Lecture # 21

Single- and multi-stage Amplifier ICs

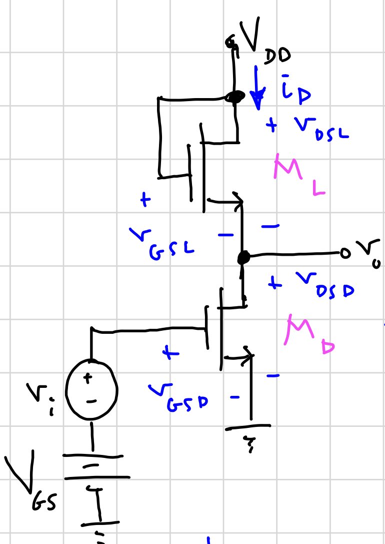
→ resistors are less practical for IC's than MOSFETs

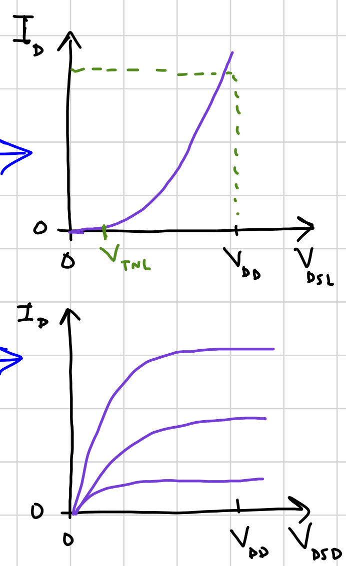
→ Need to achieve amplifiers from all-MOSFET IC's

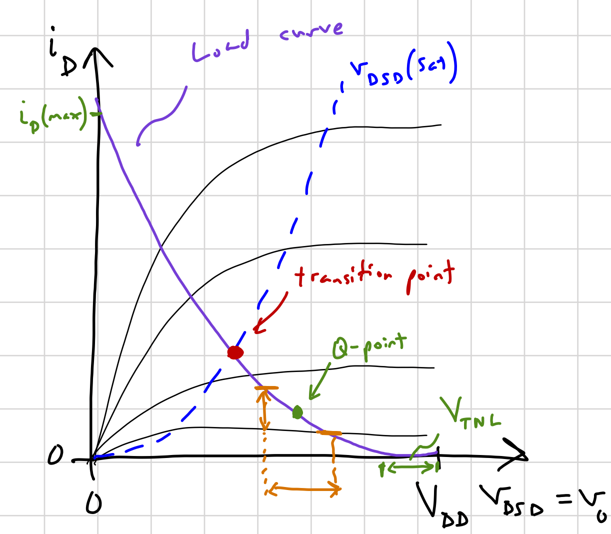
→ Can do this using inverter-style circuits but with ac input.

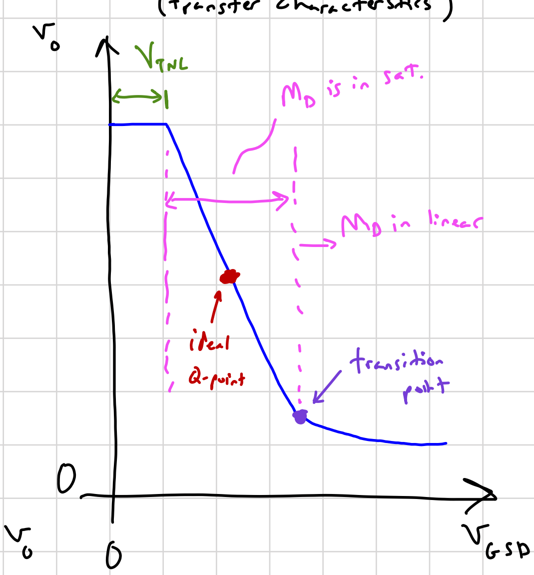
• NMOS Amplifier with Enhancement Load

(transfer characteristics)

