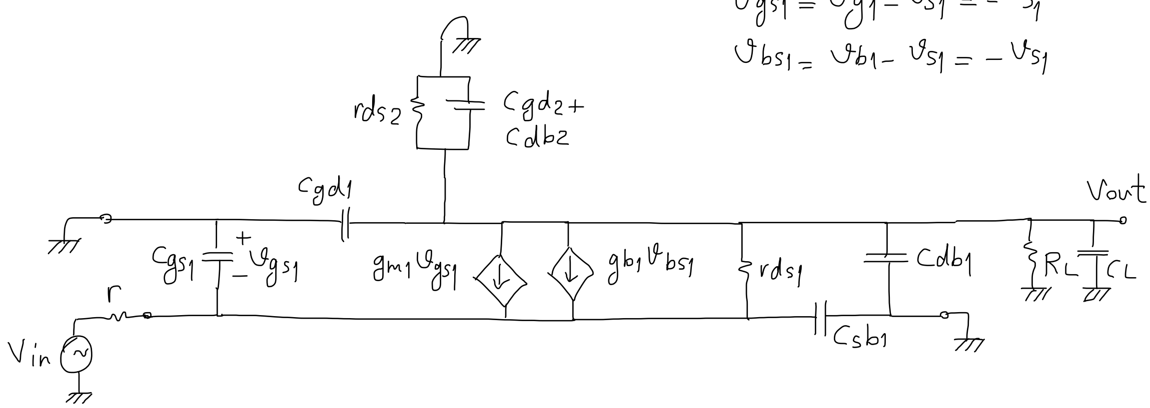
1. discard DC sources
2. short C_∞

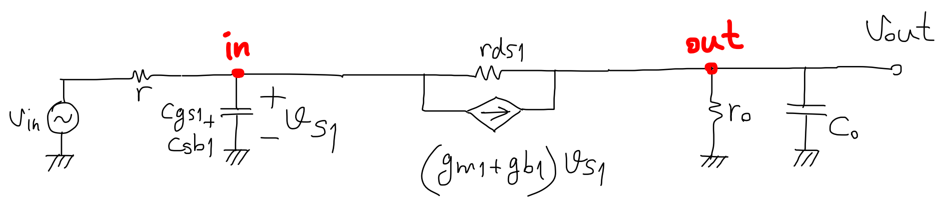


replace with small-signal model

$v_{gs1} = v_{g1} - v_{s1} = -v_{s1}$

$v_{bs1} = v_{b1} - v_{s1} = -v_{s1}$





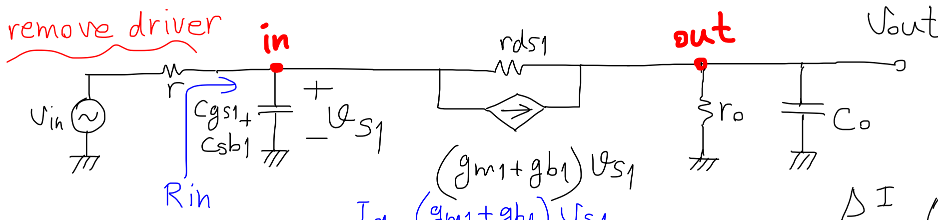
$r_o = r_{ds2} \| R_L$

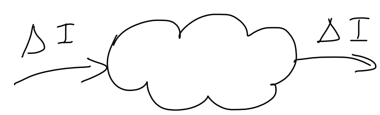
$C_o = C_{db1} + C_L + C_{gd2} + C_{db2} + C_{gd1}$

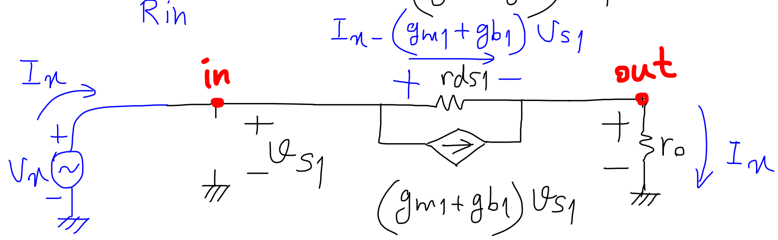
$$Z = R \pm jX$$

$\boxed{\text{* find input resistance:}}$

1. remove driver stage
2. add a V_x test source ; discard any other independent source
3. find V_x / I_x after opening all caps







$$r_o = r_{ds2} \| R_L$$

$$\begin{cases} V_x = r_{ds1}\left[I_x - (g_{m1}+g_{b1})V_{s1}\right] + r_o I_x \\ V_x = V_{s1} \end{cases} \Longrightarrow \boxed{\frac{V_x}{I_x} = \frac{r_o + r_{ds1}}{(g_{m1}+g_{b1})r_{ds1} + \cancel{1}}}$$

