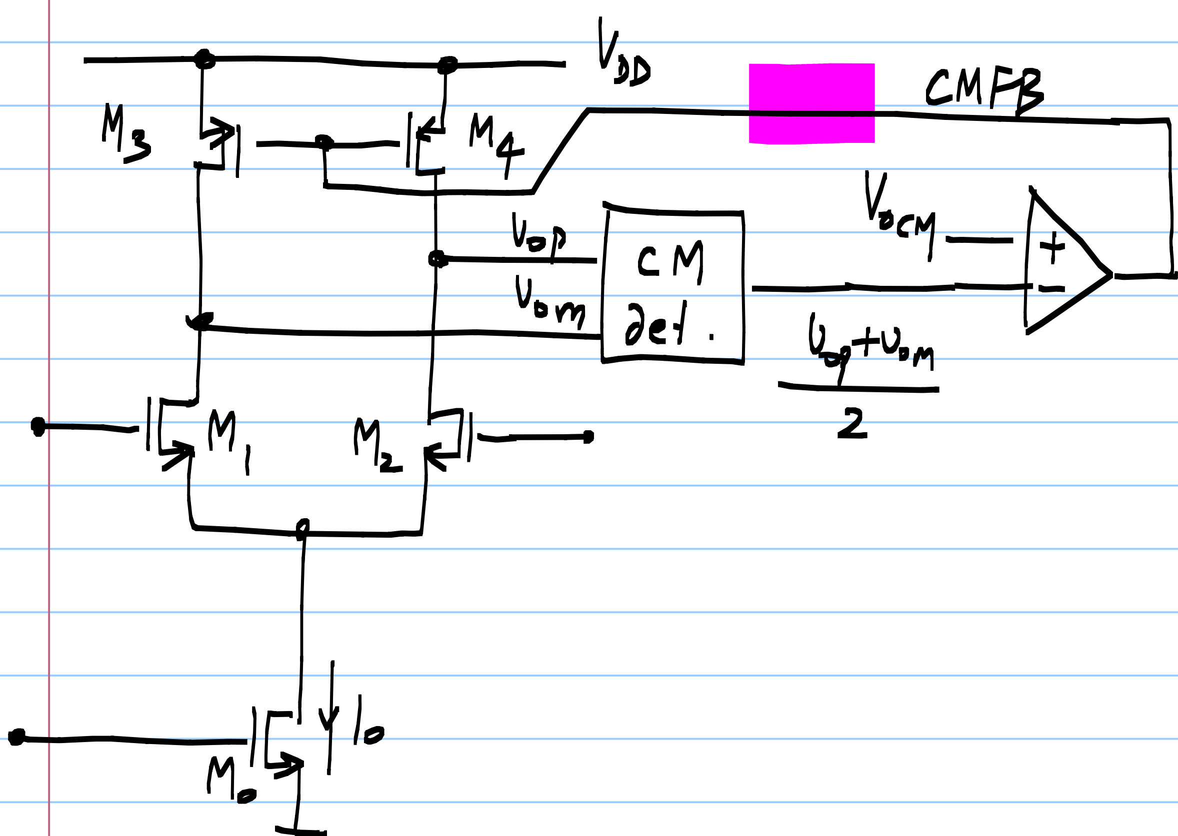
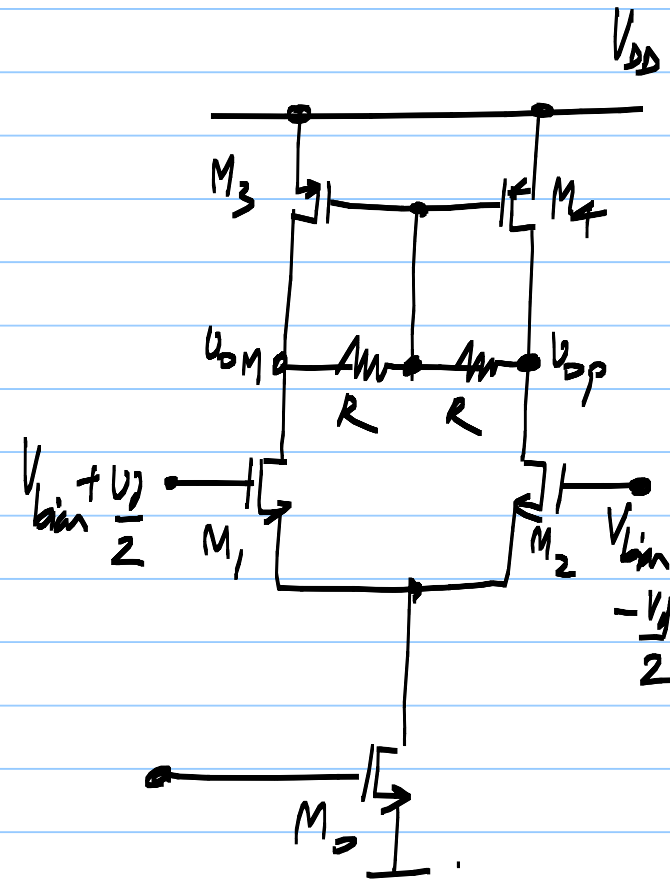
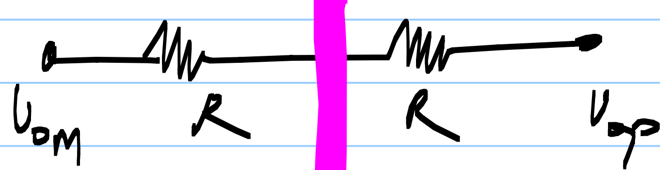
Lecture 41: Common mode feedback circuits



