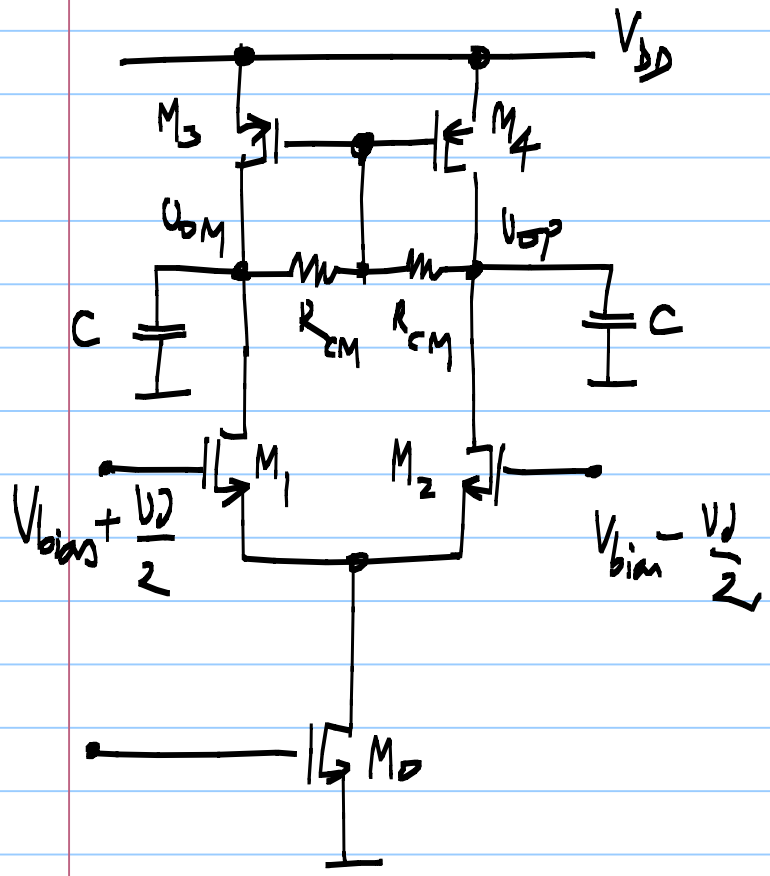
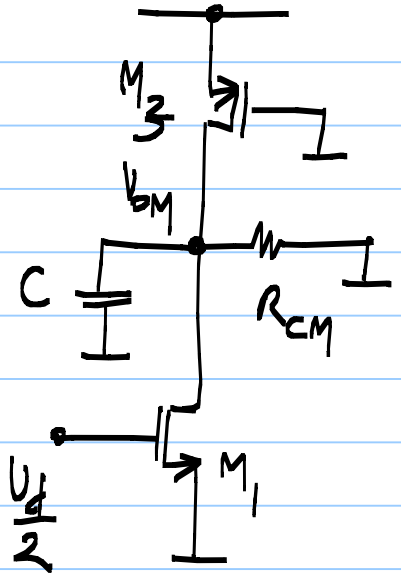
Lecture 42.

Diff. half ckt





$$A_0 = -\frac{g_{m_1}}{g_{ds_1} + g_{ds_3} + G_{LM}}$$

$$\frac{V_{DP} - V_{DM}}{V_d} = \frac{g_{m_1}}{g_{ds_1} + g_{ds_3} + G_{LM}}$$

$$\omega_u = \frac{g_{m_1}}{C}$$

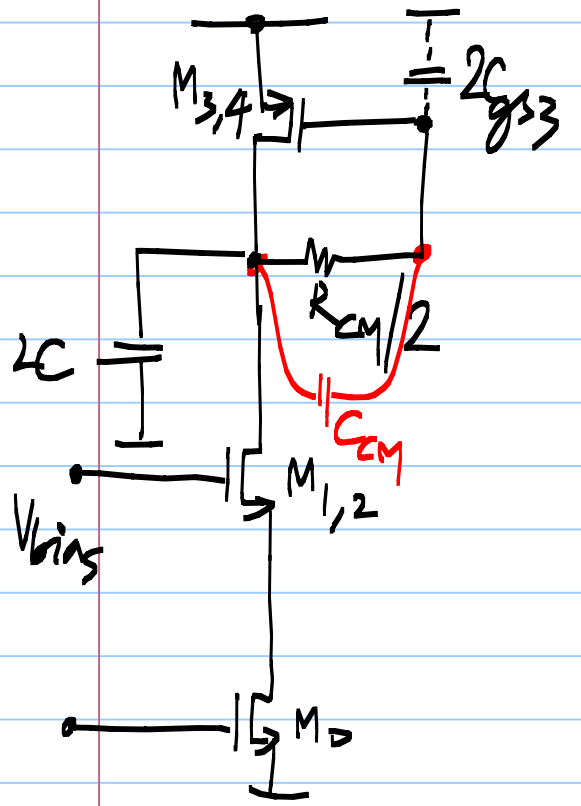
No mirror pole / zero.

$$S_{V_i} = \frac{4}{3}\frac{kT}{g_{m_1}}\left(1 + \frac{g_{m_3}}{g_{m_1}}\right); \quad SR = \frac{I_0}{C};$$

Noise from R_{CM} neglected.

$$\sigma^2_{V_{OS}} = \sigma^2_{V_{T1,2}} + \sigma^2_{V_{T3,4}} \cdot \left(\frac{g_{m3}}{g_{m1}}\right)^2$$

