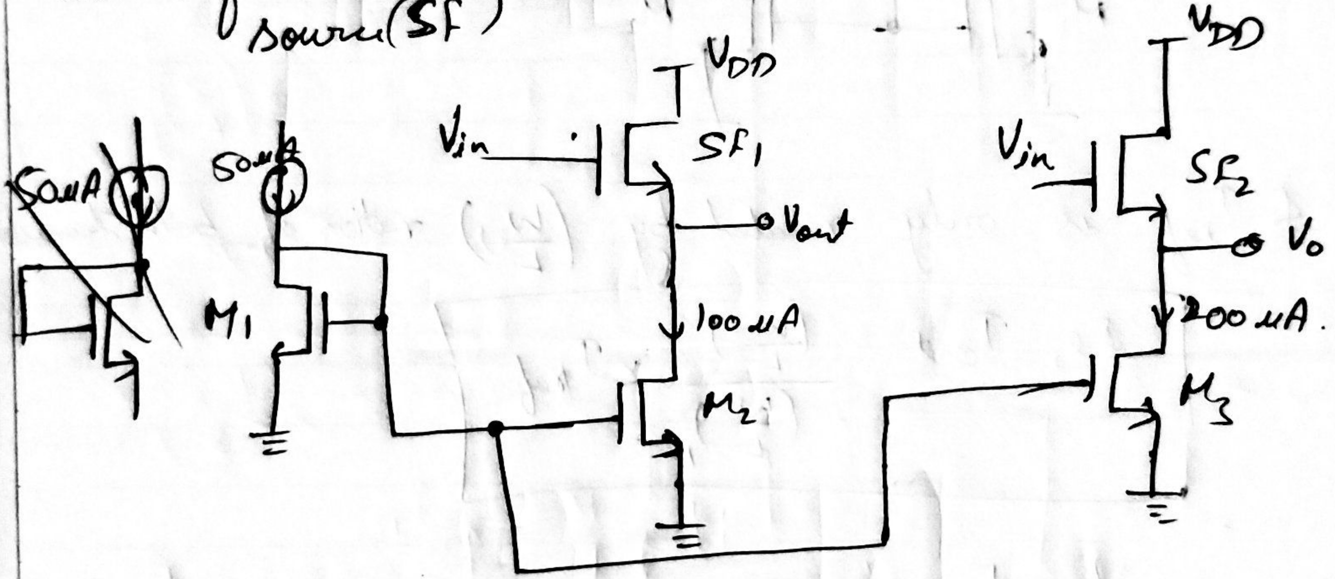
Examples:-

↳ A circuit include two source followers biased at 100 µA & 200 µA. We have a reference current of 50 µA.

Ans

Source follower:- Output at source & biased with a current source (SF)



$$I_{out} = \frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1} \times I_{ref}$$

$$10\cancel{0} = \frac{(W/L)_2}{(W/L)_1} \times 5\cancel{0}$$

$$\boxed{\left(\frac{W}{L}\right)_2 = 2 \times \left(\frac{W}{L}\right)_1}$$

$$20\cancel{0} = \frac{(W/L)_3}{(W/L)_1} \times 5\cancel{0}$$

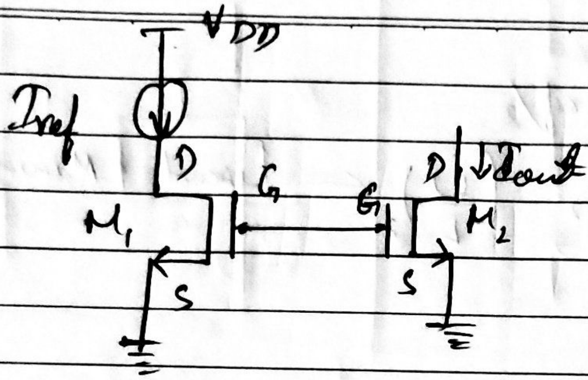
$$\boxed{\left(\frac{W}{L}\right)_3 = 4 \left(\frac{W}{L}\right)_1}$$