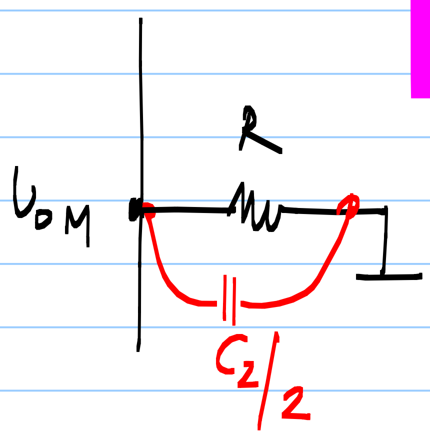


Resistive common mode detector:



$$\frac{V_{op}+V_{oM}}{2}.$$

* linear
* Range unlimited



Diff. half ckt — Loads the diff circuit.

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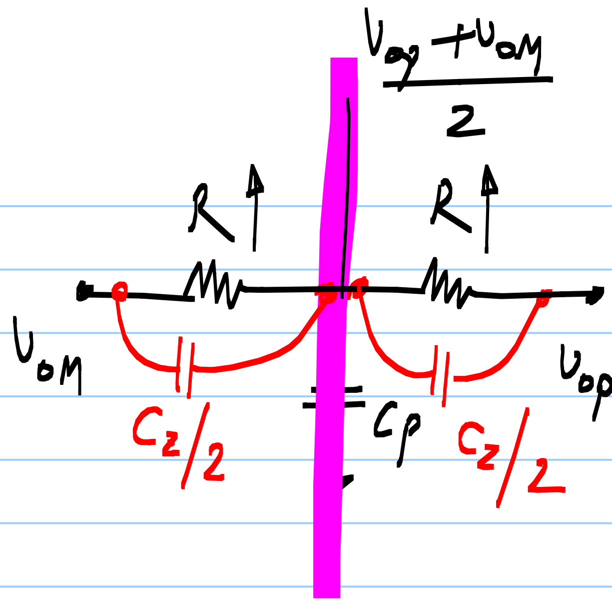
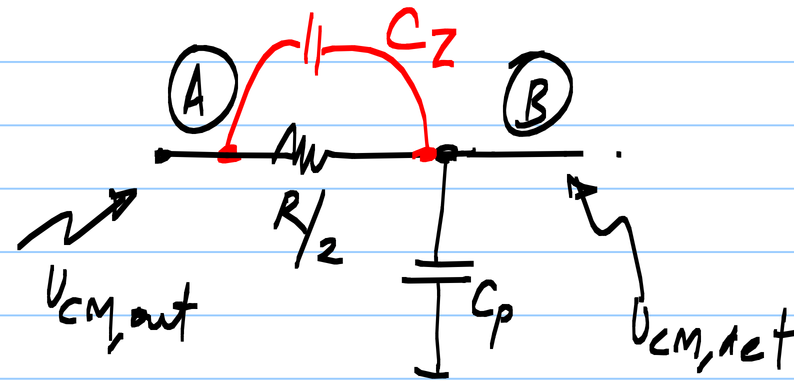


