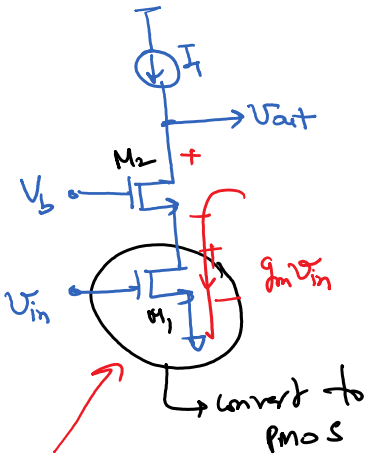
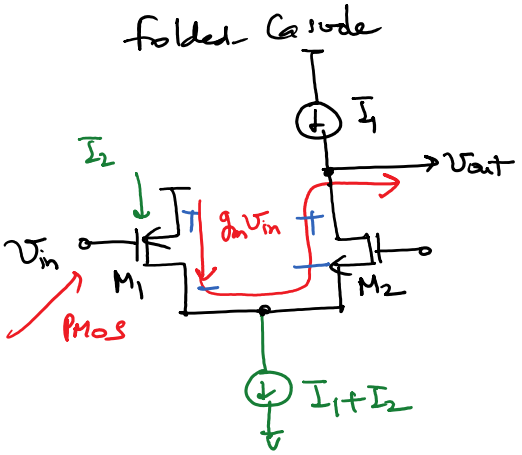
ECE 515- Lecture 23

Thursday, November 15, 2018 11:06 AM

Cascode

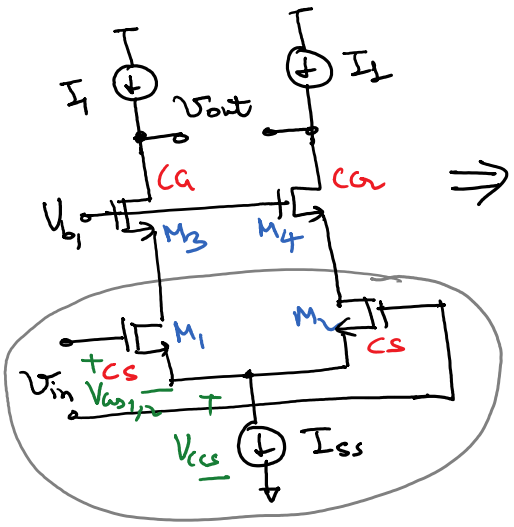


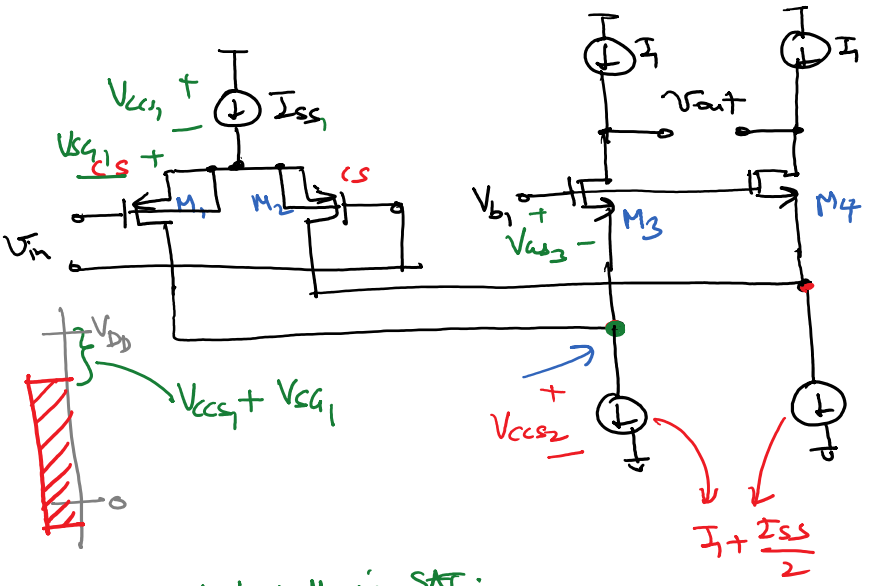
folded Cascode



Small signal current is folded

folded Cascode Diffamp.





