SUCCESSFUL SOUND FOR SMALL SPACES

Joseph D. Cornwall | CTS-D/I
AV Technology Evangelist, Legrand

Designing an audio solution can be more challenging than selecting a video solution for anyone who hasn't spent a significant amount of time diving into the realm of "hi-fi." The reason is quite easy to see. A big, colorful display possesses the magic to take you out of the installed environment, whereas ceiling speakers and their attendant amplifiers are an intimate part of that very environment. The best installations make the sound system invisible, intuitive, and of neutral personality. Most importantly, the best systems work!

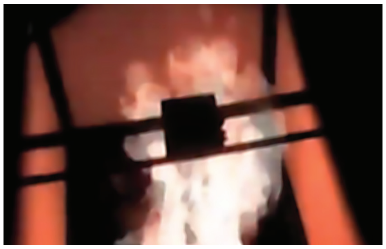
Studying how sound propagates and interacts within an enclosed space is a technical endeavor not everyone will enjoy. This article will help build a solid foundation to assist in selecting, deploying, and getting the best performance from the speakers, amplifiers and other audio gear in any small space.

Laying out the space and deciding where the gear should go

Audio equipment is often housed in an equipment rack where it's protected from damage and connected to the rest of the system. In small spaces like a conference room or classroom, it's entirely probable that an equipment rack isn't part of the build. There probably isn't room—we are examining small spaces after all. More so, why do we need a rack if the only gear in the room is the video display, the supporting audio system, and a mobile source device?

The first step in laying out any audio solution is to analyze the space. An important part of that is deciding where to place the gear. Equipment location can be influenced by the orientation of the audience, the presenter's or teacher's space, available closet space or furniture real estate. Another consideration is the direction and length of cabling and wire runs. An important thing to consider is the potential interaction of equipment and cabling with plenum air-handling spaces.

Plenum spaces are the parts of a building that facilitate air circulation for heating and air conditioning systems (HVAC). Typically, the spaces between the structural floor or a dropped ceiling are considered plenum. The National Electric Code (NEC) Section 300-21 sets the tone for installation in such spaces. It requires that installations in spaces, shafts and ducts do not increase the potential spread of fire or smoke. Further, "plenum" is used by the NEC to describe both an air space and the types of wiring methods that are specifically designed and tested for installation within such an air space.



C2G plenum-rated audio amplifier being tested for UL rating for smoke release in air-handling spaces

Wires, cables or devices that are installed in a plenum space must possess a plenum rating. Plenum-rated cable has a special insulation that's flame resistant and exhibits low-smoke characteristics. Plenum-rated cable goes through extensive burn tests to adhere to Underwriters Laboratories (UL) and National Fire Protection Association standards.

Making sense of amplifier specifications

The best way to figure out what amplifier specifications really mean in the context of a working system is to jump right in and take them apart piece-by-piece. To do this, we'll dissect the spec sheet of a C2G amplifier. Most manufacturers will publish similar specifications on their products. Let's go through this line-by-line, leaving out the more obvious bits:

Electrical Characteristics

- Impedance : >18 KΩ unbalanced
- Frequency Response: 20Hz to 20 KHz (+1 dB/-3 dB)
- THD + Noise: < ±0.05% @ 1 KHz at nominal level (1 watt)
- Signal Noise: >80 dB
- Input Sensitivity: -10 dBV (316mV)

Physical Characteristics

- Amplifier Type: Class D
- Output Power: mono—50 watt ± 3 watt at 1 KHz, 4-ohm load, stereo—25 watt + 25 watt ± 3 watt at 1 KHz, 15+15 W, 8-ohm load
- External Power Supply: 100 VAC to 240 VAC
- Enclosure: metal
- Operating Temperature: 0° TO +50° C / 10% TO 90% RH, non-condensing
- Storage Temperature: -25° TO +70° C / 10% TO 90% RH, non-condensing
- Dimensions: 1.49 x 4.31 x 4.54"
- Approvals: RoHS2, FCC, UL, plenum

This C2G plenum rated amplifier (40880) delivers tight frequency response and enough muscle to drive multiple pairs of loudspeakers.

Amplifier Type: Class D

The operational class of an electronic amplifier can tell us a lot about its function. There are several classes of operation including A, A/B, B, C, D, E, F, G, & H. Of this list, Class D is the most used in presentation audio today.

