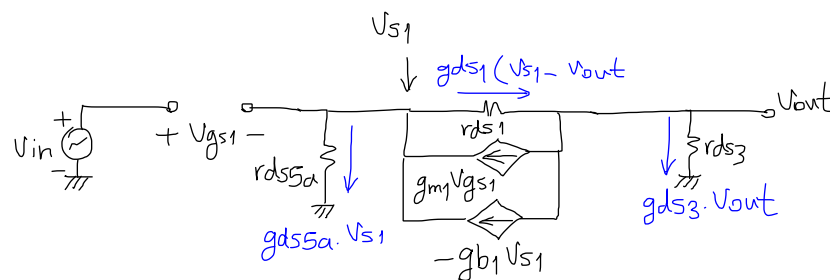
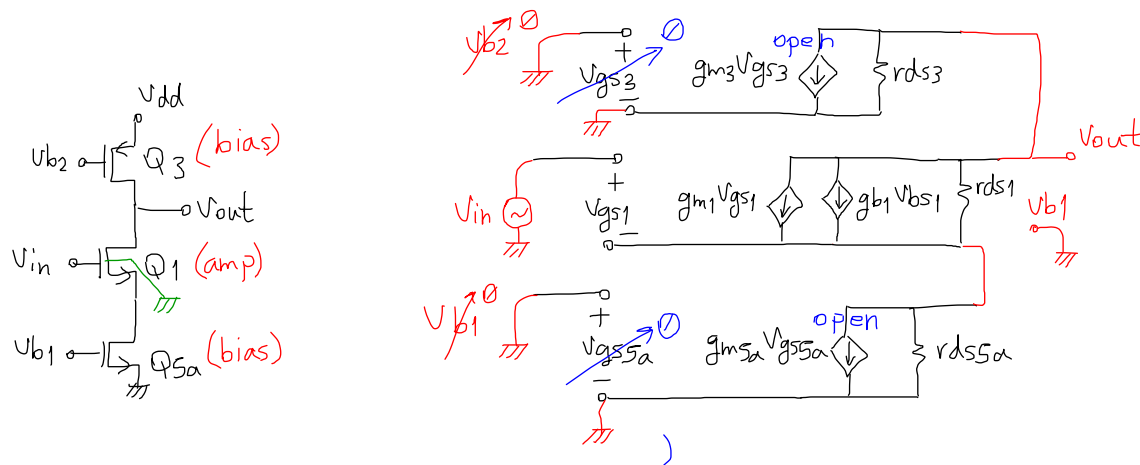


*find the gain of source degeneration amplifier:
(assume all transistors operate in Saturation)



$$\begin{cases} g_m \gg g_b \\ g_m \gg g_{ds} \end{cases}$$

$$\begin{cases} V_{s1} = V_{in} - V_{gs1} \\ KCL(s_1): g_{m1}V_{gs1} = g_{ds5a}V_{s1} + g_{b1}V_{s1} + g_{ds1}(V_{s1} - V_{out}) \\ KCL(out): g_{m1}V_{gs1} + g_{ds3}V_{out} = g_{b1}V_{s1} + g_{ds1}(V_{s1} - V_{out}) \end{cases} \quad A$$

$$\Rightarrow \begin{cases} V_{gs1}(g_{m1} + g_{ds5a} + g_{b1} + g_{ds1}) = V_{in}(g_{ds5a} + g_{b1} + g_{ds1}) - g_{ds1}V_{out} \\ V_{gs1}(g_{m1} + g_{b1} + g_{ds1}) = V_{in}(g_{b1} + g_{ds1}) - V_{out}(g_{ds1} + g_{ds3}) \end{cases} \quad B$$

$$A=B \Rightarrow V_{in} \cdot g_{ds5a} = -V_{out} \cdot g_{ds3}$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{-g_{ds5a}}{g_{ds3}} = \frac{-r_{ds3}}{r_{ds5a}} = \frac{-r_{ds3}}{2r_{ds5}}$$