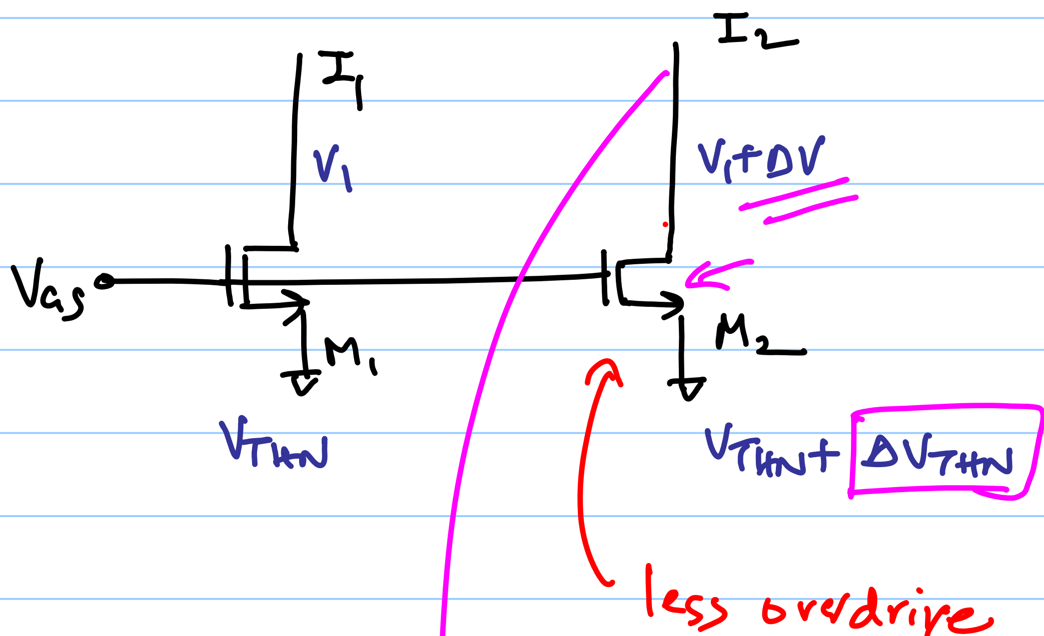
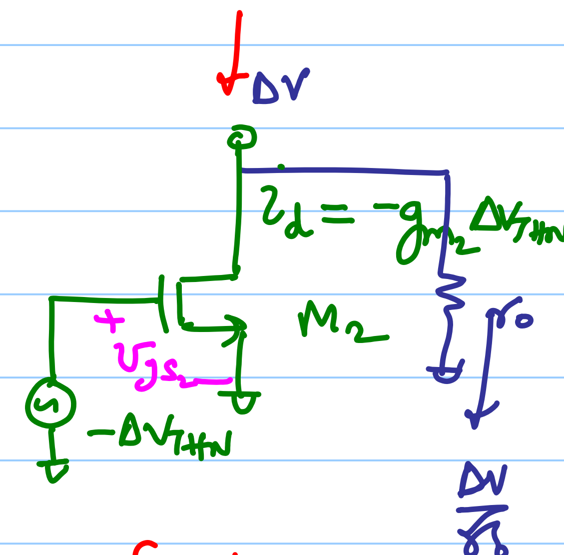
ECE 511 – Lecture 10

Note Title 2/17/2015



$$i_2 = -g_{m_2}\Delta V_{THN} + \frac{\Delta V}{r_o}$$

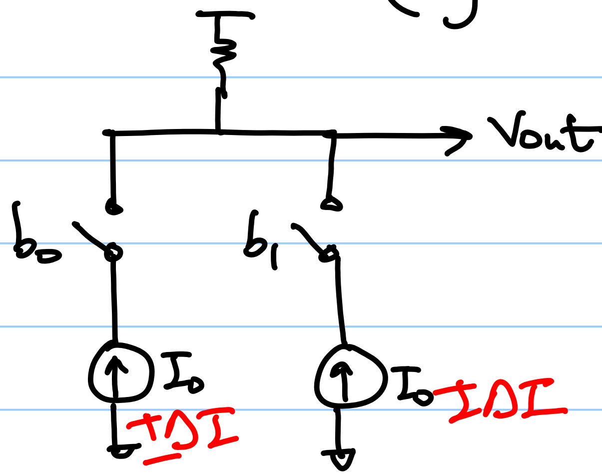


Small-signal picture for M_2

$$I_2 = I_1 + i_2$$

$$I_2 = I_1 - g_{m_2}\Delta V_{THN} + \frac{\Delta V}{r_{o_2}}$$

2-level DAC (Digital to analog converter)