A Class D amplifier is often referred to as a "digital switching amplifier." In this topology, a field-effect transistor (FET) is driven to produce an output square-wave that switches between a high and low level at a frequency outside the range of human hearing. This allows for an extremely efficient use of power, and the amplifier will rarely get hot and can convert as much as 90% of its energy into output, losing less than 10% to heat. Today most amplifiers used in classrooms or conference rooms will be Class D, regardless of manufacturer.

Input Impedance: >18 KΩ unbalanced

This specification tells us about the electrical interface on the amplifiers input side. Ideally a single-ended input will offer twenty times higher input impedance than the output impedance of the device feeding it in order to optimize the signal path for maximum voltage transfer. This helps ensure a clean signal with a high signal-to-noise (S/N) ratio.

There are two general topologies used in audio component design: single-ended (unbalanced) and balanced. This amplifier doesn't offer a balanced input, usually signified by an XLR or ¼ inch tip-ring-sleeve (TRS) phone connector. Without such a connector we can assume this is a single-ended device.

Frequency Response: 20 Hz to 20 KHz (+1 dB/-3 dB)

This tells us a little bit about the way the amplifier will "sound" or the sonic character it might imprint on the source material. Human hearing is generally thought of as covering the ten octaves from 20 Hz to 20,000 Hz. This amplifier will play back all those frequencies, but not necessarily at a relatively identical level.

The bracketed +1/-3 dB indicates this amplifier will deviate from a perfectly "flat" response by as much as a +1 dB boost or a -3 dB attenuation in playback volume. While this number might pale in comparison to the specifications of a home theater receiver, the actual impact is quite benign in small space applications. We will have more to say about decibel relationships later in this paper.

THD + Noise: < ±0.05% @ 1 KHz at nominal level (1 watt)

Here we are learning about any distortion the signal will suffer as it makes its way through the circuitry of the amplifier. AVIXA best practices suggest an electrical signal-to-noise ratio greater than 60 dB, and a total harmonic distortion (THD) less than 1%. In the earliest days of solid-state amplifier design, the pursuit of ever-lower THD figures was something of a manufacturer's arms race. Today any good amplifier should be well within AVIXA recommendations, just like this one.

Signal Noise: >80 dB

As with the above, we are learning that this amplifier is very quiet. There shouldn't be any residual hiss on the speakers when content isn't playing with an S/N in excess of 80 dB as this means the noise is 10 thousand times softer than the signal!

Input Sensitivity: -10 dBV (316 mV)

Input sensitivity tells us what input voltage level is necessary to drive the amplifier to full output. The fact this specification starts with -10 dB is an immediate give away that this is designed to work with consumer-level devices, which is exactly what we want in a multi-use scenario. Pro sound devices operate at 0 dB and 1.23 V input sensitivity. Regardless, this specification really doesn't impact performance and is pretty typical.

Output Power: mono—50 watt ± 3 watt at 1 KHz, 4-ohm load, stereo—25 watts + 25 watts, ± 3 watts @ 1 KHz, 15+15 W, 8-ohm load

Now we're getting to the gist of the device—power. Let's dig into this.

The maximum amount of power this amplifier can develop is 50 watts at 1 KHz frequency into a single channel. Why the specific frequency? Because an amplifier can deliver maximum power on a simple, single tone. It's an easier payload for the amplifier to reproduce than the complex waveforms of speech or music.

The 25-watt specification is also referencing a maximum output, but the difference is that we are driving two channels (stereo) instead of one (mono).

Specifications like this suggest what the peak power of the amplifier might be. It's similar to gross horsepower versus "real world" horsepower in the automotive world. One number tells us what the theoretical maximum is without the engine installed in an car, and the other lets us know what the performance is when the engine is pushing the weight of the chassis, transmission and wheels. In the case of an audio amplifier, what comes next is the more important number to use.

This is a 15 watt-per-channel amplifier into an 8-ohm speaker load. That's the specification we should work with as its more representative of the "real world" performance of this device. Always look for the most specific guidelines for power when creating an audio system in order to accurately predict performance.

Output Power (THD 1%) – 13 W per channel THD+N (at 10 W power output) - 0.3% per channel

These specifications confirm what we've learned above. All amplifiers can put out a large surge of power for a short time. Think of it this way; you might be able to lift a heavy weight one time, but to do repetitions you'll surely want a lighter weight!