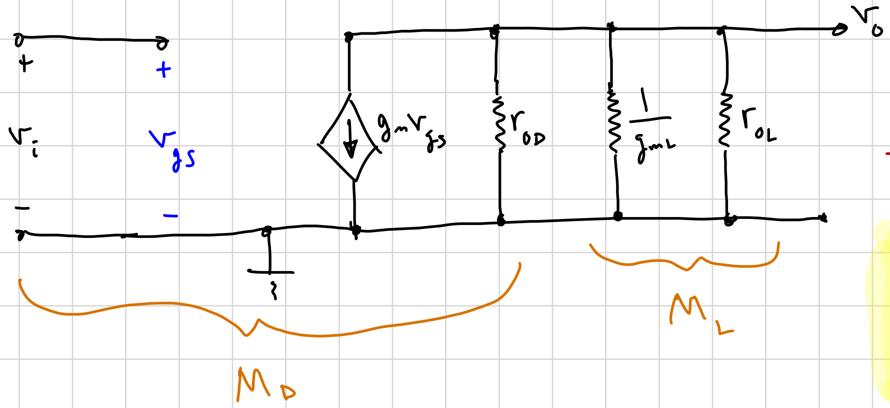








Small-signal equiv. circuit



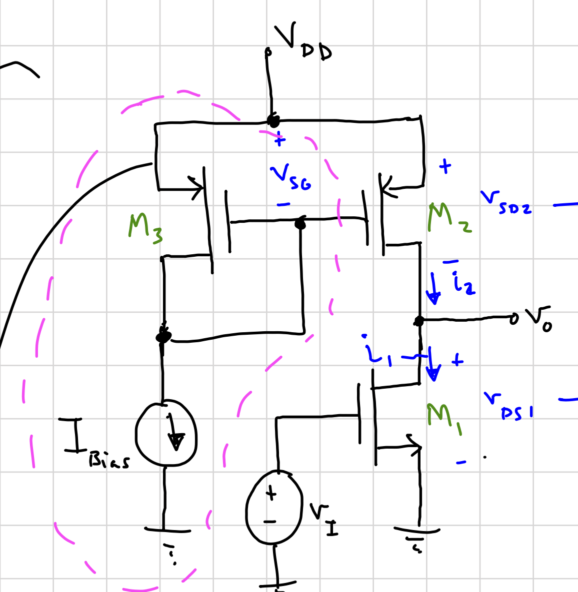
$$A_v = \frac{v_o}{v_i} = -g_{mD}\left(r_{oD} \,\|\, \frac{1}{g_{mL}} \,\|\, r_{oL}\right)$$

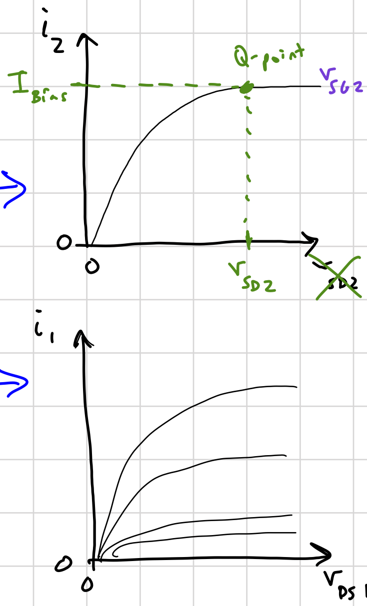
→ generally: $\frac{1}{g_{mL}} \ll r_{oL}$, $\frac{1}{g_{mD}} \ll r_{oD}$

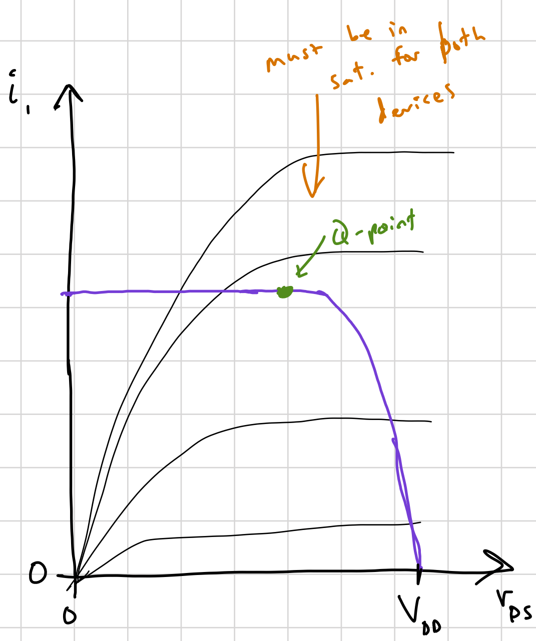
$$\boxed{A_v = \frac{-g_{mD}}{g_{mL}} = -\sqrt{\frac{K_{nD}}{K_{nL}}} = -\sqrt{\frac{\left(\frac{W}{L}\right)_D}{\left(\frac{W}{L}\right)_L}}}$$

