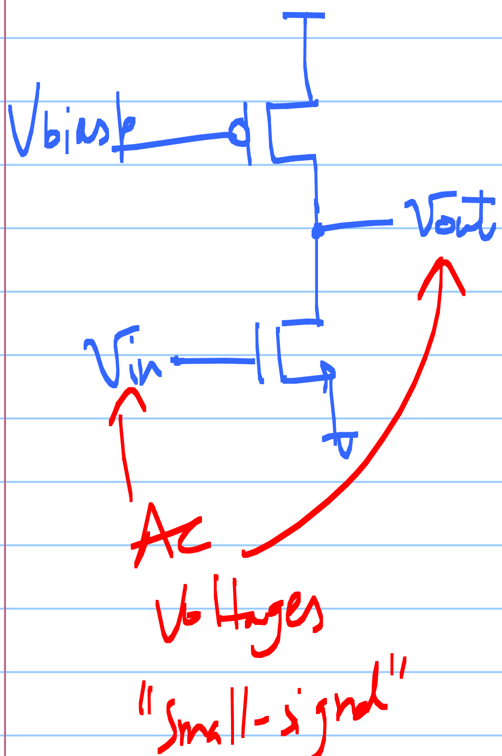
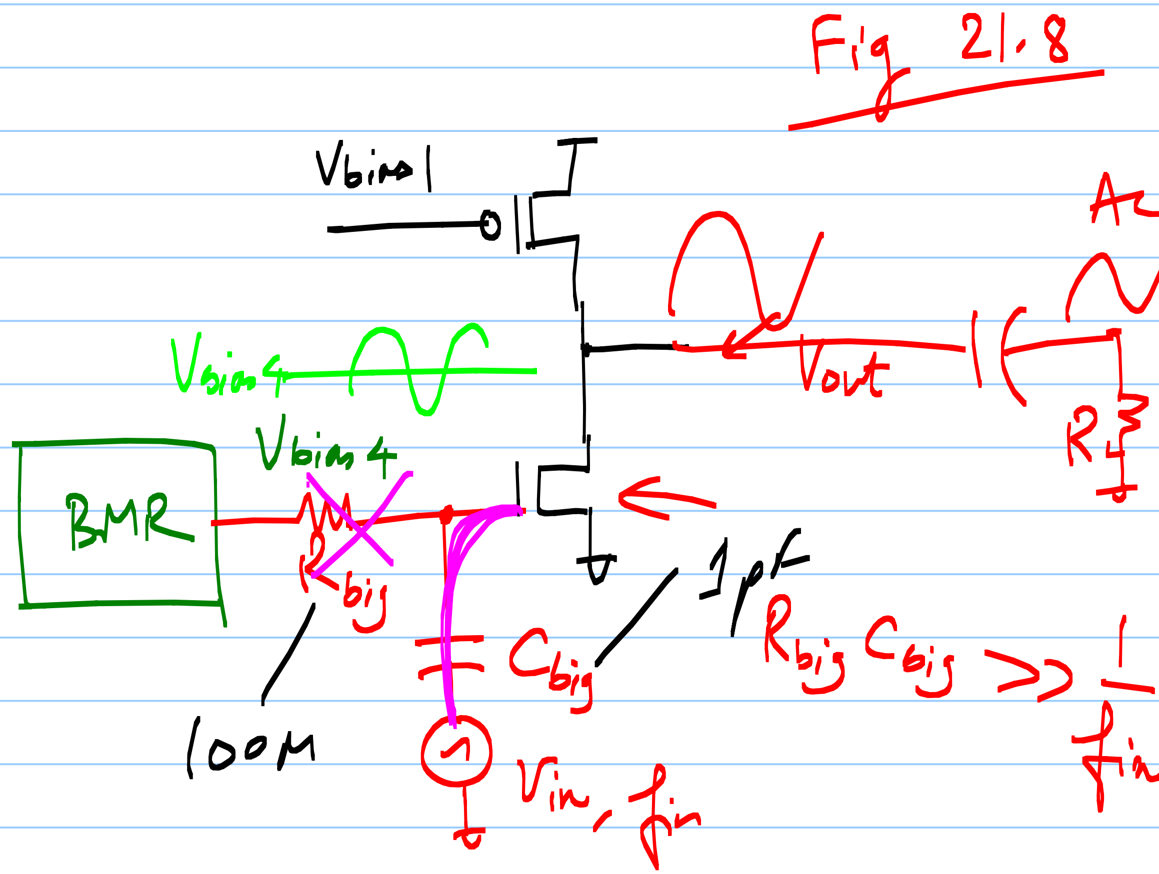
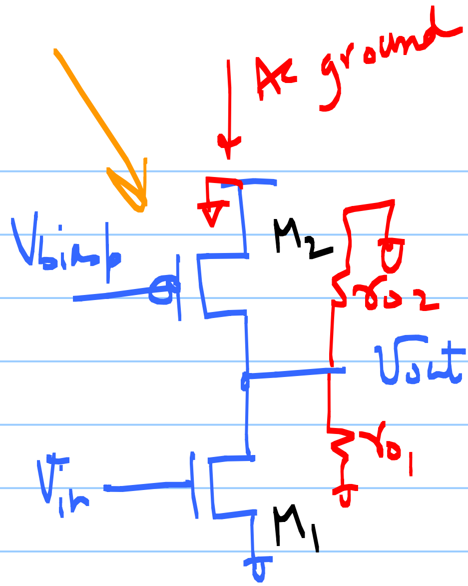
ECE 511 - Lecture 11

