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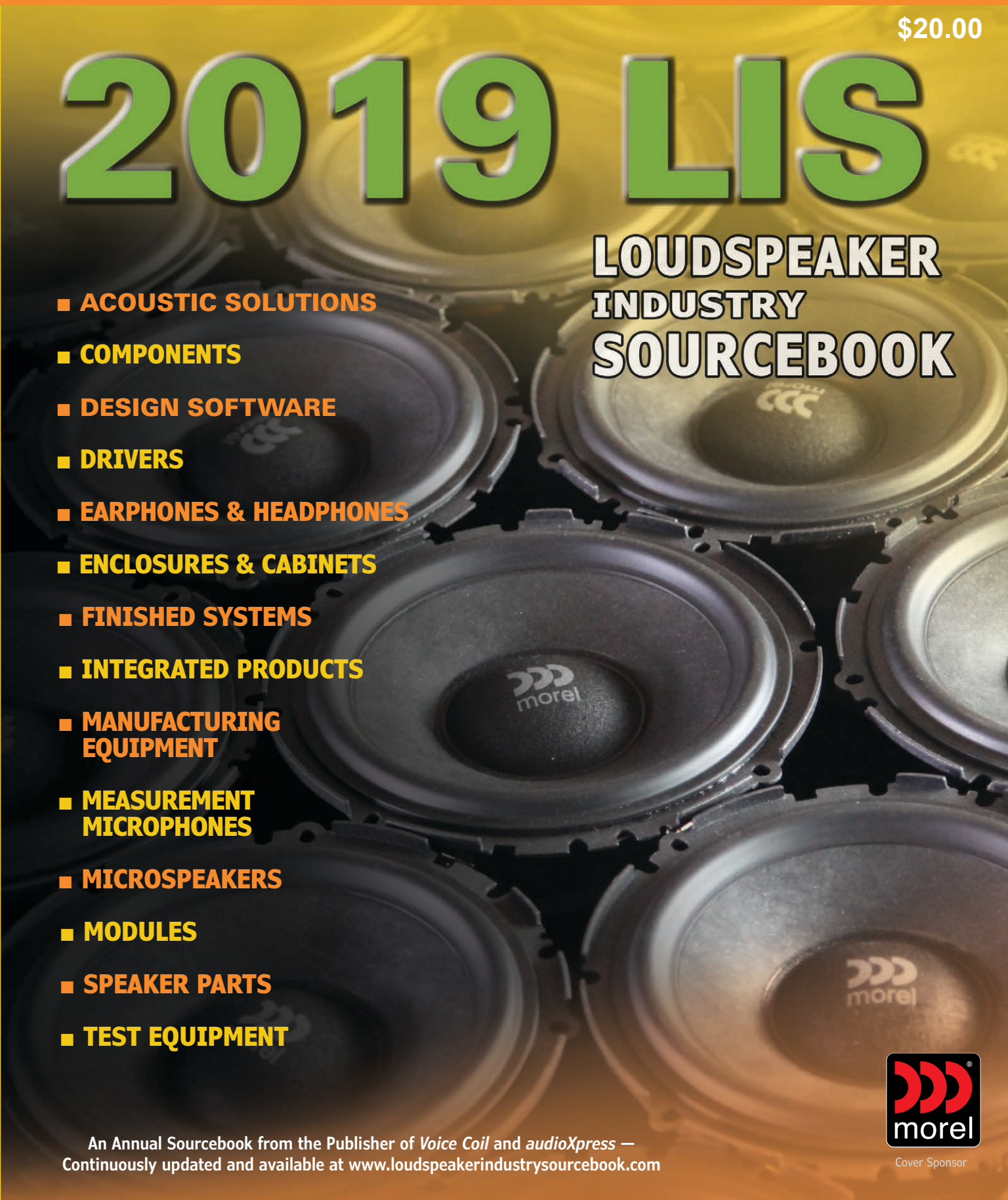

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		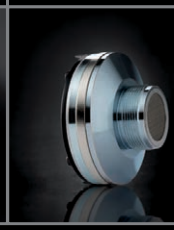	

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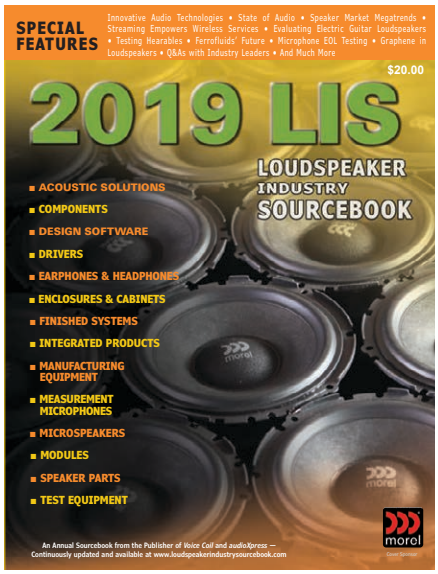
The Loudspeaker Industry Sourcebook (LIS) and specifically its printed edition has been published every year for the past 23 years. Of course, many people in the audio industry are now familiar with LIS in its online directory format, which is available at www.loudspeakerindustrysourcebook.com. The annual publication is fast becoming a year-round reference resource for everyone involved in R&D, manufacturing, technical support, marketing, or sales in the loudspeaker and related industries.



One would think that with all the online tools and social media networks currently available to us, industries would be more connected than ever, but precisely the opposite happens. The world is now a global market, and professionals trying to identify a new potential source for components, materials, or services are faced with an impossible task of actually identify who's who in the never ending maze of online search engines, supplying thousands of potential candidates with obscure keyword credentials, while a simple search in any of those tracking services results in a sudden explosion of absurd sales pitches spamming our email inboxes and messaging apps...

LIS is created annually with direct support from industry professionals who travel the world visiting companies and factories and attend the most important trade shows in the Americas, Europe, and Asia. That includes the editorial teams and contributing networks of *Voice Coil* and *audioXpress* monthly magazines, in direct cooperation with the most relevant industry associations such as the Association of Loudspeaker Manufacturing & Acoustics (ALMA) International, the Audio Engineering Society (AES), the Audiovisual and Integrated Experience Association (AVIXA), the producer of InfoComm; and the Custom Electronic Design & Installation Association (CEDIA).

The result, makes the *Loudspeaker Industry Sourcebook* the best possible compilation of company profiles for the industry in every segment. The loudspeaker manufacturing professional's indispensable resource.

And this is particularly important to highlight, at a time where our industry is going through the most challenging and disrupting trends, forcing companies to constantly reevaluate their supplier-chain, consider the logistical challenges, and potential trade-related barriers from all its vendors. It is a time when contacts and knowledge are more important than ever, and the industry needs to work together.

The *Loudspeaker Industry Sourcebook* (LIS) is an essential first tool for contacts. But this annual publication is also a valuable resource for the essential knowledge part.

As illustrated in this LIS 2019 edition, our editorial team has compiled a valuable series of high-quality Industry Features and Reports covering all major market trends. Starting with loudspeaker-related topics, but also addressing all different types of audio transducers used in headphones, earphones, smartphones, and all sorts of personal and home devices, at the core of all major audio applications.

We sincerely hope the result will inspire and help you while managing the opportunities ahead.

We hope you enjoy this 2019 edition of the *Loudspeaker Industry Sourcebook*!

—The *Loudspeaker Industry Sourcebook* Staff

Content for the *Loudspeaker Industry Sourcebook*

The *Loudspeaker Industry Sourcebook* has been published each year since 1996. Over the past eight years, we have made a concerted effort to grow the editorial content that is provided in the annual publication. Our goal has been to enhance the magazine and offer industry leaders an opportunity to share their research information and projects with the rest of the audio industry as well as take part in a Question & Answer section.

In years' past we have reached out to industry leaders who have graciously agreed to write articles for the magazine. Sometimes, the articles are culled from important papers they have written and presented at Audio Engineering Society (AES) conventions or at the Association of Loudspeaker Manufacturing and Acoustics (ALMA) International's AISE. Other times, these audio professionals have discussed new technologies. And we greatly appreciate their time and their willingness to take part in our endeavor.

With the 2019 edition of the *Loudspeaker Industry Sourcebook* complete, we wanted to issue an invitation to our readership to begin thinking about potential content that they might want to submit or see included for the 2020 sourcebook. We appreciate your suggestions and are grateful to be a part of the audio community. For more information, email Shannon Becker at sbecker@audioxpress.com.

ABOUT THIS ISSUE • ABOUT THIS ISSUE • ABOUT THIS ISSUE •

Innovative Technologies Drive the Audio Industry Forward

A Handful of Brands Reap the Bulk of the Rewards

Photo 1: Sonos's Beam—the wireless speaker company's first <$500 soundbar with built-in Amazon Alexa—saw a strong uptake on launch in Q3 2018.

By
Guy Hammett
(Futuresource Consulting)

The year 2018 witnessed strong growth for the audio market, with interest in both home and personal audio significantly up on the previous year. The two largest hardware categories (wireless speakers and headphones) saw demand boosted by rapidly increasing consumer desire for innovative technologies, although these two products have seen divergent fortunes in volumes versus value. Beyond this, home theatre interest remains robust, driven by increasingly feature rich soundbars which are adding to the quality of audio experience. Even the smaller market for Hi-Fi Separates (CD players, network audio players, stereo amplifiers, and turntables) had a positive 2018 growing in both volume and value.

Smart Speakers Drive Growth

Voice Assistants (VAs) have been the hot audio topic in recent years and 2018 was another impressive year for this technology with worldwide shipments of smart speakers up 92% over 2017 to reach 53 million units, which is about 43% of total wireless speaker shipments (see **Figure 1**). The market continues to be dominated by the US, China (which grew 622% last year), and to a lesser extent the UK. However, improving geographical availability is leading to significant shipment increases in many smaller countries. Official launches in places such as India, the Nordic Region (Denmark, Norway, Sweden, and Finland), and the Netherlands have rapidly increased interest in smart speakers, which in all three areas accounted for roughly 15% of total wireless speaker demand in the fourth quarter (Q4) of 2018.

Additionally, 2018 saw the launch of the first voice soundbars. These made up 5% of Q4 2018 soundbar shipments. Sonos Beam is by far the most popular smart soundbar to date (see **Photo 1**). However, many in the industry question whether its success reflects strong demand for soundbars with integrated voice assistants or simply demand for a quality product from a premium brand at an attractive price. Voice is likely to become one of many important features in a soundbar purchase, unlike the essential feature it has become for many choosing a wireless speaker.

While smart speakers have undoubtedly provided some incremental growth to total wireless speaker demand, focusing purely on the boost to shipment numbers doesn't tell the true story. Demand is being driven by the less than $50 models, a factor which has forced down average wireless speaker prices significantly. While wireless speaker volumes increased 27.5% in 2018, value was up just 7.8%. Of even more concern to wireless speaker vendors is the brand landscape. The top five smart speaker players last year were all non-audio brands—Amazon, Google, Alibaba,

Xiaomi, and Baidu. These vendors are primarily concerned with getting their products into homes as part of the wider battle for voice as a user interface (UI) and are willing to sell speakers at, or even below, cost to achieve growth. Traditional wireless speaker brands (those present in this market before the introduction of smart speakers) cannot compete on price with companies such as Amazon and Google, with audio brands accounting for just over 4% of the overall smart speaker market last year. This share has not changed significantly quarter-on-quarter since the first smart speaker releases from audio vendors.

This presents a dilemma for traditional audio brands. With Harman/JBL becoming increasingly dominant in the non-smart wireless speaker market (which grew just 1.8% in 2018) and efforts to penetrate the smart speaker market so far having limited success, it's unclear where the growth potential is for many of these brands.

However, there is a beacon of hope for these companies. Consumer research, including Futuresource's own, consistently finds that listening to music is by some way the number one use for smart speakers. Indeed, our research shows that, as a proportion of all users, listening to music is increasing in importance at the expense of home control functions as smart speakers move beyond early adopters. This does represent a potential medium-term opportunity for audio vendors that hope consumers will make audio quality a higher priority in the smart speaker purchasing decision, and there is some tentative evidence that this trend may be slowly developing in the most mature smart speaker market—the US.

While smart speakers are currently the dominant voice product with 44% of all "built-in" voice assistant shipments last year, the future of voice as a UI extends far beyond smart speakers. We are already seeing voice assistants built in to a wide array of other consumer electronics products. By 2022, Futuresource estimates that the smart speaker share of "built-in" VA products will fall to 22%. As other products, such as TVs, headphones, wearables, and set-top boxes, become more important in the overall voice landscape, it's possible that the voice platforms (Google, Amazon, etc) will place more focus on these other products with audio brands well positioned to regain a greater share of the wireless speaker market.

True Wireless in Headphones

While voice is also increasingly present in headphones, a different technology is making waves here—true wireless. Unlike in the wireless speaker market, this standout feature is making a more significant impact on value than volume, with in-ear average prices up 28% in 2018 on the back of true wireless headphone growth. True wireless headphones accounted for 7.8% of worldwide headphone volumes last year, with this number increasing to an astonishing 22% of the market in value terms. There is, again, a caveat that must be placed against this trend as the vast majority of true wireless volume and

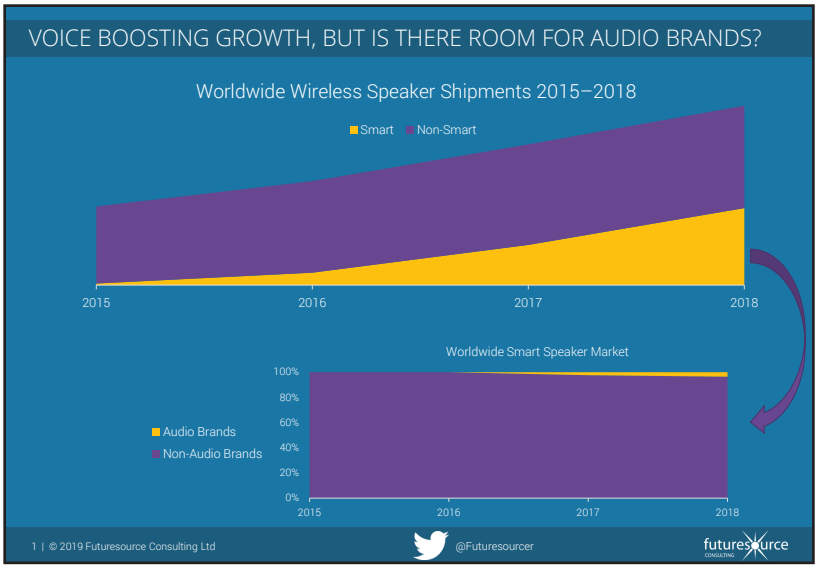


Figure 1: Smart speakers are boosting the wireless speaker market, but most of the gains are going to non-audio brands (those who've entered since the market since the introduction of smart speakers—includes Apple).

About the Author

Guy Hammett is a Market Analyst in the Consumer Electronics team at Futuresource Consulting. Guy joined Futuresource in 2016 after graduating from the University of Sussex with First Class Honours degree in Economics. Guy has worked in a variety of different Consumer Electronics areas, both continuous tracking services and one-off custom projects, and has specialised in audio research for the last two years. He currently heads up Futuresource Consulting's quarterly Home Audio tracking reports and twice yearly market reports forecasting out to 2023, in addition to an annual Loudspeaker market report, and regularly represents Futuresource at trade conferences across the globe.

About Futuresource Consulting

Futuresource Consulting delivers specialist research and consulting services, providing knowledge, experience and accuracy to support decision-making processes. Since the 1980s, Futuresource has supported a range of industry sectors, which has grown to include: Broadcast & Pro Video Equipment, Consumer Electronics, Education Technology & Content, Entertainment, Content Delivery & Manufacturing, Professional Displays, Print & Imaging, and Removable Storage.

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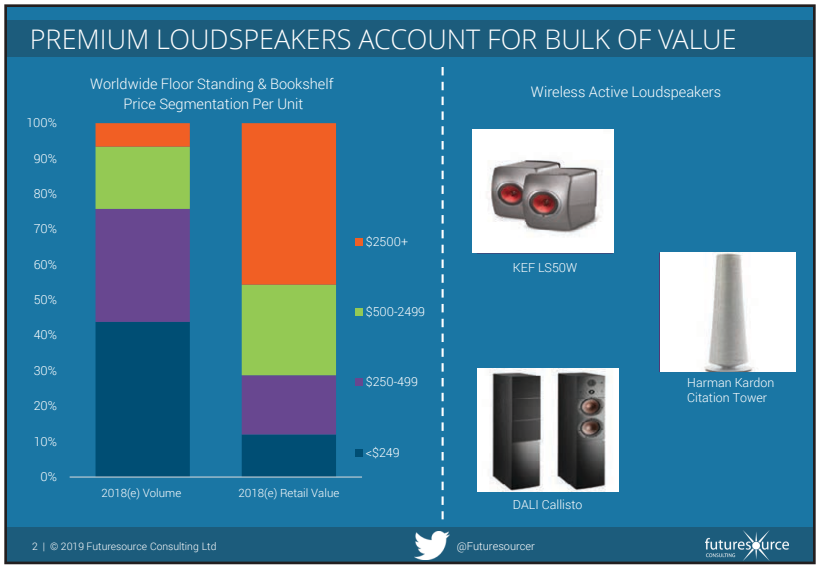

Figure 2: Low-volume premium loudspeakers are responsible for the bulk of loudspeaker value, while brands such as KEF, Harman Kardon, and DALI are bringing wireless connectivity to loudspeakers.

value belongs to Apple. As with smart speakers, the tremendous growth is not benefiting most players in the industry.

On a wider scale, the overall headphones market is experiencing value growth far exceeding increases in shipments, with revenues up 35.7% compared to just a 5.2% growth in headphone volumes. In addition to true wireless, noise cancelling continues to be an increasingly important feature growing 33.6% in volumes and 88.4% in value. Sports headphones are another category experiencing strong double-digit growth, although here volume and value increases are broadly in line with one another.

Photo 2: The loudspeaker market is adopting completely new strategies to address changing consumer habits. Recently Sonos and IKEA cooperated to reimagine the smart home with the SYMFONISK loudspeaker range.

Loudspeakers—Premium and Active

The issues currently facing wireless speaker vendors are reminiscent of those that passive loudspeaker vendors faced upon the emergence of wireless speakers. The passive speaker story has been a negative one over the last decade or so, and at a top-line level this was no different in 2018 with both bookshelf and floor-standing speakers continuing to decline year-over-year. Despite the overall picture looking challenging, there are areas of positivity for loudspeaker vendors.

First, the performance of both premium bookshelf and floor-standing speakers outshone the overall market in 2018 (see **Figure 2**). While wireless speakers have largely cannibalized lower-end passive speakers, bookshelfs in particular, there's still significant interest in the perceived higher quality of passive loudspeakers among consumers who place a premium on sound quality. This resulted in the premium categories (at a cost greater than $500 a pair for bookshelf speakers and at a cost greater than $1,000 a pair for floor-standing speakers) declining at a much slower rate than products below these price points.

Shipments of speakers priced at $10,000 a pair and above actually increased year-on-year in 2018. This trend toward premium has been boosted, to an extent, by the vinyl resurgence, which has led to some increase in stereo listening. Also, the rise of high-quality streaming amplifier receivers has helped bring streaming audio to the passive speaker owner.

Additionally, an increasing number of vendors are offering wireless active loudspeakers with built-in amplifiers (see **Photo 2**). KEF LS50W being a prime example of this type of product. Vendors producing wireless active loudspeakers reported solid sales in 2018, with overall shipments forecasted to grow 23% on 2017. However, there is still a reluctance among some in the industry to enter this market. Some vendors argue that consumers concerned with audio quality believe a wireless connection will always be inferior to a wired connection, although this is really only an issue for the most serious of audiophiles.

A more important factor, in Futuresource's opinion, is the additional associated costs for brands entering and maintaining a presence in this market. Active loudspeakers require different design and manufacturing expertise to passive

loudspeakers, with a significant initial investment cost in addition to ongoing costs around firmware updates and connectivity support. Finally, some retailers and audio dealers seem to lack enthusiasm for active speakers, possibly worried about losing revenue from selling cables and other associated accessories to passive speakers.

Lines Between B2B and Consumer Loudspeakers Continue to Blur

The professional loudspeaker industry continues to offer significant opportunity for both B2B brands and consumer loudspeaker manufacturers with the competitive climate within the installed leisure and corporate install markets continuing to intensify.

Live/touring and studio brands are moving their focus away from traditional applications in the professional space to capture higher growth on the installation side. Some brands from this category are now seeing revenues from their corporate and leisure install business surpass that of their traditional verticals. However, as outlined in Futuresource's dedicated research into the content creation space, the home and pro studio markets still offer significant potential for speaker manufacturers—both consumer-facing and pro.

Consumer-facing brands such as Bose and JBL continue to leverage their branding to reach end users in the install markets. This has proven to be especially powerful for installed leisure speakers and indicates potential for more consumer-focused brands to enter this space. Considering this, it was interesting to see Sonos exhibiting outdoor install speakers for the first time this year at ISE, following its partnership with B2B speaker manufacturer Sonance.

Recent consolidation comes in the form of RCF's acquisition of loudspeaker manufacturer EAW and DPA microphones, increasing its presence in the broadcast mic space and the live and touring speaker market in the US. More acquisitions are expected over the coming years, with many large consumer brands looking intently at opportunities in the pro audio and content creation markets and pro brands striving to quickly secure more market share.

Streaming Boosts Music Market Recovery

Away from audio hardware, 2018 witnessed continued momentum in the streaming music market around the globe, which has, in turn, fuelled a recovery in what was a down trodden overall music market five to six years ago.

Photo 3: Apple's AirPods have taken the true wireless headphones market by storm, shipping 34 times the volumes of its nearest competitor

Streaming music subscriptions now dominate consumer spend on recorded music in virtually all markets (Japan is the exception, where even CD rental stores are notable), accounting for around 90% of consumer spend in the likes of the Nordic Region, China, and Brazil, with other key music markets such as the US and UK at around 70%. In Europe and the Americas, Spotify has largely driven this sector, with Apple Music a comfortable number two, while Amazon continues its efforts to drive its music subscription service on the back of strong Echo sales in the US and UK, although availability and uptake elsewhere is in its early days.

In contrast, the vinyl revival is slowing. With turntable shipments set to peak in 2019, vinyl sales are expected to plateau and eventually steadily decline, but it will remain a key music carrier for the foreseeable future.

Exciting but Uncertain Future

In summary, 2018 was a year of substantial growth in the audio industry, but this growth brought with it challenges and 2019 is set to be no different. Smart displays are poised to carve out significant growth within the wireless speaker category, with more nontraditional audio brands entering this market (e.g., Lenovo and KitchenAid). In headphones, AirPods 2 (see **Photo 3**) will likely be the major launch, although CE giant Samsung is looking to make a statement with its Galaxy Buds. 2019 will also see the first wireless loudspeakers with an integrated voice assistant (Harman Kardon Citation Tower). Ultimately, 2019 will see more consumers listening to more music in more ways than ever before. Despite this, there remain challenges for audio brands to fully capitalize. ***LIS***

The State of the Audio and Loudspeaker Technologies Industry

A few key members of the Association of Loudspeaker Manufacturing and Acoustics (ALMA) International share their thoughts regarding the current state of the industry.

By **Barry Vogel**
(Executive Director, ALMA International)

For a "mature" industry, it certainly seems that there is a great deal going on even though it has been a common sentiment among many industry members that the loudspeaker industry is not terribly exciting anymore. After all, the electroacoustic driver is science that has not fundamentally changed since introduced in 1876. What has changed is the way we listen to audio content and the ways that make it all sound great. What has also changed is just how connected it has all become.

A cell phone speaker on its own sounds tinny and difficult to listen to. Coupled with today's digital signal processing, Mom sounds like Mom! However, the incredibly vibrant and resilient headphone industry has been a bright spot for many established and upstart companies. Remember when almost everyone predicted those iPod ear buds had destroyed the entire concept of "sound quality"? While the iPod changed the way many people listen to music, there is one thing that is entirely consistent with human beings—they always want more, better, the get me excited. And, one thing about our industry is that we love a challenge!

The headphone industry has produced an amazing array of in-ear, on-ear, open- and closed-back models as well as a dizzying array of options (e.g., portable external amplifiers and DSP systems). The sound quality of even $100 headphones is amazing. The more esoteric offerings can easily head north of $5,000 and transport listeners to another world. If there are any doubts about just how big the headphone industry is, check out one of the seven annual CanJam events hosted by Head.fi.org around the world.

Voice recognition and intelligent artificial intelligence (AI) communication is growing at a fantastic rate that will only accelerate as humans become more comfortable having conversations with inanimate objects. The technology that makes it all work is a true testimony to the growth and vibrancy of the audio industry.

It isn't about a microphone and a speaker. It is about being able to place an Alexa anywhere in a room, and have the microphone filter out unwanted noise and distortions to be able to recognize voice commands. It is about having that built-in speaker sound human and be clearly understood regardless of the unit's orientation. While most people will say it isn't perfect yet, consider where the technology was just 10 years ago. The technology that makes it all work didn't exist in any commercially applicable manner a decade ago.

It's all about connected technologies. Component pieces of the audio signal chain may no longer exist in their own isolated silos. That very recognition is being embraced and is becoming the driving force behind innovation and technologies that are making DSP, predictive modeling, proper measurement and testing a requirement for success.

On the business side, tariff wars loom and economic factors are forcing many international companies to rethink their supply chain integrity. The apparent decline of the High End Show at the Venetian during CES had many talking about the future

of the show as other venues look to give High End a place to shine.

As always, what follows are the viewpoints of two of the Association of Loudspeaker Manufacturing and Acoustics (ALMA) International Board of Directors. Their widely varying backgrounds lends itself to a wide array of opinions.

Mark Beach—Board of Directors Member and Treasurer, ALMA International

"I don't anticipate any Earth shattering changes in the next year unless…there's a trade war, then all bets are off."—Mark Beach, LIS, 2018

That was what I said last year and indeed, all bets are off: The US has imposed tariffs on China in an effort to stop theft of intellectual property and to achieve a more balanced trade agreement. As of this writing, the two countries are negotiating, but if common ground is not found, additional tariffs may be applied to Chinese goods. If common ground is not found, a temporary trade war might morph into protectionism and nobody wins.

With deregulation, lowered corporate tax rates, and full employment, the US economy is extremely robust while China's economy shows signs of vulnerability. The trade war could lead to political unrest; consequently, the electroacoustics and electronics supply chain would be threatened. The good news is that a pivot to Southeast Asia reveals many suppliers in Philippines, Thailand, Vietnam, Indonesia, Singapore, and Malaysia that can spool up reasonably quickly. If an agreement is not reached, 2019 might be "the year of the pivot." Look for a scramble to find new suppliers and urgent networking at the ALMA International Symposium & Expo (AISE), which takes place June 9–10, 2019 in Orlando, FL.

Another trend in the US is aggressive competition for talent, especially those who can use finite element method (FEM) and measurement tools, writing code, and technical sales. Evidence is that most of the student attendees at AISE are offered positions, internships, and research funding.

In the 2018 *Loudspeaker Industry Sourcebook* (LIS), I predicted the start of "last in, first out" as the smart speaker market sorts itself out to find a balance. But, the paradigm has failed to materialize…. so far. Perhaps the robust economy is fueling more startups.

Industry wide wireless audio standards are still a challenge but the Wireless Speaker & Audio Association (WiSA) is rapidly becoming the standard with a very strong showing at CES. LG's agreement to offer the WiSA standard in its new television models is evidence of the growing acceptance of their technology. For 2019, look for further coalescing of standards for wireless, hi-definition, and multi-channel audio with WiSA leading the way.

And speaking of CES, high-end audio remains flat in the US although the Audio Expo North America (AXPONA) and Rocky Mountain Audio Fest (RMAF) shows are growing. There's still a desperate need to fill the vacuum in LA/Orange County, CA (14 million residents). Conversely, high-end audio in Asia and Europe continues a rebirth of sorts: High End Munich (20,000 attendees) is the world's largest high-end show. And, Integrated Systems Europe (ISE) is seeing continued growth (80,000+ attendees) and is moving to a bigger venue in February 2021: sunny Barcelona. ALMA is in the planning stages to launch Euro-AISE, also in Barcelona and immediately preceding ISE, to better serve the European audio and loudspeaker technologies professionals in Europe.

The personal audio and wearables market remains very strong and continues to see double-digit annual growth. Innovation and new products are popping up everywhere. Some will stick, some will not, both signs of a strong demand and continued innovation.

The changes in Pro Sound, Home Theater, and Automotive are mostly evolutionary, not revolutionary. But that's still good news—Manufacturers are responding to consumer demand and consequently, the products keep getting better and better.

Overall, 2018 was a good year for the Audio and Loudspeaker Technologies industries and the same should be expected for 2019: brisk business, innovation, and upheaval. Buckle up and enjoy the ride!

Jacob Soendergaard—Board of Directors Member, ALMA International

This is an exciting time in Audio! One of the greatest movements that excites me is the development of the Voice User Interface (VUI). This is a frontier that is finally being brought to consumers, and the amount of experimentation and creativity being displayed in the industry is astounding. Of course, not all applications are suitable or feasible for a VUI, but there's a large portion of daily life that could be eased by voice control. There's a definitely a niche for safety related applications (automotive) and there's a wonderful opportunity to improve quality of life for visually impaired people.

With all these industries experimenting with audio and voice, the demand for capable audio engineers is greater than ever. And I don't see this going away any time soon. Visit the AISE show in June 2019 and take a look at the presentations, exhibits and demonstrations for insight into the type of audio engineering solutions that are being formulated. It's inspiring! ***LIS***

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ABOUT ALMA INTERNATIONAL

The Association of Loudspeaker Manufacturing and Acoustics (ALMA) International is a not-for-profit trade association. ALMA is the only international trade association dedicated to improving the design and manufacture of loudspeakers. ALMA's membership is comprised of loudspeaker designers and manufacturers as well as suppliers of test and measurement equipment and other products, consultants, and other service providers to the loudspeaker industry. Individuals, academic institutions, and educators participating in the loudspeaker industry are encouraged to join. ALMA enjoys and welcomes a global membership. The organization was founded in 1961 as "The American Loudspeaker Manufacturers Association" In 2001, ALMA changed its name to "Association of Loudspeaker Manufacturing and Acoustics International" to reflect a global reach and to embrace a more diverse membership.

Mission Statement:
"ALMA is The Source of standards, news, networking, and education for technical and business professionals in the acoustics, audio, and loudspeaker industry."
For more information about ALMA, visit https://almaint.org

Audio and Voice Megatrends Transforming the Speaker Market

By
Peter Cooney
(SAR Insight)

Over the last five years or so there have been several major technology trends that have been instrumental in transforming the speaker market. These are varied and include: digital downloads and streaming, wireless audio streaming, multi-room audio, speaker form factors, high-resolution audio, and voice control. All of these are continuing to develop and will be the building blocks for the next five years of innovation.

Digital Downloads and Streaming, and a Vinyl Revival

Looking back to the turn of the 21st century, we saw the introduction and growth of MP3 players/portable audio players as a main source of audio consumption for many consumers, with it came a massive increase in digital downloads of music. Consumers became increasingly happy to download compressed audio files to a portable device, with the trade-off of lower quality audio in exchange for carrying around their entire music collection in their pocket.

As time went on, the audio storage device of choice has moved from dedicated media players to multi-purpose devices such as tablets and, more importantly, smartphones. This combined with enhanced cloud storage capacity and vastly improved download speeds through the role out of fast broadband is making it possible for users to carry an almost infinite music library in their pockets (albeit the actual file now resides in the cloud rather than on their devices).

4G has more recently enabled and promoted the ability to stream audio content rather than downloading and the roll out of 5G networks will further advance this trend. According to the Recording Industry Association of America (RIAA), streaming grew to be the largest revenue earner accounting for 75% of total revenues in 2018, increasing from 34.3% in 2015.

However, as streaming has become the dominant way in which we consume music, physical media (at least vinyl) has started to make a comeback too. Events (e.g., Record Store Day) have helped to re-acquaint a growing number of people with vinyl records, many listening to an album on a streaming service before purchasing a record. At the same time, research suggests that younger people, those born in a "post vinyl world" are also increasingly purchasing records for their nostalgic and aesthetic value. In the UK, the British Phonographic Industry (BPI) announced that 2016 was also the first year that spending on vinyl outstripped that spent on digital downloads.

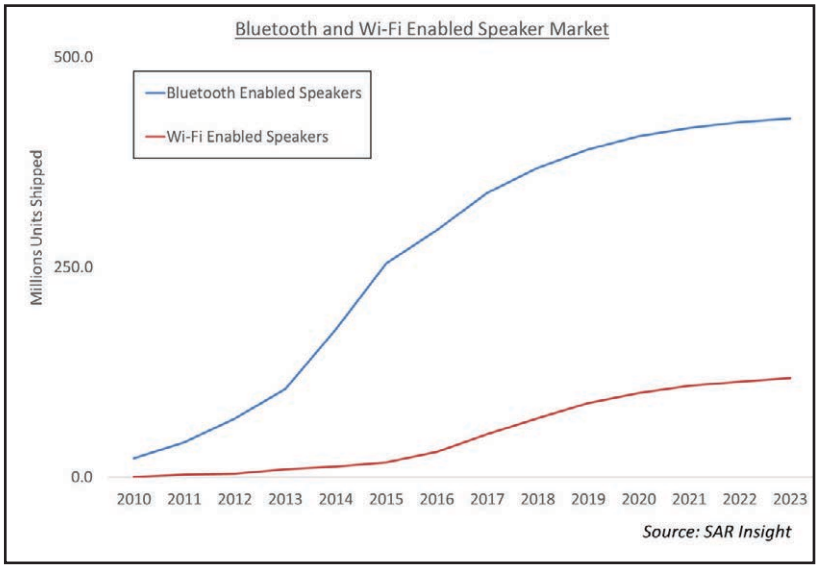


Figure 1: These figures show the unit shipments for the Bluetooth and Wi-Fi-enabled speaker market. (Source: SAR Insight and Consulting – Home AV DATAbase, First Quarter, 2019)

Wireless Audio Streaming

Since the creation of Bluetooth, wireless audio streaming has gradually been gaining momentum and today is a common technology for many consumers. That is not to say that Bluetooth has been the only horse in the race, proprietary solutions have also been widely used but none of these have had the same wide spread use, especially as the smartphone has become ubiquitous. According to SARs latest estimates, more than 3 billion Bluetooth audio-enabled devices shipped in 2018 (see **Figure 1**).

The use of Wi-Fi as an audio streaming technology has dramatically increased over the last few years. The introduction of Wi-Fi streaming technologies (e.g., Apple Airplay and Google Cast for Audio) into an increasing range of streaming audio devices via Wi-Fi has driven initial growth.

Although usually used in different ways, Bluetooth as a peer-to-peer streaming technology and Wi-Fi as a WAN technology, each technology has now become a normal part of life. Bluetooth remains the technology of choice for battery-powered devices such as headphones and speakers due to its superior efficiency, CODECs such as aptX have also significantly improved audio quality. Wi-Fi has quickly become the main audio streaming technology in the home, due largely to its networking ability and its superior bandwidth.

Multi-Room Audio

With the increasing use of Wi-Fi as a streaming technology, the ability to stream synchronized audio to multiple speakers in multiple rooms became possible. Wi-Fi's ability to carry higher quality, multi-channel, synchronized streams over long distances and its ubiquity in the home has made it the ideal technology of choice.

Sonos was one of the initial leaders in the market with numerous wireless proprietary platforms such as Airplay (Apple), AllPlay (Qualcomm), Caskeid (Imagination Technologies), Jukeblox (Microchip), Play-Fi (DTS/Xperi), and Google Cast (Google) trying to vie for supremacy (many of which have since disappeared). The market grew rapidly from 2010 but was still relatively niche and small in 2015 (less than 7 million units shipped) and it seemed that it was going to struggle to reach the mass consumer. However, with the introduction of voice-controlled smart speakers, multi-room audio has rapidly taken off, becoming an additional benefit of a smart speaker system and now available on very low-cost speakers (e.g., Amazon Echo Dot and Google Home Mini). SAR estimates that in 2019 almost 90 million multi-room audio-enabled speakers are expected to ship.

Speaker Form Factors

As the speaker market has developed, a range of form factors have emerged and the demand for these have grown significantly. SAR splits the market into three main types: active room speakers, soundbars, and portable speakers. There has been substantial growth in all three markets. Active room speakers have seen growth driven largely by increasing use of voice-controlled smart speakers (more later).

The birth of the soundbar mainly stemmed out of the poor audio quality of recent flat panel TVs. The flat panel TV cabinet design works against the audio designer as it is not a feasible task to squeeze high-quality audio components (good sounding speakers and high-quality amplifiers) into a low-volume cabinet. As a result, most flat-panel TVs provide a below-average audio experience when compared to the video experience.

About the Author

Peter Cooney is the founder of SAR Insight & Consulting. Peter has been tracking, analyzing, and commenting on technology markets for more than 15 years. Peter has covered a diverse range of markets including audio, MEMS sensors, microprocessors, and wireless connectivity ICs. Most recently, he has focused on the emerging and rapidly growing markets for voice interface technologies and virtual digital assistants. Peter is regularly quoted in the press as an audio industry expert and has serviced a wide range of clients including most of the top 20 largest semiconductor companies and many others.

The home theater market has been gradually cannibalized as soundbars become the preferred choice for many consumers to upgrade the audio quality of their flat panel TVs. Today, soundbars have evolved and offer features that rival home theater AV receivers. Furthermore, new features are emerging and being added such as immersive audio and voice control.

The portable speaker market also saw rapid growth alongside the use of Bluetooth. Today, hundreds of millions portable speakers ship per annum, primarily low-cost commodity products. However, the market is starting to have negative pressure from a number of directions: the rapid market growth of small form factor, low-cost voice-controlled smart speakers (e.g., Amazon Echo Dot and Google Home Mini), increasing pressure from consumers choosing headphones over portable speakers, and improving smartphone speaker designs, which negate the need for a low-cost companion Bluetooth speaker.

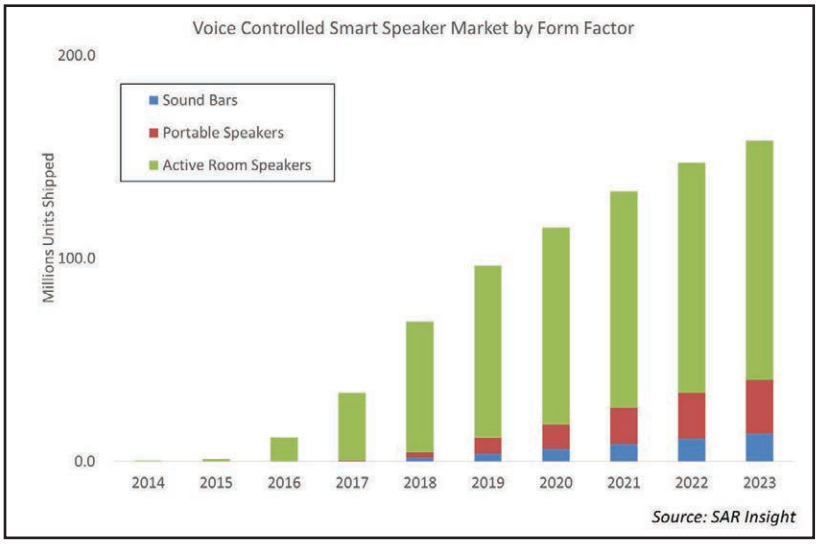


Figure 2: Here are the unit shipment numbers for the voice-enabled smart speaker market. Note: Active room speakers include form factors such as Amazon Echo, Google Home, Sonos One, Apple HomePod. (Source: SAR Insight and Consulting – Digital Assistant Platforms DATAbase, First Quarter, 2019)

High-Resolution Audio

Relentless technological advances have seen storage media capacity continue to rapidly increase as the price per gigabyte falls, while broadband/cellular speed and coverage has increased supporting higher bandwidth and faster download speeds—paving the way for higher resolution audio. There is a continued drive toward improving audio source material, the technologies used to access it, and the equipment used to play it.

The linkup between the Consumer Electronics Association, The Digital Entertainment Group, the Japan Audio Society, and major music labels, such as Sony Music Entertainment, Universal Music Group, and Warner Music Group in 2014 helped to define, build consensus, and promote high-resolution audio (HRA) formats. This resulted in formal definitions of master quality sources as a major stepping stone.

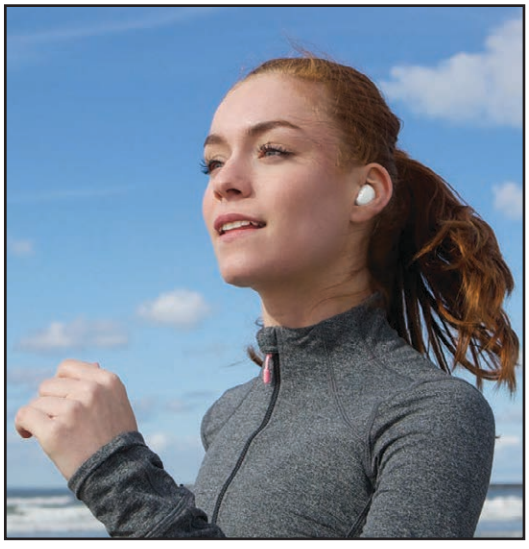
There are still hurdles to overcome. There are several barriers to market for example, consumers (particularly younger people) have become increasingly accustomed to or have grown up only listening to compressed audio. This is perhaps the most difficult hurdle to overcome for the music industry as a whole if it is to drive HRA to the mass market. It is not insurmountable but will require a big push by all parties. As the streaming industry moves toward "lossless" or "CD-quality" sources, it is expected that a move toward higher resolution will happen over time.

Voice Control

While voice recognition has been in existence for more than 10 years within the automotive sector, the voice software was lacking in reliability and caused numerous response errors for drivers. Over the years, with the advancements in artificial intelligence, improvements have been made in the accuracy rate, helping to build more confidence in the technology starting with smartphones in 2011 and speakers in 2014.

Back in 2011, the iPhone 4S was the first modern smartphone that came equipped with virtual assistant Siri as a main feature on the phone. And in 2014, Amazon launched its first smart speaker (Amazon Echo) integrated with Alexa, its proprietary voice assistant platform. This sparked the evolution of voice assistant technology and the emergence of voice-enabled smart speakers. As a result of the voice UI momentum, there are numerous digital assistant platforms now competing for market share. In the speaker market three platforms dominate: Amazon Alexa, Google Assistant, and Apple Siri, with rapid growth from China-based platforms such as Baidu Duer OS, Alibaba AlieGenie, and Tencent Xiaowei (see **Figure 2**).

Today, voice assistants may be integrated into many types of platforms and devices and have become instrumental in the revitalization of the smart IoT market. As consumer confidence in voice UI continues to grow, voice assistants have become a critical ingredient technology for consumers worldwide. Voice assistants use natural



Since the creation of Bluetooth, wireless audio streaming has gradually been gaining momentum and today is a common technology for many consumers. (Photo credit: Cobble Pro True Wireless Bluetooth Earbuds)

language processing to assess voice input and implement specific commands and continue to develop learned skills through artificial intelligence and machine learning techniques to advance the user experience. Voice assistants have become a critical component in delivering a wide variety of input and output voice services including search capabilities, email/text communication, streaming music, and many other infotainment/entertainment product offerings.

Voice assistant technology and the use case applications has been a major trend impacting the audio and voice space and has made artificial intelligence a more tangible concept to consumers. Voice assistants will continue to play an instrumental role in the development of innovative solutions to service an expanding connected ecosystem. ***LIS***

Audio Signal Chain ICs

Audio components and ICs also continue to help advance the speaker market from microelectromechanical systems (MEMS) microphones to audio amplifier ICs. MEMS microphones have been around for many years, the first capacitive devices demonstrated in 1916 at Bell Labs, technology developed relatively slowly, and it was with the first surface-mount MEMS microphones that came to market at the turn of the 21st century that a surge in MEMS microphone use began.

The inherent advantages of using MEMS microphones over traditional electret condenser microphones (ECM) include robustness, integration, power efficiency, and scalability. This has led to the widespread adoption of MEMS mics across many markets. It is estimated that 5 billion MEMS mics shipped in 2017, totaling more than 20 billion units shipped from 2010 to 2017, a massive market (see **Figure 1**).

MEMS microphones have been continually developed over the last few years with improvements in specifications such as signal-to-noise ratio (SNR), sensitivity, and acoustic overload point (AOP). There has also been a move toward miniaturization to enable more mics to be added to ever thinner products. SNR has become particularly important to improve far field voice capture for voice-assistant-enabled devices.

The audio speaker amplifier market has rapidly grown over the last few years, spurred on by growth in shipments of various devices including mobile devices, speakers and mobile computing. Market shipments have grown three times over from 2010 to 2018, due to increasing shipments of audio playing devices but also increasing number of channels per device. The use of Class-D amplifiers has grown considerably since 2010. Today, Class D has all but replaced class AB amplifiers in many markets. The main reason for this is the greatly increased efficiency of Class D.

The use of speaker protection algorithms has become standard practice in a number of applications where small form factor speakers are used (e.g., portable speakers). This enables higher output without damaging the speaker. Speaker protection can be implemented using a "smart amplifier" (i.e., with an embedded DSP—in this case the algorithm sits on the amplifier). Or it can be implemented using an "IV Sense" amplifier—in this case the algorithm sits on a separate DSP.

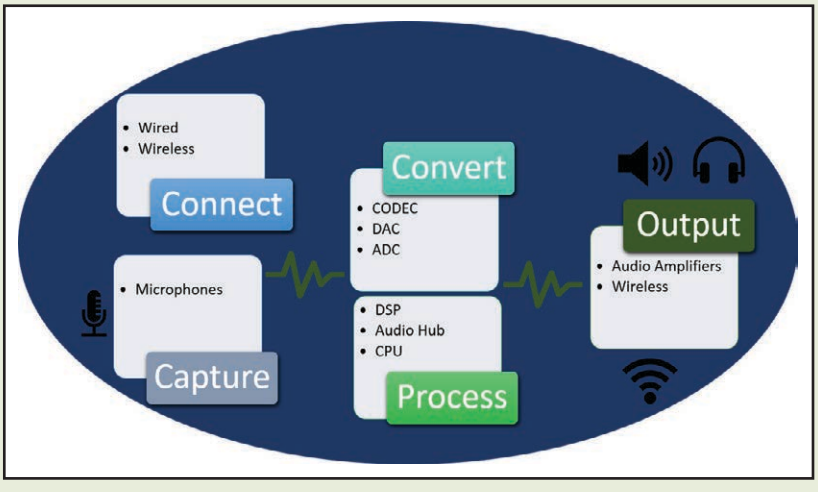


Figure 1: This is the audio signal chain. (Source SAR Insight and Consulting – Audio Signal Chain ICs DATAbase, First Quarter, 2019)

How the Rise in Streaming is Empowering Wireless Home Theater

By
Tony Ostrom
(President, WiSA Association)

The consumption of movies and television has changed drastically in the last 15 years, as anytime-anywhere streaming services continue to lead a major transformation in the entertainment industry. According to a recent report, the percentage of US households subscribing to a paid streaming service grew 450% over the last decade. Streaming services also account for more than 80% of viewing time in households and billions of hours in programming every year (see **Figure 1**).

This incredible influx in streaming reflects the public's enthusiasm of unlimited on-demand content, with many major production companies (e.g., Walt Disney) pivoting from their traditional practices to launch new platforms to meet customer demand and remain profitable.

This rise in streaming has also changed the landscape of the home theater industry. With new studies revealing that manufacturers and retailers need to make high-definition audio systems a higher priority, the industry is breaking free from its previously niche marketplace and paving a new foundation of profitability (see **Figure 2**).

However, for the home theater industry to truly be successful and reach its maximum potential,

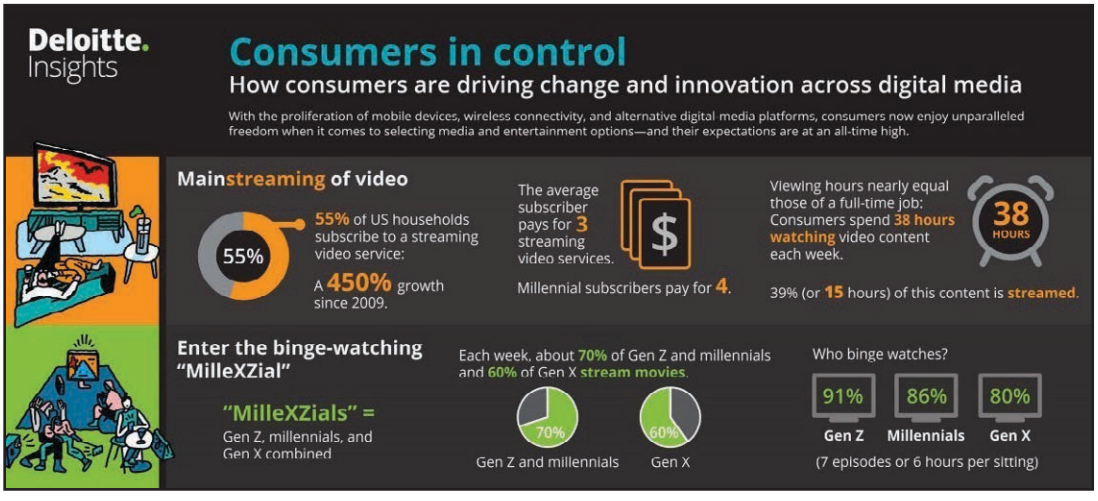


Figure 1: Consumers now enjoy unparalleled freedom when it comes to selecting media and entertainment options. (Image courtesy of Deloitte Digital Media Trends Survey, 12th Edition)

the installation and control experience needs to be extremely simple for consumers. Simply put, it needs to be free from wires and complicated installations.

Going Wireless

In previous years, bringing home the same powerful score from iconic films, such as *Star Wars* and *Jurassic Park,* typically included a colossal A/V receiver, myriad wires, and costly setup process. This has caused a critical barrier of entry for many brands and manufacturers while alienating potential customers.

Soundbars and other small wireless speakers—which allow for additional rear channels to be added and the TV sound experience to be elevated in many locations—seemed like a natural provision in the deliverance of wireless, cost-effective high-quality audio. However, consumers learned overtime that they don't present the levels of power and definition as a system comprised of component speakers.

To truly capitalize on customer appeal, it became evident that the home theater industry needed to reinvent the installation and the control experience to better adhere to customer demand.

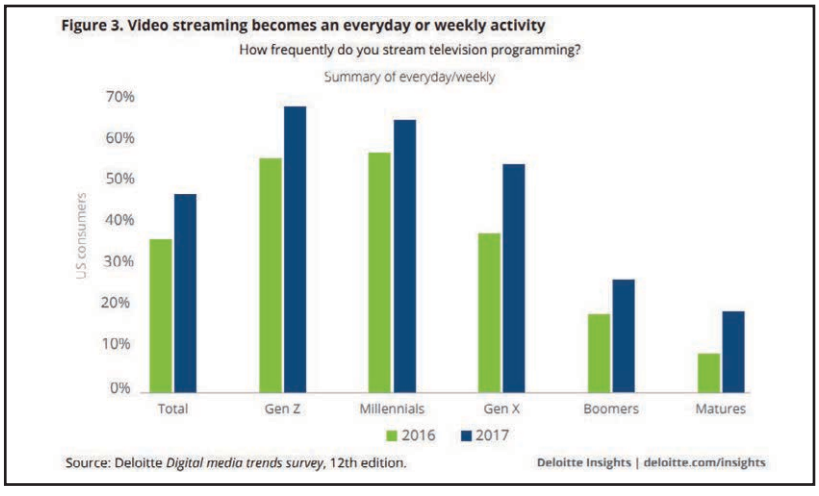


Figure 2: Video streaming account for more than 80% of viewing time in households. (Image courtesy of Deloitte Digital Media Trends Survey, 12th Edition)

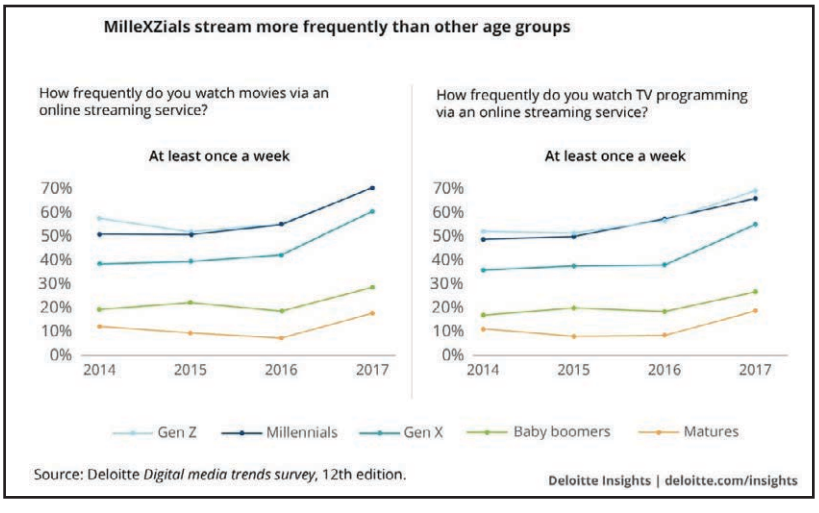


Figure 3: Mellenials, Gen X, and Gen Z stream more frequently than other age groups. (Image courtesy of Deloitte Digital Media Trends Survey, 12th Edition)

The Technology

Cutting-edge wireless technology has become the solution. It unleashes a new simplified process that eliminates the complicated installation process. It also provides an aesthetically-pleasing 5.1 or 7.1 surround-sound system without the mess of speaker wires or compromised performance while assuring interoperability between all components.

Many industry leaders have already realized the potential of this technology and integrated it into an assortment of products. For instance, Bang & Olufsen, Harman, Klipsch, Enclave, Axiim, and other leading brands have already brought high-performance systems to market that have been well-received, prompting several key retailers to allocate floor space to wireless home theater solutions as these differentiators continue to resonate lucratively with consumers (see **Figure 3**).

Furthermore, several additional companies have products in the pipeline that promote this incredible wireless technology that will be launched in the marketplace for a wide range of budget options.

In the past year, the wireless trend has advanced even further in the home theater space. Now, wireless-enabled home theater systems can be easily connected to "source brands" with a simple transmitter, allowing various compatible speakers to seamlessly work together to deliver wireless, multi-channel audio and authentic movie theater sound unlike any other audiophile experience. And thanks to its ease-of-use and heightened customer demand, this type of technology has the potential to spread to millions of platforms in 2019 alone.

Gaming system and TV manufacturers are also incorporating the transmission of wireless

About the Author

Tony Ostrom is president of the Wireless Speaker & Audio (WiSA) Association, an industry group dedicated to bringing the industry's only fully interoperable, high-resolution, multi-channel wireless audio capability to consumer and professional products. His 25-year career in the consumer electronics industry has been focused on product planning and development, consumer research, go-to-market planning, technology integration, marketing and training.

home theater audio into their products. This past January, LG announced that its new 2019 OLED and NanoCell TVs will be enabled to easily connect with certain wireless home theater systems to deliver more immersive audio experiences, which is an industry first.

During the announcement, Tim Alessi, LG's senior director of product marketing, hailed this type of technology as a "tremendous benefit that consumers will enjoy in taking advantage of truly immersive wireless sound that complements all kinds of big screen home entertainment."

This will only further empower additional manufacturers to adapt to maintain a competitive advantage by partnering alongside organizations that possess this type of technology to ensure their products can connect seamlessly with interoperable, high-definition, wireless home theater systems.

