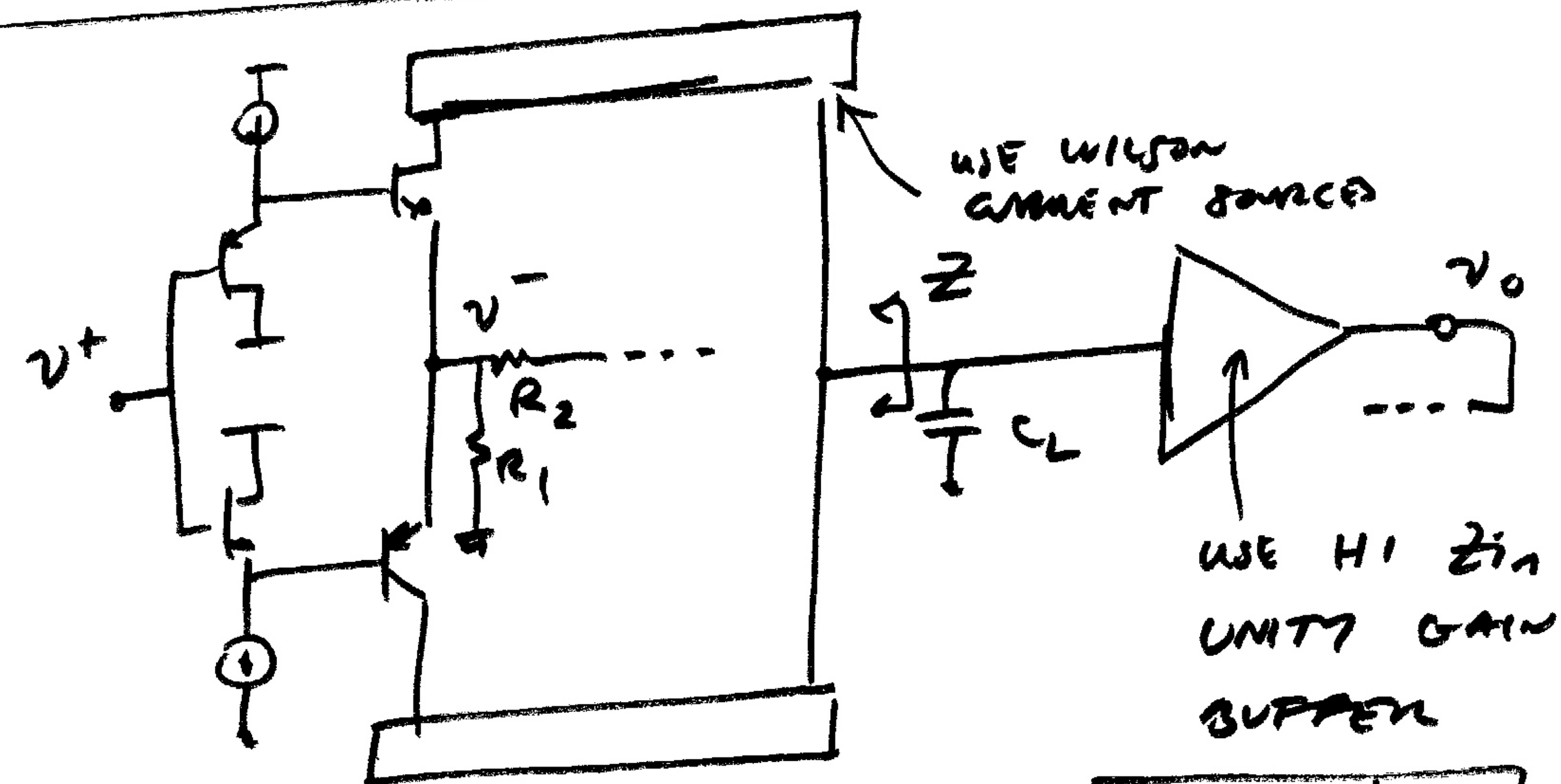
GAIN/BW PRODUCT OF CURRENT FB AMP



$$T = \frac{Z}{R_2} = \frac{R_0}{R_2} \frac{1}{1 + j\frac{\omega}{\omega_0}}$$

$$|T| = 1 = \frac{R_0}{R_2} \frac{\omega_0}{\omega_t}$$

$$\omega_0 = \frac{1}{C_L \cdot R_0}$$

$$\omega_t = \omega_0 \frac{R_0}{R_2} = \frac{1}{C_L R_2}$$

$$A_{CL} = \left(1 + \frac{R_2}{R_1}\right) \frac{1}{1 + 1/T} = \frac{\left(1 + \frac{R_2}{R_1}\right)}{1 + \frac{R_2}{R_0}\left(1 + j\frac{\omega}{\omega_0}\right)}$$

$$\frac{R_2}{R_0} \ll 1$$

$$= \frac{\left(1 + \frac{R_2}{R_1}\right)}{1 + j\frac{\omega}{\omega_0}\frac{R_2}{R_0}} = \frac{\left(1 + \frac{R_2}{R_1}\right)}{1 + j\frac{\omega}{\omega_a}}$$

$$\omega_a = \frac{R_0}{R_2} \cdot \omega_0 = \frac{1}{R_2 \cdot C_L} = \omega_t$$

R_2 CONTROLS BW $\Rightarrow$ GAIN & BANDWIDTH

DE-COUPLED

NICE FOR VGA APPLICATIONS!

VARIABLE GAIN AMP

$$\text{GAIN} \times \text{BW} = \left(1 + \frac{R_2}{R_1}\right) \cdot \frac{R_0}{R_2} \omega_0$$

$$\simeq \frac{R_0}{R_1} \omega_0 = \frac{\cancel{R_0}}{R_1} \frac{1}{C_L \cdot \cancel{R_0}} = \frac{1/R_1}{C_L}$$

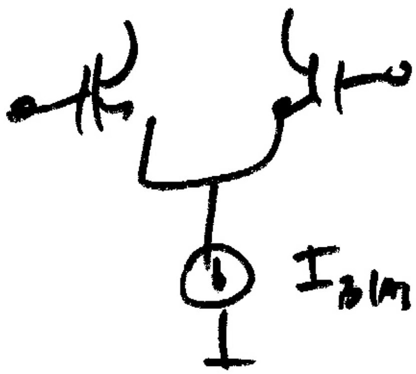
$$= \frac{G_m}{C_L}$$

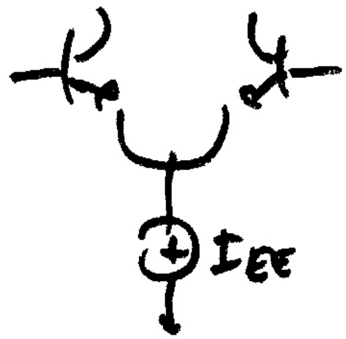
RECALL FOR VOLTAGE AMP:

