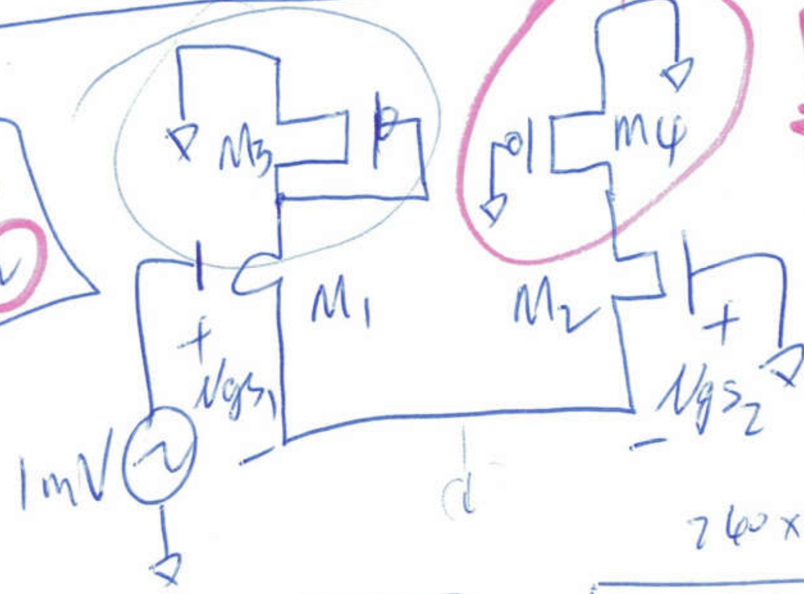
AC Analysis

CMOS Book: Chapter 9.

NMOS 10	2
PMOS 30	2

600nm → 500nm



DC Bias / DC operating point

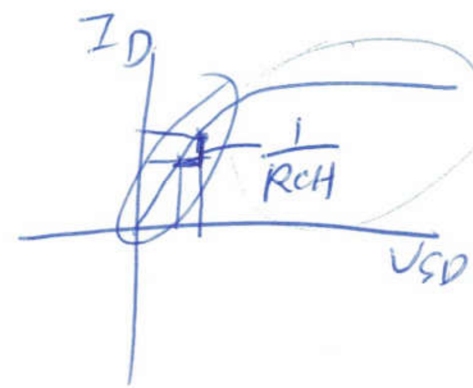
① $g_{m1} = g_{m2} = \sqrt{2\beta_n \cdot I_D} = \sqrt{2 \times \overset{240 \times 5}{\frac{120\mu \cdot 10}{2}} \cdot 20\mu} = 150\mu A/V$

② $g_{m3} = \sqrt{2\beta_p \cdot I_D} = \sqrt{2 \times 40\mu \cdot \frac{30}{2} \cdot 20\mu A} = 150\mu A/V$

80 × 15
3 × 5

③ M4: $I_D = \beta_p \left[(V_{SG4} - V_{THP}) V_{SD4} - \frac{V_{SD4}^2}{2} \right]$ (240×5)

$\frac{1}{R_{CH}} = \frac{\partial I_D}{\partial V_{SD}} = \beta_p \left[(V_{SG4} - V_{THP}) - V_{SD4} \right]$



In the linear region, if V_{SD} is $\ll V_{SG}$,

$\frac{1}{R_{CH}} = \beta_p (V_{SG4} - V_{THP})$

④

$g_{m3} v_{sg} = i_d$

$v_{sg} = v_{sd}$

so, $i_d = g_{m3} v_{sd}$

$$\frac{i_d}{v_{sd}} = g_{m3}$$

$$\frac{v_{sd}}{i_d} = 1/g_{m3}$$

important

⑤

$i_{d1} = v_{gs1} \cdot g_{m1}$

KVL:

$-1mV + v_{gs1} - v_{gs2} = 0$

$v_{gs1} - v_{gs2} = 1mV$

$i_{d1} = -i_{d2}$

$$\frac{i_{d1}}{g_{m1}} = -\frac{i_{d2}}{g_{m2}}$$

$$\boxed{v_{gs1} = -v_{gs2}}$$

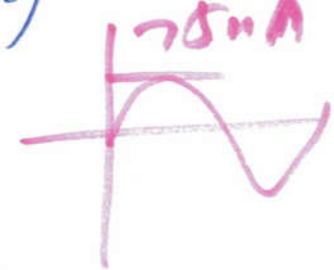
$$v_{gs1} - (-v_{gs1}) = 1\,mV$$

$$v_{gs1} = 0.5\,mV$$

$$i_{d1} = -i_{d2} = g_m v_{gs} = 150\mu \cdot 0.5\,mV = 75\,nA$$

The overall AC+DC drain current of M_1/M_3

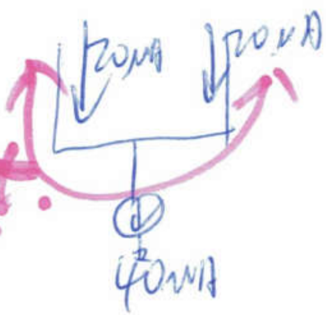
$$i_{D3} = i_{D1} = \underbrace{20\,\mu A}_{DC} + \underbrace{75\,nA}_{AC}$$



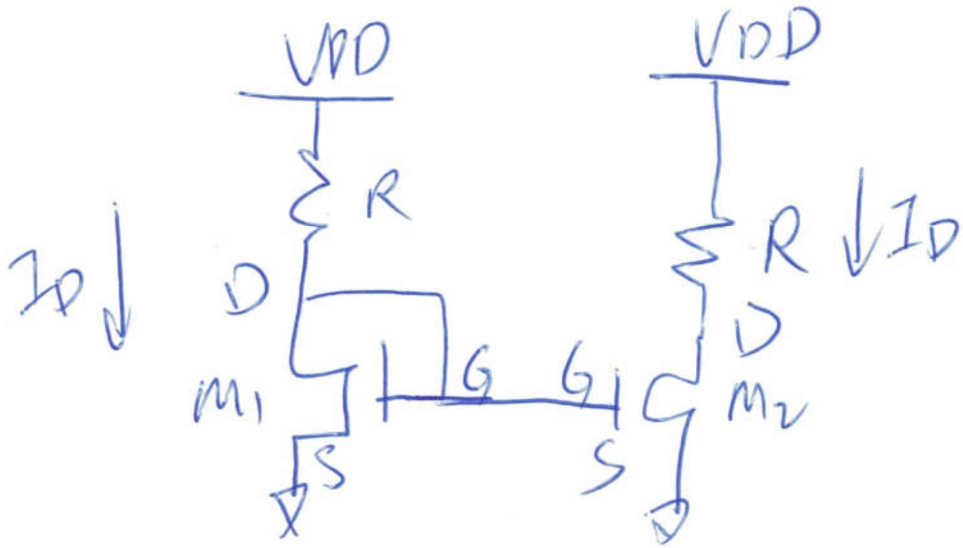
$$= \underbrace{20\,\mu A}_{DC} + \underbrace{0.075 \sin 2\pi f t}_{AC}$$

AC+DC drain current of M_2/M_4

$$i_{D2} = i_{D4} = \underbrace{20\,\mu A}_{DC} \underbrace{- 0.075 \sin 2\pi f t}_{AC}$$



Current Mirrors Chapter 20.