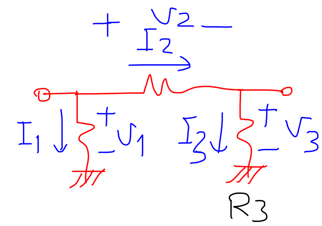
ignore

$$\Longrightarrow R_{in} = \frac{(r_{ds2}\|R_L) + r_{ds1}}{g_{m1} r_{ds1}} \; ; \text{ if } r_{ds1} = r_{ds2} = R_L \Rightarrow R_{in} = \frac{3}{2g_{m1}}$$

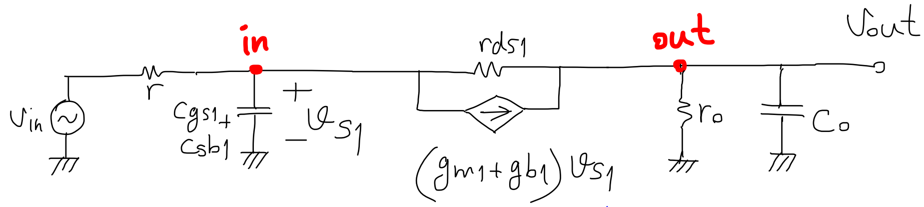
$$\begin{cases} r_{ds1} = r_{ds2} = 100k\Omega \\ R_L = 1k\Omega \\ g_m = 20\times10^{-3}\ [A/V] \end{cases} \Longrightarrow R_{in} = \frac{(100k \| 1k) + 100k}{20\times10^{-3} \times 100k} \approx \frac{1}{20\times10^{-3}} = \frac{1}{g_{m1}}$$

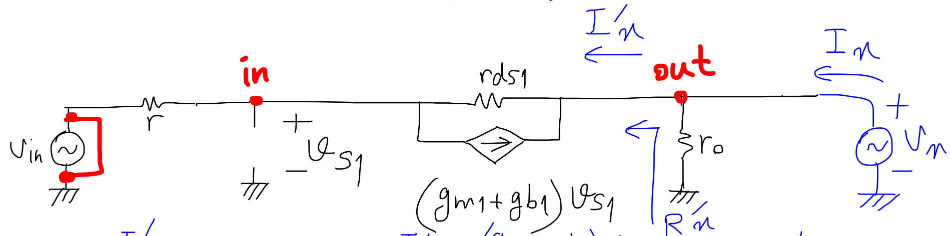
* find output resistance Rout ?

1. connect V_x test source to output
2. discard all other independent sources
3. open all capacitors
4. find $R_{out} = \frac{V_x}{I_x}$

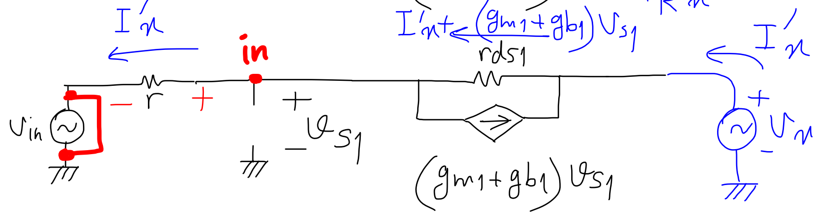


$$\frac{V_3}{I_3} = R_3 \qquad \frac{V_3}{I_1} = R_{m31}$$





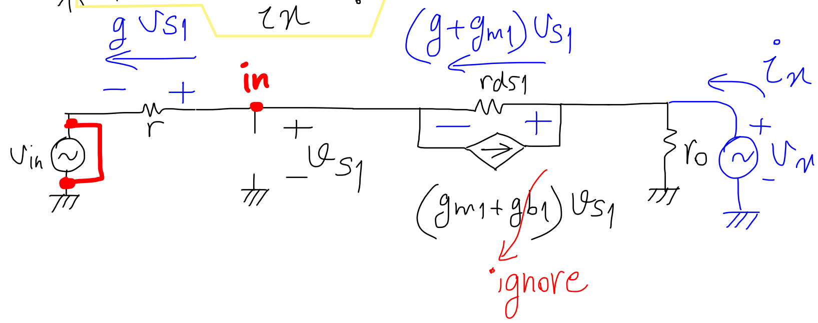
$$R_x = \frac{V_x}{I_x} = r_o \| R_x'$$



$$R_x' = \frac{V_x}{I_x'}$$

$$\begin{cases} V_{s1} = r I_x' \\ V_x = r_{ds1}\left[I_x' + (g_{m1}+g_{b1})V_{s1}\right] + r I_x' \end{cases} \Rightarrow \boxed{\frac{V_x}{I_x'} = r_{ds1} + r + (g_{m1}+g_{b1})r \cdot r_{ds1}}$$

