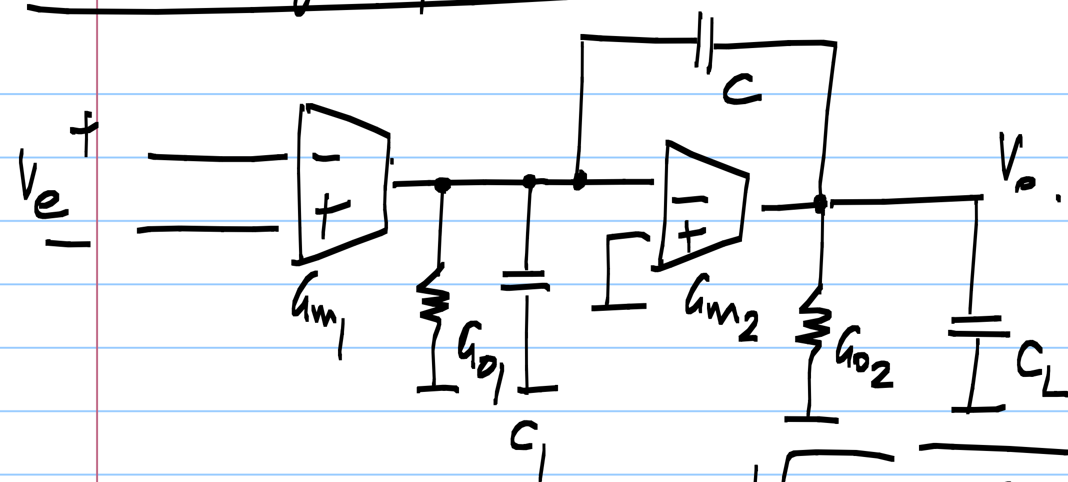
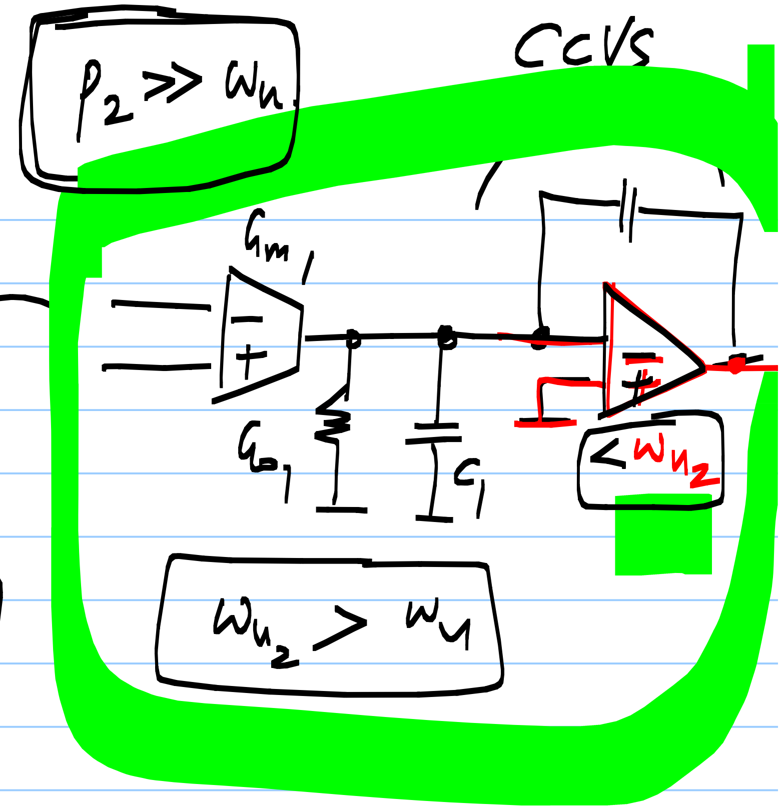
Two stage opamp.





