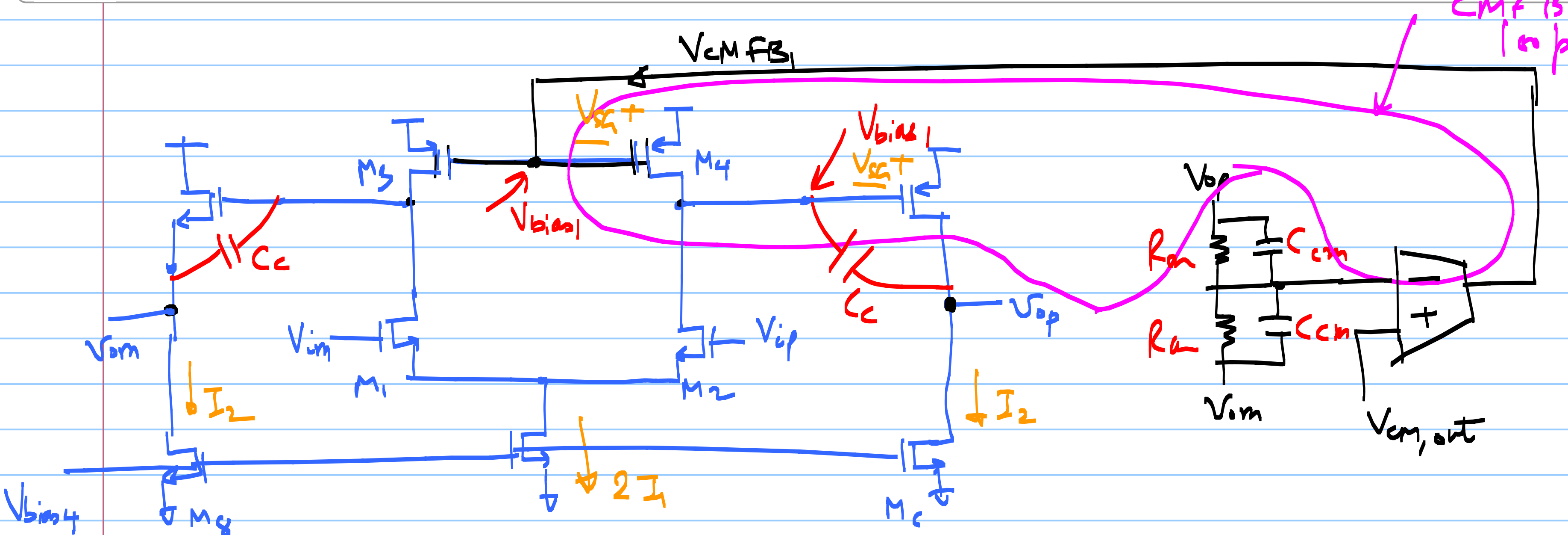
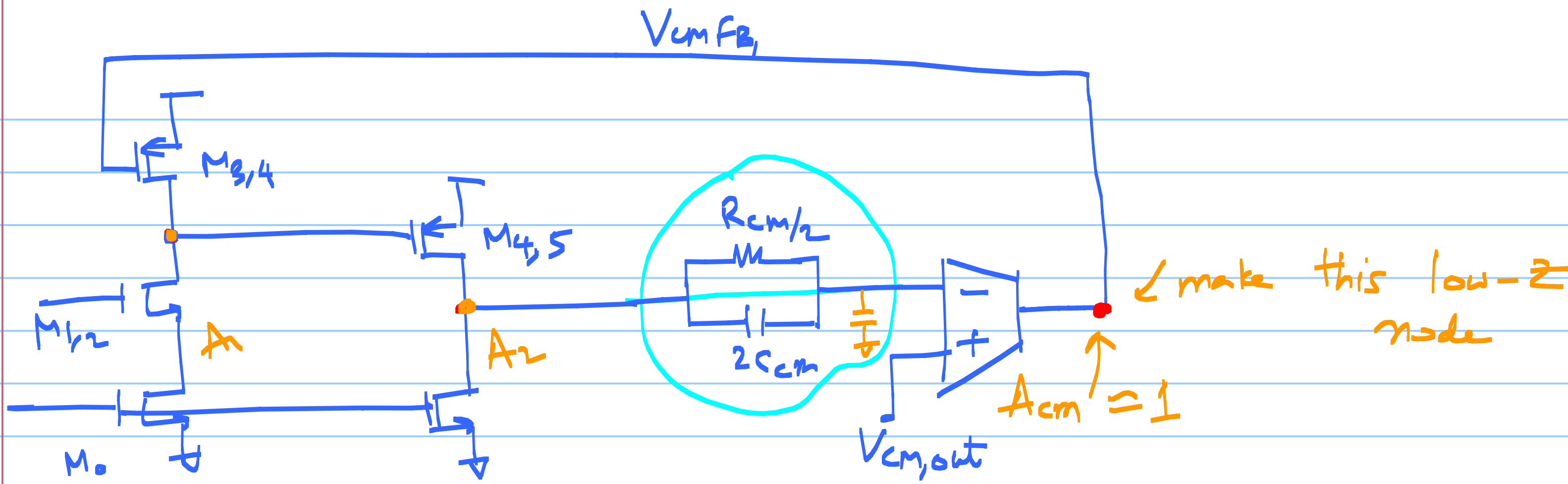
ECE 614 – Lecture 5

