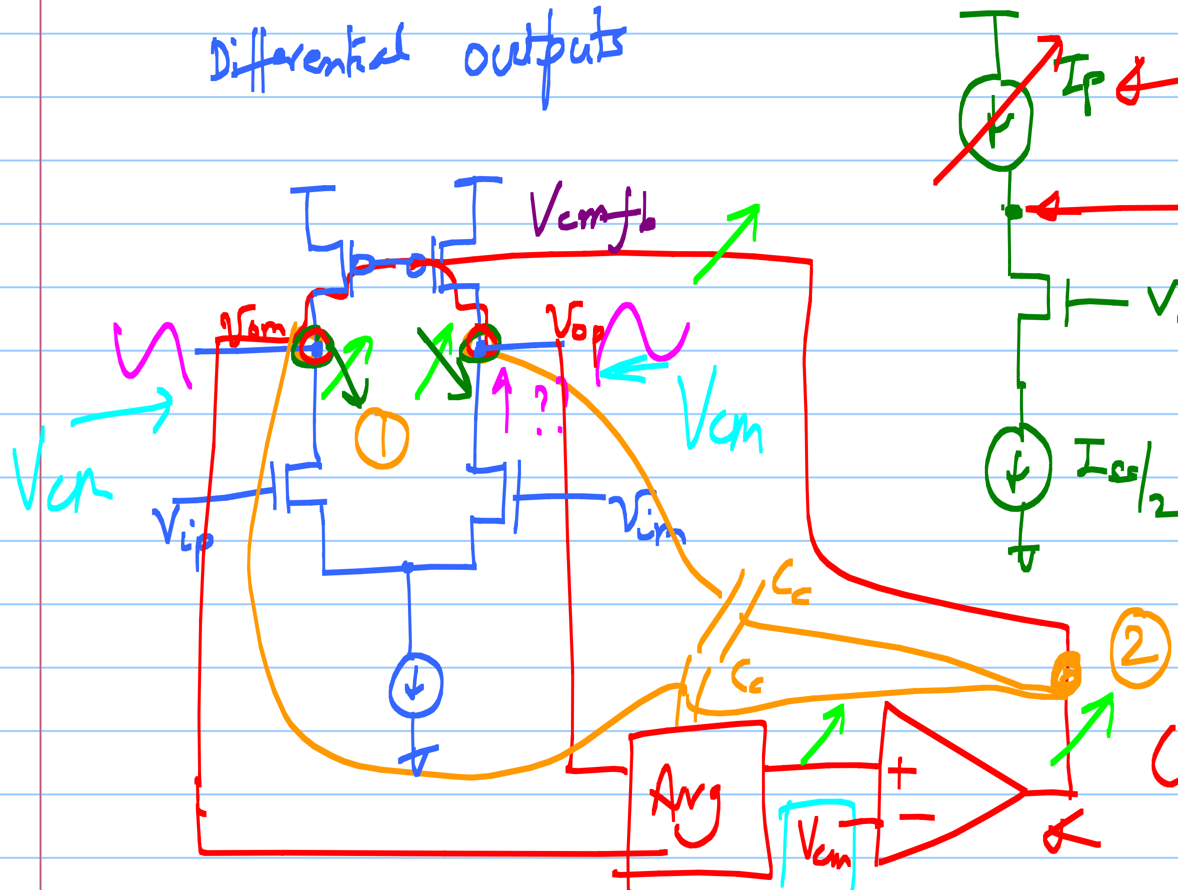
ECE511 - Lecture 19

Note Title 4/9/2012

Differential outputs

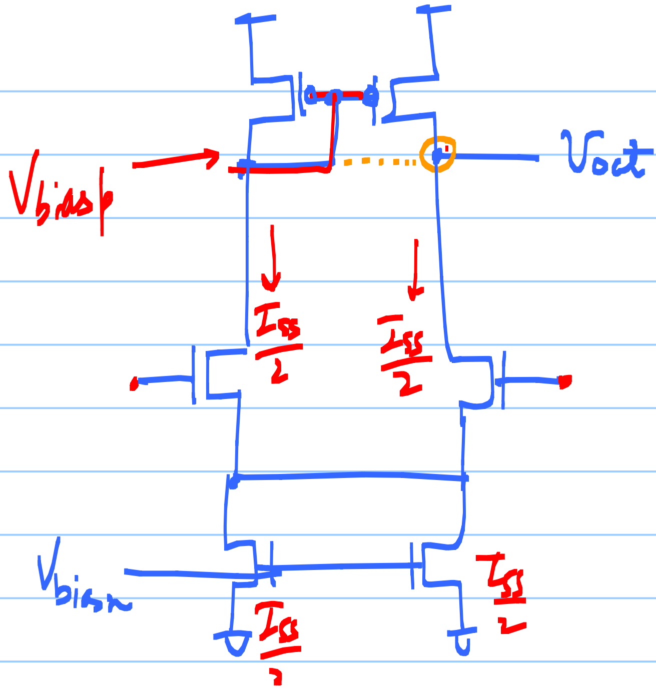


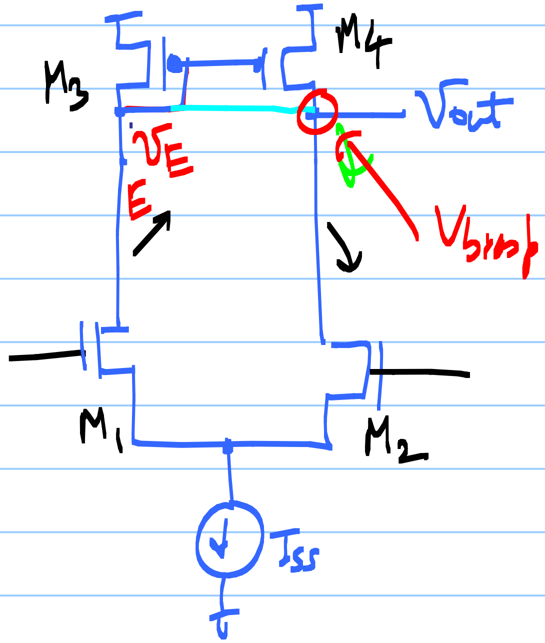
Output CM level is not defined

Common-mode feedback loop (CMFB)

