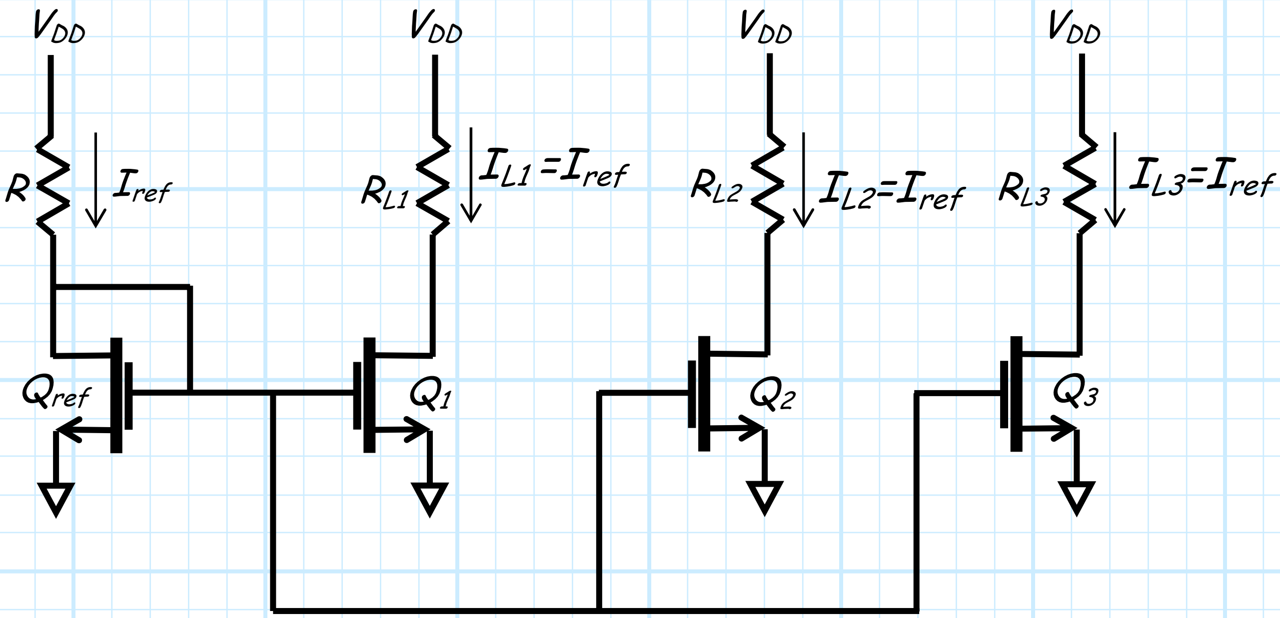
Current Steering Circuits

A current mirror may consist of **many** MOSFET current sources!



This circuit is particularly useful in integrated circuit design, where **one** resistor R is used to make **multiple** current sources.

Q: *What if we want to make the sources have **different** current values? Do we need to make **additional** current mirrors?*

A: NO!!

Recall that the current mirror simply ensures that the gate to source voltages of **each** transistor is **equal** to the gate to source voltage of the **reference**:

$$V_{GS}^{ref} = V_{GS1} = V_{GS2} = V_{GS3} = \cdots$$

Therefore, **if** each transistor is identical (i.e., $K_{ref} = K_1 = \cdots$, and $V_t^{ref} = V_{t1} = V_{t2} = \cdots$) then:

$$\begin{aligned} I_{ref} &= K_{ref}\left(V_{GS}^{ref} - V_t^{ref}\right)^2 \\ &= K_n\left(V_{GSn} - V_{tn}\right)^2 = I_{Dn} \end{aligned}$$

In other words, **if** each transistor Q_n is **identical** to Q_{ref}, then each current I_{Dn} will **equal** reference current I_{ref}.

But, consider what happens if the MOSFETS are not identical. Specifically, consider the case where $K_n \neq K_{ref}$ (but $V_{tn} = V_t^{ref}$).

Remember, we know that $V_{GSn} = V_{GS}^{ref}$ still, even when $K_n \neq K_{ref}$. Thus, the drain current I_{Dn} will now be:

$$\begin{aligned} I_{Dn} &= K_n\left(V_{GSn} - V_{tn}\right)^2 \\ &= K_n\left(V_{GS}^{ref} - V_t^{ref}\right)^2 \\ &= K_n\left(\frac{I_{ref}}{K_{ref}}\right) \\ &= \left(\frac{K_n}{K_{ref}}\right) I_{ref} \end{aligned}$$

The drain current is a scaled value of I_{ref}!

For example, if K_1 is twice that of K_{ref} (i.e., $K_1 = 2K_{ref}$), then I_{D1} will be twice as large as I_{ref} (i.e., $I_1 = 2I_{ref}$).

From the standpoint of integrated circuit design, we can change the value of K by modifying the MOSFET channel **width-to-length ratio** (W/L) for each transistor.

$$\frac{K_n}{K_{ref}} = \frac{\frac{1}{2}k'\left(\frac{W}{L}\right)_n}{\frac{1}{2}k'\left(\frac{W}{L}\right)_{ref}} = \frac{\left(\frac{W}{L}\right)_n}{\left(\frac{W}{L}\right)_{ref}}$$