$$A_0 = G_{m1} G_{m2} / G_{o1} G_{o2}$$

$$\omega_u = \frac{G_{m1}}{C}$$

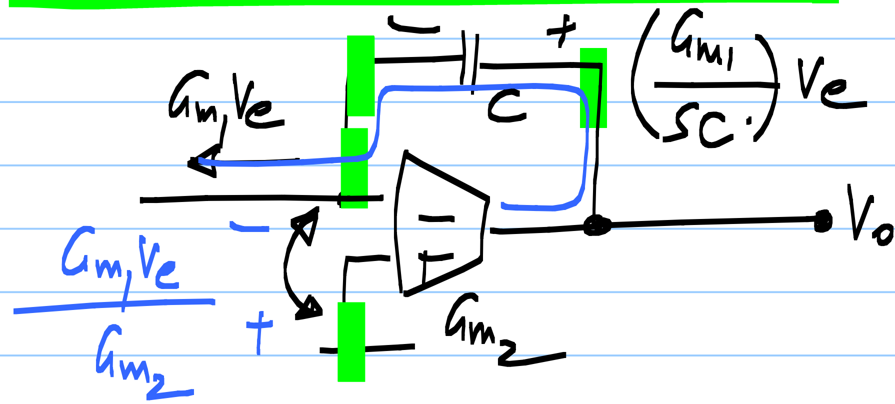
$$p_1 = - G_{o1} \Big/ \left[C_1 + C \left(G_{m2}/G_{o2} + 1 \right) \right]$$

$C \gg C_1$

$$p_2 = - \left[G_{m2} \cdot \frac{C}{C + C_1} + G_{o2} \right] \Big/ \left[C_L + \frac{C C_1}{C + C_1} \right] \simeq \frac{G_{m2} + \cancel{G_{o2}}}{C_L + C_1} \simeq \frac{G_{m2}}{C_L}$$

$$z_1 = + G_{m2}/C$$

Right half plane zero → phase lag . $\left(\frac{G_{m1} \cdot V_e}{G_{m2}}\right)$?



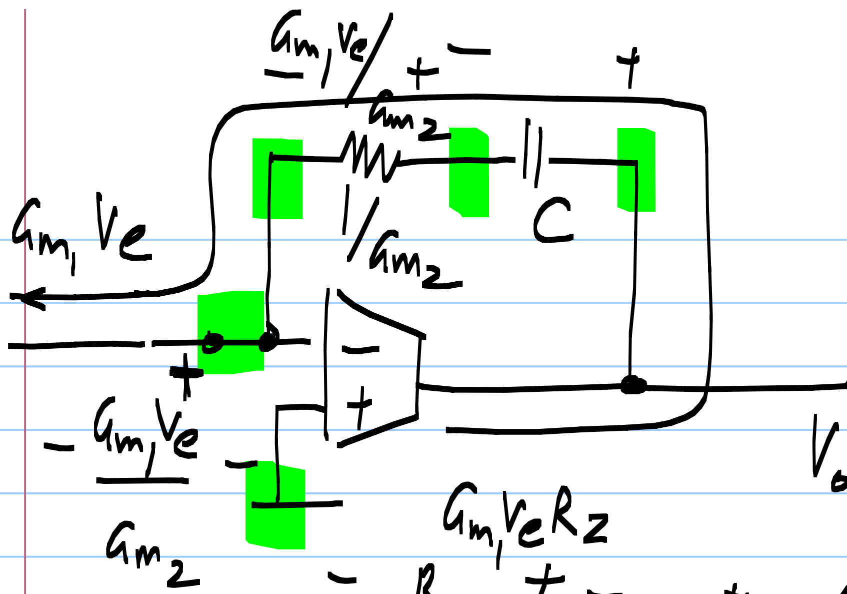
$$= \left\{ G_{m1} V_e \left(\frac{1}{sC} - \frac{1}{G_{m2}}\right) \right\}$$