* CMFB loop Compensation

Single-Ended Diff amp (CM load)





Let $V_{out} < V_E$

① $I_{D_1} > I_{D_2}$ → $I_{D_1} > \frac{I_{ss}}{2}$, $I_{D_2} < \frac{I_{ss}}{2}$

$I_{D_3} > \frac{I_{ss}}{2}$

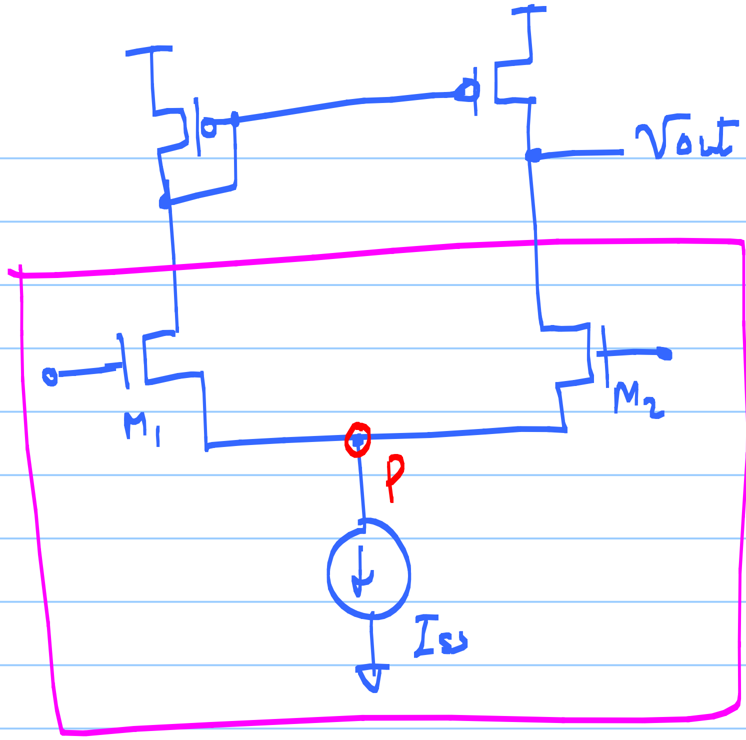
$\Rightarrow I_{D_4} < \frac{I_{ss}}{2}$

