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VOICE COIL

THE PERIODICAL FOR THE LOUDSPEAKER INDUSTRY

IN THIS ISSUE

Industry News and Developments

By Vance Dickason

A New Measurement Microphone from iSEMcon

iSEMcon has introduced the EMX-7150, a 0.25" measurement microphone that has a 10 Hz to 20 kHz, IEC61672 class-frequency response, designed for SPL measurements (see **Photo 1**). The EMX-7150 is an omni-directional type microphone, and it includes both free-field and derived diffuse field calibration data at no additional cost (calibration chart and ASCII-Data on CD). This microphone can be powered with phantom power, and it handles sound pressure levels up to 145 dB (SPL).

The robust stainless steel body construction uses a watertight, state-of-the-art, Neutrik XLR connector and comes complete with a small windshield

Photo 1: iSEMcon's new EMX-7150 measurement microphone

and spring-loaded holding clamp. Also available is an optional super guard windshield, protecting the microphone port from dirt and spraying water as well as trickle water from the back. Features include:

- Frequency range 10 Hz to 20 kHz
- Sensitivity 6 mV/Pa typ.
- Dynamic range approximately 30—greater than 145 dBspl
- 3% distortion limits 146 dBspl typ.
- Calibration chart and calibration data files included on CD
- IEC 61672 Class 1 frequency response
- Dimensions: acoustic port diameter 0.25" (7 mm)
- Microphone body 0.75" (19 mm)
- Overall length 6" (152 mm)
- Weight 0.3 oz (75 grams)

Street price should be in the $260 range. For more information, visit the iSEMcon website at www.isemcon.com.

Eminence Releases New High-Powered Impero Woofer Line

Eminence Speaker has introduced three advanced high-power additions to the Professional Series: the Impero 12A, 15A, and 18A. Italian for "empire," Impero sets the tone for this elite offering of high-quality, hand-built loudspeakers (see **Photo 2**).

Photo 2: The Impero woofer by Eminence

Using high motor strength with balanced Vas and Mms, the Impero series plays extremely loud and low in compact vented designs. Advancements include a 0.5" thick by 7.5"-diameter machined top plate, one-piece, machined T-yoke, and a 4" deep wound fiberglass voice coil. These features, combined with an ultra-linear long-excursion suspension and bumped motor assembly, allow the Impero Series to move serious air and generate serious SPL, while handling tremendous amounts of power.

At 1,100 W continuous/2,200-W program power, the 12" Impero 12A has a usable frequency range of 56 Hz to 3 kHz, making it perfect for two-way top boxes, full-range two-way boxes, bass guitar boxes, and small subwoofers.

The 15" Impero 15A is suited for two-way top boxes, full-range two-way and three-way boxes, bass guitar boxes, and small subwoofers, and is rated at 1,200 W continuous/2,400-W program. With a frequency range of 46 Hz to 2 kHz, this 15" has the extension at both ends to go low and high, perfect for small vented boxes with conventional sized horns.

This model is also available in a 4-Ω version, the Impero 15C. The 18" Impero 18A is also rated at 1,200 W continuous/2,400-W program power, has a frequency range of 39 Hz to 820 Hz, and is suited for full-range, three-way boxes, bass guitar boxes, and small subwoofers.

This model is also available in a 4-Ω version, the Impero 18C.

Like all Genuine Eminence-branded professional audio and musical instrument loudspeakers, the Impero 12A, 15A, and 18A are built by hand in the United States, and they are backed by a seven-year warranty.

For more information, visit the Eminence website at www.eminence.com. ***VC***

VOICE COIL

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Spotlight

ISeat 2011 Symposium

By Mike Klasco

In November 2011, I gave a talk at the International Symposium on Electro-Acoustic Technologies (ISEAT) 2011 in Shenzhen, China, held on November 12 and 13. ISEAT is an international platform of communication for electro-acoustic researchers, senior engineers, senior managers, and engineering students (see **Photo 1**). It is based in China and originated with audio engineering alumni of Nanjing University. ISEAT's presentations and exhibitors are global—sort of a mix of a regional AES and ALMA. Check out www.iseat.org, which provides the option of the website in English. There are a couple of somewhat overlapping audio engineering organizations in China, and I hope to cover their events in future issues.

ISEAT was initiated by Professor Yong Shen (see **Photo 2**) from the Institute of Acoustics in Nanjing University. It is held every other year. The first ISEAT, in 2007, started slow, but the most recent event (2011) was outstanding. ISEAT is composed of invited papers, posters, demonstrations, and workshops. It provides an abundance of representative and innovative technology, products, market information and a wealth of opportunity for learning and networking.

The venue is the Shenzhen Virtual University Park, which is a strategic and innovative move by the local government of Shenzhen. The "Virtual U" was founded in 1999 and is located in the Shenzhen High and New Technology Industry Development Zone on the bank of Shenzhen Bay.

Virtual? While the facility is brick-and-mortar—with impressive auditorium facilities, some classrooms and other presentation areas—the concept is distance learning in Shenzhen with other universities throughout China. Other purposes are technology incubation, technology transfer from universities to industry, and vice versa. There are 48 organizations and 18 network members in the Virtual University Park. The former includes 35 famous domestic universities such as Tsinghua University, Peking University, and Harbin Industry University, together with activity bases for academicians from both the Chinese Academy of Sciences and the Chinese Academy of Engineering, and five universities from Hong Kong, including The Hong Kong University of Science and Technology, Hong Kong Polytechnic University, City University of Hong Kong, Hong Kong Baptist University, and University of Hong Kong, as well as Lyon Central Polytechnic University of France.


Photo 1: ISEAT welcome banner

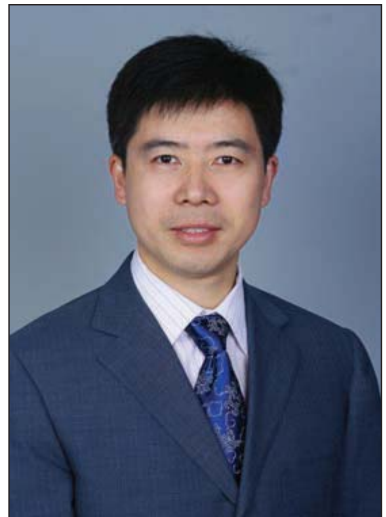
Photo 2: Yong Shen

Our ISEAT hosts were gracious (see **Photo 3**) and banquet highlights included a wonderful dinner, a ride to the banquet with Neville Thiele, Graham, and other notable characters, and a general reunion of audio personalities I have worked with in China over the last 20 years.

Exhibitors

The highlight of any show, be it an AES Convention, ALMA Symposium, or ISEAT, are the exhibits. These are the companies that participated in ISEAT 2011:

• AAC Technologies Holdings Inc.—AAC Technologies Holdings, lnc. (see **Photo 4**) has been a listed company on the Stock Exchange of Hong Kong since August 2005. (Stock code: 2018.HK) AAC designs, manufactures, and distributes a comprehensive suite of receivers, speakers, speaker modules, multi-function devices, microphones, transducers, and headsets for use in mobile devices, game consoles, notebook computers, tablets, and other consumer electronics devices. www.aactechnologies.com

• Shenzhen Horn Audio Co. Ltd.—Shenzhen Horn Audio Co., Ltd. is a high-tech company registered in Shenzhen. The company has become a principal audio products supplier to some of the world's top 500 companies such as Microsoft, Sony, and Hewlitt-Packard among others. www.szhorn.com

• Andorin Automatic Engineering Co, Ltd—After five years of basic research and three years of practice, Andorin Automatic Engineering Co, Ltd. (see **Photo 5**) has formed general loudspeaker factory-level automation solutions. www.andorin.com

• Edifier Technology Co., Ltd.—Established in Beijing, China, in May 1996, the Edifier Group quickly expanded overseas, and in 1998 developed into a transnational group company. Edifier is one of China's first specialized manufacturers producing genuine wood-enclosure speaker systems, and one of the first groups of loudspeaker manufacturers who have successfully developed an exclusive international market. The company has the envious position of occupying first place in the whole country in terms of output and sales volume, with over 6 million systems being sold in 2004. The company operates two production bases in Beijing and Shenzhen in China, respectively, Your Total Solution Company for Audio Products

Shenzhen Horn Audio Co., Ltd. is committed to the development of total solutions and applications for acoustic products.

Since developing into a major supplier of electret microphones, Shenzhen Horn has expanded its offerings to include speakers and drivers as well as OEM/ODM design and build of complete products such as corded and wireless headsets, gaming headsets, speaker bars and mini multi-media speakers. Horn is a supplier of acoustic solutions to some of the world's most respected companies.

Horn maintains and enhances its R&D capabilities by finding and hiring the best available talent and providing on-going training to our engineering staff. These steps allow us to provide total audio solutions that meet and exceed our customers' needs. Superior quality, coupled with knowledge of the most recent technological developments, allows our talented staff to take our customers' OEM/ODM products from inception through product planning and on into production.

Shenzhen Horn Audio Co.,Ltd.
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Photo 3: Presenters at ISEAT 2011

with full product research and development, plastic injection, machining, painting, silk-screen printing, and assembly. The R&D team is composed of dedicated acoustical engineers from Beijing, China, and North America. The group has more than 2,500 employees, and manufacturing facilities covering an area of 1 million square feet. The company's head offices are in Vancouver, Canada, being mainly responsible for group strategy sales, product planning, and product R&D. www.edifer.com.

• Guoguang Electric Company Limited (GGEC)—GGEC emanated from an electrical workshop in the 1950s. In its development, the company evolved from a private operation to a state-owned enterprise to a joint-venture company in December 1993, adopting the present name, Guoguang Electric Company Limited (GGEC). Company shares, a total of 200 million, were subsequently listed on the Shenzhen Stock Exchange on May 23, 2005. In the past 50-plus years, GGEC has grown to be a world class organization and one of the leading developers and largest manufacturers of speaker drivers and audio systems in China. GGEC offers a complete range of speakers, drivers, audio systems and accessories. www.ggec.com.cn

• Harman International (Shanghai) Management Co., Ltd.— Business and other management consultant activities. www.harman.com

• 3NOD Digital Group Co., Ltd.—3NOD Digital Group Co., Ltd. is a holding company engaged in the management of subsidiaries and affiliated companies. As of March 31, 2011, the company had three subsidiaries, including Shenzhen 3NOD Electronics and 3NOD Group Co., Ltd. (HK), and 16 sub-subsidiaries. Through its subsidiaries and affiliated companies, the company manufactures multimedia speakers, digital speakers, home theaters, computer cases, power supplies, notebook computers, automobile electronic products, and more. www.3nod.cn

• NTi China Co., Ltd.—NTi Audio's heritage includes over 30 years of experience in designing high-precision audio test equipment, including the classic and popular AudioTracer & AudioGraph series, portable and bench-top audio analyzers (such as the A1, the A2, and the A2D dual-domain model), and the Rapid-Test Series production line analyzers, consisting of the RT-2M and RT-2X. www.nti-audio.com

• Listen, Inc.—Listen, Inc. (see **Photo 6**) has been a manufacturer of audio test and measurement equipment since 1995 when Steve Temme, a former Brüel & Kjær audio and telecom applications engineer, introduced SoundCheck, the world's first widely available software and sound card based audio analyzer. www.listeninc.com

