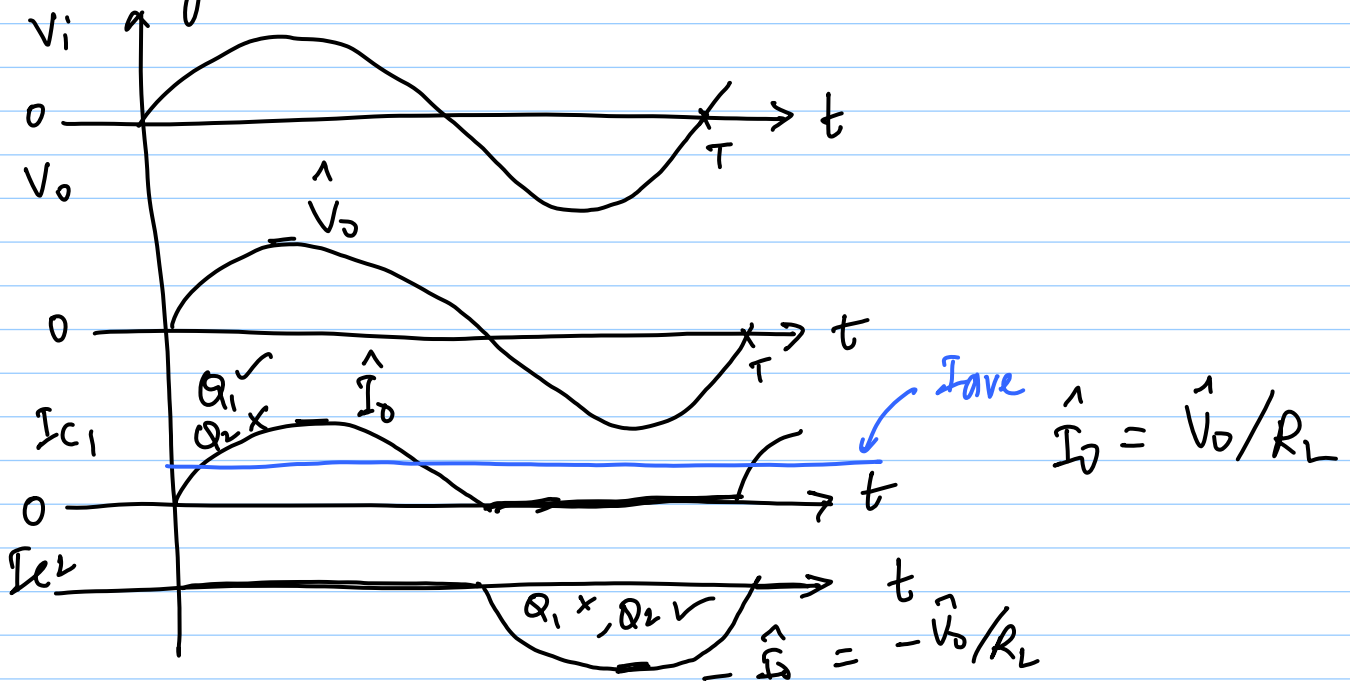
17-4-12

Lec 42

Class-B Pout & η_c

* neglect dead band



$I_{supply} \equiv$ average value of I_{c1}

$$= \frac{1}{T}\int_0^T I_{c1}(t)\,dt$$

$$= \frac{1}{T}\int_0^{T/2} \frac{V_o}{R_L}\sin\left(\frac{2\pi t}{T}\right)dt$$

$$= \frac{1}{\pi}\frac{V_o}{R_L} = \frac{1}{\pi}\hat{I}_o = \text{average value of } I_{c2}$$

$$P_{supply} = 2V_{cc}I_{sup} = \frac{2}{\pi}V_{cc}\cdot\frac{V_o}{R_L}$$

* $P_{supply} \propto \hat{V}_o$ for class B stage

$P_L \equiv$ average power delivered to load

$$= \frac{1}{2} \frac{\hat{V}_o^2}{R_L}$$

$$\eta_c = \frac{P_L}{P_{sup}} = \frac{\frac{1}{2} \frac{\hat{V}_o^2}{R_L}}{\frac{2}{\pi} \frac{V_{CC}}{R_L} \cdot \hat{V}_o}$$

