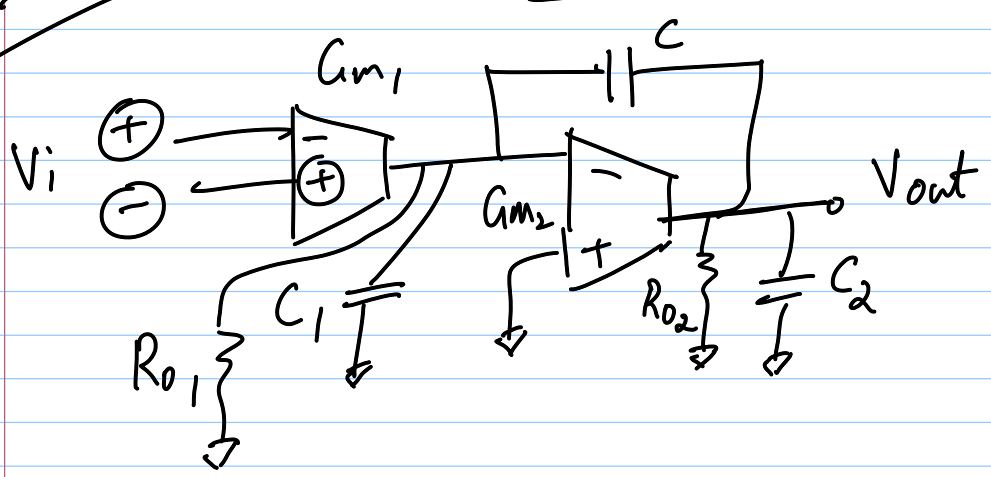
23-2-12

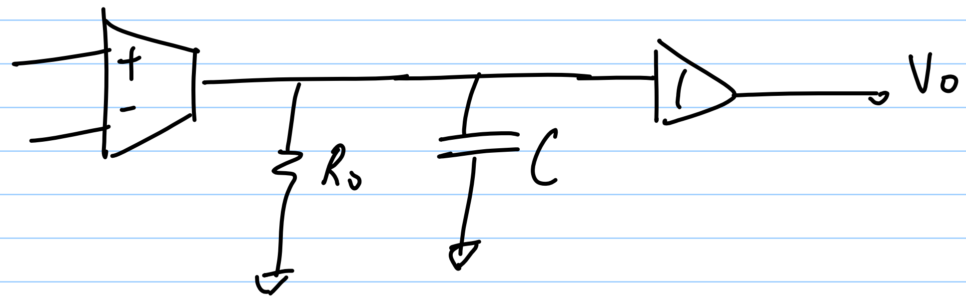
Lec-20



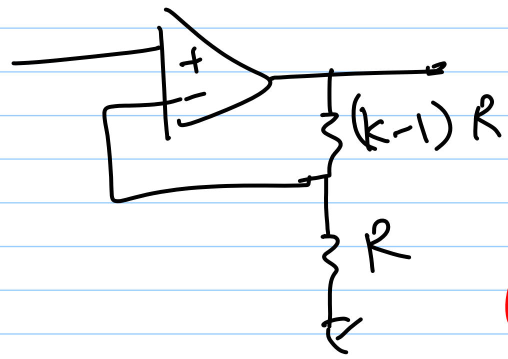
$$a(s) = \underbrace{(G_{m_1} R_{o_1}) \cdot (G_{m_2} R_{o_2})}_{\text{DC gain}} \cdot \frac{\left(1 + \frac{s}{z_1}\right)}{s^2(\ ) + s(\ ) + 1}$$

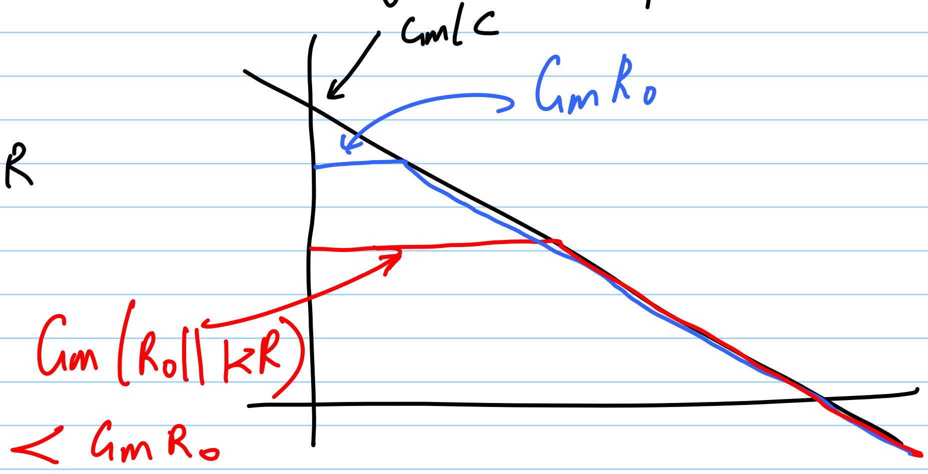
Calculate (HW):

