Loudspeaker Power Ratings

It's a matter of efficiency

By Pat Brown

One of the most confusing subjects in audio? Loudspeaker power ratings. It's generally accepted that a large loudspeaker power rating is a sign of quality and something to be desired. And it's the performance metric that probably has the greatest influence on the consumer's buying decision.

But a closer look reveals that power rating is far less significant than other metrics regarding the performance of the loudspeaker.

The term "power rating" requires further explanation to avoid misunderstanding. It's tempting to associate it with the acoustic output of the transducer, or even the recommended amplifier size. But it has little to do with either.

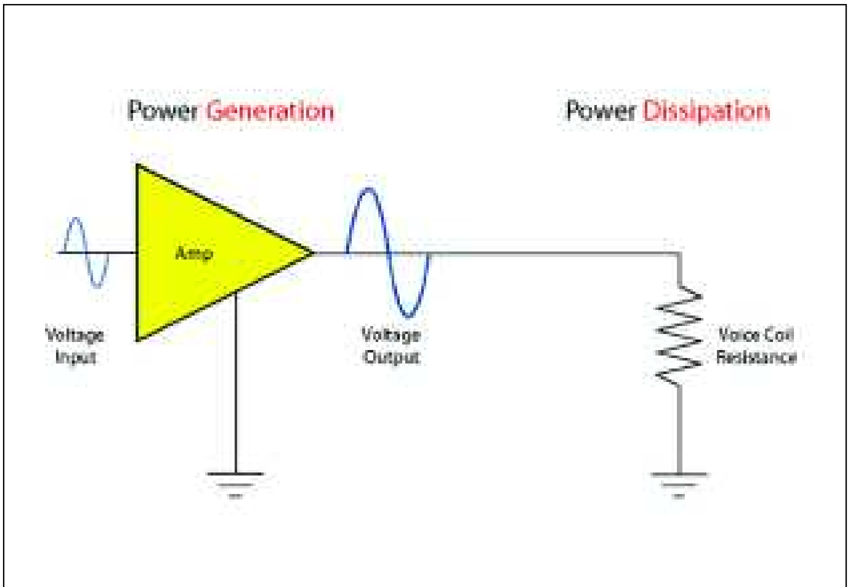

Figure 1: How the power "thing" (amplifier to loudspeaker) works.

First, let's expand the term to make it more meaningful. How about "maximum input power dissipation?" The term "input power" is appropriate because the loudspeaker presents a load to an amplifier.

Assuming negligible effects from the cable (a safe assumption if the correct wire selection criteria are used), the output power of the amplifier becomes the input power to the loudspeaker. And because bigger amplifier power ratings are accepted as better (i.e., a sport utility vehicle versus an economy car), it's assumed that larger loudspeaker power ratings indicate a better product.

Amplifiers that connect directly to loudspeakers are called power amplifiers, because their output is a higher voltage and current facsimile of the input voltage to the amplifier. (**Figure 1**) Power amplifiers are rated for power generation. A bigger number is generally better as it indicates the potential for the amplifier to do more work.

Loudspeakers are rated for power dissipation. Their power rating describes the amount of continuous power that can be dissipated in the form of heat without damage to the loudspeaker. While at first glance it may appear that more power dissipation is better, this is only true if the method used to achieve it does not compromise the efficiency of the loudspeaker.

Modern power amplifiers act as constant voltage sources to the loudspeaker. This means that the output voltage of the amplifier is essentially independent of the load placed on it by the loudspeaker. If you drive an amplifier with a signal and measure its output voltage with no load connected to the output terminals, and then connect a loudspeaker to the terminals, there is no significant change in the reading on the voltmeter.

The difference between the no-load and loaded case is that with the load present current will flow from the amplifier terminals through the loudspeaker. Lower load impedances (more loudspeakers in parallel) draw more current from the amplifier, increasing the total power transfer from source to load. (**Figure 2**)

This is why the total output power of the amplifier generally increases when driving more loudspeakers. Note that the output power of the amplifier increases, but the power is distributed among the connected loudspeakers.

So, if one loudspeaker is connected in parallel with another, the total power output of the amplifier increases but the power per loudspeaker does not. In fact, it probably drops a little. It is best to keep amplifier loads above 4 ohms to minimize cable effects and avoid excess current demands on the amplifier.