Note Title 9/11/2012



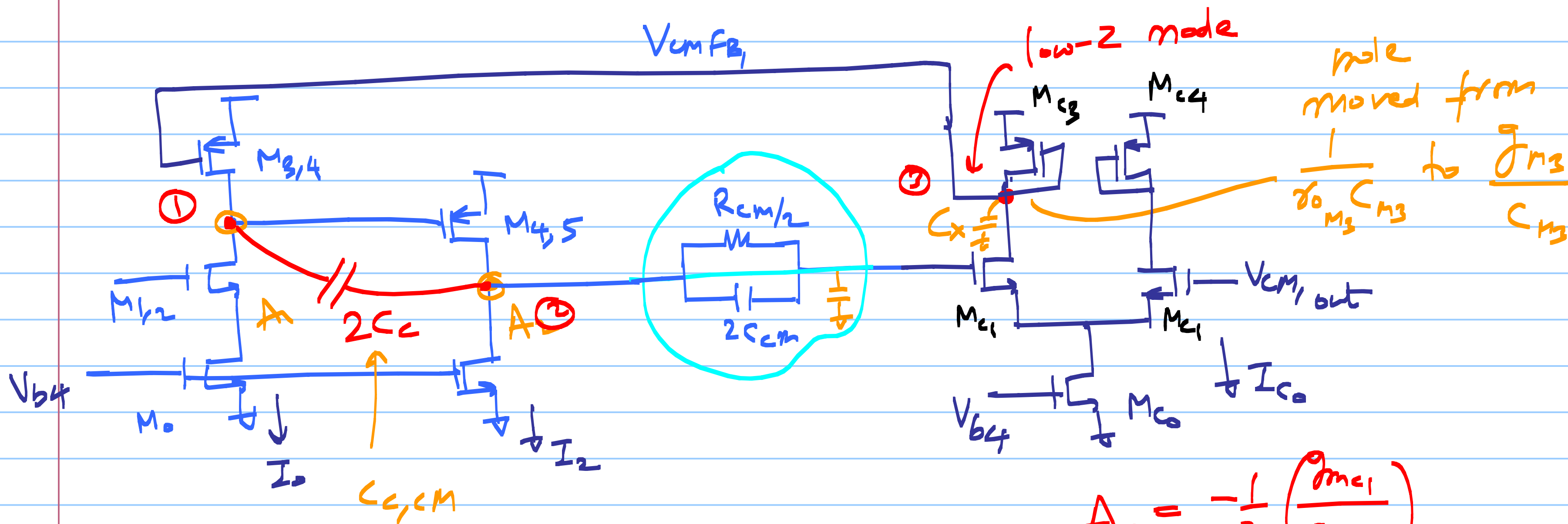
CM-equivalent circuit.