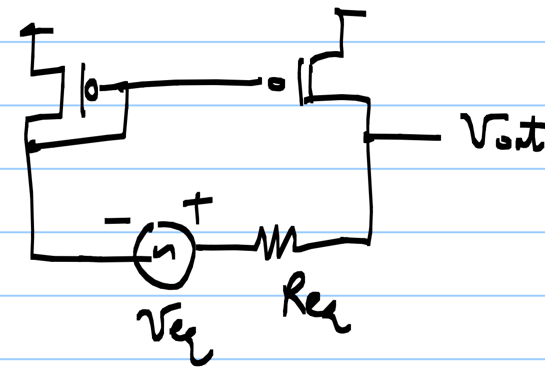
② $I_{D_4} > \frac{I_{ss}}{2}$

$><$ Contradiction

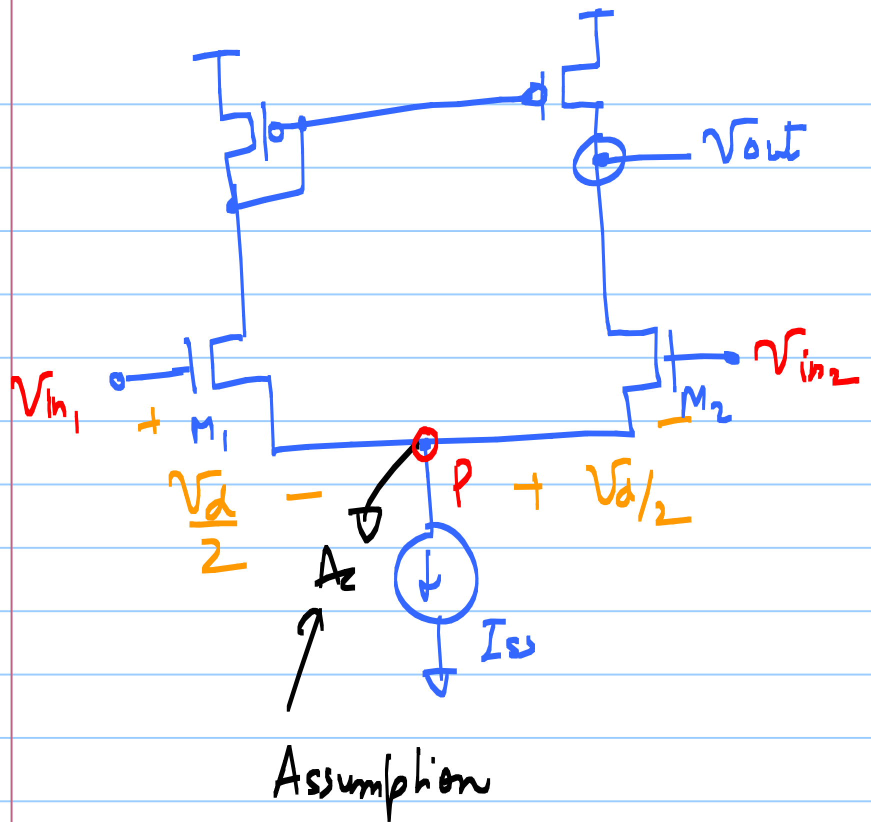
$V_{out} \triangleq V_E = V_{biasp}$

Proof by contradiction



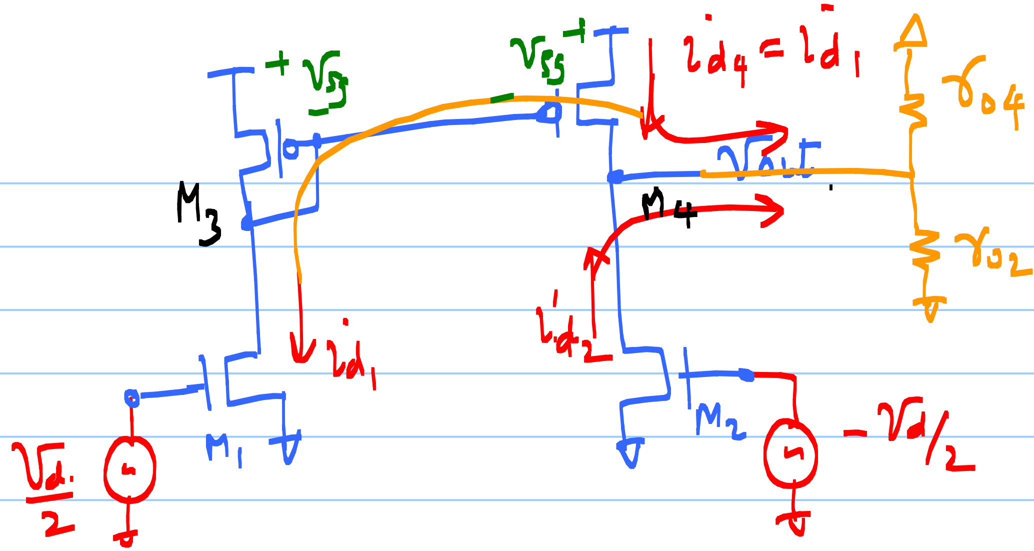


