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Focus on Acoustics

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Closer With Acoustics

When faced with the need to solve acoustical problems or plan for ideal acoustics in any type of room or space, the first rule in the book is to enlist the service of experienced acousticians or request expert advice from an acoustical solutions provider. That is the ideal way to deal with acoustics and get the best possible results.

The good news is that the understanding of acoustics and the measurement tools that are available, together with the variety and quality of acoustical solution products, is increasing. Anyone dealing with acoustical projects must have noticed how there are increasingly complete solutions available that allow users to accurately measure, analyze, and visualize the acoustics of any type of space, as well as tools to simulate and predict ways to create the ideal acoustics for the environment—depending on the application. And measurement and visualization software tools for acoustics are becoming available even for portable devices, supported when required by extremely powerful cloud-based engines, enabling us to predict behaviors of materials and installations in advance. A good example is the number of iOS and Android apps available to anyone with an interest in acoustics, and even some affordable, dedicated systems that combine hardware and software for those who want to collect some serious data, before requesting an installation project.

There is still room for improving the connection between advanced computer simulation tools and the available measurement and reporting tools used by acoustical consultants, but anyone who wants to identify the problem areas—or qualities of a space—can currently benefit from decades of developments designed for acousticians and noise and vibration control professionals.

Most audio measurement companies, from Brüel & Kjær to NTi Audio, have recently expanded the available software tools to measure room acoustical parameters according to industry standards, while most acoustic solutions providers now offer desktop and mobile apps for basic room acoustics measuring. An excellent example is Impulso and Impulse AE (a dedicated version for architects), two free apps engineered by Artnovion that enable users to measure the acoustic response of any room using an iPhone with an external measurement microphone. Of course, with most of those apps, users can not only simulate the use of the company's products to improve acoustics, but they can also directly report the measurements and request a project.

On a related note, much as audio professionals are using measurement tools to continuously monitor their working environment, many are also applying room correction solutions in studio and listening environments, with the availability of affordable but reliable solutions from IK Multimedia (ARC System), Sonarworks (Reference), DIRAC (Dirac Live), and others. All those solutions contribute to a better understanding of acoustics, which can only be a good thing.

I would also like to acknowledge the fact that while compiling some of the solution highlights for this year's Acoustic Focus edition, we couldn't help noticing the use of the terms eco-friendly and sustainable. Acoustic panel manufacturers always have highlighted their use of natural materials as a way to promote better working environments, but while the use of wood, cork,, and natural fibers is well understood and established, not all the manufacturers are fully able to disclose the use of dangerous chemicals required for fire-retardant properties, durability, or simply aesthetic reasons. Now, we increasingly see those companies doing research in areas that not only take the effectiveness of those products further, but also involve banning dangerous, non-recyclable or non-sustainable materials. Some are notably exploring the use of industry waste byproducts and even recycled post-consumer waste, such as plastics, to create new innovative acoustic treatment products.

That is certainly something that promises to define the industry for the future and a very welcome trend.

J. Martins
Editor-in-Chief

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COLUMNISTS

Vance Dickason has been working as a professional in the loudspeaker industry since 1974. He is the author of *Loudspeaker Design Cookbook*—which is now in its seventh edition and published in English, French, German, Dutch, Italian, Spanish, and Portuguese—and *The Loudspeaker Recipes*. Vance is the editor of *Voice Coil: The Periodical for the Loudspeaker Industry*, a monthly publication. Although he has been involved with publishing throughout his career, he still works as an engineering consultant for a number of loudspeaker manufacturers.

Mike Klasco is the president of Menlo Scientific, a consulting firm for the loudspeaker industry, located in Richmond, CA. He is the organizer of the Loudspeaker University seminars for speaker engineers. Mike specializes in materials and fabrication techniques to enhance speaker performance.

Dr. Richard Honeycutt fell in love with acoustics when his father brought home a copy of Leo Beranek's landmark text on the subject while Richard was in the ninth grade. Richard is a member of the North Carolina chapter of the Acoustical Society of America. Richard has his own business involving musical instruments and sound systems. He has been an active acoustics consultant since he received his PhD in electroacoustics from the Union Institute in 2004. Richard's work includes architectural acoustics, sound system design, and community noise analysis.

Steve Tatarunis has been active in the loudspeaker industry since the late 1970s. His areas of interest include product development and test engineering. He is currently a support engineer at Listen, in Boston, MA, where he provides front-line technical support to the SoundCheck test system's global user base.

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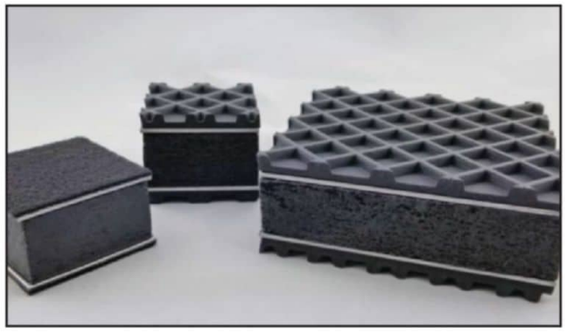

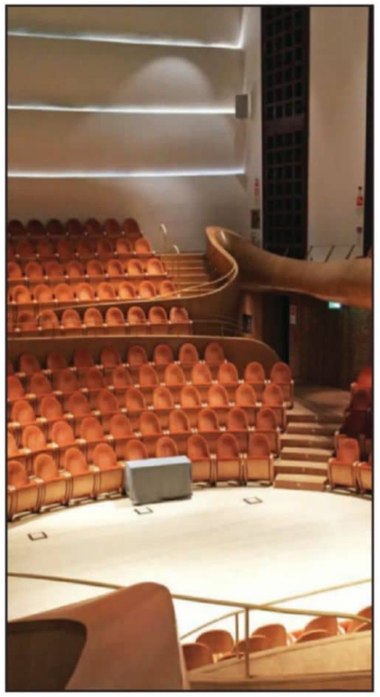

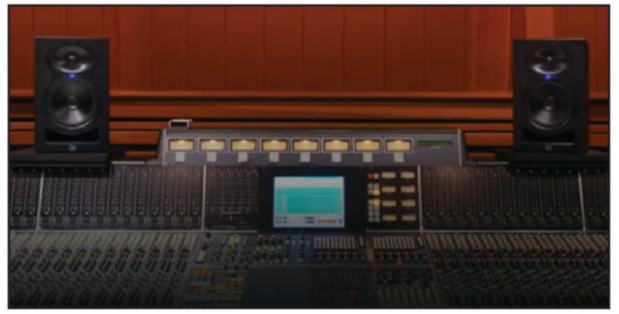

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Show Report

Audio Expo North America (AXPONA) 2019

Rainbows, Unicorns, and Great High-End

By
Oliver A. Masciarotte
(United States)

The Escher-esque Renaissance Schaumburg Convention Center and Hotel

This year's AXPONA was a sort of Groundhog Day, in that a fierce storm accompanied the event. Rather than last year's fight to get home amid the literal wreckage strewn about the highway, my battle this year was traveling to the show. However, my trusty hybrid plowed through it all, and I settled in for some excellent audio the following day.

I had read about a new speaker prior to the exhibition, and was pleased to sit down for a bit with Zoltán Bay to discuss and listen to the worldwide launch of BAYZ Audio's new flagship, the $97.1k Counterpoint (www.bayz-audio.eu). The 4 Ω Counterpoint plays "…lower (3 additional Hertz to around 24 Hz) and louder (+3 dB SPL) with a bigger vertical soundstage and lower distortion" than the existing Courante range. In the Counterpoint, his 200 mm Bay Radial Speaker (BRS) tweeter is combined with dual opposing, Danesian-designed 9.5" papyrus cone woofers and an all-carbon fiber "cabinet" for a low distortion delivery that both excelled at imaging and envelopment. The unorthodox, yet handsome pre-production prototype had crazy good sound—lively and organic.

Synergistic Research (www.synergisticresearch.com) supplied Atmospheric X Level 3 Euphoria cabling (8' speaker $5,495, 1 m RCA $3,495, and 1 m XLR $3,995) and $2,995 Power Cell 8 UEF SE power conditioning (which includes a $1,995 Atmosphere X Excite power cable) connected to CH Precision's (www.ch-precision.com) I1 integrated amp/DAC fed from one of Zoltán's custom Linux-based servers. The I1 starts at $38,000, and includes a digital input card (AES/EBU, S/PDIF, TosLink, and CH-LINK HD) and a balanced plus unbalanced analog input card. Additional options include two digital choices, $3,000 USB or $5,000 Ethernet, and a $4,500 phono stage with six EQ curves.

More Speakers

While on the subject of Danes, let's talk about the Raidho division of Dantax (www.raidho.dk). Specifically, its chief designer, Benno Meldgaard, who has been on the job for the past 18 months

since Michael Børresen decamped to start his namesake endeavor. Meldgaard and his team have upgraded and updated the D4.1 with tech adapted from its top line TD4.8, creating the new, scaled down €107,000 TD4.2. Its six new five-layer, tantalum-coated "Diamond" drivers have upgraded motors, while internal damping and the ribbon tweet has been improved as well. They also took that same tech and applied it to a new stand mounter revision, the €20,500 TD1.2. The new tweeter provides several orders lower distortion and increased sensitivity to boot. A new €88,000 TD3.8, later announced at the High End Munich show, is on its way as well...

I discovered AQ s.r.o. (www.aqaudio.cz) at last year's AXPONA, and have kept track of the company since. AQ's quality products are reasonably priced, neutrally voiced, and visually pleasing. This year, the company had its $5,000 Passion Anniversary model playing—an 8 Ω, 40" three-way tower with smoothly satisfying sound. SB Acoustics supplies a 1" tweeter and 4" polypropylene mid, both from the low distortion Satori line. For low-frequency duties, four Scan-Speak drivers are employed, for an overall response of roughly 25 Hz to 30 kHz.

Next up in the realm of speakers, the always jovial Vinnie Rossi (www.vinnierossi.com) was demo'ing his $20,000 Stiletto 15. The three-way model, a new product class for him and somewhat reminiscent of a Dalek in appearance, combines a 15" open baffle paper cone woofer with a 5.5" paper cone mid and 1" fabric dome tweeter. The mid- and high-frequency drivers are together in a sealed enclosure. Mundorf and Jantzen crossover components combined with WBT NextGen terminals round out the configuration. Response is spec'd at 39 Hz to 40 kHz ±3 dB, and impedance is a nominal 6 Ω.

Acora Acoustics (www.acoraacoustics.com) was busy at the show, with not one but two loudspeaker debuts. Playing for most of the proceedings was its $28,000 SRC-1, a ported 8 Ω two-way with 7" sandwiched paper mid-woofer and a 1" ring radiator for the high-frequency tasks. Weighing in at 246 lbs. and 43" in height, these faceted towers are constructed of 3 cm granite. The 13" stand mounter, the SRB, tips the scale at 58 lbs. With a 5.5" mid-woofer mated to a 1" beryllium dome, they don't go as low as the SRC-1, roughly 43 Hz versus 29 Hz, but the metal tweeter lets them reach up to 35 kHz.

The curvilinear carbon BAYZ Counterpoint

The towering Raidho TD4.2

AQ's limited edition Passion Anniversary

Lest you think megabucks are needed for a satisfying system, consider Vanatoo (www.vanatoo.com) and its new Transparent One Encore, introduced at the event. The $530 powered two-way includes aptX Bluetooth along with analog plus USB, Toslink and coax digital inputs, a subwoofer output and even a full remote. Together with a compact 10" RSL Speedwoofer 10S subwoofer ($399), the diminutive Transparent One Encore made, according to my notes, for a "killer entry-level system."

Local heroes Magnepan (www.magnepan.com) had another new, price conscious entrant, the 48" $650 LRS planar magnetic. Yup, 650 bucks for a

Maggie. Insanely affordable, I wrote that they offer "astounding fidelity for the price," while the diminutive size would make any significant other happy in their living space. Of course, being Maggies, they need a fair share of current to drive the 4 Ω load they present, and maybe a subwoofer if you like pant-flapping bottom (-3 dB at 50 Hz), but these little critters could become the basis for an excellent starter system anyone could live with for a very long time.

Parasound's rocking little NewClassic 200 INT integrated

An overhead view of AGD's GaN-powered Vivace

At the show, Wendell Diller was driving the little Maggies with a novel, not-for-sale Maggie amp. A more realistic choice would be the $1,195 Parasound (www.parasound.com) NewClassic 200 INT integrated amplifier/DAC, available "...in early summer." The slim unit offers a great set of analog and digital features, including 110 W of Class-D power supplied by Pascal technology. It also integrates a "...superb MM/MC phono stage," two RCA line level inputs plus digital inputs for USB, coaxial, and optical sources. There's even a home theater bypass for Left, Right, and two subs, plus a front panel auxiliary in for those damnable portable devices.

In the demo suite, the NewClassic 200 INT was fed by an OPPO Digital BDP-105 via Straight Wire $30 Musiccable II interconnects, while the amp was driving a pair of Buchardt Audio S400 two-ways (www.buchardtaudio.com) via Straight Wire's $250 Symphony SC speaker cables (www.straightwire.com). The $1,800 Danish speakers, making their North American debut, rested on $180/pair Norstone Stylum stands (www.norstone-design.com). The 4 Ω S400s are just over 14" tall, with a 6" aluminum cone midwoofer, and a 0.75" soft dome tweeter coupled to a 7" aluminum waveguide. On the back is a 5" × 8" low mass, racetrack passive radiator. They cross over at 2 kHz, and the response is listed as 33 Hz to 40 kHz ±3 dB. My notes mention that, all together, this was "...a perfect budget system" with low distortion, admirably even response and very gratifying results.

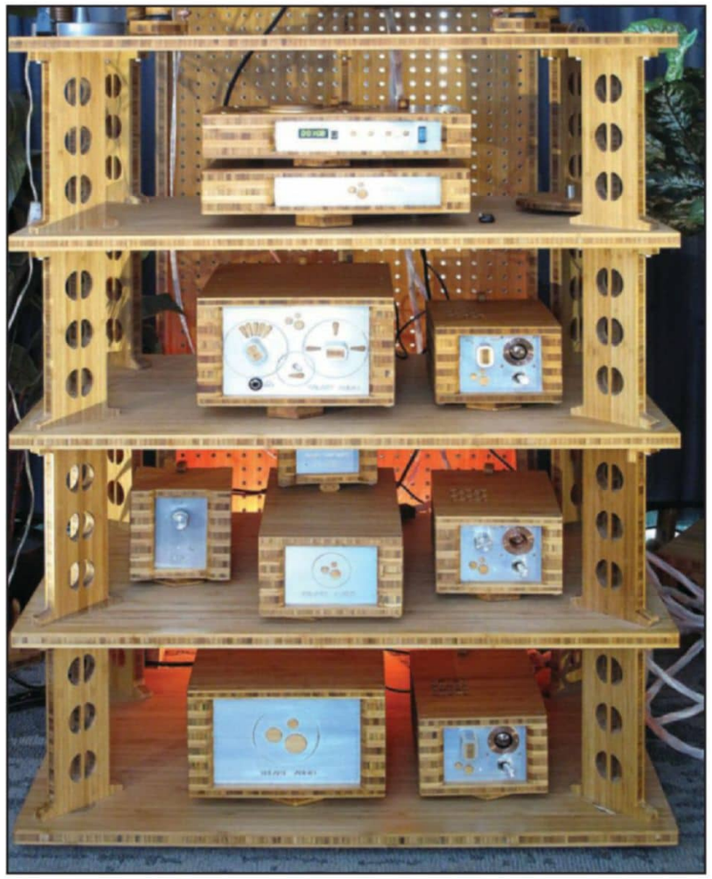
Stepping way up in cost, AXPONA saw the world premiere of EgglestonWorks' new 18" tall, tapered top Nico Evo bookshelf model (www.egglestonworks.com). These $4,295 8 Ω two-ways have a 6" custom mid/woofer mated to a 1" soft dome, both by Morel. Matching stands are $495 and, at the show, they were powered by Primare's $4,995 I35 Class D integrated (www.primare.net) and entry-level Audience cabling (www.audience-av.com).

Something Old, Something New

In the Something Old, Something New category was the AGD and Ocean Way room. If you don't know the name Ocean Way, you should. Its guiding light, Allen Sides, is an exemplary engineer and founder of storied Ocean Way Recording in Hollywood. That facility began life as the legendary United Western Recorders. In 2015, after decades of listening, Sides began selling his own line of studio monitors and, at AXPONA, I finally got to hear a pair.

At the show, a set of Ocean Way Audio Montereys (www.oceanwayaudio.com) were mated to new, 100 W into 8 Ω monoblocks from a company hitherto unbeknownst to me: AGD Productions

A pre-pro JansZen Lotus fed by my reference Calyx M DAP



A veritable forest of bamboo on show from Tri-Art Audio

(www.agdproduction.com). The gallium nitride power MOSFETS used in the design are a bit unusual but, even crazier is the form factor. The GaNTube, which incorporates the key elements of the output power stage, including the GaN semiconductors, are "…integrated within a glass tube, which not only delivers the unique look of the AGD Vivace, but also allows the possibility for future seamless upgrades of the power stage." The wide bandwidth, 5 Hz to 100 kHz ±3 dB may contribute to the sound but, all I'll say is the sound quality of their rig was detailed, unvarnished, effortless and, according to my notes, simply "lovely."

Also hewing to the Something Old, Something New theme was the "reborn" KLH brand. Along with many other rooms, I was not impressed with the sounds I heard from its $1,298 three-way Kendall towers, but I'll give them another shot at a future show.

Last year, we caught the first glimpse of headphone manufacturer Periodic Audio's upcoming amp, the "Ni" or Nickel, in keeping with its periodic table product theme (www.periodicaudio.com). This year, they were distributing evaluation examples of the forthcoming $299 self-powered miniature *analog-only* headphone amp. The tiny beast has great specs—THD "below 0.005%" across the audio passband, 150 mW of power delivery into 50 Ω, 270 mW into 16 Ω, and is stable into an 8 Ω load. A wide bandwidth, basically flat from 8 Hz to 30 kHz, ensures that your HRA content will sound properly airy.

At the last AXPONA, JansZen (www.janszenaudio.com) showed a proof-of-concept of its Lotus self-energizing active true electrostatic headphones. This year, David Janszen had an additive manufactured, pre-production version. With a 18 Hz to 30 kHz response, his over-the-ear cans sounded great. Despite the 500 gm weight, they were quite comfortable. Pricing is tiered, starting with an Indiegogo campaign price of $795, which launched in May. Once a fixed number have been sold, the price will rise in steps to $1,495.

On the subject of headphones, you may remember Warwick Acoustics (www.warwickacoustics.com) from my 2016 RMAF report. Well, they were back with a vengeance at AXPONA. The latest product, APERIO, is a stunningly good, do-everything electrostatic headphone plus energizer/pre/DAC that sets a new standard for performance. My notes indicated, "Such transparency, such ease!" The wideband hardware (subsonic to >60 kHz) is about 1U tall by 16" wide, and incorporates three distinct signal paths for LPCM (up to 384 kHz), analog and DSD (up to DSD4 over DoP). Analog is all Class A with balanced and unbalanced I/O, and the embedded DSP for equalization, etc., is (64 bit) double precision fixed point. Pricing is $24,000 for the whole kit and caboodle.

As Mike Klasco and Nora Wong reported in the May 2, 2019 *The Audio Voice*, audioXpress' e-newsletter, "True wireless (has been) the main engine of growth in the total value of the headphones market…as consumers demand for new premium features remains strong." Boy, you can say that again! Quite a few vendors had true wireless products on offer, you couldn't swing a cat without hitting one. Of them all, Sennheiser got my nod for best implementation.

Another vendor new to me, Tri-Art Audio (www.triartaudio.com), had a room filled with good sounding budget gear. First, the company debuted its $1,800 bamboo corner trap Resonating Trees. These are not your typical passive traps. In addition to quotidian corner placement for reducing low-frequency room resonances, they are also potentially active, with embedded super tweeters, though amps to drive them are not included. But wait, there's more! The trees also have holes drilled for optional resonating "wingots"—tiny silver bowls that, when activated by the super tweeters, "energize the air." Tri-Art Audio also showed the new $275 S-Series moving magnet phono preamplifier.

Decibel 9 (www.decibel9.com) was showing its three stock retro chic furniture offerings, including the $2,969 CR-101 equipment cabinet. With an MDF core and walnut veneer, this curvy fellow would complement a wide range of decor. If the stock items aren't to your liking, Decibel 9 also does custom as well.

Focal NAIM (www.focal.com) purchased North American distributor AudioPlus Services at the beginning of the year, and has added several lines, including IsoAcoustic (www.isoacoustics.com). Vice President of marketing Romain Vet hefted the beefy yet cost-effective new IsoAcoustics Delos isolation platform, in four sizes, from 18"× 15" × 1.25" at $399 on up to the 22" × 16" × 3" at $699. Vet also ran me through the new Astral AVR from Focal, the company's first foray into electronics, in addition to the huge inventory of brands and models they were showing.

Cary Audio (www.caryaudio.com) introduced the new SLI-80HS Heritage Series integrated amp ($4,495 to $5,880). Feeding the dual concentric Fyne Audio (www.fyneaudio.com) F1-10, the Cary piece "maintains the integrity of its past." Minimal feedback and solid-state rectification are highlighted, while a pair of switches select either 40 W Class A triode mode or 80 W Class AB ultra-linear mode. Fyne Audio is a company born of the sale and contraction of Tannoy a while ago, and its dual concentric designs recall Tannoys of yesteryear.

Warwick Acoustics' fantastic APERIO

Caution: Curves ahead at Decibel 9

The Cinema LTM is fine Swiss engineering

Credo Audio System (www.credo-audio.ch) had a huge room in which to demo its big speakers. The designer, Michael Kraske, took me through the construction of the new, $169,000/pair Cinema LTM three-way line array. Each speaker is composed of three cabinets: a long, front-facing polymer enclosure for the 32 ring radiator tweeters and 14 mid-woofers. The 22 mm silk dome tweeters are arrayed in six banks, while the 4" kevlar cone mids are in four. Two additional sealed cabinets, stacked one over the other, each house two passive, aluminum cone 12" woofers for response flat down to 20 Hz. EMM Labs provided the drive electronics. The cabinets and passive crossovers are all manufactured in-house.

