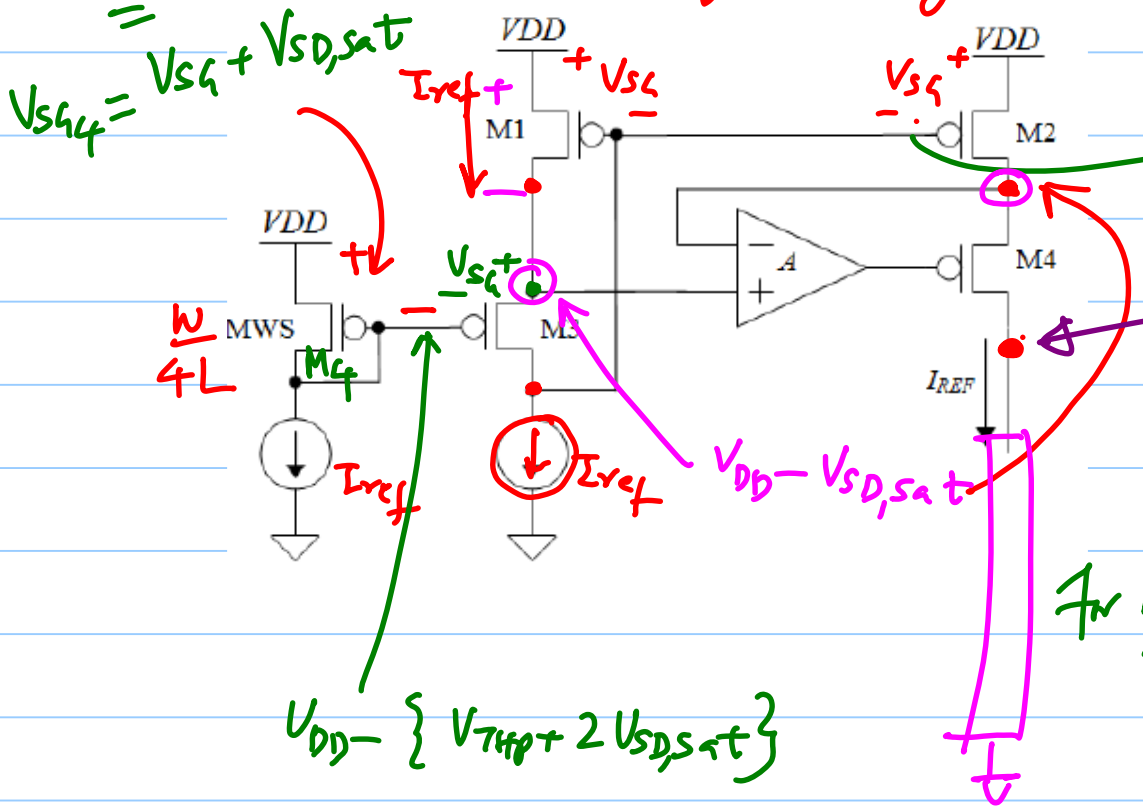
ECE 511 – Lecture 13

Note Title 3/4/2014

"Wide Swing Biasing"