$$V_{gs1,2} + V_{css} \leq V_{CM,in} \leq V_{b1} - V_{GS} + V_{TH1}$$

* to keep M_1 in SAT:

$$V_{SD_1} \geq V_{SD,sat} = V_{SG_1} - |V_{THP}|$$

$$\Rightarrow V_S - V_{D_1} \geq V_S - V_{G_1} - |V_{THP}|$$

$$\Rightarrow V_{G_1} \geq V_{D_1} - |V_{THP}|$$

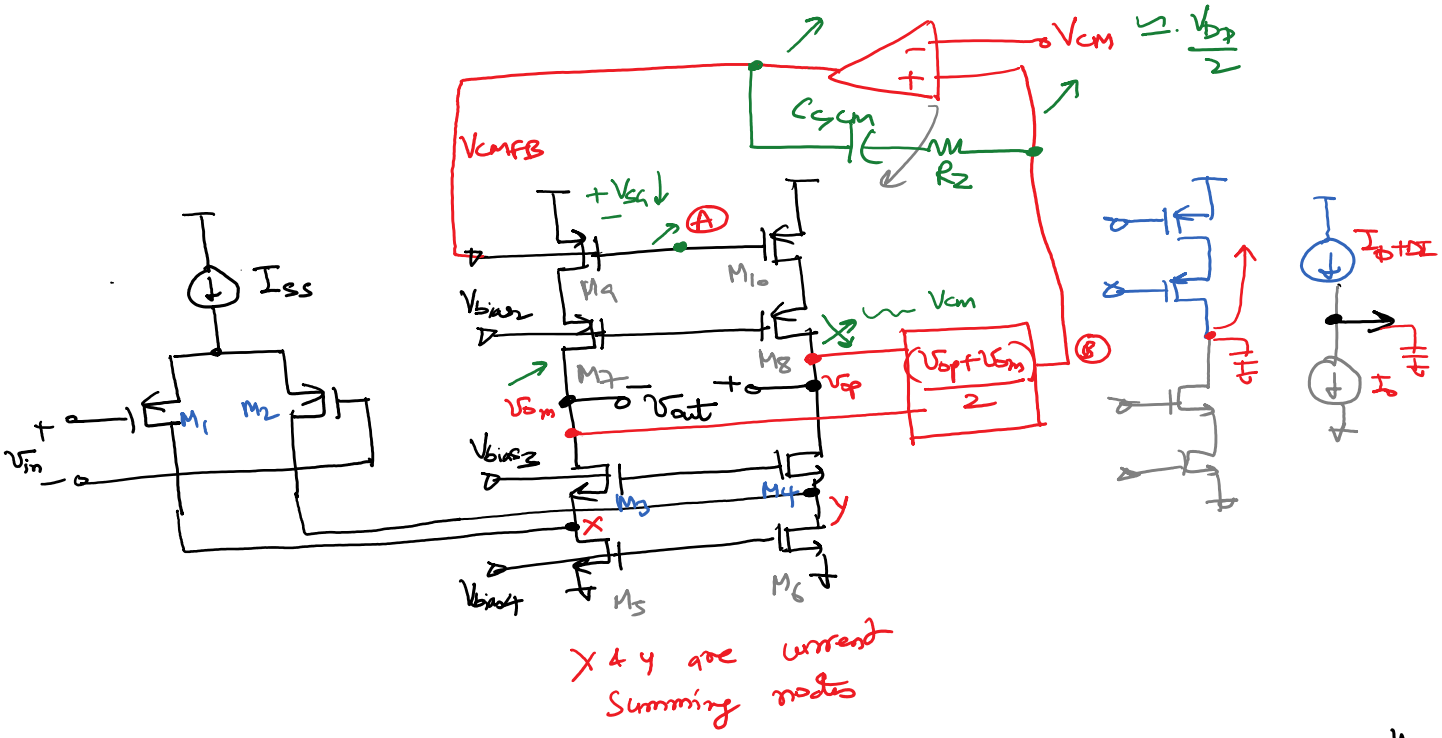
$$V_{CM,in} \geq V_{b1} - V_{SG_3} - |V_{THP}|$$

$$V_{GS_3} + V_{ccs_2}$$

$$= V_{ccs_2} - |V_{THP}|$$

$$V_{DS,sat} - |V_{THP}| < 0$$

Differential folded-Cascode opamp → Used widely in Switched Capacitor circuits.