Speaking of Swiss audio engineering, I was more than a bit surprised to see Mr. Weiss Engineering himself, Daniel Weiss manning a table in one of the big rooms. When asked why he was sitting all by his lonesome, he told me he was prospecting for new dealers and reps.

Also quite surprising, a few tables over was that force of nature, EveAnna Manley. She was holding down her own display, demo'ing the new $4,500 Absolute headphone amp/pre (www.manley.com). This feature-laden critter has variable feedback, Baxandall-style tone controls, stepped relay ladder attenuator, on-the-fly switchable push-pull or single-ended topology, and an RF remote that will work clear across the house.

Romain Vet with the substantial IsoAcoustics Delos

The aesthetically correct SINGularity monaural phono stage from Lejonklou HiFi

Truly Unique Offerings

Finally, in the "I can't even think about it…" category, was Lejonklou HiFi and its cost-is-no-object assault on vinyl's shortcomings (www.lejonklou.com). Casting aside all constraints, the new SINGularity phono stage took eight years of research and development. The beautifully minimalist result is a $42,700/pair monoblock, machined out of annealed copper billets, with 13 factory setting for cartridge loading built in.

At AXPONA, the SINGularities were paired with $9,900/pair Sagatun monoblocks mated to $9,900/pair Tundra Mono 2 power amps via Linn Silver interconnects. The source was a Linn LP12 tricked out to the tune of $23,690 and the sink was a set of Quad ESLs. In my mind, Lejonklou tied with BAYZ Audio for the "Most Audacious" award at the show.

Year of the Unicorn

2019 is shaping up to be the Year of the Unicorn, with pop culture and the financial world completely saturated with mutant equines and their attendant rainbows. Well, AXPONA 2019 certainly must have gotten the memo, since this show was chock full of "esempi di unicorno," also known as good sounding show rooms!

From budget to budget busters, I was more than happy to hear systems that exceeded all expectations, whether entry level or eye watering. Also, show attendance was up 15% over last year, with a very good mix of more than 9,500 bodies, making it the largest show to date. With so very many exhibitors and only one OMas, I have to apologize if your favorite vendor didn't make the cut for this report. I'm looking forward to next year's event, and I hope you'll be able to experience it for yourself.

Variable Acoustics

The Impossible Takes a Little Longer

Photo 1: The theater of Dionysos Eleuthereus on the south slope of the acropolis of Athens was first built in the 6th century BCE.

By
Richard Honeycutt
(United States)

Learn how acousticians have developed modern systems that represent a leap from tone deaf ancient amphitheaters to venues that are acoustically friendly for a variety of program materials.

In 1942, a slogan was adopted by a department of the United States Army: "The difficult we do immediately; the impossible takes a little longer."

Since the building of the ancient Greek amphitheaters some two-and-a-half millennia ago (see **Photo 1**), the importance of acoustics in public gathering places has been known. First-century Roman architect Marcus Vitruvius Pollio described some of these ancient practices in Volume 5 of his 10-volume work *Ten Books on Architecture*. (For more details, see my book *Acoustics in Performance*.) The main acoustical concern in these venues was that all members of the audience be able to hear the speech or performance—drama and speeches were pretty much the only functions of these amphitheaters.

Photo 2: The Vienna Opera House

Probably the first venues of significant size that were used for both music and speech were the great medieval cathedrals of Europe. In these structures, the speech was mainly ritual and ceremonial, and the music was mainly chants. These vast rooms with only acoustically hard finishes provided almost no speech intelligibility because of the long reverberation times (RTs), which allowed the music of the chants to create harmonies with notes that had been sung earlier. The performance of opera, introduced by Jacopo Peri required performance halls with good acoustics for both speech and music (see **Photo 2**).

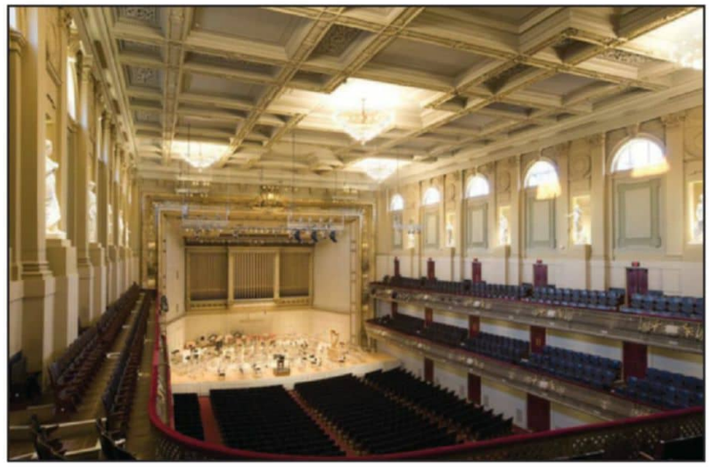


Photo 3: The Boston Symphony Hall

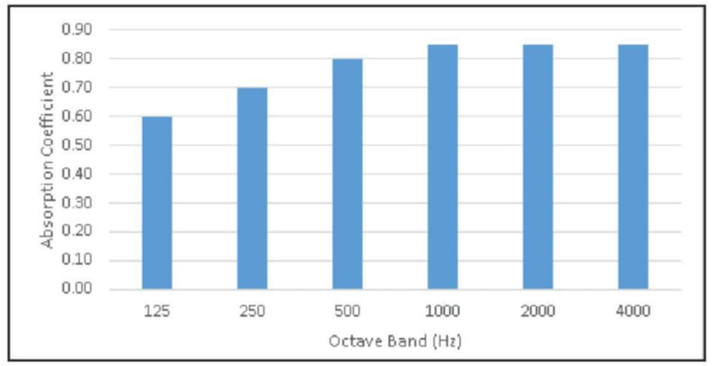


Figure 1: Acoustical absorption of thick drapes

Photo 4: Retractable acoustic absorption by AcouStac

Here begins the "difficult" phase of architectural acoustics: Good musical support generally requires a longer RT than is ideal for speech. With the development of later musical styles, ideal RTs varied according to the complexity of the music—values would range from about 1 second for speech and 1.5 seconds for Italian operas to 5-7 seconds for Gregorian chants.

Most modern concert halls have an RT of about 2 seconds. By the early-to-mid 20th century, acoustical science had developed to the point that excellent concert halls could be built based upon known scientific principles. As an example, the Boston Symphony Hall, widely considered one of the best in the world, was built in 1900, with acoustical design by the "Father of Modern Acoustics" Wallace Clement Sabine. Good acoustical design of concert halls is a well-understood science; and although difficult and not accomplished "immediately," is regularly achieved.

University and municipal theaters and community centers are subjected to an extreme variation in program material unknown to the designers of the older, more traditional concert halls: speech programs, amplified music, and jazz needing very short RTs must be accommodated, along with Romantic music, and other styles requiring RTs up to several seconds. Enter the "impossible" phase of architectural acoustics.

From a strictly architectural standpoint, the only "handles" the acoustical designer has upon RT are the enclosed volume of the room and the acoustical absorption of the room surfaces. Variable acoustics for theaters and concert halls have been provided by making both of these "handles" adjustable.

Variable Volume

An excellent example of the variable-volume approach is the Morton H. Meyerson Symphony Center in Dallas, TX. This hall incorporates a large empty room that serves as a reverberation chamber and is coupled to the main hall by operable doors. By controlling the extent to which these doors are opened, the technical staff can adjust the hall's RT. Clearly, this approach to variable acoustics is costly and not applicable to venues that have already been built.

Variable Acoustical Absorption

At first blush, it would seem that merely covering part of the walls of a hall with heavy curtains would be an effective way to control RT. This approach has been effectively used in lecture halls and "black-box" drama theaters, but it has several drawbacks. In a venue the size of the Boston Symphony Hall (see **Photo 3**), the total acoustical absorption required to achieve an RT of 2 seconds is about 13976 sabins. Bringing this down to 1.5 seconds would require about 4859 more sabins, corresponding to covering 30% of the wall area with a perfect acoustical absorber.

Heavy curtains are not a perfect acoustical absorber. At best, a drapery can absorb about 80% of incident sound, thus requiring about 38% of the wall area to be draped. If folded to half their full length and hung a few inches from a wall, they are very effective absorbers of high frequencies. But no drapery can absorb low frequencies well.

In the short RT60 configuration (draperies extended), the room would sound overly warm, perhaps boomy. And certainly the room would sound dull because of excess absorption at high frequencies (see **Figure 1**). Thus, as attractive as draperies may seem for providing variable acoustics, their performance does not fulfill their apparent promise, at least in music venues.

"Barn-door" approaches—operable hinged or sliding panels that can be positioned to reveal either an absorptive or a reflective surface—have similar limitations to draperies, although they can be built with materials having more uniform absorption across the audible frequency range than draperies. Besides the large area required, the massive barn-door structures cannot feasibly be repositioned during a concert to match the acoustical needs of the program, and they add to the workload of the technical and maintenance personnel.

Another option for adjusting the acoustical absorption in a room is to use absorption that can be rolled into a case (see **Photo 4**). This is not an inexpensive approach, but avoids some of the disadvantages of drapery or barn doors.

More Modern Approaches

Electroacoustic reverberation-enhancement ("active acoustics") systems have been in use for several decades now. These are of two varieties: regenerative and non-regenerative (sometimes called "in-line"). Sound-system operators are aware that when a sound system is operated on the verge of feedback squeal, there is an apparent increase in reverberation just before the onset of the banshee wail. By using a digital signal processor (DSP), the "verge of squeal" condition can be maintained while system stability is preserved, and the banshees are kept in check. This is a regenerative reverberation-enhancement system.

Non-regenerative systems use microphones to pick up the sound near the performers, then apply delays and reproduce the result through loudspeakers carefully positioned to mimic wall and ceiling reflections (see **Figure 2**).

Regenerative and non-regenerative approaches can be combined (= "hybrid systems"), resulting in a more stable system that makes the room sound like itself, only more reverberant. Many listeners find this approach more natural than the alternatives (see **Figure 3**). One consultant attending a demonstration of such a system described the results thus:

"It sounds like the ceiling height of the room has just been doubled."

The great advantage of electroacoustic reverberation-enhancement systems is that they can be built with presets, allowing the room acoustics to be changed with the push of a button to match the needs of a program in progress. One disadvantage is cost.

But have we really accomplished the impossible mission? Thoughtful readers will note that we have not addressed the full spectrum of acoustical concerns, only RT. Unfortunately, Sabine's work—on which modern acoustical science was founded—focused on the overly reverberant Fogg Lecture Hall at Harvard University. Of necessity, his research was directed primarily toward understanding the issue of reverberation. Thus, the invaluable tools he developed only deal with that issue.

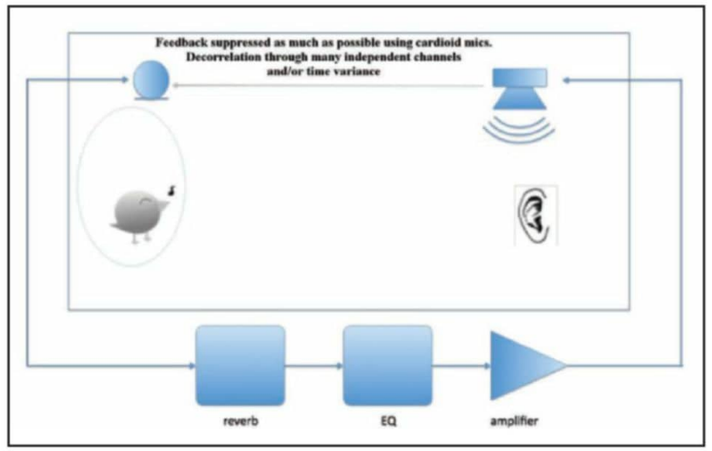


Figure 2: In-line active acoustics systems

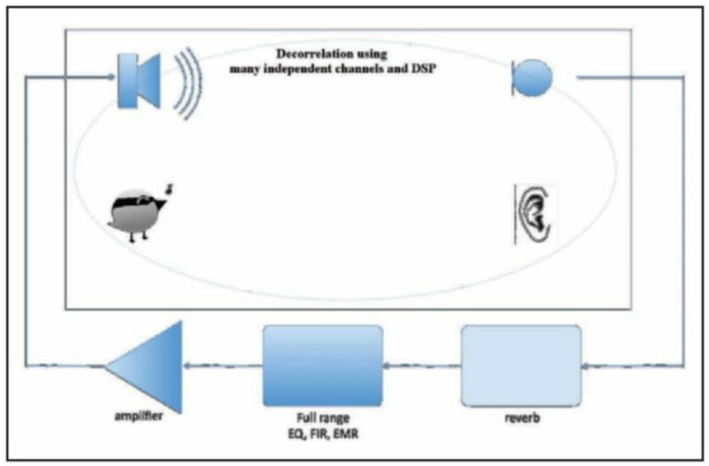


Figure 3: Hybrid active acoustics systems

During the latter half of the 20th century, investigators identified other perceptual effects involved in listener satisfaction in drama and concert performance. These include acoustical strength, intimacy, warmth, envelopment, spaciousness, clarity, definition, uniform sound coverage, and speech intelligibility.

Tapio Lokki of Aalto University (see **Photo 5**), in Finland has reported the results of careful listening experiments involving 17 listeners and nine concert halls. He found that the listener preferences fell into two groups—those preferring a hall with high definition and clarity, along with adequate loudness, reverberation, and bass; and those who liked a considerably more reverberant room with strong envelopment and strong bass. Note that only for the second group was reverberation at the top of the criteria. Other studies have emphasized spaciousness or apparent source width as most important. Where reverberation is of paramount importance, some researchers have found early decay time (time required for a sound to decay by 10 dB from its initial maximum, multiplied by 6) to be a better predictor of perceptual response than RT.

Can these other factors be modified by electroacoustical means?

- Definition and clarity are defined as the ratio of sound energy arriving in the first few milliseconds (typically 50-80) of an acoustic event, to the total sound energy arriving at all times. Only by close-miking and amplifying the sound can we affect these factors electroacoustically, and the hall's acoustics impose an ultimate limit on the effectiveness of this approach.
- Acoustical strength is perceived as the loudness of sound at the listener's ear, and can be controlled electroacoustically, but only at the cost of using a sound-amplifying and reproducing system, which is an unacceptable compromise for some listeners and musicians.
- Spaciousness and apparent source width are affected by the sidewall reflections arriving at the listeners' ears. To the extent that these reflections are not identical (measured by the Inter-Aural Correlation Coefficient or IACC), the source sounds wider, and the room more spacious. Careful placement of the side-fill speakers of an electroacoustic variable acoustics system, and careful programming of the DSPs, could conceivably improve the sense of spaciousness.

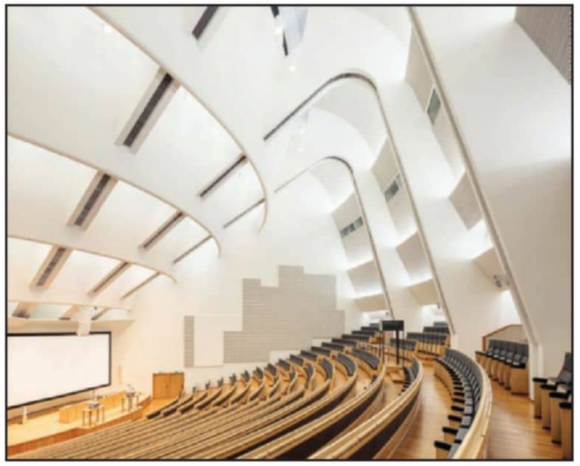


Photo 5: Aalto University's Undergraduate Centre

Given that listeners are divided on the importance of these three qualities, does it make sense to be concerned about varying them during a program, or from one program to the next? Perhaps it does. I recently attended a concert including the music of John Williams, an Italian operatic aria, military march music, Dixieland jazz, and 1960s-era jazz. The room had an RT of about 1.5 seconds. These varied genera of music would have benefitted from variable acoustics providing higher clarity and lower RT for the Williams, the marches, and the Dixieland jazz. Higher acoustical strength and greater spaciousness would have helped the Williams and the opera.

Tapio's research combined listener responses for music of different periods and different-sized orchestras, but did not distinguish the listener preferences by type of music. I believe that such an analysis of his listener responses would have revealed a difference among listeners according to music type. Certainly more work remains to be done, and active acoustics systems have kinks to be worked out, especially in terms of user interface and operator training, but I think we have reached a point from which we can see our way clear to achieving the "impossible" goal of making venues acoustically friendly to a variety of program materials. The current systems certainly represent a giant step beyond the "concert hall" ambience that some home surround receivers claim to provide.

Resources

R. Honeycutt, *Acoustics in Performance*, Elektor International Media, 2018.

M. V. Pollio, *Ten Books on Architecture,* Volume 5.

L. Tapio, "Tasting Music Like Wine, Sensory Evaluation of Concert Halls," *Physics Today*, Volume 67, No. 1, pp. 27-32, 2014.

Acoustic Solutions Round-Up 2019

Feel Good Spaces

By
J. Martins
(Editor-in-Chief)

Once again, *audioXpress* has compiled an Acoustical Solutions Round-Up, highlighting the newest products and solutions that help deal with unwanted problems such as excessive reverberation, resonances, and noise. As always, we looked for a combination of "first-approach" acoustic solutions, together with materials that are the foundation of any good acoustics project in recording studios to music listening rooms and home theaters, and also for offices, restaurants, schools, and any type of working or public space.

Unfortunately, in many projects, acoustics continues to be the last discipline to be considered, after critical decisions have been taken regarding the use of construction materials (e.g., glass, brick, and concrete), which can destroy intelligibility, ruin the music experience, and cause discomfort. And too often, an acoustics consultant is called long after money was spent on purely decorative elements of interior design. It's never repeated too often that unless a project is planned from the construction stages or with an integrated multidisciplinary approach, solving the really difficult acoustical problems becomes exponentially more expensive, while the efficiency of the solutions themselves becomes progressively limited—the law of diminishing returns.

Fortunately, acoustical solutions companies are also stepping-up their education and marketing efforts, promoting the much needed solutions to deal with those problems early, while there's also an increasing understanding of the basic approaches that place acoustics at the heart of any space. A good example might be the number of conference and collaboration spaces increasingly added to offices and corporate spaces, where acoustics are front and center, and inevitably help promote the concept of spaces where communication is enhanced and there's a sense of well-being, which sooner or later, people will want to replicate elsewhere.

Auralex Acoustics T-Coustic Ceiling Tiles

Updated Acoustical Treatment

Auralex Acoustics now offers an updated version of its T-Coustic Ceiling Tile, using a 1" thick absorptive fiberglass core that offers 20% to 45% higher NRC ratings than standard tiles.

Many commercially available "acoustic" ceiling tiles are actually fairly reflective at low, mid, and high frequencies, so they're not very good absorbers. Auralex T-Coustic Ceiling Tiles is a line of fiberglass ceiling tiles that offers desired aesthetic qualities, higher absorption coefficients, and are designed to fit into standard drop tile ceiling grids.

T-Coustic tiles reduce unwanted reflections in the room by reducing the amount of reverberation present. The result is a noticeable improvement in speech intelligibility. Sized to fit standard 2′ × 2′ and 2′ × 4′ ceiling grids, they're perfect for sound-critical spaces such as offices, conference rooms, medical facilities, and basement environments. The tiles are available in non-woven white scrim matte finish, with a black fabric color option and are "Class A" Fire-Rated per ASTM E-84.

www.auralex.com

Auralex EcoTech Eco-Friendly Acoustical Treatment Solution

The EcoTech Acoustical Panels from Auralex are a cost-effective eco-friendly fire-rated acoustical absorption solution that can be installed on walls and ceilings. Offering great absorptive properties and serving as an excellent way to improve speech intelligibility, EcoTech panels have been updated with improved fire, moisture, mold, and bacterial resistance. These panels are lightweight, easy to handle, and easy to install. The white color blends into many residential and commercial spaces, and the panels can be easily cut to fit. EcoTech panels are made of 60% recycled content and are recyclable and non-toxic. They emit no dust, and will cause no itching or skin irritation. Available in 2′ × 2′ and 2′ × 4′ sizes, with a 1" thickness, EcoTech panels provide an NRC of 0.70 and are fire-rated Class A per ASTM E-84.

www.auralex.com

Vicoustic New-Generation Acoustic Panels

Eco-Friendly and Versatile Solutions

The Portuguese manufacturer of acoustic solutions, and an industry pioneer in easy to deploy and aesthetically pleasing acoustical products, has completely revamped its catalog and corporate identity in 2019. Vicoustic introduced a new logo, considerably increased its team of acoustic engineers and designers, expanded its worldwide presence to more than 70 countries and, more important, introduced a new generation of acoustical solutions that are better tuned to the needs of the global market. With products now classified according to applications in Home Cinema and Hi-Fi, Professional Audio, Public Spaces, and Working Spaces, Vicoustic increasingly strives to meet the demands of spaces that require a sophisticated soundscape, with products of superior functionality and adaptability, but that are also sustainable and environmentally friendly.

That approach starts with apparently simple things such as the new fixing profile for acoustic panels, which the company demonstrated at recent events. By adopting a multilayered approach to acoustical surfaces, Vicoustic designed a new generation of mounting frames and fixing bases—the new VicFix Base acts as an absorption and isolation layer—to where any type of acoustic panels can be simply juxtaposed to a simple double-V-shaped slide rail.

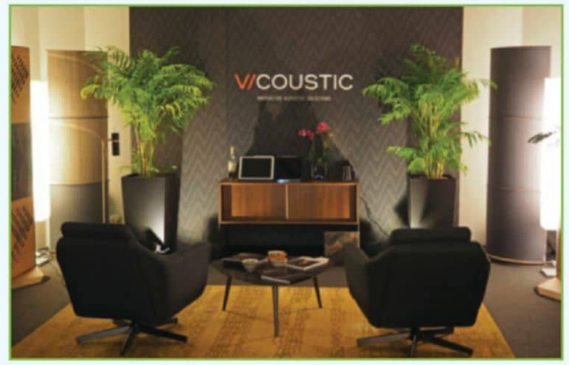
Alternatively, the VicFix J aluminum rail profile provides a similar mounting solution and is easy to fix on walls and ceilings. This new mounting shape is part of the panel design, requiring no additional parts or materials on the panels, and simplifies the entire installation process, providing a solid way to create acoustically treated surfaces that can be easily cleaned and renovated whenever needed. The design is extremely effective for listening rooms and home cinemas, but can be just as easily adopted in large rooms.