Operating Temperature: 0° TO +50° C / 10% TO 90% RH, non-condensing

This is the final specification that we will dissect and it's important for determining amplifier placement. At temperatures up to 122° F and humidity to 90% (so long as water doesn't condense), this little box is going to work just fine. No need to worry about air circulation, fans, etc. This really is designed to be a set-and-forget appliance.

What's a 70-Volt Amplifier?

What we typically call a 70-volt audio system in North America is correctly known as a constant-voltage audio system. A constant-voltage system allows a veritable network of speakers to be connected to one audio amplifier by using step-up and step-down transformers. Also known as a high-voltage audio distribution system, other names for this configuration include 25-, 70.7-, or 100-volt system (many amplifiers can support multiple voltages).

25- and 70-volt connections on a C2G constant-voltage audio amplifier (40881)

Think of a constant-voltage speaker distribution system as the audio equivalent of the power company delivering electricity to an office. The voltage generated by the power plant is stepped up to as much as 200,000 volts because voltage (electrical potential) can travel long distances over wire, but current (in amperes) will generate heat and thus a power loss in that same scenario.

After travelling to the office via the high-voltage lines, the juice is stepped down at an electrical substation and at a transformer outside the building until it's at the proper level to power the devices inside.

This entire process is governed by Ohm's Law. We'll have more to say about constant voltage amplification later in this paper.

How much amplifier power do we need?

It's not uncommon to find a project where past installations included a 100-, 200-, or even 300-watt audio power amplifier. Is it possible to use a modestly powered, compact, Class D amplifier in place of those big, heavy, rack-mounted motors of yesteryear? If we understand how decibels work the answer is clear.

The way we hear can be described in relative terms using a logarithmic unit known as a decibel (dB).The decibel is based on a measurement of power in the telegraph systems during early 20th Century. One decibel is one-tenth of one bel, named in honor of Alexander Graham Bell. Today the decibel is used for a wide variety of measurements in science and engineering, most prominently in acoustics, electronics, and control theory. In electronics the gain of an amplifier, the attenuation or gain of signals, and various signal-to-noise ratios are all expressed in decibels.

Imagine we're listening to music on a 50-watt sound system. The music sounds so good that we want to play it louder. If we double the power and install a 100-watt amplifier then the system should play twice as loud, right?

Nope.

Doubling power in an audio amplifier results in a perceived +3 dB change in volume. 3 dB is considered by industry experts as the smallest perceivable change in volume that would be noticed by an untrained listener in an uncontrolled environment. This is because our senses work logarithmically, not linearly.

Making something sound twice as loud requires a +10 dB change in volume and this equates to a tenfold increase in power. In other words, to sound twice as loud as a 50-watt amplifier (playing the same program material through the same speakers) we need a 500-watt amplifier!

An easy way to envision decibels is to remember that every 10 dB change equates to another 0 after a 1. So, a 10 dB change equals 10 times the power, a 20 dB change equals 100 times the power, and a 30 dB change means 1000 times the power. Decibels describe an order-of-magnitude change.

Doubling (or halving) amplifier power provides a barely noticeable 3 dB increase (or decrease) in volume. While there are applications where a lot of power is necessary (think very dynamic live music in a large space played at high volumes), most classrooms, huddle spaces and conference rooms have more modest requirements.
To fully understand this, we must explore a couple more concepts: speaker efficiency and the target volume necessary for clear, understandable recognition of speech.

Making sense of speaker specifications

Let's carve into some speaker specifications and see how they can be used to ensure our audio design is fully optimized. Here are some typical specifications we might encounter:

Average Sensitivity: 92 dB SPL, 1 W/1 m

This may be the most important specification to consider for small, low-power systems as this is a measure of the speaker's efficiency. With this number we'll calculate our power needs and the ability of the system to hit its volume target.

C2G offers a wide selection of low-impedance and 70-volt speakers that are ideally suited for the applications considered here.

Speaker sensitivity tells us this speaker can deliver sound at a 92-decibel sound pressure level (92dB SPL) when driven by 1 watt from an amplifier. The resulting output is measured with a calibrated meter positioned 1 meter away. The greater the efficiency of the speaker the louder it will play with any amplifier.