Note Title 2/29/2012

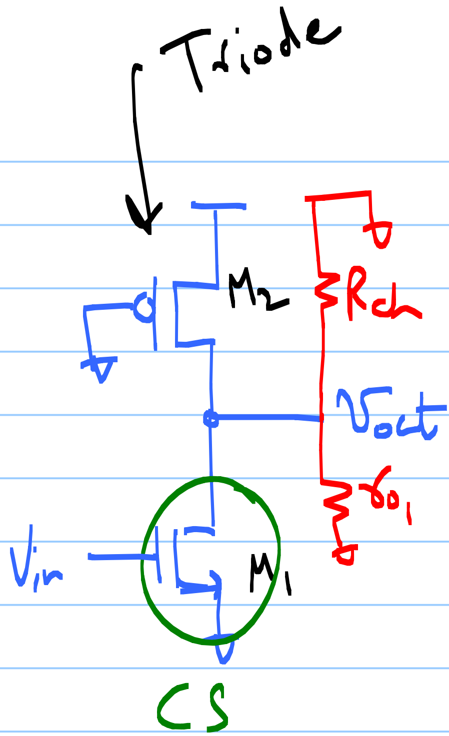






small-signal

$$\text{Ac gain} = -g_{m1} \cdot (r_{o1} \| r_{o2})$$



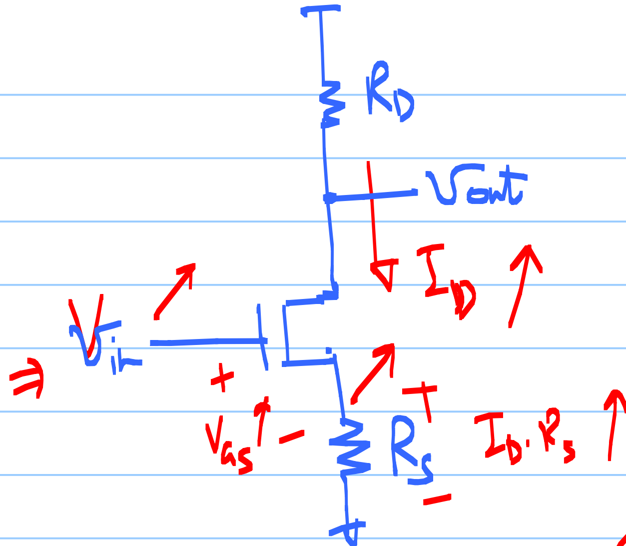
$$A_v = -g_{m1} \cdot r_{o1} \| R_{CH} \simeq -g_{m1} \cdot R_{CH}$$

"low-gain"

$$R_{CH} = \frac{1}{KP_p \frac{W}{L} (V_{SG} - V_{THN})}$$

$V_{SD} \ll V_{OD}$

CS → Source Degeneration



−ve feedback
↳ keeps V_{GS} somewhat constant.
↳ a portion of V_{in} is dropped across R_S