CM half circuit



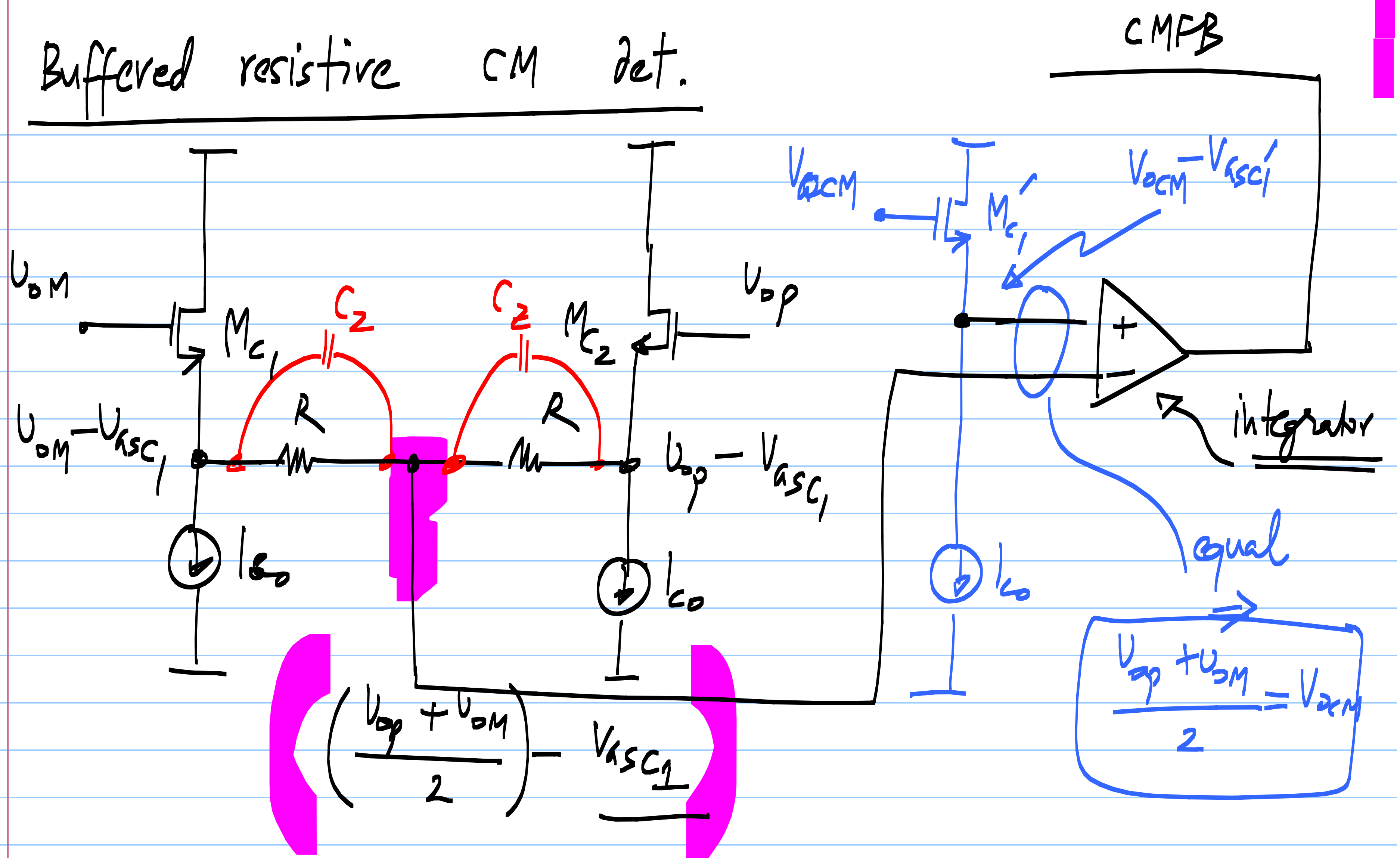
$$\frac{1}{1+sC_pR/2}$$

