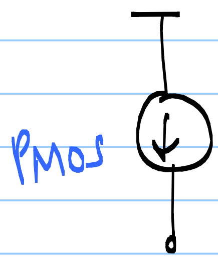
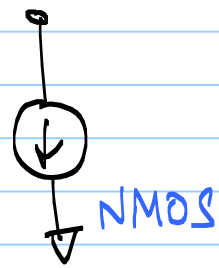
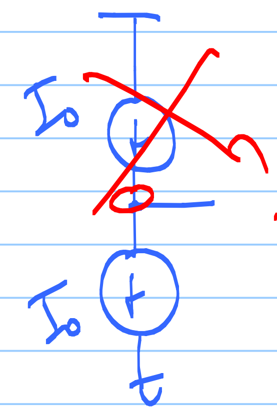
ECE 511 – Lecture 10.

Note Title 2/27/2012

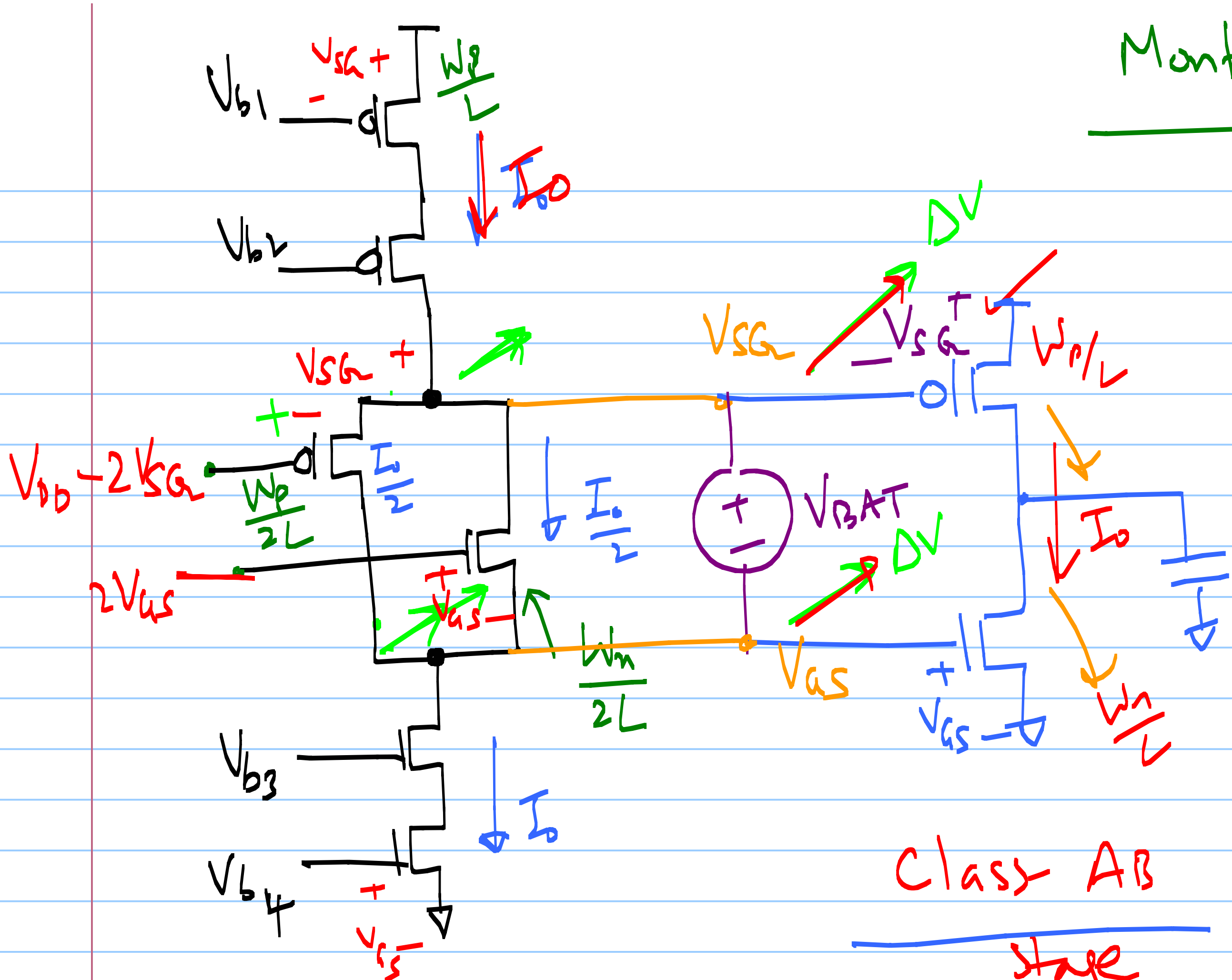
floating current source





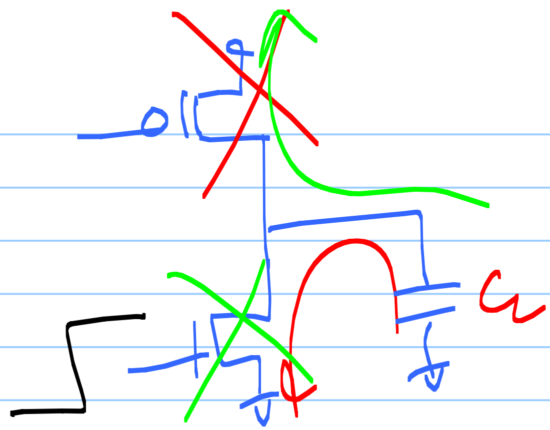


Monticelli Biasing scheme



$$V_{BAT} = (V_{DD} - V_{SG}) - (V_{GS})$$

Class AB Stage

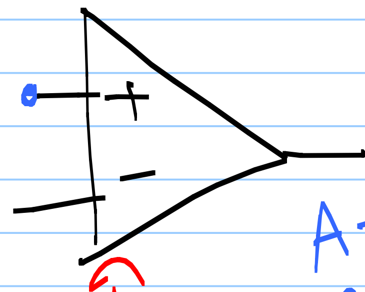