$b_1 b_0 = 00 \Rightarrow I_{out} = 0$

$b_1 b_0 \Rightarrow 01 \Rightarrow I_0$

$b_1 b_0 \Rightarrow 11 \Rightarrow 2I_0$

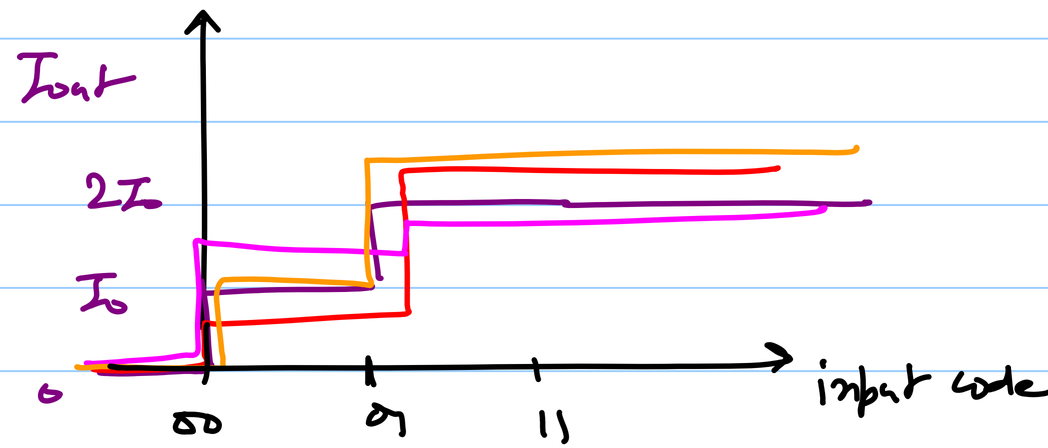
① Use larg V_{ov} to reduce mismatch

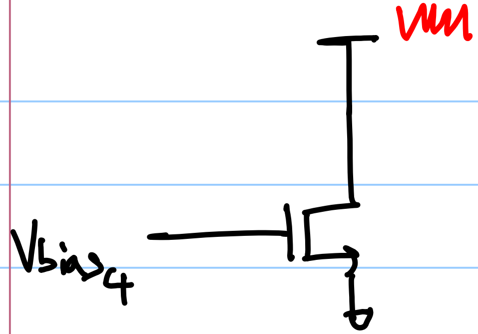
② Use large Area

ΔV_{TH}

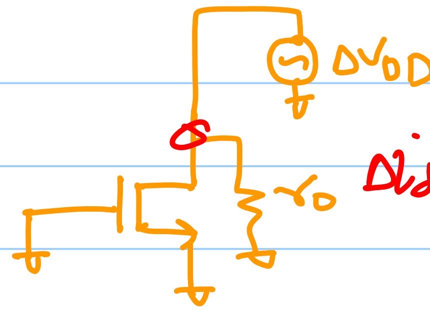
ΔV_{DS}

$\Delta\left(\frac{W}{L}\right)$

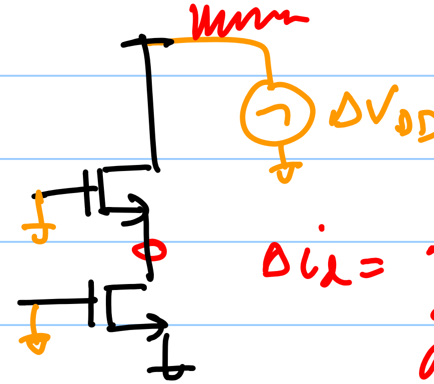




$V_{DD} + \Delta V_{DD}$

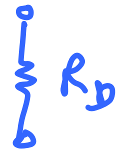


$$\Delta i_d = \frac{\Delta V_{DD}}{r_o}$$



$$\Delta i_d = \frac{\Delta V_{DD}}{g_m r_o^2}$$

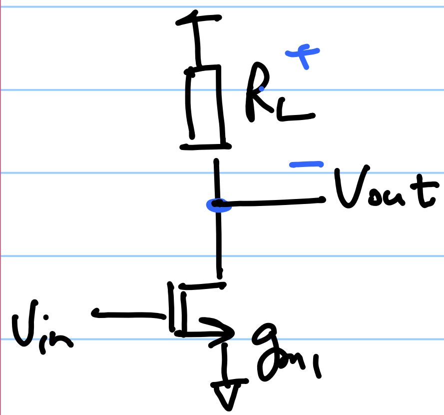
power supply insensitivity



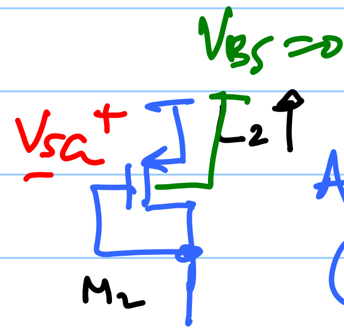
$A_v = -g_m R_D$

$R_D \uparrow$

We want to decouple the load resistance from the voltage drop across it.



