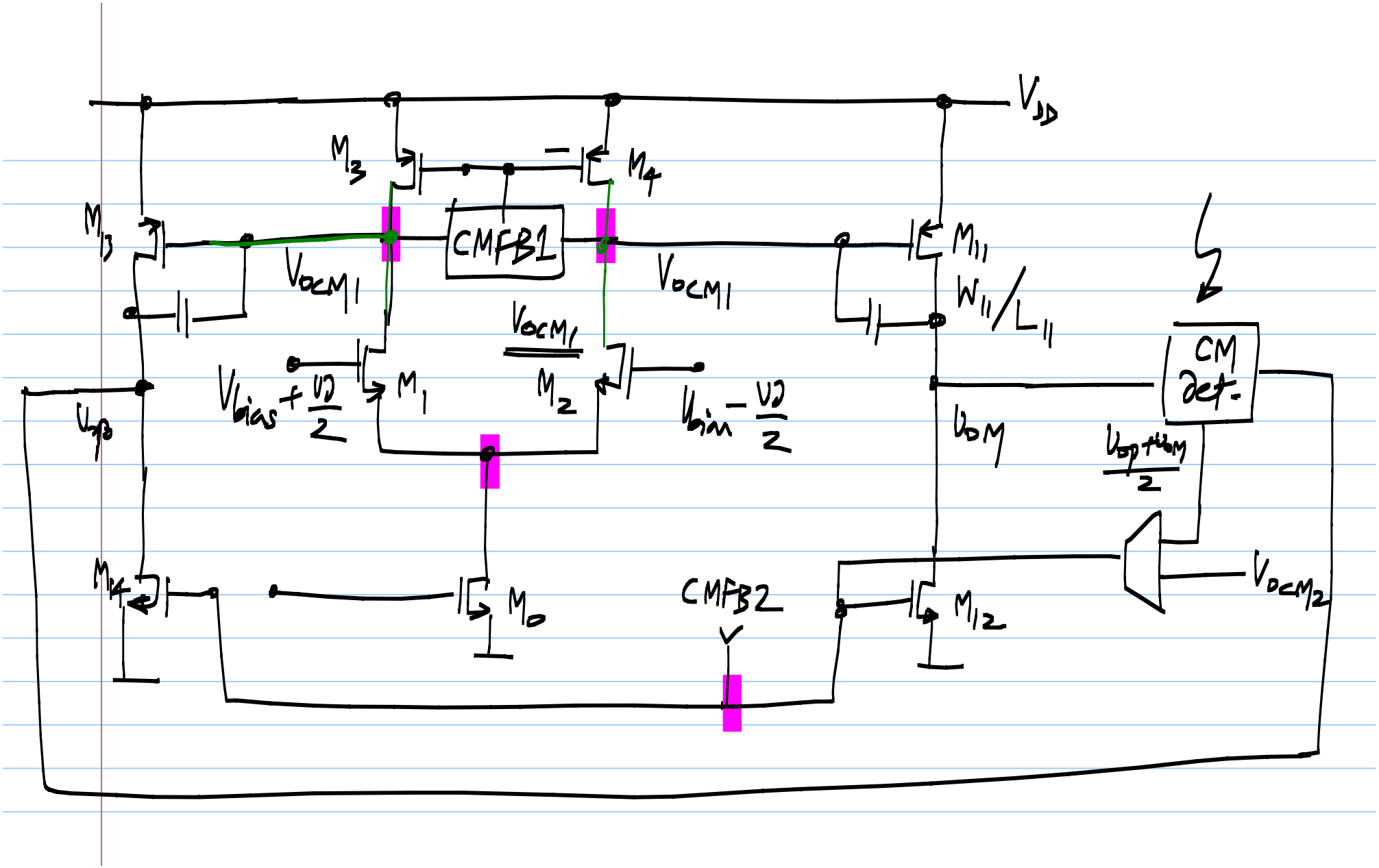
