

# audio**x**press

ADVANCING THE EVOLUTION OF AUDIO TECHNOLOGY

## Headphone Focus

### Earphone and Headphone Test Instrumentation

A Comprehensive Roundup

By Mike Klasco and J. Martins

## Fresh From the Bench

### Audio Precision AECM206 Headphone Test Fixture

By Stuart Yaniger

## R&D Stories

### Developing the HPEL Electrostatic Transducer

By Valerio Marra



**You Can DIY!**  
**Build Your Own HRTF  
Binaural Microphone Head**  
By Ron Tipton

**R&D Stories**  
**HEAD acoustics labCORE**  
**A New Modular Multi-Channel  
Front-End Measurement Platform**  
By J. Martins

**You Can DIY!**  
**TubeSociety 2A3-300B-SE  
Amplifiers (Part 1)**  
By Menno van der Veen



# PARTS CONNEXION

## The Authority on Hi-Fi DIY

Enter code: **AX0817**  
in the comments box at  
checkout to receive  
**25% Off**  
your next order.

**Your #1 Source for  
Vacuum Tubes, DIY Parts,  
Audiophile Accessories**

**&  
Premium HIGH-END Audio Gear**  
*(Discontinued • Demo • B-Stock)*

CAMBRIDGE AUDIO • MONITOR AUDIO •  
CARDAS • REGA • FOCAL • WHARFEDALE •  
MUSIC HALL • CYRUS • DEVIALET •  
ACOUSTIC ZEN • QED • BDI • SOLID TECH •  
APOLLO • TARGET • GRADO

Sales:  
[order@partsconnexion.com](mailto:order@partsconnexion.com)

**www.partsconnexion.com**

Inquires:  
[info@partsconnexion.com](mailto:info@partsconnexion.com)



**905-631-5777**

Toll-Free - US/Canada

**1-866-681-9602**

**905-681-9602**



**5403 Harvester Rd, Unit 1, Burlington, Ontario, Canada L7L 5J7**

Debit, Visa, Mastercard, Amex, PayPal, EMT, Money Order & Bank Draft





**HAMMOND  
MANUFACTURING®**



# MANUFACTURING & DESIGNING TRANSFORMERS & ENCLOSURES SINCE 1917

Chassis, Plates & Covers



Tube Output Transformers

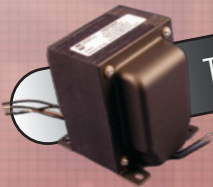
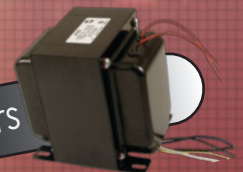
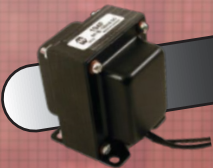


Plate & Filament Transformers



Open & Enclosed Chokes



**USA**

**Tel: (716) 630-7030  
Fax: (716) 630-7042**

**Canada**

**Tel: (519) 822-2960  
Fax: (519) 822-0715**

**UK**

**Tel: 01256 812812  
Fax: 01256 332249**

**Australia**

**Tel: 8-8240-2244  
Fax: 8-8240-2255**

[www.hammondmfg.com](http://www.hammondmfg.com)



April 2018

ISSN 1548-0628

[www.audioxpress.com](http://www.audioxpress.com)

*audioXpress* (US ISSN 1548-0628) is published monthly, at \$50 per year for the US, at \$65 per year for Canada, and at \$75 per year Foreign/ROW, by KCK Media Corp., P.O. Box 417, Chase City, VA 23924, US Periodical Postage paid at Chase City, VA, and additional offices.

Head Office:

**KCK Media Corp.**

**P.O. Box 417**

**Chase City, VA 23924, US**

**Phone: 434-533-0246**

**Fax: 888-980-1303**

Subscription Management:

**audioXpress**

**P.O. Box 462247**

**Escondido, CA 92046, US**

**Phone: 800-269-6301**

**E-mail: [audioxpress@pcspublink.com](mailto:audioxpress@pcspublink.com)**

**Internet: [www.audioxpress.com](http://www.audioxpress.com)**

Postmaster: Send address changes to:

**audioXpress**

**P.O. Box 462247**

**Escondido, CA 92046, US**

Advertising:

**Strategic Media Marketing, Inc.**

**2 Main Street**

**Gloucester, MA 01930, US**

**Phone: 978-281-7708**

**Fax: 978-281-7706**

**E-mail: [audioxpress@smmarketing.us](mailto:audioxpress@smmarketing.us)**

Advertising rates and terms available on request.

Editorial Inquiries:

**Send editorial correspondence and manuscripts to:**

**audioXpress, Editorial Department**

**P.O. Box 417**

**Chase City, VA 23924, US**

**E-mail: [editor@audioxpress.com](mailto:editor@audioxpress.com)**

Legal Notice:

Each design published in *audioXpress* is the intellectual property of its author and is offered to readers for their personal use only.

Any commercial use of such ideas or designs without prior written permission is an infringement of the copyright protection of the work of each author.

© KCK Media Corp. 2018  
Printed in the US



## Properly Measuring It

During a presentation at the 2018 ALMA International Symposium & Expo (AISE), Jude Mansilla, founder of the Head-Fi.org headphone-obsessed user community forum and website and the promoters of the CanJam Global series of events, stated, “you only get one chance of creating a good first impression.” Mansilla went on to explain how the forum’s users performed their own headphone measurements using all sorts of homemade contraptions and uncalibrated microphones, and share those “measurements” as evidence for their personal reviews, to the detriment of manufacturers.

Appealing to headphone companies to be the first to publish their own measurements when they introduce new products, Mansilla explained how the audio enthusiast community, no longer satisfied with the subjective personal impressions traditional of the hi-fi world, has taken an increasingly keen interest in all kinds of audio measurements. The results of these homegrown “measurement” systems can be found in numerous examples of published “reviews” that profoundly affect the success of new products and designs, even after confronted with Head-Fi’s own measurements, and all the efforts from the brands to contradict those published results.

As Mansilla explains, “these enthusiast-generated measurements have played a significant role in influencing online reviews of audio gear, though many of these measurements do not include any specific information about how they were made. These are the same enthusiasts who both buy your products and influence the purchasing decisions of others.”

And the problem also extends to highly doubtful reviewers who share their “findings” on websites, forums, and blogs, completely ignoring the large investments in engineering staff and professional test equipment for design and validation that are needed for audio manufacturers to perform those measurements in their labs.

As Mansilla stated, “If manufacturers don’t publish measurements, consumers will. And you only get one chance of creating a good first impression!” And this comes at a moment when the audio industry is focused on expanding the tools available for headphone evaluation, providing new “high-resolution” ear simulators, which finally address well-known problems such as high-frequency resonance and inconsistent results above 10 kHz.

Experienced journalist and reviewer, Brent Butterworth, who performed the G.R.A.S. Sound & Vibration new RA040X Ear Simulators review for *audioXpress*, published last month, was shocked with Jude Mansilla’s presentation and wrote in an editorial for [soundstagexperience.com](http://soundstagexperience.com), “Measurements taken with these systems look radically different from measurements taken using professional gear. The charts are wildly inaccurate, and impossible to compare meaningfully with anyone else’s measurements. Yet some enthusiasts are drawing conclusions about headphone performance based on these measurements.”

More importantly, Butterworth also notes: “I’ve been performing audio measurements professionally for more than 20 years, during which I’ve learned to measure speakers, subwoofers, amplifiers and, most recently, headphones. Each of these skills was added to my repertoire through laborious experimentation, countless late nights wrestling with finicky analyzers and digging through decades-old research, and long discussions with fellow professionals—and I know that the handful of professional audio reviewers who do their own measuring have all endured the same test. In my experience, it takes any technician about two years of performing a particular measurement before he or she becomes truly proficient at it. (...) Owning measurement gear—even the very best professional, standardized measuring system—doesn’t make you an expert measurer, any more than owning a trumpet makes you a trumpeter.”

That said, there is no doubt that the audio industry is taking notice of the needs of the market and, as our “Earphone and Headphone Test Instrumentation Roundup” in this edition illustrates, there was never a higher level of activity in the introduction of new critical evaluation tools, addressing all sorts of needs and applications, from R&D to production.

Identifying the companies and technology providers in this domain is also crucial. Users interested in test and measurement solutions are advised to participate in the many available seminar updates and trainings these technology providers promote. First time participants shouldn’t be surprised to see some of the most respected experts in this field also in attendance.

J. Martins  
Editor-in-Chief

---

## The Team

|                  |               |                          |                 |
|------------------|---------------|--------------------------|-----------------|
| President:       | KC Prescott   | Associate Editor:        | Shannon Becker  |
| Controller:      | Chuck Fellows | Graphics:                | Grace Chen      |
| Editor-in-Chief: | João Martins  | Advertising Coordinator: | Nathaniel Black |

---

Technical Editor: Jan Didden

Regular Contributors: Bruce Brown, Bill Christie, Joseph D’Appolito, Vance Dickason, Jan Didden, Scott Dorsey, Gary Galo, Gerhard Haas, Chuck Hansen, Richard Honeycutt, Charlie Hughes, Mike Klasco, Ward Maas, Oliver Masciarotte, Nelson Pass, Christopher Paul, Bill Reeve, Fernando Rodrigues, Steve Tatarunis, Ron Tipton, Stuart Yaniger



## OUR NETWORK

**audio**xpress

**C** circuit cellar

**LIS** LOUDSPEAKER  
INDUSTRY  
SOURCEBOOK

VOICE  COIL

## SUPPORTING COMPANIES

|                               |    |
|-------------------------------|----|
| ACO Pacific, Inc.             | 48 |
| All Electronics Corp.         | 55 |
| Amplitrex Audio Products, LLC | 43 |
| Audio Precision, Inc.         | 33 |
| Avel Lindberg, Inc.           | 65 |
| Avermetrics, LLC              | 48 |
| AXPONA                        | 17 |
| Cine Gear Expo                | 58 |
| Front Panel Express, LLC      | 57 |
| G.R.A.S. Sound & Vibration    | 35 |
| Hammond Manufacturing, Ltd.   | 3  |
| Hypex Electronics BV          | 59 |
| JLI Electronics, Inc.         | 63 |
| KAB Electro-Acoustics         | 55 |
| KLIPPEL GmbH                  | 45 |

|                                   |    |
|-----------------------------------|----|
| Linear Integrated Systems         | 56 |
| Lone Star Audio Fest              | 42 |
| LOUDSOFT, Ltd.                    | 47 |
| Menlo Scientific, Ltd.            | 67 |
| miniDSP, Ltd.                     | 43 |
| OPPO Digital, Inc.                | 11 |
| Parts ConneXion                   | 2  |
| Parts Express International, Inc. | 68 |
| Profusion, plc                    | 9  |
| SB Acoustics                      | 65 |
| Sennheiser                        | 49 |
| Sonoma Acoustics, Inc.            | 39 |
| SoundChip SA                      | 19 |
| Tympany                           | 27 |
| Wavecor, Ltd.                     | 53 |

### NOT A SUPPORTING COMPANY YET?

Contact Peter Wostrel (audioxpress@smmarketing.us, Phone: 978-281-7708, Fax: 978-281-7706)  
to reserve your own ad space in the next edition of the magazine.

## COLUMNISTS

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

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

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

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

**Ron Tipton** has degrees in electrical engineering from New Mexico State University and is retired from an engineering position at White Sands Missile Range. In 1957, he started Testronic Development Laboratory, which became TDL Technology, to develop audio electronics. All product sales and services were terminated on December 31, 2015, but the TDL website is still online with a variety of audio information and downloads.

# The Audio Voice

Sign up now for our **FREE** weekly e-newsletter



Weekly Newsletter for the Audio Industry, Professional Designers and Audio Enthusiasts  
Product Design | Audio Electronics | Acoustics | DIY | Innovations in Audio





## ● Special Headphone Focus

### 8 State-of-the-Union of Earphone and Headphone Test Instrumentation

*By Mike Klasco and J. Martins*

This comprehensive roundup highlights the latest company trailblazers in the burgeoning earphone and headphone test equipment market.

### 28 Audio Precision AECM206 Headphone Test Fixture Putting Headphones to the Test

*By Stuart Yaniger*

Stuart Yaniger put the AECM206 unit to the test to try and verify Audio Precision's claims that it is equally capable in both R&D and production test applications and well-suited for testing circum-aural, supra-aural, and intra-concha headphones and earbuds.

### 36 Developing a New Electrostatic Transducer

*By Valerio Marra*

Learn more about Warwick Audio Technologies' new type of transducer for high-end electrostatic headphones. The design process for the High-Precision Electrostatic Laminate (HPEL) transducer also inspired the team to build a completely optimized system, including electronics.

### 44 HEAD acoustics labCORE A New Modular, Multi-Channel Front-End Measurement Platform

*By J. Martins*

Discover labCORE, an all-new front-end platform from HEAD acoustics. labCORE is a modular multi-channel front end designed in response to modern measurement applications.

## COVER ART

Photo credit: Focal ([www.focal.com](http://www.focal.com))





## ● Features

### 50 TubeSociety 2A3-300B-SE Amplifier Project (Part 1) Experimentation Leads to Success

*By Menno van der Veen*

Menno van der Veen designed five challenging 300B-SE amplifiers for his students. Part 1 of this two-part article discusses his TubeSociety academy in the Netherlands and details the first four amplifiers.

### 60 A DIY HRTF Binaural Microphone Head

*By Ron Tipton*

Ron Tipton explains how to build an economical head-related transfer function (HRTF) binaural microphone head, using a Styrofoam wig holder.

## ● Departments

### 4 From the Editor's Desk

### 5 Client Index

### 66 Industry Calendar

## ● Websites

[audioxpress.com](http://audioxpress.com)

[voicecoilmagazine.com](http://voicecoilmagazine.com)

[cc-webshop.com](http://cc-webshop.com)

[loudspeakerindustrysourcebook.com](http://loudspeakerindustrysourcebook.com)



@audioxp\_editor



audioexpresscommunity



linkedin.com/company/audioxpress

# State-Of-The-Union of Earphone and Headphone Test Instrumentation

2018 is the “year of earphone and headphone” test equipment and the coming of age of the Transducer Electronic Data Sheet (“TEDS”) otherwise known as IEEE 1451.4. In this roundup our experts examine some of the latest solutions from top industry professionals.

By  
**Mike Klasco and J. Martins**

Headphones are one of the hottest audio categories and the industry is responding with new and improved solutions for all the industry’s needs, from research and development, evaluation and quality control of all the earphone- and headphone-related technologies, which increasingly includes sophisticated wireless technology systems, sensors, digital signal processing and active noise canceling (ANC).

Appropriate headphone test setups for R&D are quite different than QC online testing. Aside from the analyzer, additional equipment needed for headphone testing includes the ear coupler fixtures with passive attenuation, device positioners for manikins, and appropriate test software. The artificial ear (the ear coupler) approximates the acoustic load presented by the human ear to the headphone/earphone. The top octave characteristics of the industry standard 711 coupler are less than perfect and recent advances and refinements mentioned in this solution round-up are welcome additions, some of which are being introduced to the industry for the first time here.

## Transducer Electronic Data Sheet

The Transducer Electronic Data Sheet (TEDS) is a standard for adding calibration/ID capabilities to analog transducers. The underlying mechanism for plug-and-play identification is the standardization of TEDS. Of course, precision measurement mics are the way to go—precision calibration, stability over time and temperature, and provide the credibility

needed if you find yourself in court as an expert witness. On the other hand, it is often good enough to have a mic that is more accurate than the speaker you are testing—especially in less than pristine environments or where the test mic could get dropped or disappear altogether. Disposable measurement mics have their place but a correction curve, ideally from a recent calibration would add significant value. Low-cost ECM (self-polarized) measurement mics are common and for many years have been supplied by some vendors with a correction curve/calibration file.

TEDS is the Institute of Electrical and Electronics Engineers (IEEE) 1451.4 standard for accurate correction and characterization of a specific transducer (e.g., a test mic) containing the information needed by a measurement system (analyzer) to identify, characterize, interface, and properly use the signal from an analog sensor. Manufacturer ID, part and serial numbers, sensitivity, and response are some of the specs that can be contained in the TEDS. This electronic data sheet can reside in memory within the analog transducer (expect to see this in MEMS measurement mics in the future) or as a separate file. Expect to start seeing TEDS-enabled parameters on most new measurement mics, artificial ears, and most other transducers/sensors.

Aside from measurement instrumentation, there are consumer audio applications for TEDS that range from automatic active noise cancellation calibration of noise pickup mics and headphone drivers and

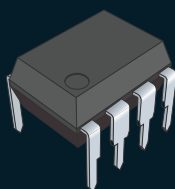


# CLEARLY THE BEST

# MUSES

BY NEW JAPAN RADIO CORPORATION

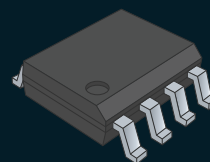
SWITCH TO NJRC & MUSES TODAY AND DISCOVER A WHOLE NEW LEVEL OF AUDIO CLARITY



## DESIGNED WITHOUT COMPROMISE

### MUSES03

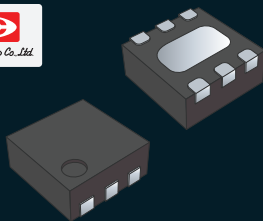
The MUSES03 JFET input op-amp is the latest in the flagship series of components by NJRC. Low noise, high speed and with virtually no distortion (0.00003%), the MUSES03 is for premium audio gear. The MUSES series includes single and dual op-amps, a volume IC and SiC diodes.



## RFI RESILIENT OP-AMPS

### NJM8XXX SERIES

By utilising the lessons learnt whilst designing the MUSES series, coupled with some unique RFI suppression circuitry, NJRC has released a series of cost effective op-amps that offer both superior sound quality and RFI immunity.



## ULTRA LOW PHASE NOISE CRYSTAL OSCILLATOR IC

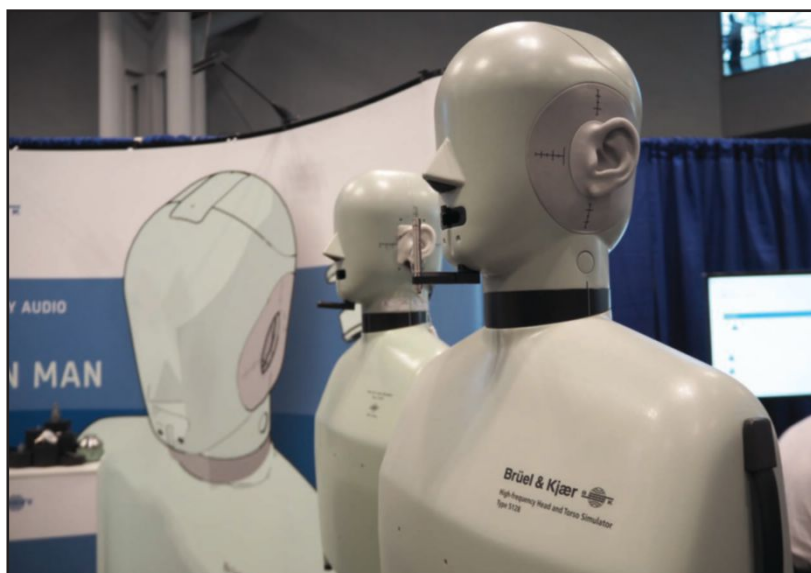
### NJU6385U

The NJU6385U is a CMOS quartz crystal oscillator IC (20 ~ 50MHz) that realises exceptionally low phase noise. Consisting of an oscillation amplifier and a 3-state output buffer, this device has been designed for audio applications in which the lowest noise is of paramount importance.

For over 25 years, Profusion has been the design engineer's distributor of choice for ICs and specialty devices used in pro audio, MI audio, and consumer audio products. We have the inventory, pricing and expertise to meet your semiconductor and electronic component demands.

 **Profusion**  
Audio semiconductors

+44 (0)1702 543500 | [www.profusion.audio/njr](http://www.profusion.audio/njr)



Brüel & Kjær recently developed a new high-frequency Head-and-Torso Simulator (HATS) Type 5128, addressing the need for realistic, accurate, and repeatable acoustic measurements across the full range of human hearing.

automatic calibration of mic arrays for automatic speech recognition voice appliances to recognition of a specific model earphone or headphone and then your smartphone corrects and tweaks its signal processing optimization to your earphone.

## Earphone and Headphone Instrumentation

This year we have a great deal of activity, both in software and hardware development (i.e., artificial



The number of headphone-focused training sessions promoted by all the test and measurement manufacturers clearly reflects the momentum this product segment is experiencing.

ears, HATS manikins, and related jigs and fixtures). The first question that comes to mind is, “If it ain’t broke why fix it?” It is tough enough dealing with the questionable updates forced on us by Windows, Skype, and so forth, where after rebooting nothing is where it used to be. Why don’t software guys just spend their time fixing problems rather than creating new ones?

At least headphone test jig developers have good reasons for their product development efforts. The human ear has various chambers and represents a complex acoustic load to earphones and headphones (and hearing aids). An “artificial ear” integrates a mic and acoustic coupler and is used for simulating the acoustic impedance of a human ear to more accurately attain realistic test data. Over the last few decades, there have been several attempts at developing a practical ear simulator coupler standard (much of it by hearing aid researchers) eventually leading to the present International Electrotechnical Commission (IEC) 60318-4 standard.

When speaker engineers first get involved with earphones and headphones they are often surprised by what they find when they visit the headphone test lab. Inside are the usual analyzers but the response curves are not what might be expected. More daunting is the seasoned headphone engineer’s advice to not take test results too seriously much past 8 kHz. With experience, you can read the tea leaves and piece together that there is too much loss at the top end probably due to the wrong adhesives being used between the voice coil and the diaphragm, or that extra mid and top-end might benefit from copper-clad aluminum voice coil wire, or the extended response might be from a higher Young’s modulus diaphragm material. Yet different manikins have different approaches to the outer pinna (the Dumbo ears) and yield different responses.

I have not seen anyone claiming to have a “correction curve” between the various head-and-torso simulators (HATS) measurements from the various manikin vendors—especially for on-the-ears headphones, which interact with the variations of springiness of the silicon pinna from the various manikins.

The (human) ear is not an empty hole, but rather loosely coupled chambers that have an acoustic impedance that loads and interacts with the earphone or headphone. The 711 (IEC) 60318-4 standard artificial ear coupler was the result of an epic effort to approximate the human ear—primarily to be used for hearing aid research. 711 artificial ears are available in various forms (e.g., HATS





Here.



There.



Stellar sound  
anywhere.



OPPO Digital's Sonica Wi-Fi Speaker fills every room of your home with pristine sound. Play a song in every room of your house, pair two together for a genuine stereo experience, or just enjoy clear audio in any room you like.

*\$299 on [oppodigital.com](http://oppodigital.com) and from select retailers nationwide*

**oppo**

OPPO Digital, Inc. | [www.oppodigital.com](http://www.oppodigital.com) | Menlo Park, CA

   @oppodigital

manikins, ear/cheek testers, etc.) from G.R.A.S. Sound & Vibration, Brüel & Kjær (B&K), HEAD acoustics, Larson Davis, Audio Precision, CRY, and other acoustic test instrumentation vendors. The 711 was mostly conceived for telephone transmission quality, and calibration is limited to 10 kHz. Above 10 kHz, the quality is not great and with the industry standard 711 coupler, there is a high rise peaking at around 14 kHz.

Yet, here we are in 2018 and wideband is already in use—not just for earphones and headphones where everyone has a reasonable expectation that the designer was well-versed in engineering decent top-end response but even your smartphone receiver (the built-in earpiece) is moving to super wideband (SWB) standard, which extends out to 14 kHz.