$$\frac{1+sC_z R/2}{1+s(C_z+C_p)R/2}$$

$$\frac{C_z}{C_z+C_p} \quad @\ \text{h.f}$$

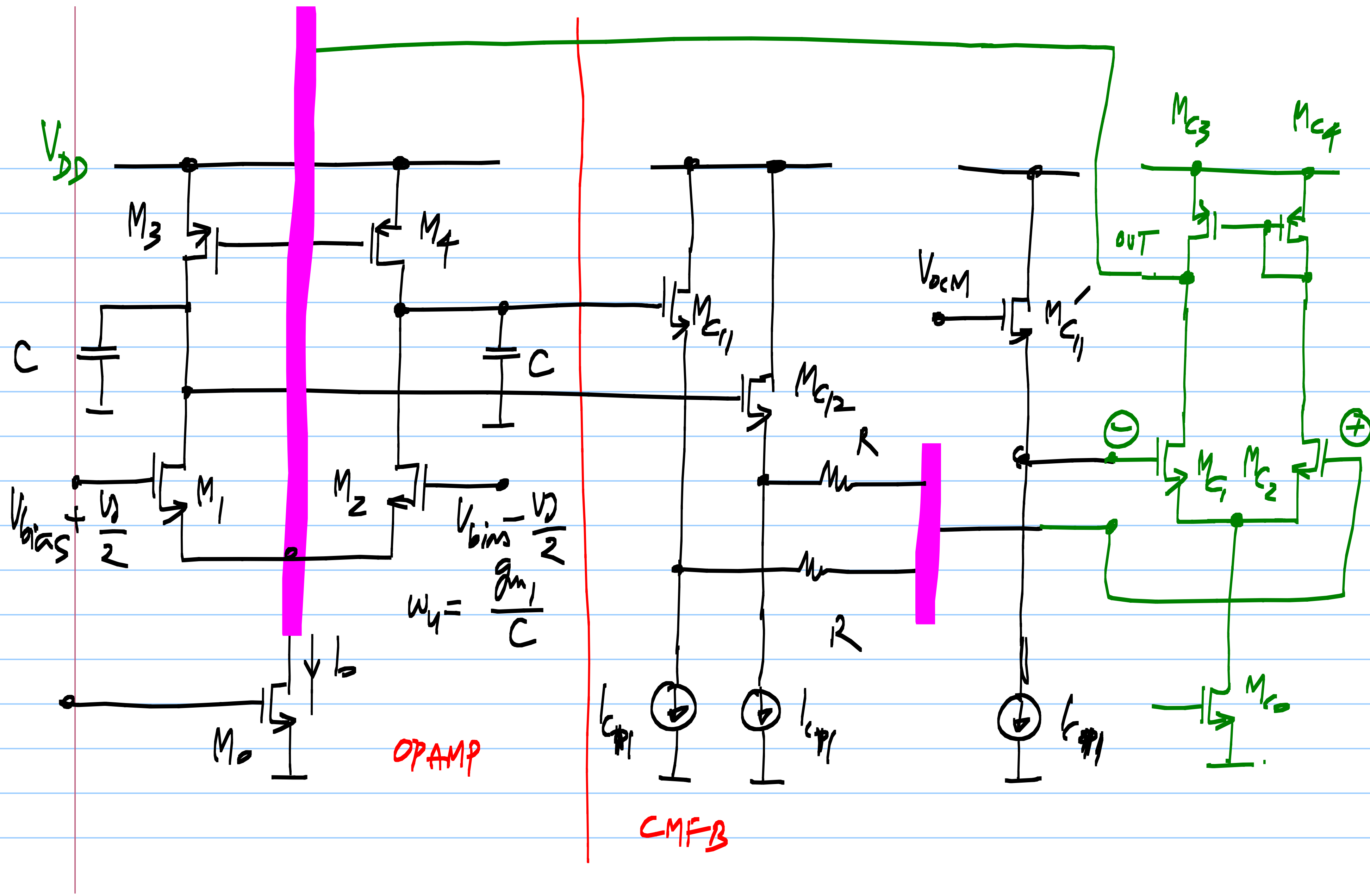
