2 stage review

RHP zero from C_c

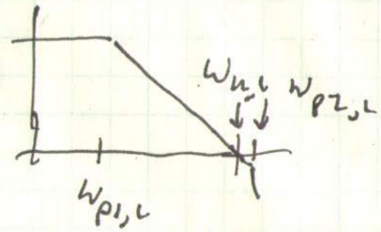
P/Z doublet from mirror

2 stage

$$\omega_{p1,c} = \frac{1}{R_1(1+G_{m2}R_{o2})C_c} \approx \frac{1}{R_1 G_{m2} R_2 C_c}$$

if PM ≥ 45 then $\omega_{p2,c} > \omega_{u,c}$

so



looks like single pole, so $\omega_{u,c} = (\omega_{p1})(A_v)$

$$\omega_{u,c} = \frac{1}{R_1(1+G_{m2}R_{o2})C_c} G_{m1}R_1G_{m2}R_2 \approx \frac{G_{m1}}{C_c}$$

$$\omega_{p2} = \frac{G_{m2}}{C_1 + C_2 + \frac{C_1C_2}{C_c}} \quad \text{must be} > \frac{G_{m1}}{C_c}$$

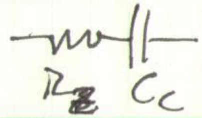
another reason to burn more current in 2nd stage.

<u>But</u> other snakes in the grass

RHP zero from C_c at $\frac{G_{m2}}{C_c}$ <u>trouble</u>

(see W8L2 p3)

<u>Fixes</u> (1)



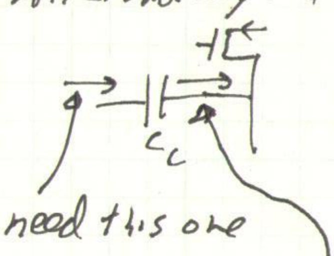
$$\omega_z = \frac{1}{C_c\left(\frac{1}{G_{m2}} - R_z\right)}$$

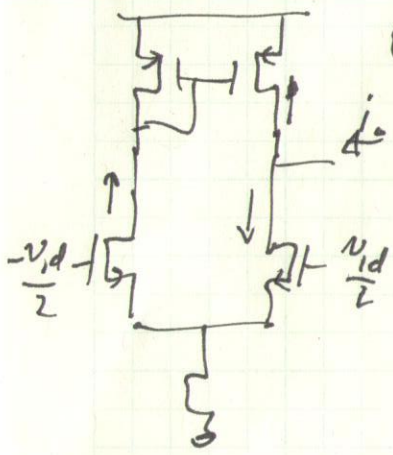
choose $R_z \approx \frac{1}{G_{m2}}$

magic! Moves zero off the right side to ∞, and then back on the left side!

Tough to set R_z right, but clever methods exist.

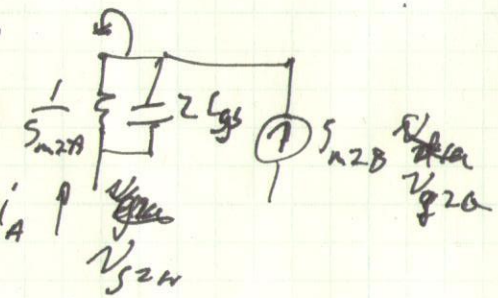
Alternatively: find a way to prevent zero.





$$i_o = g_{m1B}\frac{v_{id}}{2} + g_{m1A}\left(-\frac{v_{id}}{2}\right)\left(-\frac{g_{m2B}}{g_{m2A}}\right)$$

but



$$i_A = \frac{v_{s2A}}{g_{m2A}} + sC_{gs2}v_{s2A} \qquad \frac{v_{s2A}}{i} = \frac{1}{g_{m2A}+sC_{gs2}}$$

$$\frac{v_{s2A}}{i} = \frac{1}{g_{m2A}} \cdot \frac{1}{1+s/\omega_{pm}} \qquad \omega_{pm} = \frac{g_m}{2C_{gs2}} = \frac{1}{2}\omega_T$$

$$i_o = g_{m1B}\frac{v_{id}}{2} + g_{m2B}v_{s2A}$$

$$= g_{m1B}\frac{v_{id}}{2} + g_{m2B}\left(\frac{1}{g_{m2A}}\cdot\frac{1}{1+\frac{s}{\omega_{pm}}}\right)g_{m1A}\frac{v_{id}}{2}$$

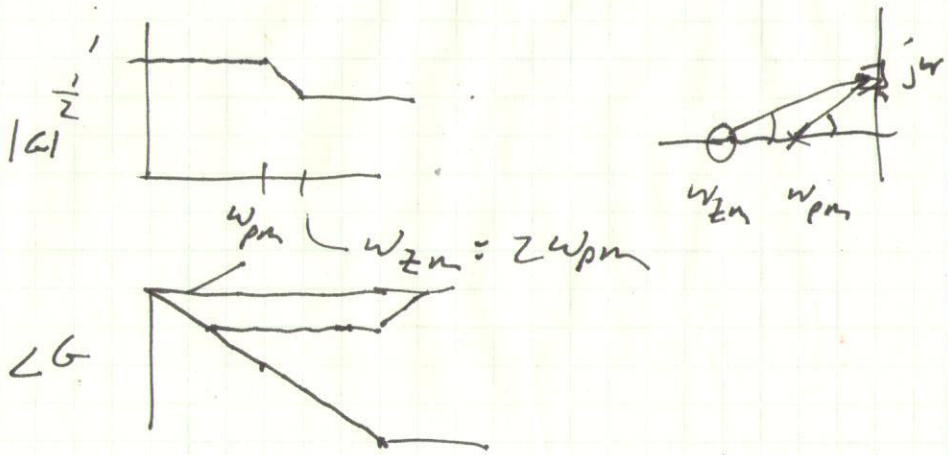
$$= g_{m1}\frac{v_{id}}{2}\left[1+\frac{g_{m2B}}{g_{m2A}}\cdot\frac{1}{1+\frac{s}{\omega_{pm}}}\right]$$

$$G_m = \frac{i_o}{v_{id}} = g_{m1}\frac{1}{2}\left[1+\frac{1}{1+s/\omega_{pm}}\right]$$

(low freq: g_{m1}; high freq: $g_{m1}/2$)

$$G_m = \frac{g_{m1}}{2}\left[\frac{1+\frac{s}{\omega_{pm}}+1}{1+s/\omega_{pm}}\right] = g_{m1}\,\frac{1+\frac{s}{2\omega_{pm}}}{1+\frac{s}{\omega_{pm}}}$$

pole/zero doublet



max $\approx 22°$ for one decade