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Issue 203, January 2016
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Volume 25, Number 1, Issue 203, January 2016

Top 15 Home Theatre Design Mistakes

(In no particular order)

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I know, 15 sounds like a lot, but in my experience, 80 percent of the home theatres out there incorporate most of the mistakes on this list. This is just the short list and is only addressing the aural aspect of the home theatre. These mistakes have a huge impact on the final experience by the observers. Note also that these mistakes care not whether the associated equipment is mid-fi or hi-fi. Electronic equipment cannot fix these problems. These mistakes occur at the design stage. This is the common, basic stuff that destroys the magic artists created.

1. Center-Channel Loudspeaker Does Not Timbre Match The Main Loudspeakers

About 90 percent of the audio information comes from the center channel, so you can imagine that it is a very important component in your playback system yet is often sacrificed with a cheaper, smaller, even different brand loudspeaker than the front left and right. This causes tonal discontinuity between the front loudspeakers. Additional compromise is frequently implemented by locating the loudspeaker much higher or lower than the mains. Lack of correlation between the loudspeakers and even the picture creates confusion.

2. Electrical Neglected

Not paying attention to the electrical layout can cause grief in the form of noise and interference, digital errors, harsh sound, flat soundstage, narrow dynamic range, loss of resolution, and numerous forms of electrical distortions. Proper grounding, power isolation, and wire dressing go a long way and usually cost little. Maintaining clean, tight contacts should be a routine.

3. EQ Averaged For All Seats

This is one of two on the list that might be considered controversial. There are two camps: one that says that you want to average the frequency response for all seats, and the other that says that you want one optimized seat. That's my camp. I can tell you that the other camp is not as cool as mine! They are missing out on all the fun. I see them over there watching an action movie or concert video—no smiles, no goose bumps, looking confused, bored, and lethargic. My camp is focused, involved, and has elevated biological activity, which is fun and what we're all trying to achieve in our home theatre. This is what the artists intended (see Figure. 1).

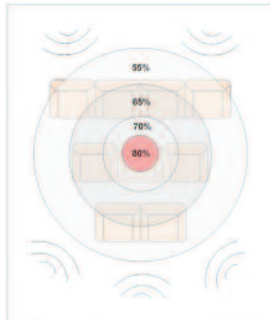

Fig. 2 Approximation of performance percentage of a 5.1 system which has been frequency "averaged" or "diluted" for all seats.

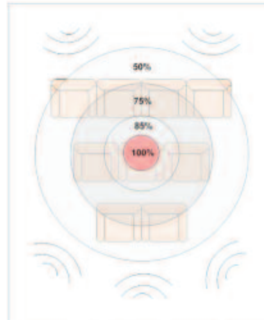

Fig. 1 Approximation of performance percentage of a properly set up and calibrated 5.1 system at different seats.

Don't go messing up the mix. Trying to average the frequency response of all the seats means that all of the seats will be compromised, no more sweet spot, no more magic chair (see Figure 2). There are many reasons why frequency averaging is a bad idea:

a. All seats become skewed, none are correct. On the other hand, when one seat hits the target, the others are closer to the target. Equalizing frequency response is usually about room modes around 250 Hz and below. These are long wavelengths and can easily swing 25 dB in sound-pressure level! Such long wavelengths can cover many seats and many rows.

b. Half of the battle with low-frequency room modes is high-pressure (loud, combining) spots, and half is low-pressure (quiet, cancelling) spots. For the most part, and no matter how fancy an equalizer you have, you can't push up the quiet frequencies, you can only pull down the loud ones. As a result, each seat will still be unique with soft frequencies.

c. Because we rarely listen to steady tones, I would rather suffer the occasional dip or bump than to suffer with lean bass response all of the time, at every seat.

d. Due to the laws of physics, there is only one point in the room where time, energy, and frequency can converge—this point should be the money seat. For example:

i. You can't seat-average time arrivals. Loudspeaker time arrival correlations are our spatial cues. They tell us where things are in the soundstage and help us determine the size of the recorded space.

ii. You can't seat-average energy levels. The loudspeaker closest to the listener will always dominate all other loudspeakers.

iii. You shouldn't seat-average frequency response. All seats are then tainted and diluted.

e. Averaged frequency response is not the sound the artists envisioned. Enjoy what was intended, and when you have guests over let them sit in the money seat. You'll be close by noticing the time and energy distortions well before the frequency imperfections.