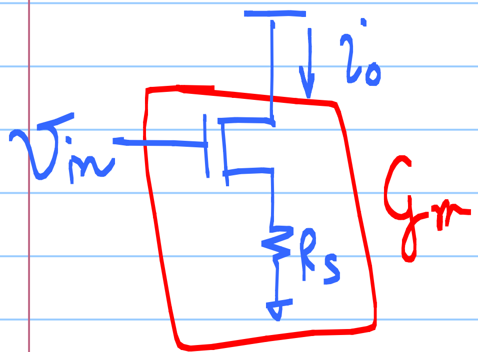
$$I_D = \frac{V_{in} - V_{GS}}{R_S}$$

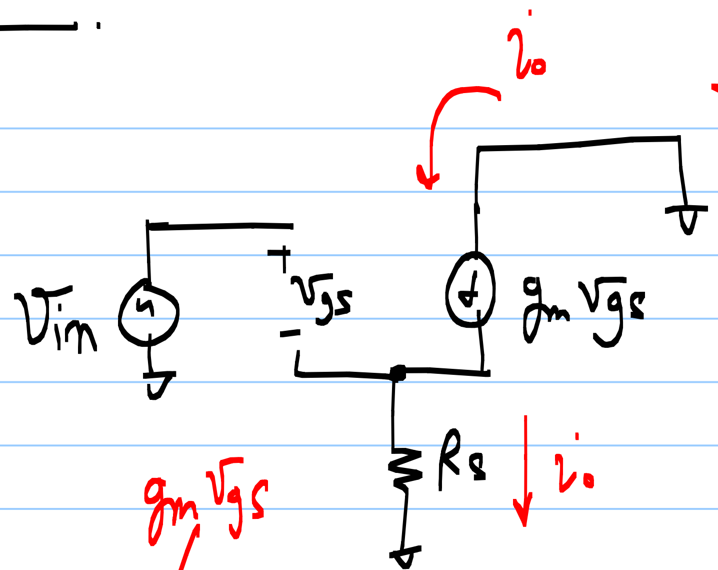
$$\propto \frac{V_{in}}{R_S}$$

I_D has linear dependence on V_{in}

Small-signal Analysis

$\lambda = 0, \; g_{mb} = 0$





$g_m v_{gs}$

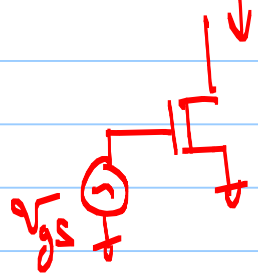
$$v_{gs} = v_{in} - i_o R_s$$

$$\Rightarrow \quad i_o = g_m v_{gs} = g_m (v_{in} - i_o R_s)$$

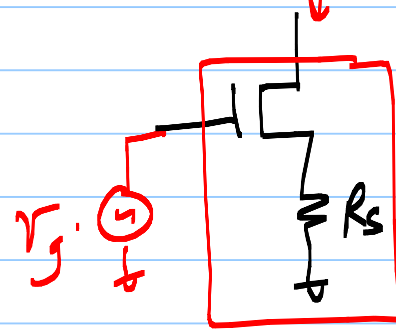
$$\Rightarrow \quad i_o (1 + g_m R_s) = g_m v_{in}$$

$$\Rightarrow \quad \frac{i_o}{v_{in}} = \boxed{\frac{g_m}{1 + g_m R_s} = G_m}$$

$i_o = \underline{\underline{g_m v_{gs}}}$



$i_o = G_m v_g$



$$G_m = \frac{g_m}{1 + g_m R_s}$$

$$= \frac{1}{\frac{1}{g_m} + R_s}$$

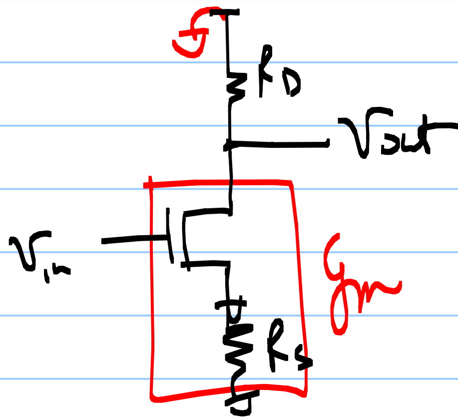
$$\simeq \boxed{\frac{1}{R_s}}$$

linear

for $\frac{1}{g_m} \ll R_s$

* $R_S \uparrow \nearrow$ $R_S >> \frac{1}{g_m} \Rightarrow$ G_m becomes a weak function of g_m