Consider that if a speaker measured 82 dB SPL @ 1 W/1 m instead of the 92 dB specified, it would require 10 times the amount of power to achieve the same volume. A 3dB difference, as discussed, would call for double or half the power, depending on the direction of change.

Loudspeaker Power Rating: 12W RMS EIA 426A Standard

This pair of speakers can't really use more than 12 watts of power.

Is that a problem?

Not really when we consider the application. We aren't playing loud movies or music with wide dynamic range and frequency response. Successful sound for small spaces focuses on intelligibility and proper sound distribution, not brute force.

The term RMS in this specification stands for "root mean square" and is an industry accepted method for comparing amplifier power. A root mean square is defined as the square root of the mean square (the arithmetic mean of the squares of a set of numbers). In the case of speakers, the set of numbers includes power handling at various frequencies. That makes this the best "real world" specification to use in designing our audio solution.

Calculated Output: 102 dB SPL, 12 W/1 m

These final numbers tell us essentially the same thing as the previous specifications—these speakers can deliver a very loud 102 dB SPL output when measured at 1 meter and fed 12 watts of power.

Frequency Response: 65 Hz - 17 kHz EIA 426A standard

This speaker can reproduce tones in a wide range from 65 cycles per second (Hz) up to 17,000 cycles per second.

Nominal Coverage Angle: 100° included angle -6 dB/2 kHz, half space

This important spec tells us about this speaker's directivity. All speakers project more sound directly to the front of the drivers than they do to the sides and back of the speaker. This speaker will roll off the volume by 6 dB as one approaches 50 degrees off axis from the speaker being directly overhead.

What is Speaker Efficiency?

Loudspeaker sensitivity specifications are critical. As we learned with amplifier power, a 3 dB change translates into twice as much (or half as much) power necessary to project audio at a certain volume. All other things being equal, the better choice is generally the more efficient design.

Speaker sensitivity is measured using an industry standard test. The result is delivered as a ratio.

A test tone is fed into the speaker at 2.83 volts across an 8-ohm speaker (Ohm's Law tells us this is one watt of power) and the output is measured using an SPL meter on-axis one meter away. Typical values are 85-89 dB for bookshelf speakers and 87 to 92 dB for large, floor standing models. Some high efficiency speakers are in the 93 to 100+ dB range.

Imagine a small pair of bookshelf speakers that are rated 84 dB SPL @ 1 W/1 m. Playing music with the loud peaks hitting 100 dB SPL will require 40 watts of amplifier power. However, playing music at the exact same level on a very efficient speaker with 99 dB @ 1 W/1 m sensitivity would require just 1.25 watts of power! Efficiency tells us what amplifier power we need in very succinct terms.

How loud do the speakers in a small space, like a classroom, really need to play?

For a sound to be intelligible to an audience its average sound pressure level should be about 25dB greater than the ambient noise of the space. This is called a 25 dB acoustic S/N ratio and it is very easy to measure.

There are many free apps for smartphones and laptops that measure sound pressure level using the device's built-in microphone. Some apps even offer real-time analyzers for determining a sound's frequency composition.

Simply measure the ambient sounds of a candidate space during its normal use hours. Most such spaces will exhibit an ambient noise floor from 40 to 60dB SPL. Simply adding 25dB to this measured noise floor will provide the target volume necessary for intelligible system volume in that space.

For example, if we measure an ambient noise field of 46 dB then the target system volume will be 71 dB SPL. This is the sound pressure level that should be delivered to the listener's ears. To narrow this number down our next step is to consider the listener's distance from the speaker

How do we determine the playback level at the listener's ears?

The inverse-square law tells us the volume of sound delivered by a loudspeaker in a room drops by a factor of four for every doubling of distance from the speaker. If we start with a 91dB SPL measured one meter from a speaker, then that sound will only have 25% of its energy if measured at two meters distance. This equates to a 6 dB drop, using the formula 20Log(D1/D2) and results in an 85dB SPL at the new measurement distance.

If we moved from 2 to 4 meters, we'd lose another 6 dB (resulting in a 79 dB SPL).

And if we went from 4 to 8 meters, the reduction would be another 6 dB (further reducing playback volume to 73 dB SPL).

As we can see, every doubling of distance from the speakers costs the system 6 dB in sound pressure level.