* 3 Low-freq poles
  ↳ need to compensate like a 3-stage opamp

OR

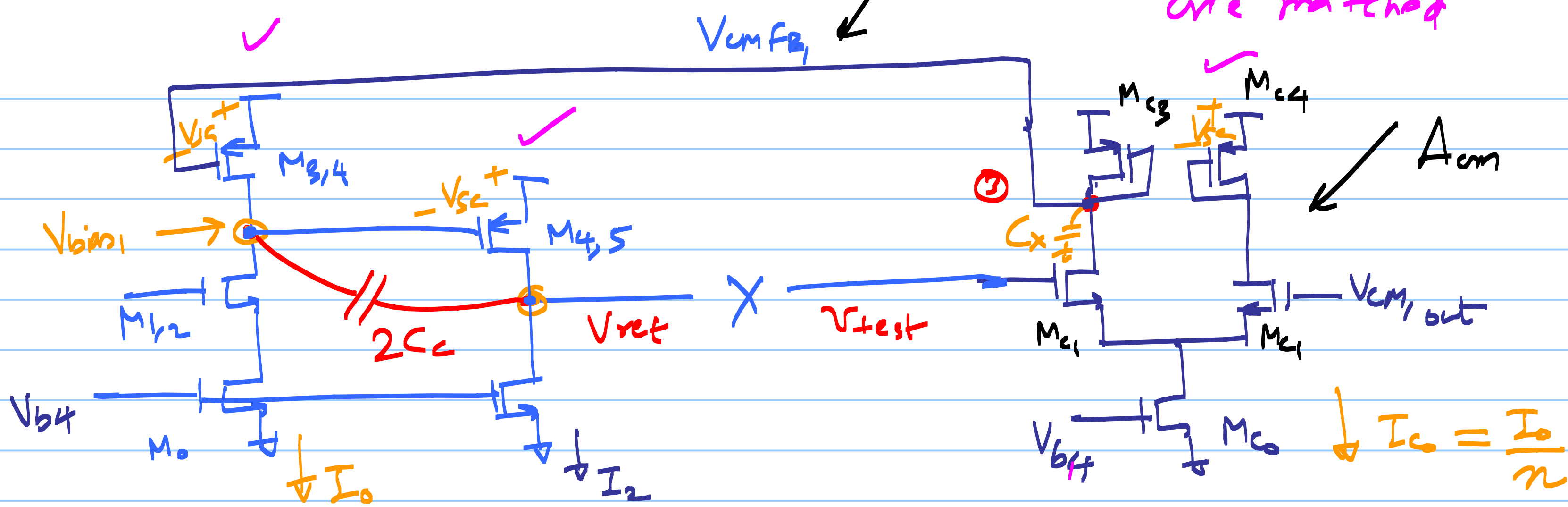
* Convert to two-pole system



$$A_{vm} = -\frac{1}{2}\left(\frac{g_{mc1}}{g_{mc3}}\right)$$

⇐ Can use the differential path C_c for compensating the CM-loop itself.

· ensure current densities are matched



@ V_{cmFB_1} ⇒

$$v_{ret} = \frac{A_{cm}\, g_{m_{3,4}}}{s \cdot 2C_c} \cdot v_{test}$$

$$\left.\frac{v_{ret}}{v_{test}}\right| = 1 \Rightarrow \omega_{u,cm} = \frac{A_{cm} \cdot g_{m_{3,4}}}{2C_c}$$

$$\omega_{u,CM} = \frac{A_{cm} \cdot g_{m3,4}}{2C_c} = \frac{1}{2}\left(\frac{g_{mc1}}{g_{mc3}}\right) \cdot \left(\frac{g_{m3,4}}{2C_c}\right) \quad 2g_{m3}$$

$$= \frac{1}{2} \cdot \frac{g_{mc1}}{g_{mc3}} \cdot \frac{g_{m3}}{C_c}$$

$$= \frac{1}{2} \cdot g_{mc1} \cdot \left(\frac{n}{C_c}\right) \qquad \because \; g_{mc1} = \frac{g_{m1}}{n}$$