$\Rightarrow$ drain current (i_o) is a linearized function of v_{in}

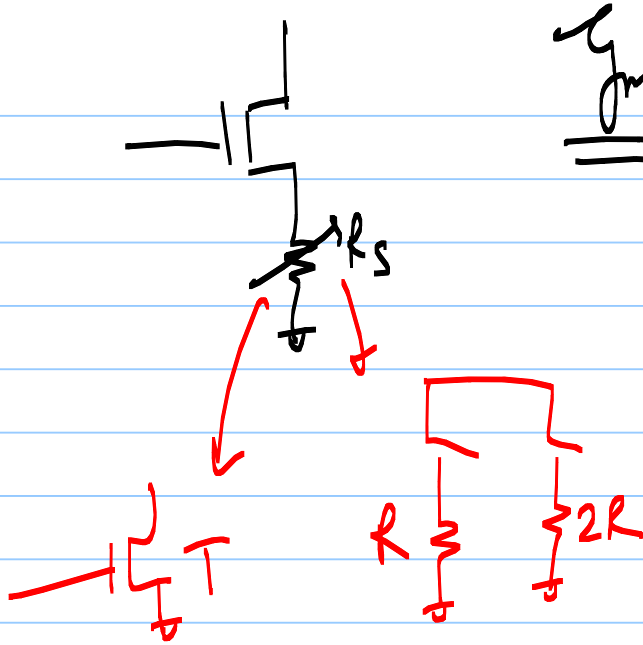


$$A_v = -G_m R_D$$

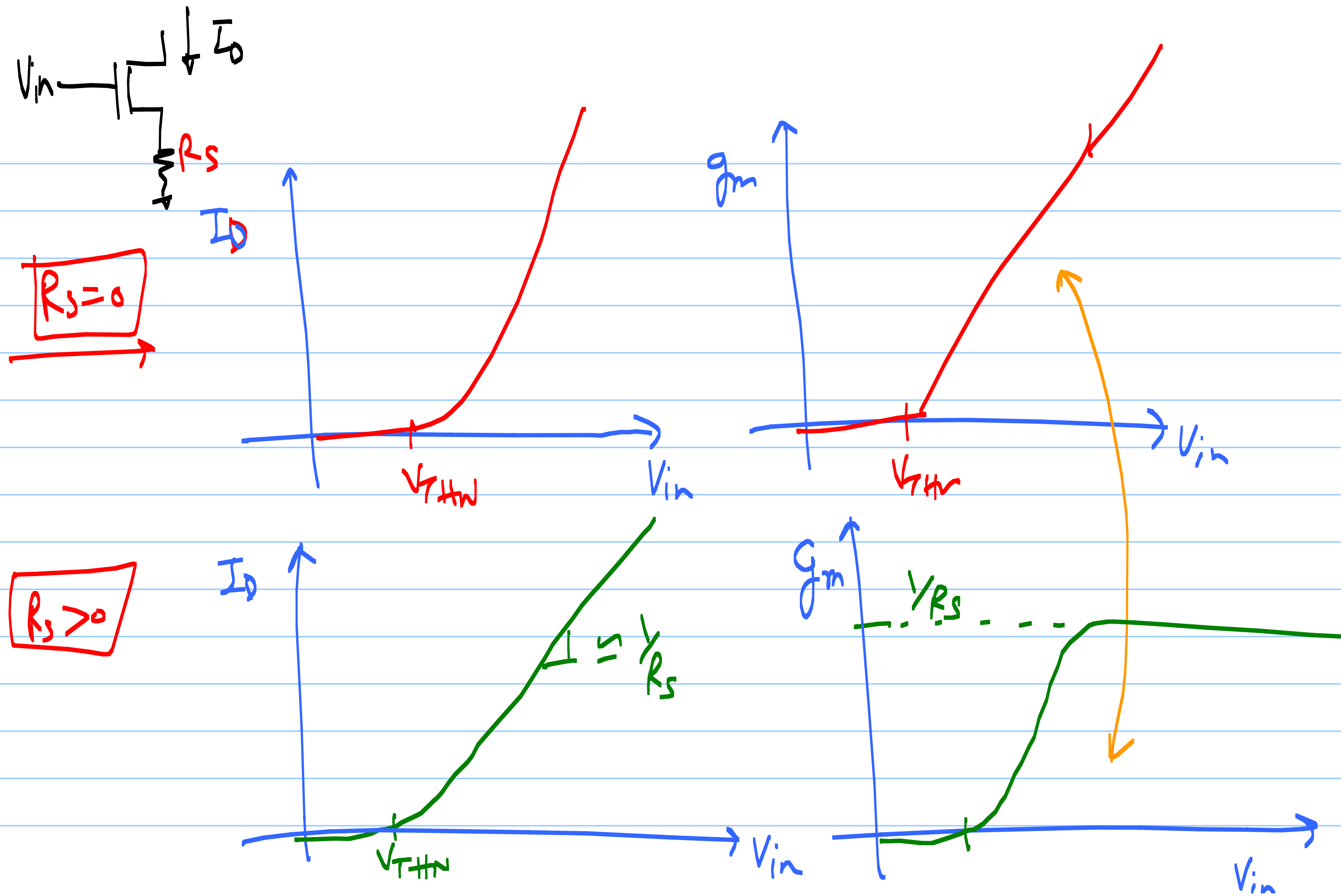
$$= -\frac{g_m R_D}{1+g_m R_s}$$

$\Leftarrow$ lower small-signal gain

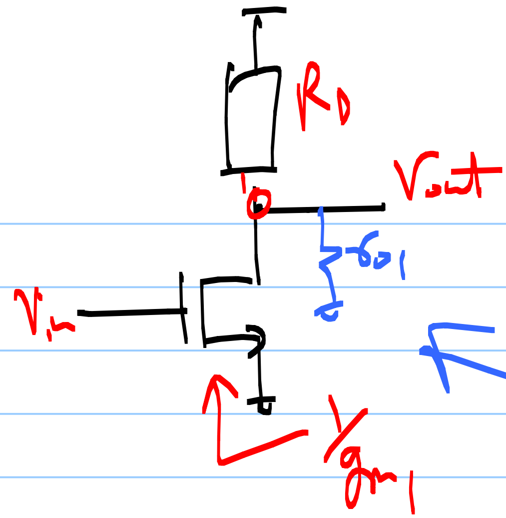
"VGA"



$$g_m \simeq \frac{1}{R_s}$$


V_{in}
I_D
R_S
$R_S = 0$
$R_S > 0$
I_D
V_{THN}
V_{in}
g_m
V_{THN}
V_{in}
$\simeq 1/R_S$
g_m
$1/R_S$