Introduce a zero

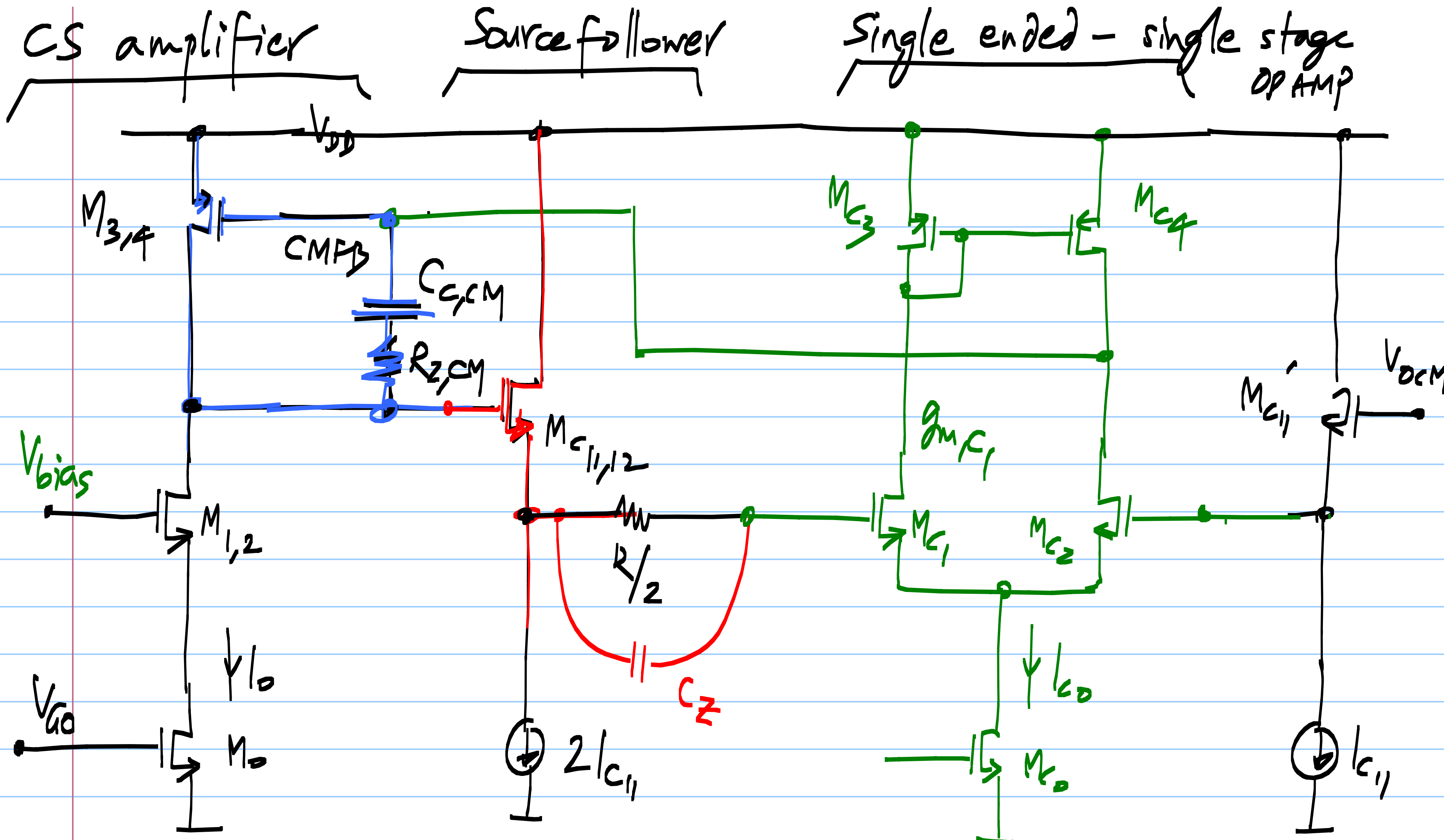
Buffered resistive CM det.