$$= \frac{1}{2} \cdot \frac{g_{m1}}{C_c}$$

if $M_{c1,c2}$ & M_1 & M_2 have the same current density

$$\omega_{u,opamp} = \frac{g_{m1}}{C_c}$$

$$\boxed{\omega_{u,CM} = \frac{1}{2} \cdot \omega_{u,opamp}}$$

$n \Rightarrow \dfrac{I_{co}}{I_o}$

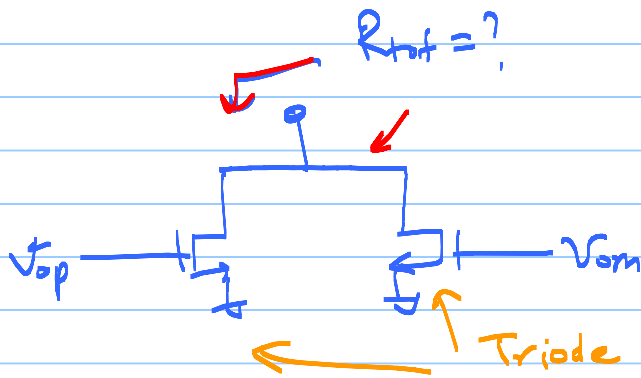
$$f_{p3} \simeq \frac{g_{m_{c3}}}{C_x} \rightarrow \underline{\underline{C_{gs_{M3}}}} + C_{gs_{error\text{-}amp}} \downarrow n$$

for $n \uparrow$

$\Rightarrow g_{m_{c3}} \downarrow$

$f_{p3} \downarrow$

CMFB using Triode Devices



$$R_{tot} = R_{on_1} \,||\, R_{on_2}$$

$$= \frac{1}{k'_n \frac{W}{L}(V_{op} - V_{THN})} \,\Big|\Big|\, \frac{1}{k'_n \frac{W}{L}(V_{om} - V_{THN})}$$

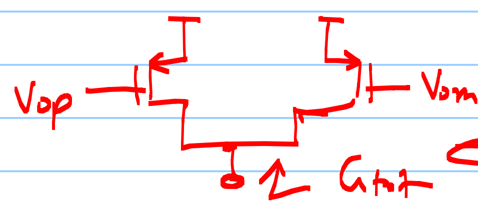
$$= \frac{1}{k'_n \frac{W}{L}(V_{op} + V_{om} - 2V_{THN})}$$

$$= \frac{1}{2\beta_n \left[\left(\frac{V_{op} + V_{om}}{2} \right) - V_{THN} \right]}$$