$A_v = -g_{m1}(r_{o1} \| R_L)$



Active load (diode connected)

(−) gain was less $A_v = -\sqrt{\frac{(W/L)_1}{(W/L)_2}}$

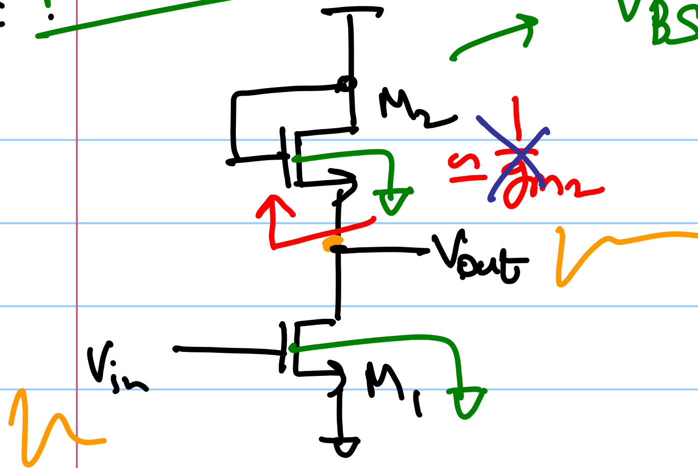
need large devices to increase gain

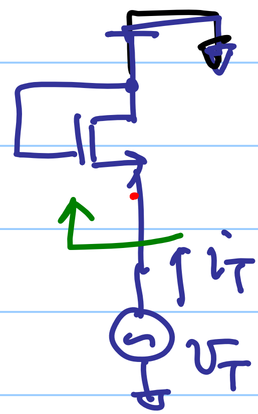
↳ more cap

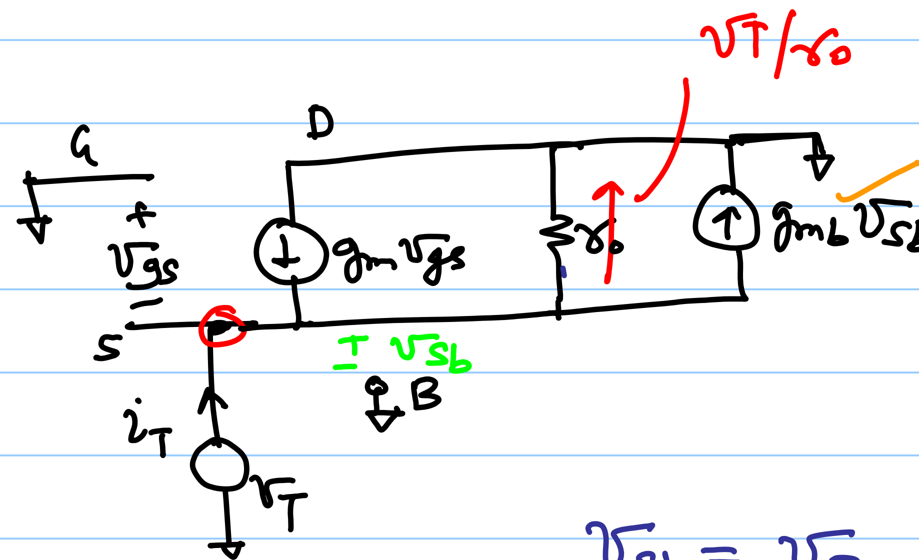
* $L \uparrow \Rightarrow V_{SG} \uparrow \Rightarrow$ headroom issues.