The Future

And this is just the beginning. In the next year, the wireless revolution will only further establish its position on the frontline of the industry. And with many key factors—such as the rise in streaming services—contributing to the burgeoning appetite of consumers who demand more convenient, high-performance wireless audio, heightened adoption and implementation will only continue and reaffirm that wireless is the future (see **Figure 4**). ***LIS***

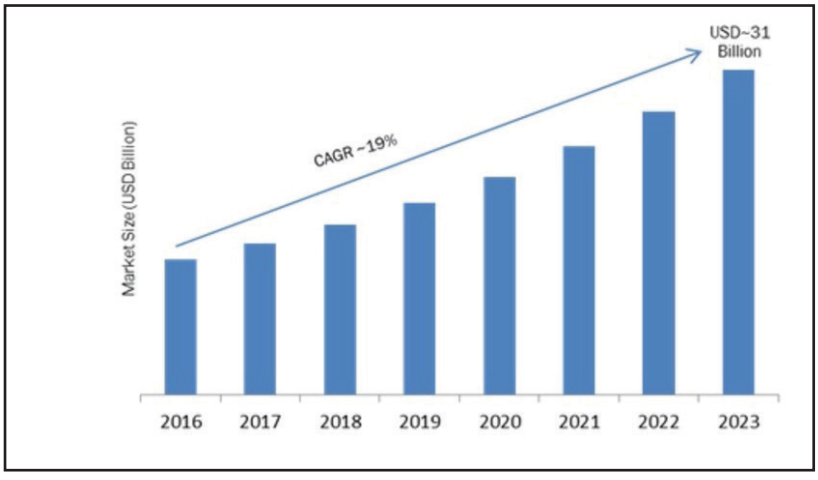


Figure 4: By 2023, the Home Theater Market Research Report indicates that $31 billion will be made in this industry. (Image courtesy of the Home Theater Market Research Report- Global Forecast 2023)

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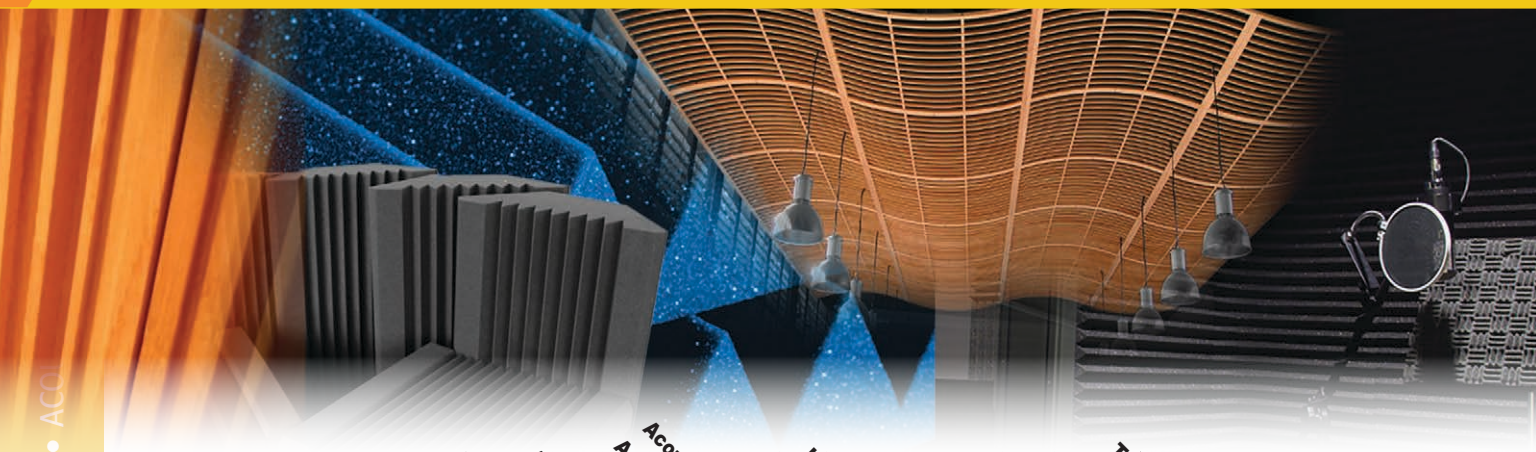
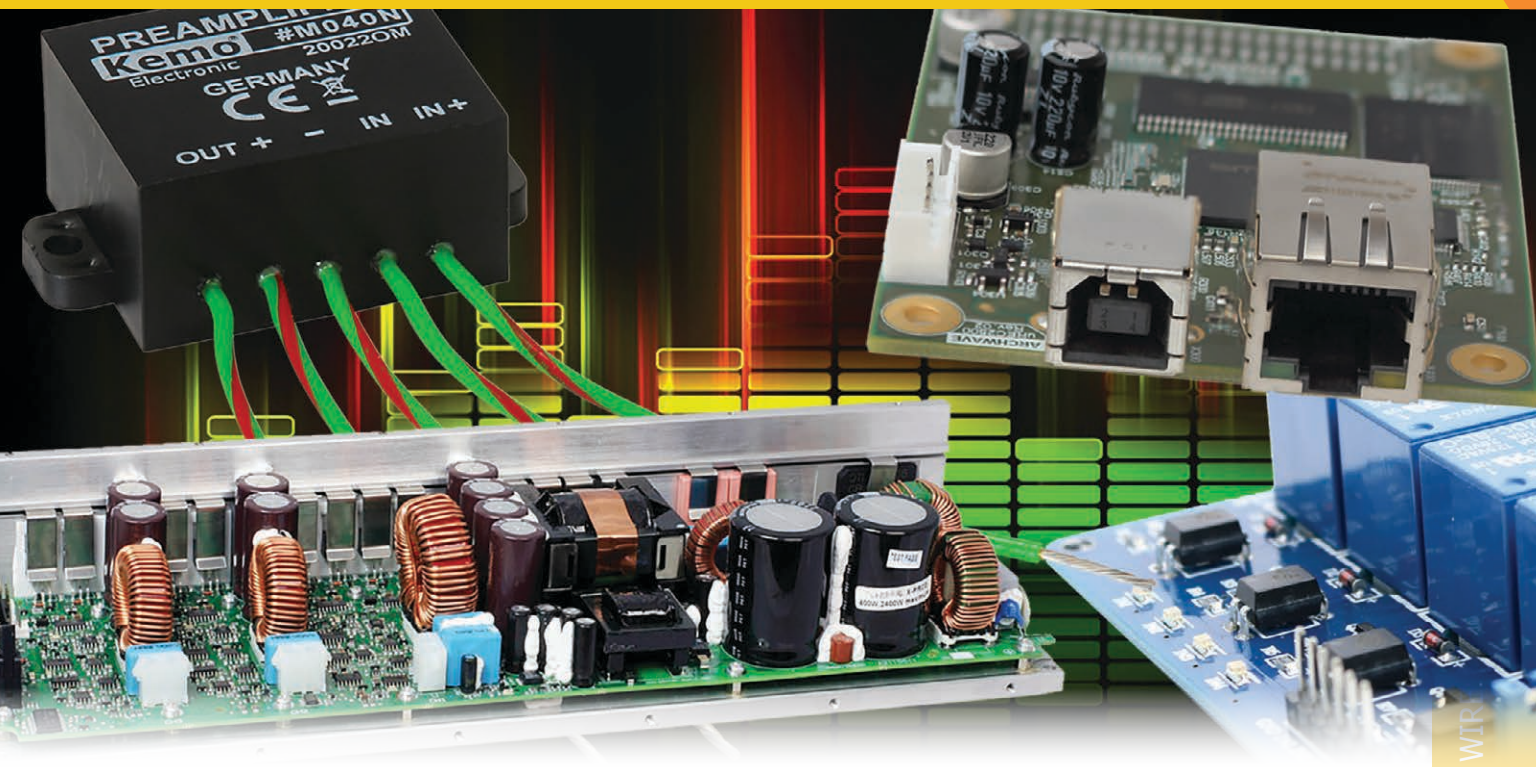


	Acoustic Consultancy Services & Design	Acoustic Doors	Acoustic Measurement	Acoustic Treatment Panels	Electroacoustical System Design	Home Theater Design	TV System Design	Multimedia and	Noise Control	Sound Booths	Sound Isolation	Theater and Concert Hall Design
AUSTRALIA												
DEQX Pty., Ltd.								•				
Soundlabs Group, Pty., Ltd.					•							
BELGIUM												
Premium Sound Solutions						•						
BRAZIL												
Newbox Industry & Commerce	•	•	•	•	•	•	•	•	•	•	•	•
Phix Eletronics	•					•	•			•		
CANADA												
DLC Loudspeaker R&D Group	•		•									
Rutherford Audio, Inc.			•	•		•				•		•
Solen Electronique, Inc.			•								•	
Sziara Sound			•			•						
CHINA												
Lumi Audio	•		•			•						
Shenzhen Malata Mobile Communications, Co., Ltd.					•							
Trueanalog Strictly OEM			•		•	•					•	
DENMARK												
Danesian Audio ApS	•		•									
K & K Development			•									
PointSource Acoustics ApS	•		•		•							
FRANCE												
KYU Systems	•											
Supravox					•							
The Concrete Family SAS						•	•					
GERMANY												
Goya Acoustics	•		•									
Jobst-Audio	•		•		•							
Klippel GmbH			•									
Lautsprecher-Produktions-Gesellschaft (LPG) mbH			•									
Physical-Lab	•		•		•							
Soundsgood Pro Audio Solutions	•		•									
Voice Point	•	•	•	•	•	•	•	•	•	•	•	•
HONG KONG												
Eastern Asia Technology (HK), Ltd.					•							
miniDSP			•	•								
INDIA												
GM Audio Technics, Ltd.	•		•	•								

	Acoustic Consultancy Services & Design	Acoustic Doors	Acoustic Measurement	Acoustic Treatment Panels	Electroacoustical System Design	Home Theater Design	TV System Design	Multimedia and	Noise Control	Sound Booths	Sound Isolation	Theater and Concert Hall Design
Power Electronics & Technologies	•			•			•					•
IRELAND												
Crossover Filter App				•								
ISRAEL												
Chorus Audio				•		•	•	•				
ITALY												
RCF, SpA	•											•
SpeakerLAB	•			•								
JAPAN												
Etani Electronics Co., Ltd.				•						•		•
LATVIA												
Acoustic Power Lab				•		•	•	•				•
MEXICO												
Aletheia, AV	•											•
NETHERLANDS												
Kamperman Engineering	•			•						•		
Sound Projects	•											
NEW ZEALAND												
Asona	•	•		•			•	•	•	•		•
NORWAY												
SEAS Fabrikker, AS				•								
POLAND												
Resnatura Audio				•								
PORTUGAL												
Jocavi, Lda.					•							•
Vicoustic	•	•	•	•	•	•	•	•	•	•	•	•
ROMANIA												
SC Poweraudio, SRL	•			•		•				•		•
SPAIN												
Brusi Acoustics	•			•								
Sottovoce Audio	•					•						
SWITZERLAND												
Acustronics Sound-Light-Systems				•								
TAIWAN												
Kingstate Electronics Corp.	•			•								
Yung International, Inc.							•	•				
THAILAND												
Clarasonic (Thailand) Co., Ltd.											•	
UKRAINE												
Mag Audio	•			•								
UNITED KINGDOM												
CE Electro-Acoustics	•											
EuroTec International, Plc.				•		•					•	
Interfacio, Ltd.						•						•
Tectonic Elements, Ltd.	•											
UNITED STATES												
Acoustic Fields	•	•		•	•		•			•	•	•	•

	Acoustic Consultancy Services & Design	Acoustic Doors	Acoustic Measurement	Acoustic Treatment Panels	Electroacoustical System Design	Home Theater Design	TV System Design	Multimedia and	Noise Control	Sound Booths	Sound Isolation	Theater and Concert Hall Design
Acoustics First Corp.	•		•	•		•		•	•	•	•	
Adrian Acoustics, Inc.				•								
American Bass USA	•							•		•		
AtlasIED								•		•		
Audio Precision, Inc.			•									
Audio-Optix	•			•		•				•		
B&H				•				•		•		
Barefoot Sound, LLC					•							
BASSBOSS												•
Beach Dynamics	•	•	•	•				•	•	•		
Broad Bridge Audio, LLC									•	•		
Campanella Associates & Acculab	•		•			•		•		•	•	
Carl Tatz Design, LLC	•	•	•	•				•	•	•		
Creative Sound Solutions, LLC	•		•									
D. L. Adams Associates, Inc.	•				•		•	•		•	•	
Dayton Audio	•											
Dragonfire Acoustics	•					•	•					
DTV Installations, LLC								•				
ETS-Lindgren	•	•	•	•				•	•	•		
Excelsior Audio Design & Services, LLC					•							
Front End Audio, LLC				•				•		•		
Full Compass Systems, Ltd.		•	•	•				•				
GGEC America, Inc.			•									
HDSound	•					•						
HEAD acoustics, Inc.			•									
Hearing Components, Inc. (Comply Memory Foam Tips)								•		•		
HX Audio Lab	•		•		•			•		•	•	
Intelligent Audio Products				•								
J&F Wood Products				•								
JP Electronics Design	•		•		•	•	•					
Meyer Sound Laboratories, Inc.				•	•							
MSC Software Corp.			•					•				
NedLab	•											
NTi Audio, Inc.			•									
ORCA Design And Manufacturing				•								
Parts Express			•					•	•	•		
Ponderosa Sound Systems	•			•	•	•	•	•		•		
PR Audio			•									
RealTraps, LLC	•			•								
Redco Audio				•								
Scantek, Inc.			•					•				
SoundKinetics	•							•				
Soundoctor			•									
Speaker Clinic	•		•									
Spectrum Audio				•				•		•		
Stetron International, Inc.	•		•									
Studio Six Digital			•									
SVS, Inc.										•		
Sweetwater Sound		•		•				•		•		
THX, Ltd.						•						•
TMI Engineering	•	•	•	•	•	•	•	•	•	•	•	•
True Technologies, Inc.	•		•		•							
US Enclosure Co.	•	•		•				•	•	•		
Vintage King Audio				•				•		•		
Warkwyn	•		•									
Westlake Audio, Inc.	•											
Wired 4 Sound, Inc.	•			•		•	•	•		•	•	
Wisdom Audio						•						

AMP, DSP, NETWORK, AND WIRELESS MODULES

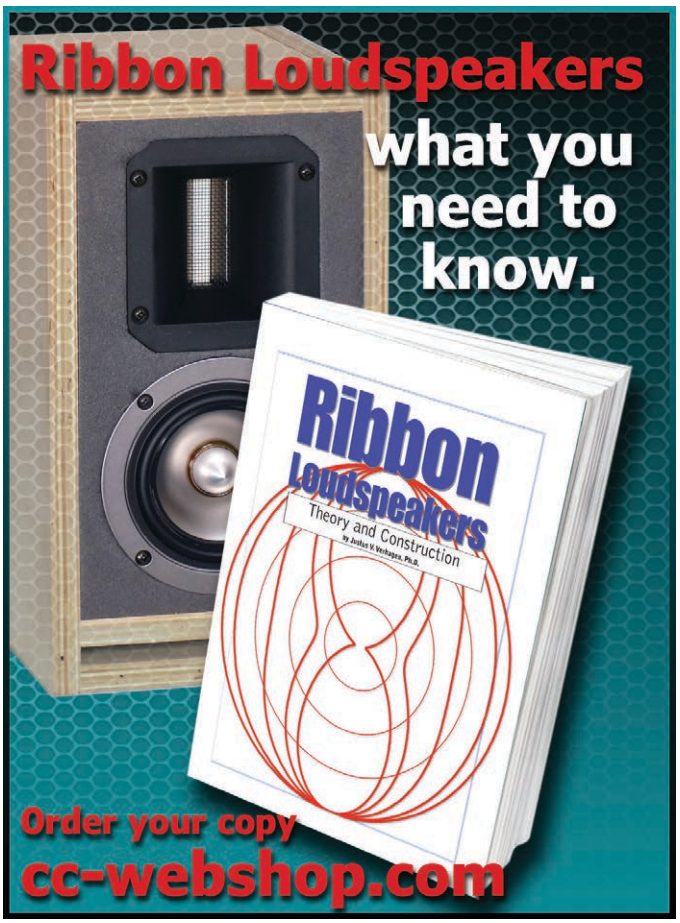


	Amplification Modules	Digital Signal Processing	Network Connectivity	Wireless Connectivity
AUSTRALIA				
DEQX Pty., Ltd.	•	•	•	•
Eclipse Audio		•		
Soundlabs Group, Pty., Ltd.	•			
BRAZIL				
Advanced Audio Technologies (AAT)	•			
AMCP Eletronica	•			
Newbox Industry & Commerce	•	•	•	•
CANADA				
Harbottle Audio	•	•		
Solen Electronique, Inc.	•	•	•	•
Space-Tech Lab, Ltd.	•	•		•
CHINA				
EASTECH Holding, Ltd.			•	•
Fountek Electronics Co., Ltd.	•	•		•
Pana Sound, Ltd.	•	•		•
DENMARK				
ICEpower, AS	•			
Pascal, AS	•			
Purifi Audio ApS	•			
FRANCE				
Amplitude Audio	•	•	•	•
IDEA	•			

	Amplification Modules	Digital Signal Processing	Network Connectivity	Wireless Connectivity
GERMANY				
Ascendo Immersive Audio GmbH		•	•	
Klippel GmbH	•	•		
HONG KONG				
Eastern Asia Technology (HK), Ltd.	•			•
miniDSP	•	•	•	
INDIA				
GM Audio Technics, Ltd.	•	•	•	
ITALY				
Axiomedia, SRL	•	•		•
Powersoft SpA	•	•	•	
JAPAN				
Etani Electronics Co., Ltd.	•	•		
S'NEXT Co., Ltd.	•	•		
NETHERLANDS				
ELTIM audio, BV	•			
Hypex Electronics, BV	•	•		
SWEDEN				
Bohmer Audio, AB	•	•	•	•
SWITZERLAND				
Archwave			•	

	Amplification Modules	Digital Signal Processing	Network Connectivity	Wireless Connectivity
TAIWAN				
Taiwan Solidex Corp.				•
UKRAINE				
Mag Audio	•			
UNITED KINGDOM				
EuroTec International, Plc.	•	•		
MJ Acoustics	•			•
Profusion plc	•	•	•	•
Tectonic Elements, Ltd.	•			
UNITED STATES				
Area 52 R&D	•	•		
AtlasIED		•	•	
Audio Advisor, Inc.	•			
Axiim	•	•	•	•
Danville Signal Processing, Inc.	•	•	•	•
Digmoda	•	•		
Dragonfire Acoustics	•	•	•	•
Eagle Acoustics	•	•	•	•
Etal Group, AB/Anaview	•			

	Amplification Modules	Digital Signal Processing	Network Connectivity	Wireless Connectivity
Full Compass Systems, Ltd.	•	•		
Globe Audio Design, Inc.	•	•	•	
JL Audio, Inc.	•	•		
Kramer Electronics	•	•	•	•
Linear Tube Audio	•			
Linkplay				•
MAAT Inc.		•		
Marchand Electronics, Inc.	•			
Meyer Sound Laboratories, Inc.		•		
MISCO	•	•		
North American Solidex LLC	•	•		•
PowerPhysics, Inc.	•	•		
Pro Flix Sales	•	•	•	•
RCF USA, Inc.	•	•	•	
SpeakerPower	•	•	•	•
Spectrum Audio	•			
US Enclosure Co.	•	•	•	•
Vintage King Audio	•			
Weltronics Corp.	•	•	•	•
Wired 4 Sound, Inc.	•	•	•	•



AUSTRALIA
Audinate, Pty., Ltd.
DEQX Pty., Ltd.

AUSTRIA
USound GmbH

BELGIUM
Donnet: Loudspeaker Repair

BRAZIL
Advanced Audio Technologies (AAT)
Edgar Prudente da Silva
Newbox Industry & Commerce
Phix Eletronics

CANADA
Arteluthe
LMH Loudspeakers
Reference 3A
Space-Tech Lab, Ltd.

CHINA
Dongguan Yuonyunn Membrane Co.
EASTECH Holding, Ltd.
Fountek Electronics Co., Ltd.
Pana Sound, Ltd.
Shenzhen Malata Mobile Communications, Co., Ltd.
Sound Technology Development, Ltd. (Factory)

DENMARK
Danesian Audio ApS
ICEpower, AS
K & K Development
LOUDSOFT, Ltd.
PointSource Acoustics ApS

EGYPT
GM Audio

FRANCE
Amplitude Audio

GERMANY
Goya Acoustics
HiFi-Tuning
Physical-Lab
Rohde & Schwarz
Voice Point

HONG KONG
Acoustic Development International
Eastern Asia Technology (HK), Ltd.
Panson Audio
WCE Acoustics

HUNGARY
Bayz Audio

JAPAN
Etani Electronics Co., Ltd.

LATVIA
Acoustic Power Lab

NETHERLANDS
ELTIM audio, BV
Kamperman Engineering
Metaxas & Sins
the BEE

NEW ZEALAND
Asona

ROMANIA
SC Poweraudio, SRL

SINGAPORE
Virtins Technology

SOUTH KOREA
Suntel Co., Ltd.

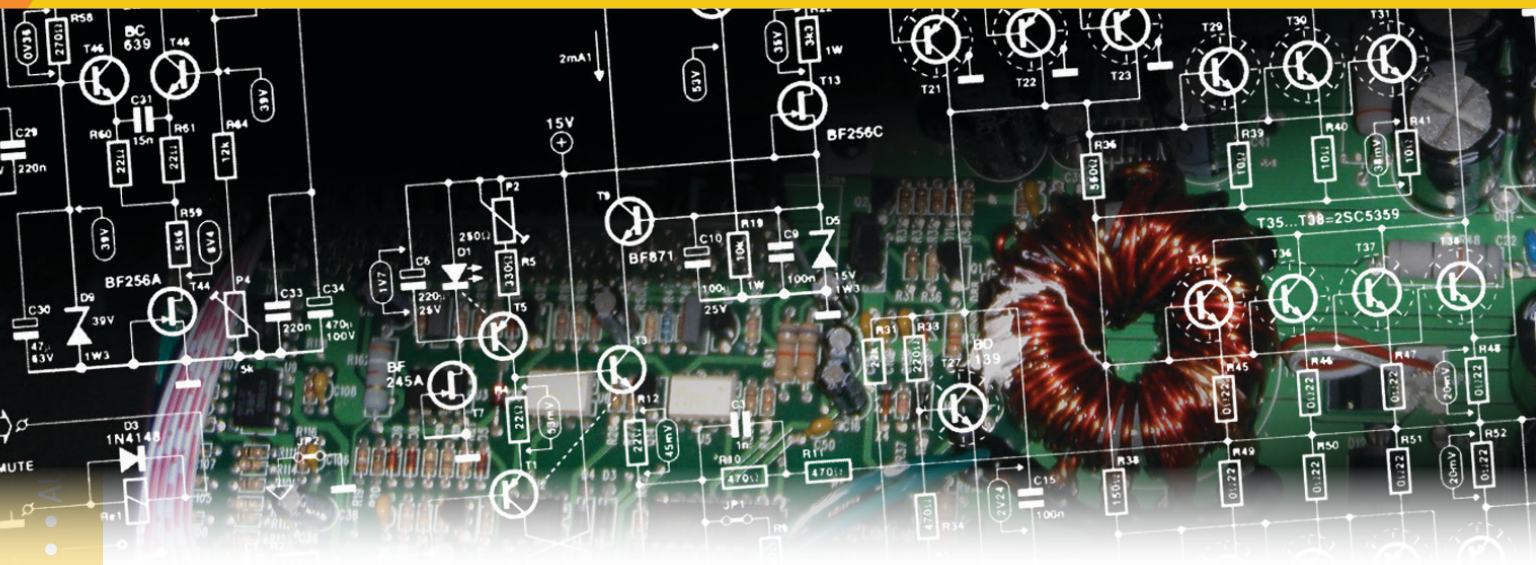
SPAIN
DAS Audio

SWITZERLAND
Acustronics Sound-Light-Systems

THAILAND
Sanit Audio Engineering Co.

UNITED KINGDOM
EuroTec International, Plc.
Fane International, Ltd.
Hill Acoustics
Interfacio, Ltd.
PACSYS, Ltd.
Precision Devices, Ltd.
Tectonic Elements, Ltd.

UNITED STATES
American Music And Sound
AmericanPowerLight.com
Apollonio Consulting
Association of Loudspeaker Manufacturing and Acoustics (ALMA) International
Audio Connection
BeStar Technologies, Inc.
Bob Young and Associates
Clear Lake Audio
Community Professional Loudspeakers
DMSI
Dragonfire Acoustics
Earthquake Sound Corp.
Geometric Designs, LLC & Geometric Consulting
Globe Audio Design, Inc.
Haiyun Electronic Co., Ltd.
HDSound
HEAD acoustics, Inc.
HX Audio Lab
Integrated Audio Technologies, LLC
Lipinski Sound
North Reading Engineering
Pacific Audio Consulting
PCB Piezotronics, Inc.
Prism Media Products, Ltd.
Pro Sound Testing, Inc.
Quest Engines, LLC
Schurter, Inc.
SoCal Sound Shop
Soundoctor
Studio Electric - David MacPherson
THX, Ltd.
True Technologies, Inc.
TSG Audio
Vance Dickason Consulting



	Consultants	Designers	Recruitment Agencies
ARGENTINA			
Laufer Speaker Electronics	•	•	
AUSTRALIA			
Audinate, Pty., Ltd.	•	•	
DEQX Pty., Ltd.	•	•	
Stone Sound Studio	•		
BELGIUM			
Donnet: Loudspeaker Repair	•	•	
BRAZIL			
Advanced Audio Technologies (AAT)	•	•	
Edgar Prudente da Silva	•	•	
Newbox Industry & Commerce	•	•	
Phix Electronics	•	•	
CANADA			
Arteluthe	•	•	
Canadian Speaker Works	•	•	
DLC Loudspeaker R&D Group	•	•	
Kravchenko-Audio	•	•	
Planet10-HiFi	•		
Reference 3A		•	
Solen Electronique, Inc.	•	•	
Space-Tech Lab, Ltd.	•	•	
Studio Reference Monitors	•	•	
Thompson by Design	•	•	
CHINA			
B.W. Audio Guangzhou Co., Ltd.	•	•	
BSWA Technology Co., Ltd.	•	•	
Dongguan Yuonyunn Membrane Co.	•	•	
Fountek Electronics Co., Ltd.	•	•	
Pana Sound, Ltd.	•	•	
Sound Technology Development, Ltd. (Factory)	•	•	
Sun Technique Electric Co., Ltd.	•	•	
Trueanalog Strictly OEM	•		
Vormag Electronics Co., Ltd.	•		
CZECH REPUBLIC			
Elfton		•	

	Consultants	Designers	Recruitment Agencies
DENMARK			
Danesian Audio ApS	•	•	
LOUDSOFT, Ltd.	•	•	
PointSource Acoustics ApS	•	•	
FRANCE			
Amplitude Audio	•	•	
KYU Systems	•	•	
GERMANY			
Goya Acoustics	•	•	
Jobst-Audio	•	•	
Klippel GmbH	•	•	
Physical-Lab	•	•	
Scherer Audio	•	•	
HONG KONG			
Acoustic Development International	•	•	
Ocean Star Electronics, Ltd.	•	•	
Panson Audio	•	•	
WCE Acoustics	•	•	
HUNGARY			
Bayz Audio		•	
INDIA			
Power Electronics & Technologies	•	•	
ITALY			
Audiomatica, SRL	•	•	
Axiomedia, SRL	•	•	
AXP	•	•	
LATVIA			
Acoustic Power Lab	•		
NETHERLANDS			
ELTIM audio, BV	•	•	
Kamperman Engineering	•	•	
POLAND			
Resnatura Audio	•	•	

	Consultants	Designers	Recruitment Agencies
SINGAPORE			
Virtins Technology	•	•	
SOUTH KOREA			
Suntel Co., Ltd.	•	•	•
SPAIN			
Sottovoce Audio		•	
UNITED KINGDOM			
EuroTec International, Plc.	•	•	
Hill Acoustics	•	•	
Interfacio, Ltd.	•		
MJ Acoustics	•	•	
Sine Audio Systems	•	•	
UNITED STATES			
Acoustic Fields	•	•	
Aempyrean	•	•	
American Bass USA	•	•	
Apollonio Consulting	•		
Association of Loudspeaker Manufacturing & Acoustics (ALMA) International	•	•	
Audio Connection	•	•	
Barefoot Sound, LLC	•	•	
BASSBOSS		•	
Beach Dynamics	•	•	
BeStar Technologies, Inc.	•	•	
Bob Young and Associates	•	•	
Bruel & Kjaer Sound & Vibration North America, Inc.	•	•	
CGN Audio Labs	•	•	
CJS Labs	•	•	
CommonSense Audio	•	•	
Community Professional Loudspeakers	•	•	
Creative Sound Solutions, LLC	•	•	
Danville Signal Processing, Inc.	•	•	
dB Design	•	•	
DMSI	•	•	
Dragonfire Acoustics	•	•	
DTV Installations, LLC	•	•	
Earthquake Sound Corp.	•	•	
eMagineFactory, LLC	•	•	
Excelsior Audio Design & Services, LLC	•	•	
Fulcrum Acoustic, LLC		•	
Geometric Designs, LLC & Geometric Consulting	•	•	
Globe Audio Design, Inc.	•	•	
GR Research	•	•	
HDSound	•	•	
HEAD acoustics, Inc.	•	•	
HX Audio Lab	•	•	
Integrated Audio Technologies, LLC	•	•	
JP Electronics Design	•	•	
Linkplay	•	•	
Lowther Speakers USA	•	•	
MAAT Inc.	•	•	
Marchand Electronics, Inc.	•	•	
McKinney & Associates, LLC	•	•	
Menlo Scientific, Ltd.	•	•	
Midwest Audio Club	•	•	
NedLab	•	•	

	Consultants	Designers	Recruitment Agencies
Pacific Audio Consulting	•	•	
PCB Piezotronics, Inc.		•	
Planot, LLC	•	•	
Ponderosa Sound Systems	•	•	
PQN Audio/PQN Enterprises, Inc.		•	
PR Audio	•	•	
Pro Sound Testing, Inc.	•	•	
Quest Engines, LLC	•	•	
RCF USA, Inc.	•	•	
SoCal Sound Shop	•	•	
SoundKinetics	•	•	
Soundoctor	•	•	
Speaker Clinic	•	•	
SpeakersAndAmps.com	•	•	
Stroud Audio, Inc.	•	•	
Studio Electric - David MacPherson	•	•	
TMI Engineering	•	•	
True Technologies, Inc.	•	•	
TSG Audio	•	•	
US Enclosure Co.	•	•	
Vance Dickason Consulting	•	•	
Warkwyn	•	•	
Wehner Technical, Inc.	•	•	
Wired 4 Sound, Inc.	•	•	
Wisdom Audio		•	

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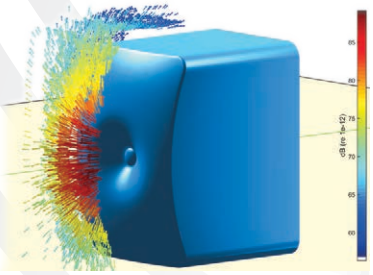

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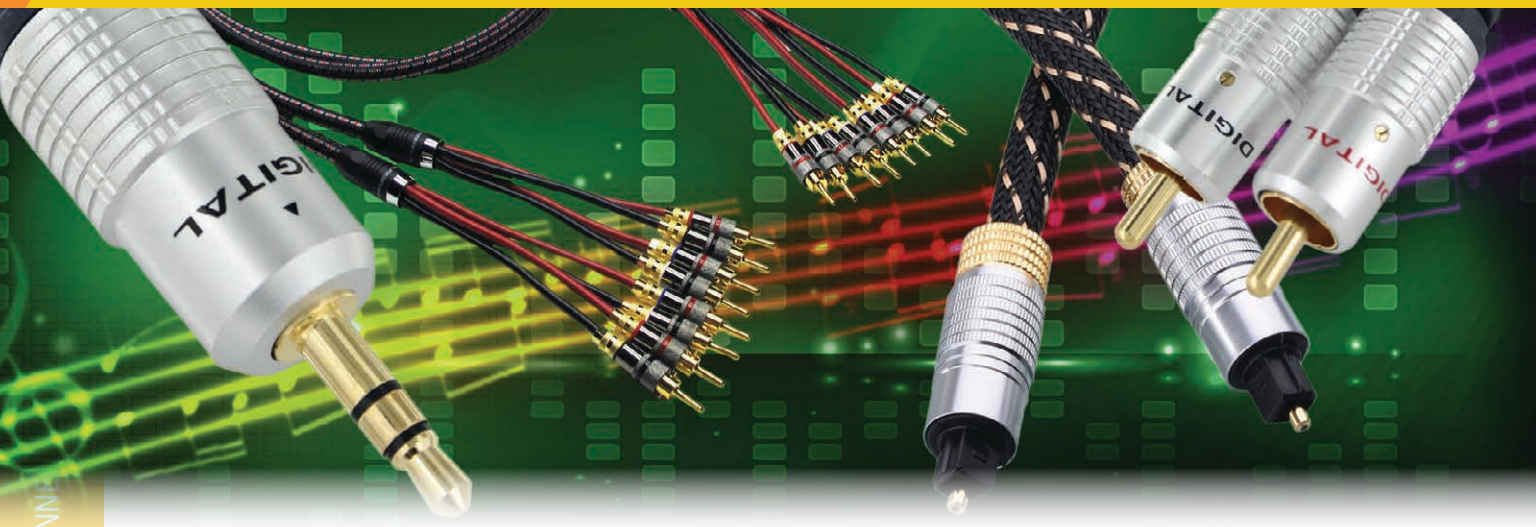

	Cables	Connectors	Wire Channel
AUSTRALIA			
Soundlabs Group, Pty., Ltd.	•	•	
Stone Sound Studio	•	•	
BRAZIL			
Newbox Industry & Commerce	•	•	•
CANADA			
Canadian Speaker Works	•	•	
DLC Loudspeaker R&D Group	•	•	
Rutherford Audio, Inc.	•		
Solen Electronique, Inc.	•	•	
The Canadian Loudspeaker Corp.		•	
CHINA			
BSWA Technology Co., Ltd.	•	•	•
Sound Technology Development, Ltd. (Factory)	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•
DENMARK			
estron, a/s	•	•	
Jantzen Audio Denmark	•		
GERMANY			
HiFi-Tuning	•	•	
Klippel GmbH	•		
Soundsgood Pro Audio Solutions	•	•	
Voice Point	•	•	•
Wolf von Langa			
HONG KONG			
WCE Acoustics	•	•	
HUNGARY			
Bayz Audio	•		
INDIA			
Power Electronics & Technologies	•	•	
IRELAND			
Crossover Filter App	•		
ITALY			
Axiomedia, SRL	•	•	

	Cables	Connectors	Wire Channel
JAPAN			
Furutech Co., Ltd.	•	•	
S'NEXT Co., Ltd.	•	•	
MEXICO			
Aletheia, AV	•		
NETHERLANDS			
ELTIM audio, BV	•	•	
Good Hifi VOF		•	
POLAND			
Resnatura Audio	•	•	
RUSSIA			
Deluxe Acoustics, Ltd.	•		
SWEDEN			
Audio Pro, AB	•		
TAIWAN			
Bentronic Components	•		•
Huey Tung International Co., Ltd.	•	•	
Yung International, Inc.	•	•	•
UKRAINE			
Mag Audio	•	•	
UNITED KINGDOM			
Arya Audio Labs, Ltd.	•		
EuroTec International, Plc.	•	•	•
MJ Acoustics	•		
Revolver Audio, Ltd.	•		
UNITED STATES			
A. Schulman, Inc.		•	
American Bass USA	•	•	
AMS Audio Enterprises, Inc.	•	•	
Audio Advisor, Inc.	•	•	
Audio Connection	•	•	•
B&H	•	•	
Blackmore Mobile	•	•	
Broad Bridge Audio, LLC	•		
Carvin Audio	•	•	
Controlled Thermal Processing, Inc.	•	•	•

	Cables	Connectors	Wire Channel
DTV Installations, LLC	•	•	•
Earthquake Sound Corp.	•		
Front End Audio, LLC	•	•	
Full Compass Systems, Ltd.	•	•	
GR Research	•	•	
GRAS Sound & Vibration	•	•	
HAVE, Inc.	•	•	•
Herman Pro	•	•	
JL Audio, Inc.	•	•	
Kramer Electronics	•	•	
Lamart Corp.	•	•	•
Loudspeakers Plus		•	
Madisound Speaker Components, Inc.	•		
Open Tip	•	•	
Parts Express	•	•	•
PowerPhysics, Inc.	•		
Pro Flix Sales	•	•	
PRV Audio Brazil	•		
Radio Design Labs (RDL)	•	•	•
Redco Audio	•	•	•
Revolution Power	•	•	
Schurter, Inc.	•	•	
Sound Pure, LLC	•	•	
Soundoctor	•	•	
Spectrum Audio	•	•	
Stillwater Designs | KICKER	•		
Straight Wire, Inc.	•	•	•
SVS, Inc.	•	•	
Sweetwater Sound	•	•	
Tonian Laboratories	•		
TSG Audio	•	•	
US Speaker, LLC	•	•	
Vidsonix Design Works	•	•	
Westlake Audio, Inc.	•	•	•
Wired 4 Sound, Inc.	•	•	•
Wireworld Cable Technology	•	•	
Yandas Music	•	•	
Zu Audio	•		
zZounds Music, LLC	•	•	

	Earphones	Headphones
AUSTRALIA		
Stone Sound Studio		•
AUSTRIA		
USound GmbH	•	•
BRAZIL		
Harman of Brazil, Ltda.	•	•
Newbox Industry & Commerce	•	•
CANADA		
DLC Loudspeaker R&D Group	•	•
Focal North America		•
Solen Electronique, Inc.	•	•
CHINA		
EASTECH Holding, Ltd.	•	•
Enkor Electronics Co., Ltd.		•
Lumi Audio		•
Pana Sound, Ltd.	•	•
Sound Technology Development, Ltd. (Factory)	•	•
Vormag Electronics Co., Ltd.	•	•
HONG KONG		
Eastern Asia Technology (HK), Ltd.	•	•
WCE Acoustics	•	•
ITALY		
RCF, SpA		•
JAPAN		
Furutech Co., Ltd.	•	•
S'NEXT Co., Ltd.	•	•
SOUTH KOREA		
Suntel Co., Ltd.	•	•
SWEDEN		
Audio Pro, AB		•
Oxeon AB/Textreme		•
TAIWAN		
Huey Tung International Co., Ltd.	•	•
Kingstate Electronics Corp.	•	•
Yung International, Inc.	•	•
THAILAND		
Clarasonic (Thailand) Co., Ltd.	•	•
Sanit Audio Engineering Co.		•

	Earphones	Headphones
UNITED KINGDOM		
Profusion plc		•
UNITED STATES		
1MORE	•	•
American Bass USA	•	•
American Music And Sound	•	•
Audio Advisor, Inc.	•	•
Audio Connection	•	•
AValive		•
B&H		•
BeStar Technologies, Inc.	•	•
Blackmore Mobile		•
Bob Young and Associates	•	•
Broad Bridge Audio, LLC	•	•
Christensen Audio, LLC		•
Dragonfire Acoustics	•	•
Earthquake Sound Corp.	•	•
Echobox Audio, LLC	•	•
ESS Laboratories, LLC		•
Front End Audio, LLC		•
Full Compass Systems, Ltd.	•	•
HAVE, Inc.		•
Hearing Components, Inc. (Comply Memory Foam Tips)	•	•
Materion		•
Open Tip	•	•
Pacific Audio Consulting	•	•
Parts Express	•	•
Peerless by Tymphany HK, Ltd.		•
PreSonus Audio Electronics, Inc.		•
Pro Flix Sales		•
Puro Sound Labs		•
RBH Sound	•	•
Revolution Power	•	
Seltech	•	•
Shure, Inc.	•	•
Sound Pure, LLC		•
Sound Sources Technology, Inc.	•	•
Spectrum Audio	•	•
Stillwater Designs | KICKER	•	•
US Enclosure Co.	•	•
Vintage King Audio		•
Yandas Music	•	•
Zu Audio		•
zZounds Music, LLC		•

ENCLOSURES & CABINETS

	Baffles		Finished Cabinets			Sub-Assemblies							Materials			Panels		Rigging
	Ceiling Speaker Plates	In-Wall Plates	Box Arrays (PA)	Boxes	Stands	Bulk Molding Compound	Carpet	Hardwood	MDF (Fiberboard)	Other	Paper/Paper Pulp	Plastic	Plywood	Veneer	Wound Geometric Tubes			
AUSTRALIA																		
Stone Sound Studio																•	•	
BELGIUM																		
Donnet: Loudspeaker Repair	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Premium Sound Solutions	•			•														
BRAZIL																		
Advanced Audio Technologies (AAT)				•														
Newbox Industry & Commerce	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•
CANADA																		
Canadian Speaker Works																•	•	•
Harbottle Audio	•	•	•	•						•			•			•		
Planet10-HiFi				•														
Solen Electronique, Inc.	•	•		•	•													
Studio Reference Monitors				•														
StudioLAB Loudspeakers				•														
Sziara Sound				•	•				•	•					•	•		
CHINA																		
EASTECH Holding, Ltd.			•	•	•													
Lumi Audio	•	•		•	•					•			•					
OBE Pro Audio Co., Ltd.																		•
Shenzhen Tekzone Loudspeaker Co., Ltd.																•	•	
Sound Technology Development, Ltd. (Factory)																•	•	
Sun Technique Electric Co., Ltd.																•	•	
Trueanalog Strictly OEM				•	•				•	•		•			•			
Vormag Electronics Co., Ltd.																•		
DENMARK																		
Kvart & Bølge				•														
FRANCE																		
Amplitude Audio	•	•		•														
KYU Systems			•	•										•		•		
GERMANY																		
Soundsgood Pro Audio Solutions	•	•	•	•	•	•		•	•	•								
Voice Point	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
HONG KONG																		
Ocean Star Electronics, Ltd.	•	•	•	•	•		•	•	•			•	•	•	•			
HUNGARY																		
Bayz Audio										•						•		

	Baffles		Finished Cabinets			Sub-Assemblies								Materials			Panels		Rigging
	Ceiling Speaker Plates	In-Wall Plates	Box Arrays (PA)	Boxes	Bulk Molding Compound	Stands	Carpet	Hardwood	MDF (Fiberboard)	Other	Paper/Paper Pulp	Plastic	Plywood	Veneer	Wound Geometric Tubes				
INDIA																			
Arulsound								•	•					•			•		
GM Audio Technics, Ltd.				•	•														
INDONESIA																			
Premiere Wood Manufacturing (PWM)	•	•		•	•	•			•	•	•		•	•	•		•	•	•
ITALY																			
Axiomedia, SRL					•	•		•									•		
MEXICO																			
Aletheia, AV				•	•	•				•	•								
NETHERLANDS																			
ELTIM audio, BV					•														
Sound Projects				•	•														•
POLAND																			
Sveda Audio					•	•													
ROMANIA																			
SC Poweraudio, SRL				•	•														
SOUTH AFRICA																			
Paks Acoustics					•	•			•	•				•	•		•		
SPAIN																			
Sottovoce Audio					•	•													
SWEDEN																			
Audio Pro, AB																	•	•	

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	Baffles		Finished Cabinets			Sub-Assemblies								Materials			Panels	Rigging
	Ceiling Speaker Plates	In-Wall Plates	Box Arrays (PA)	Boxes	Stands	Bulk Molding Compound	Carpet	Hardwood	MDF (Fiberboard)	Other	Paper/Paper Pulp	Plastic	Plywood	Veneer	Wound Geometric Tubes			
TAIWAN																		
Hi-Tech Sound System Co., Ltd.	•	•																
Huey Tung International Co., Ltd.	•	•	•	•	•	•	•			•			•					
Yie Feng Technology Enterprise Co.													•				•	
Yung International, Inc.			•	•	•					•			•		•			
THAILAND																		
Clarasonic (Thailand) Co., Ltd.											•					•		
UNITED KINGDOM																		
Bishopsound			•	•	•					•				•				
EuroTec International, Plc.	•		•	•									•					
Hill Acoustics											•							
MJ Acoustics				•					•						•			
Sine Audio Systems				•	•													
UNITED STATES																		
Acry-Tech Coatings, Inc.																•		
Adrian Acoustics, Inc.	•	•	•	•	•				•	•	•			•	•			
American Bass USA	•	•	•	•	•													
AMS Audio Enterprises, Inc.	•	•		•	•													
Area 52 R&D				•						•	•			•	•			
Audio Connection									•									
Campanella Associates & Acculab											•							
Carvin Audio				•	•													
CGN Audio Labs				•	•						•							
Dayton Audio				•														
Eagle Acoustics				•	•	•		•		•			•					•
Eminence Speaker, LLC				•	•													
Fulcrum Acoustic, LLC					•													
Full Compass Systems, Ltd.	•	•					•										•	
GGEC America, Inc.					•		•	•		•			•	•	•			
Global Audio Source, Inc.					•	•												
Globe Plastics, Inc.	•	•			•	•					•		•					
Inlow Sound					•			•				•		•	•			
Intelligent Audio Products		•	•	•	•		•			•	•			•	•		•	
J&F Wood Products	•	•	•	•	•		•	•		•				•	•			
Levister Audio					•													
Lowell Manufacturing Co.	•	•			•													
Midwest Audio Club					•	•			•	•				•	•			
Parts Express	•	•	•	•	•		•			•					•			
Ponderosa Sound Systems			•	•	•													
Precision Sound Products, Inc.											•							
Quest Engines, LLC											•							
RBH Sound	•	•			•					•	•		•					
RCF USA, Inc.			•						•				•	•				
SoCal Sound Shop			•	•														
Sound Anchors					•													
Sound Sources Technology, Inc.	•	•	•	•	•			•										
SpeakersAndAmps.com			•	•														
SSI Manufacturing, Inc.			•	•						•				•				
Studio Electric - David MacPherson			•	•					•	•					•			
TSG Audio			•	•	•													
United Gasket Corp.	•	•						•				•				•		
US Enclosure Co.	•	•	•	•	•						•		•		•			•
US Speaker, LLC			•	•	•													
Vidsonix Design Works				•						•								
Wired 4 Sound, Inc.																		•
Yandas Music				•	•													

	Enclosure Stuffing		Grille Assemblies			Hardware						
	Enclosure Grilles	Fiberglass	Foam	Synthetic	Wool	Fabric Suppliers	Foam Suppliers	Perforated Metal Suppliers	Corners	Handles	Name Plates	Fasteners & Other
AUSTRALIA												
Soundlabs Group, Pty., Ltd.	•		•	•	•	•	•	•				•
Stone Sound Studio	•											
BRAZIL												
Phix Electronics	•	•	•	•	•	•	•	•	•	•	•	•
CANADA												
Canadian Speaker Works	•		•	•			•	•		•	•	•
Reference 3A	•					•						
Solen Electronique, Inc.	•	•	•	•	•	•		•				•
Tortech Sound, Inc.	•											
CHINA												
Lumi Audio								•				
OBE Pro Audio Co., Ltd.	•								•	•		
Shenzhen Tekzone Loudspeaker Co., Ltd.	•			•								
Sound Technology Development, Ltd. (Factory)	•	•	•	•	•	•	•	•	•	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•	•	•	•	•	•	•
Trueanalog Strictly OEM											•	
FRANCE												
KYU Systems	•		•		•	•	•	•	•			
GERMANY												
Hubert Stueken GmbH & Co., KG									•			
Voice Point	•	•	•	•	•	•	•	•	•	•	•	•
HONG KONG												
Ocean Star Electronics, Ltd.	•											

	Enclosure Grilles	Enclosure Stuffing: Fiberglass	Enclosure Stuffing: Foam	Grille Assemblies: Synthetic	Grille Assemblies: Wool	Grille Assemblies: Fabric Suppliers	Hardware: Foam Suppliers	Hardware: Perforated Metal Suppliers	Hardware: Corners	Hardware: Handles	Hardware: Name Plates	Hardware: Fasteners & Other
INDIA												
Arulsound	•	•	•	•	•	•	•	•	•	•	•	•
GM Audio Technics, Ltd.			•									
ITALY												
Axiomedia, SRL						•	•		•	•	•	
NETHERLANDS												
Good Hifi VOF				•		•						
SWEDEN												
Audio Pro, AB	•	•	•	•	•	•		•	•			•
TAIWAN												
Taiwan Solidex Corp.	•										•	
Yie Feng Technology Enterprise Co.	•		•				•					
UKRAINE												
Mag Audio	•											
UNITED KINGDOM												
EuroTec International, Plc.	•	•	•	•		•	•	•				
UNITED STATES												
A. Schulman, Inc.	•											
Accurate Perforating Co., Inc.	•								•			

	Enclosure Stuffing		Grille Assemblies			Hardware						
	Enclosure Grilles	Fiberglass	Foam	Synthetic	Wool	Fabric Suppliers	Foam Suppliers	Perforated Metal Suppliers	Corners	Handles	Name Plates	Fasteners & Other
Acry-Tech Coatings, Inc.												•
Adrian Acoustics, Inc.	•	•	•	•	•	•	•					
American Bass USA	•									•	•	•	•
AMS Audio Enterprises, Inc.	•					•			•			
Carvin Audio										•	•		•
Dayton Audio	•											
Foam Speaker Grilles	•						•					
Full Compass Systems, Ltd.	•	•	•	•	•	•	•	•	•	•	•	•	•
Global Audio Source, Inc.	•											
Globe Plastics, Inc.	•									•	•	
J&F Wood Products	•	•				•						
Lowell Manufacturing Co.	•								•			
Meniscus Audio Group, Inc.			•	•								
MetalEX	•								•			
ORCA Design And Manufacturing					•							
Precision Sound Products, Inc.												•
Quest Engines, LLC												•
RBH Sound	•											
SpeakerAddict	•	•	•	•	•	•			•	•	•		•
United Gasket Corp.			•	•	•	•	•					
US Enclosure Co.	•	•	•	•	•	•	•	•				•	
US Speaker, LLC										•	•	•	•
Vidsonix Design Works	•								•				

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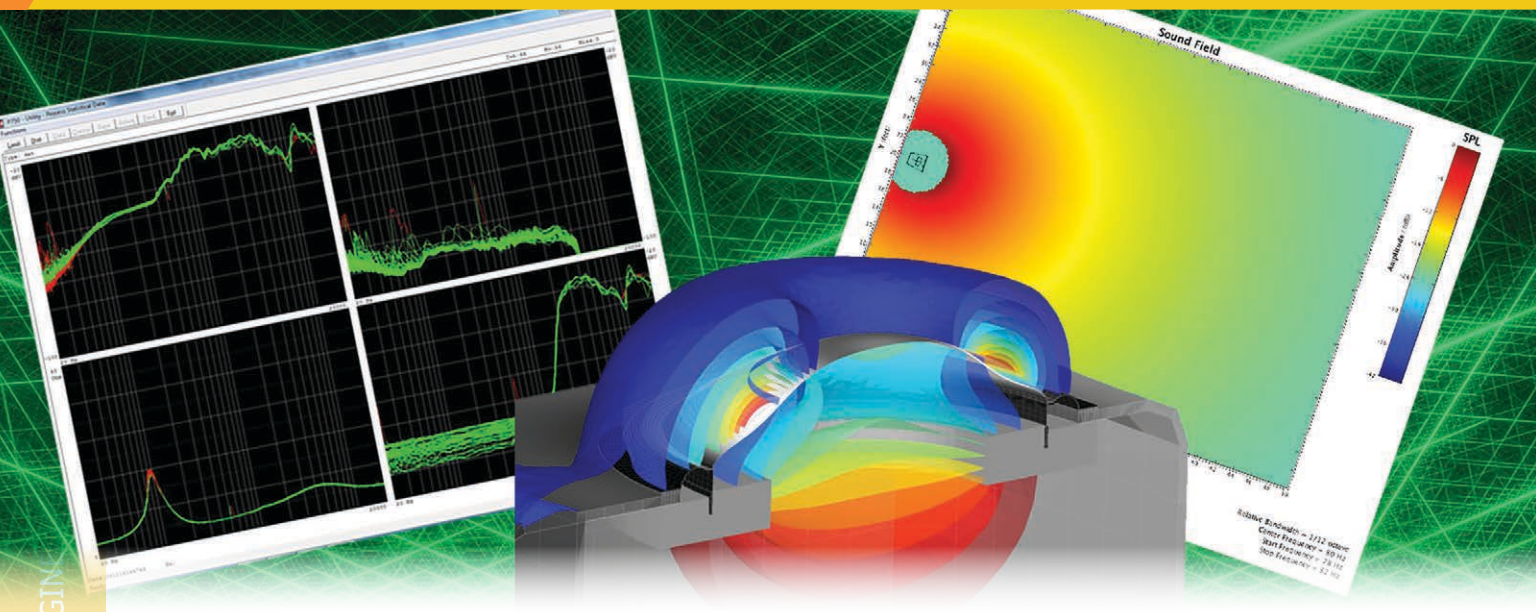


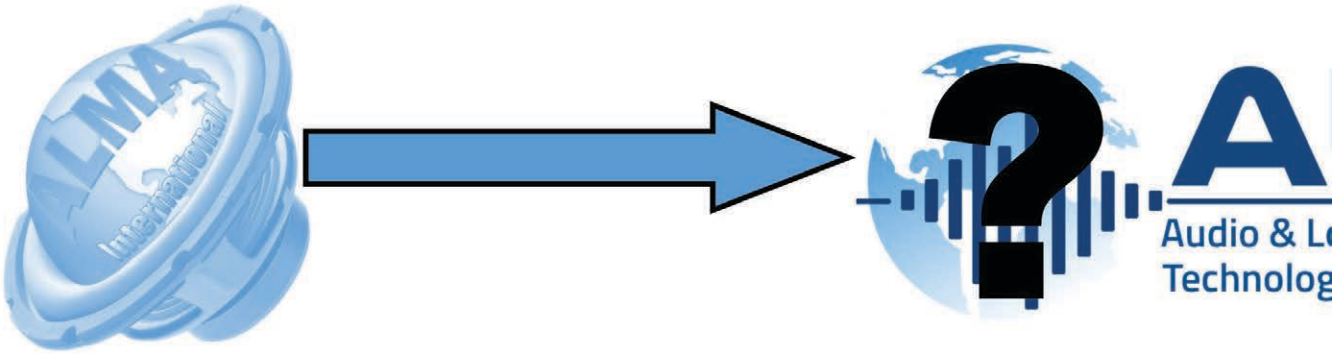
	Acoustic Analysis	Box Design	Crossover Optimizer	Network Design	CAE or CAD
AUSTRALIA					
Audinate, Pty., Ltd.	•	•	•	•	•
Audiosoft	•	•	•	•	
DEQX Pty., Ltd.	•		•	•	
Eclipse Audio			•		
Stone Sound Studio	•	•	•		•
BELGIUM					
Donnet: Loudspeaker Repair	•	•	•		
BRAZIL					
Newbox Industry & Commerce	•	•	•	•	•
CANADA					
Canadian Speaker Works	•	•			•
DLC Loudspeaker R&D Group	•	•	•	•	
Solen Electronique, Inc.	•	•	•		
Space-Tech Lab, Ltd.	•				
CHINA					
BSWA Technology Co., Ltd.	•				
EASTECH Holding, Ltd.	•	•			•
Pana Sound, Ltd.	•	•	•	•	
Shenzhen Tekzone Loudspeaker Co., Ltd.	•	•	•	•	•
Sound Technology Development, Ltd. (Factory)	•	•	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•
Trueanalog Strictly OEM		•			•
DENMARK					
K & K Development	•				
LOUDSOFT, Ltd.	•	•	•		
FRANCE					
KYU Systems	•		•	•	•

	Acoustic Analysis	Box Design	Crossover Optimizer	Network Design	CAE or CAD
GERMANY					
Klippel GmbH	•				
R&D Team Software Development	•	•	•	•	
Soundsgood Pro Audio Solutions	•	•			•
Voice Point	•	•	•	•	•
HONG KONG					
Ocean Star Electronics, Ltd.	•	•			•
INDIA					
GM Audio Technics, Ltd.	•				
IRELAND					
Crossover Filter App			•		
ISRAEL					
Coby Speakers	•	•	•	•	•
ITALY					
Audiomatica, SRL	•				
SpeakerLAB	•				•
JAPAN					
Etani Electronics Co., Ltd.	•	•			•
LATVIA					
Acoustic Power Lab	•		•		
Sonarworks SIA	•				
NETHERLANDS					
ELTIM audio, BV		•	•		
SINGAPORE					
Virtins Technology	•				