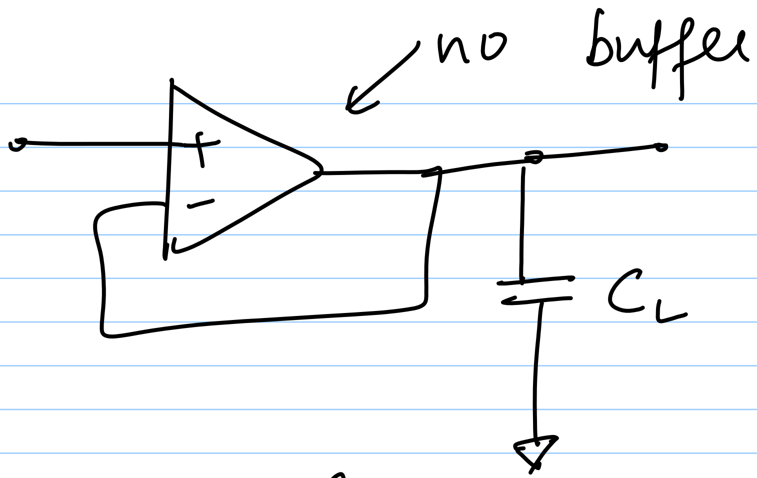
* Transfer fn.
* zero
* Approx. location for poles