Let's not forget that, as previously discussed, a 3dB change in volume will affect amplifier power by a factor of 2. For instance, increasing the volume of a system by 3dB will double the power needed by the speakers. Decrease the volume by 3dB, and the required power is halved. Thus a -6 dB change due to proximity (distance) is the equivalent of asking for 4 times more power from the amplifier to compensate for the change.

Let's put this information to use in a hypothetical classroom and calculate the effect on ceiling speakers.

Here we use the formula $H – h = D$, where H is the ceiling height, h is the height of the listener's ears, and D is the resulting listener distance from the speaker driver. 12 feet minus 4 feet (human ergonomic studies tell us that a good model for an average seated listener's ears is to assume 4 feet above the floor) gives us a total distance from the speaker to the listener's ears of 8 feet.

8 feet is 2.44 meters, so 20Log(1m/2.44m) equals a change in measured sound pressure level of -7.75dB. A speaker with a sensitivity of 91dB SPL @1 W/1 m will play back at (91-7.75) 83.25dB SPL at this distance.

With a target for the listener of 71dB SPL we see that even with just 1 watt of amplifier power we can meet our objective. Indeed, a high-quality 15 watt-per-channel amplifier is all that's needed for most classroom and conference room spaces.

How many speakers do we need and where do they go?

Now that we know we can deliver intelligible, high-quality sound using efficient in-ceiling speakers and low power amplifiers, we need to examine the number of speakers necessary for a space.

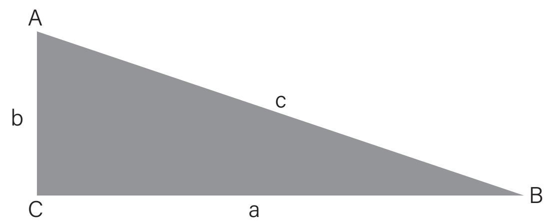
Most installations are two-channel, generally delivering stereo sound. A small huddle space probably only needs one speaker per channel for a total of two speakers. Distance is the problem in a larger classroom. If we keep turning the volume up to reach an intelligible 71 dB SPL for listeners in the back of the room, the volume may be uncomfortably loud for listeners closer to the front, where the speakers are. To mitigate this, we should place speakers throughout the room. This way any individual listener is always within the proper distance of an optimal listening experience.

There are three major speaker layouts used by AV system designers: edge-to-edge, partial overlap and 50% overlap. Most classroom and conference room installations are adequately served by the edge-to-edge layout, especially if ceiling heights are below 12-feet or lower. In spaces where sound quality is of greater importance, partial or 50% overlap patterns may be used.

We'll focus on partial overlap as this pattern provides the best price-performance ratio.

Edge-to-edge coverage is when ceiling loudspeakers are positioned such that their individual areas of coverage, which are described by the nominal coverage angle in the speaker specifications, abut each other. Partial overlap suggests closer spacing than edge-to-edge, but wider spacing than a 50% overlap. A good compromise is to calculate for 30% overlap.

The C2G speakers used in this example are rated 100° Included Angle -6 dB/2 kHz. This means we can plot the effective region of the speaker's "directivity cone" as 50° off the center axis (half the total of the cone).



In the illustration above, the distance between speakers that we want to calculate is leg a. We know that leg b equals H-h, or 8 feet (from the example above).

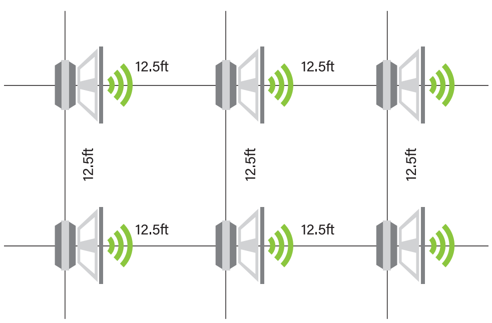
We also know that angle A is 50° (one half of the total 100° Included Angle from the specifications) and that the sum of all the angles in a triangle is always 180°.

Angle C is a right angle (90°), so angle B must be 40°.

Using the Pythagorean Theorem, we determine that leg a has a ratio of 1.2:1 compared to leg b.

To find the ideal speaker spacing, we can take our H-h measurement and, in this example, multiply it by 1.2. This gives us spacing of (8 * 1.2) approximately 9.6 feet center-to-edge.