X & Y are current summing nodes

+ Two independent current sources (PMOS & NMOS cascode) fighting to set the output common-mode (DC) level.

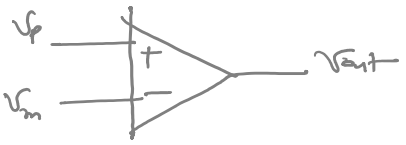
↳ Solution is to make one current dependent upon another using a feedback loop to set the output CM-level

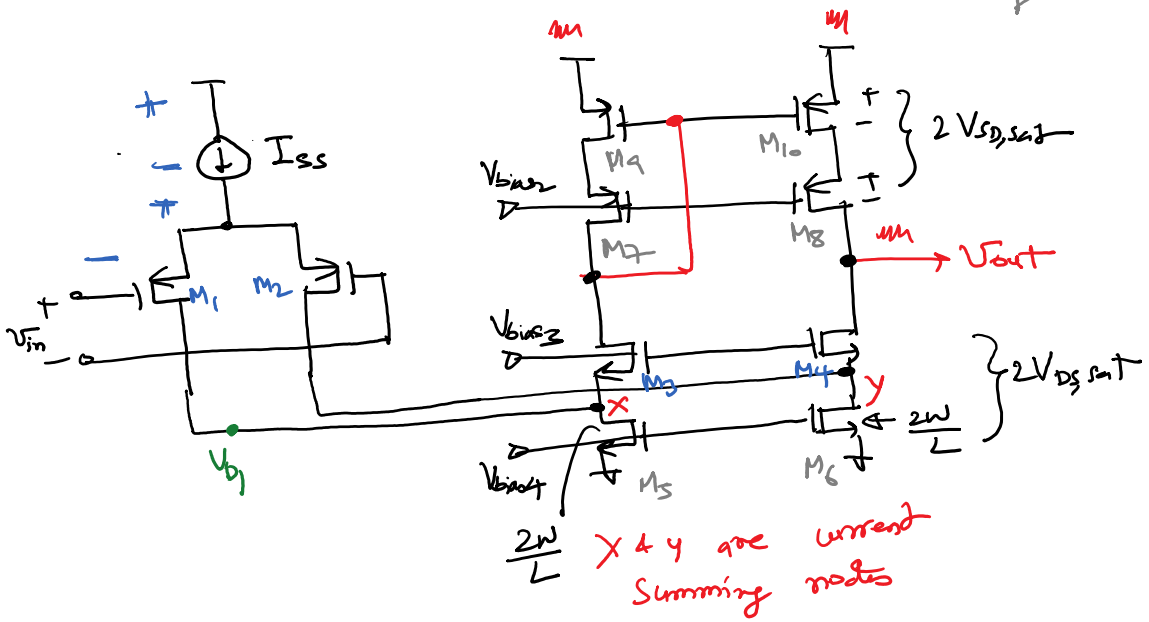
× Common-mode feedback (CMFB) loop.