$R_o \leq g_{mp} r_{op}^2 \cdot A$

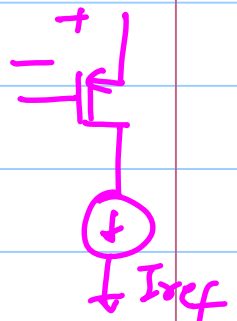
$V_{SG4} = V_{SG} + V_{SD,sat}$

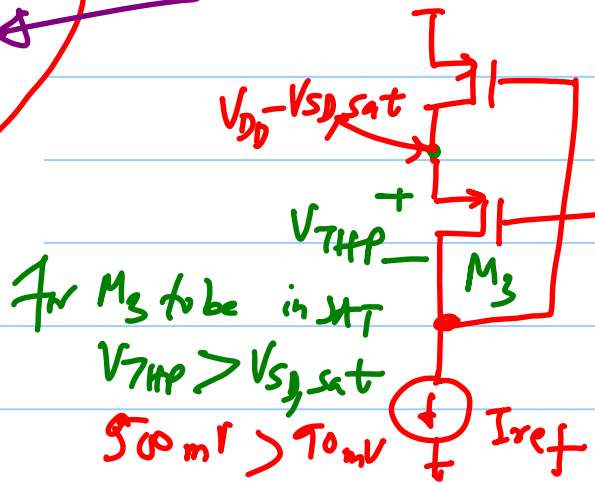


$V_{DD} - (V_{SD,sat} + V_{THP})$

$V_o \leq V_{DD} - 2V_{SD,sat}$

$V_{DD} - \{V_{THP} + 2V_{SD,sat}\}$



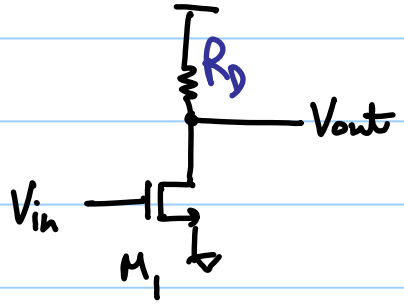


For M_3 to be in ST

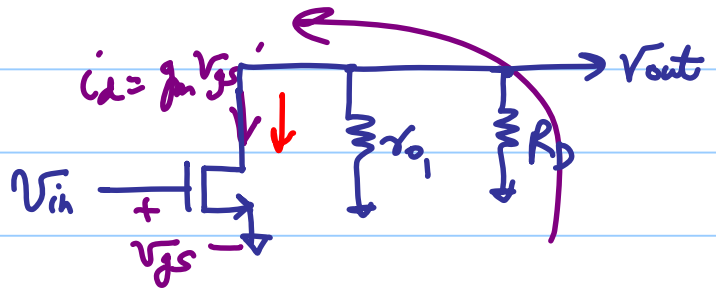
$V_{THP} > V_{SD,sat}$

500 mV > 70 mV

$$\text{Irrig} \neq \frac{2}{\beta R^2}\left(1-\frac{1}{\sqrt{k}}\right)^2$$



AC



$$v_{out} = -i_d (r_{o1} \| R_D)$$

$i_d = g_m v_{in}$

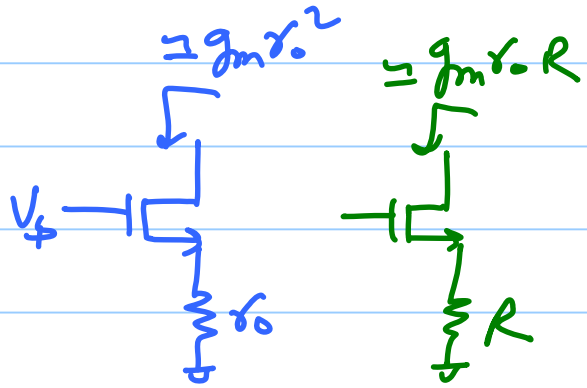
$$\Rightarrow \boxed{A_v = \frac{v_{out}}{v_{in}} = -g_m (r_{o1} \| R_D)}$$

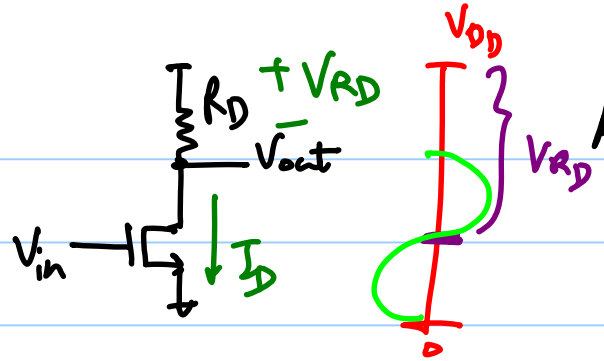
$\hookrightarrow -g_m R_D$ for $r_o \gg R_D$