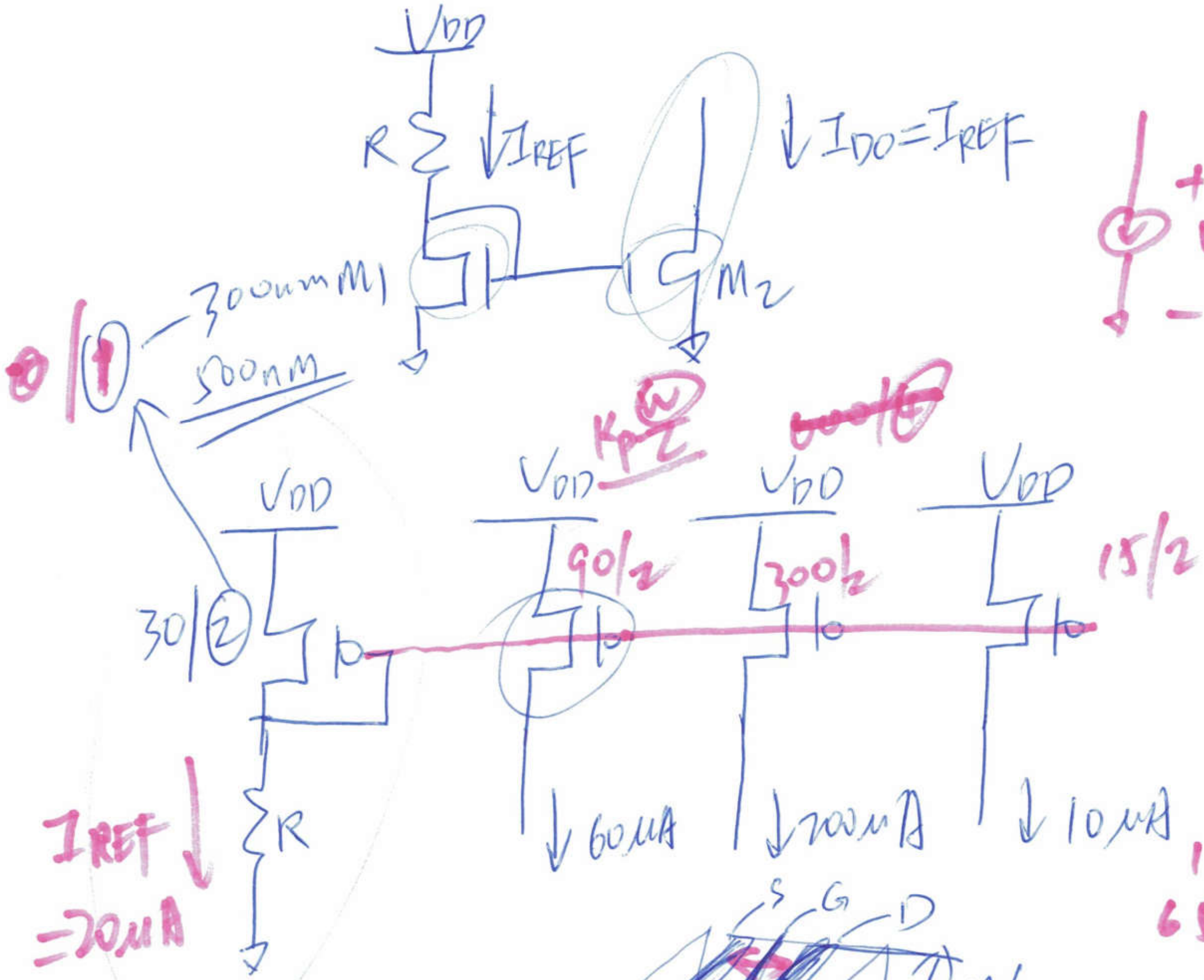


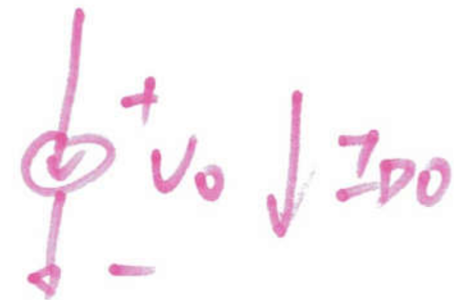
A Basic Current Mirror

① $V_{GS1} = V_{GS2} = V_{DS1}$

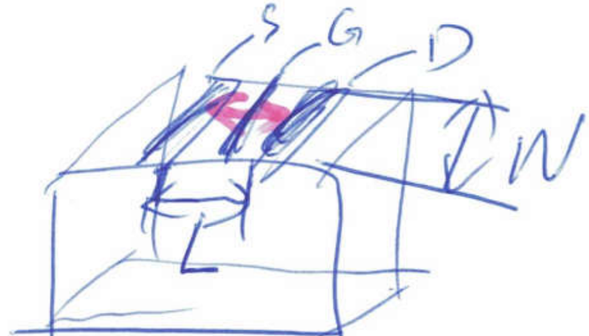
② same structure, same V_{GS}, same I_D, $\Rightarrow$
$\{$ same R.