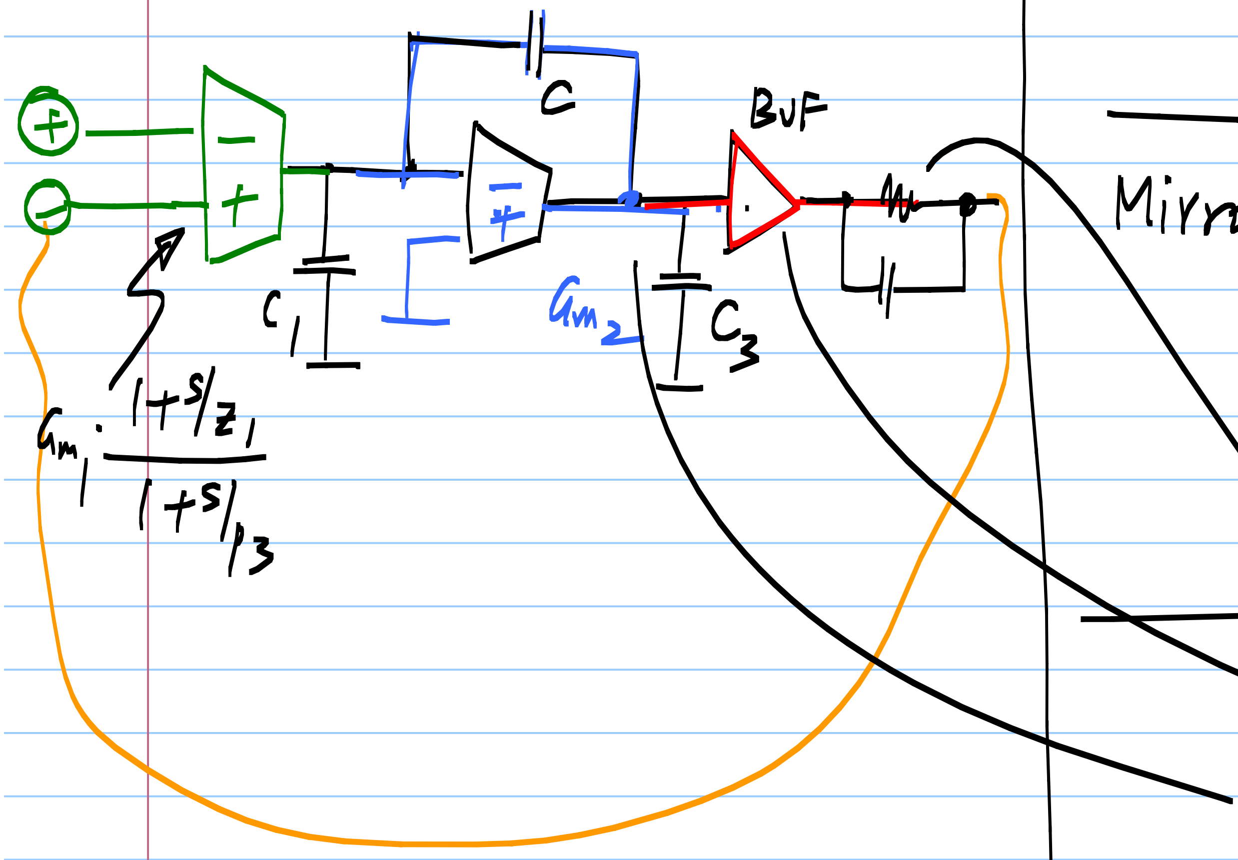
Buffered resistive CM det.

* No loading
* Swing limits
* Nonlinearity ; body effect


VDD
M3
M4
C
C
Mc11
Mc12
VOCM
Mc11'
Mc3
Mc4
OUT
R
R
M1
M2
Vbias + vd/2
Vbias − vd/2
ωu = gm1/C
Io
M0
OPAMP
Icp1
Icp1
Icp1
Mc1
Mc2
Mc0
CMFB


CS amplifier
Source follower
Single ended - single stage
op AMP
V_{DD}
$M_{3,4}$
CMFB
$C_{c,CM}$
$R_{z,CM}$
$M_{c_{11,12}}$
M_{c_3}
M_{c_4}
V_{ocM}
$M_{c_{11}}'$
g_{m,c_1}
V_{bias}
$M_{1,2}$
M_{c_1}
M_{c_2}
$R/2$
I_0
I_{c_0}
C_z
V_{G0}
M_0
$2I_{c_{11}}$
M_{c_0}
$I_{c_{11}}$

