



designers of electronic media

Speaker and Amp Workshop

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Objectives:

To explain how amplifier power and speaker efficiency equates to loudness, quality and reliability.

To explain how 2-way, 3-way, and bi-amplified systems are designed and when to use which when.

Topics addressed below include common errors such as:

- Wrong speaker coverage pattern, where dome geometry, (size, tilt, audience seating), is not taken into account.
- Spec based on watts, which actually means nothing in regards to loudness or quality.
- Too many speakers being included in the design.
- Speakers too high or too low on the dome.
- Specified amps are too small.
- Use of plastic speaker enclosures.



Speaker Types:

Passive Speaker – Or “Non-Active”. Not internally amplified. A loudspeaker that requires an external amplifier for power. Most large loudspeakers used in live touring rigs and auditorium systems are passive.

Active Speaker – Internally amplified. A loudspeaker with a built-in amplifier, also called a “powered” speaker. Many smaller speakers, including many portable PA speakers and production studio reference monitors, are active. Small active subwoofers are also common in production studios.



Crossover – A circuit that divides the audio frequencies into groups. A two-way crossover divides high and low frequencies. A three-way crossover divides high, mid, and low frequencies.

Two-Way – A loudspeaker with two separate drivers, one for low frequencies and one for high frequencies. Two-way loudspeakers commonly have a single input and an internal crossover that splits the incoming audio into low and high/mid-frequency bands and sends those bands to the appropriate drivers. A two-way loudspeaker is usually powered by a single amplifier channel and requires one cable between the amp and the speaker. This is the most common type of loudspeaker.



What this means to you: You will only need one cable per speaker in your system, and will not need a crossover unless you are pairing the speaker with a subwoofer.

Three-Way – A loudspeaker with three separate drivers for low, mid, and high frequencies. In BT systems we typically bi-amplify (see below) three way systems.

What this means to you: In large systems the third driver allows smoother, more accurate transition from low, to mid, to high frequencies.



Bi-amplified – A bi-amplified (bi-amped) speaker cabinet is similar to a two-way speaker in that it has a low and a high-frequency driver (or a set of high-mid drivers). However, unlike a standard two-way loudspeaker, a biamped speaker cabinet has two separate inputs—one for low frequencies and one for high-frequencies (or high/mid frequencies). Bi-amping uses an external crossover to separate the audio into low and high-frequency bands before the audio arrives at the amplifier. A biamped speaker cabinet requires two amp channels, (one for the low-frequency driver and one for the high-frequency driver), and two cables between the amp and the speaker cabinet.

What this means to you: The primary advantage of a three-way speaker over a standard two-way speaker is that our engineers have much greater control over the sound produced. We do this by setting the crossover to any desired frequency and EQ for each frequency band independently. This type of system actually operates somewhat more efficiently and makes better use of amp power, as well.



Matching Amps and Speakers:

Watts – Simply put, the amount of amp power a speaker can handle, and how much power an amp can deliver.

Watts have very little to do with how loud a system is or the quality of the system.

Speaker Efficiency (below) explains how a system with fewer watts can actually be louder.

Speaker Efficiency – Describes how well the speaker uses power, with less power from the amp turned into heat waste. Speaker efficiency is improved by better magnet materials, larger voice coils, more cone excursion (front to back movement of air), better crossover, etc. A more efficient speaker can generate more sound with the same or even less “watts” than a less efficient speaker.

Example:

Speaker A... This 300 watt speaker has an efficiency (input sensitivity not output SPL!!!) of **90 dB**
Its maximum output, running full with no headroom is **115dB** at 1m distance.
Its maximum output, running full with no headroom is **103dB** at 4m distance.

Speaker B... This 300 watt speaker has an efficiency (input sensitivity not output SPL!!!) of **105 dB**
Its maximum output, running full with no headroom is **130dB** at 1m distance.
Its maximum output, running full with no headroom is **118dB** at 4m distance.

To gain 3dB of output you have to double the power 5X. So, to get speaker A as loud as Speaker B you would need 9600 (yes, 9 t-h-o-u-s-a-n-d, 6 h-u-n-d-r-e-d) watts. Speaker A would actually burst into flames, (really), with this much power since it is only designed to handle 300 watts for two hours.

What this means to you: More efficient speakers mean smaller amp sizes, fewer watts of energy, and lower electric usage.

Headroom – Sometimes known as “Crest Factor”. A speaker can handle large peaks in the audio with little problem, amplifiers cannot, and just go into delivering distortion. Headroom gives the amplifier the ability to handle these peaks without speaker damaging distortion. The recommended amount of headroom acceptable is *at least* 3dB, which means clean power with minimal distortion and stress on the system. Our systems typically provide at least 6-12 Db headroom. That is one reason why they don't break and sound so great.

Impedance – The resistance of a circuit or device—such as a speaker driver or loudspeaker cabinet—to the flow of current, such as audio signals. The lower a loudspeaker's impedance, the less it resists the flow of AC from the amplifier's output, allowing more power to flow to the speaker from the amp. Manufacturers of passive loudspeakers will always provide the loudspeaker's impedance as one of the standard specs to assist in proper amplifier selection.

