

ProSoundWeb EXPERT SERIES



POWER AMPLIFICATION: HOW MUCH IS ENOUGH?

*Chapter 4 of 4 in the Amplifier
Expert Series*

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HOW MUCH POWER?

Specifying the right power amplifier for an application.

By Bruce Bartlett

Determining which power amplifier is appropriate for a specific application is not as easy as one may think. To fully understand what needs to be considered, three specific case studies will be outlined:

- » A client wants to play folk music in a coffee shop. How much amplifier power do they need?
- » A rock group will be playing in a 2,000-seat concert hall. How many watts will you need to provide?
- » A jazz-fusion group bought some PA loudspeakers. They want to play the loudspeakers as loud as they can get without blowing them up. Which amplifier should you recommend?

Questions such as these arise in any sound system design. To help you specify an optimum amount of amplifier power for a system, I'll explain the relevant audio concepts here. There are two goals:

1. Power the loudspeakers so they play as loudly as possible without burning out. In other words, determine the optimum powering for the chosen loudspeakers.
2. Achieve a certain loudness in a certain venue.

We'll cover both topics.

Signal Levels

First let's review the concept of average levels and peak levels. As shown in Figure 1, a musical signal changes in level (voltage) continuously as it plays. Imagine a musical passage with a low-level synth pad, but with high-level drum hits. The average level or volume of the passage is low, but the transient peak levels are high.

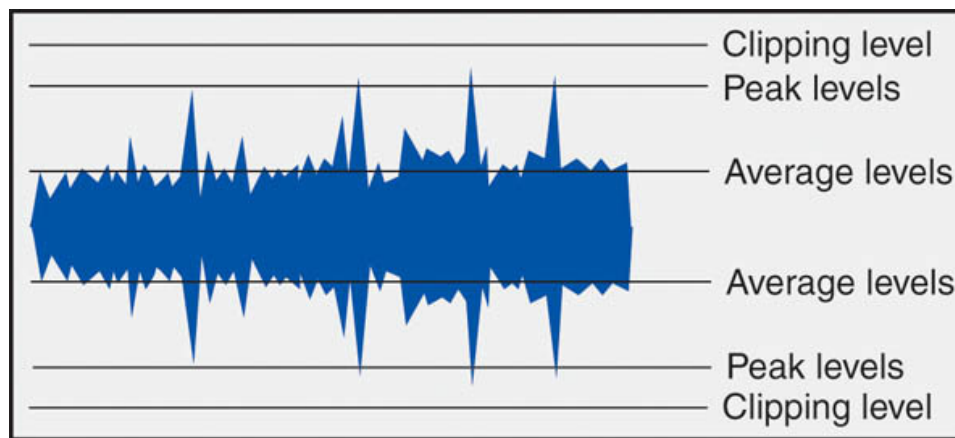


Figure 1: Average levels and peak levels in a musical signal.

Peak levels may be up to 24 dB above average levels depending on the type of signal. Percussive sounds have much higher peaks than continuous sounds do (synth pads, organ, flute) – even if the two signals have similar average levels.

The peak-to-average ratio of the signal is called the crest factor or peak factor. In other words, crest factor is the difference in dB between the peak levels and the average level of the signal. Percussive sounds have a high crest factor.

Flutes, organs and violins have a low crest factor. The crest factor of speech is about 12 dB. Highly compressed rock music has a crest factor of about 6 dB: the peaks are about 6 dB higher than the average level.

Figure 2 is a graph of signal level versus time when the amp is fed a typical musical signal. The average level corresponds to the signal's loudness. The peak level is 6 to 24 dB above the average level, depending on the type of signal. In other words, the signal crest factor is 6 to 24 dB.