	Acoustic Analysis	Box Design	Crossover Optimizer	Network Design	CAE or CAD
SOUTH KOREA					
Suntel Co., Ltd.	•	•	•	•	•
SPAIN					
Brusi Acoustics	•	•		•	
SWEDEN					
Audio Pro, AB	•	•	•	•	
Bohmer Audio, AB	•		•		•
IJData	•	•	•	•	•
SWITZERLAND					
Archwave				•	
TAIWAN					
Kingstate Electronics Corp.	•				•
UNITED KINGDOM					
EuroTec International, Plc.					•
Hill Acoustics	•	•	•		•
PACSYS, Ltd.	•				

	Acoustic Analysis	Box Design	Crossover Optimizer	Network Design	CAE or CAD
UNITED STATES					
Bruel & Kjaer Sound & Vibration North America, Inc.	•				
Community Professional Loudspeakers	•	•	•	•	•
Danville Signal Processing, Inc.	•		•	•	
Digmoda			•		
Dragonfire Acoustics	•	•	•		•
Geometric Designs, LLC & Geometric Consulting		•	•		•
HEAD acoustics, Inc.	•				
HX Audio Lab	•	•	•	•	•
Listen, Inc.	•				
MSC Software Corp.	•		•		•
NedLab		•	•	•	
Parts Express	•	•			
Prism Media Products, Ltd.	•	•	•	•	
Scantek, Inc.	•				
Soundoctor	•		•		
Speaker Clinic		•	•		•
Studio Six Digital	•				
True Technologies, Inc.	•				
Warkwyn	•	•	•	•	•

THE EVOLUTION OF AN ICON



THE REVOLUTION OF AN INDUSTRY

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	Car Audio	Home Audio	Marine Audio	Pro Audio
AUSTRALIA				
Stone Sound Studio	•	•		•
BELGIUM				
Donnet: Loudspeaker Repair	•	•	•	•
Premium Sound Solutions	•	•		
BRAZIL				
Advanced Audio Technologies (AAT)		•		
AMCP Eletronica		•		
Harman of Brazil, Ltda.	•	•	•	•
Newbox Industry & Commerce	•	•	•	•
CANADA				
Acora Acoustics Corp.		•		
Canadian Speaker Works				•
Focal North America	•	•		•
Harbottle Audio		•	•	•
LMH Loudspeakers	•	•		•
Newform Research, Inc.		•		•
Planet10-HiFi		•		
Reference 3A		•		•
Solen Electronique, Inc.	•	•		•
Space-Tech Lab, Ltd.		•		
Studio Reference Monitors				•
StudioLAB Loudspeakers		•		
The Canadian Loudspeaker Corp.	•	•		•

	Car Audio	Home Audio	Marine Audio	Pro Audio
CHINA				
Audiostar Electronics Co., Ltd.	•	•		•
B.W. Audio Guangzhou Co., Ltd.				•
EASTECH Holding, Ltd.	•	•	•	•
Enkor Electronics Co., Ltd.		•		
Fountek Electronics Co., Ltd.	•	•		•
Lumi Audio		•		•
OBE Pro Audio Co., Ltd.				•
Shenzhen Tekzone Loudspeaker Co., Ltd.		•		•
Sonos, Inc.		•		
Sound Technology Development, Ltd. (Factory)		•		•
Speakerhu Electronic Co., Ltd.	•	•		
Sun Technique Electric Co., Ltd.	•	•		•
Trueanalog Strictly OEM	•	•	•	•
Zeng Ben Industrial Corp., Ltd.	•	•		•
Zhuhai HiVi Technology Co., Ltd.	•	•		•
DENMARK				
ICEpower, AS	•	•		•
Kvart & Bølge		•		
Pascal, AS				•
Scan-Speak, AS	•			
FRANCE				
Crista Technologies		•		
KYU Systems				•
Supravox		•		•

	Car Audio	Home Audio	Marine Audio	Pro Audio
T&T Acoustic Speakers		•		
The Concrete Family SAS		•		•
Waterfall Audio		•		•
GERMANY				
Ascendo Immersive Audio GmbH		•		•
Eton GmbH	•	•		
HiFi-Tuning		•		•
ic audio GmbH			•	•
Lautsprecher-Produktions-Gesellschaft (LPG) mbH	•			
Marlok Automotive GmbH	•			
Scherer Audio		•		
Voice Point		•	•	•
HONG KONG				
Acoustic Development International	•	•		
Eastern Asia Technology (HK), Ltd.	•	•	•	•
miniDSP	•	•		•
Ocean Star Electronics, Ltd.		•		•
WCE Acoustics		•		
HUNGARY				
Bayz Audio		•		•
INDIA				
GM Audio Technics, Ltd.				•
Power Electronics & Technologies		•		•

	Car Audio	Home Audio	Marine Audio	Pro Audio
INDONESIA				
SB Acoustics		•		
IRELAND				
Crossover Filter App	•	•	•	•
ISRAEL				
Chorus Audio		•		•
Coby Speakers	•	•	•	•
Morel, Ltd.	•	•		
ITALY				
Powersoft SpA				•
JAPAN				
Etani Electronics Co., Ltd.	•	•		•
MALAYSIA				
TC Electronics, Sdn., Bhd.	•	•		
MEXICO				
Aletheia, AV		•		
NETHERLANDS				
ELTIM audio, BV		•		•
Sound Projects				•
NEW ZEALAND				
Theophany Loudspeakers, Ltd.		•		
NORWAY				
SEAS Fabrikker, AS		•		
POLAND				
Sveda Audio		•		•
ROMANIA				
SC Poweraudio, SRL				•
RUSSIA				
Deluxe Acoustics, Ltd.		•		
Star Sound Technologies	•	•		•
SOUTH KOREA				
Suntel Co., Ltd.	•	•		•
SPAIN				
DAS Audio				•
Sottovoce Audio		•		•
SWEDEN				
Audio Pro, AB	•	•		•
TAIWAN				
Bentronic Components	•	•	•	•
Huey Tung International Co., Ltd.	•	•		•
Kingstate Electronics Corp.	•	•		
UKRAINE				
Mag Audio				•

	Car Audio	Home Audio	Marine Audio	Pro Audio
UNITED KINGDOM				
Arya Audio Labs, Ltd.	•	•		•
Compbass, Ltd.		•		•
EuroTec International, Plc.	•		•	•
Fane International, Ltd.				•
Ferguson Hill Studios, Ltd.		•		•
MJ Acoustics		•	•	•
Precision Devices, Ltd.				•
Sine Audio Systems		•		
Tectonic Elements, Ltd.	•	•		•
UNITED STATES				
Aempyrean	•	•		•
Ambiance Acoustics		•		•
American Bass USA	•			
American Music And Sound	•	•	•	•
AMS Audio Enterprises, Inc.		•		•
Analysis Audio USA		•		
Area 52 R&D		•		•
Arion Audio		•		
Audioengine		•		
Audio-Optix		•		•
B&H		•		•
Barefoot Sound, LLC				•
BASSBOSS				•
Blackmore Mobile		•		•
Broad Bridge Audio, LLC		•		
Carvin Audio		•		
CGN Audio Labs				•
Clear Lake Audio				•
CommonSense Audio		•		•
Creative Sound Solutions, LLC		•		
Dayton Audio		•		
dBTechnologies				•
Digital Audio Labs				•
Digmoda		•		•
Eagle Acoustics	•	•	•	•
Earthquake Sound Corp.	•	•	•	•
Eminence Speaker, LLC				•
ESS Laboratories, LLC	•	•		
Fulcrum Acoustic, LLC				•
Geometric Designs, LLC & Geometric Consulting		•		
GGEC America, Inc.	•	•	•	•
Global Audio Source, Inc.	•	•		•
Globe Audio Design, Inc.		•		•
GoldenEar Technology		•		
Halford Loudspeakers		•		•
JL Audio, Inc.	•	•	•	
Levister Audio		•		
Lipinski Sound		•		•
Marchand Electronics, Inc.		•		
Meyer Sound Laboratories, Inc.		•		•
MISCO		•		•
NHT Audio, LLC		•		
North American Solidex LLC		•		•

	Car Audio	Home Audio	Marine Audio	Pro Audio
ORCA Design And Manufacturing	•	•		
Parts Express	•	•		•
Pazandeh Audio Designs		•		•
Peerless by Tymphany HK, Ltd.	•	•		•
Performance Audio, LLC				•
Phoenix Engineering, LLC		•		
PranaFidelity		•		
Precison Transducer Engineering (PTE)		•		•
Pro Flix Sales				•
Purist Sonics		•		•
RBH Sound		•		
RCF USA, Inc.				•
Rock The Boat			•	
RSL Speaker Systems		•		
SoCal Sound Shop	•	•	•	•
Sound & Lighting Systems				•
Sound Sources Technology, Inc.	•	•		
Soundfield Audio		•		
SpeakersAndAmps.com	•	•		•
Spectrum Audio				•
SSI Manufacturing, Inc.		•		•
Studio Electric - David MacPherson		•		•
Tonian Laboratories		•		•
TSG Audio	•	•		•
US Speaker, LLC	•	•		•
Vidsonix Design Works	•	•	•	
Weltronics Corp.		•		
Westlake Audio, Inc.		•		•
Wired 4 Sound, Inc.		•		•
Wisdom Audio		•		
Yandas Music				•
Zu Audio		•		

	DSP (Digital Signal Processing) Amplifiers	High-Power Amplifier Modules	Marine Audio Solutions	Soundbars	Subwoofer Plate Amps	Wireless
AUSTRALIA						
DEQX Pty., Ltd.	•	•	•	•		•
Eclipse Audio		•				
Soundlabs Group, Pty., Ltd.	•		•			•
Stone Sound Studio	•	•	•			•
BELGIUM						
Donnet: Loudspeaker Repair				•	•	•
BRAZIL						
Advanced Audio Technologies (AAT)	•		•			•
Harman of Brazil, Ltda.	•	•	•	•	•	•
Newbox Industry & Commerce	•	•	•	•	•	•
CANADA						
DLC Loudspeaker R&D Group	•	•	•		•	•
Harbottle Audio	•	•	•			•
Rutherford Audio, Inc.	•		•			
Solen Electronique, Inc.	•	•	•		•	•
Studio Reference Monitors	•	•				
Tortech Sound, Inc.	•					
CHINA						
EASTECH Holding, Ltd.	•	•	•	•	•	•
Enkor Electronics Co., Ltd.					•	
Fountek Electronics Co., Ltd.	•	•	•			•
Lumi Audio	•		•			•
OBE Pro Audio Co., Ltd.	•	•				•
Pana Sound, Ltd.	•	•	•		•	•
Shenzhen Tekzone Loudspeaker Co., Ltd.	•					•
Sound Technology Development, Ltd. (Factory)	•		•		•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•
DENMARK						
ICEpower, AS	•	•	•			•
Kvart & Bølge	•					•
Pascal, AS			•			
FRANCE						
Amplitude Audio	•	•				•
IDEA	•		•			
KYU Systems	•	•	•	•		•
GERMANY						
ic audio GmbH				•		•
Klippel GmbH	•	•				
Physical-Lab	•	•				•
Voice Point	•	•	•	•	•	•
HONG KONG						
Eastern Asia Technology (HK), Ltd.	•	•	•	•	•	•
miniDSP	•	•				•
WCE Acoustics					•	
INDIA						
Power Electronics & Technologies	•		•			•
INDONESIA						
Premiere Wood Manufacturing (PWM)	•	•	•	•	•	•
ISRAEL						
Coby Speakers	•	•	•	•	•	•
ITALY						
Axiomedia, SRL	•	•	•			•
Powersoft SpA	•	•	•	•		
JAPAN						
Etani Electronics Co., Ltd.	•	•	•		•	•
NETHERLANDS						
ELTIM audio, BV	•		•			
Hypex Electronics, BV	•	•	•			•
the BEE	•	•				
SWEDEN						
Audio Pro, AB		•	•		•	•
Bohmer Audio, AB	•	•	•			•
TAIWAN						
Kingstate Electronics Corp.	•				•	
Yung International, Inc.	•					•
UNITED KINGDOM						
EuroTec International, Plc.	•		•	•		
Ferguson Hill Studios, Ltd.	•	•	•			•
Kleio Audio, Ltd.	•					
MJ Acoustics			•			•
Revolver Audio, Ltd.	•					
Sine Audio Systems	•		•		•	
Tectonic Elements, Ltd.	•					
UNITED STATES						
AMS Audio Enterprises, Inc.	•					•

	Amplifiers	DSP (Digital Signal Processing)	High-Power Amplifier Modules	Marine Audio Solutions	Soundbars	Subwoofer Plate Amps	Wireless
Area 52 R&D	•	•	•			•	
Arion Audio	•						
Audio Advisor, Inc.	•						
Audio-Optix	•	•			•		•
Axiim	•	•	•	•	•	•	•
Barefoot Sound, LLC	•	•	•				
Broad Bridge Audio, LLC	•				•		
Carvin Audio	•	•					•
CGN Audio Labs							•
CommonSense Audio	•						
Danville Signal Processing, Inc.	•	•	•	•		•	
Dayton Audio	•	•	•		•	•	•
Digital Audio Labs	•	•					
Digmoda	•	•	•			•	
DMSI	•	•	•				
Dragonfire Acoustics	•	•	•	•	•	•	•
DTV Installations, LLC	•		•		•	•	•
Eagle Acoustics	•			•	•		•
Earthquake Sound Corp.	•		•			•	
Etal Group, AB/Anaview	•		•	•	•	•	
Fulcrum Acoustic, LLC		•					
JL Audio, Inc.	•	•	•	•		•	•
Kramer Electronics	•	•	•			•	•

	Amplifiers	DSP (Digital Signal Processing)	High-Power Amplifier Modules	Marine Audio Solutions	Soundbars	Subwoofer Plate Amps	Wireless
Linear Tube Audio	•		•				
MISCO	•	•	•		•		
North American Solidex LLC	•	•				•	•
Parts Express	•	•	•		•	•	•
Peerless by Tymphany HK, Ltd.	•	•	•		•		•
Ponderosa Sound Systems	•						
PowerPhysics, Inc.	•	•	•			•	
Pro Flix Sales	•						
Radio Design Labs (RDL)	•		•				
RBH Sound	•					•	
RCF USA, Inc.	•	•	•				
SpeakerAddict	•	•	•	•		•	
SpeakersAndAmps.com	•	•	•	•		•	
Spectrum Audio	•						•
Stillwater Designs | KICKER	•	•	•	•			•
TSG Audio	•	•	•		•	•	
US Enclosure Co.	•	•	•		•	•	•
US Speaker, LLC	•						
Vidsonix Design Works				•			
Weltronics Corp.	•	•	•				
Western Electric	•						
Wired 4 Sound, Inc.	•	•			•		•
Wisdom Audio		•			•		

Powersoft

POWERSOFT.COM

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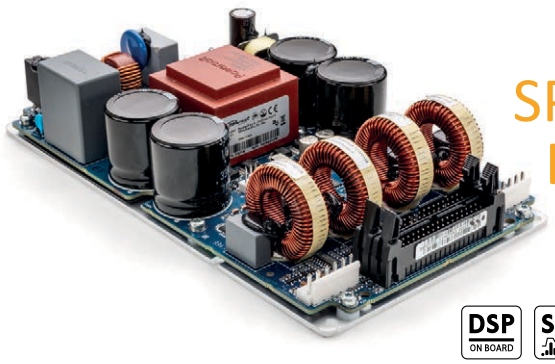
EMPOWER YOUR SPEAKER DESIGN

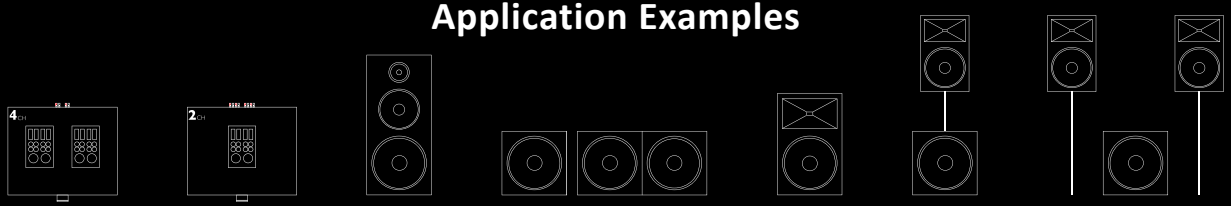


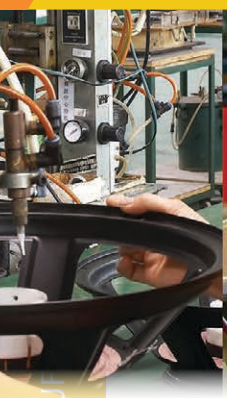
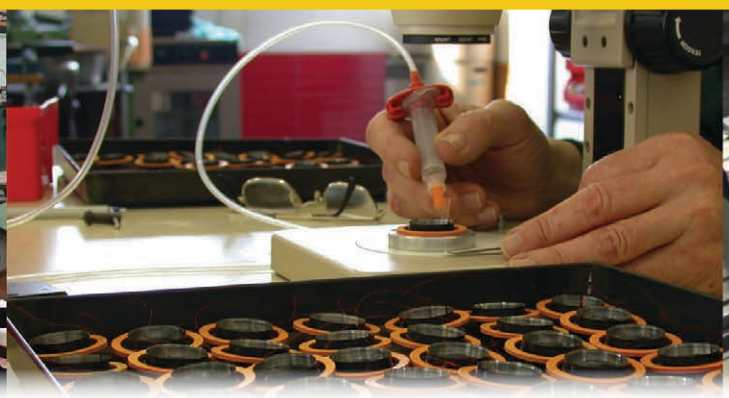
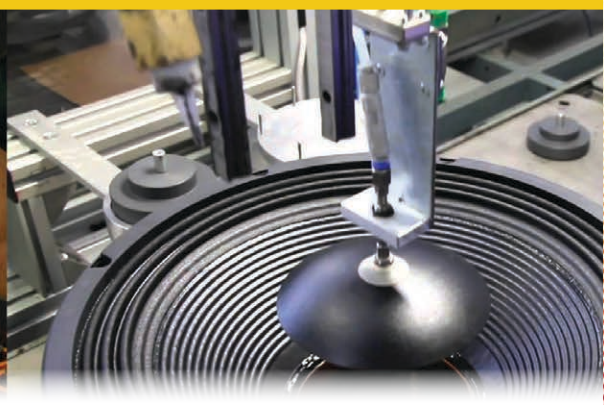
DSP ON BOARD · SRM · PFC · A+ ARMONIA

Whatever Your Applications

- 4 output stages (750W@4Ω each)
- 4, 3, 2 channels, or single high power (up to 2400W@4Ω) channel configurations
- High channel count applications
- Universal mains PFC equipped power supply
- Comprehensive set of protection and on-board limiters

Application Examples



	Adhesive Dispensers	Conveyors	Curing Ovens	Lead Out Wire Termination	Production Line Equipment	Magnetizers/Demagnetizers	Ultrasonic Assembly Equipment
AUSTRALIA							
Stone Sound Studio						•	
BRAZIL							
Newbox Industry & Commerce						•	
CANADA							
Canadian Speaker Works	•	•		•		•	
CHINA							
OBE Pro Audio Co., Ltd.	•	•	•	•	•	•	
Shenzhen Tekzone Loudspeaker Co., Ltd.	•	•				•	•
Sound Technology Development, Ltd. (Factory)	•	•	•	•	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•	•
DENMARK							
K & K Development						•	
LOUDSOFT, Ltd.						•	
GERMANY							
Klippel GmbH						•	
INDIA							
Lakshmi Metal Coils							•
JAPAN							
Etani Electronics Co., Ltd.						•	
RUSSIA							
Deluxe Acoustics, Ltd.							
SWEDEN							
Audio Pro, AB						•	
SWITZERLAND							
Kisling, AG	•						
Megatec, AG		•		•	•	•	•
TAIWAN							
Hurray Co., Ltd.	•					•	

	Adhesive Dispensers	Conveyors	Curing Ovens	Lead Out Wire Termination	Production Line Equipment	Magnetizers/Demagnetizers	Ultrasonic Assembly Equipment
THAILAND							
Clarasonic (Thailand) Co., Ltd.	•	•	•				
UNITED KINGDOM							
EuroTec International, Plc.	•	•	•	•	•	•	•
Hill Acoustics					•		
UNITED STATES							
Acoustic Design, Inc.						•	
Adrian Acoustics, Inc.		•			•		
Astro Machine Works, Inc.					•		•
Bruel & Kjaer Sound & Vibration North America, Inc.					•		
Conveyor Systems & Engineering, Inc.		•					
DELO Industrial Adhesives, LLC	•				•		
Delta H Technologies, LLC			•				
Dragonfire Acoustics						•	
Dukane Northeast Technical Center					•		•
Dymax Corp.	•						
Dynavox Electronics, Inc.						•	
Eberhard Manufacturing Co.	•				•		
Ellsworth Adhesives	•						
Fisnar, Inc.	•						
Fluid Metering, Inc.	•				•		
Glenro, Inc.			•				
Global Finishing Solutions, LLC			•				
Hernon Manufacturing, Inc.	•	•	•		•		
Krayden, Inc.	•						
LEWCO, Inc.		•	•				
Metzgar Conveyors		•					
Nordson EFD	•				•		
NTi Audio, Inc.					•		
Parts Express	•						
PRV Audio Brazil					•		
Sealant Equipment	•						
The Eraser Co.					•		
Uni-Pak Corp.		•					
Valley Design Corp.					•		•
Wisconsin Oven			•				
WSF Industries, Inc.			•				

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Musical Instrument • Professional

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Headphone and microphone suppliers

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	Consumer	Field Mics	Lab Instruments	Measuring Mics	Professional
AUSTRALIA					
DEQX Pty., Ltd.				•	
BRAZIL					
Newbox Industry & Commerce	•	•		•	•
CANADA					
Canadian Speaker Works				•	•
Solen Electronique, Inc.	•	•		•	
CHINA					
BSWA Technology Co., Ltd.		•	•	•	•
CRY Sound Co., Ltd.		•	•	•	•
Lumi Audio	•	•		•	
Shenzhen Tekzone Loudspeaker Co., Ltd.			•		
Sound Technology Development, Ltd. (Factory)					•
Sun Technique Electric Co., Ltd.	•	•	•	•	•
DENMARK					
Jantzen Audio Denmark	•				
K & K Development				•	
FRANCE					
KYU Systems			•	•	
GERMANY					
Klippel GmbH				•	
Microtech GEFELL	•	•		•	•
Voice Point	•	•	•	•	•
HONG KONG					
miniDSP				•	
WCE Acoustics	•				•

ACCURATE.
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AFFORDABLE.

Whether your venue is a small club or Albert Hall, the Audix TM1 test and measurement microphone offers an unmatched combination of exceptional linearity, consistent accuracy, and surprising affordability. Designed for room analysis software programs and sound control devices, the TM1 is an excellent tool for sound engineers, sound companies, and recording enthusiasts. Upgrade to the TM1 PLUS and receive calibration data on CD, a calibration adapter, and threaded acoustic windscreen. TM1 and TM1 PLUS are designed, machined, assembled, and tested by Audix in the USA.

"The Audix TM1 is a cost-effective tool that delivers results as clear and consistent as much more expensive devices. My TM1 Plus is an integral part of my tuning kit."

— David Seaford
XL Mediaworks, Inc.

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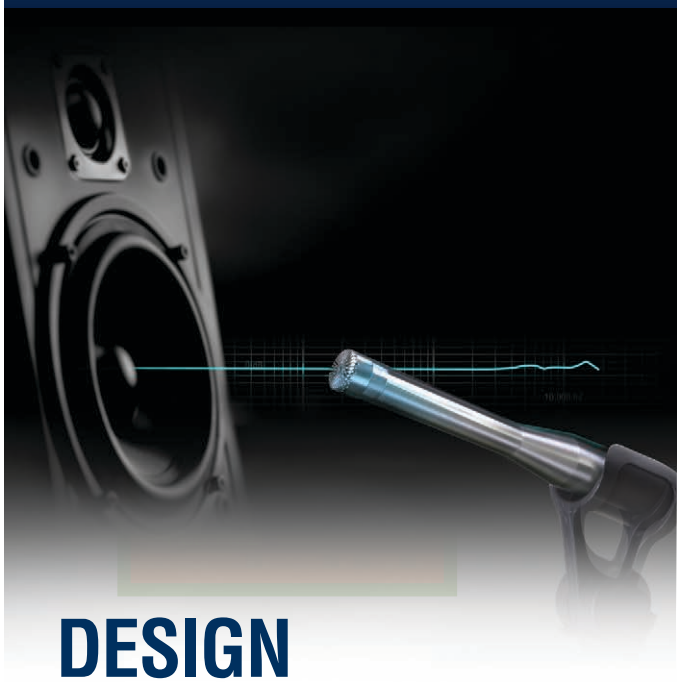

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2-IN-1 PHANTOM POWERED MICROPHONE PREAMPLIFIER

- 156 dB 1% THD and flat frequency response for high definition recording & modeling instruments
- Quickly change between ½" and ¼" 0V, IEC 61094-4 compliant microphones
- Calibrated, flat response 3 Hz to 100,000 Hz with appropriate microphone

MTS SENSORS

PCB PIEZOTRONICS
MTS SYSTEMS CORPORATION

pcb.com/phantom

	Consumer	Field Mics	Lab Instruments	Measuring Mics	Professional
INDIA					
GM Audio Technics, Ltd.				•	
JAPAN					
Etani Electronics Co., Ltd.		•	•	•	
LATVIA					
Sonarworks SIA				•	
SINGAPORE					
Virtins Technology	•		•	•	•
SOUTH KOREA					
Suntel Co., Ltd.	•	•	•	•	•
SWEDEN					
Audio Pro, AB			•	•	
TAIWAN					
Kingstate Electronics Corp.	•				
UNITED KINGDOM					
EuroTec International, Plc.			•	•	•
UNITED STATES					
ACO Pacific, Inc.		•	•	•	•
Audio Precision, Inc.			•	•	
Audix	•			•	•
AValive	•				•
B&H	•				•
Bruel & Kjaer Sound & Vibration North America, Inc.			•	•	
Dayton Audio	•	•	•	•	•
Earthworks, Inc.	•	•	•	•	•
Front End Audio, LLC	•	•	•	•	•
Full Compass Systems, Ltd.	•	•			•
GRAS Sound & Vibration	•	•	•	•	•
iSEMcon, LLC	•	•	•	•	•
JLI Electronics, Inc.	•	•	•	•	•
Listen, Inc.				•	
NTi Audio, Inc.			•	•	•
Parts Express	•	•	•	•	•
PCB Piezotronics, Inc.	•	•	•	•	•
PreSonus Audio Electronics, Inc.				•	
Scantek, Inc.		•	•	•	•
Sound Pure, LLC	•				•
Speaker Clinic				•	
Spectrum Audio	•				•
Studio Six Digital			•	•	
Sweetwater Sound	•				•
Vintage King Audio	•			•	•
Wired 4 Sound, Inc.	•	•		•	•
Yandas Music	•				•
zZounds Music, LLC					•

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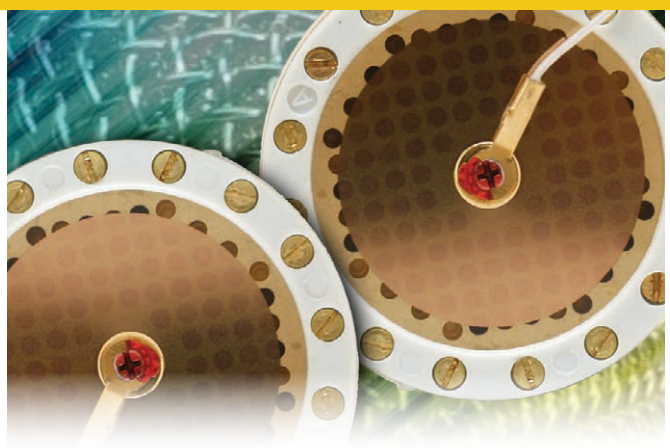

	Dynamic Capsules	ECM	LDC	MEMS	True Condenser
AUSTRIA					
USound GmbH				•	
CHINA					
BSWA Technology Co., Ltd.		•			
Shenzhen Tekzone Loudspeaker Co., Ltd.	•				
Sound Technology Development, Ltd. (Factory)	•				
Sun Technique Electric Co., Ltd.	•	•	•	•	•
FRANCE					
KYU Systems		•		•	
GERMANY					
Microtech GEFELL	•	•	•	•	•
SOUTH KOREA					
Suntel Co., Ltd.	•	•	•	•	•
SWEDEN					
Audio Pro, AB	•	•			
TAIWAN					
Kingstate Electronics Corp.		•		•	
UNITED KINGDOM					
EuroTec International, Plc.	•	•			•
UNITED STATES					
ACO Pacific, Inc.		•			
AValive	•	•	•	•	•
B&H	•	•	•	•	•
Bruel & Kjaer Sound & Vibration North America, Inc.					•
Front End Audio, LLC	•	•	•	•	•
GRAS Sound & Vibration	•	•	•	•	
JLI Electronics, Inc.	•	•			
Microphone-Parts.com			•		•
Pro Flix Sales	•	•	•	•	•
Seltech		•		•	•
Shure, Inc.	•				•
Sound Pure, LLC	•	•	•	•	
Spectrum Audio	•	•	•	•	•
Stetron International, Inc.		•			
Sweetwater Sound	•	•	•	•	•
Vintage King Audio	•	•	•	•	•
Yandas Music	•	•	•	•	•

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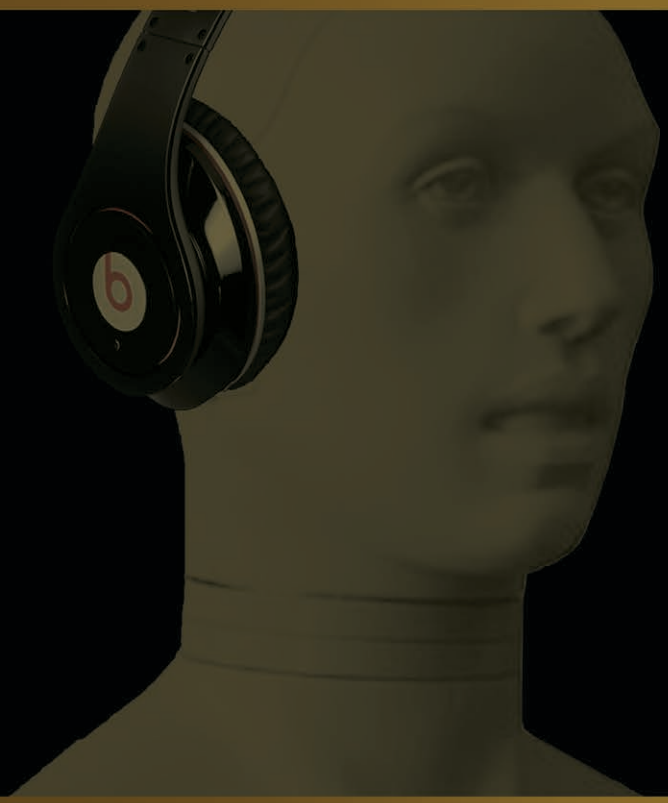

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- Technical Support for Headset, Mic, Speaker & Manufacturers
- Product Development
- Test & Measurement Instrumentation
- Sourcing Guidance

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AUSTRIA			
USound GmbH	•	•	•
CANADA			
DLC Loudspeaker R&D Group		•	•
Solen Electronique, Inc.	•	•	•
CHINA			
M-Sound Electronics Co., Ltd.			•
Shenzhen Tekzone Loudspeaker Co., Ltd.		•	
Sound Technology Development, Ltd. (Factory)	•	•	•
Speakerhu Electronic Co., Ltd.	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•
Wavecor, Ltd.		•	
GERMANY			
Voice Point		•	•
HONG KONG			
Eastern Asia Technology (HK), Ltd.		•	•
WCE Acoustics	•	•	•
SOUTH KOREA			
Suntel Co., Ltd.	•	•	•
SWEDEN			
Oxeon AB/Textreme	•	•	•
TAIWAN			
Huey Tung International Co., Ltd.	•	•	•
Kingstate Electronics Corp.	•	•	•

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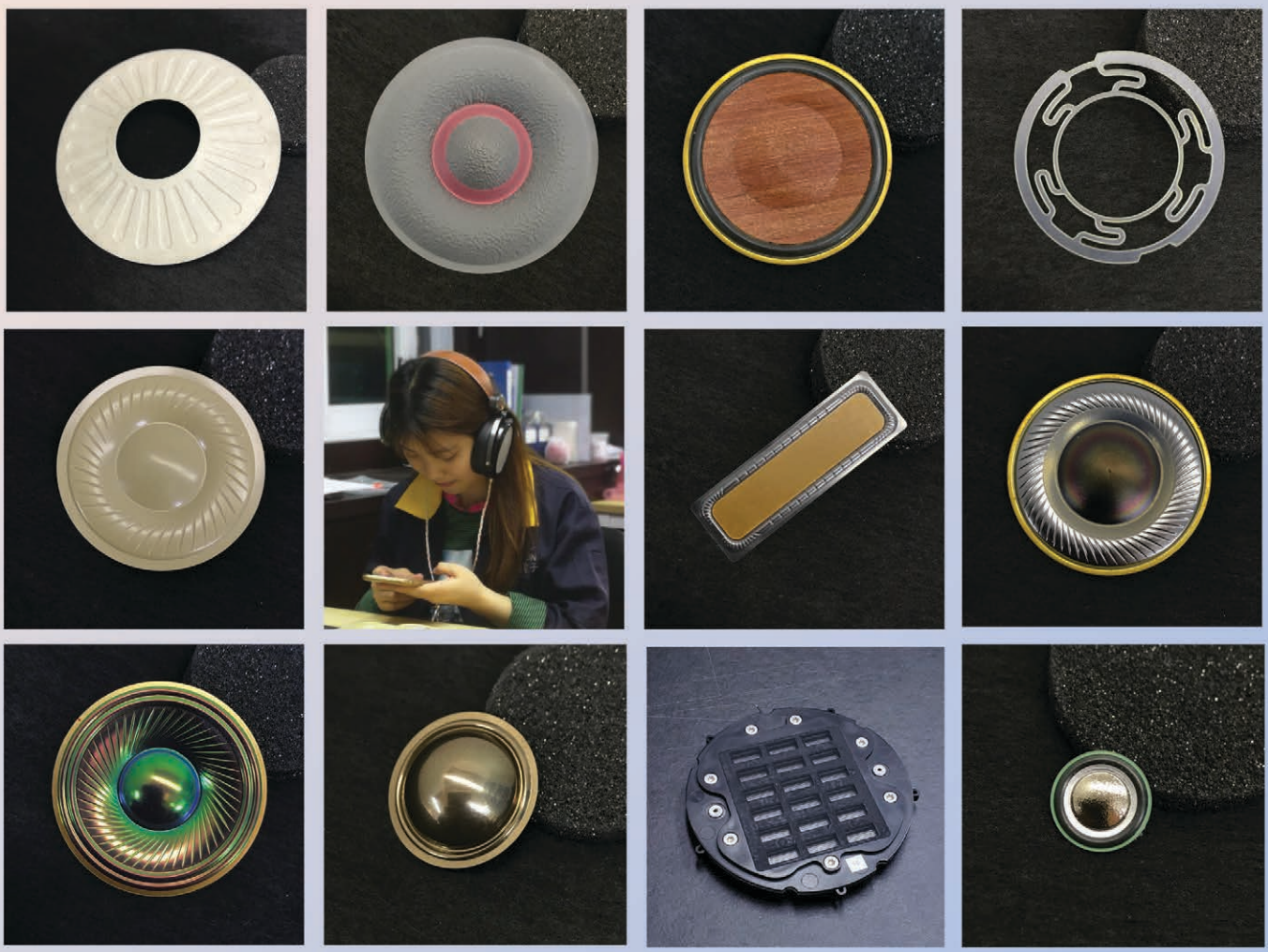

Application

Consumer Products	Electronic Components	Industrial / Medical
• Mobile Speaker / Receivers • Digital Camera • Personal media player • Headphones	• Television / projectors • Game console • Cookers / Fridge • Small stereo	• Aircraft component • Walkie-talkie • Alarm • Helmet voice system • Medical device

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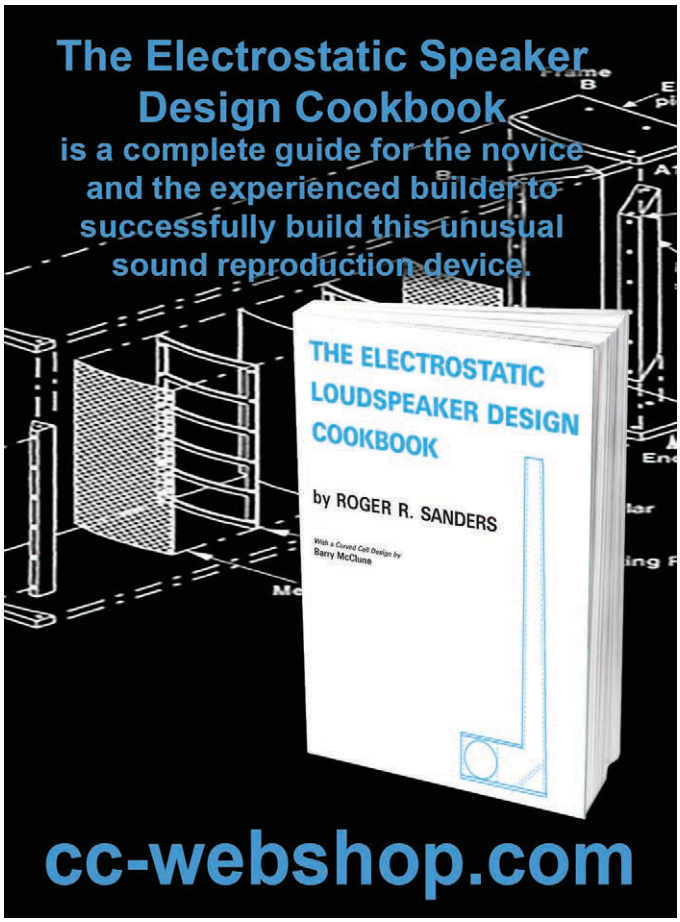
UNITED STATES			
Adafruit Industries	•	•	•
BeStar Technologies, Inc.	•	•	•
Broad Bridge Audio, LLC	•	•	•
Dayton Audio	•	•	•
Dragonfire Acoustics	•	•	•
GGEC America, Inc.	•	•	•
iT Parts Depot	•	•	•
Parts Express	•	•	•
Peerless by Tymphany HK, Ltd.		•	•
Seltech	•	•	•
Sound Sources Technology, Inc.	•		
Stetron International, Inc.		•	•
The Digital PCH	•	•	•
Trade Moon	•	•	•



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- **low** power consumption

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U SOUND

OEM SPEAKER ASSEMBLY

	Acoustic Materials	Finished Goods
AUSTRALIA		
Stone Sound Studio	•	•
AUSTRIA		
USound GmbH	•	•
BELGIUM		
Donnet: Loudspeaker Repair	•	•
BRAZIL		
Newbox Industry & Commerce	•	•
CANADA		
Canadian Speaker Works	•	•
DLC Loudspeaker R&D Group	•	•
Excelitas Technologies Corp.		•
LMH Loudspeakers		•
Planet10-HiFi		•
Reference 3A		•
Solen Electronique, Inc.	•	•
Studio Reference Monitors		•
Sziara Sound	•	•
The Canadian Loudspeaker Corp.	•	•
CHINA		
Audiostar Electronics Co., Ltd.	•	
B.W. Audio Guangzhou Co., Ltd.		•
EASTECH Holding, Ltd.	•	•
Enkor Electronics Co., Ltd.		•
Fountek Electronics Co., Ltd.		•
Lumi Audio		•
M-Sound Electronics Co., Ltd.		•

	Acoustic Materials	Finished Goods
OBE Pro Audio Co., Ltd.	•	•
Pana Sound, Ltd.		•
Shenzhen Tekzone Loudspeaker Co., Ltd.		•
Sonos, Inc.		•
Sound Technology Development, Ltd. (Factory)	•	•
Speakerhu Electronic Co., Ltd.		•
Sun Technique Electric Co., Ltd.	•	•
Trueanalog Strictly OEM	•	•
Vormag Electronics Co., Ltd.	•	
Zhuhai HiVi Technology Co., Ltd.		•
FRANCE		
Applications Acoustiques de Composites (AAC)		•
Audax		•
KYU Systems	•	
GERMANY		
Soundsgood Pro Audio Solutions		•
HONG KONG		
Eastern Asia Technology (HK), Ltd.	•	•
Ocean Star Electronics, Ltd.		•
WCE Acoustics	•	•
INDIA		
GM Audio Technics, Ltd.	•	•
Power Electronics & Technologies		•
INDONESIA		
SB Acoustics	•	•

	Acoustic Materials	Finished Goods
ISRAEL		
Chorus Audio		•
Coby Speakers	•	•
Morel, Ltd.		•
R H Sound Technology, Ltd.	•	
MALAYSIA		
TC Electronics, Sdn., Bhd.		•
MEXICO		
Aletheia, AV		•
NORWAY		
SEAS Fabrikker, AS		•
ROMANIA		
SC Poweraudio, SRL		•
RUSSIA		
Star Sound Technologies		•
SOUTH AFRICA		
Paks Acoustics	•	•
SWEDEN		
Audio Pro, AB	•	•
TAIWAN		
Huey Tung International Co., Ltd.	•	•
Kingstate Electronics Corp.		•
Taiwan Solidex Corp.		•
TB Speaker Co., Ltd.	•	•
Yung International, Inc.	•	•
THAILAND		
Clarasonic (Thailand) Co., Ltd.	•	•
UKRAINE		
Mag Audio		•
UNITED KINGDOM		
EuroTec International, Plc.	•	•
Fane International, Ltd.		•
Ferguson Hill Studios, Ltd.		•
MJ Acoustics		•
Precision Devices, Ltd.		•
Revolver Audio, Ltd.		•
Tectonic Elements, Ltd.		•
Volt Loudspeakers, Ltd.		•
UNITED STATES		
A Brown		•
A. Schulman, Inc.	•	
Adrian Acoustics, Inc.	•	•
AMS Audio Enterprises, Inc.		•
Area 52 R&D		•

	Acoustic Materials	Finished Goods
Arion Audio		•
Arnold Magnetic Technologies/ Precision Thin Metals	•	
Audio Connection		•
Audioengine		•
Audio-Optix	•	•
Barefoot Sound, LLC		•
Bob Young and Associates	•	•
Broad Bridge Audio, LLC	•	•
Campanella Associates & Acculab		•
Digmoda		•
Dynavox Electronics, Inc.		•
Earthquake Sound Corp.		•
Eminence Speaker, LLC		•
Fulcrum Acoustic, LLC		•
Geometric Designs, LLC & Geometric Consulting		•
GGEC America, Inc.	•	•
Hearing Components, Inc. (Comply Memory Foam Tips)	•	
J&F Wood Products	•	
JL Audio, Inc.		•
Lowell Manufacturing Co.		•
Materion	•	
MISCO		•
Monaero Engineering, Inc.		•
MSC Software Corp.	•	
North American Solidex LLC		•
ORCA Design And Manufacturing	•	
Parts Express	•	•
Pierce Audio Products	•	•
PQN Audio/PQN Enterprises, Inc.		•
PranaFidelity		•
RCF USA, Inc.	•	•
SoCal Sound Shop		•
Sound Sources Technology, Inc.		•
SpeakersAndAmps.com		•
SSI Manufacturing, Inc.		•
Stetron International, Inc.		•
Stillwater Designs | KICKER		•
Studio Electric - David MacPherson		•
SVS, Inc.		•
Tone Tubby, Inc.		•
TSG Audio		•
United Gasket Corp.	•	
US Enclosure Co.	•	•
US Speaker, LLC		•
Westlake Audio, Inc.		•

	Air Motion Transformer (AMT)	Compression Drivers: Tweeters	Compression Drivers: Midrange	Compression Drivers: Woofers	Electrostatic	Full Range	Horns: Woofers	Horns: Midrange
AUSTRALIA								
Soundlabs Group, Pty., Ltd.						•	•	•
Stone Sound Studio							•	
BELGIUM								
Donnet: Loudspeaker Repair		•	•	•	•	•	•	•
Premium Sound Solutions							•	
BRAZIL								
Newbox Industry & Commerce		•	•	•		•	•	•
BULGARIA								
Oberton						•	•	
CANADA								
Canadian Speaker Works								•
DLC Loudspeaker R&D Group						•	•	•
Kravchenko-Audio							•	•
ORA Graphene Audio, Inc.						•	•	
Planet10-HiFi							•	
Solen Electronique, Inc.						•	•	•
Space-Tech Lab, Ltd.					•		•	•
Studio Reference Monitors						•	•	•
The Canadian Loudspeaker Corp.						•	•	•
CHINA								
Audiostar Electronics Co., Ltd.								•
B.W. Audio Guangzhou Co., Ltd.						•		
Bozhen Acoustic Co., Ltd.						•		
EASTECH Holding, Ltd.		•	•	•	•	•	•	•
Enkor Electronics Co., Ltd.					•			
Fountek Electronics Co., Ltd.							•	•
LaVoce Co., Ltd.						•	•	•
M-Sound Electronics Co., Ltd.						•	•	•
OBE Pro Audio Co., Ltd.						•	•	
Pana Sound, Ltd.		•				•	•	•
Sound Technology Development, Ltd. (Factory)						•	•	•
Speakerhu Electronic Co., Ltd.						•		
Sun Technique Electric Co., Ltd.					•	•	•	•
Wavecor, Ltd.							•	
Zhuhai HiVi Technology Co., Ltd.							•	

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From 2" up to 5.25", using our patented Dual-Suspensions design; breaking the rules on traditional suspension transducers, to deliver high excursions and extremely low distortion. With this innovation on transducers design, now you can design small, compact systems without compromising performance.

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	Air Motion Transformer (AMT)	Electrostatic: Tweeters	Electrostatic: Midrange	Electrostatic: Woofers	Compression Drivers	Full Range	Horns	
DENMARK								
Puriti Transducer Technology ApS							•	
FRANCE								
Audax						•	•	•
KYU Systems						•	•	•
PHL Audio							•	
Supravox							•	•
Waterfall Audio					•			
GERMANY								
BMS Speakers GmbH						•	•	•
ic audio GmbH						•	•	•
Lautsprecher-Produktions-Gesellschaft (LPG) mbH							•	
Physical-Lab							•	
Voice Point		•	•	•	•	•	•	•
Wolf von Langa		•				•	•	
HONG KONG								
Eastern Asia Technology (HK), Ltd.					•		•	
Ocean Star Electronics, Ltd.							•	
WCE Acoustics					•		•	•
HUNGARY								
Bayz Audio							•	
INDIA								
GM Audio Technics, Ltd.						•	•	•

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THE EFFICIENT DEPLOYMENT OF POWER

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Combining state-of-the-art design, materials and components honed to optimum efficiency through our generations of high-end speaker design and manufacture, the result is powerful and accurate bass, musicality through the range, with low power compression and distortion.

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IMPERIUM
SERIES

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FANE

	Air Motion Transformer (AMT)	Compression Drivers: Electrostatic	Compression Drivers: Tweeters	Compression Drivers: Midrange	Compression Drivers: Woofers	Full Range	Horns
INDONESIA							
SB Acoustics					•	•	
ISRAEL							
Coby Speakers			•			•	•
Morel, Ltd.						•	
ITALY							
Axiomedia, SRL					•	•	•
AXP					•	•	
B&C Speakers, SpA					•	•	•
CIARE					•	•	•
Eighteen Sound, SRL					•		•
Faital, SpA					•	•	•
Professional Audio, Snc.					•	•	•
RCF, SpA					•	•	•
MALAYSIA							
TC Electronics, Sdn., Bhd.			•				
NETHERLANDS							
Audio Components, BV						•	
ELTIM audio, BV				•		•	•
Good Hifi VOF				•			
NORWAY							
SEAS Fabrikker, AS						•	

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From its conception every aspect has been carefully optimised for a cutting edge price-performance ratio and to expand the possibilities of competitive system designs; No compromise acoustic performance, robust design, high power handling and a very linear frequency trend to 20kHz come as standard.

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Tel: +86-756-6268133 Fax: +86-756-6268068 Website: www.hivi.us E-mail: oem_odm@hivi.com

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Featuring dual ring radiator diaphragms, the **DCX464** operates from the vocal range to the limits of human hearing, with the highest power handing and efficiency of any driver we have ever offered. A patent pending midrange integrator allows the two diaphragms to work in harmony over a wide bandwidth, for greater combined output and crossover design flexibility. Explore higher output, with greater directivity, from an increasingly compact and light weight enclosure with the **DCX464**.