{ Neglecting R_{CM} mismatch }

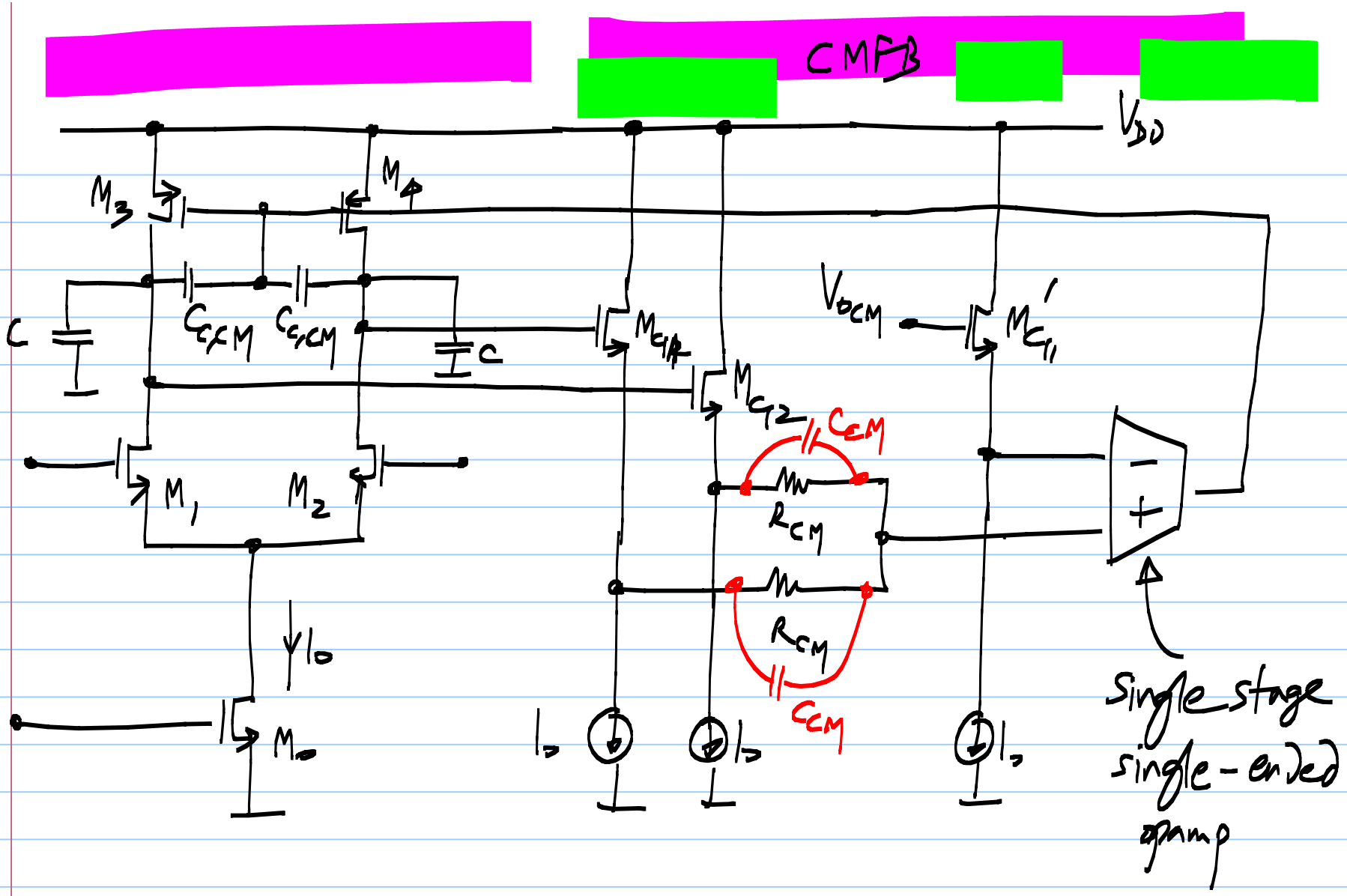


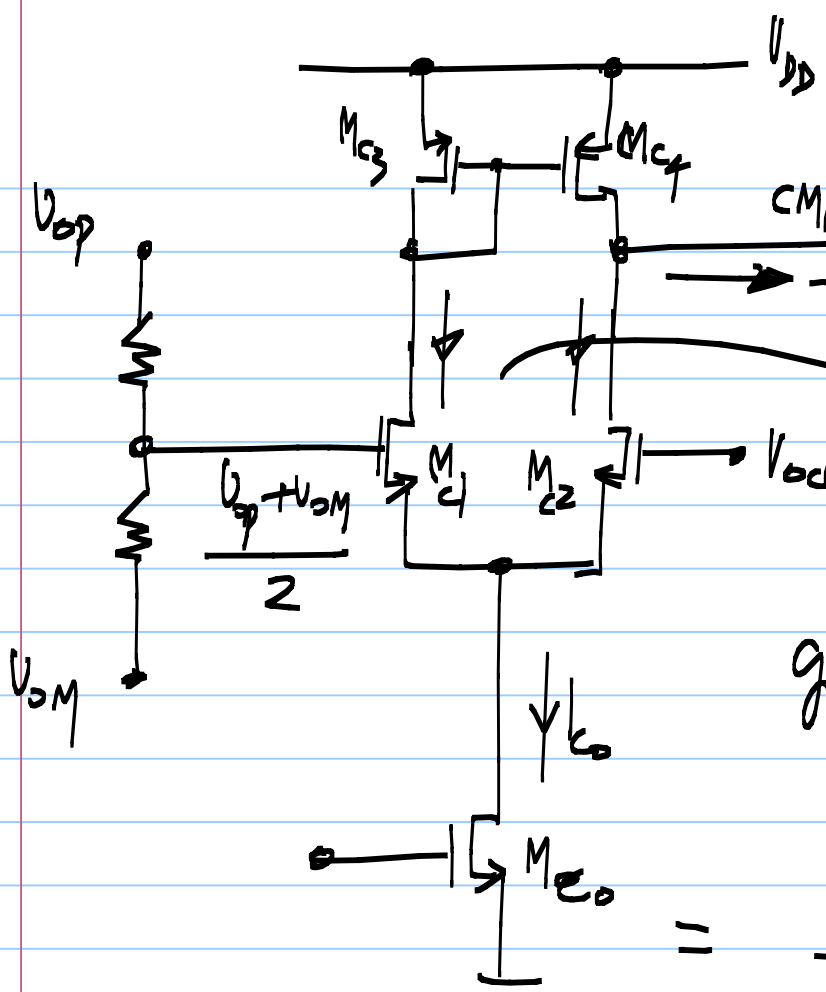
$$\omega_{u,loop,cm} = \frac{2g_{m3}}{2C} = \frac{g_{m3}}{C}$$

$$p_{2,cm} = -\frac{1}{R_{CM} \cdot C_{gs3}} \qquad |p_{2,cm}| \gg \omega_{u,loop,cm}$$

$$\left| R_{CM}/2 \;,\; \frac{1}{\omega C_{CM}} \right| \gg \frac{1}{\omega C}$$

$$p_{2,cm} = -\frac{1}{R_{CM}(C_{gs3} + C_{CM}/2)} \;;\; z_1 = -\frac{1}{R_{CM}/2 \cdot C_{CM}}$$


CMFB
V_{DD}
M_3
M_4
C
C_{CM}
C_{CM}
C
M_{C1R}
M_{C12}
V_{DCM}
M_{C11}'
M_1
M_2
C_{CM}
R_{CM}
R_{CM}
C_{CM}
I_0
M_0
I_0
I_0
I_0
Single stage single-ended opamp