$$= \frac{\pi}{4} \frac{\hat{V}_o}{V_{CC}}$$

* $\eta_c \propto \hat{V}_o / V_{CC}$ but is independent of R_L

$$\eta_{c(max.)} = \frac{P_{L(max.)}}{P_{sup}}$$

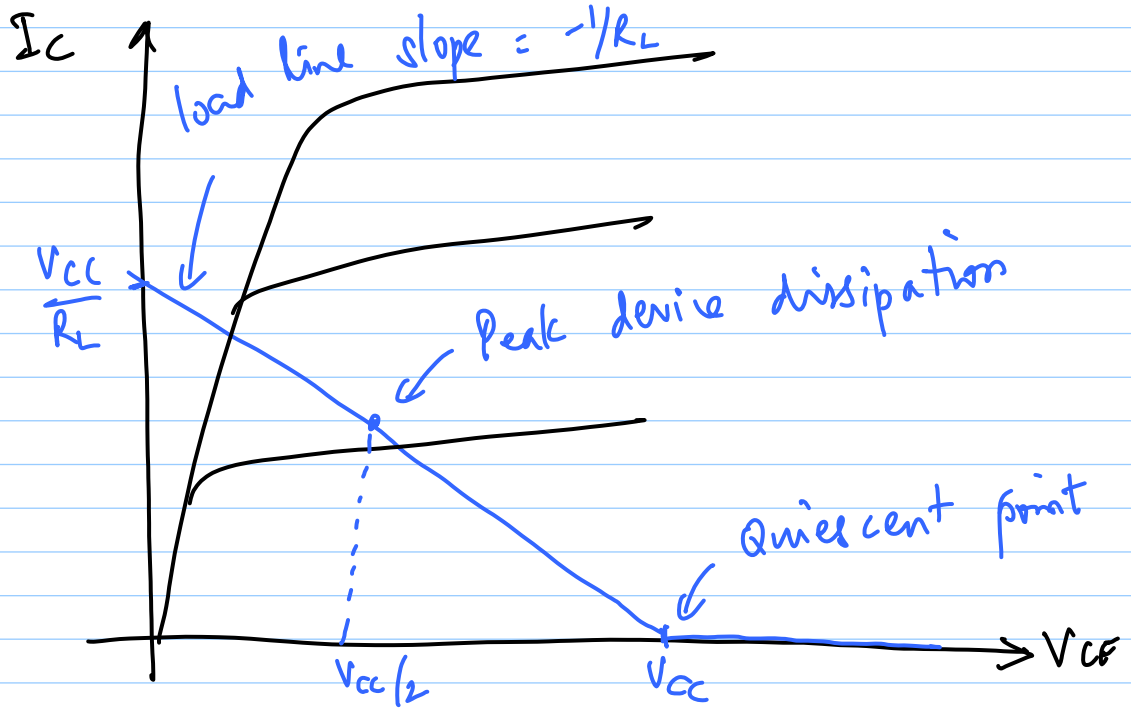
$$= \frac{\pi}{4} \frac{\hat{V}_{om}}{V_{CC}}$$

$$= \frac{\pi}{4} \frac{(V_{CC} - V_{SAT})}{V_{CC}}$$

$$= \frac{\pi}{4} \left[1 - \frac{V_{SAT}}{V_{CC}} \right]$$

$\simeq$ 78.6 % ← much larger than class A

* Standby power consumption is zero
* very high eff. η_C (>> class A)



