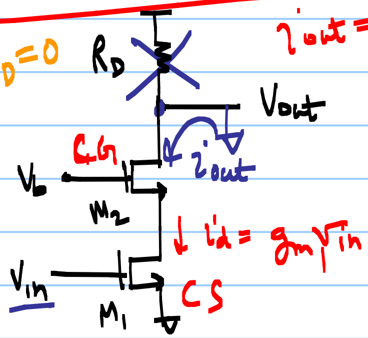
ECE 511- Lecture 13

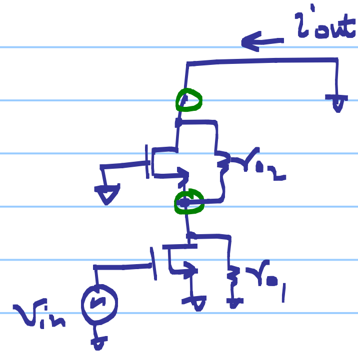
Note Title 3/5/2013

Find SC G_m

$R_D = 0$ $\quad i_{out} = g_{m1} v_{in}$



$$\boxed{G_m \triangleq g_{m1}}$$



$$A_v = -G_m \cdot R_{out}$$

$$G_m = \frac{g_{m1} r_{o1}\left[r_{o2}\left(g_{m2} + \cancel{g_{mb2}}\right) + 1\right]}{r_{o1} \cdot r_{o2}\left(g_{m2} + \cancel{g_{mb2}}\right) + r_{o1} + r_{o2}}$$

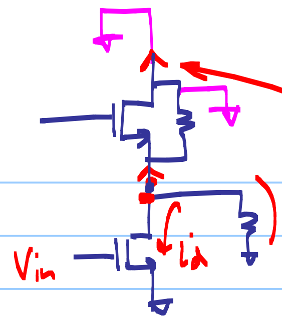
$$g_{m2} r_{o2} \gg 1$$

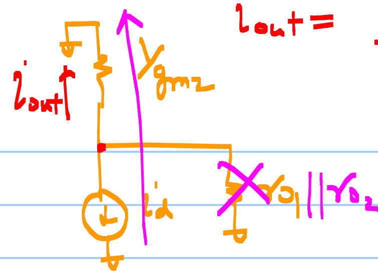
$$= \frac{g_{m1} r_{o1}\left[\frac{g_{m2} r_{o2} + 1}{g_{m2} r_{o2}}\right] \to 1}{r_{o1} + \frac{r_{o1} + r_{o2}}{g_{m2} r_{o2}} \to 0}$$

$$\simeq g_{m1}$$

CASCODE AMPLIFIER

$$r_{o1} \gg \frac{r_{o1} + r_{o2}}{g_{m2} r_{o2}}$$



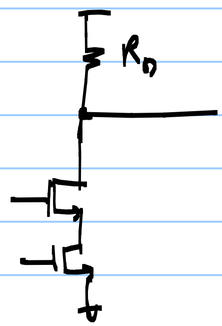


$i_{out} = \dfrac{i_d \cdot r_{o1}}{r_{o1} + 1/g_{m2}}$

$r_{o1} \| r_{o2} = \dfrac{(g_{m2} r_{o1})}{(g_m r_{o1} + 1)} \cdot i_d$

$g_m = g_{m1}$ $\qquad g_{m2} r_{o1} \gg 1$

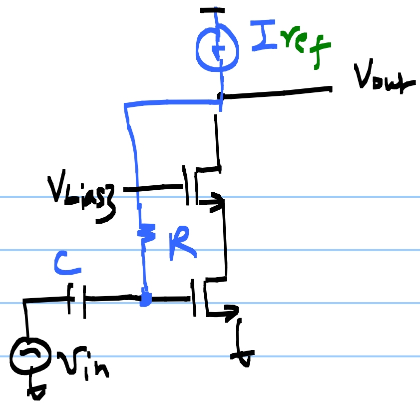
$\hookrightarrow$ CG is a perfect current buffer

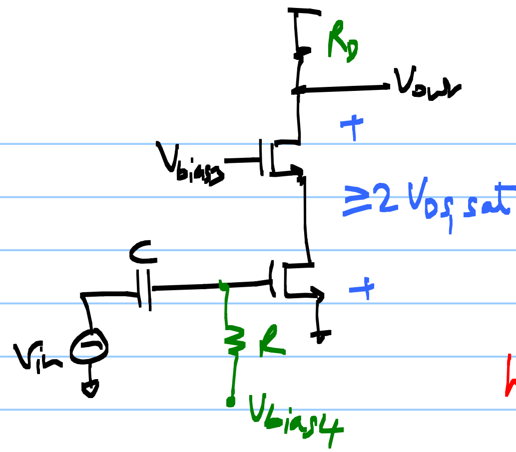


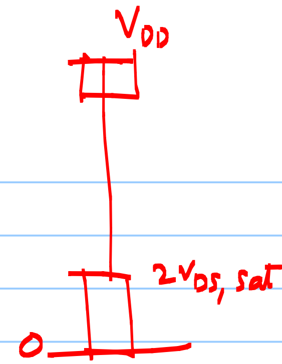
$R_{out} = (g_{m2} r_{o2} \cdot r_{o1}) \| R_D$ $\qquad$ for $R_D \to \infty$

