Making Sense of Amplifier Power Ratings

by John Meyer

More manufacturers are now producing self-powered loudspeakers, as Meyer Sound has done since 1995. But, with this trend, the subject of rating power amplifiers has begun to suffer from considerable confusion and misinformation. In order for users to have any idea of a self-powered loudspeaker's true capabilities, clarification must be brought to the topic. This paper will try to bring some clear and solid information into the discussion in the hopes that users may gain a better understanding of power amplifiers, making them better able to evaluate products. Perhaps the most common term in need of examination is "peak watts," a popular way of expressing amplifier power.

In the engineering community, the accepted method of generating a rating of the audio power produced by an amplifier is to connect it to a known load, apply a continuous sine wave signal to its inputs, and monitor its output behavior into the load. This is important to keep in mind as we examine the definition and measurement of "power."

The definition of instantaneous electrical power is quite simple: $P = EI$, where P = instantaneous power in watts, E = potential difference in volts, and I = current in amperes. However, this definition is minimally useful to us in an audio application because audio sources are not instantaneous pulses, nor are audio loads purely resistive.

A sine wave is the building block from which real-world audio signals are built, making it a more appropriate source signal for measurement of an audio system. For a sinusoidal voltage source, power, while still measured in watts, is defined as "average power." RMS (root mean square) is a method of calculating the voltage and current to obtain the average power. For example, if we look at the sine wave voltage at the output terminals of a power amplifier, we will find the RMS voltage to be the peak voltage (E_{peak}) divided by the square root of 2. If we measure the RMS sine wave current from the amplifier, we will see that, similarly, it is the peak current (I_{peak}) divided by the square root of 2.

Multiplying the two, we get:

$$(E_{peak}/(\text{sq root } 2)) * (I_{peak}/(\text{sq root } 2)) = (E_{peak} * I_{peak})/2$$

which is the average power for a sine wave.

When an amplifier is rated in RMS watts, this is a shorthand way of saying "average watts obtained by the RMS method." If you use a signal other than a sine wave, you must use a meter reading 'true' RMS voltage to obtain the correct average power.

So what about peak power? Peak power is a special case where $P_{peak} = E_{peak} * I_{peak}$. For a sine awave, this is always twice the average power. A major problem with using this rating, however, is that many power amplifiers cannot maintain peak power for more than a few milliseconds.

The standard method of testing a power amplifier to see if the power supply can maintain continuous peak power is to connect all channels of the amplifier into load resistors, drive the amplifier's input with a square wave and monitor the peak voltage at the outputs. Almost all power amplifiers will 'sag' in output power under this drive condition.

Now, having a power amplifier produce twice the continuous sine wave power is hardly necessary for music reproduction, but sometimes music signals produce short-term square wave or large sine wave-like waveforms. So how long should a power amplifier be able to maintain reproduction of a square wave or sine wave at full amplitude?

Recently Meyer Sound measured a well-known dual 18" subwoofer system that came with a power amplifier. The amplifier's power supply rail when it was not being driven sat at 160 volts. Using this rail voltage, we could calculate the instantaneous peak power for a 4 ohm (resistive) load to be:

$$E^2/R = 160^2/4 = 6{,}400 \text{ watts per channel}$$

Thus, we could claim this amplifier has well over 12,000 watts of peak power. This is a very impressive power rating to publish, but is it at all meaningful? Meyer Sound engineers drove the system with a single, drum note of 40 milliseconds in duration. The power amplifier rail voltage plummeted from 160 volts to 80 volts while playing the note. This 80-volt drop in output level acts as a compressor on the audio. The transducers used in this system were very non-linear, producing a large amount of second harmonic distortion.

This combination of sagging amplifier output and non-linear transducers imposes its distinctive sound character on signals it reproduces, preventing accurate reproduction of some signals. This presents a severe limitation to users, as the loudspeaker can only sound good on signals which are complemented by that sound character, such as the case of an over-damped, close-mic'ed drum.

With current technology, it is not necessary to limit the quality of a sound system's reproduction in order to obtain a subjectively desirable sound. The best solution to obtaining any such sound is not to use a loudspeaker as a creative processor, but to have a linear loudspeaker system capable of accurately reproducing any musical signal and then use digital processing to create compression, distortion, or other creative effects that are needed.

Driven by the same drum beat signal, Meyer Sound's 700-HP ultrahigh-power subwoofer produced more sound level, while the sound was a true reproduction of the dry sound of the recorded signal. The 700-HP, therefore, is capable of reproducing a drum beat processed with compression equally as well as one that is entirely dry and unprocessed.

Meyer Sound's research has found that, in order to reproduce music without compressing the signal, the power amplifier should be capable of maintaining reproduction of a sine wave at full amplitude (i.e. where the sine wave's peak amplitude reaches the maximum available voltage swing without clipping) into its intended load for at least 500 milliseconds. Meyer Sound refers to the average power during this 500 milliseconds as "true burst power." Peak power output should last at least 100 milliseconds in order to be useful for music reproduction. All Meyer Sound self-powered loudspeakers meet this criterion, and this rating will be included on data sheets for these products. Up until now, Meyer Sound has not published specifications relating to the peak power of this burst.

With all of this said, we are led to the question of how a self-powered loudspeaker should be measured in order to produce a useful and meaningful rating.

Meyer Sound plans to create a set of sound files in a standard format containing special burst signals that will allow users to test a self-powered loudspeaker using a standard sound level meter. These files will be posted for downloading from the Meyer Sound Web site. The proposed signals will be of sufficient duration for the 'fast' time weighting of the meter to correctly read the SPL output of the speaker.

It is hoped that this paper will serve to demystify the subject of power amplifier ratings and lead to a more uniform method of obtaining and stating ratings for amplifiers in self-powered loudspeaker systems. Good sound is the result of skilled application of high-quality audio devices, and the necessary skills can only be attained when straightforward factual information is available and understood.

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