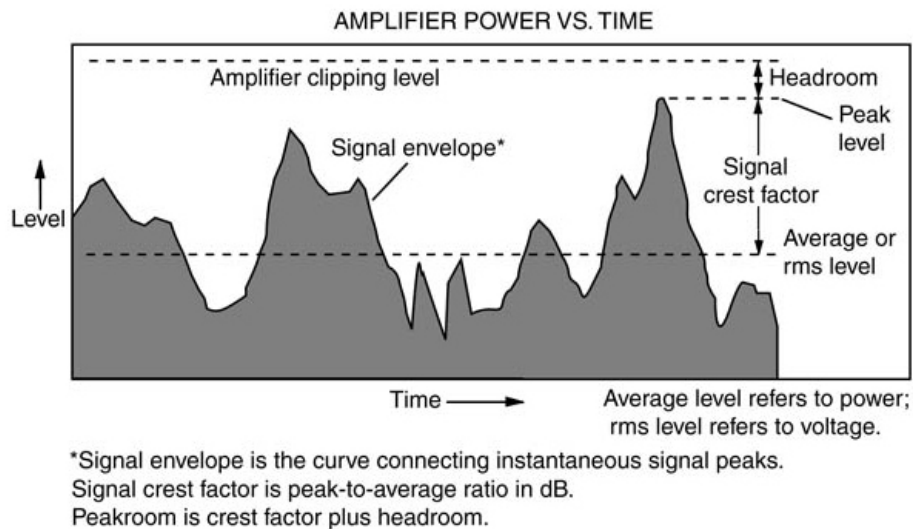
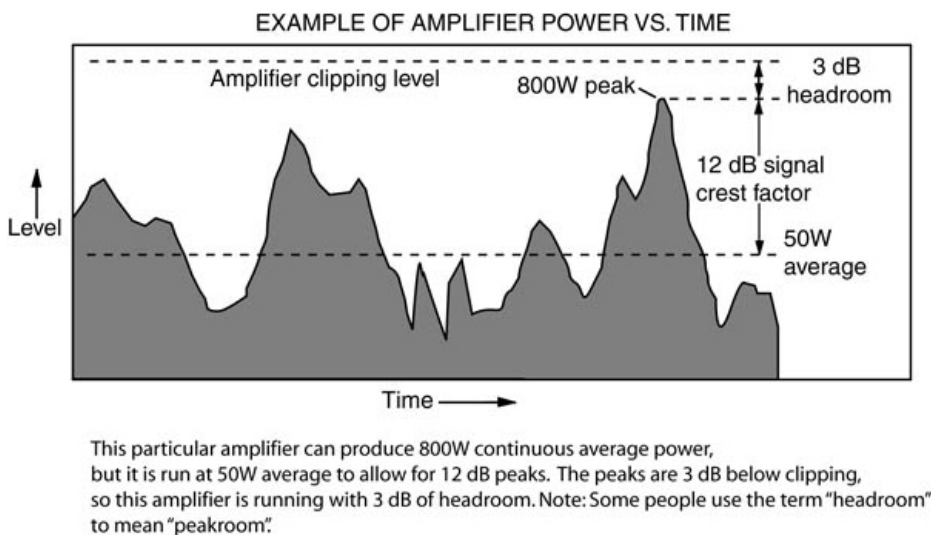


Figure 2: Amplifier power vs. time with a program signal.



The bottom of Figure 2 shows an example of amplifier power output versus time when the amp is fed a musical signal. The amplifier is rated at 800 W continuous power. That's the maximum power it can produce at rated distortion.

However, in this example the amplifier is putting out 50W on the average, so that occasional peaks of 12 dB don't exceed the amp's 800 W capability. Also, there is a little headroom so that the peaks don't clip.

Headroom

In Figure 2, headroom is the difference in dB between the signal peak levels and the amplifier's clipping level. Normally you want to allow at least 3 dB of headroom so that signal peaks don't accidentally clip.

Peakroom

This term, coined by Pat Brown of SynAudCon, is crest factor plus headroom. Peakroom indicates how many decibels that peaks can be above the average level without clipping. Now that we understand signal levels, let's see how they relate to power amp specifications.

