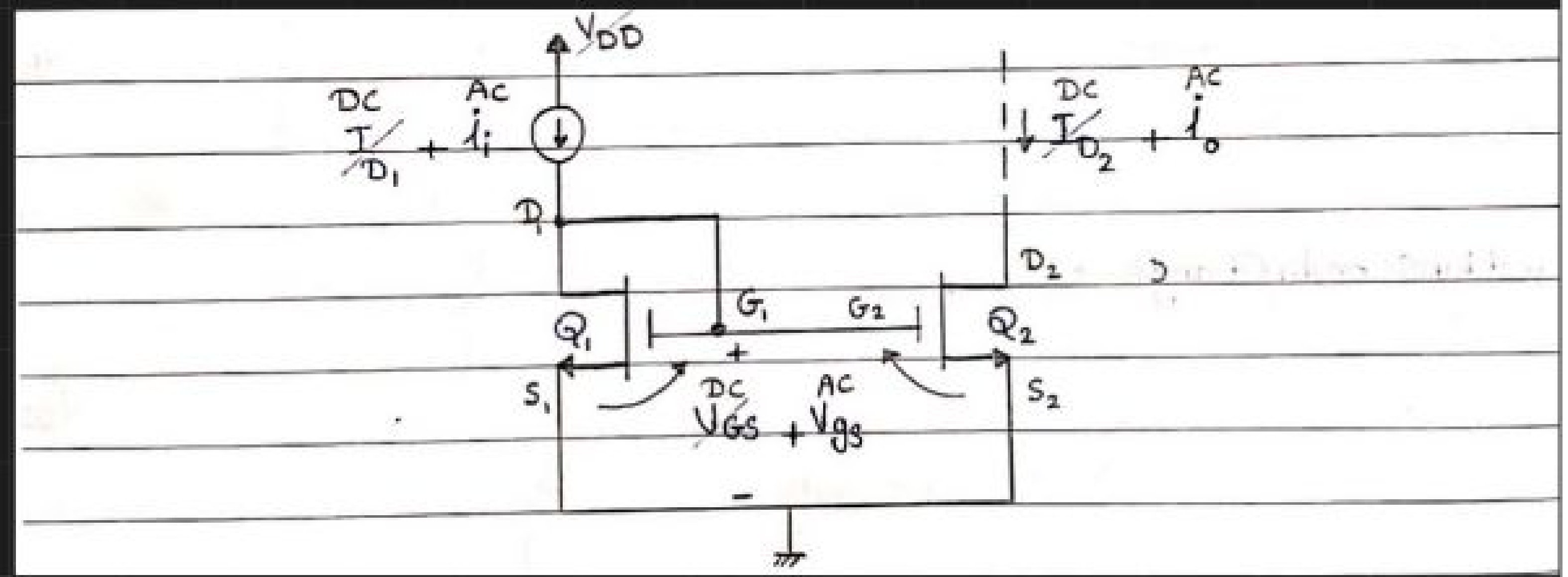
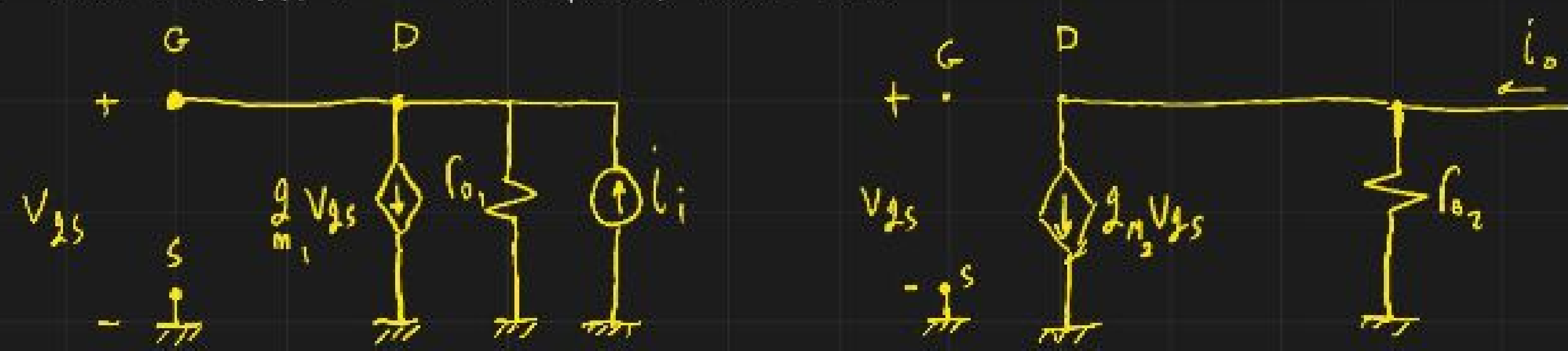
## ✰ Ac analysis:

