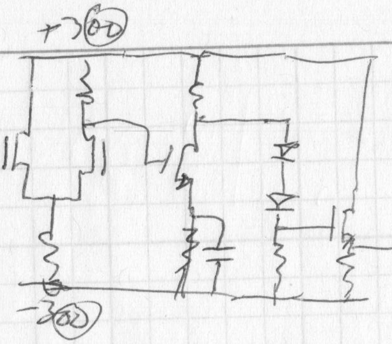
Kz-W

RHP zero

pole/zero doublet

2nd stage pole w/ C_c



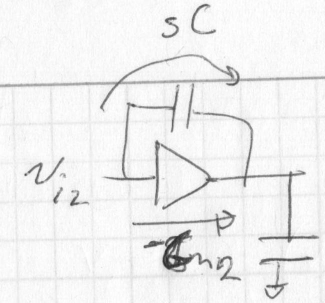
HW7 op-amp specs: swing, input common mode

determine V_{ov}'s

I_{tail} given

I_5 is given

RHP zero

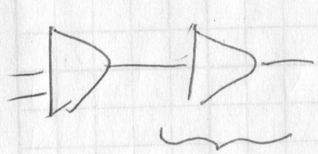


current that we want:

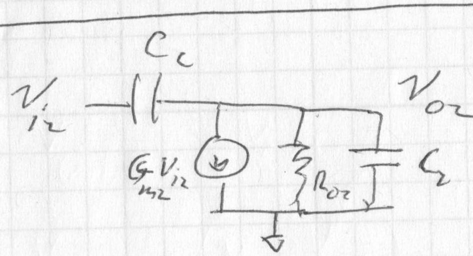
effect of v_{o2} on v_{o1} (Miller)

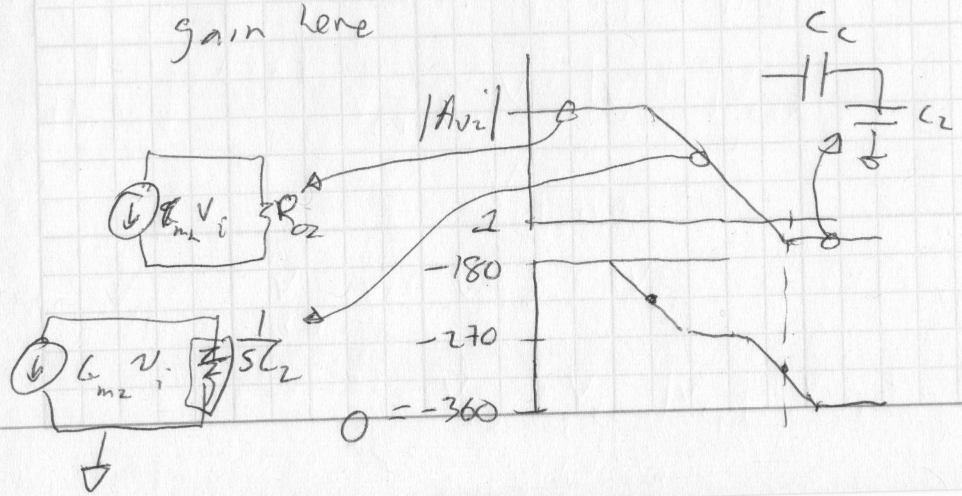
current that we don't want:

effect of v_{o1} on v_{o2}



expect negative gain here





If you move v_{i2} up fast enough then

v_{o2} initially has positive response, $\frac{C_c}{C_2+C_c}$

then settles to negative $-G_{m2}R_{o2}$

How fast is "fast enough"?

when sC_c is bigger than G_{m2}

(more current in capacitor) than in transistor)

that defines ω_z $\quad j\omega_z C_c = G_{m2}$

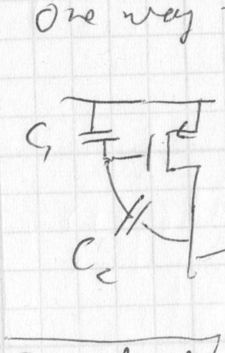
2nd stage pole: in general not easy to write a simple expression, but

assuming that Miller is used to split the poles far apart, then

$$\omega_{p2} \approx \frac{G_{m2}}{C_1 + C_2 + \frac{C_1 C_2}{C_c}}$$

$$\approx \frac{G_{m2}}{C_1 + C_2} \quad \text{if} \quad C_c > C_1 \text{ or } C_c > C_2$$

One way to look at it:



What is output resistance at high freq?