Today, when measuring premium headphones with extended top-end response (e.g., the Sennheiser HD800 claims response to 44 kHz, the beyerdynamic T1 gen2 claims 5 Hz to 50 kHz)

leads to non-standard procedures. For headphone engineers benchmarking against these flagship headphones, the response above 10 kHz is often measured with the headphone driver removed and mounted on a baffle with a precision wideband microphone in the near field. When testing, all you can do is keep the test setup the same and check the relative extended range response between products. But, what is linear to the ear's perception is anyone's guess—although there have been a number of white papers recently on what sort of response curve is preferred by headphone listeners.

G.R.A.S. introduced its new wideband artificial ear RA040X/couplers (GRAS RA0401 Externally Polarized and GRAS RA0402 Prepolarized) and now Brüel & Kjær has launched its Type 5128 new generation of wide-band HATS Manikins. The headphone test industry is upside down and what the next industry standard will be is yet to be determined.

## Brüel & Kjær's Wideband Head-and-Torso Simulator Types 5128-C and 5128-D

The Brüel & Kjær (B&K) Head-and-Torso Simulator Type 5128 was designed in response to the trend toward high-quality audio in mobile phones and the increasing popularity of headphones and headsets for communication and entertainment. This new wideband head-and-torso simulator addresses the need for accurate and repeatable acoustic measurements across the full range of human hearing and provides a realistic reproduction of the acoustic properties of an average adult human head and torso. A new generation of ear and mouth simulators, designed for in situ electro-acoustic tests and covering the full audible frequency range (up to 20 kHz), is integrated into the 5128. The 5128 is provided with electronic calibration information via the TEDS.

B&K's approach to achieving wideband accuracy was to develop a geometrically correct ear canal to the pinna, enabling in-canal earphones and hearing aids with correct anatomical positioning as they will be used. A new, state-of-the-art coupler design simulates the inner-ear and concludes the simulation of the ear of an average human adult. The manikin

also provides a larger area of silicon rubber around the pinna to enable perfect sealing of circum-aural (over the ear) headphones—as well as more accurate interaction with the pinna and headphone tensioning is on-the-ear designs.

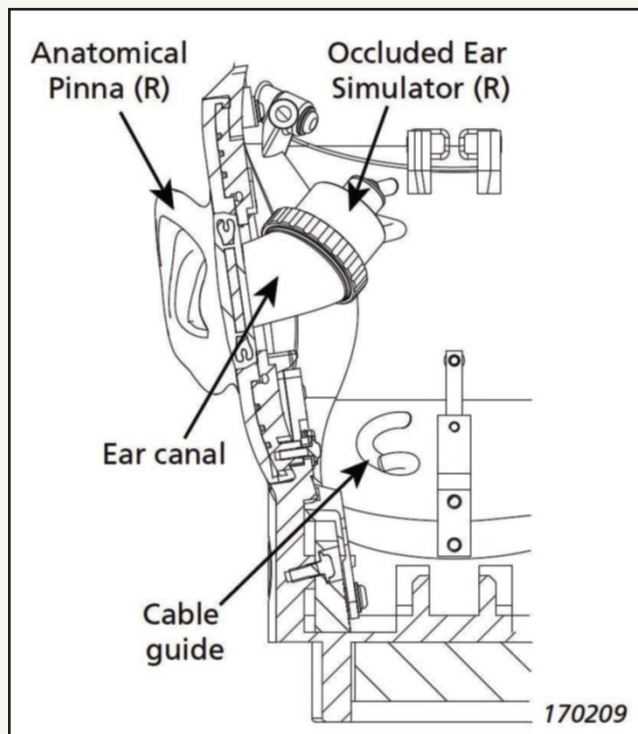
Measurement of the audio response of headphones with the 5128 is claimed to be in exactly the way a human would perceive the quality. This enables designers to identify and correct anomalies in headphone design that lead to artifacts in the frequency response. The new ear canal design provides the most benefits to designers of in-ear headphones, where the geometric fit is crucial to the evaluation.

Enhanced measurement capabilities include effective attenuation and sealing of hearing protectors with the correct ear canal geometry and head anatomy, and evaluation of the intelligibility of headset two-way communication in the presence of background noise and conditions that may produce feedback into the system. Another focus is the evaluation of intelligibility in two-way communication using hands-free devices such as conference phones based on accurate production of human speech for the evaluation of directivity, intelligibility, feedback, and background noise suppression. Additionally, the 5128 facilitates the evaluation of microphone



Brüel & Kjær now offers a high-frequency Head-and-Torso Simulator (HATS) Type 5128.





The high-frequency HATS features a human-like ear canal that enables the correct acoustic impedance across the full frequency range and ear simulators, up to 20 kHz, with associated electronic calibration information via the transducer electronic datasheet (TEDS).

recording accuracy for human speech with variations in level, directivity and sibilance.

### Ear and Mouth

Each of the new HATS 5128 artificial ear consists of a removable silicon rubber pinna joined to a human-like ear canal. The ear canal ends in an occluded ear simulator that simulates the inner part of the ear, that is, from the ear drum and inwards. The occluded ear simulator includes a prepolarized measurement microphone and preamplifier.

Each ear simulator is delivered with a pinna corresponding



The new 5128 manikin provides a larger area of silicon rubber around the pinna to better accommodate circum-aural (over-the-ear) headphones.

to ITU-T Rec. P.57 (hardness 35 on the Shore-00 scale). This allows measurements on, for example, handsets using a realistic application force and obtaining a close simulation of an average human acoustic impedance to the handset. The pinna enables realistic deformation levels for measuring in open, semi-sealed, or sealed conditions due to its specially designed human-like shape and stiffness.

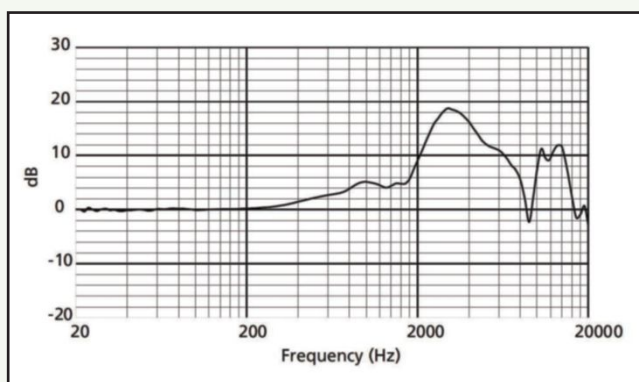
Each pinna simulator has a quick-release button directly below the pinna, allowing users to remove the pinna (and surrounding soft area) for servicing and cleaning.

Each Type 5128 ear simulator is delivered with a calibration chart specific to that ear simulator and pinna. The calibration information is also stored electronically in a chip inside the microphone preamplifier and can be utilized by measurement instrumentation that supports TEDS. Sound Calibrator Type 4231 and Pistonphone Type 4228 are suitable calibrators for these ear simulators.

The combined influence of the torso, head, pinna, and ear canal on airborne sound signals can be quantified by the acoustic free-field transfer function (i.e., the frequency response from the free field to the eardrum). This is called the listener free-field frequency response or head-related transfer function (HRTF), and the manikin frequency response in technical audiology.

For voice applications, each HATS mouth simulator has a high-compliance loudspeaker that gives powerful low-frequency response and low distortion. The acoustic transmission path from the loudspeaker to the mouth opening ensures an easily equalized frequency response of the sound pressure level in front of the mouth.

The mouth simulator produces a sound pressure distribution around the opening of the mouth simulating that of an average adult human mouth, corresponding to the figures given in ITU-T Rec. P.58. An individual equalization procedure ensures



This shows the typical listener free-field response of the Type 5128-C for sound incidence at 0° (that is, coming from the front). The frequency response data is provided with HATS.

a flat frequency response, enabling the mouth simulator to reproduce the frequency range of human subjects.

Another useful jig introduced by B&K is its Handset Positioner Type 4606 included with the Type 5128-D. The handset positioner enables a smartphone to be precisely positioned on the HATS. This results in easier test setups and better data quality from electroacoustic tests.

Measuring smartphones on manikins has been awkward although there are gizmos that enable placement, but results are not repeatable enough. B&K's new handset positioner address these issues by providing pressure, force and position read-outs, enabling accurate, repeatable mounting of smartphones on HATS in both standardized and user-defined positions.

**Brüel & Kjær**  
[www.bksv.com](http://www.bksv.com)

This is a B&K Handset Positioner Type 4606 offered for the HATS.



## Audio Precision AECM206 Binaural Headphone Test Fixture

For engineers developing and evaluating headphones, Audio Precision (AP) continues to expand its portfolio of test products, adding measurement microphones, instrument-grade amplifiers, microphone power supplies, calibrators, and headphone test fixtures, which can all be paired with APx500 Series audio analyzers. In cases where wireless headphones are being designed, AP's newest I/O module, APx Bluetooth Duo, offers an expanded list of A2DP codecs, including AAC, aptX-LL, and aptX-HD.

Recently, Audio Precision announced its new AECM206 Headphone Test Fixture, a competitively priced IEC 60318-4-compliant accessory that simplifies earbud and headphone measurements in both lab and production environments.

The new AECM206 is a dense, robust fixture mounted on a resilient base to isolate ambient noise, which can adversely affect measurement integrity. Equally capable in both R&D and production test applications, it is well-suited for testing circum-aural, supra-aural and intra-concha headphones and earbuds. The AECM206's high level of acoustic isolation also enables the measurement of noise-reduction performance of active noise canceling (ANC) headphones, as well as the evaluation of hearing



The new Audio Precision AECM206 (a) is a dense, robust fixture mounted on a resilient base to isolate ambient noise. Two sets of pinnae are provided with the unit (b).



protection ear muffs. It is a more cost-effective solution for headphone test when compared with a HATS, and is competitively priced with regard to comparable fixtures.

The Headphone Test Fixture is shipped fully assembled and ready to use upon arrival, with occluded ear simulators (microphones with acoustic couplers) and preamplifiers installed and connected to BNC-terminated coaxial cables. The microphone/preamplifier pairs are TEDS-compliant, CCP-powered and calibrated. TEDS programming allows microphone identification and calibration information to be read by a connected instrument, such as the Audio Precision APx1701 Transducer Test Interface.

Two sets of pinnae (hardness Shore OO-35 and A-25, respectively) are provided with the unit. The pinnae are symmetric, which offers convenience when testing stereo headphones and earphones. The AECM206 is also delivered with an adapter for the CAL250 sound level calibrator (optional), product documentation and disassembly tools.

From the lab to the production line, confidence in measurement results is integral to confidence in prototype or product performance. Calibration provides documented and traceable verification that instruments, and accessories meet or exceed all of their published specifications. Each AECM206 ships with calibration certificates for its integrated occluded ear simulators and preamplifiers, enabling a complete, calibrated test setup when paired with an APx Series analyzer and APx1701 Transducer Test Interface.

The AECM206 retails for US \$11,024 (€9,756.00) or US \$11,232 (€9,940.00) in an optional hard-shell roller case.

A complete review of the AECM206 can be found in this edition of *audioXpress*.

**Audio Precision**  
[www.ap.com](http://www.ap.com)

### A Complete Range of Electroacoustic Testers

CRY Sound has designed, produced and sold a full line of electroacoustic test solutions for more than 20 years. The Hangzhou (China) based company offers a comprehensive suite of test devices, jigs, instruments, and acoustic shielding test enclosures for headphones.

The CRY6151 electroacoustic tester can be applied to measure wired, Bluetooth, ANC, Lightning, and interface headphones and headsets. The CRY711 and CRY318 ear simulators are popular and also offered by other audio analyzer vendors for testing earplugs and headphones. The CRY574 Bluetooth dongle provides the link between the Bluetooth headphone and the tester. The CRY801 headphone test jig

has adjustable height, width, and angle. For headsets that require microphone testing, there is the CRY5620 Mic tester.

During the 2018 ALMA International Symposium & Expo (AISE), CRY Sound introduced its latest CRY6151B improved electroacoustic tester, built-in signal generator and programmable test sequencer, with eight inputs and four channel outputs, in a more compact unit, complemented with new Windows software for faster measurements of all types of headphones, microphones, speakers, and other acoustical devices, featuring a USB port in the front panel and mouth simulator inputs.

Complemented with CRY Sound's complete range of



The CRY Sound booth at AISE 2018 highlighted the company's CRY6151B improved electroacoustic tester, and range of microphones, and mouth-and-ear simulators for headphone measurement applications.

measurement microphones, ear simulators, and headphone and mouth test jig, the CRY6151B provides sensitivity (SPL), impedance, total harmonic distortion (THD),  $F_0$  (resonant frequency), balance degree of left and right headphone, position of left and right headphone, polarity, microphone current and voltage, signal-to-noise ratio (SNR), microphone directivity, loudspeaker Thiele-Small (T-S) parameters, and other measurements.

The new CRY6151B is able to provide fast and repeatable measurements for headphone evaluation and quality control testing, enabling automatic pairing of Bluetooth headsets, and testing two components of headphones and two microphones, synchronously. Frequency sweeping methods and pseudo white noise test can be selected, with one-time-sweep testing able to determine parameters such as frequency response, sensitivity (SPL), THD, impedance,  $F_0$ , phase, balance degree, polarity, etc.

Also new is the company's CRY709 Anechoic Box, a self-contained solution with high noise isolation (over 40 dB at 1 kHz), suitable for headset and microphone testing.

**CRY Sound**  
[www.crysound.com](http://www.crysound.com)

CRY Sound offers a complete range of ear and mouth simulators.



## Pioneering Headphone Measurement Solutions

G.R.A.S. Sound & Vibration offers versatile solutions for developing and testing headphones/earphones, phones/tablets, and loudspeakers. The G.R.A.S. product portfolio supports the product development cycle, from R&D through production line QC testing.

The G.R.A.S. KEMAR Head-and-Torso Simulator was invented in collaboration with the audiological industry for the use of hearing aid development and is still the de facto standard for this industry. However, the usage of KEMAR has spread into a multitude of other industries (e.g., telecommunications, hearing protection, automotive development, etc.). KEMAR has been built using statistical research of the average human body—meaning the KEMAR HATS has the same acoustical properties as an average human,

including distinct facial features, which are important to mimic the human experience.

G.R.A.S. has developed a range of accessories and special versions of KEMAR—enabling the design of test setups for research

in specific industries. KEMAR meets the international standards that are specified by the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the American National Standards Institute (ANSI). G.R.A.S. offers a number of preconfigured KEMAR such as the 45BB-X without Mouth Simulator and the 45BC-X with Mouth Simulator for specific purposes as well as non-configured.

For measuring products going into the concha and ear canal, the new G.R.A.S. KB5000 pinnae with the anthropometric ear canal offers a much more natural and realistic fit. It greatly improves repeatability and enables engineers to test final version devices under test (DUT) with the ear tips fitted more accurately in a much shorter amount of time. And because it provides a greater fit and more realistic seal, it enables users to better



Almost a symbol of G.R.A.S. Sound & Vibration, the KEMAR manikin is the standardized, anthropomorphic head-and-torso simulator that replicates the human auditory system while thoroughly representing the listener in the soundscape.



# AXPONA

AUDIO EXPO NORTH AMERICA

APRIL 13-15, 2018 • CHICAGO  
RENAISSANCE SCHAUMBURG  
HOTEL & CONVENTION CENTER

## WHERE MUSIC MATTERS MOST.

Be a part of North America's largest annual audio event. Listen to your favorite music on over 150 audio systems in our listening rooms. Tour our newly expanded Expo Hall, enjoy live music and concerts, learn from experts and connect with our community of audio enthusiasts and music lovers.

**Tickets are on sale now!**  
**For details, visit [www.axpona.com](http://www.axpona.com)**

### See these companies and brands (and more) represented at AXPONA:

64 Audio  
ACA (Angel City Audio)  
Accent Speaker  
Technology  
ACE Computers  
Acoustic Energy  
Acoustic Research  
Acoustic Sounds  
Acoustique Quality  
ADV SOUND, Inc.  
Aerial Acoustics  
Aesthetix  
American Sound of  
Canada  
Ansuz Acoustics  
ANTICABLES  
Astell & Kern  
ATC Loudspeakers  
Audeze  
Audio Envy Cables  
Audio Plus Services  
Audio Technica  
Audio Union  
Audio Video Interiors of  
Chicago  
Audionet  
Audiophile Direct, LLC  
AudioQuest  
AudioThesis  
AURALiC North America  
Inc.  
auranas®  
Aurender  
AVM  
AXISS Audio  
Ayon Audio USA

Bandwidth Audio  
Bending Wave USA  
Bionic Cables  
Border Patrol  
Bricasti Design  
Bryston Ltd.  
Burwell & Sons  
Loudspeakers  
Cambridge Audio  
Canton  
Caprice Audio  
Cardas Audio  
Cayin  
CH Precision  
Channel D  
Chicago Audio Society  
Clarus Cable  
Clear Tune Monitors Inc.  
Clearaudio  
CLEER, Inc.  
Comply Foam  
Constellation Audio  
Convergent Audio  
Technology  
Core Power Technologies  
Creative Sound  
Solutions  
D Digital  
Daedalus Audio  
Dan D'Agostino Master  
Audio Systems  
Danacable  
David Michael Audio  
Dekoni Audio  
Delmark Records  
DR vinyl

Dynamique Audio Ltd  
Earsonics  
Eccentricity of Wood  
Egglesonworks  
EINSTEIN Audio  
Components GmbH  
ELAC  
Elite Audio Systems  
Elite AV Distribution  
Elusive Disc  
Emerald Physics  
EMM Labs  
Emotiva  
Empire Ears  
EnKlein  
Erhard Audio  
Esoteric  
Etymotic Research  
EXOGAL  
FERN & Roby  
Fidelis  
final  
Finest Fidelity  
Focal  
Galen Carol Audio  
Gayle Sanders Audio  
Gershman Acoustics  
Ginkgo Audio  
Göbel High End  
GTT Audio & Video  
Haniwa  
Hanson Audio Video LLC  
HeadAmp Audio  
Electronics  
HHR Exotic Speakers  
Hi-Fi+

HiFiMan  
High Fidelity Cables  
High Fidelity Services  
High Impact AV / Jriver  
High Water Sound  
HighEnd By Oz  
Holm Audio  
HSU Research  
iFi Audio  
J & B Distributors Inc  
JansZen Audio  
Jeff Rowland  
Jolida Inc / Black Ice  
Audio  
Joseph Audio  
JTR Speakers  
Kii Audio  
Kimber Kable  
KirmussAudio  
Kubala-Sosna Research  
Kuzma  
Kyomi Audio  
Legacy Audio  
Lindemann Audio GmbH  
Linear Tube Audio  
Lone Mountain Audio  
Luxman  
MA Recordings  
Madisound Speaker  
Components  
Magico, LLC  
Manger Audio  
Mark Audio - SOTA  
Martin Logan  
Mastersound  
MBL North America

Merging Technologies  
Merrill-Williams Audio  
ModWright Instruments  
MoFi Distribution  
Morrow Audio  
MrSpeakers  
MSB Technology  
Music Direct  
Mytek  
Next Level HiFi  
Noble Audio  
Northstar Design  
Odyssey  
Paragon Sight and  
Sound  
Parts Express  
Pass Labs  
Perfect Vinyl Forever  
Periodic Audio, Inc.  
Pioneer Onkyo USA Corp  
pNeanue Audio, Inc.  
PranaFidelity  
Precision Audio Video  
Prism Sound  
Pro-Audio  
Pro-Ject  
PS Audio  
PureAudioProject  
Quintessence Audio  
Raidho Acoustics  
Rainbow Audio  
Raven Audio  
Rega  
Rosso Fiorentino  
Rupert Neve Designs, LLC  
Rutherford Audio

Ryan Speakers  
Saturday Audio  
Exchange  
SB Acoustics  
Scaena Loudspeakers  
Schiit Audio  
Scott Walker Audio  
Seaton Sound, Inc.  
Sennheiser  
Seymour-Screen  
Excellence  
Shunyata Research  
Shure Incorporated  
Silnote Audio  
Snake River Audio  
Sonist Audio  
Sonner Audio  
Sonoma Acoustics  
Sonus Faber  
SOTA Sound Inventions,  
LLC  
SOTM  
STAX  
Stereohaven  
Stereophile  
Swan Song Audio  
Synergistic Research  
The Audio Surgeon  
The Sound Organisation  
The Tweak Studio  
The Voice That Is  
Thrax  
Timbre & Lucus USA LLC  
Triangle Art  
Triangle Loudspeakers  
Triode Wire Labs

UltraSonic Records  
US Soundlabs  
Valve Amplification  
Company, VAC  
VANATOO  
Vehement Audio Group  
Velodyne Acoustics  
Vinnie Rossi  
Vinyl Times Magazine  
Viola Labs  
Vitus Audio  
VK Music  
Volti Audio  
Von Schweikert Audio  
Well Pleased AV  
Well Rounded Sound  
Wells Audio  
Western Electric  
Wilson Audio  
Wolf Audio Systems  
Wynn Audio  
Wyred 4 Sound  
WyWires  
Zesto Audio  
ZMF Headphones

*Exhibit list as of 1/18/18.  
Visit  
[www.axpona.com](http://www.axpona.com)  
for an updated list*

characterize ANC (if applicable) and low-frequency performance as well as low-end passive isolation.

The G.R.A.S. 45CA Hearing-Protector Test Fixture is a versatile test fixture for measuring sound isolation of hearing-protectors according to ISO 4869-3 and ear and headphones according to IEC60318-1 or 60318-4.

The G.R.A.S. 43AG Ear-and-Cheek Simulator represents the section of an average human head needed for realistic reproduction of the ear's acoustic properties. It allows the use of an ITU-T type 3.3 pinna or an anthropometric pinna—either with an IEC 60318-4 ear simulator or a low-noise ear simulator system.

The G.R.A.S. 45CC is a flexible and configurable platform for dual-channel testing of headphones and headsets. It has multiple configuration options—microphones, IEC 60318-1 ear simulators, and mouth simulators. It can be precisely adjusted to support different headphone/headset designs and sizes, and it is in a league of its own with respect to accuracy and repeatability. It is equally well suited for QC and PL testing.

The G.R.A.S. Sound & Vibration Green Book about headphone testing with the KEMAR manikin is free and available online at: [www.gras.us/files/k/e/kemar\\_manikin\\_measurements.pdf](http://www.gras.us/files/k/e/kemar_manikin_measurements.pdf).

## High-Resolution Ear Simulator

The new G.R.A.S. High Resolution Ear Simulator is available in two versions: The GRAS RA0401 Externally Polarized and the GRAS RA0402 Prepolarized and is available on multiple test platforms for R&D, production testing and verification. Both are fully backward compatible with the standard IEC 60318-4 (711) ear simulator.

A unique feature is a special dampening system that extends its useful frequency range to 20 kHz. This has significant advantages when measuring sophisticated earphones and headphones and technologically advanced, wide-band hearing aids.

Now, for the first time, it is possible to obtain accurate, reliable, and repeatable measurements above 10 kHz. The dampened resonance means better distortion measurements, even from as low as 3-5 kHz, while the solution improves accuracy and minimizes operator error.



This is the GRAS 43AG Ear-and-Cheek Simulator and the new GRAS RA040X High-Resolution Ear Simulator.