Chapter 21 – Amplifiers

* low-frequency small-signal behavior

* LNA

opamp.

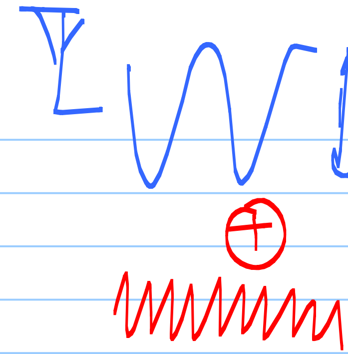


$A \to \infty$

$R_{in} \to \infty$

$R_{out} \to 0$

Signal processing

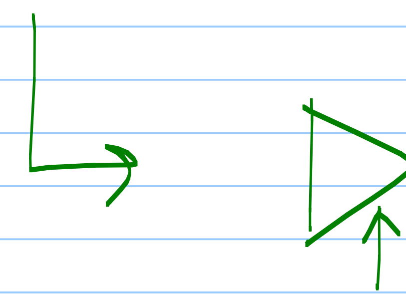


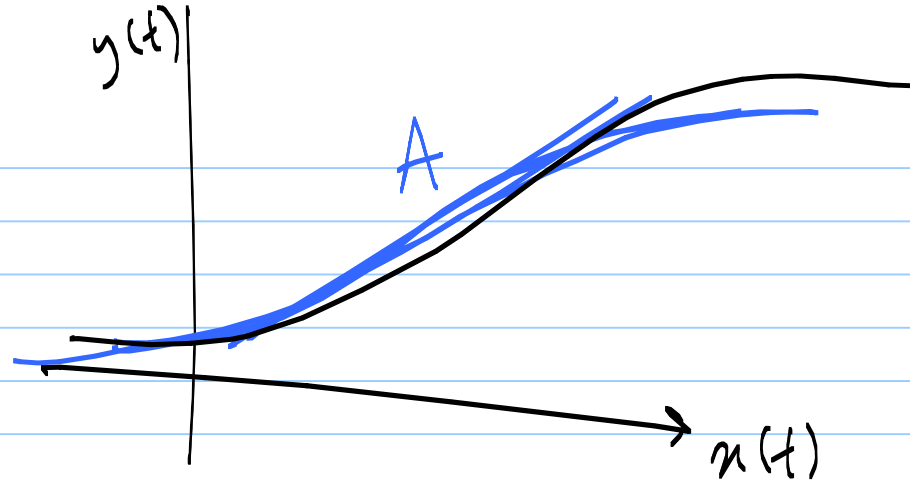
100 μV

10 μV

SNR

10





$$y(t) = \alpha_0 + \alpha_1 x_1(t) + \cancel{\underline{\alpha_2 x^2(t)}} + \alpha_3 x^3(t) + \cancel{\cdots},$$