$$R_D = g_{m_2} r_{o_2} R$$

$$A_v = -g_{m_1}\left(r_{o_1} \| g_{m_2} r_{o_2} R\right)$$

$\gamma = 0$





$r_o >> R_D$

$$A_v = -g_m R_D$$

$$= -\sqrt{2 K_{Pn} \frac{W}{L} I_D} \cdot R_D$$

$$= -\sqrt{2 K_{Pn} \frac{W}{L} I_D} \cdot \frac{V_{RD}}{I_D}$$

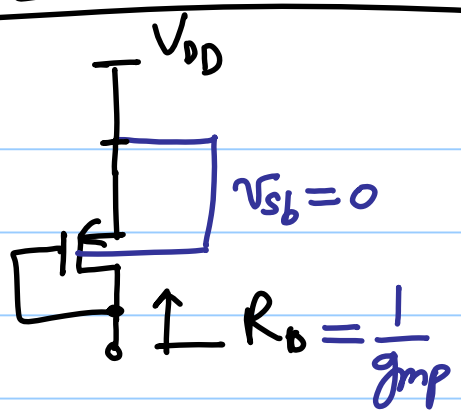
$$= -\sqrt{2 K_{Pn} \frac{W}{L}} \cdot \frac{V_{RD}}{\sqrt{I_D}}$$

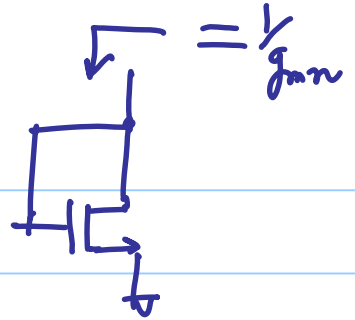
How to increase $|A_v|$ ↑ ??

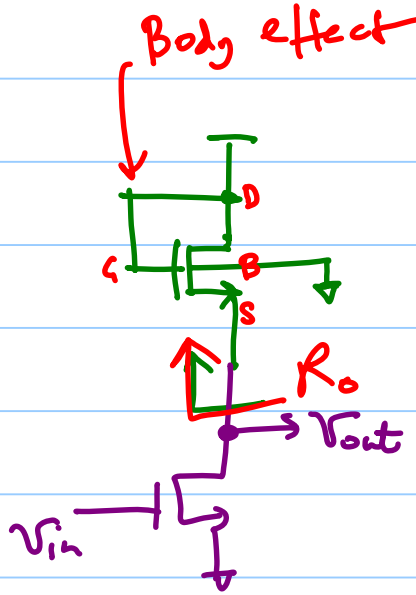
- $\frac{W}{L}$ ↑ → large device cap
- V_{RD} ↑ → less swing
- I_D ↓ ⇒ lower speed

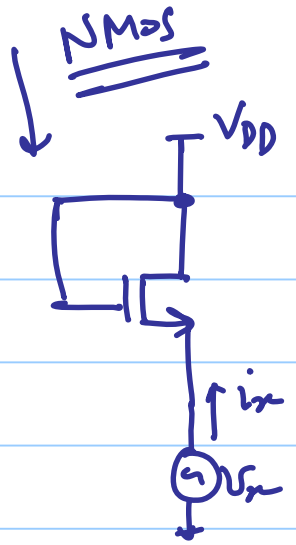
decouple R_D from V_{RD}

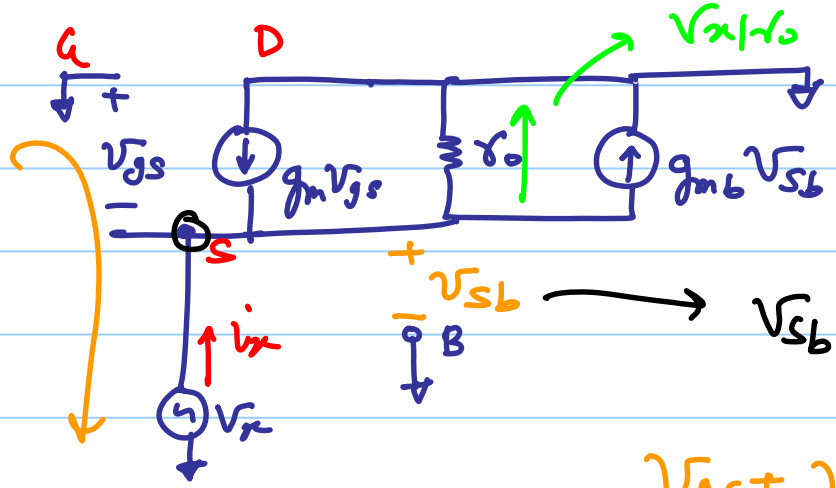
Diode Connected Loads











$V_{gs} + V_x = 0$

$\Rightarrow V_{gs} = -V_x$ → (1)