B&C SPEAKERS®

www.bcspeakers.com

made in Italy

	Air Motion Transformer (AMT)	Electrostatic: Tweeters	Electrostatic: Midrange	Electrostatic: Woofers	Compression Drivers	Full Range	Horns	
RUSSIA								
Star Sound Technologies							•	
SPAIN								
Acustica Beyma S.L.						•	•	•
SWEDEN								
Audio Pro, AB					•	•	•	
Oxeon AB/Textreme						•	•	
TAIWAN								
Hi-Tech System Co., Ltd.		•	•	•	•		•	
Huey Tung International Co., Ltd.					•	•	•	•
TB Speaker Co., Ltd.							•	
THAILAND								
Clarasonic (Thailand) Co., Ltd.							•	
UKRAINE								
Mag Audio						•	•	•
UNITED KINGDOM								
Arya Audio Labs, Ltd.		•	•	•		•	•	
Bishopsound						•	•	
Celestion						•	•	•
Compbass, Ltd.						•		
EuroTec International, Plc.					•	•	•	•
Fane International, Ltd.						•	•	•
MJ Acoustics					•			
Precision Devices, Ltd.						•	•	

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	Air Motion Transformer (AMT)	Electrostatic: Tweeters	Electrostatic: Midrange	Electrostatic: Woofers	Compression Drivers	Full Range	Horns	
Sine Audio Systems							•	•
Tectonic Elements, Ltd.							•	
Volt Loudspeakers, Ltd.							•	
UNITED STATES								
Acoustic Design, Inc.						•		•
American Bass USA					•	•	•	•
American Music And Sound					•			
AMS Audio Enterprises, Inc.						•	•	•
Analysis Audio USA		•	•					
Arion Audio		•	•	•				
Beyma Pro Audio		•	•		•	•	•	•
Broad Bridge Audio, LLC		•	•				•	
CGN Audio Labs							•	
Christensen Audio, LLC		•	•			•		
CommonSense Audio							•	
Dayton Audio						•	•	•
DC Gold Audio							•	
Dragonfire Acoustics			•	•	•		•	
Dynavox Electronics, Inc.						•	•	•
Earthquake Sound Corp.						•	•	•
Eminence Speaker, LLC					•	•	•	•
ESS Laboratories, LLC					•			
GGEC America, Inc.						•	•	•
Global Audio Source, Inc.						•	•	
Knowles Electronics, LLC							•	
Loudspeakers Plus						•	•	•

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"Serving the loudspeaker industry"

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- Custom transducer design
- Cross-over design
- Systems design / voicing
- Vendor selection / Prototypes
- Lab and Klippel measurements

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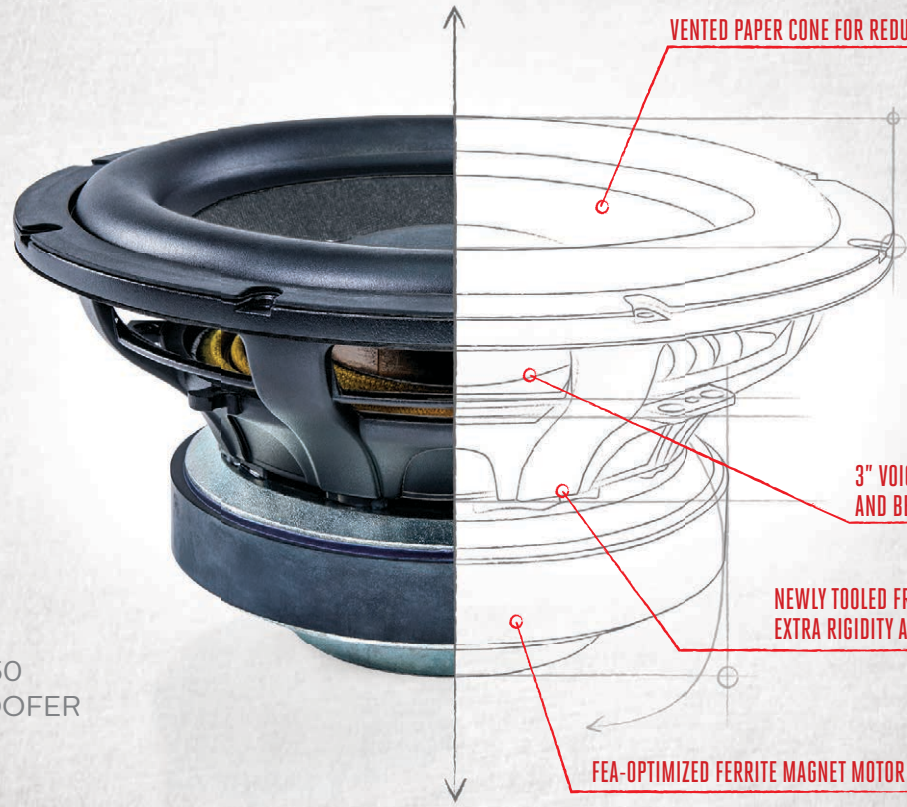

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DA

High-Performance Corundum-Dome Tweeters

PMT

Bigger Sound from a Small Footprint

NCP

More Power Handling for Professional Systems

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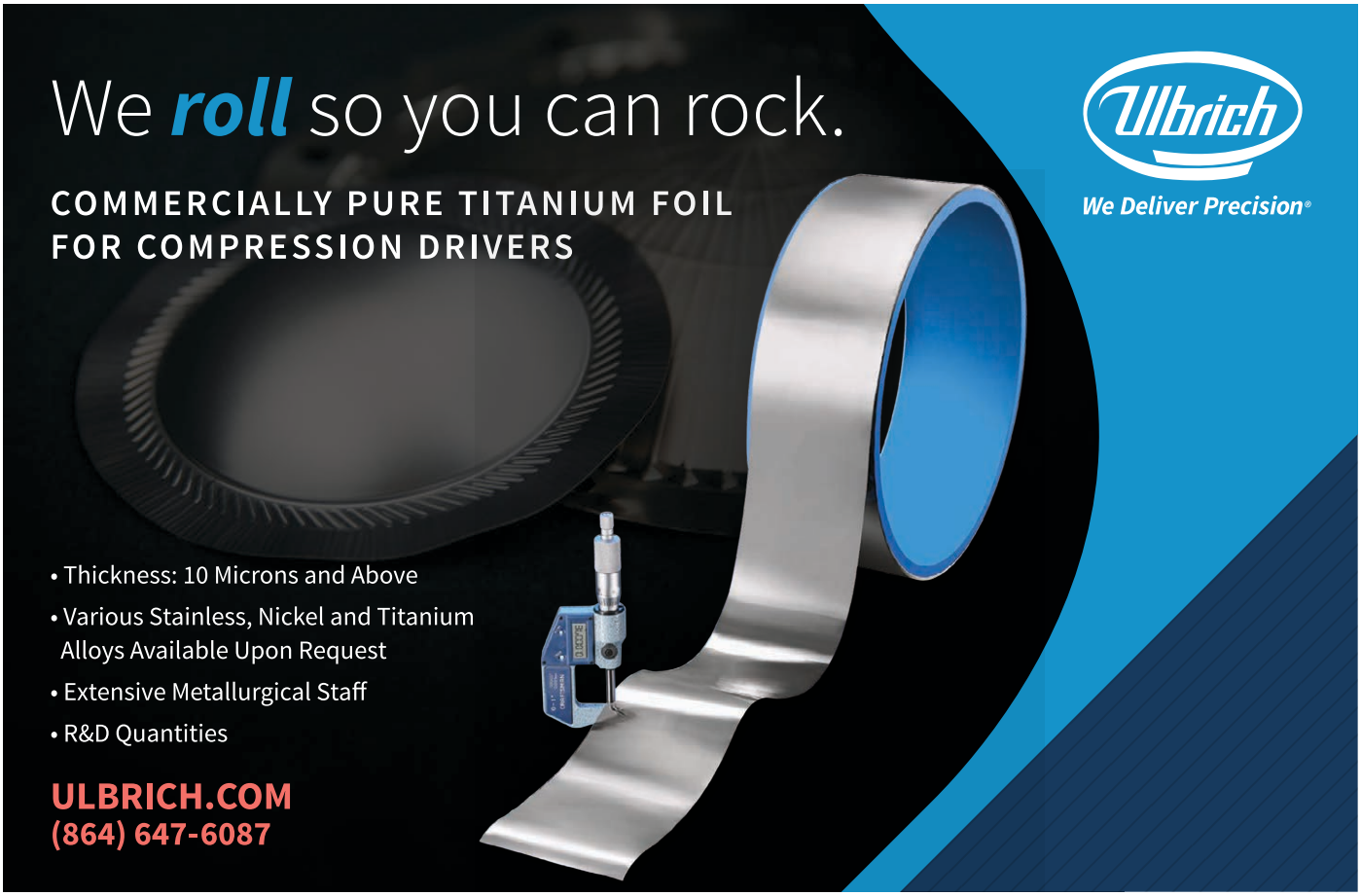
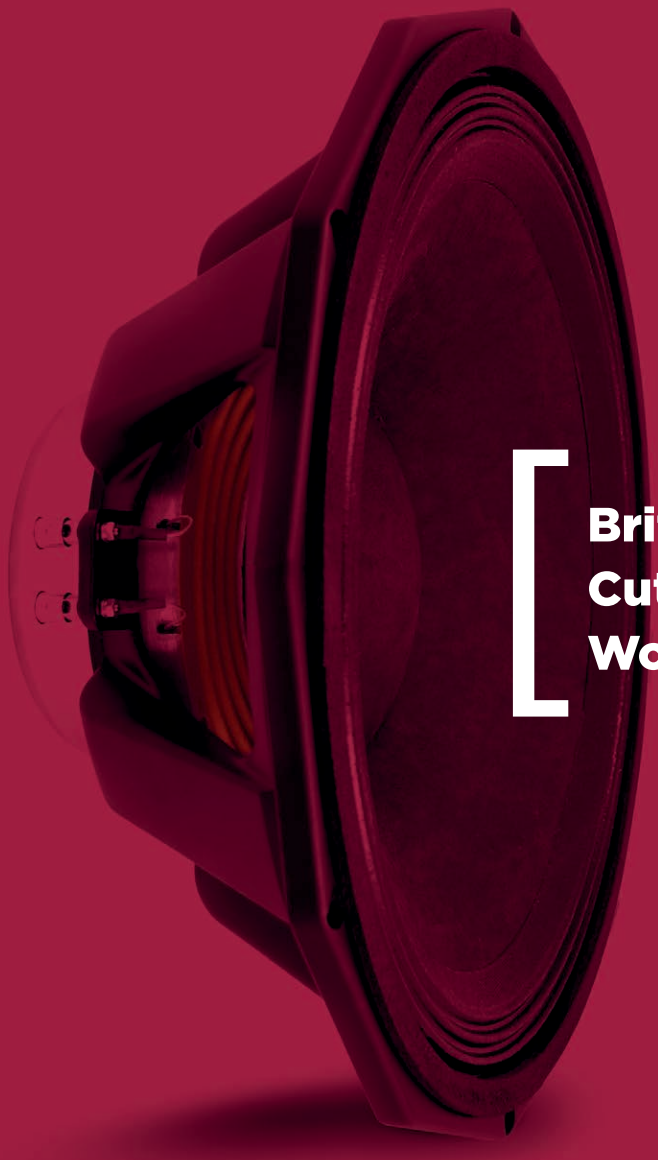
	Air Motion Transformer (AMT)	Electrostatic: Tweeters	Electrostatic: Midrange	Electrostatic: Woofers	Compression Drivers	Full Range	Horns	
Lowther Speakers USA							•	
Materion						•		
MISCO						•	•	
NedLab							•	
North American Solidex LLC						•	•	•
Parts Express		•	•		•	•	•	•
Peerless by Tymphany HK, Ltd.						•	•	
PQN Audio/PQN Enterprises, Inc.							•	
RBH Sound		•						
Recycled Sound			•					
Sanming Sound						•		•
Seltech							•	
Simply Speakers						•		
SoCal Sound Shop						•	•	
SpeakerAddict					•	•	•	•
SpeakersAndAmps.com						•	•	•
Stetron International, Inc.							•	
Stillwater Designs | KICKER						•	•	
SVS, Inc.							•	
Tone Tubby, Inc.							•	
Tonian Laboratories							•	
TSG Audio					•	•	•	•
Ulbrich Stainless Steels & Special Metals, Inc.						•		
US Speaker, LLC						•		•
Vidsonix Design Works							•	
Western Electric		•	•	•				
Yandas Music						•		





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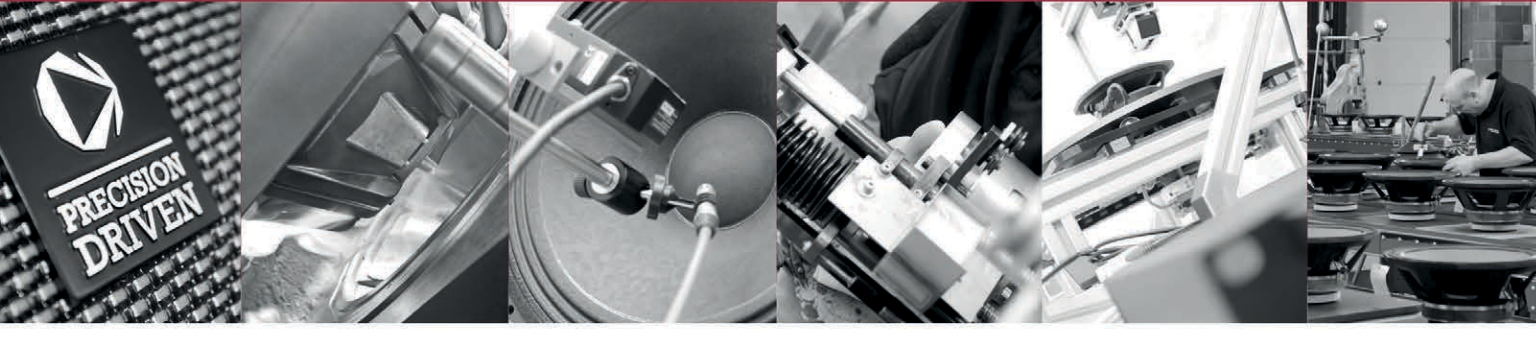

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	Midrange						Paging Horns		Siren/Voice Warning		Tweeters				Woofers	
	Cone	Dome	Electrostatic	Planar	Ribbon	Piezo	Planar	Cone		Cone	Dome	Electrostatic	Ribbon			
AUSTRALIA																
Soundlabs Group, Pty., Ltd.	•	•				•					•	•		•	•	
Stone Sound Studio	•	•			•	•					•	•		•	•	
BELGIUM																
Donnet: Loudspeaker Repair	•	•	•	•	•	•	•	•	•		•	•	•	•	•	
Premium Sound Solutions	•	•						•			•	•		•	•	
BRAZIL																
Newbox Industry & Commerce	•	•	•		•	•		•			•	•	•	•	•	
BULGARIA																
Oberton	•							•							•	
CANADA																
Canadian Speaker Works															•	
DLC Loudspeaker R&D Group	•	•	•	•	•		•	•			•	•	•	•	•	
Harbottle Audio															•	
Kravchenko-Audio				•				•				•			•	
Newform Research, Inc.					•									•		
ORA Graphene Audio, Inc.	•	•		•				•			•	•			•	
Planet10-HiFi															•	
Reference 3A												•			•	
Solen Electronique, Inc.	•	•						•			•	•		•	•	
Space-Tech Lab, Ltd.	•	•									•	•		•	•	
Studio Reference Monitors	•											•			•	
The Canadian Loudspeaker Corp.	•											•			•	
CHINA																
Audiostar Electronics Co., Ltd.															•	
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Bozhen Acoustic Co., Ltd.														•	•	
EASTECH Holding, Ltd.	•	•	•	•	•	•	•	•	•		•	•	•	•	•	
Enkor Electronics Co., Ltd.	•	•									•	•			•	
Fountek Electronics Co., Ltd.														•	•	
LaVoce Co., Ltd.	•	•									•	•			•	
M-Sound Electronics Co., Ltd.		•			•						•	•		•		
OBE Pro Audio Co., Ltd.															•	
Pana Sound, Ltd.	•	•									•	•		•	•	
Shenzhen Tekzone Loudspeaker Co., Ltd.	•	•										•		•	•	

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Squeaky Clean Bass.

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The LDLC (low distortion low compression) engineering model has been created to favor the source material component of audio, specifically distortion and compression free audio.

Ridge drivers are purpose built to minimize distortion characteristics found within driver operation and harmonic distortion found in the upper end of the frequency range. This makes it excessively easy to blend bass systems with loudspeakers and create an audio experience unlike any other.

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Fort St John, BC
Canada

	Midrange					Paging Horns		Siren/Voice Warning		Tweeters				Woofers
	Cone	Dome	Electrostatic	Planar	Ribbon	Piezo	Planar			Cone	Dome	Electrostatic	Ribbon	
Sonos, Inc.	•	•								•	•			•
Sound Technology Development, Ltd. (Factory)	•	•				•	•			•	•			•
Speakerhu Electronic Co., Ltd.	•	•								•	•			•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Wavecor, Ltd.	•	•								•	•			•
Zhuhai HiVi Technology Co., Ltd.		•								•	•		•	•
DENMARK														
Higuphon											•			
Puriti Transducer Technology ApS	•										•			•
Scan-Speak, AS	•	•								•	•	•		
FRANCE														
Audax	•	•								•	•			•
KYU Systems	•			•				•						•
PHL Audio	•										•			•
Supravox	•									•	•			•
Waterfall Audio														•
GERMANY														
BMS Speakers GmbH	•			•				•	•					•
ic audio GmbH						•								
Lautsprecher-Produktions-Gesellschaft (LPG) mbH	•										•			•
Physical-Lab											•			
Voice Point	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Wolf von Langa	•													•

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	Midrange					Paging Horns		Siren/Voice Warning		Tweeters				Woofers
	Cone	Dome	Electrostatic	Planar	Ribbon	Piezo	Planar	Cone	Dome	Electrostatic	Ribbon			
HONG KONG														
Eastern Asia Technology (HK), Ltd.	•	•								•	•			•
Ocean Star Electronics, Ltd.	•	•								•	•			•
WCE Acoustics	•	•	•	•	•	•	•	•	•	•	•			•
HUNGARY														
Bayz Audio								•						
INDIA														
GM Audio Technics, Ltd.	•	•								•				•
INDONESIA														
Premiere Wood Manufacturing (PWM)								•						
SB Acoustics	•	•					•			•	•		•	•
ISRAEL														
Coby Speakers	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Morel, Ltd.	•	•									•			•
ITALY														
Axiomedia, SRL	•	•									•		•	•
AXP	•	•								•	•			•
B&C Speakers, SpA	•										•		•	•
CIARE														•
Eighteen Sound, SRL														•
Faital, SpA	•	•								•	•			•
Powersoft SpA														•
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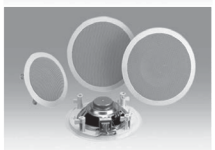

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	Midrange					Paging Horns		Siren/Voice Warning		Tweeters				Woofers
	Cone	Dome	Electrostatic	Planar	Ribbon	Piezo	Planar	Cone		Dome	Electrostatic	Ribbon		
RCF, SpA														•
MALAYSIA														
TC Electronics, Sdn., Bhd.	•	•								•	•			•
NETHERLANDS														
Audio Components, BV		•									•			•
ELTIM audio, BV	•	•									•			•
Good Hifi VOF	•									•	•			•
NORWAY														
SEAS Fabrikker, AS	•	•									•			•
RUSSIA														
Star Sound Technologies	•	•								•	•			•
SPAIN														
Acustica Beyma S.L.	•										•		•	•
SWEDEN														
Audio Pro, AB	•	•		•	•		•	•		•	•		•	•
Oxeon AB/Textreme	•	•									•			•
TAIWAN														
BESTON Technology Corp.				•	•			•					•	
Hi-Tech System Co., Ltd.	•	•								•	•			•
Huey Tung International Co., Ltd.	•	•	•				•		•	•	•	•		•
Kingstate Electronics Corp.							•		•					

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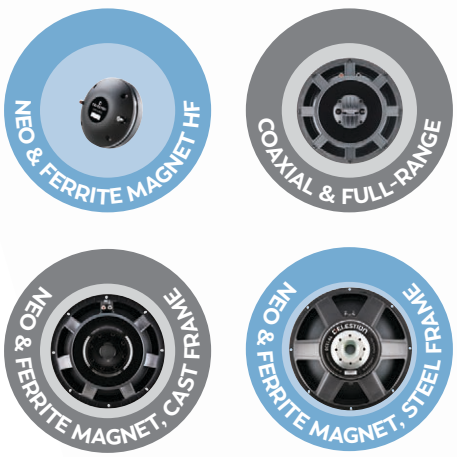

	Midrange					Paging Horns		Siren/Voice Warning	Tweeters				Woofers	
	Cone	Dome	Electrostatic	Planar	Ribbon	Piezo	Planar	Cone	Dome	Electrostatic	Ribbon		
Taiwan Solidex Corp.							•					•	•
TB Speaker Co., Ltd.	•	•			•				•	•		•	•
Yie Feng Technology Enterprise Co.	•												
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Clarasonic (Thailand) Co., Ltd.	•	•							•	•			•
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Bishopsound													•
Celestion	•							•					•
Compbass, Ltd.													•
EuroTec International, Plc.	•	•	•					•	•	•	•	•	•
Fane International, Ltd.	•								•	•			•
MJ Acoustics													•
Precision Devices, Ltd.	•									•			•
Sine Audio Systems	•	•							•	•		•	•
Volt Loudspeakers, Ltd.	•	•											•
UNITED STATES													
Acoustic Design Inc.		•											
Aempyrean								•					
American Bass USA	•	•	•	•	•	•		•	•	•	•	•	•
American Music And Sound													•

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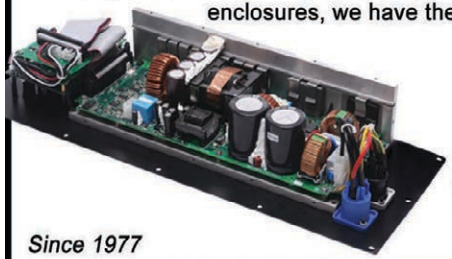

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	Midrange					Tweeters									Woofers
	Cone	Dome	Electrostatic	Planar	Ribbon	Paging Horns	Piezo	Planar	Siren/Voice Warning	Cone	Dome	Electrostatic	Ribbon		
AMS Audio Enterprises, Inc.	•	•									•	•			•
Analysis Audio USA					•				•					•	
Area 52 R&D	•											•			•
Arnold Magnetic Technologies/Precision Thin Metals		•										•			
BeStar Technologies, Inc.								•							
Beyma Pro Audio	•	•	•	•	•	•	•				•	•	•	•	•
Broad Bridge Audio, LLC				•	•			•			•	•		•	•
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CGN Audio Labs														•	•
Dayton Audio	•	•		•	•	•		•			•	•		•	•
DC Gold	•														
Dragonfire Acoustics			•	•	•			•					•	•	•
Dynavox Electronics, Inc.	•	•			•	•	•	•	•		•	•		•	•
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Electro Mavin	•	•										•			•
Eminence Speaker, LLC	•	•	•	•	•	•	•	•	•		•	•	•	•	•
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Full Compass Systems, Ltd.	•	•	•								•	•	•	•	•
GGEC America, Inc.	•	•					•		•		•	•	•	•	•
Global Audio Source, Inc.											•	•			•
HDSound								•						•	•
JL Audio, Inc.	•														•
Loudspeakers Plus	•														•
Meniscus Audio Group, Inc.															•
MISCO	•						•		•		•	•			•

	Midrange					Paging Horns		Siren/Voice Warning		Tweeters				Woofers
	Cone	Dome	Electrostatic	Planar	Ribbon	Piezo	Planar		Cone	Dome	Electrostatic	Ribbon		
NedLab	•	•								•	•			•
North American Solidex LLC	•	•		•				•		•			•	•
ORCA Design And Manufacturing	•				•						•		•	•
Parts Express	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Peerless by Tymphany HK, Ltd.	•	•								•	•			•
Pierce Audio Products														•
RBH Sound	•										•			•
Sanming Sound						•			•					
Simply Speakers	•	•					•			•	•			•
SoCal Sound Shop														•
SpeakerAddict	•	•	•	•	•	•	•	•	•	•	•	•	•	•
SpeakersAndAmps.com	•	•		•	•	•		•		•	•		•	•
Stetron International, Inc.		•									•			•
Stillwater Designs | KICKER	•										•			•
Studio Electric - David MacPherson														•
SVS, Inc.	•										•			•
Tonian Laboratories													•	•
Transducer Lab, LLC											•			
TSG Audio	•	•	•	•	•	•	•	•	•	•	•	•	•	•
US Speaker, LLC							•							•
Vidsonix Design Works	•										•			•
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AUSTRALIA																
Soundlabs Group, Pty., Ltd.	•		•	•	•	•			•	•	•			•	•	
Stone Sound Studio	•	•	•			•		•	•					•	•	
BRAZIL																
Advanced Audio Technologies (AAT)														•		
Newbox Industry & Commerce	•		•	•	•	•	•	•	•	•	•	•		•	•	•
CANADA																
Canadian Speaker Works	•	•	•			•	•	•	•	•					•	
DLC Loudspeaker R&D Group	•		•	•		•	•		•		•			•	•	•
Reference 3A				•												
Solen Electronique, Inc.	•		•	•	•	•		•	•	•	•				•	•
Space-Tech Lab, Ltd.														•	•	
The Canadian Loudspeaker Corp.	•	•	•	•						•		•			•	
CHINA																
Sound Technology Development, Ltd. (Factory)			•		•	•	•	•	•					•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•
DENMARK																
Jantzen Audio Denmark			•	•		•	•		•							
FRANCE																
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The ultimate inductor for the bass section

- Made with a unique toroidal sandwiched core design, for extremely low resistance
- Can shift large amounts of power without becoming overheated
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- Available in 16, 14, 12 and 8 AWG foil

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- Made with smooth foil for better sonic properties.
- Extremely low capacitance tolerance of only 5%

Cross Cap:

Cost efficient standard type MKP capacitor

- The best performance/quality to price ratio on the market
- High quality capacitor with foil made in the EU
- Available in a wide range of values

Alumen Z-Cap:

The flagship of Jantzen Audio capacitors

- Pure aluminum foil capacitor, with extremely low ESR and fast response
- Specifically designed for tweeters and mid-range drivers
- Offers an increased, yet highly balanced, tonal transparency and detail richness

Superior Z-Cap:

The original Jantzen Audio Super MKP capacitor

- The sound of the Superior Z-Cap will never get over-edged
- You will feel the superb naturalness with a slightly bright top-end
- An affordable Super MKP capacitor with a lot more performance than the price suggests

JA-8008 HQM:

Designed by Troels Gravesen (Denmark)

- State of the art paper cone mid-woofer
- Manufactured exclusively for Jantzen Audio by SEAS in Norway
- The “HMQ” is the mark II version of this driver and features several design improvements

ViaWave GRT-145 Ribbon Tweeter:

A revolutionary new ribbon tweeter design

- Features SRT (Sealed Ribbon Tweeter) technology
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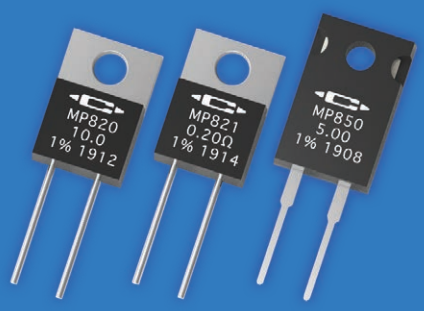

Heat Sink Mountable *with Non-Inductive Design*

Power rating is based on a +25°C case temperature. The thermal mounting issues are the same as with power semiconductors.

Resistor Style	Model No.	Power Rating at +25°C Case Temp.	Resistance Range	Comments
TO-220 Style Package	MP820	20 Watts	10 Ω to 10K	Metal Mounting Tab
	MP821	20 Watts	0.02 Ω to 9.99 Ω	Metal Mounting Tab
	MP850	50 Watts	0.2 Ω to 10K	Copper Heat Sink Integral in the Molded Package

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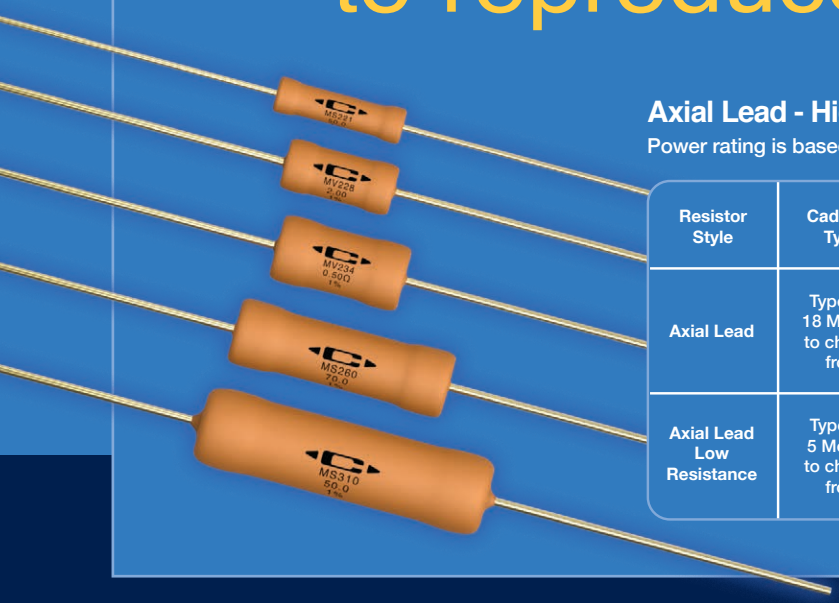

Axial Lead - High Power *with Non-Inductive Design*

Power rating is based on +25°C ambient, derated at higher ambient temperature.

Resistor Style	Caddock Type	Power Rating	Resistance Range	Comments
Axial Lead	Type MS 18 Models to choose from	0.5 Watt up to 22 Watts	20 Ω up to 30 Meg	These non-inductive resistors are about as inductive as a straight piece of wire the length of the resistor body. Standard tolerance 1%
Axial Lead Low Resistance	Type MV 5 Models to choose from	1.5 Watts up to 10 Watts	0.10 Ω up to 50 Ω	Low Resistance with EXTREMELY low inductance. Standard tolerance 1% (5% and 10% available)

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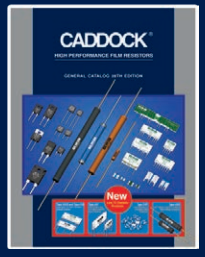

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GERMANY															
ic audio GmbH												•			
Jobst-Audio										•				•	
Voice Point								•	•	•	•	•		•	•
HONG KONG															
WCE Acoustics															•
INDIA															
GM Audio Technics, Ltd.													•	•	
INDONESIA															
Premiere Wood Manufacturing (PWM)			•		•		•							•	
ISRAEL															
R H Sound Technology, Ltd.	•	•	•	•	•	•	•	•	•	•	•	•		•	•
ITALY															
Axiomedia, SRL	•		•	•		•	•	•	•	•	•			•	
JAPAN															
Furutech Co., Ltd.										•					•
MEXICO															
Aletheia, AV														•	•
NETHERLANDS															
Audio Components, BV	•		•			•	•	•	•	•	•			•	
ELTIM audio, BV	•		•	•		•	•		•	•	•	•	•	•	•
POLAND															
Resnatura Audio				•								•			•
ROMANIA															
SC Poweraudio, SRL													•	•	
SWEDEN															
Audio Pro, AB	•				•	•			•			•	•		
TAIWAN															
Bentronic Components	•		•	•		•	•		•		•			•	•
Huey Tung International Co., Ltd.									•			•			
Kingstate Electronics Corp.		•													
UNITED KINGDOM															
EuroTec International, Plc.					•								•	•	•
Sine Audio Systems													•		
Volt Loudspeakers, Ltd.						•	•								
UNITED STATES															
AMS Audio Enterprises, Inc.	•		•	•	•	•		•	•		•	•		•	•
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Caddock Electronics									•						
Carvin Audio													•		

	Passive Components												Finished Passive Crossover Nets	Electronic Crossover	Wire & Wiring Harnesses
	Attenuators	Capacitors		Driver Protection Devices	Inductors		Plugs & Jack Dishes	Resistors	Solder	Terminal Plates	Transformers				
		Ceramic	Electrolytic Non-Polar	Film	Air Core	Iron Core									
Danville Signal Processing, Inc.													•		
Dayton Audio				•	•			•	•				•	•	
DMSI													•		
Dragonfire Acoustics					•								•		
Dynavox Electronics, Inc.				•	•		•	•	•		•	•			
Electro Mavin														•	
Eminence Speaker, LLC					•									•	
ESS Laboratories, LLC												•			
Full Compass Systems, Ltd.	•					•	•				•	•	•		•
Geometric Designs, LLC & Geometric Consulting													•	•	
Global Audio Source, Inc.															•
Globe Audio Design, Inc.													•		
GR Research				•		•			•						
Hearing Components, Inc. (Comply Memory Foam Tips)	•														
Lamart Corp.										•		•			•
Lowell Manufacturing Co.												•			
Madisound Speaker Components, Inc.				•	•		•	•		•				•	
Marchand Electronics, Inc.	•												•	•	
Meniscus Audio Group, Inc.				•	•		•	•		•	•	•		•	•
NedLab														•	
North American Solidex LLC														•	
ORCA Design And Manufacturing					•										
Parts Express	•	•		•	•		•	•		•	•	•	•		•
Quest Engines, LLC								•							
Recycled Sound	•														
Redco Audio								•		•					•
Schurter, Inc.								•				•			•
Simply Speakers	•													•	
SpeakersAndAmps.com					•								•		
Spectrum Audio													•		
Studio Electric - David MacPherson														•	
UpTone Audio, LLC				•											
Vidsonix Design Works	•				•						•				•
Vintage King Audio													•		
Whitmor Wirenetics															•
Yandas Music													•		

Solen Fast Capacitors™ & Solen Perfect Layer Inductors, often imitated, sometimes copied - even counterfeited - yet never equaled.

SOLEN

SOLEN CAPACITORS

Metallized Polypropylene Flim Fast Capacitors™
-First to use the "Fast Capacitors"™
-First to use bi-axially oriented metabolized polypropylene film
-Lowest dissipation factor, lowest dielectric absorption
-Widest range of values, from 0.01uf to 330uf
-Widest range of voltages, from 250Vdc to 630Vdc
Metallized Teflon™ Film - 0.22uf to 10uf, 1300Vdc
Silver Metallized Polypropylene Film - 0.10uf to 56uf, 700Vdc
Teflon™ Film & Foil - 0.033uf to 0.82uf, 1000Vdc
Polypropylene Film & Tin Foil - 0.01uf to 8.2uf, 100Vdc to 1200Vdc
Metallized Polypropylene Can Type - 22uf, 33uf, 51uf & 100uf, 630Vdc
Metallized Polyester Film - 1.0uf to 47uf, 160Vdc
Non-Polar Electrolytic .5% DF - 10uf to 330uf, 100Vdc
Polarized Electrolytic - .33uf to 33000uf, 63Vdc to 450Vdc

SOLEN INDUCTORS

Perfect Layer Hexagonal Winding Air Core
-First to use Perfect Layer Hexagonal winding technique
-First to use Hepta-Litz seven strand insulated wire
-First to use H49-Litz forty-nine strand insulated wire
-Zero distortion air core, lowest dc resistance
-Widest range of values 0.05mH to 85mH
-Wide range of wire diameters, from 0.8mm (20awg) to 3.1mm (8awg)

SOLEN RESISTORS

Wire wound 10w 5% - 0.5 ohm to 82 ohm
Metal Oxide Link 10w 5% non inductive - 1 ohm to 47 ohm
AchrOhmiC 16w 2% MIL Spec non inductive - 0.5 ohm to 82 ohm

SOLEN TUBES

-Electro Harmonix -Genalex Gold Lion
-Mullard -Sovtek -Tesla JJ -Tung-Sol

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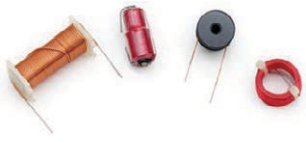
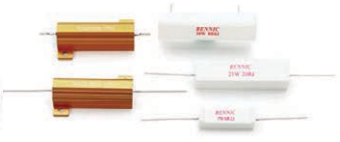
Inductors



Resistors



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	Adhesives & Glues					Cone Additives & Other Treatments					Cone & Suspension Components										
											Cones		Domes				Spiders	Surrounds			
	Acrylic Adhesives	Epoxy	Infra-Red Cure	Instant Adhesives	Water & Vinyl Based	Damping	Fire Resistance	Lacquers	Waterproofing	Wet Lock	Composite	Paper Pulp	Plastic	Metal	Aluminum/Titanium/Metal	Fabric/Mylar/Resin/Soft	Phenolic & Other Domes		Fabric	Foam	Rubber
AUSTRALIA																					
Soundlabs Group, Pty., Ltd.							•		•												
BELGIUM																					
Donnet: Loudspeaker Repair							•		•	•	•	•	•	•	•	•	•	•	•	•	•
CANADA																					
Canadian Speaker Works	•	•				•	•	•		•		•	•					•	•	•	•
DLC Loudspeaker R&D Group												•	•	•	•	•	•	•	•	•	•
ORA Graphene Audio, Inc.												•	•	•	•	•	•	•			
Reference 3A	•	•		•								•						•			•
Solen Electronique, Inc.							•				•										
The Canadian Loudspeaker Corp.							•					•	•	•		•	•	•	•	•	•
CHINA																					
Audiostar Electronics Co., Ltd.				•																	
Dong Guan Yen Lung Electronics Co., Ltd.												•	•					•			
Lumi Audio												•	•	•	•	•	•	•	•	•	•
Sound Technology Development, Ltd. (Factory)	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Tianyi Electronic Co., Ltd.												•	•	•	•	•	•	•	•	•	•
TopOne Loudspeaker Cone Co., Ltd.													•								
Vormag Electronics Co., Ltd.		•																			
DENMARK																					
Jantzen Audio Denmark							•														
FRANCE																					
Applications Acoustiques de Composites (AAC)							•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
KYU Systems	•	•	•	•	•		•					•	•	•	•	•	•		•	•	•

	Adhesives & Glues					Cone Additives & Other Treatments					Cone & Suspension Components										
											Cones			Domes			Spiders	Surrounds		
	Acrylic Adhesives	Epoxy	Infra-Red Cure	Instant Adhesives	Water & Vinyl Based	Damping	Fire Resistance	Lacquers	Waterproofing	Wet Lock	Composite	Paper Pulp	Plastic	Aluminum/Titanium/Metal	Fabric/Mylar/Resin/Soft	Phenolic & Other Domes		Fabric	Foam	Rubber
GERMANY																				
Dr. Kurt Mueller											•	•	•	•	•	•	•	•	•	•
Henkel, AG & Co., KGaA	•	•	•	•	•															
Hubert Stueken GmbH & Co., KG														•	•					
Propex Fabrics GmbH & Co., KG											•		•						•	
Voice Point	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
HONG KONG																				
WCE Acoustics											•	•	•	•	•	•	•	•	•	•
INDIA																				
Wizard India Private, Ltd.											•	•	•			•	•	•	•	•
INDONESIA																				
SB Acoustics												•			•	•		•		•
ISRAEL																				
R H Sound Technology, Ltd.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
ITALY																				
OEB, SRL											•	•						•	•	•
Professional Audio, Snc.											•		•	•	•		•	•	•	•

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	Adhesives & Glues					Cone Additives & Other Treatments				Cone & Suspension Components										
										Cones			Domes			Spiders	Surrounds			
	Acrylic Adhesives	Epoxy	Infra-Red Cure	Instant Adhesives	Water & Vinyl Based	Damping	Fire Resistance	Lacquers	Waterproofing	Wet Look	Composite	Paper Pulp	Plastic	Metal	Aluminum/Titanium/Metal	Fabric/Mylar/Resin/Soft	Phenolic & Other Domes		Fabric	Foam	Rubber
NETHERLANDS																					
Good Hifi VOF		•				•									•	•	•		•	•	•
NORWAY																					
Soundcare AS							•							•							
SOUTH KOREA																					
Suntel Co., Ltd.											•	•	•	•	•	•	•	•	•	•	•
SWEDEN																					
Audio Pro, AB						•					•	•	•	•	•	•	•	•	•	•	•
Oxeon AB/Textreme											•										
SWITZERLAND																					
Kisling, AG	•	•		•																	
TAIWAN																					
Hi-Tech System Co., Ltd.											•		•		•	•					•
Huey Tung International Co., Ltd.											•	•	•	•	•	•	•	•	•	•	•
Shiuh Sheng Electronics Factory											•	•	•	•							
Sonic Electronic Co.											•	•	•			•	•				
Yie Feng Technology Enterprise Co.											•		•					•	•		•

Domes | Cones | Headphones

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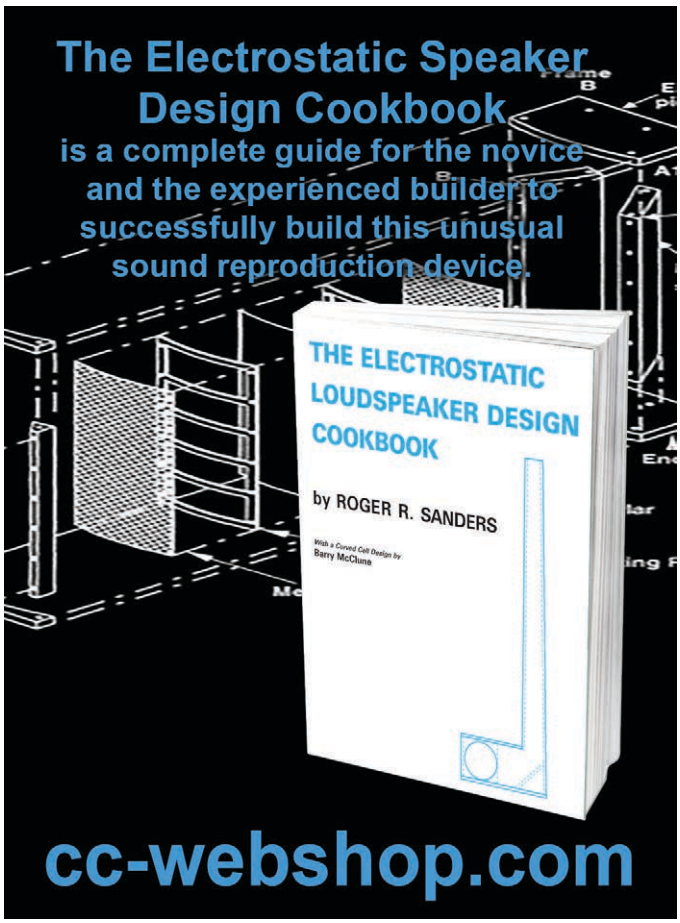

	Adhesives & Glues						Cone Additives & Other Treatments					Cone & Suspension Components												
												Cones			Domes			Spiders	Surrounds		
	Acrylic Adhesives	Epoxy	Infra-Red Cure	Instant Adhesives	Water & Vinyl Based	Damping	Fire Resistance	Lacquers	Waterproofing	Wet Lock	Composite	Paper Pulp	Plastic	Aluminum/Titanium/Metal	Fabric/Mylar/Resin/Soft	Phenolic & Other Domes		Fabric	Foam	Rubber
THAILAND																				
Clarasonic (Thailand) Co., Ltd.							•				•					•				
FSK (Thailand) Co., Ltd.											•		•		•					
Sanit Audio Engineering Co.	•	•									•					•		•	•	•
UNITED KINGDOM																				
EuroTec International, Plc.	•						•	•	•	•	•	•	•		•	•	•	•	•	•
Volt Loudspeakers, Ltd.													•							
UNITED STATES																				
AcousTex Fabrics																		•		
Arnold Magnetic Technologies/ Precision Thin Metals																•				
DELO Industrial Adhesives, LLC	•	•	•	•																
Dragonfire Acoustics							•		•	•										
Dymax Corp.	•	•	•	•	•															
Dynavox Electronics, Inc.											•	•	•	•	•	•	•	•	•	•
Ellsworth Adhesives	•	•	•	•	•															
Engineered Fibers Technology							•	•		•										
Fulcrum Acoustic, LLC										•										
Full Compass Systems, Ltd.						•														
Global Audio Source, Inc.											•	•	•	•						

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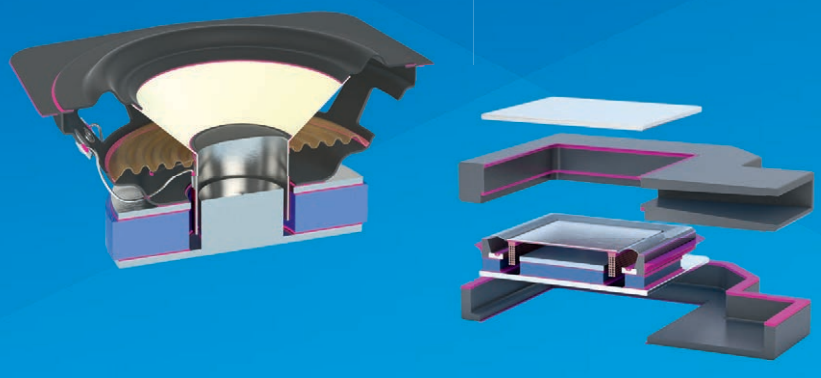

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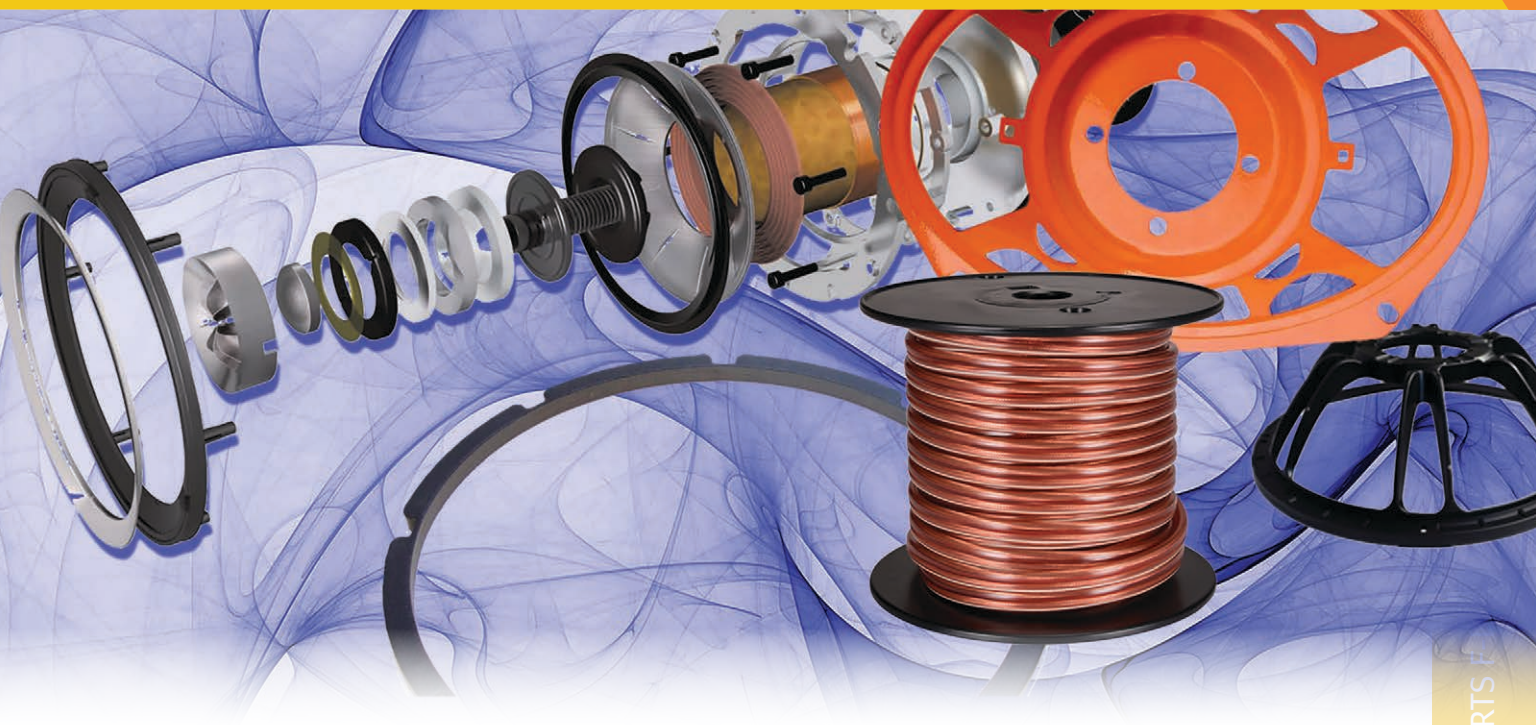
	Adhesives & Glues					Cone Additives & Other Treatments					Cone & Suspension Components										
											Cones			Domes			Spiders	Surrounds		
	Acrylic Adhesives	Epoxy	Infra-Red Cure	Instant Adhesives	Water & Vinyl Based	Damping	Fire Resistance	Lacquers	Waterproofing	Wet Look	Composite	Paper Pulp	Plastic	Aluminum/Titanium/Metal	Metal	Fabric/Mylar/Resin/Soft	Phenolic & Other Domes		Fabric	Foam	Rubber
Hernon Manufacturing, Inc.	•	•	•	•	•																
J&F Wood Products						•															
Krayden, Inc.	•	•		•	•																
Lamart Corp.	•			•	•											•	•				
Loudspeaker Components											•	•	•	•	•	•	•	•	•	•	•
Master Bond, Inc.	•	•	•	•	•																
Materion															•	•					
MISCO							•														
NedLab											•		•	•	•	•	•		•	•	•
Parts Express		•		•																	
Permabond Engineering Adhesives	•	•		•																	
Pierce Audio Products		•									•	•		•				•	•	•	•
Quick Draw & Machining, Inc.															•	•					
RTP Co.		•		•			•		•												
Sherwood Industries, Inc.																				•	•
Simply Speakers	•	•		•	•				•	•		•	•					•	•	•	•
United Gasket Corp.						•													•	•	•
US Enclosure Co.						•					•							•			
Vidsonix Design Works									•												



	Frames & Baskets						Lead Out Wire					
	Stamped Steel						Flat Strip			Termination/Crimps		Lead Out Wire
	Frame Gaskets						Range of Diameters					
	Cast Alloy		Damped Metal				Braided			Litz	Stranded	
		Bumped		Double Bumped				Beryllium Copper	Phosphor Bronze			
BELGIUM												
Donnet: Loudspeaker Repair							•	•	•	•	•	•
BRAZIL												
Newbox Industry & Commerce	•	•	•	•	•	•	•	•	•	•	•	•
CANADA												
Canadian Speaker Works	•									•		•
DLC Loudspeaker R&D Group							•			•	•	
Reference 3A	•						•					•
CHINA												
Lumi Audio	•	•	•	•	•	•						
Sound Technology Development, Ltd. (Factory)	•		•	•			•	•	•	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•	•	•	•	•	•	•
Zhuhai HiVi Technology Co., Ltd.	•											
DENMARK												
estron, a/s										•	•	•
FRANCE												
KYU Systems	•	•						•				
GERMANY												
Hubert Stueken GmbH & Co., KG	•	•	•	•	•	•						
Voice Point							•	•	•	•	•	•

	Frames & Baskets						Lead Out Wire					
	Frame Gaskets		Stamped Steel				Flat Strip			Braided		Lead Out Wire Termination/Crimps
	Cast Alloy		Bumped	Damped Metal	Double Bumped	Range of Diameters	Beryllium Copper	Phosphor Bronze		Litz	Stranded	
HONG KONG												
Eastern Asia Technology (HK), Ltd.	•	•	•	•	•	•						
WCE Acoustics										•		
INDIA												
Vidyut Teletronics, Ltd.							•				•	
Wizard India Private, Ltd.	•	•										
INDONESIA												
SB Acoustics			•	•	•	•				•		
ISRAEL												
Chorus Audio	•							•	•	•		
Coby Speakers	•	•	•	•	•	•	•	•	•	•	•	•
R H Sound Technology, Ltd.							•	•		•	•	•
ITALY												
Axiomedia, SRL							•	•	•		•	
Faital, SpA	•	•									•	•
Professional Audio, Snc.	•	•	•	•	•	•	•	•	•	•	•	•
JAPAN												
Furutech Co., Ltd.											•	
SWEDEN												
Audio Pro, AB	•	•	•	•	•	•	•	•		•		•
TAIWAN												
Hi-Tech Sound System Co., Ltd.		•	•	•								
Huey Tung International Co., Ltd.	•	•	•	•	•	•	•	•			•	
Maeden Innovation Co., Ltd.							•			•	•	•
Yie Feng Technology Enterprise Co.		•										
UNITED KINGDOM												
EuroTec International, Plc.	•	•	•	•	•	•	•	•	•			•
Precision Devices, Ltd.	•	•					•					
UNITED STATES												
A. Schulman, Inc.	•											
American Bass USA	•	•	•	•	•	•	•	•	•	•	•	•
AMS Audio Enterprises, Inc.	•	•				•						•
Dynavox Electronics, Inc.	•	•	•	•	•	•	•			•	•	
Global Audio Source, Inc.	•	•	•	•	•	•						
Herman Pro, AV							•	•	•	•	•	•
Materion								•				
NedLab	•	•										

	Frames & Baskets						Lead Out Wire					
	Frame Gaskets		Stamped Steel				Flat Strip			Termination/Crimps		Lead Out Wire
	Cast Alloy		Bumped	Damped Metal	Double Bumped	Range of Diameters	Braided	Beryllium Copper	Phosphor Bronze	Litz	Stranded	
New England Wire Technologies							•	•	•	•	•	•
North Reading Engineering	•	•	•	•	•	•	•	•	•	•	•	•
Pierce Audio Products	•	•	•		•	•						
Quick Draw & Machining, Inc.	•			•	•	•						
RDS Wire & Cable							•	•	•	•	•	•
Redco Audio											•	
Simply Speakers							•					
Standard Wire & Cable Co.							•	•	•	•	•	•
United Gasket Corp.		•										
Western Electric							•				•	
Whitmor Wirenetics							•	•	•	•	•	•

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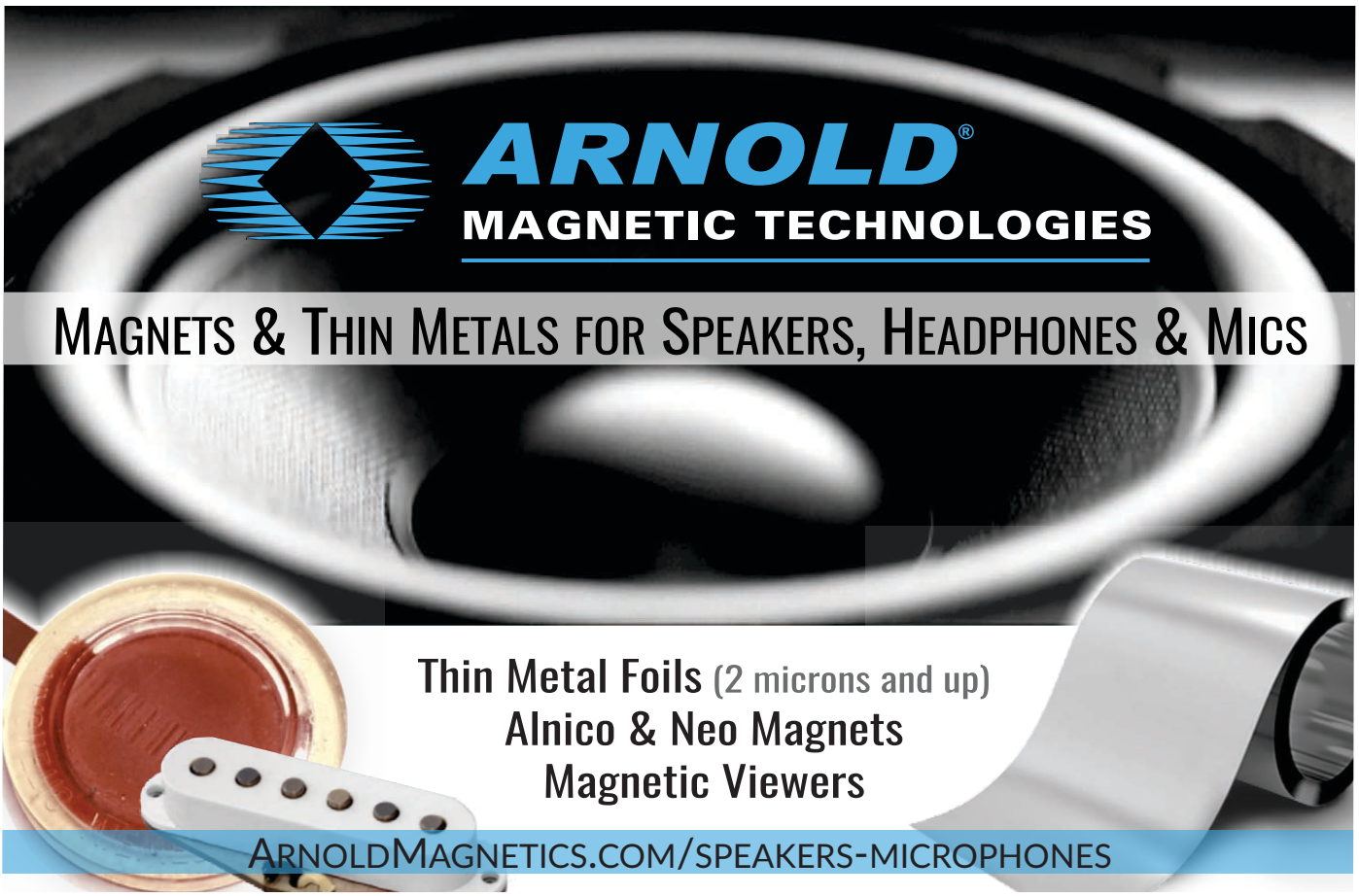
	Magnetic Assemblies							Voice Coil Components								
	Back Plates	Magnets		Magnetic Fluids	Pole Pieces	T-Yokes Top Plates	Bobbins/Formers	Collars	Magnet Wire	Polyimide Tape for Collars	Voice Coil Assemblies			Amplifiers		
		Alnico	Ferrite	Neodymium							Flat Wire	Round Wire	Voice Coil Stacks	Powered Speakers	Amplifier for Subwoofer Plate Amplifier	
AUSTRALIA																
Soundlabs Group, Pty., Ltd.															•	
Stone Sound Studio																•
BRAZIL																
Newbox Industry & Commerce	•	•	•	•	•	•	•			•		•	•	•	•	•
CANADA																
Canadian Speaker Works	•		•	•	•	•	•					•	•	•	•	
DLC Loudspeaker R&D Group	•				•	•	•	•	•	•	•	•	•	•	•	
Reference 3A													•			
Solen Electronique, Inc.			•							•					•	
Studio Reference Monitors															•	
Tortech Sound, Inc.															•	
CHINA																
Audiostar Electronics Co., Ltd.								•	•	•	•	•	•	•		
Changzhou Xiantong Magnetic Materials Co., Ltd.		•	•	•												
Lumi Audio															•	•
OBE Pro Audio Co., Ltd.															•	•
One Magnet Electronic Co., Ltd.		•	•	•												
Sound Technology Development, Ltd. (Factory)	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Sun Technique Electric Co., Ltd.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

	Magnetic Assemblies							Voice Coil Components								
	Back Plates	Magnets		Magnetic Fluids	Pole Pieces	T-Yokes Top Plates	Bobbins/Formers	Collars	Magnet Wire	Polyimide Tape for Collars	Voice Coil Assemblies			Amplifiers		
		Alnico	Ferrite	Neodymium							Flat Wire	Round Wire	Voice Coil Stacks	Powered Speakers	Amplifier for	Subwoofer Plate Amplifier
Tianyi Electronic Co., Ltd.		•		•	•	•		•								
Trueanalog Strictly OEM	•						•	•								
Vormag Electronics Co., Ltd.		•		•	•					•						
Zeng Ben Industrial Corp., Ltd.							•	•								
Zenith Audio Electronics Co., Ltd.										•		•	•	•		
FRANCE																
KYU Systems	•				•	•	•	•		•		•			•	•
GERMANY																
Voice Point	•	•		•	•	•	•									
HONG KONG																
Eastern Asia Technology (HK), Ltd.												•	•	•	•	•
WCE Acoustics	•	•		•			•	•	•	•	•	•	•	•		•
INDIA																
Lakshmi Metal Coils													•			
Power Electronics & Technologies															•	•
Vidyut Teletronics, Ltd.										•	•	•	•			
Wizard India Private, Ltd.				•			•									

	Magnetic Assemblies							Voice Coil Components								
	Back Plates	Magnets		Magnetic Fluids		Pole Pieces	T-Yokes Top Plates	Bobbins/Formers	Collars	Magnet Wire	Polyimide Tape for Collars	Voice Coil Assemblies			Amplifiers	
		Alnico	Ferrite	Neodymium								Flat Wire	Round Wire	Voice Coil Stacks	Powered Speakers	Subwoofer Plate Amplifier
INDONESIA																
SB Acoustics	•			•	•		•	•	•				•	•	•	
ISRAEL																
Chorus Audio	•	•		•	•		•	•								
Coby Speakers	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•
R H Sound Technology, Ltd.								•	•	•	•	•	•	•	•	•
ITALY																
Axiomedia, SRL				•											•	•
Faital, SpA	•			•	•			•	•				•			
OEB, SRL													•	•		
Powersoft SpA															•	
Professional Audio, Snc.	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•
NETHERLANDS																
ELTIM audio, BV															•	
Hypex Electronics, BV															•	•
POLAND																
Resnatura Audio										•			•	•	•	



	Magnetic Assemblies							Voice Coil Components								
	Back Plates	Magnets		Magnetic Fluids		Pole Pieces	T-Yokes Top Plates	Bobbins/Formers	Polyimide Tape for Collars	Magnet Wire	Voice Coil Assemblies			Amplifiers		
		Alnico	Ferrite	Neodymium				Collars			Flat Wire	Round Wire	Voice Coil Stacks	Powered Speakers	Amplifier for Subwoofer Plate Amplifier	
Sveda Audio															•	
SOUTH AFRICA																
Paks Acoustics	•	•		•	•		•	•								
SOUTH KOREA																
Suntel Co., Ltd.								•	•	•	•	•	•	•	•	•
TAIWAN																
Hi-Tech Sound System Co., Ltd.															•	•
Huey Tung International Co., Ltd.	•	•		•	•	•	•	•		•		•	•	•	•	•
Kingstate Electronics Corp.															•	
Shining Jins Enterprise Co., Ltd.	•					•	•									
THAILAND																
FSK (Thailand) Co., Ltd.								•			•					
UNITED KINGDOM																
Bishopsound															•	•
EuroTec International, Plc.	•	•		•	•	•	•	•	•	•	•	•	•	•		•
Precision Devices, Ltd.	•			•	•	•	•	•		•		•	•			