Ex NMOS load

$V_{BS} \neq 0$







$$\left.\begin{aligned} v_{sb} &= v_T \\ v_{gs} &= -v_T \end{aligned}\right\}$$

$$g_m v_{gs} - g_{mb} v_{sb} + i_T - \frac{v_T}{r_o} = 0$$

$$-(g_m + g_{mb}) v_T + i_T - \frac{v_T}{r_o} = 0$$

$$v_T\left[(g_m + g_{mb}) + \frac{1}{r_o}\right] = i_T$$

$$R_T = \frac{1}{g_m + g_{mb} + r_o^{-1}}$$

Assume

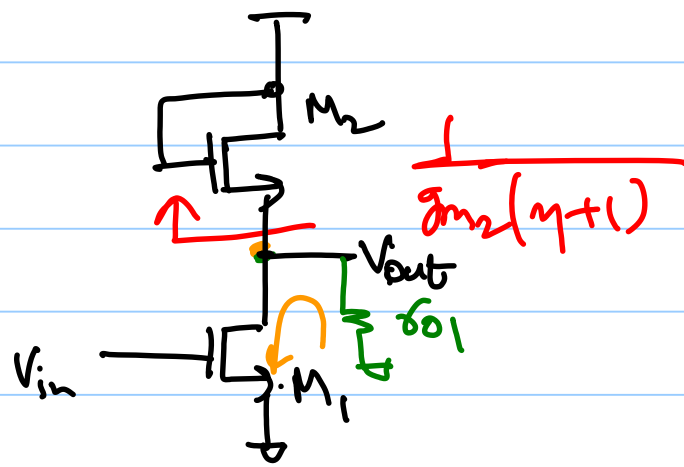
$$g_m \gg \frac{1}{r_o}$$

$$\simeq \frac{1}{g_m + g_{mb}}$$

$$g_{mb} = \eta\, g_m$$

$$= \frac{1}{g_m(\eta+1)}$$

impedance is actually lower by $\frac{1}{(\eta+1)}$

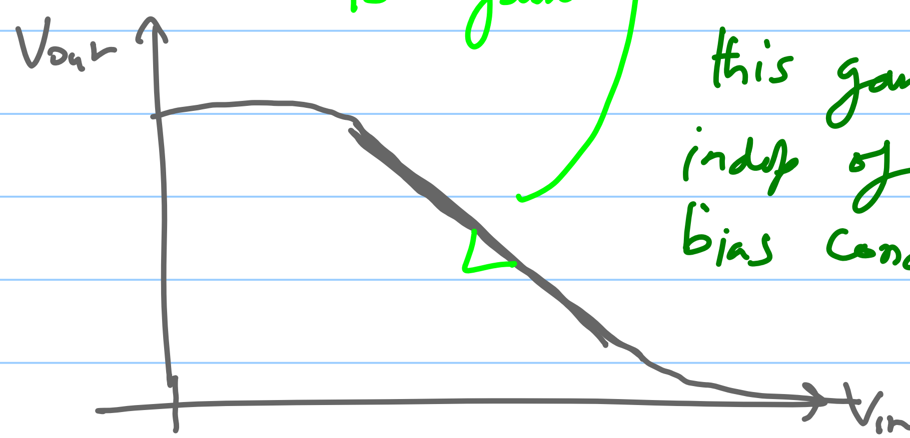


$$A_v = -g_{m1}\left[r_{o1} \,\|\, \frac{1}{g_{m2}(\eta+1)}\right]$$

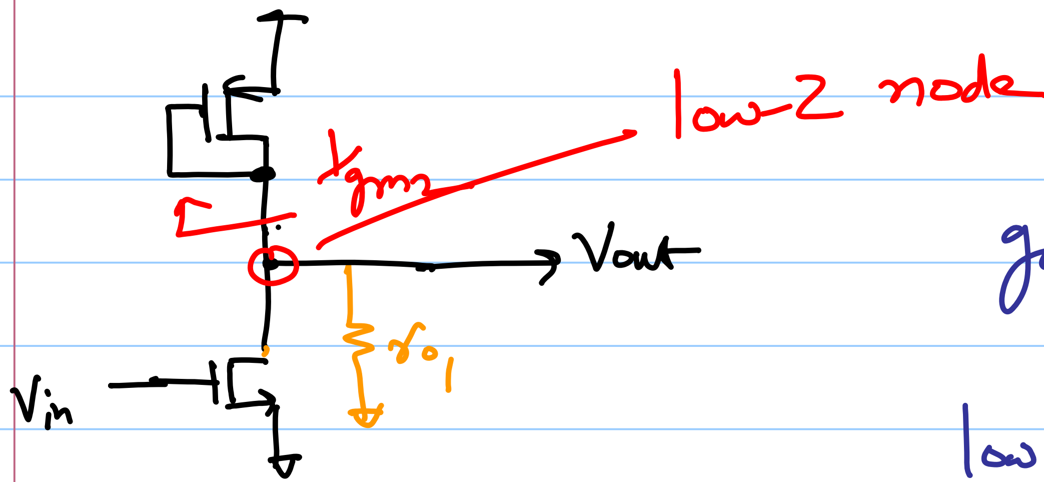
$$\simeq -\frac{g_{m1}}{g_{m2}(\eta+1)}$$