KCL:

$$i_x + g_m V_{gs} - g_{mb} V_{sb} - \frac{V_x}{r_o} = 0$$

$$i_x - g_m V_x - g_{mb} V_x - \frac{V_x}{r_o} = 0$$

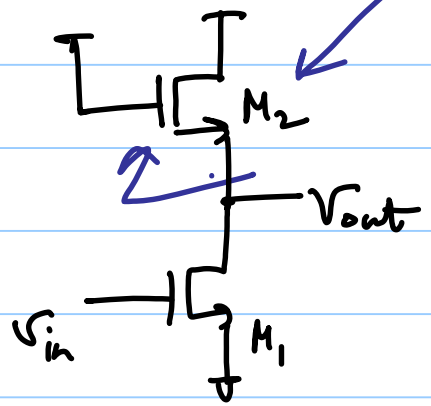
$$i_x = V_x \left[(g_m + g_{mb}) + \frac{1}{r_o} \right]$$

$$\Rightarrow R_x = \frac{V_x}{i_x} = \frac{1}{(g_m + g_{mb}) + r_o^{-1}}$$

if $g_m \gg \frac{1}{r_o}$

$$\simeq \frac{1}{(g_m + g_{mb})} \qquad g_{mb} = \eta\, g_m$$

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



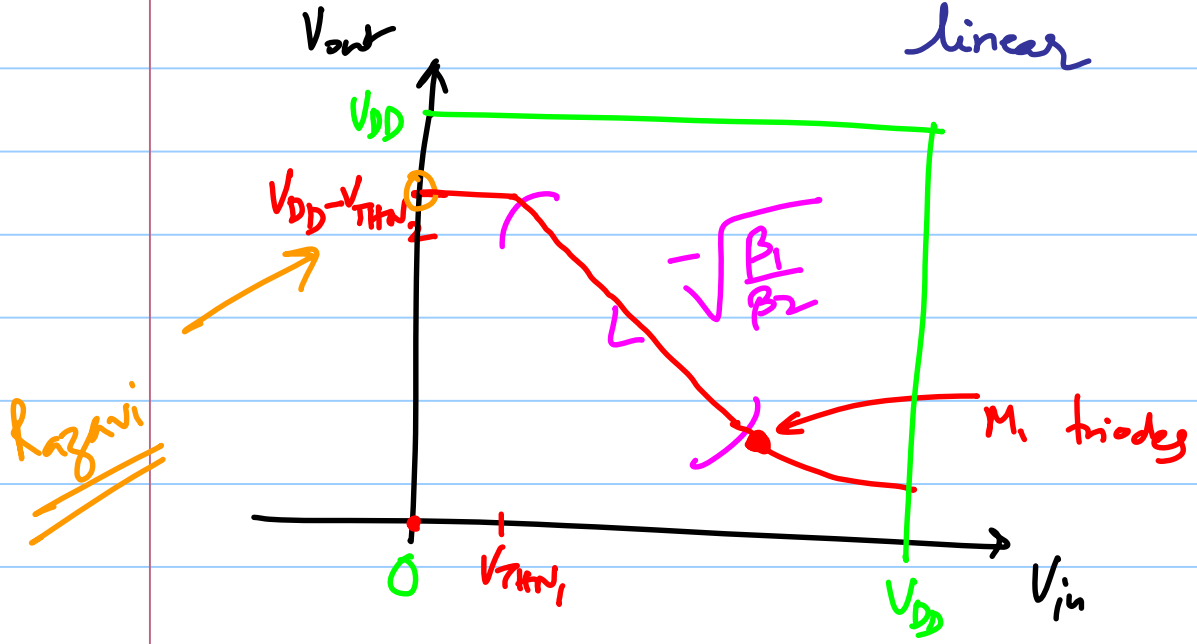
$$A_v = -g_{m_1}\cdot\left\{r_{o_1} \,//\, \left(\frac{1}{g_{m_2}(\eta+1)}\right)\right\}$$

