Bergantino™
AUDIO SYSTEMS

Why 2.67-Ohms?

Ever since Class D amps have become the main stay of today's amplifier technology and designs, one of their limiting factors has always been their ability to drive speaker loads down to 2-Ohms. As a new generation of Class D amps become available, even though they are not necessarily specified down to 2-Ohms, there are ways designers can allow these amps to operate safely down to 2-Ohms with certain caveats in mind.

The biggest concern running a power amp rated at 4-Ohms down to 2-Ohms is the extra power demand in terms of current the amplifier will try to deliver to these lower impedance loads. When a manufacturer designs an amp's power supply and output stage, they design it to operate safely at a specified rated output power. In other words, why go through the trouble and expense of designing a power supply and output stage that can handle 1000 watts when you're only going to deliver 500 watts? They would have to charge based on the added cost of the 1000 watt design, but without delivering the full 1000 watts. Not a very wise design choice from a pure economical and business perspective. Another thing to realize and understand is that getting an amplifier to handle a lower impedance load doesn't necessarily mean it can or will deliver more power than its designers intended it to. It just means it can deliver and distribute its maximum, available output power into a lower impedance load safely.

So what does this all mean?

Let's first consider the following equations (you didn't think you would need to remember your basic high school algebra to read this article, did you?)

Ohms Law:

1.) V = I x Z where V = voltage, I = current, and Z = impedance

This equation can also be written as:

2.) I = V/Z

Amplifier Power output is calculated as follows:

3.) $P = V \times I$ where P = power, V = voltage, and I = current

Substituting for I with equation 2, Power can also be calculated as:

4.) $P = V^2/Z$

or:

5.) $V^2 = P \times Z$; ➔ $V = \mathrm{sqrt}(P \times Z)$; sqrt ➔ square root

Now that we got that over with: (there may be a pop quiz on Monday, btw!)

Let's take an example of a typical amplifier rated at 500 Watts @ 4-Ohm

Using **equation 5** we can calculate the amp's maximum output voltage before clipping:

$$V^2 = P \times Z$$

$$V^2 = 500 \times 4$$

$$V^2 = 2000$$

$$V = \mathrm{sqrt}\ 2000$$

$V = 44.72$ Volts. This is the maximum voltage the amp is capable of producing.

And just to check what this amp will deliver into an 8-Ohm load given the same output voltage we can use **equation 4** as follows:

$$P = V^2/Z$$

$$P = 44.72^2/8$$

$$P = 2000/8$$

$$P = 250 \text{ watts}$$

This is typical of an amplifier's power spec such that it will deliver half as much power into 8-Ohms as it does at 4-Ohms, given the maximum output voltage is the same for both impedances.

➔ Notice from the above example and **equation 4** that as the impedance goes up, the power output goes down proportionately. In other words, Power Output **(P)** is inversely proportional to Impedance **(Z).**

So, what if we hook up a 2-Ohm load to this amplifier without taking any precautions?

Using **equation 4** and solving for Power, using **Z = 2-Ohms** we get:

$$P = 44.72^2/2$$

$$P = 2000/2$$

$$P = 1000 \text{ watts!}$$

This is clearly much more power than the amp was designed to deliver. Hopefully the amp's protection features will kick in long before it tries to deliver anything close to 1000 watts, as the amp's power supply and output devices were not designed to handle this extra current and power demand. So what does this translate to in the real world if you were to hook up a 2-Ohm load to this amp as is? Chances are, during your bass solo when you're digging in having a grand ole' time for yourself, the amp will enter protect mode from either over current, over temperature, or both and shut itself down. So much for your bass solo!

So what can a designer do to allow two 4-Ohm cabs in parallel (2-Ohm load) to be connected safely to this amp? They can limit the output voltage swing such that the power output can never exceed 500 watts, even at 2-Ohms. And how do we determine this voltage level?

Using **equation 5**, we can calculate the maximum output voltage we want in order for the amp to only deliver **500 watts @ 2-Ohms** as follows:

$$V^2 = P \times Z$$

$$V^2 = 500 \times 2$$

$$V^2=1000$$

$$V = \text{sqrt } 1000 = 31.62 \text{ Volts}$$

If we can limit the amp's output voltage to 31.62 Volts instead of 44.72 volts when the amp is driving a 2-Ohm load, we can make sure the amp still doesn't deliver more than 500 watts, which is in line with what the amp was designed to do (assuming it can safely handle the required current of 15.8 amps @ 2 ohms vs. 11.18 amps @ 4-Ohms ➔ see **equation 4**).

How is this done? There are various ways to accomplish this which is beyond the intended scope of this paper.

But….you knew there was going to be a "but"! What about a **2.67-Ohm** load, which is becoming more and more common these days, with players adding an 8-Ohm 112 cabinet to their 4-Ohm 212 cabinet, or combining an 8-Ohm 210 cabinet with their 4-Ohm 410 cabinet?

Let's find out:

Using **equation 4** and **V = 44.72 volts** (amp's max. output voltage) and **Z = 2.67-Ohms**, solving for Power we get:

$$P = V^2/Z$$

$$P = 44.72^2/2.67$$

$$P = 2000/2.67$$

P = 750 watts

Again, like in the case of the 2-Ohm load at the amp's maximum output voltage of 44.72 Volts, the amp is still being placed in a potentially compromising position, by being called upon to deliver more current and power than it was safely designed to do. At higher volumes, this could cause it to enter protect mode and shut itself down, not something a player would want to risk have happen in the middle of a gig.

Re-calculating using the 2 ohm Voltage output of **V=31.62 Volts**, and again using **equation 4**

$$P = 31.62^2/2.67$$

$$P = 1000/2.67$$

P = 375 watts

This is much safer and well within the amps power ratings, ***but,*** we just lost 125 watts or ¼ (25%) of the amps total available output power at 2.67-Ohms! Just like above in the 4-Ohm vs. 8-Ohm scenario, when you hold the output voltage constant and raise the impedance, you get proportionately less power to the load (speaker). However, unlike the 8-Ohm example above, where its power output was limited by the available output voltage, this is not the case here. It would be great if this amp could offer a 3rd selection for 2.67-Ohm operation and allow the amp's output voltage to reach **36.54 Volts** when being used with a 2.67-Ohm load. It certainly has this output voltage available to it. This would give us the amp's full output capability of 500 watt at 2.67-Ohms as shown below using **equation 4** and **V= 36.54 Volts**:

$$P = 36.54^2/2.67$$

$$P = 1335/2.67$$

P = 500 watts!

So **"Why 2.67-Ohms?"** Being able to safely extract the maximum available output power of an amplifier at various impedances gives players using various combination of cabinets much better access to the amplifiers full output capabilities without leaving any "Watts on the table".

And with the B|AMP's software based architecture, along with its computer controlled, DSP processor, it was just a few extra lines of code to allow the B|AMP to deliver its full output power of **800 watts,** not only into **2-Ohms**, but into **2.67-Ohms** as well. Without a 2.67-Ohm option, the B|AMP, and any other 800 watt amp for that matter, would only be able to deliver 600 watts, or 25% less, safely into 2.67-Ohms. Pretty cool, huh? And speaking of "cool", even though the amp's output power may be the same at 2-Ohms as it is at 2.67-Ohms, its current is not. Higher operating current, and the associated heat that goes with it, is still a concern that needs to be addressed when designing an amp capable of 2-Ohm operation. That is why with the B|AMP, when 2-Ohm operation is selected, the fan is automatically engaged, keeping its heatsinks running cooler, ensuring a safe operating condition for the amplifier under these more demanding conditions. We know of no other commercially available Bass Amp on the market that does all this!