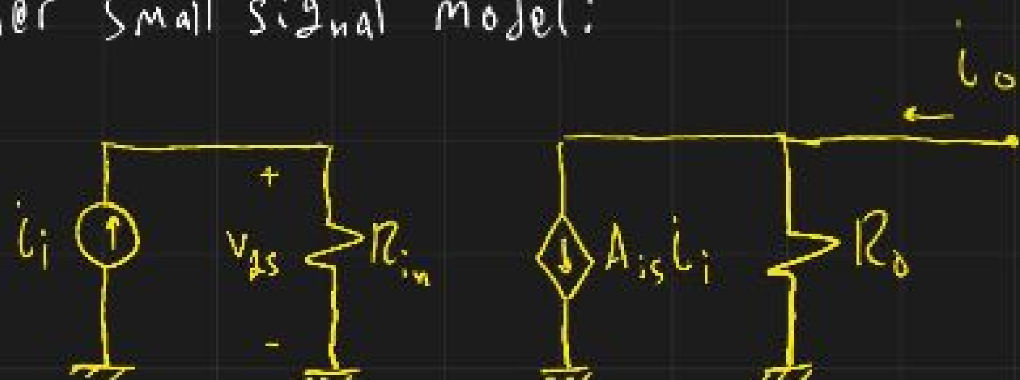



→ Small signal model For the current mirror:




(1)

→ Current amplifier Small signal model:




(2)

. the goal is to map (2) to (1)

$$\rightarrow i_i = \frac{v_{gs}}{r_{o_1}} + g_{m_1} v_{gs} = v_{gs}\left(g_{m_1} + \frac{1}{r_{o_1}}\right)$$

$$\rightarrow R_{in} = \frac{v_{gs}}{i_i} = \frac{1}{g_{m_1} + 1/r_o} \rightarrow \therefore \frac{1}{R_{in}} = \frac{1}{r_{o_1}} + g_{m_1} \rightarrow \therefore R_{in} = r_{o_1} \parallel \frac{1}{g_{m_1}}$$

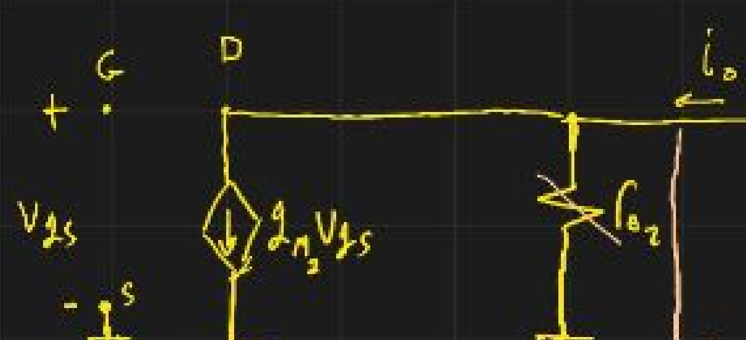
→ $R_o$ : independent C.S → o.c , independent V.S → S.C

$\therefore R_o = r_{o_2}$

→ $A_{is}$ : Connect S.C to the o/p → $r_{o_2} = 0$ → $R_o = 0$

$\cdot A_{is} = \dfrac{i_o}{i_i}$ , $\because i_o = g_{m_2} v_{gs}$

$\because v_{gs} = i_i R_{in}$




$$\therefore A_{is} = \frac{g_{m_2} v_{gs}}{v_{gs}/R_{in}} \longrightarrow \therefore A_{is} = g_{m_2} R_{in}$$

$$A_{is} = g_{m_2} R_{in} \qquad \because R_{in} = \frac{1}{\frac{1}{r_{o_1}} + g_{m_1}} = \frac{1}{g_{m_1}} \cdot \frac{1}{1 + \frac{1}{g_{m_1} r_{o_1}}}$$

$$\therefore A_{is} = \frac{g_{m_2}}{g_{m_1}} \cdot \frac{1}{1 + \frac{1}{g_{m_1} r_{o_1}}} \rightarrow (5)$$

$$\because g_m = \sqrt{I_D} \sqrt{2 \mu_n C_{ox} \left(\frac{W}{L}\right)} = \frac{2 I_D}{V_{ov}} \qquad \therefore g_m \propto I_D$$