$$= G_{m1} V_e \left(\frac{G_{m2} - sC}{G_{m2} \cdot sC}\right)$$

$$G_{m1} V_e \left[\frac{1}{sC} - \frac{1}{G_{m2}} + \frac{1}{G_{m2}} \right]$$

✓ ✗

Add this term for eliminating the RHP zero

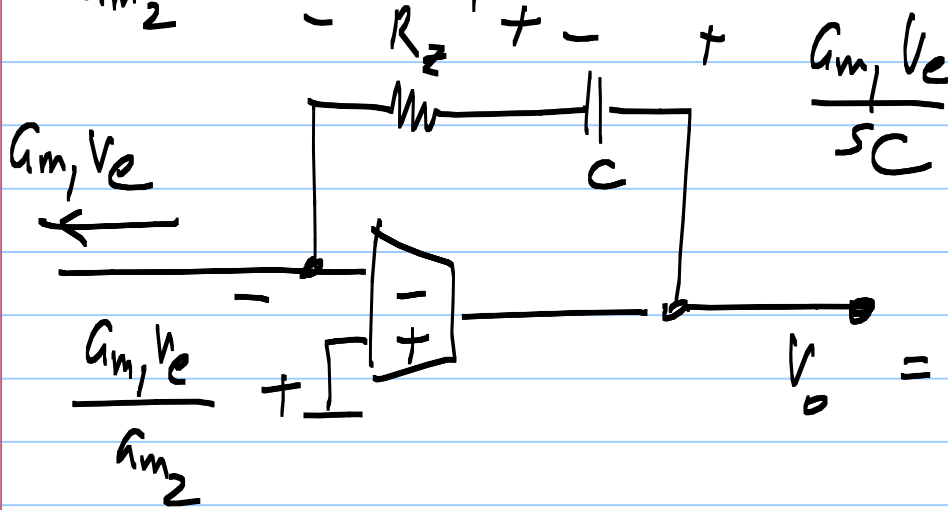


$$\frac{G_{m1}}{G_{m2}} \cdot V_e$$

$$V_o = \frac{G_{m1} \cdot V_e}{sC}$$

Zero:

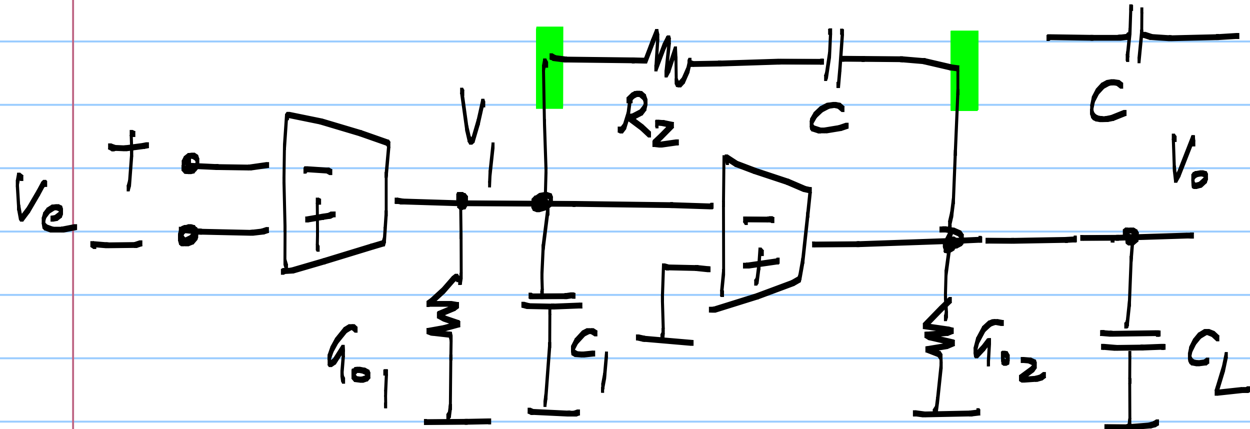
$$-\frac{G_{m2}}{(G_{m2}R_z - 1)\,C}$$



$$V_o = G_{m1}V_e\left[\frac{1}{sC} + R_z - \frac{1}{G_{m2}}\right]$$

$$= G_{m1}V_e\left[\frac{G_{m2} + (G_{m2}R_z - 1)sC}{sC \cdot G_{m2}}\right]$$

Two stage opamp with RHP zero cancellation



3 poles

$$sC \rightarrow \frac{sC}{1+sCR_z}$$

$$\begin{bmatrix} sC_1 + \frac{sC}{1+sCR_z} + G_{o1} & -\frac{sC}{1+sCR_z} \\ G_{m2} - \frac{sC}{1+sCR_z} & sC_L + \frac{sC}{1+sCR_z} + G_{o2} \end{bmatrix} \begin{bmatrix} V_1 \\ V_o \end{bmatrix} = \begin{bmatrix} -G_{m1}V_e \\ 0 \end{bmatrix}$$