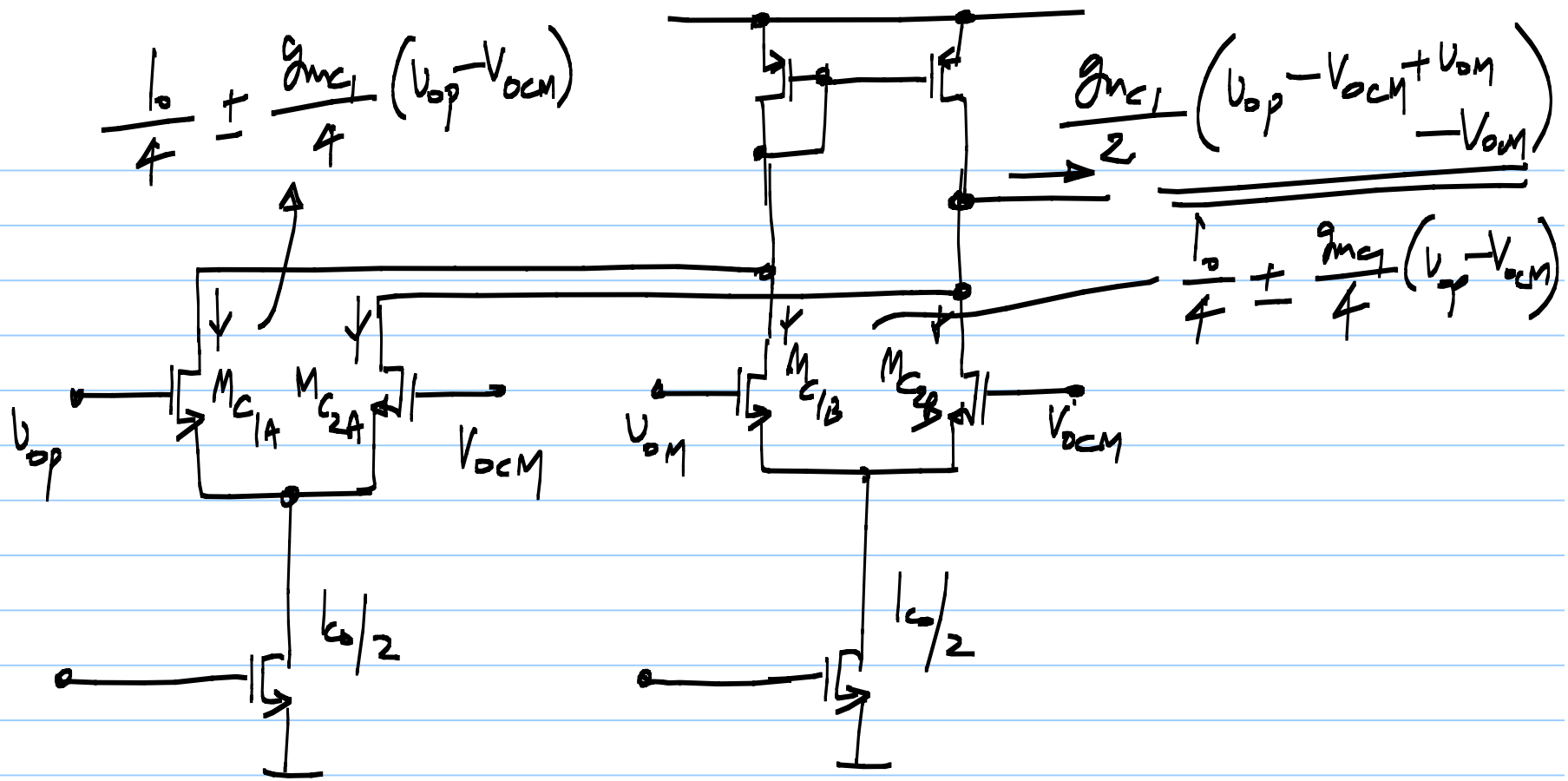


$$g_{mC_1}\left[\frac{V_{op}+V_{oM}}{2}-V_{OCM}\right]$$

