Easy Acoustic Control

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In the consumer audio world, we try to replicate what the artist created. We want to get as close to the artist as possible. Many will invest significant money in their equipment in order to get good sound quality. Most will hardly consider acoustics. In this article, you will learn how backwards that approach is, how important it is to address acoustics, and how easy it is to address many of the acoustic issues that plague most cinema users.

I'm sure you've heard it before, but it bears emphasizing; mid-fi equipment in an acoustically great environment will out-perform state-of-the-art equipment in an acoustically poor environment every time. Understand that most of the sound waves bombarding your eardrums are not coming from the loudspeakers, but from the room.

As I have covered in previous articles, the acoustics of the room has to be controlled in order for the playback fidelity to be reproduced faithfully. We have to create an acoustic environment similar to that, which the original music was created. By that, I don't mean recorded, rather mixed/mastered for reproduction. We have to follow the same rules as the original art in order to experience what was intended—this means a room set-up that is acoustically neutral. For reference, the rules or standards in audio have been established by human audio perception, which is dictated by human biology. It continues to evolve as we learn and as we discover and apply new technologies. The point is, there is a lot of science behind it.

Acoustic control is a lofty goal. The difference between chaotic and organized sound is extremely rewarding. Every room has unique acoustic characteristics, and they may or may not be easily addressable. There may be physical space limitations, budget restrictions, décor, time, etc. that may affect the capabilities and performance results. In my many years in the industry, **the number one reason that the experience falls short of the equipment's potential is uncontrolled acoustics.** Much of today's mid-fi electronics are capable of realism enough to cause goosebumps, startle you, increase your heart rate, and stir your emotions when set up right. But when the environment does not allow sound to be delivered properly, the experience suffers big time. **Acoustics will govern the quality of your experience and does not care how much you invested in your equipment.** Controlling the acoustics in the home theatre means optimizing the interaction between the room and the electronics. They work together as a single system.

Acoustic Issues to Control

1. Noise floor. Noise is any sound other than that contained in the soundtrack. It masks and distorts signals. It can distract and annoy. In order to obtain quality sound, you must first have a low noise floor. Sound quality attributes would include low-level resolution and dynamic range, both of which are lost when the noise floor is higher than the audio signal. The ambient noise floor is dictated by noise generated both inside and outside of the listening space. Here is a list of common distracting noises:

a. Mechanical noises in the room generated by electronic equipment. For example; projector fan noise.

b. Flanking noises generated by noise sources outside of the space. For example: a gap at the door threshold allowing sound entry, or in-line HVAC ductwork creating an acoustic intercom between rooms.

c. Electrical noises. For example; a 60 Hz. ground hum, or appliance causing interference on the AC.

d.. Buzz, rattles and resonances. Structural vibrations caused by sound energy, inside or outside of the room.

e. Plumbing. For example; water splashing, flowing and pipe hammering.

f. HVAC air turbulence, fan noise, compressor noise, plenum noise, etc.

2. Loudspeaker/Listener locations. This is how you obtain good bass response, and soundstaging.

3. Calibration. This involves both electronic calibration of the equipment, such as adjusting levels and delays, and physical calibration of the loudspeakers, such as adjusting angles for proper imaging and timbre.

4. First order reflections. Each loudspeaker reflects off of each surface, which interferes with the direct signal from loudspeaker to ear. This causes timbre and spatial errors.

5. Reverberation times. Excessive reverberation masks low-level resolution, limits dynamic range, and causes poor speech intelligibility and musical articulation.

6. Room Modes. These boundary resonances cause some low frequencies to be louder or softer than others.

Not-So-Easy Acoustic Control

Let's start off by quickly identifying acoustic issues that may not be easy to control, especially in an existing space.

1. Room modes. These are low-frequency resonances controlled by the room dimensions and construction materials and methods. The boundaries of the room cause sound waves to reflect back into the oncoming waves, which cause audible pressure peaks and valleys at related (sound wave length) frequencies. These can easily vary 30 dB SPL. All enclosed spaces have room modes—some will be better than others.

Room mode remedies:

- Good room dimensions (for example; not evenly divisible by each other). Ideal dimensions are such that their distribution allows for even spacing, offering a more linear bass response. Though I've had existing walls moved for clients, this is easiest to address before the build.
- Construction materials and methods. Resilient construc-

tion methods can be designed to include low-frequency absorption, which otherwise is next to impossible to implement with any effectiveness because the low-frequency wave lengths are so large and so strong. Mass and constrained-layer damping can help improve room modes, cavity resonances, as well as noise control *(See Photo 1)*.