R_z	z_1
$= \frac{1}{G_{m2}}$	∞
$< \frac{1}{G_{m2}}$	RHP
$> \frac{1}{G_{m2}}$	LHP

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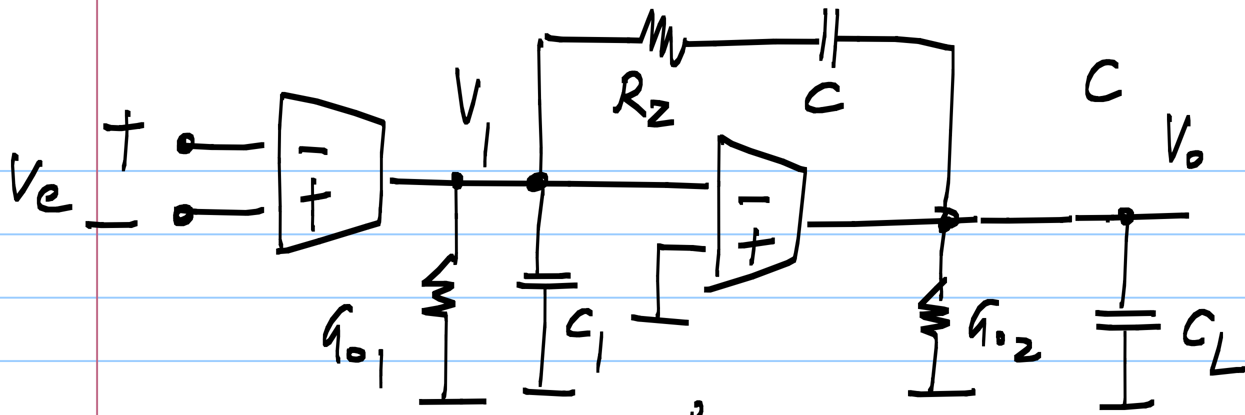
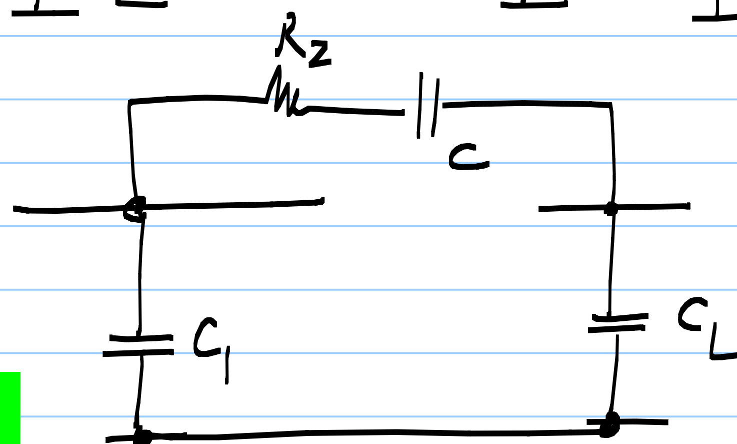


$p_3 \simeq$

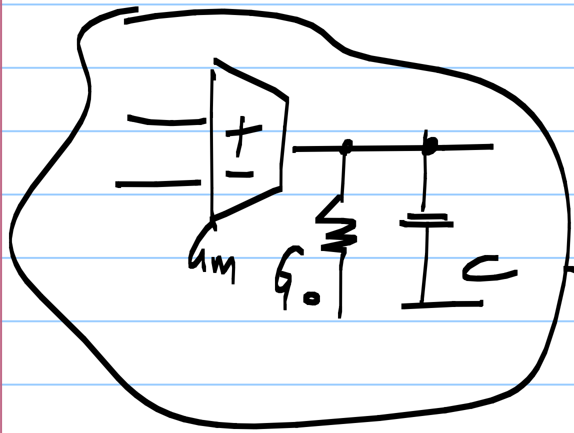
$$-\frac{1}{R_z}\cdot\left(\frac{1}{C}+\frac{1}{C_L}+\frac{1}{C_1}\right)$$