So,

$$\left(\frac{W}{L}\right)_2 = 2 \times \left(\frac{W}{L}\right)_1$$

$$\left(\frac{W}{L}\right)_3 = 4 \times \left(\frac{W}{L}\right)_1$$

* Alternative Perspective



In sat :-

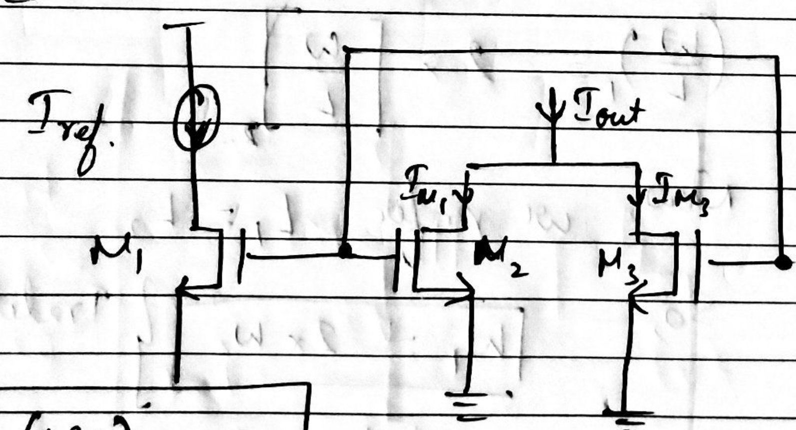
$$I_{D_1} = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right)_1 (V_{GS} - V_{TH})^2$$

$$I_{D_2} = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right)_2 (V_{GS} - V_{TH})^2$$

$$\boxed{\left(\frac{I_{D_2}}{I_{D_1}}\right) = \frac{(W/L)_2}{(W/L)_1}}$$

Example :-

Determine Iout



$$\boxed{I_{M_2} = \frac{(W/L)_2}{(W/L)_1} \times I_{ref}}$$

$$\boxed{I_{M_3} = \frac{(W/L)_3}{(W/L)_1} I_{ref}}$$

So,

$$I_{out} = I_{M_2} + I_{M_3}$$

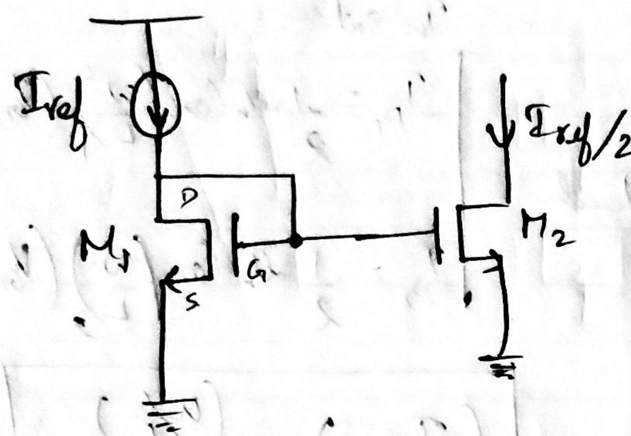
$$\boxed{I_{out} = \frac{I_{ref}}{(W/L)_1} \left[\left(\frac{W}{L}\right)_2 + \left(\frac{W}{L}\right)_3\right]}$$

