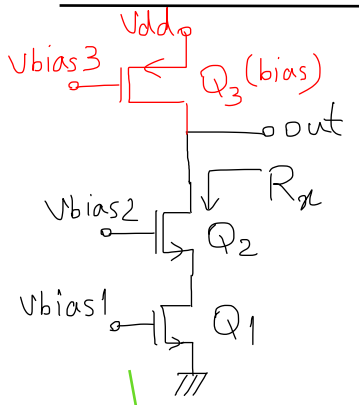
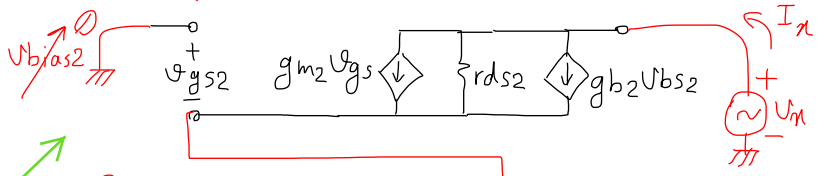
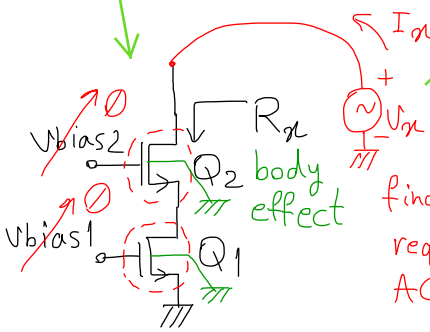
* Rsistance of cascode transistors :

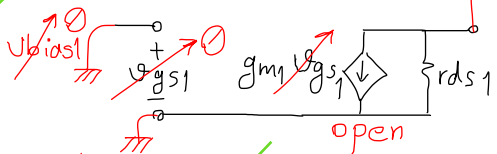


$R_{out} = R_x \parallel r_{ds3}$?

$\begin{cases} V_{bs2} = V_{b2} - V_{s2} = -V_{s2} \\ V_{gs2} = V_{g2} - V_{s2} = -V_{s2} \end{cases}$

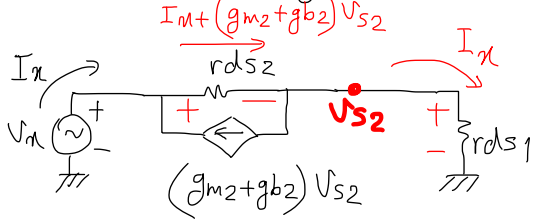


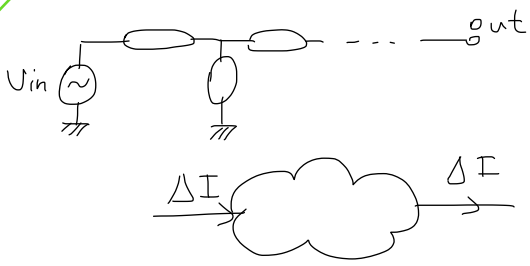




finding resistance requires low-freq AC analysis

→ create TT arrayed circuit :





$$\begin{cases} V_x = r_{ds2}\left[I_x + (g_{m2}+g_{b2}) V_{s2} \right] + r_{ds1} I_x \\ V_{s2} = r_{ds1} \cdot I_x \end{cases}$$

intrinsic gain

$\begin{cases} g_m \cdot r_{ds} \gg 1 \\ g_m \gg g_b \end{cases}$

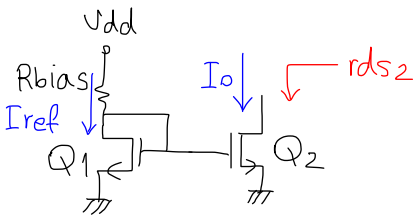
$$\Rightarrow R_x = \frac{V_x}{I_x} = r_{ds1} + r_{ds2} + (g_{m2}+g_{b2}) r_{ds1} r_{ds2} = (g_{m2} r_{ds2}) r_{ds1}$$

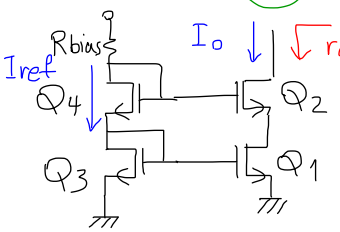
dominant

large

Amp $A_v = g_m (r_{ds} \parallel g_m r_{ds}^2)$

* current mirrors :