for small $\underline{\underline{x(t)}}$

$$y(t) \simeq \alpha_0 + \alpha_1 x_1(t)$$

DC operating point

small-signal gain

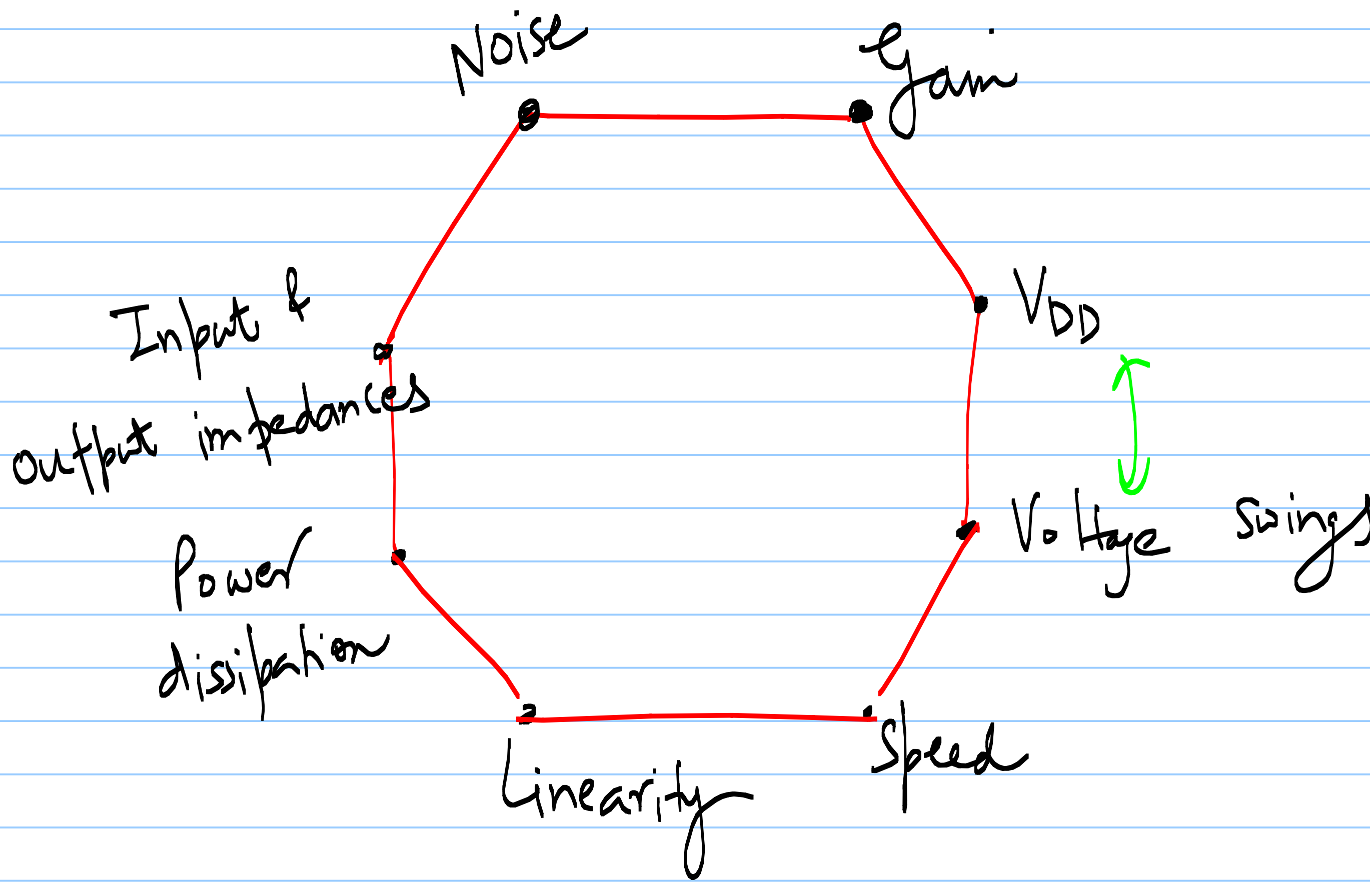
$x(t) \uparrow \Rightarrow \cancel{x^2(t)}, \underline{\underline{x^3(t)}}$

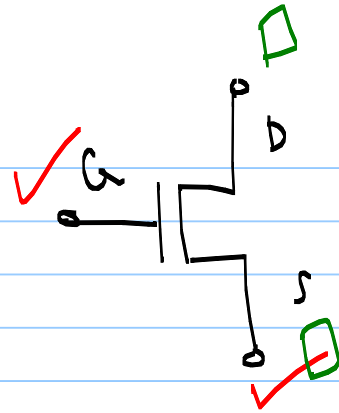
non-linearity

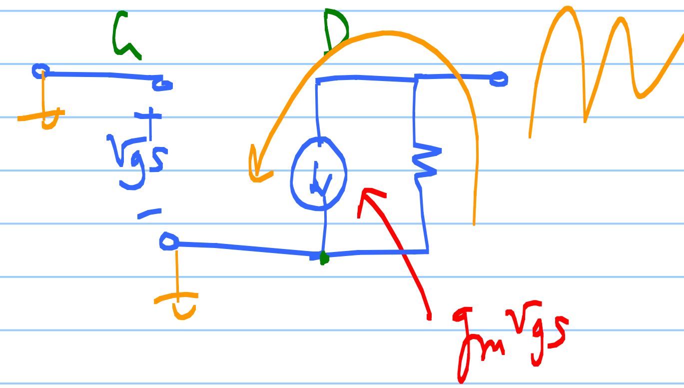
$\Rightarrow$ the feedback to improve linearity non-linearity metrics $\longrightarrow$ HD_3