Now, if M_1, M_2 & M_3 are identical

So,

$$\boxed{I_{out} = 2 I_{ref}}$$

Quiz



$\left(\frac{W}{L}\right)_2$ ← Fixed. [Minimum Size]

$$\frac{I_{ref}}{2} = \frac{(W/L)_2}{(W/L)_1} \times I_{ref}$$

$$\left(\frac{W}{L}\right)_1 = 2 \times \left[\frac{W}{L}\right]_2$$

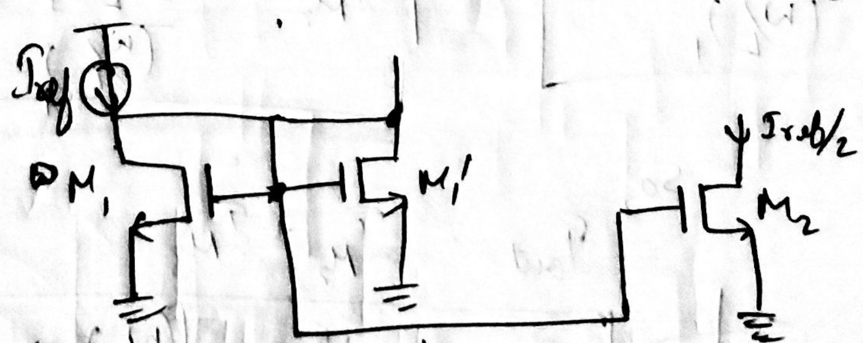
Now, we prefer $L_1 = L_2$

So,

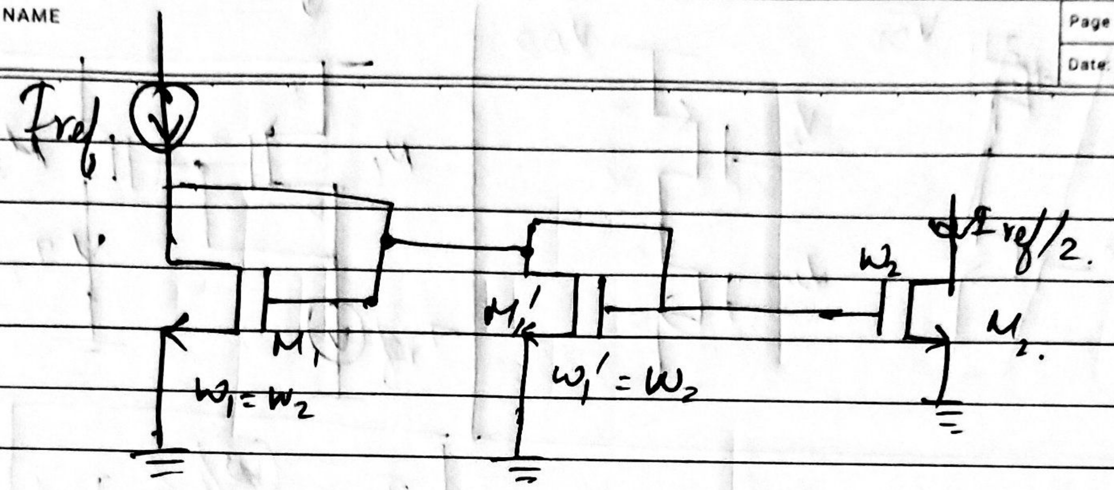
$$\boxed{W_1 = 2 \times W_2}$$ } Traditional method.

Since we have to make $\left(\frac{W}{L}\right)_2$ fixed

So,

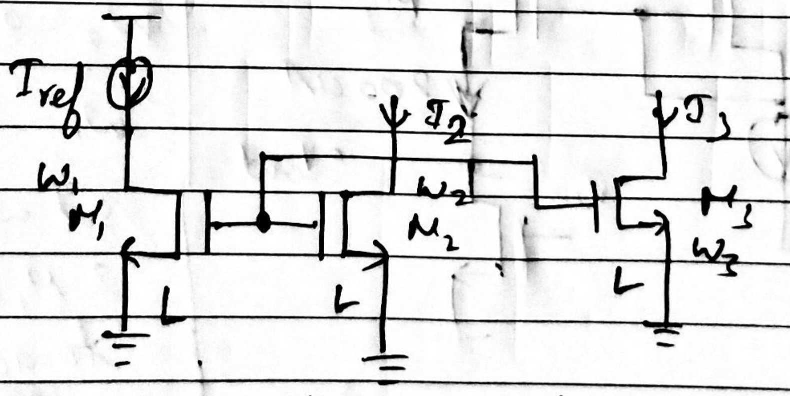


$W_1 = W_2$ $\quad$ $W_1' = W_2$



→ When we put 2 transistors in parallel, they behave like their width becomes double (if they have same width), as you can see in the above example.