$$\simeq -\frac{g_{m_1}}{g_{m_2}}\cdot\frac{1}{(\eta+1)} \qquad r_{o_1} \gg \frac{1}{g_m}$$

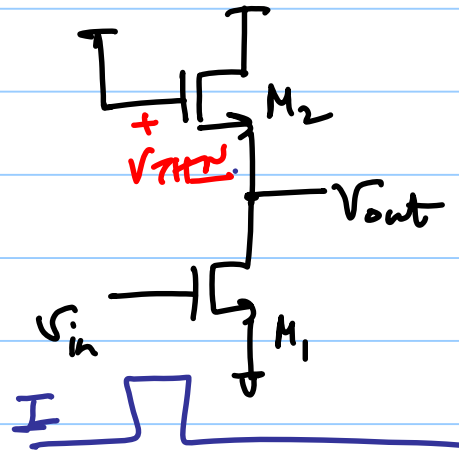
$$\Rightarrow A_v = -\sqrt{\frac{(W/L)_1}{(W/L)_2}}\cdot\frac{1}{(\eta+1)} \qquad \because g_m = \sqrt{2\beta I_D}$$

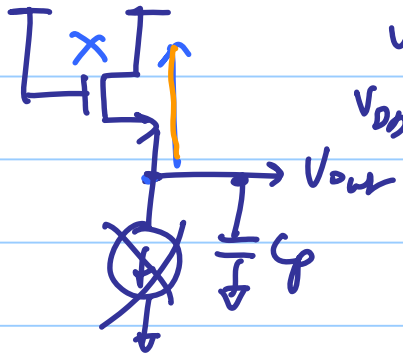
* Low small-signal gain

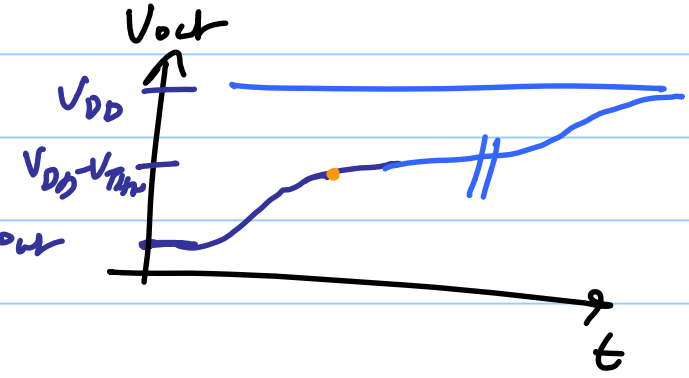
* Input/output characteristic is relatively linear