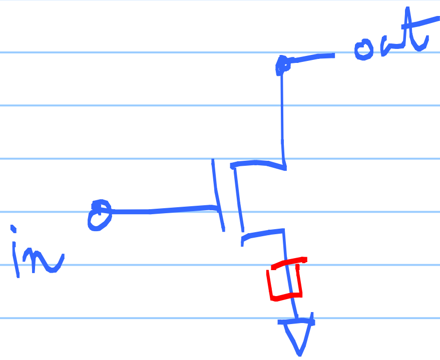
RF system $\rightarrow$ $\boxed{IIP_3, \quad IIM_3}$

Trade-off's

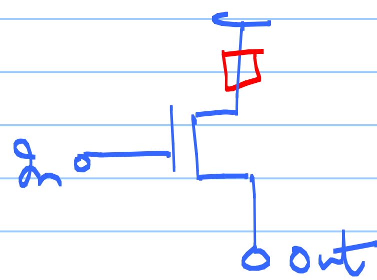

Noise
Gain
V_{DD}
Voltage swings
Speed
Linearity
Power dissipation
Input & output impedances



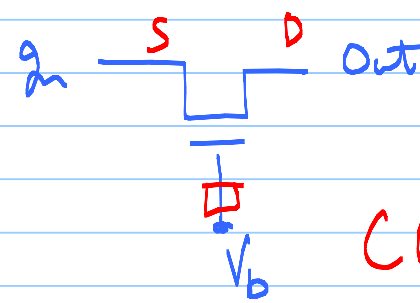




CS

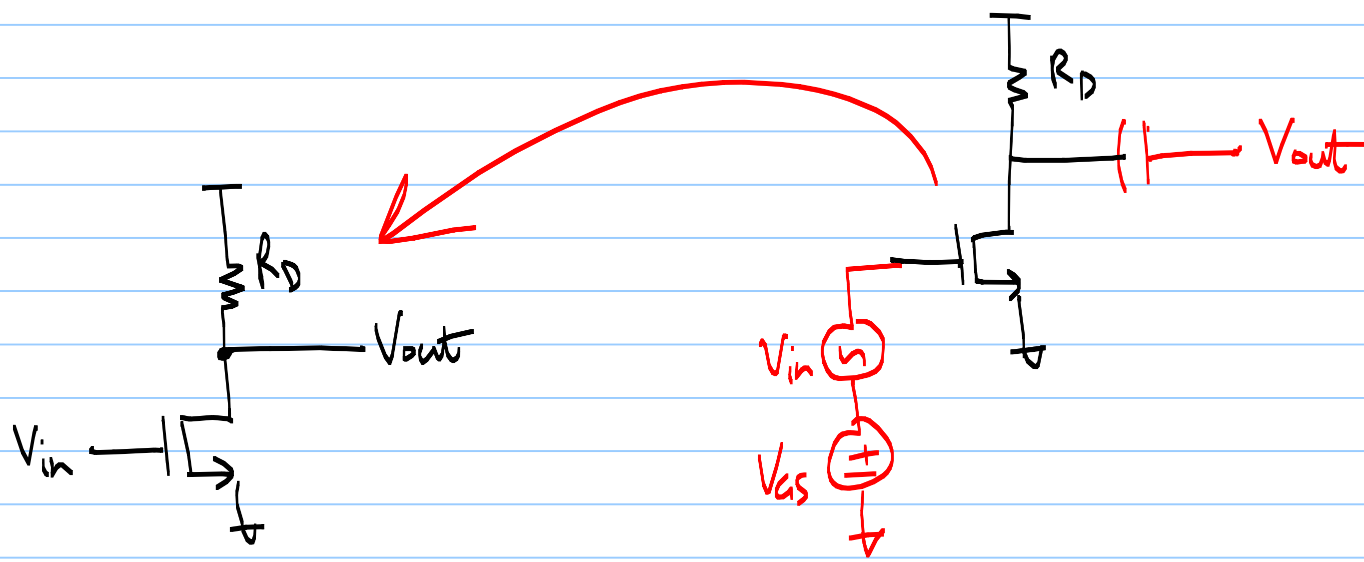


CD
(source follower)