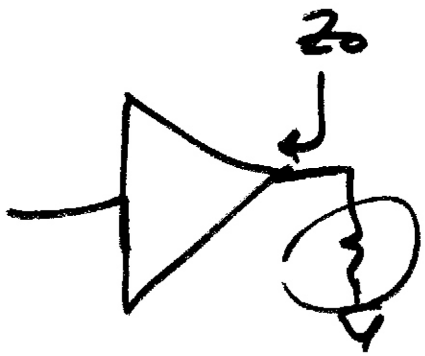
$$A = \frac{A}{1 + Af} = \left(\frac{A_0}{1 + A_0 f}\right) \frac{1}{1 + j \frac{\omega}{\omega_0 (1 + A_0 f)}}$$

$$\text{GAIN} \times \text{BW} = \left(\frac{A_0}{1 + \cancel{A_0 f}}\right) \times \omega_0 (1 + \cancel{A_0 f})$$

$$= A_0 \omega_0 = \omega_u = \frac{G_m}{C_L}$$

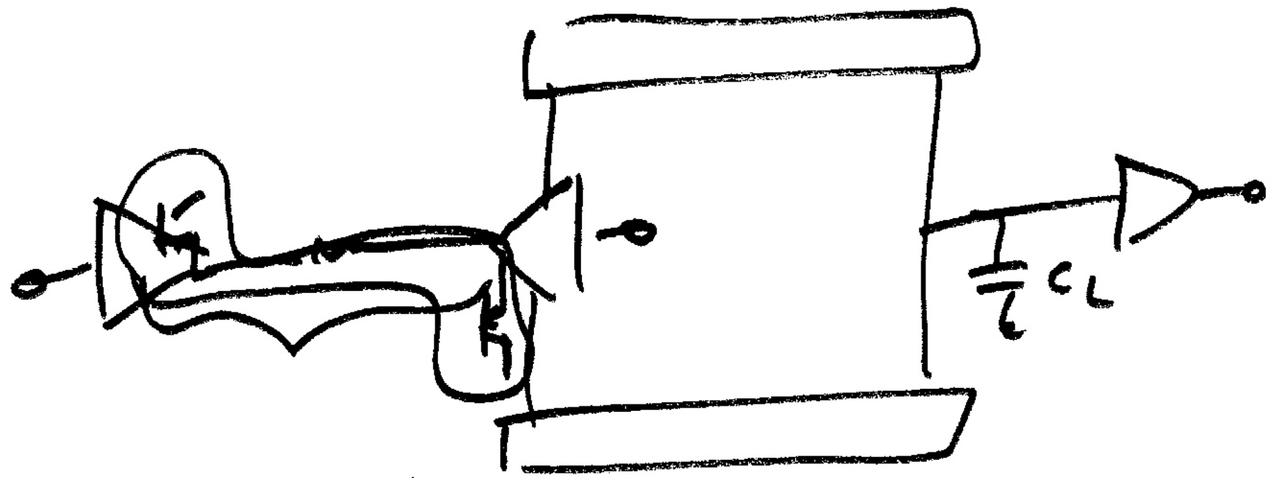