Continuous Average Power

The power specification of most amplifiers is continuous average power. That's the maximum power in watts that the amplifier can produce at rated distortion, at a certain load impedance, when playing a continuous sine wave. That sine wave signal is either a 1 kHz tone or is a range of tones from 20 Hz to 20 kHz.

For example, one amplifier puts out 1,800 W per channel into 4 ohms in stereo mode at 0.1% THD at 1 kHz. Another amp produces 8,000 W into 8 ohms in bridge-mono mode at 0.35% THD from 20 Hz to 20 kHz.

Many loudspeakers are also rated in continuous or average power handling. If the loudspeaker's continuous power handling is 500 watts, that means it can handle 500 watts of pink noise continuously without mechanical or thermal damage.

To generate that power-handling spec, the loudspeaker is usually fed "AES pink noise," which is pink noise that is clipped so that its crest factor is 6 dB. Normally pink noise has a crest factor of 12 dB. The AES loudspeaker test signal IEC 268-5 specifies band-limited pink noise with a crest factor of 6 dB.

I recommend that the amplifier's continuous power be twice the loudspeaker's continuous power handling (within 80% to 125%). If the amp's continuous power is higher than 125%, you risk damaging the loudspeaker with too much power in the event of feedback. If the amp's continuous power is lower than 80%, you will probably clip the signal in an attempt to get enough volume out of the loudspeaker. Clipping a signal produces strong high frequencies which can burn out tweeters.

For example, suppose a loudspeaker has 200 watts continuous power handling. The amplifier's continuous average power should be twice that, or 400 watts (within 80% to 125%, or 320 watts to 500 watts).

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Program Power

Some loudspeakers are rated in program power (music power), which is usually twice the continuous average power. A suitable amplifier should have a continuous average power that matches the loudspeaker's program power (within 80% to 125%). For example, if a loudspeaker is rated at 400 W program, the amp should provide 400 watts continuous (x 80% to 125%).

Peak Power

This is the power, in watts, that an amplifier can produce during short peaks or transients. Typically, peak power is 1 to 3 dB higher than the continuous power. Peak power depends on the amplifier's power reserves (energy storage). If the amplifier's power supply has a bank of large filter capacitors, they can store energy that can be released during short peaks.

Many loudspeakers are rated in the peak power they can handle. Ideally, the power amplifier's peak power should not exceed the loudspeaker's peak power rating. If the power amp does not have a peak power spec, just make sure that the amp's continuous power is twice that of the loudspeaker (within 80% to 125%).

Creating Headroom For Signal Peaks

In practice, you don't run the amp at full continuous power because that does not allow extra power for signal peaks, which might be 6 to 24 dB above the average level. Instead, the amp's average power is typically 6 to 24 dB below clipping to allow for undistorted signal peaks.

For example, you might turn the amp down so it puts out 1/16th of its rated continuous power on the average. Occasional peaks will make the amp produce its rated continuous power during those peaks. Suppose an amp is rated at 800 W continuous average power. You might run it at 50W on the average so that occasional peaks can reach 800W without clipping.

In other words, you allow 12 dB for signal peaks (return to Figure 2, bottom). Actually, peaks can be a bit higher than that because an amplifier's peak power is typically 1 to 3 dB higher than its continuous power.

In this case, crest factor (dB) = $10 * \log (800/50) = 12 \text{ dB}$.

These power specs are continuous average power:

- » An 800 watts amp run at 400 watts allows for 3 dB peaks above the average level. In this case, the only undistorted signal you could play would be a sine wave or square wave.
- » An 800-watt amp run at 200 watts allows for 6 dB peaks above the average level. This is adequate for highly compressed rock music or a rock broadcast.

IDEALLY, THE POWER
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POWER RATING.