same V_{DS} $\Rightarrow$ $V_{GS1} = V_{GS2} = V_{DS1} = V_{DS2}$





130 nm
65 nm
25 nm
10 nm
Length



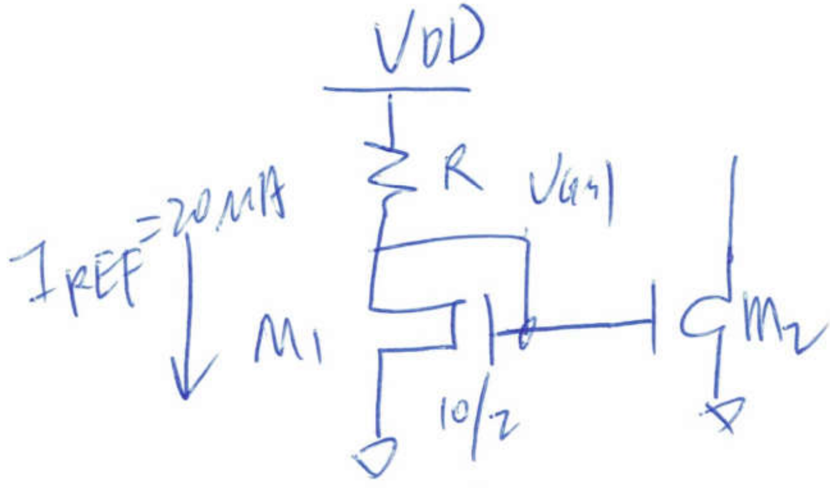


Fig 1.

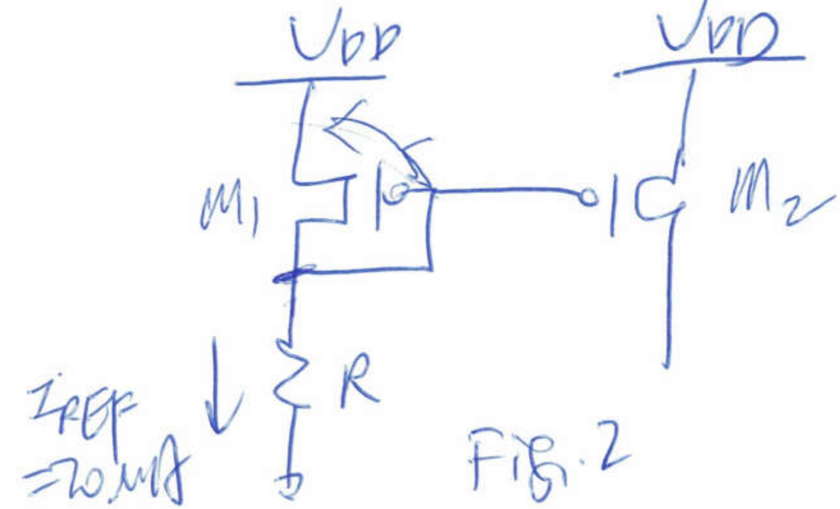


Fig. 2

△ Determine the value of the resistor needed in Fig. 1 and Fig. 2. so the reference drain currents are 20µA.

$$I_{REF} = \frac{V_{DD}-V_{GS1}}{R} = \underbrace{\frac{KP}{2}\frac{10}{2}}_{\beta_n}(V_{GS1}-V_{THN})^2 \qquad \frac{40}{600}$$

$$\cancel{I_D = I_{REF}} \quad V_{GS1} = \sqrt{\frac{2 I_D}{\beta_n}} + V_{THN} = \sqrt{\frac{2\cdot 20\mu A}{120\mu\cdot\frac{10}{2}}} + 0.8$$

$$= 0.25 + 0.8$$

$$= 1.05\,V$$

$$\frac{V_{DD}-V_{GS1}}{R} = 20\mu A$$

$$\frac{5-1.05}{R} = 20\mu A, \quad R = \cancel{200}\,\frac{3.95}{20\mu A} = 197.5K$$

(b)

$$\frac{V_{DD}-V_{SG1}}{R}=I_D=20\mu A$$

$$V_{SG1}=\sqrt{\frac{2I_D}{\beta_p}}+V_{THP}$$

$$=\sqrt{\frac{2\times 20\mu A}{40\mu\cdot\frac{30}{2}}}+0.9$$

$$=0.259+0.9=1.159$$

$$\frac{5-1.159}{R}=20\mu A$$

$$R=200k\Omega$$