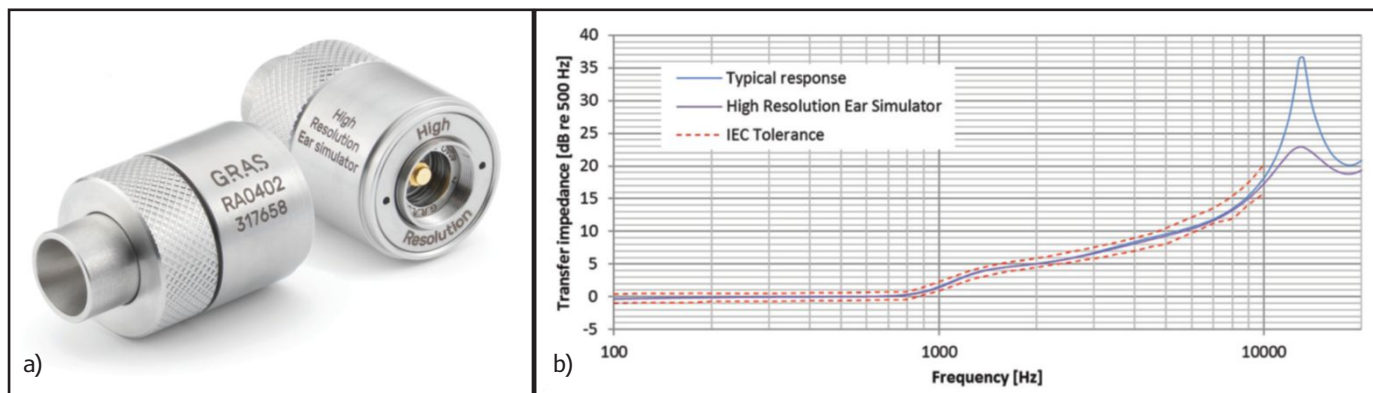
The GRAS RA0401/402 is a high-resolution version of the well-known standardized 60318-4 ear simulator, which has gained wide acceptance as the preferred tool for measurements with simulation of the acoustic load presented by the human ear.

For R&D of headphones, the RA0401/RA0402 can be mounted in a KEMAR. When furnished with the anthropometric pinna, tests of supra-aural and circum-aural headphones can be done to a much higher degree of realism than previously possible. For QC purposes, the RA0401/RA0402 can be mounted in a 45CA Headphone/Hearing-Protector Test Fixture.

The RA0401 can be used with a standard LEMO preamplifier (e.g., the GRAS 26AK 1/2" Preamplifier or the GRAS 26AC-1 1/4" Preamplifier fitted with an adapter). The RA0402 can be used with a standard CCP preamplifier (e.g., the GRAS 26CA 1/2" Preamplifier or the GRAS 26CB 1/4" Preamplifier fitted with an adapter). For the 1/4" preamplifier, the straight RA0003 Adapter or the right-angled RA0001 Adapter can be used.

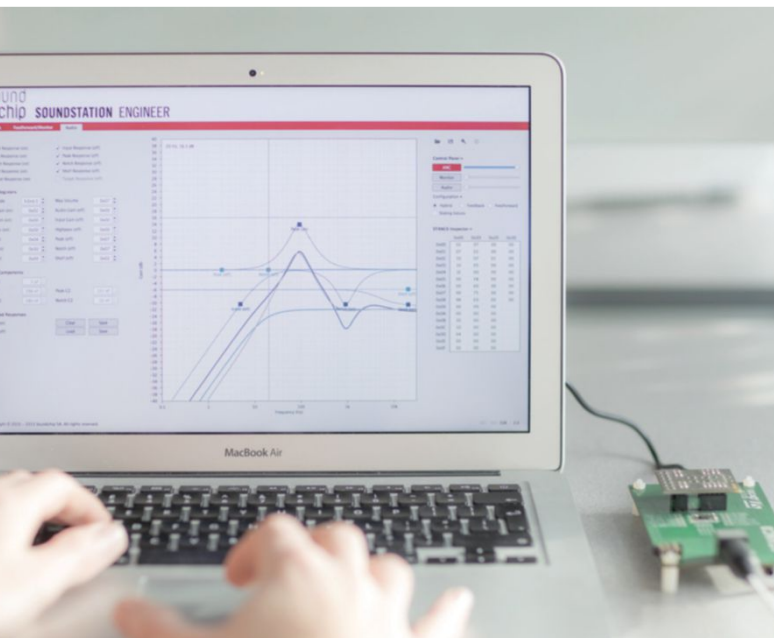
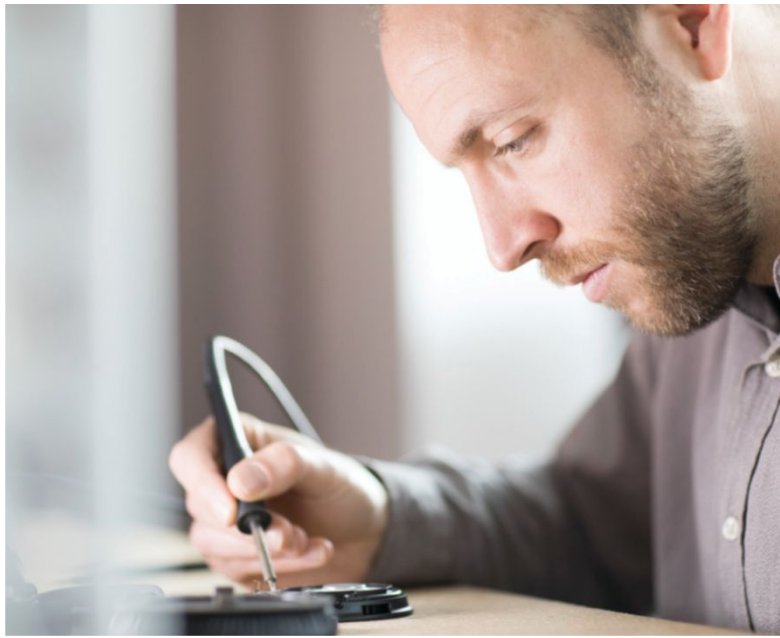
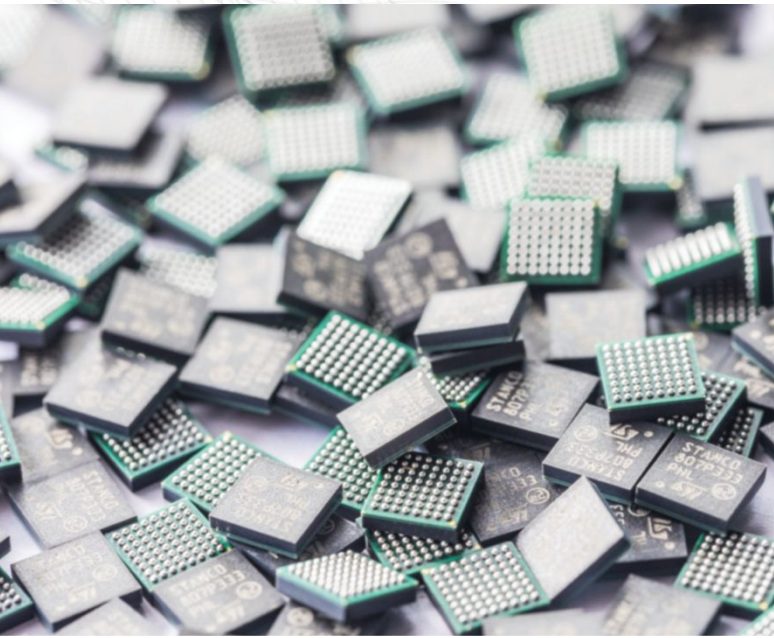
A review of the GRAS RA040X was featured in the *audioXpress* March 2018 test and measurement focus edition.

**G.R.A.S. Sound & Vibration**  
[www.gras.dk](http://www.gras.dk) | [www.gras.us](http://www.gras.us)



For QC purposes, the RA0401/RA0402 can be mounted in a 45CA Headphone/Hearing-Protector Test Fixture (a). The measurement test compares the resonance of a typical standard 60318-4 Ear Simulator and a RA040X High-Resolution Ear Simulator (b).





**Smarter noise cancelling.  
Simply delivered.**

## Super-Wideband Testing with HEAD acoustics Artificial HEAD

German specialist HEAD acoustics specializes in analyzing and evaluating devices that can do two-way communication including headphone audio response characterization and application-specific manikins including:

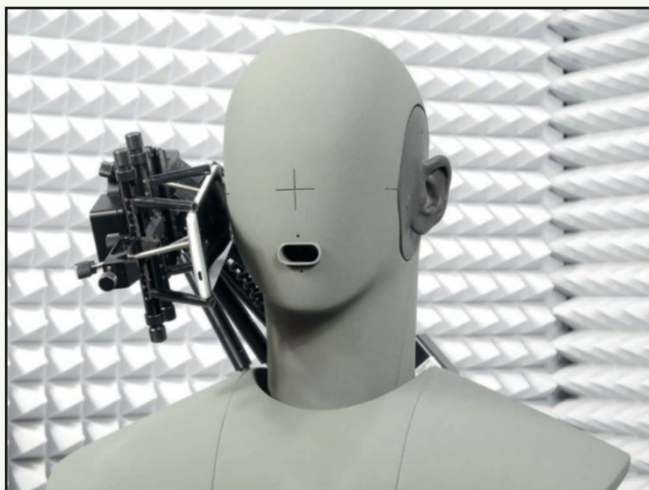
- HMS II.3 with ears and a mouth tests listening and talking quality ([www.head-acoustics.de/eng/telecom\\_hms\\_II\\_3.htm](http://www.head-acoustics.de/eng/telecom_hms_II_3.htm))
- HMS II.4 with ears (no mouth) only to test the listening side ([www.head-acoustics.de/eng/telecom\\_hms\\_II\\_4.htm](http://www.head-acoustics.de/eng/telecom_hms_II_4.htm))

HEAD acoustics' ACQUA software is capable of diverse audio tests (e.g., frequency response, levels, distortion, THD, etc.) and can be upgraded to include more advanced analysis methods such as:

- Speech Intelligibility (SII) and Speech Transmission (STI)
- Heading models (e.g., Zwicker Loudness and Relative Approach)
- PESQ, TOSQA, and POLQA speech quality evaluation
- More sophisticated communication algorithms (e.g., EQUEST and Double Talk analysis)

HEAD acoustics has a variety of measurement front ends (MFEs) that enable users to connect via analog; using the MFE VI.1 or the HIB I; VoIP using the MFE VIII.1; Bluetooth using the MFE XI, and Wi-Fi using the MFE IX.

ANC and similar noise-reduction-method testing requires appropriate background noise simulation methods. Most manufacturers today demand that their audio gear works in the real world—and that it can handle communication aspects as well. For background noise simulation, HEAD acoustics



HEAD acoustics' HMS II.3 artificial head measurement system is super-wideband capable and suited for testing the upcoming generation of VoLTE mobile phones.



HEAD acoustics HMS II.3 is an artificial head measurement system to measure the performance of close to-the-ear transducers: handsets, headsets, headphones, hearing protectors, and hearing aids.

offers the 3PASS (3-dimensional Playback of Acoustic Sound Scenarios) system, a series of playback and recording systems capable of preserving and reproducing real-life background noise scenarios in different test rooms or in vehicle cabins. 3PASS lab is especially suited for the evaluation of complex noise reduction algorithms and conforms to the ETSI standard TS-103-224 and includes a noise database as specified by the standard.

New is the modular multi-channel front end labCORE (see the separate article about labCORE in this edition). A wide selection of digital and analog inputs and outputs as well as programmable interfaces makes labCORE a powerful and expandable all-in-one solution for voice and audio quality measurements. Also, just launched, is 3QUEST-SWB/FB, a new calculation method designed for super-wideband and full-band scenarios (i.e., audio in the frequency range up to 20 kHz).

### HMS II.3 Artificial Head Measurement System

HEAD acoustics' HMS II.3 Artificial Head Measurement System is able to transmit real speech equalized up to almost 20 kHz. According to the German company, the HMS II.3 Artificial Head, designed for measurement of close to-the-ear transducers (e.g., handsets, headsets, headphones, hearing protectors and hearing aids) is perfectly suited for testing the upcoming generation of VoLTE mobile phones, among many other applications that require super-wideband capabilities.

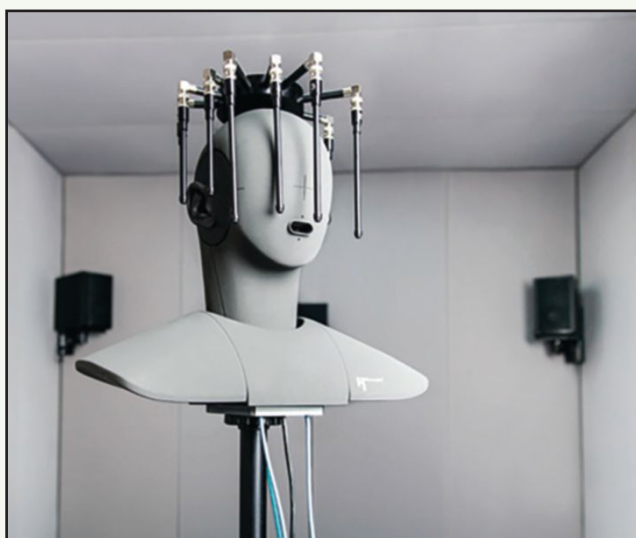
In more and more applications, super-wideband technology plays an increasingly important role: The upcoming generation of VoLTE mobile phones as well as already established voice messenger systems such as Skype or Apple FaceTime support super-wideband. In order to test corresponding terminals accordingly, high-performance measurement equipment is essential. With its HMS II.3, HEAD acoustics provides a high-



quality artificial head measurement system, comprising ear simulator and artificial mouth, which is fully capable for super-wideband testing in sending and receiving direction. In its basic version, the artificial head is equipped with an artificial mouth and with an impedance simulator in the right ear—optionally also the left ear can be equipped with an ear simulator. The HMS II.3 complies with all relevant international standards.

The artificial mouth of the HMS II.3 transmits real speech equalized at least up to almost 20 kHz. Considering the frequency range of real speech signals, the mouth of the artificial head measurement system is able to play back the complete spectrum of human voice for all relevant levels with low distortion. This is a main feature to enable super-wideband measurements in sending direction. With the help of the communication quality analysis system ACQUA, the artificial mouth can be comfortably equalized via a digital FIR filter which is tuned by an automated and fast equalization process. HMS II.3 also enables its users to carry out measurements of far to-the-ear transducers such as hands-free equipment.

**HEAD acoustics, GmbH**  
[www.head-acoustics.de](http://www.head-acoustics.de)



Combined with an eight-loudspeaker configuration, HEAD acoustics' 3PASS solution—with the MSA I microphone array and the HMS II.3 artificial head—is able to reproduce and measure the essential spatial characteristics of background noise, which makes the system valuable for the development of complex background noise reduction algorithms.

## Measuring Microspeakers, Headphone Transducers, and Headsets

As a renowned company dedicated to loudspeaker testing, diagnostics, and control, KLIPPEL provides a complete tool chain for measuring and testing headphones, earphones, and headsets on system, transducer, and component levels. Fast and comprehensive system level tests are widely covered by the KLIPPEL QC System dedicated to end-of-line testing. For the R&D engineer, the KLIPPEL R&D System provides all necessary tools to evaluate and optimize headphone transducer design choices related to material and component properties, vibration patterns, break up modes, rocking mode analysis based on the Scanning System, sound radiation, distortion, and rub and buzz diagnostics as well as linear and nonlinear parameters. The measurement capabilities are enhanced by powerful simulation and auralization tools.

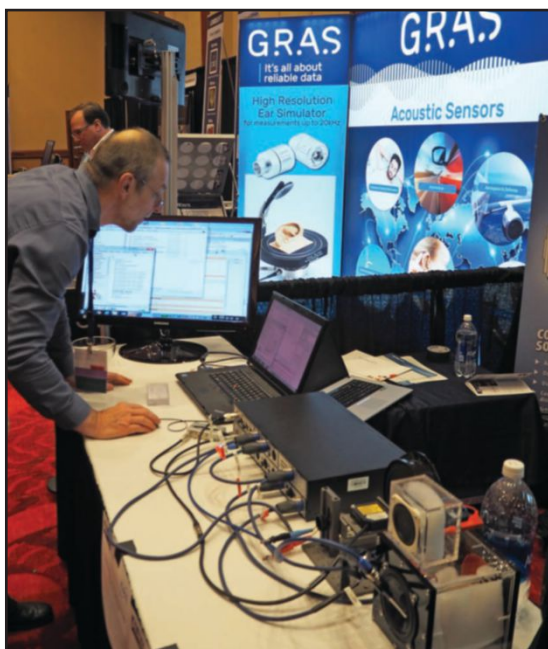
The KLIPPEL QC Standard System satisfies the particular demands of headphone testing at the end of the assembly line, in routine tests used in pilot runs preparing for manufacturing and for incoming goods inspection. Both, the final headphone as well as the transducer benefit from the high-speed acoustical test.

The test hardware setup may be selected according to the particular needs. Both, the KLIPPEL Production

Analyzer as well as the new, modular KA3—KLIPPEL Analyzer System measurement hardware with an integrated amplifier module provide optimal performance and flexibility. Cost-efficient custom solutions for acoustical testing can be realized using any third-party audio interface. This flexibility enables testing the complete range of headphones including passive, active, digital, and wireless (e.g., Bluetooth).

The SYN add-on ensures sample-accurate synchronization coping with asynchronous playback and varying sample rates of wireless and digital devices. For transducers and passive headphones, electrical tests provide valuable information (e.g., impedance magnitude, T-S parameters, or even nonlinear parameters such as voice coil offset or suspension asymmetry using the dedicated KLIPPEL Analyzer hardware). The QC System focuses on dynamic headphones and other transduction principles can be tested. The Balanced Armature Check is a unique tool to measure the armature offset as the main root cause of distortion in balanced armature transducers within extremely short time.

Based on this comprehensive range of software and hardware modules, KLIPPEL provides turnkey test solutions including pre-tested



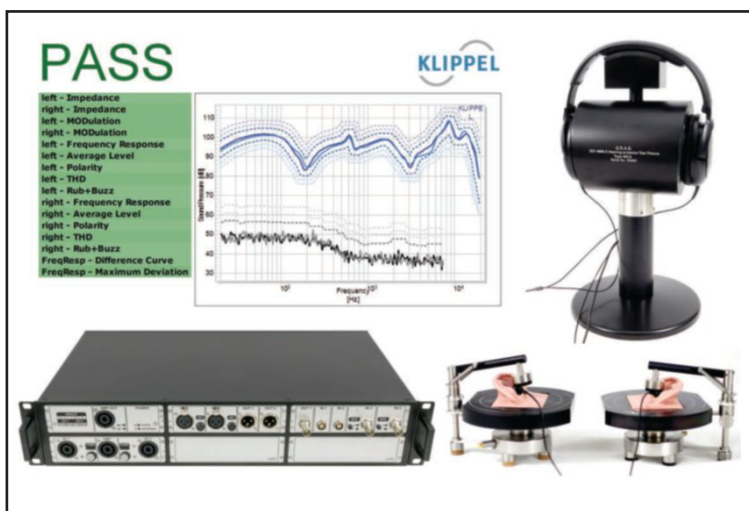
The new KLIPPEL software was on display at the 2018 AISE.

microphones as well as headphone test jigs, couplers, and artificial ears and mouths by G.R.A.S. Sound & Vibration.

**KLIPPEL GmbH**  
[www.klippel.de](http://www.klippel.de)

**Warkwyn (KLIPPEL's US representative)**  
[www.warkwyn.com](http://www.warkwyn.com)

Fast end-of-line testing of headphone and earphones can be conducted with KLIPPEL QC and G.R.A.S. headphone test equipment. (Image courtesy of KLIPPEL)



## Acoustic Couplers and Ear Simulators

Renowned for its extensive test and measurement microphone range, Larson Davis now offers a full range of artificial ear couplers. The AEC100 Coupler is a rugged artificial ear for testing supra-aural earphones designed primarily for 1" microphones and the calibration/testing of supra-aural earphones used in audiometry. It enables accurate and repeatable measurements within its frequency response (up to 8 kHz). It may also be used for production testing where correlation between the coupler and real ear response is not a requisite.

AEC201-A is a new wideband ear simulator for testing a variety of earphones using the latest standards and designed to be used with supra-aural and circum-aural earphones at frequencies up to 16,000 Hz. Its design meets the requirements of IEC 60318-1:2009 Edition 2 and ANSI S3.7 section 5.4 which make it compatible with earphones (e.g., the TDH 39, the TDH 49, the TDH 50, the HDA200, and the Koss HV/1A). The AEC201-A is supplied with the 377B13 microphone and a Type 1 adapter plate.

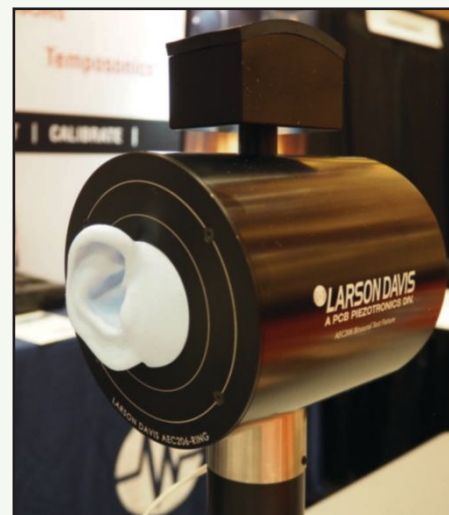
The optional AEC201-2 is a Type 2 adapter plate for testing earphones such as Koss HV/1A. Weights, accessories, and the AEC201-A are all packaged in a durable weather-tight case.

AMC493B Artificial Mastoid is an innovative transducer for bone vibrator testing used to calibrate bone conduction hearing aids and audiometer bone vibrators. The AMC493B is cost effective and simple to use and its patented design converts the vibrator force output to an acoustic signal measured with the system's sound level meter. It is used with the AEC100 coupler or the AEC201-A Ear Simulator to perform bone vibrator tests.

The AEC202 2 cc Coupler for 0.5" microphone is used for insert-type hearing aids and earphones (IEC 60126, IEC 60318-5, and ANSI S3.7). The AEC203 2 cc Coupler for 1" microphone used for insert-type hearing aids and earphones (IEC60126, IEC60318-5, and ANSI S3.7 2 cc). The AEC304 Occluded-Ear Simulator is used for the measurement of earphones coupled to the ear by ear inserts (IEC 60318-4 and IEC 60711:1981) and includes a 0.5" 12.5 mV/Pa matched microphone.

The Larson Davis Model AEC206 Binaural Test Fixture is the tool for testing supra-aural, circum-aural, supra-concha, intra-concha, and insert-type headphones. Preassembled with IEC 60318-4 (711) occluded-ear simulators and TEDS-compatible preamplifiers that provide electronic calibration information, the Model AEC206 is user-friendly and easy to learn. Additionally, calibration is a simple process—a custom adapter is included for the Model CAL250 acoustic calibrator or similar device.

Whether performing quality assurance testing of headphones on an assembly line or using it in the lab for R&D, Model AEC206 ships pre-assembled and ready-to-use in a rugged case with IEC 60318-4 (711) occluded ear simulators with microphones, ICP (IEPE) preamplifiers with TEDS, and four pinnae (two left and two right).



This is the new Larson Davis Model AEC206 Binaural Test Fixture.



Larson Davis/PCB AEC304 Occluded-Ear Simulator is used to measure earphones coupled to the ear by ear inserts.

**Larson Davis Division**  
**PCB Piezotronics, Inc.**  
[www.larsondavis.com](http://www.larsondavis.com)



## Powering Headphone Test Systems

Listen, Inc.'s SoundCheck offers simple, fast, and accurate testing of any headphone or headset—no matter what the form factor, functionality, connector, or additional features. It measures a full range of driver parameters via traditional analog, Bluetooth, lightning or USB connections, as well as microphone performance, active noise cancellation (ANC), and more. Measurements include frequency response, phase, distortion, Rub & Buzz, polarity, impedance, sensitivity, Left/Right earphone tracking, maximum SPL to EN-50332, diffuse or free-field corrected responses (IEC 268-7, IEC 581-10, and other target curves), ANC, and passive attenuation.