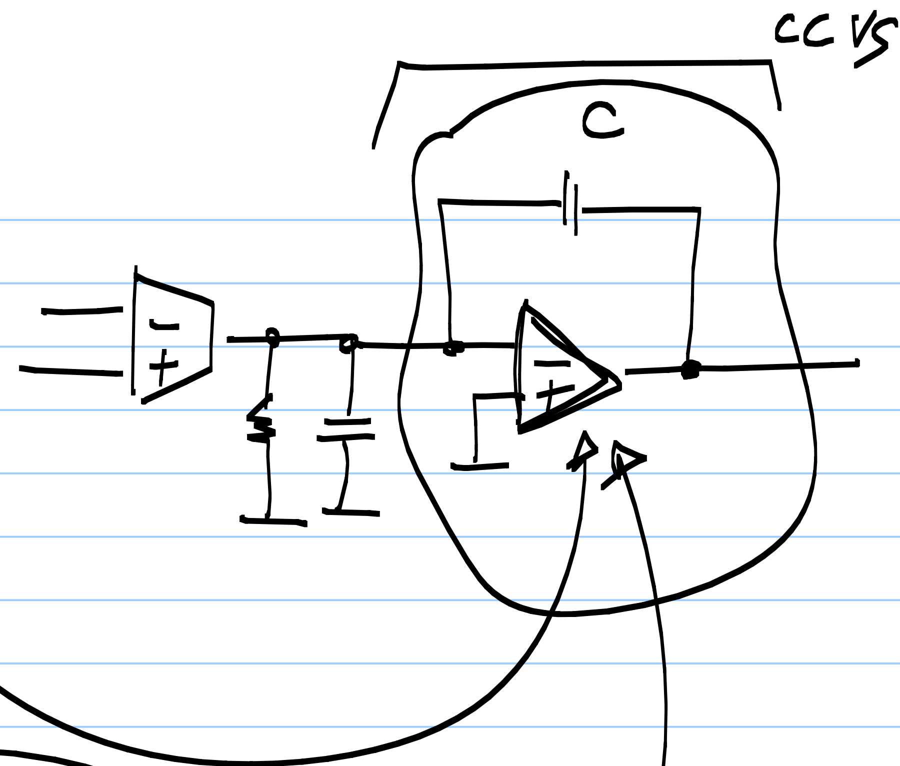


$R_z = \frac{1}{G_{m2}}$ ~~RHP zero~~ ; $-G_{m2}\left(\frac{1}{C}+\frac{1}{C_L}+\frac{1}{C_1}\right)$

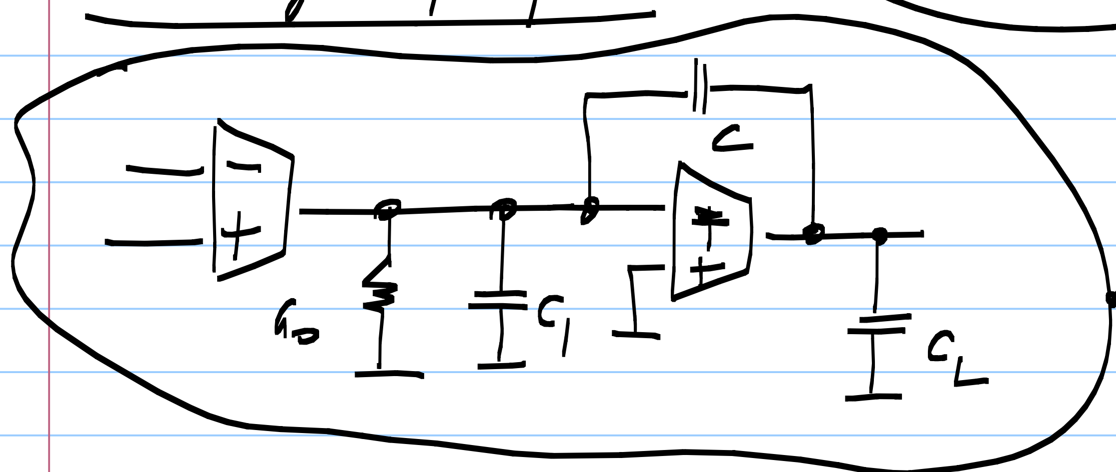
(G_{m2}/C)

Single stage opamp:

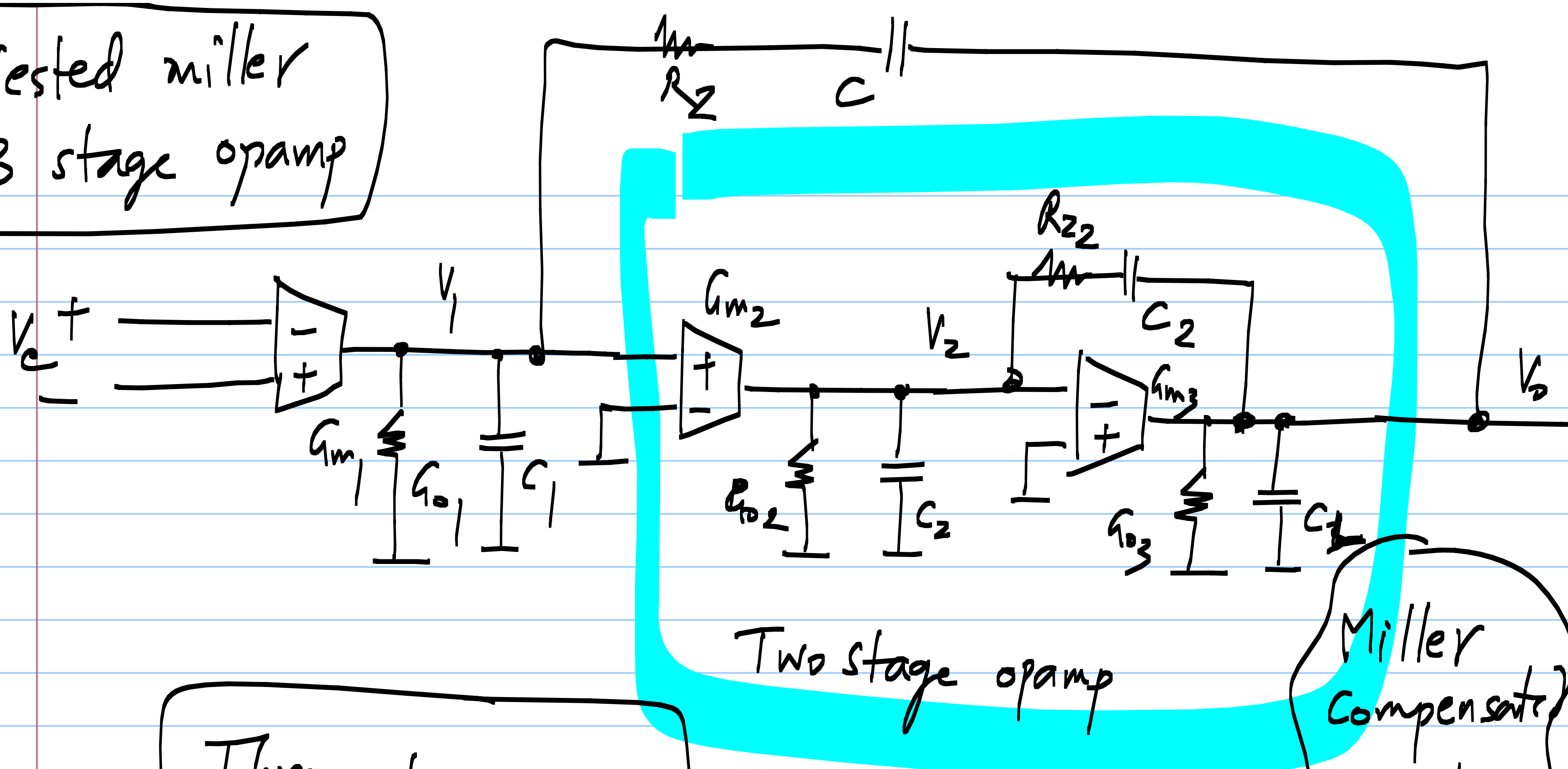




Two stage opamp:



Nested miller 3 stage opamp



Three stage opamp

$$A_0 = \frac{G_{m_1} G_{m_2} G_{m_3}}{G_{o_1} G_{o_2} G_{o_3}}$$

Miller Compensated 2 stage opamp

* Unity gain frequency of the opamp being realized $= \frac{G_{m1}}{C}$

* Unity gain frequency of the two stage opamp used for the CCVS $= \frac{G_{m2}}{C_2}$