4. HVAC Not Dedicated

Not having a dedicated HVAC system designed for the home theatre can cause the following problems:

a. Uncomfortable temperature in the room. Often home theatres, with their amplifiers, people, insulation, and interior acoustic treatments become hot boxes. But, it can go the other way too when the temperature is being regulated elsewhere.

b. HVAC systems can be noisy. They can be a distraction when they turn on or off, pulling you out of the movie experience. Dedicated systems can include quieter compressors, duct lining and/or silencers, lagging, several means of reducing noisy air turbulence, etc.

c. They can be a means of noise being transferred to or from other rooms, acting like acoustic intercoms. You may not be able to use the home theatre after the kids go to bed. On the other hand, you may hear your kid's music when you are using the home theatre.

d. Noisy HVAC systems reduce dynamic range. In order to hear small details, you have to turn up the volume, which is not always practical, or even possible. This means that low-level details will be masked.

5. Lack of Acoustic Treatments For Noise Control

There are two types of noise transmission: airborne and structure-borne. Airborne, originating in the air from, say, singing is then transferred to another space via the air path of a ventilation duct or open window. Structure-borne originates from mechanical energy imparted directly to the building structure, like a washing machine. There are many different pathways sound can use to be transmitted from one space to another, or as is usually the case, to all of the building. In typical construction, everything is tightly connected to each other, making it easy for sound to travel from one end of the building to the other. Frequently, sound transmission involves a combination of airborne and structure-borne. For example: sound waves from singing impinge on the surface of a wall, which in turn forces vibrations to the wall on the other side, which then generates airborne sound that is heard. Sound energy travels faster and further in solids than it does in air.

There are many methods of introducing noise control:

a. De-couple all structural connecting points.

b. Fill all air gaps and penetrations of the shell with materials that remain flexible. This is usually foam and sealant. The room should be airtight. A gap just 1 percent of the surface area can negate the noise control effort.

c. Add mass to partitions to block sound.

d. Add insulation and damping materials to partitions to help absorb sound energy.

e. Locate sound sources far away from the receiver.

f. Enclose and isolate noise sources such as projector fans, HVAC, plumbing, etc.

6. Lack Of Acoustic Treatments For Sound Quality

This is addressing interior acoustic treatments. Certainly, you have to have noise control in place before you can achieve sound quality. Without sound quality, you have a unique hodge-podge of unorganized sound, which makes the storytelling difficult, confusing, and frustrating—not enjoyable. Organized, normalized sound will deliver what the artists originally created. There are several areas to address in order to reach that criterion:

a. Reduce the first order reflections from each loudspeaker, on each surface. These sound reflections distort spatial cues and tonality. Placing absorption or diffusion at those locations make the soundstage bigger, more solid and more defined, and improve tonal characteristics.

b. Control the reverberation times of the room. Too much reverberation means poor articulation, loss of information, and narrow dynamic range. Too little means a very uncomfortable room, sounding unnatural and feeling small and congested. Ideally, the reverberation times are between 0.25 and 0.4 seconds from 125 Hz on up, with a slightly longer tail below 125 Hz (see Figure 3).