• Klippel GmbH—The Klippel GmbH (see **Photo 7**) is a German company founded by Prof. Wolfgang Klippel in 1997 to produce novel control and measurement systems for loudspeakers. The current developments are based on the results of loudspeaker research performed for nearly 20 years and published in numerous scientific papers and patents. Wolfgang Klippel contributed to the development of large-signal models for loudspeakers, which are the basis for digital compensation of the nonlinear distortion. His pioneering work was recognized by awards from the Audio Engineering Society. www.klippel.de

• Ministry of Foreign Affairs of Denmark—Attended ISEAT to promote business with Denmark. um.dk/en

Photo 4: AAC exhibit at ISEAT 2011

Photo 5: Andorin exhibit at ISEAT 2011

Photo 6: Listen, Inc. exhibit at ISEAT 2011

Photo 7: The Klippel GmbH exhibit at ISEAT 2011

• Taiden Industrial Co., Ltd.—Taiden industrial Co., Ltd., established in 1996, is a high-tech enterprise specializing in R&D, manufacturing, and worldwide sales of modern digital conference systems. Taiden is one of the world's leading conference system manufacturers, as well as China's largest conference system manufacturer. Taiden is the member of International Congress & Convention Association (ICCA) for technical assistance on international conferencing. www.taiden.com

• Desfine Audio Inc.—Desfine Audio manufacturers pro sound loudspeakers, horns for loudspeakers, videorecorders, megaphones, equalizers for audio systems, cabinets for loudspeakers, microphones, acoustic conduits, and diaphragms for microphones. www.desfineaudio.cn

Presentation Highlights

I have included a few presentation highlights, but it is not my intention to minimize the work that went into the presentations and the proceedings of ISEAT in this article. More complete coverage is available in a bound copy, and I will see what I can do to make them available in the United States.

• Neville Thiele, "Closed-Box Loudspeaker with a Series Capacitor"—The connection of a capacitor in series with a closed-box loudspeaker can extend its response at lower frequencies with a smaller box. At the same time, it confers protection against excessive excursion of its voice coil from subsonic input signals, which produce no useful acoustic output. A

Photo 8: Professor Yong Shen and Neville Thiele at ISEAT 2011

design procedure and suitable transfer functions were presented by Neville Thiele (see **Photo 8**).

• Jose Martinez (Acoustica Beyma), "High SPL Small Transducer: Improvements and Limitations"—This paper explored solutions to the problems in small direct radiators at high Sound Pressure Level (SPL) at low frequencies. The dynamic behavior of the moving assembly, using the Finite Elements Model (FEM) to quantify the influence of small changes in geometry and material characteristics such as the number of folds in the suspension (spider), the distance between these suspensions, or the effect of unbalanced forces inherent in the speaker construction.

• Wolfgang Klippel (Klippel GmbH), "Measurement and Perception of Signal Distortion Generated by Loudspeaker Systems"—Certain residual distortion(s) are directly related to the geometry and properties of the material used in loudspeaker design and found in all good units passing the assembling line. Those regular distortions are the result of an optimization process giving the designer's intended best compromise between perceived sound quality, maximal output, cost, weight and size. This paper discusses the physical causes of these distortions, their modeling by using lumped and distributed parameters, the objective assessment using modern measurement techniques, and the perception by the human ear.

• Wang Gang, "Study on the Design of Double Drive Speaker for Minispeakers"—With the development of flat screen TVs and the minispeakers systems—where the box width and thickness is less than 30 mm based on the equivalent circuit analysis of closed boxes—this presentation explored the effect of equivalent air volume of a loudspeaker drive unit, which affects the functions of Loudspeaker box. Examples demonstrating double drive's positive influence on the frequency response of a mini Loudspeaker box are given, while equivalent air volume of a loudspeaker driver (Veq) of a double drive speaker is decreased.

• Xie Shou-hua, "Application of Doublet Sound Source Tweeter"—This paper discusses doublet sound source and design of a tweeter module with low directivity index and application of this design for PC multimedia systems.

• Xu Xin-guo, "A New Type Reflex Enclosure"—For all existing reflex enclosures, the internal air is not flowable. Therefore, when it is used high power, the internal temperature will continue to rise and power compression will increasingly become an issue. With the increase of the voice coil temperature, it reduces the safety as well as reliability of the loudspeaker. To solve this problem, a type of enclosure was developed that will make the internal air flow unidirectional.

• Guan Shan-qun, "The Nonlinear Distortion of Condenser Microphone"—The study on nonlinear distortion of a mechanical-electro transducer in a condenser microphone is reported. The results show that the nonlinear distortion is in proportion to the ratio of the "fixed capacity" to the overall capacity.

• Wookeun Song, "Background Noise Reproduction Using Spherical Microphone Array"—Background noise reproduction for the evaluation of telecommunication devices, such as a mobile phone, was investigated using the measurement of spherical microphone arrays. Binaural synthesis, using headphones and higher-order Ambisonics, were evaluated for the study. Binaural synthesis was made by performing spherical beam forming, and subsequently taking head-related transfer functions (HRTFs) into account. The investigation provides practical examples for objective and subjective assessment of background noise and reveals the advantages of the techniques for the evaluation of devices under test in the presence of background noise.

• Wu Zong-han, "The Discussion on the ECM's Characteristics Affected by Material"—This study contains a detailed analysis of the ECM's characteristics as they are affected by material with some experimental results to confirm our analysis. This article also contains a discussion on the capacitance characteristics, output characteristics, and phase characteristics of ECM.

• Feng Zi-xin, "Latest Progress of International Audio Engineering: A Review and Analysis of the 129th and 130th AES Conventions"—There is some discussion of notable AES papers on the latest progress of international audio engineering concerning loudspeakers, microphones, other electro-acoustic equipment, architectural acoustic and sound reinforcement, psychoacoustic and subjective evaluation, spatial acoustics and hearing, sound recording and reproduction, audio codec, signal processing, audio transmission and broadcast instruments, and measurement.

• Yu Jin-yuan (GGEC), "General Summary for New Developments in Loudspeakers"—This article discusses loudspeaker technology development, recent updates and industrial affairs, first issued by the ALMA Expert Forum. It also introduces loudspeaker technology development trends from CEDIA EXPO. Finally, it introduces the features of BNT (sodium bismuth titanate lead-free), which replaces traditional piezoelectric ceramic speaker material (PZT).

• Wang Yi-Zhen, "A Review on Line Array Systems of Twenty-Five Brands"—The article compares and contrasts the common characteristics and rules of line array systems through the analysis of line array systems of 25 brands international brands.

• Wolfgang Klippel (Klippel GmbH), "Measurement and Perception of Loudspeaker Defects"—Loudspeaker defects caused by manufacturing, aging, overload or climate impact generate special kinds of irregular distortion commonly known as Rub & Buzz, which are highly audible and intolerable for the human ear. Contrary to regular loudspeaker distortions defined in the design process, the irregular distortions are hardly predictable and are generated by an independent process, triggered by the input signal. Traditional distortion measurements such as THD fail in the reliable detection of these defects. The paper discusses the most important defect classes, new measurement techniques, audibility, and the impact on perceived sound quality.

• Steve F. Temme, "Automated Perceptual Rub & Buzz Distortion"—All manufacturers want two things from their loudspeaker and headphone assembly lines—good sound quality and high yields. One way that higher yields can be achieved without sacrificing product quality is to detect Rub & Buzz defects using an automated perceptual Rub & Buzz detection model rather than a conventional one. This is a model which detects only audible Rub & Buzz faults rather than ALL Rub & Buzz faults. Automated perceptual Rub & Buzz measurement better reproduces the results obtained by a human listener but with higher throughput and full integration with automated production lines.

• Gregor Schmidle, "A Systematic Approach to Measurement Limit Definitions in Loudspeaker Production"—A typical end-of-line loudspeaker test comprises 10 or more different parameters. Each parameter has its own pass/fail limits, contributing to the overall test result of the loudspeaker, and therefore, to the yield of the production line. This paper gives a comprehensive overview about commonly used limit calculation methods and procedures in the industry. It also delivers systematic guidance for choosing the right limit scheme for maximizing yield, quality, and throughput.

• D. B. Keele, Jr., "Performance Ranking of Arrays" —While Don was not able to participate in person, his presentation was given on a large screen in the main auditorium. Various types of loudspeaker line arrays were ranked considering eight performance parameters including: Beamwidth uniformity; Directivity uniformity; Sound field uniformity; Side lobe suppression; Uniformity of polar response; Smoothness of off-axis frequency response; Sound pressure roll-off versus distance; and Near-far polar pattern uniformity. Line arrays analyzed include: 1. Un-shaded straight-line array; 2. Hann-shaded straight-line array; 3. "J"-line array; 4. Spiral- or progressive-line array; 5. Un-shaded circular-arc array; 6. CBT circular-arc array; and 7. CBT delay-curved straight-line array. All arrays were analyzed assuming no extra drive signal processing other than frequency-independent shading. A weighted performance analysis yielded the following ranking from best to worse 6, 7, 5, 4, 3, 2, 1, with the CBT Legendre-shaded circular-arc array on top and the un-shaded straight-line array on the bottom.

• Richard Little, "An Examination of Acoustic Performance Characteristics of the LAT"—While a few years ago the LAT cylindrical transducer created quite a stir, attention has waned. Richard's paper shows serious work continues. A good first approximation can be modeled by the standard linear time-invariant small signal parameter (SSP) model, used to describe the operation of more standard loudspeakers. Previous work has established a more accurate LAT SSP model. This paper examines the acoustic behavior of LAT devices, in comparison to the expected behavior of the LAT SSP model, but also examines acoustic behavior of LAT devices not covered by the LAT SSP model, such as acoustic radiation characteristics, and sound pressure output limitations. A LAT is shown to function similarly to a normal transducer mounted inside a dual-bandpass enclosure, and to have an unusual acoustic radiation pattern. The technical challenges in measuring the small signal parameters of a LAT are also briefly examined.

• Liu Yun-feng, "Omni-directivity Sound Girder and Its Use (Sound Girder = Dispersion Lens)"—After the optimization of the sound girder's directivity in the horizontal direction and its acoustic power by QR timing or phase delay, sinc setup or quadratic residue setup, its frequency response is also improved in directions deviated from its axis. An omni-directivity sound girder can be installed easily in classrooms, meeting rooms, flat panel TVs, and looks artistic.

• Xiaoli Zhong, "Customization of Individualized Head-Related Transfer Function"—Virtual auditory display (VAD) recreates desired spatial auditory events by synthesizing binaural signals with head-related transfer function (HRTF) and rendering them through headphone. VAD has been widely used in research of binaural hearing as well as consumer electronics and entertainments in recent decades. Existing studies have emphasized that faithful performance of VAD needs incorporating individualized HRTFs. Empirical measurement is a conventional way to accurately obtain individualized HRTFs. However, it is difficult to measure individualized HRTFs for each of potential users with high spatial resolution. A variety of approaches to approximating or customizing individualized HRTFs have been developed, which become hot issues in research of VAD. Although moderate success has been achieved, further validation and improvement of those customization approaches are required. This article reviews latest development in this field with emphasis on existing problems and future directions.

