



**Musical Amplification:
Power Without Corruption**

November 23, 2009

The Purpose of Power

“More power, more volume.”

It’s an assumption many musicians make. And it’s partially true.

But, it’s only one chapter in a complex story. A more thorough understanding of the fundamentals of musical instrument amplification can help you as a player better select and utilize amp and speaker systems. Hence these few paragraphs.

I’ll start by explaining what “loudness” is and what creates it as far as the ear is concerned. I’ll then explain the role that amp power plays in creating “loudness.” Following that, I’ll discuss how amp power affects the reproduction of music signals and then finish with a discussion of the trade off between increasing amp power and adding more speakers. Finally, I’ll summarize what all this means in the store and on the gig.

What is Loudness?

Humans hear changes in sound intensity caused by the compression and rarefaction of sound waves (think of the ups and downs on a sine wave or the waves created when you drop a rock in a still pond). Interestingly, the sound pressure our ear responds to is a non linear function— expressed as pressure squared. This is an important aspect of hearing that gives our ears a wide dynamic range and it affects how amp power relates to perceived loudness. Typically, the level of sound is stated as Sound Pressure Level or SPL, which is calculated as a ratio of the square of the pressure level measured to the square of the smallest pressure level that can be heard (aka the threshold of hearing). SPL is measured in decibels (or dB for short), and is calculated using logarithms. If you would like more detail on this subject, check out any book on acoustics or simply google “definition of SPL.”

You have probably seen tables that tell you the SPL of various sounds. For example, the threshold of hearing is 0 dB SPL, the threshold of pain (where permanent damage to your ears happens in a very short time) is 135 dB, typical conversation is 60 dB, and a jet plane taking off is 120 dB. This doesn’t mean that a jet is twice as loud as people talking...it is a *thousand* times louder. And polite conversation itself is a thousand times louder than the threshold of hearing. Obviously, the ear is both pretty sensitive and versatile.

How does all this relate to amplifier power? Basically, a loudspeaker converts electrical watts (the rating on your amp) into *acoustic* watts which are in turn perceived as changes in sound intensity (or SPL) by the ear. An acoustic watt measures sound intensity *per unit of area*. So, when converting from acoustic watts to SPL, the size of the room has to be taken into account. To put this in the real world, the same amp with the same wattage rating will *sound* much louder in your living room than in Madison Square Garden.

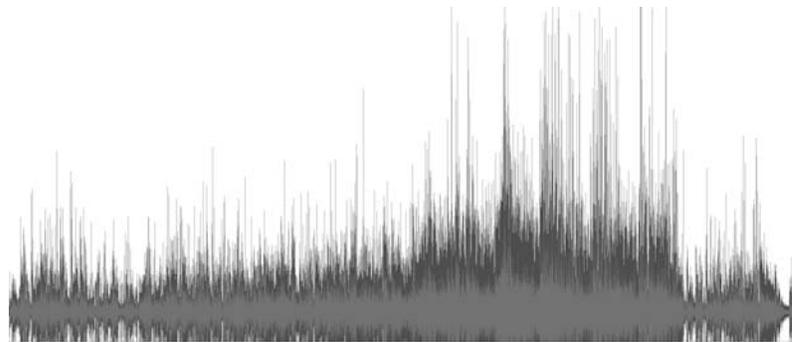
It may surprise you that the typical loudspeaker is pretty inefficient, with a conversion efficiency of a few percent, often less than 1 percent. Fortunately, a small value of acoustic watts will create a high SPL in a moderate sized room. For example, 0.5 acoustic watts will produce an SPL of 100 dB in a 100 cubic meter room (a typical living room) and 4 acoustic watts will produce an SPL of 90 dB in a 10,000 cubic meter room (the size of a largish club).

Given all this, how much amplifier power do you *need*? The calculations are complicated, so you will have to take my word for this, but let's assume a loudspeaker that has an efficiency of 1% and the need to produce an SPL of 90 dB in a moderate sized club. That's a situation that most club-playing musicians face. It turns out that about 0.4 acoustic watts would be needed. So a 40 watt amp would suffice. Right?

Unfortunately, it's not that simple. The above calculations are for an average SPL, so an average of 40 watts would be required. And a music signal is far from average. Let's take a look.

What Does A Music Waveform Look Like?

