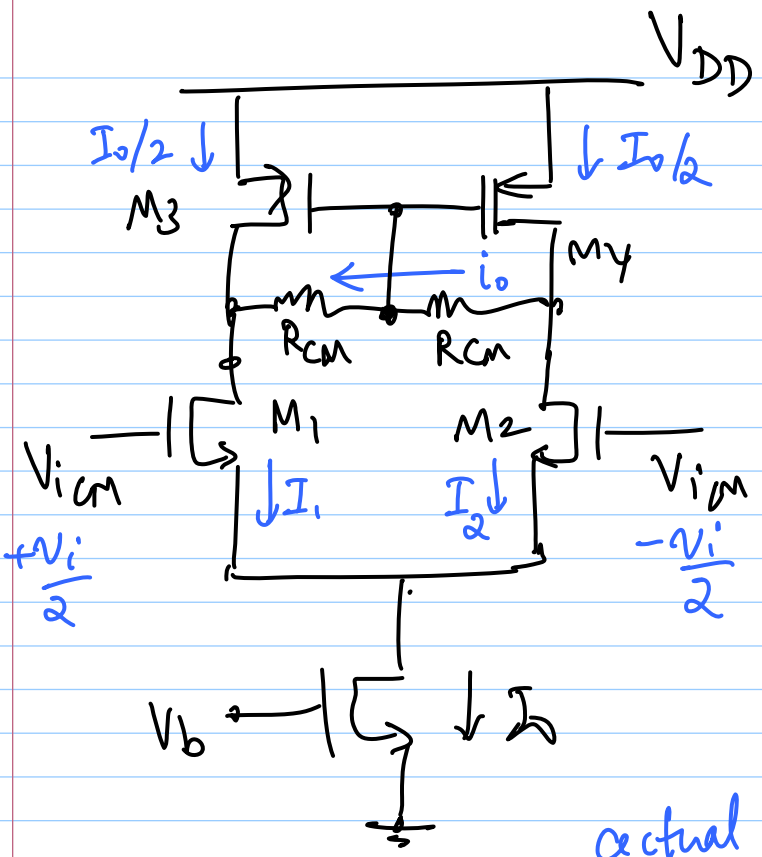
22-3-17

# Lec 33

## Common-mode feedback (CMFB)

* Measure o/p CM
* feedback in the right direction
* CM loop gain $= \infty \Rightarrow V_{o,cm} = V_{cm,ref}$