V_{in}
V_{THN}
V_{in}

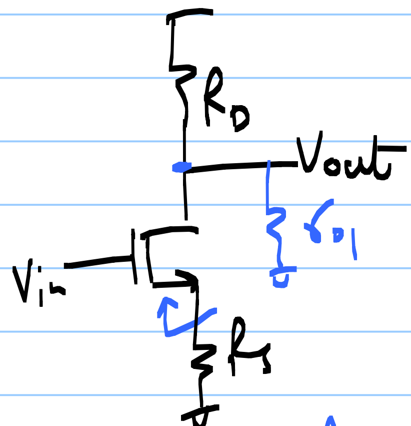
Pg 659



$$A_v = -\frac{\text{Resistance seen in the drain}}{\text{Resistance seen in the source path}}$$

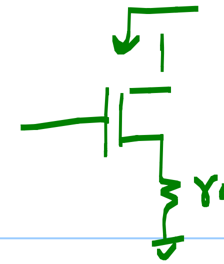
$$= -\frac{R_D \,||\, r_{o1}}{1/g_{m1}}$$

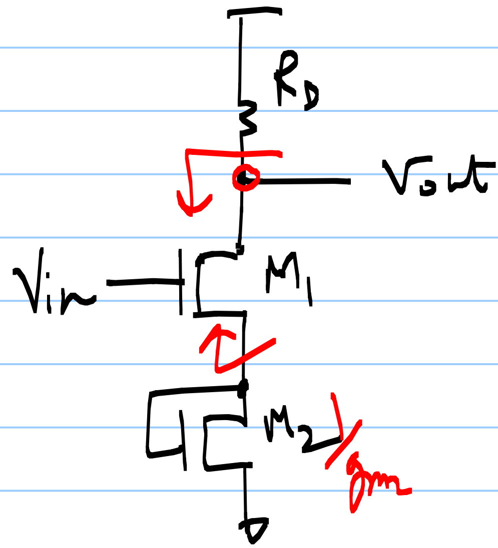
$$= -g_{m1}(R_D \,||\, r_{o1})$$



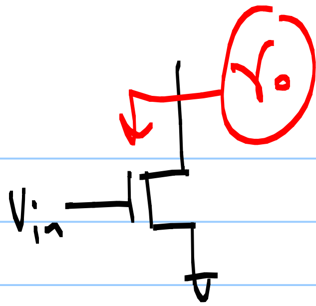
$$A_v = -\frac{(R_D \,||\, r_{o1})}{R_s + 1/g_m}$$

Ex.