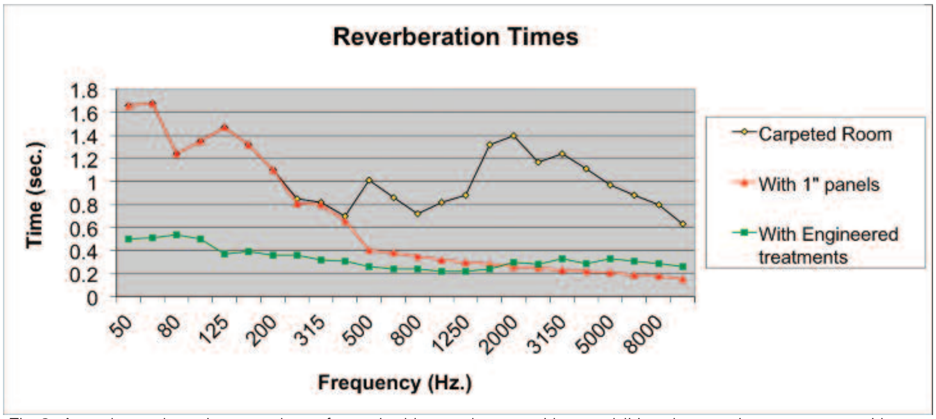

Fig 3. Actual reverberation test data of a typical home theatre without additional acoustic treatments, with optimized typical treatments, and with engineered treatments. More commonly, the red curve dips lower beginning at around 500 Hz.

7. Listeners Too Close To Loudspeaker

I pity anyone sitting close to one loudspeaker. They are a few feet from one loudspeaker and many yards from the others. They essentially have no soundstage. They often can't tell what's going on because all they can hear are sound effects. Understand that as the number of seats increase, so must the size of the theatre. It works like inflating a balloon. You can't just push someone next to a loudspeaker—it's cruel.

8. Listeners Too Close To the Wall(s)

I pity anyone sitting in the back corner of the theatre. The same rules apply as above. Everyone knows that it sounds weird when you (or a loudspeaker) are close to the wall. It sounds muddy from the bass build-up—the mids and highs also experience reflective interferences that distort tonality and spatiality.

9. No Center Seat

This one bothers me the most and is frequently done—a good soundstage is created with symmetry. Yet, often the point of optimal sound convergence for the room, and the point centered in front of the screen, is occupied by an armrest with a seat on each side of it. How can you go to all this effort and expense and not design for an optimized seat? Where do I calibrate from—this seat, that seat, or the armrest?

10. Over-absorption Of The Mids And Highs, None For The Lows

A very common mistake with acoustic treatment is to use too much standard foam or fiberglass board that only absorbs frequencies found in the upper half of the piano and offers no treatment for the lower half. This sounds very unnatural, dry, closed in, and very uncomfortable in the mids and highs, leaving the lower mids and low frequencies untouched, sounding slow and muddled. There are specially designed acoustical products available to help address low frequencies. As mentioned above in section 6-b, in order to sound neutral and natural, you must control the entire audible range in a linear fashion, within the desired time window (see Figure 3). This means combining the right product, at the right locations, with the right quantity.

11. Poor Shell Construction

Typical home construction does not offer enough sound energy containment, so sound is easily heard on the other side of the partition and vise versa. The materials and methods don't have enough mass to block the sound. Especially, low frequencies travel right through, as if it's not even there. Not only is this a problem from a noise control point of view, but also from a sound-quality view. The thin, light materials mean that too much energy is lost and you have to turn up the volume to feel visceral impacts. On the other hand, a concrete bunker can do a good job of blocking transmission but means that too little energy is lost inside the room, and the bass lingers and muddies up the sound big time.

Typical home construction also allows cavity resonances to play back into the room. Note the sound of a drum when you hit your fist between studs. Any time that frequency is played by a loudspeaker that wall will sympathetically resonate and play back the frequencies into the room later in time—more mud, less fun. Walls, floors, ceilings, risers, etc. have cavities with different notes. No wonder most rooms sound droning and inarticulate.

There is a fine balance in construction materials and methods in order to create a room that controls sound transmission and sound quality optimally. Mass, but not too much, decoupling, damping, bracing, insulation, and sealing are the design tools needed. Again, the low frequencies are very difficult to control. The shell itself can be a great low-frequency absorber if designed well.