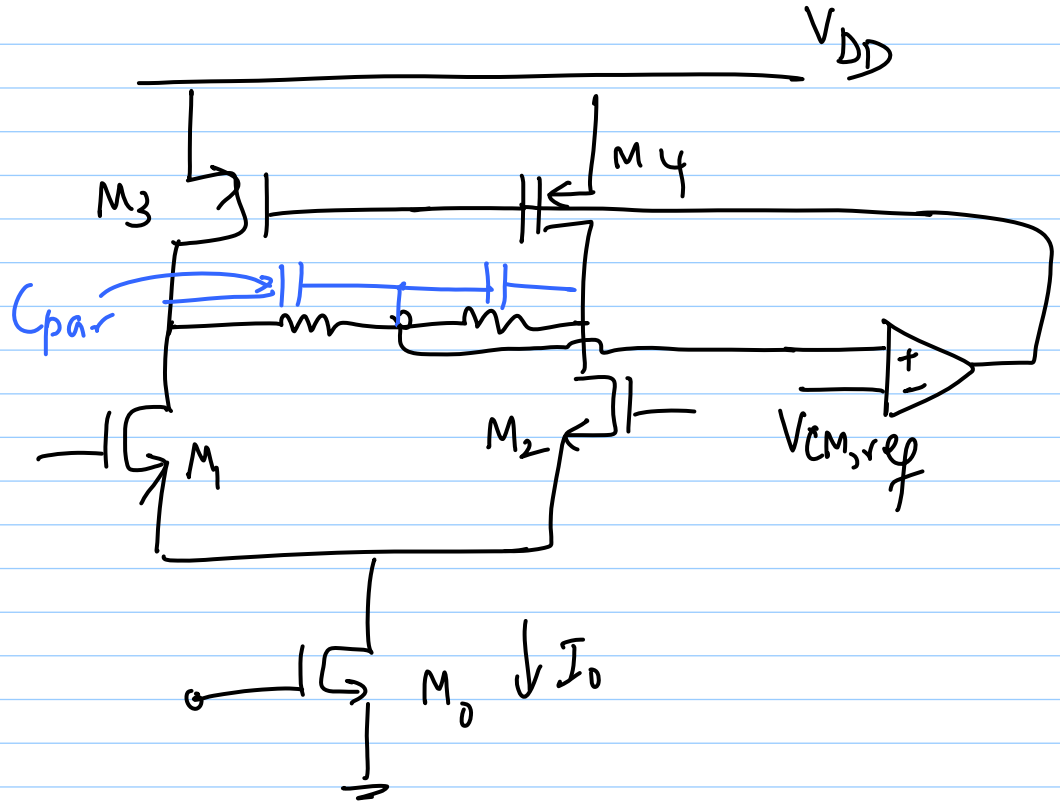

$V_{o,cm} = V_{DD} - V_{SG_{3,4}}$