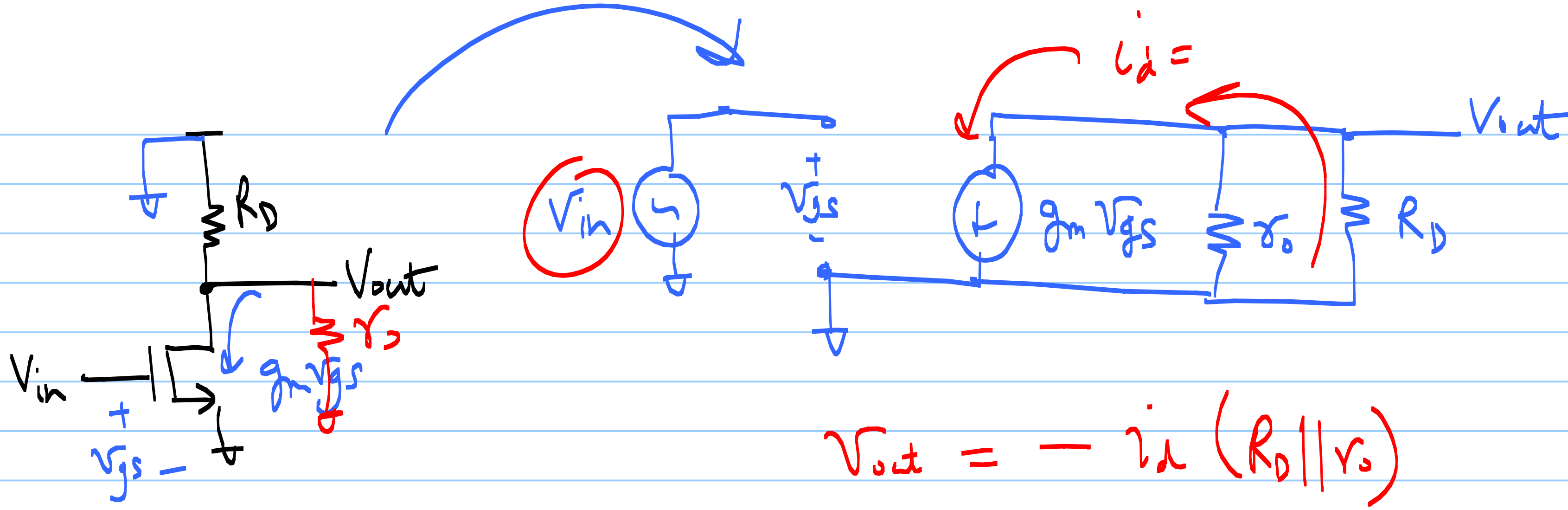


CG

Common Source Amplifier (Stage)