↑ Look at the posted notes online



$V_d = V_{in_1} - V_{in_2}$

AC DM equivalent circuit



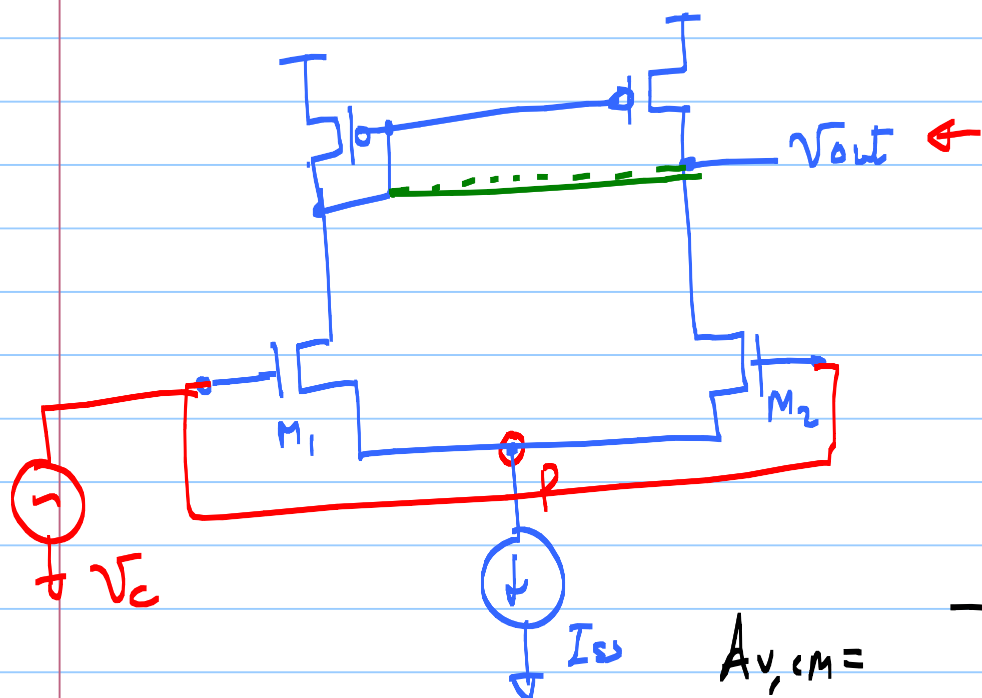
$$v_{out} = + \left(i_{d_2} + i_{d_4}\right)\left(r_{o2} \,||\, r_{o4}\right)$$