THE ARMS RACE

The power drawn by the loudspeaker from the amplifier is found by multiplying the voltage times the current. Conservation of energy says that all of the power from an amplifier must be accounted for. Part of the power produces the mechanical movement of the loudspeaker, and the rest of it becomes heat. The mechanical movement of the cone produces the sound from the loudspeaker.

The heat is a waste by-product, and like any waste quantity, it must be disposed of. Unfortunately the conversion of electrical power to acoustical power is an inefficient process (less than 10 percent is typical) so most of the amplifier power is wasted (heat) and must be dissipated.

The power rating of the loudspeaker describes the capacity of the loudspeaker to dispose of the heat produced by the inefficiencies of the conversion process – so back to our expanded definition of "maximum input power dissipation."

As such, it's a mistake to associate the power rating of the loudspeaker with its sonic performance. Higher power dissipation ratings simply mean that the loudspeaker is better at cooling itself. But power ratings by themselves give no indication of efficiency in producing acoustic power, which is the purpose of the loudspeaker.

It's possible to increase the power dissipation rating of the loudspeaker by reducing its efficiency. One could simply add some resistive elements internally. The result is a very large power rating but very little sound – not what we're after!

The sound pressure level (SPL) produced by a loudspeaker is more closely related to the applied voltage than the applied power. This can be seen by plotting the on-axis SPL against both. (**Figure 3**)

The power drawn by the transducer varies with frequency, and while the SPL is often referenced to the input power, it actually tracks the input voltage quite closely. It's desirable for the loudspeaker to have a flat voltage response, so that equal drive voltage per frequency produces a flat magnitude response on-axis.

The ideal loudspeaker could produce the desired sound pressure level

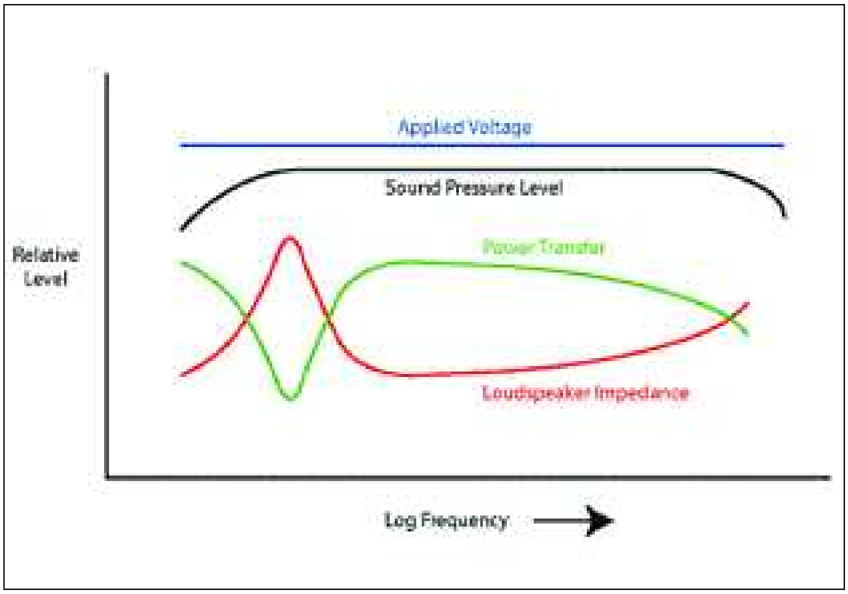

Figure 3: On-axis SPL against applied voltage and applied power.

