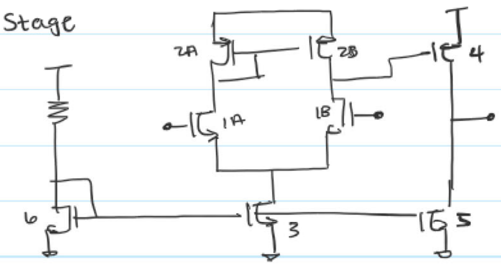
2019.10.18

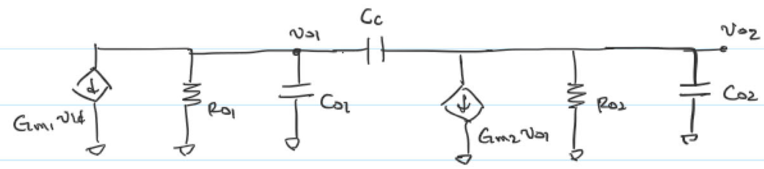
Friday, October 18, 2019 11:13 AM

2-Stage
Miller
RHPZ
frequency response
PZ doublet

common mode gain
slewing

I) 2-Stage





- No compensation: $(C_c = 0F)$

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

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

$$A_{v0} = G_{m1}R_{o1}G_{m2}R_{o2} \approx \frac{(g_m r_o)^2}{4}$$

Compensated: $(C_c \neq 0)$

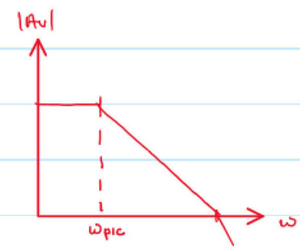
$$\omega_{p1c} \approx \frac{1}{G_{m2}R_{o2}R_{o1}C_c}$$ ← Ignore the 1+ and assume $C_c \gg C_{o1}$

$$\omega_{p2c} \approx \frac{G_{m2}}{C_1+C_2+C_1C_2/C_c}$$ ← Derivation in the book

$$\approx \frac{G_{m2}}{C_1+C_2}$$ ← $C_c \gg C_1$ or $C_c \gg C_2$ (and?)

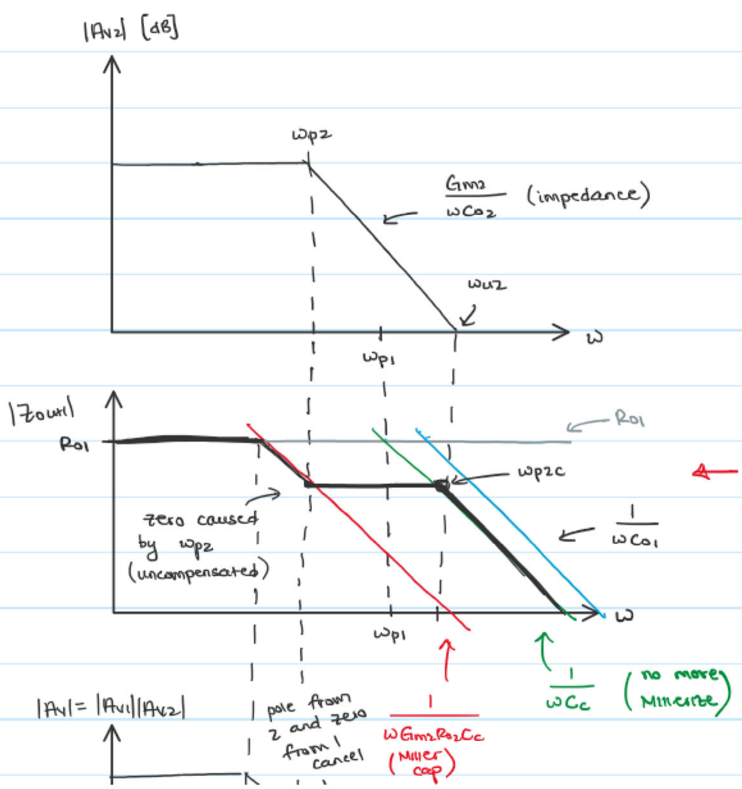
$$\omega_{uc} \approx A_{v0}\,\omega_{p1c} \approx \frac{G_{m1}}{C_c}$$ ← Assuming (1) $\omega_{pc2} > \omega_u$ (2) $\omega_{pc1} < \omega_{pc2}$

- Often interested in $f=1$, $\varphi_{PM} \geq 45°$ } second pole (nondominant pole) should be $\geq \omega_{uc}$ — THINK OF THE BODE PLOT!

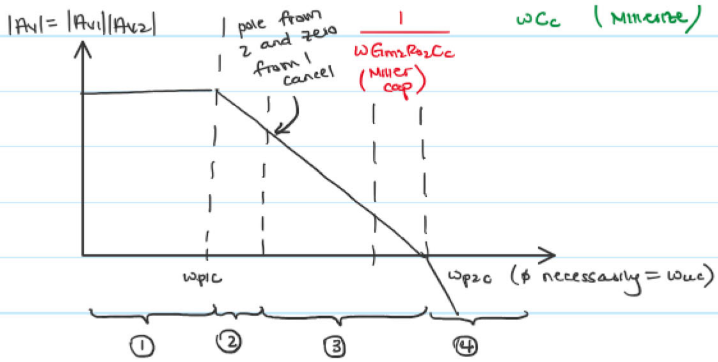


- What if $f \neq 1$?