Sustainable

Producing acoustic solutions in a sustainable and environmentally conscious way has been at the forefront of Vicoustic's mindset for some time. In 2017, Vicoustic began the development and production of a new, sustainable raw material called VicPET Wool, leading to the introduction of the first product line using this material, Vicoustic VMT.

PET Wool is a non-woven textile with superb acoustic performance, predominantly made from recycled plastic bottles. Through extensive research and testing, Vicoustic fine-tuned this material, which can now be found across a range of Vicoustic products. This includes acoustic panels and clouds such as Flat Panel VMT, ViClouds VMT, VicWallpaper, and many new products.

This research lead to the production of acoustic products during 2018 using more than 84 tons of plastic waste, an equivalent of roughly 7.5 million standard PET bottles being recycled. The



Details of the new Vicoustic Mounting system with the VicFix J profile (right) and VicFix Base and panels (left).

Acoustical Solutions Update

commitment to making products in an environmentally friendly way is also being extended across the entire Vicoustic product line and is an integral part of future product development. The goal is to replace all foam-based products with VicPET Wool and be a leading example for the use of sustainable materials. However, sustainability is not limited to manufacturing. Vicoustic's aim for a greener product is also in the quality and durability of their creations.

Alongside VicPET Wool, Vicoustic is also using melamine combined with MDF. This is an extremely resistant raw material that allows a high consistency and intensity of color than wood. Using this material not only contributes to the preservation of natural resources on the planet, but also allows for products that are more durable and environmentally conscious whilst maintaining a superior acoustic performance.

An example of the new VicPattern Ultra Lilly, inspired by Portuguese tiles.

New Generation Panels

Implementing this research and eco-friendly approach, Vicoustic has been busy designing new acoustic panels that also feature new finishes and the increasing use of ethnic patterns that are proving extremely popular all over the world.

An example is the new VicPattern Ultra Series, a high-performance sound absorption panel with an innovative design, created for the most demanding interior designers and acousticians where aesthetics is a must. The panels are available in multiple finishes and patterns, which can be easily visualized on the company's website. Manufactured with high-quality fire-rated MDF, VicPet Wool, and anti-scratch melamine, VicPattern Ultra panels provide medium- and high-frequency absorption (NRC: 0.65), are polyurethane free, recyclable, and feature removable filling to allow passing lighting and sound cables where needed. The new panels already use the VicFix J Profile professional mounting system.

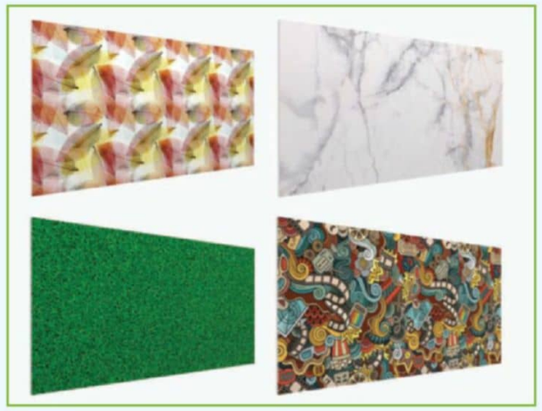
Another new panel is the updated Wavewood, which acts as an absorber at medium frequencies and diffuser at high frequencies, using nonlinear, sequential cavities. The Wavewood panel is one of the leading solutions in the Vicoustic portfolio—part of the Absorption and Reflection Control System (ARCS) research—an ideal solution when striving for a balanced sound that can also, simultaneously, control any noise energy in a room (NRC: 0.70). Made with highly durable melamine, the Wavewood panels combine specially engineered PET wool, are available in 10 different colors/finishes, and also use the new mounting system.

The new generation Wavewood panels (providing absorption and reflection in the same surface) now combine specially engineered sustainable materials.

But probably the best expression of Vicoustic's new eco-friendly approach is the new Flat Panel VMT, a new product range for residential and commercial applications. Created exclusively from VicPET Wool produced mainly from recycled plastic bottles, and using an innovative dyeing technology, the Flat Panel VMT panels can simulate concrete, marble, wood, and other materials. The panels are designed to perform primarily in the medium and high frequencies and can be used on ceilings and walls, creating endless surfaces that are perfect for both new construction and refurbishment projects. The VMT range can be fixed to any surface, using from simple Velcro (included) to other more long-lasting mounting solutions available (sold separately).

The Flat Panel VMT panels are available in different sized modules and two different thicknesses (20 mm NRC: 0.55, or 40 mm NRC: 0.60), are washable and scratch resistant and have fire ratings according to European, US. and Canada safety requirements.

www.vicoustic.com



Flat Panel VMT panels are available in amazing textures and are exclusively made from VicPET Wool, produced mainly from recycled plastic bottles.

GIK Acoustics Room Acoustics Visualizer

A Good Head Start

Founded in Atlanta, GA, in 2004, GIK Acoustics-U.S.A. and GIK Acoustics-Europe (based in Bradford, UK) manufacture and sell bass traps, acoustic panels, and diffusors around the world, and offer a large selection of high-quality products at affordable prices, supported with a professional design department to achieve a quality acoustic space.

But with the scope of projects and clients expanding every day, the company has also been working on a way to better support the market and recently rolled out some major changes in the way people can order on its website. The company has taken the guesswork out of selection and design, namely how it will look once it is installed in the actual space.

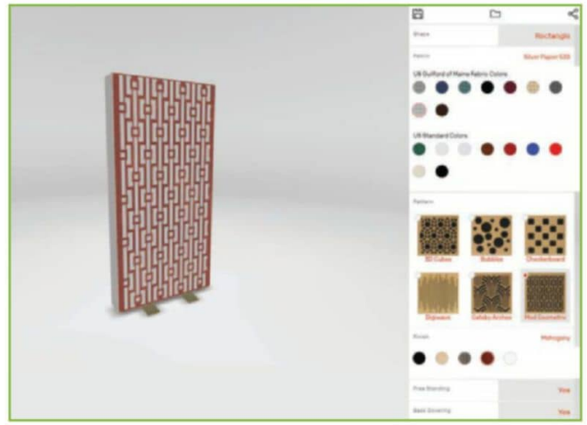
GIK Acoustics has already introduced product customizers on many of the company's popular products, making it easy to see what colors and shapes will look like hanging on the wall, but more recently introduced another online visualization technology—the Room Acoustics Visualizer.

This visualization tool enables users to build their own rooms and place GIK products inside a virtual reality framework. The free in-browser 3D design program does not require any installation and lets users see how their rooms will look before they purchase, and take the guesswork out of designing a space.

Users can design their own rooms down to the dimensions, or start from one of the available pre-set designs. GIK Acoustics assembled a number of pre-set plans that their project department commonly sees, which closely follow the company's suggestions for acoustic treatment.

Some of the features include two-dimensional, three-dimensional, and virtual reality views, enabling users to walk around inside the room, with everything being customizable and movable. Users can change the colors, sizes, and designs of the panels as well as the walls, the furniture, and more. Overall, it is a way to provide a great experience while shopping for acoustical solutions and avoid surprises when placing an order.

www.gikacoustics.com/room-acoustics-visualizer/



The Room Acoustics Visualizer is currently in beta version on the GIK Acoustics website. The online tool is free to use. Users will be able to register and sign up to save or share their designs.

The visualization possibilities are a valuable way to give someone a head-start to designing effectively, while making a room sound better.

GIK Acoustics allows clients to create a virtual layout and customize everything.

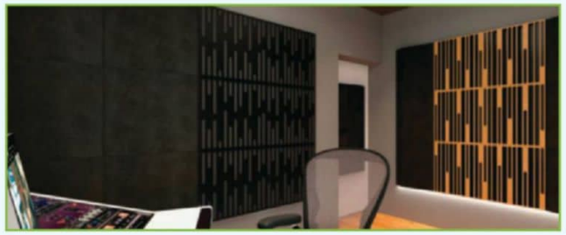
Shaping Sound with Artnovion

New Lagos and Aries Diffusers

Based in Portugal, in the northern industrial region of the country known as one of the leading furniture production hubs in the world, Artnovion was founded in 2015 by acoustical engineer and visionary entrepreneur, Jorge Castro.

Quickly established at a global level as one of the most innovative manufacturers of high-quality, affordable acoustic products, Artnovion built an extensive portfolio that includes a range of absorption and diffusion panels, bass traps, portable acoustic products, and variable acoustic

The new Lagos diffuser panel is available in natural wood veneer and lacquered HMDF and was designed to be used with other Artnovion products, having the same thickness as the brand's standard absorbers.



The Aries diffuser was optimized for a broadband response as required in professional studios and recording applications.

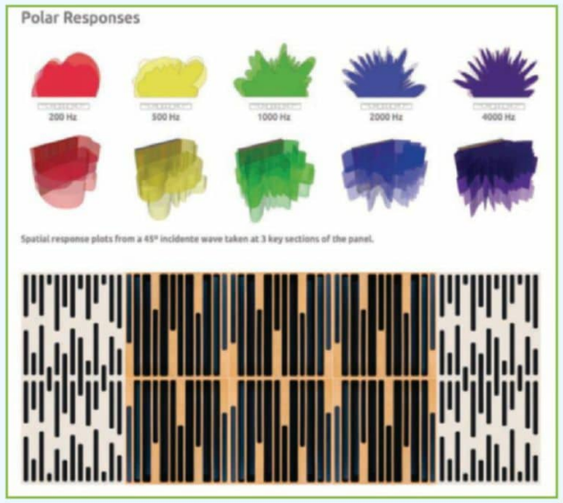
solutions. Artnovion's three business divisions—Pro Audio & Studio, Residential & Hi Fi, and Architectural & Engineering—support a growing international customer base and its products are distributed worldwide.

With room design gaining more importance in the hospitality, corporate, residential, and professional audio markets, Artnovion stands out for the elegant design of its products and leading research in diffusion and advanced absorption solutions working with leading universities and European research institutions. Its acoustic products not only use the latest technology advances in acoustic treatment but are always innovative in all aspects of design, from practical and versatile mounting solutions to unique high-quality finishes.

The latest releases from Artnovion are the result of extensive exploration into the science of diffusion, a prime component of any balanced acoustic treatment, improving speech intelligibility, music quality, and creating a more uniform, larger sweet spot.

This is essential in any dedicated listening or studio environment—while also treating phenomena (e.g., flutter echoes and phase cancelling). The lower energy scattered waves mimic the effect of wave decay over long distances, making it sound like the room is larger than it truly is—an important tool for smaller rooms.

Diffusers are generally tuned to work in a certain frequency range using a certain texture surface sequence—the larger the building scale, the lower the frequency range covered. With many QRD and MLS sequence diffusers, this sequence is usually mirrored over the panel. While this is good practice to tune the panel, when scaled and used in larger arrays this creates periodic lobing—basically a non-uniform scattering, that is the opposite of the desired function.



Designed using a combination of computer simulation and extensive measurements in real environments, the Aries diffuser is only 60 mm thick but provides extended low-range diffusion and prevents lobing when used in larger arrays.

Lagos Diffuser

Lagos is the result of extensive research into diffusion techniques—it is based on a traditional QRD diffuser, but combines varying widths with each cell depth, overcoming some of the limitations of the standard QRD diffuser.

The phase grating surface of the diffuser is designed to provide a more uniform sound field through mid-high frequency diffusion. The well depths are individually tuned to enhance performance at certain frequencies, essentially increasing the effective range of the panel, without compromising the overall linear response. According to Artnovion, the result is that Lagos performs 15% to 20% lower with a linear frequency response.

The panel's semi-cylindrical response pattern make it the perfect solution for multichannel rooms and can easily be installed in specific arrays to provide 2D diffusion.

Lagos panels are available in both wood and fabric finishes with a scattering range from 350 Hz to 6,000 Hz and are ideal for Hi-Fi listening rooms, media rooms, and home cinemas. The fixing system is already integrated on the panel.

Aries Diffuser

A similarly engineered solution better adapted to the professional audio market, the new Artnovion Aries Diffuser was designed using various diffusion techniques—inspired from traditional numeric sequence diffusers. The panel is composed of asymmetrical multi-depth wells in which specific wells use a folded-depth technique to boost the mid-low diffusion range.

While the panel itself is only 60 mm thick, the extended wells on the diffuser are designed to be effective at 160 Hz and 400 Hz, with a linear diffusion pattern from 700 Hz upward—providing an unheard-of diffusion capacity for its size.

The asymmetric wells are also arranged in an optimized sequence to prevent lobbing when used in larger arrays. In combination with the extended low-range diffusion, Aries surfaces can go lower and outperform any other diffuser in its class, a clear advance in performance over the traditional QRD design.

The new Aries panels are recommended to enlarge the sweet spot and provide specular reflection and flutter echo control in all types of control rooms and recording spaces. The integrated fixing system allows easy installation and the panels can be rotated 90º to any orientation.

www.artnovion.com

Acoustic Geometry Pro Room And Home Room Packs

Ready to Use First-Approach Solutions

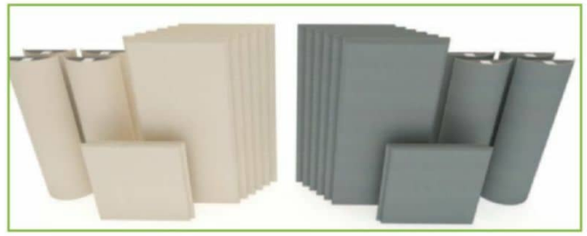
Acoustic Geometry continues to offer innovative, effective, and affordable acoustic and noise-control products for a wide range of professional audio, residential, and business applications. The company's Pro Room Packs are a unique set of acoustical products aimed at the professional audio market while the Home Room Packs are a cost-effective grouping of acoustical products designed for residential audio spaces.

Each set offers balanced room audio treatments ideal for all applicable settings, be it a home theater or high-end recording studio, while incorporating a visually appealing design element.

Delivering professional-level acoustical performance at four cost-saving price points, Acoustic Geometry's Pro Room Packs combine phase-coherent diffusion, proven low-frequency room mode mitigation and broadband sound absorption. These combinations will greatly benefit nearly all audio spaces, including recording studios, audio post-production rooms, high-end two-channel listening rooms and dedicated home theaters.

Pro Room Packs are available in six "ship-from-stock" fabric color options and 23 additional colors requiring a bit longer lead time. Colors range from the most popular, Onyx and Birch, to unique color textures such as Beach Glass and Sandy Pebble. Available as Pro Room Packs 6, 8, 10, and 12, all packages include Fabric-Wrapped Panels and Ceiling Clouds (absorbers), Curve Diffusors, CornerSorbers and a complete set of mounting hardware.

Pro Room Packs are a unique grouping of acoustical products aimed at the professional audio market. Packages for studios and high-end audio rooms include Fabric-Wrapped Panels and Ceiling Clouds (absorbers), Curve Diffusors, CornerSorbers, and all mounting hardware.



Acoustic Geometry's Home Room Packs are a cost-effective grouping of acoustical products designed for residential audio spaces, including ready-to-ship diffusers and absorbers in two different neutral finishes.

Home Room Packs

A cost-effective grouping of acoustical products designed for residential audio spaces, Acoustic Geometry's Home Room Packs were designed to address a range of common residential acoustical challenges. This includes reducing echo and reverberation in small spaces (Pack 1 or 2) or combining broadband sound absorption with industry-leading phase-coherent diffusion (Packs 3, 4, or 5).

Room Pack 1 includes a set of six Fabric-Wrapped Panel sound absorbers that improve the sound of smaller rooms, such as family rooms, dens, or libraries. Pack 2's four additional larger and thicker Fabric-Wrapped Panel absorbers make it ideal for controlling sound in small home theaters and medium-size media rooms.

The small Curve Diffusors included in Packs 3 and 4 evenly scatter sound energy, which results in an evenly distributed sound-field that will greatly benefit medium to large theaters, listening rooms, and home studios. Home Room Pack 5 includes medium and small Curve Diffusors, making it a great value for larger home theaters, listening rooms and home recording studios applications.

These five product packages are a visually-elegant option for any room in the home, with two "ship-from-stock" fabric color options, Serengeti or Graphite. Just like the Pro Room Packs, other basic fabric colors will have a slightly longer lead time. Mounting hardware is included for all products in every Home and Pro Room Pack.

In order to increase exposure within the retail markets, Acoustic Geometry recently expanded availability of its Pro Room Pack and Home Room Pack solutions at Best Buy's Magnolia Home Theater locations.

www.acousticgeometry.com

JOCAVI Advanced Diffusers and Absorbers

Solutions for the Most Demanding Ears

Founded in 1992, JOCAVI was the original acoustic solutions manufacturer that placed Portugal on the map as one of the leading global producers of acoustic panels, combining the expertise in audio engineering and acoustic science with the love for music of the company's founder—João Carlos Vieira.

Always admired for its advanced designs and the serious science applied to all its products, JOCAVI has gradually expanded its portfolio from simple practical recording solutions and commercial recording studios, all the way to large-scale installations in auditoriums and concert halls worldwide, as well as industry and public spaces.

The company is recognized for creating "solutions for the most demanding ears," and for unique flagship products that are recognized by leading acousticians and designers all over the world. Its catalog with more than 500 Acoustic Treatment and Acoustic Insulation products is now available for direct purchase in the US through the JOCAVI online store, at AcousticShop.net.

Always more focused on the professional audio industry, JOCAVI gradually expanded into other market segments, even if its main source of inspiration always has been the challenges faced by "demanding ears," such as those of audio engineers.

The most recent expansion of JOCAVI's catalog for 2019 reflects that passion for engineering, focusing on perfecting and refining new types of absorption and diffusion panels that deliver superior performance levels. These include two new high-end diffuser acoustic panels - WOODquad and the TWIN - together with four new high-end low-frequency tuned absorbers: the HUMcut BXW, HUMcut BXA, Tonal Wall and Tonal Corner.

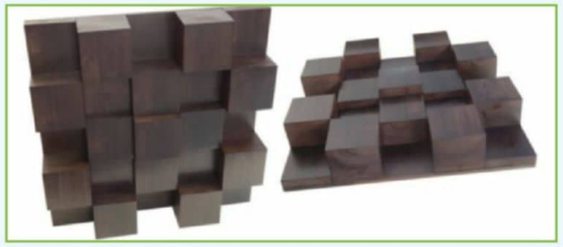
Acoustical Solutions Update

WOODquad Alure

The WOODquad is a two-dimensional quadratic residue sound diffusor created to expand effective acoustical solution options, anchored in classical designs. It is designed to provide a more uniform sound field through mid and high frequencies, providing wide angles of incidence, and offering optimal hemispherical scattering to control primary reflections.

This wood diffusion panel provides large spectrum bandwidth diffusion in a single integrated piece with minimal depth, offering the uniform scattering properties of a quadratic diffuser in a modern, more aesthetically pleasing alternative.

Applicable to both ceiling and walls, the WOODquad is made of solid, self-sustainable forest pine wood with a finish of five different colors of ecological veneer.



Manufactured in pine wood, the WOODquad two-dimensional diffusor uses 2D QRD reflection phase grating that offers acoustically pleasing results and is aesthetically very attractive.

TWIN Options

The new JOCAVI TWIN panel is both an absorber and diffuser element, purposely designed to combine both features, balancing these two assets perfectly in a symmetrical way. With its ingenious design, the TWIN enables the creation of uniform surfaces with a single model that softly absorbs the sound waves while maintaining the vivacity of the musical instruments' harmonics, which is vital for a natural acoustic environment.

A great combination of absorption and diffusion patterns, the TWIN panel is an essential product when a better control of high-frequencies is required, adding some absorption to the mid-range of the sound spectrum. Avoiding an excess of absorption, the panel provides a balanced combination of diffusion to demanding acoustic environments, reaching the required acoustics when combined with low-frequency bass traps. An ideal solution for music study rooms, piano and acoustic instrument rooms, live rooms, auditoriums, theaters, as well as all the spaces that need specific care on sound intelligibility.

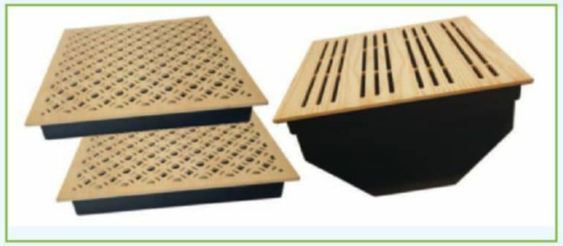
The TWIN panels are manufactured with recyclable High-Impact Polystyrene (HIPS) and melamine foam with a velvet finishing providing an average diffusion of 0.61/m^2 (>100 Hz;<5 kHz) and NRC of 0.70/m^2 (>250 Hz;<10 kHz). All installation accessories are included and multiple color options are available.

A modern example of an acoustic treatment solution, the TWIN combines absorption and diffusion using a combination of HIPS and melamine with a velvet finishing and RAL colors available.

Tuned Absorbers

The latest low-frequency membrane absorption panel from JOCAVI, the HUMcut BXW, is tuned to 125 Hz and is meant to be used in flat surfaces like walls and ceilings. The principle used in this model combines a HIPS box, which has an appropriately closed resonance box with mass and density components. The front plate is made of wood and several punching patterns and colors are available.

In order to archive the best results, this model can be used in combination with the also new HUMcut BXA panel, tuned to 63 Hz, meant to be used in 90° corners. The combination of these two models, placed on the corners and walls, greatly broadens the low-frequency absorption capacity as it extends the absorption range to the previous harmonic frequency. Both panels are made of 100% recyclable materials, with the front plate using natural wood veneer.



The new HUMcut BXW and HUMcut BXA tuned low-frequency absorption panels are meant to be applied in ceilings, walls and corners, expanding their effect. The front plate is made of wood and recyclable materials.

