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IS YOUR AMPLIFIER DESIGNED TO DRIVE A LOUDSPEAKER OR A HEATER?

Chapter 4 of 4 in the Loudspeaker Expert Series

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IS YOUR AMPLIFIER DESIGNED TO DRIVE A LOUDSPEAKER OR A HEATER?

by Dale Shirk, Senior Applications Engineer

This is a rather strange question to be asking. The audio business has no application needing an amplifier connected to a heater. Except that's exactly what we do when we test amplifiers, we connect them to resistors and heat air, water or oil. My goal today is to point out how our normal amplifier testing procedures can lead to inappropriate design choices.

Load Characteristics

What are the characteristics of the load? A heater is simple, it's a resistor which responds to the RMS value of the signal. Whether it's a continuous sine wave or a signal with lots of peaks makes no difference. It does not store reactive energy, it does not have back EMF that needs to be overcome. It simply converts the RMS value of the applied signal to heat.

A loudspeaker on the other hand is a complex dynamic load. Defining its maximum signal is not an easy task. Voice coils are burned by excessive continuous power. The time frame for voice coil heating is on the order of tenths of seconds to several seconds, depending on the size and mass of the coil. Long-term heating of the magnet and pole structure reduces the coil's ability to dissipate heat, further reducing its power handling. A burnt voice coil generally indicates an excess of continuous power for at least a few seconds.

A loudspeaker can also be destroyed by exceeding its excursion limits. This is highly dependent on the frequency content of the signal. For a given piston size and the same SPL, every octave lower in frequency requires four times the excursion. Thus, excursion limits are generally only a concern at the lowest frequency in a driver's passband. It's very important that the high-pass filter and/or crossover filters are applied correctly. However, when properly filtered, a loudspeaker can produce momentary peaks far in excess of its continuous level, up to +12 dB or greater. These peaks help give music its live dynamic feel.

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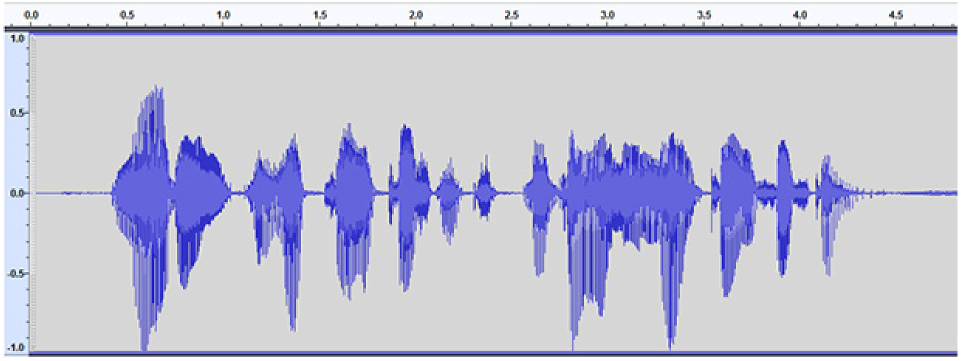
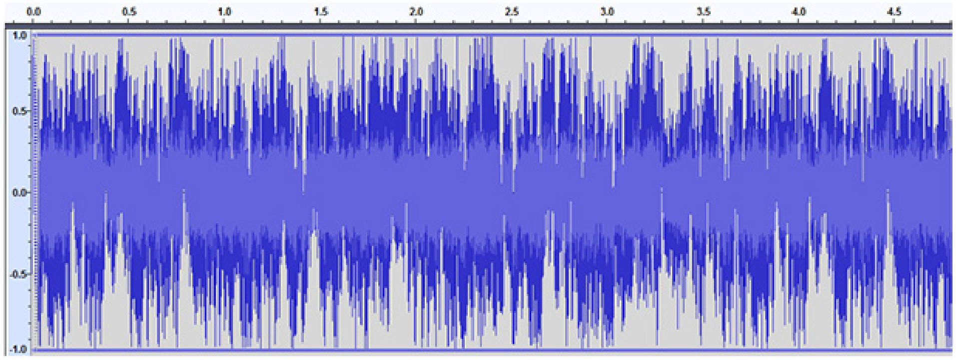
Signal Characteristics

Let's look a bit at signal characteristics. A continuous sine wave has a crest factor of 3 dB. That is, its peak value is only 3 dB greater than its RMS value. Real program material, music and speech, can have much higher crest factors, 16 - 20 dB. Even highly compressed program will have 6 - 10 dB crest factor. Shaped noise, as it has traditionally been used for loudspeaker testing, has 6 dB crest factor. Other test signals have been developed to more closely simulate program audio and can have crest factors of 12 -18 dB.



Speech has 12 to 16 dB Crest factor



Pink Noise has a 6 dB Crest factor

Amplifier Design

If one were to design an amplifier specifically to drive a heater, it would have a continuous power capability matched to the load. It would need to be able to hold that continuous power level indefinitely. (Be honest, how many of us have run an amplifier at its maximum output for an hour to see how it will do in a concert and how well it's cooling and thermal protection design works?) The heater amplifier does not need more than about 3dB peak capability above its continuous level. Examples of these are almost every amplifier over 20 years old.