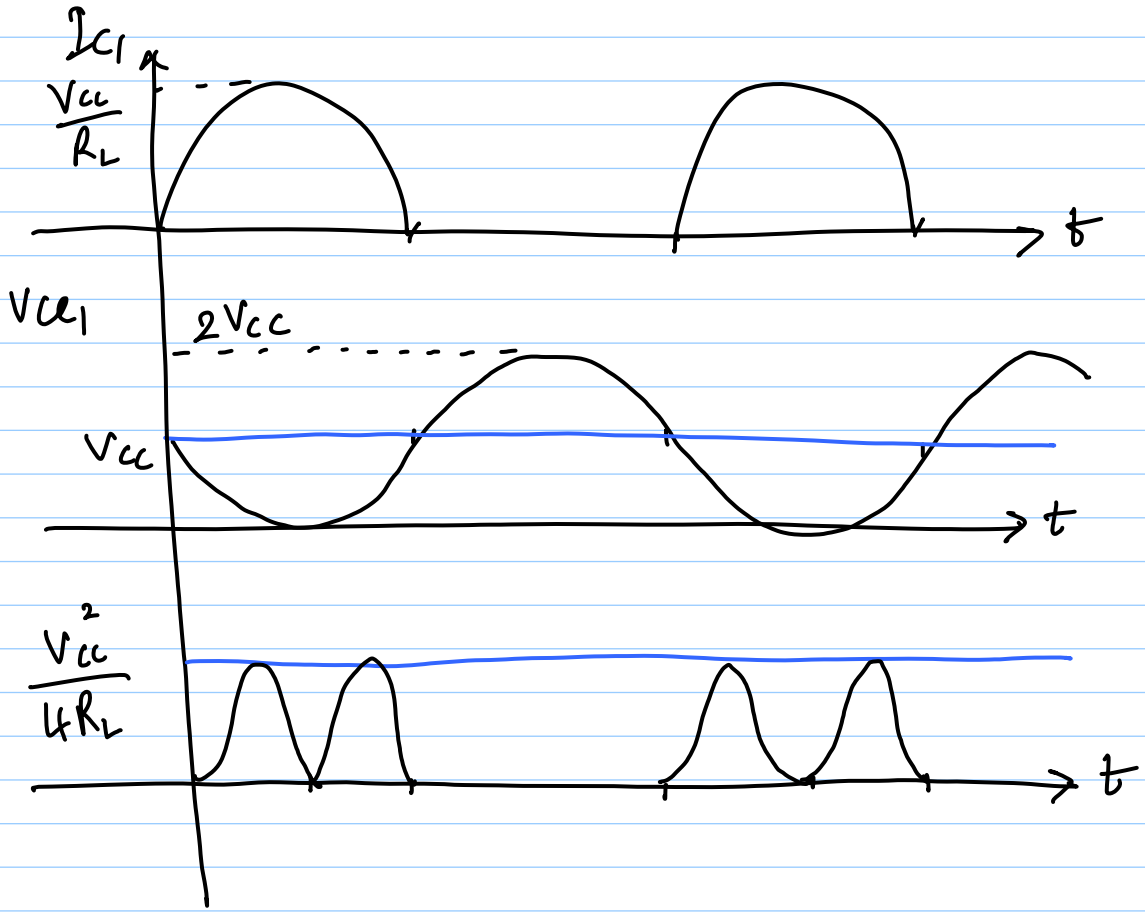
$$P_C = I_C \cdot V_{ce}$$

$$= I_C \left[V_{CC} - I_C R_L \right]$$

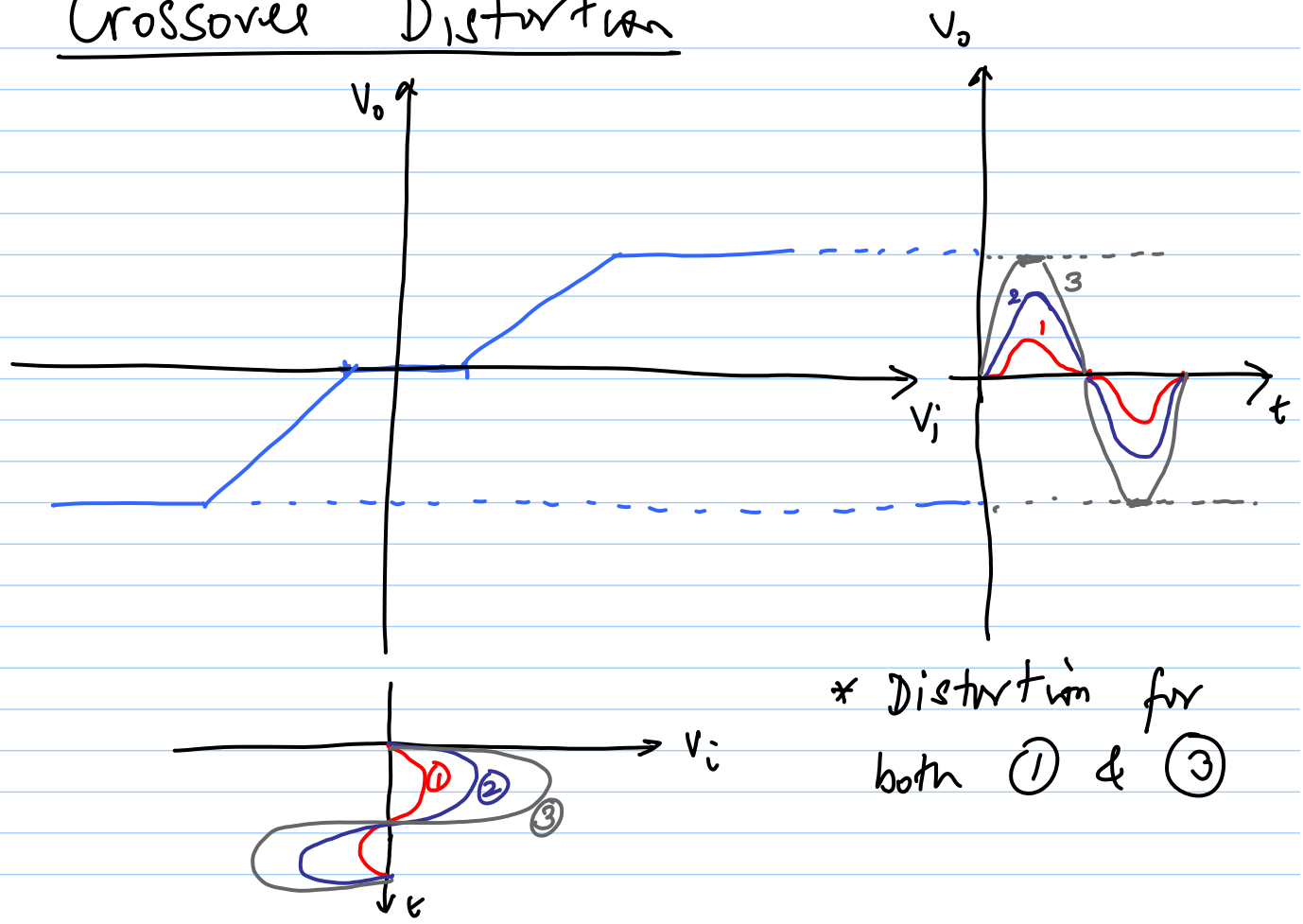
$$= I_{CC} V_{CC} - I_C^2 R_L$$

$$\frac{\partial P_C}{\partial I_C} = 0 \Rightarrow I_C \Big|_{P_{C\max.}} = \frac{V_{CC}}{2R_L}$$