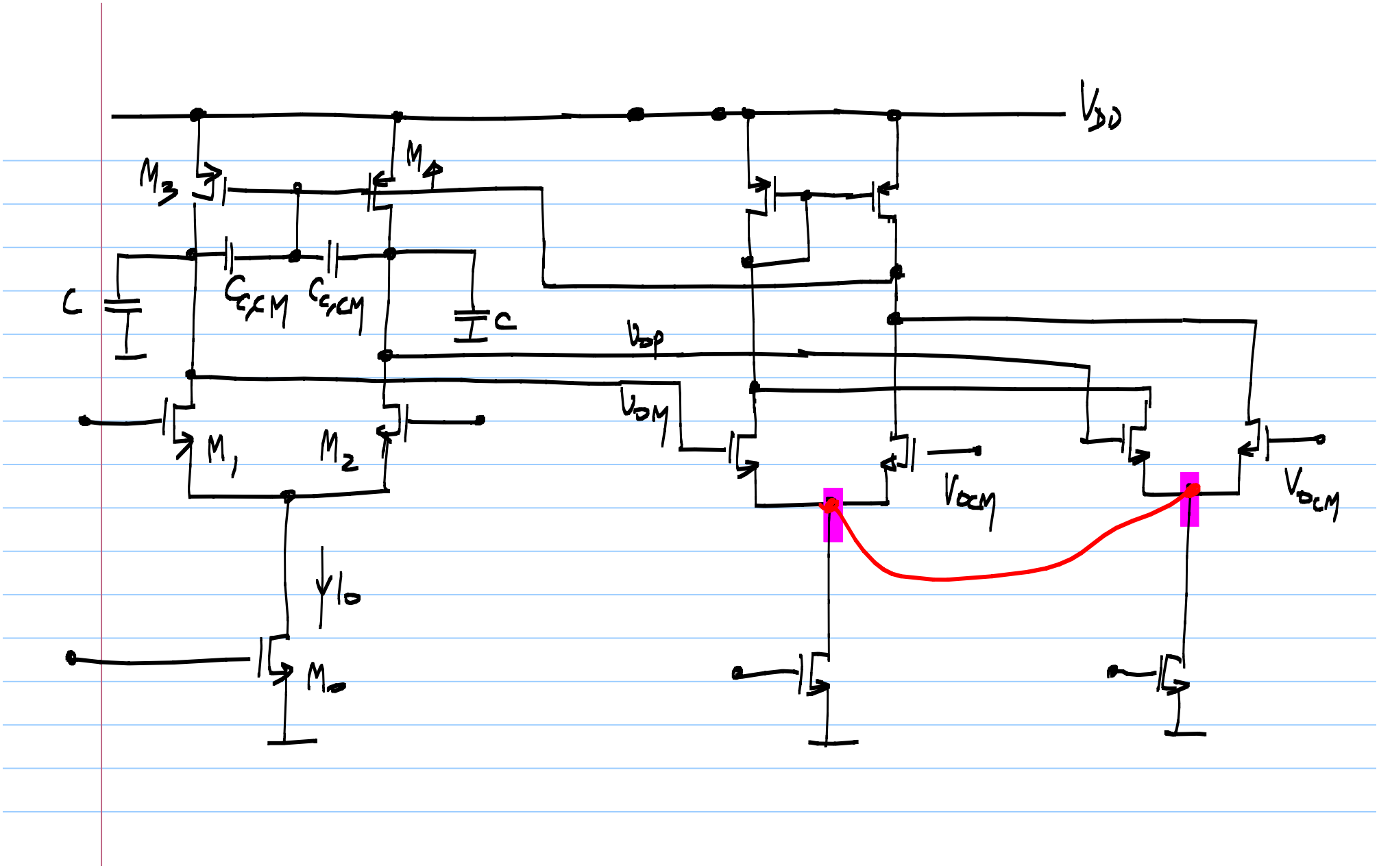
$$\frac{I_o}{2}+\frac{g_{mC_1}}{2}\left[\frac{V_{op}+V_{oM}}{2}-V_{OCM}\right]$$