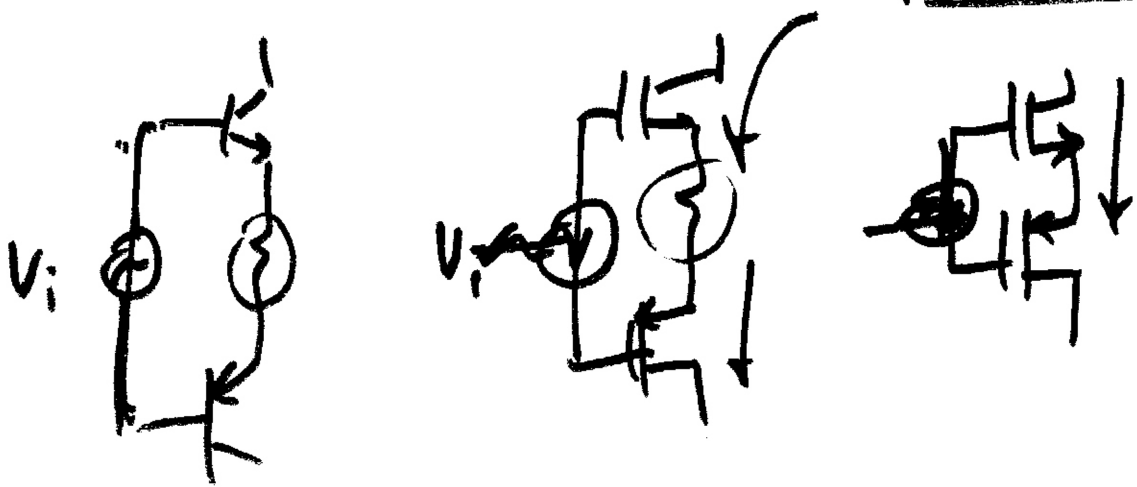




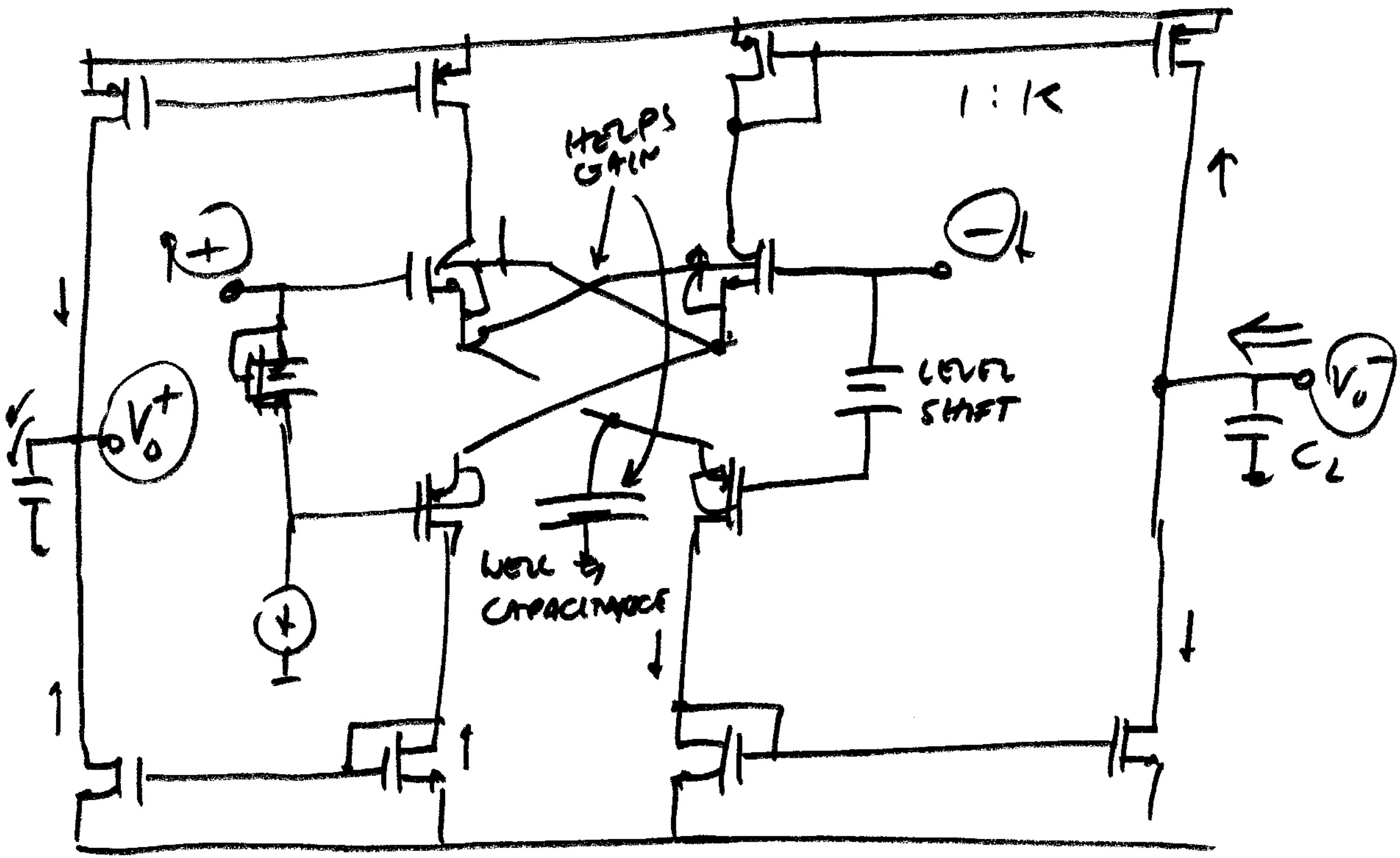
$G_m \propto 1/R$

CMOS CLASS A/B STAGE

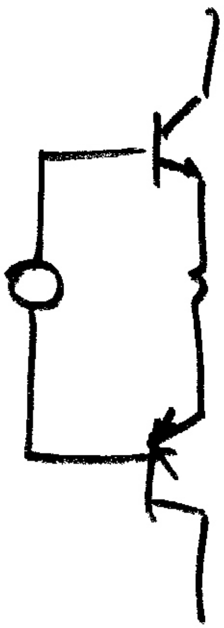


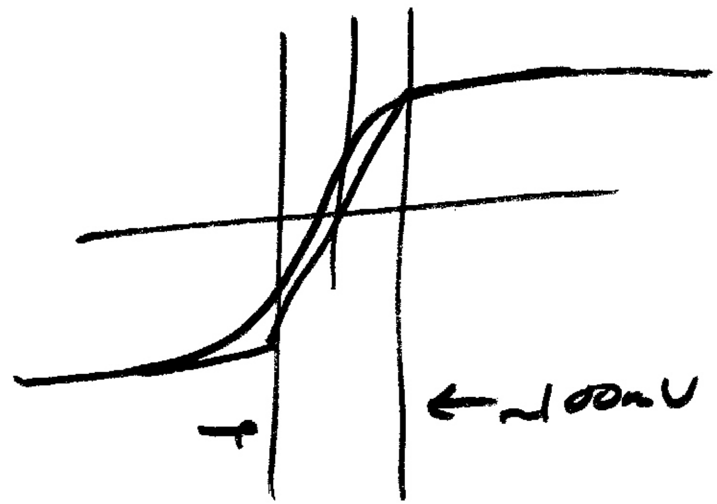


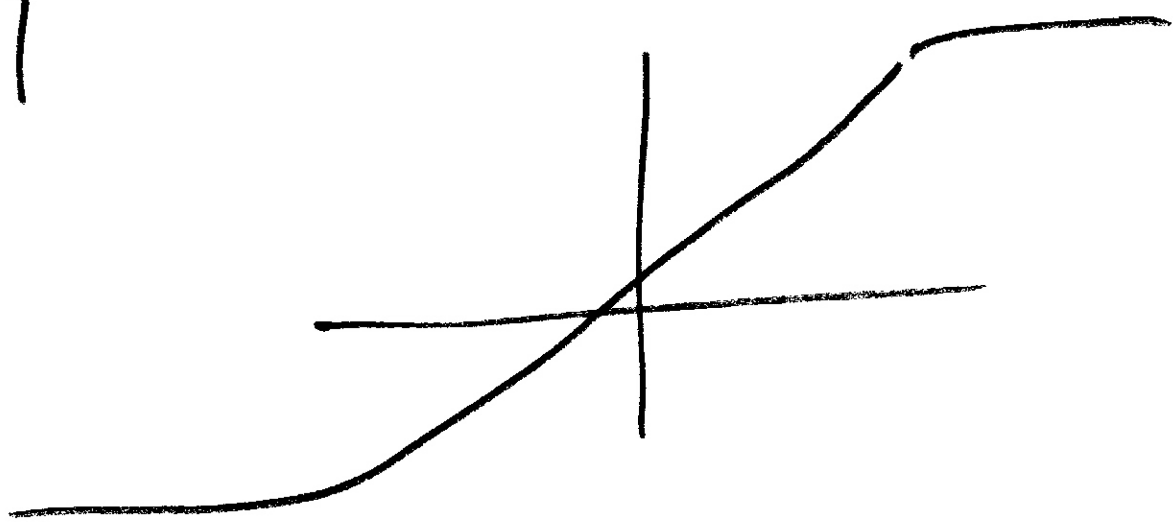
BASIC
CLASS A/B
BUILDING
BLOCK



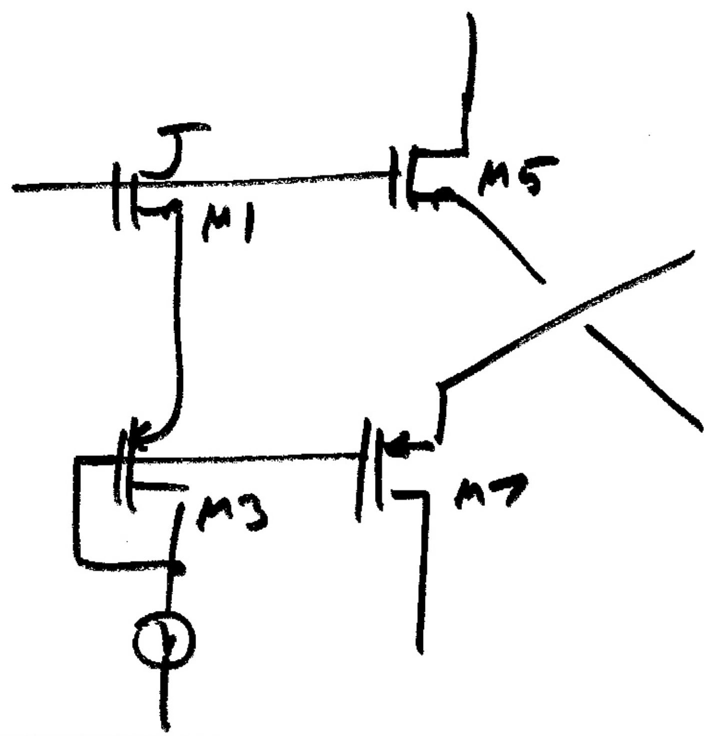
HELPS GAIN
1 : K
+
−
LEVEL SHIFT
V_0^+
V_0^-
C_L
WELL to CAPACITANCE