Two other new absorption solutions in JOCAVI's portfolio include the Tonal Wall and Tonal Corner. Tonal Wall is a low-frequency membrane absorbent panel in fabric finishing, tuned at 125 Hz, and designed to be used in flat surfaces like walls and ceilings. It was developed to fine tune the modal distribution of small rooms such as studio control rooms and home theaters, and can be combined with Tonal Corner, in order to enhance bass absorption. Tonal Corner is a low-frequency membrane absorbent panel designed to fit 90° corners, and its available tuning frequencies are 40 Hz, 63 Hz, and 80 Hz. This combination is one of the best ways to treat low-frequency problems in small- and medium-sized rooms.

www.jocaviusa.com | www.acousticshop.net | www.jocavi.net

Acoustical Surfaces Introduces Envirocoustic Wood Wool

Acoustical Surfaces, Inc. (ASI), a pioneer in the business of controlling sound serving the commercial, industrial, educational, house of worship, and OEM markets, announced its new Envirocoustic Wood Wool acoustical wall and ceiling panels. Available in several variations, the panels offer a high-quality acoustical product featuring square corners and consistent thickness at a cost-effective price.

"We are proud to offer this high-quality acoustical panel at such a competitive price," says J.R. Andersen, president of ASI. "This new solution offers NRC-rated sound absorption, panel durability, and stock and custom colors for various applications including gymnasiums, classrooms, restaurants and bars, manufacturing and industrial facilities, parking garages, airports, and more."

The Envirocoustic Wood Wool manufacturing process creates a panel with less dust, allowing for cleaner installations and environments. The panels come in natural and white finishes, and are also paintable with vivid SonoKote colors. ASI is also addressing the need for consistent-thickness panels. The stock wall and ceiling direct-attach panels are beveled and have a tight thickness tolerance (±0.005) compared to competitors. The same tolerances hold true for the regular ceiling tiles. In addition, while competing panels are often inconsistent in shape, ASI's Envirocoustic Wood Wool panels have consistently-square corners, which also makes installation easier and provides a clean final appearance.

"Envirocoustic Wood Wool also has environmental advantages," continues Anderson. "The product is Class A fire rated, has a low VOC and is made of three simple ingredients: wood fiber, cement, and water. All these factors contribute to a refined, economical and great-looking final product."

www.acousticalsurfaces.com

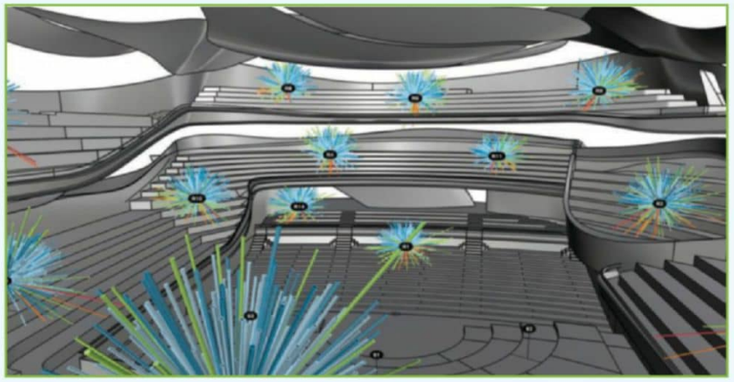
Envirocoustic Wood Wool panels can be mounted in ceilings or walls, are paintable and available with a wide range of SonoKote colors, and are an effective sound absorber.

An eco-friendly, high-performance, cost-effective acoustical-panel products category, Envirocoustic Wood Wool performs well by absorbing sound while thermally insulating.

IRIS Acoustic Measurement and Visualization Software

Something New in Room Acoustics

Part of the ACOEM Group of companies, active in air, noise, and vibration pollution control as well as protection solutions for the industry and military, French company 01dB is a leading manufacturer of vibration and noise monitoring, sound-level meter/analyzers, and room acoustics solutions. In partnership with Marshall Day Acoustics—the famous international acoustic consultancy firm, one of the largest acoustic engineering firms worldwide, with offices in New Zealand, Australia, China, Hong Kong, and France—01dB created IRIS, a powerful measurement tool for room acoustics.



Leveraging the power of modern computers and 3D simulation tools, IRIS is a powerful and user-friendly measurement system for capturing and analyzing spatial room impulse responses in 3D, already recognized by an independent study published in the April 2017 edition of the *Journal of the Acoustical Society of America,* as the most easy-to-use room acoustics measurement solution.

The system was designed by acousticians for easy reliable and efficient measurements in real-world situations, and enables to compare the acoustic performance between different positions/seats and to correct architectural aberrations.

The IRIS measurement system uses a simple compact tetrahedral microphone array—such as the Core Sound TetraMic (www.core-sound.com)—which is placed at the desired receiver

position. The room is excited by a loudspeaker at the source position, driven with a single swept sine stimulus. The IRIS software provides the stimulus, records the room's response and processes and visualizes the results immediately. A single Ethernet cable is used to transfer the microphone signals.

The system allows users to view and analyze the acoustic impulse response in a room with 3D incoming sound rays, while the software calculates the main acoustic performance indicators. The IRIS plot is at the heart of the IRIS system, where sound rays arriving at the measurement position are represented as a series of easy to identify colored spikes, immediately after the measurement is conducted.

Examples of measurements made with the IRIS system by Marshall Day Acoustics for the Philharmonie de Paris acoustic design project. (Images courtesy of Marshall Day Acoustics)

The IRIS plot can be used to relate sound rays to physical features of the room, observe the directional distribution of early and late sound energy, as well as identify surfaces causing problematic reflections. Each ray provides numerical magnitude, direction, and time information for comprehensive analysis.

IRIS accurately captures how the room's surfaces direct sound to the receiver position in three-dimensions. The 3D image plot displays the measurement via the easy-to-use interface, generating an efficient visual comparison of the acoustical properties within a room, or between different rooms. IRIS can also be used to identify late reflections, or to identify the effect of specific reflective or absorptive surfaces within the room.

www.01db.com | www.iris.co.nz

Acoustics Vendor and Services Directory

acouStaCorp
www.acoustacorp.com

Acoustic Fields
www.acousticfields.com

Acoustics First
www.acousticsfirst.com

Acoustics in a Box
www.acousticsinabox.com

Acoustic Manufacture
www.acousticmanufacture.com.pl

Acoustic Systems
www.acousticsystems.com

Acoustic Sciences
www.acousticsciences.com

Acoustical Solutions
www.acousticalsolutions.com

Acoustical Surfaces
www.acousticalsurfaces.com
www.asiproaudio.com
www.proaudioacoustics.com

Acoustic Geometry
www.acousticgeometry.com

Artnovion Acoustics
www.artnovion.com

Aural-Aid
www.auralaid.com

Auralex
www.auralex.com

ClearSonic
www.clearsonic.com

Delta H Design
http://deltahdesign.com

Eccentricity of Wood
www.woodblocks.design

GIK Acoustics
www.gikacoustics.com

Golden Acoustics
www.goldenacoustics.com

G&S Acoustics (Golterman & Sabo)
www.gsacoustics.com

International Cellulose Corp. (ICC)
www.spray-on.com

ISOacoustis
www.isoacoustics.com

Jocavi Acoustic Panels
http://jocavi.net

Listen Audio Systems
www.listen-speakers.com

Media Specialty Resources
www.msr-inc.com

Overtone Acoustics
www.overtoneacoustics.com

Pinta Acoustic
www.pinta-acoustic.com

Primacoustic
www.primacoustic.com

Prosocoustic
www.prosocoustic.com

Ready Acoustics
www.readyacoustics.com

RealTraps
http://realtraps.com

Resolution Acoustics
www.resolutionacoustics.com

RPG Acoustical Systems
http://rpgacoustics.com

Silent Source
www.silentsource.com

Sonex
www.sonex-online.com

Vibrant Technology
www.vibetech.com

Vicoustic
www.vicoustic.com
www.audioplusservices.com

VocalBooth
www.vocalbooth.com

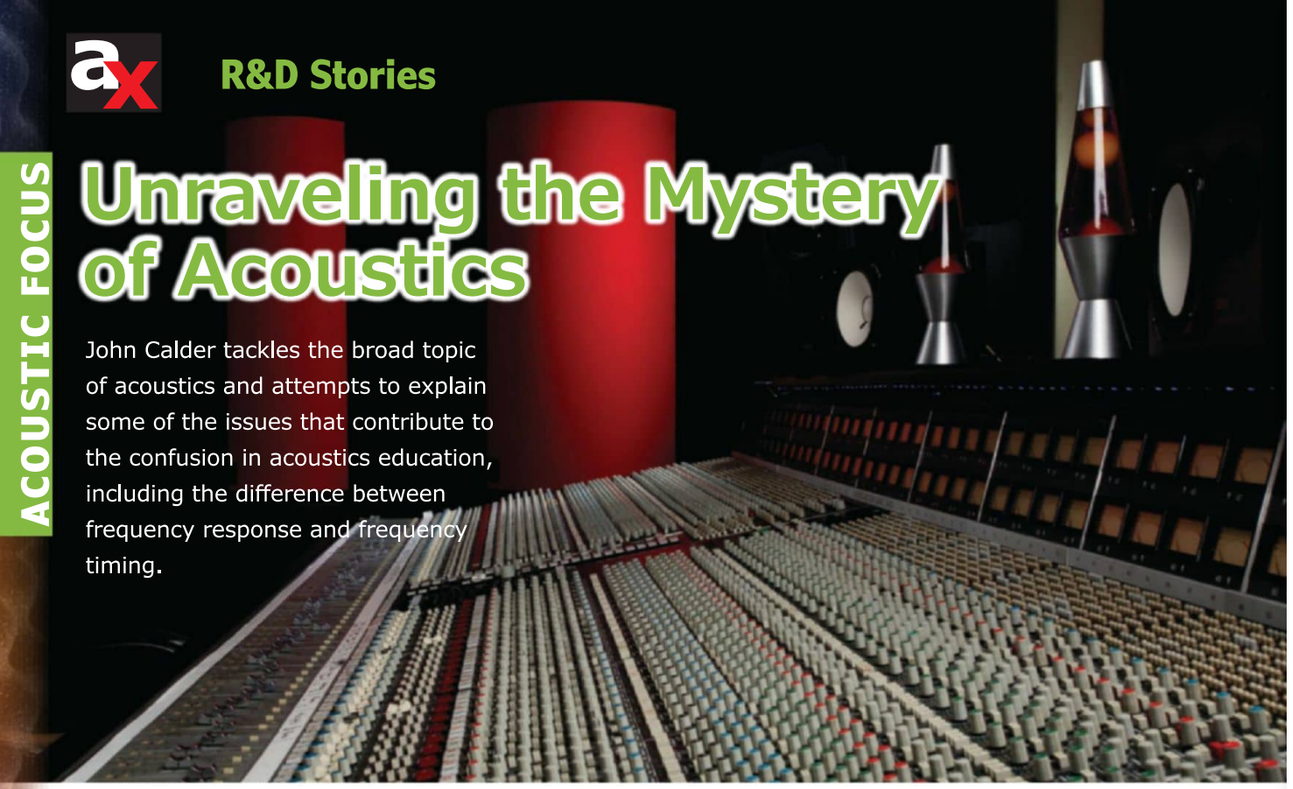
Wenger Corp.
www.wengercorp.com

WhisperRoom Sound Isolation Enclosures
www.whisperroom.com

R&D Stories

Unraveling the Mystery of Acoustics

John Calder tackles the broad topic of acoustics and attempts to explain some of the issues that contribute to the confusion in acoustics education, including the difference between frequency response and frequency timing.



Curve diffusors are shown inside a studio. (Photo courtesy of RiverRock Studios)

By
John Calder
(Acoustic Geometry)

Of all the "niche" topics in the wide world of sound, "acoustics" tends to bring out the most wild-eyed (wild-eared?) assumptions, even when compared to DIY speaker topics. At least that's how it feels to those of us who work in the acoustical-product trenches.

As a modern science, architectural and room acoustics began with Wallace Clement Sabine in 1895. His work was groundbreaking in an era of nearly zero sound-measurement capabilities. Equipped with only a stopwatch, auditorium seat cushions, and his ears, he brought something previously thought of as "art" into the realm of the scientific method.

After more than a century of scientific research and development, it would be forgivable to assume that acoustical science hasn't finished any "new" work and is now simply refining what is known. However, that's not the case. Aside from the growth of many different disciplines (e.g., underwater, ultrasound, and insect-sound acoustics), there is still a lot of work to be done for room acoustics.

The biggest single issue in acoustics education is the nearly exclusive focus on frequency response and the corresponding lack of attention on timing or phase response, and the available testing protocols for each. Most of us in audio believe we understand frequency response—this is not true for timing response.

Human hearing systems with no age- or loudness-related losses can detect frequencies from 20 Hz to 20,000 Hz and, if the frequency response of a sound recording or reproduction system is "flat," we tend to think all is well. Linear or flat frequency response has been the "holy grail" for sound equipment since the vacuum tube was invented. For electronics, it has largely been achieved. Accurate frequency response testing procedures are well-established and nearly any analog or digital electronic system is now capable of flat frequency response, except for microphones and loudspeakers, which suffer from... acoustics.

Sound in Air

In acoustics or, as I'm fond of saying, "sound in air," there is a problem: the effects of sound reflections from boundaries in rooms.

Boundaries—large flat solid surfaces (e.g., walls, floors, ceilings, and small surfaces like tabletops)—can be very destructive to sound in air. Strong flat-surface reflections recombine with sound from original sources to cause distortions to the frequency response of the microphone or speaker. Those distortions—known as "comb filtering" because the resulting frequency response graph looks like a comb's teeth—have several cancellation dips throughout the audible range. This greatly affects the "naturalness" of a microphone's output signal, the accuracy of a loudspeaker's playback and, at a high-level view, the way we perceive all sound in rooms.

It's not as simple as "reflections in rooms are bad"—they're not. The right amount of echo and reverberation is usually perceived as "natural," if purposefully designed into a concert space or as short, well-distributed "ambience" decays in critical listening rooms (e.g., recording studios and high-end stereo rooms). It is the full-strength, flat-surface bounces that destructively alter the sound from original sources, whether live or reproduced. Mitigating strong sound bounces is what acoustic treatment products are supposed to do.

However, we're looking at the problem from the wrong end of the microscope. Yes, frequency response is destructively affected by undiminished and unchanged reflections, but it's not a frequency response problem. It's a timing response problem.

Why is that? When hearing audio directly from sources, whether live or reproduced, the sound waves are travelling through the air at about 1,130 feet-per-second. Sound arrives at your ears from its source, delayed by the distance (in feet) from the source divided by the speed of sound (in feet, usually stated in milliseconds). Reflected sounds arrive at your ears but are delayed more, because they are travelling farther.

Look at it as a triangle with one longer side and two shorter-length sides (see **Figure 1**). The long side represents direct sound from the source to your ears, the two shorter-length sides represent the path of sound from the same source reflected from a boundary. Adding the two short side lengths together gives you the total path length for the reflected sound, which is longer than the direct sound path. The sound at your ears then has two components—the direct and the delayed/reflected sound. The mixture of these components causes destructive interference, which alters the way you perceive the original sound. It's a timing response problem that creates not only comb-filtering frequency response problems but other issues (beyond just frequency response errors) that are more critical to accurate sound perception.

Problems Greater Than Frequency Response Errors

Wait, what? Problems greater than frequency response errors? Yep—here's why (not an opinion). Our hearing system is made up of two ears and dedicated sections of our brain (parietal and temporal lobes, cerebellum). This is an extremely important part of our survival mechanism and has been evolving for millions of years. Our hearing system is always awake (eyesight sleeps) and sensitive to any short, sharp sounds ("transients") that might represent a threat to us.

Your hearing system immediately tells you to wake up and tells you which direction the sound is coming from, based on if the sound arrives sooner at your left ear versus your right. This completely time-based bit of direction calculation is done in microseconds in your subconscious.

Thanks to our hearing system, our very accurate sound timing capabilities give us an accurate aural view of the world. With that capability comes the awareness of the spaces we inhabit. Recent research found human timing acuity to be up to 10 times more accurate than previously thought.[1]

We're very good at time-driven sound perception, and that makes acoustical timing accuracy in rooms far more important than frequency-driven perception—have you seen the Fletcher-Munson Response Curves?[2] Our hearing system is obviously nonlinear in the frequency domain and is much more sensitive in the middle frequencies, which equate to sensitivity to transient sounds.

The Importance of Acoustical Timing Accuracy

Let's back up a bit. I just said that acoustical timing accuracy in rooms is far more important than frequency accuracy. What does that mean?

Let's consider the room as the last component in your sound system, because it has a large influence on the accuracy of the sound you hear. Room boundaries—walls, ceiling, and floor—reflect original sound and cause delays, resulting in frequency-

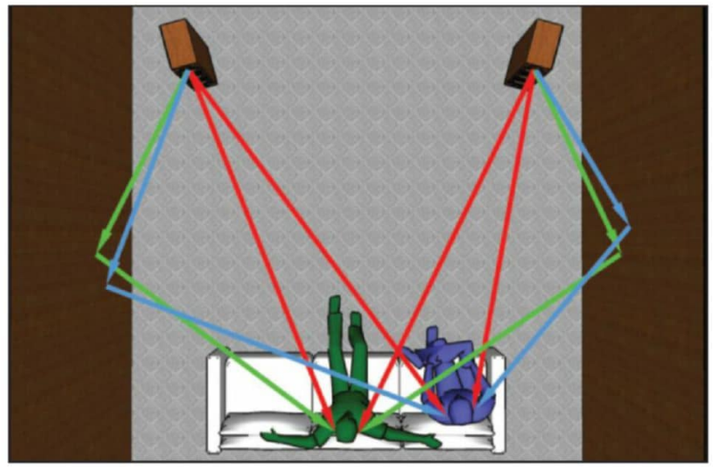


Figure 1: Speaker bounce is shown with no treatments applied.

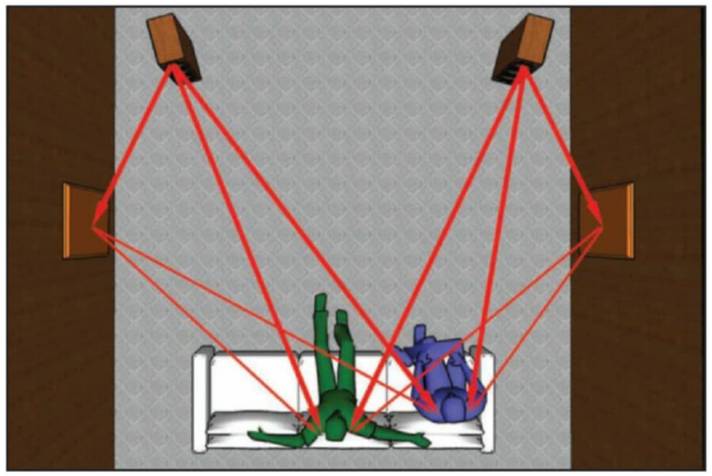


Figure 2: Speaker bounce is shown with absorbers in place.

domain problems. Delayed sounds also cause issues with directional accuracy (sound-imaging or sound-staging) that can destroy the illusion of an orchestra playing in your room. If the frequency response of a system can be degraded by room acoustics, imagine the greater degradation to the directional and "depth-of-field" information that is part of the sound. Our hearing system is much more forgiving of frequency response errors than of timing errors. A person can have the flattest sound system in the world, but if your room induces sizeable timing errors, it will not sound good.

The next question is, of course, how can a "time-accurate" room acoustic be created? The most frequent answer from people who are at least partly knowledgeable in acoustical products will say "add sound absorption panels" (see **Figure 2**). That's logical, but we've also discovered that too much absorption in rooms causes people to miss subtle changes in "pitch, loudness, and tone color."[3] A person can become habituated to "dead-sounding" rooms—there are probably thousands of overly-absorptive critical listening spaces in the US—but they can be inherently inaccurate and discomforting. They are imprecise in the frequency domain as well.

Here's why: nearly all "standard" sound-absorption products are frequency-band limited due to the nature of fiber- and foam-based absorber panels.

A common 2"-thick wall-mounted fiberglass panel is nonlinear above around 300 Hz and ineffective below 300 Hz (same-thickness foam panels are worse, becoming ineffective below about 1,000 Hz). These panels are more absorbent for high frequencies above 3 kHz. The result is a nonlinear sound decay signature that allows undiminished lower frequencies to reflect around the room until air friction absorbs them. There are other types of low-frequency absorbers, notably membrane-based, that respond more effectively to low-frequency boundary pressure than to fiber or foam,[4] but the room will still sound uneven or "dull" to most ears.

To find a solution to too much absorption, one must diffuse some of the flat-surface reflections rather than simply attempting to absorb everything. Spreading out the reflections allows some sound energy to remain in the room to be perceived as ambience, while still diminishing the amount reflected toward a listener's ears.

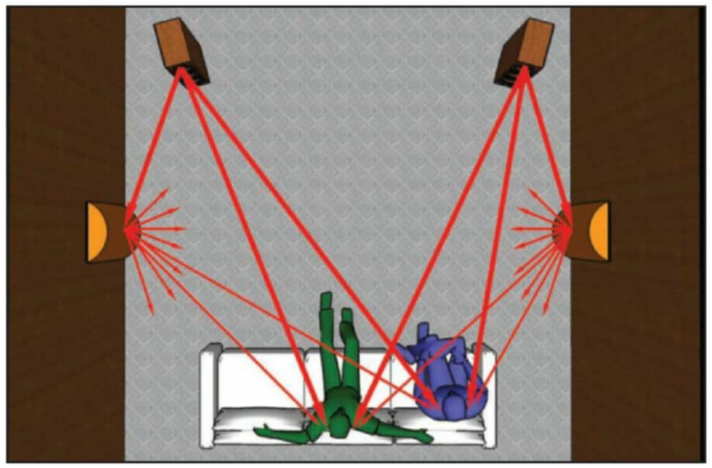


Figure 3: Speaker bounce is shown with bounce diffusors applied.