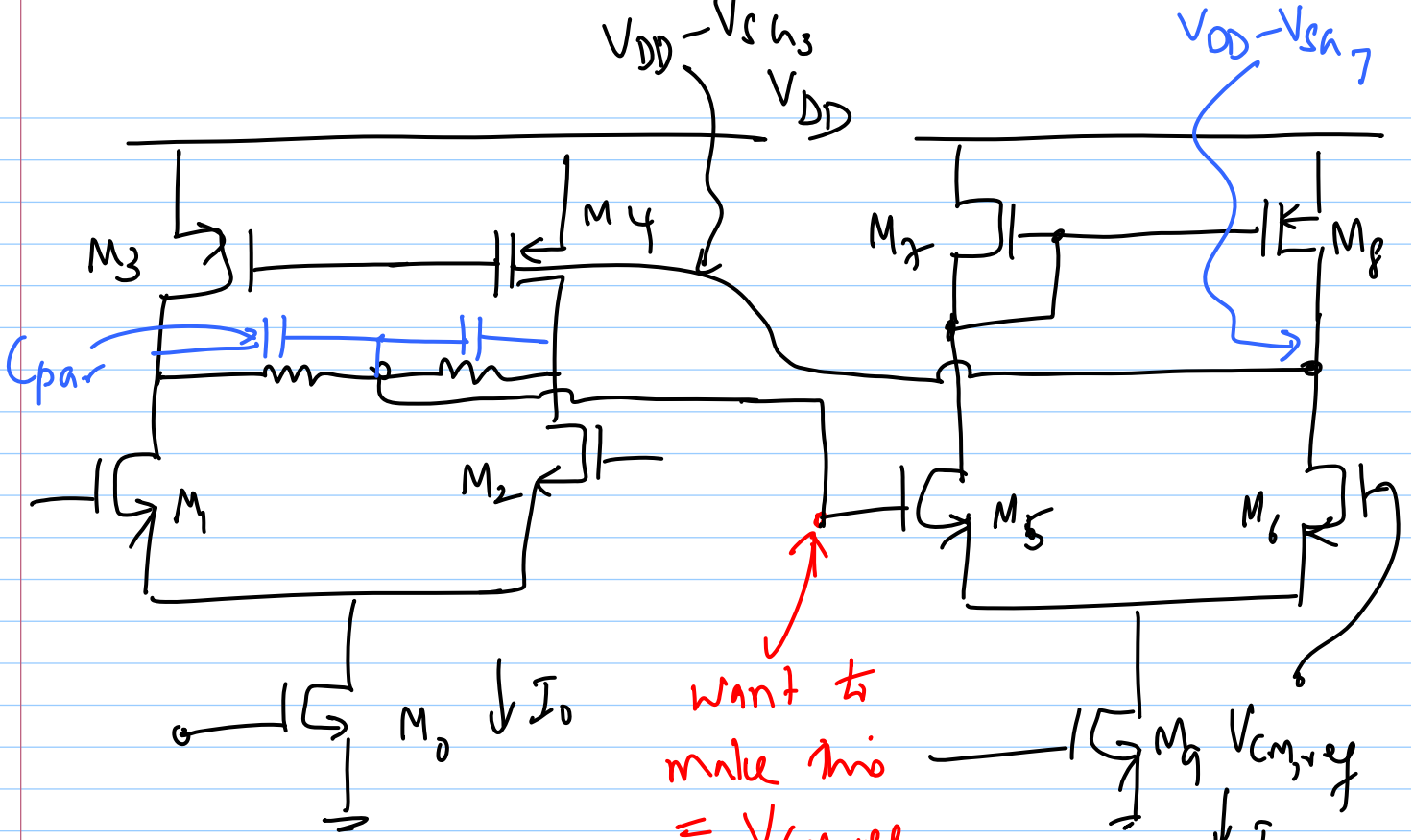
$I_1 = \frac{I_o}{2} + g_{m_1}\frac{v_i}{2}$