SoundCheck's modular combination of hardware and software is cost-effective, flexible, and expandable. At the heart of the system is the SoundCheck software. Powerful, fast, and accurate, it measures every audio parameter from the R&D laboratory to the production line. Complete flexibility in stimulus choice enables any test signal (even music) to be used. Virtual instruments offer the functionality of stand-alone hardware. Advanced analysis and powerful post-processing options allow all types of analysis and mathematical operations—for example, placing the stimulus on the device and using a triggered recording to test headphones with proprietary connectors (e.g., Lightning connector), or the application of any target curve to a headphone response.

Display options range from comprehensive Microsoft Word or Excel reports to simple pass/fail output or writing to a database. Repeatable, automated tests are quickly and easily created, modified, and saved using the simple point-and-click interface. Several fully editable sample headphone sequences are provided, and more complex sequences are available for specific test standards (e.g., IEC 60268-7 and EN-50332).

Listen also offers a range of its own and third-party hardware for both R&D and production headphone testing, including audio interfaces, a microphone (or a HATS, a coupler, etc.), and appropriate power supplies and amplifiers. Listen's headphone test hardware includes AudioConnect, compact audio interface with built in headphone amplifier and a power supply for up to two SCM microphones; AmpConnect, an all-in-one hardware interface that includes an audio interface, headphone amplifier, power for



Listen currently offers complete software routines for headphone measurements, with a large selection of stimuli, analysis, and post-processing options, as well as a range of interfaces for Bluetooth testing, open-loop testing, and more.

up to two SCM or IEPE microphones (for use with couplers or IEPE-powered HATS) and an amplifier to power a speaker for ANC tests; and SoundConnect 2, a two-channel microphone power supply (SCM, IEPE, or 200 V polarization) ideal for applications where polarization is required, or for switching between acoustic and impedance measurements with a two-channel audio interface.

Listen also offers the BTC-4148 and BQC-4148 Bluetooth interfaces, designed for R&D and production, respectively, offering full control over all Bluetooth protocol settings and explicit control over the CODEC choice and transmitter power. Third-party hardware, including HATS, ear couplers, headphone test fixtures and more can also be used.

## SoundCheck 16 Expands Options

Listen recently announced the release of version 16 of SoundCheck, its flagship audio measurement software. With a consistent schedule of product updates since the original launch in 1995, the new release includes a bundle of new features that expands its capability and simplifies ease of use. A completely redesigned THD+N analysis algorithm is more accurate and significantly faster than other audio test systems, and is compliant with the AES17 standard for measurement of digital audio equipment.

Following the introduction of SoundCheck14 in 2015, when Listen brought its powerful test and measurement platform



In the R&D lab, Listen's SoundCheck is used with a head-and-torso simulator to measure a complete set of loudspeaker parameters such as frequency response, distortion, maximum SPL, and diffuse or free-field corrected responses.



On the production line, SoundCheck offers extremely fast testing, simple pass/failure (with optional failure mode) output, and full integration with footswitches, barcode readers, and other production line automation.

for Mac OS X, as a native 64-bit application, the Boston-based company launched SoundCheck 15 in 2016, expanding its testing capabilities with additional external control, calibration, audio mixing, and hardware integration. SoundCheck 15 also introduced the first in the company's redesigned virtual instruments, the multimeter.

Now, with version 16, SoundCheck's functionality is enhanced with several new optional modules, including a Real Time Distortion Analyzer, Frequency Counter, and Strip Chart Recorder.

The Real Time Distortion Analyzer provides continuous real-time measurement of output distortion including THD and THD+N, THD and THD+N residual level, and SINAD. The Frequency Counter offers an accurate and clear visual indication of frequency, determining the dominant signal in a selected signal path and returning a precise frequency measurement, and the New Strip Chart Recorder enables the multimeter, distortion analyzer, and frequency counter to plot measurements over time—a modern day equivalent of connecting a paper chart recorder to a classic, stand-alone hardware instrument. The multimeter, distortion analyzer, and frequency counter can all save results to the memory list, enabling an instantaneous measurement to be recorded without having to run a sequence, and allowing saved values to be used within sequences.

Listen's completely redesigned THD+N analysis algorithm is compliant with the AES17 standard, and is more accurate and significantly faster. High accuracy is achieved, even with short and/or low-level test signals, through the use of a synthetic notch filter—an extremely precise digital notch filter. A traditional notch filter option is also offered to enable correlation with measurements made on legacy systems. The algorithm also includes high- and low-pass filters for controlling the measurement bandwidth and for filtering noise in electronic measurements.



SoundCheck 16 shows frequency response, distortion, and L/R tracking.

This feature-packed Windows/Mac release includes several new features and algorithms for distortion measurements, a new frequency counter, an optional strip chart recorder that emulates a traditional strip chart, and more. There are also improvements on the usability side, including increased setup automation and control via Python.

SoundCheck 16 now automatically scans for new devices and setting changes when opened, and updates the Hardware Editor, Audio Hardware, and Listen Hardware Tabs. This makes setup much faster. The ability to also manually adjust hardware setup and preserve third-party hardware settings offers flexibility and makes it easier to integrate Listen and third-party hardware. To simplify audio interface setup, sample rates are restricted to the selection valid for that device. If changes are made during a SoundCheck session, a simple "refresh" will scan for changes and update the settings.

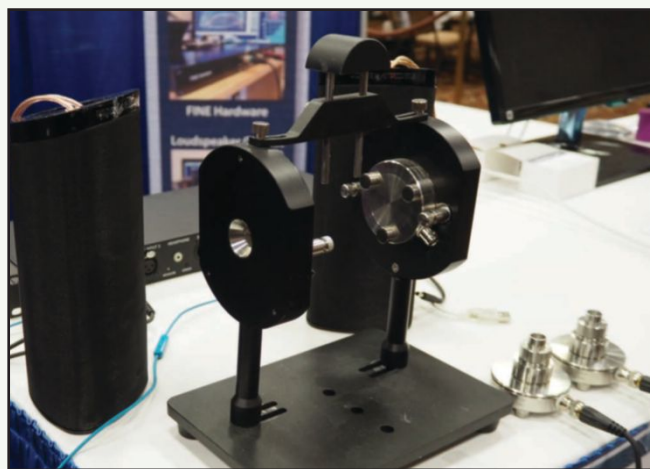
**Listen, Inc.**  
[www.listeninc.com](http://www.listeninc.com)

## Solutions for Lab and End-of-Line Headphone Tests

Peter Larsen's software for loudspeaker design is complemented by LOUDSOFT's FINE QC and FINE R+D acoustic analyzers. The new FINE R+D 2018 version measures sound pressure level (SPL) and impedance up to ~100 kHz with sample rates at 48 kHz, 96 kHz, and 192 kHz. It includes the new intermodulation and difference distortion module. In addition, both low and high current impedance modes as well as Bluetooth are provided.

LOUDSOFT now also supplies the FINE QC/Headphone FAST Production Test system with Left/Right test including the Noise Cancel Test. This intuitive QC test system is specially made for testing headphones and earphones (Lab and End-of-Line Test). Rub & Buzz is measured with limits for Left and Right plus SPL sensitivity and polarity. Bluetooth headphones can be tested using automatic delay. Noise cancelling headphones (passive and active mode) can be fully tested during the test sequence.

FINE QC for Windows 7/8/10 (including 64 bit) measures all drivers and systems using the 19" FINE USB Hardware. It includes FINEBuzz, which fully replaces manual listening



With its systems, LOUDSOFT supplies G.R.A.S. microphones and artificial ears with measurement microphones and CRY Sound solutions for QC control in volume production.



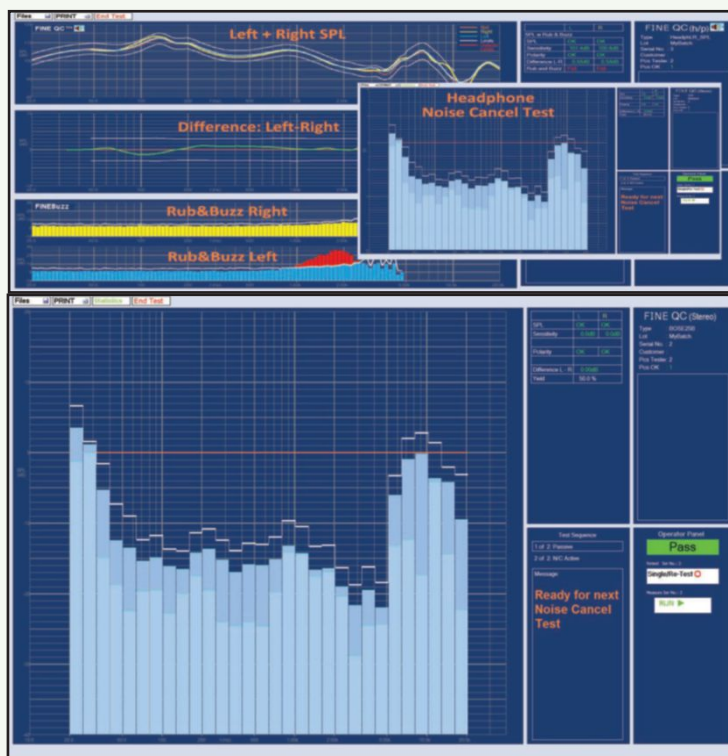
in production. In less than 1 second all Rub & Buzz is measured as well as SPL, sensitivity, and polarity. The Rub & Buzz is easily set by measuring some good and bad units. Bluetooth units can be tested using automatic delay as well as reading the barcode/serial number.

With its systems, LOUDSOFT supplies the world renowned G.R.A.S. microphones and artificial ears. The G.R.A.S. 46BE free-field 1/4" precision measurement microphone directly connects to FINE R+D/FINE QC without using a separate microphone preamplifier.

The high-quality Danish FL1-calibrated microphone completes the FINE QC package, with a gold-plated diaphragm and a double-vent protection system to ensure durability in production environments. For cost-effective Headphone QC tests in larger scale production, LOUDSOFT recommends the CRY Sound headphone fixture with condenser microphones.

**LOUDSOFT, Ltd.**  
[www.loudsoft.com](http://www.loudsoft.com)

LOUDSOFT software for headphone testing includes cost-effective solutions for headphone QC tests in larger scale production.



## Earphone Audio Response System (EARS)

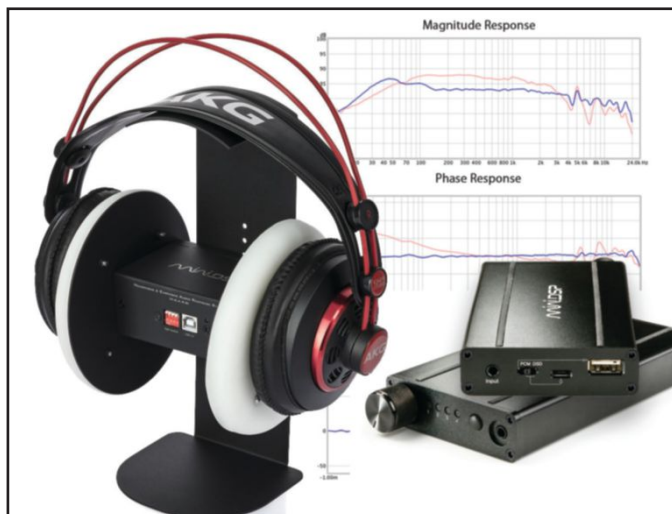
miniDSP offers a product line of respectable “prosumer” test gear for loudspeaker and room analyzers and has just introduced its Earphone Audio Response System (EARS) calibrated test jig for headphone measurements. While the headphone world is well-served by existing vendors, no one is going to toss their precision instrumentation 711 couples for this stuff. Yet, miniDSP’s entry is quite interesting as the price is \$179 US!

EARS is a calibrated test jig for headphone measurements. There are endless uses where this product will come in handy and the industry will eat these like candies. Featuring dual low-noise calibrated mics with interchangeable silicon ears and the new miniDSP HA-DSP DSP headphone amplifier, end users have an accurate way to tune headphones. The EARS are powered from the

USB interface so there is no need for an external power supply.

To measure headphones, users just need to mount their headphones on the rig and run a measurement sweep using their headphone amp and a measurement program (e.g., miniDSP’s Room EQ Wizard). With each EARS, miniDSP supplies two calibration files (one for large headphones and one for in-ear monitoring) that correct for the response of the microphone capsule and the ear. The EARS system is a simple USB Audio Class 1.0 device that doesn’t require any interface to be connected with Windows, Mac, or Linux computers, allowing the use of any measurement software.

A full review of miniDSP’s EARS will be published by *audioXpress* in a future edition.



With each EARS, miniDSP supplies two calibration files—one for large headphones and one for in-ear monitors (IEMs)—that correct for the response of the microphone capsule and the ear.



miniDSP surprised the market with its Earphone Audio Response System (EARS) calibrated test jig for headphone measurements.

**miniDSP**  
[www.minidsp.com](http://www.minidsp.com)

## ANC Specialists Expand Headphone Test Options

SoundChip may not have a high profile in headphone test instrumentation, but the firm is an international leader in system-level solutions for ANC. Its unique circuit topology implements the seamless digital control of analog circuitry delivering class-leading performance while minimizing audio quality degradation. SoundChip collaborates with ANC chip manufacturers, as well as offers headphone designers advanced computer-aided engineering (CAE) tools, to automate production line testing and calibration. SoundChip has achieved design wins with Philips, Bowers & Wilkins, and Panasonic, among other large and small audio brands and Tier 1 handset OEMs.

SoundChip's Soundstation Engineer is a design tool for tuning active noise cancelling headsets, which implements the company's patented, digitally programmable Soundcore electronic platform.

Comprising proprietary design software and a development board, this solution overcomes the time-consuming task of tuning a headset's noise cancelling and audio compensation filters. Using Soundstation Engineer, filter parameters are tuned "point-and-click" using the mouse. Selected tunings are automatically synchronized with the Soundcore-enabled silicon on a development board, which is also connected to the headset-in-design. The user may listen to or measure the performance of their tuning in real time, which enables a more efficient tuning process without the errors and frustration associated with replacing discrete filter components.

Soundstation Production is an application-specific, turnkey test, calibration and programming solution, comprising HATS, custom hardware, test software, and cloud-based data analysis tools. The solution accurately captures the electroacoustic DNA of headset-under-test (HUT) using high-precision MEMS-based ear simulators. User defined test scripts operate on the captured test dataset to calibrate, screen and program the headset's noise cancelling and audio compensation filters—whether Soundcore-based or other supported silicon.

The recently introduced Soundstation Production 2 next-generation test system automates the test through programming process for smart hybrid noise cancelling headsets in under 30 seconds with the HUT placed on a product-specific coupling plate of the production-HATS to achieve more reliable and repeatable measurements than using lab HATS-based systems. By combining advanced measurement techniques with powerful algorithms, tailored for each product, Soundstation Production can identify the root cause of failure for any NG headset and report this to the operator following each test—this streamlines repair and drives second-pass yield to near 100%.

To complement Soundstation Production, SoundChip offers access to Soundstation Mission Control—a cloud-based software application and Big Data repository that securely stores, analyzes, and generates reports using measurement data captured by the company's Soundstation Production test and calibration equipment. Mission Control provides remote access to raw measurement data, production metrics and product screening results, to help domain experts identify and analyze batch-rated issues. This extra layer of information helps to maintain production line stability and drive yields higher. Mission Control can also be used to collate bespoke reports for production and acoustic engineers, line managers, and business owners.

**SoundChip**  
[www.soundchip.ch](http://www.soundchip.ch)



This is SoundChip's head-and-torso simulator.

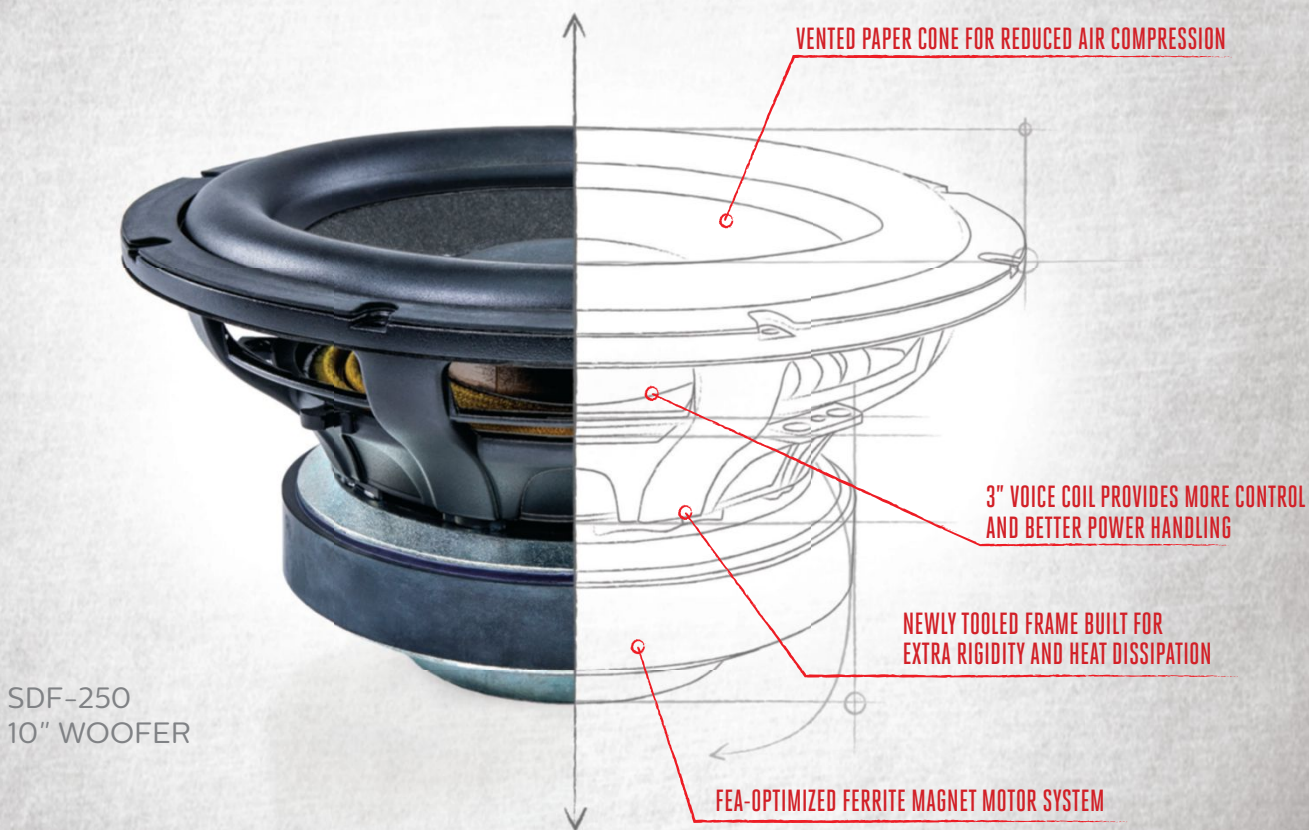


SoundChip continues to expand headphone measurement options, including production solutions with its Soundstation Production range.





# DEFINING NEW STANDARDS



SDF-250  
10" WOOFER

**SINCE  
1926,**

Peerless has continued to push the boundaries of what's possible in acoustics, material science, and design. Here's a look at some of our most recent developments.



**STW**

188mm Voice Coil for More Bass in  
Smaller Enclosures



**DA**

High-Performance  
Corundum-Dome Tweeters



**PMT**

Bigger Sound from  
a Small Footprint



**NCP**

More Power Handling for  
Professional Systems

To see more, visit **[TYMPHANY.COM/PEERLESS](https://www.tymphany.com/peerless)**

Peerless and Tymphany are registered trademarks of Tymphany HK Limited. © 2017 Tymphany



# Audio Precision AECM206 Headphone Test Fixture

## Putting Headphones to the Test

HEADPHONE FOCUS



The AECM206 Headphone Test Fixture is a dense, robust fixture mounted on a resilient base to isolate ambient noise, which can adversely affect measurement integrity. Audio Precision claims the AECM206 is equally capable in both R&D and production test applications and well-suited for testing circum-aural, supra-aural, and intra-concha headphones and earbuds. After receiving the test fixture, Stuart Yaniger put the unit through a series of tests. His primary regret was that he didn't have more time with it.

By  
**Stuart Yaniger**

(United States)

Photos by Cynthia Wenslow

Of all audio electroacoustic measurements, the most difficult and least certain is the measurement of headphones. There's great controversy over frequency response targets and how they should be measured. One attempt at standardization is the common International Electrotechnical Commission (IEC) 60318, which only covers the range up to 8 kHz. IEC 60711 covers up to 10 kHz, but is oriented to in-ear (insert) headphones, and additionally, the fixtures compliant to that

standard have the disadvantage of a built-in frequency response peak at 13.5 kHz. The point is that because of the interactions between transducer, pinnae, and ear canal, and the details of the acoustic space defined by the ear and the headphone, the notion of "frequency response" becomes a bit more complex than is the case for electronics and even loudspeakers. There's certainly several schools of thought on what the target functions should be and how they should



be measured. The former is beyond the scope of this article, but the latter is pertinent.

A couple years back, Mike Klasco (president of Menlo Scientific) did a great overview of the measurement standards in the context of reviewing the GRAS 43BB ear simulator, which has become popular in the industry. He also covered more sophisticated solutions such as the KEMAR head-and-torso simulator (see Resources). This is required reading for a good overview of the subject area and included a very comprehensive bibliography. So I'll not rehash this other than in occasional summary points.

Likewise, Audio Precision published an applications note (see Resources) that also surveyed the field nicely and shows the sort of measurements that you can get using the AECM206 test fixture reviewed here. The AECM206 (see **Photo 1**) contains two microphones (constant current powered) and two acoustic couplers within its 21 lb. mass. It doesn't have the torso shape or the realistic head of something such as the KEMAR, which is important for accurate measurement that takes into account the full head-related transfer function (HRTF), but at approximately \$11,000 base price, it's quite a bit less expensive.

### First Impression

The AECM206 test fixture arrived in a heavy-duty travel case that looked and felt like it would withstand a full-on attack by a horde of enraged monkeys (see **Photo 2**). On opening it, the first thing that struck me was the baby blue molded ears (see **Photo 3**), which made me immediately think of the Sherlock Holmes story, "The Cardboard Box." The ears are provided in two different durometers (hardness)—35 Shore 00 and 25 Shore A—and are pressure-fit into the test fixture when used.

The second thing that I noticed was the mass and solidity of the test fixture. It feels heavy and (acoustically) dead. There are two thin 1.5 m long PTFE coaxial cables attached to the internal mics and electronics, and the cables are terminated with standard BNC plugs. The mics are TEDs-compliant. When I attached them to the Audio Precision AP1701x acoustic interface, the calibration data was automatically sent to the APx515 test system. This was the first time I've had both TEDs-compliant mics and the AP1700x at the same time, and I have to say that this method of acquiring calibration data is slick!

One slight annoyance was that the black protective foam in which everything was packed was crumbly, and the ears (which have a bit of a tacky surface) had to be cleaned before use.



Photo 1: The AECM206 is a massive solid fixture the width of an average head and containing two microphones.



Photo 2: The test fixture and accessories arrived in a rugged foam-lined case, which survived the rigors of shipping.



Photo 3: The system includes two sets of molded ears with different stiffness.

## Test Setup

I placed the AECM206 on my test bench next to the AP1701x and the APx515. Connection and set up took only seconds and was incredibly convenient due to the TEDs system mentioned earlier. The only downside here is that the fan noise from the AP1701x could interfere with low level measurements. For very low noise floors, one would need to make long extension cables to the AECM206 microphones in order to increase

the distance to the measurement system. Other than that, set up was totally uneventful, which is how I like it.