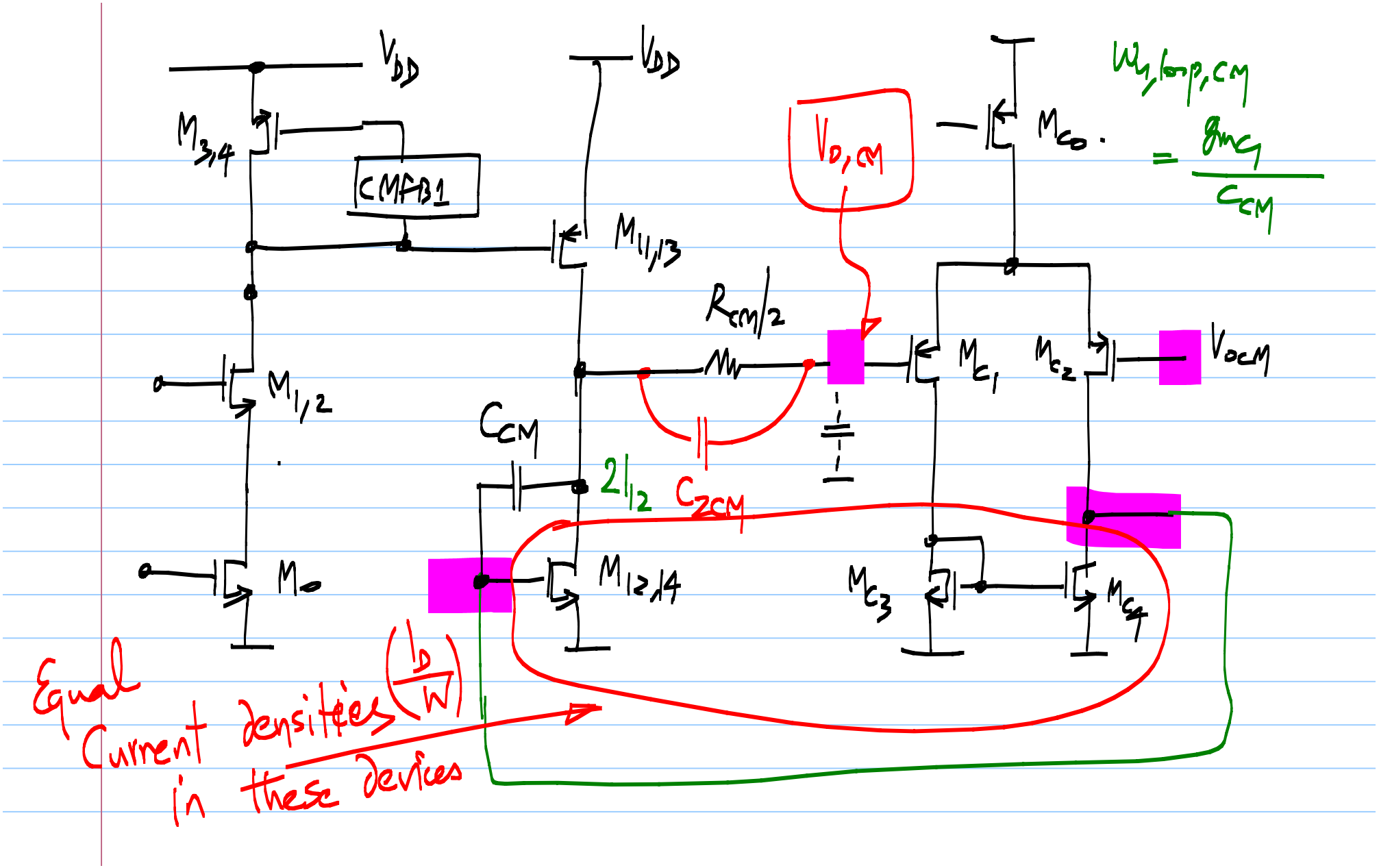