Diffusor Selection Is Critical

While diffusion products have gained acceptance in many professional uses, the type of diffusor is also critical. Over the last 30 years, there has been a shift away from "polycylindrical" diffusors, used in recording studios and concert venues in the early part of the 20th century, toward Quadratic-Residue Diffusors (QRDs). These use groups of small resonant chambers to delay designated bands of frequencies, then redirects those frequencies back into the space at different angles than they arrived. If this is done at multiple frequency bands covering a normally flat reflective surface, the result is a scattering of sound reflections at the designated frequency bands.

The serious problem caused by this approach is that the timing/phase of the reflected sound is intentionally distorted. When recombined with the original sound, it causes sound imaging and directional cue information to be scrambled. This is further aggravated when QRD panels are placed in the most effective locations to mitigate flat-surface reflections, a room's "first-reflection points," which are the first and worst places for sound to bounce on the way to the listener's ears, and are present on all wall, ceiling and floor surfaces. Typically, the worst of the first reflections occur at the side walls, near stereo speakers, where many acoustic consultants place absorber panels to reduce strong first reflections. Absorbers are frequency-dependent but not timing-dependent, which helps retain the timing information contained in the reflection, and that affects sound imaging less than the unabsorbed reflection. However, using QRDs in first-reflection points distorts important timing information—that's how they're designed—and therefore are most-often deployed in the rear of the listening space.

A second type of diffusion product is the cylindrical diffusor, which is phase-coherent. This means the reflected sound energy is not only spread out, reducing destructive interference from full-strength reflections, but also that the timing information in the reflected sound is altered very little in comparison to QRDs (see **Figure 3**).

Cylindrical (constant-radius) phase-coherent diffusors (see **Photo 1**) can be used effectively anywhere in the room with minimal damage to reflection timing accuracy, especially at first-reflection points, while still spreading out reflected sound energy and retaining a "naturalistic" level of delay ambience. This creates "hearing-friendly" sound environments more than absorption-only or QRD-type room treatments (see **Photo 2**).

Photo 1: Curve diffusors can be effectively used anywhere in the room. (Photo courtesy of Acoustic Geometry)

Testing Procedures

I mentioned at the beginning that available testing procedures and equipment are almost entirely frequency domain-based. This is because the test standards with which we measure acoustical properties have only been developed for determining reverberation times by frequency bands in

reverberant test chambers, and those test results (absorption coefficients) are calculated indirectly. We cannot directly measure absorption or diffusion and the testing standards themselves have come under increased scrutiny due to discrepancies in results across different test labs from the same testing standard.

To develop and promote intelligent decision-making about which tools to deploy to solve acoustical problems, several organizations work diligently with researchers, academic theorists and product manufacturers to design acoustical-testing processes and procedures with which to judge the performance of theoretical assumptions and practical acoustical products. People are then better able to compare the results of those tests and make informed decisions about which to use. Groups like the Acoustical Society of America (ASA), ASTM International, and the International Organization for Standardization (ISO) (see Resources) are part of a world-wide effort to improve the sound in spaces and for other acoustic disciplines (e.g., sonar-based undersea mapping and natural habitat mitigation).

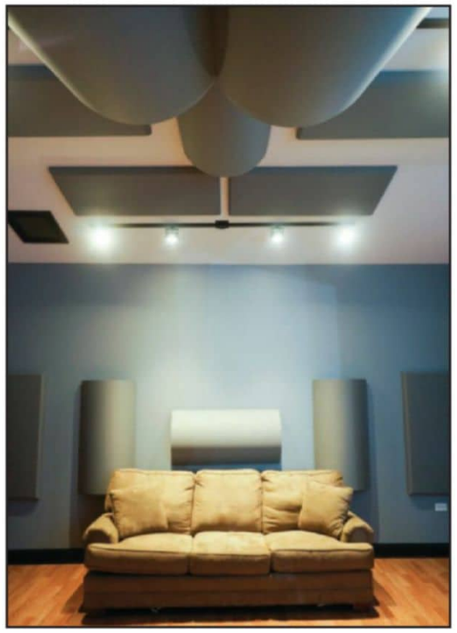


Photo 2: Curves are being used to create a more hearing-friendly environment. (Photo courtesy of Sound Vault Studios)

Resources

Several national and international non-profit and professional organizations review, regulate, and research acoustical knowledge and testing procedures:

- ASTM International (formerly known as American Society for Testing and Materials) is the standards organization charged with researching, creating and maintaining acoustical testing standards for commercial and academic laboratories globally; headquartered in West Conshohocken, PA. | www.astm.org
- Institute of Noise Control Engineering (INCE) has a stated purpose of promoting noise control solutions to environmental, product, machinery, industrial and other noise problems; based in Reston, VA. | www.inceusa.org
- International Organization for Standardization (ISO) is the group that develops and publishes international standards; headquartered in Geneva, Switzerland. | www.iso.org
- National Council of Acoustical Consultants (NCAC) is an organization "committed to supporting expert Acoustical Consultants and Engineers and providing a reference tool for the public to learn more about the profession;" based in Indianapolis, IN. | https://ncac.com
- The Acoustical Society of America (ASA) whose stated purpose is to generate, disseminate, and promote the knowledge and practical applications of acoustics; based in Melville, NY | https://acousticalsociety.org

These organizations, groups, and others have somewhat differing goals or points of view—and serve different professional and academic purposes—but they all encompass working toward a better understanding of acoustics and how acoustical science relates to human perception and the improvement of life.

About the Author

John Calder has more than four decades of professional sound experience, as a musician, recording engineer, studio owner, sound designer, and post-production audio mixer. Other credits include product developer, instructor, marketer and video producer. He is currently Director of Marketing and Communications for Acoustical Surfaces, Inc. and Director of Retail Sales for Acoustic Geometry.

References

[1] J. N. Oppenheim and M. O. Magnasco "Human Time-Frequency Acuity Beats the Fourier Uncertainty Principle," Laboratory of Mathematical Physics, 2013.

[2] H. Fletcher and W. A. Munson, "Loudness, its definition, measurement and calculation," *Journal of the Acoustical Society of America*, Volume 5, pp. 82-108, 1933.

[3] A. H. Benade, *Fundamentals of Musical Acoustics*, 2nd Edition, pp. 197, Dover Publications, 1990.

[4] J. Calder, "New Research on Low-Frequency Membrane Absorbers," Proceedings of Meetings on Acoustics, Volume 33, 175th Meeting of the Acoustical Society of America, 2018.

Good Vibrations (Part 1)

The Basic Principles of Unwanted Vibrations

When we play back audio, we only want to hear sound waves created from the electro-mechanical vibrations produced by the loudspeaker. They are the result and intention of the artists. They are the original signals. These are good vibrations. However, for this article, we will focus on the basic principles of unwanted vibrations of audio playback environments.

By
Norman Varney
(United States)

There are good vibrations, and there are bad vibrations. Everyone knows that, right? It turns out, not everybody does. At least not to the extent they should.

In the listening environment, there is much more than just the direct speaker-to-ear sound waves happening in the room. The construction materials and methods of the room, the dimensions and shape, even the furnishings can influence the direct sound waves. Some of these sound waves are desirable from a psychoacoustic point of view, but many, in fact most, are unwanted. They are new, unoriginal signals. They are bad vibrations.

When the driver in a loudspeaker moves, it pushes air molecules, which produce what we perceive as sound. Sound is vibration. Air is an elastic medium, which when pushed by the diaphragm of the loudspeaker, causes the particles to bump into the adjacent particles, after which, they return to their normal resting position. So, the particles don't actually travel across the room at approximately 1,130 feet per second, only the waves do. The action causes high and low pressures per unit area as the particles are displaced by compression and rarefaction. The action is a transfer of energy from one particle to the next.

Newton's Three Laws of Motion

Newton's three laws of motion may be stated as follows:

- Every object in a state of uniform motion will remain in that state of motion unless an external force acts on it.
- Force equals mass times acceleration [$f(t) = ma(t)$].
- For every action there is an equal and opposite reaction.

The first law, also called the law of inertia, was pioneered by Galileo. Before Galileo, people believed Aristotle's formulation that, wherever there is motion, there is an external force producing that motion.

The second law, $f(t) = ma(t)$, actually implies the first law, since when $f(t) = 0$ (no applied force), the acceleration $a(t)$ is zero, implying a constant velocity $v(t)$. The velocity is simply the integral with respect to time of $a(t) = \dot{v}(t)$.

Newton's third law implies conservation of momentum. It follows from the second law: When one object "pushes" a second object at some (massless) point of contact using an applied force, there must be an equal and opposite force from the second object that cancels the applied force. Otherwise, there would be a nonzero net force on a massless point which, by the second law, would accelerate the point of contact by an infinite amount.

In summary, Newton's laws come down to $f = ma$. Think of the enormous quantity of physical science has been developed, and continues to be developed, by applying this simple mathematical law to different physical situations.

Sound Waves

In a room, as sound waves are propagating out from the loudspeakers, they not only reach our ears, but they bombard into everything in their path until their energy is diminished via absorption. Absorption of sound energy is the conversion from sound energy to heat energy via friction of particles. Sound energy can also be reflected and transmitted. Transmission meaning sound energy being transferred from one medium to another (e.g., air to sheet rock to air). In our room, most of the sound waves traveling around are subjected to combinations of absorption, reflection and transmission.

Sound waves are pretty powerful and their interaction with the room can interfere with the direct sound more than most people realize. Sound waves can displace walls, cause cavities to resonate, or rattle and buzz the structure, all from a mid-fi stereo system not much louder than a normal conversation. Of course, if we extend the lower frequencies and boost the amplitude, we can increase these affects.

Loudspeaker designers and manufacturers put a lot of resources into the cabinet to control and prevent vibrations from introducing unwanted tonal colorations. Construction materials and methods are critical to the performance outcome. In general, the more you pay for the loudspeaker, the more of that money goes toward the loudspeaker enclosure to keep things under control. The cabinet's wall construction, bracing, damping, loading, fastening and driver mounting each play a role in the performance quality.

In addition, there is one more vital component that can impede the potential performance of the equipment and enjoyment factor for the listener—the speaker enclosure/platform coupling.

Most of us have experienced an audible subwoofer from a level above or below us, or even from the other end of the building. This is from the enclosure's vibrations being transmitted into the interconnected structure and is known as flanking (see **Figure 1**). Common construction techniques involve hard connections with no breaks. This is a noise control issue to be certain, but there are also sound quality issues being introduced.

Cabinet vibrations are coupled to the floor (or speaker stand, shelf, etc.), which in turn couples with the air, the rest of the structure, and pretty much everything contained in the room. Some people do not think that such vibrations contribute much. I would like you to think harder about that.

Experimenting With Vibration

DIY Vibration Experiment #1: Discover how much your speaker cabinets vibrate and can transmit vibrations to their resting platforms, etc.

Though speaker manufacturers may spend significant resources on anti-vibration elements for their cabinets, they still move. You may think that the speaker cabinet doesn't move and you may not feel it move to the touch, but even those made of concrete move.

Try striking a tuning fork and hold the end to the cabinet surface. Notice how the cabinet surface acts as a soundboard. The tuning fork becomes much louder because the cabinet is moving and pushing a greater volume of air. The amplitude will depend on the cabinet construction, but I'm sure it is much greater than the sound of the fork in free-air. The most common tuning fork is A440. That's of course, 440 Hz, midrange, and about the middle of the piano keyboard. You probably cannot see the tines move with the naked eye, and you can barely hear them vibrate un-aided. Especially difficult at the holding end where the energy is being transferred.

DIY Vibration Experiment #2: Discover how much your room vibrates and interferes with the direct

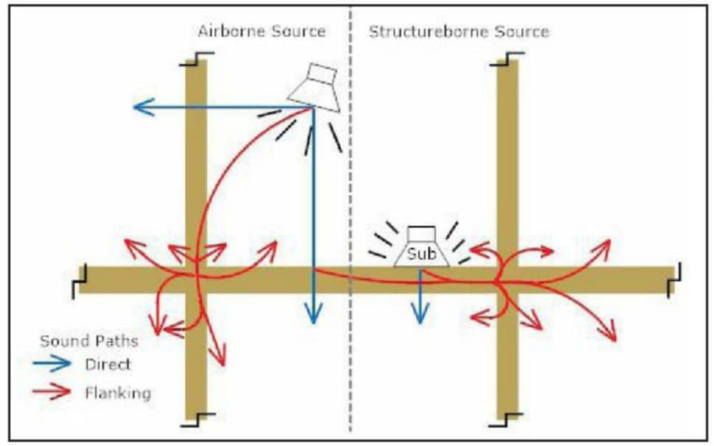


Figure 1: Depicting the difference between direct and flanking sound paths. In general, the effect of the structureborne flanking can be thought of as a point or line source (the force excites free bending waves in the panel to radiate sound) to the second radiating panel of the partition.

sound waves. Strike a tuning fork and place it on your walls, floor, ceiling, etc. These large surfaces are set into motion through the hard connections found in typical construction—the loudspeaker cabinet transfers vibrations to its stand, shelf, or floor causing the floor to vibrate, which is connected to the walls, which is connected to the ceiling. In fact the entire house is typically hard connected, which is why you can hear the subwoofer at the opposite end of the house, upstairs and downstairs. It is also why you can hear someone talking from the other side of the wall. In the listening room, the movements of these surfaces are acting as additional loudspeakers, adding to the original sound waves, later in time and from all around.

The tines of the tuning fork are barely audible until coupled to a hard plate (like the wall). It is impressive that the tiny tines can displace an entire wall even at say 440 Hz. Of course, lower frequencies will move the wall even more. However, the higher energy of lower frequencies is more difficult to diminish, which is why you can hear the subwoofer many rooms away through structure-borne vibrations.

DIY Vibration Experiment #3: Lightly hit the skin (sheathing) of the wall between studs with your fist. The stud cavity produces a low boom, just like a big drum. In typical US construction, you're hearing about 70 Hz. This is a function of the surface mass of the skin and the thickness of the airspace. Whenever your music plays 70 Hz (which is probably most of the time), your walls sing along in sympathy. Not cool. This makes the room sound slow, muddy, and droning. In addition, such resonances occur later in time and duration than the original signal. This ringing is the cavity acting like a capacitor storing the energy and then releasing it later in time. This happens from the airborne sound waves impinging on the surface to be sure, but most of this excitement is generated from the mechanical structure-borne vibrations transmitted via the loudspeaker/platform interface.

When the bending sound waves form within the surface sheets of a wall, floor, or ceiling partition and coincide with the incident sound wave striking the panel, a resonance forms called "coincidence." It is quite typical in Transmission Loss (TL) curves to see a fairly narrow but major dip in the TL performance. The location and magnitude of this dip is primarily dependent on the density of the material, its modulus of elasticity, and the material thickness. For a given material such as drywall, the density and modulus of elasticity is constant, therefore, the driving factor is typically thickness.

There are a number of ways to reduce or shift the coincidence frequency. Elastomeric treatments work very well in this region. Introducing other materials and changing the thickness of the material reduces coincidence.

A common remedy is to change out thicker gypsum boards with the application of multiple thinner layers. As you can guess, gypsum wall board is a major player for most of the surface treatment of wall and ceiling partitions in the United States. The critical frequency for gypsum board can be calculated using the formula:

$$fc \times t = 30.8$$

where "fc" is the critical frequency in Hertz and "t" is the thickness of the gypsum board in meters. For example, ½" or 13 mm gypsum has a coincidence frequency of 2,422 Hz.

Rooms are containers of sound. We cannot function comfortably without them, but they do create a lot of havoc on the music being reproduced.

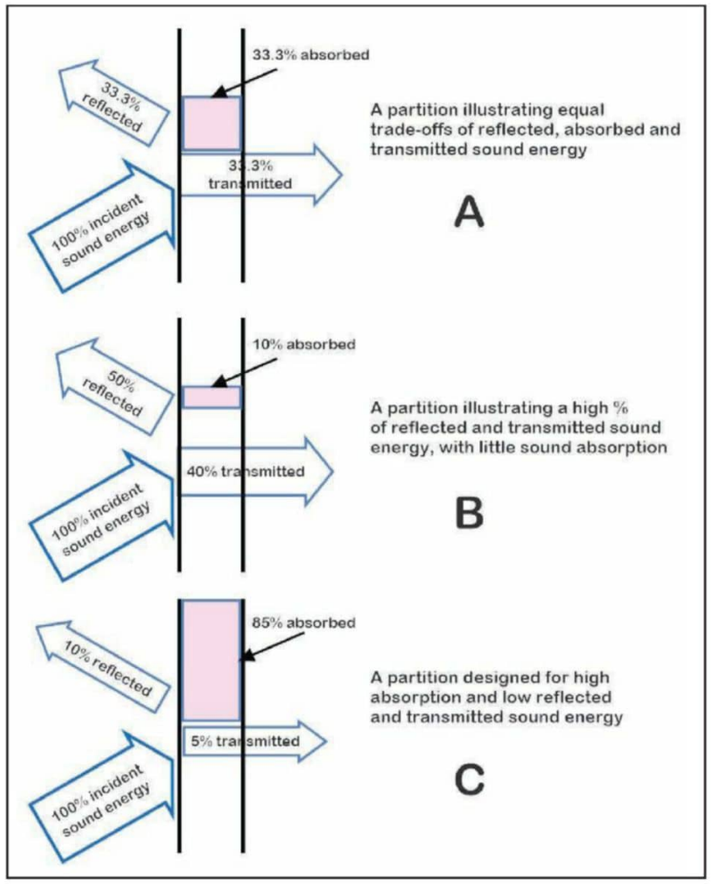


Figure 2: Illustrating how different types of partitions may reflect, absorb, and transmit sound energy

We need them for noise control, both entering and exiting the space. They also help reinforce the sound energy. This is where the difficult balance of noise control and sound quality meet. We must control the first-order reflections to retain the original spatial and timbre qualities. We must also control the reverberation times to keep the original characteristics of dynamic range, articulation and low-level resolution. And, we must control the room mode distribution for linear bass response, etc. All of these room issues influence the final outcome we experience.

Vibrations and reflections are different principals. When airborne sound waves impinge on a surface, some of the energy is reflected, some absorbed (converted into heat energy), some is transmitted to the other side (see **Figure 2**), and some causes the surface to move and re-radiate back into the room. This part of the action is actually a new sound source. What is not represented in Figure 2 are cavity, panel, framing, and other resonances, which can contribute as new sources of sound energy. These can come from the shell of the room, and even furnishings in the room. We may also hear the structure become agitated and produce buzzes and rattles.

About the Author

Norman Varney is the owner of AV RoomService, an acoustic design company that also offers a few acoustical products. Having been in the noise control and sound quality industries for decades, he has earned awards for acoustical products and room designs while working for AV RoomService, Kinetics Noise Control, Owens Corning Science & Technology Center, and MIT. Norman has presented white papers to the industry and written 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), the Acoustic Society of America, the Institute of Noise Control Engineering, the Audio Engineering Society, the National Association of Music Merchants, CEDIA, and others.

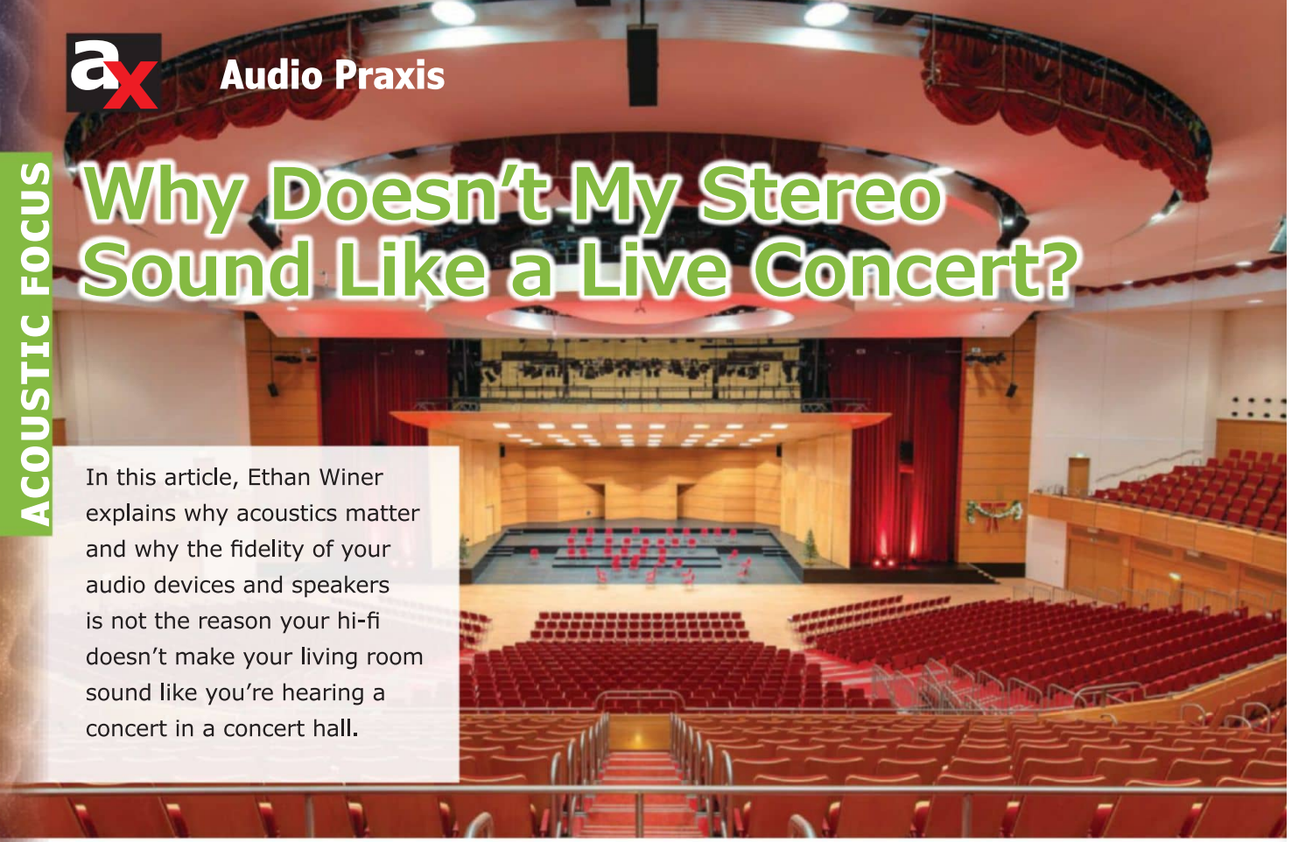
We can think of the room as functioning much like an acoustic guitar:

- The room dimensions, like the dimensions of the guitar body, determine the modes that are reinforced.
- The shell construction of the room, like the guitar, act as a soundboard to amplify certain frequencies.