$$= \left(-\sqrt{\frac{(W/L)_1}{(W/L)_2}}\right) \cdot \frac{1}{\eta+1}$$

low gain

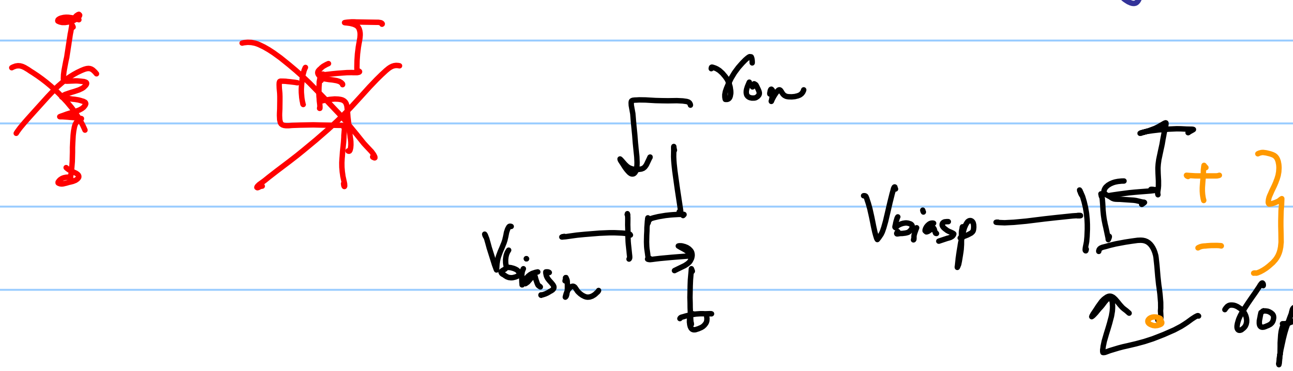


this gain is indep of bias conditions

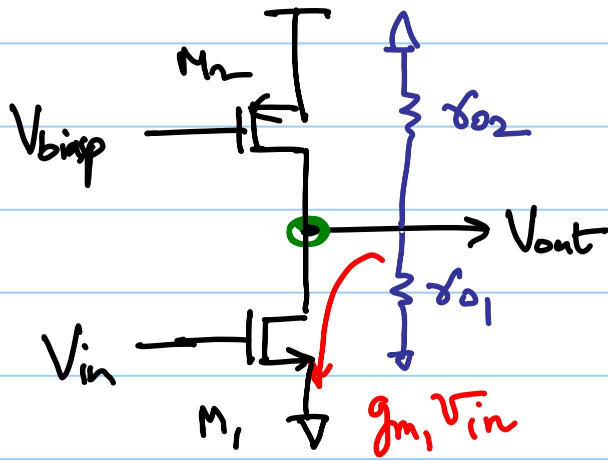


gain $\simeq g_m \cdot Z_{out}$

low-impedance at the output kills the gain

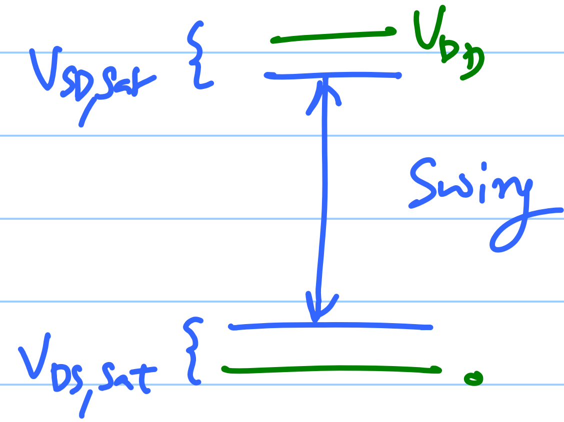


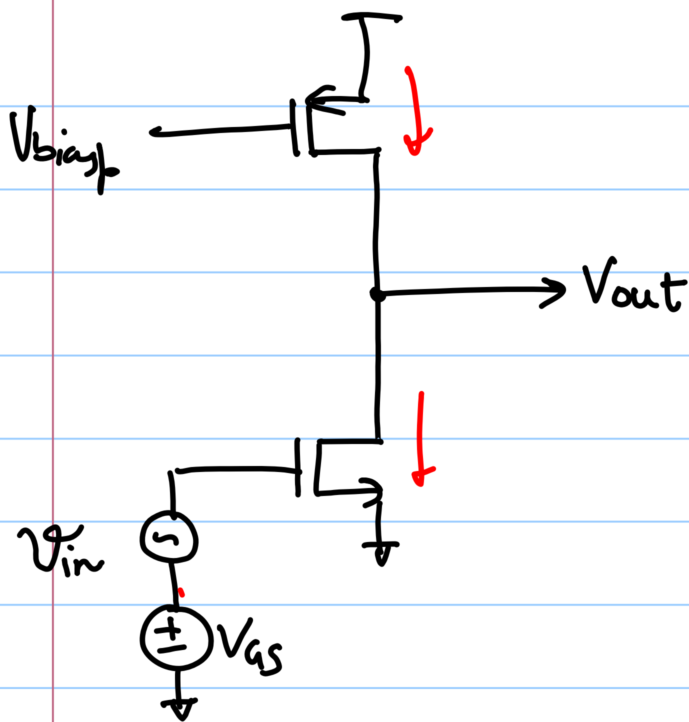