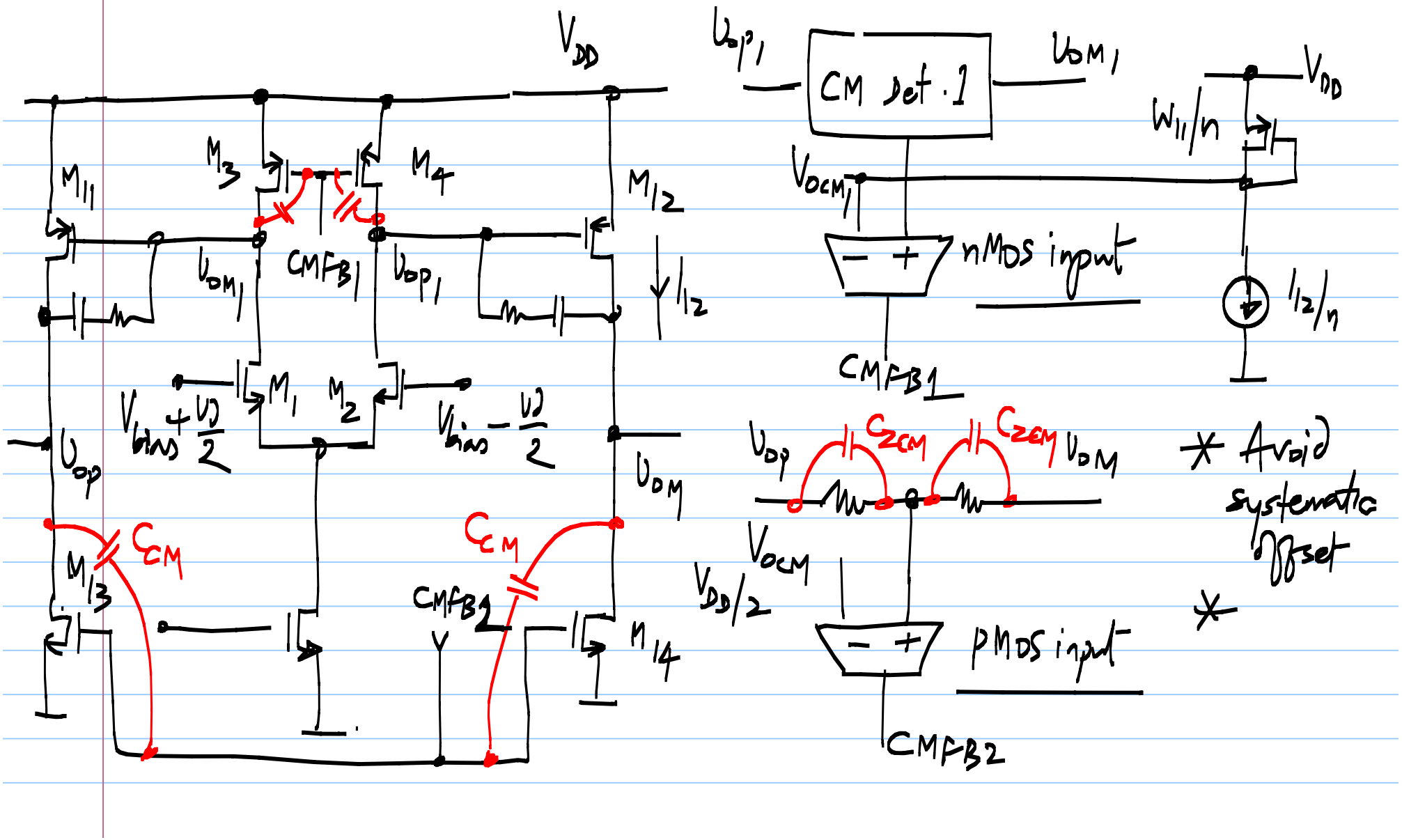
Lecture 43 :