Small signal
equivalent



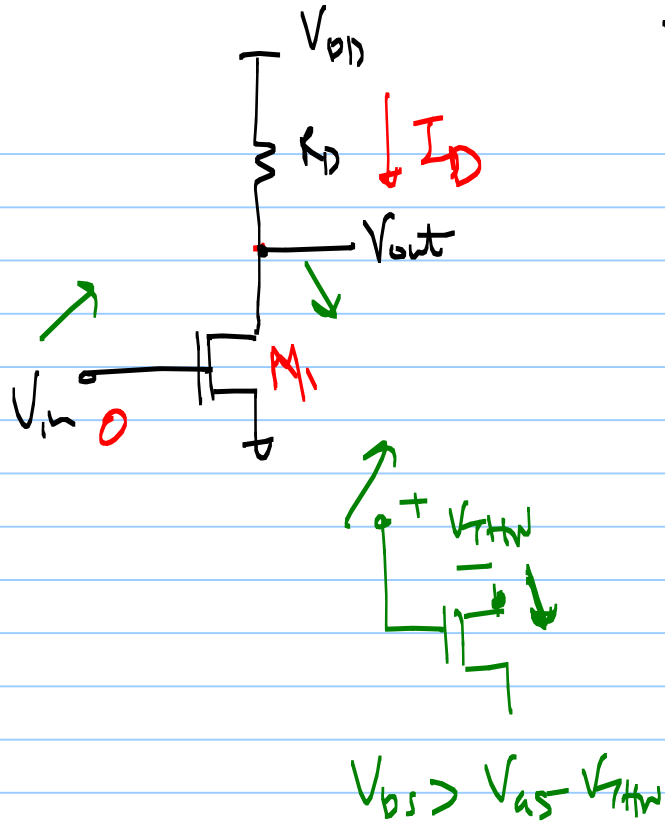
$$v_{out} = -i_d\,(R_D \| r_o)$$

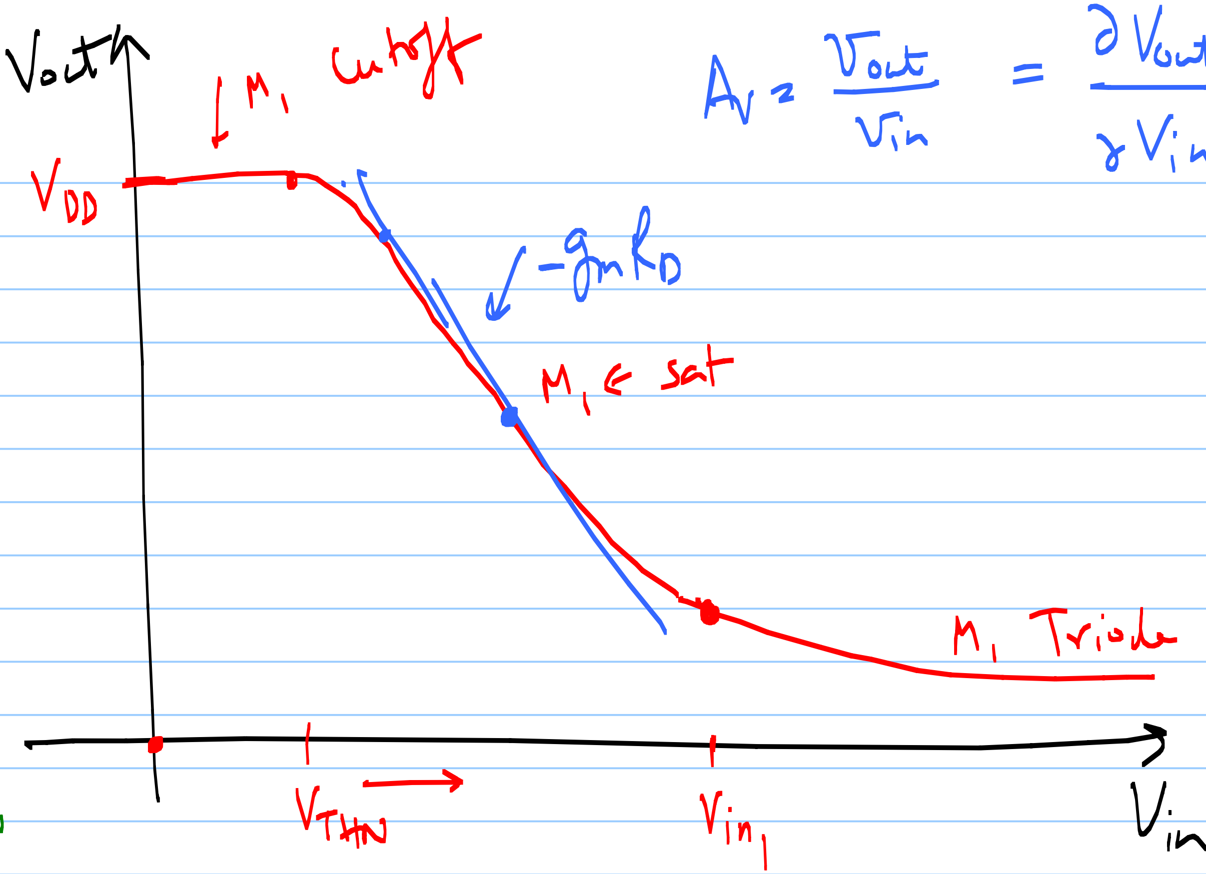
$$= -g_m v_{gs}\,(R_D \| r_o)$$

$$\Rightarrow \boxed{\frac{v_{out}}{v_{in}} = -g_m\,(R_D \| r_o)}$$

$R_D \ll r_o$

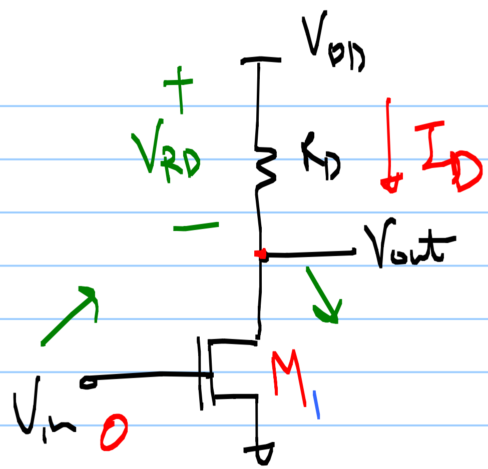
$$A_v = \frac{v_{out}}{v_{in}} \simeq -g_m R_D$$





$$A_v = \frac{V_{out}}{V_{in}} = \frac{\partial V_{out}}{\partial V_{in}}$$

Large signal behavior



$$V_{out} = V_{DD} - I_D \cdot R_D$$

$$V_{out} = V_{DD} - \frac{Kp_n}{2} \frac{W}{L} \cdot R_D \left(V_{in} - V_{THN}\right)^2$$

$$A_v = \frac{\partial V_{out}}{\partial V_{in}} = -\underbrace{\boxed{Kp_n \frac{W}{L}\left(V_{in} - V_{THN}\right)}}_{g_m} R_D$$

$$= \boxed{-g_m R_D}$$

$$A_v = -g_m R_D \qquad g_m = \sqrt{2\beta I_D}$$

$$= -\sqrt{2 KP_n \frac{W}{L} I_D} \cdot R_D \qquad \frac{V_{RD}}{I_D}$$

$$\boxed{A_v = -\sqrt{2 KP_n \left(\frac{W}{L}\right)} \cdot \frac{V_{RD}}{\sqrt{I_D}}}$$