What this means to you: It is important to choose the appropriate combination of speakers and amplifiers for a given application. If the loudspeaker's impedance is too high, the amplifier may not provide enough power. If the speaker's impedance is too low, the amplifier will strain to produce enough power and could overheat and sustain damage.



Proper Speaker Selection:

Coverage Pattern – The angle of effective coverage for sound radiating from a driver. This usually refers to mid and high-frequency drivers, as low frequencies are not particularly directional. The coverage pattern, (also called Dispersion Pattern), of a loudspeaker is determined by the shape of the horn, or waveguide, which resides in front of the high-frequency driver and is usually vaguely conical or horn-shaped. The coverage pattern is listed as a horizontal angle and a vertical angle (i.e. 90° x 45°) which describes how wide or focused the “cone” of sound radiating from the driver will be.

What this means to you: Choosing the proper coverage angle for a given application will ensure that all listeners in the space will hear the system's full range and will improve system efficiency and intelligibility. Poorly chosen coverage patterns will result in acoustic weaknesses and “blind spots”, (which usually cause volume levels to be increased in an effort to properly cover the space with sound), and can result in phase coherence problems that will degrade the overall sound quality.

Amp Power Calculations-Most audio professionals agree that amplifier power should be 1.5 to 2 times the rated power of the speaker requirement. This prevents amp clipping distortion that is destructive to speakers by producing excess heat the speaker cannot dissipate. More speaker failures are caused by too little amplifier power than by too much.

RMS Power Handling – Unlike peak power handling, RMS (also called Average, Program, or Continuous) power handling is based on the average power output of an amplifier over a period of time. This is more accurately representative of the energy in most audio, as high-level transients are only a small percentage of the overall program material.

What this means to you: The RMS power handling of a speaker cabinet is the number that should be considered when choosing an amplifier.

Peak Power Handling – The maximum power handling capacity of a speaker cabinet, often given in watts. This spec is sometimes combined with the speaker cabinet’s impedance (i.e. 1000W @ 8 Ohms), and represents the maximum power that the speaker can handle during brief, high-amplitude transients without sustaining damage.

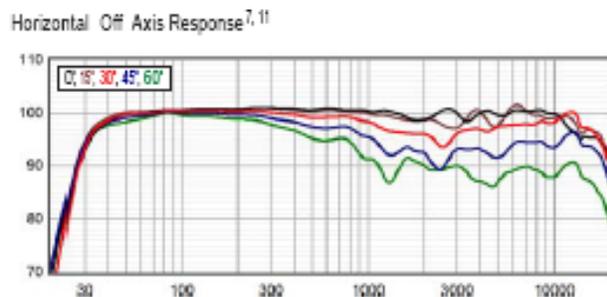
What this means to you: The peak power handling of a speaker is not generally useful in system design.

Frequency Range – The range of audio frequencies that a speaker or speaker cabinet is capable of reproducing. This is generally given as the range of frequencies that a speaker can reproduce within a certain range of amplitude levels (i.e. 20Hz – 20kHz \pm 3dB). Frequencies that are more than 3dB below the given range are not considered to have enough power and are therefore not included. There has been a recent trend among speaker manufacturers to extend this range to 10dB, which allows them to list a wider frequency range for the speaker cabinet (even though many of those frequencies have relatively low amplitudes compared to the rest of the signal).

What this means to you: A speaker’s frequency range spec will give you an idea of its overall sonic capabilities, but does not give any information about what is actually going on within that range.

Frequency Response – The frequency range of a speaker or cabinet versus the amplitude of its output (usually shown as a graph with frequency across the x-axis and amplitude across the y-axis). This gives additional detail about how the frequencies across the speaker’s frequency range are reproduced relative to one another.

What this means to you: A speaker’s frequency response graph gives you detailed information about the speaker’s frequency characteristics and can be useful in room tuning, EQ, and identifying phase problems. Speaker manufacturers generally try to get a very “flat” frequency response so that the speaker cabinet does not introduce too much “color” to the sound. This has led some manufacturers to scale the amplitude axis of their frequency response graphs in such a way that the speaker’s response appears very flat when it actually is not.



Summary: Most Common Errors

The most common errors we see in system specs:

Dome geometry (size, tilt, audience seating) is not taken into account. Coverage patterns on vertical and horizontal axis should cover the seating pattern, not the floorspace under the entire dome. That determines the type of speaker pattern selected.

A spec based on watts, which actually means nothing in terms of loudness or quality.

Too many speakers being included in the design. Less is more. The proper coverage with one speaker per channel/location (if coverage is assured) is always the best design since phase coherency is preserved.

Speakers too high or too low on the dome. Too high and the stereo imaging suffers. Too low and proper audience coverage is not maintained.

Specified amps are too small. Example: 350 watt speakers with 300 watt amps. No headroom. A 300 watt amp should probably be sized with a 150-200 watt speaker. If a speaker that size doesn't get it done, you need a higher power speaker and a larger amp.

Use of plastic speaker enclosures. These should only be used on very, very low power systems. Every knowledgeable designer knows that plastic enclosures simply resonate, i.e. they "honk". No way around it. Just avoid this by specifying wood constructed enclosures.