• My presentation, "What Do These Crazy Americans Want?" was on vendor selection criteria for larger western companies and will appear in a future issue of *Voice Coil*. I would like to thank Jimmy Ying of Sea Galleon for all of his help, and give him credit for many of the pictures (see **Photo 9**).

Photo 9: Menlo Scientific President Mike Klasco giving a presentation

So far, no date has been set for the next ISEAT. Having participated in my share of organizing seminars myself, I don't think Professor Shen wants to think about this just yet, but readers who travel to China from time to time should consider attending in 2013. Maybe there could be an ALMA contingent next time around? ***VC***

Acoustic Patents

By James Croft, Croft Acoustical

The following loudspeaker-related patents were filed primarily under the Office of Patent and Trademarks classification 181 for acoustical devices and 381 for electrical-signal processing systems and HO4R for international patents. This also includes new patent applications that are published in the *Patent Application Journal*.

VEHICLE LOUDSPEAKER ARRAY

Patent Number: U.S. 8,073,156

Inventors: Steven W. Hutt (Bloomington, IN), D. Broadus Keele, Jr. (Bloomington, IN)

Assignee: Harman International Industries, Inc. (Northridge, CA)

Filed: May 19, 2005

U.S. Class: 381/86

Granted: December 6, 2011, 26 Claims, 7 Drawings

Abstract from Patent

An audio processing system for a vehicle includes a plurality of loudspeakers positioned to form a single line array. The loudspeaker line array is position-able in a vehicle on a dashboard of the vehicle substantially at the convergence of the dashboard and a window of the vehicle (see **Figure 1a** and **1b**). When the loudspeaker line array is driven by an audio signal, a vertically and horizontally focused and narrowed sound pattern is perceived by a listener in the vehicle. The sound pattern is the result of the constructive combination of the direct sound impulses and the reflected sound impulses produced by each loudspeaker in the array. Using delay, attenuation and phase adjustment of the audio signal, the sound pattern may be controlled, limited, and directed to one or more locations in the vehicle.

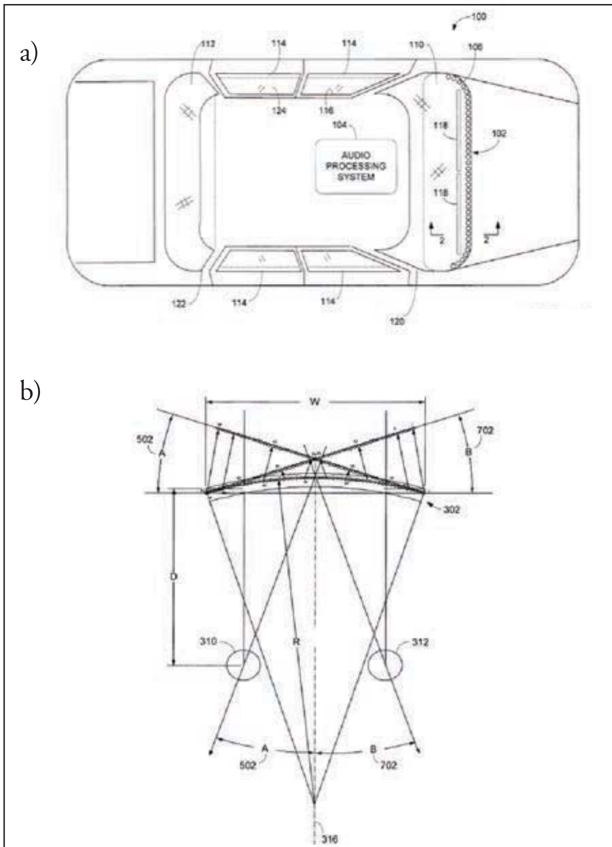

Figure 1a: An audio processing system for a vehicle. b: A diagram of the sound pattern within a vehicle

Independent Claims

1. An audio system for use in a vehicle, the audio system comprising: a line array of at least four loudspeakers; and a shelf configured to be installed in the vehicle, where the array is mounted on the shelf and positioned adjacent to a sound reflective surface that extends above the shelf, and the sound reflective surface forms an angle between the shelf and the sound reflective surface; where the line array is positioned juxtaposed to a convergence of the sound reflective surface and the shelf, and where the loudspeakers are positioned on the shelf with respect to the sound reflective surface so that a first direct sound impulse provided by each of the loudspeakers is constructively combined with a reflected sound impulse created by reflection from the sound reflective surface of a second direct sound impulse provided by the same loudspeaker that provided the first direct sound impulse.

5. An audio system for use in a vehicle, the audio system comprising: a single line array of at least four loudspeakers; and a shelf configured to be installed in the vehicle, the line array mounted at a peripheral edge of the shelf; where the peripheral edge is positioned in the vehicle adjacent a sound reflective surface that forms an angle with the shelf so that the single line array is configured for constructive combination of direct sound impulses from one of the loudspeakers with reflected sound impulses that result from reflection of the direct sound impulses by the sound reflective surface.

17. An audio system for use in a vehicle, the audio system comprising: a plurality of loudspeakers formed in a line array; a direct sound impulse produced by each of the loudspeakers; and a reflected sound impulse produced by reflection of a portion of the direct sound impulse with a sound reflective surface; where the direct sound impulse and the reflected sound impulse combine substantially in phase due to a distance between the loudspeakers and the sound reflective surface.

23. An audio system for use in a vehicle, the audio system comprising: a line array of at least four loudspeakers, the at least four loudspeakers contiguously positioned in the line array to form a single line; and a shelf configured to be installed in the vehicle, where the array is coupled to the shelf and positioned adjacent to a window in the vehicle that extends above the shelf and the shelf forms an angle between the shelf and the window, where the line array is juxtaposed to a convergence of the window and the shelf; and where the at least four loudspeakers are positioned on the shelf with respect to the window so that a first direct sound impulse provided by each of the at least four loudspeakers is constructively combined with a reflected sound impulse created by reflection from the window of a second sound impulse provided

by the same loudspeaker that provided the first direct sound impulse.

REVIEWER COMMENTS

Disclosed in this patent is a loudspeaker array for use in a vehicle with an audio system that includes an array of transducers and associated amplifiers individually driving each transducer, or groups of transducers, to create multi-channel sound field images for listeners seated in the vehicle. The preferred transducer array is composed of a plurality of wideband miniature loudspeakers that are located in the vehicle at the converging intersection of the windshield and the dashboard.

The array is driven by one or more audio signals provided by a bank of multi-channel processor-controlled automotive amplifiers capable of providing separate processor/amplifier power to each loudspeaker in the array. Due to the rather extended length of the array, relative to the wavelengths being reproduced, the array can beam steer a wave-front to virtually any horizontal location in the vehicle cabin. By driving all the transducers with all the channels of the sound source, a separate, beam-steered, wave-front direction can be created for each channel, and/or a separate beam-steered wave-front can be created for each desired direction or sonic location for any input signal.

Along with this horizontal directivity control, the vertical directivity is maintained by way of the natural waveguide formed by the dashboard and the windshield. Further, the transducers are positioned relative to the windshield/reflector, such that over a major portion of the frequency range of the system the direct and reflected signals sum constructively.

Different audio signal processing configurations are also used to further control the coverage pattern of the sound field produced by the array of loudspeakers. For example, signal delay may be used to focus audio content produced by the array at the driver and/or passenger locations. Amplitude shading may also be used to minimize crosstalk and further focus the array. Selective application of delay, amplitude shading, and inversion to the audio signals driving the loudspeakers in the array can form illuminated privacy zones for one or more passengers in a vehicle, even producing different program material simultaneously for each passenger region. This can be used for reproducing audio program material or also for other applications, such as private listening for hands-free phone calls.

The success of any private listening is subject to the reflective properties of the passenger cabin surfaces, which can substantially defeat a private listening zone due to strong reflections bouncing around the interior of the vehicle.

The system is based on the multi-channel, beam-steered, single-speaker surround sound systems, developed by Anthony Hooley of 1-Ltd. in England and produced by Pioneer as a two-dimensional array (with height information steering included) and eventually patented by Yamaha and Pioneer as a simplified, one-dimensional, horizontal array (see U.S. 5,953,432) which most closely resembles the current invention. While this multi-channel system architecture has

been available for home theater use since the late-1990s, this patent appears to disclose the first application of this technology to a vehicle sound system.

Other approaches to isolated listening and directivity control in vehicle sound systems have been attempted by different means, such as parametric directional transducers, and multiple planar magnetic transducers in various in-vehicle arrangements (see Thigpen U.S. 7,343,020), but one would expect the current invention to achieve a superior combination of directivity control, combined with a maximization of maximum output capability from a given transducer set, due to multi-channel power sharing and inherent incorporation of the natural horn/waveguide formed by the location of the source of acoustic output.

This appears to be an effective use of this type of loudspeaker array and signal processing, and should be an useful system that substantially meets intended goals.

PLANAR SPEAKER DRIVER

Patent Number: U.S. 8,031,901
Inventors: Igor Levitsky (Toronto, CA)
Assignee: Bohlender Graebener Corp. (Carson City, NV)
Filed: September 13, 2007
Granted: October 4, 2011
Current Class: 381/399, 7 Claims, 6 Drawings

Reviewer Comments

Disclosed is a double-ended or push-pull, planar magnetic transducer (see **Figure 2**). It includes the standard elements, such as opposing rows of magnets with a thin film, tensioned diaphragm including conductive traces, positioned between the front and back-set of magnets. There are a number of additional elements shown, but not claimed, such as the driver having selectively corrugated along the periphery of the diaphragm.

One of the issues that practitioners of this type of device often have to deal with is that of the fact that the opposing magnet rows have a common polarity facing each other, and therefore significant repulsion forces pushing the magnets apart, and therefore attempting to push the front and back magnet/frame assemblies apart from each other. This can cause a bulge in the middle of the device, causing a larger gap between the magnet and film in the center than at the outer edges of the transducer, and also can cause a reduction in diaphragm tension, which can change the resonant frequency and cause buzzing. This has become an even more significant issue in the last decade, as high-energy neodymium iron magnets have been incorporated

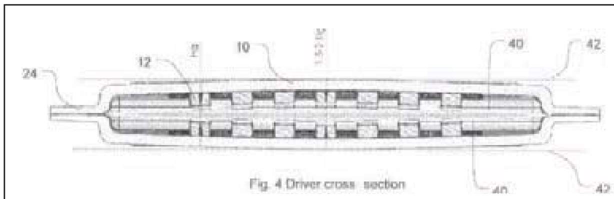

Figure 2: U.S. Patent 8,031,901

into planar magnetic transducers.

There are two basic approaches to dealing with this problem: 1) use thicker, stronger frames, add bracing across the outside of the front and the back of the transducer, or 2) adopt the specific claimed approach of the patent, which is to allow the central portion of the transducer to bow out and create a larger central gap, while setting the film tension to be optimal under this condition. The advantage of allowing the center of the device to bow outward, is to create a larger gap for greater excursion ability in the center, where the excursion is greatest at low frequencies, and to allow the system to reach a mechanical stasis with the frames bowed in the center as the predetermined final form that remains substantially unchanged over time.