Two stage opamp



$$G_{m1} \cdot \frac{1+s/z_1}{1+s/p_3}$$

$$\omega_{u,loop,CM} = \frac{g_{mc1}}{C_{c,CM}}$$

Mirror pole & zero : $-\frac{g_{mc3}}{C_{p,c3}}$; $-\frac{2g_{mc3}}{C_{p,c3}}$

} Poles & Zeros

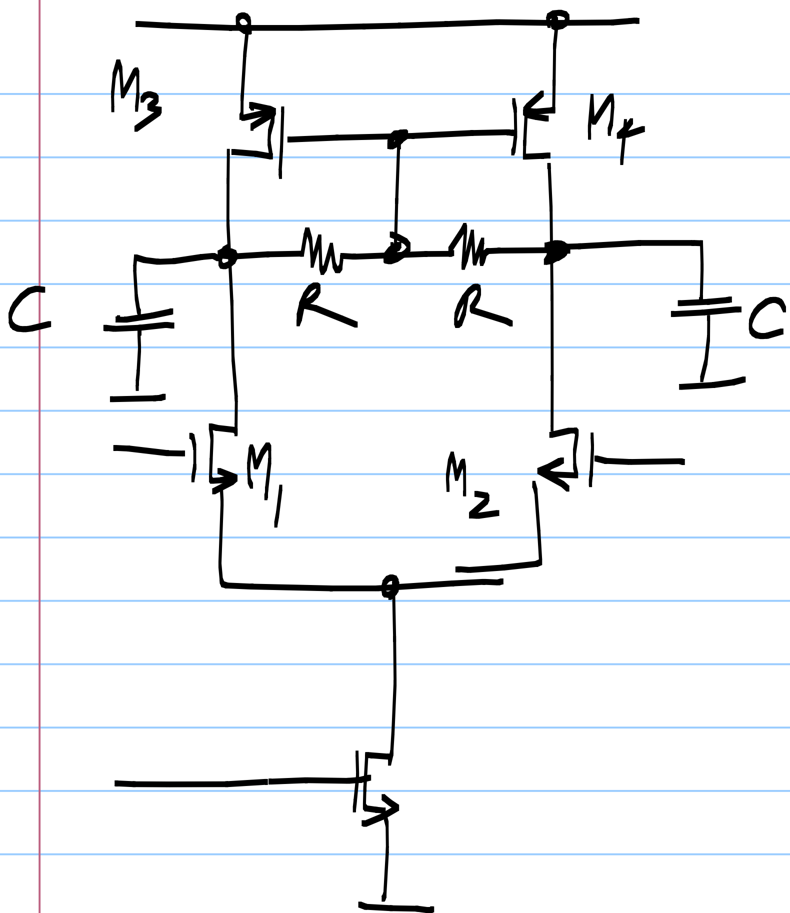
- Common mode feedback circuit is required to stabilize the o/p CM voltage of fully differential circuits

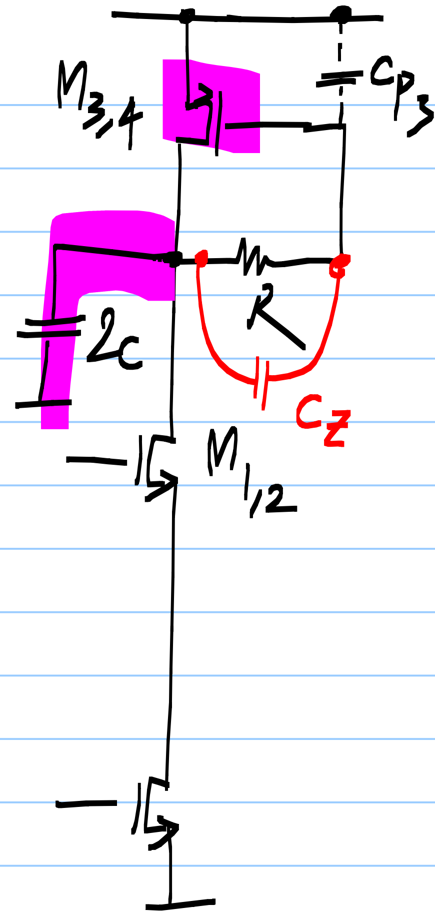
{ Common mode detector
{ Transconductor / opAMP