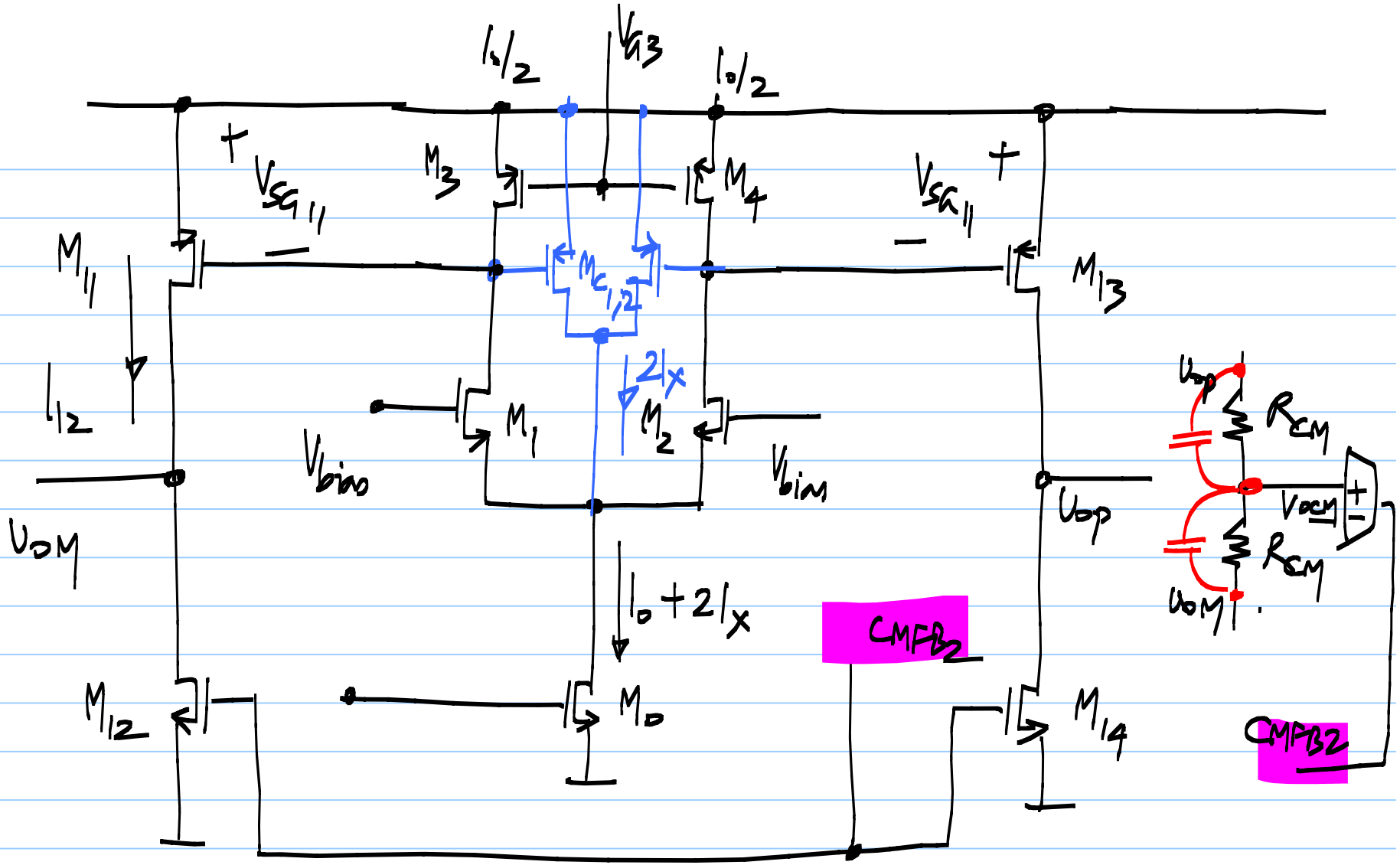
Two stage fully differential opamp

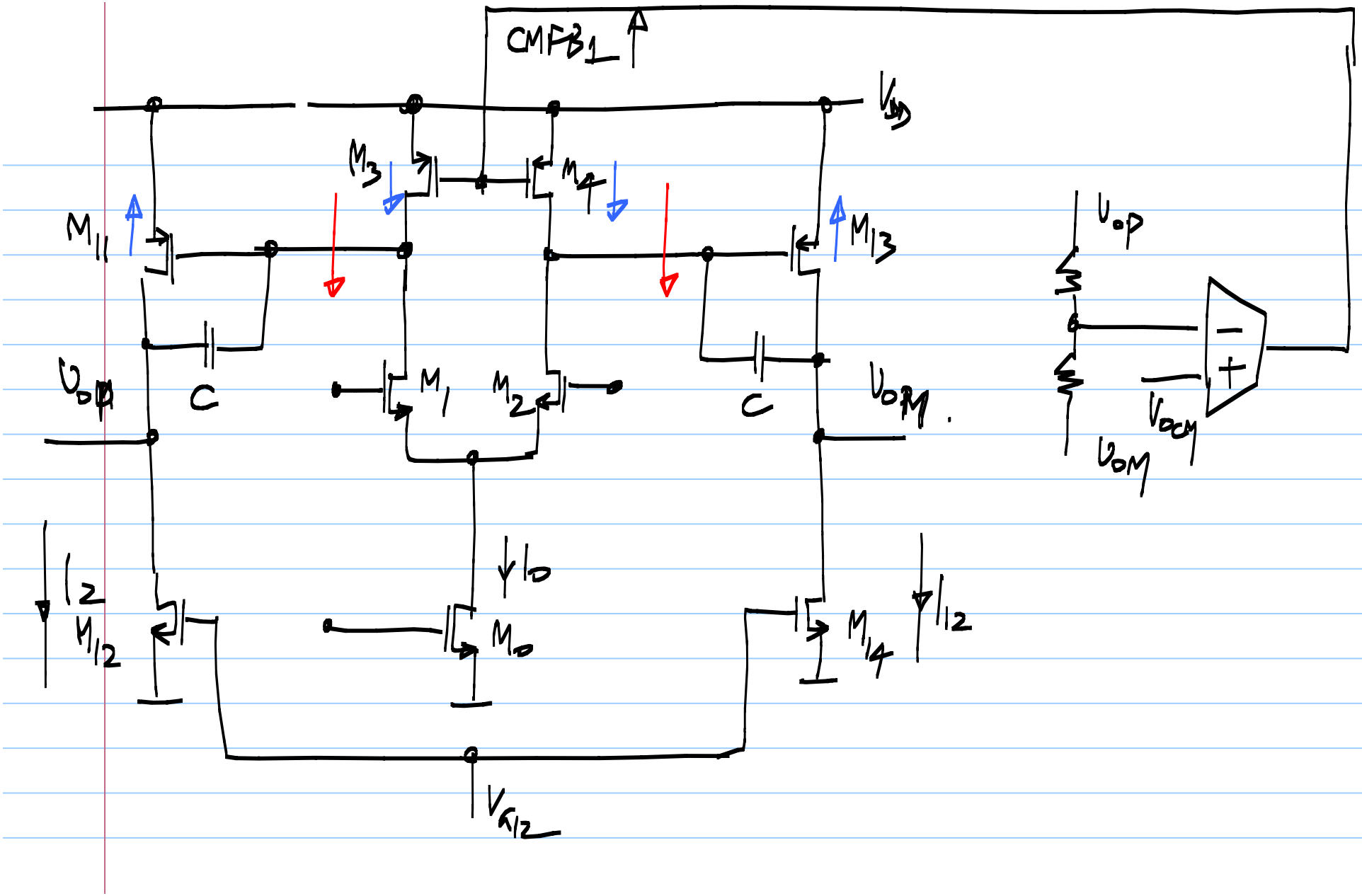
- DC gain, slew rate, Noise, offset, signal swing limits
  Similar to the single ended two stage opamp.
- $\omega_u = \frac{g_{m1}}{C}$; $p_2 = \frac{g_{m3} \cdot \frac{C}{C+C_1}}{\frac{CC_1}{C+C_1} + C_L}$; Mirror pole/zero not present