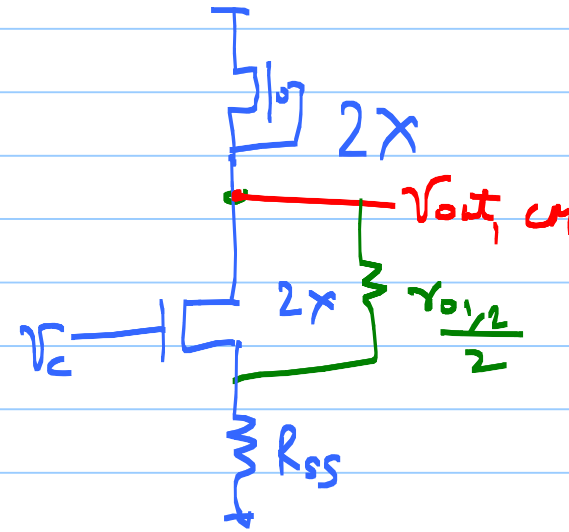
$$= 2\, \underbrace{i_{d_2}}_{g_m \frac{v_d}{2}} \left(r_{o2} \,||\, r_{o4}\right) = \cancel{2} \cdot \frac{g_m}{\cancel{2}} \left(r_{o2} \,||\, r_{o4}\right) v_d$$

$$= \boxed{g_m \left(r_{o2} \,||\, r_{o4}\right) v_d}$$

$$A_{v,DM} = + g_{m_{1/2}} \left(r_{o2} \,||\, r_{o4}\right)$$

Common-mode analysis





CS-SD

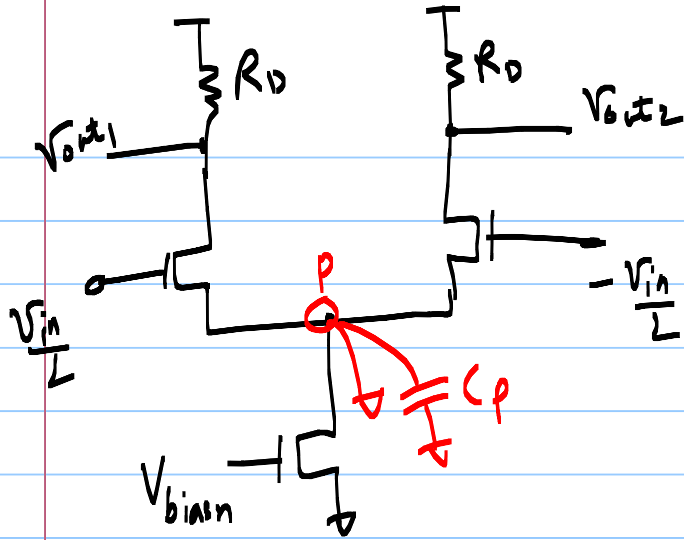
$$A_{v,cm} = \frac{-\dfrac{1}{2g_{m3,4}} \,\Big\|\, \cancel{\dfrac{r_{o3,4}}{2}}}{\dfrac{1}{g_{m1,2}} + R_{SS}}$$

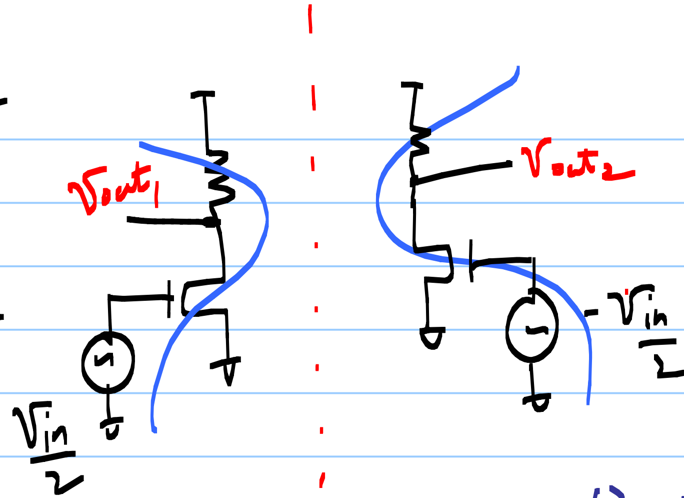
$$A_{v,CM} = \frac{-1}{\cancel{1+} 2\,\cancel{g_{m1,2}} R_{SS}} \cdot \frac{\cancel{g_{m1,2}}}{g_{m3,4}}$$