- » An 800-watt amp run at 100 watts allows for 9 dB peaks above the average level.
- » An 800-watt amp run at 50 watts allows for 12 dB peaks above the average level. This is adequate for speech.

Many power amplifiers include an output limiter to prevent clipping. If you drive that limiter hard enough, it will reduce the signal peaks frequently, letting you bring up the average level to increase loudness. I don't recommend that practice because it will make the amp and loudspeaker run hotter and may cause shutdown.

If you can prevent the power amp from clipping (by using a limiter), use a power amp that supplies two to four times the loudspeaker's continuous power rating per channel. This allows 3 to 6 dB of headroom for peaks in the audio signal. Loudspeakers are built to handle those short-term peaks.

If you can't keep the power amp from clipping (say, you have no limiter and the system is overdriven or goes into feedback) the amplifier's maximum power should equal the loudspeaker's continuous power rating. That way the loudspeaker won't be damaged if the amp clips when you overdrive its input.

If you're mainly doing light dance music or voice, I recommend that the amplifier power be 1.6 times the Continuous Power rating per channel. If you're doing heavy metal/grunge, try 2.5 times the Continuous Power rating per channel. The amplifier power must be rated for the impedance of the loudspeaker (2, 4, 8 or 16 ohms).

Here's an example. Suppose the impedance of your loudspeaker is 4 ohms, and its Continuous Power Handling is 100 watts. If you're playing light dance music, the amplifier's 4-ohm power should be 1.6×100 watts or 160 watts continuous per channel. To handle heavy metal/grunge, the amplifier's 4-ohm power should be 2.5×100 watts or 250 watts continuous per channel.

If you use two loudspeakers in parallel per channel, each loudspeaker receives half of the amplifier's power output. So the amplifier power per channel should be 4 times one loudspeaker's continuous power rating instead of 2 times. If both speakers are 8 ohms, refer to the amp's 4-ohm power spec (because the paralleled impedance is 4 ohms).

Example 1:

Two 8-ohm loudspeakers are wired in parallel to one amplifier channel. Each loudspeaker is rated at 300 watts program. The amplifier should provide 600 watts into 4 ohms per channel. That's 4X one loudspeaker's continuous power rating and half the loudspeaker's impedance.

IF YOU'RE MAINLY DOING LIGHT DANCE MUSIC OR VOICE, I RECOMMEND THAT THE AMPLIFIER POWER BE 1.6 TIMES THE CONTINUOUS POWER RATING PER CHANNEL.

Example 2:

Two 8-ohm loudspeakers are wired in parallel to an amplifier in bridge mono mode. Each loudspeaker is rated at 300 W program. The amplifier should provide 600 watts continuous (300 watts per loudspeaker) into 4 ohms in bridge-mono mode.

Summary

- » Amplifier continuous power should equal 2X the loudspeaker's continuous power handling (at the same impedance).
- » Amplifier continuous power should equal the loudspeaker's program power handling (at the same impedance).
- » If two loudspeakers are wired in parallel, amplifier continuous power should equal 4X one loudspeaker's continuous power handling (at one half of the loudspeaker's impedance).
- » Multiply the amp's power by 80% to 125% to get a range of acceptable power levels.

AES and SynAudCon member Bruce Bartlett is a recording engineer, audio journalist, and microphone engineer (bartlettaudio.com). His latest books are "Practical Recording Techniques 7th Edition" and "Recording Music On Location, 2nd Edition."

About Dynacord

For over 70 years, Dynacord has designed and engineered professional audio systems — products that offer unparalleled performance and premium quality, the perfect balance of power and precision. We seek to surpass the highest standards of today's audio professionals, audiences and performers. Our industrial design combines finely tuned form with feature-rich functionality across every detail — clean lines and clean sound — and our dedication to durability is demonstrated in the industry's most rigorous product testing program. In applications where failure is not an option, you can rely on Dynacord to be heard loud and clear.

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