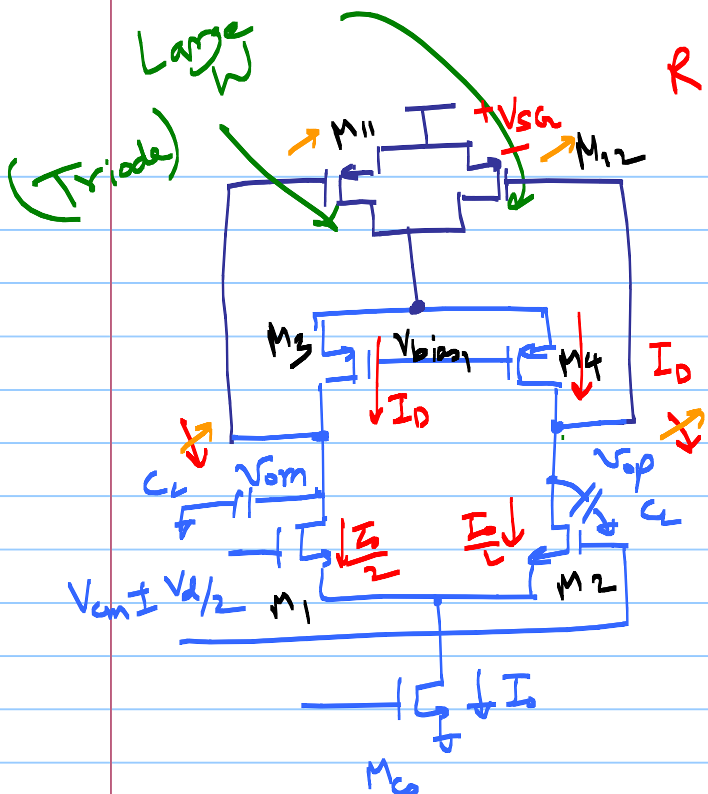
$V_{o,cm}$

$$g_{tot} = 2\beta_n \left[\frac{V_{op} + V_{om}}{2} - V_{THN} \right]$$

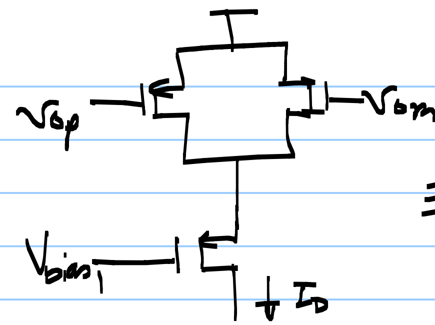
$$g_{tot} = f(V_{o,cm})$$



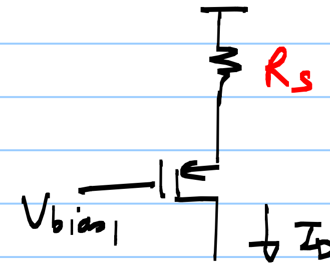
PMOS CM-detector



$$R_{on} \propto \frac{1}{V_{SG} - V_{THP}}$$



$\equiv$



$R_s \downarrow \Rightarrow$

$$\frac{V_{op} + V_{om}}{2} = ?$$

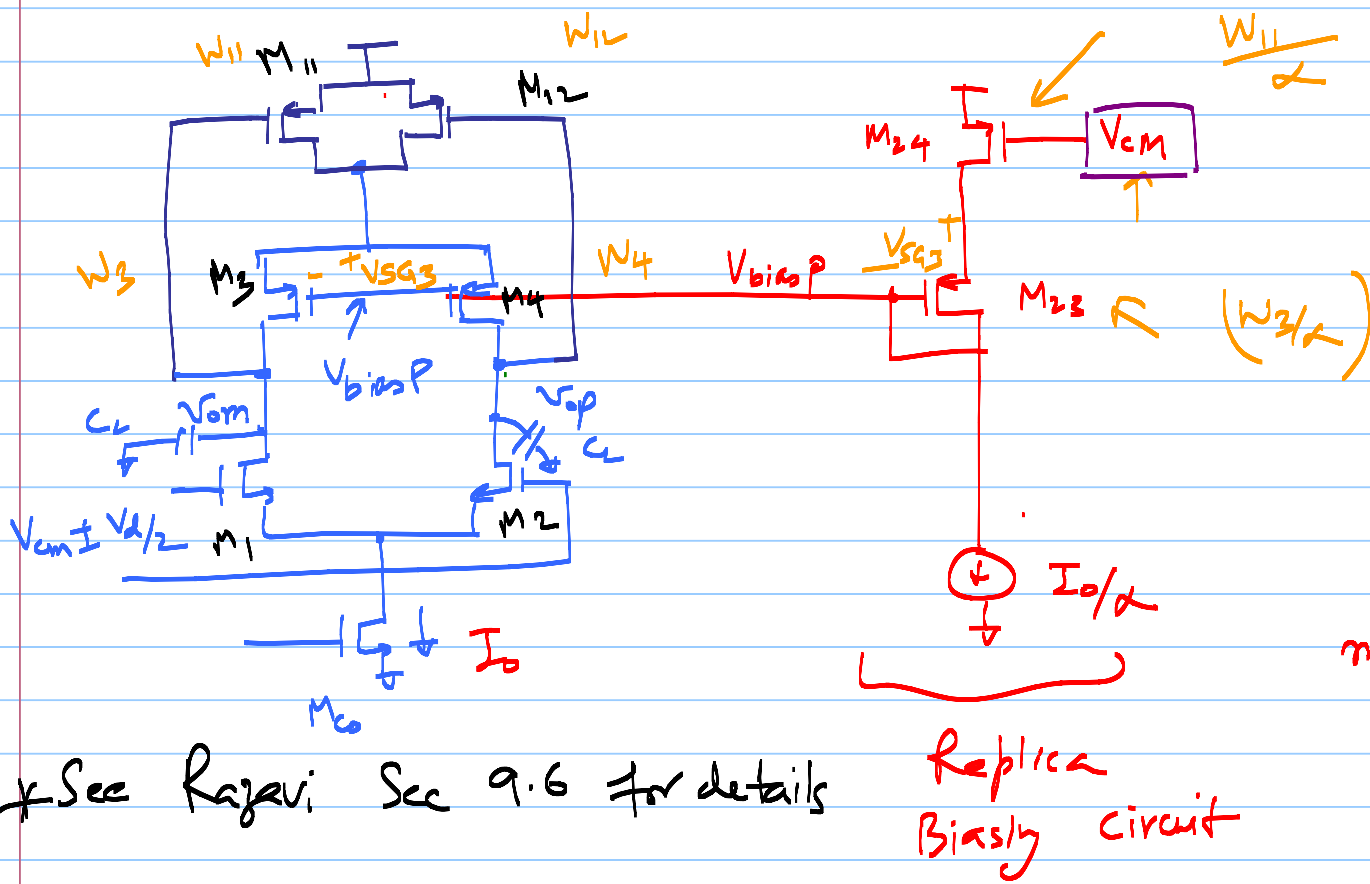
$$G_m = \frac{g_m}{1 + g_m R_s}$$