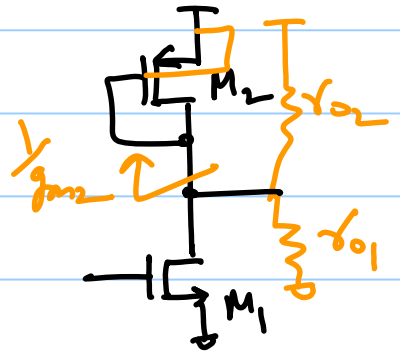


Ragavi







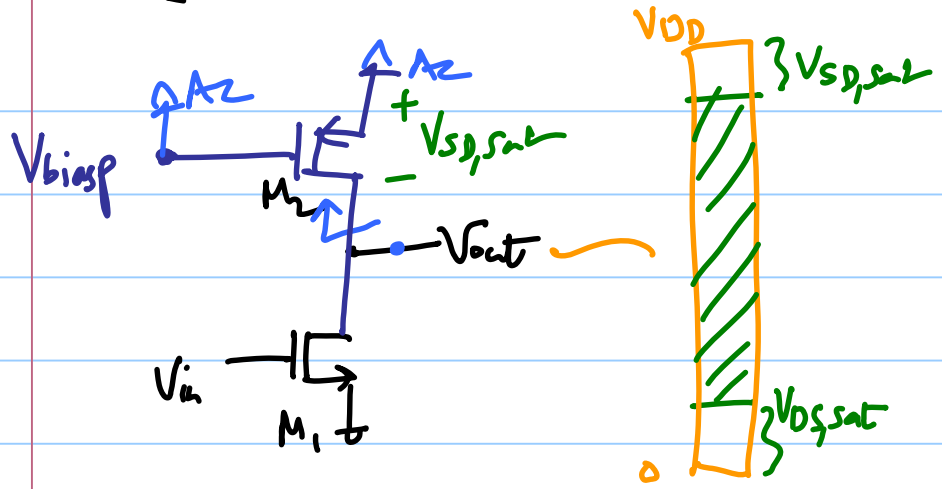


$$A_V \simeq -g_{m1}\left(r_{o1} \| r_{o2} \| \frac{1}{g_{m2}}\right)$$

$$\simeq -\frac{g_{m1}}{g_{m2}}$$

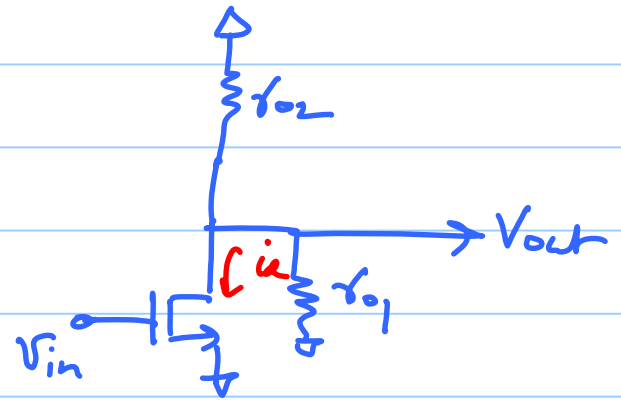
if r_o's are large

CS stage with current-source load



* Large o/p swing
* Large gain

