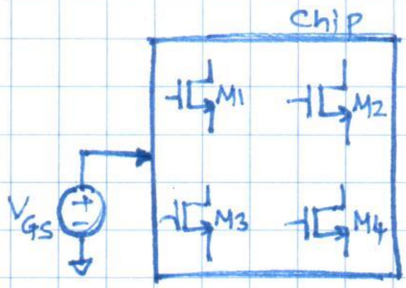
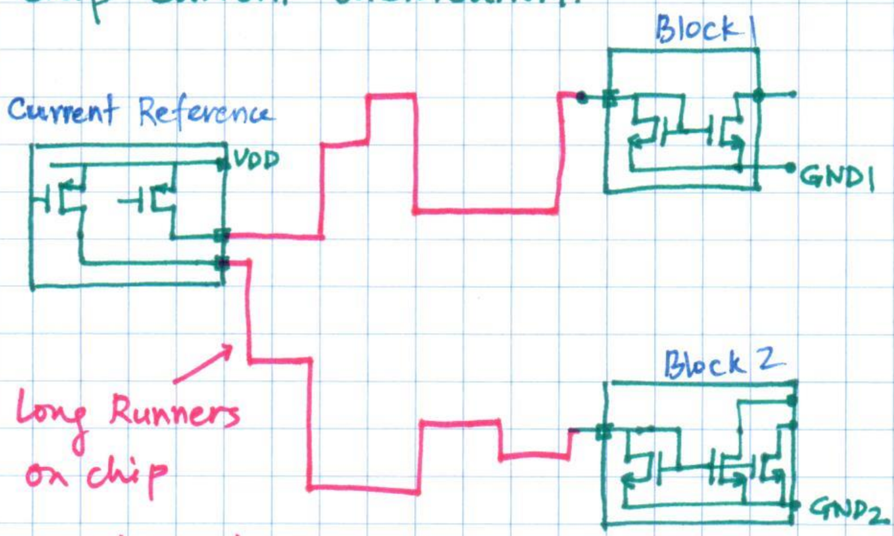
Current Mirrors / Sources



Voltage biasing — Bad idea

- → PROCESS VARIATIONS M1, M2, M3 ...
- → GND, VDD potentials could be different across chip (IR drops)
- → Transistor properties across chip change.

On Chip current distribution.



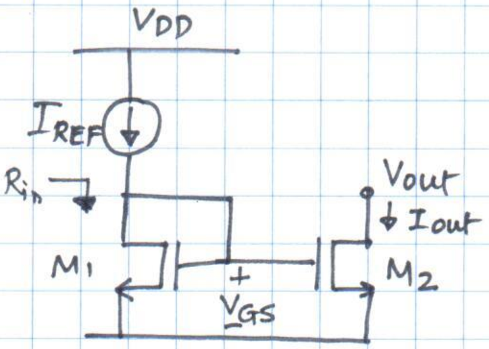
- can have large R.

→ current is faithfully replicated allover chip.

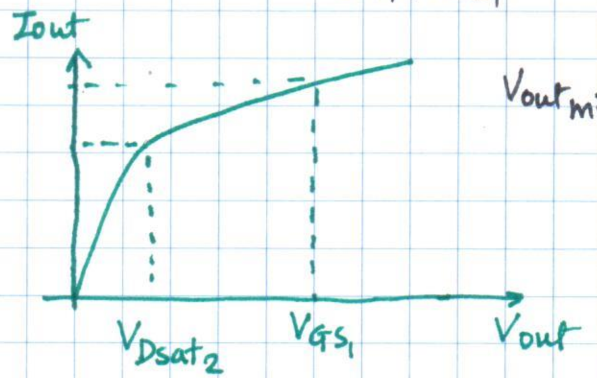
Current Sources used for DC biasing

Specs → O/p resistance
→ voltage compliance (min – max voltage)
→ Accuracy & process independance
→ DC balance
→ i/p Resistance } for current mirrors

Simple Current Mirror



$$R_{in} = \frac{1}{g_{m_1} + g_{ds_1}} \qquad g_{ds_1} = \frac{1}{V_{o_1}}$$



$$V_{out_{min}} = V_{Dsat_2}$$

$$I_{REF} = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_1 (V_{GS} - V_{TH_1})^2 (1 + \lambda_1 V_{GS_1})$$

$$I_{OUT} = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_2 (V_{GS} - V_{TH_2})^2 (1 + \lambda_2 V_{OUT})$$