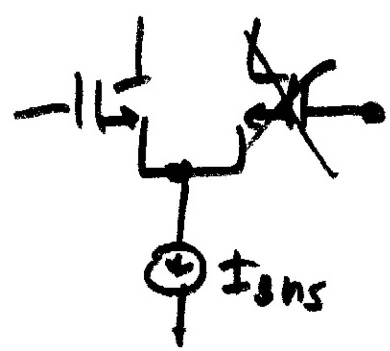

v_i

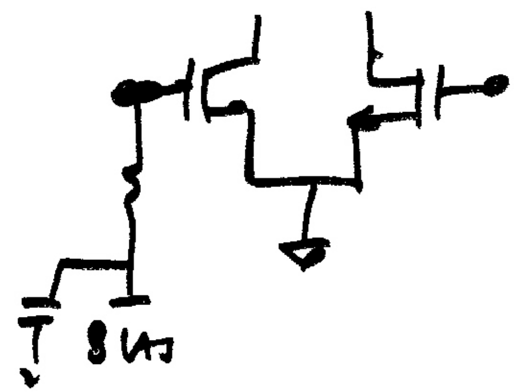

~100mV

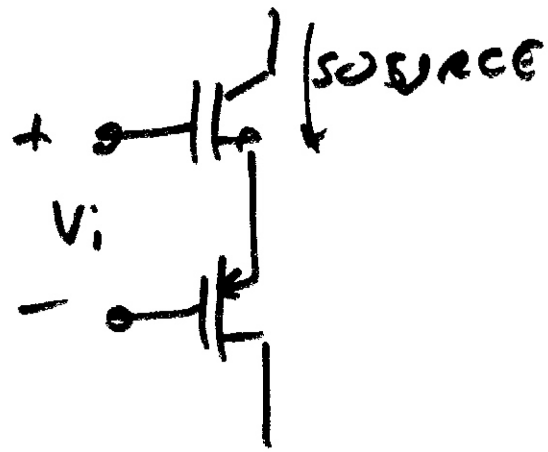


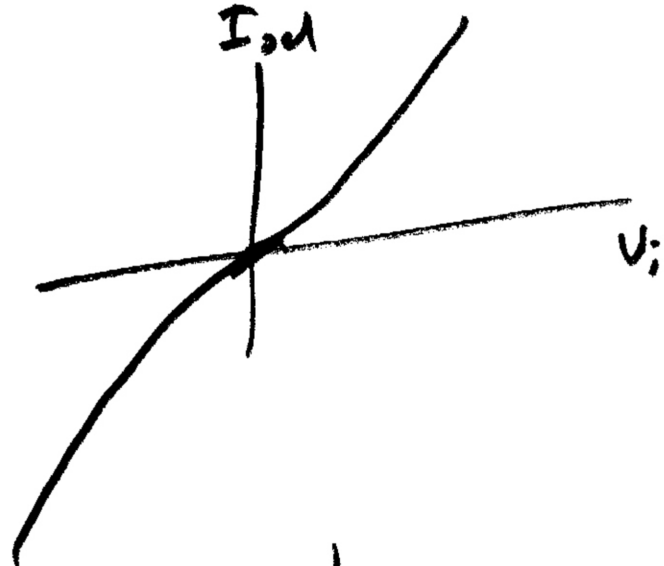
CLASS A-B

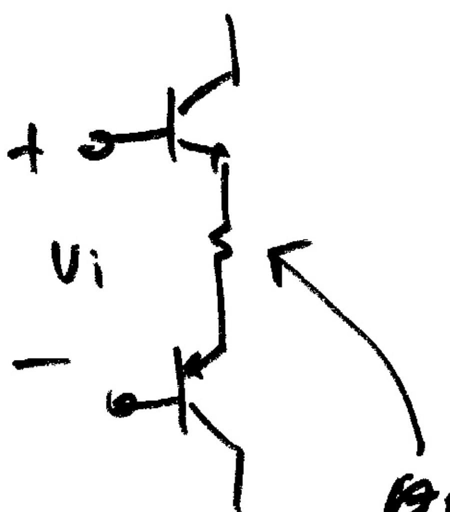


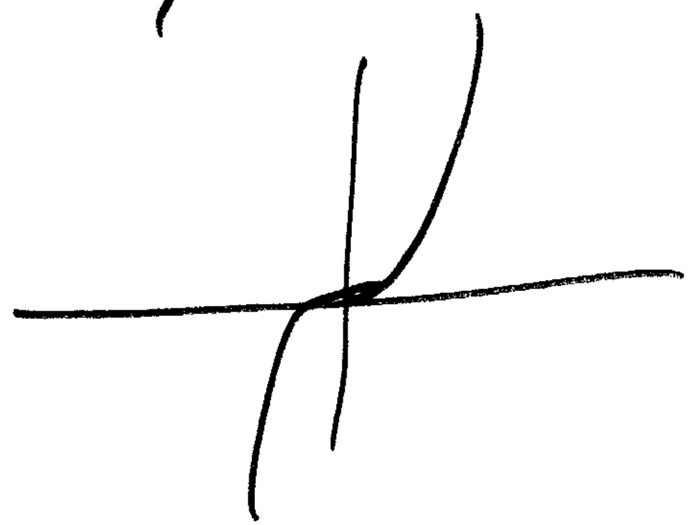




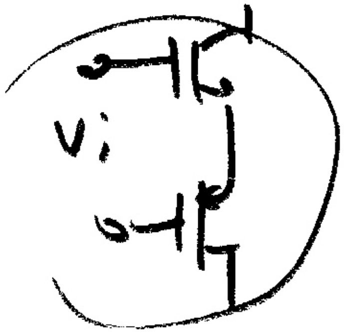








RESISTOR IS NEEDED FOR LINEARITY.



≡

EQUIV TRANSISTOR

ASSUME SQUARE LAW

$$I_D = \mu C_{ox}\left(\frac{W}{L}\right)\left(V_{GS} - V_T\right)^2$$

$$V_i = V_{GSn} + |V_{GSp}|$$

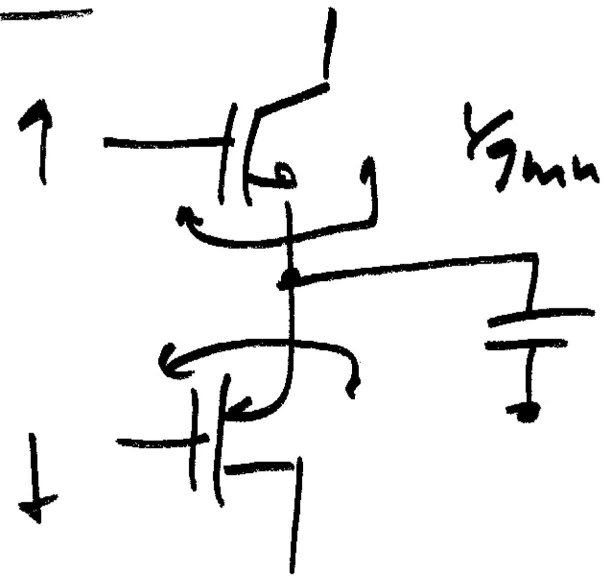
$$= V_{Tn} + V_{Tp} + \sqrt{\frac{2 I_D}{\mu C_{ox}\left(\frac{W}{L}\right)_n}} + \sqrt{\frac{2 I_D}{\mu C_{ox}\left(\frac{W}{L}\right)_p}}$$

$$= \underbrace{\left(V_{Tn} + V_{Tp}\right)}_{V_{Teff}} + \sqrt{2 I_D}\left(\sqrt{\frac{1}{\left(\mu C_{ox}\frac{W}{L}\right)_n}} + \sqrt{\frac{1}{\left(\;\right)_p}}\right)$$

Effective $\mu C_{ox}\left(\frac{W}{L}\right)$

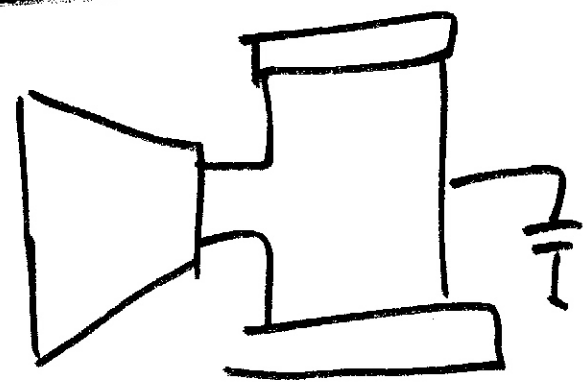
$$V_i = V_{T,eff} + \frac{\sqrt{2 I_D}}{\sqrt{\left(k'\left(\frac{W}{L}\right)\right)_{eff}}}$$

FREQ RESP :