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	Magnetic Assemblies							Voice Coil Components								
	Back Plates	Magnets		Magnetic Fluids		Pole Pieces T-Yokes Top Plates	Bobbins/Formers	Magnet Wire Collars	Polyimide Tape for Collars	Voice Coil Assemblies			Amplifiers		
		Alnico	Ferrite	Neodymium							Flat Wire	Round Wire	Voice Coil Stacks	Powered Speakers Amplifier for	Subwoofer Plate Amplifier
Volt Loudspeakers, Ltd.													•		
UNITED STATES															
Acoustic Design, Inc.	•					•	•					•	•	•	
American Bass USA	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
AMS Audio Enterprises, Inc.	•	•	•		•	•	•						•		•	•
Area 52 R&D	•		•	•		•	•								•	•
Arnold Magnetic Technologies/ Precision Thin Metals		•	•	•												
CommonSense Audio															•	
Dayton Audio															•	•
DMSI															•	
Dragonfire Acoustics												•	•	•	•	•
Dynavox Electronics, Inc.	•	•	•		•	•	•	•	•	•			•		•	•
Etal Group, AB/Anaview															•	
Ferrotec (USA) Corp.					•											
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	Magnetic Assemblies							Voice Coil Components							
	Back Plates	Magnets		Magnetic Fluids		Pole Pieces	T-Yokes Top Plates	Bobbins/Formers	Polyimide Tape for Collars	Magnet Wire	Voice Coil Assemblies			Amplifiers	
		Alnico	Ferrite	Neodymium				Collars			Flat Wire	Round Wire	Voice Coil Stacks	Powered Speakers Amplifier for	Subwoofer Plate Amplifier
Marchand Electronics, Inc.														•	•
Materion								•							
MISCO														•	
NedLab								•							
Pierce Audio Products	•			•	•		•	•				•	•		
Precision Econowind, LLC								•	•	•	•	•	•	•	
PRV Audio Brazil				•	•									•	
Radio Design Labs (RDL)														•	•
RBH Sound															•
RCF USA, Inc.														•	
Simply Speakers						•									
Sound Sources Technology, Inc.														•	•
SpeakersAndAmps.com														•	•
Transducer Lab, LLC	•			•	•	•	•	•							
US Enclosure Co.														•	•
Vidsonix Design Works				•	•										
Whitmor Wirenetics										•					

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	Accelerometers	Anechoic Chambers	Audio Analyzers	Gaussmeters	LCR Bridges	MLS	Multimeters	Oscilloscopes	Resistance Bridges	Signal Generators	Sine/Square Wave Oscillators	Speaker Parts	Speaker Turntables	Spectrum Analyzers	1/3 Octave	FFT	Heterodyne	TDS	Stroboscopes	Test Mics	Testing Cabinets	Turns Counters
AUSTRALIA																						
DEQX Pty., Ltd.				•																		
Soundlabs Group, Pty., Ltd.									•		•											
Stone Sound Studio	•			•		•		•	•			•	•	•			•			•	•	
BELGIUM																						
Donnet: Loudspeaker Repair		•		•		•		•	•		•	•		•		•	•		•	•	•	•
CANADA																						
Canadian Speaker Works	•			•		•		•		•	•	•				•	•				•	
DLC Loudspeaker R&D Group	•			•		•		•	•		•	•				•	•		•		•	
Solen Electronique, Inc.				•												•	•				•	
Space-Tech Lab, Ltd.				•					•		•	•		•			•					
Sziara Sound																					•	
CHINA																						
BSWA Technology Co., Ltd.	•															•	•					
CRY Sound Co., Ltd.		•		•					•		•	•				•	•		•		•	
Shenzhen Tekzone Loudspeaker Co., Ltd.		•		•		•		•	•		•	•					•				•	•
Sound Technology Development, Ltd. (Factory)		•		•					•		•	•		•		•	•		•		•	
Sun Technique Electric Co., Ltd.	•	•		•		•		•	•		•	•		•		•	•		•	•	•	•

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- Bluetooth measurements w Delay compensation
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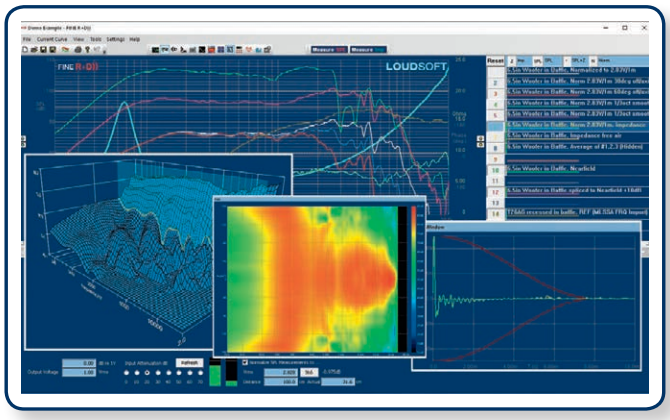

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- Bluetooth measure w Delay compensation
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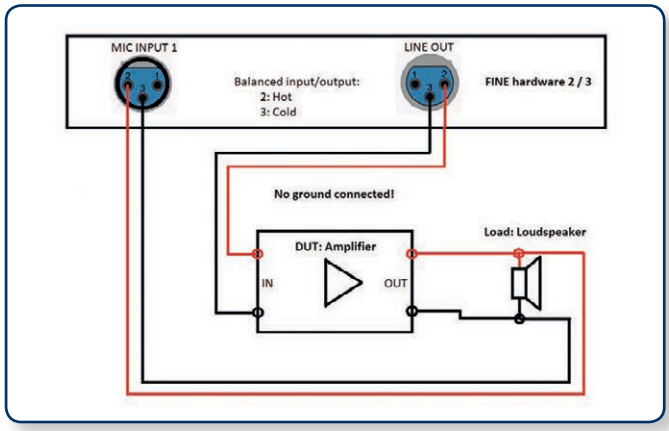

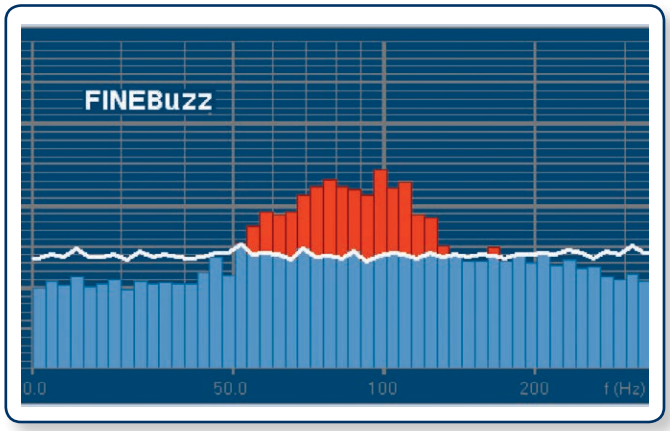

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DENMARK																						
K & K Development				•								•	•									
LOUDSOFT, Ltd.				•			•					•				•	•				•	•
PointSource Acoustics ApS			•	•				•	•			•	•	•		•	•			•	•	
FRANCE																						
KYU Systems				•		•	•							•			•				•	•
GERMANY																						
Klippel GmbH				•	•		•					•		•	•	•	•	•			•	
Physical-Lab	•	•		•																	•	
Rohde & Schwarz				•				•	•							•	•	•	•			•
ISRAEL																						
Coby Speakers	•	•	•	•	•	•	•	•	•	•	•	•	•	•						•	•	•
R H Sound Technology, Ltd.						•		•	•	•	•		•									
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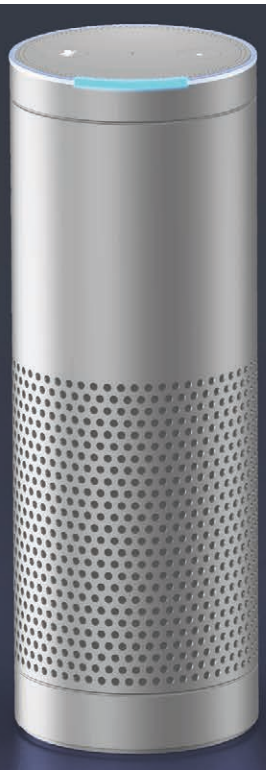

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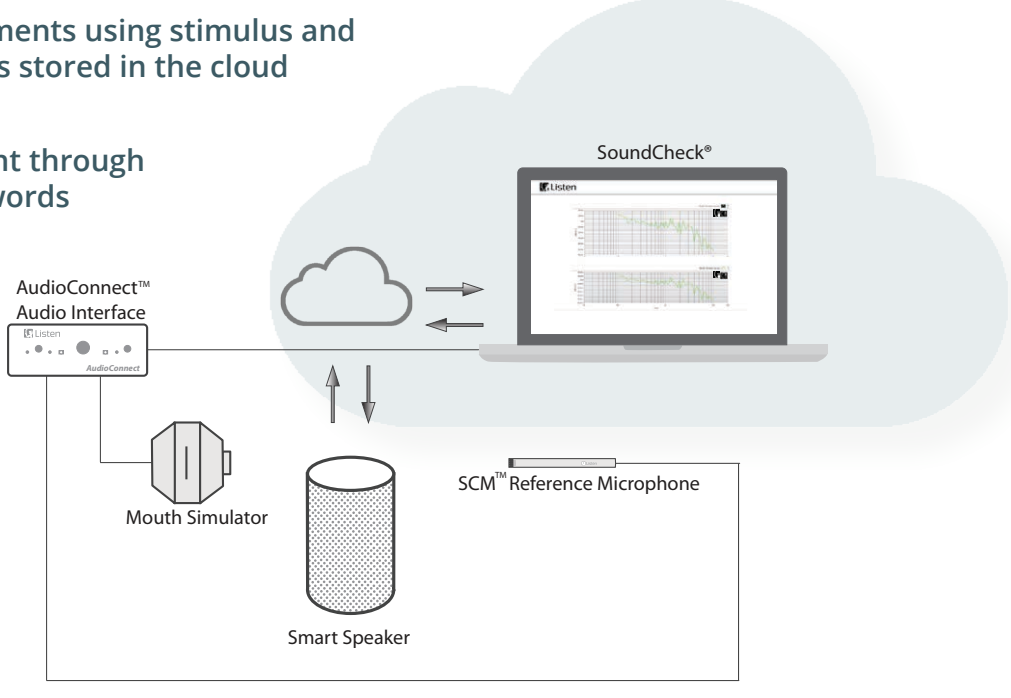

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Axiomedia, SRL						•																
SpeakerLAB				•																		
JAPAN																						
Etani Electronics Co., Ltd.		•	•				•	•			•			•	•	•					•	•
LATVIA																						
Sonarworks SIA																					•	
NETHERLANDS																						
Audio Components, BV				•											•	•						
SINGAPORE																						
Virtins Technology	•			•		•	•	•	•		•	•		•	•	•	•	•			•	
SWEDEN																						
Audio Pro, AB	•			•		•									•	•		•				
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UNITED KINGDOM																						
EuroTec International, Plc.			•	•			•	•	•		•	•	•			•	•				•	•
Hill Acoustics			•																			•
UNITED STATES																						
ACO Pacific, Inc.												•									•	
Adafruit Industries	•								•	•												
Allied Electronics, Inc.				•					•	•		•										
Audio Advisor, Inc.															•							
Audio Precision, Inc.				•								•									•	
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Bruel & Kjaer Sound & Vibration North America, Inc.	•		•	•								•			•	•	•	•			•	•
Danville Signal Processing, Inc.	•			•								•				•	•				•	
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Fotronic Corp.	•			•		•			•	•		•				•	•	•	•	•		

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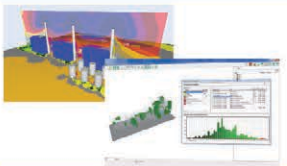

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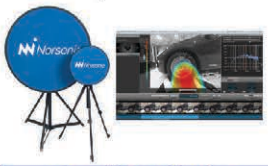

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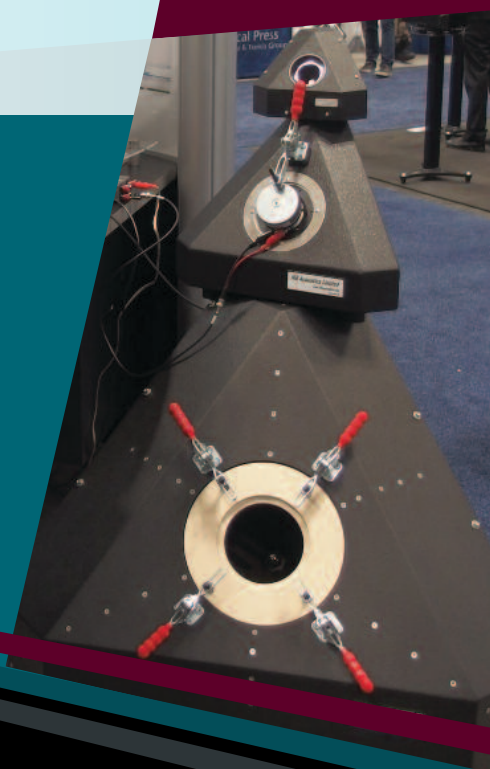

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GL Communications, Inc.					•							•									•	
GRAS Sound & Vibration																					•	•
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iT Parts Depot									•	•												
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Marchand Electronics, Inc.					•							•	•									
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MCM Electronics					•		•		•	•		•	•	•	•	•	•	•				
Meniscus Audio Group, Inc.	•													•								
Meyer Sound Laboratories, Inc.					•																	
NedLab	•					•			•			•		•	•							
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Parts Express				•				•													•	
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Prism Media Products, Ltd.				•									•	•		•	•		•			
PRV Audio Brazil															•							
Radio Design Labs (RDL)				•		•					•		•	•		•	•	•	•			
Redco Audio									•				•		•							
Scantek, Inc.	•															•	•					
Smith and Larson Audio				•		•					•		•	•							•	
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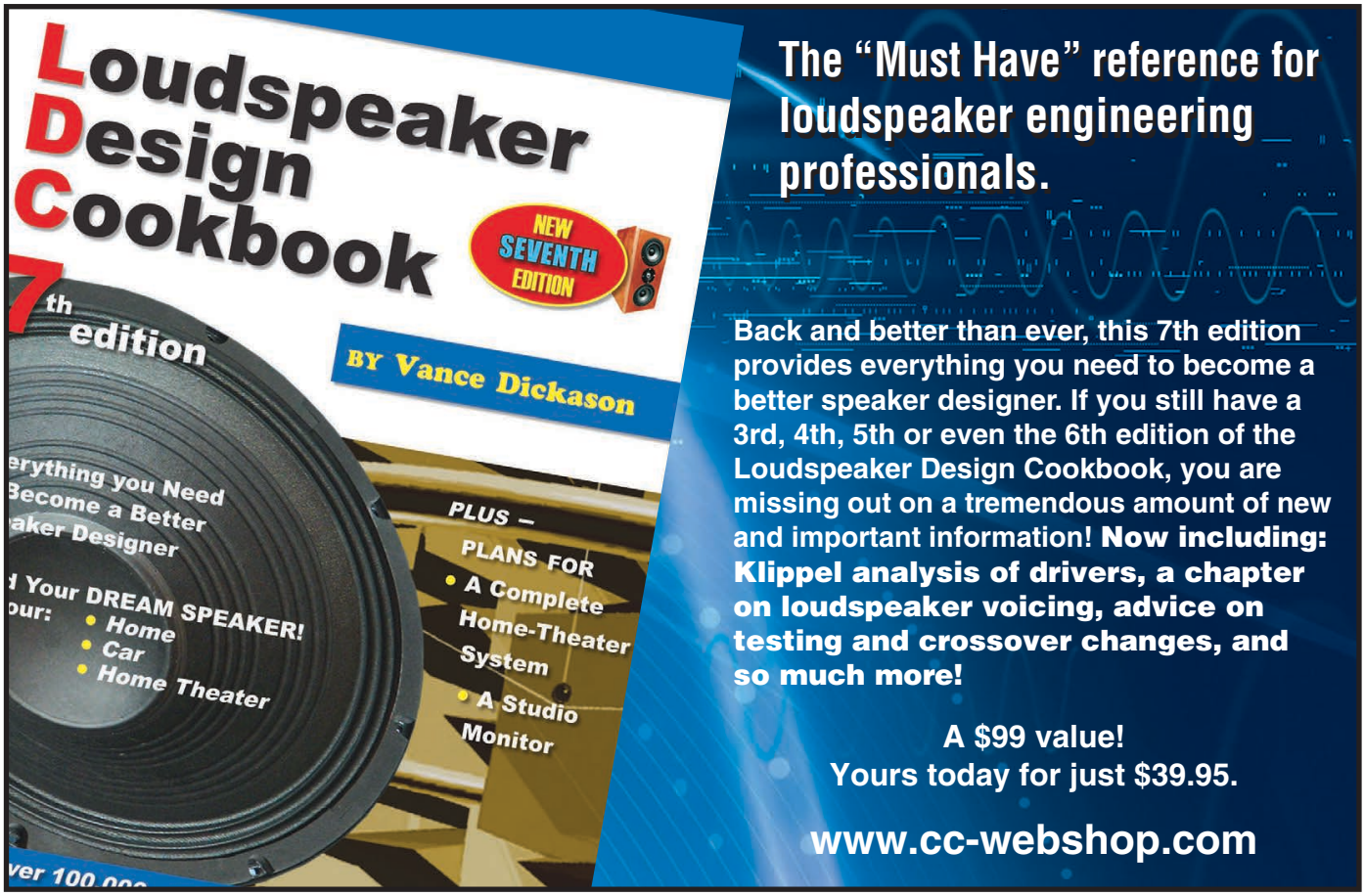
Techni-Tool, Inc.				•					•	•			•			•	•	•	•	•		
TEquipment						•			•	•			•									
US Enclosure Co.														•								•
Vidsonix Design Works				•																		
Vintage King Audio						•				•			•								•	
Warkwyn				•									•	•		•	•	•	•			



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Physical and Perceptual Evaluation of Electric Guitar Loudspeakers

This article presents a systematic methodology to investigate the influence of the loudspeaker on the reproduction of typical guitar sounds.

By
Wolfgang Klippel
(KLIPPEL GmbH)

Loudspeakers used in combination with electric guitars shall not only reproduce the electric signal captured by the pickup with low signal distortion, but the loudspeaker is part of the musical instrument and is allowed to shape the spectral components of the sound and to create new signal components as well.[1]

A combination of measurement, signal analysis, physical modeling, and listening test reveals the critical modal resonances, dominant nonlinearities, and other causes that generated the characteristic sound. This knowledge is required to optimize the design of the passive loudspeaker and to develop software algorithms that synthesize those distortions generating a desired artistic effect. This analysis is illustrated on a transducer used in many guitar loudspeakers.

Signal Distortion

Figure 1 shows a black box model that explains the generation of additional distortion components in the output signal $p(t)$, which are not in the input signal $u(t)$. The linear subsystem with the transfer function $H(s)$-1 in Figure 1 generates the linear distortion component $p_l(t)$, which represents the time-invariant deviation of the output signal from the input signal at small amplitudes. Those linear distortion $d_l(t)$ can be predicted by equivalent circuits and numerical simulation (FEA, BEA) using lumped parameters (Thiele-Small), modal parameters and geometry and material information.

The time-variant subsystem in Figure 1 generates a distortion signal that is coherent with the stimulus but varies over time. The heating of the coil increases the voice coil resistance. In consequence, the output at the resonance frequency is boosted due to the lower electrical damping but reduces the output at all other frequencies. The visco-elastic behavior, aging, and fatigue of the suspension material also contributes to this kind of distortion.

The nonlinear system in Figure 1 generates the nonlinear distortion signal $d_n(t)$ that represents the regular nonlinearities in the loudspeaker system, which are related to the geometry, material, and other design criteria. This distortion signal $d_n(t)$ is incoherent with the stimulus signal but has deterministic properties, which can be revealed by repeating the measurement. This signal becomes negligible in guitar loudspeakers, if the amplitude of stimulus is sufficiently small.

The last subsystem in Figure 1 represents signal distortion $d_l(t)$, which are not related to the design goals but are related to unpredictable nonlinear dynamics caused by loudspeaker defects. Those distortions are also incoherent with the stimulus but they usually have much less energy than the regular nonlinear distortion $d_n(t)$ and can also not be modelled due to the random nature of most defects. A unique characteristic is a much higher crest factor than for regular nonlinear distortion. The impulsive distortions reflect as high-frequency components in the reproduced audio signal spectrum. They are easily audible for a low-frequency stimulus and significantly degrade the sound quality.

While the linear and nonlinear distortion generated by the first three subsystems are exploited and intentionally generated in guitar loudspeakers, the irregular distortion $d_i(t)$ indicate a defective speaker that has to be replaced before the distortion become audible.

In-Situ Testing in Target Application

The systematic evaluation of a loudspeaker from a physical and perceptual perspective while reproducing typical guitar sounds requires a recording and differential auralization techniques to separate the distortion components by linear or nonlinear modeling.[2]

Figure 2 shows the spectrum of a typical guitar sound stimulus of 13 s with a maximum in sound pressure at 1 kHz and low spectral energy below 150 Hz. **Figure 3** shows the internal states of the guitar loudspeaker while recording this stimulus. The maximum real input power averaged over 1 s exceeds 20 W while the high crest factor of the stimulus generates a peak voltage at the terminals at 60 V. The loudspeaker generates a significantly higher positive excursion (4 mm) than negative excursion (3 mm): This indicates asymmetrical nonlinearities inherent in the transducer rectifying the AC signal and generating a DC displacement, dynamically. The voice coil resistance varies by more than 15%, indicating a significant increase of voice coil temperature.

A simple technique is shown in **Figure 4** where a linear residuum $d_r(t)$ is generated by adaptive linear modeling of the transfer path from the speaker terminals to the microphone output and subtracting the modeled signal $p_{lin}(t)$ from the measured sound pressure $p(t)$. The linear model is adaptively adjusted to the device under test (DUT) by minimizing the residuum $d_r(t)$. It also compensates for any time-varying linear transducer properties but cannot explain any distortion components that are incoherent to the electrical stimulus $s(t)$. The particular guitar loudspeaker under test generates 1 to 2 dB variations of the amplitude response within a few seconds due to voice coil heating. Perceptual modeling can be used to calculate the loudness spectra of the electric stimulus $s(t)$ and modeled linear signal $p_{lin}(t)$ to describe the variation of sharpness, roughness, coloration, and other perceptual characteristics.

More important is the residuum $d_r(t)$, which contains the regular nonlinear and irregular distortion generated by loudspeaker nonlinearities and defects. Careful listening to the residuum $d_r(t)$ of the example guitar loudspeaker does not reveal any indication for impulsive distortion caused by voice coil rubbing or bottoming, parasitic vibration of loose parts, and other defects. However, the residuum $d_r(t)$ contains significant nonlinear distortion at low frequencies, generated when the stimulus $s(t)$ contains a significant bass signal (see **Figure 5**).

Auralization of Signal Distortion

Mixing the modeled signal $p_{lin}(t)$ and the weighted residuum $S_{dis} \times d_r(t)$ allows users to generate virtual loudspeaker outputs where the distortion is attenuated or enhanced by scaling factor S_{dis}.[5] The audibility, preference, and suitability for the artistic expression can be evaluated by performing a double-blind listening test. The nonlinear distortion generated in this particular loudspeaker has to be increased by

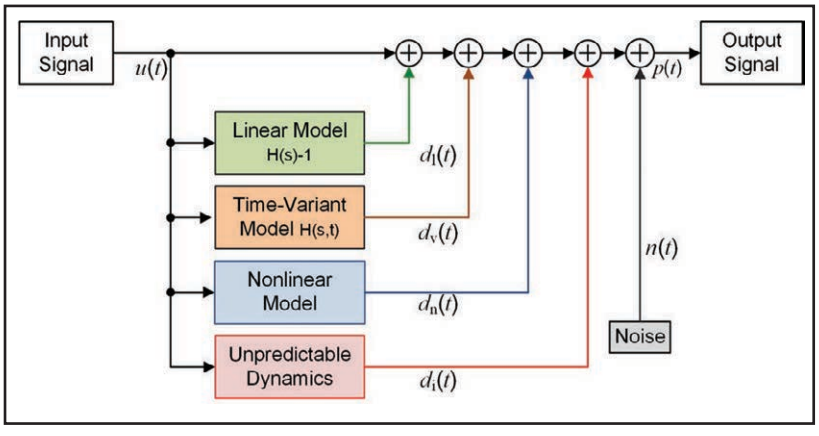


Figure 1: Black box modeling of the distortion components generated in a loudspeaker

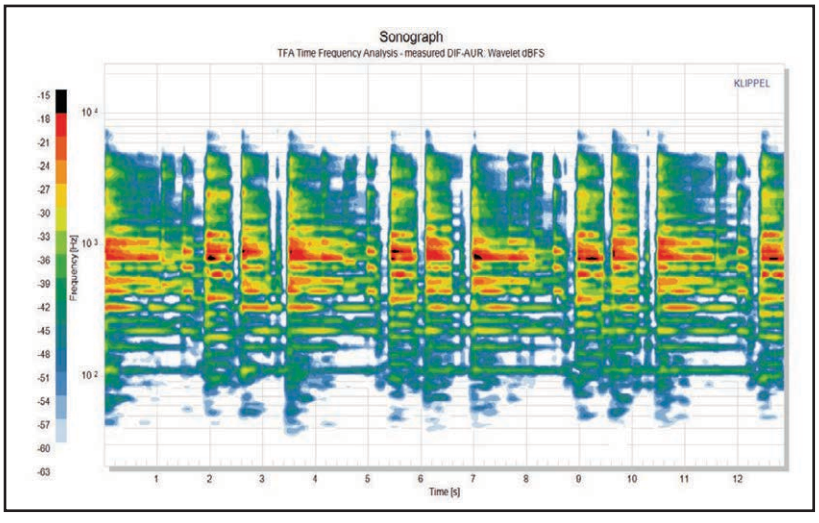


Figure 2: Sound pressure level versus frequency and time (spectrogram) of the reproduced guitar sound stimulus

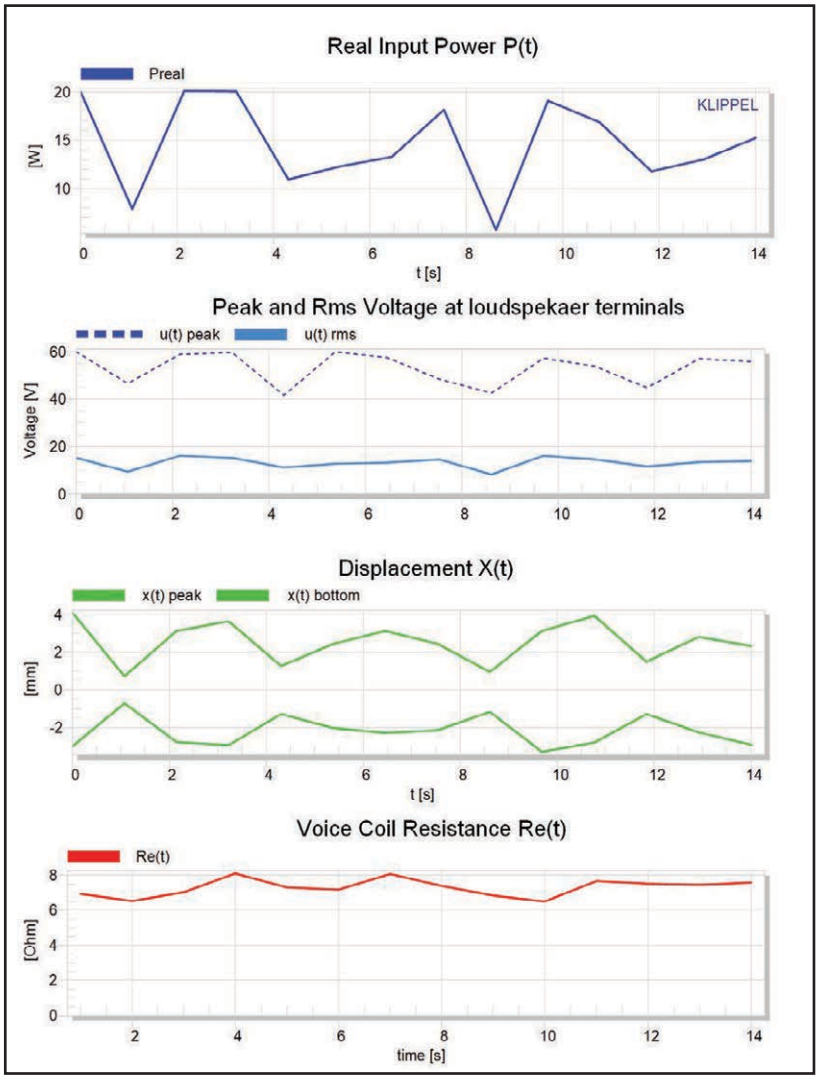


Figure 3: Real input power, peak, and rms voltage, peak and bottom displacement and the variation of the voice coil resistance versus time

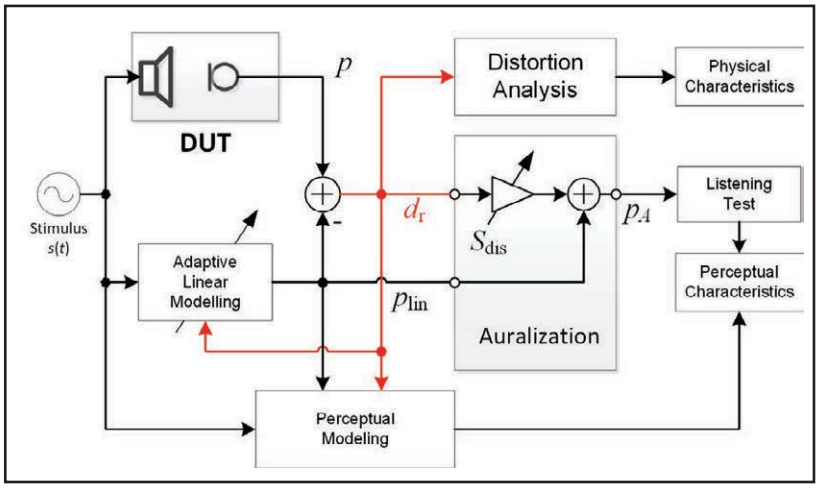


Figure 4: Evaluation of the loudspeaker while using typical guitar sound from the pickup as a stimulus

S_{dis} = 12 dB in order to make them audible. The spectral components of the nonlinear distortion shown as a sonograph in **Figure 6** versus time and frequency are about 20 dB lower than the linear components and are almost masked by the dense spectrum of the particular guitar sample shown in Figure 2.

Furthermore, the nonlinear distortions are also coupled to the musical time structure and are not recognized as an independent event disturbing the musical idea. The nonlinearities in the loudspeaker increase the dynamics of the reproduced guitar sound, which corresponds to higher crest factor measured in the residuum $d_r(t)$. The nonlinear distortion becomes more audible if a less complex guitar stimulus (e.g., single tone) is played or equalization is applied to enhance the low frequency components below 150 Hz.

Nonlinear Distortion Measurement

Figure 7 shows the sound pressure spectrum of a reproduced sparse multi-tone complex comprising 10 tones per octave over the full audio band where all the tones have the same voltage amplitude.[3] The harmonic and intermodulation distortion show between the excited frequencies at almost the same level between 50 Hz and 5 kHz. The fundamental components that are rising in this frequency band are about 10 to 25 dB higher.

Figure 8 shows the total harmonic distortion (THD) generated by a single tone of 25 V_{RMS}. This signal generates higher voice coil displacement and the THD components exceed the fundamental component at low frequencies. At higher frequencies, there are peaks at distinct frequencies.

The interpretation of the harmonic distortion can be simplified by filtering the sound pressure signal with the inverse linear transfer function of the speaker, which effectively transforms all signal components to the loudspeaker input terminals.[5] The fundamental component becomes an almost constant value corresponding to the amplitude of 25 V_{RMS} of the sinusoidal sweep and the nonlinear compression effect.

The harmonic distortions appear as equivalent input distortion (EHID)[2] in volts and can directly be compared to the excitation voltage. The frequency responses of EHID are relatively smooth curves and shows the distortions close the output of the nonlinear system without the linear transfer path through the mechanical and acoustical system generating a complex frequency response with additional peaks and dips as shown in **Figure 9**. The total value of the EHID at the

resonance frequency f_0 of the fundamental piston mode is 15 dB below the input voltage level. At higher frequencies f_1, f_2, and f_3 there are distinct peak values in the second-order distortion in EHID.

Dominant Loudspeaker Nonlinearities

Nonlinear system identification can be used to measure the dominant nonlinearities inherent in the guitar loudspeaker.[7]

Figure 10 reveals a significant asymmetry in the measured stiffness $K_{ms}(x)$ versus displacement x that generates significant second-order harmonics at the fundamental resonance frequency f_0 as shown in Figure 9.

Figure 11 shows an almost perfect symmetrical characteristic of the force factor nonlinearity $Bl(x)$ that generates third-order harmonic distortion for a single tone with a frequency below 100 Hz in Figure 9 and causes amplitude intermodulation of any signal reproduced by the guitar speaker.

References

[1] M. Zöllner, "Physik der Elektrogitarre," Regensburg, 2015.

[2] International Electrotechnical Commission (IEC) 60268-21: Sound System Equipment – Part Acoustical (Output Based) Measurements, (Draft, 2017).

[3] International Electrotechnical Commission (IEC) 60268-22: (Draft) Sound System Equipment – Electrical and Mechanical Measurements on Transducers (Draft, 2017).

[4] W. Klippel, "Evaluation of Audio Performance Over Product Life," presented at the 142nd Convention of the Audio Engineering Society (AES) in Berlin, Germany (May 20–23, 2017).

[5] W. Klippel, "Auralization of Signal Distortion in Audio Systems, Part 1: Generic Modeling," presented at the 51st International Conference: Loudspeakers and Headphones (August, 2013).

[6] W. Klippel, "Measurement and Application of Equivalent Input Distortion," *Journal of Audio Engineering Society* (JAES), Volume 52, Issue 9, pp. 931-947.

[7] W. Klippel, "Loudspeaker Nonlinearities – Causes Parameters, Symptoms," *Journal of Audio Engineering Society* (JAES), Volume 54, No. 10, pp. 907-939, (October, 2006).

[8] W. Klippel, J. Schlechter "Distributed Mechanical Parameters of Loudspeakers, Part 1: Measurements," *Journal of Audio Engineering Society.*

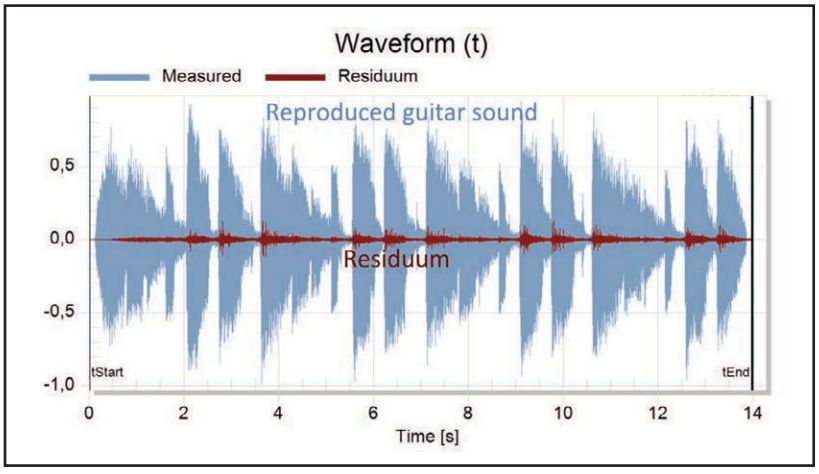


Figure 5: Nonlinear distortion—residuum $d_r(t)$) separated from the reproduced guitar sound stimulus $p(t)$

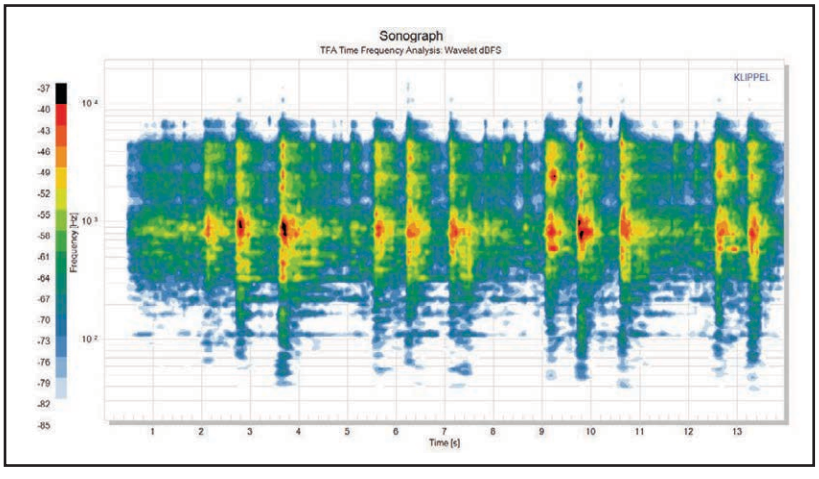


Figure 6: Spectrogram showing the nonlinear distortion (residuum) in the reproduced guitar sound stimulus versus time and frequency

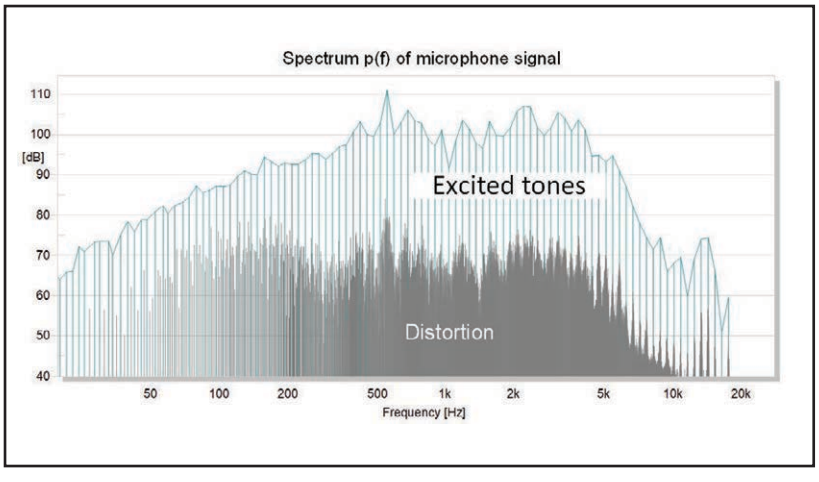


Figure 7: Sound pressure spectrum of a reproduced multi-tone stimulus at 25 V total terminal voltage

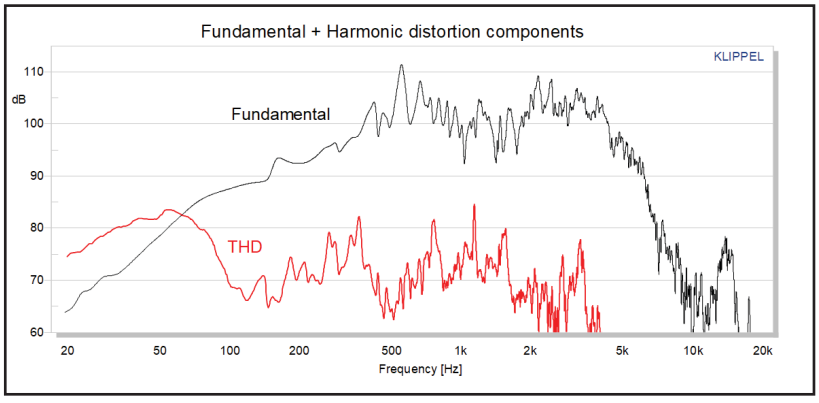


Figure 8: Total harmonic distortion (THD) compared to the fundamental component in SPL generated by a sinusoidal sweep with 25 V_{RMS} at the input terminals.

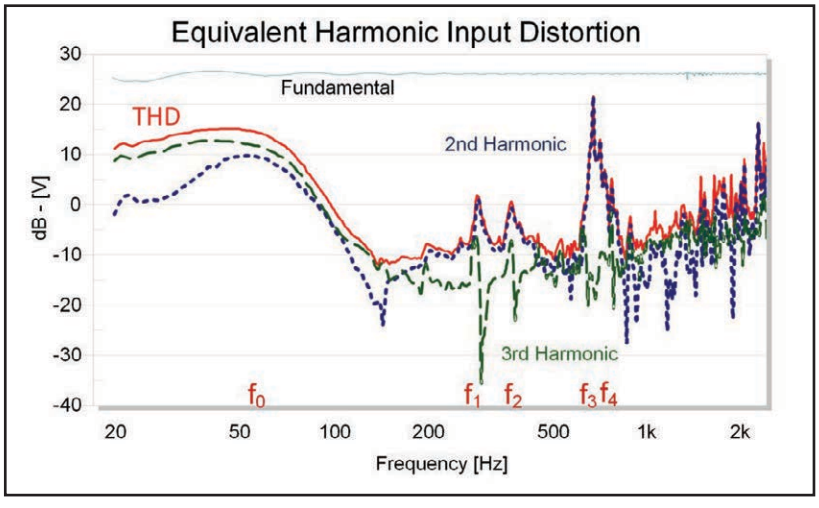


Figure 9: Second-order and third-order components and total harmonic distortion (THD) compared to the fundamental component transformed to the loudspeaker input terminals

The nonlinear dependency of the voice coil inductance $L(x)$ on displacement x as shown in **Figure 12** also generates significant intermodulation distortion in the audio band. The intermodulation distortion generated by $Bl(x)$ and $L(x)$ are dominant in the multi-tone distortion measurement and in the residuum of the reproduced guitar sound stimulus. Since the high-frequency components are modulated by a low-frequency bass signal ($f < 100$ Hz) the variation of the envelope is perceived as an increased roughness by the human ear.

Modal Vibration

The significant values of the harmonic distortion (EHID) found at higher frequencies f_1, f_2, f_3, and f_4 in Figure 9 can be explained by measuring the mechanical vibration by laser vibrometry and calculating the accumulated acceleration level (AAL)[8] shown as red dashed line in **Figure 13**. The AAL corresponds to mechanical energy of the radiation surface accessible to the laser sensor. It is comparable to the sound pressure at a defined observation point in the far field.

The AAL is also a convenient metric[8] to perform a modal analysis. This analysis reveals the contributions of the dominant vibration modes to the total vibration as shown in Figure 13. The AAL response of each mode reveals a second-order resonance curve with a natural frequency f_n and a modal loss factor η_n. Contrary to the fundamental piston mode at f_0 the higher-order modes ($n > 0$) usually have a lower damping generating a distinct resonance peak.

The higher-order modes also generate at least one nodal line in the vibration pattern (cone break-up) as shown in **Figure 14** for $n = 1...4$. The axial-symmetrical modes at frequencies f_3 and f_4

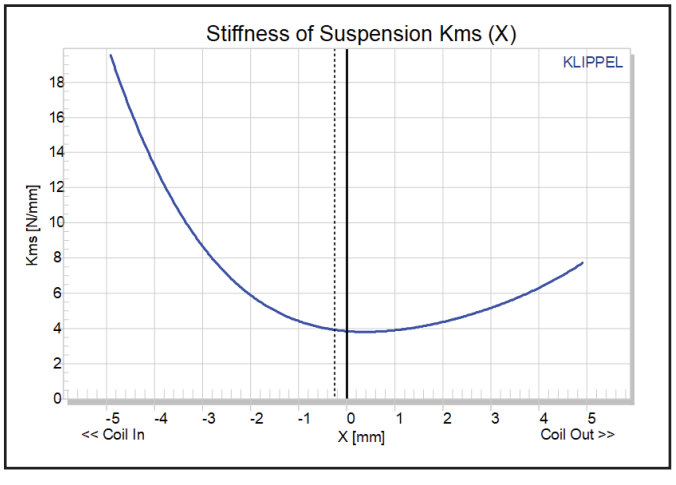


Figure 10: Stiffness $K_{ms}(x)$ versus displacement x

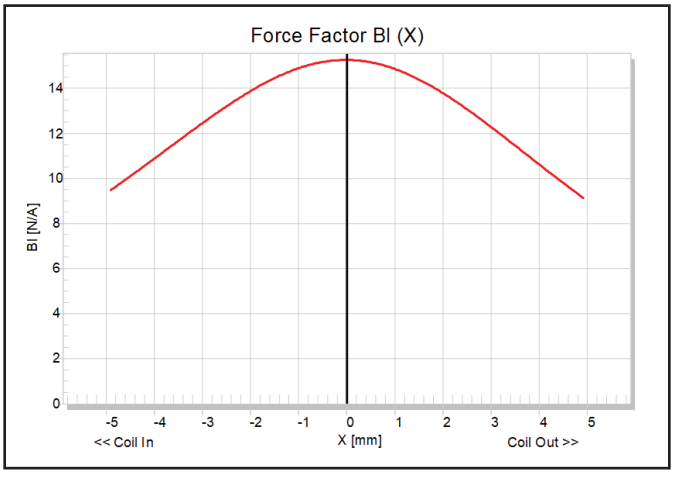


Figure 11: Force factor $Bl(x)$ versus displacement x

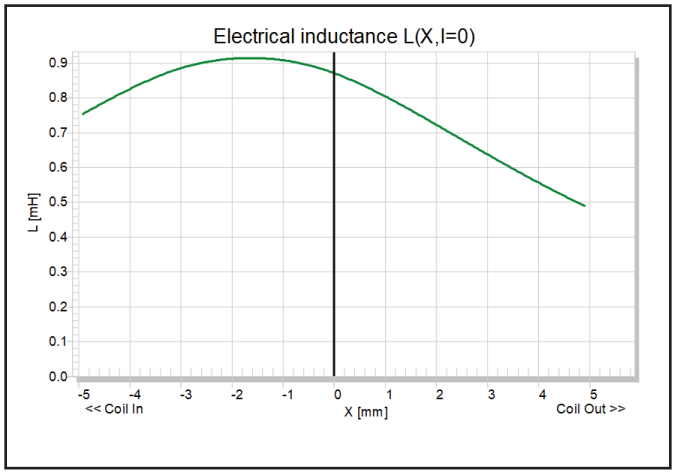


Figure 12: Voice coil inductance L(x) versus displacement x

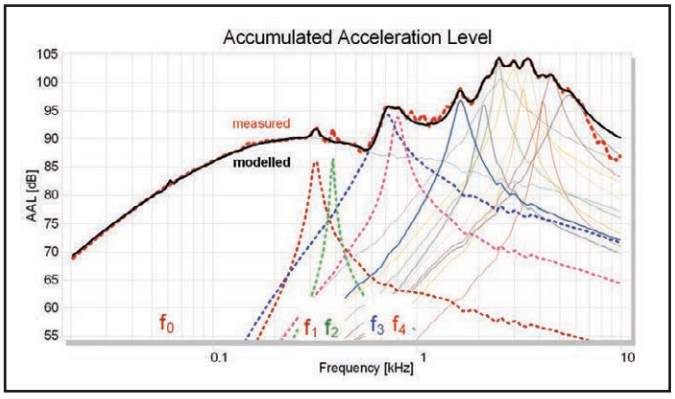


Figure 13: Contribution of the mechanical vibration modes on the radiation surface (cone, surround, and dust-cap) to the measured and modelled accumulated acceleration level (AAL)

generate an 8 dB higher AAL-value than the piston mode and a significant deformation of the surround geometry. Since the surround profile of the particular guitar speaker has a highly asymmetrical shape (few corrugation rolls), this geometrical nonlinearity generates the high level of second-order distortion at the same excitation frequencies in Figure 8. The first two break-up modes at frequencies f_1 and f_2 have a circular vibration pattern on the cone as shown in Figure 14. Since those modes have 8 dB lower AAL value distributed on a much larger area than the radial modes at f_3 and f_4, the circular modes generate second-order distortion that are 20 dB lower.

However, the nonlinear modal vibration in the particular guitar speaker is less critical than the motor nonlinearities $Bl(x)$ and $L(x)$ for a broad band guitar sound as used in the auralization and listening test because the spectral density of the stimulus provides a much lower excitation of the modal resonator than the sinusoidal stimulus at 25 V_{RMS}. The sonograph of the residuum reveals no symptoms of the harmonics generated by the modal resonances.

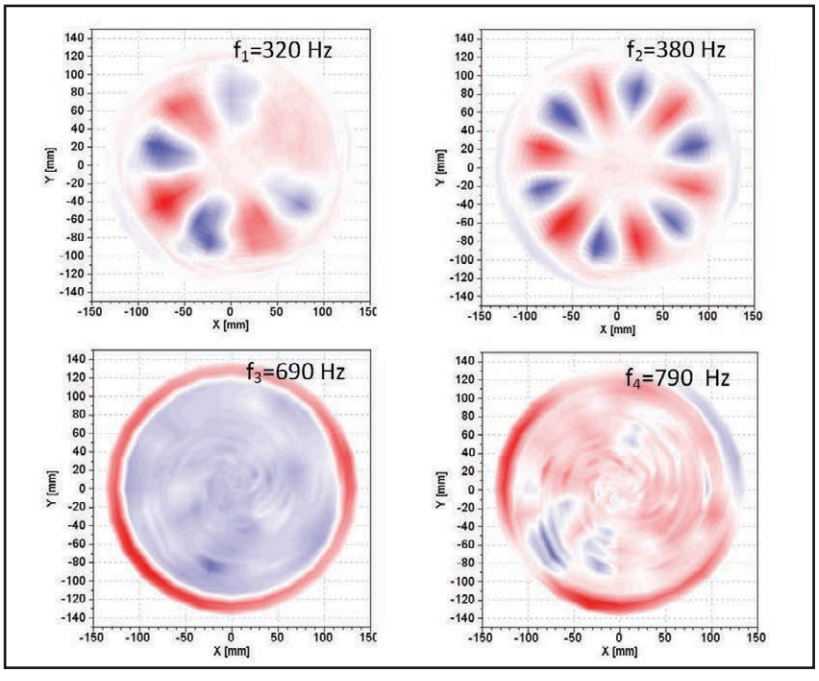


Figure 14: Vibration pattern of selected modes at natural frequencies f_1, f_2, f_3, and f_4, which generate the significant second-order harmonic input distortion (EHID) shown in Figure 12

Conclusions

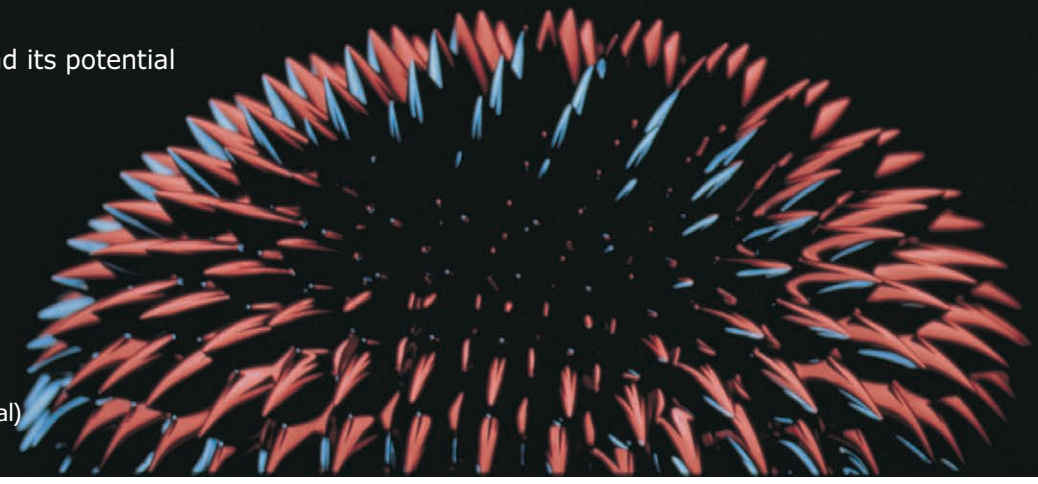
Recent progress in loudspeaker modeling leads to new measurements techniques that combine the physical and perceptual evaluation of the reproduced sound to understand the root cause of the distortion. Auralization techniques are the basis for systematic listening tests to investigate the audibility of signal distortions and preference of sound effect generated by design choices. Nonlinearities are not only interesting for guitar speakers but for any transducer generating more output at higher efficiency while using less resources (size, weight, energy, and manufacturing effort). ***LIS***

About the Author

Wolfgang Klippel studied electrical engineering at the University of Technology in Dresden, in the former East Germany, where his initial studies focused on speech recognition. Afterward, he joined a loudspeaker company in the eastern part of Germany where he was engaged in transducer modelling, acoustic measurement, and psychoacoustics. He later returned to his studies and received a PhD in Technical Acoustics in 1987. After spending a post-doctoral year at the Audio Research Group in Waterloo, Canada and working at Harman/JBL in Northridge, CA, he returned to Dresden in 1997 and founded Klippel GmbH, a company that develops novel control and measurement systems dedicated to loudspeakers and other transducers. Dr. Klippel has also been engaged as Professor of Electro-acoustics at the University of Technology in Dresden since 2007. His papers and tutorials on loudspeaker modeling and measurement—particularly those on large signal behavior and physical distortion mechanisms—are considered reference works in the field.

The Role of Ferrofluid in the Future of the Audio Industry

Learn more about ferrofluid and its potential benefits to the audio industry.



By
Vanessa Rene
(Senior Product Specialist, Ferrotec, and Vice President, ALMA International)

Photo 1: This crown of spikes is actually ferrofluid, which is a stable colloidal suspension of nano-scale particles of magnetite, coated with a surfactant or dispersing agent that keeps them from touching and sticking to each other, that are then suspended in a carrier liquid of some sort, be it oil, water, or some other medium.

If you had asked me 25 years ago what ferrofluid was, I would have given you a blank stare and said "ferro-what?". That's the response you'll see today from nearly all non-industry individuals, but what is more than a little disturbing is that you will also see it from many industry professionals. The older generation of design engineers and transducer specialists is reaching retirement age, and in their wake comes a new crop of young professionals who have not had a proper indoctrination into the science and practical applications of ferrofluids.

For many of them, their concerns are more with cost containment and simplicity of manufacturing and less with exploring the rationale behind putting some liquid that they don't understand into the air gaps of their drivers. This is not necessarily the fault of this new generation of engineers. It is the responsibility of their mentors to understand that not all aspects of their trade are "givens" and that the only way to assure continuity in design and function is to go beyond the traditional education these young engineers receive and introduce them to some of the more ephemeral aspects of tweaking drivers to perfection.

Ferrofluid Description

Simply stated, a ferrofluid is a stable colloidal suspension of nano-scale particles of magnetite, coated with a surfactant or dispersing agent that keeps them from touching and sticking to each other, that are then suspended in a carrier liquid of some sort, be it oil, water, or some other medium (see **Photo 1**). On a deeper level, decades of research have been dedicated to creating and improving dozens upon dozens of different ferrofluid formulations for a wide variety of applications, many of them for the loudspeaker industry.

The term stable colloid means that the particles do not settle out of their medium and the fluid behaves as a single entity when acted upon by an outside (in this case, magnetic) force. The ferrofluid does not have any inherent magnetism of its own due to the particle orientation (the north-south poles of the particles) being totally random, but when placed in a magnetic field, the particles align with the lines of magnetic flux and form a strong attraction that keeps them in place. This is why you can add a measured amount of ferrofluid to the magnetic air gap of a loudspeaker and it will stay where it is placed, no matter the orientation of the speaker (see **Figure 1**).

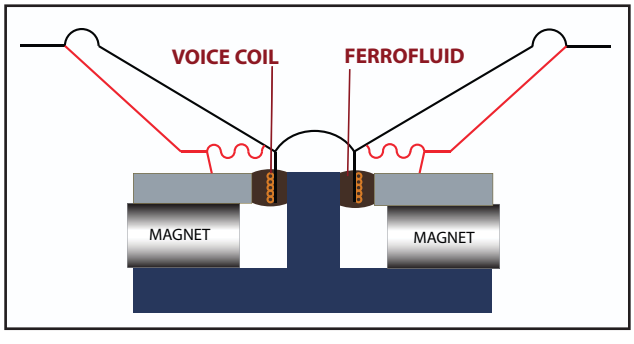


Figure 1: The ferrofluid does not have any inherent magnetism of its own due to the particle orientation.

Ferrofluid's Benefits

Ferrofluid has four basic benefits for loudspeakers of all types: 1) thermal transfer; 2) voice coil centering; 3) reduction of power compression; and 4) damping (reduction of signal anomalies). Thermal transfer, or voice coil cooling, was one of the first phenomena noted with application of ferrofluid to a voice coil. Keeping the coil from overheating is probably the one greatest advantage you can impart upon your speakers, allowing you to significantly turn up the power without blowing out the unit (think of the first scene in the movie *Back to the Future*, when Marty McFly cranks up his enormous driver and blows it out with dramatic results).

Ferrofluid has approximately four times the heat transfer capacity of air and can allow a driver to be pushed beyond its normal boundaries with little to no decay in sound production. When ferrofluid is applied to a driver with an eccentric voice coil, a strange and magical thing happens: The ferrofluid distributes itself evenly around the air gap, forcing the coil assembly into the center of the gap uniformly all around (see **Photo 2**). This phenomenon is visible, and is one of the more entertaining clips that we show prospective clients when illustrating the value of ferrofluid. When the coil is centered, there is no longer an issue with rub and scrape, as the coil tracks evenly as long as the ferrofluid is present. Noting the third benefit, power compression takes place in loudspeaker voice coils when they heat up and their resistance increases. This causes less power to be drawn from the amplifier and a reduction in sound pressure level. This is experienced as a loss of decibel output with the same power input into the loudspeaker. Ferrofluids, with their ability to transfer heat, help to minimize this phenomenon.

