CINEMA AUDIO SOLUTIONS

Tech Note: Realistic Assessment of Amplifier and Loudspeaker Specifications

The audio industry has a long history of system design practices that lead to an overspecification of loudspeakers and power amplifiers. While it's common to design sound systems that provide significant headroom and performance capability, doing so without regard to the real-world of actual modern loudspeakers, power amplifiers, and venues in which they are to perform can also result in a customer paying for much more capability than they will ever need or use.

In the early days of audio technology, overspecification might have been justified; distortion levels in both transducers and power amplifiers were often quite high, and clipping was common even with higher quality components. Today, however, vast improvements in both loudspeaker design and power amplifier topologies enable solutions that can minimize the wasteful and expensive practice of overspecification.

Power Amplifier Performance and Specifications

Great care must be taken when attempting to interpret published specification numbers. Many amplifier manufacturers follow a standard procedure that uses a sine wave as a test signal into load resistors (simulating loudspeaker loads). While these specifications can be useful for comparison purposes, it must be recognized that specifications derived in this manner do <u>not</u> represent real-world program material into real loudspeakers.

There are many ways to cite power ratings. Some are measured, and some are calculations based on Ohm's Law. Headroom factors are often a matter of judgment based on real-world experience.

DC Rail Voltage – the positive (+) and negative (-) voltage that the amplifier's power supply provides to the amplifier output section, and the maximum voltage that can be applied to a loudspeaker.

8 ohm peak – the highest rail voltage squared, then divided by the impedance ($P=V^2/R$).

8 ohm burst rms – the rms (or "root mean squared") value is one-half the power, or -3 dB, from the peak power.

8 ohm "rated" – the specification sheet rating that the manufacturer chooses to publish.

8 ohm + 1.5 dB – a factor added to account for dynamic headroom, and is a good approximation for the DCA amplifiers.

Peak (Burst) Rating - the specification sheet peak (or burst) rating that the manufacturer chooses to publish.

QSC has recently introduced a new power amplifier platform that uses Class D power supplies and a new, proprietary power module. The platform is used in several new QSC amplifier series including PLD, CXD, CXD-Q, DPA, and DPA-Q.

The following table is a comparison of different specifications of QSC's DCA and DPA Series amplifiers.

Model	DC Rail Voltage	8 ohm peak	8 ohm burst rms	8 ohm "rated"	8 ohm + 1.5 dB	Peak (Burst) Rating
DCA 1222	67	561	280	200	283	275
DCA 1622	83	861	430	300	424	400
DPA 4.2 / 4.2Q	83	861	430	400	n/a	500
DCA 2422	99	1225	612	425	600	600
DCA 3022	115	1653	826	550	777	800
DCA 3422	132	2178	1089	700	989	1000
DPA 4.3 / 4.3 Q DPA 4.5 / 4.5Q	155	3003	1502	625 1150	n/a	900 1200

The new amplifier platform is radically different from any other amplifier platform that exists on the market today. While it has many distinguishing features, perhaps its most significant performance characteristic is that the power supply is capable of producing extremely high DC voltage rails – producing much higher peak amplifier output compared to normal linear amps. As a result, they can handle extremely large peaks on real-world program material–without clipping.

Because of this capability, we recommend using the published "burst" power (or "peak rating") specifications when calculating maximum power with our DPA and DPA-Q Series. This is in the best interest of our customers, since it means that smaller (and thus less costly) amplifiers can be used to achieve maximum output levels. For example, our DPA 4.3 amplifier is rated at 625 watts continuous power at 4 ohms. Its burst power capability, however, is 1400 watts at 4 ohms. This means it can deliver up to 1400 watts of peak power before clipping. If an application requires a loudspeaker rated at 400 watts continuous power handling, powered by an amplifier that can provide 3 dB of headroom (twice the continuous power, or 800 watts), then DPA 4.3 would be an over-specification by a significant margin. A much more realistic (and economical) choice would be QSC model DPA 4.2, which can provide burst power up to 700 watts per channel at 4 ohms, saving the customer nearly 25% on the cost of the amplifier.