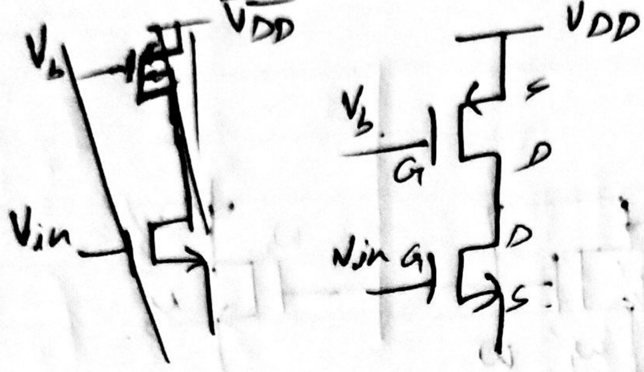
* Proper Scaling

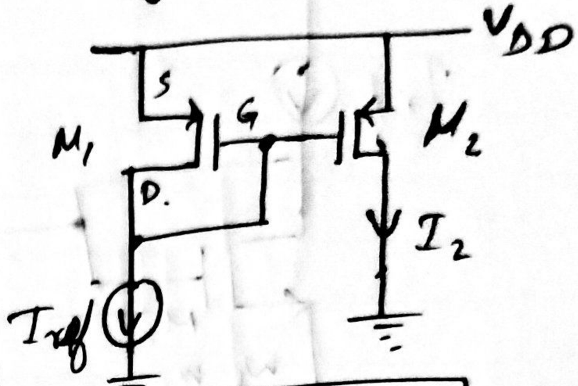


→ Always choose the same L, only scale W:

$$\left(\frac{W_2}{W_1}\right) I_{ref} = I_2 \quad \Big| \quad \left(\frac{W_3}{W_1}\right) I_{ref} = I_3 .$$

* PMOS Current Mirrors

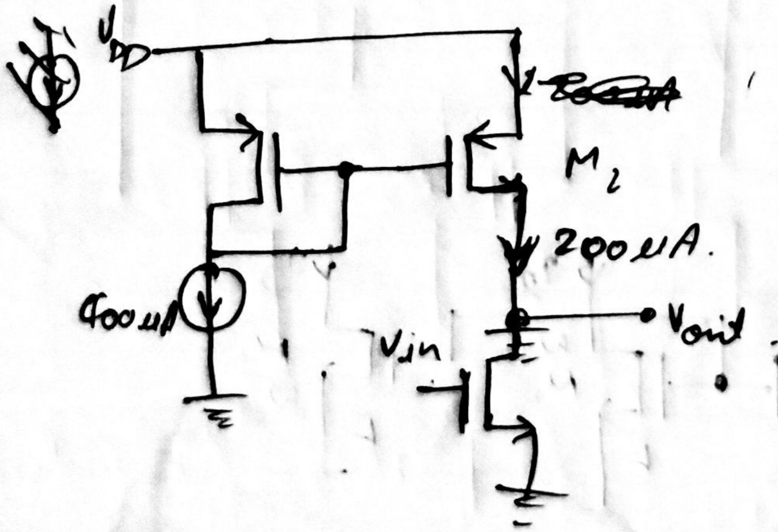




$$\boxed{I_2 = \frac{(W/L)_2}{(W/L)_1} I_{ref}}$$

Example

An NMOS common source stage requires a load current source equal to 200 µA. We have a reference current equal to 400 µA.



Traditional method.

$L_1 = L_2$.