* find $\dfrac{v_x}{i_x} = ?$ $\qquad r_o = r_{ds2} \,||\, R_L$



$$\begin{cases} v_x = r_{ds1}\left[g+g_{m1}\right]v_{s1} + v_{s1} \\ i_x = g_o v_x + g\, v_{s1} \end{cases} \Longrightarrow v_x = \left[1+(g+g_{m1})r_{ds1}\right]\underbrace{\left[\frac{i_x - g_o v_x}{g}\right]}_{v_{s1}}$$

$$v_x\left[g + g_o\left(1+(g+g_{m1})r_{ds1}\right)\right] = i_x\left[1+(g+g_{m1})r_{ds1}\right] \Longrightarrow \frac{v_x}{i_x} = \frac{1+(g+g_{m1})r_{ds1}}{g+g_o\left(1+(g+g_{m1})r_{ds1}\right)}$$

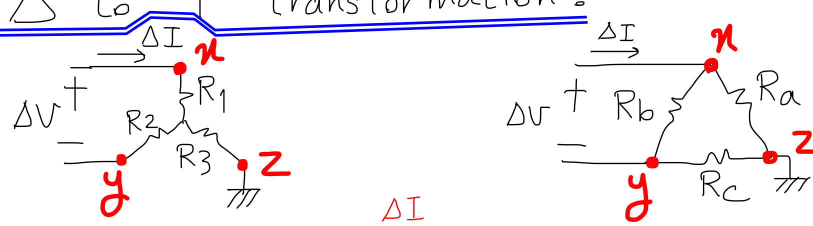
Answer: $\dfrac{v_x}{i_x} = r_o \,||\, \left(r + r_{ds1} + g_{m1} r_{ds1} r\right)$

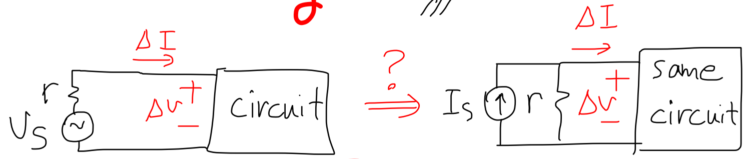
$$R_1 \,||\, R_2 = \frac{1}{G_1+G_2} \qquad \frac{1}{G_1 \,||\, G_2} = R_1 + R_2$$

$$G_a = \frac{G_1 G_3}{G_1+G_2+G_3}$$

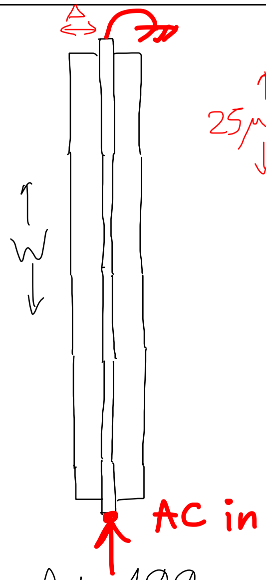
* Delta Δ to Y transformation:

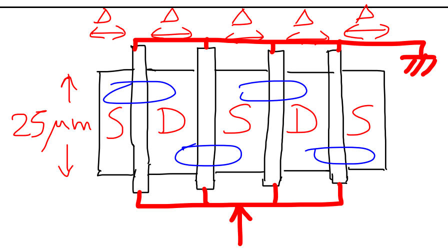
$$G_b = \frac{G_1 G_2}{G_1+G_2+G_3}$$





$V_s = r \cdot I_s$





0.18 μm

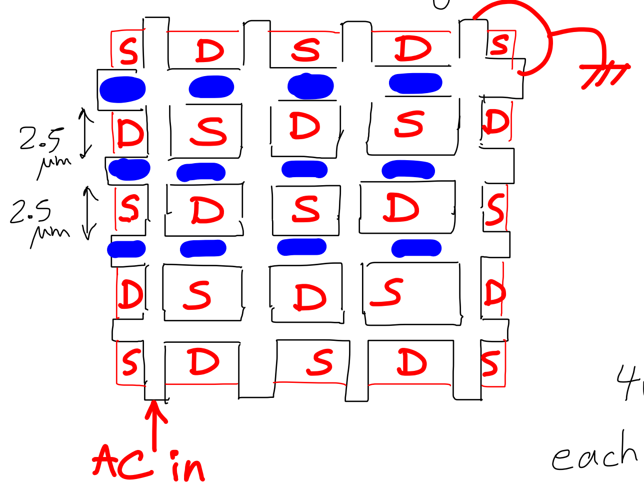
$\Delta = 500nm$

$W = 100\mu m$

$A_d = 2 \times 25\mu m \times \Delta$

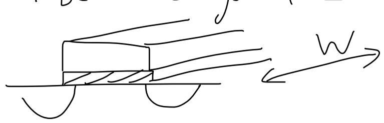
$P_d = 4\Delta$

waffle layout



$A_d = 100\mu m \times \Delta$

$P_d = 100\mu m + 2\Delta$



polysilicon

$\rho = 50\Omega.cm$

40 transistor

each transistor width = 2.5μm