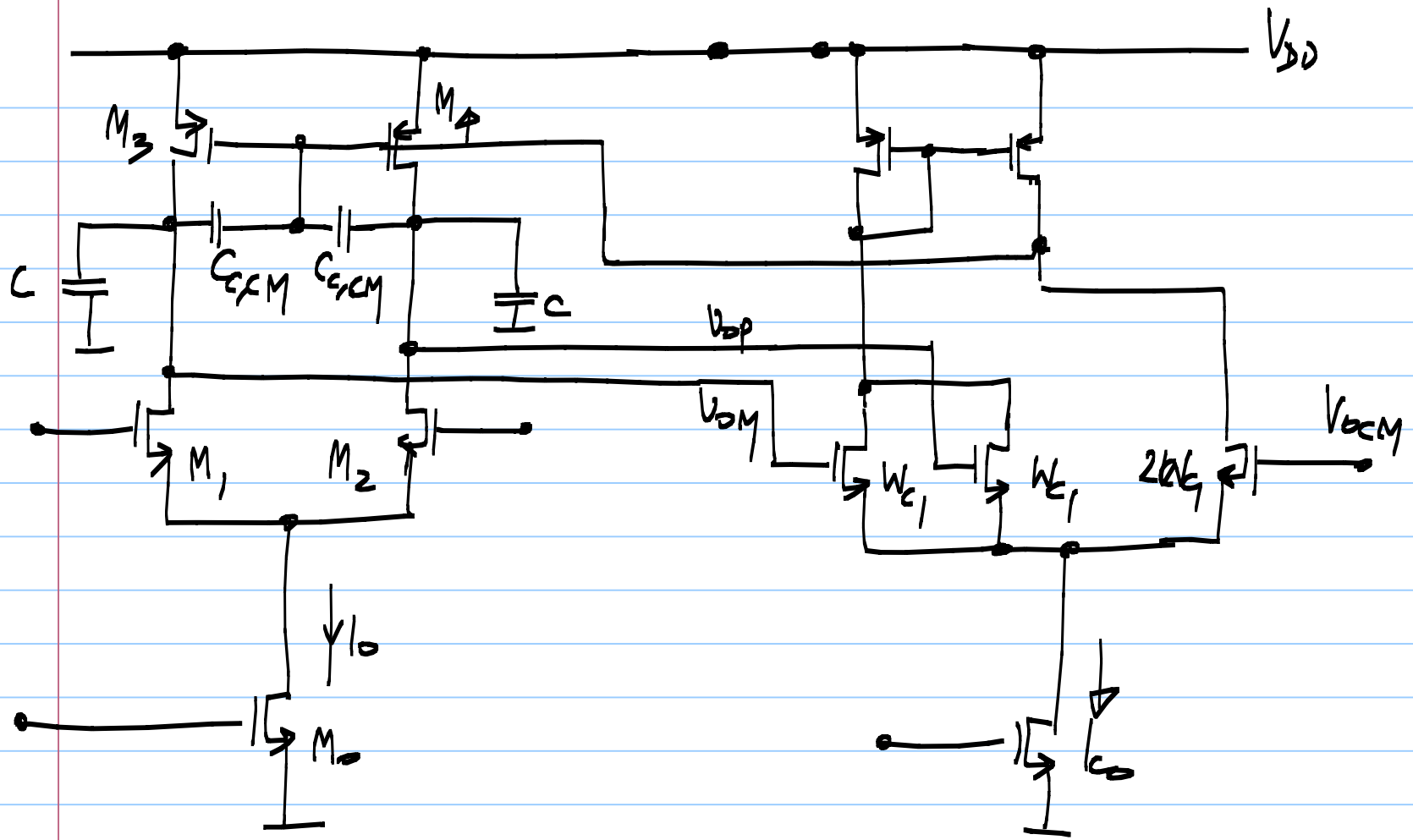
$$g_{mC_1}\left[\frac{V_{op}+V_{oM}}{2}-V_{OCM}\right]$$

$$=\frac{g_{mC_1}}{2}\left[V_{op}-V_{OCM}\right]+\frac{g_{mC_1}}{2}\left[V_{oM}-V_{OCM}\right]$$