Out of necessity, this review is a bit limited—I only had the AECM206 for a couple of weeks, and there were a few hundred more things I wanted to do with it... That said, I had three sets of headphones available for basic measurements during the test period: intra-concha Apple EarPods that came with my iPhone, supra-aural Sony MDRZX110NC noise-canceling headphones, and Superlux HD681 circum-aural headphones.

## Measurements

Audio Precision was nice enough to include in the package a Larson Davis CAL250 SPL calibrator, which is placed on the test fixture surface (minus the ears), and generates a 250 Hz signal at 114 dB SPL. This allowed me to check the mic calibrations, which were dead-on.

Typically, I measure microphone noise floors using my improvised BLANK chamber, that is, wrapping the microphone in a plastic bag and duct tape for protection, and then burying it in about 100 lb. of a mixture of sand and cat litter. Unfortunately, the size and geometry of the AECM206 precluded this method. However, since I am familiar with the microphone elements and electronics used in this test fixture, I can estimate the noise floor as being under 25 dB SPL with a 20 kHz bandwidth and A-weighting.

After inserting the stiffer ears, I ran some basic repeatability and frequency response checks. I conducted all frequency response measurements with a 300 ms logarithmic sweep (Farina chirp method). With the stiffer ears inserted, I ran a series of measurements on the Sony supra-aural headphones by placing them in the fixture, running a frequency response measurement, removing the headphones, replacing them, and running another measurement.

A plot of two sequential measurements is shown in **Figure 1**. The repeatability is pretty poor and certainly dominated by the details of physical positioning of the headphones and the degree to which the artificial ears' compliance interacts with the headphone pressure. Indeed, a headphone user will almost unconsciously adjust the headphone position on his or her head until it "feels" right—a sort of tactile feedback system that can't be achieved with a test fixture. The bottom line is that to get meaningful frequency response curves, multiple measurements must be taken and averaged. Audio Precision recommends a minimum of five repetitions, which seems reasonable.

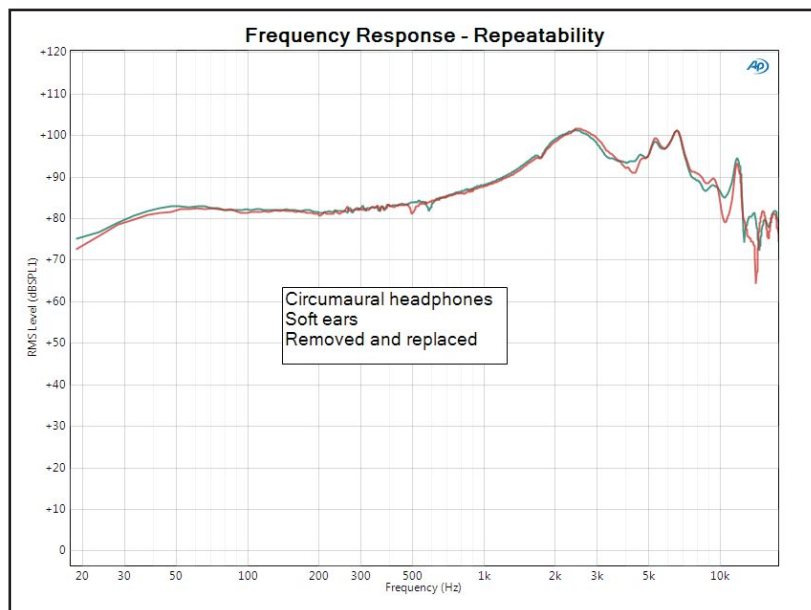


Figure 1: Removing and replacing headphones will cause variations in frequency response. It's recommended to take at least five averages.

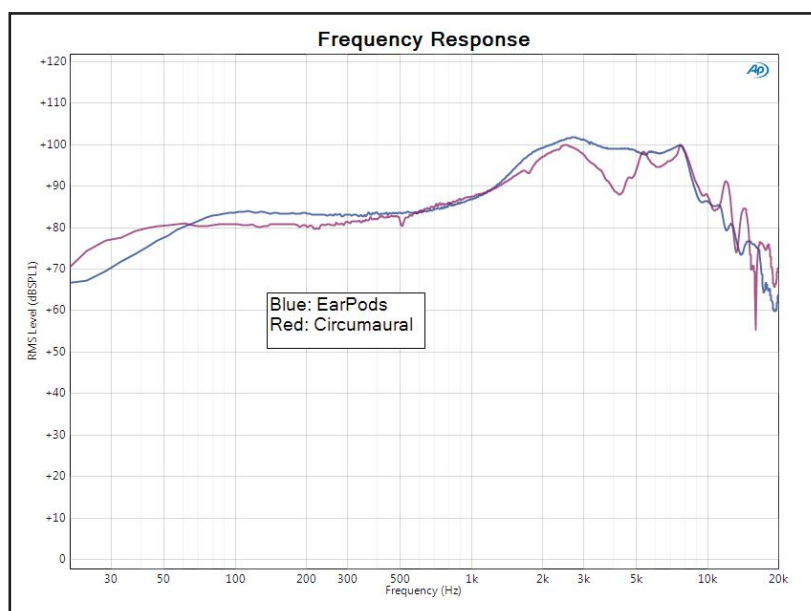


Figure 2: The comparison of the frequency response of the Apple EarPods and the circumaural headphones shows the expected differences in the bass response.



**Figure 2** shows the frequency response of the Apple EarPods versus the Superlux headphones. As one might guess, the Superlux circum-aural headphones show a much smoother and deeper bass response, very much in accord with my subjective perception. Acquiring these data was rapid and uneventful, which is a compliment! Interpretation of headphone response curves above the bass region is controversial, and of course, this response will vary from person to person.

A few years ago, *audioXpress* Technical Editor Jan Didden and I were experimenting with an interesting device, an early version of the Smyth Realiser, which used psychoacoustic processing to cause the headphone image to appear to be emanating from a stereo pair of loudspeakers used in calibration and setup. Part of the calibration process was to measure response of the cavity formed by the headphones and the user's pinnae. The device gave a remarkable illusion, but one interesting aspect was when Didden and I traded calibration curves (I used his calibration and he used mine, taken at the same spot with the same loudspeakers, but different pinnae)—the spectral balance of the sound was totally different and the localization illusion was destroyed. Clearly, ear shape is critical for frequency response!

Along that line of thought, one might ask what the effects of the ears are on the acoustical space. The provided ears are standardized to ITU-T P.57:2009, so they match exactly one pair of ears on Earth. Nonetheless, standardization at least provides a means of comparing data across experiments and facilities. **Figure 3** shows the frequency responses of the Sony supra-aural headphones with the harder ears in place and removed. The differences are massive, which is not a great surprise. However, it is nice to see this quantified, and certainly suggests that we can get a good sense of how frequency responses vary from person to person with a bit of work casting ear replicas.

Another use for the AECM206 that suggested itself was quantifying the noise-cancellation feature offered in many headphones. The Sony supra-aural phones I had on hand had this option, which I often use when traveling by air. Sony's claim is that the noise cancelling is 95% effective. Though the change in noise background and sound was quite noticeable with this feature switched on, my subjective impression was that the noise reduction wasn't nearly that high. Objective data would be nice to have, so I took the opportunity.

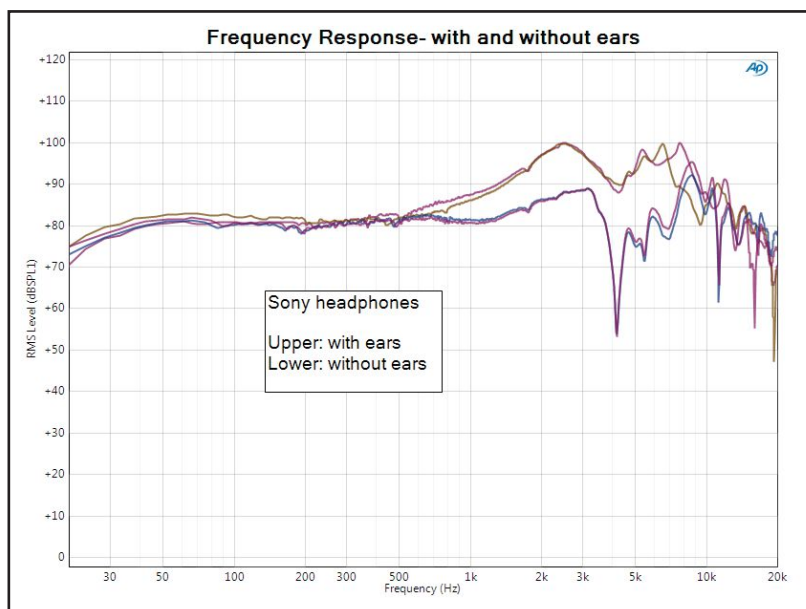


Figure 3: The effect of the artificial pinnae on the frequency response is quite large; different shaped pinnae will also cause changes in the response.

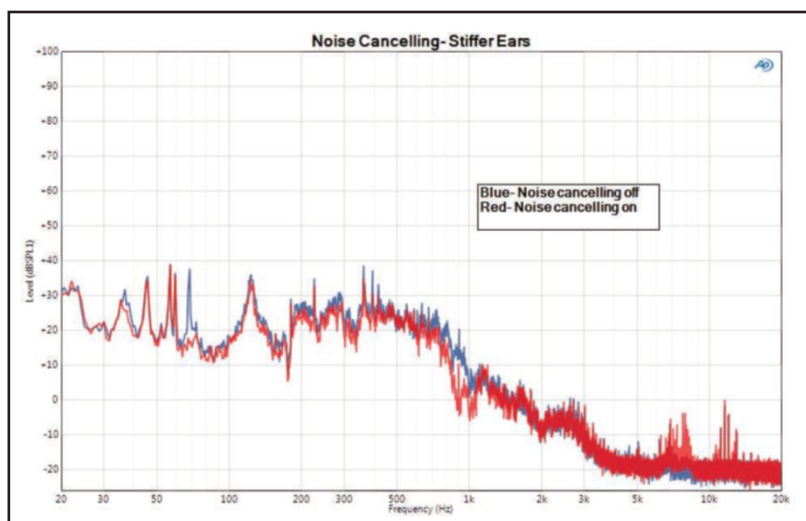


Figure 4: Using the stiffer pinnae, there was insufficient compliance to prevent enough acoustic leakage from nullifying the noise cancelling effect.

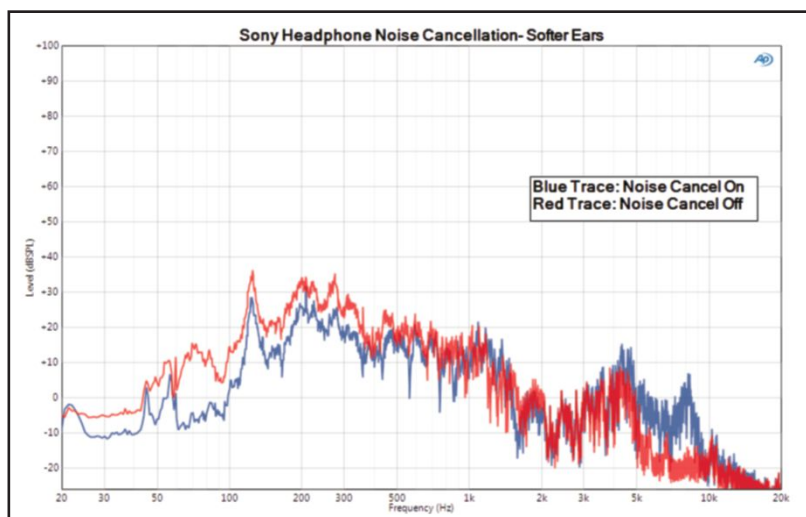


Figure 5: The softer pinnae allowed the noise cancellation function to work properly.



Photo 4: To test the noise cancellation of headphones, I set up a loudspeaker near the AECM206 on my test bench.

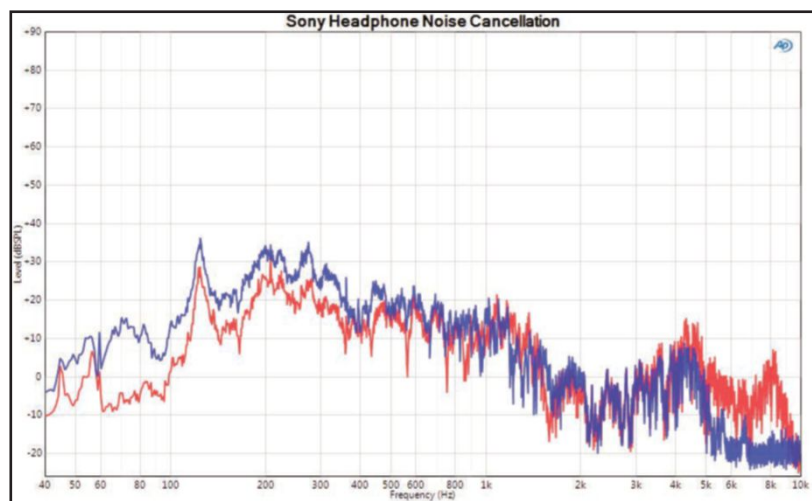


Figure 6: Impinging pink noise shows a similar degree of noise cancellation.

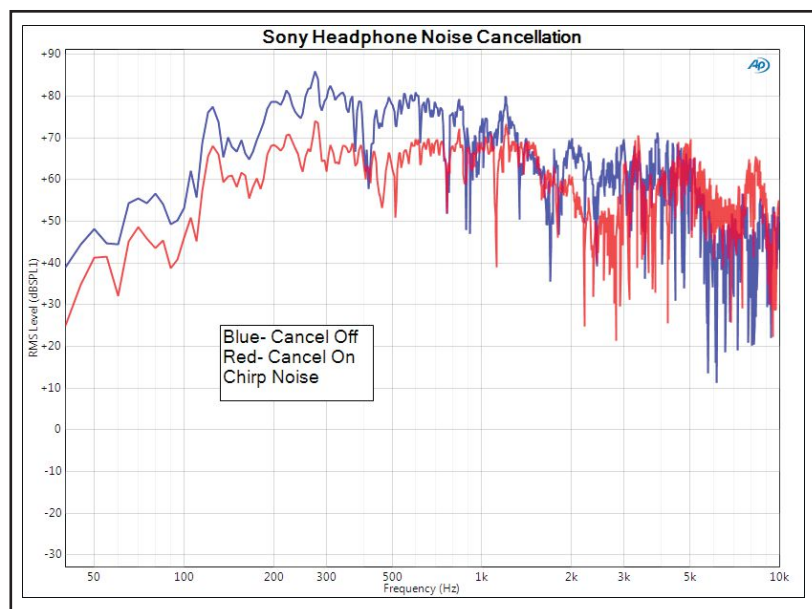


Figure 7: Using a chirp signal, the degree of noise cancellation at different frequencies can be quantitatively determined.

My first attempt, using the stiffer ears, was not terribly successful (see **Figure 4**). The measured noise cancellation is insignificant, which suggested an experimental problem. I noticed that the headphones were resting on the artificial pinnae without significantly compressing them. On my head, my pinnae were definitely pinned back, so I attributed the lack of noise cancelling to acoustic leakage due to the resulting poor seal. Substituting the softer ears, I obtained the results shown in **Figure 5**, which seemed much closer to my subjective impression. The effect of the noise cancelling was most pronounced at lower frequencies and was on the order of 5 to 10 dB. Interestingly, the noise cancelling feature added a bit of noise in the 5 to 10 kHz range, which reflected itself in a subjective impression of a more forward sound. I would like to explore this further at some point in the future.

Once I had the ear issue sorted out, I thought it would be interesting to try a few different external acoustic stimuli to see how the noise cancellation operated. **Photo 4** shows the test setup I used. I set up a Vanatoo Transparent Zero loudspeaker about a meter away from the AECM206 and blasted away with different sounds. **Figure 6** shows the effects of noise cancellation with about 80 dB of pink noise impinging on the headphones. As before, the main reduction is at lower frequencies, and there's a bit of an increase in noise in the treble region.

I also tried a swept frequency acoustic stimulus. **Figure 7** shows the response of the noise cancelling with a 20 Hz–20 kHz 300 ms chirp. Again, it's evident that the noise cancellation is most effective at lower frequencies and that there's an increase in noise in the treble range. If I had more time with the AECM206, I would have tried some other signals and also varied the angle between the loudspeaker and the headphones. Perhaps if I can get my hands on this test fixture again...

## Headphone Accessory Measurements

As another example of the usefulness of the AECM206, I conducted some measurements on a headphone accessory, the REVx REV33 accessory, which is a unit inserted between the headphone amplifier and the headphones that is supposed to reduce distortion, increase signal to noise, and reduce listening fatigue. In some simple electrical modeling and measurement work (posted on my website, see Resources), I found that the device had a transfer function resembling a low-pass filter. The AECM206 gave me an opportunity



# Testing Headphones?



*Check out the  
AECM206 Headphone Test Fixture*

**Audio**   
**precision**

[www.ap.com](http://www.ap.com)

to confirm its operation with actual acoustic measurements on headphones.

For these measurements, I used the circum-aural Superlux headphones, since their impedance curve matched that of the headphones with which I originally tested the REV33. The softer ears were fitted to the test fixture for this series of measurements. **Figure 8** shows the frequency response of the headphones with the REV33 inserted, normalized to the frequency response without the REV33. Satisfyingly, the

frequency response matches fairly well with the frequency response I obtained with pure electrical measurement, that is, the device acts as a fourth-order low-pass filter with a corner frequency of about 10 kHz.

One thing I could not do electrically was to measure the effect of the accessory on acoustic distortion. The AECM206 allowed me to do this, and the results are shown in **Figure 9**. These were taken at an SPL of 85 dB at 1 kHz. As the data show, the effect on distortion is minimal.

## Nit Picking

I can always find the dark lining in any silver cloud, and in this case, it's the molded silicone ears. As I mentioned, the higher durometer ears didn't work well with supra-aural headphones, refusing to bend back in the manner of human ears. The soft ones bent back, but also compressed in a rather unnatural way. Both had the issue of positional repeatability. When you remove and replace them from the fixture, they have to be oriented by eye, and the angle from vertical may not match perfectly from left to right and from setup to setup.

The second issue is an easy fix. Each molded ear has a small parting line where the mold is opened after casting. This line is close to the top of the ear. If a fiducial mark were added to the concentric circles in the test fixture, this would give a reference point so that the parting lines and fiducial marks can be aligned on both sides.

The first issue is a bit tougher, and is common to all headphone test fixtures I'm aware of. But what I think would be a solution for a better human ear simulation is practical, if not quite as easy as adding a reference mark. Feel your ear. If you're a normal human, you'll notice that it is not constant hardness in all parts, and most of it comprises a stiff cartilage overlaid by soft tissue. So the solution becomes obvious—use a two-part system for the simulated ear, with a stiffer inner layer overlaid by a softer outer layer.

There are at least two easy ways to manufacture this without extensive tooling since this is an item produced in the hundreds, rather than the millions. A 3D printed dual durometer version would work (or a hybrid, with the stiffer frame 3D printed and then placed in the mold for coating with soft silicone), or a stiffer polymer sheet can be die cut, then folded into the correct shape for a frame, which is then inserted into the mold for the softer silicone to surround it as before. The stiff polymer could also be thermoformed, albeit at a higher tooling cost.

Note that my cavil applies to just about every

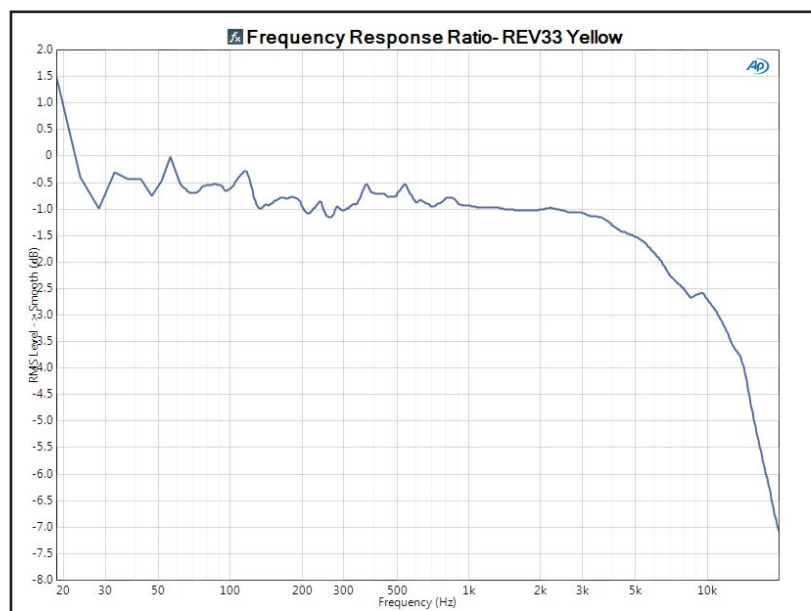


Figure 8: The REV33 headphone accessory acts as a low-pass filter when the acoustic output of the headphone is measured.

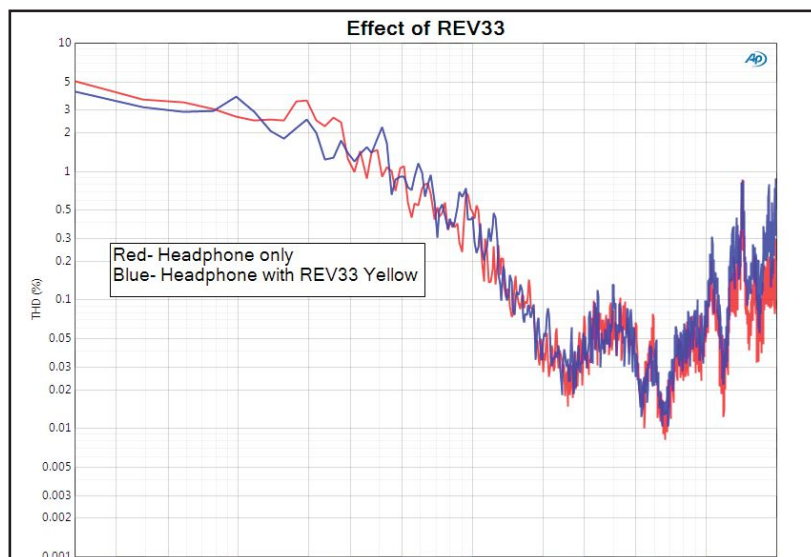


Figure 9: The REV33 headphone accessory has little to no effect on headphone distortion.



test fixture using artificial pinnae, not just Audio Precision's device. At some point, I would like to put my two-part molded ear into practice.

### Overall Opinion

My two weeks with the AECM206 test fixture barely scratched the surface of its capabilities. Besides headphones, I would want to test various items of ear protection to determine their efficacy. This is a particular issue in my day job, where we have great concern about the effect of machine noise on workers' hearing. I'd also want to look at noise cancellation in more detail, as well as the effects of pinnae shapes on frequency responses. It's the sure sign of a useful device when one can come up with more and more questions as answers are obtained. Although it doesn't have the capabilities to be as accurate or repeatable as complete head-torso systems like the G.R.A.S. KEMAR or Bruel & Kjaer's HATS because it will not simulate complete HRTF (most important for measurement of supra-aural and circum-aural headphones), at \$11,000, this is much less expensive than similar alternatives, and is well within the reach of small labs doing

work on headphones, hearing, and safety. I was both grateful for the opportunity to work with it and unhappy with the limited time I had to experiment. 