$I_D$ ← DC

$$\therefore \frac{g_{m_2}}{g_{m_1}} = \frac{I_{D_2}}{I_{D_1}} \rightarrow (6)$$

Sub from (6) in (5)

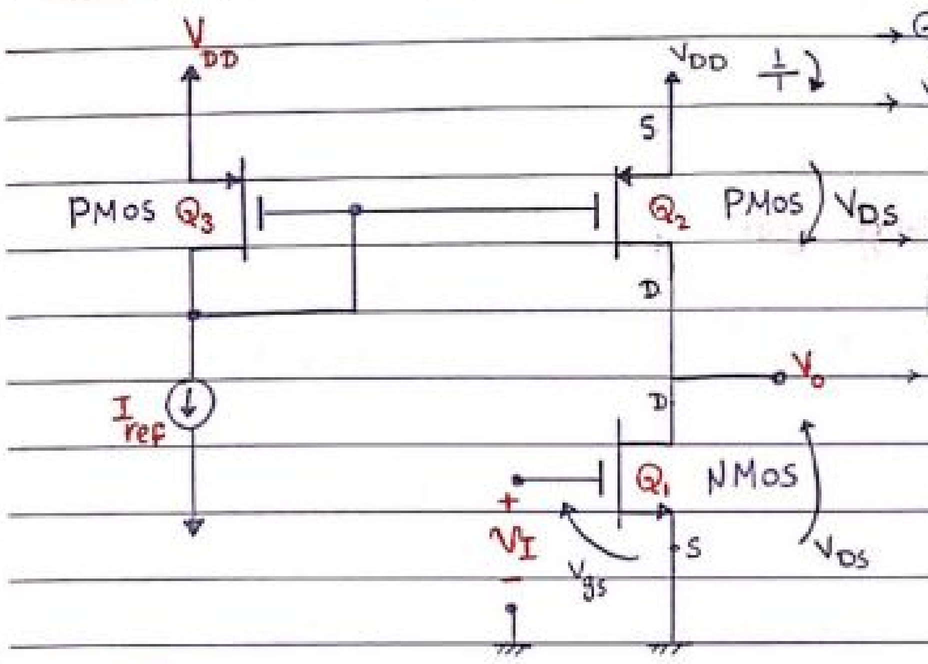
$$A_{is} = \frac{I_{D_2}}{I_{D_1}} \cdot \frac{1}{1 + \frac{1}{g_{m_1} r_{o_1}}}$$

$\because$ from saturation eqn $I_D \propto \frac{W}{L}$

$$A_{is} = \frac{(W/L)_2}{(W/L)_1} \cdot \frac{1}{1 + \frac{1}{g_{m_1} r_{o_1}}}$$

## 2. Common Source amplifier with Current Source Load

Ex (8.3) Page (555)




→ $Q_2$ & $Q_3$ are matched

→ $V_{DD} = 1.8$ V

$V_{tn} = -V_{tp} = 0.5$ V

→ $\mu_n C_{ox} = 4 \mu_p C_{ox} = 400\ \mu A/V^2$

$|V_A| = 5$ V for all transistors

→ $I_{ref} = 100\ \mu A$

$\mu_n C_{ox} = 400\ \mu A/V^2$

$\mu_p C_{ox} = 100\ \mu A/V^2$

find:

a) DC Component of $V_I$ & $\frac{W}{L}$ for all transistors at $|V_{ov}| = 0.2$V.

b) the small signal voltage gain $A_v$.

c) allowable range of signal swing at the o/p for almost Linear operation.

a) $V_I = V_{I_{DC}} + V_{i_{AC}}$ , $V_{I_{DC}} = V_{gs_{DC}} = V_{ov} + V_t = 0.2 + 0.5$