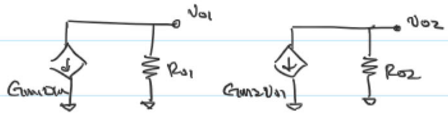
— May not need to compensate at all



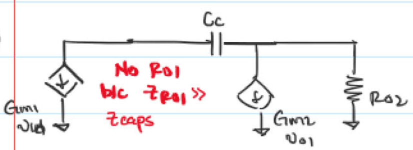
← To get 1st stage gain, multiply by G_{m1}



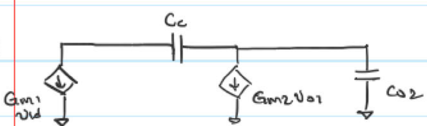
① @ $\omega < \omega_{p1c}$ (DC):



②



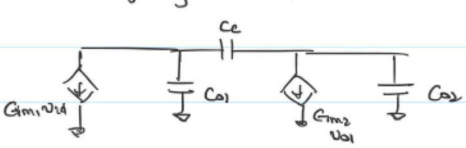
③



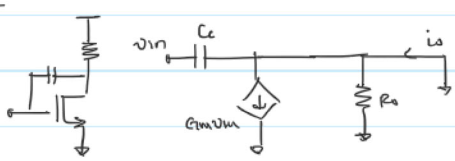
④ $\omega > \omega_{u2}$

No more resistors to get rid of!

C_c stops getting smaller, looks constant and C_{o1} actually features



- RHPZ



Calculate $G_m(s)$: ← Intuition: multiple paths to output which can cancel

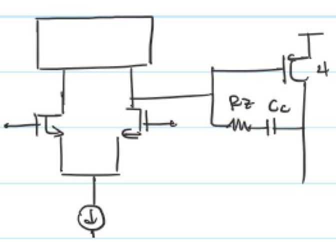
$$i_o = -v_{in}(sC_c) + G_m v_{in}$$
$$= v_{in}(G_m - sC_c)$$
$$\frac{i_o}{v_{in}} = G_m\left(1 - s\frac{C_c}{G_m}\right)$$ ← zero in RHP

$$\omega_{z,RHP} = \frac{G_{m2}}{C_c}$$

- RHPZ gives ↑ magnitude, BUT negative ∡

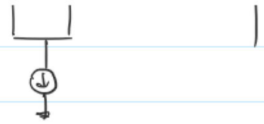
- How to deal w/ RHPZ?

(1) Series resistance



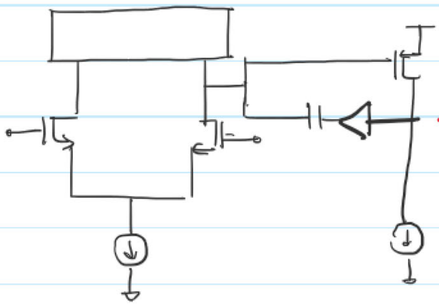
$$\omega_{z,\text{shifted RHPZ}} = \frac{1}{C_c\left(\frac{1}{g_m} - R_z\right)}$$

- $g_m = g_{m4}$
- Can push into LHP
- Trying to cancel poles = risky

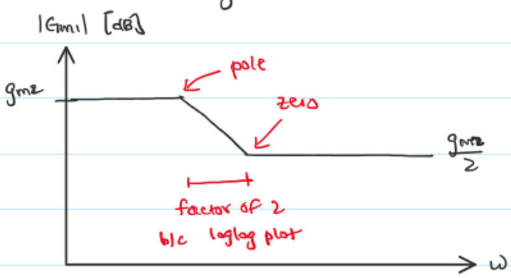


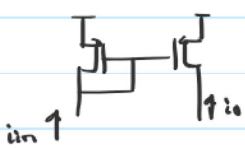
└ Trying to cancel poles = risky

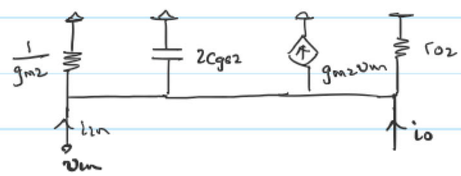
(2) Remove feed-forward where 2nd stage sees C_c → want C_c to affect Z_{out1} → $\not$ want 2nd stage to see C_c



- Current mirror frequency response
- current mirror has a pole ⇒ G_m of 1st stage drops to $\frac{1}{2}$ because no more mirroring



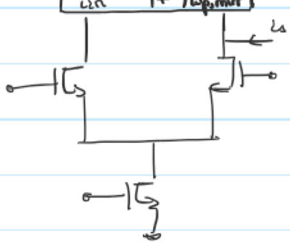




Calculate $G_m(s)$:

$$\omega_{p,mirror} = \frac{g_{m2}}{2C_{gs}} \leftarrow \frac{1}{2}\omega_T$$ (pretty big)

$$\boxed{\frac{i_o}{i_{in}} = \frac{1}{1+s/\omega_{p,mirror}}}$$



$$i_o = g_{m1a}\left(\frac{v_{id}}{2}\right)\left(\frac{1}{1+s/\omega_{p,mirror}}\right) + g_{m1b}\left(\frac{v_{id}}{2}\right)$$

$$G_{m1}(s) = \frac{v_{id}}{i_o} = -\frac{g_{m1}}{2}\left(1 + \frac{1}{1+s/\omega_{p,mirror}}\right)$$

$$= -\frac{g_{m1}}{2}\left(\frac{2+s/\omega_{p,mirror}}{1+s/\omega_{p,mirror}}\right)$$ ← zero 2x higher than pole

checks out :D