The **Voltage Follower**

The *voltage follower* has a open-circuit voltage gain $A_{vo} = 1$—with the result that $v_{out} = v_{in}$!

To see why the voltage follower is *important*, consider the following example.

Q: *Pfft! The output voltage is equal to the input voltage?!*

Why even bother?

A: To see *why* the voltage follower is *important*, consider the following example.
What a great amp...

Say you have toiled for hours to design and build the following audio amplifier:

\[
\begin{align*}
A_{vo} &= -200 \text{ (midband)} \\
R_{out} &= 1 \, \text{K} \\
R_i &= 370 \, \Omega \\
\end{align*}
\]

Q: \( A_v = -200 \) ! With this much gain we'll be shakin the windows—right?
...or, maybe not

A: Actually, if we connected this amplifier directly to a speaker, nothing would happen—silence!

Q: ???

A: The reason for this is that the resistance of most speakers is very small (4 Ω-8 Ω).
What’s the problem then?

We can use the linear equivalent circuit model of the audio amplifier to analyze the result:

\[ v_{out} = -200v_{in}\left(\frac{4}{4+1000}\right) = -0.8v_{in} \]

The output of this amplifier is even smaller than its input!

The problem, of course, is not that the open-circuit voltage gain is too small—after all, it’s -200!
The output resistance is just too large!

The problem is that the amplifier output resistance \( R_{\text{out}} = 377 \Omega \) is much larger than the load resistance \( R_L = 4 \Omega \).

Therefore, we have tremendous loss due to the resulting voltage divider:

\[
\frac{4}{4 + 1000} \approx 0.004
\]

There is a solution to this problem—use a voltage follower!
The voltage follower to the rescue!

Let's again use the linear equivalent model to analyze this circuit and find the output voltage $v_{out}$.

\[ v_{out} = -200 v_{in} \left( \frac{\infty}{1000 + \infty} \right) 1 \left( \frac{4}{0 + 4} \right) = -200 v_{in} \]

We've got back our gain!
The voltage follower: a useful buffer

Note:

1. **Instead** of 4Ω, the audio amp "sees" a load of ∞, the **input resistance** of the voltage follower—this is **ideal**!

2. **Instead** of 377Ω, the speaker "sees" a source resistance of 0, the **output resistance** of the voltage follower—this too is **ideal**!

Remember, there are **three** characterizing parameters of an amplifier—open circuit voltage gain is just **one** of those three!

The input and output impedance of the voltage follower make it an excellent "**buffer**" between two circuits!