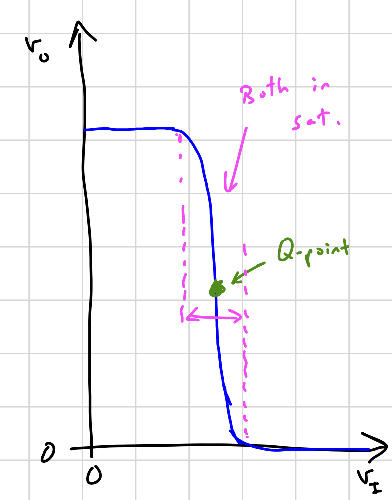
• CMOS Common-Source Amplifier

→ CMOS Amplifiers are the most relevant





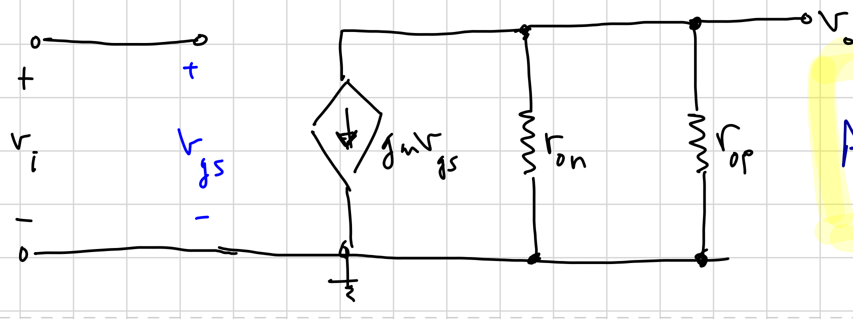




Bias M_2 with this to enable more precise setting of Q-point

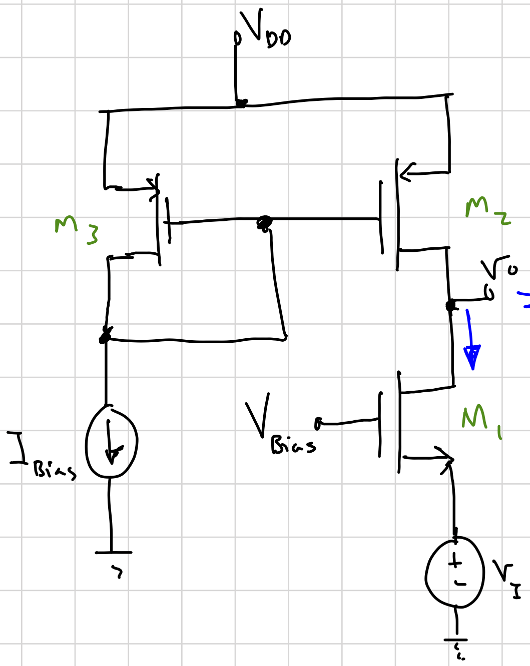
☆ causes $i_2 = I_{Bias}$ (see Fig. 3.49)