CS stage with current-source load



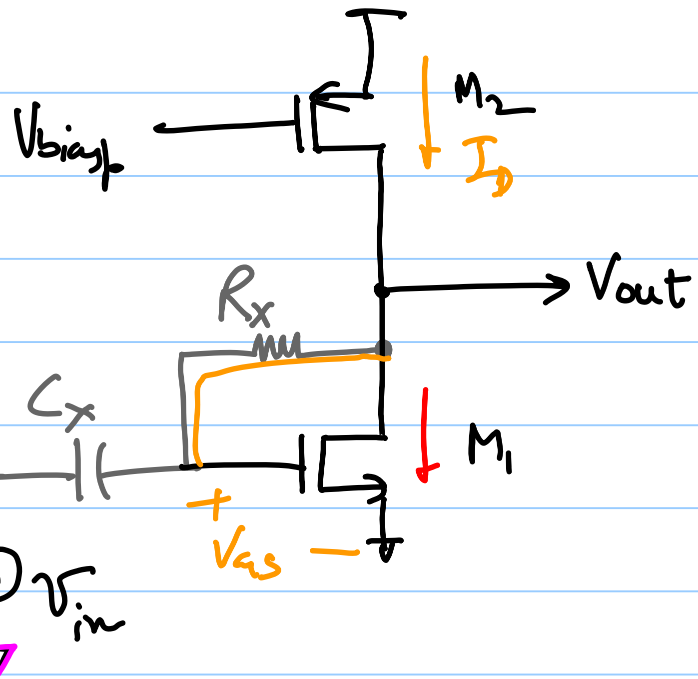
$$A_v = -g_{m1}(r_{o1} \| r_{o2})$$

$$\simeq \frac{g_m r_o}{2}$$



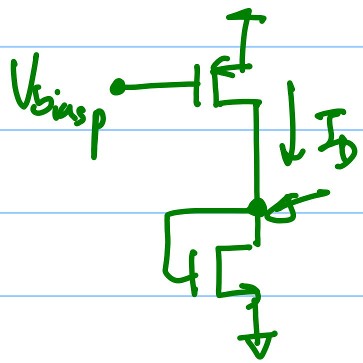


Vbiasp
Vout
vin
VGS



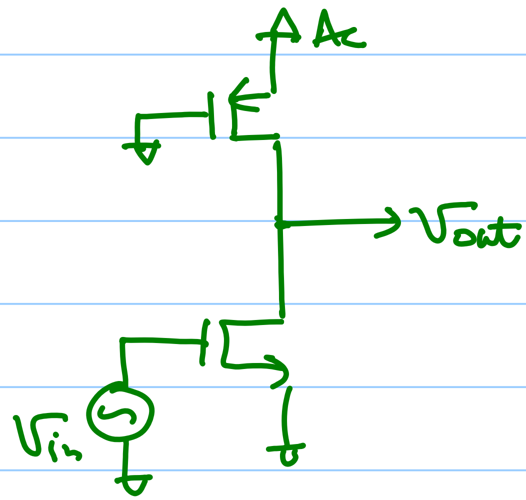
Vbiasp
M2
ID
Vout
Rx
Cx
M1
+
VGS
−
vin

Dc

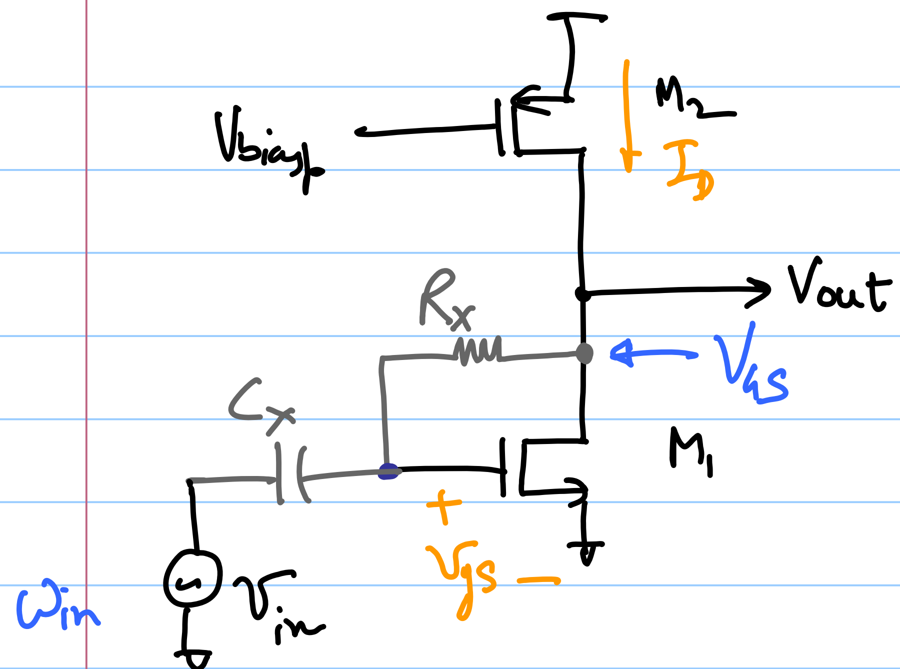


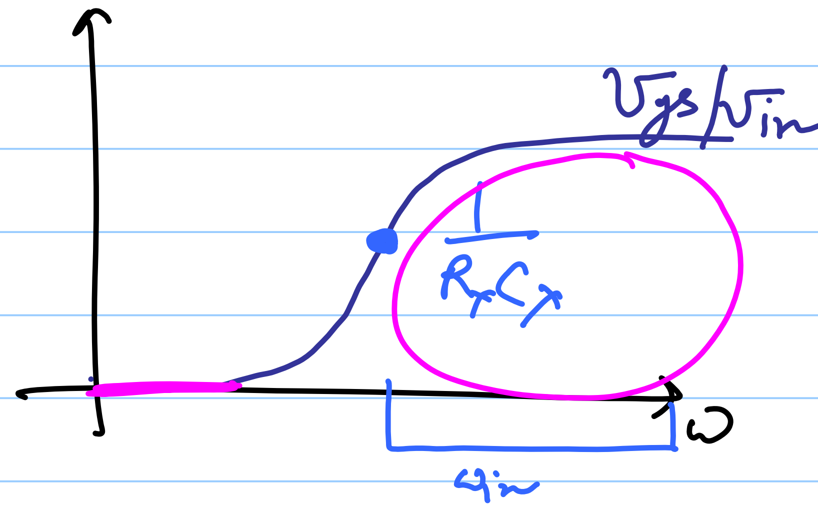
Vbiasp
ID