The construction form does have precedent, in that it was first disclosed in James Winey's early Magnepan single-ended patents of the 1970s (U.S. 3919499) and was also expressed in a number of the models of the large area double-ended, push-pull ribbons of the Carver Amazing Loudspeaker models developed by David Graebener and this reviewer in the mid-1980s. The approach is an effective construction technique for this type of device, and does allow for the performance advantages of greater excursion due to a larger gap, as suggested in the patent. Of course, the larger gap has an associated reduction in efficiency, but a balance of excursion and efficiency is a standard tradeoff among all transducers and this is an effective technique to balance the attributes in planar magnetic devices. ***VC***

Big Woofer, Small Woofer

By Vance Dickason

Samples received for this month's Test Bench review (it's really more of an objective explication) are from the opposite ends of the woofer spectrum, an 18" high-powered pro sound subwoofer from BMS, the BMS 18N862, and just for contrast, a 3" full-range from Fountek, the FR89EX.

The January 2012 issue of *Voice Coil* featured the BMS 15" extended range neo woofer, the BMS 15N850V2. This month I received the BMS 18" extended low-frequency neodymium motor woofer, the 18N862, a new version of their successful 18N860. Like the 15N850V2, the 18N862-8 features a rather high-rated nominal power handling of 1500 W (AES).

The BMS 18N862 is a new version of the BMS 18" neodymium motor 18N860 extended low-range woofer, the primary difference being the surround configuration. Like its 18N860, the 18N862-8 is built on a proprietary eight-spoke cast aluminum frame that is further CNC machined at the factory to guarantee a better contact between the frame and the motor system for enhanced thermal contact, supplemented by a special silicone compound for better heat transfer. The frame is also additionally machined on the spider mounting shelve to ensure a ±0.05-mm vertical dimension to avoid DC offset by getting an exact magnetic center location. For cooling, the frame has eight sets of heatsink fins, grouped four to a set, each with five 2 mm × 30 mm vents between the fins, for a total of 24 heatsink fins and 40 vent slits located between the spider mounting shelf and the back of the frame. Along with this, there are also four 6-mm diameter round vents around the peripheral of the motor base.

The cone assembly features an 18"-diameter double-coated (for moisture resistance) straight profile, lightweight, carbon fiber filled paper cone with a 6"-diameter coated paper dust cap. Compliance is provided by a three-roll coated cloth "M" type surround and a 7"-diameter cloth spider mounted directly to the frame. Driving this assembly is a 101.6 mm (4") diameter voice coil wound both inside and outside with round copper wire on a proprietary 0.22-mm thick glass fiber former. BMS refers to this as a "sandwich" voice coil. Heavy insulated tinsel lead wire are terminated to a pair of chrome, color-coded push terminals.

Testing for the BMS 18N862 began using the LinearX LMS and VIBox to generate both voltage and admittance (current) curves with the driver clamped to a rigid test fixture in free-air at 1 V, 3 V, 6 V, 10 V, 15 V, 20 V, and 30 V, however, the device was still measuring very linear at 30 V and would likely have been good to 50 to 60 V, but with 94 to 95 dB sensitivity, it gets extremely loud, even with ear protectors. Using the testing protocol that I have established for Test Bench, the fixed Mmd method was used rather than the delta mass (added mass) or the delta compliance (sealed test box) methods for obtaining the Vas of the driver. As with the 15N850V2, this data was provided by BMS transducer engineer Svetly Alexandrov.

Following this measurement sequence, the 14 550-point stepped sine wave sweeps for each sample were post-processed and the voltage curves divided by the current curves to create impedance curves, the phase calculated and along with the accompanying voltage curves, imported to the LEAP 5 Enclosure Shop software. Obviously, this is a much more time consuming process that the usual single-impedance, low-voltage curve method used for deriving Thiele-Small parameters (see **Figure 1** for the family of multi-voltage impedance curves created by this process). The obvious thermal change is due to playing a 200-Hz sine tone at the sweep voltage level from 10 to 50 s between sweeps in order to approximate the 3rd thermal time constant. This method incorporated into the LEAP 5 LTD model results in a significantly more accurate prediction of excursion at high voltage levels than the standard or LEAP 4 TSL

Photo 1a: The BMS 18N862 top view. b: The 18N862 bottom view

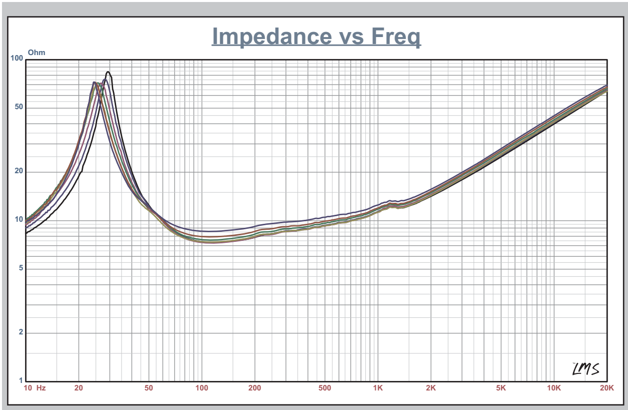

Figure 1: Family of BMS 18N862 impedance curves created from the LEAP 5 LTD parameter calculation process

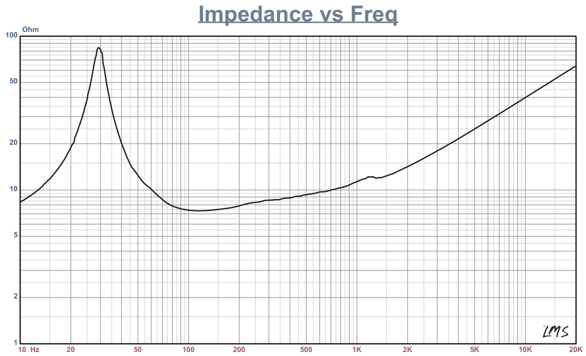

Figure 2: BMS 18N862 woofer free-air impedance plot

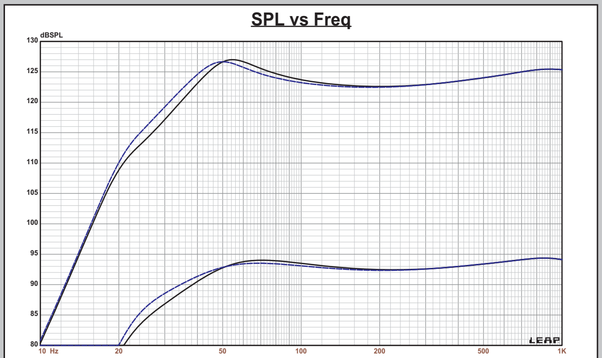

Figure 3: BMS 18N862 computer box simulations (black solid = vented 1 @ 2.83 V; Blue dash = vented 2@ 2.83 V; black solid = vented 1@ 36 V; blue dash = vented 2 @ 36 V)

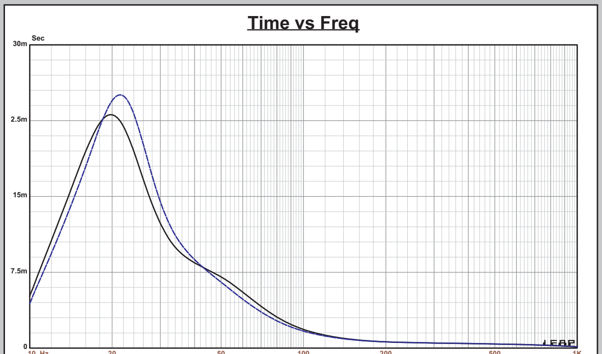

Figure 4: Group delay curves for the 2.83-V curves in Figure 3

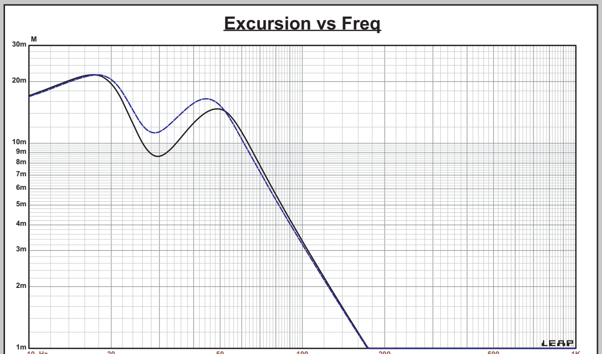

Figure 5: Cone excursion curves for the 100-V curves in Figure 3

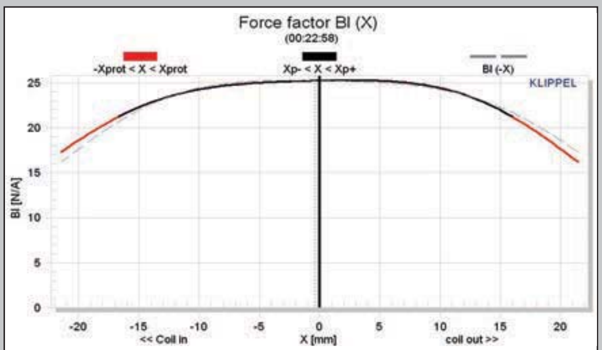

Figure 6: Klippel Analyzer Bl (X) curve for the BMS 18N862

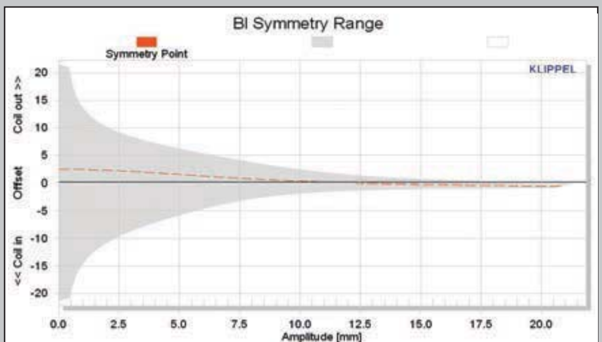

Figure 7: Klippel Analyzer Bl symmetry range curve for the BMS 18N862

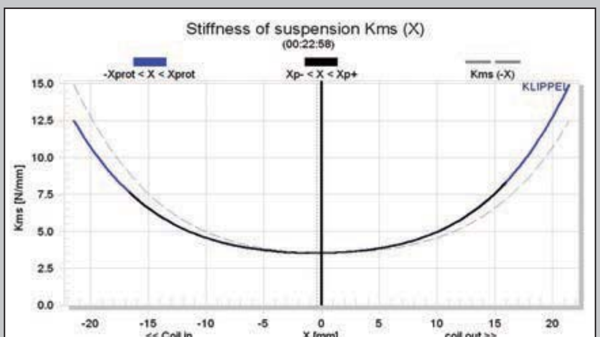

Figure 8: Klippel Analyzer mechanical stiffness of suspension Kms (X) curve for the BMS 18N862

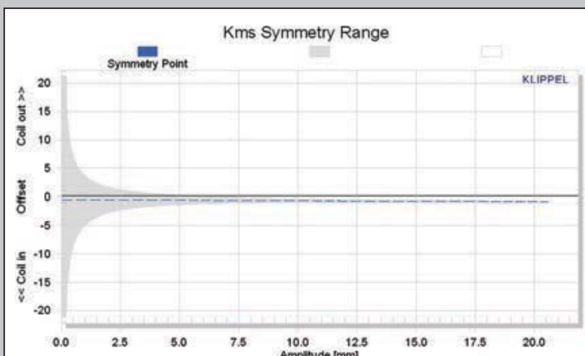

Figure 9: Klippel Analyzer Kms symmetry range curve for the BMS 18N862

models, which is one of the important advantages of the LEAP 5 software and why I use it for Test Bench testing.