↳ Need to compensate the CMFB loop

↳ $\phi_{PM} \simeq 60°$

Single-Ended folded Cascode Amplifier

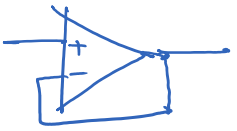


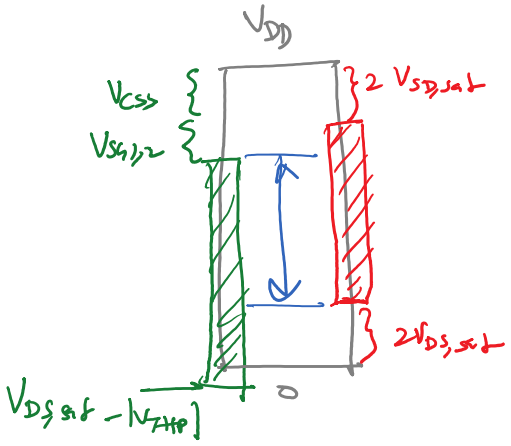


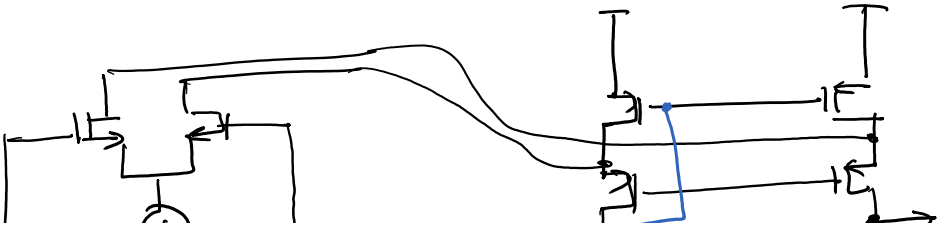
$$V_{CM,in} \leq V_{DD} - V_{CSS} - V_{SG1,2}$$

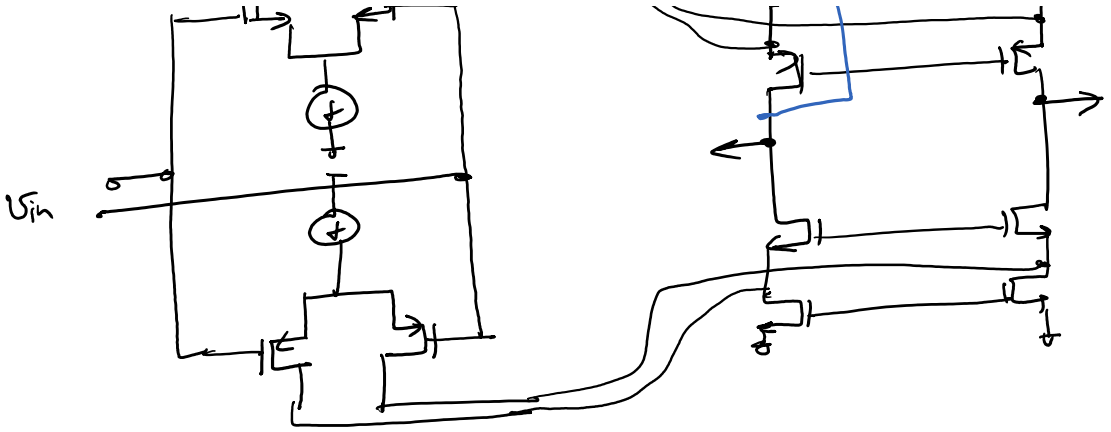
$$V_{CM,in} = V_{G1} \geq V_{D1} - |V_{THP}|$$

