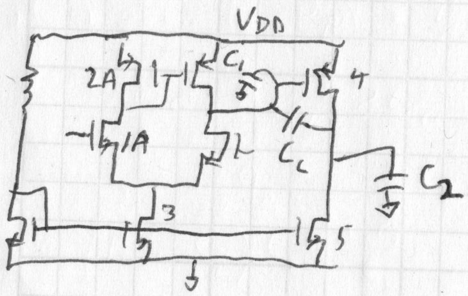
Compensation

pole splitting

Midterm Friday April 1   1:10 – 2:30



$A_{v_0} = G_{m1} R_{o1} G_{m2} R_{o2}$

if $C_c = 0$

$\cancel{\omega_{p1} = \frac{1}{R_{o1}(G_{m2}R_{o2})C_c}}$

$\omega_{p1} = \frac{1}{R_{o1} C_1}$

$\omega_{p2} = \frac{1}{R_{o2} C_2}$

uncompensated

with $C_c \neq 0$, both poles move

from 9.31 in book

$$\omega_{p1c} \doteq \frac{1}{R_{o1}(G_{m2} R_{o2} C_c)}$$

$$\omega_{p2c} \approx \frac{G_{m2}}{C_1 + C_2 + \frac{C_1 C_2}{C_c}} \approx \omega_{u2}$$

magic!

ω_{p1} goes down, ω_{p2} goes up!

Compensation

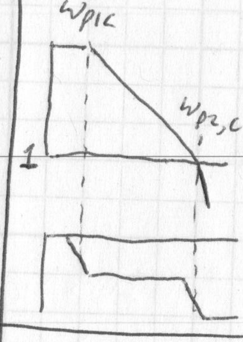
change circuit to move poles of open loop amplifier so that closed loop system will have desired properties.

typically: add C_c across a gain stage

(K2-W, LM324, lab3)

to get a phase margin $\geq 45°$

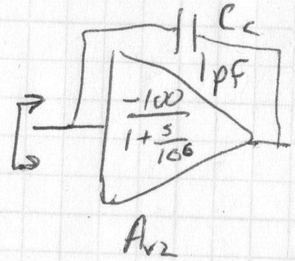
need at least $\omega_{p2c} > \omega_{uc}$

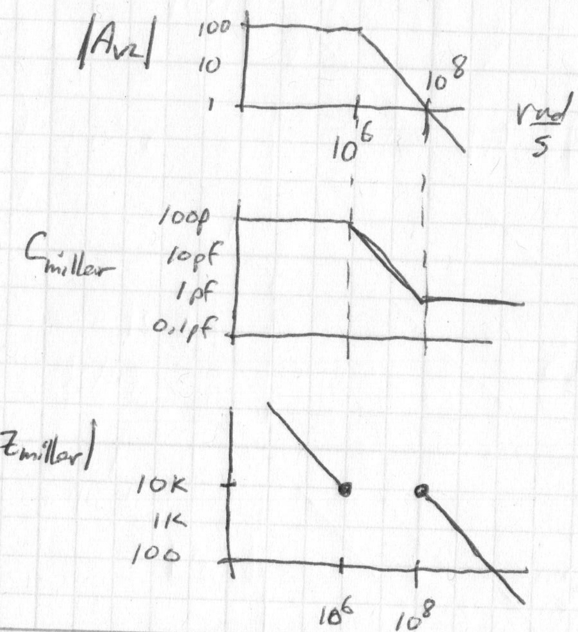


so $\omega_{uc} = A_v \omega_{p1c}$

$= \frac{G_{m1}}{C_c}$!

from last time



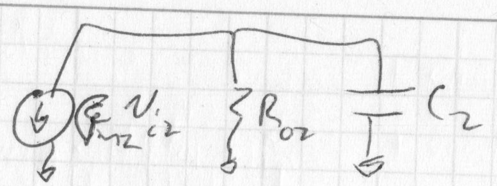


140

165P

196M

v_{i2} r



$$G_m v_{i2} + \frac{1}{R_{o2}} v_{o2} + sC_2 v_{o2} = 0$$

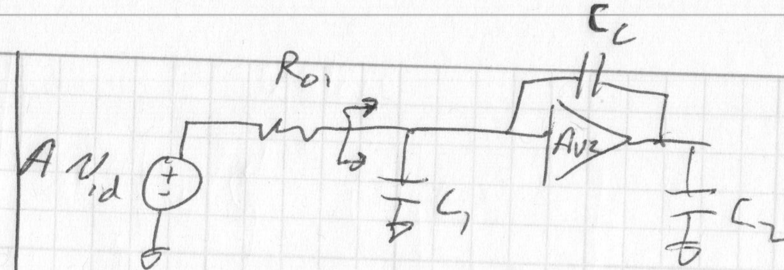
$$\frac{v_{o2}}{v_{i2}} = \frac{-G_{m2}}{\frac{1}{R_{o2}} + sC_2}$$