$I_2 = \frac{I_o}{2} - g_{m_1}\frac{v_i}{2}$

$i_o = g_{m_1}\frac{v_d}{2}$ (neglecting $r_{ds}$)

actual gain $= g_{m_1}(r_{ds_1} \| r_{ds_3} \| R_{CM})$




$\Rightarrow V_{DD} - V_{SG_4} = V_{DD} - V_{SG_8}$ so that no offset

$\Rightarrow V_{SG_3}\big|_{I_{D/2}} = V_{SG_7}\big|_{I_{D/2}}$

$\Rightarrow$ same current density

$\frac{W_3}{I_{D/2}} = \frac{W_9}{I_{D/2}}$ ) replica bias ) very impt!

* opamp2 does not need to burn same amt. of current as opamp1
$\Rightarrow$ just scale down original opamp.

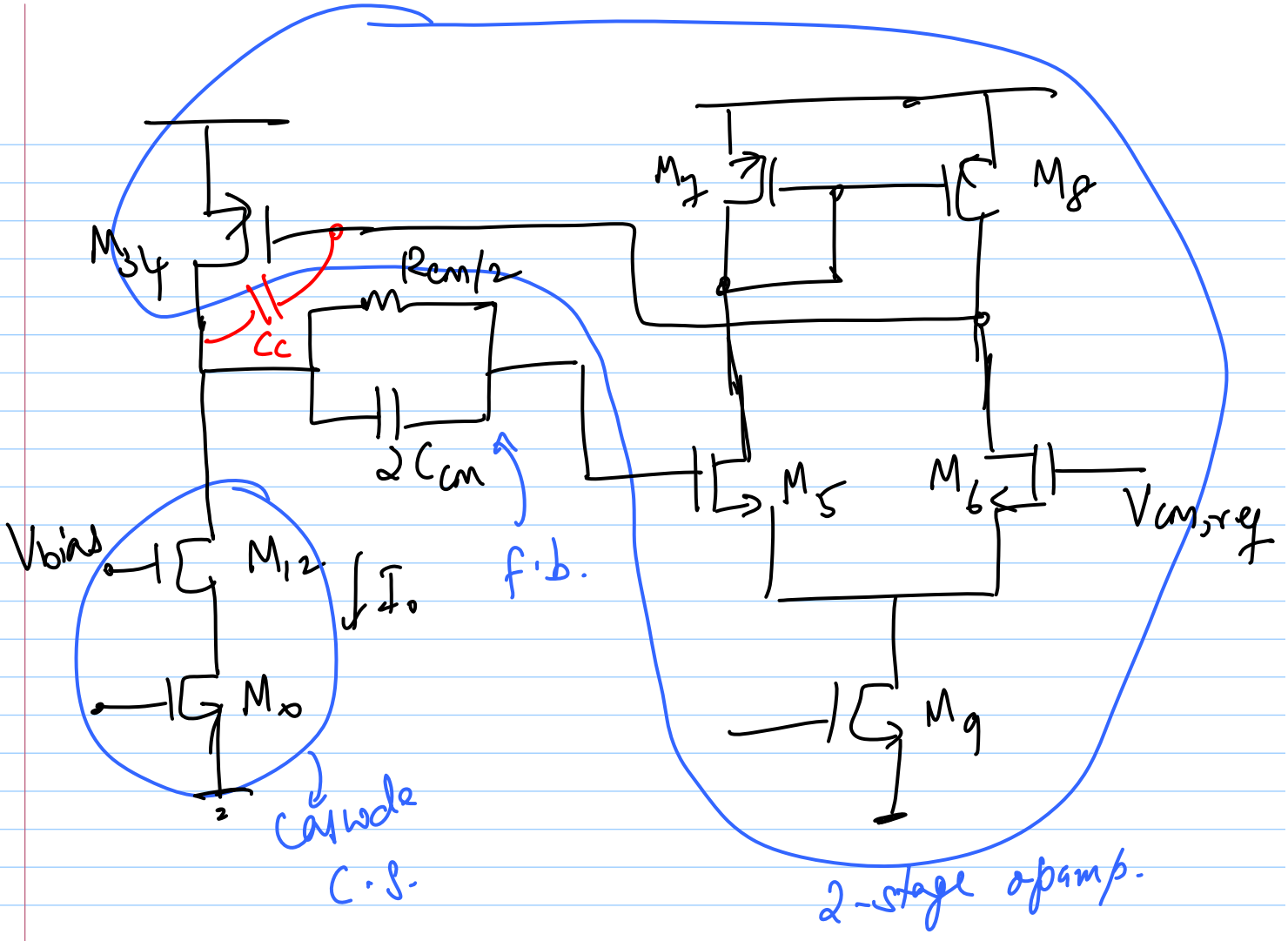
---

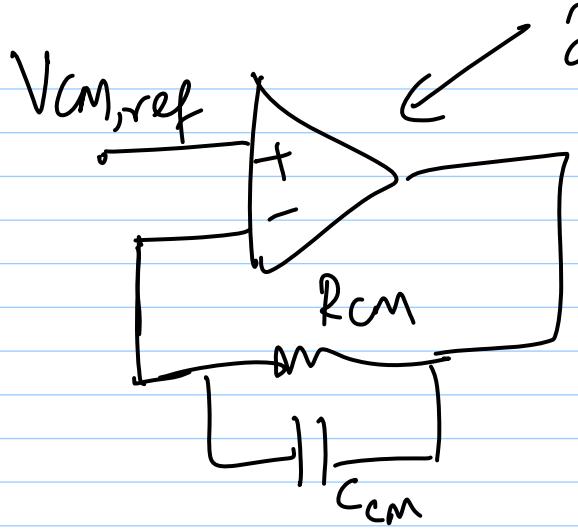
* If you use a diff. current density,

$V_{o_{CM}} = V_{CM,ref} + \frac{V_{SG_3}\big|_{I_{D/2}} - V_{SG_7}\big|_{I_{D/2}}}{A_{CMFB}}$

## Stability

* Calculate $L_H$ of CMFB loop
$\rightarrow$ draw CM equivalent ckt.