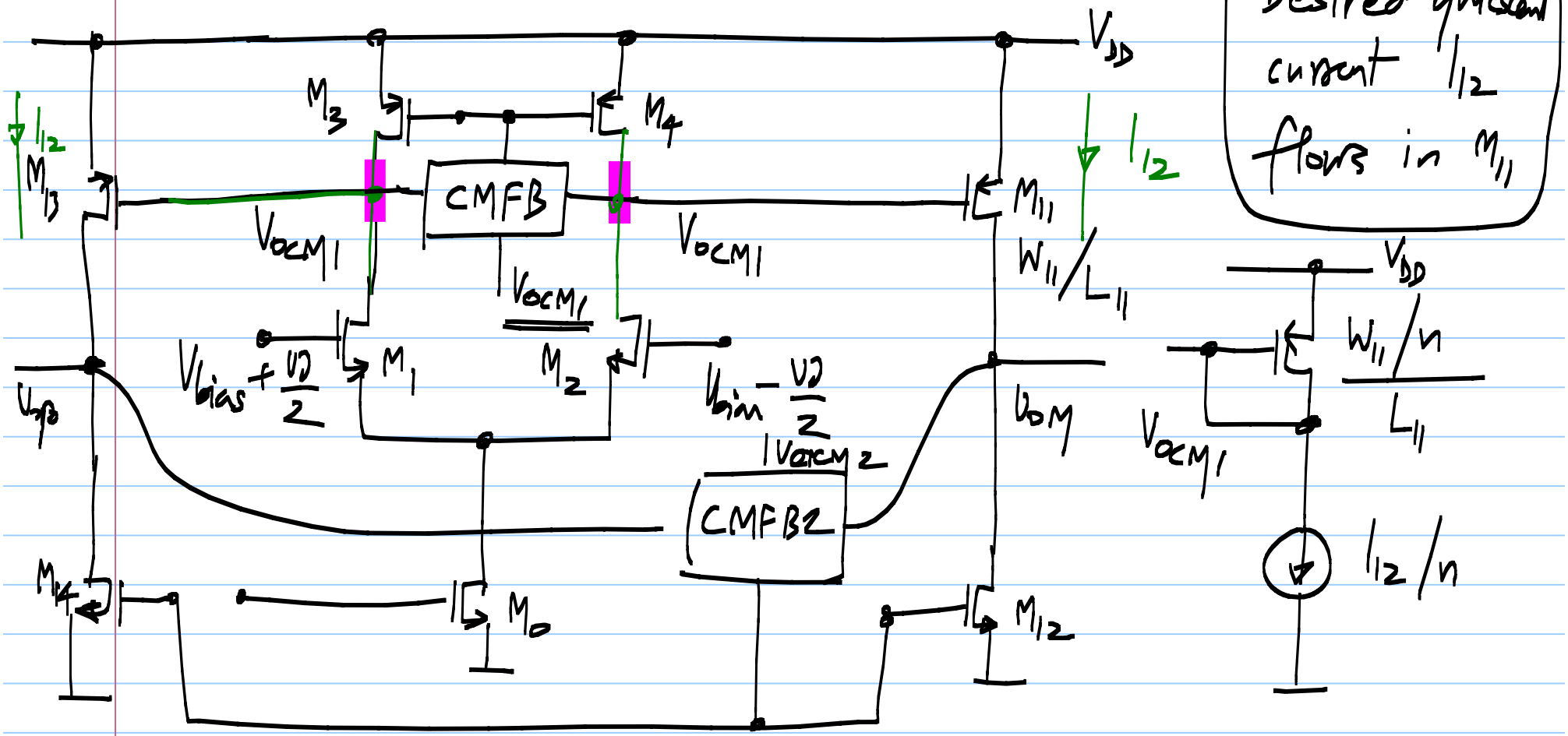


$$M_{C1A,1B,2A,2B} = \frac{1}{2} M_{C1}$$

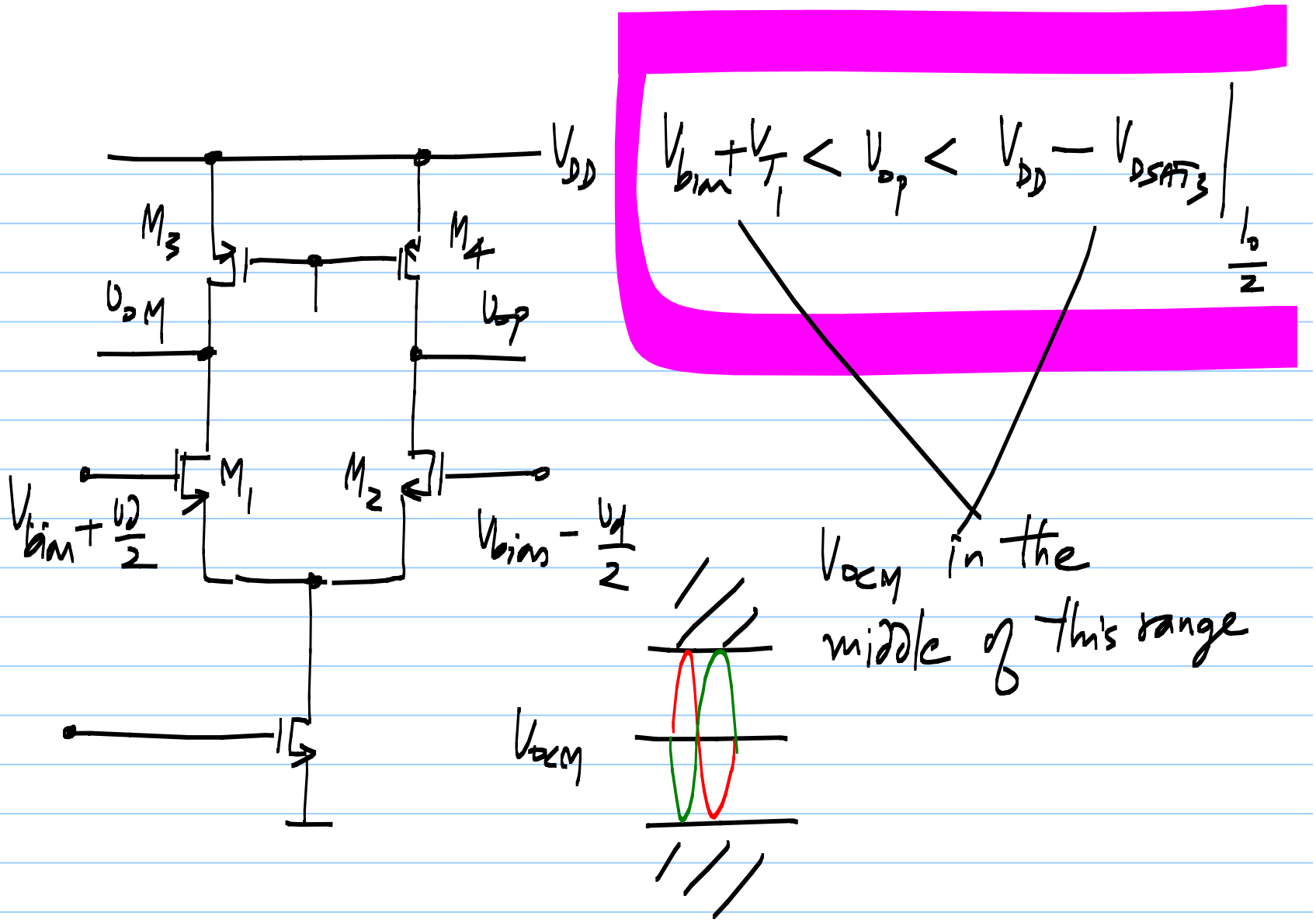

V_{DD}
M_3
M_4
C
C_{CM}
C_{CM}
C
V_{bp}
V_{DM}
M_1
M_2
V_{OCM}
V_{OCM}
I_0
M_0

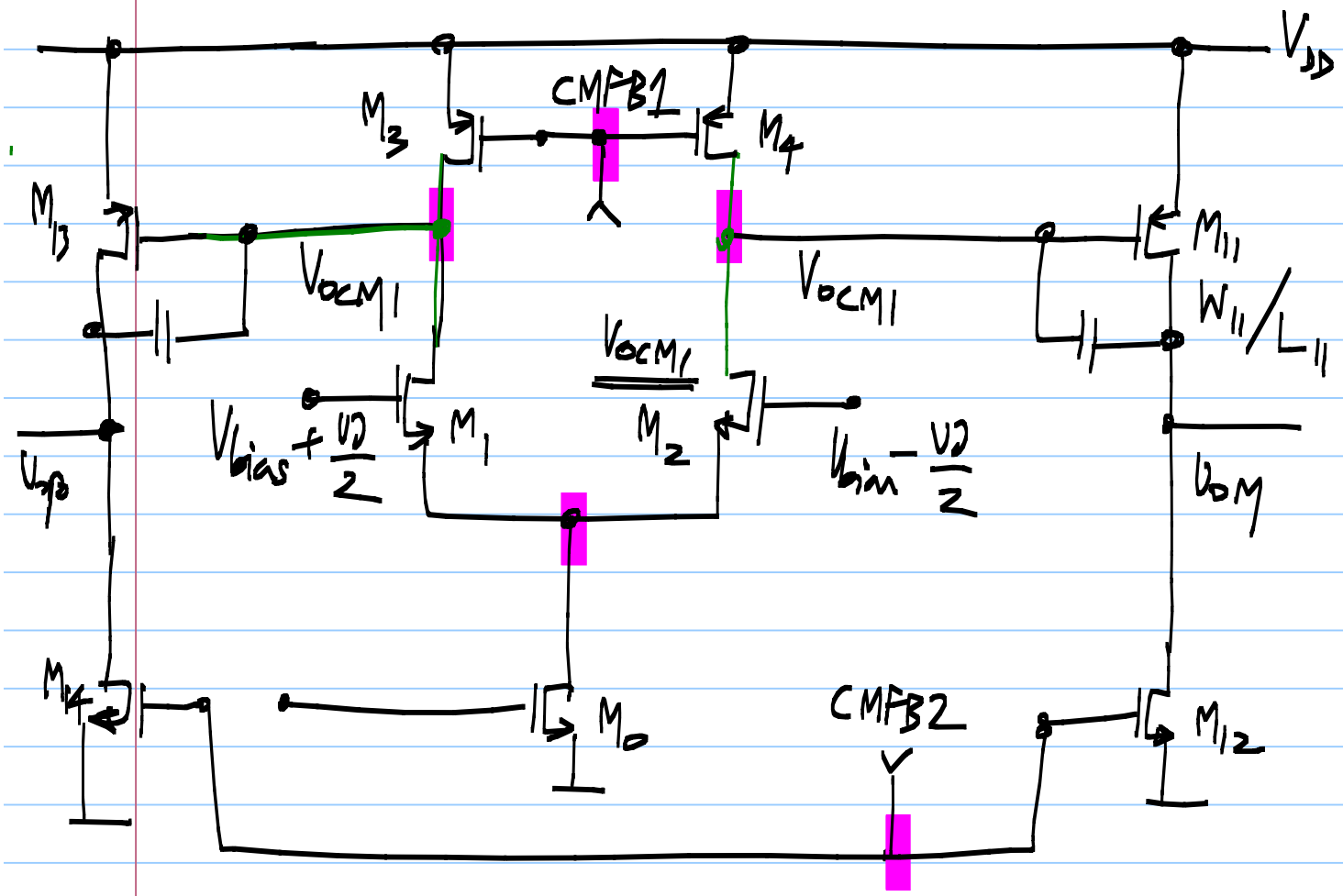

V_{DD}
M_3
M_4
C
C_{CM}
C_{CM}
C
V_{bp}
V_{OM}
V_{OCM}
M_1
M_2
W_{C_1}
W_{C_1}
2[C]
I_{bias}
M_0
I_{CO}

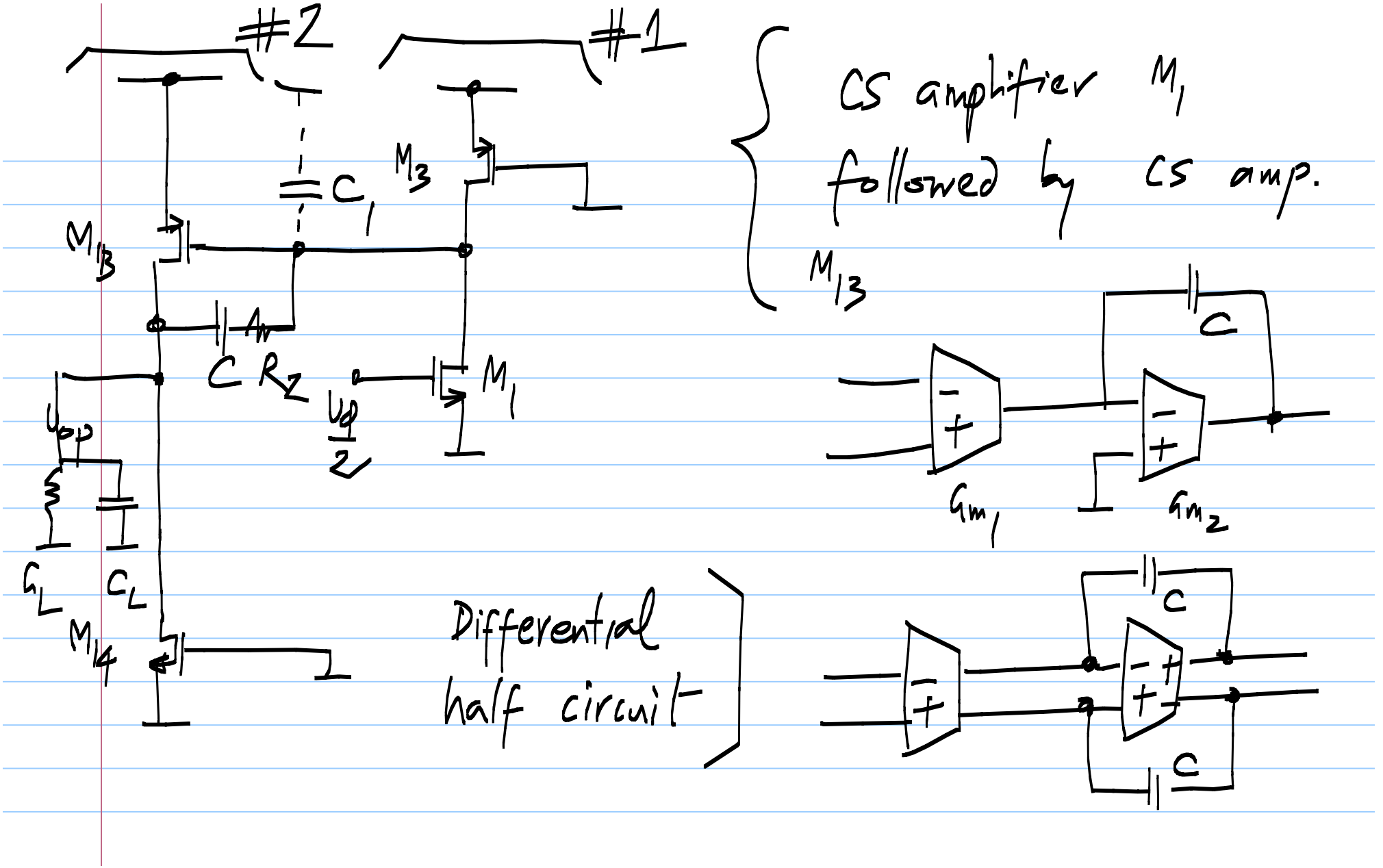
Fully differential two stage opamp.