With a 30% overlap (partial overlap), we'd place speakers approximately 12.5 feet apart, center-to-center and symmetrically in the ceiling over the audience.



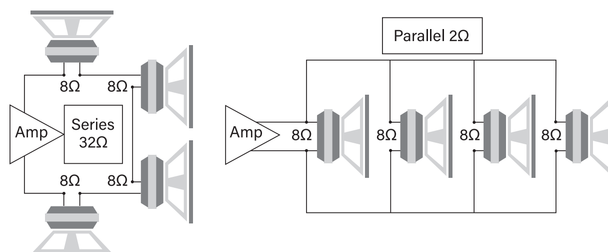
What is speaker impedance? How does it affect our design?

There are two ways to connect speakers to an audio amplifier. The most common method, particularly in small spaces or residential installations, is the low-impedance connection. Deploying this technology does requires a decision on how to wire the speakers in parallel or series (if there is more than one speaker per channel) in order to present a safe load to the amplifier. If a lot of speakers are necessary, this can make the system more complex than is desirable.

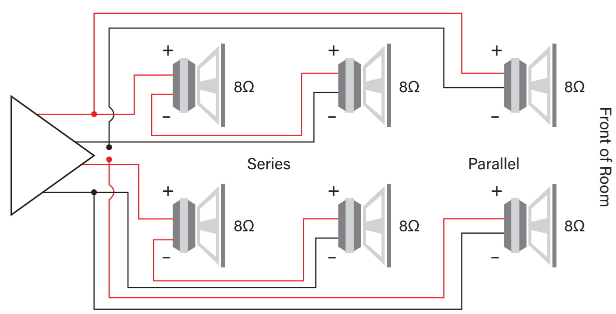
What do we mean by a "safe load"? Too many pairs of speakers connected to a low-impedance amplifier can damage the equipment. Most commercial audio amplifiers specify 4-ohms as the lower limit for speaker impedance. As impedance drops, the amplifier needs to increase current to deliver the same amount of power (described in Ohm's Law).

C2G amplifiers have protection against overcurrent conditions, but for the best performance, the speaker load should always be matched to the capability of the amplifier.

If the speakers are rated at 8-ohms impedance, then two pair may be connected in parallel. This will result in a 4-ohm total impedance for the amplifier, which is within product specifications. For installations that require more than two pair, a constant voltage (70-volt) connection is recommended.



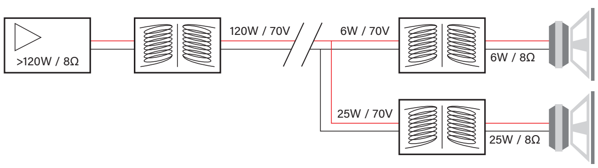
The example below illustrates the proper connection for three pairs of speakers in a series/parallel configuration.



Total impedance at amplifier = 5.33Ω

What About the Transformers and that Constant Voltage Version?

In systems that require more speakers, we can either use multiple amplifiers with each amp connected to one or two pairs of speakers, or we can use a constant voltage amplifier that is better suited to driving strings of multiple speakers. What is constant voltage? Well, it's just a smaller version of the transformers that we use to send electricity across the national electric grid! By using a transformer to increase voltage while decreasing current, we can send electricity (the signal) over a thinner conductor for longer distances.



If our system required six to eight speakers (or more) to comfortably cover the audience space, we could use the C2G 25/70V 50W Audio Amplifier (40881) and matching 2x2 Drop in Ceiling Speakers - 70V (41509). To use this configuration, we need to think about how to "tap" the speakers. Selecting the correct tap means deciding which winding of the speaker's matching transformer—which is marked in watts of power to be delivered to the speaker—is best suited to the project. The choices on this speaker are .31 W, .63 W, 1.25 W, 2.5 W and 5 W. We know from our previous calculations that we need substantially less than one watt of amplifier power to deliver an intelligible signal to the audience, and because these C2G speakers are so efficient, we need only .5 watt for typical program material. If we select the 1.25 W tap, we can safely run as many as 10 pairs of speakers (1.25 W x 10 = 12.5 W) across as much as 300 feet of 18 AWG copper plenum speaker wire using a single amplifier.