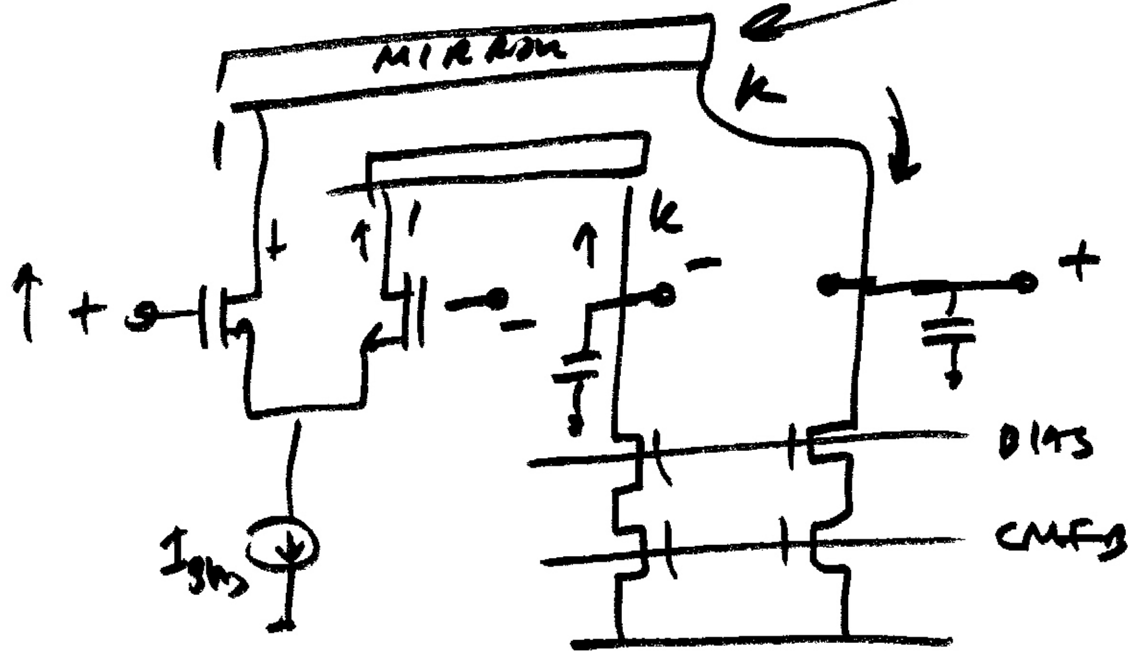


$1/g_{mn} = 1/g_{mp}$

CURRENT MIRROR OP-AMP



GAIN $= G_m \cdot K \cdot Z$



NON-DOMINANT POLE

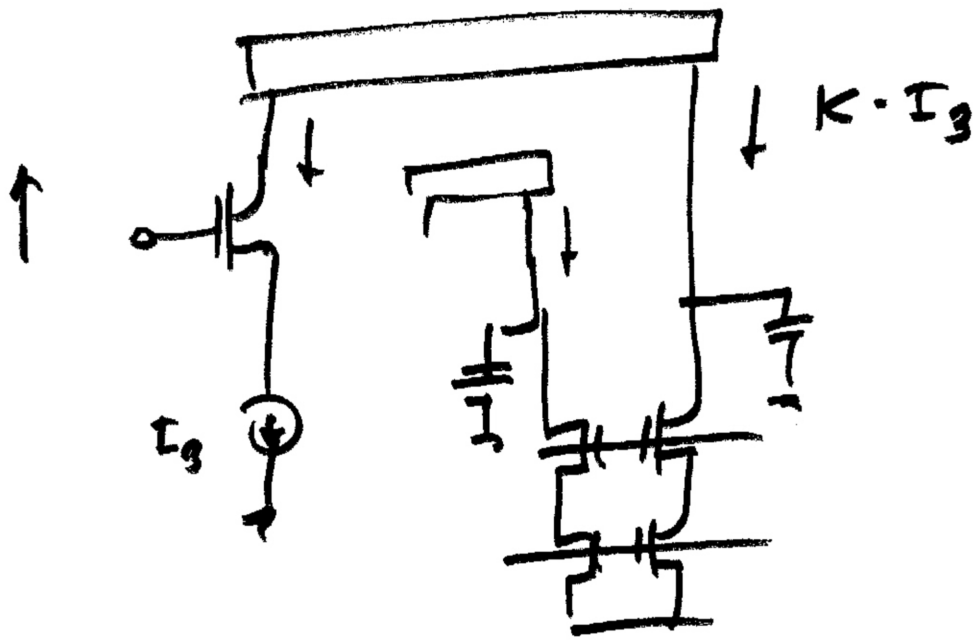
$\frac{f_{TP}}{K}$

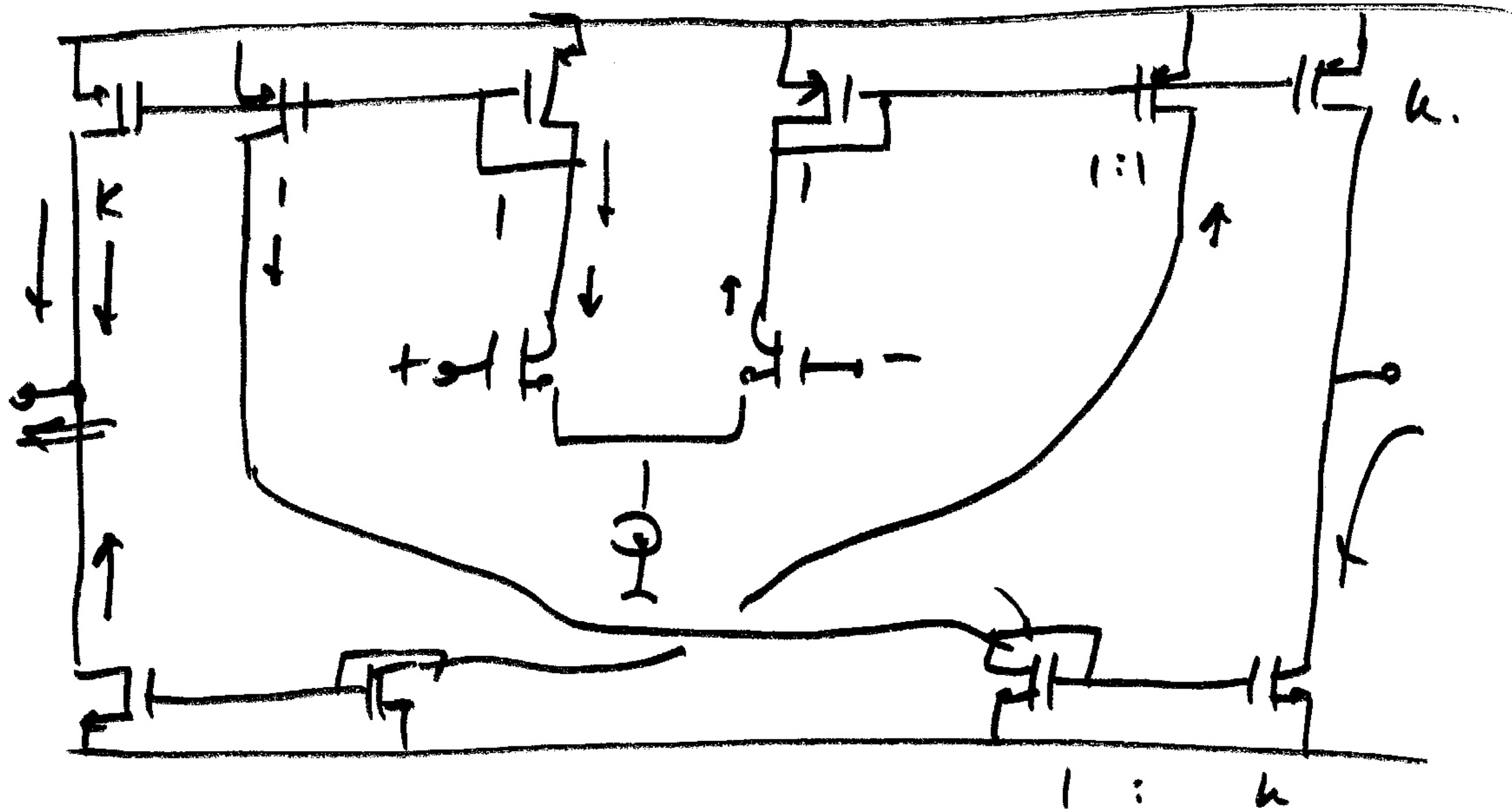
NMOS I/P STAGE : LOWER NOISE

1/f BETTER!