Damping is required when your driver design is less than perfect and you have signal spikes that lead to a harsh or "edgy" sound. Damping from a ferrofluid can vary greatly from next to nothing to significant signal conditioning, depending on the viscosity or thickness of the ferrofluid. Proper damping of a loudspeaker can make a cheap, under-designed driver speaker sound like a much higher end unit. All of these benefits together can greatly reduce manufacturing loss due to quality failure and make an average or less-than-average loudspeaker significantly better. All of these properties are directly translatable to any audio platform, be it a large woofer or a tiny in-ear device, and it is critical that the next generation of engineers understands that ferrofluids are an indispensable tool for improvement of audio signals from all sources. Ferrofluids, however, are application/driver specific, which essentially means that it is not a one-size-fits-all technology. It is necessary for the audio engineer to work closely with a ferrofluid professional to assure a correct match.

Photo 2: The ferrofluid distributes itself evenly around the air gap, forcing the coil assembly into the center of the gap uniformly all around.

The Makers of Ferrofluid

Ferrotec (which started out as Ferrofluidics Corp. in the late 1960s) has been involved with the ALMA International organization practically from the company's beginning, when the value of ferrofluids for loudspeakers was first recognized. The mission of the Association of Loudspeaker Manufacturing and Acoustics (ALMA) International is to bring together industry professionals and to educate students and the industry itself regarding the innovations and future expectations of the loudspeaker technologies industries. ALMA International is the only organization of its type with an emphasis on audio loudspeaker technologies alone. It has done more to promote the industry amongst the next generation of student audio engineers than practically any other organization. This is why Ferrotec remains a loyal member, because this platform of education is the perfect place to promote the benefits of ferrofluids for the loudspeaker industry.

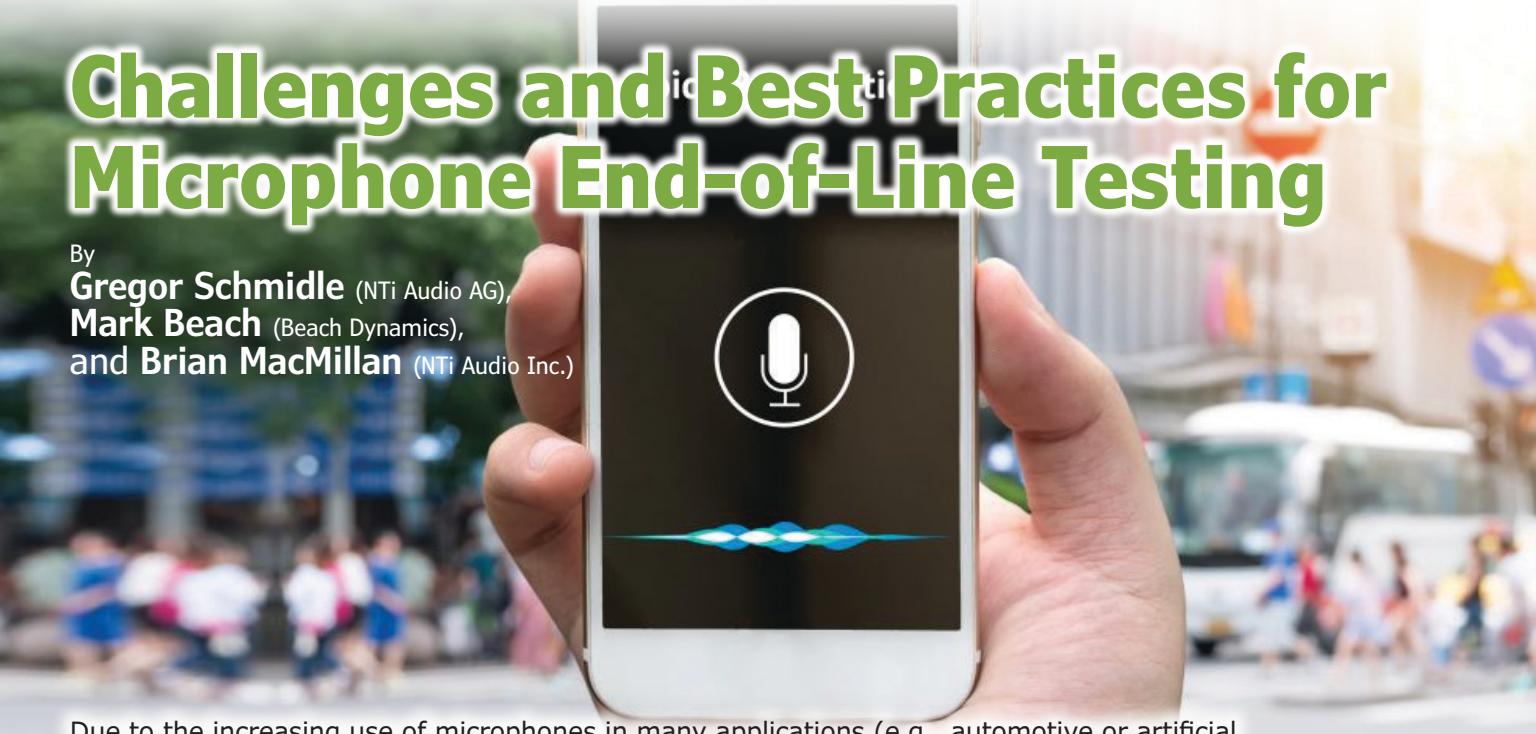
With the emergence of personal and automotive audio devices as taking the forefront, a trend away from home audio systems, the importance of continued research and development of new fluids products for these more demanding systems is clearer than it ever has been. Ferrotec expects to pave the way for the future of audio, with special formulations for mini and microspeakers, in-ear devices, mobile platforms, and forward looking devices that have not even been imagined yet. In order to maintain a continuity of design excellence and product quality, it remains an imperative that the audio engineers in days to come must understand the technologies of the past that span the decades into the future. ***LIS***

About the Author

Vanessa Rene is the Senior Product Specialist for the Ferrofluids division of Ferrotec (USA) Corp., and serves on the ALMA International Board of Directors, as well as on the Executive Committee as a Vice President. You can meet her at the AISE 2019 event in Orlando, FL, this June 9-10.

Challenges and Best Practices for Microphone End-of-Line Testing

By
Gregor Schmidle (NTi Audio AG),
Mark Beach (Beach Dynamics),
and **Brian MacMillan** (NTi Audio Inc.)



Due to the increasing use of microphones in many applications (e.g., automotive or artificial intelligence), the demand for fast and reliable microphone test processes is growing. This article covers various aspects of the design of an end-of-line (EOL) microphone test system. A prevailing challenge is to properly control the sound source, as loudspeakers have a tendency to vary their performance due to many influences. The acoustic environment for the test must provide reproducible conditions and is ideally anechoic. Noise from outside must be damped across the measurement bandwidth, so that it doesn't affect the results. In this article, the authors show different testing requirements for various types of microphones and discuss different methods for defining limit criteria.

During the last couple of years, the employment of microphones in systems has been significantly increasing. Automotive driver assistance systems, artificial intelligence home loudspeakers, or consumer devices with voice control are just a few examples that boost the demand for microphones. Along with that demand, the need for fast and reliable industrial end-of-line (EOL) microphone test processes is growing. A typical microphone EOL test system consists of an audio analyzer, a reference microphone, a reference loudspeaker, and an acoustic test box. A microphone test software takes care of controlling each component, as well as processing the measured results. It ensures that the system is calibrated properly and delivers measurement values that are both precise and accurate. This makes it possible to have multiple test stations on different manufacturing lines, delivering the same results and comparing them against a commonly-used set of pass/fail criteria.

Challenges in Microphone EOL Testing

One of the biggest challenges in a microphone EOL test system is to monitor and control the performance of the reference loudspeaker. Due to its nature, loudspeakers tend to vary in their performance across several characteristics (e.g., temperature and age), as well asT between separate samples of the same model. Therefore, the reference loudspeaker performance must be, (periodically or permanently) monitored by a reference microphone. The reference microphone is much more stable than the loudspeaker.

The other critical component of the test system is the acoustic test box. It shall provide reproducible acoustic conditions, and also protect the test setup from environmental noise interference.

Figure 1 shows a block diagram of a generalized setup for an EOL microphone test setup. The general measurement concept for the test box includes the following:

- The microphone under test (device under test or DUT) and reference microphone are placed next to each other at the same distance to and offset from the loudspeaker, therefore, exposed to the same SPL.
- The audio analyzer runs a sweep signal through the loudspeaker.
- From the reference microphone, the audio analyzer knows what SPL should be at that position for each frequency for the microphone under test.
- With the input signal coming from the DUT microphone at the same location, the test system calculates the sensitivity for each frequency point.
- Thus, the deviations of the loudspeaker are taken care of.

Microphone Types and Requirements

Technology

Although there are numerous technologies to convert sound into signals, the majority of industrial and professional applications are covered with these four types:

- Dynamic microphones: these are used for live sound or event applications because of their robustness.
- (True) Condenser microphones are popular in recording studios. Also, measurement microphones are typically condenser microphones.
- Electret microphones are a low-cost variant of the condenser microphones. They are found in the vast majority of industrial and consumer products, where prime performance and full-frequency bandwidth is not required.
- Microelectromechanical systems (MEMS) microphones are rapidly replacing electret microphones in applications where further signal processing is required, such as for microphone arrays. Also, they are popular because their small size takes up little space.

Signal Formats

When testing microphones at the component level, all models except digital MEMS microphones provide an analog signal. Typical voltages are in the range of a few tens of millivolts. Some MEMS microphone models also output an analog signal. However, the majority of MEMS microphones in use deliver a digital half-cycle PDM data stream.

When testing microphones embedded into modules or devices, the audio signal can adopt to any applicable analog or digital audio format. The automotive industry, for example, is more and more applying the Automotive Audio Bus (A2B) standard.

Power Supply

All listed microphone types except the dynamic microphone require some kind of supply for operation. For the true condenser microphones, this is mostly a 48 V phantom power supply, or a constant current power (CCP), aka ICP for prepolarized microphones. For externally polarized microphones, typically a 200 V voltage is required.

Electret type microphones don't need a polarization voltage but require a bias voltage to operate the built-in field-effect transistor (FET). This voltage is typically in the range of a few volts.

Test System Requirements

The test system must provide the required power supply for both the reference and the DUT microphone. Also, the given signal interface for the DUT microphone is required. If the signal interface is not provided by the audio analyzer, external converters can be applied to the system. However, these converters must be characterized and considered when calibrating the complete signal path.

Measurement Parameters

This list of measurements does not include all common microphone measurements, but only those that are commonly performed in an EOL test.

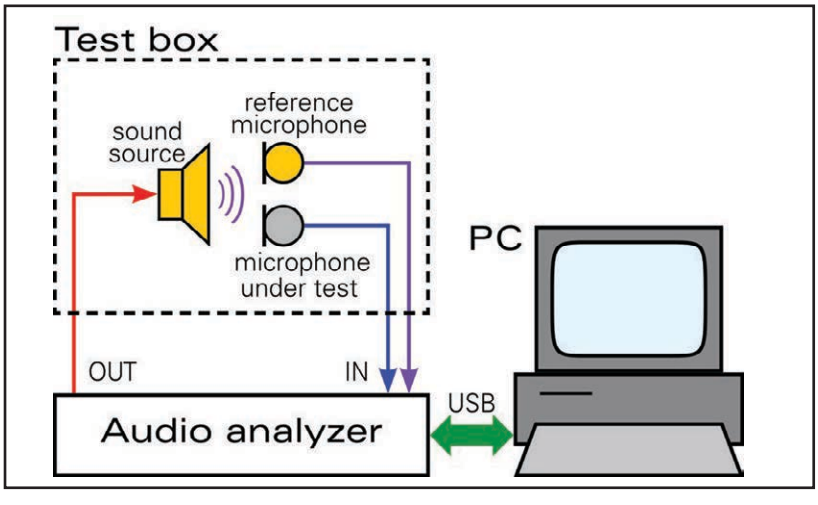


Figure 1: Test setup block diagram

Frequency Response

The frequency response of a microphone describes the sensitivity of the microphone over the measured frequency bandwidth. At this point, the effect of the reference loudspeaker is already eliminated. The frequency response is typically displayed in [dBV/Pa]. Alternatively, the frequency response can be visualized relative to a reference frequency (e.g., 1 kHz).

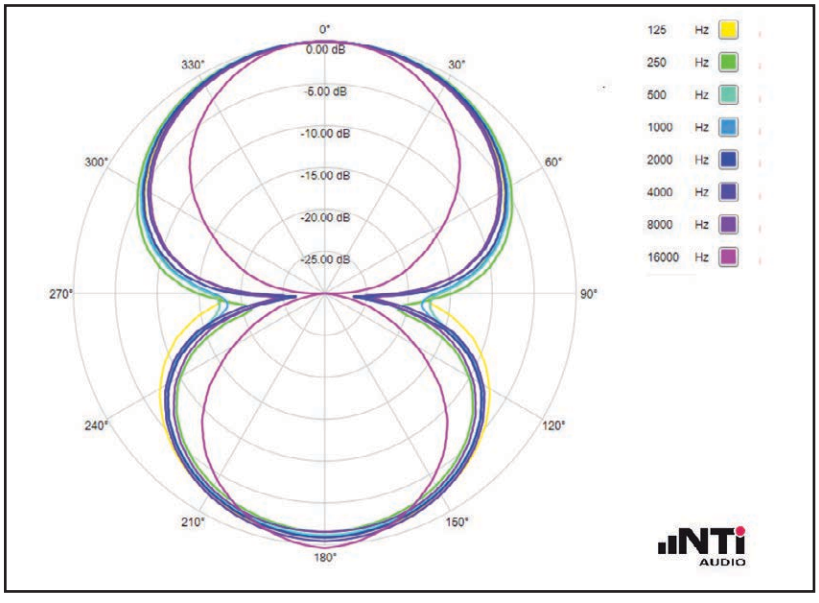


Figure 2: Directivity plot of a bi-polar microphone

About the Authors

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Gregor Schmidle is Product Manager at NTi Audio in Schaan, Liechtenstein. He completed a Bachelor of Science degree at the Interstate University of Applied Sciences of Technology in Buchs, Switzerland in 1992 and a Master of Science degree at the University of Applied Sciences in Dornbirn, Austria in 2004. Gregor has been in the audio and acoustic Test & Measurement industry for more than 25 years. After working several years at NEUTRIK as a hardware and software developer, he continued his career at NTI Audio as an applications support engineer. In his current position, Gregor is in charge of NTi Audio's industrial key customers worldwide.

Mark Beach/Beach Dynamics

Mark Beach marketed his first commercial loudspeaker design in 1979 while attending the University of Cincinnati in Cincinnati, OH. Specializing in acoustics, vibrations, and modal analysis, he graduated with a Master's Degree in Mechanical Engineering in 1984 and formed Beach Dynamics Company consulting with and manufacturing end-of-line acoustic test booths and anechoic chambers for Ford, Delphi, P&G, 3M, John Deere, Valeo, Whirlpool, and others. Mark currently serves on the Board of Directors and is the Treasurer for ALMA International.

Brian MacMillan/NTi Audio, Inc.

Brian MacMillan is General Manager for NTi Audio US office in Portland, OR. Brian has worked in sound and vibration instrumentation for more than 25 years in local sales and support and as a Product Manager. He has worked with a variety of customers and markets in the US, Denmark, and the United Kingdom.

Sensitivity

The sensitivity, along with the frequency response is a core parameter of any microphone. It tells how much output voltage the microphone delivers at a standard sound pressure of 1 Pa. The sensitivity is either displayed in [dBV/Pa] or [mV/Pa]. Since the sensitivity is a single number, it is either specified for one frequency (typically 1 kHz) or is an averaged result from a list of frequencies. In most cases, the sensitivity is calculated from the results of the frequency response. For measurement microphones, the sensitivity is measured with a microphone calibrator.

Distortion

Distortion of microphones is often specified as the SPL level at which the microphone exceeds a certain total harmonic distortion (THD) value. A typical specification would be, for example:

SPL (THD = 1%) > 106 dBSPL

This value often defines the upper dynamic limit point of a microphone. Measuring the SPL that causes 1% distortion is an iterative procedure, and therefore, not suitable for an EOL test. Instead in this example, the THD would be verified to be: ≤ 1% at an SPL of 106 dBSPL.

Some microphone specifications use that format directly and specify the maximum distortion for a certain SPL value either at a single frequency, or a specified frequency bandwidth.

Signal-to-Noise Ratio

The signal-to-noise ratio (SNR) is measured in two steps. First the signal from the microphone at a specified level and frequency is measured (e.g., 1 kHz/94 dBSPL). Next, the signal from the microphone without any stimulus signal is acquired and A-weighted. The ratio of these two results is displayed in decibels.

While measuring the SNR is straightforward, providing the measurement condition is often not. Microphone SNR specifications are typically > 60 dB(A). Assuming a 94 dBSPL level for the signal measurement, the inside of the acoustic test box must be as quiet as < 34 dB(A). Given that the test box is in a manufacturing environment, it requires a great effort to provide the required sound insulation. Thus, having to measure SNR has a large impact on the insulation requirements of the acoustic test box.

Phase and Polarity

The phase and polarity of microphones are important for microphones that are used in applications where multiple microphones are in

use, such as music and voice microphones, as well as microphones used in an array configuration.

Off-Axis Measurements

The directional behavior of microphones or devices is typically measured with a turntable, measuring at multiple equidistant-spaced angles along a 180° or 360° rotation. The directional behavior for selected frequencies are then displayed as a polar plot (see **Figure 2**).

In an EOL test, this approach is not always reasonable because it is quite time consuming. Instead, the frequency response can be measured with a few additional loudspeakers only located at the angles of most interest. The gathered responses are then compared to the on-axis frequency response (see **Figure 3**).

Output Impedance

For analog microphones, the output impedance is usually specified at a certain SPL and frequency. The output impedance can be measured by performing two measurements at the specified SPL and frequency—one with and one without a defined load resistance. The output impedance of the microphone can be calculated from the two measured microphone signal voltages.

Power Consumption

Electret condenser microphones as well as microphones with digital output signal require a power supply. The current supplied by this power supply is typically specified by a maximum value. This current can be measured with DC-current instrument, integrated to, or controlled by the microphone EOL test system.

Rub & Buzz

Dynamic microphones work with diaphragm connected to a moving induction coil inside a magnetic field. Due to mechanical damage, particles inside the microphone, or manufacturing process problems, the free-wheeling of the coil in the magnetic field can be affected. These electro-mechanical imperfections are detected best with a measurement system searching for unwanted transients in the microphone output signal.

Reference Loudspeaker

The goal for the sound source in a microphone test system is to have a homogenous dispersion of the sound waves around the loudspeaker, aka point sound source. In real life, the most practical to use are loudspeakers with a coaxial design. This type of design is often found in acoustic reference loudspeakers or in studio monitors.

Core Parameters

The frequency bandwidth of the loudspeaker must fully cover the frequency bandwidth of the microphone test setup. Within that bandwidth, the loudspeaker shall provide a flat response. Although the loudspeaker response gets equalized, a rather flat response is easier to work with.

The loudspeaker shall provide the required SPL for the microphone test, at the location of the reference microphone and the DUT. The loudspeaker must not produce significant distortion at this level. When SNR are part of the test sequence, the loudspeaker must be absolutely silent when muted. This mainly concerns the amplifier driving the loudspeaker.

Monitor and Control

During calibration, the test system software determines the required output voltage to reach the requested SPL at the reference microphone. Additionally, the acoustic frequency response of the loudspeaker is characterized, also using the reference microphone.

If required, the reference loudspeaker frequency response can be equalized at the location of the reference microphone. The measured frequency response is inverted and applied as frequency weighting to the generator of the audio analyzer. The result is a flat frequency response at the location at the reference (and DUT) microphone.

The calibration shows the loudspeaker characteristic at that very moment. Assuming that the behavior will not change significantly, those

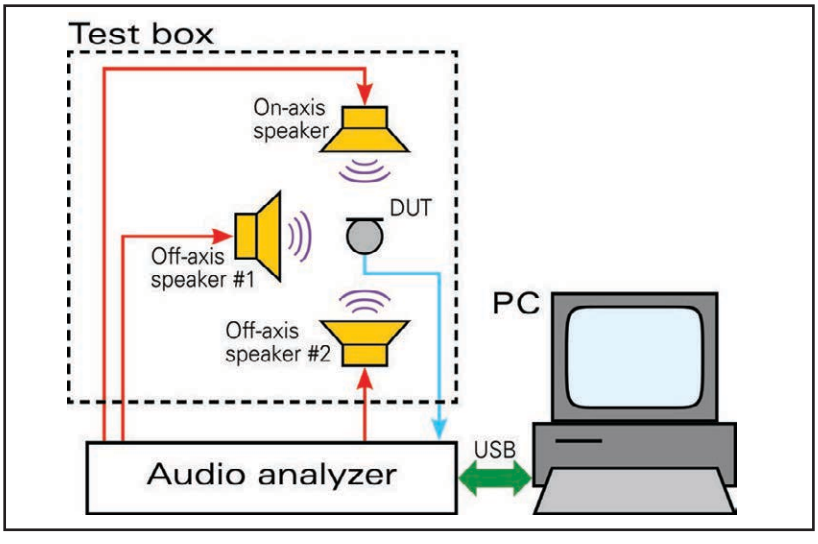


Figure 3: Off-axis measurements at 90° and 180°

results can be used to mathematically eliminate the loudspeaker's nonlinearity. The reference microphone would only be used for calibration. Depending on the accuracy demands, the calibration is performed more or less frequently.

A safer approach is to use the reference microphone permanently in the test setup. This way, the performance of the reference loudspeaker gets characterized and eliminated for each measurement individually. Loudspeaker drifts over time or temperature, therefore, do not influence the microphone measurement results.

Acoustic Test Chamber

This section describes the requirements and design aspects of an acoustic test chamber for an automotive microphone application.

Photo 1: Acoustic test chamber

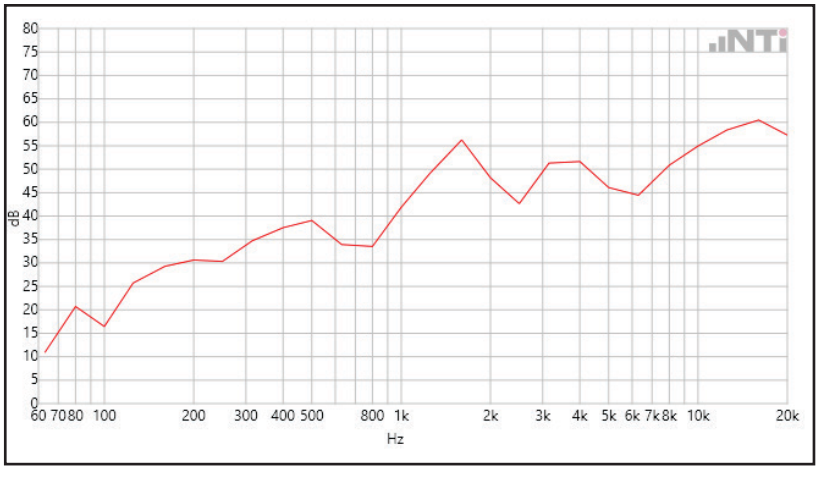


Figure 4: Acoustic test chamber insertion loss

The purpose of the acoustic test chamber is to provide an environment that yields accurate, repeatable measurements. This is achieved by providing:

- A sufficiently low noise floor
- A non-reverberant environment
- A stable time-invariant stimulus
- Repeatable positioning of the microphones

Additionally, if the chamber is used in production as opposed to R&D only, the time required for loading and unloading of the DUT must be considered as well as ergonomics, hardware lifespan, and maintenance.

An acoustic test chamber was built as a "table top" unit measuring 135 cm × 80 cm × 80 cm with a manual 60 cm × 60 cm clear opening access door (see **Photo 1**). The unit is also modular allowing additional sections to be added if the customer desires lower frequency measurements in the future or a different stimulus loudspeaker. The addition of modules does not require any tools nor welding. Additionally, the configuration easily accommodates vibration isolation if conditions require it.

Sufficiently Low Noise Floor

If frequency response measurements only are required, the acoustic test chamber should provide an absolute minimum internal noise floor of 10 dB less than the measured signal; however, 25 dB to 30 dB or more is recommended especially when exterior transient noise levels are considered: forklift traffic, alarms, pallet stacking, and other temporary conditions, which would result in false failures and time loss due to retesting.

If a full battery of measurements are required (frequency response, sensitivity, distortion, signal-to-noise, and polar response), then a noise floor of 60 dB less than the measured signal is desirable. For a typical DUT microphone tested at 94 dB at 1 kHz, a 34 dB noise floor is desired.

The acoustic test chamber was built with a typical microphone specification in mind: 94 dB at 1 kHz at the DUT microphone. The microphone test chamber's insertion loss was measured with an external stimulus at a distance of 3 m. A reference microphone measured the stimulus at the acoustic test chamber's front plane and a second microphone measured the stimulus from inside the acoustic test chamber.

The measured insertion loss is shown in **Figure 4** indicating an insertion loss of 26 dB at 125 Hz increasing to 60 dB at 16 kHz. The

mass controlled region rolls off at approximately 4 dB/octave to 5 dB/octave instead of the expected 6 dB/octave perhaps because of the acoustic test chamber's internal absorption.

In a typical production environment, the overall noise level could be a very loud 85 dBA. In this theoretical example, the noise floor would be approximately 31 dB at 1 kHz. In a typical research and development environment, the lab's overall ambient noise level might be on the order of 60 dBA and the microphone test chamber's noise floor at 1 kHz would be less than 10 dB and would be below many microphone/power supply electrical and mechanical noise floors.

Non-Reverberant Environment

The test chamber would ideally absorb all of the generated stimulus reflections at all frequencies, essentially a full anechoic chamber. This is not feasible due to large size requirements, excessive cost, and reduction in throughput; however, a table top acoustic test chamber meets most of these considerations.

Because of the acoustic test chamber's small internal dimensions, a typical anechoic chamber SPL vs. distance mapping is not practical. Instead, the microphone stimulus (loudspeaker) was used to energize the chamber volume for 5 s before decay times were measured. The stimulus loudspeaker is electronically protected providing adequate energy from 315 Hz to 20 kHz. Ten RT60 measurements were recorded and averaged; however, as absorption α approaches one, RT60 approaches zero and the smallest perturbation in time recorded, typically several milliseconds, results in large variations in calculated absorption. Consequently, further study and measurements are required using time-domain analysis.

While measured absorption coefficients could not be measured, a description can be provided: the absorber thickness on the end walls in the direction of the sound wave is 46 cm and 25 cm while the ceiling, floor and other two walls used 15 cm thick absorption.

Stable Time-Invariant Stimulus

The test signal generated should be time-invariant, nominally linear with respect to frequency and output, provide adequate sound pressure level, and ideally, propagate a plane wave. Loudspeakers are extremely inefficient: A typical cone loudspeaker has an efficiency of 88 dB/W/m. This equates to an electrical efficiency of 0.4%. The other 99.6% of electrical input is rejected as heat causing the voice coil and magnet to increase in temperature. The increase in material temperatures causes the loudspeaker's output to decrease, a phenomenon referred to as "power compression" and effectively decreases efficiency resulting in a nonlinear output. The increase in material temperatures can require two to four times the electrical power to overcome power compression losses. Essentially, the loudspeaker varies with respect to time and is unacceptable as a stable stimulus.

The loudspeaker chosen for the acoustic test chamber is extremely efficient, about 108 dB/W/m approaching 40% efficiency. At 108 dB, the acoustic test chamber loudspeaker needs to reject only 0.6 W, of heat thus providing a time-invariant stimulus. At the same 108 dB, the aforementioned cone loudspeaker would need to reject 99.6 W of heat not including power compression. In practice, the cone loudspeaker needs to be housed in its own enclosure further degrading its ability to reject heat. However, the acoustic test chamber loudspeaker does not require a rear enclosure; its motor is mounted in free air and is able to reject heat easily (see **Photo 2**).

Providing adequate sound pressure is another stimulus requirement. The acoustic test chamber loudspeaker is capable of producing in excess of 125 dB from 400 Hz to 20 kHz; however, power compression would have to be considered at those levels.

The last consideration is that the stimulus generate a signal whereby the reference mic and DUT mic receive the same signal. If the wave front is planar or near planar, this objective is achieved. However, most loudspeakers create a hemispherical wave front whose radiation pattern begins to "beam" at higher frequencies. If the

Photo 2: Externally mounted loudspeaker

distance between the loudspeaker and the mic is sufficiently large, the wave front approaches a plane wave. The distance between the acoustic test chamber's loudspeaker and the microphone is approximately 85 cm.

Repeatable Positioning of the Microphones

To determine repeatability, the same DUT microphone was measured 10 times at a distance of 3 cm from the reference microphone and 85 cm from the stimulus loudspeaker. Each time, the DUT microphone was unloaded and re-loaded. In a production or a research and development lab environment, a fixture would insure the DUT microphone was loaded in the exact same location. However, in this test, a permanent DUT microphone fixture was not used; consequently, the DUT microphone's location varied by ±3 mm. Despite the variance in the DUT microphone's location, the repeatability was a maximum of ±0.20 dB and typically ±0.10 dB. At 1 kHz, the repeatability was ±0.08 dB (see **Figure 5**).

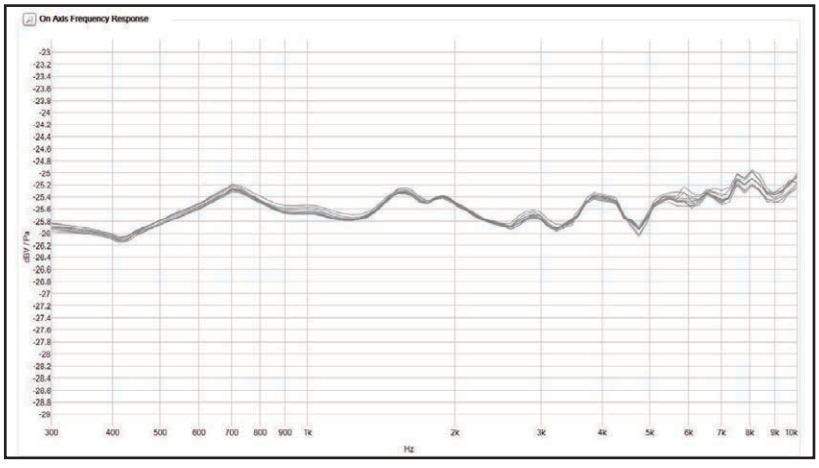


Figure 5: Ten DUT measurement repetitions

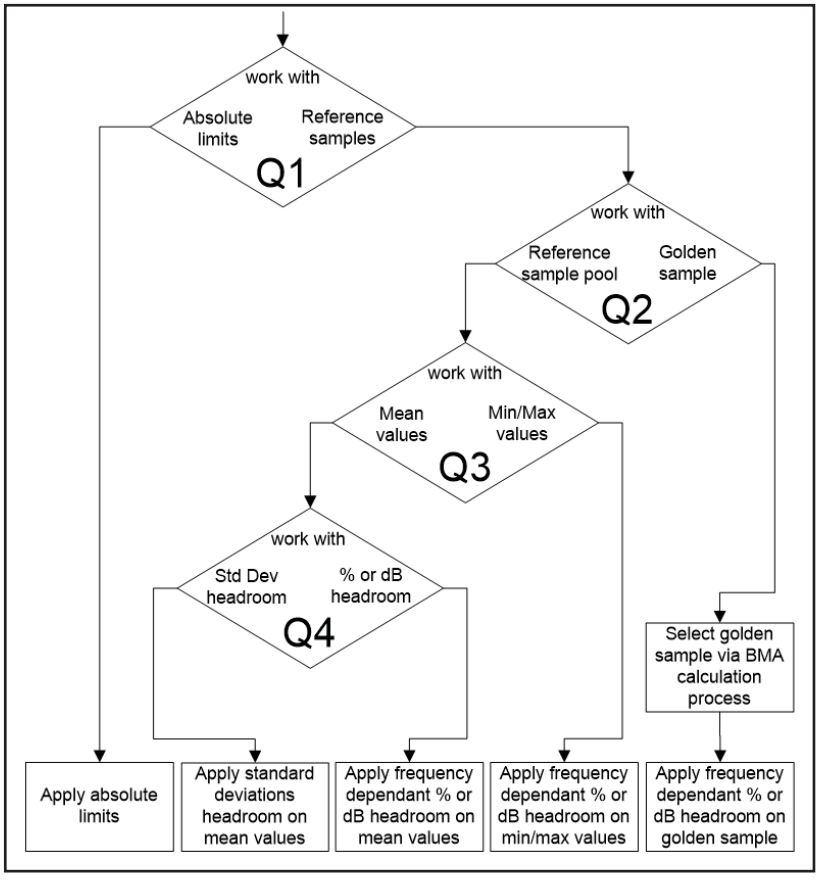


Figure 6: Generic limit calculation decision tree

Parametrizing the Test System

The stimulus signal shall cover the required frequency range for the microphone under test. Of course, the reference loudspeaker must cover that frequency bandwidth also. The duration of the stimulus sweep signal is predominantly depending on the start frequency. The lower the start frequency, the longer the sweep duration. A 100 Hz to 20 kHz sweep for example will require 1 s to 2 s. Once the test results are stable, the sweep duration can be reduced stepwise until the results start to deviate.

The sound pressure of the test signal shall correspond to the conditions stated on the microphone specification sheet. The SPL shall be high enough to provide an appropriate SNR under the actual test conditions. The reference loudspeaker must be able to provide that SPL within its linear operating range.

Ideally, all measurement parameters are determined from one stimulus signal. However, if certain measurements require a different frequency bandwidth and/or a different test level, multiple stimulus signals might be applied.

Sensitivity Calculation

The sensitivity of the microphone under test is calculated from the frequency response measurement. Depending on the microphone specification, the sensitivity is determined at either a single frequency, a number of defined frequencies, or a frequency band.

Limit Definition

There are various methods and strategies to define limits for a microphone test. A detailed process is described in a 2011 Audio Engineering Society paper on loudspeaker production measurement limits, called "A Systematic Approach to Measurement Limit Definitions in Loudspeaker Production." The major decision is to

work with absolute limits (i.e., from a specification) or to use one or several golden samples. The decision process is shown in **Figure 6**. The limit-finding strategy should be evaluated for each measurement function separately.

Typical measurement functions for absolute limits are frequency and distortion response, as well as all derivate results such as sensitivity. When using absolute limits for acoustic measurements, it is important to know the condition within which the limits are valid (e.g., free field). If the acoustic condition in the EOL test is different, the measurement result must be corrected accordingly. Reference samples are usually used when no objective specification is available (e.g., for Rub & Buzz).

Component vs. Device Testing

When testing the microphone as a component, the output signal is available in an analog or digital audio signal format. A simple closed-loop measurement setup is possible.

When the microphone(s) is/are embedded into a device or module however, not all of the before-mentioned assumptions might apply. Some devices might not allow a closed loop signal chain because the microphone signal cannot be routed directly to an audio output. In such setups, using an open loop test setup is very useful. The test signal from the reference loudspeaker gets recorded and played back at a different time with significant and variable delay. The solution for that is to use a trigger signal as header before the actual sweep signal. This way, the signal generation and the signal analysis can be separated timewise.

When testing devices or modules with microphone arrays, the individual array microphones might be tested individually if the configuration of the module allows to do so. Alternatively, the module might be tested with several off-axis measurements to ensure the function of each microphone (see Figure 3) and the array signal processing.

Maintaining the Test System

Calibration procedures for the devices in the setup as well as the complete microphone test system ensure the accuracy of the measured results. In device calibrations, the measurement result of a single device is compared against a highly-accurate reference of that measurement, and if necessary corrected. Device calibrations are usually performed annually by the device manufacturer. These are standards-traceable calibrations under The International Organization for Standardization (ISO) or other quality systems. Typical devices for a calibration in a microphone end-of-line tester are the audio analyzer, and the reference microphone.

A system calibration is a procedure that is executed by the operator with a DUT connected to the test system. It involves:

- Calibrating the input voltage to the reference loudspeaker so that the SPL level at the reference microphone is as specified.
- Characterizing or equalizing the frequency response of the reference loudspeaker.
- Calibration of the reference microphone sensitivity with a microphone calibrator.

Mechanics and Hardware

Some parts of a microphone EOL test system are vulnerable to wear and tear and should be checked or renewed periodically.

- The electrical contacts that connect the DUT microphone to the test system often shows wear from friction or contamination, resulting in increased resistance or total loss of connection.
- The reference microphone membrane can be contaminated by dust and dirt. This can cause changes in microphone frequency response and sensitivity. An easy prevention is to use a dust cap and exchange this periodically.
- The reference loudspeaker membrane can also be affected by dust, dirt or particles. This causes unwanted signal components that can falsify the measurement results.
- The mechanical fixture that holds the DUT microphone needs to be checked for the correction position, especially if it is mechanically adjustable.

System Check

Some manufacturers require that the functionality of the microphone test system be checked at the start of each shift, mainly to verify that all parts are connected and switched on. This can be done by implementing a system check. A known reference sample microphone is tested against regular or even tightened limits. If it passes, the system is considered to be working correctly.

Data Handling

Almost every microphone manufacturer is required to be able to trace back the EOL test results of their products, especially when using a quality management system. This typically allows tracing back the factory location, manufacturing date and production line number.

For the data logging, this means that the EOL test software must be able to log several complementary data besides the measurement results, such as date and time, calendar week, project name, operator name, and serial or batch number as well as environmental data (e.g., temperature and humidity).

Backup and Recovery Plan

To guarantee high availability of the EOL test system, it is advisable to be prepared for disasters. Obviously, it is a good idea to have spare parts of all elements of a test system, especially for the ones that have a high risk of being worn out or damaged. But also, there should be documented procedures on any configuration steps that need to be done in case of an exchange. For example, when exchanging the reference microphone, the sensitivity of the new reference microphone must be configured in the test system. This minimizes the system downtime.

To be prepared for an IT disaster such as a PC or hard disk failure, a regular backup of system and project settings is recommended. Again, a documented procedure on how to restore the data helps to setup a new system quickly and efficiently, thus reducing downtime.

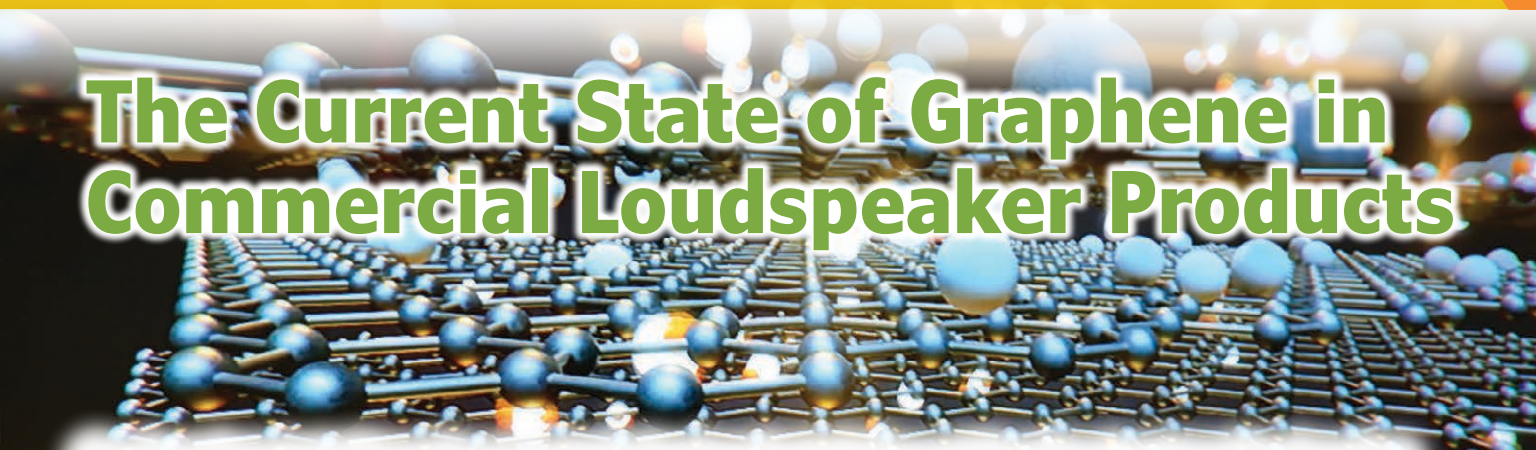
Conclusions

The measurement functions performed in an EOL test are selected by the microphone type and its specification. The reference loudspeaker is selected by its technology, frequency bandwidth coverage, flatness and required power. Special attention might be required to lead off heat. The test system must be able to monitor, equalize or correct any loudspeaker drift. The acoustic environment must provide reproducible, anechoic and low noise conditions. Test parameters are defined according to specifications where possible. Otherwise, reference measurements are used. Finally, proper maintenance and periodic calibration ensures constant precision and accuracy. ***LIS***

Resources

G. Schmidle, "A Systematic Approach to Measurement Limit Definitions in Loudspeaker Production," Audio Engineering Society Convention 131, October 2011, www.aes.org/e-lib/browse.cfm?elib=15998

The Current State of Graphene in Commercial Loudspeaker Products



Graphene has started to make waves in the loudspeaker industry, catching the attention of loudspeaker designers and consumers alike. Graphene promises lower distortion, increased bandwidth, improved transient response, and a host of other potential improvements over the standard materials we have become accustomed to such as paper, aluminum, Polypropylene, and PET. Products have started to hit the consumer market with claims of "graphene drivers." But what does that mean? Do these drivers actually use a single atomic layer of two-dimensional carbon atoms to produce sound? Robert-Eric Gaskell, one of the leaders in graphene acoustics and co-founder of Ora Graphene Audio Inc., reports on the current state of graphene loudspeaker commercialization. Gaskell takes a look at the various graphene loudspeaker technologies currently in development and presents an analysis of some of the commercially available products claiming to use "graphene drivers."

By
Robert-Eric Gaskell Ph.D.

Graphene is a new material with a huge potential. It has very interesting electrical properties and it is the strongest and lightest material ever isolated. When work on graphene began at the University of Manchester in 2004, there was a lot of excitement around this "wonder material." Graphene may one day improve all sorts of products, from super computers to tennis shoes and, of course, loudspeakers. Graphene has an extraordinarily high Young's modulus (a measurement of material stiffness) as well as a very high loss factor (a measurement of the internal damping of a material), and a low density making it ideal for loudspeaker membrane applications.

Still, as with most new materials, a significant amount of research and development is necessary to fully take advantage of graphene's properties. Applying graphene to consumer loudspeakers requires advancements in the graphene materials and in loudspeaker designs as well as in graphene manufacturing so that the new loudspeakers can be manufactured economically and at scale. Work in this area has been ongoing and there are many different techniques that have been developed to apply graphene to loudspeakers. This article will review the most common methods being explored today. A couple of these methods have become mature enough that consumer products are available on the market using the technologies. In order to better understand what advantages graphene is providing in current, commercially available graphene audio products, both laboratory measurements of the materials as well as acoustic tests of the products were performed. Raman spectroscopy was used to investigate the material composition of the membranes and dynamic mechanical analysis (DMA) was used to test the properties of the membranes. The drivers themselves were subjected to acoustic tests to explore the impact that graphene has on loudspeaker performance.

Background

History will likely look back at this period as the "Wild West" of graphene commercialization. There are currently no regulations or standards insofar as what can be marketed as "graphene."

Unsubstantiated claims are being made not only in the loudspeaker industry but in many segments where graphene has shown potential to improve product performance. In a recent article about a loudspeaker company working to develop graphene transducers, the CEO is quoted as saying "We've expanded the definition of graphene to a three-dimensional structure…" For those familiar with graphene, this statement simply makes no sense. Graphene is defined as a two-dimensional material which, in its pristine form, is only one atomic layer thick. Graphene's surface area is constructed from a hexagonal crystal lattice of carbon atoms. Each carbon atom has six electrons so, in a 2D lattice, the carbon forms a perfect "honeycomb" structure. Single crystalline layers of carbon atoms can be stacked together to from multi-layer graphene as long as each layer consists of a continuous hexagonal lattice. Many different types of graphene exist but a big issue, not only for the loudspeaker industry, is that not all raw materials marketed as "graphene" truly meet one of the definitions for what can be considered graphene.

Commercially, graphene is typically sourced from suppliers who specialize in producing small flakes of carbon materials. Suppliers generally offer multiple products claiming to be either single-layer graphene flakes, multi-layer graphene flakes, or graphene-oxide flakes. These flakes will have a very small surface area, on the order of a few square microns, and are at most a few nanometers thick. Flakes must be further processed to form larger sheets of graphene or to make them applicable to products or laboratory research. As it turns out, not all graphene flakes are created equal. In a recent 2018 paper in the journal *Advanced Materials* co-authored by one of the Nobel Prize winners for first isolating graphene, Konstantin Novoselov, Kauling, et al. call for standardization. [1] The authors look at the raw "graphene" flakes provided by 60 producers across the globe, running tests and categorization analysis on the materials. In conclusion, the authors state that "It is shown unequivocally that the quality of the graphene produced in the world today is rather poor, not optimal for most applications, and most companies are producing graphite microplatelets." Organizations such as the National Physical Laboratory (NPL) and the National Graphene Institute (NGI) at UK's Manchester University are working to implement standards (see **Figure 1**).

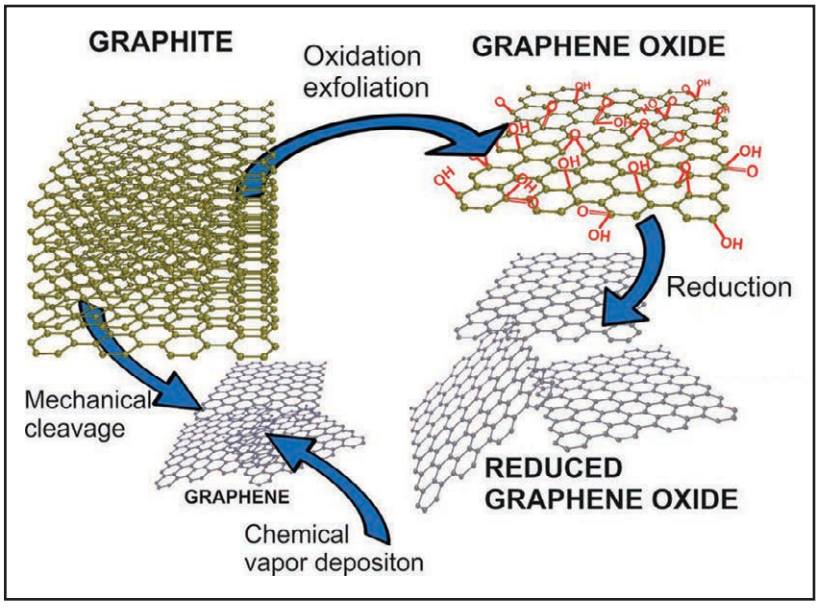


Figure 1: This chart shows the various states of carbon. Graphite can be processed to form graphene or graphene oxide. Graphene oxide (GO) has oxygen groups that hang off the 2D layer of carbon allowing crosslinking. GO can also be reduced to remove the oxygen leaving only graphene.

Currently, only a few standards exist that address the classification of graphene materials. NPL published its first ISO graphene standard in 2017 defining the appropriate language to use when talking about graphene materials. The International Organization for Standardization (ISO) standard 80004-13:2017 suggests categories for "graphene," "multi-layer graphene," "graphene-oxide," "graphite microplatelets," and more.

Despite being published in the ISO, the standard has not been widely adopted by manufacturers and there is no requirement for manufacturers to adhere to the standard when naming or marketing of their products. From the consumers' perspective, a product advertised as using graphene may not actually achieve any real-world advantages as the result of the use of graphene; worse yet, this means the "graphene" used in the product may not actually even be graphene.

Graphene in Loudspeakers

There are currently several methods being researched and developed to apply graphene to improve loudspeakers. The five most prominent methods are: 1) Using continuous sheets of single or multi-layer graphene, deposited onto a substrate to form the diaphragms of small electrostatic transducers; 2) functionalizing graphene with oxygen and other crosslinking elements to form freestanding graphene oxide (GO) membranes; 3) Using graphene or graphene oxide to create thermo-acoustic transducers with no moving parts; 4) Mixing in flakes of graphene or graphene oxide

to polymers and compounding carbon-loaded plastics; and 5) Using adhesives to coat polymer sheets with a thin layer of graphene flakes.

Other uses of graphene in loudspeakers also exist. For example, SEAS has developed a protective paint using graphene that can be applied to magnesium cones in order to protect the magnesium and prevent oxidation.[2] However, in this case, graphene is not improving the fundamental audio performance of the loudspeaker, only the speakers' environmental stability. The applications of graphene that are of the most interest for loudspeakers are those that have the potential to improve audio quality.

Method #1: Pristine or Few-Layer Graphene in Electrostatic Loudspeakers

The first application, using graphene in electrostatic transducers, has some significant barriers toward commercialization. Scalable, cost effective methods of producing continuous sheets of pristine graphene do not yet exist. Even to make graphene membranes large enough to use in tiny earbuds or hearing aids requires a process called chemical vapor deposition (CVD). This is a slow process where graphene is grown from small carbon containing molecules such as methane onto a suitable substrate. CVD is a relatively expensive and time-consuming process that produces a significant amount of hazardous waste.

Patents from UC Berkley[3] and Infineon Technologies AG[4] both describe methods to apply graphene to electrostatic loudspeakers. The company Graphaudio in California has licensed the Berkley patent and is actively working on commercializing very small graphene electrostatic transducers. A major drawback to the electrostatic embodiments is that the graphene layers require a substrate for support. Unfortunately, the substrate either becomes part of the transducer membrane, reducing the benefits of the graphene by adding the mass and relatively low Young's modulus of the substrate to the membrane's overall mechanical properties or the substrate needs to be etched away in another time-consuming process that requires more hazardous chemicals.

Method #2: Graphene Oxide Loudspeaker Membranes

The second method, graphene oxide (GO) loudspeaker membranes, was invented by researchers at McGill University and is under development by the company Ora Graphene Audio, Inc. [I'll break the third wall here and point out that I am one of those researchers and a co-founder of Ora. While I will attempt to keep this article focused on the science and measurement, it is important to call attention to my bias].

Graphene oxide allows a unique advantage relative to other graphene materials because free-standing membranes of graphene oxide can easily be produced that do not require a substrate for support. As a result, the total membrane has a very high percentage of graphene. GO is produced as single or multi-layer graphene flakes but then undergoes an additional step where the graphene is functionalized with oxygen groups that hang off the flake, perpendicular to the carbon crystal lattice. These oxygen groups allow the GO flakes to crosslink such that many layers of graphene flakes can be strongly bonded together.

The resultant material takes advantage of the low density and high Young's modulus of pristine graphene and, although GO is only about 1/10th as stiff as pristine graphene, it is far more economical and scalable to produce in large surface areas because the GO flakes will self-assemble into layers, and GO membrane manufacturing does not require expensive processes such as CVD (see **Photo 1**).

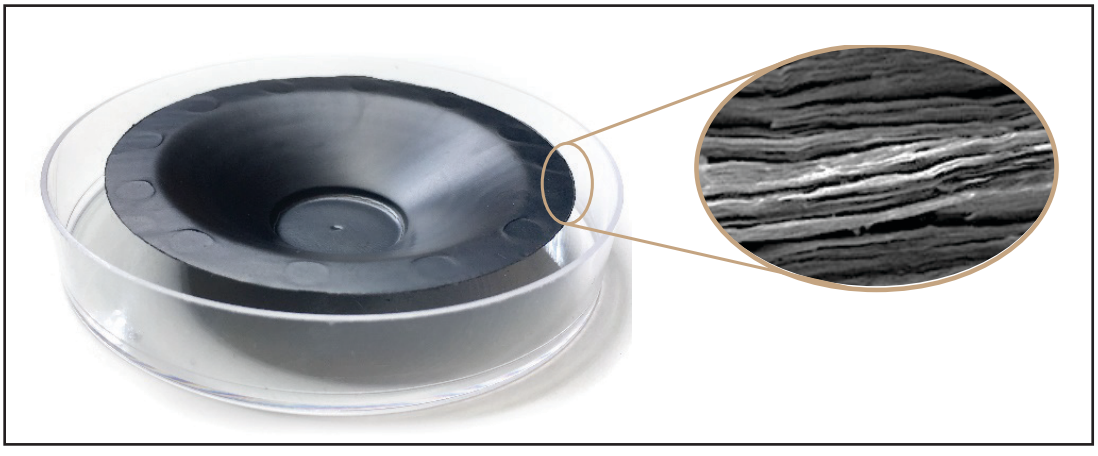


Photo 1: Ora's GrapheneQ in a 3" loudspeaker cone. An electron microscope image of the edge of the cone shows GrapheneQ's laminate nanostructure. Flakes of graphene are bonded together with crosslinkers to produce a multi-layer graphene oxide material.

Method #3: Graphene-Based Thermoacoustic Loudspeakers

Thermoacoustic applications are very exciting as they promise acoustic transducers with no moving parts. This method leverages the high electron mobility in graphene to rapidly heat and cool a surface which, in turn, expands and contracts air molecules producing pressure waves. Prototypes have been made in laboratories but the technology is limited in its bandwidth and output capabilities. Graphene thermoacoustic transducers will require significantly more development before solutions for consumer products are possible. Korea's KAIST, researchers at the University of Exeter, and the Taiwanese company Enerage, among others, are working on solutions for graphene-based thermoacoustic loudspeakers.

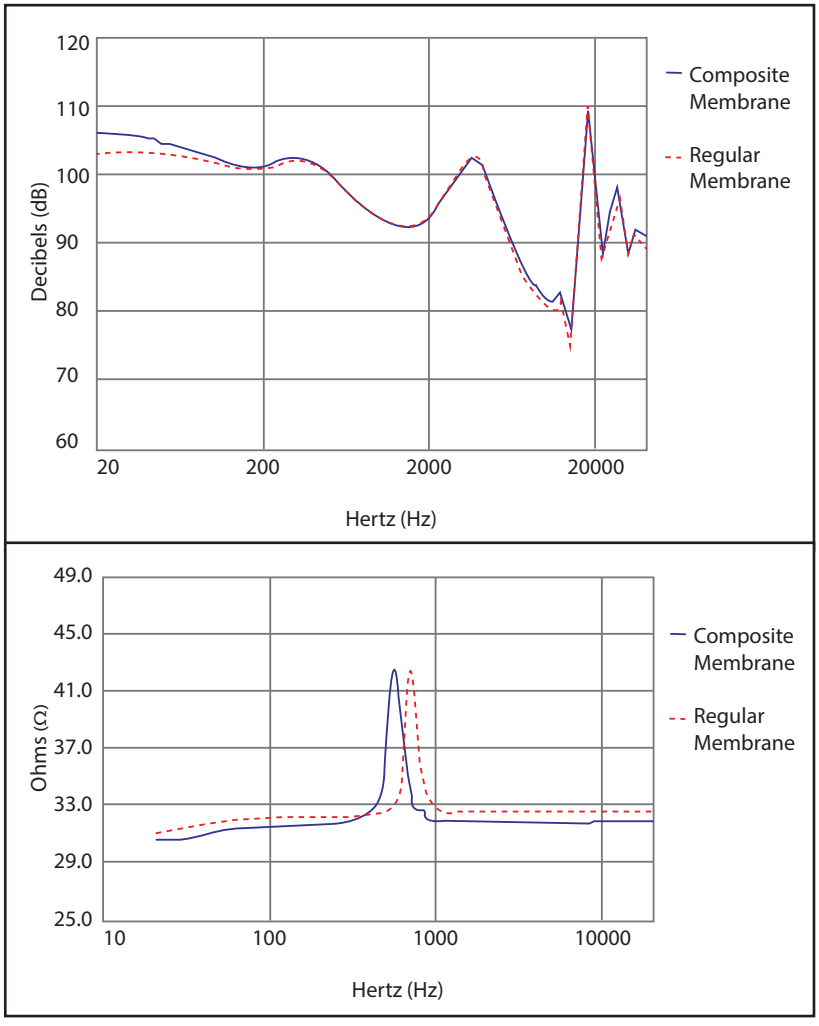


Figure 2: Frequency response (left) and impedance (right) of a standard PET driver (dotted) vs and graphene coated PET material (black). There appears to be no significant difference in performance between the coated PET and the original PET with the exception of additional mass shifting F_0 down in frequency and producing slightly more bass.