$$\Rightarrow V_o \Big|_{P_{C\max.}} = \frac{V_{CC}}{2}$$



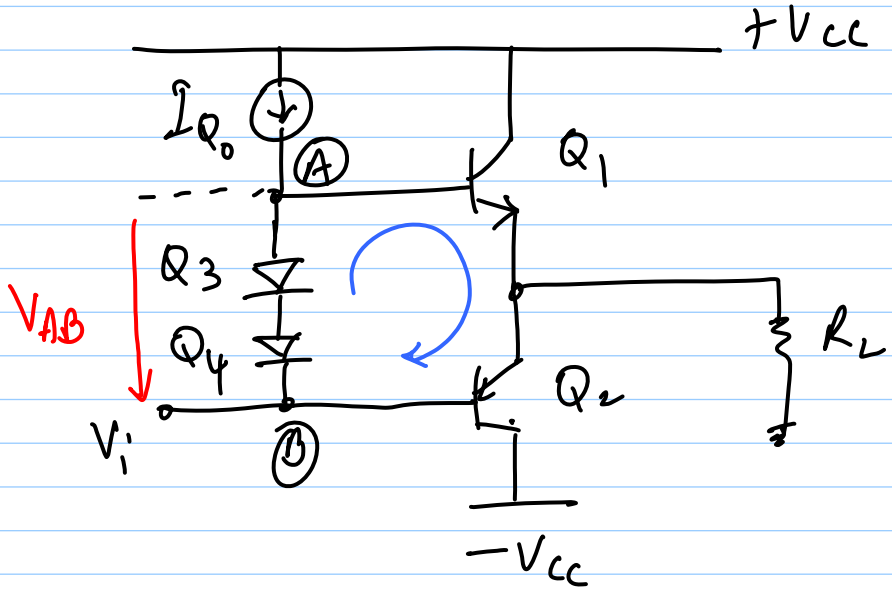
Crossover Distortion



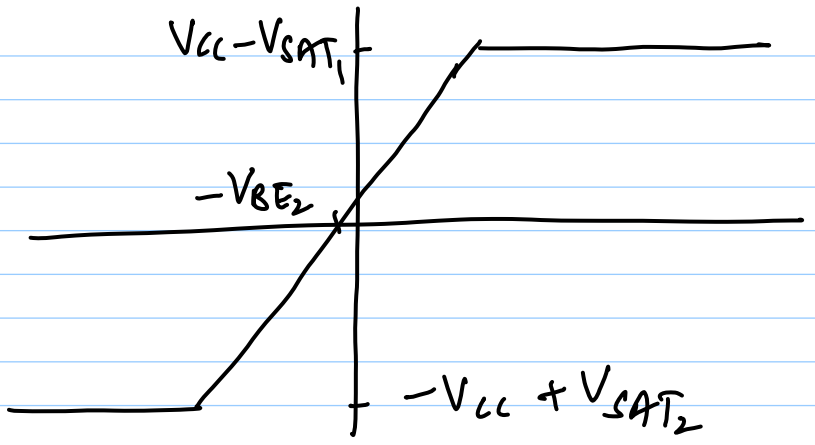
* Distortion for both ① & ③

Class AB output stage

* Q_1 & Q_2 should conduct with small I_Q @ $V_i = 0$



* $I_{Q_{1,2}}$ depends on area ratios of $Q_1 - Q_4$

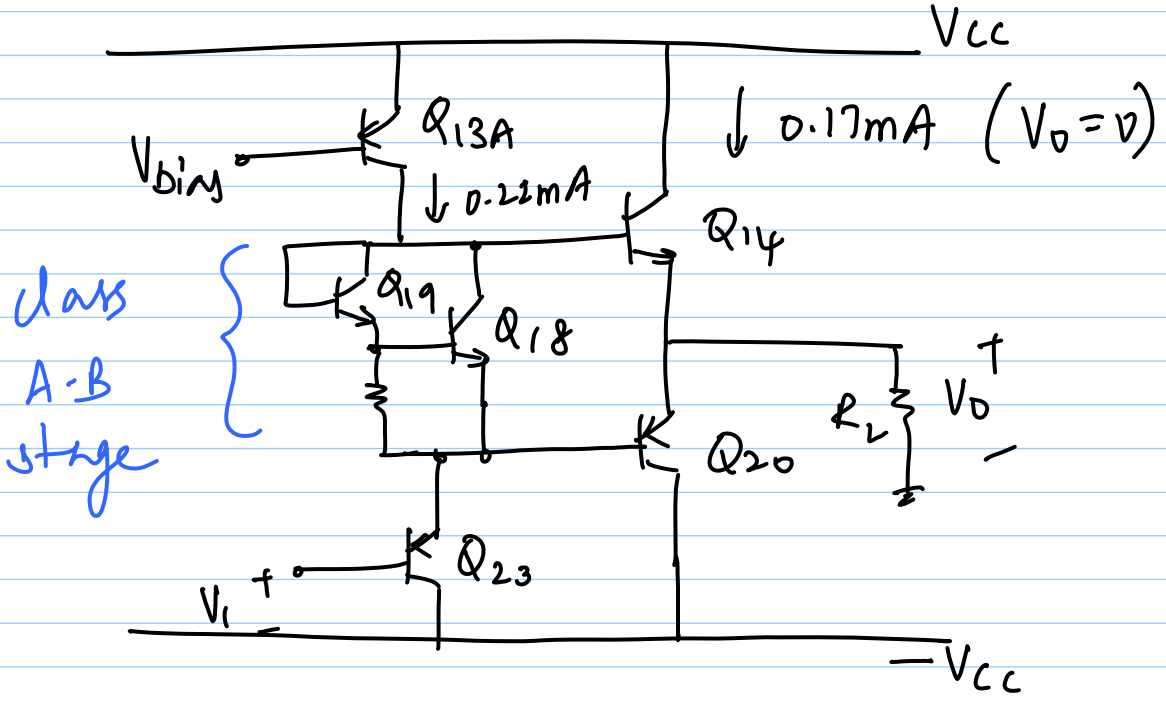


* V_{AB} = constant $\Rightarrow |\Delta V_{BE_1}| = |\Delta V_{BE_2}|$
* When $V_o < 0$, Q_1 is ON, but delivers no Pout (I_{E_1} is very small)

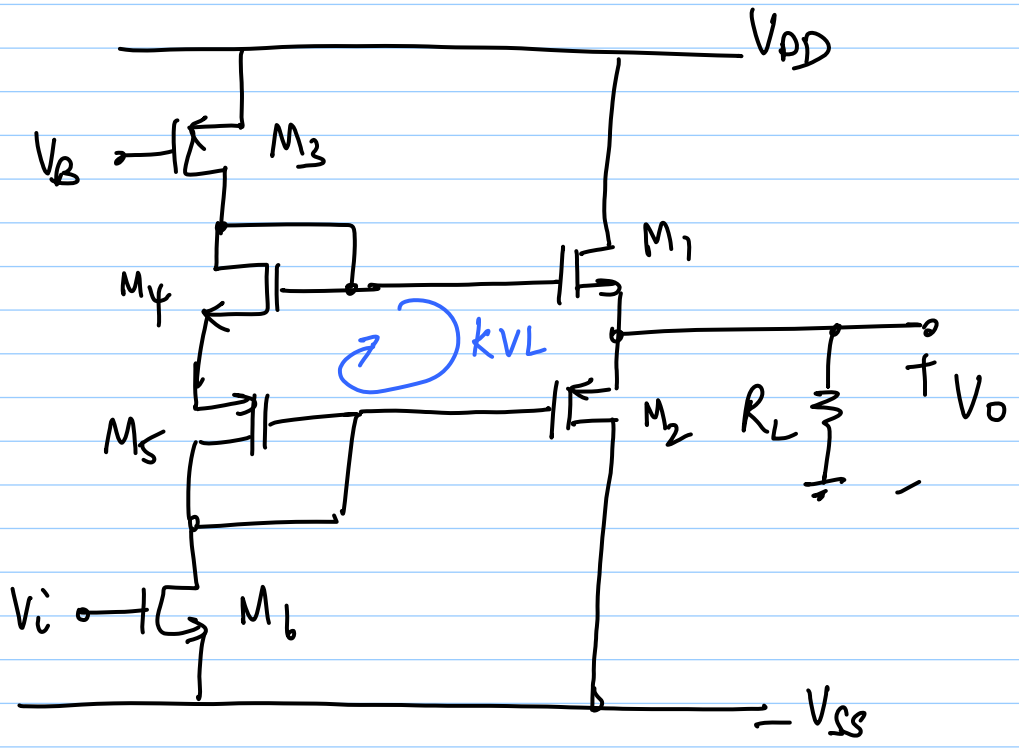
  $V_i / V_o > 0 \Rightarrow$ Q_1 delivers power

  Q_2 is ON, but small I_{E_2}

741 output stage



CMOS class AB stages



KVL $\quad V_{sg_5} + V_{as_4} = V_{gs_1} + V_{sg_2}$

* ignore Body Effect

If I_{D_3} = constant, $V_{sg_5} + V_{as_4}$ = constant

* Initially assume $\quad V_{sg5} + V_{asy} = 0$

$\Rightarrow V_{gs_1} = V_{gs_2}$

M_1 is ON when $\quad V_{gs_1} > V_{T_1}$ $\qquad V_{T_1} > 0$

M_2 " " " $\quad V_{gs_2} < V_{T_2}$ $\qquad V_{T_2} < 0$

$\Rightarrow$ class B stage

* If $\quad V_{sg5} + V_{asy} > 0 \Rightarrow$ M_1 & M_2 are ON when $V_o = 0 \Rightarrow$ class AB operation