No buffer ⇒ DC gain w/ f.b. ↓





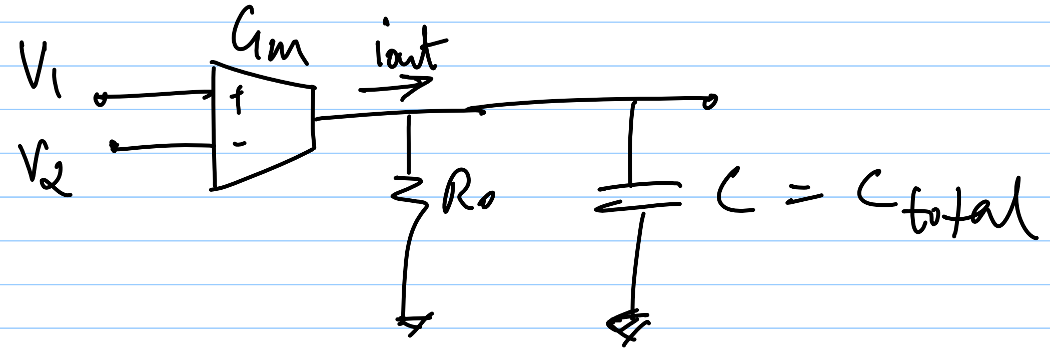


$*\quad \omega_u = \dfrac{G_m}{C + C_L}$

* steady state error doesn't change

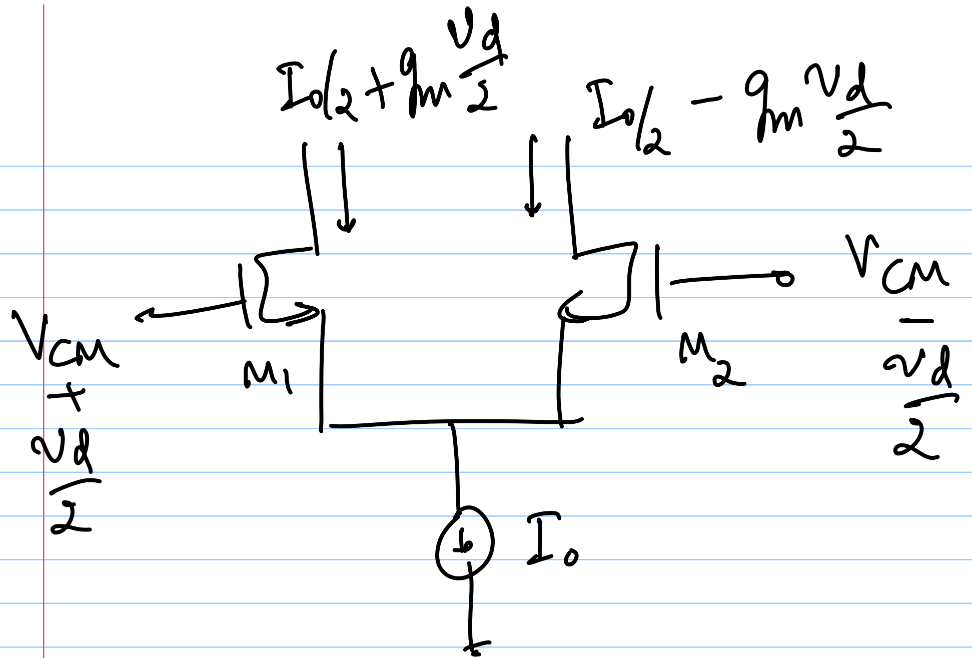
→ cap. loads ⇒ don't need buffer

⇒ Single-stage opamp (purely cap. load)



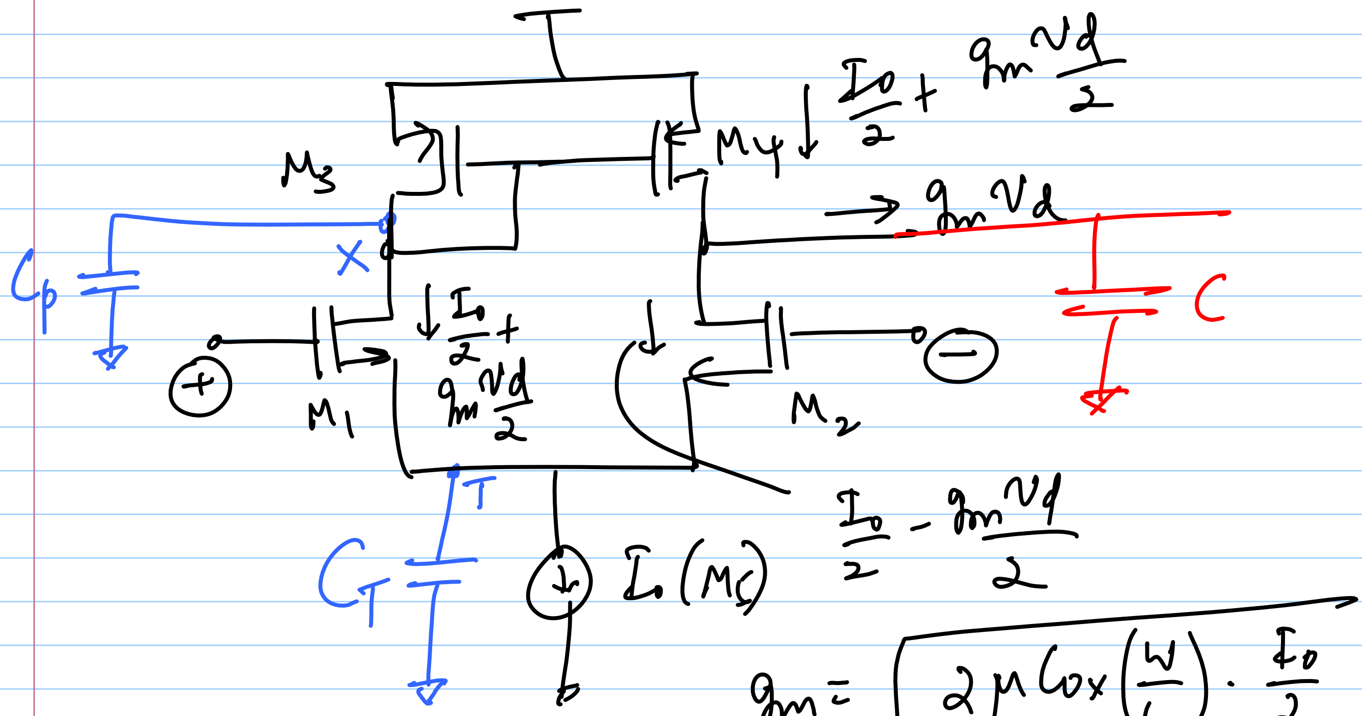
buffer → Source follower
(major swing limitation)

* ok for general purpose opamps w/ large supplies



* No bias current in i_{out}
* No wasted signal

PMOS active load



$$g_{m_{1,2}} = \sqrt{2\mu C_{ox}\left(\frac{W}{L}\right)\cdot\frac{I_o}{2}}$$

$$\omega_u = \frac{g_m}{C}$$

$$\text{DC gain} = \frac{g_m}{g_{ds_4} + g_{ds_2}} \sim 10\text{'s to } 200$$

parasitic caps:

C_p @ X

C_T @ T

$v_T = 0$ (virtual node)

when input is differential & $g_m \gg g_{ds}$

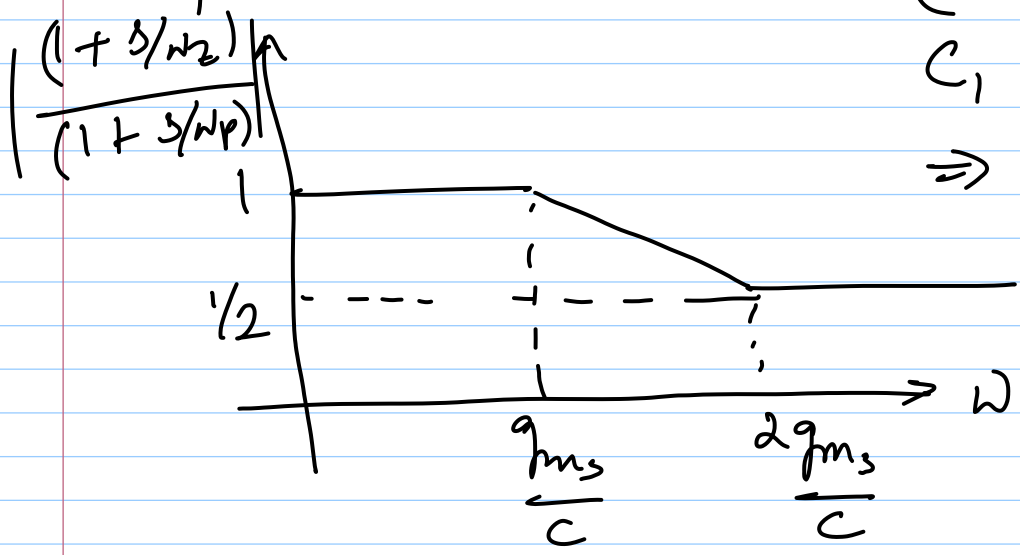
$\Rightarrow$ 2nd order system (C_T has no effect)

* If C_{gd} is ignored, no interaction between poles
* neglect g_{ds}

$$p_1 = \frac{g_{m3}}{C_p}$$

$$\frac{\left(\frac{g_{m1}}{C}\right)\left[1 + s\frac{C_1}{2g_{m3}}\right]}{s\left(1 + s\cdot\frac{C_p}{g_{m3}}\right)}$$

pole-zero doublet



@ hi freq.,
C_1 bypasses i_1
$\Rightarrow G_m = \frac{g_m}{2}$;
$i_{out} = g_m \frac{v_d}{2}$

polarity of phase-shift decides whether LHP or RHP zero

$$\frac{V_o}{V_i}(s) = \frac{g_{m1}}{sC} \frac{1+\frac{sC_1}{2g_{m3}}}{1+\frac{sC_1}{g_{m3}}}$$

with g_{ds} :