PMOS I/P STAGE : HIGHER B/W DUE TO NON-DOM. POLE CURRENT MIRROR

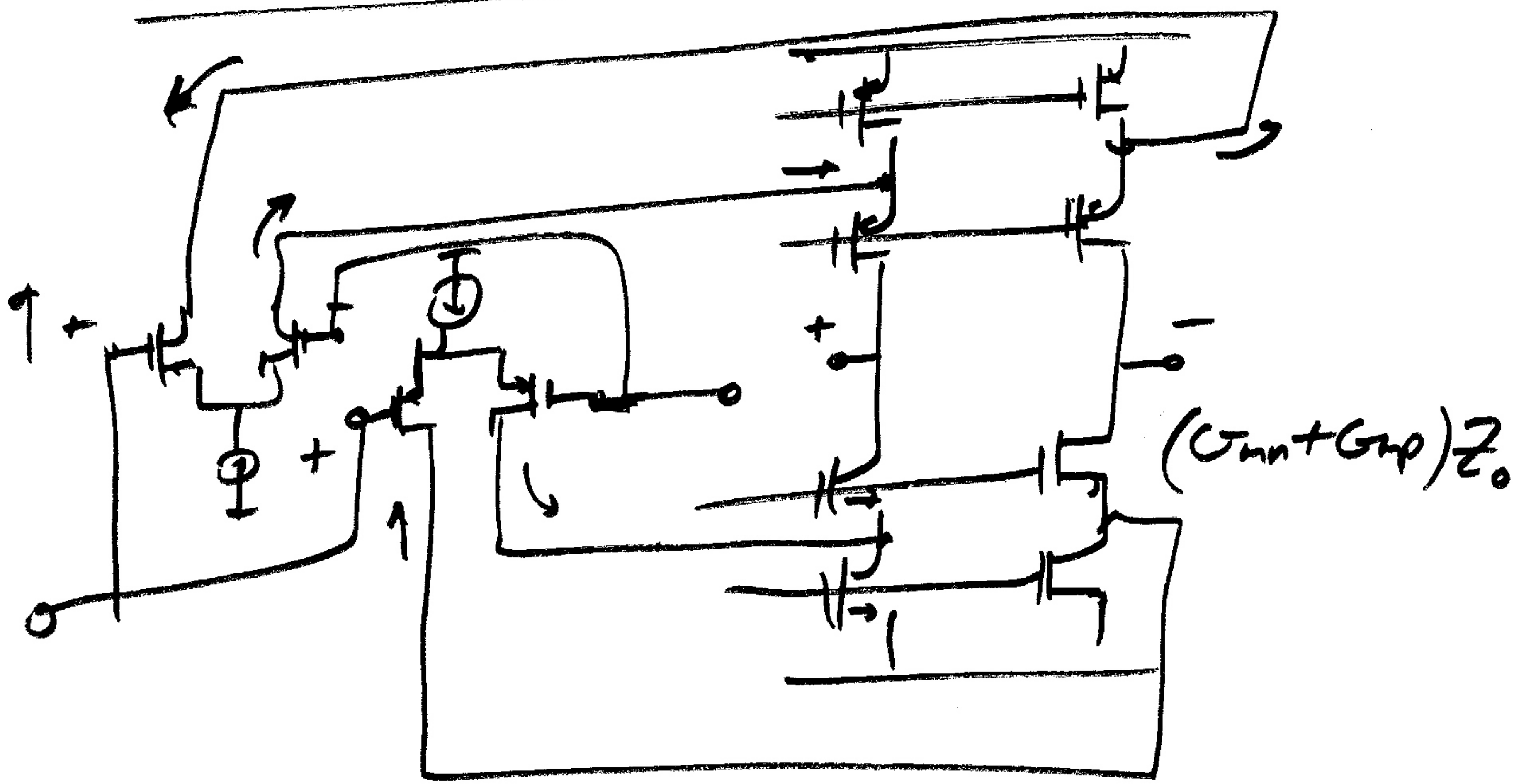
SR LIMITING





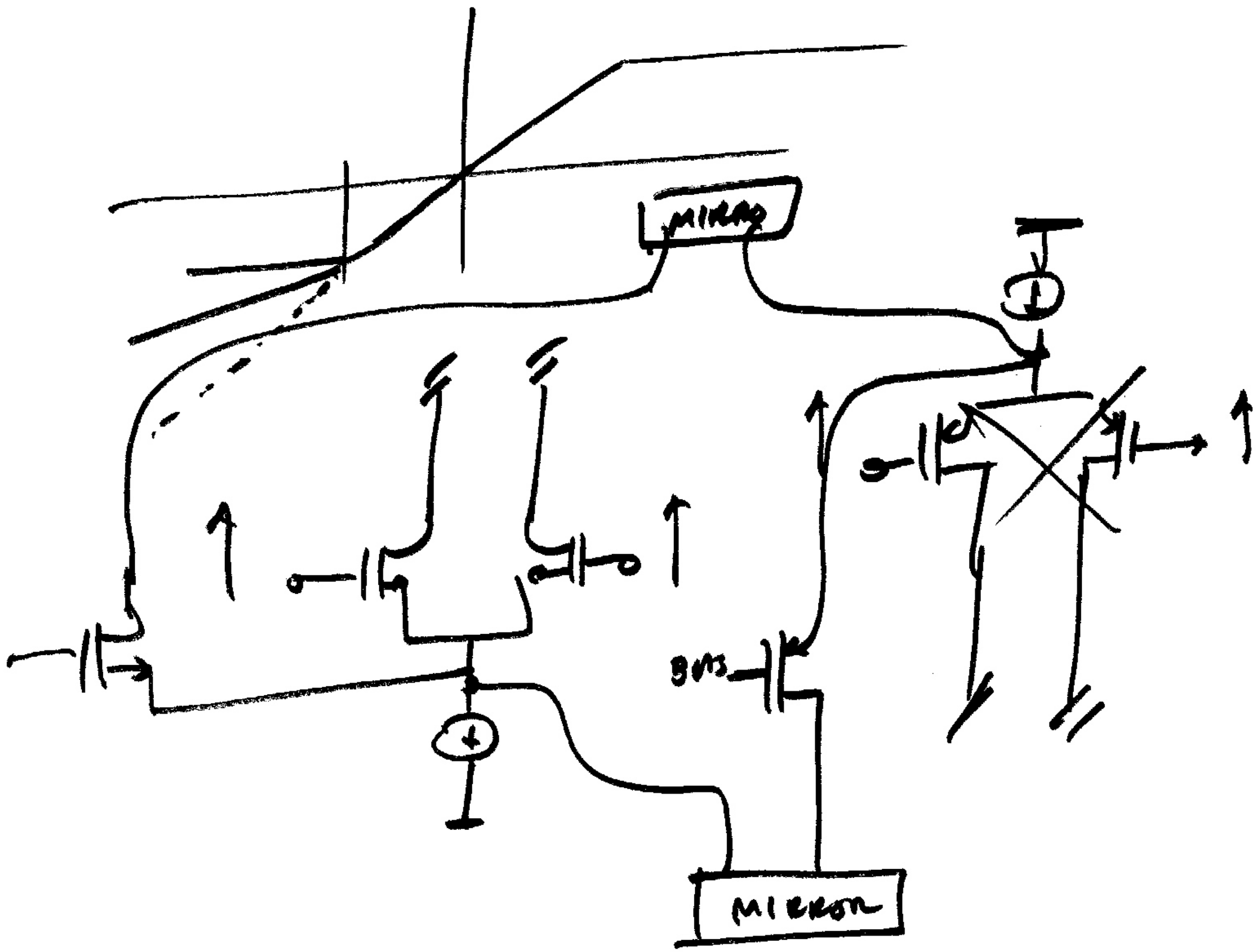
THIS CIRCUIT CAN SLEW
SYMMETRICLY

FOLDED CASCODE

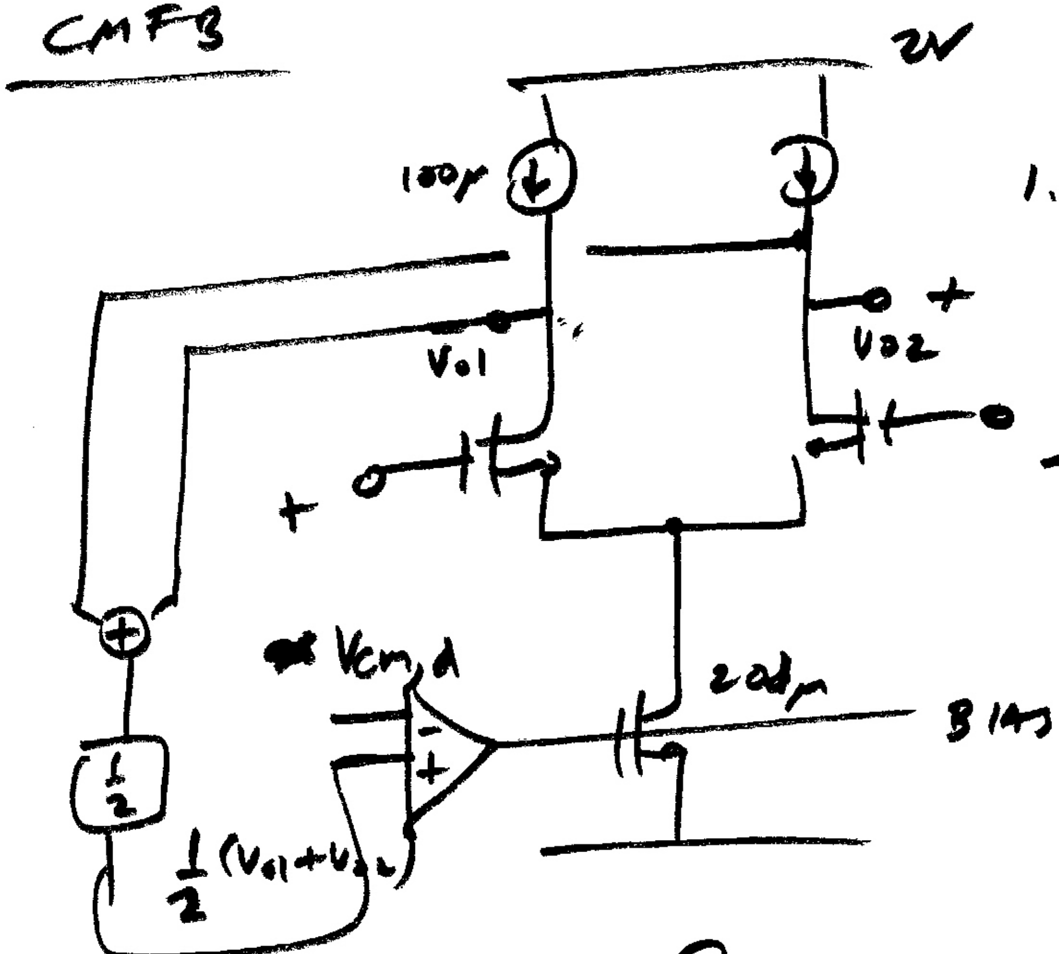