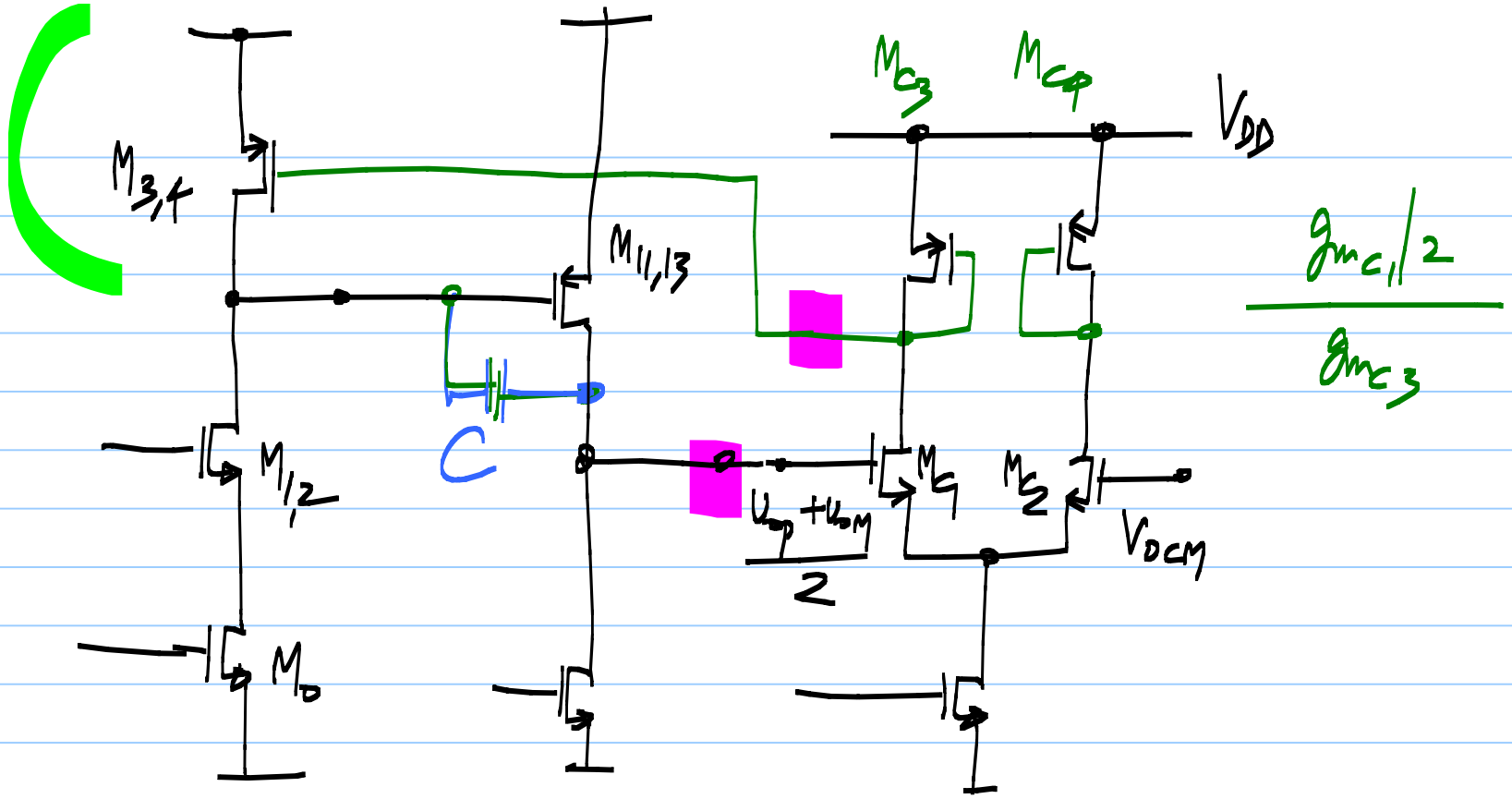

V_{DD}
M_3
M_4
M_5
CMFB1
V_{OCM1}
V_{OCM1}
M_{11}
W_{11}/L_{11}
V_{OCM1}
M_1
M_2
$V_{bias} + \frac{VD}{2}$
$V_{bias} - \frac{VD}{2}$
V_{fb}
V_{DM}
CM det.
$\frac{V_{op}+V_{om}}{2}$
M_4
M_0
CMFB2
M_{12}
V_{OCM2}