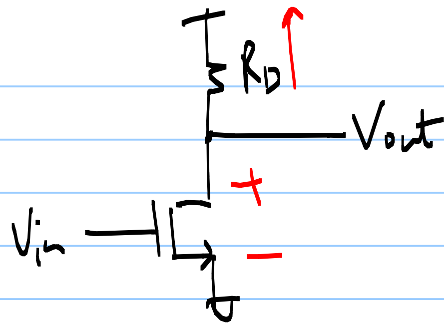
$A_v \uparrow \Rightarrow$

- $\left(\frac{W}{L}\right) \uparrow$
- $V_{RD} \uparrow \Rightarrow$ swing $\downarrow$
- $I_D \downarrow \Rightarrow$ ~~lower~~ speeds

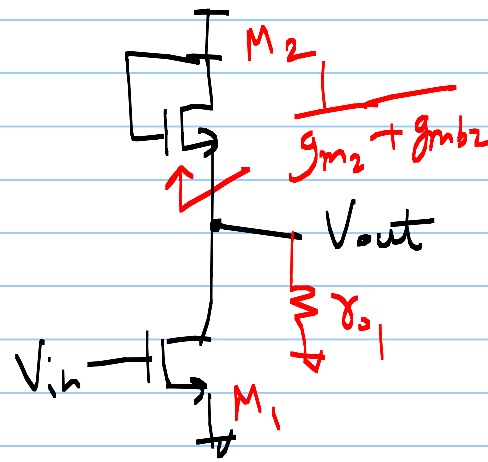
$g_m R_D$

$R_D \uparrow$

$V_{RD} \uparrow$



Diode-connected load

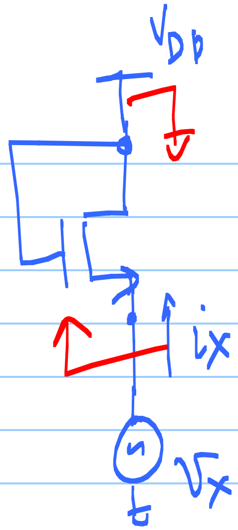


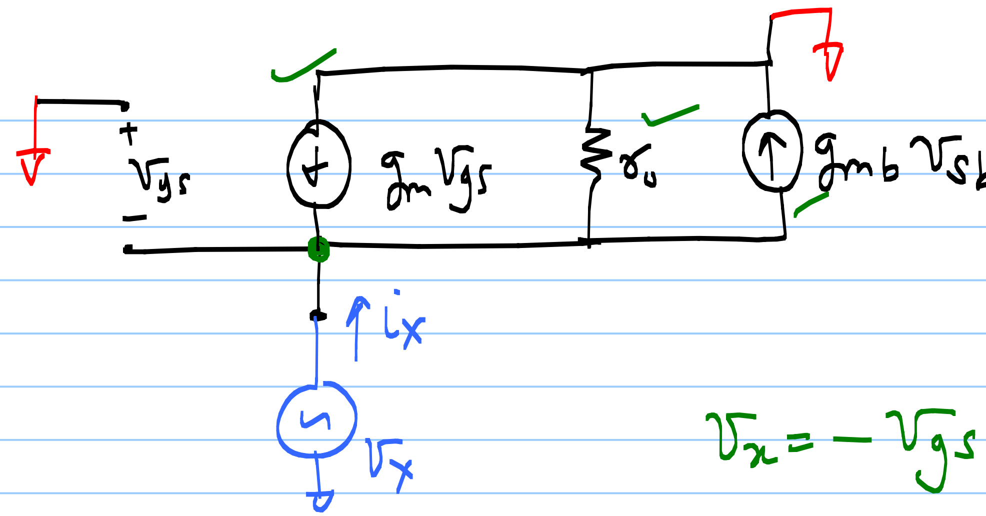
$$A_v = -g_{m1}\left(\frac{1}{g_{m2}+g_{mb2}} \,\Big\|\, r_{o1}\right)$$

$$\approx -\frac{g_{m1}}{g_{m2}+g_{mb2}}$$

$$g_{mb2} = \eta\, g_{m2}$$

$$= -\left(\frac{g_{m1}}{g_{m2}(1+\eta)}\right) = \frac{\sqrt{\cancel{2}\beta_1 \cancel{I_D}}}{\sqrt{2\beta_2 \cancel{I_D}}}\,\frac{1}{(1+\eta)}$$