### About the Author

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

### Resources

"Application Note: Headphone Electroacoustic Measurements," Audio Precision, 2016, [www.ap.com](http://www.ap.com)

Audio Precision, [www.ap.com](http://www.ap.com)

M. Klasco, "Testing Headphones and Earphones: The G.R.A.S. 43BB Low-Noise Ear Simulator," *audioXpress*, March 2016.

"REV33 Headphone Accessories- Measurements Part 1," SYclotron Audio, [www.syclotron.com/rev33-headphone-accessories-measurements-part-1](http://www.syclotron.com/rev33-headphone-accessories-measurements-part-1)

Smyth Research, Ltd., [www.smyth-research.com](http://www.smyth-research.com)

## Measure up to 20 kHz!

High resolution audio is quickly becoming an important market driver in personal audio and traditional testing equipment is no longer ideal for high frequencies. Here's what you can expect with our **High Resolution Ear Simulator**:

- > From 10 to 20 kHz the response is within  $\pm 2.2$  dB
- > The 13.5 kHz resonance dampened by approximately 14 dB
- > Upgraded IEC 60318-4 ear simulator - same form factor
- > Full backwards compatible with standard IEC 60318-4 (711) ear simulator



RA0401 Externally Polarized  
RA0402 Prepolarized

# GRAS

Acoustic Sensors

[www.gras.us](http://www.gras.us)

P: 800.579.GRAS  
E: [sales@gras.us](mailto:sales@gras.us)



# Developing a New Electrostatic Transducer

By  
**Valerio Marra**  
(COMSOL)

Warwick Audio Technologies, Ltd., designed a new type of transducer for high-end electrostatic headphones. The design process for this High-Precision Electrostatic Laminate (HPEL) transducer inspired the team to build a completely optimized system, including electronics. “You cannot have the benefits of one without the other,” says the team.

Serious hi-fi enthusiasts get excited about the musical experience delivered by electrostatic headphones. Producing a natural, airy sound, they provide greater clarity, less distortion, and extended bandwidth when compared to other types of headphones where high-resolution audio sources are involved.

Most electrostatic speakers apply an electric charge on a thin elastic membrane situated between two conductive plates. The charged membrane moves in direct response to the electrical input, generating the sound waves that our ears and brain interpret as music, and moving us to joy and tears.

Despite their high quality and accurate audio reproduction, electrostatic speakers can be prohibitively expensive, sometimes fragile, and until recently, were handmade because of mechanical precision requirements. Seeing a need for affordable, high-quality headphones that could be more easily

manufactured, Warwick Audio Technologies, Ltd. designed the High-Precision Electrostatic Laminate (HPEL) transducer, a patented technology based on an ultra-thin diaphragm and a single conductive plate instead of a pair (see **Photo 1**). With its origins at Warwick University in the UK, Warwick Audio has developed a lightweight laminate only 0.7 mm thick that is perfectly suited for electrostatic headphones.

The new HPELs are lightweight thin-film structures manufactured through a semi-automated lamination process. “The technology we’ve developed is unique,” explains Martin Roberts, Director of Warwick Audio Technologies (WAT) and MD of Sonoma Acoustics. “The HPEL transducer is made up of a metallized polypropylene film, a polymer spacer with hexagonal cells, and a conductive mesh” (see **Photo 2**).

In the typical setup, direct current (DC) bias voltage is applied to the elastic membrane and alternating current (AC) drive signal to the

Photo 1: The Sonoma Model One are the world’s first headphones to use High-Precision Electrostatic Laminate (HPEL) audio transducers.



surrounding plates. Warwick's one-sided speaker involves both the DC bias and the AC drive signal applied to the elastic membrane, with a single wire mesh (plate) positioned opposite the membrane as a ground plane. The fabrication method makes it possible to reproduce the transducers at a significantly lower cost than traditional electrostatic speakers. This means that for the first time, electrostatics may be considered a commercially viable high-resolution audio option across a wide range of device types and market segments.

### Simulating Acoustic Playback

To develop a transducer like this, which can be easily manufactured and inexpensive without compromising sound quality, the Warwick Audio team thoroughly investigated the influence of many design elements before settling on a final version. "We had developed numerous prototypes that clearly performed. The big issue was that we were not entirely sure how varying individual material and design parameters affected the transducer's performance," Roberts says.

The dynamics of the HPEL are dependent on the extremely complex interplay between membrane tension, AC signal level, speaker geometry, elastic and dielectric material properties, thermoacoustic losses,

and the added mass effects of the air next to the open side of the membrane. The designers wanted to improve bass performance by reducing low-end roll-off, minimizing distortion, and maximizing the sound pressure level for a given electrical input. But they discovered that small changes to any component greatly affected the acoustic output.

Although Warwick Audio had significant mechanical, electrical, and acoustic expertise, they had no in-house simulation capability to help them understand this interplay. In order to perform a virtual optimization of the HPEL transducer design, they enlisted the help of Xi Engineering, a COMSOL Certified Consultant firm that specializes in computational modeling, design recommendations, and solving noise and vibration problems in machinery and other technology.

Dr. Brett Marmo, technical director of Xi Engineering, oversaw the development of the COMSOL Multiphysics software models they used to analyze the behavior of the HPEL. COMSOL software enabled Xi Engineering to model nonlinear effects that would arise with amendments to the HPEL's asymmetrical design.

"We kept the early model simple, focusing on specifics that influence sound quality. For example, keeping the first harmonic as low as possible to understand the acoustic-structure interaction and

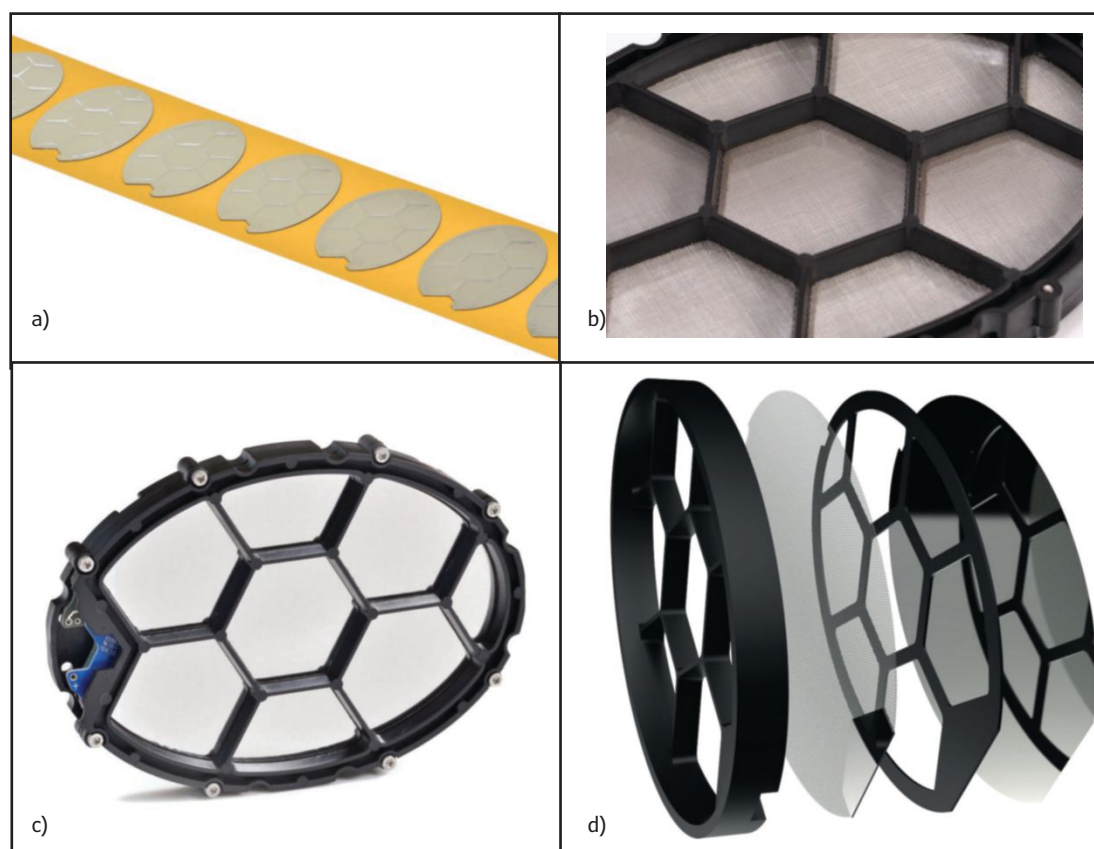


Photo 2: The photos show a strip of Warwick Audio's HPEL transducers (a); the mesh ground plane (b), assembled (c), and exploded views (d) of a finished HPEL transducer. All laminates are made in the UK.

the HPEL's performance at low frequency," Marmo explains, describing their preliminary tests. "Our model showed how applied voltage affects signal levels, which helped us understand sound distortion for an initial case."

Because the transducer is one-sided, the electrostatic force varies with the position of the vibrating membrane, decreasing with the square of the distance between the membrane and the mesh. Once they understood the resulting nonlinear distortion and were able to predict its effects, the Warwick engineers could then electrically cancel any related distortions.

## Perfecting the HPEL Transducer Design

In a more extensive simulation that involved a structural-MEMS-acoustic coupling, he examined the impact of adjusting parameters like the size of the hexagonal cells in the wire mesh, thickness of the wires, membrane tension, spacing between membrane and mesh, and material properties of each component. Marmo and his colleagues also studied the effects of different DC biases, which are often responsible for distortion at low frequencies, and looked at conductivity along the plate to discern whether voltages were higher in one area than another. They then used COMSOL to study the thermoacoustic losses and model the displacement of the membrane for different frequencies (see **Figure 1**).

"We found that this type of simulation was the only accurate way to truly model planar electrostatic transducers," Marmo continues. "For this case, lumped parameter modeling can characterize limited aspects of performance, such as low-frequency amplitude response. One parameter might be excellent but there may be significant

distortion created elsewhere. Multiphysics modeling encompasses all dimensions that affect our perception of sound, such as the time-domain response and nonlinear distortion."

The simulations made it possible for the engineers at Warwick to tweak design parameters in order to optimize overall performance. Ultimately, they were able to predict what was causing spikes in the frequency response and smooth out the signal for better fidelity.

"This represented a huge cost and time benefit for us," says Roberts. "We went from making multiple prototypes by hand each week to simply dialing up a new one in the software. In addition to settling on a final design we're very happy with, it is now easy for us to customize our transducers for clients' individual requirements."

Marmo's team compared each model with physical measurements provided by the Warwick design team. "The simulation results were astoundingly close to the physical measurements," comments Dan Anagnos, CTO at WAT. "That was probably the most exciting aspect, seeing the simulation come to life and knowing it was giving us an accurate picture of how the speaker would perform."

## Freedom and Flexibility with a Simulation App

With simulation results verified and Warwick satisfied with their design, the next step was for Xi Engineering to put Warwick in control of further modeling. The Application Builder available in COMSOL software enabled Marmo's team to build an app from their simulation and host it online.

The app's interface allows users to change certain inputs to test changes to a number of parameters,

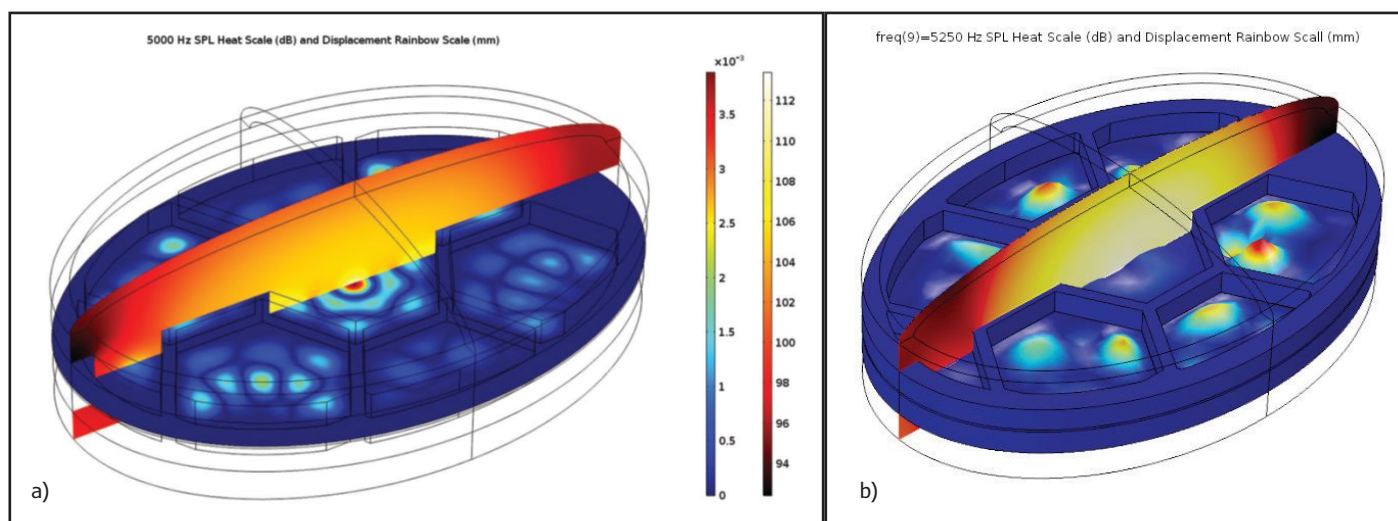


Figure 1: The simulation plot shows the sound pressure level (thermal color surface) in decibels at 5,000 Hz (a) and the displacement of the membrane (rainbow color surface) in millimeters from a fully coupled acoustics-MEMS model solved in the frequency domain at 5,250 Hz (b).



# SONOMA™

Experience the  
award-winning  
**Sonoma™ Model One**  
**Electrostatic**  
**Headphone System**

**TONE**Audio  
PRODUCT OF THE YEAR 2017

"This is one of the most incredible  
personal listening experiences going."

**Jeff Dorgay, TONEAudio**



Join us at:

**AXPONA**  
AUDIO EXPO NORTH AMERICA

**April 13-15 2018**

Room 466, Renaissance Schaumburg  
Hotel & Convention Center



[www.sonomaacoustics.com](http://www.sonomaacoustics.com)

Sonoma™ and its logo are trademarks of Super Audio Center, LLC, Colorado, USA and are used under license.

DISTRIBUTED IN NORTH AMERICA BY BLUEBIRD MUSIC LIMITED ·  
WWW.BLUEBIRDMUSIC.COM · TEL: 416.638.8207

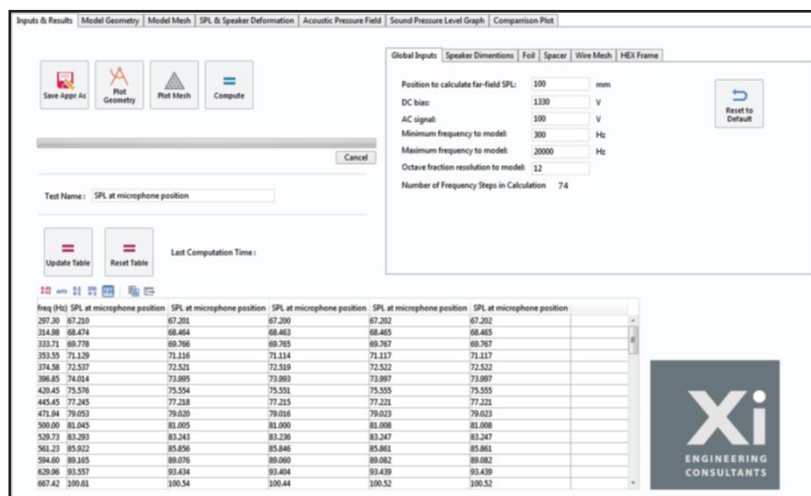


Photo 3. The bottom of the screenshot shows the app developed by Xi Engineering, which allows engineers to vary parameters related to frequency, electrical input, speaker dimensions, and properties of the membrane, spacer, and wire mesh. Results give the sound pressure levels for different cases, membrane displacement, frequency response to different DC biases, and a comparison of the simulated design against experimental results.

## About the Author

Valerio Marra is the marketing director at COMSOL in Burlington, MA. Previous roles include working in applications, technical support, and sales. Valerio received his PhD in fluid machines and energy systems engineering.

such as the DC bias, AC signal level, frequency range and resolution, material properties, speaker size, wire mesh shape and size, and spacer placement (see **Photo 3**). The original model setup is not accessible from the app; instead, it allows users to run further tests without needing to learn the software.

“Providing Warwick with a simulation app removed the need for them to purchase the software or appoint an experienced user,” Marmo says. “Simulation apps put customers in charge, so they don’t have to come back to us for small changes and they can test exactly what they want. It also frees us to explore new challenges, rather than working on variations of the same problem.” Xi Engineering expects to use computational apps more and more in the course of its work for other customers.

Warwick is doing the same, sharing the app with their own customers—companies wanting to find the HPEL transducer best suited to their particular headphone designs.

“The team at Xi Engineering have been superb. They have deep expertise and helped to unpack the complexity of our product,” adds Roberts. “The intuitive app that Xi developed for us is an additional bonus. Without revealing any intellectual property, we can give our own clients access to our design through the app, so they can test and incorporate the technology into their own high-end headphones.”

# Warwick Audio’s HPEL Electrostatic System

HPEL transducers are manufactured exclusively by Warwick Audio Technologies, Ltd. in the United Kingdom. The Warwick HPEL transducer is available to OEMs and ODMs for licensing in a range of headphone and loudspeaker products.

HPEL transducers are manufactured by a bespoke, semi-automated process with finished laminates assembled into HPEL support frames or “cassettes.” This means that customization for individual customer needs is both simple and relatively inexpensive. HPEL transducers can be customized in size (surface area) and be formed in nearly any shape—round, oval, rectangular, etc., including flat or curved. Various internal cell sizes and shapes can be accommodated, and custom mounting frames can be molded to specific requirements, with various electrical termination schemes from their integrated PCBs.

HPEL transducers show a linear performance from the lowest frequencies, around 10 Hz, to the highest frequencies, above 50 kHz, with a surprising wide dynamic range. Dynamic range is not defined

by how loud a system can play, but by how quiet it can play while still resolving very low level detail and information accurately. This translates into resolving ability at the bottom end of the dynamic range, defined by the noise floor and distortion limits. Dynamics also means how quickly a system can go from very quiet levels to very loud levels, and vice versa—the transition



The HPEL audio transducer uses a thin (15  $\mu$ m), flexible laminated film for the “front” grid, affixed to the open (cell) structure of an insulating spacer (made of Formex). A stainless-steel mesh forms the “back” grid. When the audio signal is superimposed on a 1350 V DC bias voltage, the “drum-skins” formed by the flexible “front” grid vibrate, producing sound.



in between must be “lightning-fast” and effortless.

Thanks to its very large diaphragm area without separate suspension components, HPEL transducers also show superior performance in terms of harmonic, intermodulation and transient intermodulation distortion with great time domain fidelity, the result of its 15  $\mu\text{m}$  thick diaphragm with ultra-low moving mass.

## The Electronics

A sound reproduction system is only as good as its weakest link. For this reason, Warwick Audio Technologies has designed HPEL proprietary drive electronics to meet two goals:

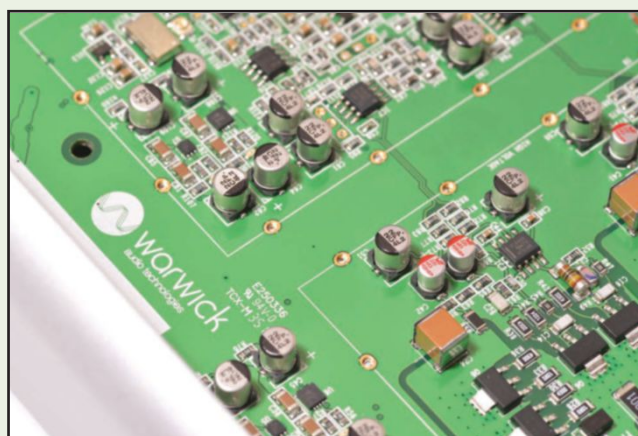
- To reproduce Hi-Res Audio without degradation or compromise—ensuring that the electronic circuitry has superior audio performance in terms of wide bandwidth and dynamic range, low noise and distortion, and requisite time domain fidelity.
- To energize and power the HPEL transducer in the most ideal manner, fully optimized for the reactive load impedance over the entire operating range.

Driving the HPEL transducer effectively requires highly specialized electronic circuitry that will provide a high charge voltage or bias, of 1350 VDC and amplify the audio signal to high voltages—as high as 425 VPEAK—over the full operating range and load impedance variation of the HPEL. The electrostatic drive principal upon which the HPEL transducer is based requires a high DC voltage to be applied to the diaphragm to establish an adequate static charge (aka, “energizing”). This charge forms the basis for the electrostatic force that will move the diaphragm.

The HPEL transducer presents a reactive load impedance that is quite unlike standard electrodynamic and planar magnet transducers. The impedance increases in capacitance as frequency increases, approaching a purely capacitive load at high frequencies (especially above 20 kHz). This means that the AC amplification circuitry must be able to drive very high voltage swings at low frequencies and deliver high current



The first product using Warwick's complete HPEL technology, the Sonoma M1 Headphone System as seen at the High End 2017 show, combined with Merging Technologies' network-connected NADAC for DSD playback.



This is Warwick Audio's HPEL Drive Electronics PCB-A.

at high frequencies. Warwick's circuitry can drive the HPEL transducer with over 145 VRMS without clipping or distorting, even at higher frequencies, where the load approaches a dead short ( $0\ \Omega$ ).

These drive requirements are implemented in best-in-class operational topologies for audio reproduction, and Warwick's HPEL Drive Electronics use discrete transistor output stages and high-quality carefully selected passive components. Designs are available in various configurations to address portable, mobile and low power applications as well as stand-alone, at-home and in-studio use.

An assembled printed circuit board (PCB-A) provides a turn-key solution for ultra-high performance headphones and small form-factor loudspeakers for home use. This PCB combines a discrete FET Class A amplifier with very low distortion and wide bandwidth, custom 64-bit, double-precision, fixed-point DSP, with all incoming analog signals converted to digital ahead of the DSP from a multi-channel 32-bit/384 kHz AKM Premium ADC, which delivers a measured signal-to-noise ratio (SNR) in excess of 120 dB.

To guarantee the highest performance regardless of the input signal format, the design uses an ultra-low phase noise oscillator from Crystek, operating at 100 MHz and the output analog signals are converted using two ESS Sabre 32-bit Reference DAC chips, each operated in mono mode to provide a measured 129 dB signal-to-noise ratio. All audio circuitry is supplied by multiple stages of ultra-low noise, high current linear regulators from Analog Devices. Isolated power regulation stages are used for both analog and digital sections as well as high and low level circuit stages. These regulation stages are fed by a custom-designed, universal voltage, outboard switch-mode power supply unit, capable of delivering about 3.5 times the maximum power the amplifier is designed to draw under steady-state conditions. In addition, the unit uses a fixed high frequency switcher (operating at over 85 kHz) to avoid the possibility of any switching noise entering the audio band. This unit is designed with improved internal filtering to yield extremely low noise and ripple ( $< 50\ \text{mV}_{\text{pp}}$ ).

## Mobile Applications

Designed for mobile Hi-Res Audio reproduction where low power consumption and compact designs

are essential, Warwick's HPEL Portable Drive Electronics Modules are another solution for driving the company's HPEL transducers in any portable application. These drive electronics were designed in the form of miniaturized "daughter-board" modules that provide a turn-key solution for mobile headphones, small, battery-powered and wireless, loudspeakers, Virtual Reality headsets, or even specialized OEM automotive, marine and aerospace applications.

Warwick's HPEL Portable Drive Electronics Modules are meant to be driven from a standard low voltage DC power source or by standard 3.7 VDC lithium polymer rechargeable batteries.

The modules feature discrete amplifiers optimized to drive HPELs in a small form-factor, and can be configured as mono, stereo or multi-channel, with or without power supply. The ultra-efficient design draws < 250 mW in typical use, and provide 8+ hours of life from a 500 mAh battery, in stereo headphone applications.

Analog inputs are configurable to match any low level input source, and the modules feature pre-processing, and multi-band parametric EQ for sound optimization and

customization from an external DSP. For more information, visit [www.warwickaudiotech.com](http://www.warwickaudiotech.com).