We will look at other means to combat room modes later on.

2. Noise Control. In order to hear low-level information or be held in suspense by silence, the ambient noise floor in the room must be very low. It is very distracting to hear a car drive by while watching a submarine movie, or a thunder storm while deep in outer space. It is just as distracting to hear the HVAC suddenly turn off or on. The projector fan noise can mask audio information important to the storytelling. On the other side of the coin, the home theatre may be distracting to others residing elsewhere at the time. Home theatres are built all the time adjacent to a bedroom, only to discover that it cannot be used in the evening hours! Structural vibrations and flanking noise (sound finding non-direct path ways to adjoining rooms) is a two-way street and can be very difficult to control.

Noise control remedies:

- Let's just say that noise control is a huge topic, too large to even skim through here. Most all noise control should be addressed in the design phase of the project, and if not, will be expensive to deal with afterward. Noise control is about blocking, absorbing, isolating the noise source, and/or breaking its sound path. There are too many possible scenarios to try to cover here. Below is a graph *(See Graph 1)* depicting possibilities for post-build noise control. The key to noise control is resilient, airtight construction, which sounds easy, but is not

Photo 1. Applying RoomDamp2 constrained-layer damping compound to the back of sheathing to be sandwiched between sheathing layers.

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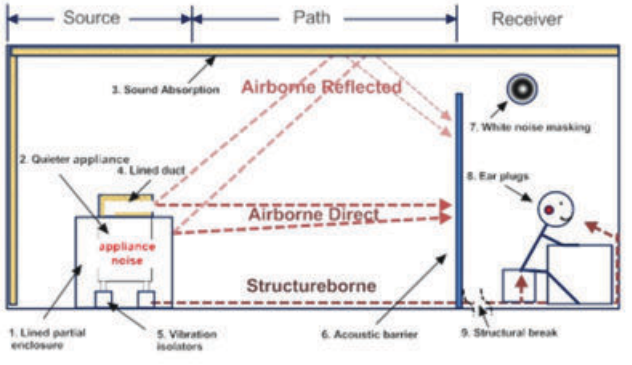
Well, depending—at least easier to control. I feel that if it does not involve room reconstruction, it is easy to control. You may disagree with me, depending on your particular scenario, but that's how I'm differentiating easy versus not so easy.

1. Loudspeaker/Listener locations. This will call out your bass response, soundstage, image and tonality. At minimum, keep yourself and your loudspeakers well away from the room boundaries and aim for an equidistant triangle between you and the front main left and right loudspeakers *(See Graph 2)*. This is the point you build the rest of the soundstage (loudspeaker locations) from. At maximum, listen for the best bass response in the room for the primary listening seat, then do the same for the loudspeaker bass response. From there optimize for soundstage and timbre by aiming the loudspeakers toward the primary seat. Follow surround recommendations for angles of degree to the primary listening position. Because of the way our two ears are positioned on each side of our head, we do not perceive sound the same from the rear, or above, as we do from the front horizontal plane. Remember that there is only one point in space where all the loudspeakers can converge at the same time and the same energy. Ideally, all loudspeakers are physically the same distance to the primary seat. Get this right and the primary seat will experience magic, and those surrounding will be that much closer to the target.v



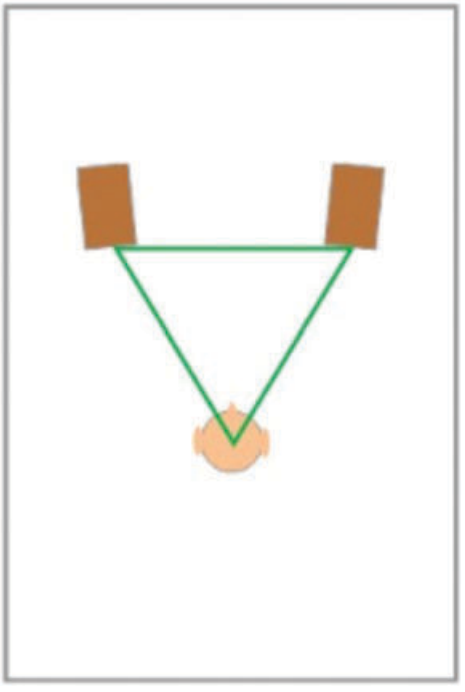
Graph 1. Possible noise path control solutions.