Because most TS parameter data provided by OEM manufacturers is being produced using either a standard method or the LEAP 4 TSL model, I additionally created a LEAP 4 TSL model using the 1-V free-air curves. The complete data set, the multiple voltage impedance curves for the LTD model (see **Figure 2** for the woofer 1-V free-air impedance curve) and the 1-V impedance curves for the TSL model were selected in the Transducer Derivation menu in LEAP 5 and the parameters created for the computer enclosure simulations. **Table 1** compares the LEAP 5 LTD and TSL data and factory parameters for both BMS 18N862 samples.

	TSL model		LTD model		Factory
	sample 1	sample 2	sample 1	sample 2	
Fs	29.2 Hz	29.5 Hz	28.1 Hz	28.6 Hz	29.0 Hz
Revc	5.40	5.40	5.40	5.40	5.7
Sd	0.118	0.118	0.118	0.118	0.1195
Qms	6.35	6.90	4.66	5.15	4.8
Qes	0.43	0.42	0.33	0.32	0.46
Qts	0.40	0.39	0.31	0.30	0.42
Vas	222 ltr	218 ltr	243 ltr	234 ltr	231.0 ltr
SPL 2.83 V	93.0 dB	93.1 dB	94.0 dB	94.1 dB	95 dB 1 W/1 m
Xmax	19 mm	19 mm	19 mm	19 mm	19 mm

Table 1: BMS 18N862-8

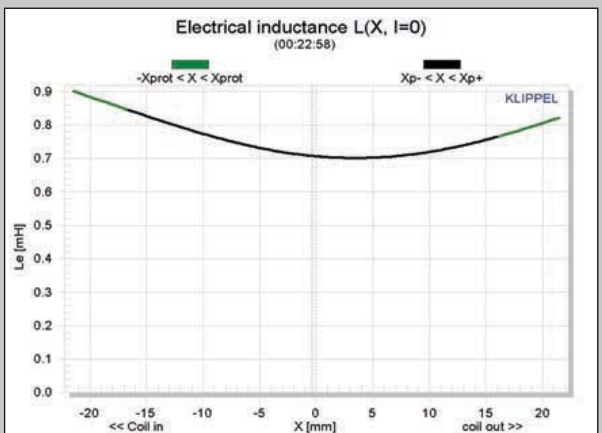

Figure 10: Klippel Analyzer L(X) curve for the BMS 18N862

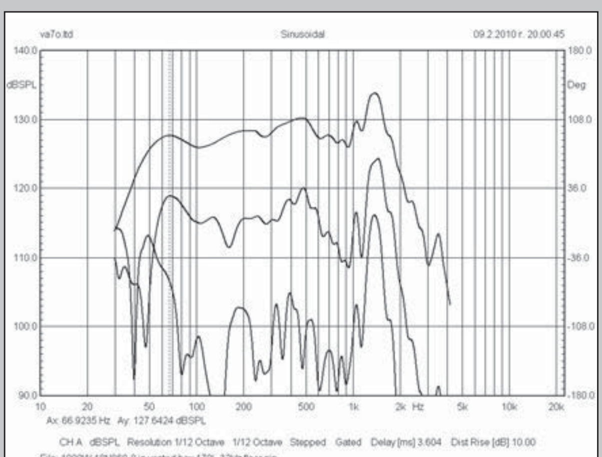

Figure 11: BMS 18N862 on-axis frequency response

TSL Parameter measurement results for the BMS 18N862-8 showed fairly close agreement with the factory-published data, with the exception of the sensitivity, the difference being that my data was sensitivity at 2.83 V, while BMS uses the 1 W/1 m criteria with a 5.7-Ω Re yields a somewhat larger number. A larger variance occurred with the LTD data; however, I followed my usual protocol and programmed computer enclosure simulations using the LEAP 5's LTD parameters for Sample 1. This included two vented alignments, one recommended by BMS for this driver, a 7 ft^3 vented box with 15% fiberglass fill material tuned to 27 Hz, and a 5 ft^3 Extended Bass Shelf (EBS) vented alignment enclosure with 15% fiberglass fill material and tuned to 28 Hz from the LEAP 5 Quick Design utility.

Figure 3 displays the results for the BMS 18N862-8 for the two-vented box designs at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to Xmax + 15% (22 mm for the BMS 18"). This produced a –3dB frequency of 42 Hz (–6 dB = 33 Hz) for the 5 ft^3 enclosure and F3 = 26 Hz (F6 = 38 Hz) for the 7 ft^3 vented simulation. Increasing the voltage input to the simulations until the maximum linear cone excursion was reached resulted in 127 dB at 160 V for the 5-ft^3 enclosure simulation and the same 127 dB with the same 160-V input level for the larger vented box (see **Figures 4** and **5** for the 2.83-V group delay curves and the 160-V excursion curves). Note that the criterion for these high-excursion SPL numbers was the maximum excursion at 18 Hz. If a 20 to 25-Hz high-pass filter was used, the SPL would be higher.

Klippel analysis for BMS 18N862-8 (our analyzer is provided courtesy of Klippel GmbH), which as usual was performed by Patrick Turnmire, Red Rock Acoustics (author of the SpeaD and RevSpeaD transducer simulation software) produced the the Bl(X), Kms(X) and Bl and Kms Symmetry Range plots given in **Figures 6** to **9**. Like many of the pro sound companies that contribute samples to *Voice Coil* for this column, BMS has its own Klippel analyzer.

The Bl(X) curve for the 18N862-8 (see **Figure 6**) is nicely broad and symmetrical typical of a high Xmax driver (19-mm Xmax is a lot of excursion capability for a pro sound 18" woofer) with a very small amount of coil out (forward) offset. Looking at the Bl Symmetry plot (see **Figure** 7), this curve shows negligible 0.79 mm of forward (coil-out) offset in the 5-mm position (a more reliable number than at rest in this case) decreasing to zero offset at the drivers physical Xmax of 19 mm, all of which is of no real consequence. **Figures 8** and **9** depict the Kms(X) and Kms Symmetry Range curves for the BMS 18N862-8. The Kms(X) curve is also symmetrical with small amount of rearward coil in offset. The Kms Symmetry Range curve shows a minor 0.5-mm forward offset at 5-mm excursion point (where the data is more reliable), and staying constant at that small amount out to the physical Xmax of the driver. Like the BMS 15N850V2, all the effort to CNC the bottom of the frame pays off with the voice coil placed in pretty much the exact magnetic center of the motor structure.

Displacement limiting numbers calculated by the Klippel analyzer for the BMS 18N862-8 were XBl @ 70% (Bl decreasing to 70% of its maximum value) was 15.9 mm and for XC @ 50% (compliance decreasing to 50% of its maximum value) was 14.3 mm, which means that for the BMS 18N862-8, the compliance is the limiting factor for the prescribed distortion level of 20% for using this driver as a subwoofer. Again, as with the BMS 15N850V2, data this good is about as good as it gets. Plaudits and Kudos to the engineers at BMS!

Figure 10 gives the inductance curve L(X) for the BMS pro subwoofer. Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area unless the driver incorporates a shorting ring, and the BMS 18" incorporates a triple aluminum shorting ring format. This is readily apparent in the L(X) curve. As you can see, the inductance variation is extremely small, only 0.07 to 0.17 mH from rest to Xmax in either direction. Minimal inductance variation is critical to a low distortion and an accurate sounding driver.

Since I don't keep an inventory of test enclosures for 18" and larger drivers, and since this driver is really intended for subwoofer applications, I did not do the usual on- and off-axis SPL curves, but instead, **Figure 11** displays the BMS published SPL curve for the BMS 18N860, which should be close to the BMS 18N862.

For the last test on the BMS 18" woofer, I used the Listen, Inc. SoundCheck analyzer and SCM microphone and power supply (courtesy of Listen, Inc.) to measure distortion. Since this driver is really meant for subwoofer applications, I also dispensed with the time frequency plots. Setting up for the distortion measure-

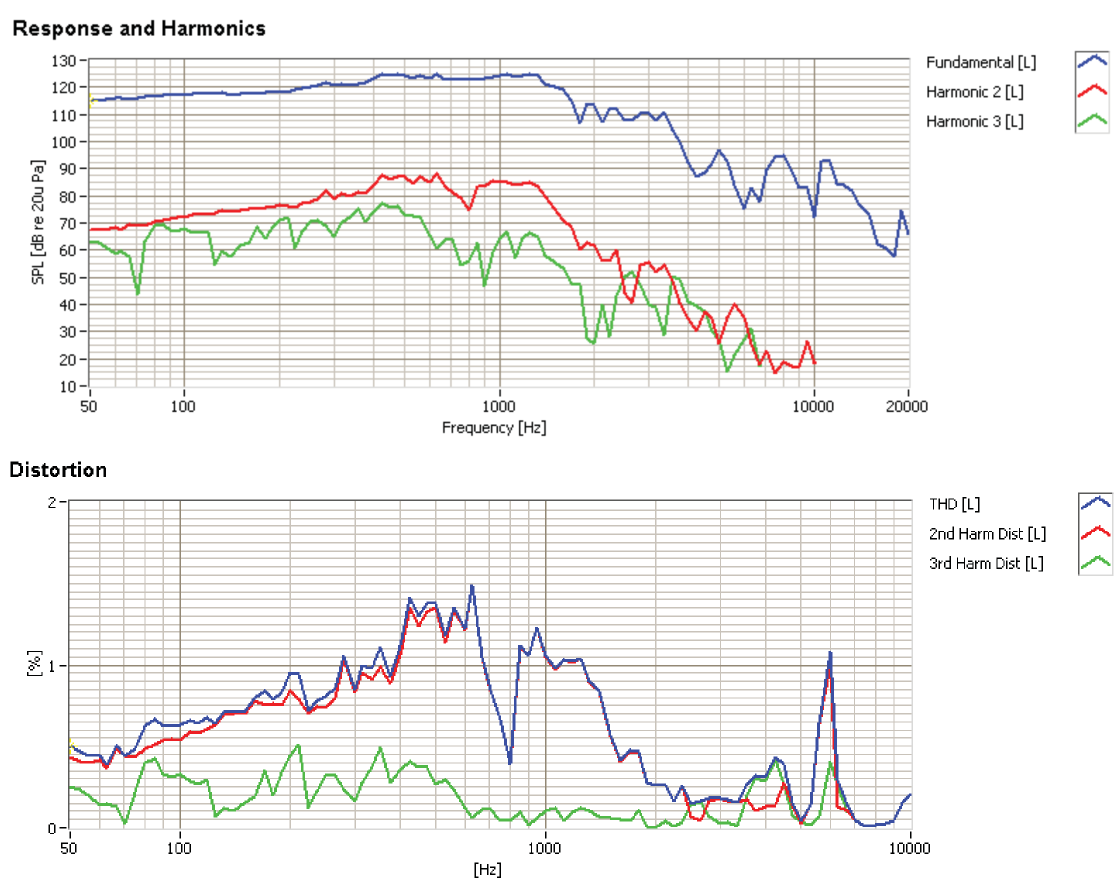

Figure 12: BMS 18N862 SoundCheck distortion plots

ment consisted of mounting the woofer rigidly in free-air, and the SPL set to 104 dB at 1 m (8.5 V) using a noise stimulus (SoundCheck has a built-in noise generator and SPL meter as two of its utilities), and then the distortion measured with the SCM microphone placed 10 cm from the dust cap. This produced the distortion curves shown in **Figure 12**.

