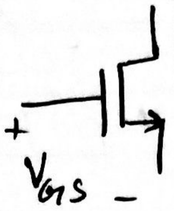
* Current Mirrors

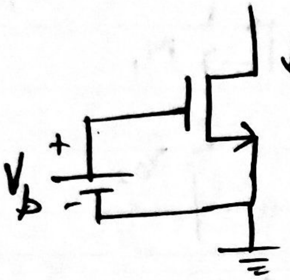
Basic Concept

→ Problem of biasing current sources



$$\downarrow I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS}-V_{th})^2$$

(1) Issue (1)



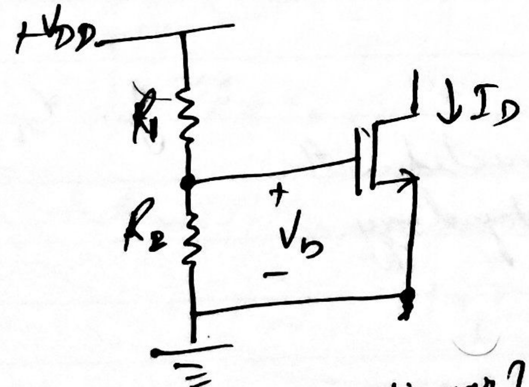
$$\downarrow I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_b - V_{th})^2$$

μ_n, V_{th} → Vary with temp.

(2) Issue (2)

How generate V_b from V_{DD}:

V_{DD} → Main supply voltage.



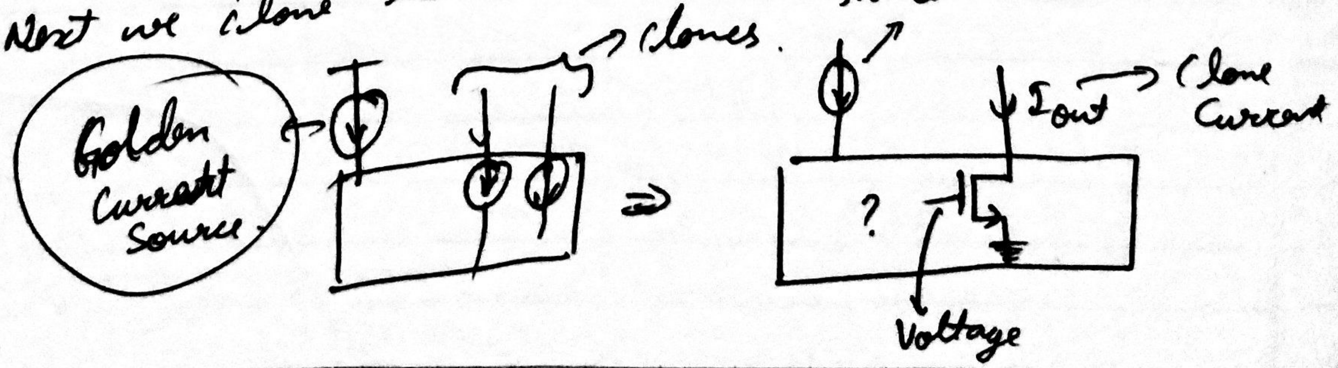
$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left[\frac{R_2 V_{DD}}{R_1+R_2} - V_{th}\right]^2$$

Supply dependent.

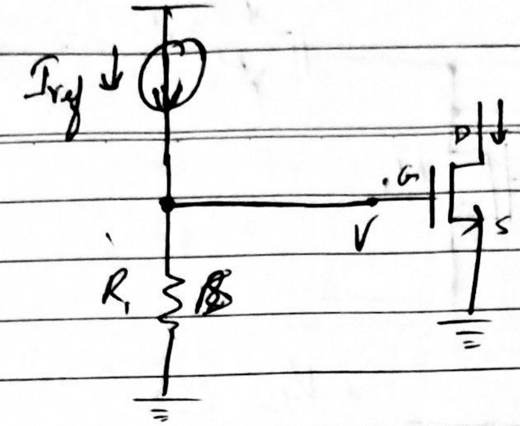
Now the solution [Current Mirror]:-

→ First ~~one~~ build one 'golden' ~~circuit~~ current source using a 'Bandgap' circuit.

→ Next we clone this current source to build many others.



Quiz



$V = I_{ref} R_1$

Sat.

$$I_{out} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left[V_{GS} - V_{th}\right]^2$$

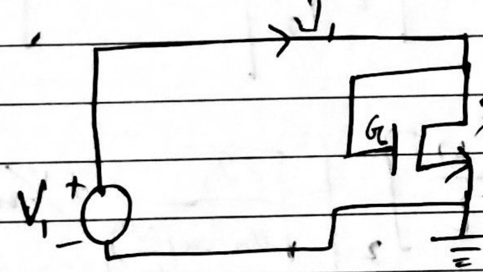
$$I_{out} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left[I_{ref}R_1 - V_{th}\right]^2$$

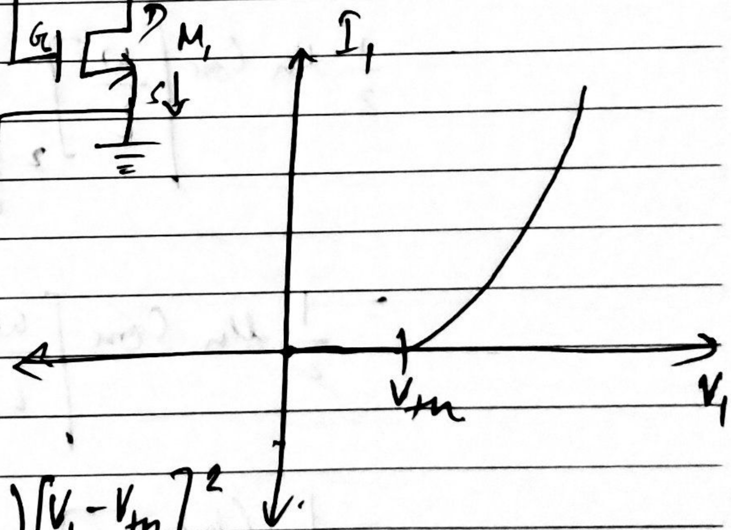
0 → vary with temp.