Small-sig. equiv. circuit

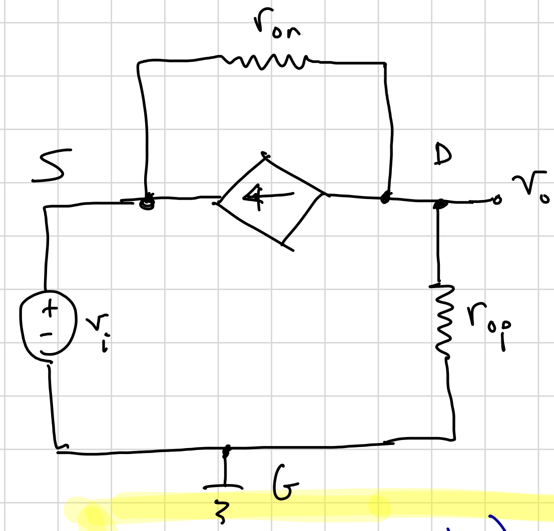


$$\boxed{A_v = \frac{v_o}{v_i} = -g_{mn}\left(r_{on} \,\|\, r_{op}\right)}$$

• CMOS Common-Gate Amplifier



small-signal equiv. circuit



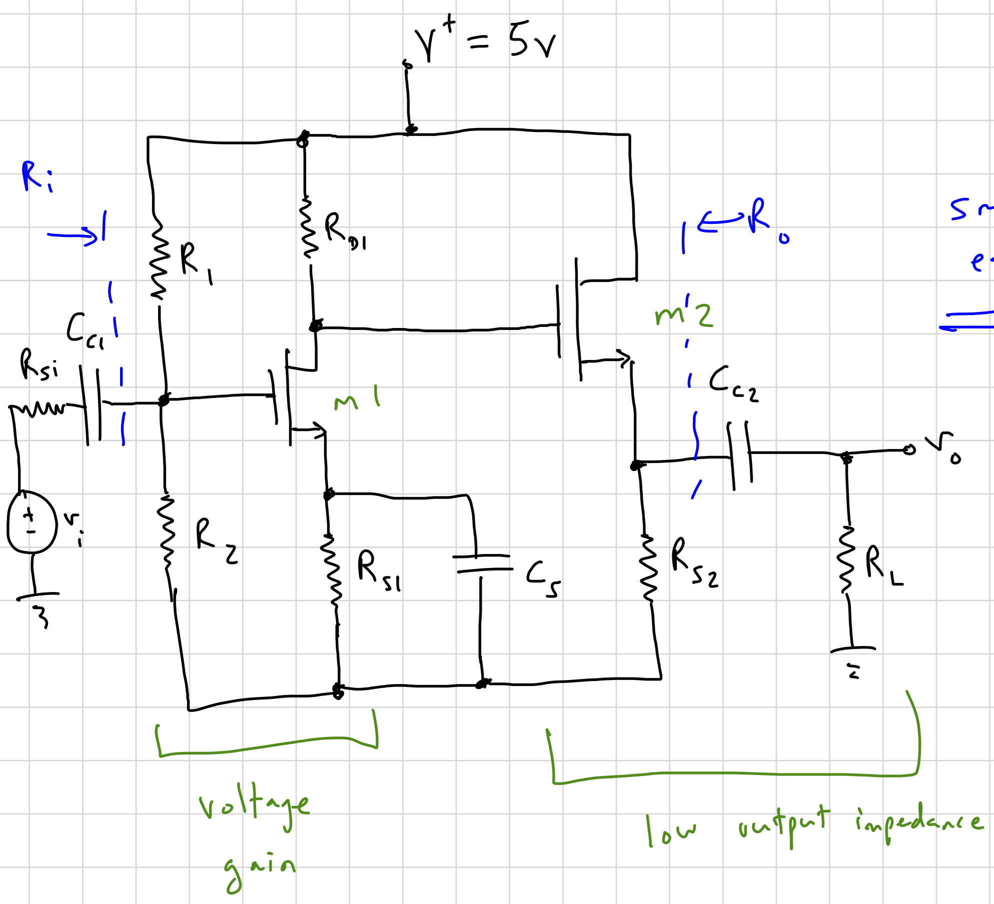
$$\boxed{A_v = \frac{\left(g_{mn} + \frac{1}{r_{on}}\right)}{\left(\frac{1}{r_{op}} + \frac{1}{r_{on}}\right)}}$$

• Multi-stage Amplifiers

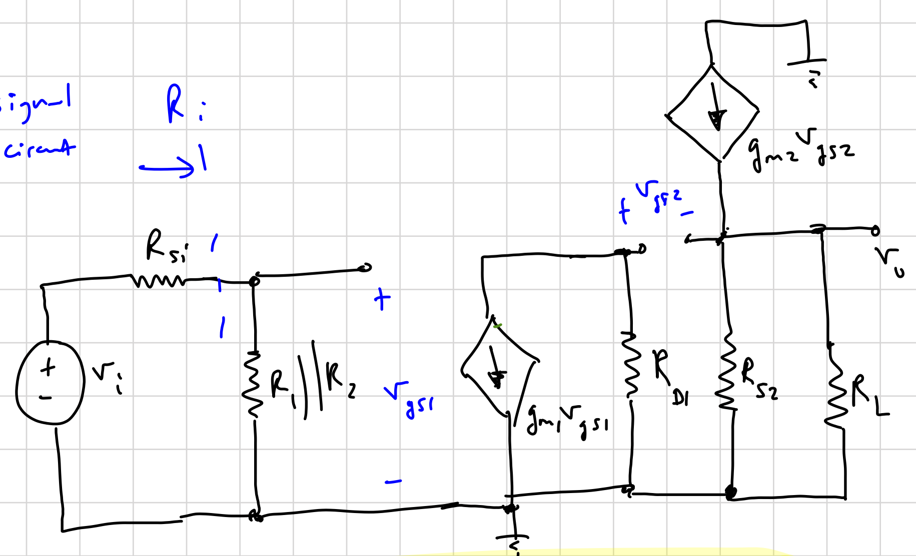
→ single-stage amplifiers often can't get the job done

→ cascade them together:

EX: Common-source followed by common-drain



small-signal equiv. circuit



$$\boxed{A_v = \frac{-g_{m1} g_{m2} R_{D1} \left(R_{S2} || R_L\right)}{1 + g_{m2}\left(R_{S2} || R_L\right)} \left(\frac{R_i}{R_i + R_{Si}}\right)}$$