V_{DD}
V_{DD}
$M_{3,4}$
CMFB1
$M_{1,13}$
$R_{CM}/2$
$V_{D,CM}$
M_{C0}
$M_{1,2}$
M_{C1}
M_{C2}
V_{OCM}
C_{CM}
$2I_2$ C_{2CM}
M_0
$M_{12,14}$
M_{C3}
M_{C4}
g_{mCM}
C_{CM}
Equal Current densities $\left(\frac{I_D}{W}\right)$ in these devices

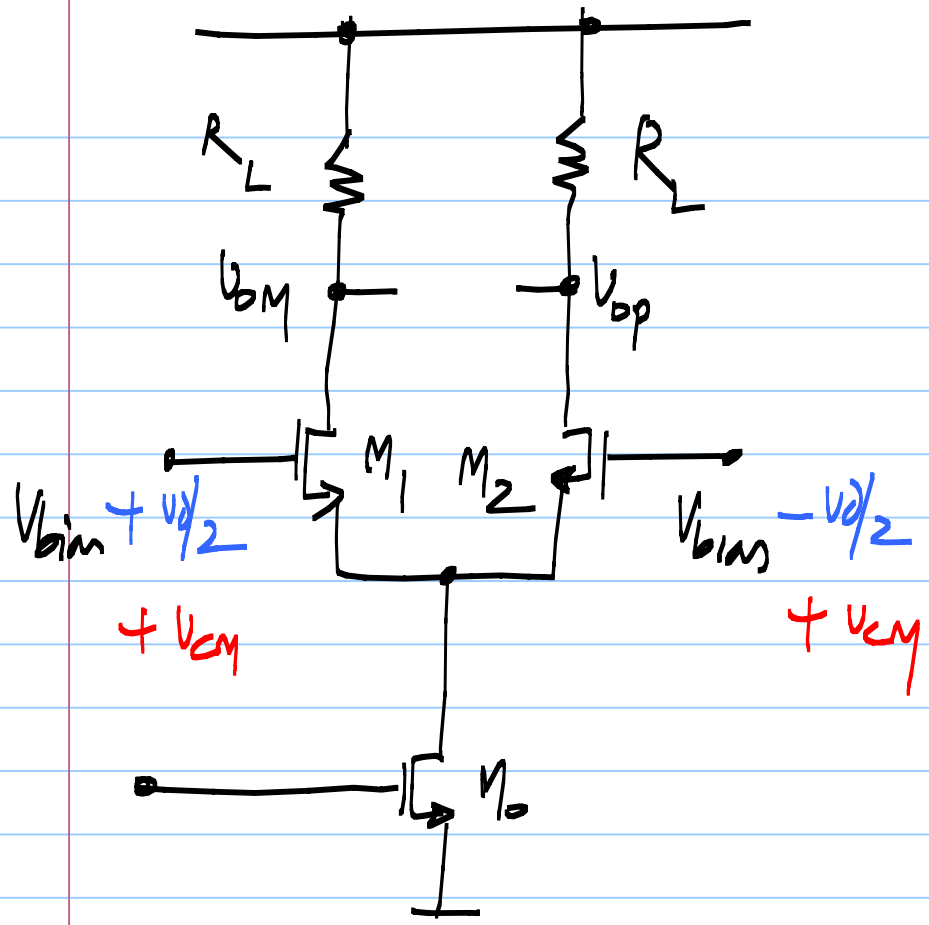

V_{DD}
M_{11}
M_3
M_4
M_{12}
V_{OM1}
CMFB1
V_{OP1}
I_{12}
M_1
M_2
$V_{bias} + \frac{VJ}{2}$
$V_{bias} - \frac{VJ}{2}$
V_{OP}
V_{OM}
C_{CM}
M_{13}
C_{CM}
CMFB2
M_{14}
V_{OP1}
CM det. 1
V_{OM1}
V_{OCM1}
nMOS input
CMFB1
W_{11}/n
V_{DD}
I_{12}/n
V_{OP}
C_{2CM}
C_{2CM}
V_{OM}
V_{OCM}
$V_{DD}/2$
pMOS input
CMFB2
* Avoid systematic offset *