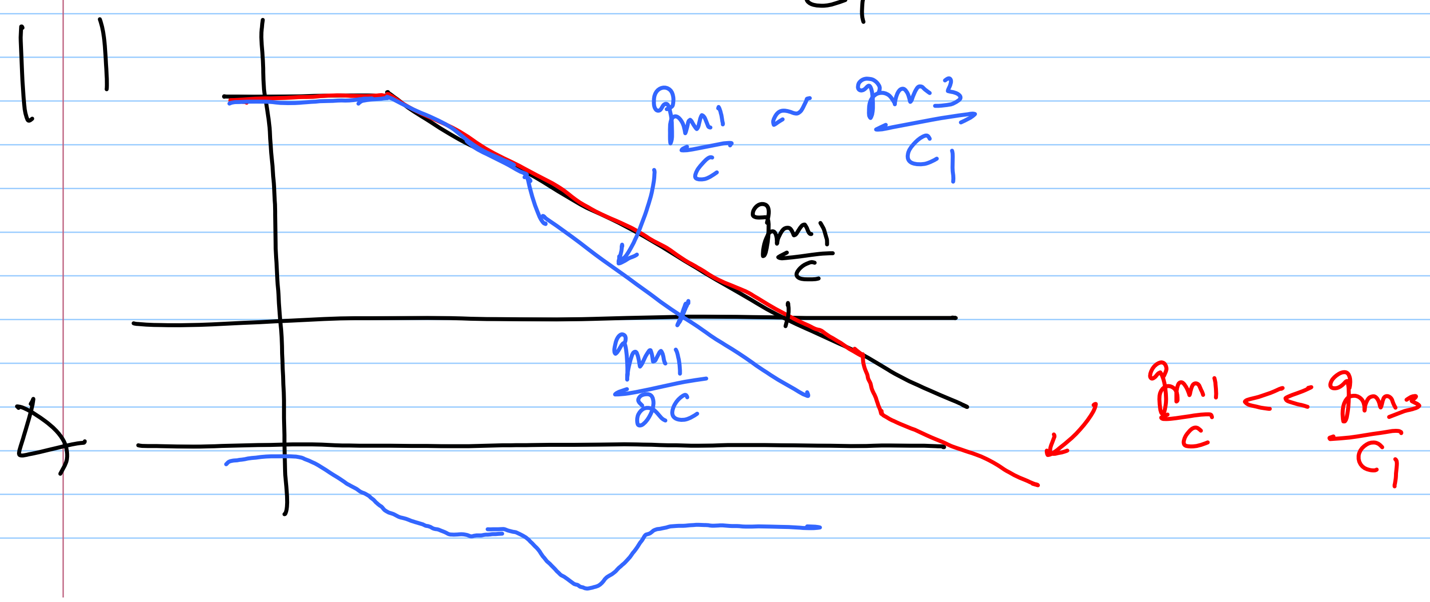
$$= \frac{g_{m1}}{sC+g_{ds2}+g_{ds4}} \cdot \frac{1+\frac{sC_1}{2g_{m3}}}{1+sC_1/g_{m3}}$$

$$= \frac{g_{m1}/(g_{ds2}+g_{ds4})}{\left(1+\frac{sC}{g_{ds2}+g_{ds4}}\right)} \cdot \left(\frac{1+s\frac{C_1}{2g_{m3}}}{1+s\frac{C_1}{g_{m3}}}\right)$$

Stability

in Unity gain config.

* We want $\frac{g_{m3}}{C_1} \gg \frac{g_{m1}}{C}$



If f.b. ratio $= 1/k$,

$$\frac{g_{m3}}{C_1} \gg \frac{g_{m1}}{C} \cdot \frac{1}{k}$$

$$\frac{g_{m3}}{C_1} \gg \frac{g_{m1}}{C}$$

<u>Options to maintain stability:</u>

* $\uparrow C \Rightarrow$ but, BW $\downarrow$

* $\uparrow g_{m3} \Rightarrow$ but, C_1 also $\uparrow$

$$C_1 = C_{gs3} + C_{gs4} + C_{db3} + C_{db1}$$

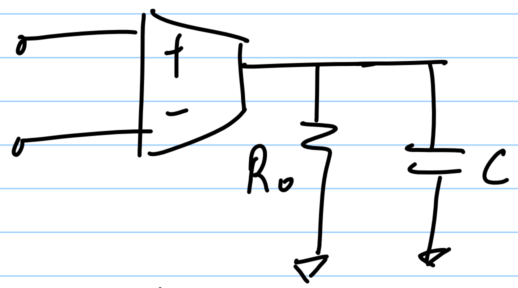
* $\uparrow I_0 \Rightarrow g_{m1}$ & $g_{m3} \uparrow$

$\uparrow I_0$ <u>&</u> $\downarrow \left(\frac{W}{L}\right)_1 \Rightarrow g_{m1} =$ constant, $g_{m3} \uparrow$

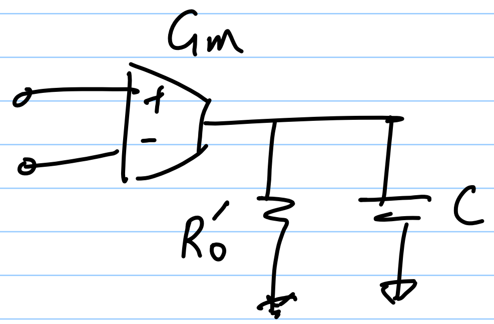
$\Rightarrow$ Burn more power to achieve higher speeds

* Affects $V_{ov} \Rightarrow$ swing limits $\downarrow$

———— X ————



single-stage diff-pair opamp



cascode opamp

$R_o' \gg R_o$; $G_m = g_m$

$$\omega_u' = \omega_u = \frac{g_m}{C} \quad \text{(same)}$$

* DC gain much larger
* No better w/ resistive loads