$\therefore V_{I_{DC}} = 0.7$ v

$Q_1$) $I_{D_1} = \frac{1}{2} (\mu_n C_{ox}) \left(\frac{W}{L}\right)_1 (V_{ov})^2$

$\therefore 100 = \frac{1}{2} (400) \left(\frac{W}{L}\right)_1 (0.2)^2$

$\therefore \left(\frac{W}{L}\right)_1 = 12.5$

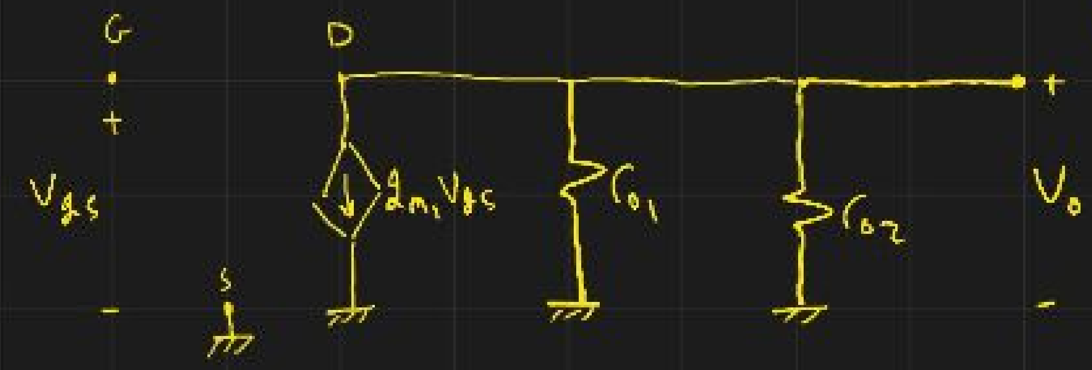
$Q_{2,3}$) $I_{D_2} = \frac{1}{2} (\mu_p C_{ox}) \left(\frac{W}{L}\right)_2 (V_{ov})^2$

$\therefore 100 = \frac{1}{2} (100) \left(\frac{W}{L}\right)_2 (0.2)^2$

$\therefore \left(\frac{W}{L}\right)_2 = \left(\frac{W}{L}\right)_3 = 50$

(Q$_1$

b)




$\cdot A_v = \frac{V_o}{V_{gs}} = \frac{-g_{m_1}\cancel{V_{gs}}(r_{o_1}//r_{o_2})}{\cancel{V_{gs}}}$

$\therefore A_v = -g_{m_1}(r_{o_1}//r_{o_2})$

$\rightarrow g_{m_1} = \frac{2I_{D_1}}{V_{ov}} = \frac{2(100\mu)}{0.2}$

$\therefore g_{m_1} = 1 \text{ mA/v}$

$\rightarrow r_{o_1} = \frac{V_A}{I_{D_1}} = \frac{5}{100\mu}$

$\therefore r_{o_1} = 50 \text{ K}\Omega$

$\rightarrow r_{o_2} = \frac{V_A}{I_{D_2}} = \frac{5}{100\mu}$

$\therefore r_{o_2} = 50 \text{ K}\Omega$

$\therefore r_{o_1}//r_{o_2} = 25 \text{ K}\Omega$

$\therefore \boxed{A_v = -(1)(25) = -25}$

c) signal swings around the DC value


Q$_1$) $V_{DS_1} \geq V_{ov_1}$

$\because V_{DS_1} = V_o$ , $\because V_{DS_{min}} = V_{ov_1} \rightarrow \therefore V_{o_{min}} = 0.2 \text{ v}$

$\therefore V_o \geq 0.2 \rightarrow$ ①

Q$_2$) $V_{DS_2} \leq V_{ov_2}$

$\because V_o = V_{DD} + V_{DS_2} \rightarrow \therefore V_o - V_{DD} \leq V_{ov_2}$

$\therefore V_o \leq V_{DD} + V_{ov_2}$

$\therefore V_o \leq 1.8 + (-0.2)$

$\therefore V_o \leq 1.6 \text{ v} \rightarrow$ ②

$\therefore \boxed{0.2 \leq V_o \leq 1.6}$

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