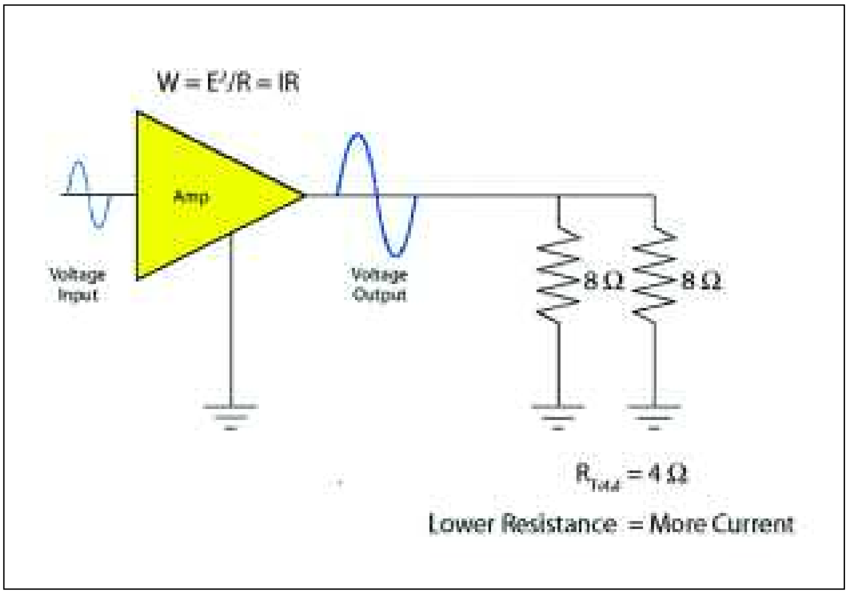

Figure 2: Lower impedances (loudspeakers in parallel) draw more current.

using as little power as possible. There would be less heating due to the higher efficiency. So there is nothing impressive or inherently beneficial to driving lots of power into a loudspeaker.

It's more impressive to get lots of sound with less applied power. Think of mileage ratings for automobiles, and you have the right idea. It's more about efficiency than consumption. Horn loading and boundary placements are methods of increasing loudspeaker efficiency, allowing more sound per applied electrical watt.

PROPER PERSPECTIVE

The same misconceptions about power ratings in loudspeakers occur when we choose a light bulb. The wattage rating is often associated with the light output – more watts, more light.

Bulbs have a luminosity rating that describes their light output, but few consumers ever consider it. So, if we need more light in a room we buy a "bigger" bulb (higher wattage rating). It's only natural to apply this assumption to loudspeakers. Next time, shop for the highest lumens output for a given power input and you'll get the best value.

A very high power rating on a loudspeaker doesn't mean that it will be very loud. Rather than saying "Wow, the Killsound 5K handles 5000 watts!" it would be better to ask "Why do I have to feed 5000 watts to the Killsound 5K to get 100 dB SPL in the audience? The Efficienator 1 can produce that level and only have to dissipate 100 watts!"

A more meaningful loudspeaker rating would be that of maximum SPL. This rating can be found by scaling the loudspeaker's sensitivity rating by the maximum input power rating. It allows a loudspeaker with a lower power rating – but higher sensitivity – to compare favorably with a loudspeaker with a higher power rating but lower sensitivity.

It's unfortunate that misunderstandings about power ratings have precipitated an arms race among manufacturers to provide large numbers. Big power ratings are an easy sell, but high efficiency is a better goal.

POWER TEST

Many methods exist for determining the maximum input power to a loudspeaker. All of them have their merits, and all have similar attributes. A meaningful power test must include:

- A broadband noise stimulus that is band-limited for the device-under-test.

- A method of determining the power transfer between the amplifier and the device-under-test.

- A time metric that describes how long the loudspeaker can dissipate the applied power.

- And (ideally) a measurement of SPL from the loudspeaker.

Figure 4 shows a useful way of plotting the results of the test.

The noise stimulus is often pink noise (equal energy per 1/n-octaves). Some methods use flat pink noise and others use a weighting scale to simulate the spectral content of music. The latter type can produce higher power ratings since more of the electrical energy is shifted toward the lower frequency bands where a transducer can usually dissipate more heat due to its heavier construction.

To determine power transfer both the voltage and the current applied to the device-under-test must be monitored. It's not sufficient to calculate the power transfer from the applied RMS voltage and the nominal impedance of the load. The load impedance will increase when the device-under-test heats up, reducing the power drawn by the load (power compression).

When a loudspeaker is operated near its power dissipation limits it is not unusual to increase the power applied to the load by turning up the amplifier, but with the result of no additional sound pressure level and even a reduction in power transfer.

It's best to consider power ratings on a decibel (proportional) rating scale. Wattage ratings can be extremely misleading with regard to the performance of a device.

Consider the fact that a loudspeaker with a 500 watt continuous power rating will only be slightly louder than one with a 250 watt rating (+3 dB), assuming that the efficiency of both are the same. This means that there is little practical difference between the two, even though there is an apparent large difference in their ratings.

Most power tests modify the pink noise stimulus to have a lower crest factor – the peaks in the program material are reduced by a clipping circuit. The practical reason for clipping the waveform is to allow the amplifier to deliver more power to the load.