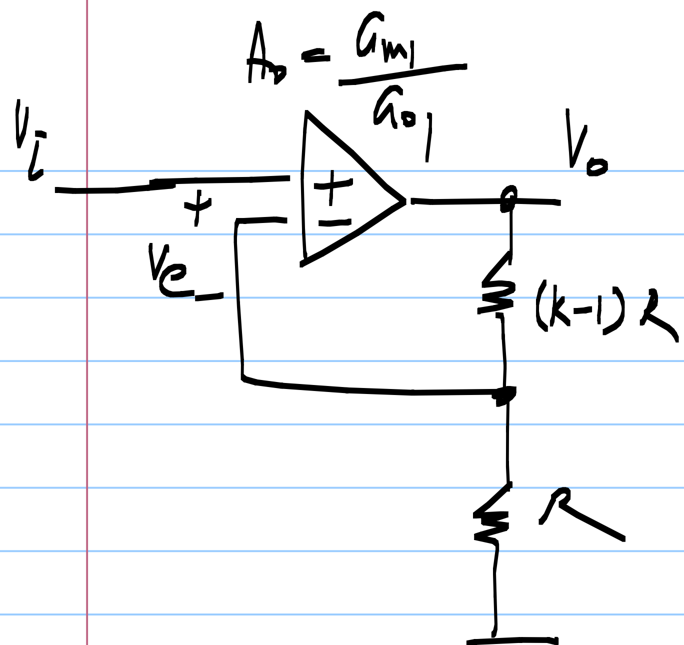
$$\frac{G_{m2}}{C_2} > \frac{G_{m1}}{C}$$

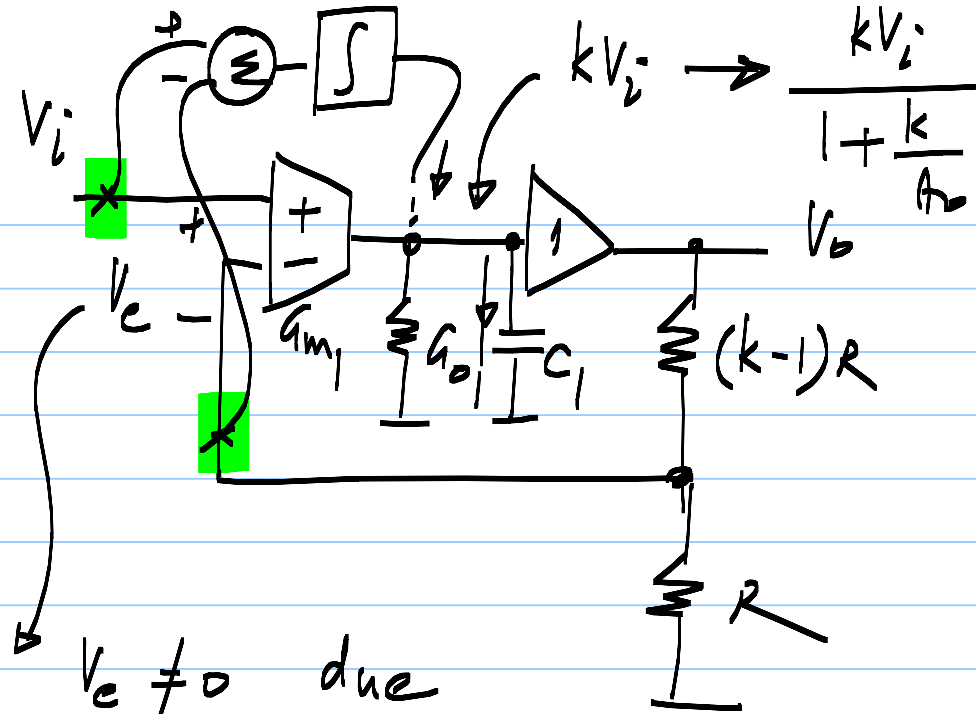
* Unity gain frequency of the single stage opamp used for CCVS in the two stage opamp $= \frac{G_{m3}}{C_L}$

$$\frac{G_{m3}}{C_L} > \frac{G_{m2}}{C_2} > \frac{G_{m1}}{C}$$

$$\frac{G_{m5}}{C_5} > \frac{G_{m4}}{C_4} > \frac{G_{m3}}{C_3} > \frac{G_{m2}}{C_2} > \frac{G_{m1}}{C}$$

$$C_5 = C_L$$





$V_e \neq 0$ due to finite dc gain.