Warwick Audio's HPEL Portable Drive Electronics Modules are another solution for driving the company's HPEL transducers.



*"The Woodstock of high-end audio shows"*

Embassy Suites Dallas Park Central

May 4, 5 and 6, 2018

# The Sonoma M1 Headphone System

The first product using Warwick Audio's complete HPEL technology is the multi-award winning Sonoma M1 Headphone System. This comprises the M1 circumaural headphone, the world's first to use HPEL audio transducers, and the dedicated DAC & Energizer electronics. One cannot be used without the other, and Sonoma sells the complete integrated package, including the connecting cable, designed in collaboration with Straight Wire, Inc. At the amplifier end, the jack is electrically isolated from the amplifier chassis, while on the headphones high-precision self-latching connectors are used to ensure a secure connection. A sense loop built into the cable runs to each ear cup, and if the cable is disconnected at either the amplifier or headphone ends then the amplifier automatically shuts itself down.

The dedicated headphone amplifier features USB 2.0, and coaxial S/PDIF for digital inputs, as well as RCA (x2) jacks, and a 3.5 mm stereo jack as analog inputs. The USB 2.0 input accepts all Hi-Res Audio formats up to 32-bit/384 kHz PCM and DSD via DoP (DSD64/DSD128), while the S/PDIF input accepts all PCM

formats up to 24-bit/192 kHz. The high-level RCA inputs operate with a maximum input signal of 2.1 V (rms), while the low-level 3.5 mm jack accepts a maximum signal of 850 mV (rms).

Sonoma Acoustics, Inc. is a new company founded by members of the former SACD Project, that designs, manufactures, and sells audio playback equipment optimized for high-resolution music listening. The Model One electrostatic headphone system is its first product. Sonoma Acoustics started shipping the first production units of the M1 in the US, UK and Japan in mid 2017, with an MSRP of \$4,995 for a complete system.

The Sonoma M1 Headphone System can be seen and auditioned at a growing number of Hi-Fi dealers the world over. Sonoma Acoustics is also exhibiting at CanJam Singapore, AXPONA, Munich High-End, The LA Audio Show, CanJam London, RMAF, The Australian Hi-Fi Show, and CanJam Shanghai throughout 2018 so you can go experience the amazing Sonoma M1 yourselves. For full details on the dealer network and future events visit [www.sonomaacoustics.com](http://www.sonomaacoustics.com).



## AMPLITREX AUDIO PRODUCTS, LLC



The **AMPLITREX AT1000**  
Simple, accurate,  
quality tube testing since 2004

[www.amplitrex.com](http://www.amplitrex.com)  
[amplitrex@gmail.com](mailto:amplitrex@gmail.com)

## miniDSP

### UMIK-1

- USB Measurement Mic
- Unique calibration file  
(Frequency, gain & SPL for 0/90deg)
- Extended support for  
REW, Dirac Live, FuzzMeasure, Audiotools...



### EARS

- Headphone test jig
- Stereo USB audio
- Unique calibration file  
& compensation curves



[www.minidsp.com](http://www.minidsp.com)

Unit 307, 13 Wang Hoi Road,  
Kowloon Bay - Hong Kong

Contact us  
[info@minidsp.com](mailto:info@minidsp.com)



# HEAD acoustics labCORE

## A New Modular, Multi-Channel Front-End Measurement Platform

By  
**J. Martins**  
(Editor-in-Chief)



HEAD acoustics, one of the world's leading companies in voice and audio quality measurements and optimization, recently introduced its all-new front-end platform, labCORE. The unit is a modular multi-channel front end platform designed in response to modern measurement applications.

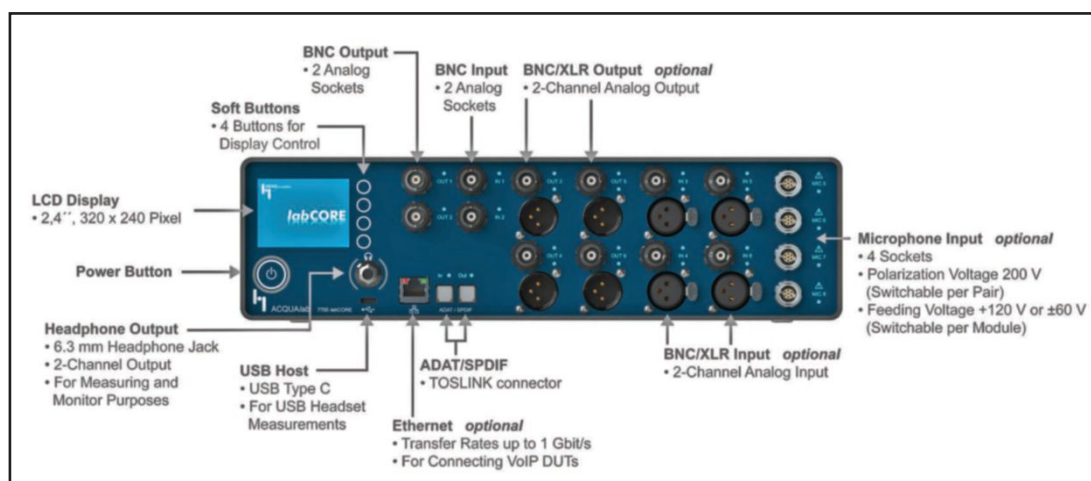
labCORE is a modular multi-channel front end platform for precise and efficient voice and audio quality measurements.

This powerful and versatile all-in-one solution expands the German company's application scope, creating an important expansion platform where technologies can be quickly added. Due to its modularity, its wide selection of digital and analog inputs and outputs as well as its programmable interfaces, labCORE is an all-in-one solution for voice and audio quality measurements. As they continue to expand, products such as smartphones, headphones, and smart speakers must be tested for the highest demands, and users can expand labCORE flexibly at any time by fitting optional modules, and thus, tailor the equipment to the exact measuring tasks. With labCORE, the technology company from Herzogenrath can also combine a multi-channel front-end platform with its complete range of software tools, ACQUA lab, tailoring the system to their individual measuring tasks.

### labCORE Basics

labCORE enables users to simultaneously transfer up to 32 channels at 48 kHz or up to eight channels at 192 kHz from a PC to labCORE, bidirectionally. All configurations for the multi-channel front end can be set up quickly and easily in the upcoming version of ACQUA 4.0, advanced communication quality analysis software from HEAD acoustics, which enables users to conduct fully automated measurements.

All currently common interfaces that are relevant for measurements of telecommunication devices as well as audio applications are integrated into labCORE. Available by default are a USB host interface (USB type C), interfaces for I<sup>2</sup>S (Inter-IC Sound), AES/EBU, ADAT and SPDIF as well as a two-channel headphone connection (6.3 mm jack) for measurement or monitoring (130 mW per channel,  $\geq 32 \Omega$ ). Current optional modules include high



Even the basic configuration of labCORE—without the optional modules—offers numerous interfaces to users that underline the versatility and performance of the front end.

quality two-channel analog inputs (coreIN-A2) and outputs (coreOUT-A2), available from the outset, which can be switched to XLR/BNC. The THD+N value of these module inputs is  $-112$  dB over wide frequency ranges and the signal to noise is better than  $-118$  dB. In addition, sampling rates of up to 192 kHz are possible, making labCORE ideally suited for high-end audio testing.

On the front side of labCORE, there is a 2.4" LCD (320 × 240 pixels) display for status notification purposes. With the help of four soft buttons, the display can be operated easily and intuitively. For mobile use, a HEADlab Power Box can be connected to the interface as an external battery. Another

advantage is the connection of the front end to the software. Depending on the selected configuration and the respective measurements, no further front ends are required. Users can integrate labCORE into their measuring environments and, if other front ends are required for certain measurements, labCORE can be easily combined with existing HEAD acoustics front ends.

### Additional Modules

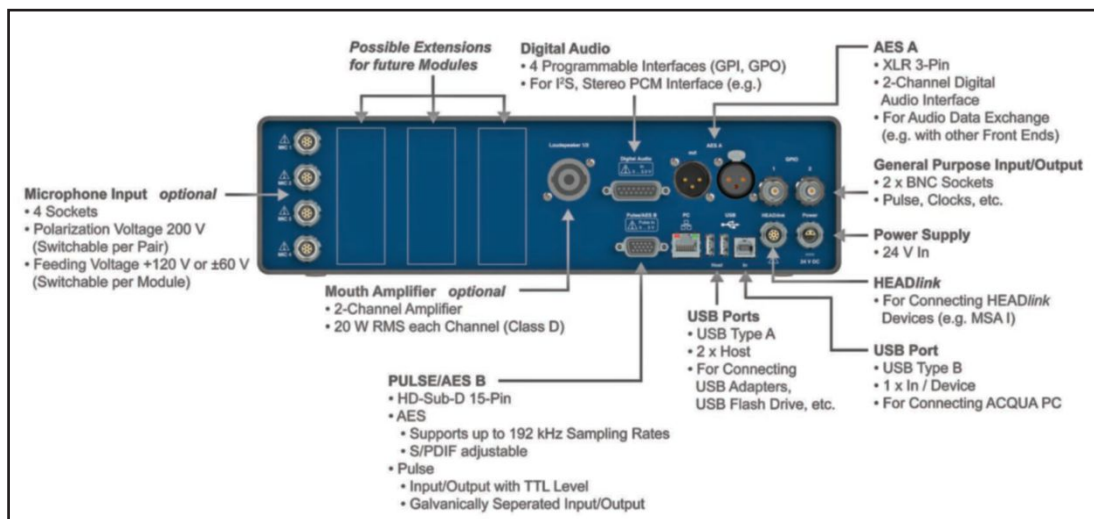
Various additional modules are available to extend the functionality of labCORE. First is coreBUS, a required bridge board to connect the mainboard and the individual extension modules—

## Headphone EOL Testing

- ▶ Analog, digital, wireless (Bluetooth)
- ▶ Extremely fast measurement
- ▶ Stereo frequency & difference response
- ▶ Sample-accurate synchronization
- ▶ Active noise cancellation & leakage
- ▶ Automated pair matching
- ▶ Voice coil and armature position



This view of the rear panel shows where further expansion panels can be configured.



up to 10 are possible. The bus mainboard is equipped with a Field Programmable Gate Array (FPGA), which allows high data transfer rates.

Additional modules cover functions such as a two-channel mouth amplifier (coreOUT-Amp2), binaural equalization (coreBEQ) and four microphone inputs (coreIN-Mic4). Each amplifier channel provides 20 WRMS per channel ( $\geq 4 \Omega$ , Class D) and are provided via a four-pin Speakon socket.

The coreOUT-Amp2 module can be added to labCORE twice, allowing for four channels without the need of additional external amplifiers, and making possible to configure test setups with two artificial head measurement systems, such as for In-Car Communication testing or acoustic-to-acoustic (end-to-end) testing.

With the coreBEQ binaural equalizer, the front

end allows the digital equalization of artificial head signals, all in real time.

The module coreIN-Mic4 provides four microphone inputs (LEMO 7-pin) for externally polarized microphones and enables concurrent connection of the ears of the artificial head measuring system and up to two measuring microphones. Alternatively, users can connect two artificial heads simultaneously. Users choose their inputs via the ACQUA software. Thus, labCORE enables fully automated measurements, as a manual swap of microphones is no longer necessary.

When more analog inputs and outputs are needed, the coreIN-A2 and coreOUT-A2 modules provide two-channel analog high-end inputs and outputs each. The connectors can be used in balanced (XLR) and unbalanced (BNC) mode, switchable via the software. The analog inputs support ICP and have a 48 V phantom feeding (switchable per channel). Their THD+N value is -112 dB over wide frequency ranges and the S/N is better than -118 dB. In addition, sampling rates of up to 192 kHz are possible.

Different coreIP modules are available for users who conduct VoIP measurements and want to measure the voice quality of digital communication devices and transmission networks. Codecs such as EVS, AMR or OPUS as well as the Impairment function, which allows users to simulate different IP network failures directly at the signal source and apply them to the outgoing IP packets of the front end, are part of the optional IP modules. The IP functionalities are provided via the Ethernet interface (up to 1 Gbps) on the front of labCORE.

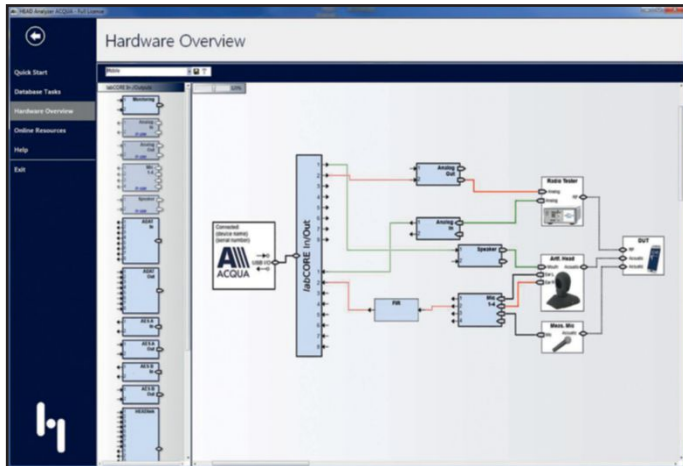
## labCORE Summary

Overall, labCORE has considerably more processing power due to the improved motherboard,

| labCORE Modules |                                                                               |
|-----------------|-------------------------------------------------------------------------------|
| Module Name     | Module Description                                                            |
| labCORE         | ACQUALab modular multi-channel front end for speech and audio quality testing |
| coreBUS         | labCORE I/O bus mainboard                                                     |
| coreOUT-Amp2    | labCORE output module, power amplifier (2 channels)                           |
| coreIN-Mic4     | labCORE input module, microphone (4 channels)                                 |
| coreBEQ         | labCORE binaural equalization                                                 |
| coreOUT-A2      | labCORE output module, analog balanced/unbalanced (2 channels)                |
| coreIN-A2       | labCORE input module, analog balanced/unbalanced (2 channels)                 |
| coreIP          | labCORE I/O module, Voice over IP (VoIP) reference gateway                    |
| coreIP-IMP      | labCORE VoIP impairment option                                                |
| coreIP-AMR      | labCORE VoIP AMR codec option                                                 |
| coreIP-EVS      | labCORE VoIP EVS codec option                                                 |
| coreIP-OPUS     | labCORE VoIP OPUS codec option                                                |

Table 1: This is an overview of labCORE's modules (further modules are in preparation).





ACQUA is a Windows-based software package for measurement and analysis, documentation, and archiving of measurement data in the time and frequency domain.

allowing more complex computing operations, significantly higher data transfer rates, and significantly more audio effects in real time. Because it was designed as a test and measurement platform for future expansion, labCORE is ahead of many front ends in the market in terms of performance. Also, for audio measurements, the hardware is designed in such a way that it does not require a fan. It works absolutely noiseless.

### ACQUA Software

With its HQS-EA (HQS = HEAD acoustics Quality Standard), HEAD acoustics already provides basic measurements. HQS-EA is a standard developed by HEAD acoustics for the analysis of electro-acoustical parameters of microphones, loudspeakers, and other acoustic transducers as well as hearing aids in the time and frequency domain. Combined with ACQUA and the company's front ends, HQS-EA with its predefined measurement descriptors and automated measurement sequences allows the fast and easy acquisition, analysis and documentation of measurement data.

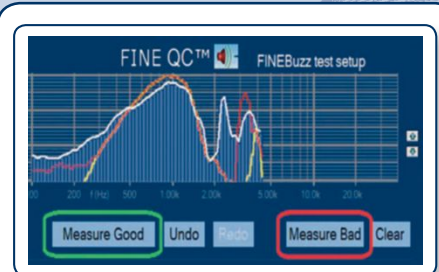
The current version of HQS-EA includes the following measurements:

- Frequency Response (n-th octaves; FFT resolution)
- Loudness Ratings (SLR/RLR)
- Distortion/THD/THD+N
- Rub & Buzz
- Level
- Polarity
- SNR
- Transfer Function
- Impulse Response
- Electrical Impedance

The company's development team is currently working on a new HQS-EA version that includes further measurements such as Thiele-Small parameters and other measurements suitable for many application areas. An exact release date for the new version of HQS-EA is to be confirmed. For more information, visit [www.head-acoustics.de](http://www.head-acoustics.de). 

## FINE QC™

Best performing Rub & Buzz test (ever)



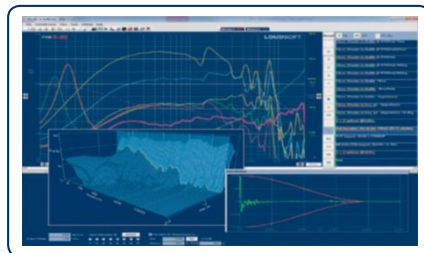
### FINE QC™

- Finds All Rub & Buzz
- Auto "Golden Average Unit"
- Auto Good / Bad learning
- SPL, Imp, Polarity, Sens, Rub & Buzz in one measurement < 0.5sec



### Headphone QC

- Simultaneous Left + Right test
- Full Test w Rub & Buzz < 0.5sec
- L – R Difference w tolerances
- Auto Good / Bad learning
- SPL, THD, Polarity, Sens, R&B



### FINE R+D))™

- Multiple curves 16 + 16 +
- Anechoic in normal rooms
- Normalizing of SPL to 2.83V@1m
- Real Time Analyser RTA
- Auto-Save Time: Change window / smoothing later

[www.loudsoft.com](http://www.loudsoft.com)

## High-Precision HRT I Measurement Turntable

HEAD acoustics recently launched the HRT I (HEAD acoustics Remote-operated Turntable), a high-precision turntable, enabling users to perform automated, orientation-dependent acoustic measurements. The rotation unit of the turntable offers a 360° rotation range, which can be approached in 0.1° steps, allowing manual or automated measurements.

This is ideal to measure multiple devices, rotating devices to specific angles, including loudspeakers, and even measurement equipment (e.g., HEAD acoustics' HMS artificial head and torso).

The adjusted angles can be reproduced to an accuracy of 0.02°, and the HRT I can be operated manually via buttons on the front panel of the turntable. This allows users to set an absolute reference position (0° position) and rotate the turntable clockwise or counter-clockwise.

In addition to manual control, users can control the HRT I fully automatically via the communication

analysis system ACQUA to conduct fully automated measurements. Based on the RS485 interface, data transmission over long distances is also possible.

The turntable has a sturdy design, allowing test objects up to 50 kg to be aligned with precision, and it does not generate any noise in the measurement position. Only during rotation there is a low noise emission.



## AVERLAB Audio Analyzer \$3000



Analog to 88 kHz  
Digital rates to 192k  
Mac & PC software  
Expandable hardware  
Portable: < 6 lbs  
Quite, fan-less operation  
Ethernet connectivity  
More details online

User assignable front-panel controls for bench-friendly operation

Available at  
**amazon**

**AVERMETRICS**  
www.avermetrics.com

For Over 35 Years

**ACO**ustics begins with **ACO**™



Community/Industrial  
Noise Monitors/Alarms  
Indoors and Out

Measurement  
Microphones  
Polarized and Electret



Windscreens  
3 to 18 inch & Custom  
Weather/UV Resistant



Microphone Systems  
Standalone  
IEPE Powered  
Phantom Power  
Custom



**ACO Pacific, Inc**

www.acopacific.com sales@acopacific.com

Tel: +1-650-595-8588



DIGITAL 6000

No intermodulation.  
More channels.  
More power for your business.

**Others dodge problems. We prefer to solve them.**

Of course, you can work your way around intermodulation and do some software magic—but that is no real solution in the already congested and limited frequency spectrum. By design, Digital 6000 has no intermodulation artifacts. Our superior RF technology results in more channels and more flexibility for any production and any stage—with no trade-off in transmission power or quality. Smarter, leaner, more efficient—this is the built-in principle from user interface up to spectrum efficiency. Redundant Dante™ sockets and the command function are just two components of the recent update.

**More about the next step towards the future of audio:**

[www.sennheiser.com/digital-6000](http://www.sennheiser.com/digital-6000)



**SENNHEISER**



# TubeSociety 2A3-300B-SE Amplifier Project (Part 1)

## *Experimentation Leads to Success*

Menno van der Veen designed five challenging 300B-SE amplifiers for his students. Part 1 of this two-part article discusses his TubeSociety academy in the Netherlands and details the first four amplifiers. Part 2 of the article will describe the fifth amplifier, plus provide information about the power supplies and construction.

Photo 1: Menno van der Veen is pictured with members of the TubeSociety community.

By  
**Menno van der Veen**

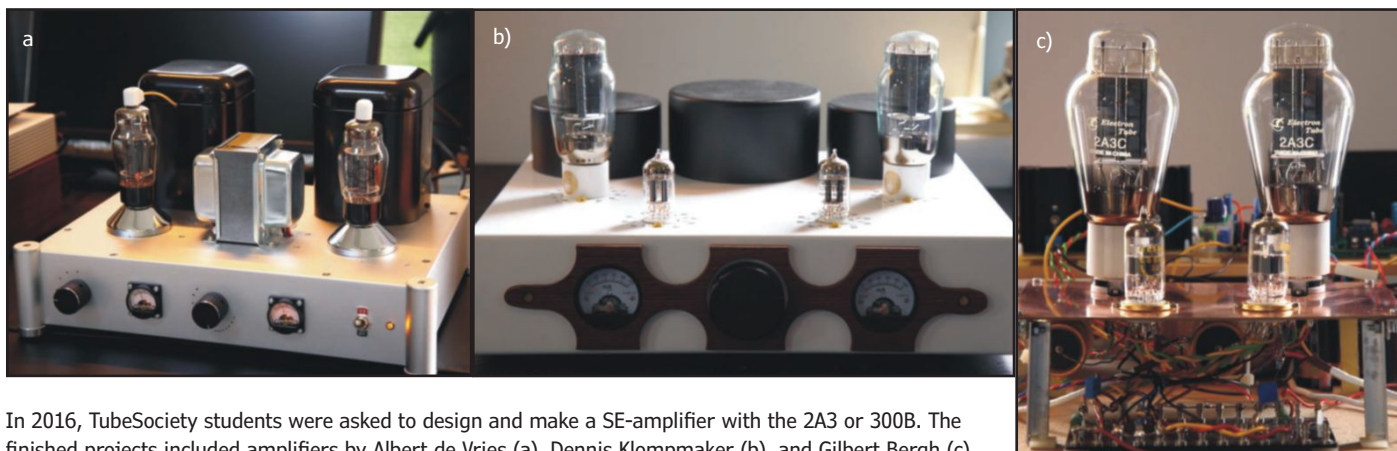
(The Netherlands)

About 12 years ago, I started my TubeSociety academy<sup>[1]</sup>, where I try to teach my TubeSociety students to become the best designers and constructors of tube amplifiers. Once a student said: "I don't wish to be a copier, I want to do it all by myself." That is a rather hefty saying, but it describes exactly the spirit in my biweekly Saturday school (see **Photo 1**). Besides explaining standard stuff such as Ohm's law and characteristics of tubes, I also select a year's topic. In 2016, I asked students to "design and make a SE-amplifier with the 2A3

or 300B" tubes. After one year of hard study and labor, the final results were striking (see **Photo 2**).

These fantastic designs did not occur by accident or good luck, but were founded on literature study, intensive cooperation among all the students and me, sharing new ideas and helping those who required assistance. We built on each other shoulders.

Imagine that next year's project would be "make a race car." A starting foundation would be very helpful. For instance a chassis, some wheels, and a motor. This is exactly what I provided at the



In 2016, TubeSociety students were asked to design and make a SE-amplifier with the 2A3 or 300B. The finished projects included amplifiers by Albert de Vries (a), Dennis Klompmaker (b), and Gilbert Bergh (c). (Photos courtesy of Yeb de Witte)



Photo 3: Menno van der Veen's Amplifier 1 is an FET driver stage plus 300B in 2A3 configuration.

start: some conceptual schematics<sup>[2]</sup> plus a student support group who organized casing and a set of standard components. After that we all (including me) started to design and showed our results during lessons. This fine cooperation made the year's end a great happening. We all were happy with the high quality of our final products.