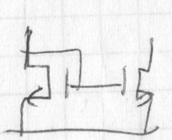
V_o controls gate via cap divider $V_g = \frac{C_c}{C_c + C_1} V_o$

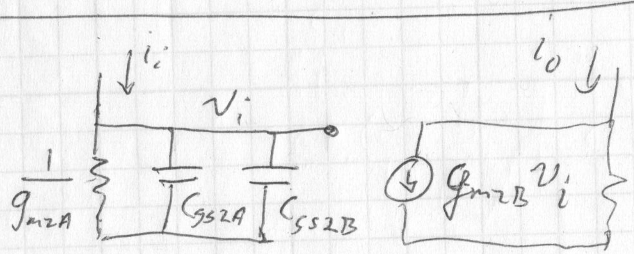
R_{o2} reduced by Af!

$$\text{high freq. } "R_{o2}" \approx \frac{1}{G_{m2} \frac{C_c}{C_c + C_1}} = \frac{C_1 + C_c}{G_{m2} C_c}$$

$$C_{o2} = C_2 + \frac{C_c C_1}{C_c + C_1} \Rightarrow \omega_{p2} \text{ same result!}$$

mirror pole:

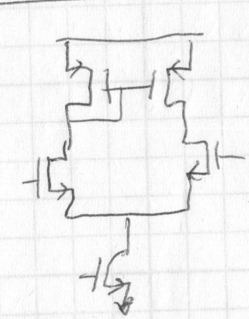




$$i_i = g_{m2A} v_i + 2 s C_{gs2} v_i$$

$$\frac{i_i}{v_i} = g_{m2a}\left(1 + \frac{s}{(g_m/2C_{gs})}\right)$$

$$\frac{i_o}{i_i} = \frac{g_{m2b}}{g_{m2a}} \frac{1}{1 + s/\omega_{pm}} \qquad \omega_{pm} = \frac{g_{m2a}}{2 C_{gs}}$$



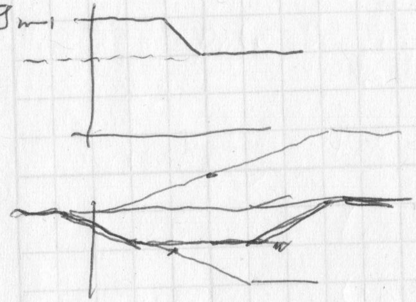
$$G_m = \frac{1}{2} g_{m1b} + \frac{1}{2} g_{m1a} \quad \text{(mirror)}$$

$$= \frac{g_{m1}}{2}\left(1 + \frac{1}{1 + s/\omega_{pm}}\right)$$

$$= \frac{g_{m1}}{2}\left(\frac{2 + s/\omega_{pm}}{1 + s/\omega_{pm}}\right)$$

$$= \frac{g_{m1}}{2}(2)\frac{\left(1 + \frac{s}{2\omega_{pm}}\right)}{1 + s/\omega_{pm}}$$

$$= g_{m1} \frac{1 + s/\omega_{zm}}{1 + s/\omega_{pm}}$$



-3 degrees @ $\frac{\omega_p}{10}$

and @ $10\,\omega_z$

-22 degreese @ $\sqrt{2}\,\omega_p$

	uncompensated	(Miller) compensated
ω_{p1}	$\frac{1}{R_{o1}C_1}$	$\frac{1}{R_{o1}G_{m2}R_{o2}C_c}$
ω_{p2}	$\frac{1}{R_{o2}C_2}$	$\frac{g_{m2}}{C_1+C_2+\frac{C_1C_2}{C_c}}$
mirror doublet	$\omega_{pm}=\frac{g_{m2}}{2C_{gs2}}$ $\omega_{zm}=2\,\omega_{pm}$	same
unity gain	?	$\frac{G_{m1}}{C_c}$ (assuming 1) 2) 3))

in feedback, $\omega_{p1f}\approx$ ~~$\frac{1}{f}$~~ $f\,\omega_{uc}$ $\quad \omega_{uf}=\omega_{uc}$