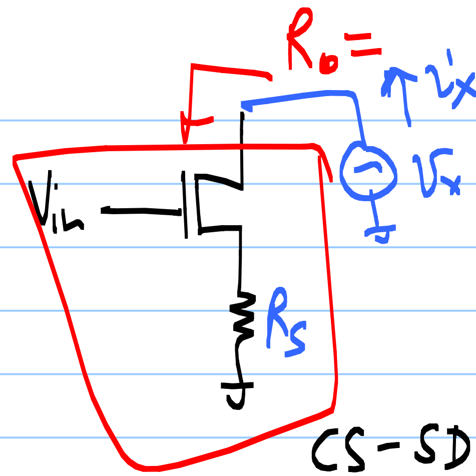




$$A_v = -\frac{R_D \,\|\, \left(g_{m1} r_{o1} \cdot \frac{1}{g_{m2}}\right)}{\frac{1}{g_{m2}} + \frac{1}{g_{m1}}}$$



CS



CS-SD

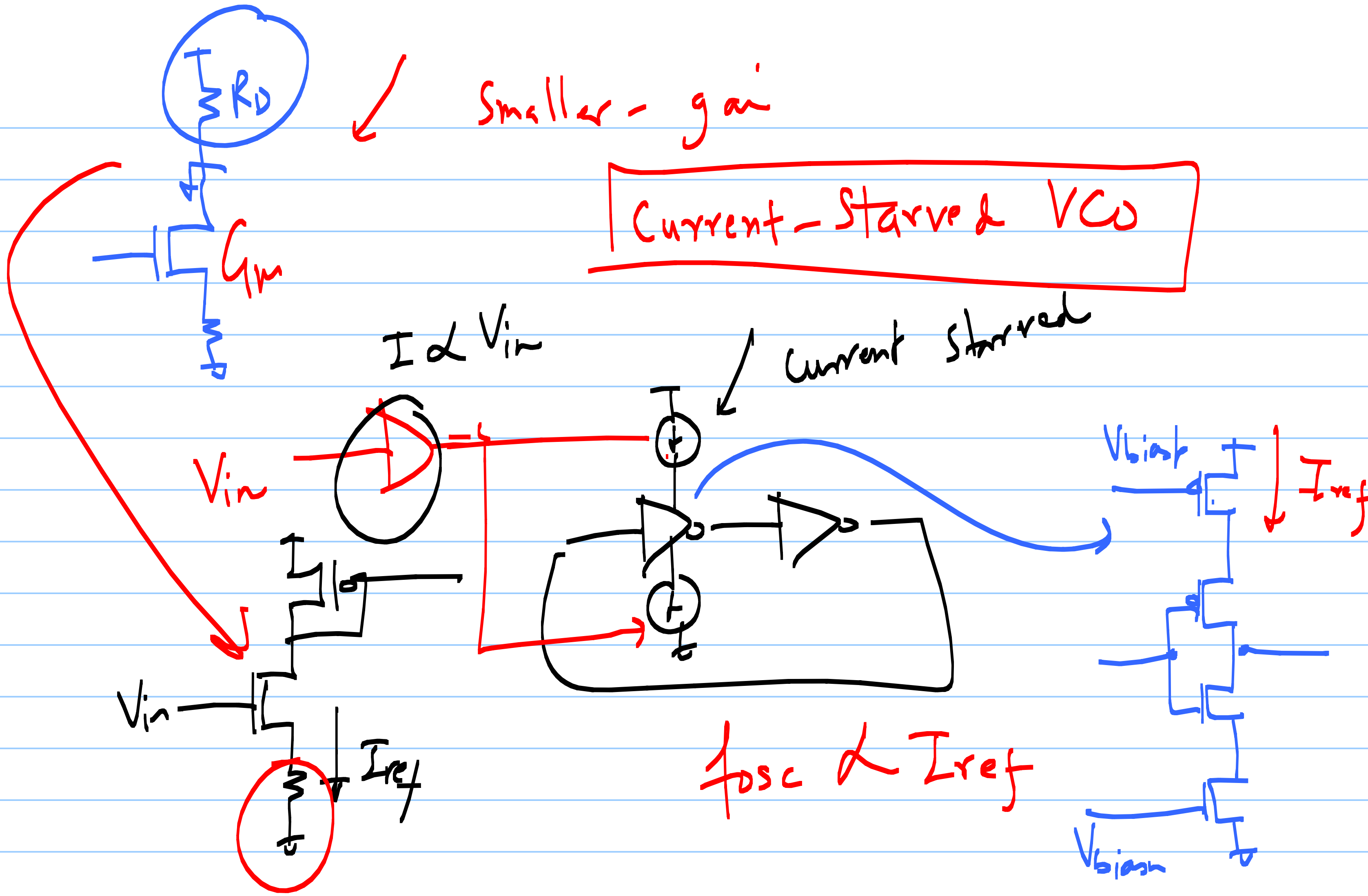
exact expression

$$R_o = \left[1 + (g_m + g_{mb}) R_s\right] r_o$$

$$\simeq g_m R_s r_o = (g_m r_o) R_s \gg r_o$$

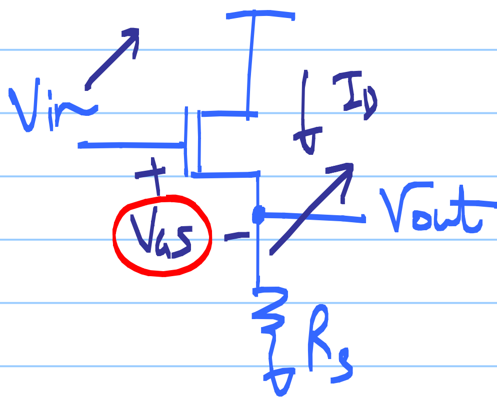
$\boxed{\text{Current-Starved VCO}}$

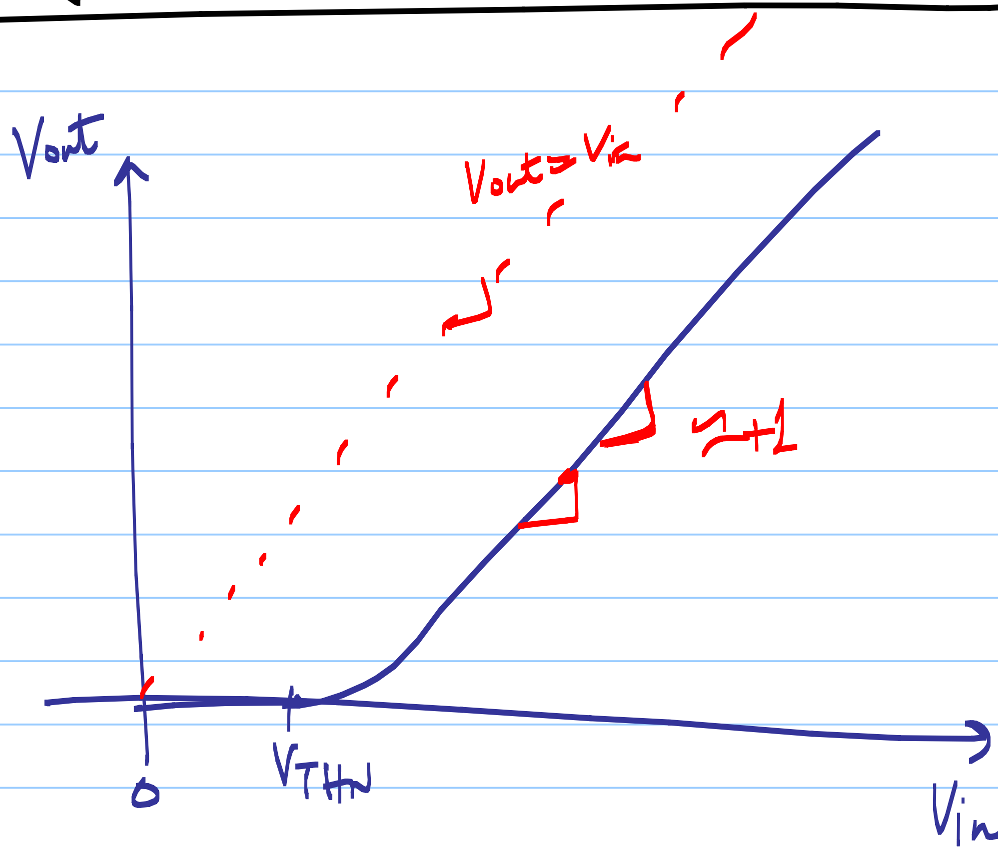
