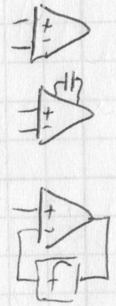
140/240A 17 SP W7L2

uncompensated

compensated

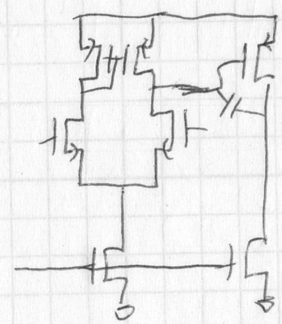
closed-loop

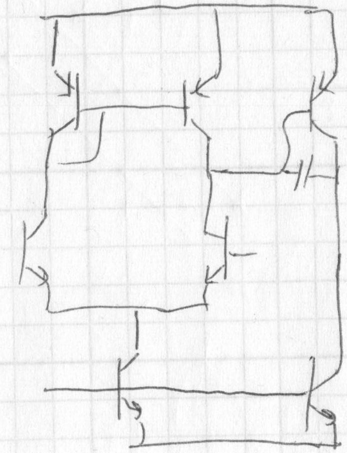


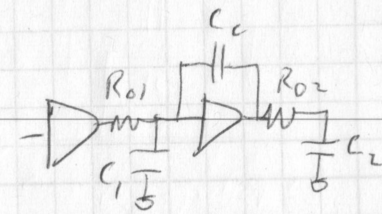
original poles
compensated poles
} metric: phase margin assuming some f

closed-loop poles } - stability - step response

Miller Compensation & pole splitting







Slew rate

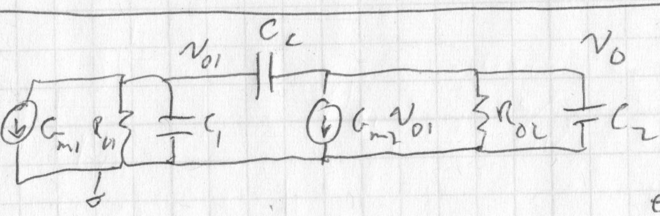


Fig 6.15

eqn 6.30

$$\frac{v_o}{v_{id}} = G_{m1}R_{o1}G_{m2}R_{o2}\frac{\cancel{1} - s/\omega_z}{(1+s/\omega_{p1})(1+s/\omega_{p2})}$$

typically before compensation (C_c small)

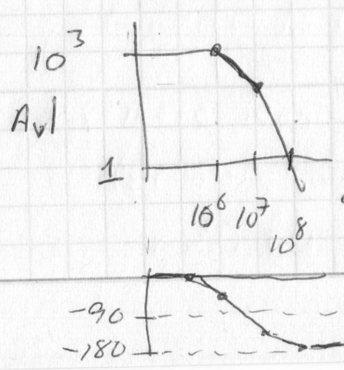
$$\omega_{p1,u} = \frac{1}{R_{o1}C_1} \qquad \omega_{p2,u} = \frac{1}{R_{o2}C_2}$$

uncompensated: typically high gain w/ poles close together

$\Rightarrow$ unstable in unity gain ($f=1$)

only stable if $f < \frac{1}{A_0}\frac{\omega_{phigh}}{\omega_{plo}}$ } roughly

$A_{cl} \gtrsim A_0 \frac{\omega_{plo}}{\omega_{phigh}}$

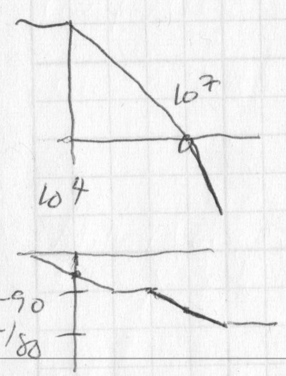


$f = 0.01$ OK (PM = 45°)

What if we want a C.L. gain less than 100?