Method #4: Polymer-Graphene Compound Loudspeaker Cones

Compounding graphene flakes into polymers is the most common method of applying graphene to other consumer product segments including tennis rackets, running shoes, skis, fishing poles, and so forth. There are many companies producing materials like this including Montreal-based NanoXplore and New York-based Graphene Supermarket. In this method, a small percentage of graphene flake can be mixed, or "compounded" with various different polymers to affect the polymers' mechanical properties. These graphene-loaded polymers can either be extruded into flat sheets and thermoformed or injection molded into loudspeaker cones or domes. Loading polymers with carbon materials is not new. There are many commercially available materials that already use graphite and other forms of carbon in polymers to modify material properties.

The addition of graphene to polymers results in graphene flakes suspended within the polymer matrix. The graphene flakes are not oriented in any particular way, do not connect to each other, and do not form continuous graphene layers. Still, polymer-graphene compounds show some exciting results often doubling or as much as tripling the Young's modulus of the polymer through adding 3%-5% graphene. This can be achieved without adding much additional mass or density to the polymer due to the low weight of the graphene flakes.[5]

While graphene-loaded polymers offer a significant improvement over polymers alone, they still cannot compete with the Young's modulus and overall figure of merit of many other loudspeaker materials. The technique does have potential. Apple, Inc. even has a patent[6] on using this method to selectively stiffen portions of a loudspeaker membrane although no Apple products have yet employed this technique. It would not be surprising to see graphene-loaded polymers begin to make their way into loudspeakers in the not too distant future.

Method #5: Graphene-Coated Polymer Loudspeaker Membranes

This method uses adhesives to stick flakes of graphene to the surface of polymers such as Polyethylene terephthalate (PET) and Polypropylene. The method is similar to compounding polymers with graphene in that the graphene flakes are randomly oriented and do not connect with each other to create a continuous layer. This approach is even more limited than Method #4, however, since the overall percentage

of graphene in the material is far lower than in polymer compounds. When coating, the graphene only sits on top of the polymer material rather than integrating into the polymer matrix.

There appears to be a Chinese patent[7] covering this technique. In the abstract of this patent, the method is described as: "the steps of: adding the graphene or the mixture of the graphene and the graphite powder to the diluent, and mixing evenly to form graphene suspension or graphene-graphite powder suspension; coating the graphene suspension or the graphene-graphite powder suspension on the surface of a base material; and coating glue on the surface of the strengthened layer, and drying the surface."

Gluing graphene flakes to the surface of a polymer is a simple and cost-effective method to add graphene to loudspeaker membranes. The amount of graphene in the membrane relative to the amount of polymer and glue, however, is very low. Intuitively, one may not anticipate a significant contribution from the graphene. Indeed, in the figures of the patent (see **Figure 2**) there is a slight downward shift of F_0, which would be expected from the additional mass of the carbon and glue, but there does not appear to be any significant improvement in overall frequency response. The shift in the impedance results in some additional low frequency energy but the performance of the membrane at high frequencies, where the benefits of graphene would be anticipated, is unchanged.

Commercially Available Graphene Loudspeaker Products

Of the five methods listed, only two are currently being used in commercially available products. At least one company has claimed to use Method #4, graphene compounded in a polymer cone, but has since changed their marketing to more accurately reflect the use of a material similar to Arkema's Graphistrength that uses carbon nanotubes, not graphene, dispersed in polymers and thermoplastics. Method #2, graphene-oxide cones and domes, is now available from Ora in its GQ headphones. Ora expects to provide this technology to other audio manufacturers within the next year.

The vast majority of "graphene" audio products on the market today use Method #5, graphene-coated polymers. Products from several Chinese headphone manufacturers have begun to advertise "graphene drivers" using this type of material. Established, legacy brands in North America, Europe, and Japan are yet to apply these types

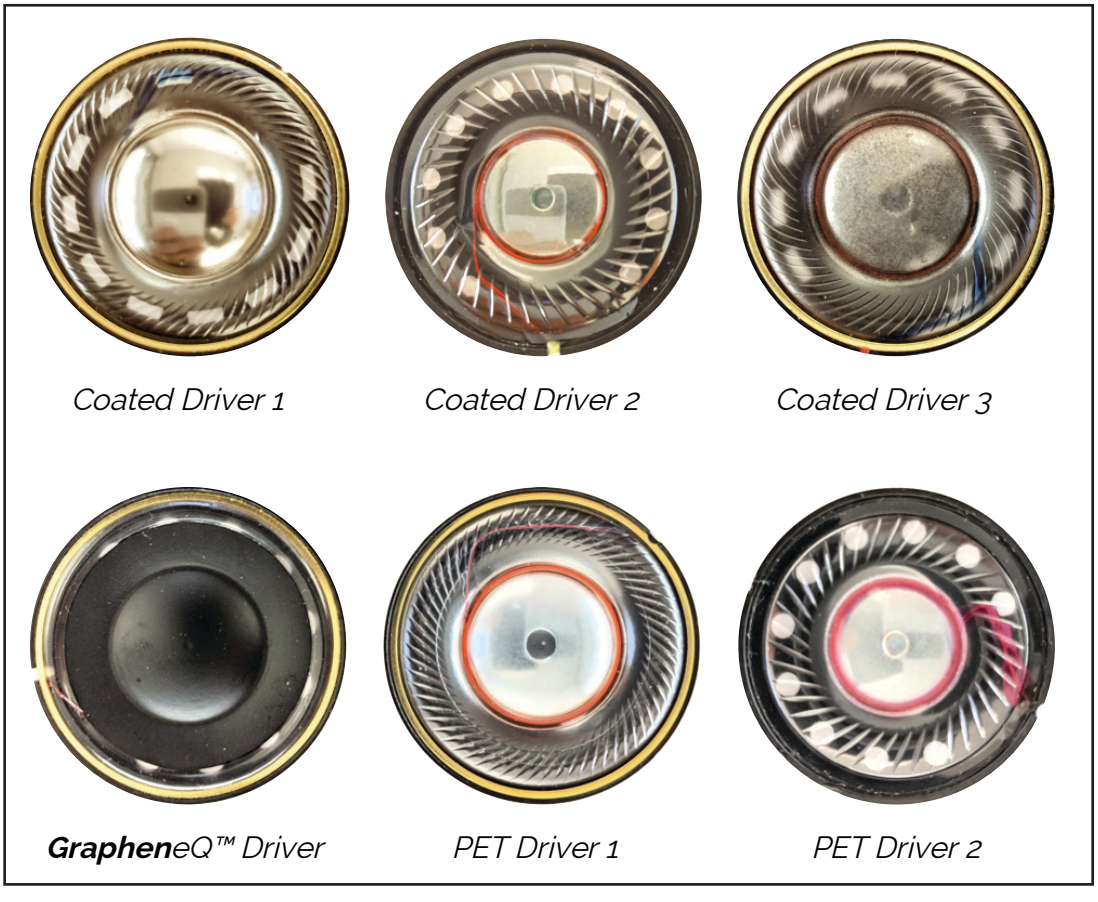


Photo 2: The six headphone drivers tested. The coated drivers exhibit a slightly grey/brown coloration, while the PET drivers both have crystal clear membranes. Ora's GrapheneQ membrane has a dark black coloration. All drivers are a standard 40 mm diameter.

of materials in their products. Chinese brands employing "graphene" coated polymers in their headphone and earbud products have made some bold claims about the advantages of these materials. It is not uncommon to see product descriptions of "graphene" headphones suggesting "graphene drivers produce next-level HD audio experience," or "Pioneering Graphene-Enhanced technology produces exceptional clarity, delivering dynamic sound with deep bass and clear treble," and "Graphene-Enhanced: a wafer-like thin layer of carbon. Extra rigid, super-lightweight graphene-coated drivers ensure precision oscillation."

To better understand the real-world advantages of adhering graphene flakes to the surface of polymer loudspeaker membranes, several commercially available headphone products were purchased and the performance of the drivers was measured. The materials were also analyzed in the laboratory, viewing them under a high-magnification microscope, testing their mechanical properties, and performing Raman spectroscopy to reveal the chemical makeup of the membranes.

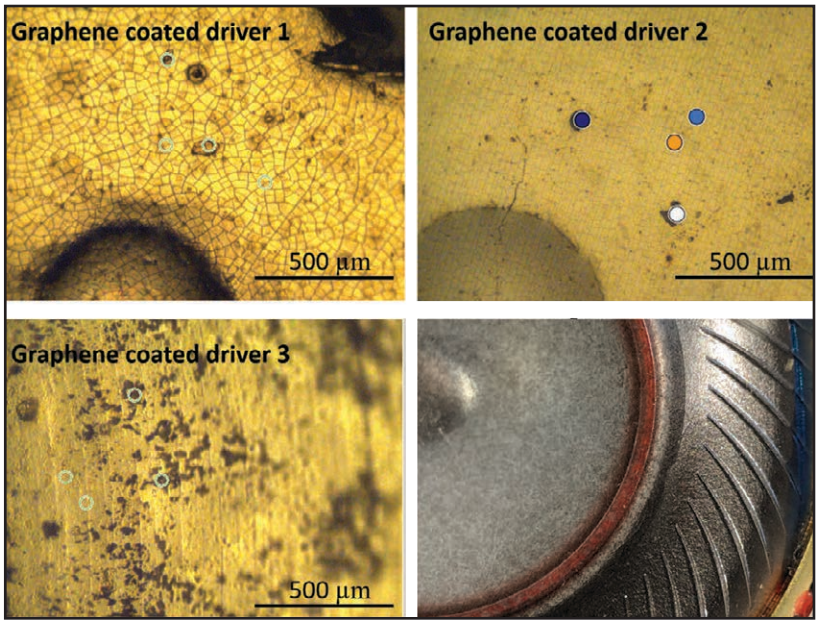


Photo 3: Top: 20× optical microscope image of coated Drivers 1 and 2. Bottom: 20× optical microscope image of coated Driver 3 (left) and 2x close-up photograph of coated Driver 3 showing detail of visible speckling on surface. In all three coated drivers, the "graphene" flakes are randomly distributed onto PET with no consistent orientation and no connection between flakes. Superimposed circles indicate Raman measurement areas.

About the Author

Robert-Eric Gaskell is an audio researcher, electronics designer, and Juno award-winning recording engineer. He holds a PhD in Sound Recording from McGill University where he continues to teach courses in analog and digital electronics. Dr. Gaskell began his career designing and manufacturing ribbon microphones for AEA in Pasadena, CA. Since then he has published extensively on the influence of electronic components on listener perception of sonic character and quality in audio reproduction. Along with a team of researchers at McGill University, he developed and patented the use of graphene oxide in acoustic transducers. In 2016, Dr. Gaskell co-founded Ora Graphene Audio, Inc. to further develop and commercialize this graphene loudspeaker technology.

Analysis of Commercially Available Graphene Membrane Materials

In order to observe a wide range of materials, headphone products from three different brands were purchased. All three selected products used standard 40 mm headphone drivers so that acoustic measurements could be made to directly compare the audio performance of these coated drivers with common PET drivers as well as Ora Graphene Audio, Inc.'s GrapheneQ drivers. Altogether, six drivers were tested: three graphene coated polymer drivers, Ora's GrapheneQ driver, and two standard PET drivers (see **Photo 2**).

Optical Microscope

Viewing these materials under a high magnification (20×) microscope allows for both a visual inspection and an intuitive understanding of how graphene is contributing to the mechanical properties of a material. Without magnification, it is still possible to observe that the coated membranes are speckled with small bits of grey/brown materials. Under extreme magnification, it is possible to view how the carbon flakes are distributed on the surface of the polymer. The three coated drivers vary in the amount of material as well as the size of the flakes adhered to the surface of the membranes. It is quite obvious that for all three drivers, the flakes do not connect with each other and do not form a continuous layer of graphene (see **Photo 3**).

Raman Spectroscopy

As Kauling, et al. point out in their recent "Advanced Materials" publication[1], not all graphene is created equal and, in many cases, much of it should not actually be considered graphene. Raman spectroscopy is a method that reveals the chemical make-up of a material. If there is hexagonally bonded carbon present, Raman will exhibit strong peaks around 1350 and 1580 cm^{-1} corresponding to the D and G band of graphitic carbon. Other materials also have distinct signatures. PET, for example, produces strong peaks at 1615 and 1726 cm^{-1}. Using Raman, the membranes of all three coated polymer drivers were compared to an Ora GrapheneQ membrane,

a typical PET membrane, a polycarbonate material, and graphene polymer compound made from polycarbonate loaded with 5% graphene flakes.

Both the GrapheneQ membrane and the graphene-loaded polycarbonate show distinct peaks that one would expect when graphene is present (see **Figure 3**). The PET membrane has a different, distinct signature that can also be seen in Coated Driver #2. Coated Drivers #1 and #3, however, show a lot of noise likely as the result of impurities in both the PET, the adhesive, and whatever the "graphene" material is speckled on the membrane's surface. None of the coated drivers show any indication of the distinctive graphene Raman signature.

DMA Measurements

Dynamic mechanical analysis (DMA) is a method of testing the viscoelastic properties that influence the performance of a material in a loudspeaker. DMA can be used to measure the Young's modulus (material stiffness) and loss factor (internal damping) of a material. For the DMA comparison, a frequency of 10 kHz was selected as the baseline frequency since this is in the range of where speaker break-up typically occurs for 40 mm headphone drivers. Loudspeaker break-up produces peaks and dips in the frequency response and introduces additional distortion often leading to a "harsh" sound quality.

All of the coated membranes measured approximately the same values. An average of the three different graphene coated polymers was compared to the mechanical properties of standard PET as well as the properties of pristine graphene, aluminum, and Ora's GrapheneQ. The

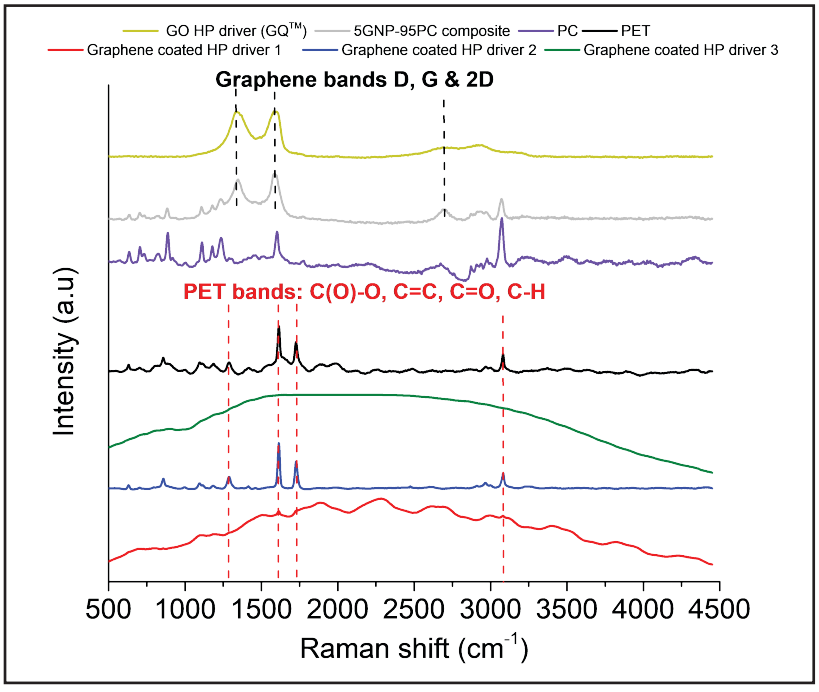


Figure 3: Raman Spectroscopy results from Ora GrapheneQ (top, yellow), graphene-loaded PC polycarbonate (grey), unloaded PC (purple), PET (black), coated Driver 3 (green), coated Driver 2 (blue), and coated Driver 1 (red). GrapheneQ and the loaded PC show distinctive peaks for graphene. Coated Drivers 1 and 3 exhibit a lot of noise and no graphene peaks are visible. Coated Driver 2 shows the distinctive peaks of PET but no graphene peaks.

	Young's Modulus E (Gpa) at 10 kHz	Density (g/cm³)	Loss Factor tan ∂	Speed of Sound (m/s) at 10 kHz	Poisson's Ratio	$FOM_a = \frac{v_s}{\rho} = \sqrt{\frac{E}{\rho^3}}$ FOM at 10 kHz
Aluminum	72	2.7	0.002	5164	0.33	1.913
Pristine Graphene (reported)	1000	2.27	0.05	20989	0.2	9.246
Polyethylene Terephthalate (PET)	4.9	1.38	0.034	1884	0.41	1.365
Graphene-Coated PET	4.9	1.39	0.034	1878	0.41	1.353
Polycarbonate	2.4	1.2	0.01	1414	0.4	1.179
Graphene-Loaded Polycarbonate 5%	3.55	1.21	0.01	1713	0.4	1.416
Ora Graphene Q (GO) as of March 2019	65	1.6	0.066	6374	0.2	3.984

Table 1: DMA test results for aluminum PET, "graphene" coated PET, PC, graphen-loaded PC, and Ora's GrapheneQ. Theoretical values fo pristine graphene are also provided. The properties of "graphene" coated PET are not significantly different than PET alone. The overall FOM is reduced in coated PET vs. uncoated PET. Ora's GrapheneQ has the highest FOM with the exception of the theoretic value for pristine graphene. A real-world pristine graphene membrane would require a substrate for support that would significantly reduce the mechancial properties of the membrane and the figure of merit (FOM).

DMA test results in **Table 1** show no significant improvement in the mechanical properties of the coated membranes over the performance of PET alone. In fact, the densities of the coated drivers were higher than that of uncoated PET with no shift in Young's modulus. The coating of the drivers appears to provide no benefit to the mechanical properties of the material. The figure of merit (FOM), a calculation of the first bending mode for a disk of a material, gives an overall value for how well-suited a material is for loudspeaker applications. The FOM is lower for the coated membranes than for the PET membranes suggesting that the coating would actually reduce audio performance, not enhance it. Ora's GrapheneQ has a FOM of 3.98 while pristine graphene, in theory, would have over double that: 9.25. In reality, the presence of substrates, layering, or impurities would likely result in a much lower FOM for pristine graphene loudspeaker membranes.

Acoustic Measurements of Graphene Headphone Drivers

Laboratory tests of the materials reveal some interesting results; however, the most relevant tests for these drivers are acoustic tests of their audio performance. The six 40 mm headphone drivers were all measured to allow apples-to-apples comparisons between standard PET, coated PET and Ora's GrapheneQ. It is important to note that these measurements are of the raw drivers, outside of the acoustics of their headsets. The measurements were made using an IEC 60318 compliant coupler for the low frequencies and, since these couplers are only accurate up to ~8 kHz, the measurements cross over to an IEC 268-5 compliant baffle for the high frequencies.

The graphs shown in **Figure 4** provide frequency response data from 10 Hz to 30 kHz. Ora's GrapheneQ driver stands apart from the rest of the group with a far smoother response that does not roll-off significantly at high frequencies.

Based on the acoustic measurements, it does not appear that graphene coated polymers offer any advantage over polymers alone. PET Driver 2 has the second best response after Ora's GrapheneQ driver with the coated drivers generally showing equal, if not worse,

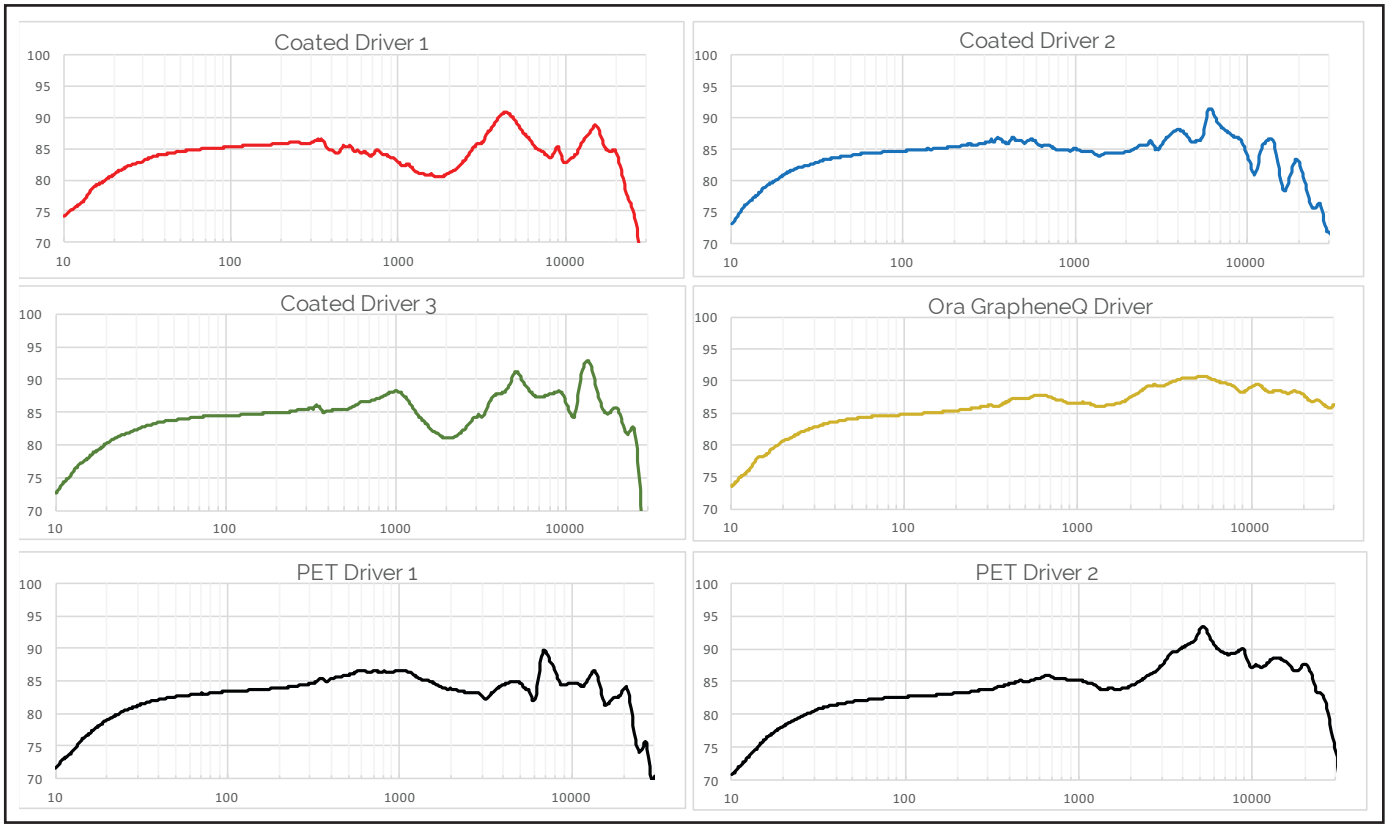


Figure 4: Testing the 40 mm headphone drivers: frequency response measurements for coated vs. uncoated PET drivers as well as Ora's GrapheneQ drivers. Measurements made with IEC 60318 coupler for low frequency and IEC 268-5 baffle for high frequency (above 2 kHz). Measurements shown from 10 Hz to 30 kHz. GrapheneQ has a much smother response than any of the PET drivers. The coated drivers show no significant improvement over PET alone and, are generally worse than the uncoated PET drivers.

performance compared with the uncoated PET drivers.

The good news is that two of the three graphene-coated PET headphone products studied did actually sound quite good in subjective tests and provided frequency responses close to Sean Olive's published Harman target response. While this likely has more to do with the acoustic tuning of the headsets than the use of "graphene" in the drivers, it would seem that when companies take the effort to apply these pseudo-graphene materials, they also pay a bit more attention to the product design and tuning.

Conclusions

There are many different ways to apply graphene to loudspeakers. Some of these methods are more effective than others. Graphene loudspeaker products should be judged, not on the presence of graphene but rather on how the graphene affects performance and audio quality.

All the different methods being developed to apply graphene to loudspeakers have their benefits and drawbacks. Electrostatic applications have the benefit of using pristine graphene but are limited by size, by the use of any support substrate, and by the cost to manufacture. Graphene oxide is limited by its maximum Young's modulus relative to pristine graphene but has the benefit of being free-standing and manufacturable at scale. Thermoacoustic methods are limited in their development but with more time, may have potential. Graphene-loaded polymers are very manufacturable but may not provide sufficient performance improvements to warrant the additional cost. Finally, graphene coating methods are extremely inexpensive but, as these measurements have shown, the "graphene" coatings do not appear to provide any appreciable performance benefits.

Graphene has an exciting future in the audio industry but most of what is advertised as having "graphene drivers" will not embody the true potential that graphene has to improve sound quality in thousands of consumer products across the globe. Graphene audio should not be judged on the performance of coated PET solutions; still, the presence of these pseudo-graphene products in the market shows the enthusiasm of consumers for the potential of graphene. There seems to be both a desire for better sound quality and an excitement for the prospects of what graphene audio will provide.

Technological advances take time to develop. From the time thermoplastics were first invented, it took nearly 100 years before widespread commercial applications were achieved.[8] Despite graphene's huge potential, it will require many incremental steps to fully exploit graphene in loudspeakers.

At Ora, we are excited to be releasing the first commercially available graphene loudspeaker product that truly takes advantage of graphene's unique properties and improves on the audio performance of standard loudspeakers. We are also excited for what the future holds as other methods to apply graphene to loudspeakers reach maturity. Other applications may eventually outperform Ora's graphene oxide technology but GrapheneQ is currently the only graphene loudspeaker solution on the market that provides real-world benefits over existing materials.

Graphene is an exciting new material but consumers curious about the acoustic benefits of this material must be aware of the different graphene loudspeaker technologies in order to cut through the marketing hype. Simply sprinkling some graphene on top is not sufficient to take advantage of this "wonder-material." This does not mean that graphene's benefits are limited, only that we still have more road ahead before graphene reaches its full potential for the loudspeaker industry. ***LIS***

Resources

[1]A. P. Kauling, et al.. "The Worldwide Graphene Flake Production," *Advanced Materials* 30.44, 2018: 1803784.

[2] "SEAS Graphene Magnesium Technology White Paper," SEAS Excel Graphene, February 2019, www.seas.no/images/SEAS_Graphene_White_Paper.pdf.

[3] Q. Zhou and A. Zettl, Patent No. WO 2014100012A1, 2016.

[4] A. Dehe and G. Ruhl, US Patent No. 9,516,428, U.S. Patent and Trademark Office, Washington, DC , 2016.

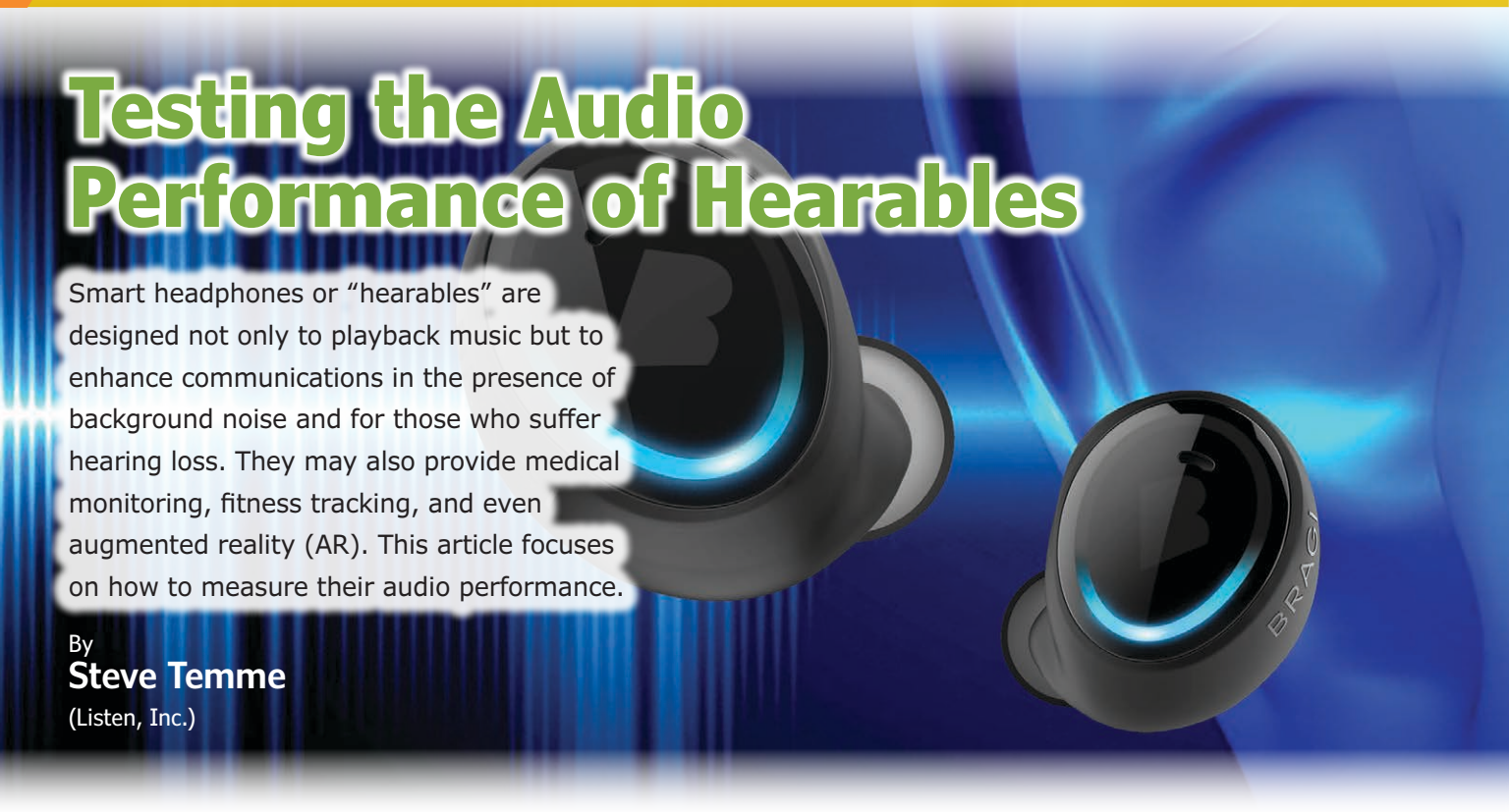
[5] R.J. Young et al. "The mechanics of Graphene Nanocomposites: A Review," Composites Science and Technology, Volume 72, No. 12, pp. 1459–1476, 2012.

[6] V. Luzzato, J. Poole, and C Prest, US Patent No. 20170006382A1, 2015.

[7] C. He, P. Yi, and X Meng, Chinese Patent No. CN 106060721A, 2016.

[8] S. Freinkel, "A Brief History of Plastic's Conquest of the World: Cheap plastic has unleashed a flood of consumer goods," *Scientific American*, May 2011, www.scientificamerican.com/article/a-brief-history-of-plastic-world-conquest

Testing the Audio Performance of Hearables



Smart headphones or "hearables" are designed not only to playback music but to enhance communications in the presence of background noise and for those who suffer hearing loss. They may also provide medical monitoring, fitness tracking, and even augmented reality (AR). This article focuses on how to measure their audio performance.

By
Steve Temme
(Listen, Inc.)

Hearables are notoriously challenging to test. They have various interfaces ranging from hardwired to wireless (e.g., Bluetooth) and contain much signal processing, both on the record side (e.g., beamforming, background noise filtering, and voice activity detection) and on the playback side (e.g., loudness, compression, equalization, and active noise cancellation). This means that their characteristics change according to "real world" conditions such as their physical environment and background noises. Some even have wake word detection (e.g., "Hey Siri").

Furthermore, their multifunctional nature means that there are many aspects of the device that may need to be tested, ranging from voice recognition to music playback or even operation as a telephone handset or hearing aid. Due to their complex nonlinear use cases, these devices often need to be tested at different levels and in different environmental conditions (e.g., with background noise, different signals, etc.).

Although, there are currently no standards for testing smart devices such as hearables, we can borrow principles and test configurations from many other audio devices, and use existing standards such as International Electrotechnical Commission (IEC) headphones, Institute of Electrical and Electronics Engineers (IEEE) headsets, European Telecommunications Standards Institute (ETSI) background noise, Telecommunications Industry Association (TIA)/International Telecommunication Union (ITU) telephone test, and American National Standards Institute (ANSI) hearing aids standards. Flexibility of the test system and experience with testing a wide range of acoustic devices is critical to enable a device to be completely characterized. In this article, we will discuss how to implement basic acoustic tests and some of the more complex real-world tests, along with the techniques and standards that may be used. Finally, we present a check list of the test-system functionality you should look for when selecting a system to fully characterize smart headphones or hearables.

Basic Acoustic Tests

Basic acoustic tests essentially measure the device under static conditions to evaluate microphone/microphone array and earphone characteristics such as frequency response, distortion and left/right tracking for stereo headphones. If possible, it is a good idea to measure both wired and wireless performance for comparison. This requires a calibrated headphone amplifier for wired headphone responses and a calibrated Bluetooth interface for wireless headphone responses. In addition, a calibrated mouth simulator equalized for a constant output level versus frequency, and ear simulators are required for both send and receive responses (see **Figure 1**).

In some cases, it is not possible to use a standard wired or wireless connection. Some headphones require USB-C or Lightning connections while some hearables (e.g., Alexa, Siri, Google, and Cortana enabled devices) will only respond to speech activation through wake words. While the measurements themselves are similar to standard headphone and microphone measurements, injecting the stimulus and extracting the recorded signal present can be challenging. Unless you happen to be the device's manufacturer and have access via a debugger or other remote access tool, or are testing headphone Bluetooth performance only, you have a true black box test solution. This is generally the case when comparing performance of different headphones, for example, for reviewing or competitive benchmarking. Without knowing what is inside the device under test (DUT), you need to get signals in and out of it, and the only way to do this is like an actual user—using real music and speech.

To further complicate matters, the test signal may need to be in the cloud to enable playback. Each manufacturer's ecosystem is different in how it plays back from the cloud. Some enable you to upload your own recordings (although you should bear in mind that these will probably be compressed). Others require them to be on a media streaming platform such as Spotify. For microphone testing, some systems such as Alexa allow you to access recordings you have made, whereas others do not for security and privacy reasons. This makes microphone testing challenging. Although the actual physical testing setup is very similar from one headphone brand to another, for each it is necessary to understand how to wirelessly route the signal. Furthermore, each device needs activating with a different wake word, has a different delay compensation, and records for a different amount of time after it hears the wake word. This, therefore, needs figuring out (largely by trial and error) for each headphone that you need to test.

The Test Setup

Let us first discuss the physical setup. At this point there are no test standards specifically written for hearables. Their practical use case, however, closely resembles headsets, so the physical geometry recommended by IEEE 269 is a good starting point. Following this, tests would be conducted with the hearable worn on a head-and-torso simulator (HATS) defined in **Figure 2**.

The setup includes an artificial mouth (contained within the HATS) to play the voice activation commands to the hearable's microphone(s), which is typically connected via Bluetooth to a smart phone. The smart phone communicates to the proprietary voice services in the cloud, such as Alexa Voice Services (AVS), that tells the voice services which uploaded test signal to stream/play back through the smart phone via Bluetooth to the hearable's earphones. The test measurement system uses a triggered record to capture both the left and right earphones' playback signals that can then be analyzed by the test system.

Let's now discuss the steps necessary to create a test. It is ideal to automate the test as much as possible, so wake words and test stimuli should be pre-recorded and uploaded so that they can be triggered by the test system.

First, we need to record the activation signal.

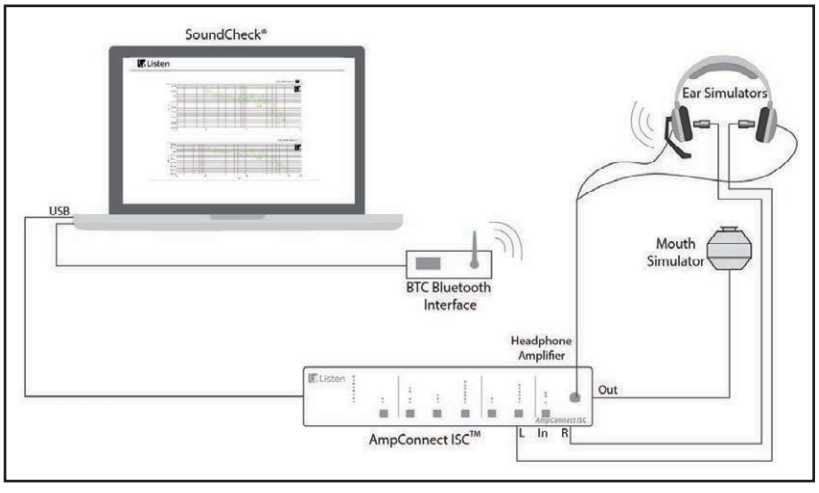


Figure 1: Test configuration for basic wired and wireless (Bluetooth) headset measurements

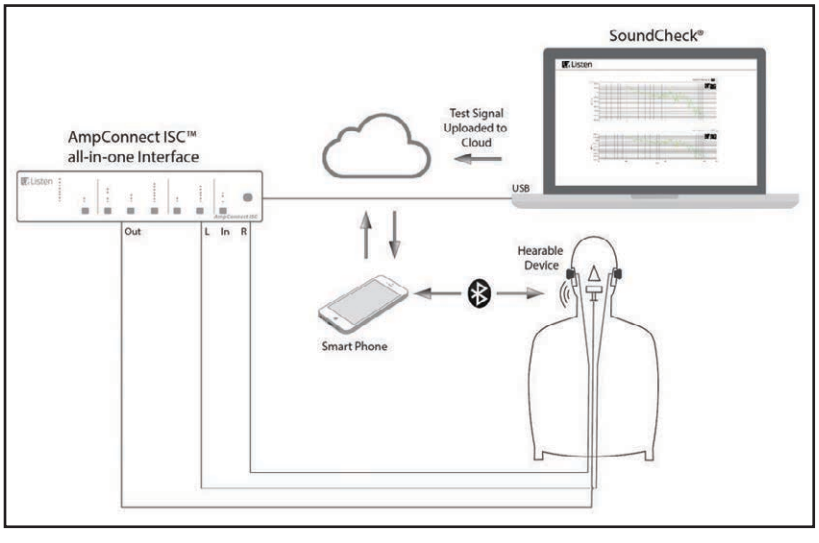


Figure 2: Test configuration for stereo headphone measurement using voice activation

This might be something like "Alexa, play test signal 1." Naturally, the system's appropriate wake word should be used. If a wide range of different voice services is being used, it makes sense to record the wake words separately from the command so that any combination can be selected.

The test stimulus also needs to be created and uploaded to the cloud. Bear in mind that it may be compressed when it is uploaded, which might introduce some distortion. You can verify that the MP3 encoding itself does not degrade the test signal by encoding and decoding the test signal, and using transfer function analysis between the original signal and the encoded version. We'll discuss test signals in more depth later, but for basic earphone performance testing we tend to use a standard swept sine sweep (Stweep).

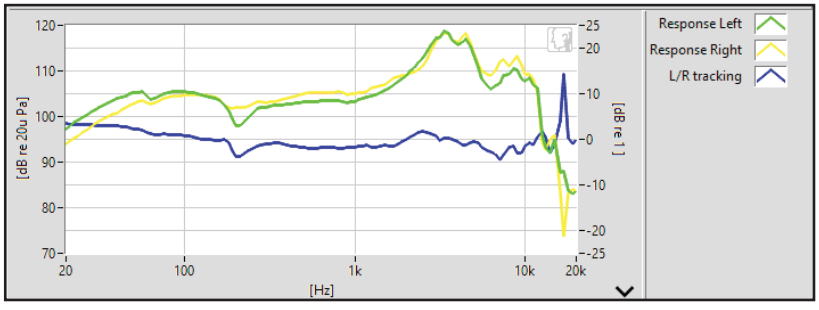


Figure 3: This graph shows the frequency and left/right tracking responses of a smart headphone.

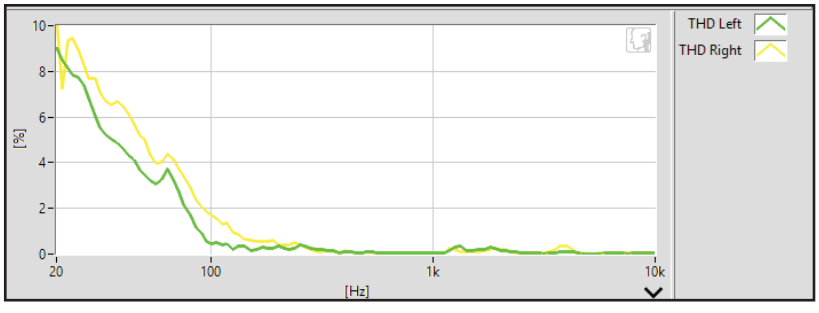


Figure 4: Here are the distortion responses of a smart headphone.

About the Author

Steve Temme is founder and President of Listen, Inc., a manufacturer of the SoundCheck audio test system. Steve founded the company in 1995, and for the past 24 years the company has remained on the cutting edge of research into audio measurement, regularly introducing new measurement techniques, algorithms, and hardware to enable testing of all kinds of devices ranging from basic transducers to complex audio systems. In recent years, Listen's product development focus has been on creating the algorithms, interfaces, and test methods to measure today's many and varied wireless and cloud-communicating devices. Prior to founding Listen, Steve worked for many years as an acoustic test and measurement applications engineer at Brüel & Kjær, and also as a loudspeaker design engineer at Apogee Acoustics. He holds a BSME from Tufts University, has authored numerous papers on acoustic testing, and has lectured extensively throughout the world.

Once the stimuli and voice commands are created and uploaded, the test sequence simply needs to play the wake word followed by the activation command via the mouth simulator and capture the response with the ear simulators. Stimulus and analysis are then compared as in a traditional measurement to objectively qualify characteristics, such as frequency response and distortion.

However, it is not as simple as it looks—although the good news is that with the right test system, the complicated analysis happens "under the hood" so there is very little that the user needs to do other than make sure their test system has been told to analyze it correctly.

One of the main challenges that test system manufacturers have faced in developing accurate smart headphone tests is overcoming sampling rate error. Traditional measurement systems rely on the DUT having a synchronous input and output. As a category, hearables connected to a smart phone are intrinsically open loop, which means that although the device can record or playback a signal there is no synchronous signal path.

This introduces the possibility for sampling rate error. In other words, the device may record a signal to a file with a sample rate of 44.1 kHz, but it may have been recorded at a slightly different sample rate (e.g., 44.09 kHz) due to skew in the actual rate of the clock crystal used to drive the sampler. A similar error can occur when playing back test signals. That is, the test stimulus may be sampled at 44.1 kHz, but due to error in the playback sample rate the file is actually played back at a slightly faster or slower rate.

This sampling rate error results in the component tones of the test stimulus being shifted to either a higher or lower frequency. This shift can then lead to measurement errors due to loss of coherence between the stimulus and response signals.

To overcome this sampling rate error, an algorithm is applied which searches the beginning of the response waveform for a "trigger," which is used to provide a reference point for alignment and shifting of the stimulus and response signal. This trigger may be a steady-state sinusoid at a pre-set level and frequency, or for more robust performance that is less susceptible to false triggers, a log chirp (SoundCheck offers both). The signal is then shifted to DC using a heterodyne filter and all other frequencies are filtered out.

The output of the heterodyne filter includes the phase information, which is ultimately used to estimate actual playback or recording sample

rate of the response signal. With this information, the entire response waveform is resampled to the correct stimulus sample rate prior to analysis. This frequency shift step corrects for sampling rate error in the device and makes testing them straightforward.

With the test system taking care of all these, frequency output and distortion can be displayed in exactly the same way as for wired headphones, or a headphone connected via a Bluetooth interface or directly via a debug port (see **Figure 3** and **Figure 4**).

Of course, it is also necessary to measure the microphone or microphone array in the hearable. The setup for this is very similar (see **Figure 5**), except that in this case, the wake word and the test stimulus is played through the mouth simulator, captured by the hearable's microphone(s), the recorded test stimulus is downloaded from the cloud and routed back into the test system using a virtual audio cable. Once the signal has been brought into the test system this way, as with the headphone test, the appropriate calculations are applied to overcome frequency shift and error, and it is analyzed as normal (see **Figure 6** and **Figure 7**).

Advanced, or "Real World" Testing of Hearables

While the basic hearable test described earlier is ideal for measuring frequency response and distortion, it barely scratches the surface in terms of the breadth and depth of tests that one might want to carry out on a hearable in the R&D lab. Consider that smart devices are generally nonlinear and their response varies according to many factors (e.g., type of background noise, volume of background noise, whether the device is playing music or communicating voice, and more). These considerations alone bring up a multitude of tests that could yield valuable information about the device's performance. While the specific tests that are carried out will vary according to the manufacturer's design objectives, we can discuss some of the test methodologies that we might use and some of the industry standards that provide a useful starting point.

A significant difference from basic tests is that advanced tests generally require the use of speech or music as test signals. This means that a test system that can support such test signals is essential, and it is also important that the system can measure the active speech level of speech-based signals to ensure calibration and standardization as commonly used in telephony measurements.

Noise Cancellation

A noise cancelling headphone test procedure (see **Figure 8**) can be broken down into three measurements and three calculations. First, the headphones are removed from the head and

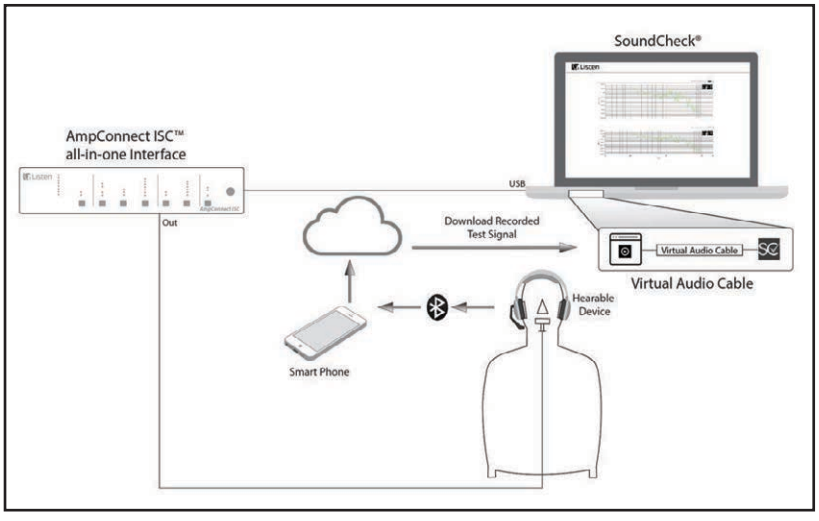


Figure 5: Test configuration for headset microphone measurement using voice activation

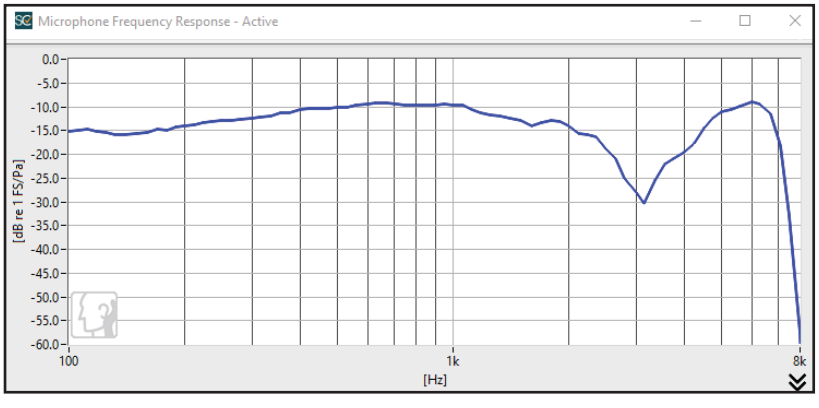


Figure 6: This graph shows the frequency responses of hearable microphone array.

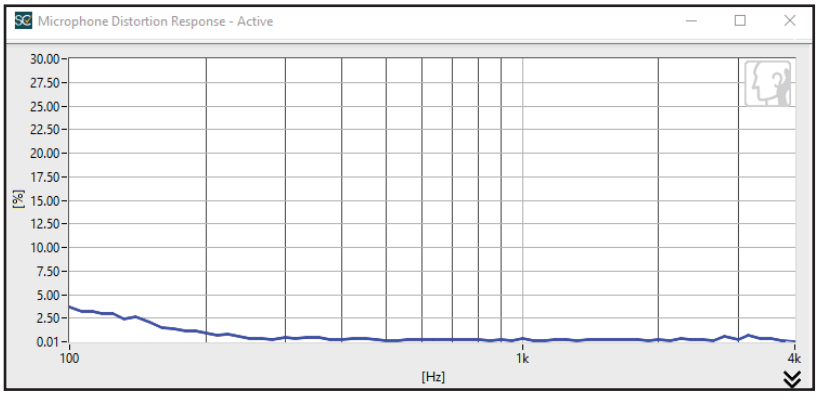


Figure 7: Here are the distortion responses of a hearable microphone array.

torso, the noise signal is played, and the spectrum measured through the open ear. This un-occluded ear spectrum is used as the baseline for the noise. Next, passive isolation is measured by placing the headphones onto the head and torso, playing the noise signal again, and measuring the noise through the artificial ear. Finally, the measurement is repeated with the active noise cancellation circuit turned on.

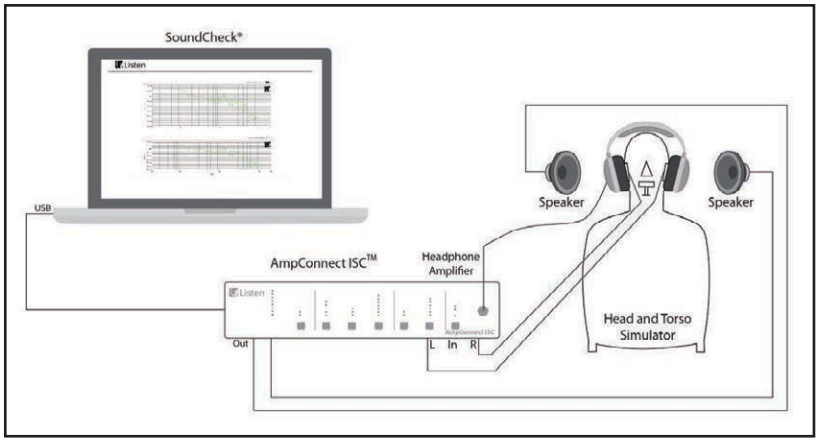


Figure 8: Test configuration for measuring ANC headphones

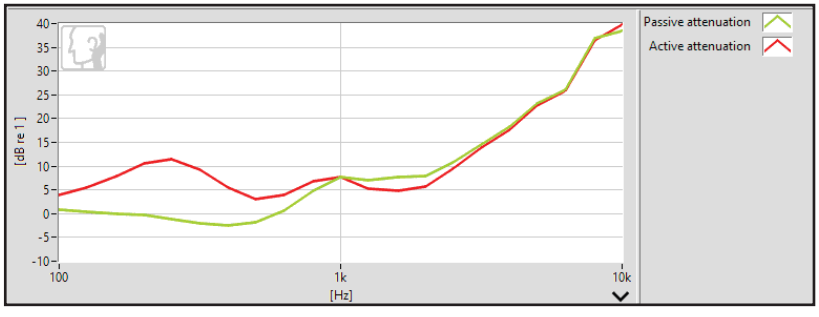


Figure 9: Typical noise cancelling measurement results

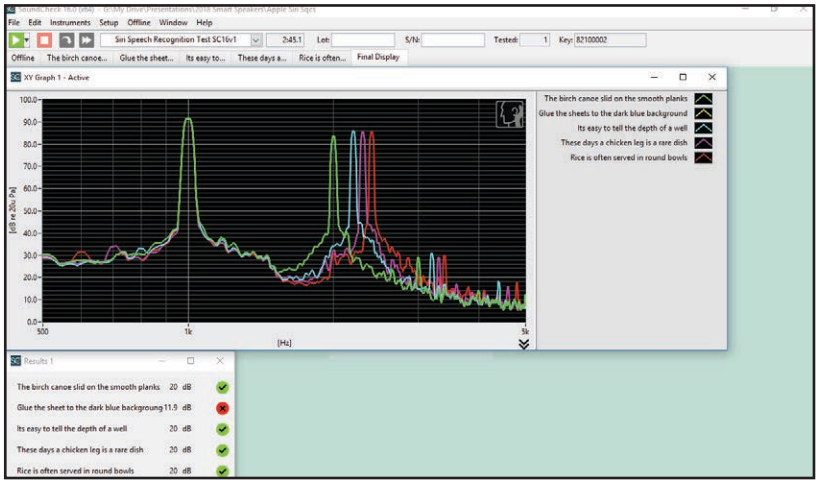


Figure 10: Results of end-to-end speech recognition

These measurements result in three spectra, which are used to calculate the three attenuation parameters. Passive isolation, which quantifies how much noise is attenuated simply by the headphones being worn, is calculated by subtracting the un-occluded baseline curve from the second measurement where the headphones are in place but noise cancellation is dis-engaged. Passive isolation can be significant across the frequency band, but is most prominent at higher frequencies. Circum-aural headphones and in-ear earphones provide a reasonable level of passive isolation, whereas supra-aural headphones and on-ear earbuds typically offer much less.

Active attenuation, which quantifies how much noise is reduced (or sometimes increased) when the active cancellation circuit is engaged, is calculated by subtracting the second measurement (noise cancellation off) from the third measurement (noise cancellation on). Typically this will be most prominent in the lower frequencies.

Finally, total attenuation is calculated by subtracting the curve with noise cancellation turned on from the baseline measurement without headphones. This represents the end-user's experience of the device, combining both passive and active components in attenuating background noise (see **Figure 9**).

Often this test is optimized by performing each measurement multiple times and averaging the resulting spectra. This accounts for variations in the fit of the headphones, which for some devices can impact the passive and even the active portions of the noise cancellation performance.

Some noise cancelling headphones will actually alter the frequency response of the music being played when the noise cancelling circuit is engaged. To test for this effect, one can measure the frequency response using the methods outlined above, both with and without the noise cancellation turned on, and compare the resulting response curves. Differences, if they are present, will typically be in the 1 kHz to 3 kHz range.

Speech Recognition

Speech recognition tests are important for evaluating the device's ability to understand voice commands. The physical setup is the same as that shown in Figure 2.

One option is to create a series of specially titled musical tracks and upload them to the cloud. The track titles are the words or phrases that you want to test, and the actual content of the tracks

is a single, dual or multitone that enables you to identify the track by its audio content. Generally "Harvard Sentences"—a collection of phonetically balanced sentences that use specific phonemes at the same frequency they appear in English—are used for the track titles. These are recommended by The Institute of Electrical and Electronics Engineers' "IEEE Recommended Practices for Speech Quality Measurements for Voip, Cellular, and other telephone systems" and widely used in telecoms voice recognition. Pre-recorded versions of these can be downloaded online, or your own can be recorded (e.g., if you are testing the device with different accents). These track titles are used to request playbacks, and a limit is used to detect whether the correct, or indeed any, signal was played back (see **Figure 10**).

There are many variations on this test, for example testing different voices and accents, testing an active speaker versus an interfering speaker or background noise levels, testing with different types of background noise, and so forth.

Background Noise

Where background noise is needed, ETSI standard ES 202 396-1 contains binaural recordings made in different noise environments (e.g., cafe noise, traffic noise, subway etc.). While there are many ways of playing these, for example through purchasing an expensive dedicated system or by programming your own, SoundCheck offers an optional European Telecommunications Standards Institute (ETSI) standard ES 202 396-1 module. This integrates the ETSI standard library with the test system, playing the background noise at calibrated levels, which can be controlled and adjusted as part of a pre-programmed test sequence. This test sequence may include loops to incrementally increase the volume or change the noise and repeat the test, making it simple to create a test that increases the background noise by fixed levels until the voice is no longer accurately recognized. In addition to being a very cost-effective approach, it also significantly simplifies the physical test setup and reduces test development time. Background noise testing (see **Figure 11** and **Figure 12**) is necessary for a wide range of hearable device tests including voice recognition, SNR optimization of mic arrays, beamforming directionality studies, and more.