Like the BMS 15" evaluated in *Voice Coil*, January 2012, the BMS 18N862-8 is a very well-engineered woofer, as can be seen from the above analysis, plus the overall excellent fit and finish that I observed certainly indicate that this is a very well-crafted product. As I said last month, I was especially impressed with the extent the company went to ensure the cone assemble was positioned nearly perfectly at the magnetic center of the motor. Not having the voice coil properly located in the gap is an all too frequent problem that I see in the Test Bench reviews. For more on the BMS 18N862 and other BMS products, visit the company website at www.bmspro.com.

The Fountek FR89EX

The next driver to test this month was a very interesting 3" full-range from Fountek. Fountek Electronics is a relatively new high-end audio manufacturer out of China. Founded April 2003 in Shanghai, China, the company released its first ribbon transducer in June of that year. Besides OEM transducers like the FR89EX that is the subject of this review, Fountek also produces finished home audio speakers, a line of solid state and tube amplifiers, plus a line of powered studio monitors.

The Fountek FR89EX is 3"-diameter aluminum cone neodymium motor full-range transducer built on a four-spoke, cast aluminum frame. For cooling, the proprietary frame has four 2 mm × 35 mm vents below the spider-mounting shelf, located between the frame spokes. The cone assembly consists of a silver (natural finish) coated aluminum cone with a 1"-diameter

Photo 1a: The Fountek FR89EX top view. b: The FR89EX bottom view

	TSL model		LTD model		Factory
	sample 1	sample 2	sample 1	sample 2	
Fs	101 Hz	101 Hz	101 Hz	103 Hz	96 Hz
Revc	3.20	3.21	3.20	3.21	3.40
Sd	0.0027	0.0027	0.0027	0.0027	0.0027
Qms	1.16	1.08	1.26	1.21	1.47
Qes	0.55	0.51	0.57	0.59	0.65
Qts	0.37	0.35	0.40	0.40	0.45
Vas	1.01 ltr	1.02 ltr	1.07 ltr	1.03 ltr	1.11 ltr
SPL 2.83 V	84.7 dB	85.0 dB	84.4 dB	84.4 dB	83.7 dB
Xmax	5.0 mm	5.0 mm	5.0 mm	5.0 mm	5.0 mm

Table 2: Fountek FR89EX Full-range

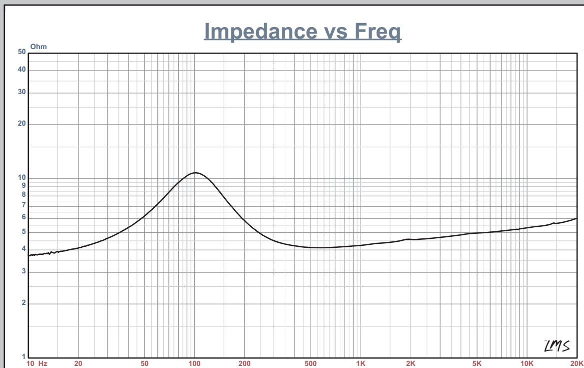

Figure 13: Fountek FR89EX free-air impedance plot

coated aluminum dust cap. Suspending the cone and dust cap are a low-loss NBR surround and a treated cloth spider that has been vented with four 4-mm diameter holes. The FR89EX has a 25-mm diameter single layer voice coil wound with flat (ribbon) copper wire on aluminum former and terminated to a pair of gold-plated terminals. Powering this structure is an underhung neodymium motor with a black emissive coating on the motor return cup for better heat transfer to the surrounding air.

I commenced testing the Fountek FR89EX full-range using the LinearX LMS analyzer and VIBox to create both voltage and admittance (current) curves with the driver clamped to a rigid test fixture in free-air at 0.3 V, 1 V, 3 V, 6 V, and 10 V. The 10-V curve was too non-linear to get an appropriate curve and was discarded. Next, the eight 550-point stepped sine wave sweeps (four current and four voltage sweeps) for each FR89EX samples were post-processed and the voltage curves divided by the current curves (admittance curves) to produce the impedance curves, phase generated by the LMS calculation method, and along with the accompanying voltage curves, imported to the LEAP 5 Enclosure Shop software. Since most Thiele-Small data provided by OEM manufacturers is being produced using either a standard transducer model or the LEAP 4 TSL model, I additionally created a LEAP 4 TSL model using the 1-V free-air curves. The complete data set, the multiple voltage impedance curves for the LTD model (see **Figure 13** for the 1V free-air impedance curve) and the 1-V impedance curve for the TSL model were selected in the transducer derivation menu in LEAP 5 and the parameters created for the computer box

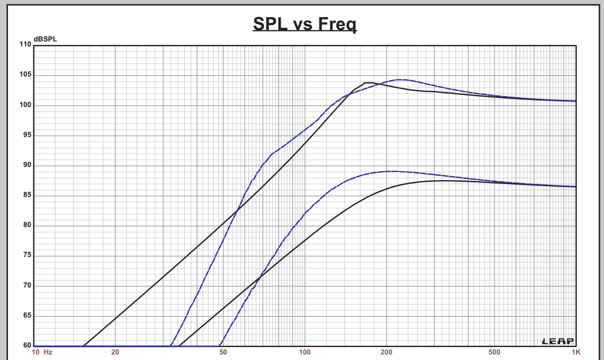

Figure 14: Fountek FR89EX computer box simulations (black solid = sealed @ 2.83 V; blue dash = vented @ 2.83 V; black solid = sealed at 21 V; Blue dash = vented @ 21 V)

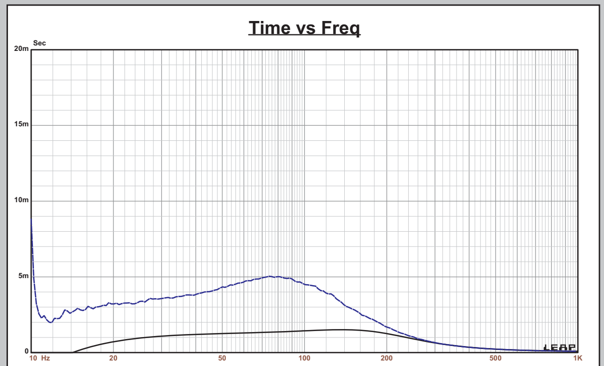

Figure 15: Group delay curves for the 2.83-V curves in Figure 14

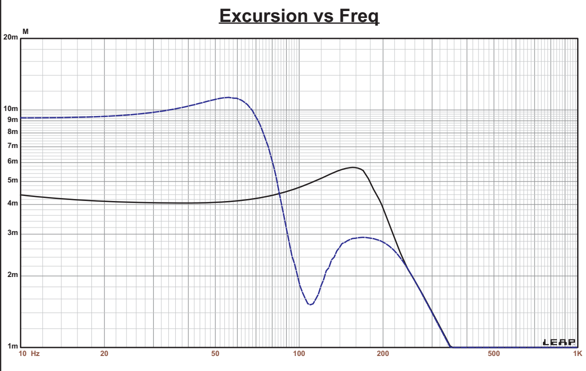

Figure 16: Cone excursion curves for the 21-V curves in Figure 14

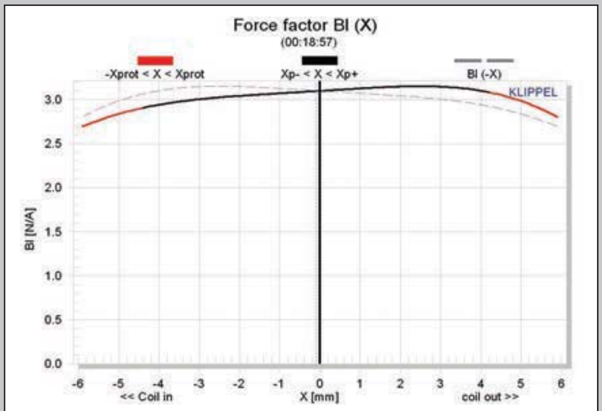

Figure 17: Klippel Analyzer Bl (X) curve for the Fountek FR89EX

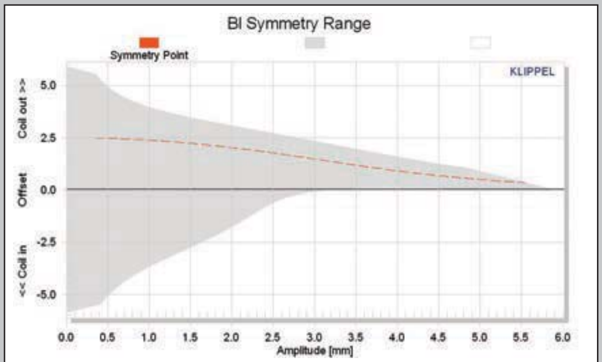

Figure 18: Klippel Analyzer Bl symmetry range curve for the Fountek FR89EX

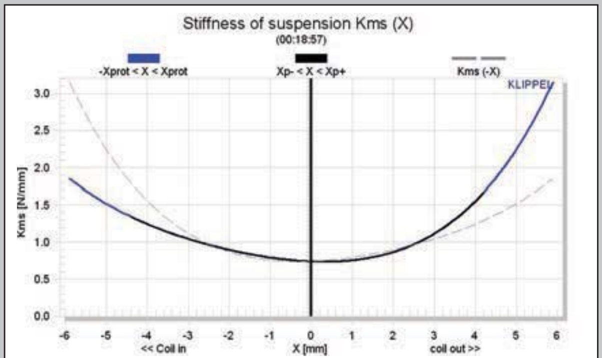

Figure 19: Klippel Analyzer mechanical stiffness of suspension Kms (X) curve for the Fountek FR89EX