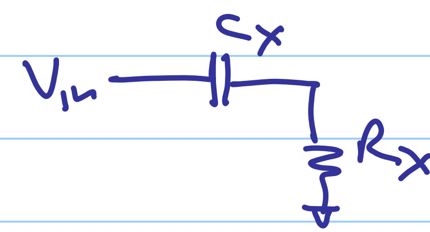
Ac



Ac
Vout
vin







$$\omega_x \ll \omega_{in}$$

$$\frac{1}{R_x C_x} \ll \omega_{in}$$

$$R_x C_x \gg \frac{1}{\omega_{in}} = \frac{10}{\omega_{in}}$$

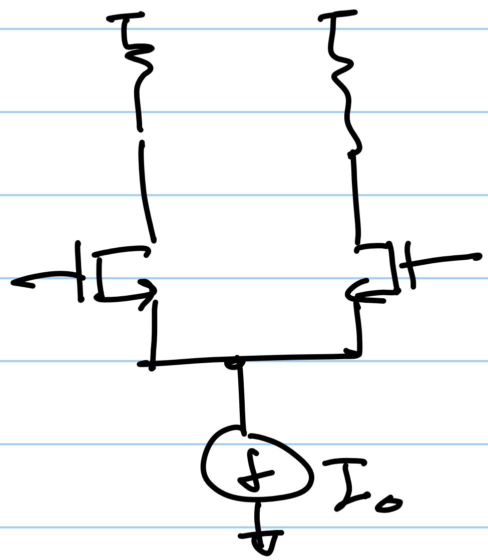
$\omega_{in} = 2\pi \times 1\text{kHz}$

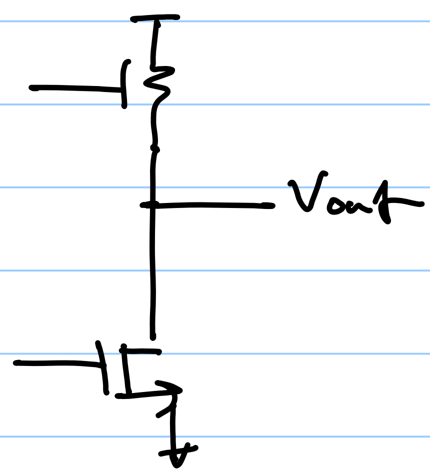
$$R_x C_x \geq \frac{10}{6.28 \times 10^3} = 1.6 \text{ ms}$$