Assume $V_{TH_1} = V_{TH_2}$

$$\frac{I_{OUT}}{I_{REF}} = \frac{(W/L)_2}{(W/L)_1} \frac{(1 + \lambda_2 V_{OUT})}{(1 + \underbrace{\lambda_1 V_{GS}}_{\text{small}})} \Rightarrow$$

For accurate mirroring keep $L_1 = L_2$

$\Rightarrow \lambda_1 = \lambda_2 = \lambda$

$$\frac{I_{OUT}}{I_{REF}} = \frac{W_2}{W_1}\left(1 + \lambda(V_{out} - V_{GS})\right)$$

To keep λ small → use long channel devices

$L \gg L_{min}$

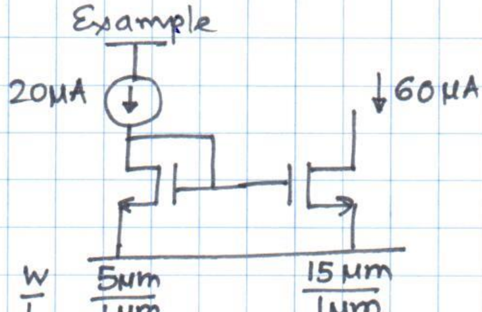
$$\frac{I_{OUT}}{I_{REF}} \approx \frac{W_2}{W_1}$$

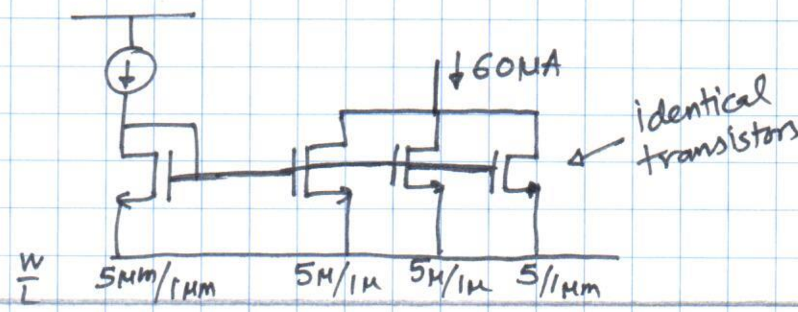
For accurate mirroring

keep $W_2 = N W_1$ N integer

Replicate transistors – Don't streatch W

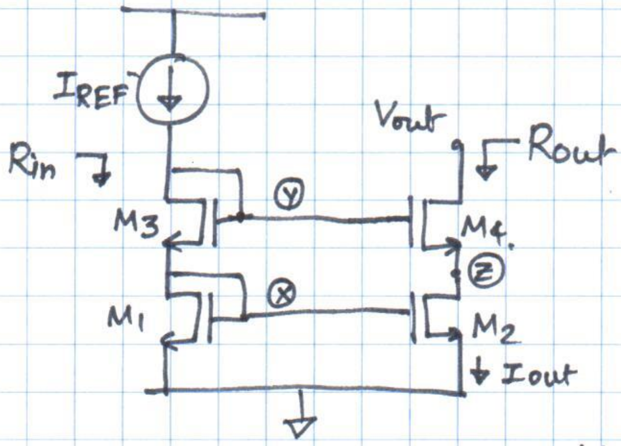
Example





How to scale currents / transistor sizes?

Cascode Current Mirror.



$$R_{in} = \frac{1}{g_{m_1}} + \frac{1}{g_{m_3}} = \frac{2}{g_m}.$$

$$R_{out} \cong (g_{m_4} r_{o_4}) r_{o_2}$$

$$V_Y = V_{GS_3} + V_{GS_1}$$

$$V_Z = V_{GS_3} + V_{GS_1} - V_{GS_4} = V_{GS_1}$$

$$V_{out_{min}} = V_Z + V_{dsat4}.$$

$$\doteq V_{GS_1} + V_{dsat4}.$$

$$\approx V_T + V_{dsat_1} + V_{dsat4}$$

$$\approx V_T + 2V_{dsat}$$

$$\approx 0.5V + 2(0.2) = 0.9V$$

Not suitable for low voltage operation $V_{DD} = 1.2V$.