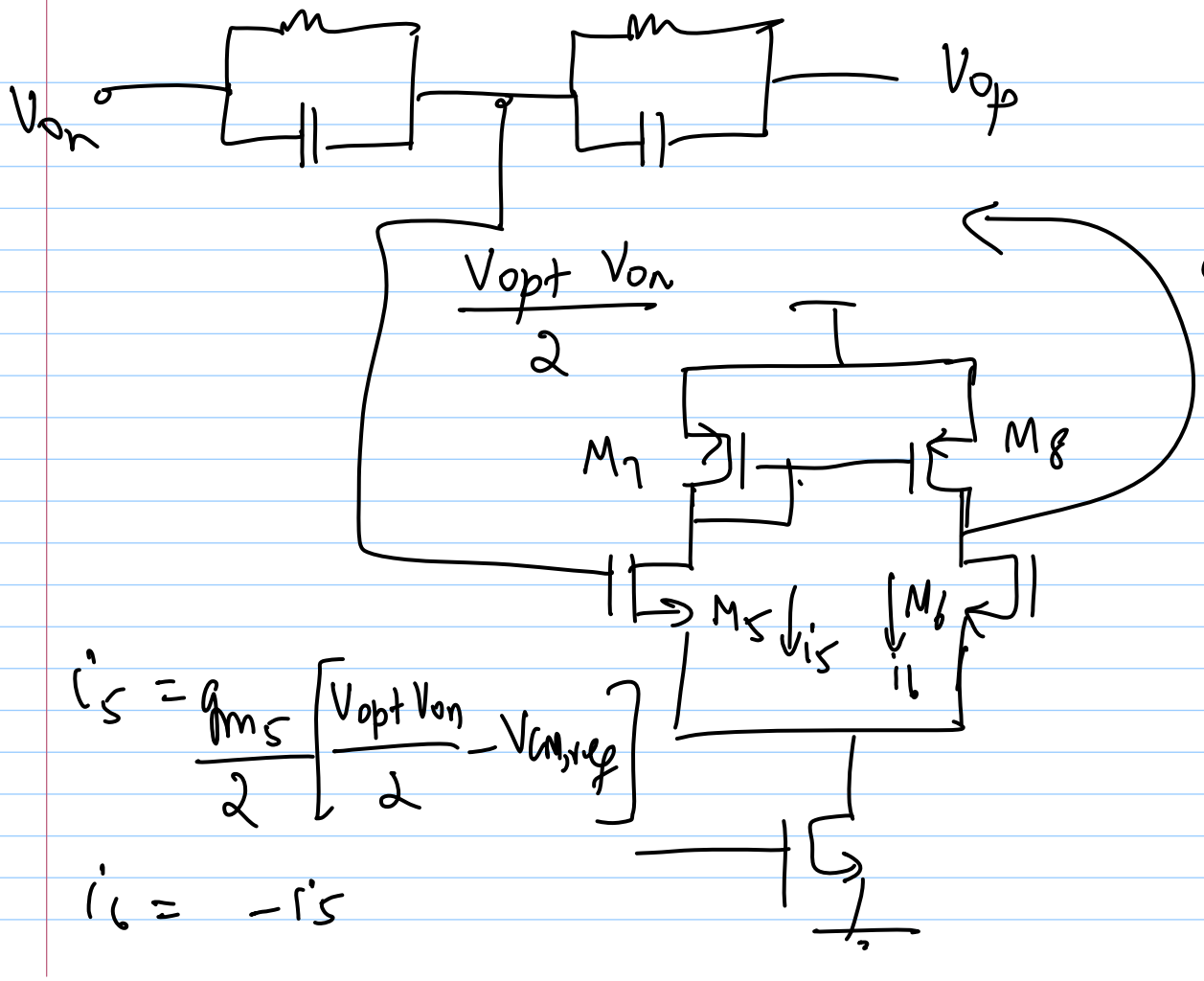

2-stage opamp w/ VA feedback

but Cc loads main path (diff. opamp)