The maximum output power for unclipped pink noise is about 1/10th of the amplifier's sine wave rated power. Clipped pink noise can produce about 1/2 of the amplifier's sine wave power rating, allowing power

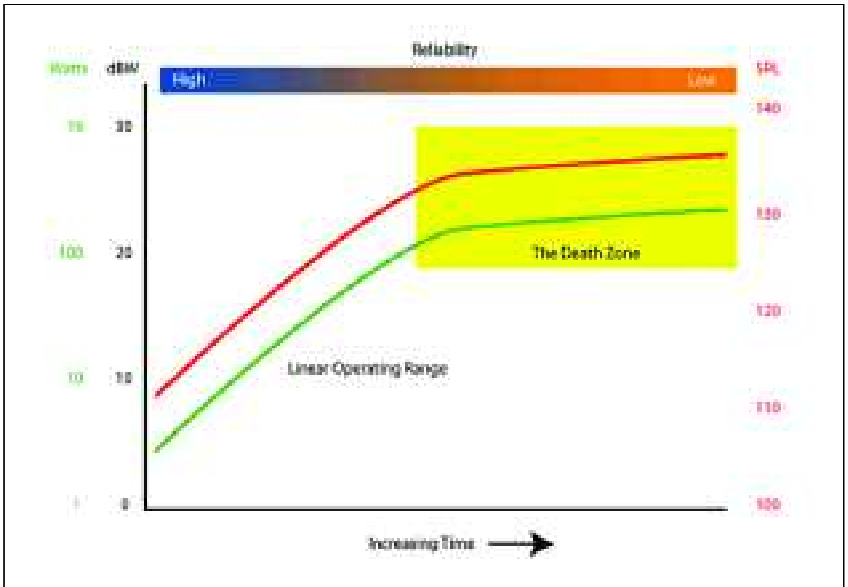

Figure 4: A good way to plot power test results.

testing with reasonable amplifier sizes. The clipping artifacts do not contribute significantly to the heating of the loudspeaker, but the lower crest factor produces more power (higher RMS voltage) into the load.

A continuous power test feeds 6 dB crest factor pink noise to the loudspeaker for a specified period of time (i.e. two hours). This is a demanding test for the loudspeaker, since there are no breaks in the program material to allow cooling.

Program power ratings attempt to simulate music or speech by reducing the duty cycle of the waveform. If the noise is pulsed, some cooling can occur between bursts and more short term power can be applied prior to failure. Many manufacturers estimate the program power rating by doubling the continuous power rating (+3 dB or 2x is a reasonable assumption). The actual recommended amplifier size will be larger than either of these ratings.

A reasonable estimate is the continuous power rating +6 dB (4x). Given these definitions, a complete and meaningful power rating for a loudspeaker might be:

Maximum Input Power – 200W/400W/800W (continuous, program, recommended amplifier size)

APPLES TO APPLES

Once can easily see the problem with comparing loudspeaker power ratings. It takes a lot of research to assure an "apples to apples" comparison, and many specs simply don't include enough background information to allow this.

Feeding a loudspeaker with less than its rated power presents no danger. In fact, it will have a longer, happier life with less power. I recommend limiting the input power to no more than one-half (-3 dB) of the continuous rating for reliable operation. In the preceding example, this would mean using an 800-watt amplifier, feeding it typical program material (10 dB to 14 dB crest factor) and driving it just to the brink of clipping as a maximum.

Under these conditions, the amplifier will be producing about 80 watts or less into the loudspeaker, which is safely below the continuous rating. Since the amplifier has a potentially large output, care must be taken to assure that low crest factor program material is not turned up too loud as it could damage the loudspeaker.

Finally, it's important to realize when the point of diminishing returns is being reached when turning up the volume on a sound system. Each 40 percent increase in applied voltage to the loudspeaker produces twice the input power, and a slight (+3 dB) increase in sound level.

Big power ratings are an easy sell, but high efficiency is a better goal

Remember that with audio it is the proportional chance that matters. As the volume of the system is increased in 3 dB steps, eventually the limits of heat dissipation are reached and the next 3 dB "breaks the camel's back." A loudspeaker is very near its maximum loudness at one-half of its rated power. There is nothing to be gained by going further and the loudspeaker will likely suffer permanent damage.

Advancements in automotive technology have produced vehicles with greater efficiency and lower operating cost due to reduced waste. The audio industry should have a similar goal – achieving the desired SPL using less amplifier power.

As efficiencies increase, the need to dissipate lots of power should diminish – as should our fascination with high power ratings. ■

Pat and Brenda Brown own and operate Syn-Aud-Con, conducting training seminars around the world. For more info go to www.synaudcon.com.