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

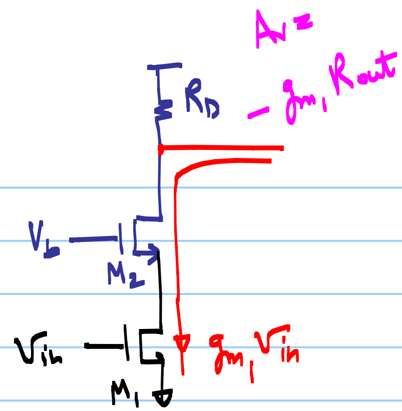
$\simeq -(g_{m1} \cdot r_{o1}) \cdot (g_{m2} r_{o2}) = -(g_m r_o)^2$



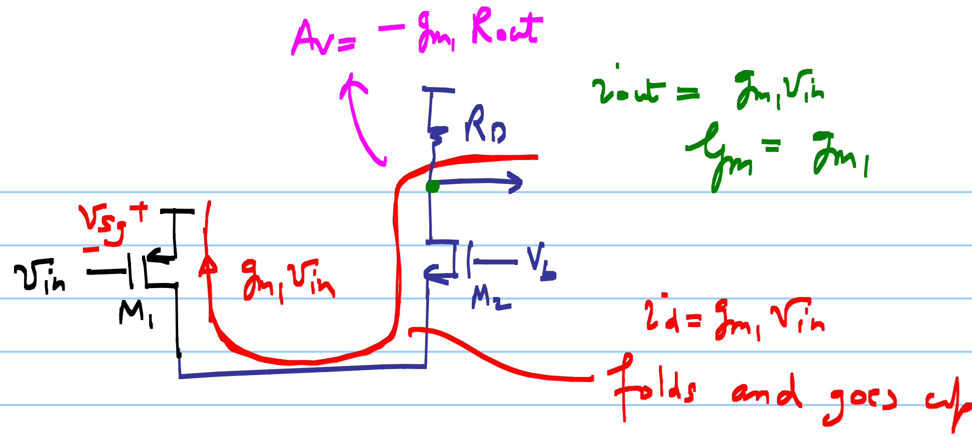




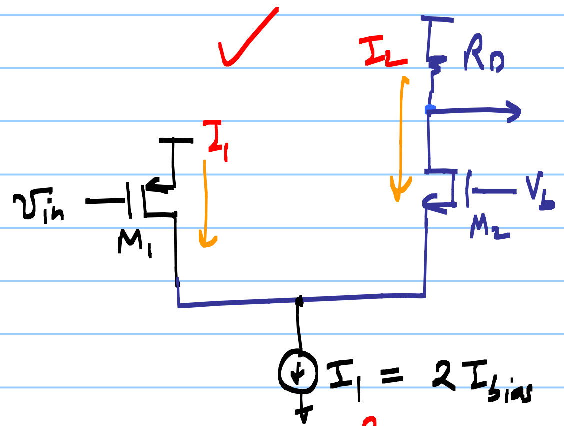
headroom is reduced



NMOS CS



PMOS + NMOS combination performs the same function = Folded Cascode Topology

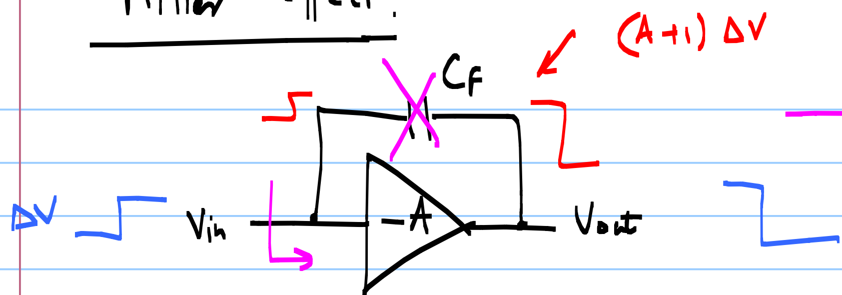


2x current

⇒ more ↑power

* better ↑headroom

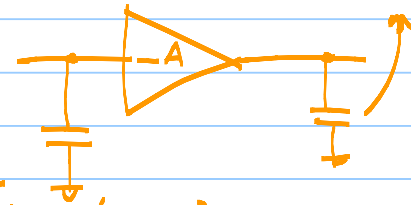
Miller Effect:



$C_{in} = (|A|+1)\, C_F$

$\xrightarrow{\text{Miller Theorem}}$

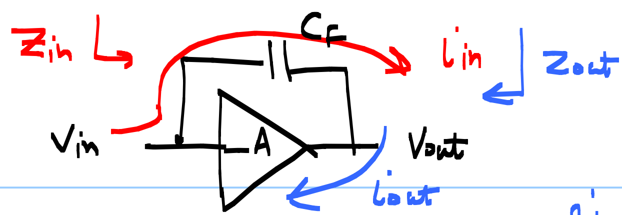
$C_F \simeq C_F\left(1+\frac{1}{|A|}\right)$