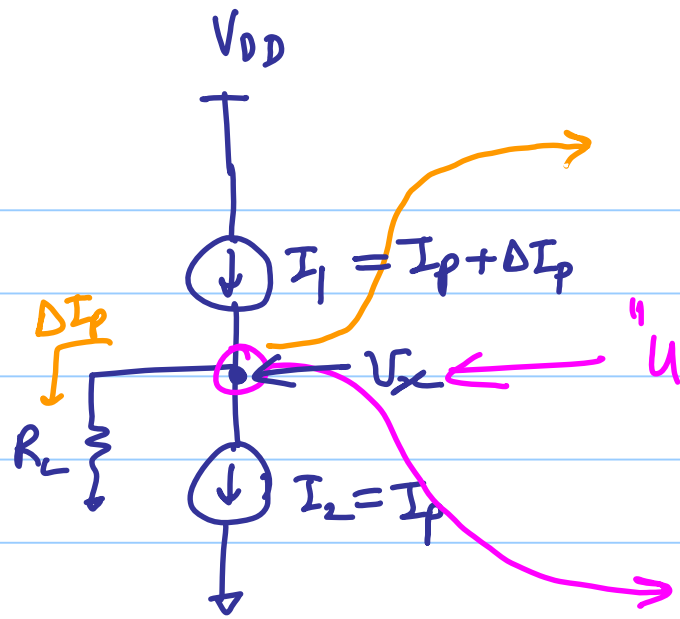
Δz picture



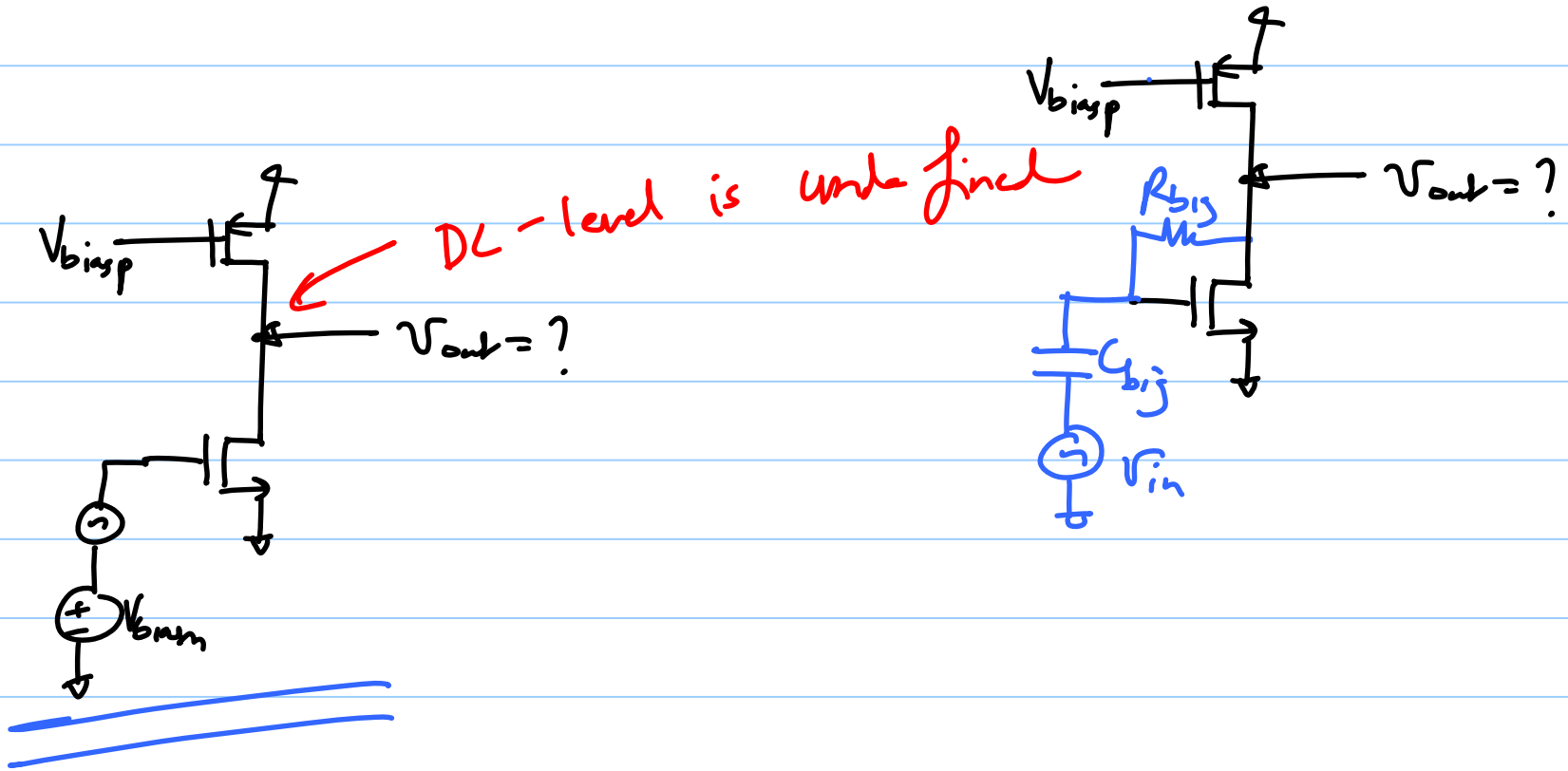
$$V_{out} = -(g_m v_{in})(r_{o1} \| r_{o2})$$

$$\Rightarrow \boxed{A_v = -g_m(r_{o1} \| r_{o2})}$$

$$\simeq -g_m \frac{r_o}{2}$$



"Undefined in a practical circuit"


V_{biasp}
$V_{out} = ?$
DC-level is undefined
V_{bmsm}
R_{big}
C_{big}
V_{in}