Observations:-

(1)

Diode-connected device.
→ IV charc.





→ If M_1 is on it is in saturation

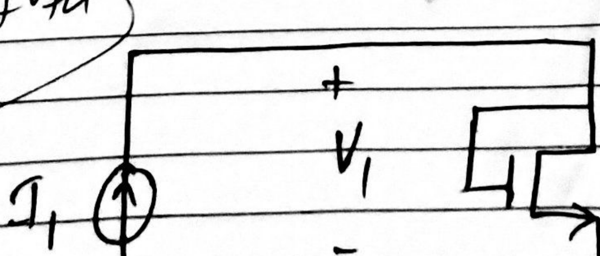
↳ $V_{GS} \geq V_{th}$

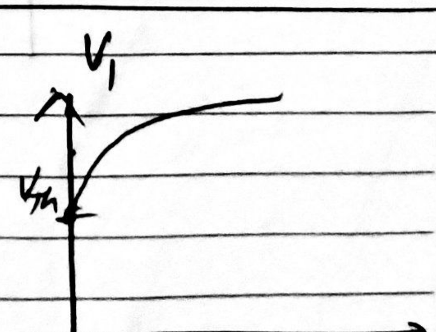
$V_1 \leftarrow V_{DS} \geq (V_{GS} - V_{th})$

At Sat :- $I_1 = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left[V_1 - V_{th}\right]^2$

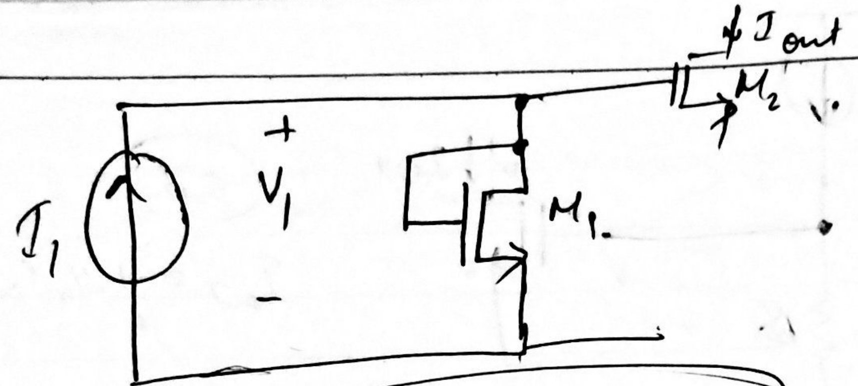
↳ $V_1 \geq V_{th}$

(2) $V_1 = \sqrt{\dfrac{2I_1}{\mu_n C_{ox}\left(\frac{W}{L}\right)}} + V_{th}$





(3)



$$V_1 = \sqrt{\frac{2I_1}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}} + V_{th}$$

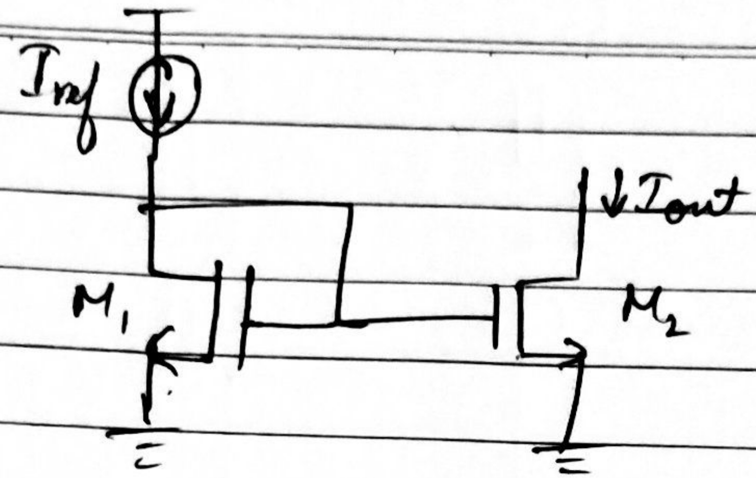
So, $$I_{out} = \frac{1}{2}\mu_n C_{ox}\left[\frac{W}{L}\right]_2\left[V_1 - V_{th}\right]^2$$

$$= \frac{1}{2}\mu_n C_{ox}\left[\frac{W}{L}\right]_2\left[\sqrt{\frac{2I_1}{\mu_n C_{ox}\left(\frac{W}{L}\right)_1}} + \cancel{V_{th}} - \cancel{V_{th}}\right]^2.$$

$$= \frac{1}{\cancel{2}}\cancel{\mu_n}\cancel{C_{ox}}\left[\frac{W}{L}\right]_2\left[\frac{\cancel{2}I_1}{\cancel{\mu_n C_{ox}}\left(\frac{W}{L}\right)_1}\right]$$

$$= \left[\frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1}\right] \times I_1.$$

Current Mirror



→ I_{out} & I_{ref} is only related by $\left(\frac{W}{L}\right)$ ratios of both transistors

$$\boxed{\text{i.e, } I_{out} = \frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1} \times I_{ref}}$$

$L_1 = L_2$ alway.

& Select W_1 & W_2 accordingly.