$I_0/2$
V_{B3}
$I_0/2$
V_{SG11}
M_3
M_4
V_{SG11}
M_{11}
$M_{C1,2}$
M_{13}
$2I_X$
I_{12}
M_1
M_2
V_{bias}
V_{bias}
V_{op}
R_{CM}
V_{OCM}
R_{CM}
V_{om}
V_{om}
V_{op}
$I_0 + 2I_X$
CMFB2
M_{12}
M_0
M_{14}
CMFB2


CMFB1
VDD
M3
M4
M11
M13
C
C
M1
M2
VoP
VoM
VoP
VoCM
VoM
I2
M12
Io
Mo
M14
I2
VG12



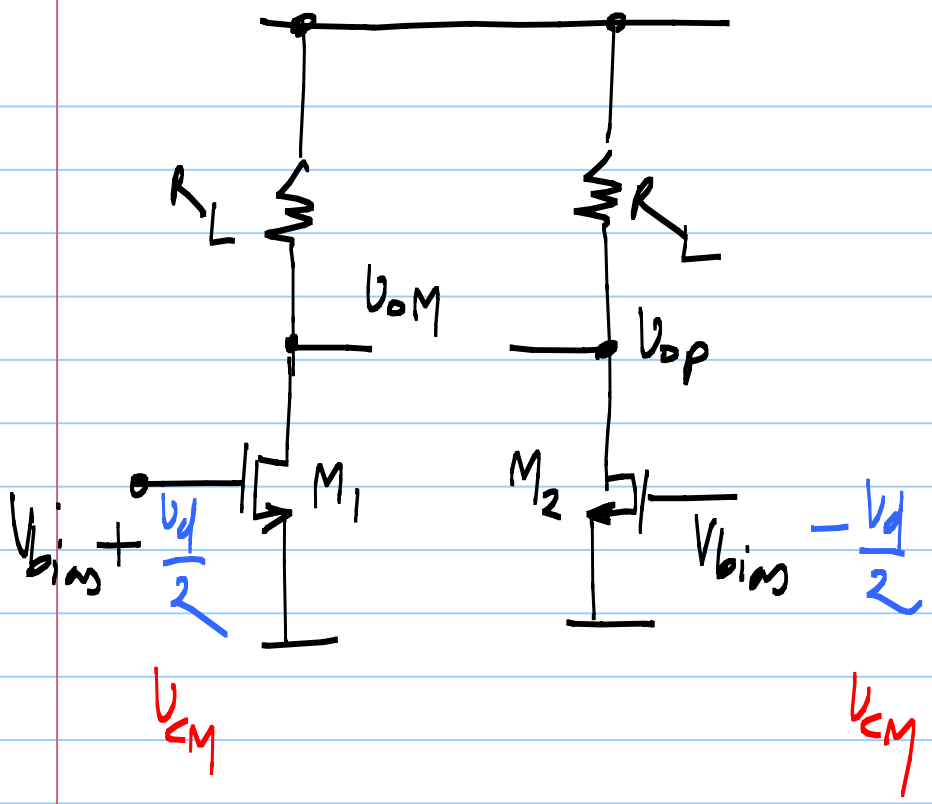
Single CMFB loop for a 2 stage opAmp



$$A_d = \frac{v_{op} - v_{oM}}{v_d} = g_{m1} \cdot R_L$$

$$A_{cm} = \frac{(v_{op} + v_{oM})/2}{v_{cm}} = \frac{R}{2r_{ds0}}$$

$$A_{cm} \ll A_d \; ; \quad \underline{\underline{A_{cm} \ll 1}}$$



$$A_d = \frac{v_{op} - v_{oM}}{v_d} = g_{m1} \cdot R_L$$

$$A_{CM} = \frac{(v_{op} + v_{oM})/2}{v_{CM}} = g_{m1} R_L$$

$$\boxed{A_{CM} = A_d} \quad \times$$

With CMFB circuitry $A_{CM} \longrightarrow 0$