$$R_S = R_{on_1} \| R_{in_2} = \frac{(V_{DD} - V_{bias_1} - V_{SG_{3,4}})}{2 I_D} = \frac{1}{2 k p_p \left(\frac{W}{L}\right)_{1,2} \left(\frac{V_{op} + V_{om}}{2} - V_{THp}\right)}$$

Solve

$$V_{o,cm} = \frac{V_{op} + V_{om}}{2} = \frac{I_D}{k p_p \cdot \left(\frac{W}{L}\right)_{3,4}} \cdot \frac{1}{V_{DD} - V_{bias_1} - V_{SG_{3,4}}} + V_{THp}$$

depends on device parameters



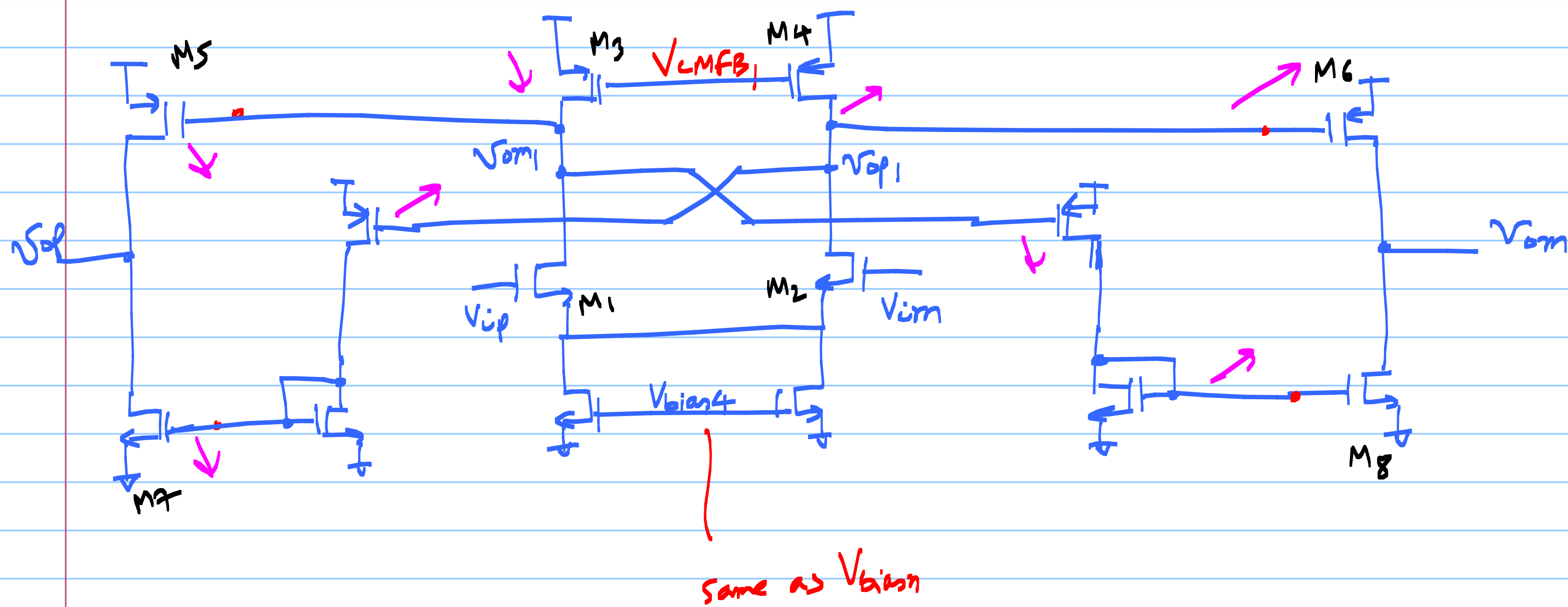
$$\left(\frac{V_{op}+V_{om}}{2}\right) \triangleq V_{cm}$$