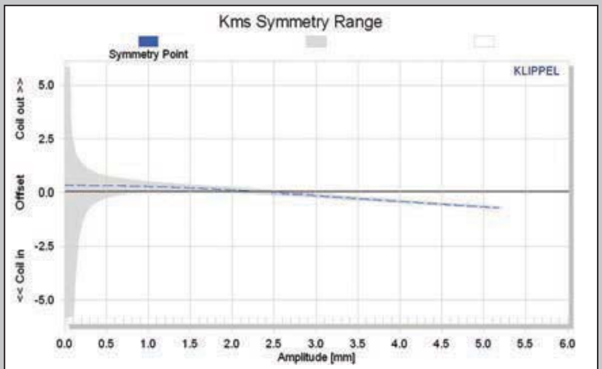

Figure 20: Klippel Analyzer symmetry range curve for the Fountek FR89EX

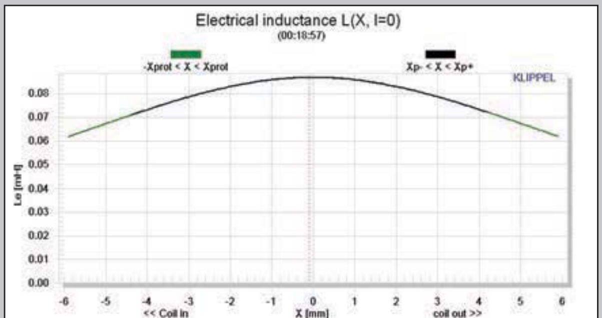

Figure 21: Klippel Analyzer Le (X) curve for the Fountek FR89EX

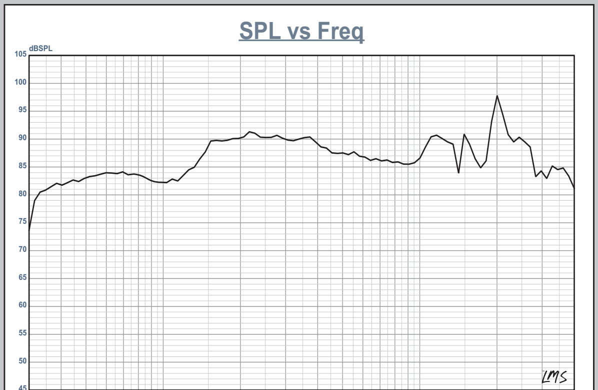

Figure 22: Fountek FR89EX on-axis frequency response

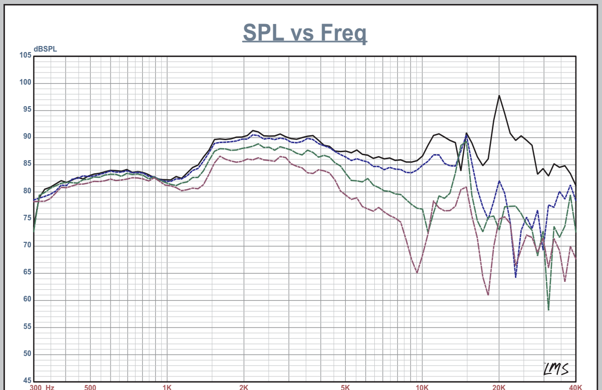

Figure 23: Fountek FR89EX on- and off-axis frequency response at 0° (black-solid), 15° (blue-dot), 30° (green-dash), and 45° (purple-dot/dash)

simulations. **Table 2** compares the LEAP 5 LTD and TSL data and Fountek factory parameters for both of FR89EX samples.

LEAP parameter calculation results for the FR89EX were sufficiently close to the factory data, so I proceeded to set up computer enclosure simulations using the LEAP LTD parameters for Sample 1. Two computer box simulations were programmed into LEAP, a 30-cubic-inch sealed box alignment (50% fill material) and a 42-cubic-inch vented alignment tuned to 103 Hz (15% fill material). **Figure 14** displays the results for the Fountek full-range driver in the two enclosure simulations at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to Xmax + 15% (5.8 mm for the FR89EX). This produced a F^3 frequency of 165 Hz with a box/driver Qtc of 0.71 for the 30-cubic-inch sealed enclosure and –3 dB = 103 Hz 42-cubic-inch vented box simulation. Increasing the voltage input to the simulations until the maximum linear cone excursion was reached resulted in 104 dB at 21 V for the sealed enclosure simulation and 104.5 dB with a 21-V input level for the larger vented enclosure (see **Figures 15** and **16** for the 2.83-V group delay curves and the 21-V excursion curves).

Klippel analysis for the Fountek 3" full-range (our analyzer is provided courtesy of Klippel GmbH), and testing performed by Pat Turnmire, Red Rock Acoustics (author of the SpeaD and RevSpeaD software) produced the Bl(X), Kms(X) and Bl and Kms Symmetry Range plots given in **Figures 17** to **20**. The Bl(X) curve for the FR89EX (see **Figure 17**) is relatively broad and with a degree of asymmetry. Looking at the Bl Symmetry plot (see **Figure 18**), this curve shows a 2.5-mm coil-out offset at the rest position that decreases to 0.50 mm at the physical 5.0 mm Xmax of the driver.

Figures 19 and **20** show the Kms(X) and Kms Symmetry Range curves for the Fountek full-range driver. The Kms(X) curve is also somewhat asymmetrical, and has a very minor forward (coil-out) offset of about 0.3 mm at the rest position, decreasing to zero at 2.5 mm, and ending up at 5-mm excursion with about 0.6-mm coil-in offset. Displacement limiting numbers calculated by the Klippel analyzer for the FR89EX were XBl @ 82% Bl is 4.2 mm and for XC @ 75% Cms minimum was 2.9 mm, which means that for this Fountek woofer, the compliance is the most limiting factor for prescribed distortion level of 10%.

Figure 21 gives the inductance curve Le(X) for the FR89EX.

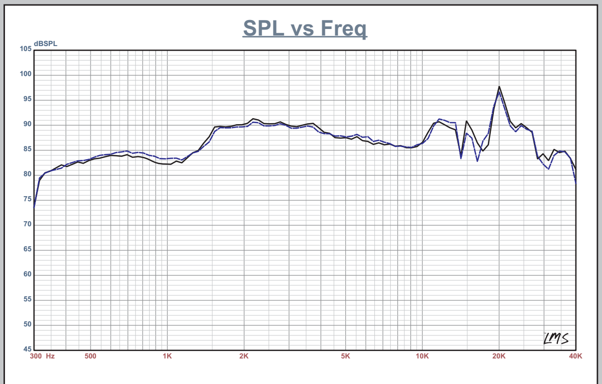

Figure 24: Fountek FR89EX two-sample SPL comparison

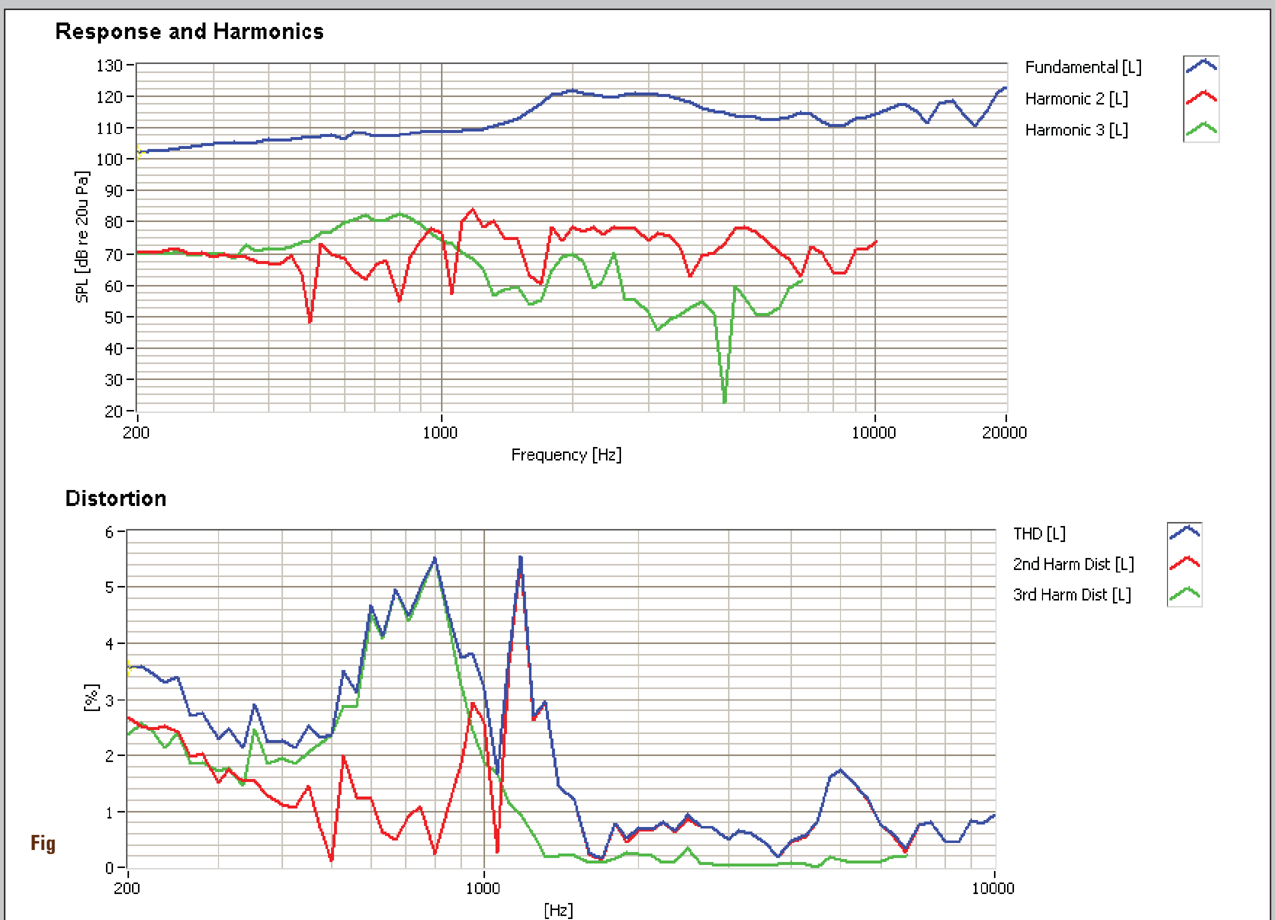

Figure 25: Fountek FR89EX SoundCheck distortion plots

Inductance will typically increase in the rear direction from the zero rest position as the voice coil covers more pole area; however, the FR89EX inductance variance due to the neodymium motor structure is rather small. The inductance variation is only 0.09 mH from the in and out Xmax positions, which is very good.

Next, I mounted the FR89EX full-range in an enclosure which had a 9"× 4" baffle, filled with damping material (foam), and then measured the transducer on- and off-axis from 300 Hz to 40-kHz frequency response at 2.83 V/1 m using the LinearX LMS analyzer set to a 100-point gated sine wave sweep. **Figure 22** gives the FR89EX's on-axis response indicating a smoothly rising response to about 10 kHz with a 6-dB step between 1 kHz and 1.5 kHz, and some break-up peaking at 20 kHz prior the high-pass roll-off. However, it definitely has a response on-axis out to 35 kHz.

Figure 23 displays the on- and off-axis frequency response at 0°, 15°, 30°, and 45°. As with most full-range transducers, the 30° off-axis is about the same as any 3" piston driver. The last SPL measurement is given in **Figure 24**, and illustrates the two-sample SPL comparison for the 3" driver, showing a close match to within less than 1 dB throughout the operating range.

For the remaining series of tests, I employed the Listen, Inc. SoundCheck analyzer with the Listen, Inc. ¼" SCM microphone and power supply (courtesy of Listen, Inc.) to measure distortion and generate time frequency plots. For the distortion measurement, the Fountek fullrange was mounted rigidly in free-air, and the SPL set to 94 dB at 1 m (6.4 V) using a noise stimulus, and then the distortion measured at with the microphone placed 10 cm from the dust cap. This produced the distortion curves shown in **Figure 25**. I then used SoundCheck to get a 2.83 V/1 m impulse response for this driver and imported the data into Listen, Inc.'s SoundMap Time/Frequency software. The resulting CSD waterfall plot is given in **Figure 26** and the Wigner-Ville (for its better low-frequency performance) plot in **Figure 27**.