— ISSUES → EXTRA NON-DOMINANT POLE

→ INPUT RANGE VERY LARGE


MIRROR
BIAS
MIRROR

CMFB



1.5V SWING!

$$\Delta V = \Delta I \cdot R_{BIG}$$

$$= 1\mu A \cdot 1M\Omega = 1V$$

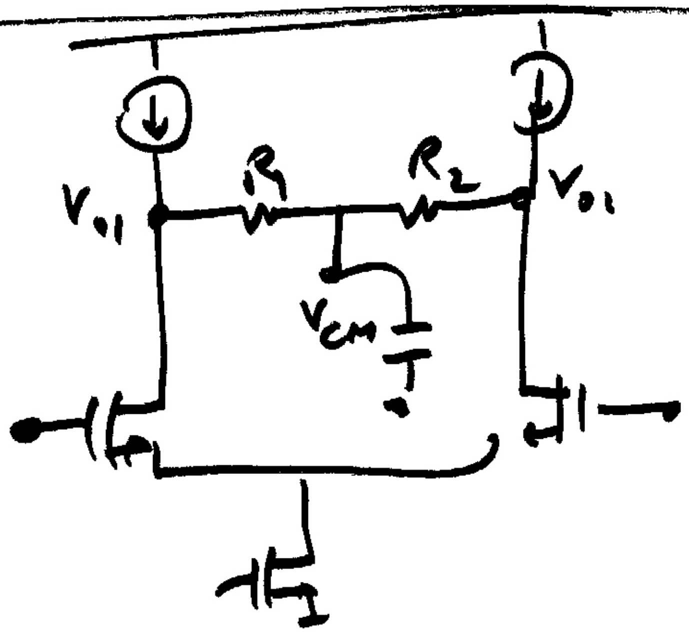
EVEN IF 100mV → LOSE SWING.