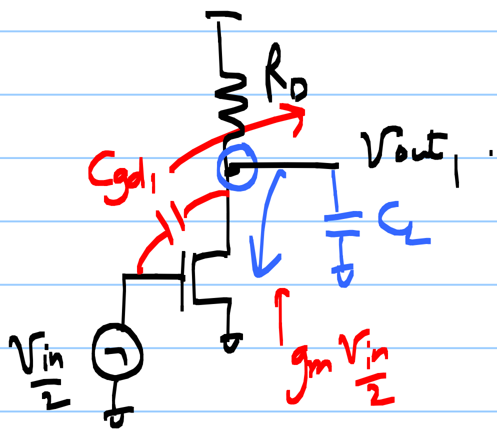
$$\simeq \frac{-1}{2\, g_{m3,4} \cdot R_{SS}}$$

$$CMRR = \left| \frac{A_{v,DM}}{A_{v,CM}} \right| = g_{m1,2}\,(r_{o1,2} \,\|\, r_{o3,4}) \cdot 2\, g_{m3,4} \cdot R_{SS}$$

DM AC Response







1 pole

1 RHP zero

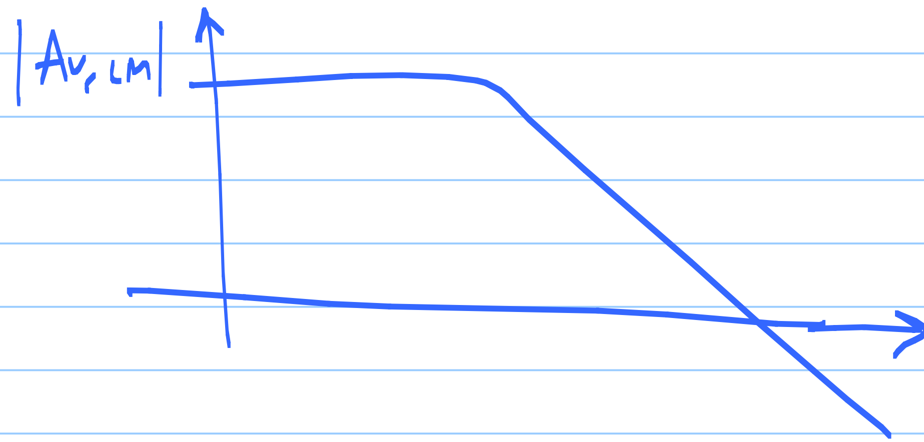
$$\omega_{p_1} = \frac{1}{(r_o || R_D) C_L}$$

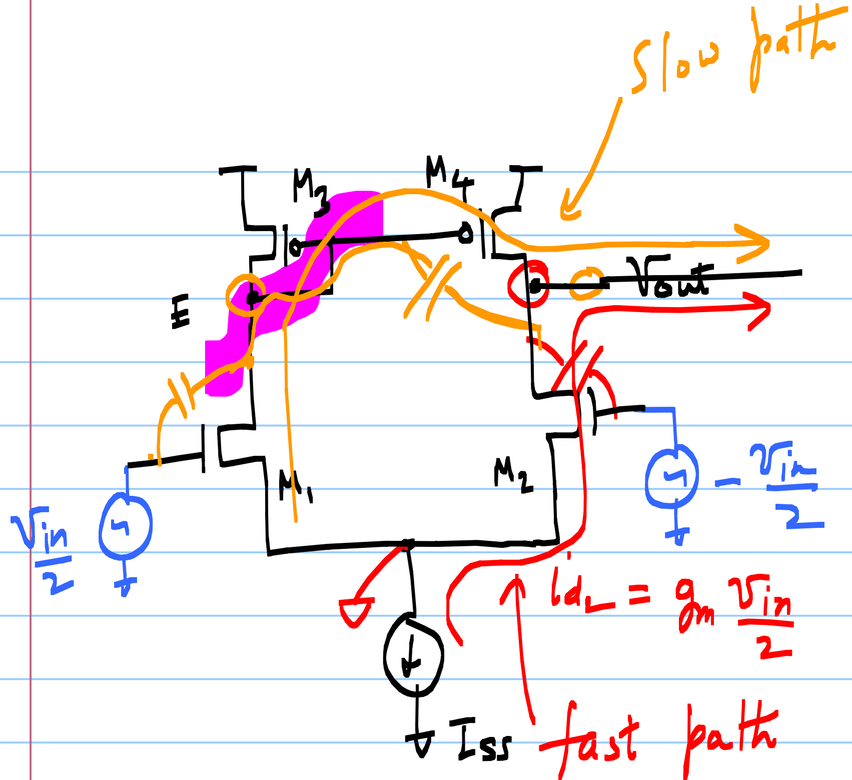
$$\omega_z = + \frac{g_{m1,2}}{C_{gd_{1,2}}}$$