$$= V_{DS,sat5} - |V_{THP}| < 0$$

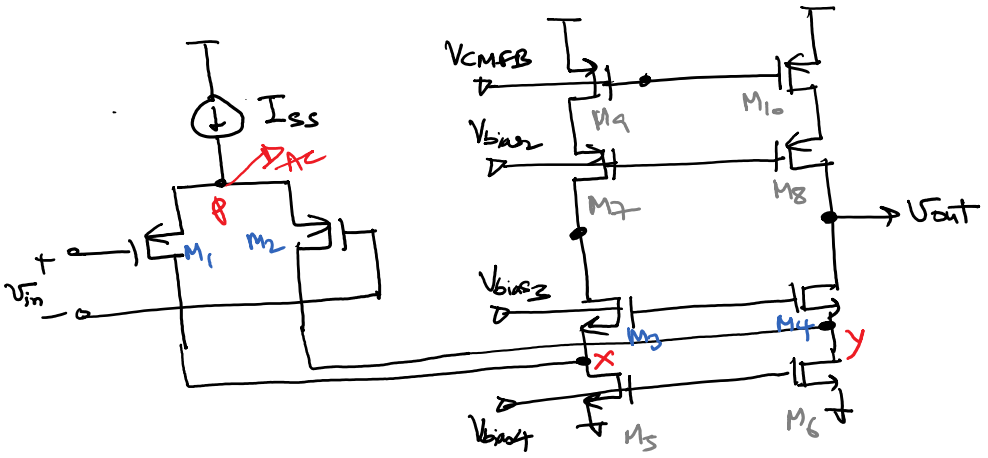




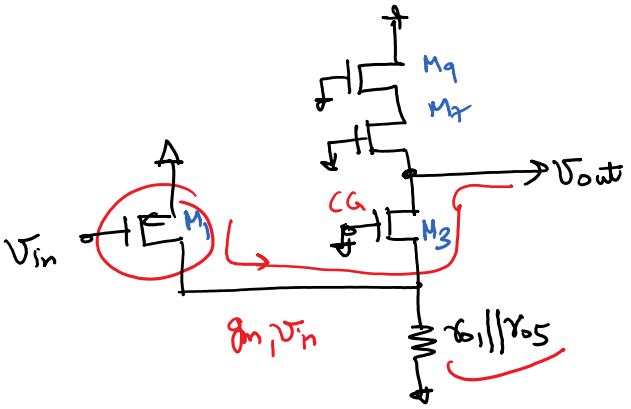




Full rail-to-rail input swing



Differential Half Circuit



$A_{v,DM} = -g_m \times R_{out}$

g_{m_1}

$R_{casp} \parallel R_{casn}$

$= (g_{m7} r_{o7} r_{o9}) \parallel (g_{m3} r_{o3} \cdot r_{o1} \parallel r_{o5})$

Assume all g_m's are g_m

all r_o's are r_o

$$\Rightarrow A_{v,DM} = -g_m \cdot (g_m r_o^2) \parallel \left(g_m r_o \cdot \frac{r_o}{2}\right)$$

$$= -g_m \cdot g_m r_o^2 \parallel \frac{g_m r_o^2}{2}$$

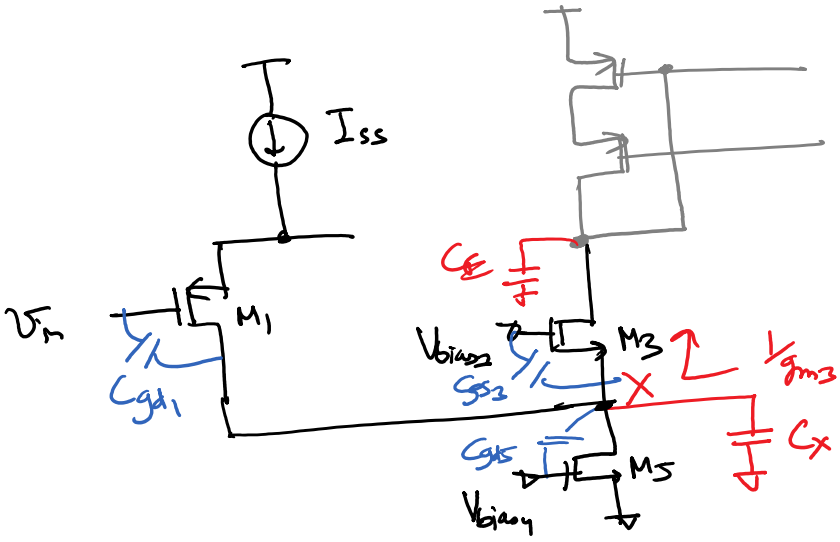
$$= -\frac{1}{3} \cdot g_m^2 r_o^2$$

$1 \parallel \frac{1}{2}$

$\frac{\frac{1}{2}}{3/2} = \frac{1}{3}$

gain slightly smaller than Telescopic Stage

fc Pole locations:



$$C_x = \underbrace{C_{gs_3} + C_{sb_3}}_{M_3} + \underbrace{C_{db_1} + C_{gd_1}}_{M_1} + \underbrace{C_{gd_5} + C_{db_5}}_{M_5}$$

$$\omega_x \simeq \frac{1}{\frac{1}{g_{m3}} \cdot C_x}$$

* Current summing node creates another pole, hopefully at higher frequencies $\omega_x \gg \omega_{um}$

$$\omega_{um} \simeq \frac{g_{m1}}{C_L} \longleftarrow \text{single-stage}$$