$$V_{o1} = V_{cm} + \frac{\Delta V}{2}$$

$$V_{o2} = V_{cm} - \frac{\Delta V}{2}$$

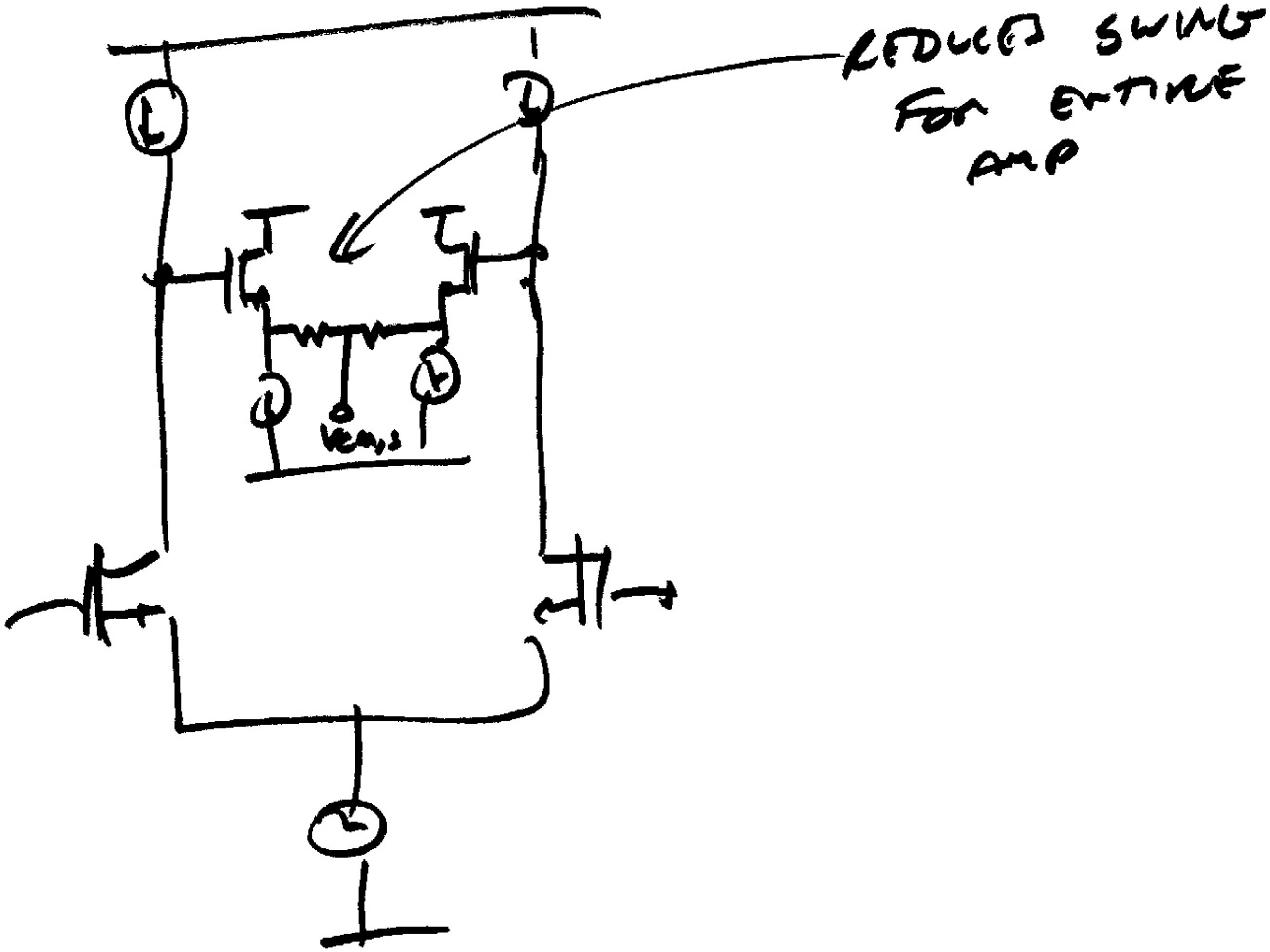
$$\frac{V_{o1} + V_{o2}}{2} = \underline{V_{cm}}$$

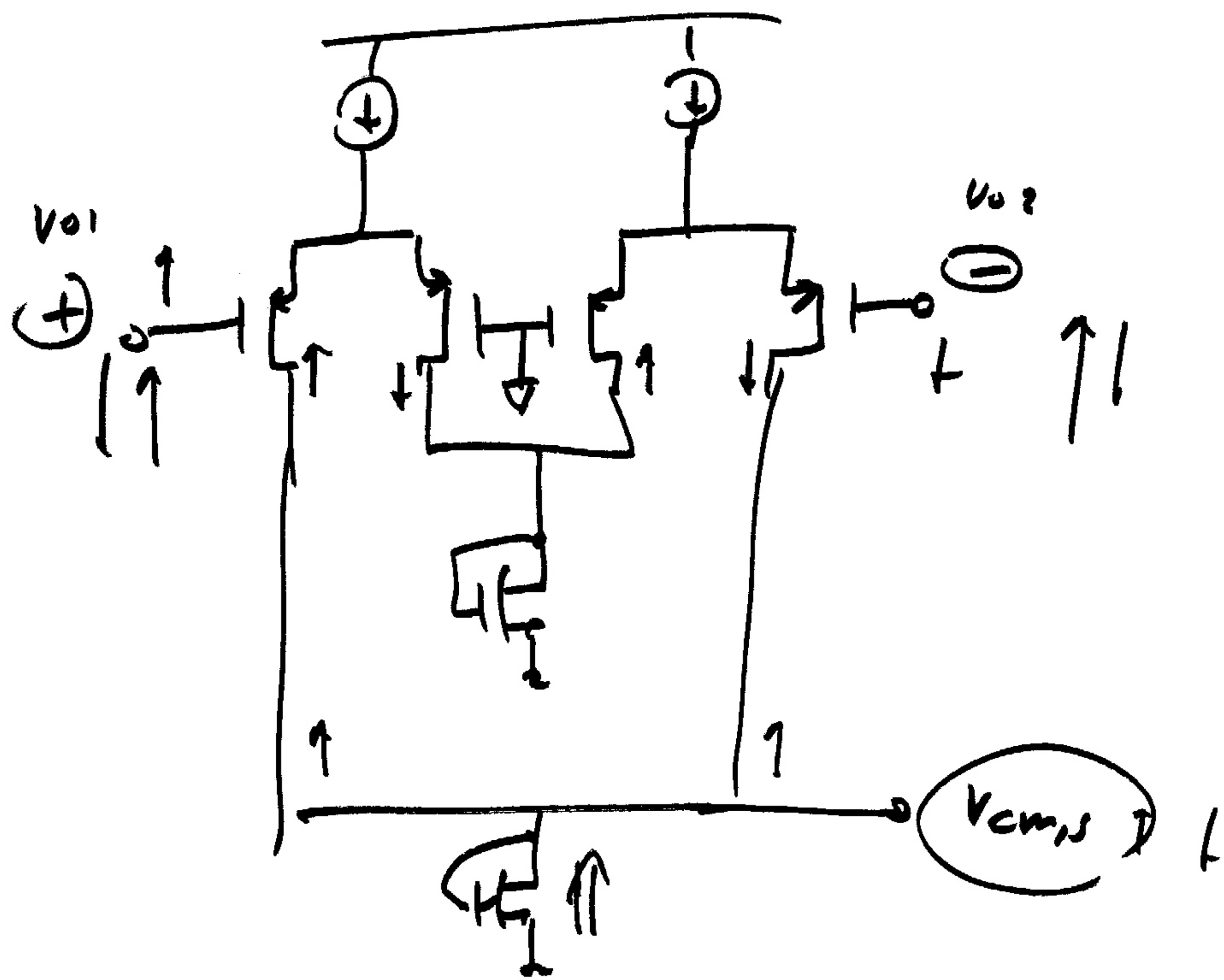
HOW TO SENSE THE CM VOLTAGE



$$V_{cm} = V_{o1} \frac{R_2}{R_1+R_2} + V_{o2} \frac{R_1}{R_1+R_2}$$

$$= \frac{1}{2}(V_{o1} + V_{o2})$$


VCMIS
REDUCED SWING FOR ENTIRE AMP


Vo1
+
Vo2
−
Vcmfb