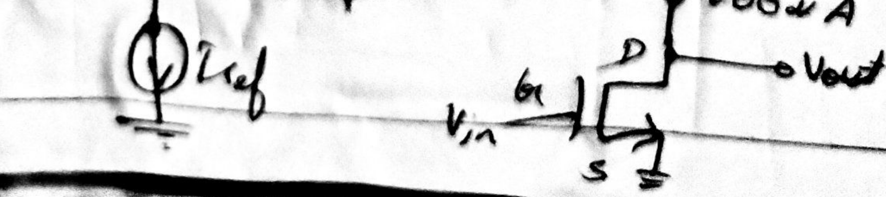
$W_2 = 0.5 W_1$

$W_1 = 2 W_2$

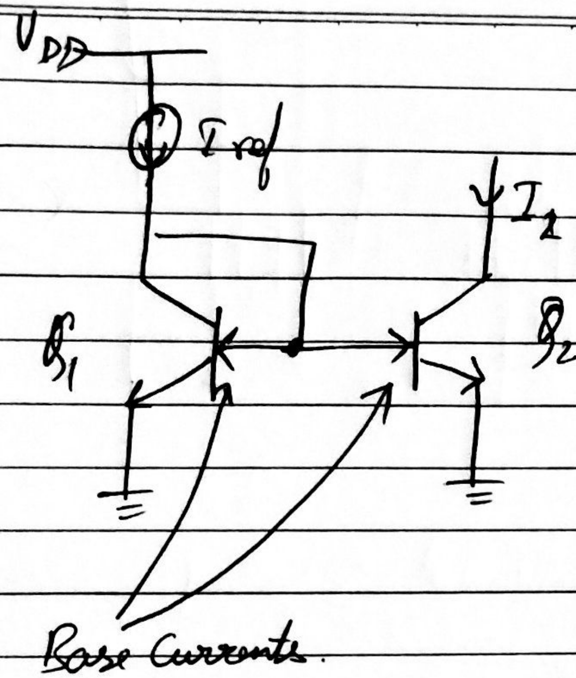
But we'll use 2 M_1s in parallel to achieve the result

Actual circuit

→ 2 unit devices [PMOS]
↳ so same W & L.



* Bipolar Current Mirrors



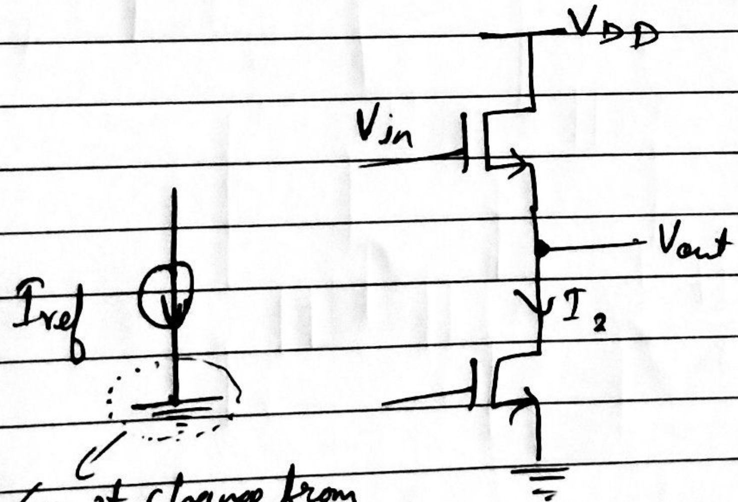
$$I_{C1} = I_{S1} \exp\left\{\frac{V_{BE}}{V_T}\right\}$$

$$I_{C2} = I_{S2} \exp\left\{\frac{V_{BE}}{V_T}\right\}$$

$$\boxed{\frac{I_{C2}}{I_{C1}} = \frac{I_{S2}}{I_{S1}}}$$

→ If Q_1 & Q_2 are identical

Problem:-



Can't change from ground.

How to use I_{ref} so I_2 is a good copy of I_{ref}?