2. Calibration goes hand-in-hand with the above.

a. From the electronic equipment point of view, calibration means to first make sure that the equipment is operating and configured correctly—that is, verifying output channels, levels, delays, polarity, bass management, etc. Undoubtedly, you will have to make electronic compensations in the processor for channel levels and delays due to physical compensations of loudspeaker locations.

b. From a physical point of view, it has to do with fine-tuning the aiming of the loudspeakers. The loudspeakers were designed to be heard with the individual drivers in each loudspeaker cabinet performing in-concert, as one voice. For example, if the tweeter is different in distance to the listener than the woofer, it will not sound as intended. The high fre-

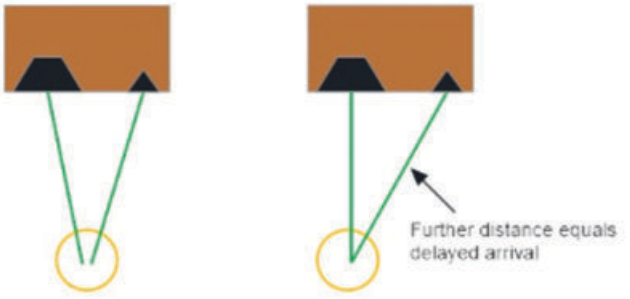
quencies and the low frequencies will not arrive at the same time, and signal distortion will occur *(See Graph 3)*. In addition, high frequencies are very directional. If the loudspeaker is mounted above the head and not aimed down towards the listener, much of the tweeter information will be lost. Sound wave propagation, both time, level and angle will effect spatial and timbre information. The devil is in the details!



Graph 2. Stereo foundation showing equidistant triangle. This is a good way to start setting up the best soundstage. Loudspeaker toe-in angle will also affect soundstage and timbre.

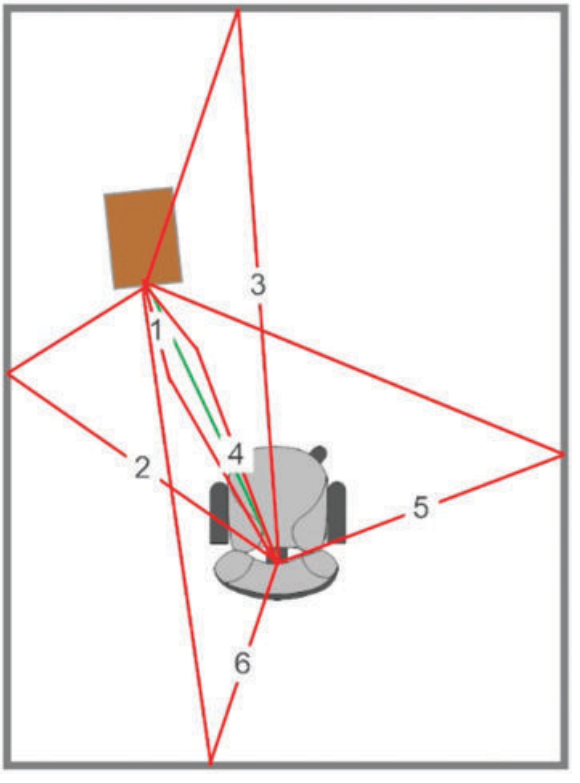
3. First order reflections can be controlled with absorption or diffusion. They are controlled best by specifically designed acoustic panels, as small as 2'x2', with wide, efficient and linear absorption. However, curtains, even large leafed plants, books, etc. can help reduce hard specular reflections that would otherwise interfere with the direct sound waves of the loudspeaker. Each loudspeaker will have a geometric reflection on each room boundary (likely six) with each listening position(s) *(See Graph 4)*. These reflections affect spatial and tonal information if left untreated.

4. Reverberation times are the easiest to control, at least in the upper frequencies, say above middle C on a piano. Not the case for lower frequencies. Reverberation, next to bass response, is the acoustic characteristic people notice and judge room sound quality by. Reverberation is the slow decay of thousands of sound reflections. Every room has a unique reverberation curve of time over frequency *(See Graph 5)*. Carpet and padding will help a great deal. Cloth-covered furniture, throw rugs with padding, large throw pillows, etc. will increase the absorption of sound energy and lower its influence from bouncing around the room. Adding absorption at the first order reflection points provides double-duty



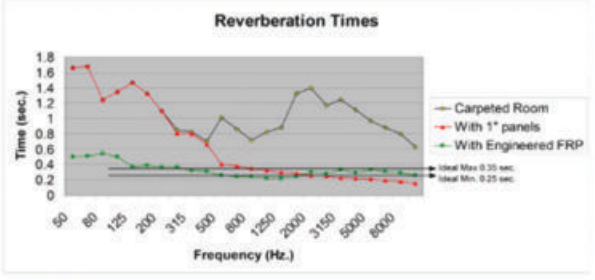
Graph 3. Indicating how if the loudspeaker is not oriented (tilted/angled) properly to the listener, time arrivals are distorted, causing frequency response anomalies.

to help decrease reverberation times. Uncontrolled reverberation changes the tonality of the sound but is most problematic with its destruction of articulation, masking of low-level resolution, and dynamic range.