V_{OCM1} : Desired quiescent current I_{12} flows in M_{11}


V_{DD}
M_3
M_4
V_{oM}
V_{op}
M_1
M_2
$V_{bias} + \frac{V_d}{2}$
$V_{bias} - \frac{V_d}{2}$
$V_{bias} + V_T < V_{op} < V_{DD} - V_{DSAT3}$
$\frac{I_0}{2}$
V_{OCM} in the middle of this range
V_{OCM}


V_{DD}
CMFB1
M_3
M_4
M_{13}
V_{OCM1}
V_{OCM1}
M_{11}
W_{11}/L_{11}
V_{OCM1}
$V_{bias} + \frac{V_D}{2}$
M_1
M_2
$V_{bias} - \frac{V_D}{2}$
V_{DM}
M_{14}
M_0
CMFB2
M_{12}


#2
#1
C_1
M_3
M_{13}
C
R_z
M_1
V_{in}
$\frac{V_o}{2}$
G_L
C_L
M_{14}
CS amplifier M_1
followed by CS amp.
M_{13}
C
G_{m_1}
G_{m_2}
Differential
half circuit
C
C

$$A_{2c} = \frac{g_{m_1}}{g_{ds_1} + g_{ds_3}} \cdot \frac{g_{m_{13}}}{g_{ds_{13}} + g_{ds_{14}} + G_L}$$

$$\omega_4 = \frac{g_{m_1}}{C}$$

$$p_2 = \frac{g_{m_{13}} \cdot \frac{C}{C + C_1}}{\frac{C \cdot C_1}{C + C_1} + C_L}$$

$$z_1 = \frac{g_{m_{13}}}{C} \rightsquigarrow \text{cancelled using } R_2$$