In a constant voltage system, all speakers are connected in a parallel configuration. We will learn more about constant voltage systems, including 70-volt and 25-volt configurations, in a future article.

Is there a length limit for speaker wire?

Short answer: yes.

In most circumstances, the more important design element is to use roughly the same length of speaker wire for each speaker. If, for example, there is three feet of 18 AWG wire to the left speaker and 18 feet to the right speaker, there may be a noticeable disparity in the volume between the left and right channels. This is because of the equivalent series resistance introduced into the design by the wire itself.

A good recommendation to follow is to ensure the resistance of the speaker wire doesn't exceed 5% of the rated impedance of the speaker-amplifier link. The chart below is a useful in helping us decide which wire gauge is best suited to a specific run length.

Wire Size	2 Ω Load	4 Ω Load	6 Ω Load	8 Ω Load
22AWG ($0.326\ mm^2$)	3ft (0.9m)	6ft (1.8m)	9ft (2.7m)	12ft (3.6m)
20AWG ($0.518\ mm^2$)	5ft (1.5m)	10ft (3m)	15ft (4.5m)	20ft (6m)
18AWG ($0.823\ mm^2$)	8ft (2.4m)	16ft (4.9m)	24ft (7.3m)	32ft (9.7m)
16AWG ($1.31\ mm^2$)	12ft (3.6m)	24ft (7.3m)	36ft (11m)	48ft (15m)
14AWG ($2.08\ mm^2$)	20ft (6.1m)	40ft (12m)	60ft (18m)*	80ft (24m)*
12AWG ($3.31\ mm^2$)	30ft (9.1m)	60ft (18m)*	90ft (27m)*	120ft (36m)*
10AWG ($5.26\ mm^2$)	50ft (15m)	100ft (30m)*	150ft (46m)*	200ft (61m)*

The resistance of the speaker wire should not exceed 5% of the rated impedance of the system.

It's not the first thing that comes to mind when laying out an AV system, but speaker wire follows some very basic rules.

Because speakers require power, we need to have enough electrically conductive material to deliver the power from the amplifier to the speaker. On a small pair of bookshelf speakers connected to a low-power amplifier just a few feet away, a piece of 18 AWG wire is fine.

For a larger, more powerful system operating with hundreds of watts of power, there's a real need for heavier 12 AWG cable. C2G has a selection of the right speaker wire for most conference and classroom installations readily available and in stock.

For low-impedance installations where wider dynamic range or wider frequency range is designed into the parameters, or in situations using high-power amplifiers over 100 watts rating, a 12 AWG speaker wire is a good choice.

Many commercial installations use 14 AWG as a workhorse gauge.

A plenum-rated 18 AWG is ideal for constant-voltage (70-volt) systems as the very nature of a constant-voltage design decreases the need to carry high current signals.

And that's all there is to it!

Creating a useful audio playback system for a small space like classrooms, conference rooms or huddle spaces demands critical consideration. It's a process filled with subtleties and, while the system may be small, its importance to the audience is not. Consider this quote from noted film producer Michael Moore: "I tell students that sound is more important than pictures. The audience will forgive you if an image is a little blurry but not if they can't hear or understand what's going on. Sound carries the story."

With a little understanding and some creative analysis, we find that small amplifiers and efficient speakers are the perfect solution for many projects.

- An amplifier doesn't have to be an ungainly, heavy, hot component. Amplifiers designed for huddle space, conference room, and classroom applications are small form factor, efficient and may even be plenum-rated. Placing amplifiers in plenum ceiling equipment boxes is easy and can even make the installation more efficient.
- Audio component specifications are vital to the design process. We need to fully understand the actual power delivery capability, frequency response range and environmental needs of audio devices.
- For best results, optimize intelligibility for the audience. This is achieved through distortion-free playback at a 25 dB Acoustic S/N ratio with less than 6 dB variation in playback level at any location within the audience position.
- Mapping the room is central to a good audio design. In addition to dimensions, we should also measure ambient noise.
- There are three common speaker layout patterns for distributed audio systems: edge-to-edge, partial overlap, and 50% overlap. An edge-to-edge layout will provide an acceptable +/-6 dB variation in SPL throughout the listening area while keeping costs under control.
- There are best practices regarding speaker wire. Specifically, the total DC resistance of the speaker wires

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