The difference is these attributes are for enhancement of the guitar, where as they are detriments to be controlled for the room. Imagine how much better the music might sound if all those unwanted vibrations did not exist.

In Part 2 of this article, we explore ways to solve these issues using various products that my company, AV RoomService, Ltd., has successfully developed when helping clients with their acoustic problems.

Why Doesn't My Stereo Sound Like a Live Concert?



In this article, Ethan Winer explains why acoustics matter and why the fidelity of your audio devices and speakers is not the reason your hi-fi doesn't make your living room sound like you're hearing a concert in a concert hall.

By
Ethan Winer
(United States)

I contribute to many audio forums and Facebook groups, often to explain how audio fidelity is defined and measured. Only four parameters are needed to assess every aspect of fidelity: frequency response, noise, distortion, and time-based errors. However, there are subsets such as hum and buzz that fall under noise, or vinyl record wow, and analog tape flutter, which are time-based. And some things encompass more than one parameter—such as ringing, which affects frequency response yet is also time-based. But these four parameters are the basics that define audio fidelity.

When a someone asks which power amplifier or digital-to-analog converter (DAC) they should buy, I usually bring up the importance of measurements, and point out that performance specs published by major manufacturers can generally be trusted. I often add that most modern electronic audio devices are good enough to be audibly transparent. This means they color the sound so little that human ears can't detect a change, even if test equipment can measure a difference. This also means that when compared properly, most DACs and power amps—and other modern devices too—sound alike since they impart no coloration of their own onto the audio passing through them. Even when a change to the sound might be heard, audio engineers can usually tell with reasonable certainty what types and amounts of coloration are sufficient to actually harm the listening experience. Ten percent distortion is sure to be noticed, while jitter noise 110 dB below the music will never be heard.

When I post information like this, inevitably someone will counter, "You can't measure a symphony" or "If most audio devices are transparent, why doesn't my stereo sound like I'm at a live concert?" Of course, the enjoyment of a symphony or any other music is purely subjective, versus equipment performance that's based entirely in science and can be measured precisely.

Obviously nobody can define the worth of a piece of music for anyone but himself. Just because some people dislike opera music doesn't mean that opera music is bad. Further, musical tastes can change over time. One famous example is the 1913 premier of Igor Stravinsky's *The Rite of Spring*—it was so poorly received that the audience actually rioted! Today, it's considered an important work. Even your own taste can change—it's common to like a song more after you've heard it a few times. But that has nothing to do with the accuracy of a recording or playback system.

However, the second question is more difficult to answer. To be sure, the difference in sound between a venue and your living room is not due to any inaccuracy of your audio electronics. A good professional voltmeter can easily measure a response error or volume change of 0.02 dB, but nobody could possibly hear that. A Fast Fourier Transform (FFT) display in audio editing software can identify distortion components 130 dB or more below a sine wave test tone, but even the most gifted audiophile can't possibly hear that. Now, loudspeakers do vary audibly, but that's caused mostly by response errors that change the frequency balance by some amount. And most speakers ring at least a little at some frequencies. But clearly, the fidelity of your audio devices and speakers is not the reason your hi-fi doesn't make your living room sound like you're hearing a concert in Alice Tully Hall.

Acoustics Dominates

The real issue is the vast difference in acoustics. Forget for a moment trying to make your hi-fi sound like you're listening to music in a venue, and just consider how musical instruments generate sound. One reason a loudspeaker playing a recording of a violin in your living room doesn't sound like a live violinist playing in your living room has nothing to do with the accuracy of your equipment. The radiation pattern of a loudspeaker is very different from that of a violin. At mid and high frequencies, a typical "box" loudspeaker sends sound mostly forward, which then spreads outward over distance. But starting around 300 Hz and going lower, most loudspeakers become more and more omnidirectional. At 100 Hz sound leaves most speakers in every direction more or less equally.

In contrast, a violin sends different frequencies off in many different directions. High frequencies go straight up off the top plate, low frequencies go downward and off to one side, and so forth. Most of the items in a typical drum set are also highly directional. Therefore, different frequencies reach the walls, the floor, and the ceiling in a manner that's very different from a loudspeaker playing a recording of the same violin performance. Of course, all those different reflection source locations affect the sound reaching your ears.

Another factor is that reflections in a home-size room are considered "early" and arrive much sooner than in a 70' wide concert hall. The reflections are also very strong because the room boundaries are so close, so they aren't attenuated as much by distance. Likewise, high frequencies diminish more over distance than low frequencies, so reflections from the nearby surfaces in your home are brighter sounding than in a venue. When surround speakers are available, mixing engineers can more easily create the sound of a large space by simply delaying the sound to the rear speakers and attenuating higher frequencies. That creates the effect of your rear walls being farther away. In fact, many consumer receivers include various faux environment options just for this purpose. (Though I never enable those effects!) Indeed, most movie sound tracks already contain whatever embedded surround ambience and delays the producers and engineers deem desirable. However, for this to be truly convincing, the room must be well treated to

There is a reason why a live concert will always be a different experience from your living room. (Photo courtesy of Montreux Jazz Festival)

A loudspeaker playing a recording of a violin in your living room doesn't sound like a live violinist playing in your living room.

Even if you use a violin as a sound radiator, like Juno Audio tried in this speaker design shown at CES 2015, it only sounded great with violin recordings.

Great auditoriums with great acoustics have been designed to enhance the live concert experience.

About the Author

Ethan Winer has been an audio engineer and professional musician for more than 45 years. His "Cello Rondo" music video has received nearly 2 million views on YouTube and other websites, and his book *The Audio Expert* published by Focal Press, now in its second edition, is available at www.amazon.com and on Ethan Winer's own website, www.ethanwiner.com. Ethan is also a principal at RealTraps, a US manufacturer of high-quality acoustic treatment.

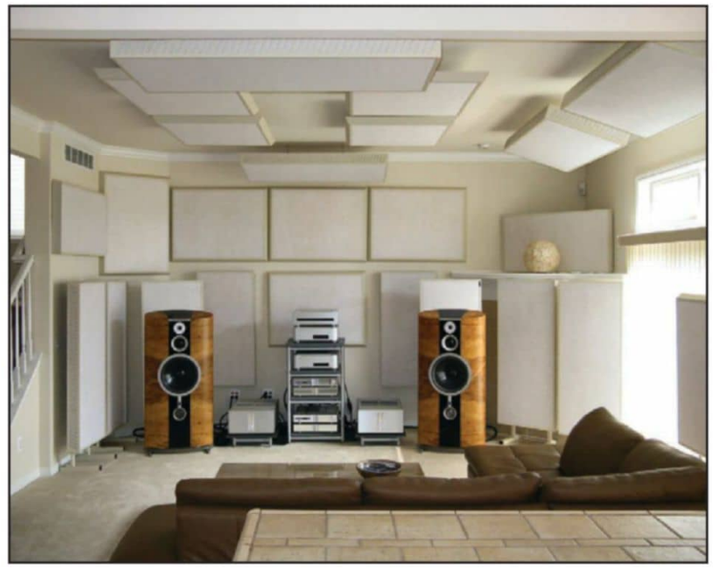
prevent the inevitable early room reflections from contaminating and diluting the effect. Sadly, many hi-fi listening rooms and home theaters have no acoustic treatment at all.

Electronic instruments such as synthesizers and electric guitars can often be made to sound like they're playing live in your room. The original source for an electric guitar is the loudspeaker in a guitar amplifier. So if you play an accurate recording of a guitar amp through your hi-fi, it can sound pretty much like the guitar amp was in the room with you at that same location. (Or at some location midway between the left and right stereo speakers.) However, this requires the recording microphone to have been very close to the guitar amp's own speaker to avoid picking up ambience from the room in which it was being recorded. This is how electric guitars are usually recorded anyway. Or a guitar can be recorded direct, with no amplifier, through an "amp-sim" device that simulates the tone and intentional distortion of a real guitar amplifier. I've done this many times and I know it works. This is especially common when recording electric basses, which are usually captured through an electrical feed rather than using a microphone with a bass amp. Sometimes a microphone is used, depending on the style of music, but a direct feed is almost always recorded too. So an electric bass can also sound pretty much the same as having a bass amp in your living room.

As explained earlier, achieving this sort of realism is difficult with acoustic instruments because of their varied radiation patterns versus frequency. But there's another related problem: Most acoustic instruments emit different sounds from different places. This is not the same as different frequencies leaving in different directions. For example, some of the sound of a clarinet emits from the finger holes along the length of the body, and some comes out the main "bore" opening at the far end. The frequency spectrum is different at those locations, so a clarinet's characteristic sound is really the summation of those frequencies. A microphone placed about a foot above the instrument, and slightly out in front, can usually capture the full complement of frequencies.

But a cello or string bass is much larger than a clarinet, so you can't place a microphone close enough to avoid room tone because there's no one place that contains the full range of frequencies these instruments generate. If you put a microphone near the "f" holes, you'll get a bassy sound lacking clarity. If you put it near the bridge, the sound captured will be very thin. A microphone placed near the 12th fret of an acoustic guitar captures a very different sound than when it's near the sound hole. Likewise for a grand piano, which is even larger. It's true that high-quality studio recordings are often made by placing mics very close to the piano strings. Especially for popular music and modern jazz. But those recordings don't actually sound like a piano is physically in your room when played back through loudspeakers. Often the sound is even fuller and clearer! I'll have more to say about that in a moment.

This is why good recordings are made in large rooms, whether in a concert hall or a professional recording studio. A large room lets you put the microphones far enough away to capture the full range of frequencies from the instrument, without sounding boxy and off-mic as happens when recording in someone's untreated bedroom. The back wall of every auditorium stage is reflective, and it's usually curved or angled to focus and project sound exiting the rear of an orchestra back out to the audience in front. This also helps the players hear each other better. A curved or angled "roof" is often placed above the stage, again to ensure that all the sound energy generated at all frequencies gets out to the audience seats.



No matter how expensive your living room music reproduction system is, the reflections in a home-size room will always arrive much sooner than in a 70' wide concert hall. Acoustic treatment is the most important thing you can have to achieve realism in a home listening environment. (Photo Courtesy of Paragon Sight & Sound)

This is also why home recording studios need to be well treated acoustically. In fact, the smaller the room, the more dead sounding it needs to be for both recording and mixing. Acoustic treatment makes a room more neutral sounding by avoiding the coloration known as comb filtering that manifests as a series of response peaks and deep nulls. With acoustic treatment to absorb the early reflections, you can pull the microphones back far enough from an instrument to capture its complete range of frequencies, without also picking up the small-room ambience that exists in all untreated home size rooms.

Better Than Real Life

In my 70 years, I've been to Carnegie Hall, and I've heard the National Symphony Orchestra perform at Kennedy Center. I've been to dozens of other venues both large and small to hear all types of music. In my opinion, a good recording can and should sound better than being at a live concert! Aside from not hearing people cough or shush their children, and being able to press Pause to grab a snack, I think recordings should sound larger than reality, and closer than a seat 20′ to 30′ from the stage in a concert hall. In an educational video sponsored by plug-in maker Waves, black belt mixing engineer Alan Meyerson shows many of the techniques he used when mixing the score for the movie *Wonder Woman* to make the orchestra sound larger, clearer, and just plain better than reality.

In my experience, listening to a good recording through headphones provides the largest and most spacious sound stage. The instruments sound almost close enough to touch, and the recording's embedded reverb is truly enveloping. You can get a similar effect in a home-size room by placing absorption at the side-wall and ceiling reflection points, and on the rear wall too if it's closer than 10′ to 15′ from your ears. As explained in my "Early Reflections" article, when music is played back in a small untreated room, the strong early reflections from nearby surfaces drown out the larger sounding reverb already present in the recording. This makes the music sound smaller and narrower, not larger and wider as many people believe. This is precisely why all excellent hi-fi rooms and home theaters have plenty of acoustic treatment, especially absorption.

It's important to mention that sound stage and imaging have nothing to do with electronics. There's nothing a preamp, wire, or so forth can do to affect imaging, though frequency response changes can affect apparent depth slightly, with less treble making instruments and voices sound farther back. The width and depth of stereo placement, and imaging effects, are mostly a function of echoes and reverb in the original source recording. Untamed reflections in your own listening room can only damage imaging. Further, contrary to popular belief stereo width can be measured. The device that does this is called a Phase Correlation Meter, and it shows the amount and phase of left-right channel differences. Recording studios use this to verify mono compatibility, to ensure that nothing in a stereo recording will be lost if the two channels are reduced to mono.

Indeed, it's clear that acoustic treatment is the most important thing you can have to achieve realism in a home listening environment. It gets you closest to the spacious sound of headphones, while enjoying the benefits of loudspeakers. In my well-treated stereo/home theater room, cars and traffic sounds on TV and in movies often sound like a car is in my driveway or out on the road. When a cat meows in a movie, I often have to look over to see if it was one of my own cats! And good orchestra recordings sound much more like "being there" than in any room that lacks the basic reflection control described here. Indeed, acoustic treatment is one of the last things many audiophiles consider, yet it's the one thing that truly will make their systems sound more real and lifelike. And then they might finally be satisfied and cease the endless, futile cycle of "upgrading" their audio gear!

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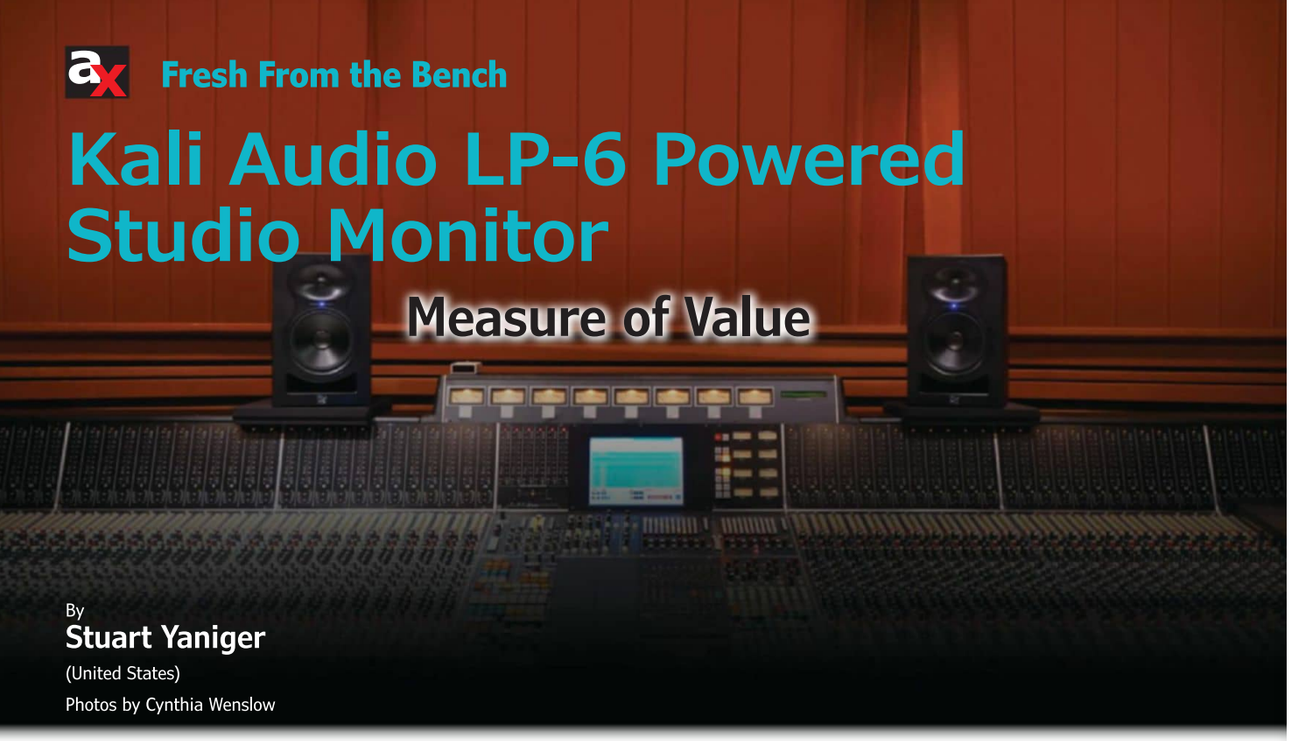
Kali Audio LP-6 Powered Studio Monitor

Measure of Value



By
Stuart Yaniger
(United States)
Photos by Cynthia Wenslow

Photo 1: The Kali LP-6 monitor speaker has a plain, businesslike appearance, with a 6.5" woofer-midrange, a 1" tweeter, and a front-firing port.

It's been observed that if automobiles developed at the same pace as computers, a family sedan would get 10,000 miles per gallon, travel 500 miles per hour, and cost $25. Although this hasn't happened to cars, it's certainly happened in audio—we have essentially perfect sources and recording gear that cost less than a couple tanks of gas and are smaller than a dictionary.

Along those lines, the past couple of years have seen the emergence into the mainstream of a product category of small, powered loudspeakers that are highly engineered, low cost, high performance, and remarkably inexpensive. With the addition of a music source, they can form the basis of an excellent sound system, replacing separate power amplifiers and speakers with integrated solutions, and doing this for prices that would have been unimaginable just 5 years ago. They can also be used in home studios for monitoring and mastering purposes, taking a role that until recently was dominated by either poor quality inexpensive boxes with shrieking and rattling resonances or by ultra-expensive professional-grade monitors. The idea is to offer 90% of the sound of the latter at a similar price as the former—and add in amplification and equalization at no extra cost.

All of these new products have several things in common. They are designed by engineering teams in the United States, use componentry and tooling manufactured with great efficiency by high-quality companies in China, use digital signal processing (DSP) and active crossovers, leverage modern amplifier technologies, which can be built into the cabinets without worries of heat and excessive electrical use, and have form factors suitable for unobtrusive placement in homes and studios. Some even come with remote controls, which make them quite convenient to use in a living room setting.

A big driver here is the emergence of prosumer audio and home-based studios as a rapidly growing market. Musicians have discovered that with a laptop computer, a couple of microphones, some inexpensive (or free) software, and an interface, they can create music in a home setting that can rival studio productions.

The availability of high-quality recording without the expense of a studio has unleashed the creativity of hundreds of thousands of musicians who no longer have this barrier to entry. This has resulted in a flood of so-called bedroom productions, and although Sturgeon's Rule applies with a vengeance, the diversity and the creativity of available music has been a huge boon to music enthusiasts whose preferences lay outside of the mainstream. Besides recording equipment, high-quality monitor speakers are necessary for mixing and mastering, and with the new wave of powered loudspeakers breaking free of the old constraints (passive crossovers, separate amplification), quantum leaps in performance can be achieved. That's because the loudspeaker drivers and the amplifiers are properly matched to one another, DSP can be used to generate high slope crossovers (which can reduce distortion and give unprecedented control of polar pattern) and phase correction, and the built-in signal processing capabilities can be used to equalize the speakers for different placement options.

Enter Kali

Kali Audio is a new California-based company formed by a group of (now former) JBL employees who left following the sale of Harman (JBL's parent company). They brought with them expertise in acoustic design, driver engineering, DSP, and perhaps most importantly, knowledge of how to source high-quality subcontracted product from China. Their choice of a company name has set up much speculation among bloggers and YouTubers—in Hinduism, Kali is a destroyer of evil forces, but also represents ultimate reality and liberation.

The lead engineer at Kali is Charles Sprinkle, who is best known for the fabulous JBL M2 loudspeakers, as well as the popular LS305 and LS308 monitors. The Kali LP-6s can be seen as direct competition to the 305s, and perhaps a bit more, as we shall see.

A year or so ago, I wrote a review of one of the products falling under the new paradigm, the excellent Vanatoo Transparent Zeros (see Resources). The Kali LP-6 speakers under review here are, in a sense, the opposite of the Vanatoos—the Vanatoos are home audio speakers that could be used for monitoring, whereas the Kali LP6s are monitoring speakers that could be used for home audio.

The LP-6s (the LP stands for "Lone Pine," a town in the California Sierra Mountains) have an almost Amish styling, plain but functional (see **Photo 1**). They're basically unadorned 0.75 ft^3 15 lbs. black boxes with no grilles, a 6.5" plastic coned woofer, an oddly shaped front port, and a dome tweeter that is loaded with a shallow horn or waveguide.

The lack of a grille might cause issues in living room setups where there's children present, but of course, for their intended use as monitors, the lack of grilles is a positive—there's no acoustic issues with covering the front of the speakers. Front port location is useful for maximum placement flexibility. Their matte black finish and simple near-rectangular shape allow the speakers to blend in nicely with studio consoles and not be a visual distraction—clearly this design concentrates on function rather than form. The only concession to styling is the blue LED sitting between the woofer and the tweeter, indicating that the speaker is powered on.

When we view the rear of the speaker, we get some hints of the design's sophistication (see **Photo 2**). Besides an IEC connector for power (the internal power supplies can run off any line voltage from the Japanese 100 V to European 220 V), there are three analog inputs: an unbalanced RCA and balanced 1/4" TRS and XLR sockets. The RCA input is meant for home audio sources and has a sensitivity of -10 dBV (0.32 V) for full output. The TRS and XLR inputs are set for pro audio line levels and have a sensitivity of 6 dBU (1.5 V). The sensitivities are marked near the input jacks, but it's odd that they use different units (dBV versus dBU) for each one.

Next to the XLR jack is a volume control with a range of -∞ (fully off) to +6 dB, which can be used to adjust the input sensitivity for different sources—it has a detent at 0 dB, which is where Kali Audio recommends you set it unless you have sources with non-standard output levels. The balanced connectors are wired in parallel, so they should not be used simultaneously. The user can choose between balanced and unbalanced inputs by settings on the DIP switches located just above the volume control.