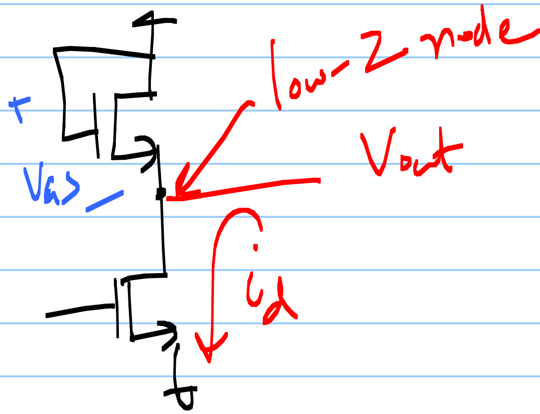
$$v_x = -v_{gs}$$

$$v_{sb} = v_x$$

$$(g_m + g_{mb})v_x + \frac{v_x}{r_o} = i_x$$

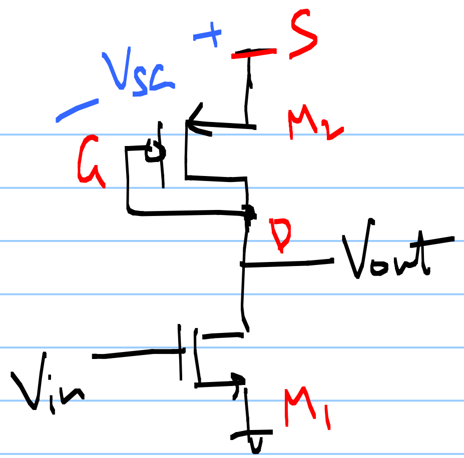
$$\frac{v_x}{i_x} = \frac{1}{g_m + g_{mb} + r_o^{-1}} \simeq \frac{1}{g_m + g_{mb}}$$

$$A_v = -\sqrt{\frac{(W/L)_1}{(W/L)_2} \cdot \frac{1}{(\eta+1)}}$$



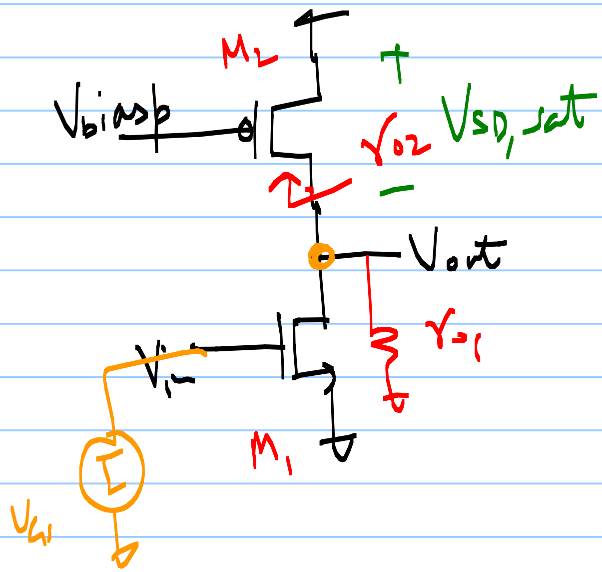
$$V_{out} = -i_d \cdot R_D$$

$$= -g_m v_{in} R_D$$



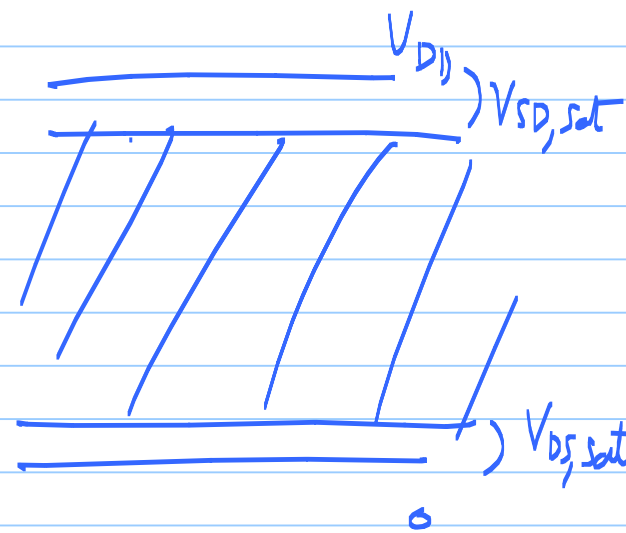
$$A_v = -\frac{g_{m1}}{g_{m2}} = -\frac{\sqrt{(W/L)_1}}{\sqrt{(W/L)_2}}$$

current mirror load



$$A_v = -g_{m1} \cdot (r_{o1} \,||\, r_{o2})$$

* good swing



$\boxed{21:30}$