Limiting Components in Multi-Way Loudspeaker Systems

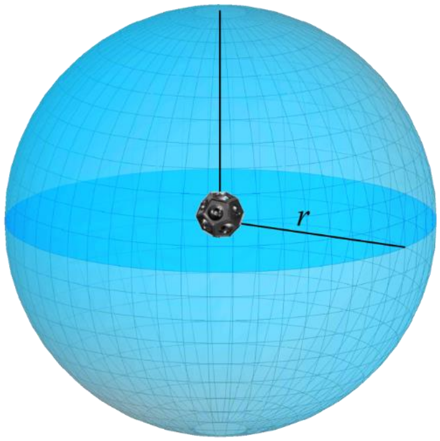
A standard method of selecting appropriately sized power amplifiers for loudspeakers is to determine the required sound pressure level at a certain point in the room. Using published loudspeaker sensitivity and power ratings, the loudspeaker's maximum SPL can be calculated at a given distance. For bi-, tri-, or quad-amplified systems, one component is likely to be a limiting factor, since the higher-output components will need to be attenuated to produce balanced, full-range sound. In most cases, the LF component is the limiting factor, since LF transducers are inherently less efficient (and hence, lower in sensitivity) than MF and HF transducers. When SPL calculations are based on the potential SPL of the limiting factor, there is potential for overspecifying both loudspeakers and power amplifiers. In actual use, the other loudspeaker components (e.g., MF and HF sections) will obviously add to the overall sound energy in the room. This is why it is important to consider performance as a complete system. By choosing a supplier with a comprehensive range of product offerings, you'll be more able to find a solution that exactly fits your performance and budgetary requirements.

Inverse Square Law Calculations

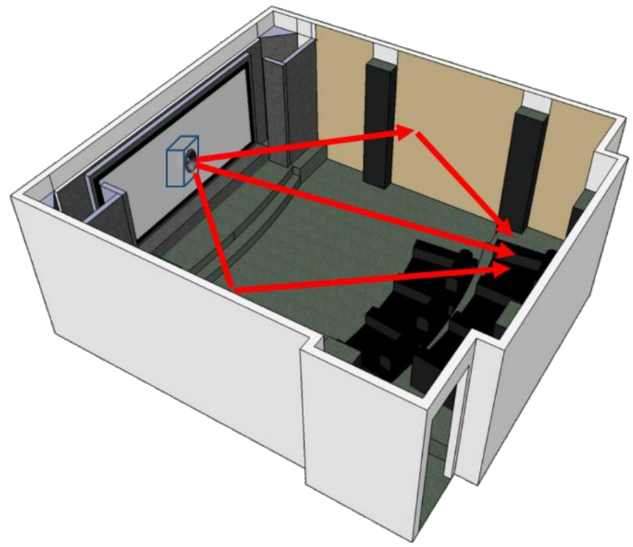
Another common practice that leads to overspecification is the application of the so-called inverse square law.

In the world of physics, it is widely accepted that sound intensity from a point source of sound will obey the inverse square law if there are no reflections or reverberation and no directivity in the source's radiation (which is inherent with a true point source). The key assumptions here are that 1) the source is a "point source" (which is a theoretical concept and not a practical loudspeaker design), and 2) the sound is produced in the free-field, with no reflections or reverberation. An outdoor environment with no buildings in the vicinity is a good approximation of a free-field environment.

The commonly used formula for calculating sound pressure level decrease due to distance from a source is 20 Log (D_1/D_2), where D_1 is the reference distance and D_2 is the distance at which you'd like to calculate the SPL loss. However, since the real-world environment of a cinema is not a free-field environment, and no cinema loudspeaker is anything like a point source, using the standard formula for loss due to distance from the source will yield results that are higher than is realistic for a conventional loudspeaker in a room. Since cinema measurements are traditionally made using a steady-state noise source (as opposed to an impulse response), there is time for a build-up of reflections from surfaces in the room, which add a measurable amount of energy to the total sound level produced in the room. Waveguides also "focus" the sound produced by a loudspeaker, so that more of the total radiated energy produced by the vibrating membrane is directed toward the listening area. None of these factors are accounted for in the standard inverse square law calculation. QSC has conducted extensive measurements and testing in both our own laboratory and in real-world venues, and our results indicate that a calculation based on 15 Log (D_1/D_2) yields an attenuation loss figure that is much more realistic.



Inverse square law assumes a point source in free-field.



Total radiated power from real loudspeakers in real rooms is greater, due to reverberation and the loudspeaker's enclosure and waveguide (if any).

In sound system design, more is not always better. In fact, the best designs are often those that use the minimum number of loudspeaker elements, with only enough power to provide necessary headroom for the anticipated real-world program material, whether that's a cinema soundtrack, a live musical performance, dance club music, or a single talker.

The use of continuous amplifier power ratings (instead of burst or peak ratings), calculations based on only the limiting section of a multi-way loudspeaker, and using the "worst case" idealized inverse square law calculation are three ways that can lead to overspecification of a sound system. Our experience has shown that these practices can easily result in a system specification with as much as 2 to 4 times the amplifier power actually needed, producing 3 to 6 dB more output than is required—and an inflated equipment budget.