Graph 4. First order reflections. The green line indicates the direct sound from the loudspeaker and is the first to arrive. Line 1 represents sound reflected off of the floor and arrives a little later in time. Line 2 is a bounce from the side wall later still. Then the front wall reflection arrives, then the ceiling, later the other side wall, and finally the rear wall reflection. If these first reflections are not controlled, they will continue on to reflect off of more surfaces, adding to the confusion.

5. Room modes, or bass response, is typically the first acoustic characteristic people notice about the room. They will notice that the room sounds muddy and slow and/or that some frequencies are loud and others soft compared to most. There are many ways to address the bass response of the room. We covered the difficult ones; room dimensions and construction materials and methods. We have also covered some of the easy ones; listener and loudspeaker locations within the room. Note that placing yourself and/or your bass drivers close to the wall will amplify your room's unique modes. Avoid this practice for better sound.



Actual RT60 of a Home Cinema

The Yellow line represents the room typically furnished. Note the unique sonic "signature."

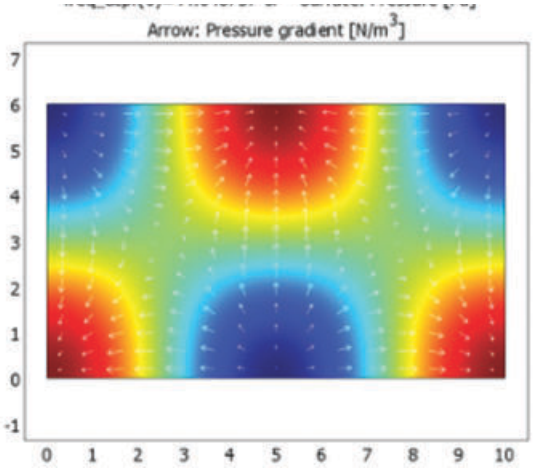
The Red line represents optimum 1" fiberglass panels. Usually we would see more area treated, resulting in an even steeper dive than shown here. Consequently, this treatment over-damps above 500Hz. and does not address frequencies below 500Hz. (middle C).

The Green line represents application of FRP engineered, broadband acoustic treatment system.

Graph 5. Actual reverberation times of a home cinema with different acoustic treatments.

Now let's discuss a couple of other easy ones. First would be acoustic treatments. Note they need to be large to be effective. They also need to be in the right location to be effective. The best spot is, as mentioned, the tri-corners. Next best are the midway points. Remember that modes are primary in all three axis; length, width and height *(See Graph 6).* Caution: most interior acoustic treatments have no effect on low frequencies. They exist but are specially engineered panels incorporating different passive techniques. Personally, I avoid incorporating DSP whenever possible for bass problems. They are very limited in what they can address, and I just don't care for what they do to the sound. I'll use a passive analog parametric EQ if I have to.

Here's the easiest acoustic treatment there is. It may also be the cheapest. Loudspeaker vibration isolation (not to be confused with coupling spikes, cones or blocks, etc.). By eliminating vibrations from being transferred into the structure, you address both sound quality and sound privacy. The room no longer resonates, buzzes, rattles, or transfers sound to adjoining spaces. It does not treat room modes but does greatly improve articulation and reduce sound transfer to adjacent spaces. Equipment Vibration Protectors (EVP) are simply placed under the loudspeakers and the mechanical vibration energy is transferred into heat energy.



Graph 6. Measurement snapshot of a room mode. This can represent a floor or elevation plan view. Shown are strong fundamental modes in the corners and middle of the room.

I hope that this article conveyed to you the importance of the audio foundation and how many of the common issues can be easily addressed. Without proper acoustics in place, audio nirvana is pretty much unobtainable. The foundation is about acoustics and set-up, not gear. I also hope that it instilled a desire for you to try to optimize your existing system before replacing any gear in effort to enhance your enjoyment. It is impossible to improve the sound quality when the room is overpowering it. **WSR**