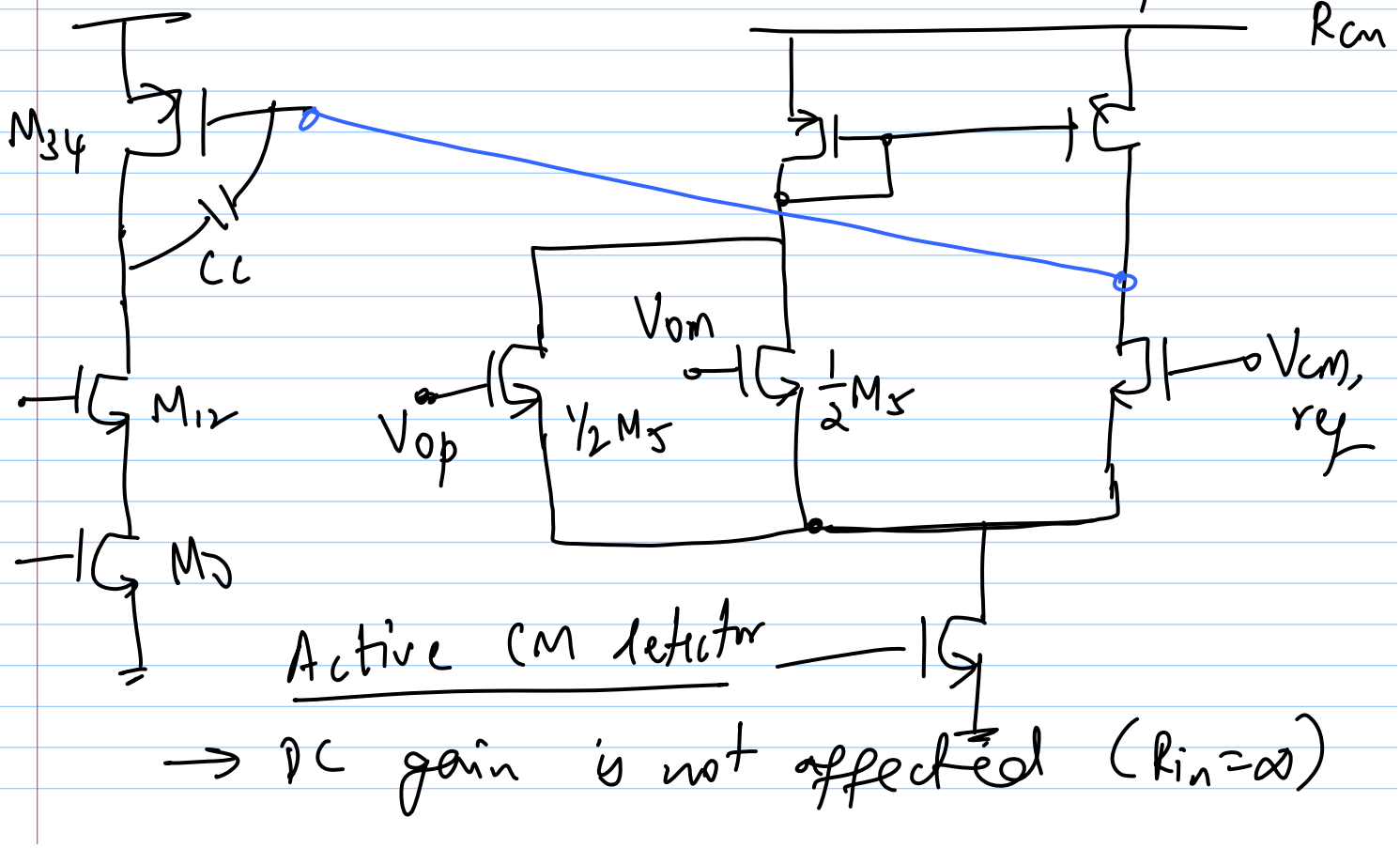
* compensation cap. is missing

→ G to D of $M_{34}$ in CM picture

→ 2 caps $C_c/2$ from G to D of $M_3$ & $M_4$ in overall ckt.




Split $M_5$ into 2 halves: ( instead of using $R_{cm}$




→ DC gain is not affected ($R_{in}=\infty$)