12. Poor Room Modes Distribution

The room modes are dictated by the dimensions of the room—more specifically, what frequencies are determined mathematically by the length, width, and height of the room. When a loudspeaker radiates sound in a space between two parallel surfaces, it can create a resonance at a frequency determined by the speed of sound, divided by their distance in feet. As mentioned above, the construction can play a factor into how problematic these modes may be—they can be really bad in a concrete room because the shell does not move to absorb the energy. An enclosed space will have modes by default. We are really only concerned with modes below about 250 Hz. The ideal design is one where these mode frequencies are distributed evenly so that they are not too close to another, nor too far apart. Dimensions, which are divisible by another are going to create problems. A cube would be the worst scenario. When modes are a problem, they audibly stand out so that some frequencies are much louder or softer than others, and you have non-linear bass response.

13. Screen Is Too Wide For Proper Soundstage

Now that pixel resolution is so high, people are pushing the screen size beyond comfortable and practical, to the point where you have to scan the picture in order to see it all. This is not what the artist intended, and you may miss information in the scene designed to be seen. What is worse is what happens to the audio when the screen is too wide. Because you have to push the loudspeakers so far out to the sides, you lose the solid sound imaging. The audio industry standard is that the left and right front loudspeakers should form an equidistant triangle with the primary seat. This offers a naturally spacious and solid image, which correlates with the picture. It also complies with SMPTE and THX video standards. Both standards are a result of biological human traits, rather than egos. With loudspeakers too far apart, sounds occur outside the pictured action—the soundstage is not convincing and the LCR loudspeaker locations are obvious. Placing loudspeakers behind a perforated screen can help, but it is not a total fix, and other issues are introduced.

14. Seat Backs Above Shoulders

This wins as the dumbest mistake on the list, and I would say most hi-end home theatres suffer from it. Having a seat back above your shoulders will create two very serious distortions; the seat back will reflect the front loudspeakers and block the surround loudspeakers. Seriously dumb, right? You are not even in the ballpark when using such seats. There is only one way to fix it—replace it. Recliners are for watching TV and taking naps, not for a home theatre experience.

15. Sub(s) In Corner(s)

This is the other one on the list that might be considered controversial. The best place to place subwoofers is where they avoid the room mode problems and up next to the front mains. This is where they offer the most linear bass response and blend with the main loudspeakers to sound like one voice. Sure, it is convenient to place them in corners, and yes that offers greater bass energy output for less power input but:

a. Exciting all the room modes is not accurate and will require some frequency equalizing, phase, delay, and level-matching finesse.

b. Even with all that optimized, you will be audibly aware of their location, as they will not blend with the mains as one voice.

There is also the idea of placing the subwoofers in the mid-point between each wall. Their location becomes even more audible there. Yes, it offers some smoothing of room modes, but you will not have one voice, and it would be especially annoying to someone sitting close to one.

I recommend two subwoofers up front. If the room is larger, then incorporate larger or additional subwoofers up front to handle the space. You shouldn't have to place any in the back unless the surrounds are only good down to, say, 80 Hz.

There, you have 15 of the most common home theatre design mistakes. Should we be surprised that these design errors are common? Yes. In this day and age of accessible information, training, certifications, books, etc., these faults should not be happening. Certainly, some might occur as the result of a compromise made after an informed decision process, but most on the list here are avoidable in every home theatre situation. Most on the list do not cost extra to implement. Most of these common blunders should be common sense. They are not new opinions, they are well documented, backed by objective and subjective data and should be standard practice. Therefore, I believe that these design mistakes are a matter of laziness found in our industry. It is the responsibility of the designers and integrators to educate their clients so they understand the consequences resulting from deviations and compromises, and then they can make informed decisions. Paying attention to these basic issues will bring a much higher level of performance, which translates to a much more enjoyable experience for everyone. WSR

Norman Varney is the Acoustical Product Development Manager for Kinetics Noise Control in Dublin, OH. Having been in the noise control and sound quality industries for decades he has earned many awards for acoustical products, room designs, etc. while working for A/V RoomService, Owens Corning Science & Technology Center and MIT. Mr. Varney has presented many white papers to the industry and written many articles on acoustics for numerous publications over the years, as well as participated in seminars and panel discussions. He is an active member of ASTM (Committee E-33 on Building and Environmental Acoustics), Acoustic Society of America, Institute of Noise Control Engineering, AES, NAMM, CEDIA, etc.