**Current and Voltage Amplifiers**



**Q:** *I’ll admit to being* ***dog-gone*** *confused. You say that* ***every*** *amplifier can be described* ***equally*** *well in terms of* ***either*** *its open-circuit voltage gain Avo,* ***or*** *its short-circuit current gain Ais.*

*Yet, amps I have seen are denoted* ***specifically*** *as either a dad-gum* ***current*** *amplifier or a gul-darn* ***voltage*** *amplifier.*

***Are*** *voltage and current amplifiers* ***separate*** *devices, and if so,* ***what*** *are the differences between them?*

**A: Any** amplifier can be used as **either** a current amp **or** as a voltage amp. However, we will find that an amp that works well as **one** does not generally work well as the **other**! Hence, we can in general **classify** amps as either voltage amps or current amps.

**Define a gain**

To see the difference we first need to provide some **definitions**.

First, consider the following circuit:

+

-

*Rs*

**

**

**

*io* (*t*)

*RL*

**

**Q:** *Isn’t that just Avo??*

We **define** a voltage gain *Av* as:





**A:** NO! Notice that the output of the amplifier is **not open circuited**.

**This is what the model is for**

Likewise, the **source** voltage *vs* is **not** generally equal to the **input** voltage *vin.*

We must use a **circuit model** to determine voltage gain *Av* .

Although we can use **either** model, we will find it easier to analyze the **voltage** gain if we use the model with the dependent **voltage** source:

+

-

*Rin*

*Rout*



**

+

-

*Rs*

**

*RL*

*io* (*t*)

**

**

**The result**

Analyzing the **input** section of this circuit, we find:

??



and analyzing the **output**:





**combining** the two expressions we get:



and therefore the **voltage gain** *Av* is:



**How to maximize voltage gain**

Note in the above expression that the first and third product terms are **limited**:



We find that each of these terms will approach their **maximum** value (i.e., one) when:



Thus, if the **input** resistance is very **large** (>>*Rs*) and the **output** resistance is very **small** (<<*RL*), the voltage gain for this circuit will be **maximized** and have a value approximately **equal** to the **open-circuit voltage gain**!



**A good voltage amplifier**

Thus, we can infer **three** characteristics of a good **voltage amplifier**:

1. Very **large input** resistance ().

**2.** Very **small output** resistance ().

**3.** Large open-circuit **voltage gain** ().

**Now for current gain**

Now let’s consider a **second** circuit:

**

**

**

**

**

*RL*

*Rs*

We define **current gain** *Ai* as:



Note that this gain is **not** equal to the **short-circuit** current gain *Ais*. This current gain *Ai* depends on the **source** and **load** resistances, as well as the amplifier parameters.

Therefore, we must use a **circuit model** to determine current gain *Ai* .

**Use the other model**

Although we can use **either** model, we will find it easier to analyze the **current** gain if we use the model with the dependent **current** source:

*Rin*

*Rout*



*Rs*

*RL*

**

**

**

**

**

Analyzing the **input** section, we can use **current division** to determine:



We likewise can use current division to analyze the **output** section:



**How to maximize current gain**



Combining these results, we find that:



and therefore the **current gain** *Ai* is:



Note in the above expression that the first and third product terms are **limited**:



We find that each of these terms will approach their **maximum** value (i.e., one) when:



**The ideal current amp**

Thus, if the **input** resistance is very **small** (<<*Rs*) and the **output** resistance is very **large** (>>*RL*), the voltage gain for this circuit will be maximized and have a value approximately equal to the short-circuit current gain!



Thus, we can infer **three** characteristics of a good **current amplifier**:

**1.** Very **small input** resistance ().

**2.** Very **large output** resistance ().

**3.** Large short-circuit **current gain** ().

Note the ideal resistances are **opposite** to those of the ideal **voltage** amplifier!

**You can trust ol’ Roy!**

*It’s actually quite simple. An amplifier with* ***low*** *input resistance and* ***high*** *output resistance will typically provide great* ***current*** *gain but lousy* ***voltage*** *gain.*

*Conversely, an amplifier with* ***high*** *input resistance and* ***low*** *output resistance will typically make a great* ***voltage*** *amplifier but a dog-gone poor* ***current*** *amp.*