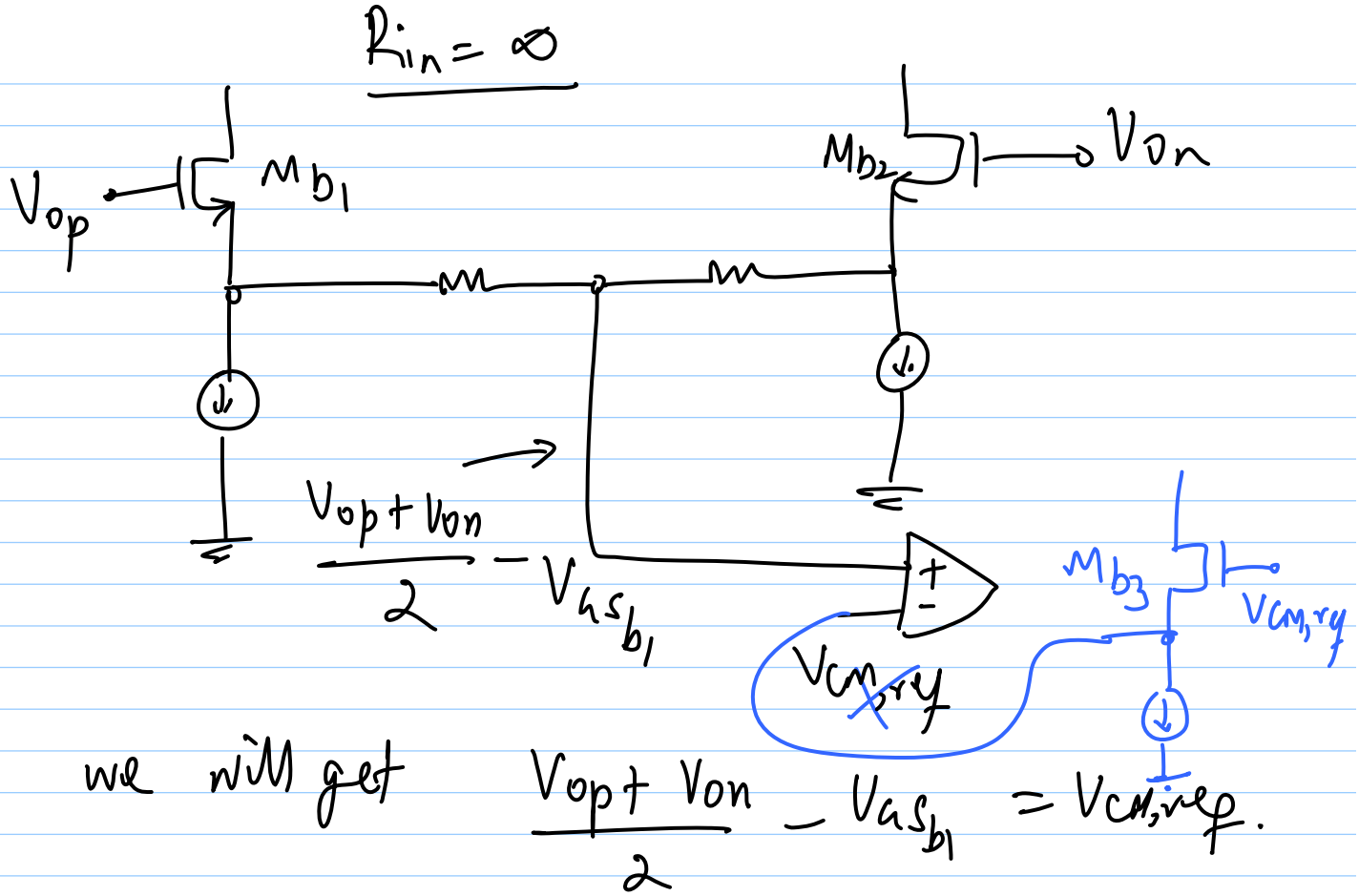
But:

→ $R_{cm}$ is linear (even for large $V_{op}, V_{on}$)

→ this detector is linear only for small $V_{op,on}$

* can be used in 1st stage of a 2-stage opamp (small swing)

→ 2nd stage can have resistive detector (can drive res. loads)




we will get $\frac{V_{op}+V_{on}}{2} - V_{GS_{b1}} = V_{CM,reg}$.

⇒ * Use replica bias ← make current density equal

$V_{GS_{b_1}} = V_{GS_{b_3}}$

S.F. gain < 1 ⇒ affects all equally & just changes overall CMFB L.h.