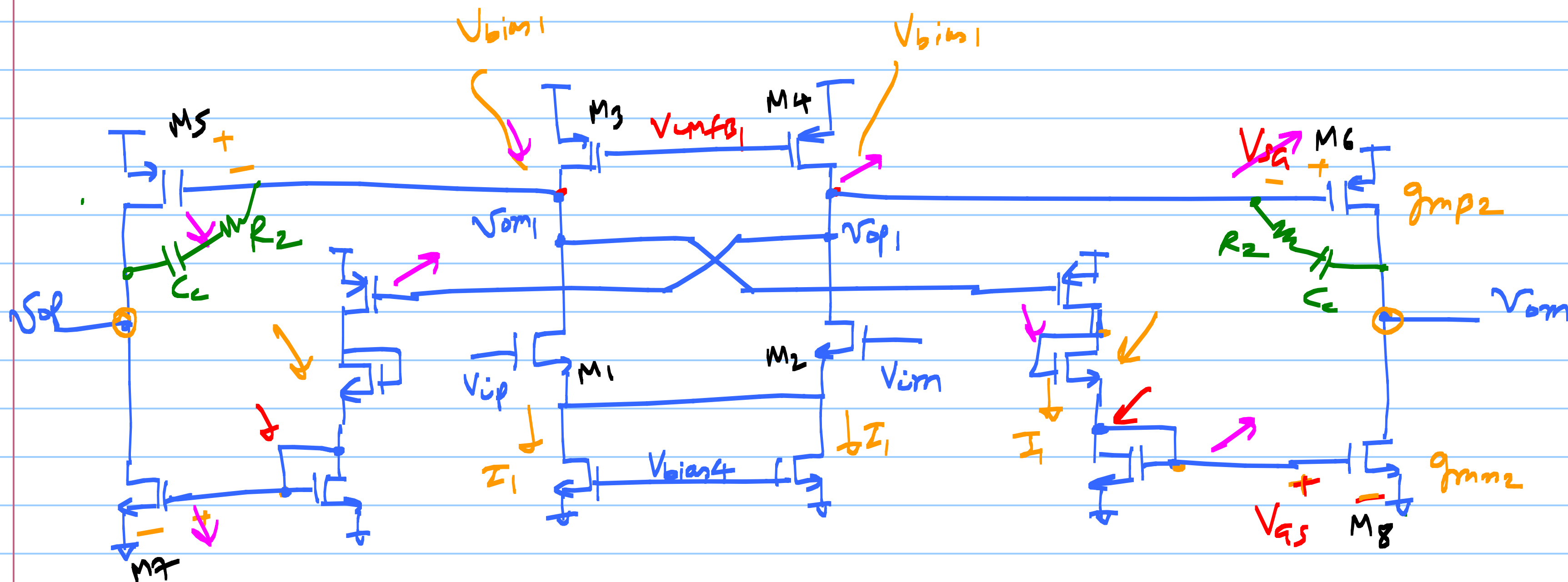
match the (W/I)

$$\frac{W_{11/12}}{I_0} = \frac{W_{34}}{I_0/\alpha}$$

* See Razavi Sec 9.6 for details

Class-AB output stage





Vbias1
Vbias1
M5
M3
Vcmfb1
M4
M6
Vom1
Vop1
R2
Cc
Vop
Vom
Vip
M1
M2
Vin
I1
I1
Vbias4
gmp2
gmn2
Vgs
M7
M8