Smaller gai

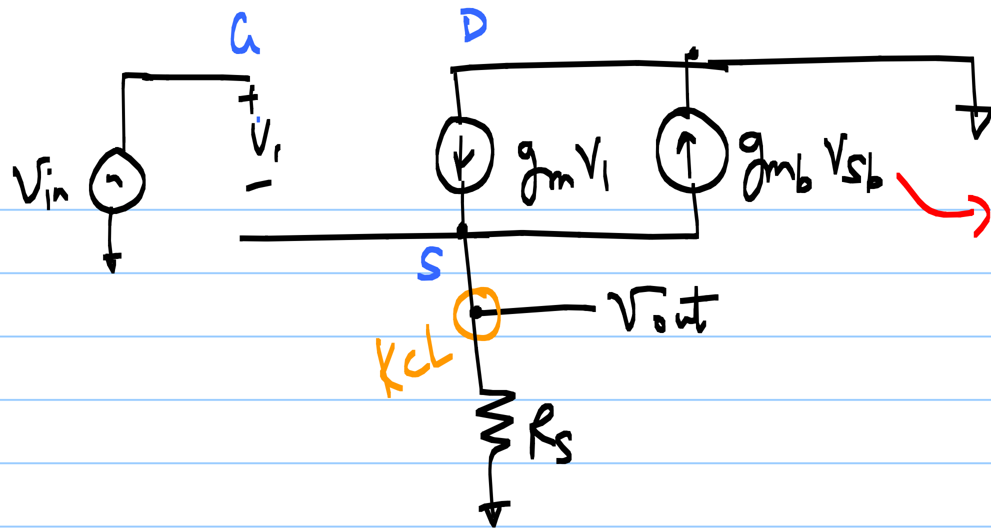


$f_{osc} \propto I_{ref}$

Source Follower (Common Drain Amplifier)







$V_{sb} = V_{out}$

$$V_{in} - V_1 = V_{out} \longrightarrow (1)$$

$$g_m V_1 - g_{mb} V_{out} = \frac{V_{out}}{R_s} \longrightarrow (2)$$

$$V_{out}\left[(g_m + g_{mb}) + \frac{1}{R_s}\right] = g_m V_{in}$$

$$\Rightarrow \quad A_v = \frac{v_{out}}{v_{in}} = \frac{g_m R_S}{1 + (g_m + g_{mb}) R_S}$$

$g_{mb} = \eta \cdot g_m$

