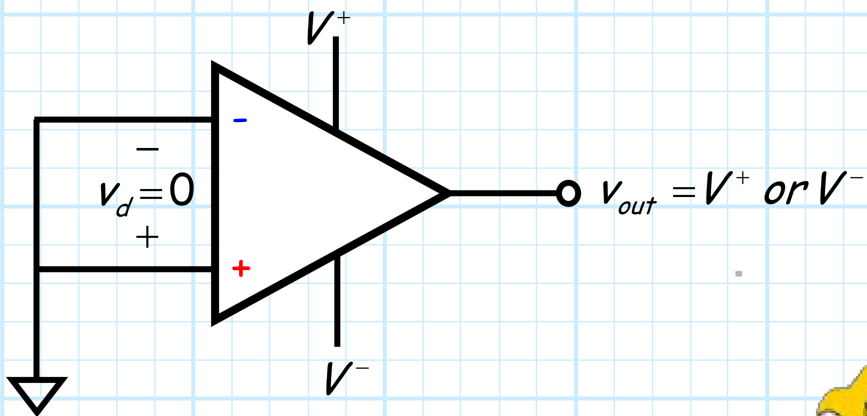
The Input Offset Voltage

For real op-amps, we typically find that if both inputs are grounded, the output will be—**saturated**!



Q: *What!? Why isn't*

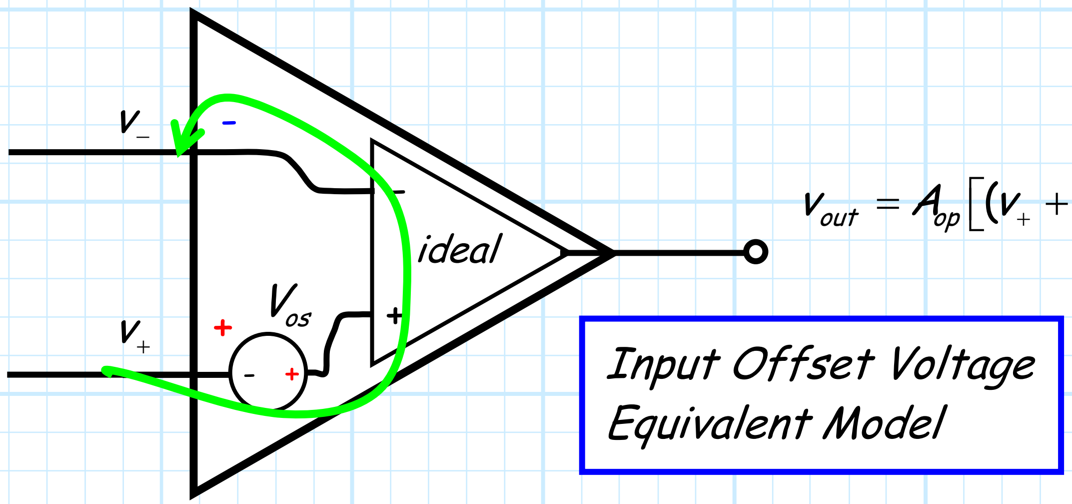
$$v_{out}(t) = A_{op} v_d$$
$$= A_{op}(0) \;??$$
$$= 0$$

A: The reason the output is saturated is that real op-amps exhibit a phenomenon called the **input offset voltage** V_{os}.

The input offset voltage model

This value can be either positive **or** negative, **typically** with a magnitude of 5 mV or less ($|V_{os}| < 5 \text{ mV}$).

A real op-amp therefore behaves as if it has a small, **internal voltage source** at the non-inverting input:



$$v_{out} = A_{op}\left[(v_+ + V_{os}) - v_-\right]$$

Applying the concept of a virtual short to the **ideal** op-amp, we find from **KVL**

$$v_- = v_+ + V_{os}$$

Thus, $v_- \neq v_+$!

The new virtual "short"

Recall, however, that the input offset voltage is typically **very small** (i.e., $|V_{os}| < 5\,mV$), so that $v_- \approx v_+$.

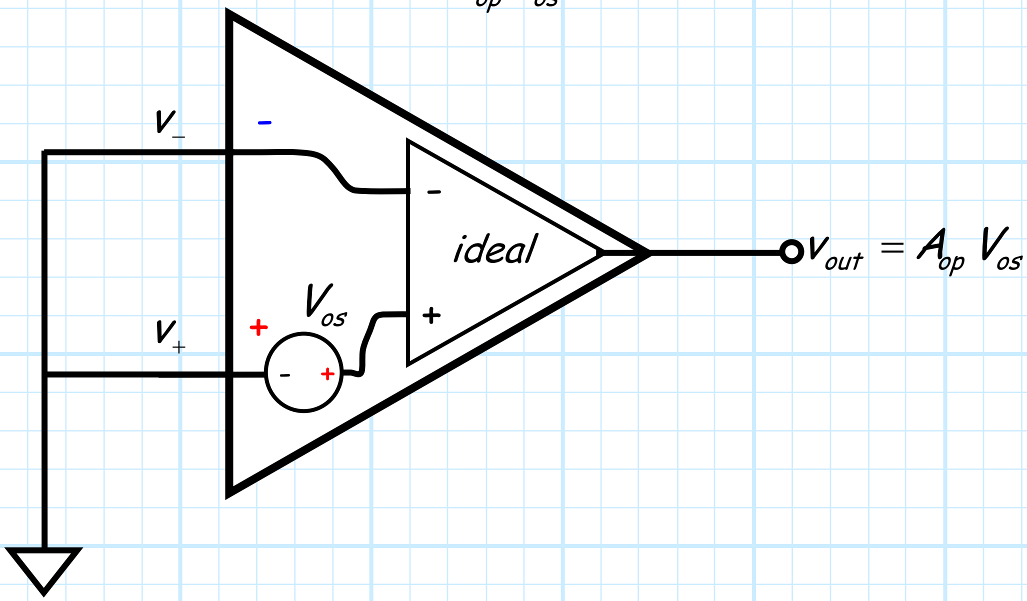
So, for an op-amp with an **input offset voltage**, the virtual "short" equation turns out to be:

$$v_- = V_{os} + v_+$$

Small, but large enough to saturate!

Therefore, **if** $v_- = v_+ = 0$, we find that the output voltage of this op-amp is **ideally** equal to:

$$\begin{aligned} v_{out} &= A_{op}\left(v_+ - v_- + V_{os}\right) \\ &= A_{op}\left(0 - 0 + V_{os}\right) \\ &= A_{op}\, V_{os} \end{aligned}$$



Of course, since the differential voltage A_{op} is **very** large, the product $A_{op}\, V_{os}$ is likewise large, such that the output of **real** op-amps will **saturate**.

This changes our previous results

Q: *Does this mean that V_{os} will cause the output of op-amp **circuits** and **amplifiers** to saturate?*

A: Fortunately **no**!

However, the input offset voltage **will** affect the **output** of circuits and amplifiers made with op-amps.