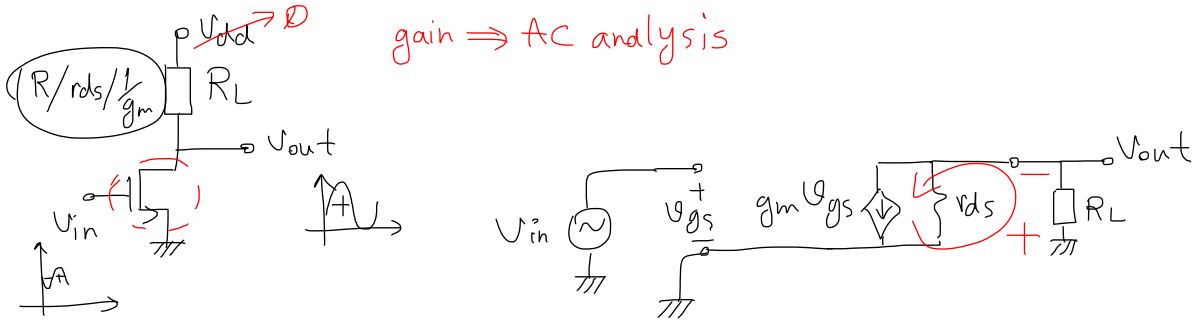




$r_{ds2} + r_{ds1} + g_{m2} r_{ds2} r_{ds1}$

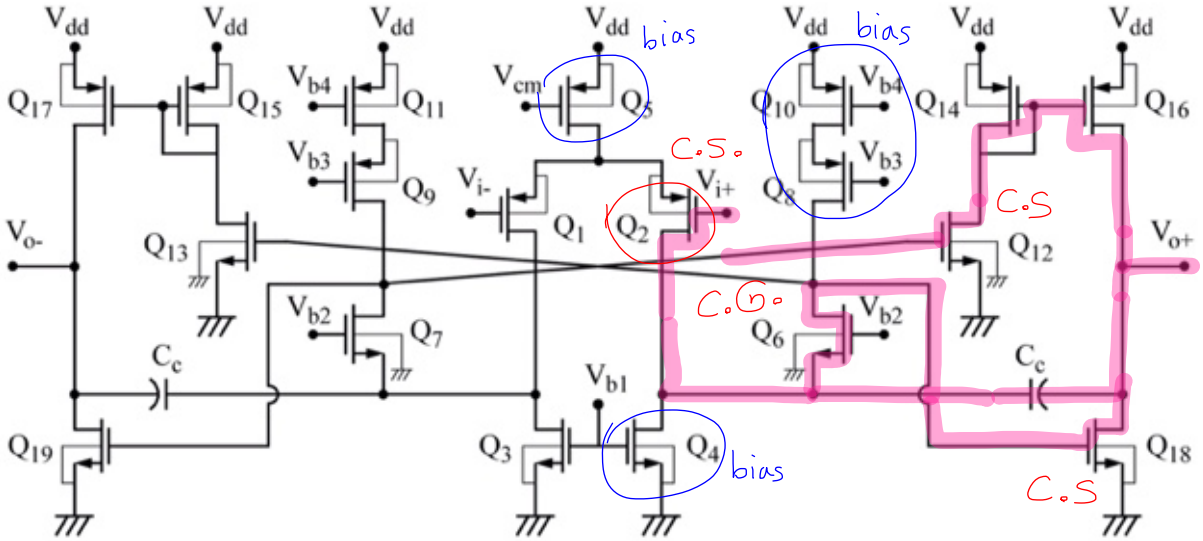
dominant

here the difference between Io and Iref decreases.

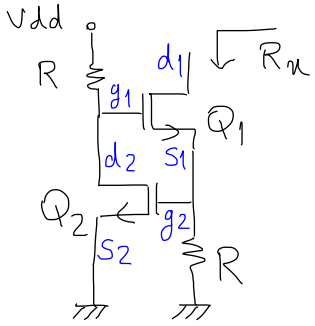


$$\begin{cases} V_{out} = -g_m v_{gs}(r_{ds} \| R_L) \\ v_{gs} = v_{in} \end{cases} \Longrightarrow gain = \frac{v_{out}}{v_{in}} = -g_m(r_{ds} \| R_L)$$

R_L must be very large to increase gain. As a result, drain of biasing transistor is always connected to output node.

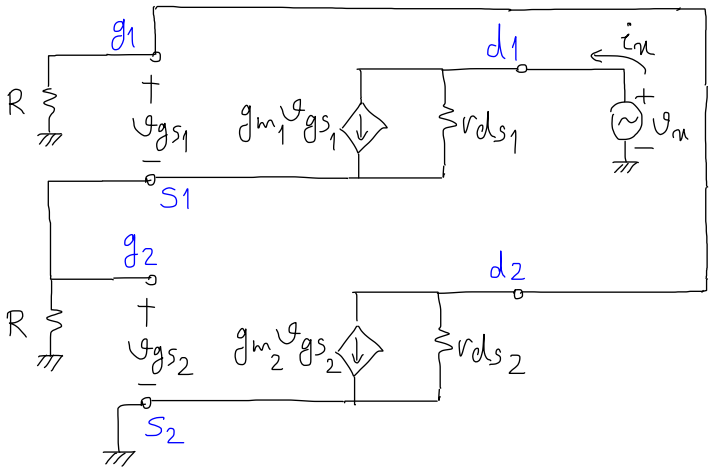


✳ Assume all transistors operate in saturation. ignore body effect. find R_{in} ?

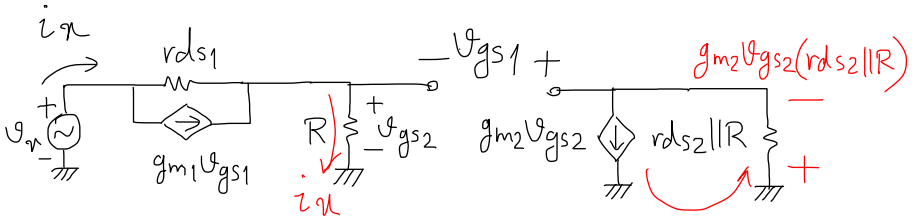


→ discard all DC sources
short voltage sources
open current sources
→ replace transistors with small-signal model
→ connect v_{in}, find $R_{in} = \frac{v_{in}}{i_{in}}$

✳ Small-signal AC model



✳ TT-arrayed small-signal AC model



$$\begin{cases} v_{gs2} = -v_{gs1} - g_{m_2}v_{gs2}(r_{ds2}\|R) \\ v_{gs2} = R\, i_{in} \\ v_{in} = r_{ds1}\left[i_{in} - g_{m_1}v_{gs1}\right] + v_{gs2} \end{cases} \Longrightarrow R_{in} = \frac{v_{in}}{i_{in}} = r_{ds1} + R + \dots$$