The Body Effect

In an integrated circuit using MOSFET devices, there can be thousands or millions of transistors.

As a result, there are thousands or millions of MOSFET source terminals!

But, there is only one Body (B)—the Silicon substrate.

Thus, if we were to tie (connect) all the MOSFET source terminals to the single body terminal, we would be connecting all the MOSFET source terminals to each other!
This would almost certainly result in a useless circuit!

Thus, for integrated circuits, the MOSFET source terminals are not connected to the substrate body.

Q: Yikes! What happens to MOSFET behavior if the source is not attached to the body??

A: We must consider the MOSFET Body Effect!

We note that the voltage \( v_{SB} \) (voltage source-to-body) is not necessarily equal to zero (i.e., \( v_{SB} \neq 0 \))! Thus, we’re back to a four-terminal MOSFET device.

There are many ramifications of this body effect; perhaps the most significant is with regard to the threshold voltage \( V_t \).

We find that when \( v_{SB} \neq 0 \), a more accurate expression of the threshold voltage is:

\[
V_t = V_{t0} + \gamma \sqrt{2\phi_f} + v_{SB} - \gamma \sqrt{2\phi_f}
\]

where \( \gamma \) and \( \phi_f \) are MOSFET device parameters.
Note the value $V_{t0}$ is the value of the threshold voltage when $v_{SB} = 0$, i.e.:

$$V_t = V_{t0} \quad \text{when} \quad v_{SB} = 0, 0$$

Thus, the value $V_{t0}$ is simply the value of the device parameter $V_t$ that we have been calling the threshold voltage up till now!

In other words, $V_{t0}$ is the value of the threshold voltage when we ignored the Body Effect, or when $v_{SB} = 0$.

It is thus evident that the term:

$$\gamma \sqrt{2\phi_f + v_{SB}} - \gamma \sqrt{2\phi_f}$$

simply expresses an extra value added to the “ideal” threshold voltage $V_{t0}$ when $v_{SB} \neq 0$.

For many cases, we find that this Body Effect is relatively insignificant, so we will (unless otherwise stated) ignore the Body Effect.

However, do not conclude that the Body Effect is always insignificant—it can in some cases have a tremendous impact on MOSFET circuit performance!