A music signal has an average level but it also has many peaks in it that correspond to *transients* coming from the instrument being amplified. A pop or slap from a bass or the sound of the pick on a guitar string can produce a momentary increase in loudness from the instrument. The transient signal typically lasts a fraction of a second and it does little to increase the average loudness. Here's an example:



This is several second clip of a piano trio. As you can see, there is an average component to the waveform and there are many transient signals with amplitudes that are considerably higher than the average,

in some cases up to ten times.

An amplifier reproducing this complex signal has to instantaneously deliver power to recreate the transients without compressing or clipping them. Otherwise, what results is a loss of fidelity and transparency of the amplified signal. So, in the example mentioned above, the amp outputting 40 Watts to reproduce the average level of the signal (90 dB SPL in a moderate sized club) has to output 400 Watts for a fraction of a second to reproduce the full fidelity of the music signal. If the transient is larger than the assumed ten times, more power is required.

So, one important purpose of power output capability is to reproduce the full dynamic range of the complex signal being amplified without damaging it (or as we put it at AI, to create “power without corruption”).

What If You Need More Volume?

So, if you need more volume, you should get an amp with more power, right? Not necessarily.

There are two ways to get more volume. One is to increase the output power of the amp and keep the speaker the same, the other is to keep the power output the same and add an identical speaker.

So if you double the power output of the amp, the result is 3 dB more acoustic output from the speaker and 3 dB higher SPL. If you double the number of speakers, the result is double the sound radiating area and doubling of the pressure level coming from the speakers. Since SPL is proportional to pressure squared, the output of the system is increased by a factor of 4 or 6dB. So, doubling the output power results in 3 dB higher SPL while doubling the *speaker* radiating area results in 6 dB higher SPL.

As you can see, adding speakers is a much more efficient way to increase volume in an amp/speaker system.

The Purpose Of Power

So what does this mean to you, the performing musician? At the risk of over generalizing, let me say this: the most important purpose of power is to increase fidelity. If you need more volume, add more speaker radiating area. When shopping for an amp and speaker combination, don't just go for the power rating of the amp, take into account the speaker configuration that will give you the volume level that is appropriate for your playing situations. Overall, consider the amp as the means for getting the *quality* of sound you want and consider the speaker as the means for getting the *quantity* of sound you need.

In considering amp power, you should be aware of the fact that not all manufacturers measure and rate their amps the same way. Some use an *rms* (root

mean square, don't ask) rating, some use a music power rating, some use a peak rating and some just make up a number. What's more, some may use a single frequency to measure the power level and some may specify the power over a range of frequencies. Other important factors are the distortion level at the rated power and the load used for the measurements. The resulting difference in power ratings from these approaches can be large. For example, a peak power rating can be more than two times the rms rating and a rating at 5% distortion can be 25 to 50% higher than a rating at 0.5% distortion. So, as a buyer and user, you should be aware of how your amp's power rating has been obtained and, when comparing power ratings, you should make sure that they are obtained under the same circumstances. Otherwise, you're comparing apples to oranges.

So, bottom line, how much power do you really need?

The example I gave is a pretty good one: 40 Watts on average will result in adequate SPL in moderate sized rooms for "acoustic" amplification. Allowing for clean reproduction of transients (10X more power) brings you to 400 Watts. This should be an rms power rating at a distortion of less than 3% and should be over the frequency range of 40 to 10k Hz. Having more power than that only improves the transient reproduction for a marginally cleaner sound and doesn't substantially increase the volume at which you can play. If you need more volume, add more speakers.

A Final Word

Of course, even if you find two different amplifiers with the same power, headroom and distortion ratings and play them through the same speaker and enclosure, they will not sound the same (I did say that this was a complex issue and we will need to deal with this and other matters in future articles). So, ultimately, you will have to use your ears to decide what sounds best to you.

But if you will excuse a commercial moment, here is a simple statement that provides a solid basis of comparison: at Acoustic Image, we custom design our portable, full-featured amplifiers without off-the-shelf modules...to produce a high-fidelity, transparent signal that doesn't color the sound...and to assure tons of headroom. We rate power output conservatively—and carefully (and tortuously) test every amplifier to make sure it meets precise specifications before it leaves the shop. Most of all, we use our ears in testing to make sure the amps sound good. We also equip every combo (and extension cab) with a downfiring woofer which makes a relatively small speaker sound louder by increasing its effective radiating area through something called the "dipole effect" (more about that too later).

If you have questions, shoot me an email.

Rick Jones
rick@acousticimg.com