1) assume $\quad V_{T_1} = V_{T_4}$ & $V_{T_2} = V_{T_5}$

2) $\quad I_{D_5} = -I_{D_4}$

$$\sqrt{\frac{2I_{D_4}}{k_p'(W/L)_5}} + \sqrt{\frac{2I_{D_4}}{k_n'(W/L)_4}} = \sqrt{\frac{2I_{d_1}}{k_n'(W/L)_1}} + \sqrt{\frac{2|I_{d_2}|}{k_p'(W/L)_2}}$$

$V_o = 0 \Rightarrow I_{d_2} = -I_{d_1}$

$$\therefore \quad I_{D_1} = I_{D_4} \frac{\frac{1}{k_n'(W/L)_4} + \frac{1}{k_p'(W/L)_5}}{\frac{1}{k_n'(W/L)_1} + \frac{1}{k_p'(W/L)_2}}$$

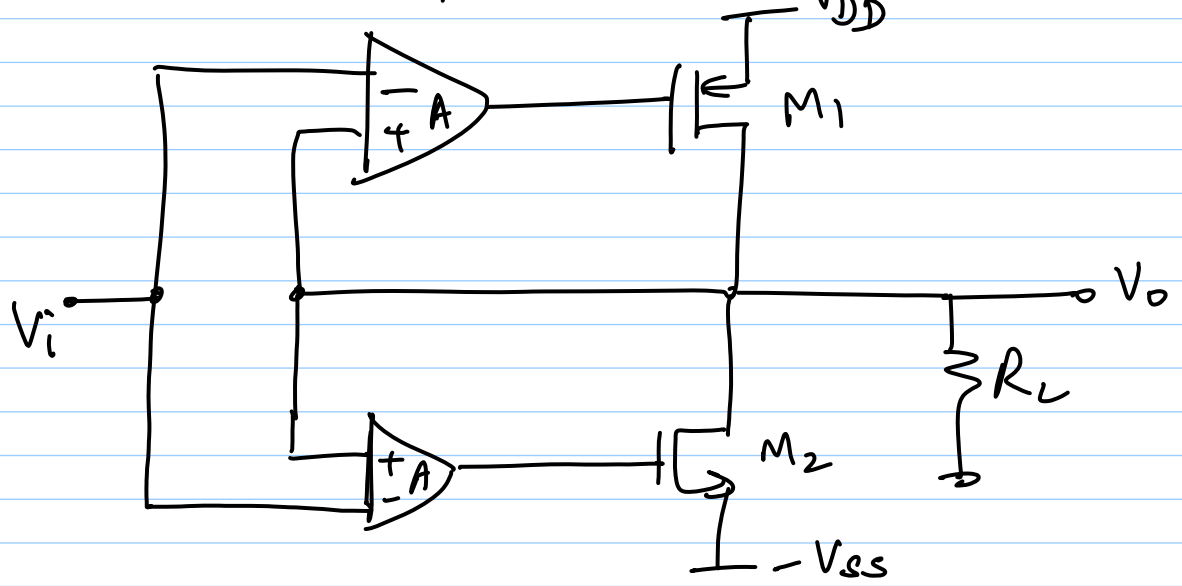
for $V_o > 0$,

$$V_o = V_{DD} - V_{sd_3} - V_{gs_1}$$

$$\Rightarrow V_{om}^{+} = V_{DD} - |V_{ov_3}| - V_{gs_1}$$

(worse than bipolar case)

Error Amplifiers (CS config.)



* Error amps drive $V_i = V_o$ (-ve f.b.)

* $R_o = r_{o_1} \| r_{o_2} \| \frac{1}{(g_{m_1} + g_{m_2})A}$

$\uparrow A \Rightarrow \downarrow R_o$

* $V_o = \dfrac{V_i}{1 + \dfrac{1}{2Ag_mR_L}} \simeq V_i\left[1 - \dfrac{1}{2Ag_mR_L}\right]$

* $LG = 2Ag_mR_L$

* Analyse errors due to offsets