$R_x = 100\text{k}\Omega$

$$C_x = \frac{1.6 \times 10^{-3}}{10^5} = 1.6 \times 10^{-8}$$

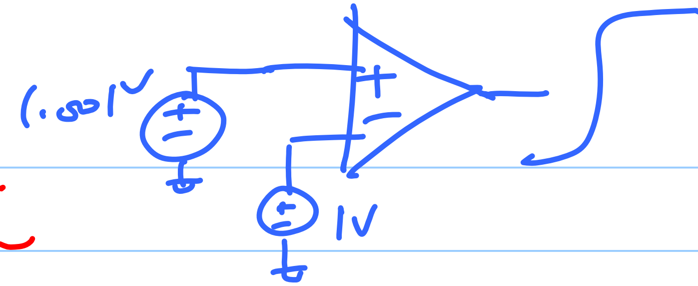
$= 16 \text{ nF}$





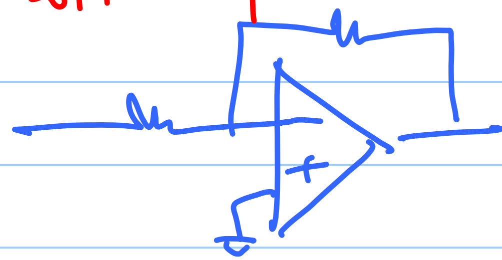
Triode load

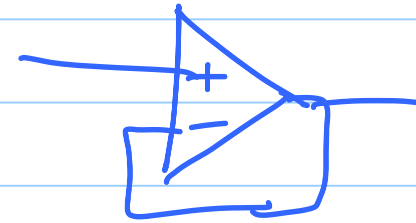
↳ poor gain

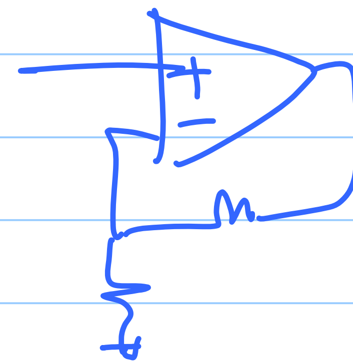


Always use large gain

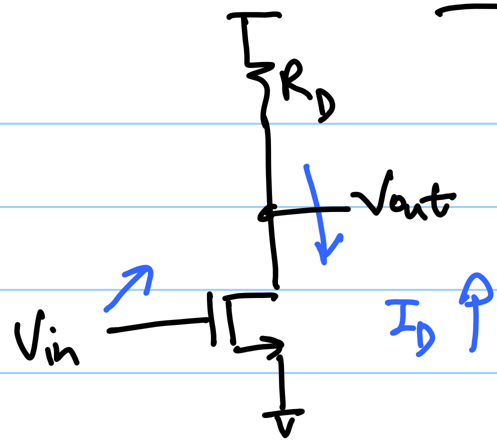
Stays with feedback

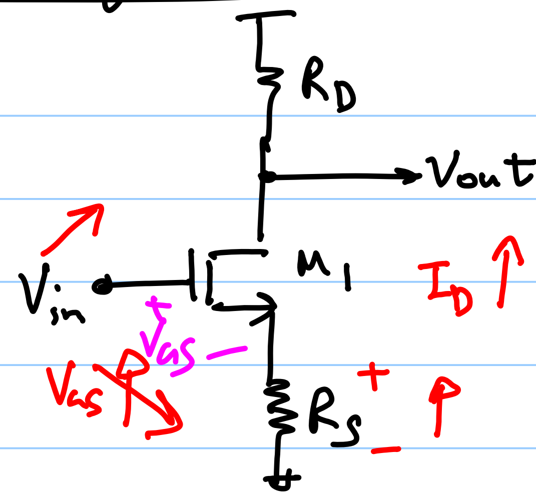






Source Degeneration





$$I_D = \frac{V_{in} - V_{GS}}{R_S}$$

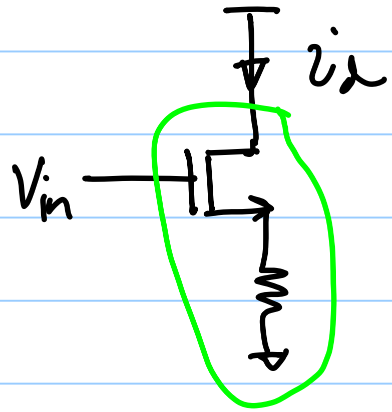
$M_1 \Rightarrow$ non linear IV characteristics

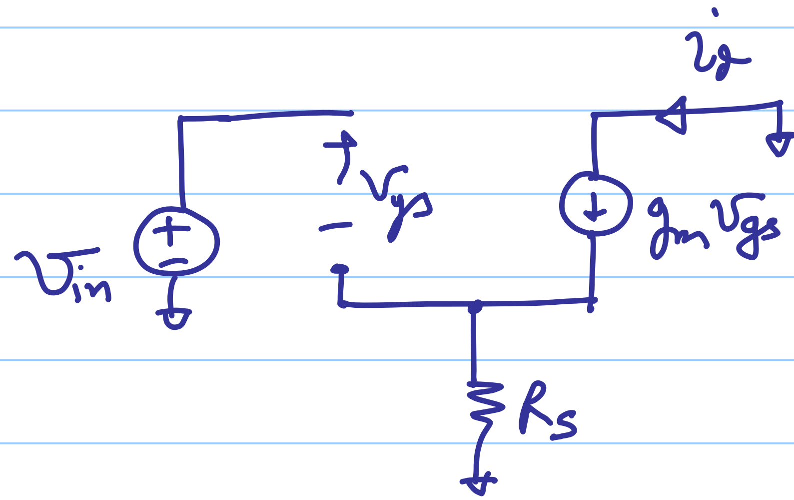
$R_S \Rightarrow$ linear resistance

$\Rightarrow$ a large portion of V_{in} is dropped across R_S

↳ I_D shows linear dependence on V_{in}

$\lambda = 0, \quad \gamma = 0$





$$G_m = \frac{g_m}{1 + g_m R_S}$$

$$\simeq \frac{1}{R_S} \quad \text{for } g_m R_S \gg 1$$