The speakers each contain two 40 W Class-D amplifiers along with the DSP (see **Photo 3**). These

Photo 2: The rear of the Kali LP-6 has analog inputs, controls, and a clear set of graphics indicating DIP switch setting for different placements, frequency response tailoring, and inputs.

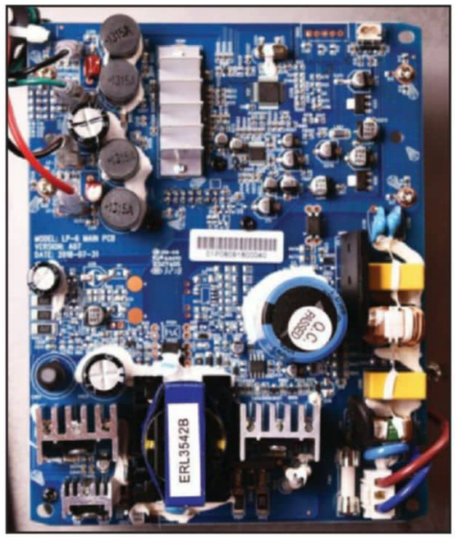


Photo 3: All DSP and audio power are provided by a pair of built-in 40 W Class-D amplifiers.

are sufficient to achieve over 100 dBSPL at a 1 m distance, far louder than I'm comfortable with. At that level, limiters start kicking in to protect the drivers from burnout. At my listening position, 90 dBSPL sounded clean and unstrained. The amplification is clearly well matched to driver efficiencies. The crossover point between the 6.5" bass/midrange driver and the tweeter is set to an unusually low 1.5 kHz. Generally, a crossover point this low will stress a small tweeter, increasing midrange distortion and reducing power handling and SPL capability. Presumably, Kali could get away with this by using high slope crossovers and taking advantage of the tweeter loading by the waveguide.

Photo 4: The oddly shaped port is made from an injection-molded plastic and is flared to reduce turbulence.

The really interesting stuff is also controlled by the DIP switch settings—equalization for boundaries. It's well known that a speaker's frequency response will change depending on where it's sited within a room. A simple example is bass response—if a conventional speaker is standing free in a large space, it is essentially firing its bass out omnidirectionally (i.e., into 4 π space), whereas the midrange and treble are firing mostly forward (i.e., into 2 π space). If you place the speaker against a wall, the bass will now be firing into 2 π space. So if a speaker is balanced to have a flat bass response when out in the room, the bass response will be doubled when the speaker is placed against the wall and will sound too heavy. There are other effects that come into play as well (e.g., interference in the midrange due to the physical depth of the speaker when wall placement is used), but clearly a speaker will only function as intended when it is placed in the type of environment for which it was designed.

This is a severe restriction for monitoring. Sometimes placement on a console is desired. Sometimes speakers are placed on stands away from walls. Sometimes speakers are placed against walls, all depending on the studio (or bedroom!) layout. With this in mind, Sprinkle and his team did a series of measurements in a typical studio (in their case, The Village Studios in Los Angeles, CA) to determine the effects of different placement on the speakers' frequency response. This information was used to create a set of equalization curves, any of which can be selected by the user with DIP switch settings, depending on the speaker placement. The graphics on the back of the speaker seen in Photo 3 are simple and clear. In addition to the boundary equalization settings, the user can also select a relatively subtle (2 dB) treble or bass shelf as a tone control.

As I mentioned earlier in the article, the LP-6s use a port for the bass that appears to be an injection-molded plastic. The shape of it is rather unusual. Kali claims that the shape was determined in order to have all air flowing through the port at the same velocity (implying laminar flow). It certainly gives the front panel a distinctive appearance. **Photo 4** shows the shape of the port inside the cabinet and it clearly has a more complex flared shape than the usual cylindrical port. Between the molds needed for the port and for the tweeter waveguide, tooling costs for production would likely not have been trivial. Again, I am amazed at what Kali has been able to do for the price.

I noted that once the back panel is removed, the LED can easily be disconnected from the circuit board if it bothers you. I'm fine with it, but for some people, the blue light can be a visual distraction.

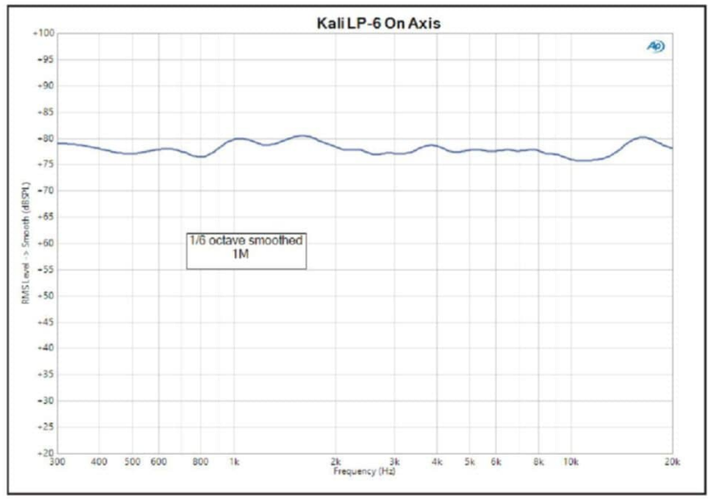


Figure 1: The on-axis quasi-anechoic response at 1 m is flat to within 2 dB.

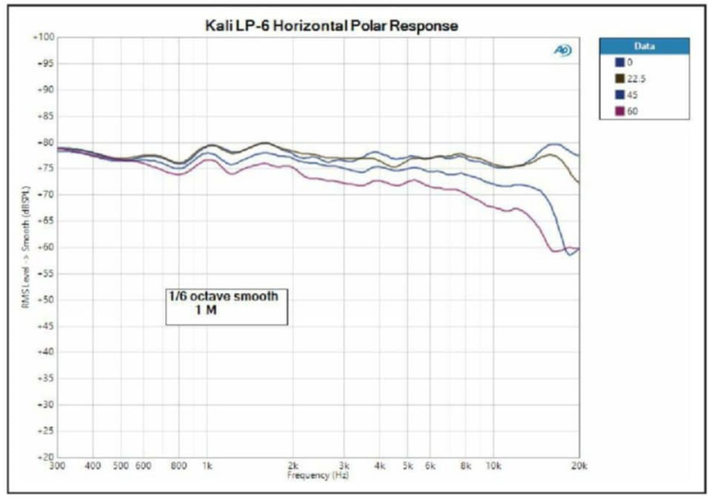


Figure 2: The LP-6's horizontal polar pattern is almost textbook, with response nearly unchanged at small angles, then rolling off smoothly at larger angles.

About the Author

Stuart Yaniger has been designing and building audio equipment for nearly half a century, and currently works as a technical director for a large industrial company. His professional research interests have spanned theoretical physics, electronics, chemistry, spectroscopy, aerospace, biology, and sensory science. One day, he will figure out what he would like to be when he grows up.

The Kali LP-6 In Use

I set the LP-6s up in my lab listening space on stands which raised them to height where the blue LEDs were at ear level. They were spaced approximately 2 m apart and about 1.5 m from each sidewall. This position brought then about 2.5 m from the back wall, and the listening position was about 3 m away. According to Kali, the positioning away from boundaries is the optimum way to use these monitors. The LP-6s were driven from a balanced source (a Focusrite Scarlett 2i2) through the XLR inputs, with the LP-6's volume controls set to 0 dB.

With a wide variety of recorded music, the tonal balance was neutral and clean, with a more forward and analytical sound than the Vanatoo T0s that were formerly in that position. Tonally, they were a close match to my reference speakers—a very close match. The apparent soundstage was not as large as the T0s, but was in no way constricted-sounding. Imaging was precise and solid. What really struck me as unusual was how wide the listening axis was—I could move my head vertically and horizontally without hearing any change in tonality or image wander. These do not have a narrow sweet spot! The LP-6s are superior to nearly everything else I have heard in this regard.

The bass is reasonably extended for the genre, covering the entire fretboard of an electric bass (to 41.2 Hz for E1), well-defined and far from anemic, but clearly the bottom octave from 20 Hz to 40 Hz just isn't there. That's not unexpected for speakers this size, but does suggest that for critical listening using material like pipe organs or electronic instruments, subwoofers might be appropriate. Hard drive did not result in any audible chuffing noise through the port, so the odd port shape seems to be effective. Overall, this was very good bass for a box its size, and pushing high SPLs didn't muddy it.

Listening to tracks from my own recordings, which are uncompressed and dynamic, I got no sense of any compression, and the ability to really take my mixes apart (aurally) was impressive—unfortunately, I was able to clearly hear a few of my clumsier fades. I'll blame the speakers because it couldn't possibly be my fault!

I then placed the speakers on my desk, flanking my mixing board (aka, the Adobe Audition control panel on my laptop), with the DIP switches set to compensate. The equalization worked as advertised, with only minor differences from stand placement. Here, though, I ran into a deficiency—with the speakers under a meter away from my ears, I could plainly hear a hiss from the tweeters. It wasn't particularly loud, but when the music faded out and the room was quiet, I could certainly notice it. Once the music started up, it was masked, but this may be more of a problem for people with lower auditory thresholds and more extended high frequency perception than my old ears. With the speakers sited on stands 3 m away as described above, the hiss was totally inaudible to me.

Finally, returning the speakers to the stands away from boundaries, I ran the superb Sonarworks Reference 4 room measurement and correction software (see Resources). The amount of needed correction past 300 Hz was minimal, and unlike the case with other speakers with which I've used this system, the changes in sound were quite subtle. Where the Sonarworks came in handiest was allowing the LP-6s to simulate other speakers, and the chameleon-like change in the sound was striking. This was especially true for the Yamaha NS10 simulation, which was startlingly (and distressingly!) true to form. Using the Brüel & Kjær (B&K) 1974 emulation curves, the LP-6s suddenly sounded more like typical audiophile speakers—but at a fraction of the cost.

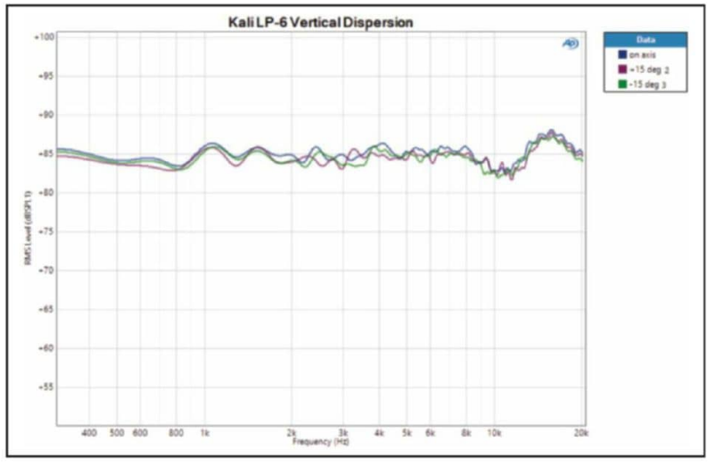


Figure 3: Despite non-coincident drivers, the LP-6's vertical polar response is impressively even.

Measurements

As usual, my measurement setup consisted of an Audio Precision APx525 audio analyzer, an Audio Precision APx1701 acoustic interface, and a PCB Piezotronics 377B01 ½" calibrated condenser laboratory microphone. For near-field woofer and port measurements, I switched mics to the PCB Piezotronics 377C03 ¼" mic, which has a higher SPL capability than the 377B01.

The APx525 balanced outputs were cabled to the LP-6 balanced XLR input, with the LP-6 volume control set to 0 dB. Frequency response and distortion

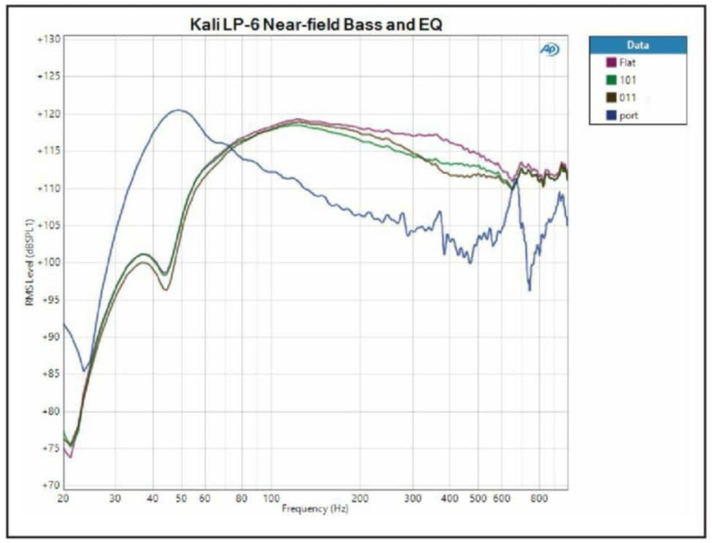


Figure 4: Near-field measurements of the woofer and port show response starting to roll off at 40 Hz. The DIP switch settings, indicated by their binary code, adjust equalization for different placements (see text).

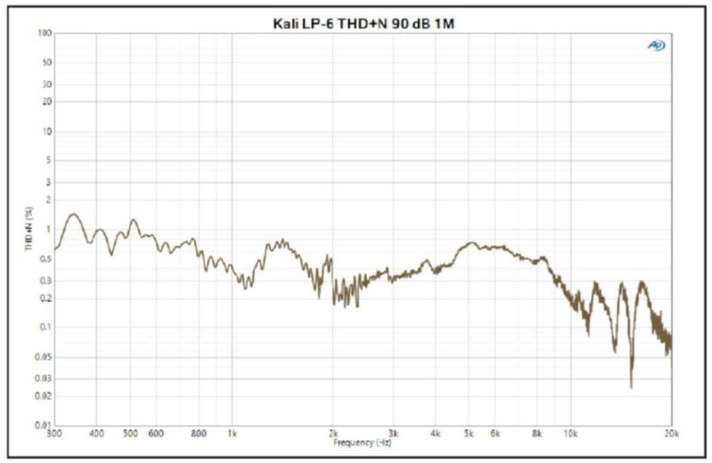


Figure 5: This graph indicates harmonic distortion versus frequency at 1 m on axis.

measurements were acquired using a swept tone, which is transformed into an impulse response and Fourier transformed after gating out the reflections.

Figure 1 shows the unsmoothed quasi-anechoic (gated FFT) frequency response at 1 m on-axis, the axis being in line with the blue LED. The response is quite smooth and flat and doesn't show the typical downward slope or midrange dips seen in many other speakers. The response fits within a ±2 dB window. In the treble, the waveguide causes a small dip and peak, but I emphasize "small." I was unable to hear any coloration that I could attribute to this feature, despite my personal prejudice about anything resembling a horn. There's a slight elevation at around 1 kHz, which may correlate with my impression of a "forward" sound.

And the horn, errrr, waveguide does seem to work as intended, especially coupled with the crossover and DSP. **Figure 2** shows the variation in frequency response with horizontal angle, taken at a 1 m distance. The response at 22.5° off-axis is almost unchanged from the on-axis response. As the angle increases to 45° and 60°, the treble smoothly rolls off. This engineered polar pattern unsurprisingly follows the recommendations developed at Harman by Floyd Toole through extensive psychoacoustic testing (see Resources).

Looking at vertical polar pattern, comparing on-axis frequency response to responses at +15° and -15° (see **Figure 3**), the waveguide and crossover combine to provide an extremely smooth result—usually, one sees significant lobing vertically when a tweeter and woofer are non-coincident, with big peaks and dips in the midrange. This is extremely impressive, some of the best results in this respect that I've ever seen. The horizontal and vertical dispersion results imply that the "sweet spot" is rather broad and that imaging should be excellent, which indeed it was.

Figure 4 is admittedly a bit busy. At the low end, it shows the bass response at the cone and at the port taken as a near-field measurement as described by Don Keele (see Resources). I measured the cone and vent separately and overlaid their spectra. You can see that the reflex is tuned to 45 Hz, and the overall response below that rolls off at a fourth-order (24 dB/octave) rate. The speaker's bass response holds up very well to the roll-off point, which correlates with my subjective impression of strong but not ultra-deep bass. The peaks and dips at 600 Hz to 900 Hz are likely due to reflections from the rear of the cabinet reflected through the port or from pipe resonances in the port itself. In listening tests, I did not notice coloration in that region.

In Figure 4, I also included the effects of a couple of the boundary equalization settings. The "flat" response is with the speaker set for stand mounting away from walls. I marked the others with the DIP switch setting for their particular speaker placement.

There are eight settings in all, but I show two examples here for the purposes of brevity. The 101 and 011 settings are the equalized responses for desktop mounting away from a rear wall surface and desktop mounting against a rear wall, respectively. I had been expecting a simple bass correction, but the curves shown here indicate that the equalization not only cover the bass range, but also boundary effects in the midrange up to 600 Hz or so. Not shown are the bass and the treble trim options, also DIP switch selectable, which shelve the regions above and below 1600 Hz or so by about 2 dB up or down.

The distortion versus frequency at 90 dB SPL and 1 m distance is shown in **Figure 5**. While not exactly a low-distortion champion, the LP-6's distortion is reasonably low in the critical midrange and treble, with none of the spikes one can see in inexpensive speakers having significant resonances or poorly implemented crossover slopes and positions. In fact, through the critical parts of the midband, the distortion remains at 0.3% and lower. Analysis of the harmonic content (see **Figure 6**) shows that the distortion is dominated by third-order, especially in the tweeter range, which suggests a very symmetrical motor assembly on the drivers.

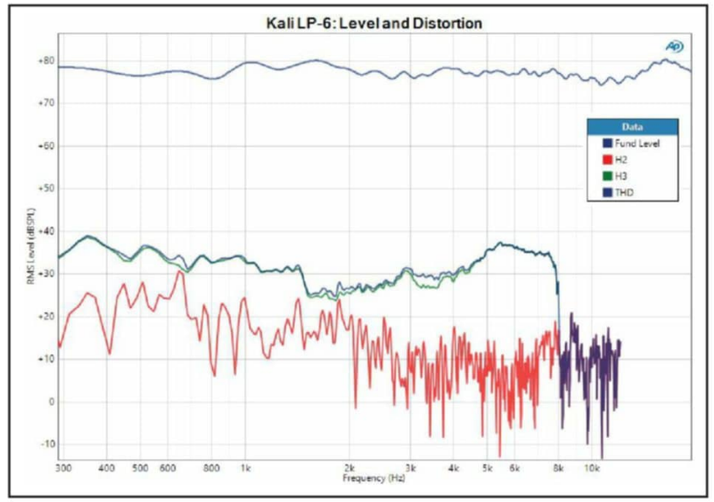


Figure 6: Comparing total distortion to distortion by individual harmonics, the third-order products are seen to be dominant.

Photo 5: Near-field measurement of the Kali Audio LP-6 Studio Monitor shows excellent bass extension and quality.

Overall Evaluation

You're probably sick of me saying "I can't believe what you get for $300 per pair!" so I won't say it again. But I'll sure think it. The sound is clean, dynamic, and uncolored, and from 40 Hz up, makes one reconsider whether spending more will get real improvement.

There are a few downsides: the slight hiss at close range, the lack of true deep bass and wall-shaking SPLs in larger rooms, and a lack of digital inputs. The last is supposed to be addressed with a Bluetooth adapter bridge scheduled for release sometime during mid-2019, but I would like it more if there were a TOSLINK optical or coaxial digital input. For home music use, I miss having a remote control like the one supplied with the Vanatoo speakers.

But home use is a bonus. For studio mixing, mastering, and monitoring, the Kali LP-6 more than delivers the goods, with clean, dynamic sound, superb dispersion, and a very clever and well-thought-out boundary correction system. All of that for $300 including amplification (see **Photo 5**). Highly, highly recommended.

Resources

D. B. Keele, "Low Frequency Loudspeaker Assessment By Near Field Sound Pressure measurement," *Journal of the Audio Engineering Society*, Volume 22-3, pp. 154-162, April 1974, www.xlrtechs.com/dbkeele.com/PDF/Keele%20(1974-04%20AES%20Published)%20-%20Nearfield%20Paper.pdf

F. Toole, *Sound Reproduction: The Acoustics and Psychoacoustics of Loudspeaker and Rooms*, 3rd edition, Routledge, 2018.

S. Yaniger, "Vanatoo Transparent Zero Powered Speakers," *audioXpress*, January 2018. www.audioxpress.com/article/fresh-from-the-bench-vanatoo-transparent-zero-powered-speakers

S. Yaniger, "Sonarworks Reference 4 Studio Edition Loudspeaker and Headphone Correction System," *audioXpress*, July 2018, www.audioxpress.com/article/fresh-from-the-bench-sonarworks-reference-4-studio-edition-loudspeaker-and-headphone-correction-system

Swans Speakers DIY Kits

Everything You Need Is Inside the Box

Photo 1: All the parts needed for equipping two speakers are shown. Note the labeled packaging on the hardware items.

With the renewed interest in two-channel stereo comes a resurgence of DIY speaker systems. In this article, Ken Bird details his experience in building a set of speakers from the new Swans Speakers Kits catalog.

Ken Bird
(United States)

Speaker kits have been around since the dawn of the hi-fi craze in the early 1950s. During that period, the major driver manufacturers (e.g., Electro Voice, University, Sherwood, Argos, and Utah) offered kits to the DIY market. Major distributors also entered the market with Allied, Lafayette, McGee Radio. One of the most popular suppliers, Heathkit, sold thousands of speaker kits along with its line of other electronic kits. The off-the-shelf speaker market offered by RadioShack, Best Buy, and retailers reduced the number of speaker kit suppliers in the last third of the century, forcing the DIY audio hobbyist who wanted a better-quality speaker to purchase wood, drivers, and other supplies to build their own. The advent of multiple-channel surround sound systems and portable music devices further reduced the interest in DIY speaker building. The average non-technical audio enthusiast was left with whatever the consumer market offered in off-the-shelf speakers.

Photo 2: The materials for constructing the two speakers are contained in one well packed box weighing about 70 lbs. The components are individually packaged and well labeled for identification.

The renewed interest in vinyl by baby boomers and millennials alike has once again spawned an interest in two-channel stereo, opening a mass market for DIY speaker systems sold through online suppliers. One company, Swans, a long-time supplier of high-quality high-end speakers and well known by audio enthusiasts, is now offering DIY speaker kits through Amazon under the Swans Speaker Kits name (www.swanskits.com).