The Fountek FR89EX is a well-designed 3" full range and possible applications would include use as a driver in a high-end iPOD speaker, as a midrange in a three-way speaker, are in high-end line-source speaker. For more on this well-crafted 3" driver, visit the Fountek website at www.fountek.net. ***VC***

Submissions for Test Bench

Test Bench is an open forum for OEM driver manufacturers in the industry and all OEMs are invited to submit samples to *Voice Coil* for inclusion in the monthly Test Bench column.

Any woofer, midrange, or tweeter an OEM manufacture feels is representative of their work, is welcome to send samples. Contact *Voice Coil* Editor Vance Dickason to discuss which drivers are being submitted.

Samples should be sent in pairs and addressed to:

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333 S. State St., #152
Lake Oswego, OR 97034
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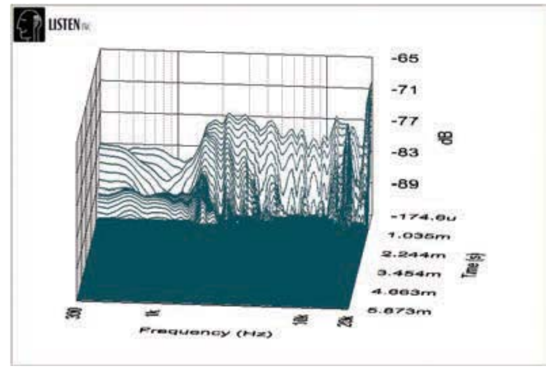


Figure 26: Fountek FR89EX SoundCheck CSD waterfall plot

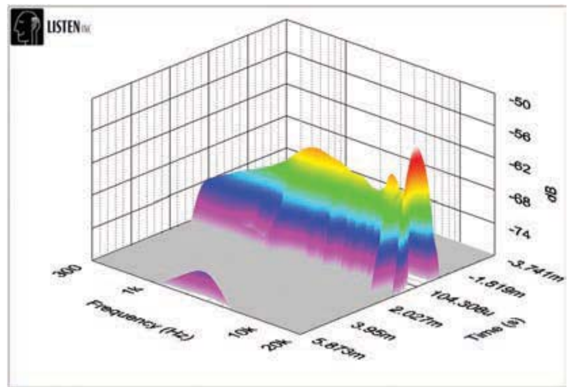


Figure 27: Fountek FR89EX SoundCheck Wigner-Ville plot

Industry Watch

By Vance Dickason

Gibson Creates Pro Audio Division

As part of its continued expansion as a lifestyle brand, Gibson Guitar, one of the truly premier musical instrument manufacturers, has announced the creation of its pro audio division through the acquisition of the platform assets of the Stanton Group. Stanton Group is comprised of KRK Systems, Cerwin-Vega, and Stanton DJ and makes products for both the consumers and professional audio markets. Together, the companies will form Gibson Pro Audio division, which will be headquartered in Nashville, TN.

Moses Named AES Executive Director

Bob Moses, longtime AES member and officer, accomplished product designer, technologist, and pro audio industry advocate, has been named executive director of the Audio Engineering Society. Moses assumed his new role January 1, 2012. In accepting the position, Bob Moses said, "The AES has been the backbone of my career. It has provided me with a unique platform to evangelize my ideas and seek feedback from the industry. I've learned almost everything I know about audio, and met many of my closest colleagues, through AES activities. I can't imagine achieving my career goals without AES there to support me. Outgoing Executive Director Roger Furness has done an incredible job over the past 17 years, and I deeply appreciate his decision to remain aboard throughout 2012. My initial task is to identify where the AES provides maximum value to its membership and the industry, and to advance new ways to enhance this value. Sixty-three years ago the AES was the place for the scientific community to share ideas. Over time, AES conventions evolved as the best forum for manufactures to exhibit professional audio products. But today, the Internet and persistent economic challenges worldwide have changed the game. Based on my own experience as an AES member, author, and exhibitor, I know the AES remains a vital resource for audio professionals. We need to clarify that value and communicate it better. I'm ready for the challenge."

In 1987 after graduating from McGill University with an electrical engineering degree, Bob Moses joined Rane Corporation as a digital audio product designer. In 1995, he invented a novel means of transporting audio over Firewire and cofounded Digital Harmony Technologies (DHT) to deploy this technology. Moses worked as a consultant to numerous consumer and professional audio manufacturers until he was recruited by THAT Corporation in 2006 as program manager of its integrated circuit (IC) business. During the past five years, he has concentrated his energies on managing new technology development at THAT.

As a member of the AES Board of Governors since 1999; vice preseident, Western Region, (2001–2006); and president, (2007–2008), Bob Moses has served an increasingly integral role within the organization and on convention development, including several consecutive turns as Product Design Track chairman.

Audiovox Now Called VOXX International

Audiovox Corp. has officially changed its name to VOXX International. According to the company, the character of the firm has changed dramatically in the past several years. Audiovox continues to be a good brand, but it is associated as a good, value CE line available at an attractive price. But with the acquisitions of Klipsch, RCA, and others, Audiovox doesn't really describe what the company is today. VOXX has a host of brands in the CE and automotive industries. In the United States the brands are: Audiovox, RCA, Acoustic Research, Jensen, Advent, Code Alarm, Invision, Prestige, Omega, Excalibur, Pursuit, Terk and Surface—as well as Klipsch, which is also an international brand. On the international side, VOXX also has Jamo, Energy, Mirage, Mac Audio, Magnat, Heco, Schwaiger, and Oehlback.

Baldwin Steps Down As CEDIA CEO

CEDIA and Utz Baldwin have agreed on Mr. Baldwin's departure from CEDIA as chief executive officer. CEDIA's Board of Directors will continue to provide strategic leadership for the organization as it continues to build strength as the dominant global association in residential technologies. Don Gilpin will assume a more active role as CEDIA's chief operating officer under the direction of the Board of Directors. Randy Stearns, the Board's immediate past chairman said, "As we continue to grow, we will be calling on more members to volunteer and help us be the best trade association in the world."

Harman's Sales Increase

Harman International Industries reported higher net sales and net profits in its fiscal first quarter, ended September 30. Net sales for the first quarter were $1.051 million, an increase of 26% compared with the same period last year. Excluding foreign currency translation, net sales increased by 19%, Harman said. Net income was $48 million, up from the prior year's $27 million. Operating income was $74 million, compared with $43 million in the same period last year. During this quarter, all three of the company's divisions reported higher sales. In the infotainment division, net sales were $603 million up from the prior year's $446 million. Operating income was $47 million, up from $8 million. Harman attributed higher sales to pent-up demand from the Japan tsunami and earthquake and continued growth in BRIC countries. In its lifestyle division, sales were up 19% to $300 million compared with last year due to the same factors in the infotainment division, but operating income was down $3 million to $26 million. Profits were down due to higher costs of neodymium magnets, Harman said. In the professional division net sales were $148 million, up $8 million, while operating profit was down $6 million from the prior year's quarter to $19 million.

Logitech Sees Little Growth

Logitech International's second-quarter sales were essentially flat for the fiscal year, with operating and net income both down. Sales for the second quarter were $589 million, up 1% from $582 million in the prior-year period. When the favorable impact of the exchange rate is taken out of the equation, sales declined 2%. Operating income was $23 million, compared with the prior-year's $51 million, and net income was $17 million, compared with $41 million. Gross margin for the quarter was 33.7%, down from last year's 37.3%. Retail sales increased 2% for the quarter, driven by a 22% increase in Asia. Sales in the Americas and EMEA decreased 1% . OEM sales decreased 17%, but sales for its LifeSize division were up 19%.

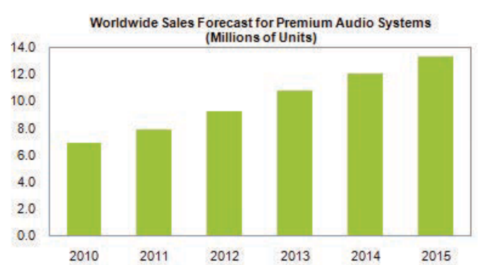
Guerrino De Luca, Logitech chairman of the board and acting president and CEO, said in a statement they were consistent with expectations. De Luca became acting president and CEO after Logitech posted an operating loss of $45 million in the first quarter and then-president/CEO Gerald Quinlan stepped down. Last September, the company attributed its losses to the poor economic climate and the underperformance of its Google Revue device.

Growth Seen in Audio Systems

Premium audio systems in cars were projected to reach double-digit sales growth worldwide in 2011 and beyond thanks to the proliferation of quality sound systems in mid-range cars. Global sales in 2011 of premium audio systems reached 7.9 million units, up 14% from 6.9 million units last year, and will hit 13.3 million units by 2015. Premium audio systems are defined by IHS as having any or all of the following: surround sound, eight or more speakers and 400 W or more. Branded systems are also included. This year's sales will yield worldwide revenue of $7.3 billion for the market, the firm noted, which is up 11% from $6.6 billion in 2010 (see the accompanying graph). According to IHS, Bose and Harman/Kardon are the leading premium audio system suppliers. When it comes to trends, the research group said that 5.1 and 7.1 surround formats are growing in popularity, as are matrix systems that synthesize surround sound from stereo, speaker count, and Class D amplifiers that fit with multichannel audio, and portable music player interfaces.

	2010	2011	2012	2013	2014	2015
Millions of Units	6.9	7.9	9.3	10.8	12.1	13.3

Source: IHS iSuppli Research, November 2011



Premium audio graph

Best Buy Shows 3rd Quarter Gain

Best Buy showed gains in third-quarter revenue and comp-store sales, but they came at a cost. Net earnings fell 29% to $154 million for the three months, ended Nov. 26, as the company flexed its promotional muscles during Black November and took a $150 million pretax restructuring charge to shut its 11 big-box U.K. stores and dispose of certain "entertainment assets" in the U.S. Total revenue rose 1.7% to $12.1 billion during the quarter on essentially flat comp-sales growth of 0.3%. Within the U.S., net sales edged up 2% to $8.9 billion and comps increased 0.9%, reversing five consecutive quarters of same-store sales declines. In addition, an expanded online assortment and more competitive pricing helped fuel a 20% increase in e-commerce sales. ***VC***

Products & Services Index

CATEGORY KEY

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B = CONSULTANTS & ENGINEERS
C = CROSSOVERS & PASSIVE COMPONENTS
D = DRIVERS
E = EMPLOYMENT OPPORTUNITIES
F = ENCLOSURES & ENCLOSURE PARTS
G = ENGINEERING/DESIGN SOFTWARE
H = FINISHED SYSTEMS
I = MAGNETS & EQUIPMENT
J = MANUFACTURING EQUIPMENT
K = MICROPHONES
L = PARTS
M = RECONING
N = TEST EQUIPMENT
O = VOICE COILS – COMPONENTS & MATERIALS
P = TRANSDUCERS
Q = ACOUSTIC MESH
R = ACOUSTICAL & SOUNDPROOFING MATERIALS
S = AMPLIFICATION
T = TRADE SHOW
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We're thinking **small**