Voice Quality

Hearables often function as handsfree communication devices. For such use cases, we can lean heavily on telephone test sequences such as the Telecommunications Industry Association (TIA) standards for headset devices (TIA920-B). In fact a hearable can be tested as a headset exactly as defined in the TIA standard. Although the test setup is identical to the basic smart headphone test outlined earlier, the test sequences for measurement to the standard are highly complex and either require considerable expertise in this area to create them, or they need to be purchased as an off-the-shelf package.

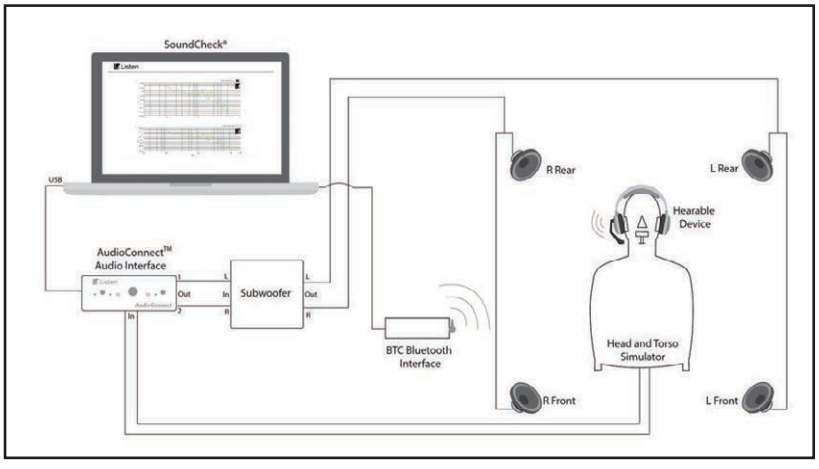


Figure 11: Test configuration for headset measurements with ETSI standard background noise

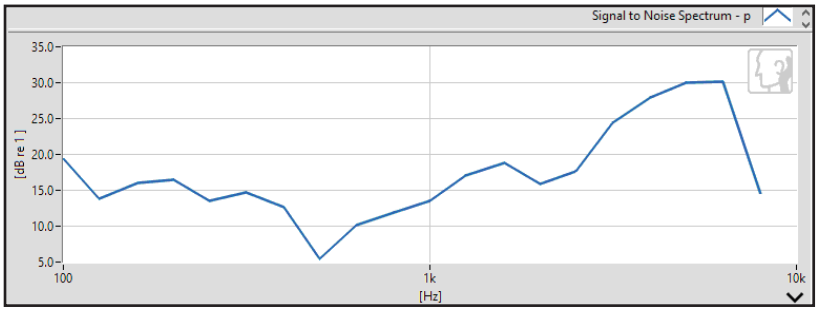


Figure 12: SNR for a smart headset measured with ETSI standard background noise

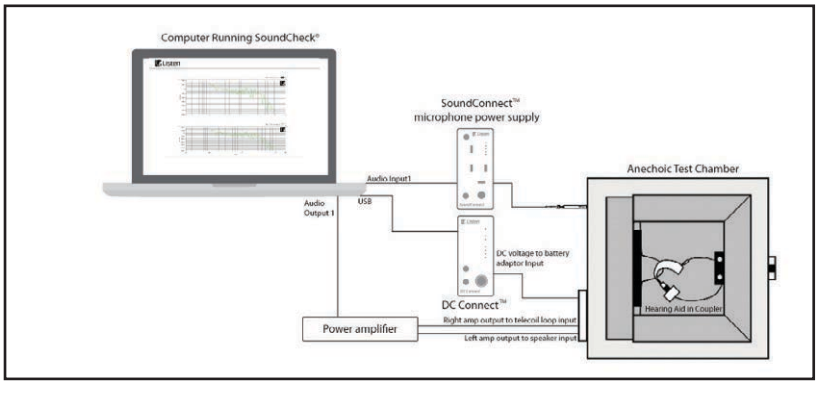


Figure 13: Test configuration for measuring hearing aids

Hearing Assistance

Since some hearables can also act as Personal Sound Amplification Products (PSAPs) or essentially hearing aids, it makes sense to measure their amplification or compression along with the corresponding attack and release time. This is usually measured according to the ANSI/IEC standard in an anechoic test box (see **Figure 13**) where the loudspeaker is equalized to have a flat frequency response and the hearable is inserted in a 2cc coupler or "artificial ear."

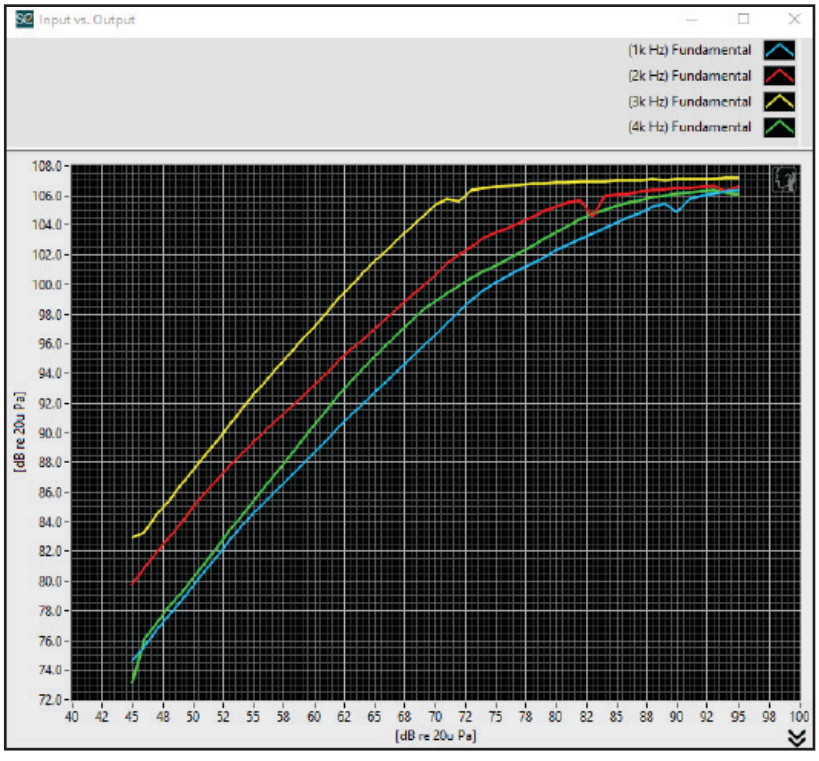


Figure 14: Hearable measurement of input vs. output

The ANSI S3.22 standard describes the method for testing hearing aids with automatic gain control (AGC) and could be applied to hearables that offer this functionality. The device is placed in an anechoic box, and an amplitude sweep from 50 dBSPL to 90 dBSPL played through the test box speaker.

This sweep is repeated at four frequencies (1 kHz to 4 kHz) in 1 kHz increments. The output of the hearable is plotted vs. the input on the graph (see **Figure 14**) to quantify the gain added for low level signals and compression at high levels for hearing loss compensation.

Choosing a Test System

Hearables represent the convergence of tests from headphones, microphones, telephones, hearing aids, and more. It is, therefore, advantageous to select a system from a manufacturer that truly understands these varying applications and has the various test stimuli, algorithms and post-processing functionality for these in their toolkit, along with the expertise.

A checklist of the functionality that is important for characterizing smart devices includes:

- Tests both headphones and microphones
- Can create a compound stimulus with frequency and/or log chirp trigger to enable accurate open-loop testing
- Can be set to analyze only parts of the response signal, so that the trigger tone can be eliminated from the analysis
- Ability to use speech and music as test signals, calibrate levels, and equalize a mouth simulator (requires the inclusion of active speech algorithms)
- Background noise generation—although this can be generated externally, testing is much simpler and faster if it can be created by the test system and integrated with the test sequence
- Can accept signal via virtual audio cable in order to route in signals from the cloud—native windows multimedia interface
- Availability of pre-written TIA test sequences if device needs to be tested as for telephony purposes (may be manually programmed with sufficient expertise)
- Sophisticated sequence writer that allows duplication of sub-sequences and loops—essential when repeating a test at various levels
- Bluetooth interface available ***LIS***

Resources

American National Standards Institute (ANSI) S3.22, "Specification of Hearing Aid Characteristics," www.ansi.org.

European Telecommunications Standards Institute (ETSI) ES 202 396-1, "Speech and multimedia Transmission Quality (STQ); Speech quality performance in presence of background noise; Part 1: Background noise simulation technique and background noise database," www.etsi.org.

Institute of Electrical and Electronics Engineers (IEEE) 269, "Standard Methods for Measuring Transmission Performance of Analog and Digital Telephone Sets, Handsets, and Headsets," www.ieee.org.

International Electrotechnical Commission (IEC) 60268-7 "Sound System Equipment – Part 7: Headphones and Earphones," www.iec.ch.

International Electrotechnical Commission (IEC) 60118-7, "Electroacoustics - Hearing Aids - Part 7: Measurement of the performance characteristics of hearing aids for production, supply and delivery quality assurance purposes," www.iec.ch.

Telecommunications Industry Association (TIA) 920.130, "Telecommunications Communications Products Transmission Requirements for Digital Interface Communications Devices with Headsets," www.tiaonline.org.

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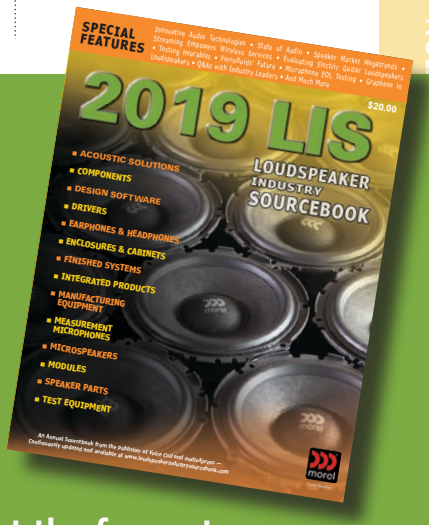
Get Connected to the Loudspeaker Industry Sourcebook



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Editor's Note: For the Questions & Answers interviews, we sent several notable industry professionals a list of questions and asked them to select the ones that they wanted to answer. The following content contains the questions they selected and their responses.

Armin Prommersberger

CTO, Dirac Research

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

PROMMERSBERGER: The constant demand for advances in device miniaturization and intelligence are the two key drivers for Dirac's strategic initiatives. Consumer electronic devices are getting smaller in size, yet consumers still expect these devices to deliver higher levels of performance. This expectation is being driven by the ongoing advancements in the semiconductor space. When dealing with the reproduction of sound, this expectation poses a major challenge as the advancements in transducer technology cannot keep up with this demand for increased miniaturization and performance.

We are closely collaborating with transducer manufacturers like AAC Technologies in their research phase to provide control and compensation algorithms in the linear and nonlinear domain to maximize the performance vs. package ratio.

Another core driver of our research and product development investments has been the continuous drive toward more intelligent, contextual devices. This mega trend is affecting all of the industries we serve, such as Automotive, Mobile, Consumer Audio, and Gaming. We are completing our offering as a One-Stop-Shop that provides our customers with everything they need, from capturing sound to reproducing it.

QUESTION 2: In your opinion, what was the most important technology that appeared in the audio industry during the past year?

PROMMERSBERGER: We look at "the audio industry" from the distinct perspective of all the industries we serve. To me, the most important technology that underlies all of our markets is the ascent of learning-based signal processing, which is completing or replacing traditional signal processing methods. To the consumer this means more contextual features, which is important in the connected world we live in today. In sound quality, many devices can reach an acceptable level in isolation, yet through connectivity and context we can group individual devices together to create personal audio eco-systems for the users—and this can improve how users listen to music, as well as their immersive movie watching and gaming experiences. On a product level, I think it is remarkable how many companies are at least starting to think about how to make the user experience more seamless and engaging. The result is less time reading manuals and more time playing right out of the box!

QUESTION 3: How do you see the following audio technologies evolving in the next five years? Bluetooth, Wireless audio, Music Streaming Services, and Audio over IP (AoIP)?

PROMMERSBERGER: Just a few years ago, if you

wanted hassle-free audio most people would use cables to connect their devices. Today, we have reached a level of robustness in wireless audio that allows for a very natural, care-free engagement with technically highly complex devices. This trend will mature even further and wired audio devices, with the exception of power cables, will become a niche for audiophile hobbyists. However, going forward, mainstream users will not even think about cables, or even physical media for that matter.

New Composite and Nano Materials?

PROMMERSBERGER: Material science is the next frontier for addressing the challenges of continuous miniaturization. Furthermore, the combination of advanced signal processing with mechanical designs that incorporate the idea of processing right from inception will also prove to be a powerful combination.

That said, material science is an expensive domain that requires time to realize results. Thus, it remains to be seen if smaller companies will be able to compete with global corporations that have the required strengths and resources in these areas.

Home-Theater, Smart Speakers, Soundbars, and Audio Conferencing?

PROMMERSBERGER: All of these domains perform their function in a room, which always is the dominant factor in perception. Advanced room correction technologies such as Dirac Live will become a must-have in each of these domains in order to create that targeted immersive experience. In the next five years, we will see the evolution toward a care-free, out of the box experience with simplified to automatic environmental calibration.

Headphones and Hearables?

PROMMERSBERGER: The traditional headphone will go away. Hearables—intelligent portable in- and over-ear audio devices—will become highly customizable by intelligent software functions that adapt to their user. The same device can be a hearing aid-like device to one person while it can be a workout partner to someone else. The sensors, package, and mechanical features do not necessarily differ, because it is the software that determines the use case. Dealing with this level of complexity, along with long operation hours, is the challenge that must be solved in order to create a seamless user experience.

Voice Assistants and Voice Capture/ Recognition?

PROMMERSBERGER: Voice assistants are finally here to stay, and voice control is becoming as natural as talking to a person. Yet, we are still living in a world where voice assistants are competitive, despite the reality that the user will hardly only live in one eco-system—specifically as voice assistants go from mobile phone and audio devices to literally everything. It is time to figure out how to easily transition from Google Voice or Amazon Alexa to "my" voice assistant that negotiates all my tasks in the background with the eco-system bound assistants. This will also drive the need for simplified but higher performing capturing hardware and pre-processing algorithms, as edge device intelligence and improved data infrastructures become requirements to handle the increase of bandwidth hunger from a multitude of home and mobile devices. In combination with privacy concerns, this is a major challenge.

Audio for Automotive?

PROMMERSBERGER: Besides the same challenge as mentioned for the home, Automotive Audio is trying to figure out what the autonomous car will mean to it. Now, if we limit the view to five years, it might not be so fundamentally different because the cars developed today will still be on the road five years from now. Yet, as soon as auto interiors become more flexible, and passenger positions become less predictable, a very different approach to tuning and architecting a sound system in a car will be required—as it needs now to dynamically adjust not only to noise but to non-constrained seat positions.

This means the sound system must become contextual and understand if one is front facing in a focused listening mode—and wants ADAS warnings that are augmented spatially correct into the cabin—or if some passengers are grouped for a conversation, facing each other, while others are watching a movie in a more flat-bed position.

We will need visual sensors in addition to positional sensors and then a sound system that can take these inputs, make sense of them, and process multiple sources of audio in multiple zones in the cabin accordingly. As sound zones have also a physical limitation, there is a lot of work to be done to meet future customer expectations.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

PROMMERSBERGER: CES. This show has evolved into an event that spans all industries, which represent the trends we see around audio. Audio is becoming an integral part of the experience of devices across countless applications and it is no longer its own isolated feature but connected and contextual. CES can be overwhelming, but it is representative of this trend.

QUESTION 5: Does your company have plans for voice implementation in 2018 and beyond? Cloud connected, or local voice commands?

PROMMERSBERGER: You actually need both, and it is use-case dependent. More complex, natural voice control will require an uplink, while many devices going forward will be able to do "good enough" with a limited feature set yet still natural in language. Hybrids of both have proven a robust way to secure response times that the users expect.

QUESTION 6: How important have smart speakers and voice recognition technologies been or will be for your business?

PROMMERSBERGER: Smart speakers became a category by themselves really fast, yet over time I doubt there will be this category distinction. All speakers are on their way to becoming smart and connected, except for some very narrow use cases. This is part of what we call the Intelligent Audio trend. We are fully committed to providing users and B2B customers with the experiences and tools they desire. We can see many product categories becoming intelligent, even with companies that are not audio specialists per se. Just observe what is happening around refrigerators and household appliances, in general.

QUESTION 7: What features introduced in connected devices (smart speakers, smart TVs, soundbars, personal audio,

appliances) do you think will be more important for the audio industry moving forward?

PROMMERSBERGER: Intelligence as a whole. From non-invasive voice control where it makes sense; to reacting to changes in the environment or user behavior; to deep individual-based personalization; to seamless collaboration between devices, breaking down the barriers of isolated devices in one's home or meeting room—I believe Intelligent Audio devices will be key success factors going forward. The time of highly specialized, isolated and hardware defined products has come to an end.

Personal Question: Did your music listening habits change in the last 12 months? Which speakers/headphones do you use more often to listen to music?

PROMMERSBERGER: Actually, they did. Due to my line of work I have a huge selection of headphones of all form factors. What I realized over the last year or so is that I no longer have one headphone for all occasions. I have different devices for different use cases. I carry at least two sets when I am traveling, unless I do benchmarking on a flight, which might be a funny scene to other passengers, with me changing headphones every 10 minutes! Currently, I've settled on one favorite over-ear noise cancellation headphone, the AKG N700, for flights and work.

For convenience, I use AirPods, as they are really well integrated with my iPhone; for walking a city, I mainly use AKG N5005; for working out, JBL Under Armour's; and for recording, I use a variety of AKG and Sennheiser headphones as I am used to them.

I can see this trend of having more than one headphone for differing applications become common for a lot of people—and I guess I can confirm the wireless trend with my behavior. The only place I still consciously use wired headphones is when creating music. ***LIS***

Jyri Huopaniemi

Head of Product and Technology Strategy, Technology Licensing, Nokia Technologies

OZO
NOKIA

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

HUOPANIEMI: The Nokia OZO family of audio solutions started with multimicrophone audio capture technology with our OZO Audio product, offering a suite of novel features for device OEMs—primarily smartphone and camera manufacturers. The product features include spatial audio capture with universal sharing, audio zooming and focusing, as well as wind noise reduction. Recently, we expanded our technology offering with an industry-first editing feature that allows users to browse the recorded sound field, post-capture, giving them the ability to zoom and focus audio as well as reduce unwanted sounds such as wind noise. Furthermore, we have introduced an innovative playback software product for smartphone stereo loudspeakers, allowing the highest-quality spatial reproduction in a range of mobile devices.

The mobile industry has realized that audio innovation has not kept pace with visual innovation

in recent years, and the attention is now shifting toward higher quality audio with more innovative features. This is a trend that is likely to continue into the future, especially as audio and AI technologies become more integrated, especially around voice technologies, smart assistants, and communication systems.

QUESTION 2: In your opinion, what was the most important technology that appeared in the audio industry during the past year?

HUOPANIEMI: In terms of important technology appearances, the progress made in smartphone audio has been remarkable, bringing new features for both audio capture as well as audio playback on mobile devices. The Nokia OZO product portfolio is actively driving this trend forward, offering a complete line of features from smart audio capture and editing to immersive audio playback.

From an overall audio business perspective, the ever-growing focus on voice assistants and smart speakers is a very positive trend. It is putting considerable demand on further innovation in smart audio capture and processing, as well natural language understanding and artificial intelligence (AI).

Question 3: How do you see audio technologies evolving in the next five years?

HUOPANIEMI: I see three important trends where there will be significant advances over the next five years. The first is sensory technologies that capture the truest picture of our surroundings. Next is incorporating data intelligence to give meaning to captured information. Finally, smart experiences that bring added dimension to content interaction.

For the first trend, this is really about higher quality capture of audio for sensory, communication, and entertainment use. We will be able capture true-to-life audio and sense the surroundings with quality and accuracy that has so far not been possible.

With the second trend this large amount of sensory data will be turned into meaning as well as processed for distribution. With advances in machine learning, we can offer more and more intelligence for everyday use-cases, such as the capturing of audio together with images and video, communication both person-to-person and person-to-machine, as in the case of voice assistants. On the other hand, next-generation codecs and formats, those driven in standardization efforts, for example in MPEG and 3GPP, will enable the rich captured data to be encoded, transmitted and optimized for rendering.

The third trend is something we are already starting to see—for example, the advances in voice recognition and natural language understanding have brought smart, voice-based assistants to the reach of most consumers. I expect this trend to further strengthen, and there will be new innovations around immersion and communication, one future example could be low-latency immersive conferencing over 5G networks.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

HUOPANIEMI: I attended the Audio Engineering Society (AES) convention in New York in October 2018. Having attended AES shows for the past 25 years, but with a break of a few years in between, it was great to reconnect with many industry colleagues. The combination of a high-quality scientific agenda with a dedicated trade show is what I enjoy the most, as this brings today's products and tomorrow's technologies under the same roof for a few days.

QUESTION 7: What features introduced in connected devices (smart speakers, smart TVs, soundbars, personal audio, appliances) do you think will be more important for the audio industry moving forward?

HUOPANIEMI: I personally think the audio industry as a whole needs to develop a deeper understanding of consumer needs and trends. We need to aim to develop solutions that ultimately solve a problem or create new—or significant improvements to—compelling usage scenarios for users. When it comes to audio, this can be achieved by, for example, improving the robustness of smart speakers, further improving audio capture and playback in challenging and changing everyday conditions and offering memorable experiences with innovative audio capabilities.

Personal Question: Did your music listening habits change in the last 12 months? Which speakers/headphones do you use more often to listen to music?

HUOPANIEMI: At home I use Genelec speakers. The simplest and most family-friendly configuration is to just connect them directly to a smart speaker front-end output, but the home theater setup caters for more serious listening, both stereo and multichannel. My headphone listening varies from small headphones (like AirPods) to more analytical listening using Sennheiser higher-end headphones. More and more of my listening happens these days on the move—outdoors, in a car, train, or airplane. ***LIS***

Mark Valentino

Product Marketing Manager, PCB Piezotronics, Inc.

PCB PIEZOTRONICS
MTS SYSTEMS CORPORATION

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

Valentino: PCB Piezotronics is a sensor manufacturer of not just microphones, but also accelerometers, pressure, force, and load sensors. Our company growth is tied to research and development divisions in the auto, aerospace and defense, industrial, and energy industries, and audio OEMs. PCB had a great year for growth in 2018 due to diversification within our target markets, allowing us greater flexibility to overcome economic downturns that inherently occur in various market segments. PCB prides itself on its large customer base and ability to penetrate new market segments through innovation.

Question 3: How do you see the following audio technologies evolving in the next five years? Voice Assistants and Voice Capture/Recognition?

Valentino: Voice assistants and voice recognition will continue to offer a higher quality of lifestyle. Today, we can remotely start an oven or unlock the front door. The vision impaired, handicapped, or elderly can turn on lights or a television, change the temperature in their house, order amenities online, or call for help, without leaving their chair. I envision many more daily tasks being achieved remotely in the next 5 years.

Audio Conferencing?

Valentino: For technical sales, it is always advantageous to get in front of the customer to discuss the application in person. Sometimes timing and the overwhelming cost of trips do not warrant a single visit. Audio conferencing has allowed the manufacturers a cost-effective way to be face to face with the end user. This has gained popularity over the years and will continue to become more popular with increased cost per on-site visits.

Audio for Automotive?

Valentino: While many auto speaker manufacturers are continuing to improve audio sound quality with building better speakers or using different techniques like noise cancellation for an enhanced user experience, the combination of voice recognition with automobiles will evolve and potentially provide a safer travel experience. It will not only allow us to pick out a station to listen to on the radio, or make a phone call, but new technologies will allow operators to start the vehicle and not just state a desired destination, but have the car drive itself via voice commands.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

Valentino: Being primarily a test and measurement sensor manufacturer, the International Modal Analysis Conference (IMAC) and Power Gen International are some of our biggest and most useful trade shows for the vibration, industrial, and energy sectors of our business. For acoustics, Inter-Noise and AISE/ALMA are the shows that provided the greatest rewards for PCB in 2018, in regard to relevant market and opportunity discussions.

QUESTION 6: How did the emergence of smart speakers affect your business?

Valentino: For smart speakers to work optimally, the input and output must be as intuitive as possible. The more accurate you can make input and output intelligibility, along with minimizing background noise, the more it enhances the user's experience with the

end product. Because of this, very accurate test-and-measurement-grade microphones are used in the research and development phases of the new models. PCB is seeing greater interest in microphones for these applications, due to a very flat response for sensitivity over wide frequency ranges that laboratory-grade microphones offer.

QUESTION 7: Do you think any of the smart speaker abilities (digital signal processing, beamforming, acoustic compensation, self-calibration, sensors, etc.) could make sense in other speaker and audio product categories?

Valentino: I believe that many of the smart speaker capabilities can be used in other speaker applications. DSP in many cases is desirable. Two of the more common tools utilized for interior auto cabin noise are beamforming and acoustic cameras. These, coupled with the proper placement of sensors (test and measurement grade microphones), allow for more accurate noise source location testing, helping to improve noise cancellation in cabins. Greater employment of user calibrations is also becoming more popular for speakers and audio product categories, because it is a quantifiable method of achieving and verifying improved sound quality.

Personal Question: Have your music listening habits changed in the last 12 months? Which speakers/headphones do you use more often to listen to music?

VALENTINO: My musical listening habits have not changed much in 2018. This is mainly because my musical taste is very diverse. When not working as a product manager for PCB, I perform weekly—singing and playing guitar in a musical group that is in the Buffalo Music Hall of Fame. We have performed with 40 national acts ranging from Frankie Vali and the 4 Seasons, to the Kinks, Little River Band, Steppenwolf, Bret Michaels (of Poison), Survivor, The Guess Who, Asia, The Rascals, Boston and more. My in-ear (headphones) monitors for musical events for shows are Shure SE846s and SE535s. I like each for different reasons. The SE846s with quad drivers and interchangeable high-pass and low-pass filters offer exceptional sound quality and clarity, while the more cost effective SE535s have an extended dynamic range 119 dB (compared to 114 dB for the SE846's), so the vocals cut through the mix a little better. The 5 dB at first may not sound like much, but a 6 dB increase is a doubling of sound pressure. ***LIS***

Jonny McClintock

Director, Product Marketing, Qualcomm Technologies International, Ltd.

Qualcomm

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

MCCLINTOCK: Over the past 12 months, for aptX we have been very focused on releasing Qualcomm aptX Adaptive, which is an audio codec for Bluetooth that ensures robustness and dynamically adapts to both the RF environment and content. Effectively, aptX Adaptive provides all of the benefits of wired connectivity without the hassle of wires. Going forward, I believe the next big hurdle to clear for Bluetooth wireless connectivity is to address low-latency, interactive applications. Bluetooth for music has been on a journey from a poor consumer experience 10 years ago to now being viewed as good enough for all users. We now have to take Gaming through that same journey.

QUESTION 2: In your opinion, what was the most

important technology that appeared in the audio industry during the past year?

MCCLINTOCK: One of the most significant changes that will affect the audio industry—the potential removal of the audio jack—has a massive implication. We are now being forced to re-evaluate an interface that's existed for more than 50 years. More recently, the emergence of personalized audio along with truly wireless earbuds could offer a more elegant solution for a demographic that uses hearing assistants.

Question 3: How do you see the following audio technologies evolving in the next five years? Bluetooth, Wireless Audio, High-Resolution Audio?

MCCLINTOCK: Bluetooth will address interactive use cases (i.e., Gaming). Wireless audio will see reduction in proprietary solutions as Bluetooth covers more use cases. For Music Streaming Services, 5G should be the enabler for high-res. And, High-Resolution Audio will become more mainstream as transport speeds increase.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

MCCLINTOCK: I normally attend IFA, CES, MWC, and an AES conference (either Europe or US). For aptX, they all address different needs, for example highlighting new technology, launching products for both Bluetooth Source (Handsets) and Sink (Headsets and Speakers).

QUESTION 5: Does your company have plans for voice implementation in 2019 and beyond? Cloud connected, or local voice commands?

MCCLINTOCK: We're figuring out how to make voice activation and assistance experiences (both local and cloud-connected) better for end users. One part of this is driving improvements in the technologies that capture wake-words. For example microphone arrays, processing, software and algorithms, and even AI—to deliver faster, more accurate and more robust voice capture, even in environments with high-levels of background noise.

We are bringing these improved voice activation features to a wide array of consumer devices—from smart headsets, to smart soundbars—with advanced power optimization such that voice detection and many other rich features can last for longer and longer periods for products running from very small capacity batteries.

Creating the underlying tech that can support the next generation of voice activated products is complex and requires expertise in areas like compute, connectivity, sound quality and AI—these are all areas we excel at.

Our wide portfolio of technologies, including our QCS400 SoC series for smart speakers and soundbars and our Smart Headset Platform with Amazon Alexa Voice Service, means that we can support different ecosystem providers, so our customers can use our platforms to create consumer products that support the voice assistant of their choice.

QUESTION 6: How important have smart speakers and voice recognition technologies been or will be for your business?

MCCLINTOCK: Hugely Important. Smart speakers are a key product category for us. They are forecast for fast growth in the coming years, and are playing a major role in driving consumer adoption of voice UI and the smart home.

QUESTION 7: What features introduced in connected devices (smart speakers, smart TVs, soundbars, personal audio, appliances) do you think will be more important for the audio industry moving forward?

MCCLINTOCK: As always, superior sound quality is one of the most critical features for consumer audio products, both for supporting richer and more powerful music playback, and also improved voice pick up for better performing voice UI experiences.

Enhanced and robust connectivity is another essential feature, as next-generation audio experiences must support music streaming via Bluetooth, low-latency networking for wireless audio playback that supports great video and gaming, immersive surround sound, multi-room speaker networking and the home control features necessary to realize the vision of the connected smart home.

One other vital capability will be extended battery life, to improve portability of speakers around the home and outdoors, and allow people to enjoy more hours of playback and smart speaker use when not connected to the mains power supply.

Personal Question: Did your music listening habits change in the last 12 months? Which speakers/headphones do you use more often to listen to music?

MCCLINTOCK: I stream content from Spotify and enjoy the ability select an ecletic mix of songs but nearly always regress to The Undertones, U2, and The Saw Doctors. I use a Creative ZiiSound speaker and Sennheiser Momentum headset (both aptX enabled). ***LIS***

Jann U. Evers

Sales Director, Scan-Speak

QUESTION 1: How did your current business evolve in the past 12 months?

EVERS: Our business was stable with only the usual fluctuations in product mix and who is buying more or less, overall we saw a small growth in sales.

What were the main trends and macroeconomic factors affecting your business (good and bad)?

EVERS: Despite many political issues globally, we seem to be in a marked segment that had very little impact from it.

What are the perspectives for the next 12 months?

EVERS: We see the coming 12 months to follow the same trend.

QUESTION 2: In your opinion, what was the most important technology that appeared in the audio industry during the past year?

EVERS: Within our market segment of high-end loudspeaker transducers—which is very mature—we rarely see ground-breaking new technologies, we mostly see a slow moving evolution within materials and manufacturing techniques. The latest big new thing was in 2017 when we—Scan-Speak—launched our Ellipticor family that as a new a ground-breaking feature has an elliptical voice coil and magnet gap, very powerful AirCirc magnet systems, and several other top features. It sets a completely new standard of accurate sound reproduction with outstanding dynamics and lower distortion than in any other loudspeaker transducers we have ever seen!

Question 3: How do you see the following audio technologies evolving in the next five years? Bluetooth, Wireless Audio, Music Streaming Services, High-Resolution Audio, New Composite and Nano Materials, Home-Theater, Headphones and Hearables, Smart Speakers, Soundbars, and Audio for Automotive?

EVERS: Bluetooth—It may have reached its peak, I see it stagnating.

Wireless audio will most likely grow and will be seen in more high-end applications

Music Streaming Services will continue its growth, and will offer more high-resolution content.

High-Resolution Audio will definitely grow, especially as high-speed internet improves and get available everywhere.

New composite and nano materials are surely an interesting area that most likely will bring out something new.

Home-Theater topped out long time ago in terms of sold quantities, but there is still an interesting niche marked for high-end home theaters almost at professional level that will continue for a few specialized companies and enthusiastic consumers.

Headphones and Hearables seems to continue its growth and part of that industry are moving upward in performance, as well as a part of it are going to the luxury goods group, where more than sound and ease of use matters, this category has no limits on prices, it will hit more or less the same category of buyers as expensive Swiss watch makes.

Smart Speakers are very hot right now and the highest fashion in the audio world, but as any other hot item it will get colder and I predict people at some point will not accept to have on-line microphones listening to EVERYTHING happening in their homes.

With soundbars, there seems to be no signs of TV starting to include good sound in a TV, so its market will stay and it will grow in new technologies and features.

For speakers I see the trend continuing with the high-end market being even more high-end and exclusive, and the volume market offering more performance keeping more or less same price points.

I also see the price gap between these segments getting bigger.

Audio for Automotive will continue to grow, as we spend more and more time in vehicles and soon we will have self-driving vehicles and will have plenty of time to listen to music and watch videos (with audio) when driving as passenger.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

EVERS: The High End Show in Munich, as it has the most attendees in our industry and it continues to maintain its position and DNA as an audio show of great quality. And because it, unlike CES, stayed away from the "growth syndrome" where big global consumer electronics players were allowed to push the smaller audio companies out by their demand for space and ability to carry higher show cost.

QUESTION 5: Specifically on speaker design, components, drivers and materials. What developments, products or technologies impressed you the most in the last 12 months?

EVERS: I'm not easy to impress, regarding speakers I listen to every high-end brand and model on the planet as part of my job.

QUESTION 6: How did the emergence of smart speakers affect your business?

EVERS: Not at all, no smart speaker has yet made its way into high-end audio.

QUESTION 7: Do you think any of the smart speaker abilities (digital signal processing, beam-forming, acoustic compensation, self-calibration, sensors...) could make sense in other speaker and audio product categories?

EVERS: Probably, but the market is very conservative.

Personal Question: Did your music listening habits changed in the last 12 months?

EVERS: No I still listen to a lot of music every day as it is part of my job.

Which speakers/headphones do you use more often to listen to music?

EVERS: As a speaker guy, I don't listen to music via headphones, it simply does not satisfy me, so the only place I wear headphones is on airplanes as I need the noise cancellation. ***LIS***

Claus Futtrup

Chief Technical Officer, SEAS

Thank you for offering me the opportunity to give you my personal point of view on the audio industry in the *Loudspeaker Industry Sourcebook*. As always, my perspective is based on classical (relatively high-end) loudspeakers; most of the time working with transducers.

QUESTION 1: How did your current business evolve in the past 12 months? What were the main trends and macroeconomic factors affecting your business (good and bad)? What are the perspectives for the next 12 months?

FUTTRUP: SEAS experienced a very successful first half of 2018, with a long slow-down period in the second half. We expect a dip in the fall, because it's normal for us, but the length was unusual and probably because SEAS products are used in luxury items—a market that slows down when people are nervous about the future. I think this bump in the road is a result of the political climate. Here at the end of Q1, it looks like business is picking up again. We spent the available time on developing new products and have made additional investments in production, in preparation for the future. SEAS is

launching several new products and are developing our product line(s) to position SEAS in the future market.

QUESTION 2: In your opinion, what was the most important technology that appeared in the audio industry during the past year?

FUTTRUP: The higher-end of the loudspeaker business where SEAS is involved is conservative and I cannot identify a new technology that jumps straight out of nowhere and into the main scene. The part of the industry I'm working with are still focused on basic two-channel stereo and the move from passive to active speakers is slowly moving up into the higher priced market.

If anything is impressing me, it's the continuous strive toward higher-quality amplifiers with low power consumption (for the most part Class-D style). Within a few years, Class D might be on-par with the best in class analog amplifiers. I know some people will say it's already there, but that statement is based on compromising on some properties in favor of others, whereas I'll wait until these amplifiers are better in all aspects to call it a clear win (high bandwidth and low intermodulation distortion comes to my mind).

QUESTION 3: How do you see the following audio technologies evolving in the next five years? Wireless Audio, Music Streaming Services, and High-Resolution Audio?

FUTTRUP: Music streaming continues to evolve and as program material and streaming services, like Qobus or Tidal, broaden their offers of 24-bit and 96 kHz high-res, this provides a larger market for high-quality products, like what we do at SEAS. The trend toward higher quality is highly appreciated and it is needed for streaming services to give listeners the feeling that their neck hairs raise, and they have that goosebump feeling, to become successful in the high-end market. This is what SEAS is all about.

I think that the higher end of the loudspeaker market will eventually have to adapt to customer demands for active speakers with digital AoIP input, possibly wireless if it can be made good enough. It might cause a stir among our customers because some can adapt whereas others stay with the classical passive speaker market.

Our part of the industry is conservative and although High-Res audio is consciously becoming an integral part, it is not always well understood how loudspeakers with soft cones (e.g., paper cones) will not be able to follow suit into true high-res audio reproduction. We see a broad spectrum of customers (who design and sell finished speaker systems), that choose to work with paper cones, even semi pro-audio units, to attempt to resolve details, but I think it's a misunderstanding as to what can be accomplished by such means.

SEAS offers speakers with paper cones if that is what the customer wants, but for true high-res reproduction, the cone needs to follow the voice coil and the voice coil needs to follow the input signal. Proper acoustics, dispersion as well as break-up modes, at higher frequencies might dictate smaller diaphragms.

New Composite and Nano Materials?

FUTTRUP: Bringing new materials from the experimental state into mainstream production, especially for audio purposes, is not easy. Price is a concern, as well as volume quantity, etc. In our industry, there are a lot of sidesteps and not many big steps forward, but overall the ambition is to increase on stiffness and damping and lower the mass. That triangle of properties, mechanically we're talking relative high frequencies (kilo-Hertz), has been and will continue to be a focal point.

When available, the industry will either choose to work by sampling cones/domes (craftsmanship) or by simulating the properties. The capability to work with stiffness, damping, and mass/density and the bridging of the capabilities of the materials supplier, potentially through a component supplier, to the specific demands of the loudspeaker (transducer) industry, is where it is most difficult to make the ends meet. I cross my fingers we will see the gap being filled over the next few years.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

FUTTRUP: The most important show for SEAS is the Munich High End Show in May because this is a big venue with international appeal where we can meet many of our existing and potential customers.

QUESTION 5: Specifically on speaker design, components, drivers and materials. What developments, products or technologies impressed you the most in the last 12 months?

FUTTRUP: Speakers and electro-dynamic transducers for speakers is a mature technology, but as high-power amplifiers and digital technology continues to evolve, this requires the speaker industry to adapt accordingly. For adaptation to the high-res signals, the speaker should handle the high dynamic range and yet remain capable of reproducing the signals with low distortion so that the lower signals do not disappear into the noise floor ("distortion floor") in the presence of loud signals.

New materials continue to show up, which must strive toward stiffer, lighter, and better damped behavior. Essentially, we need the drivers to operate in their pistonic range. SEAS cast magnesium technology for woofer cones is currently one of the best options available and although we looked carefully for some years already, we haven't been able to identify a better material. At the same time, system designers might just have to accept that some of the classical choices, like 2 kHz to 3 kHz crossover frequency in a two-way speaker design with a fairly large mid-woofer, needs to change toward using smaller mid-woofers or using a lower crossover point, which could increase the load on the tweeter. SEAS tweeters, including the textile dome tweeters, can reproduce low frequencies with high sound quality and we strive toward higher power handling.

On the development side, we continue seeing a progression toward more scientific work with computer simulations, rather than good old craftsmanship, and this will continue in the years to come. I find it tremendously difficult to assess the overall performance by looking at computer models and simulations, and eventually craftsmanship is needed to complete the design. At least, that's my take on the situation, with the higher-end market in mind, where at the end of the day, the sound quality from a holistic point of view is what matters.

QUESTION 6: How did the emergence of smart speakers affected your business?

FUTTRUP: If we define smart speakers as communication devices with voice response, etc., then the smart speaker market has

not affected SEAS at all, neither positive or negative. We have analyzed a product and see how it pushes the physical limits, but not in a good way from a sound quality perspective.

For the smart speaker business to become relevant for our customers (and hence, SEAS), the focus must change from features to fundamental sonic qualities, and features become a natural but unobtrusive extension. We are waiting for the initial fascination of smart features to decay and find its natural place. Basic concerns about the hackability of the products and privacy concerns needs to be addressed.

QUESTION 7: Do you think any of the smart speaker abilities (digital signal processing, beam-forming, acoustic compensation, self-calibration, sensors, etc.) could make sense in other speaker and audio product categories?

FUTTRUP: With our market segment in mind, and the associated speaker products, the weakest link seems to be the speaker-room interaction, and indeed there are several products in the market, which addresses this. Early on we had the Bang & Olufsen Beolab 5 (launched into the market in 2003), which is an active speaker that includes a measurement microphone for self-calibration/room adaptation. Later we had the Grimm Audio LS1, then the Kii Audio Three, then Dutch-Dutch (e.g., 8c) and it seems to me that especially in the Netherlands there is a great amount of attention to the speaker-room interface, sometimes implemented with passive technology and sometimes utilizing active technology. We also have the Linkwitz LX521 kit, which as a dipole attempts to address the room interaction for better stereo imaging.

For faithful reproduction at low frequencies, a good DSP room correction remains a viable option, even for a good room because any room affects the sound, if not by room modes, then by anechoic behavior. You just cannot get around it. Some would go as far as to say that DSP room-correction is mandatory for faithful reproduction of low frequencies, below the Schröder frequency, in any room.

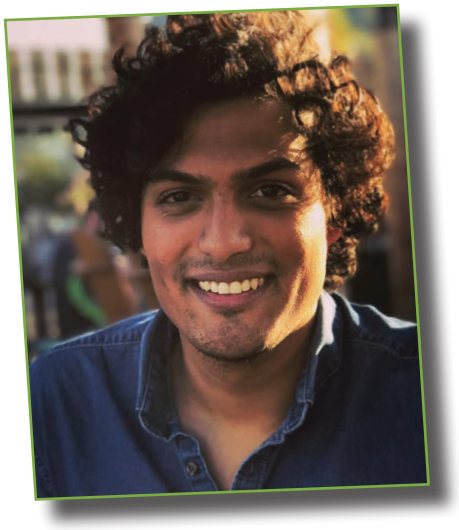
We also have the Bang & Olufsen Beolab 90, where beam-forming can be adapted at will. I think Beolab 90 is a very early indication of something that can evolve over the next 25 years in our industry, potentially.

If we look at the object-based audio technology as it is outlined today, then each loudspeaker in your setup communicates certain objects. A rendering engine defines what each object should become in your specific setup. Actually, none of these technologies or any of the mentioned loudspeakers solve the fundamental problem, which is that each instrument has their own radiation characteristic. It raises the question, should the speaker attempt to disperse the sound into the room in a similar way to what the recorded instrument did on the recording site? If so, could the concept of object-based audio be utilized to define instruments and could a rendering engine be capable of sending instructions to a loudspeaker to imitate such instruments (multiple instruments, simultaneously)?

If our industry decides to follow this path, then loudspeakers will convert from using a few larger drivers into using a very large number of small drivers. DSP, beam-forming, and so forth, could all be tricks in the bag for such a transformation. As mentioned previously, to be successful at the higher-end of the market, the focus shall be on the acoustic performance, not playful features, and besides the speaker-room interaction I think there's sonic improvements to be gained in basic qualities, like timbre and lower distortion for high-res reproduction.

Personal Question: Did your music listening habits change in the last 12 months? Which speakers/headphones do you use more often to listen to music?

FUTTRUP: My listening habits are essentially unchanged. I purchased an apartment in Norway at the end of 2017 and have improved on the overall audio performance of my living room/listening environment. The speakers I designed and made 10 years ago are a basic two-way design with a 6.5" woofer and a 1" tweeter. In 2018, I built a music streamer based on a Raspberry Pi and experimented with digital upsample filters. Overall, I have played more music the last six months than the previous years, and I enjoy listening to all sorts of different styles of music. I never listen to headphones and although the technology to improve on the stereophonic quality is evolving, so far, I haven't found pleasure in listening to music this way. ***LIS***



Vincent Nallatamby

CEO, Tempow

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

Nallatamby: Timing is everything and we could not have been luckier in the past 12 months with regard to industry trends that highlight a need for our solutions. At Tempow, we provide a software solution for True Wireless Earbuds or Hearables, and the popularity of products like Apple's AirPods has driven phenomenal demand for our solution from competing brands. We've been working with many brands to design their own earbuds and expect this phenomenon to keep growing in the years to come.

QUESTION 2: In your opinion, what was the most important technology that appeared in the audio industry during the past year?

NALLATAMBY: In 2018 we got very close to being able to stream audio and voice over Bluetooth low energy, which would have a huge effect on the whole industry. Specifically, it would allow all audio devices to communicate together, which changes the fundamental structure of the industry. I expect the first solution to be ready for an end-product in 2021.

Question 3: How do you see the following audio technologies evolving in the next five years? Bluetooth, Headphones and Hearables, Smart Speakers, and, Voice Assistants?

NALLATAMBY: Bluetooth is positioned to evolve in 2020 with the ability to send audio over Bluetooth Low Energy (BLE). This will be a massive challenge for consumers to understand and use effectively, but it represents a tremendous opportunity for the market to enhance the Bluetooth experience.

Headphones and Hearables: I don't think everyone fully realizes how quickly the hearable market is growing. Miniaturization and battery life are the two intertwined challenges that we still need to overcome in the coming years. I expect the hearables companies to keep investing and looking for more battery efficient solutions, which will allow them to create smaller and sleeker devices that still have a decent battery life.

Smart Speakers, Voice Assistants and Voice Capture/Recognition: For users today, Alexa is Echo, and Echo is Alexa, but this will change—smart speakers will no longer be the only gateways for the voice assistant of the future. Your voice assistant should be available in any room of your house, and soon it will be. The main challenge is developing technology that can capture voice on a large surface, so I expect several technologies of distributed microphones to come to market in the coming years.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

NALLATAMBY: Without any originality: CES. It's not because of the cool technology you can see and listen to at the show, but because it's a unique opportunity to bring many people around the table and forge partnerships with companies you might not otherwise cross paths with.

QUESTION 5: Does your company have plans for voice implementation in 2019 in beyond? Cloud connected, or local voice commands?

NALLATAMBY: Yes, and we're looking toward cloud-connected. Implementing the wake-word detection only allows us to keep the minimal architecture we use for our True Wireless Earbuds reference design.

QUESTION 6: How important have smart speakers and voice recognition technologies been or will be for your business?

NALLATAMBY: Extremely important. We are investing massively in R&D to create the next generation of smart speakers: the invisible ones! We believe in an "ambient assistant" that will be everywhere for the user and not embedded into one single device.

QUESTION 7: What features introduced in connected devices (smart speakers, smart TVs, soundbars, personal audio, and appliances) do you think will be more important for the audio industry moving forward?

NALLATAMBY: The most important feature is not a feature at all—it's actually the setup process. We need to collectively make the setup of our products, and the enablement of all features, more accessible. If the user experience is amazing, we will be able to promote great new features and see users actually adopting them.

Personal Question: Did your music listening habits change in the last 12 months? Which speakers/headphones do you use more often to listen to music?

NALLATAMBY: I upgraded my set-top-box "FREE" in France, which now includes an amazing speaker with virtual 5.1 effects. Both the hardware and the software are designed by audio company Devialet, and the results are seriously impressive.

Otherwise, I use my AirPods every day. I tried the new Sennheiser Momentum True Wireless for a couple of weeks but I was extremely disappointed by the product and reverted back to my trusted AirPods. ***LIS***

Ferruccio Bottoni

CEO, USound

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

BOTTONI: In the past 12 months, we reached significant technical and commercial milestones: We completed the development of our MEMS-based microspeakers and distributed our reference designs to many industry-leading customers, gaining valuable and very positive feedback from ODMs and from end users that tested out our earphones and headphones at multiple events. They often ask us where they can buy our products—even though we are still in a pre-production phase. We started mass production and have reached an overall yield of 96%. The current market and technology trends, such as TWS, show that our technology is right on time and on track. Our focus for this and the next year is to extend our portfolio and bring our speakers into all portable applications.

QUESTION 2: In your opinion, what was the most important technology that appeared in the audio industry during the past year?

BOTTONI: We saw a lot of interesting things happen in 2018, such as the continuation of the True Wireless revolution and the 360° audio… but for us, of course, MEMS used for loudspeakers was the most relevant thing to happen because it is our technology that will enable and propel the development of the aforementioned, and of many more. MEMS microspeakers will revolutionize the way mobile audio devices and wearables are constructed, and we are proud to be a leading driver for this development.

Question 3: In your field, how do you see audio technologies evolving in the next five years?

BOTTONI: The overall general trend seen in the tech industry is to make everything smarter and the audio segment is not an exception. With the increasing need for greater computational power but the limitations on space, the smallest reduction on any component will ensure saving costs in manufacturing.

So, taking into account the emerging trend of wearables and TWS becoming smaller to fit all, as well as these being more naturally integrated in

the consumer's life, it's only reasonable to believe that the MEMS technology with its reduced size, audio quality, and lower power consumption, is here to save the day…and to stay.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

BOTTONI: USound exhibited at both, CES in Las Vegas, NV, and MWC in Barcelona, Spain, both of which were very important for us due to two main reasons—potential customers and partners, journalists, and other experts working the audio sector were there, and because those two events are key for the overall development, and trends forecast, of the tech industry. These events are always a great opportunity to meet up and discuss future projects, and of course, to gain feedback on our products and reference designs.

QUESTION 5: Specifically on speaker design, components, drivers and materials. What developments, products or technologies impressed you the most in the last 12 months?

BOTTONI: In opposition to software, when it comes to hardware in the form of components or workaround the materials for these components, the development demands a longer cycle time. Because of that, we are confident to admit that USound took a major leap that will revolutionize the audio industry with the application of its MEMS technology. It has impressed us how our customers and project partners have seamlessly and easily integrated MEMS loudspeakers into their applications.

We believe the next trend will be natural hearing, meaning open-ear and the possibility to listen to music while also staying in touch with our environment, combined with wireless technologies. Slightly in that direction, it was surprising to discover the company Noveto and its "Focused Audio" through beam-forming.

QUESTION 6: How did the emergence of smart speakers affect your business?

BOTTONI: As of now, our main focus has been directed toward implementing our technology into portable and personal devices, so we can't say that smart speakers have influenced USound directly. However, we do not discard the option to widen our area of action in the future.

QUESTION 7: Do you think any of the smart speaker abilities (digital signal processing, beam-forming, acoustic compensation, self-calibration, sensors, etc.) could make sense in other speaker and audio product categories?

BOTTONI: We see a lot of potential in the combination of different technologies and application possibilities, and in the evolution of existing products. So, for us, smart speaker abilities make a lot of sense in hearables, for instance.

Personal Question: Did your music listening habits change in the last 12 months? Which speakers/headphones do you use more often to listen to music?

BOTTONI: My music listening habits did not change, but with the development of our reference design for in-ear earphones, Megaclite, I, and many of our employees have switched to this system. At the same time, we are all evaluating wireless earphone models, testing how they fit our personal everyday lives. It's a very interesting process that is happening right now. ***LIS***

Tim Whitwell

Vice President of Engineering, Tectonic Audio Labs

Tectonic

QUESTION 1: How did your business evolve in the last 12 months and what are your perspectives for the next 12 months?

WHITWELL: Tectonic Audio Labs continues to push the boundaries of applying bending wave technology to audio solutions across our three primary focus areas: smart speaker technology, professional audio products, and the creation of audio components for IoT devices, automotive, and other high-fidelity environments.

The common thread between these is the increased

need for intelligibility. The proliferation of voice-enabled and IoT devices is a great example of the market driving a resurgence in the importance of audio quality. Our patented Balanced Mode Radiator (BMR) drive units provide high voice intelligibility and wide directivity up to the highest frequencies from a single transducer and can be used in small embodiments, creating new applications for IoT and smart speaker solutions to be delivered in market. Likewise, our Distributed Mode Loudspeaker (DML) offerings solve acoustical challenges at venues requiring high voice intelligibility such as auditoriums, gymnasiums, transportation terminals and more.

We expect our technologies to be adopted across even more vertical applications seeking improved fidelity, portability, and simplified designs.

QUESTION 3: How do you see the following audio technologies evolving in the next five years? Smart Speakers, Soundbars, and, Audio for Automotive?

WHITWELL: In general, we're seeing a push for products that are smaller, have wider directivity, and better voice intelligibility. At Tectonic, we believe this can be done with an extremely high-quality and fully immersive sound.

There are multiple advantages to this approach. For devices like smart speakers and soundbars, for example, reducing the size and consolidating the tweeter and midrange speakers into a single transducer can free up space for additional components and/or allow for shrinking of the overall form factor while improving the sound quality of the product. This can be accomplished with our BMRs, which are designed to provide wide directivity output up to the highest frequencies, ensuring clear intelligibility throughout the room. BMRs are becoming invaluable in the development of compact applications and everything from smoke alarms to smart-home devices. They're also ideal for home theaters, sound bars, computers, and other applications where ample space and portability is at a premium.

In the automotive sector, manufacturers are looking at every possible way to shave weight while drawing less power. They're turning to Tectonic, because our solutions can reduce the total number of speakers required and, therefore, take up less space, save weight and use less power. All while providing a premium immersive listening experience for the end-user.

QUESTION 4: What was the best and most useful trade show you attended in 2018 and why?

WHITWELL: We're fortunate to be in an industry with some excellent shows. We typically attend several shows to reach our different audiences, including CES, NAMM, ALMA International, and InfoComm. All have been great opportunities to network with others in the industry, and meet with customers, buyers, distributors, and integrators.

QUESTION 5: Does your company have plans for voice implementation in 2019 and beyond? Cloud connected, or local voice commands?

WHITWELL: Although Tectonic is not planning to offer its own voice service platform, as part of our engineering services, we have been working closely with partners who specialize in this area, and we are aware of many of the key challenges and stumbling blocks they encounter.

QUESTION 6: How important have smart speakers and voice recognition technologies been or will be for your business?

WHITWELL: Tectonic's BMR products are built specifically to fit small form factors where directivity and intelligibility are paramount. More and more, product engineers and managers are turning to Tectonic earlier in the development stages to build quality sound into their devices. As market demand for smart-home and voice-enabled products continues to increase, this remains a significant growth opportunity for Tectonic.

QUESTION 7: What features introduced in connected devices (smart speakers, smart TVs, soundbars, personal audio, appliances) do you think will be more important for the audio industry moving forward?

WHITWELL: We're definitely experiencing a shift in how people will interact with technology. Voice-enabled is becoming the new norm and is projected to phase out keyboards and other physical input devices. With that, products are being required to do more with less. For example, soundbars in lieu of home theaters and "big" sound expected from small voice assistants and connected devices. This shift means products must now be designed with sound in mind, including products where it has never been a consideration. That creates an opportunity for Tectonic and others to innovate and work in partnership with product engineers and managers throughout the product development cycle. ***LIS***

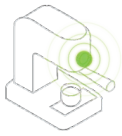
Tectonic

THE CLEAR CHOICE
FOR NATURAL VOICE REPRODUCTION

Tectonic's Balanced Mode Radiator (BMR), is a unique flat diaphragm loudspeaker that addresses two significant limitations of conventional cone diaphragms; break up and power beaming.

The BMR delivers extended SPL on and off-axis leading to room filling sound with improved coverage for all listeners. Because the BMR is a single full-range solution it eliminates the need for crossovers in the critical vocal region, resulting in excellent voice intelligibility even when off-axis.

BMRs can be found in the market today in:



IoT Devices

Smart Speakers

Automobiles

	BMR	Conventional Full-range	Conventional Multi-way
Wide directivity across full audible range	YES	Maybe*	Maybe*
Smooth sound power response (SWL v Frequency)	YES	No	Yes
Low distortion	YES	Yes	Yes
No crossover needed in vocal region	YES	Yes	No

*Design dependent

TO LEARN MORE VISIT:
TECTONICAUDIOLABS.COM/TECHNOLOGY/BMR-TECHNOLOGY

Contact us at: **oem_solutions@tectonicaudiolabs.com** or **425.686.7640**

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