Swans is a now a division of HiVi Research, a manufacturer of fine quality drivers. They produce more than 3 million drivers annually for use in the OEM market. Swans Speakers currently has two kits

available. One is a two-way bookshelf design, the DIY 2.2A and the slightly larger three-way design, the DIY 3.1A. Both models incorporate HiVi drivers.

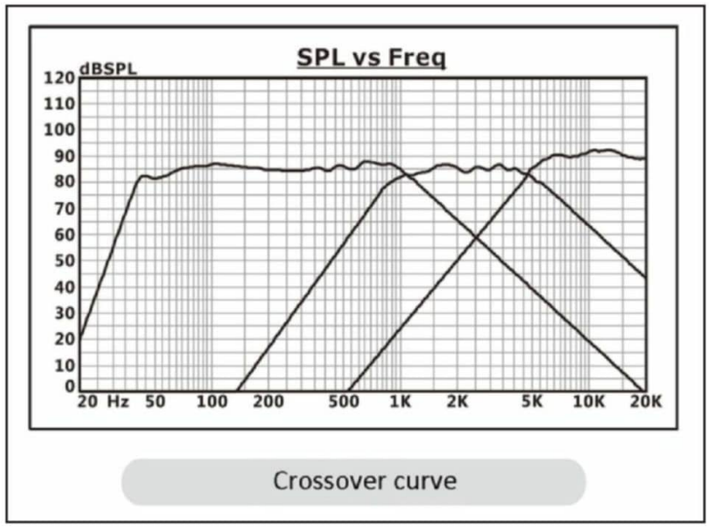


Figure 1: Crossover chart of the 3.1 system. (Image courtesy of Swans Speakers Kits)

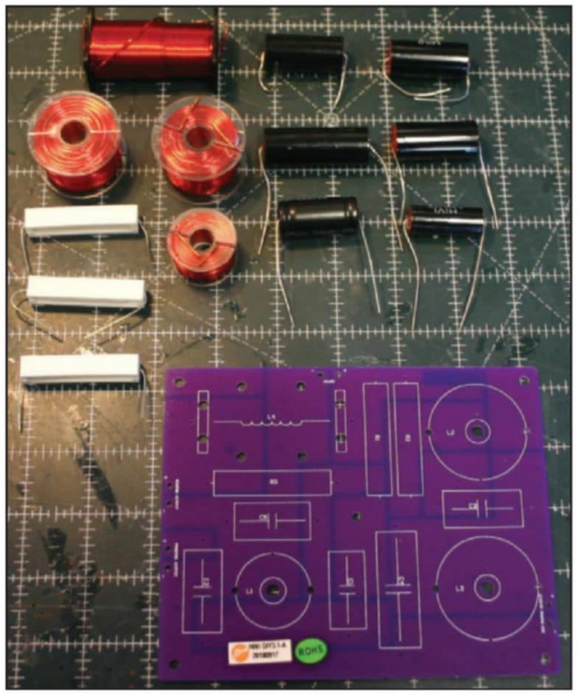


Photo 3: The second-order crossover uses quality components that are easy to assemble on the well marked circuit board.

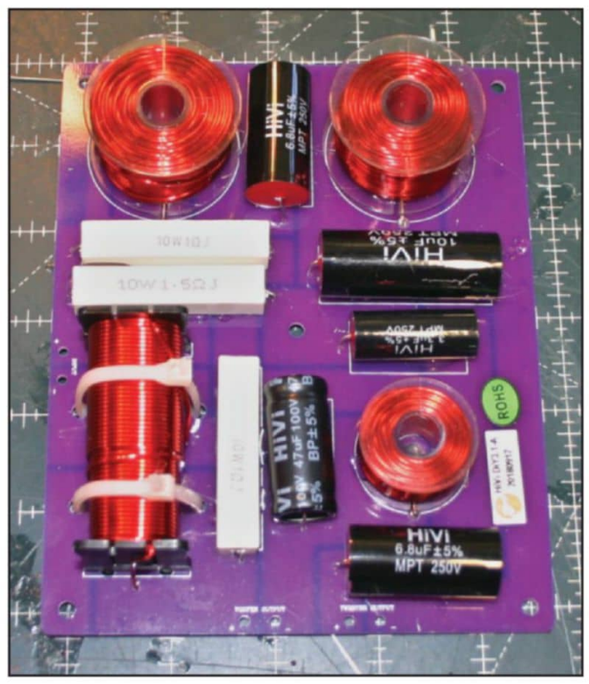


Photo 4: The assembled circuit is ready for wire connections.

The Speakers

The speakers were shipped via the US Postal Service, and being on a rural route, the 70 lbs. box was too large for home delivery, requiring a trip to the post office. Once I got the packages home and in the shop, the un-boxing commenced. The packaging was most impressive with liberal use of protective foam. Each of the drivers was separately boxed and the pre-cut MDF cabinet parts were also boxed separately and wrapped in protective plastic separated by foam sheets. The driver hardware and other parts were equally well packaged (see **Photo 1** and **Photo 2**).

The assembly instructions were sketchy, being written in "Chinese English," but photos in the manual made identification of the parts easy. All of the small hardware parts were bagged and marked with an identification letter. Like any project of this type, following the directions, with exceptions noted later in the article, is the best way to proceed. Use the manual as a guide and conduct an inventory for each part before assembly.

The Drivers

The drivers supplied with the kit are fine quality Hi-Vi models. The woofer is the L6-4R 6" with a woven Kevlar cone and phase plug. It is rated at 4 Ω, with an F_S of 50 Hz and a nominal 30 W of power handling. The midrange is the HiVi DMN-A, a chambered 50 mm soft dome driver with a neodymium magnet and a range of 800 to 9 kHz.

The tweeter is the HiVi RT1, from the isodynamic series of drivers using a membrane-style cone and neodymium magnets. It has a range of 2.5 kHz to 40 kHz. The speakers are crossed over at 1.1 kHz and 4.8 kHz (see **Figure 1**).

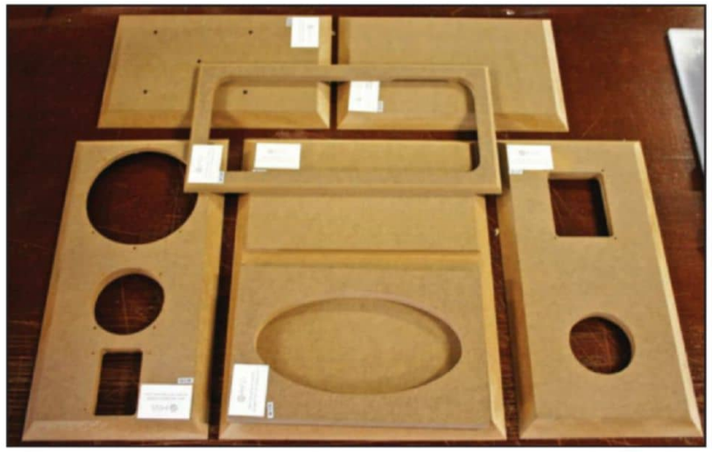


Photo 5: The precut MDF panels are laid out for assembly.

Photo 6: Clamps are used to hold the panels as the glue dries. An optional step is to use a nail gun to hold the panels, which reduces the need for multiple clamps.

Crossover Assembly

Assembly starts with the crossover networks. All the parts are contained in clearly marked plastic bags and can be easily identified by using the photos and the list

Photo 7: I applied the grill cloth into the pre-milled grills using a thin putty knife to stuff the cloth into the glue-filled grooves.

Photo 8: I painted the assembled enclosures a satin black. Note the predrilled holes for the rubber grille holders.

shown in the manual (see **Photo 3**). The crossover board is well marked for the parts location and only requires insertion of the parts and a solder connection on the bottom of the board (see **Photo 4**). While assembling the parts, I used a glue gun to hold the capacitors, the resistors, and two of the small coils in place prior to soldering. I anchored the larger coil to the board with cable ties. Once I installed the components, I installed the included pre-cut speaker wires and soldered them to the board.

Cabinet Assembly

The cabinets are composed of pre-cut and drilled MDF, which accounts for the hefty weight of the enclosures. All the pieces were smooth and cut to very accurate dimensions and all the mounting holes for the speakers, the crossover, and the speaker terminal were pre-cut and drilled (see **Photo 5**). Screws and nails are not used in the assembly of the enclosure, and in my opinion, that could be problematic. Relying on just clamped wood glue joints may threaten the structural integrity and does not guarantee a good air seal that can affect woofer performance. The manual says to "add some acoustic stuffing into the enclosure and press it hard against the side panels."

This is a bit vague but it is an important step in the construction. Without some damping material, the lower midrange could be made muddy by woofer reflections in the cabinet. A better solution was to line the side panels, top, bottom, and rear panels with 1" polyester batting before assembly. I cut the material to fit and stapled it in place allowing 0.5" clearance on the internal cabinet edges.

As recommended, I used cabinet clamps during the assembly to hold the pieces (see **Photo 6**). If the builder has an extra pair of hands, it would make assembly easier. Start by gluing in the centerboard and then the opposite side using clamps to hold the sides together. An optional step would be to use a nail gun with 2" staples to secure the center board and each subsequent joint. Another optional step would be to add a bead of window caulking on the inside joints as the enclosure is being pieced to assure a good air seal. Once assembled, check for any glue seepage and allow the cabinets to dry overnight before finishing.

The grilles provided were pre-grooved for inserting the supplied black grille cloth. I painted each grille black and inserted the cloth into the pre-glued slot with a putty knife (see **Photo 7**). I then applied the

Photo 9: I wired the speakers using the supplied cable. The polyester battens lining the insides can be seen.

optional supplied SWAN logo to the lower right of the grilles.

Cabinet Finishing

I sanded the enclosures to remove any surface imperfections or glue seepage. The user can elect to cover the cabinet with the supplied black vinyl material, or the enclosures can be painted or have a wood veneer applied. The instructions for applying the vinyl "veneer" is to apply the glue (not supplied in the kit) to the back of the vinyl and "paste" it to the cabinet. The instructions further recommended that a hot cloth be used to make the vinyl softer when applying. No glue type is specified in the manual. I decided not to apply the vinyl and instead I painted them with satin black enamel (see **Photo 8**). After painting the enclosures, I installed the port tube using a bead of window caulk around the rim and attached the supplied rubber feet.

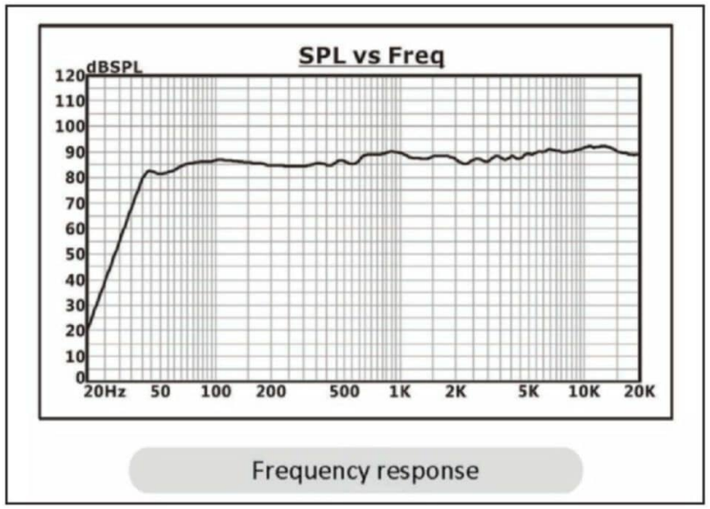


Figure 2: Over all response of the system (Image courtesy of Swans Speakers Kits)

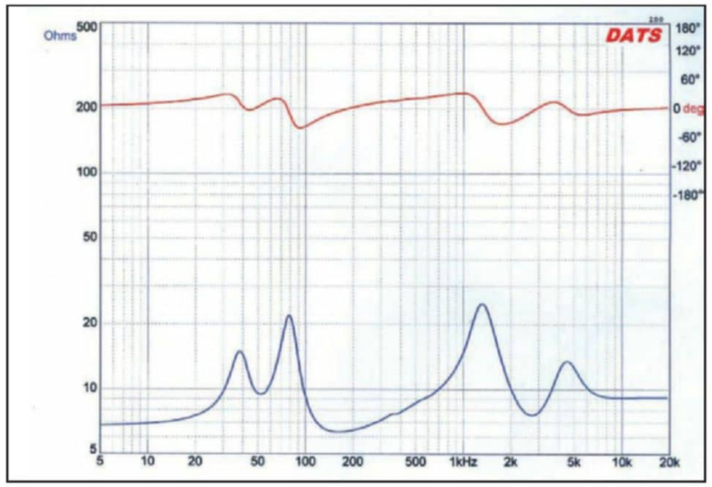


Figure 3: Impedance chart, obtained with the Dayton DATS system, shows the box is tuned to 50 Hz.

About the Author

Ken Bird has had a 40-year engineering and product management career focusing on consumer, industrial, and telecommunications electronics. Ken retired to his native Missouri and now pursues his interest in building speakers and tube amplifiers, along with model railroading, amateur radio (WOKLB), and digital photography.

Installing the Drivers

Before installing the drivers, the previously wired crossover network must be installed in the bottom of the cabinet using the supplied screw retainers. I hammered them into pre-drilled holes in the bottom. Then, I soldered the input wire to the speaker terminal board and mounted it in the rear of the cabinet. I made sure the red wire was soldered to the + terminal.

Installation of the drivers was not difficult as all the hardware was provided. The screws use "Star" type heads rather the common Phillips type, but bits for them are available at any hardware or home store. Gaskets are provided with each driver for forming a good air seal. I soldered each driver to the previously installed wire on the crossover network (see **Photo 9**). Careful note of the polarity requires the red lead to be on the red terminal on each speaker. An optional metal trim ring was supplied for the woofer.

Testing

The speakers measured about 6.54 Ω impedance and the enclosure resonance was seen at 50 Hz, or about the resonance of the raw driver. The speakers are advertised at a 45 kHz to 20 kHz response and the response graph, supplied by Swans, showed they should have no problem meeting those specifications (see **Figure 2**). The impedance graph that I measured shows the system was tuned to 50 Hz (see **Figure 3**).

The speakers will need to be used with stands to be properly positioned for listening. Those shown in **Photo 10** were improvised using discarded copper wire spools. I began testing by attaching the speakers to a receiver and slowly bringing up the volume, listening for any rattles or distortion that may indicate a poor connection or defective speaker. No problems were evident and the listening test continued with a variety of classical, rock, country, and vocal music.

The speakers performed exceptionally well. The bass was surprisingly tight and deep, without boom, even on some very low organ pieces. The midrange was crisp, bright, and had a forward sound that some audio enthusiasts might find annoying, but turning the treble down from the flat position will modify the midrange to the satisfaction of most listeners. Advanced speaker builders could tinker with the resistors on the crossover board to change the crossover energy to the midrange and the tweeter. The following web location has some suggestions: https://diy.midwestaudio.club/discussion/550/hivi-diy-3-1-revisited.

Vocalists stood out very well on the speakers and the lack of any discernible distortion even at higher that moderate listen levels were evident. Swans engineering, using the HiVi drivers, has produced a speaker that performs at the level appreciated by an experienced audiophile, at a price the average listener can afford. They also could find good use in the professional audio field as studio monitors or would make great surround sound speakers.

Photo 10: I used the completed speakers in a 2.1 audio system.

Summation

These kits are not the assemble-on-the-kitchen-table type as they do require an individual to have some tool handling knowledge, especially soldering, plus some additional tools the average household might not have (e.g., multiple cabinet clamps and "star bits"). However, anyone who has assembled an IKEA product or other built-it-yourself-type project should have little difficulty in assembling these speakers. Once completed, the owner will have a high-quality audio product that should give years of listening pleasure.

A pre-assembled pair of speakers of this quality would sell for $1,000 or more, and purchasing just the raw drivers would set you back $263, making the $289.99 price for the entire kit on Amazon a real bargain.

Industry Calendar

Here are a few places where you might find a copy of *audioXpress* and possibly meet one of our authors and staff members.

August 27–29, 2019
2019 AES International Conference on Headphone Technology
The Golden Gate Club, San Francisco, CA
www.aes.org/conferences/2019/headphones

The Audio Engineering Society (AES) announced its second AES International Conference on Headphone Technology, which will be held on August 27–29, 2019 in San Francisco, CA. The conference will focus on Mobile Spatial Audio, Individualization, Assistive Listening, and Audio for Augmented Reality. Anyone doing research in the field is invited to participate.

The first—and very successful—edition of the conference was held in August 2016 in Aalborg, Denmark, following a first experiment in 2013, with a conference on Loudspeakers and Headphones in Helsinki, Finland. The Aalborg event received approximately 160 registered participants and more than 40 paper and keynote presentations, with 20 companies promoting demonstrations.

The choice of San Francisco for this event is also not a coincidence, being the home base for many headphone brands and some of the largest technology companies, some of which are directly sponsoring the conference. An ideal setting for a fascinating and informative conference!

Confirmed keynote lectures include Dr. Ing. Daniel Beer, Fraunhofer IDMT, addressing acoustics and design with MEMS drivers; Prof. Ramani Duraiswami, University of Maryland, discussing HRTF modeling and rendering; Prof. Woon-Seng Gan, Nanyang Technological University, Singapore, talking about signal processing for AR; Prof. Dorte Hammershøi, Aalborg University, on hearing damage risk from headphone-based listening; and Prof. Michael Vorländer, Aachen University, on acoustic transparency of earphones and headphones.

September 6-8, 2019
Rocky Mountain International Audio Fest (RMAF)
Gaylord Rockies Resort & Convention Center
6700 North Gaylord Rockies Blvd, Aurora, CO
www.audiofest.net

While its status has been challenged by other shows, the annual Rocky Mountain International Audio Fest (RMAF) is currently the largest consumer audio and home entertainment show in the US. Denver, Colorado's own audio wonderland now features more than 160 exhibit spaces representing more than 400 companies from North and South America, Europe, Australia and Asia. The 2019 edition will be remembered for the change to a new and improved location, the Gaylord Rockies Resort & Convention Center.

Most RMAF exhibitors are manufacturers, distributors, retailers, and craftsmen from the international electronics industry. The RMAF Exhibitor List is certainly impressive, combining the most established consumer and high-end audio brands from US and Canada with European and Asian counterparts. And the show is always complemented with a nice mix of seminars, entertainment, and a room full of the latest headphone gear, with the concurrent HeadSpace@ RMAF. For the first time in some years, RMAF will not be complemented by the traditional CanJam@RMAF, promoted by Head-fi. However, the headphone and personal audio experience at the Denver show will remain, only now it will be organized by the Colorado Audio Society, promoters of the show. The organization is promising the latest and greatest in headphone technology.

The move to the Gaylord Rockies Resort & Convention Center also looks like a winning opportunity. The resort and convention center opened to the public on December 18, 2018 and the facility includes 1501 rooms and 114 larger suites, allowing for more than enough space for RMAF to satisfy exhibitor demand. Also, the resort has excellent dining facilities, with at least eight restaurants and a bar with views of downtown Denver and the Rocky Mountains.

September 6–11, 2019
IFA Berlin (The International Funkausstellung)
IFA Exhibition Center, Berlin, Germany
www.ifa-berlin.com

For the second year, IFA 2019 will take place in two fully occupied exhibition areas: the entire Berlin Exhibition Grounds as well as IFA Global Markets (for trade visitors only) at Station Berlin on Gleisdreieck. Europe's giant trade show for Consumer and Home Electronics will again underline the event's unique global standing as a driving force for growth and innovation, and there's plenty of new exhibits and events.

IFA is a gigantic show focused on consumer electronics, appliances, and provides a strategic moment for CE and technology brands to promote their products before the shopping season at the end of another year.

The IFA+ Summit (www.ifaplussummit.com) has been the IFA's think tank since 2014, the world's largest show for consumer and home electronics. Each year, it draws in more than 550 participants from over 30 countries and more than 50 speakers. The two-day IFA+ Summit is part of the IFA NEXT innovation forum and takes place September 8–9 at the IFA fair grounds in Grand Theater, Hall 26b.

The IFA NEXT (www.ifanext.com) exhibition area, which doubled its size in 2018, continues to focus on digital innovations for a healthier lifestyle and to promote the industry's Innovation Engines. This year, IFA Next announced Japan as its first official Global Innovation Partner.

Connectivity, artificial intelligence, voice control and 5G are the big trends driving innovation for consumer electronics and home appliances this year, and they will be showcased across the network of global IFA events this year.

Confirmed keynote speakers at IFA Berlin 2019 include Richard Yu, the Chief Executive Officer of Huawei; and Cristiano Amon, the President of Qualcomm. IFA also has its first IFA Global Audio Partner in Sennheiser, a company that has been exhibiting at IFA for the past 69 years. Sennheiser will support key IFA events with its range of professional audio gear and support journalists with equipment and technical support. While IFA has always been visionary, ever since the days when Albert Einstein addressed the event, it is also the ultimate showcase for audio technologies.

September 10-14, 2019
CEDIA Expo
Colorado Convention Center, Denver, CO
www.cediaexpo.com

CEDIA Expo is the annual show created for the Custom Electronic Design & Installation Association (CEDIA), founded to advocate home technology, and promoting training/certification, business, and the residential integration industry in general. Now operated by Emerald Expositions, the 2019 edition is promoting a new expansion era, toward the connected home and connected built environments.

More than 20,000 home technology professionals and 500+ exhibitors will convene at CEDIA Expo for the annual leading event in connected technology. The return to the Denver Convention Center promises to reenergize the sector, now highlighting the broader smart home concept. CEDIA Expo is also the event where the residential integration industry promotes new products, breakthrough innovations and targeted training.

For the 2019 edition of the CEDIA Expo, CEDIA has already confirmed an expanded educational conference lineup, with more than 125 classes, 50% of them new and covering 17 different areas of expertise.

CEDIA Expo will also see the return of the Design Connection program, which made its debut at CEDIA Expo 2018 and will feature multiple programs and networking opportunities, including viewing products in the Design Connection Pavilion, participating in the Design Connection Tour Series, and networking at the Bourbon, Bubbly & Brownies event.

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