$C_{in} = \underbrace{(|A|+1)}_{\text{Cap multiplication}} C_F$

short @ High frequencies

→ zero missed !



$$Z_{in}(s) = \frac{V_{in}}{i_{in}} \qquad V_{out} = -|A|\,V_{in}$$

$$i_{in} = \frac{V_{in} - V_{out}}{1/sC_f}$$

$$= V_{in}\,(1+|A|)\cdot sC_f$$

$$\Rightarrow Z_{in}(s) = \frac{V_{in}}{i_{in}}(s) = \frac{1}{s\boxed{(1+|A|)\,C_f}}$$

$$C_{in} = (1+|A|)\,C_f$$

$$i_{out} = -i_{in}$$

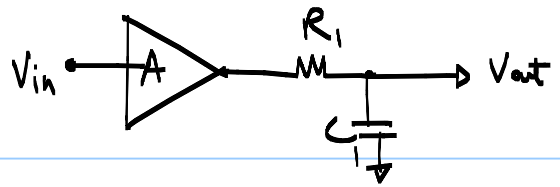
$$= -sC_f\,(V_{in} - V_{out})$$

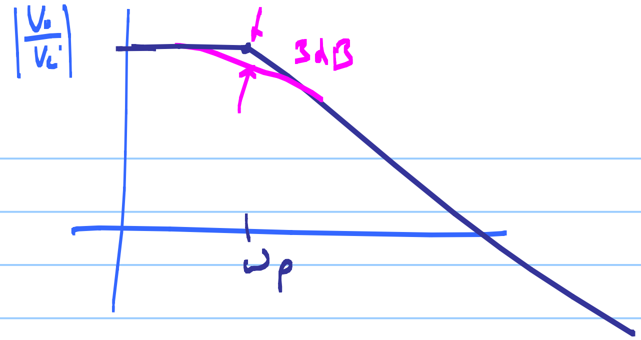
$$= -sC_f\left(-\frac{V_{out}}{|A|} - V_{out}\right)$$

$$Z_{out} = \frac{V_{out}}{i_{out}} = \frac{1}{sC_f\left(1+\frac{1}{|A|}\right)}$$

$$C_{out} = C_f\left(1+\frac{1}{|A|}\right)$$

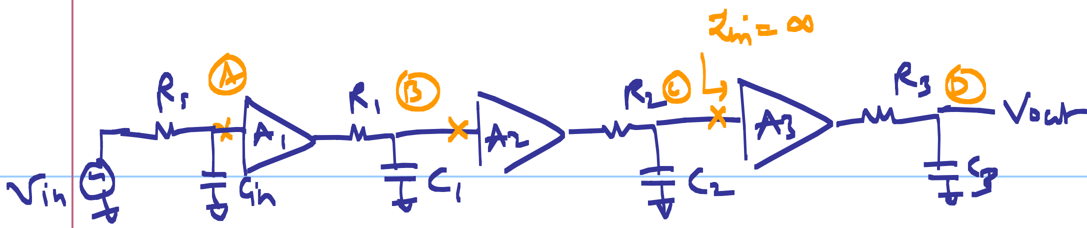
QED





$$\frac{V_{out}}{V_{in}}(s) = \frac{A}{1 + sR_1C_1} = \frac{A}{1 + s/\omega_p}$$

$$\omega_p = \frac{1}{R_1C_1}$$



$$\frac{V_o}{V_i}(s) = \frac{1}{1+sR_sC_{in}} \cdot \frac{A_1}{1+sR_AC_2} \cdot \frac{A_2}{1+sR_2C_2} \cdot \frac{A_3}{1+sR_3C_3}$$

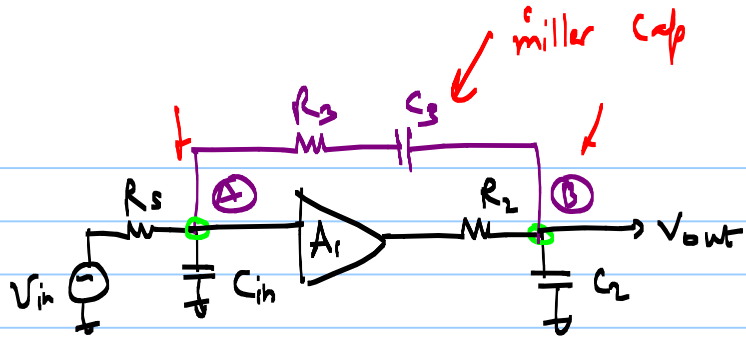
$$= \frac{1}{(1+sR_sC_{in})} \cdot \frac{A^3}{(1+sRC)^3}$$

$BW = f_0$

4 poles → each of the nodes contribute a pole

$$\tau_i = R_i C_i$$

* all the nodes are not interacting with each other



A & B are interacting

In general we can't associate a pole to a node

⇒ All poles are contributed by all the nodes

↳ But, still Miller appx is useful in limited scenarios

Model