$$\frac{V_{out}}{V_{in}}(s) = -\frac{A_{vo}\left(1 - s/\omega_z\right)}{\left(1 + s/\omega_{p1}\right)}$$

$$A_{v_0} \Rightarrow g_{m1,2}\left(r_{o2} \parallel r_{o4}\right)$$

$$A_{v,cm} = - \frac{\frac{R_D}{2} \parallel \frac{1}{sC_L}}{\frac{1}{2g_{m1,2}} + r_{o3} \parallel \left(\frac{1}{sC_P}\right)}$$

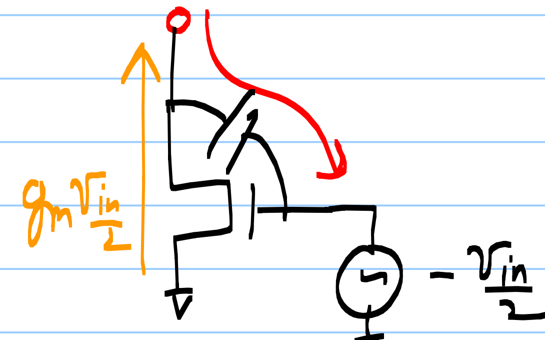




$V_{out} \rightarrow$ Dominant pole

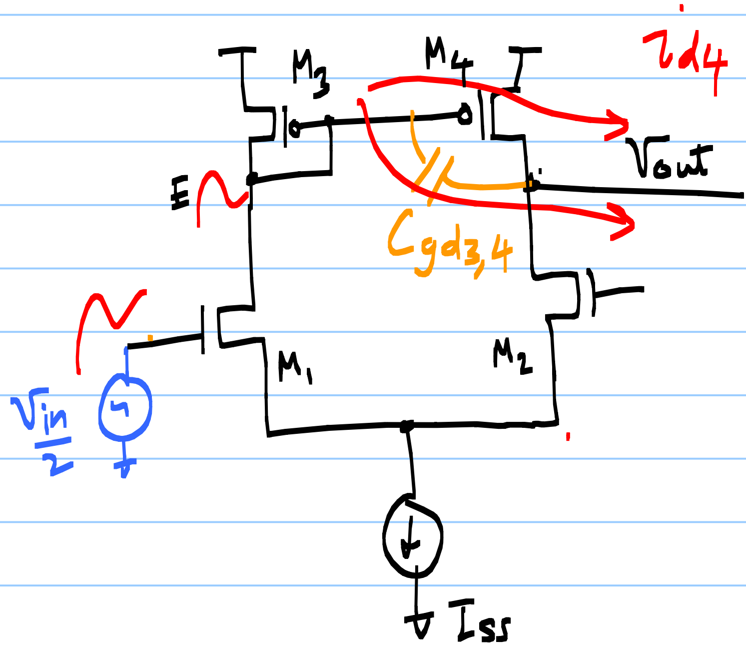
$E \Rightarrow$ Mirror pole

RHP zero



RHP zero

(fast path zero)



LHP zero

$$\frac{g_{m4}}{C_{gd3,4}}$$