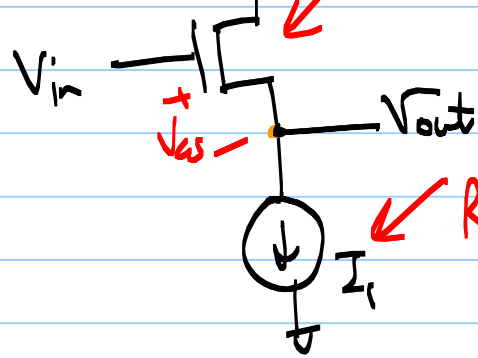
$$= \frac{g_m R_S}{1 + (\eta + 1)\, g_m R_S}$$

$$= \frac{1}{(\eta + 1) + \left(\frac{1}{g_m R_S}\right)} \simeq \boxed{\frac{1}{\eta + 1}} < 1$$

$g_m R_S \gg 1$

$(g_{m1} r_o)$

biasing this device



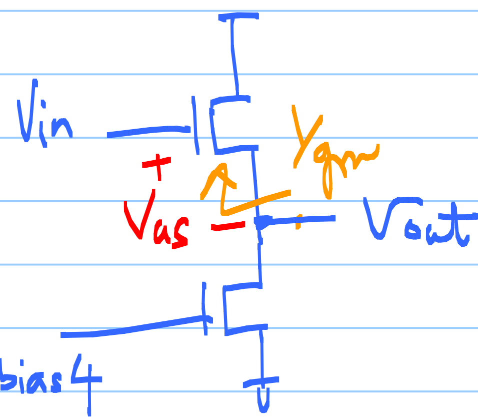
R_S large

for $R_S \to \infty$

$$A \simeq \frac{1}{\eta + 1} \simeq 0.8$$

η ← body factor

$$\eta = \frac{g_{mb}}{g_m}$$



is level-shifted down by V_{GS}

$V_{biasn} = V_{bias4}$