= Two stage single ended opAMP

- CMFB loop { CM eq. circuit of the complete opAMP } must be stable [Single stage opamp + Buffered CM det. + Single stage single-ended G_m - CMFB]

CM eq. half ckt

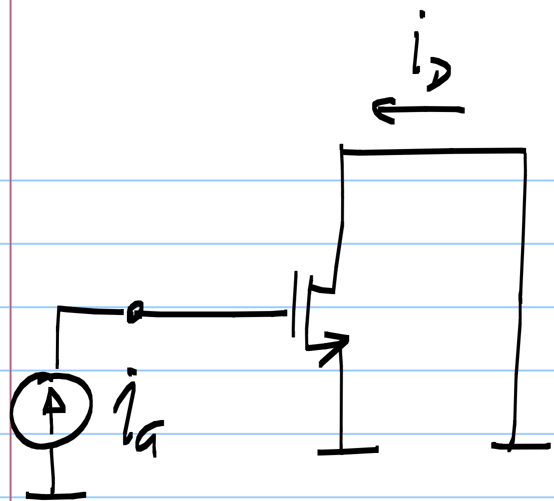


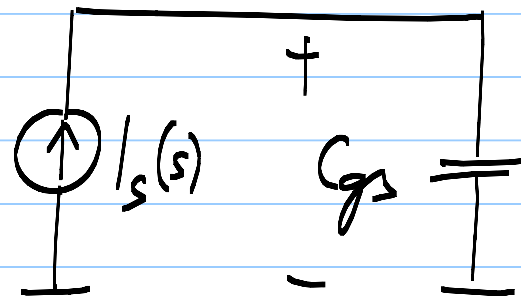


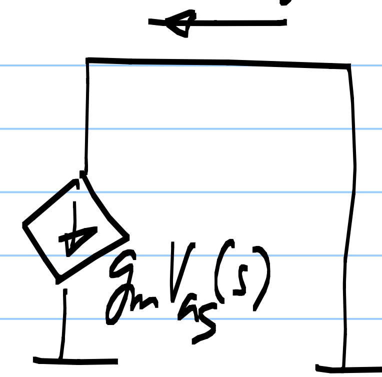
$M_{3/4}$

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

$$I_d = \frac{g_m}{sC_{gs}} I_s$$







MOS in saturation

$$V_{gs} = \frac{I_s}{s \cdot C_{gs}}$$

$$\frac{I_d}{I_g} = \frac{g_m}{sC_{gs}}\Bigg|_{s = j\omega} \xrightarrow{\text{mag.}} \frac{g_m}{\omega C_{gs}}$$

Unity gain frequency of $\left|\frac{I_D}{I_G}\right|$

Velocity saturation

$\frac{\mu (V_{GS}-V_T)}{L} \rightarrow v_{SAT}$

Transit frequency $\boxed{\omega_T = \frac{g_m}{C_{gs}}}$ $\quad f_T = \frac{g_m}{2\pi C_{gs}}$

$$\omega_T = \frac{g_m}{C_{gs}} = \frac{\mu C_{ox} \frac{W}{L} \cdot (V_{GS}-V_T)}{\frac{2}{3} C_{ox} \cdot WL} = \frac{3}{2} \cdot \frac{\mu (V_{GS}-V_T)}{L^2}$$

$(V_{GS}-V_T)$

$$\frac{3}{2} \cdot \frac{v_{SAT}}{L}$$

* $\omega_T = \frac{3}{2} \frac{\mu (V_{GS} - V_T)}{L^2}$ OR $\frac{3}{2} \cdot \frac{v_{SAT}}{L}$ has to be high — HIGH SPEED

Short channel L.

High $(V_{GS} - V_T)$; small parasitic capacitances

* $\sigma_{I_D}^2 = \frac{2 \mu C_{ox}}{I_D} \cdot \frac{A_{V_T}^2}{L^2} + \frac{A_\beta^2}{WL}$ — HIGH PRECISION

Long channel L, large W ⇒ large parasitic cap.

* Low power $I_D = \left(\frac{V_{GS} - V_T}{2}\right) g_m$ OR $\eta V_t \cdot g_m$

Low $(V_{GS} - V_T)$