Compensation by lowering lowest pole

move ω_{p1} left 2 decades



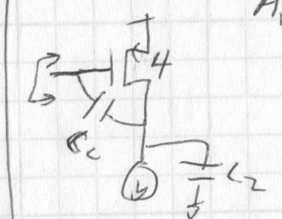
$f = 1 \Rightarrow Pm = 45°$

$BW \simeq 10^7$

$\tau \simeq 100ns$

Better: compensation by splitting the poles

push one down, push the other up



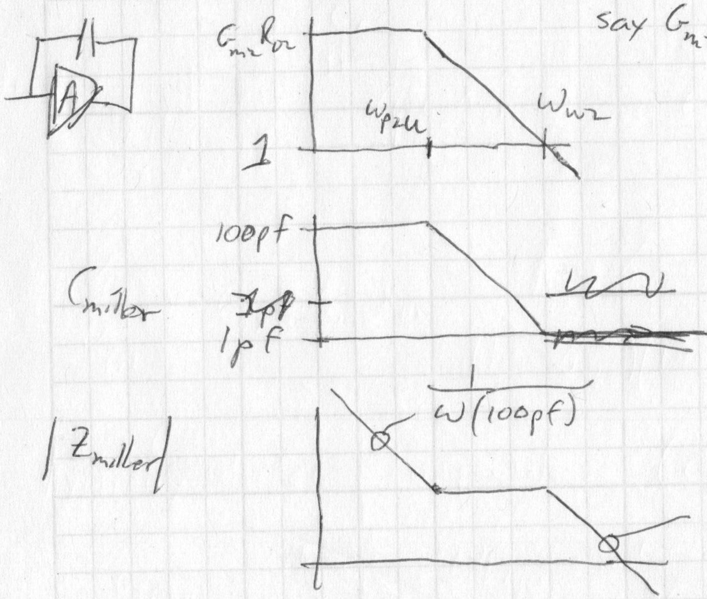
$A_{v2} = \frac{v_o}{v_{o1}} = \frac{-G_m R_{o2}}{1 + s/\omega_{p2}}$ $\quad \omega_{p2} \cong \frac{1}{R_{o2}(C_2 + C_c)}$

(also a RHP zero $\omega_z = \frac{-G_{m2}}{C_c}$)

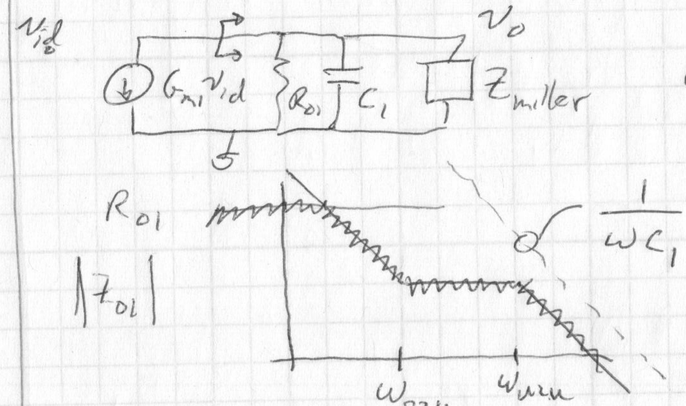
(ignore for now)

say $G_{m2} R_{o2} = 100$

$C_c = 1pF$



1st stage gain = $-G_{m1} Z_{o1}$

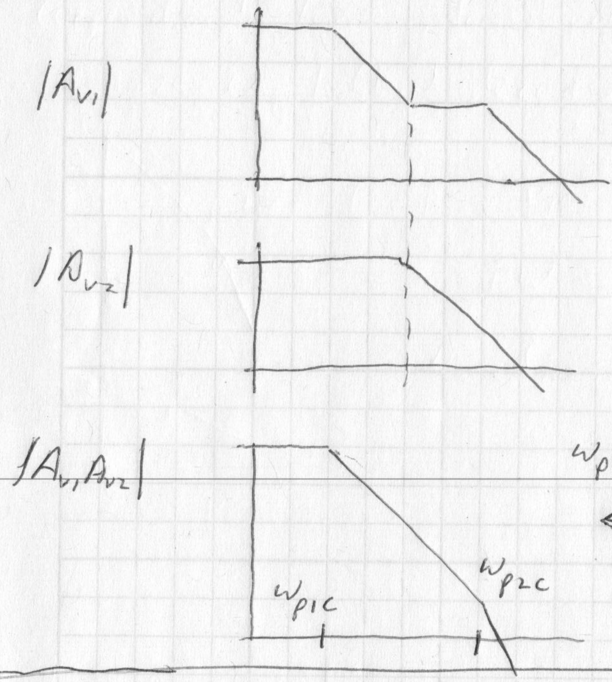


assure $C_1 < C_c$

4 regions: R_{o1}, C_{miller}, transition, C_c

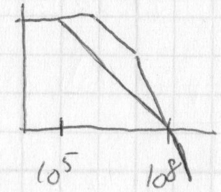
pole, zero, pole

$\frac{1}{R_{o1} C_{miller}}$ $\quad \omega_{p2u}$ $\quad \omega_{u2}$



$\omega_{p1c} \ll \omega_{p1}$ ⟵ $\omega_{p2} \ll \omega_{p2c}$ ⟶

e.g.



$\omega_{p1} \searrow 10\times$ $\omega_{p2} \nearrow 10\times$

$BW \cong 10^8$

$\tau = 10ns$

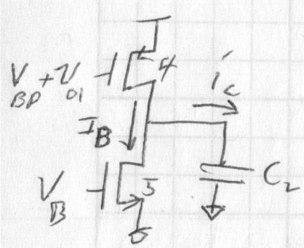
$10\times$ faster than just increasing C_1 or C_2

<u>much</u> less capacitance needed

(saves die area and/or bond pads)

<u>Slewing</u> nonlinear effect. We model [transistor] as $g_m v_{gs}$

what if v_{gs} is so big that [transistor] turns off?



$$\frac{dv_o}{dt} = \frac{i_c}{C_2}$$

if M4 turns <u>off</u>

$i_c = -I_B$ (bias current in M5) $\approx$ const

$$\frac{dv_o}{dt} = \frac{-I_B}{C_2}$$

2 stage w/ C_c