The ideal loudspeaker amplifier needs continuous power capability near the capability of the load. However, it needs peak output capability far in excess of its continuous level, ten times greater, or more. Exactly how long it needs to be able to hold this peak level is open to debate, but 20 to 50 milliseconds

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is a good starting point. Peaks that are just a small amount above the continuous could be sustained longer. Also, it should not generate significant distortion products when either the peak or continuous levels are exceeded. It should simply dial back the gain as a compressor would, for the duration of the excess, then recover quickly. Examples of these are becoming quite common, if not quite so well understood. For instance, if you see an amplifier with 4-channels of 50 Watts each, and the whole thing is powered by 30 Watts of Power-Over-Ethernet, you know it's not making 200 Watts of power from a 30 Watt source. That's a burst rating. Similarly, an amplifier with over 6000 Watts combined output, while drawing less than 800 Watts from the AC power supply is also a burst rating.

Bear with me here, but I'll be referring to the former as heater amplifiers and the latter as loudspeaker amplifiers for the remainder of this article.

Deploying Heater Amplifiers to Loudspeakers

Since the heater amplifier is measured with 3 dB crest factor continuous sine waves, and has no additional burst capability, we need to oversize the amplifier. Let's say we want to at least cover the 6 dB crest factor used in the shaped noise with which the loudspeaker was tested. This means we need an amplifier with double the continuous power as the loudspeaker is rated for. If we want to cleanly pass a 12 dB crest factor signal level, we'll need 8 times the power. Now we have more than enough continuous power to totally toast the voice coils. Therefore, it needs to be protected. Having a sane, attentive operator who turns the level down at the first hint of distortion is one way. But a moment of inattention, a few seconds of feedback when the operator is distracted, is all it takes to destroy the speakers. A signal limiter can be set up to protect the speaker, and it must be calibrated to the voltage sent to the loudspeaker, therefore beyond any user adjustable gain controls in the signal chain, and it must be locked away from nefarious fingers. Ideally it should be triggered by the RMS signal level with slow enough attack to pass peaks and slow enough release that it does not serve to reduce the crest factor inherent in the program material.

Deploying loudspeaker amplifiers is much simpler. Just choose an amplifier with a continuous rating just short of the continuous rating of the loudspeaker. Enjoy the peak capability of the loudspeakers without the fear of thermal destruction. That's not to say that it's impossible to damage the loudspeaker, but it will require an unusual spectrum, such as pink or white noise putting too much energy into the HF or out of band frequencies.

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What about the Published Ratings?

Are those people lying about the big numbers? Not really. Product Managers and Marketing people are of course paid to publish the best defensible numbers for each product. The perceived "loudness" of an amplifier is determined by how high the continuous level is before the peaks begin to clip. Since we are interested in the loudness with actual program material, which has high crest factor, the heater amplifier's high continuous capability doesn't really help it any. Therefore, the 20 millisecond burst rating of each amplifier will actually be a reasonable comparison of their actual audio program performance, more so than the continuous rating. This leads the makers of loudspeaker amplifiers to publish burst ratings with little or no fine print qualification. Which, of course, leads to cries that these amplifiers are inadequate and their proponents, deceptive.

Of course, the alternate perspective is that when comparing amplifiers of the same continuous output, the heater amplifier falls way short in being able to pass signal peaks. Perhaps the best perspective is to look at cost comparisons. The heater amplifier spends a lot of money on the power supply and heat sinks to maintain the high continuous output, that isn't needed with program audio.

Manufacturers of all amplifiers should publish both the burst and continuous output powers of their amplifiers. They should publish the peak unclipped voltage and the peak current. These numbers are very informative about how an amplifier will handle high peaks, low impedances and reactive loads. Also, it's important to know how long an amplifier can hold a peak, and the gain profile as it reduces its output, does it ramp down gracefully or step-switch to a lower gain?

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Common Amplifier Format (CAF)

https://www.prosoundweb.com/apples-vs-apples-introducing-the-common-amplifier-format-caf/

CAF goes a long way towards quantifying how an amplifier behaves. CAF, as presently implemented, shows how the amplifier behaves under various load conditions, using 20 ms bursts, 200 ms bursts of low frequency and 15 second continuous sine waves, all measured with the THD held below 1%. While this still leaves some open questions about what happens between those discrete time points, it's very informative about the design philosophies behind an amplifier.

Selecting an Amplifier

Amplifiers should be selected based on the expected loads, type of program material and application. If the application is a siren, loudspeaker testing or some other continuous signal situation, then of course continuous power ratings are what's important. The typical loudspeaker's high peak capability is useless. Likewise, any additional burst power the amplifier may be capable of is pointless, only its continuous power is important. Heater amplifiers are appropriate. However, for a typical loudspeaker playing typical audio program material, the peaks become very important, the continuous power requirements are much lower. The loudspeaker's protection is still in the continuous realm.

What about Subwoofers

Subwoofer loudspeakers and programming aren't a lot different than full range loudspeakers, except that the larger voice coils have slightly longer thermal time constants. Therefore, the power bursts can be slightly longer before the total continuous power comes into play. If your definition of "music" includes 30 second continuous tones, then it all reverts to the siren and continuous signal picture outlined above, for both the loudspeaker and the amplifier.

Wrap up

Today's smart power amplifiers are capable of driving loudspeakers to greater output while protecting them from damage, better than ever before. We need to understand their unique capabilities and not be prejudiced against them by our biases from the old ways of doing things. Likewise, we need to understand when a special purpose application may be best served by an older design amplifier.

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