$$= \frac{-G_{m2}R_{o2}}{1 + sR_{o2}C_2}$$

$$C_{miller} = \left(1 + A_{v2}\right) \frac{1 + \frac{s}{(1+A_{v2})\omega_{p2}}}{1 + s/\omega_{p2}} C_c$$

$$\approx \begin{cases} (1+A_{v2,0})C_c & \omega \ll \omega_{p2} \\ ? & \omega_{p2} < \omega < \omega_{u2} \\ C_c & \omega \gg \omega_{u2} \end{cases}$$

$$\approx \frac{(1+A_{v2,0})C_c}{s/\omega_{p2}}$$



$$C_{in2} = C_1 + \underbrace{(1 - A_{v2})C_c}$$

$$C_{miller} = \left(1 - \frac{-G_m R_{o2}}{1 + s/\omega_{p2}}\right) C_c$$

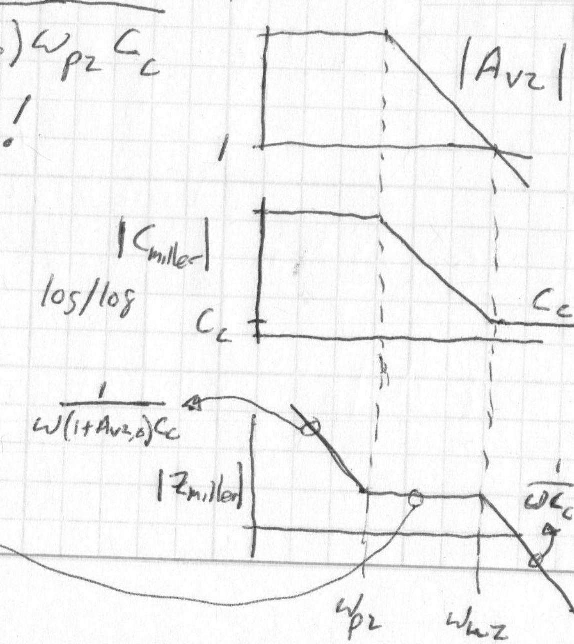
$$= \frac{1 + s/\omega_{p2} + A_{v2}}{1 + s/\omega_{p2}} C_c$$

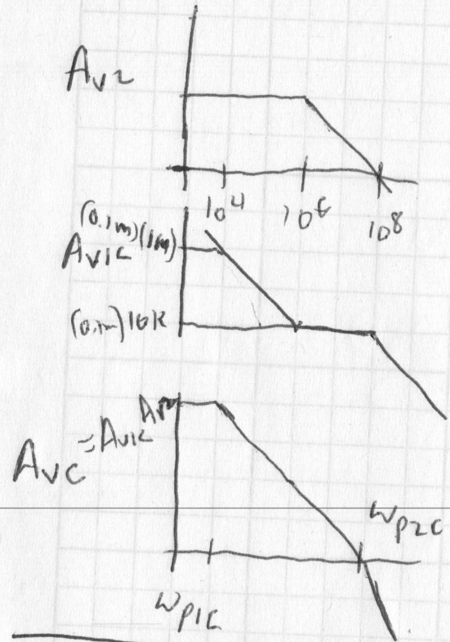
$\omega_{p2} < \omega < \omega_{u2}$

$$Z_{miller} = \frac{1}{j\omega C_{miller}} = \frac{1}{j\omega\left(\frac{(1+A_{v2,0})C_c\,\omega_{p2}}{j\omega}\right)}$$

$$= \frac{1}{(1+A_{v2,0})\omega_{p2}C_c}$$

constant, real!





$\omega_{p1} \longrightarrow \omega_{p1c}$

ω_{p2} canceled by $\omega_{z,miller}$