To support my students "on the road," I designed five SE-amps and shared my results. Through this process, I taught them the knowledge they needed to build their own amplifiers.

### Amplifier 1

Amplifier 1 was designed with a field-effect transistor (FET) driver stage plus 300 B vacuum tubes in a 2A3 configuration (see **Photo 3**). The concept of the audio-signal stage is shown in **Figure 1**. To begin, I applied BSP135 FETs in a very simple clean driver stage. I added a source follower, to compensate for the rather large grid capacitance (Miller influence) of the 300B. Almost every student used my VDV-2512-SEE single-ended toroidal output transformer<sup>[3]</sup>. However, I applied a sample transformer that my Chinese student Zhou Ke sent to me for evaluation. His OPT was designed for the 2A3 with 2.5 k $\Omega$  primary impedance and a quiescent current of 60 mA. For that reason I set the 300B in that specific operation point. Surely not optimal for the 300B, but, this was a fine opportunity to test the Zhou Ke OPT.

At each FET, I placed two 12 V Zener diodes between the source and the gate to protect the amplifier at start-up. The total harmonic distortion (THD) of only the driver section is 0.8 % at 1 kHz at maximum output power of 4 W, way below the 300B distortion. **Photo 4** shows the interior of the amplifier as it is being built.

The most important measurement results are shown in **Figures 2-5**. I took the measurements with the Arta programs developed by Ivo Mateljan<sup>[4]</sup>. For

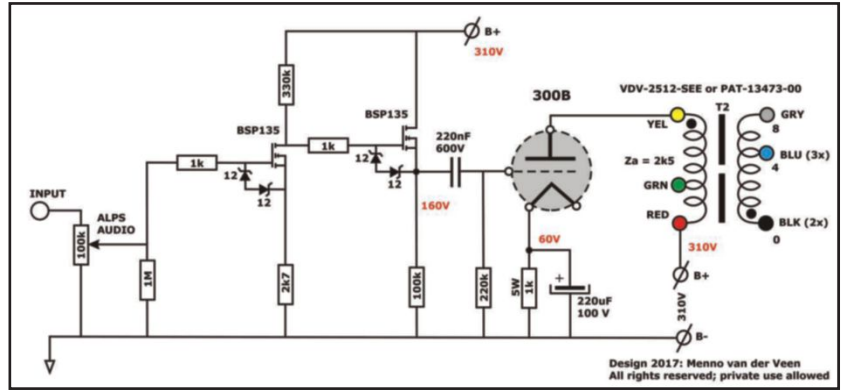


Figure 1: This is a schematic of the audio section for Amplifier 1.

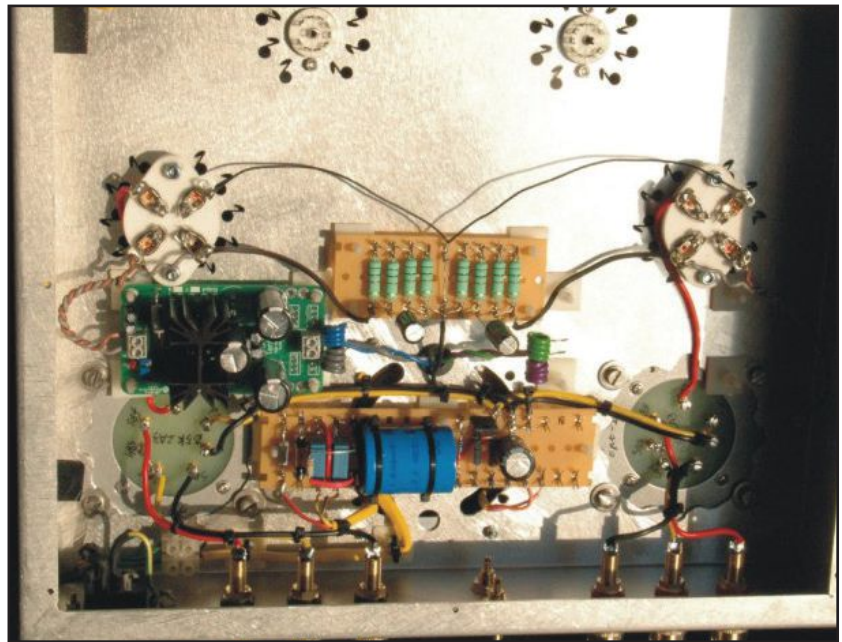


Photo 4: This is an inside view of van der Veen's Amplifier 1.

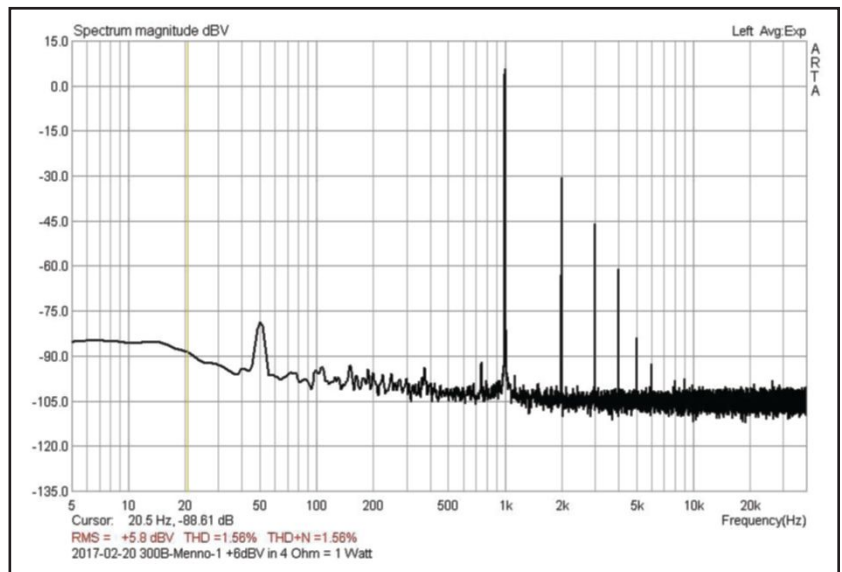


Figure 2: Amplifier 1 is shown with a 1 kHz spectrum at 1 W in 4  $\Omega$ .



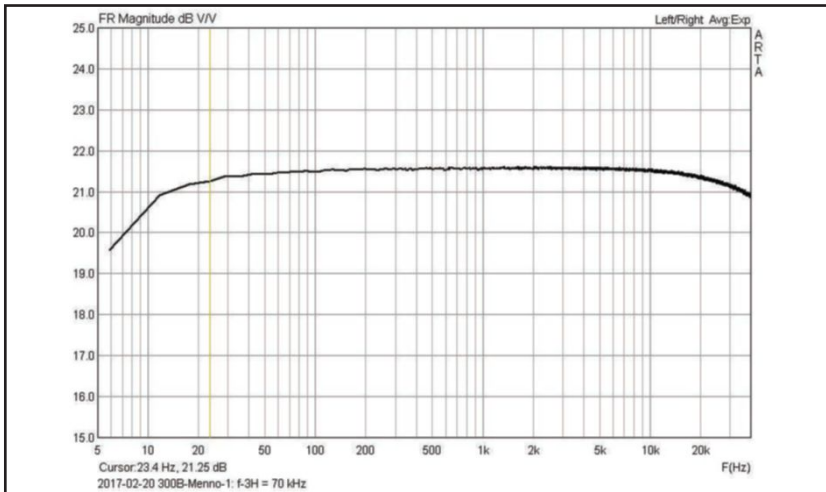


Figure 3: Amplifier 1 is shown with gain and frequency range at 1 W in 4  $\Omega$ .

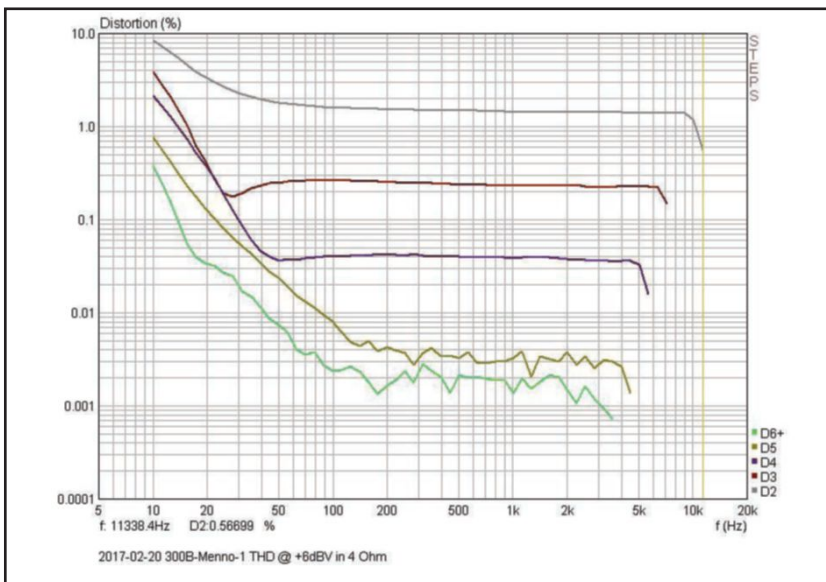


Figure 4: Amplifier 1 is shown with harmonics at 1 W in 4  $\Omega$ .

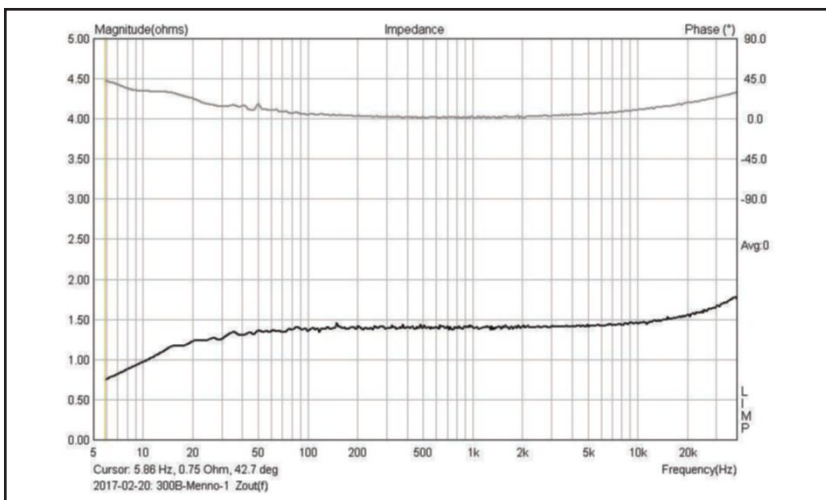


Figure 5: Amplifier 1 is shown with output impedance (lower curve) at 4  $\Omega$  tap. The upper curve is the electrical phase of the impedance (right hand scale).

my TubeSociety students, I designed a special sound card interface, called Arta-2 (see **Photo 5**), which is fully described on my website<sup>[5]</sup>. With a big smile my students call it “the poor man’s Audio Precision.” I know that Audio Precision is much better, but isn’t that a compliment? Feel free to copy this powerful calibrated device for your private use. (Any business-related manufacturers are only allowed to use it with my approval provided in writing.)

As for the measurements, you might ask why I mostly measure at 1 W in 4  $\Omega$ . I use excellent horn loudspeakers<sup>[6]</sup>. With only 1 W I get 99 dB SPL, which is very loud. Mostly I will listen below this level. So, I measure at the 1 W level and below, not at super output powers. My listening room is not a disco.

The harmonic spectrum shown in Figure 4 nicely follows the masking curve of our ear. This behavior is preferred in most literature. I will explain later why I disagree. The frequency range shown in Figure 5 extends without any resonance to -3 dB at 70 kHz. The OPT alone, driven by a 800  $\Omega$  voltage source, extends to -3 dB at 100 kHz without any ringing, which is excellent. So, I gave Zhou Ke my compliments.

Figure 5 shows the specific small output impedance of triode SE-amp. This is excellent behavior, because the lower the tube’s plate resistance, the lower the magnetic distortion in the output transformer. This conclusion is based on the famous research of Allen Partridge. At the lowest frequencies, the starting shrinking impedance of the primary inductance  $L_p$  of the OPT is noticeable<sup>[7]</sup>. At the highest frequencies, the onset of the influence of the primary leakage inductance  $L_{sp}$  is just visible. Both effects are almost outside our effective hearing range and hardly influence the perception.

Conclusion: The measurements show a healthy amplifier with many goodies according to today’s standards in SE-amp design. But how does it sound? The amp sounds warm, however, with it has too many second harmonics, preventing micro details from being heard. This character did not impress me, but it functioned. Not that bad for a first try.

## Amplifier 2—Focus on the Coupling Capacitor

Amplifier 1 and Amplifier 2 are exactly the same except that in Amplifier 2, we changed the brand of the u22/630V coupling capacitor. The students and I listened to the following types: the Jensen Silver foil; the Jensen Copper foil; the Mundorf Mcap Silver/Gold/Oil; the Russian Pio K40Y:9; the Koweg; the LCR PCHVSWF; the Lcap KPSd; the Siemens MKP; the Wima-red MKP10; and several other unmarked brands.

The results were striking. The sequence of this



list shows our appreciation, with the Jensen Silver foil as the absolute winner. The Jensen Copper foil was somewhat less compared to the Jensen Silver foil. The Mundorf Mcap Silver/Gold/Oil was next on the declining scale and so on.

The observations were as follows: Nothing was changed in volume, only the capacitors interchanged,

followed by an almost blind listening test (because no one knew what to expect). With the Jensen Silver foil, the sound stage was open, fluent, deep, no sharp character, friendly and warm, highly attractive human-like sound character. With the other capacitors on the list, these good observations declined until the sound character became flat and not attractive at all. Next, I



Photo 5: The Arta-2 measuring unit can be connected to a sound card.

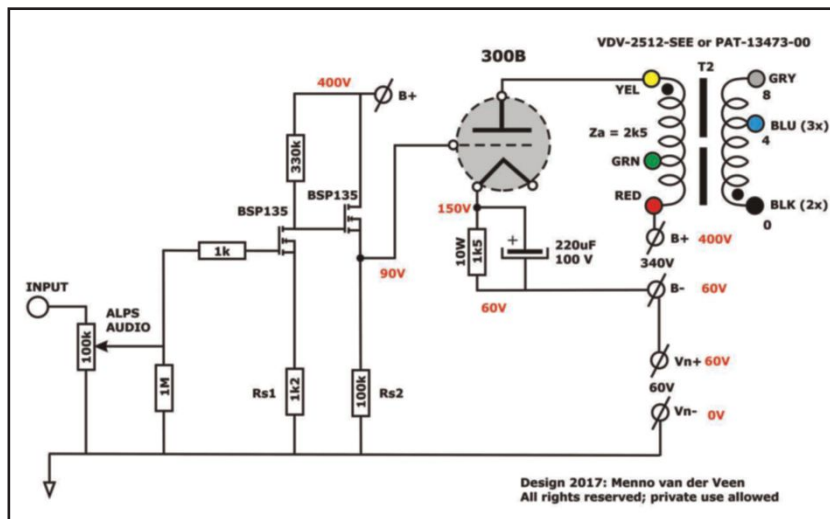


Figure 6: Here is the schematic used for Amplifier 3.

## 10" PA Mid/Woofer WF259PA01

**wavecor**

94dB sensitivity, 1W/1m

300W power handling  
(continuous 100 hours, IEC)

3" voice coil

Rigid die cast alu chassis

Vented voice coil former

Linear freq. response to 3kHz

Vented center pole with dual flares

Built-in alu field-stabilizing ring

Conex spider



[www.WAVECOR.com](http://www.WAVECOR.com)

performed standard measurements of the distortions (as I did in Figure 4) and I noticed no differences between the various capacitors.

Consequently I am forced to a rather stringent reformulation of my conclusions of Amplifier 1: “The subjective quality of the amp is mainly influenced by only one component: the coupling capacitor.”

It was impossible to measure any effect with my standard measurements. They seem to be invalid in judging subjective sound quality. Let me be cautious here: The measurements are valid in showing good design, but that is not the topic of this discussion. I am well aware of the influence of construction and materials in coupling capacitors. I even wrote an Audio Engineering Society (AES) paper<sup>[8]</sup> about some of those remarkable effects. That is not my problem. It is that conclusions drawn from standard

accepted measurements seem to be invalid when you wish to say something about the appreciation of an amplifier’s sound. Therefore, I shall use my standard measurements only to determine the health of the design. I will not be able derive conclusions from them about how it sounds.

A last small remark: If the coupling capacitor has such a huge influence, why not the same for resistors or transformer core steel or ..... I understand that people are willing to spend thousands of euros (or dollars) to get the sound character they want, to approach the holy grail. Is this the way to proceed for me and my students? I decided not to continue down this expensive trail, but to use another way of thinking. Let’s see what this brings us.

Conclusion: The simple Amplifier 1 sounds amazing when you apply Jensen Silver in oil coupling capacitors. They are expensive but surely you get audio value for the money.

## Amplifier 3—FET Driver Stage, No Coupling Capacitor Nor Zener Diodes

If the coupling capacitor has such a huge influence, why not remove it by changing the circuit into direct coupling? I also noticed that the protecting 12 V Zener diodes have a leakage current in the micro ampère range, creating noticeable distortions. So, I got rid of them (see **Figure 6**).

Two voltage sources are applied. (I will provide more detail in Part 2 of this article.) The B+ supply delivers 340 V and sends 60 mA current through the primary of the OPT, through the 300B, through its cathode resistor of 1.5 kΩ, back to the B- side of the supply. However, the B- side is NOT grounded, but lifted 60 V above ground by means of the second supply Vn. Consequently, the filament cathode of the 300B is at  $(60 + 60 \text{ mA} \times 1.5 \text{ k}\Omega) = 150 \text{ V}$  above ground.

The FET source follower has its output +90 V above ground, which can be trimmed with Rs1. Under this condition the grid of the 300B is 60 V lower in potential than the filament cathode. This corresponds with an operating point of  $V_{ak} = 250 \text{ V}$  and  $I_o = 60 \text{ mA}$  of the 300B. Drifting in time or by changes in Vmains are counteracted by the rather large cathode resistor  $R_k = 1.5 \text{ k}\Omega$ . As you see, the coupling capacitor and protecting Zener diodes are not present anymore. Also note that the current capabilities of the B-supply are large (about 120 mA for stereo in this set up), while the very “clean” Vn only has to deliver a few milliamps (see **Figure 7** and **Figure 8**).

In Figure 7, the higher harmonics 5, 6, 7, and 8 are less suppressed. The harmonic 2, 3, 4 levels are a little smaller than in Amplifier 1 and Amplifier 2, but the difference is not very convincing.

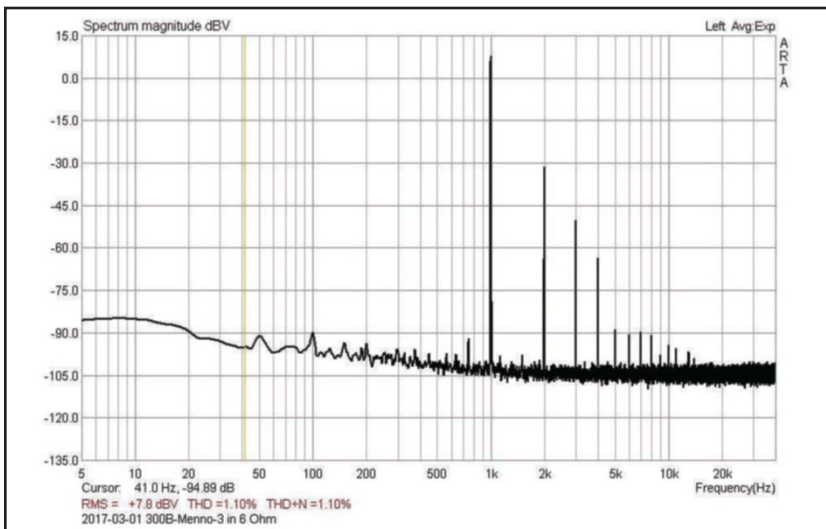


Figure 7: Amplifier 3 is shown with a 1 kHz harmonic spectrum.

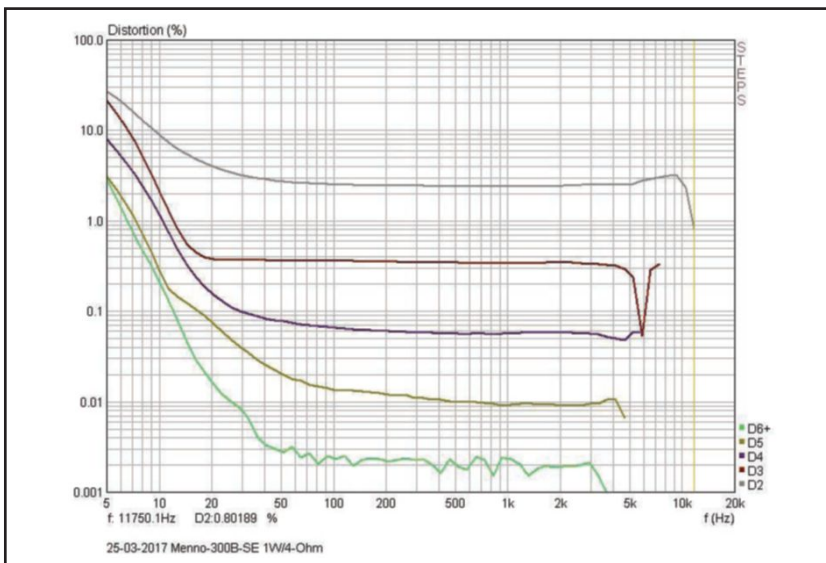


Figure 8: Amplifier 3 is shown with with harmonics at 1 W.

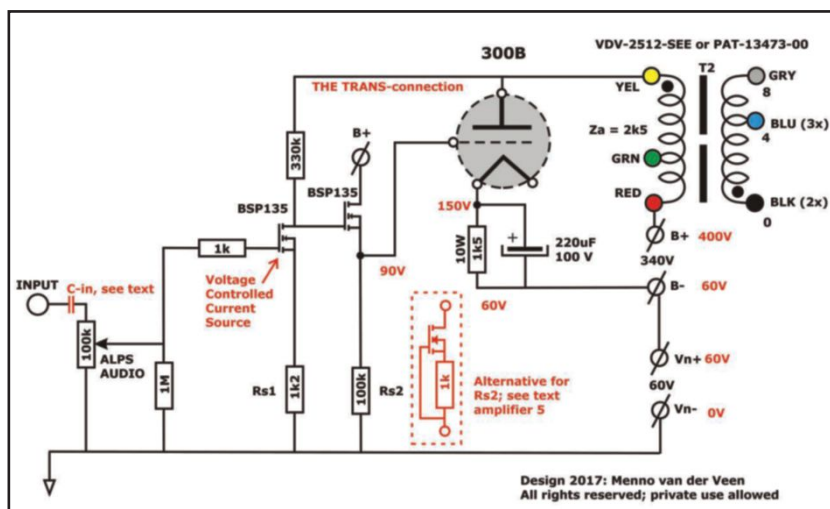
So, how does this amp sound? The sound character is close to that of Amplifier 2 with the Jensen Copper foil capacitor. Lots of space and depth, but not all the details are totally clear, I still observe a curtain (= second harmonics), but lesser than that found in Amplifier 1. My wife Annemieke said, "The sound character is a little too bright." And the measurement shown in Figure 7 confirms this observation by the higher levels of harmonics 5 and above.

Conclusion: Not all is optimal yet, removing C-coupling seems to be a promising route. Let me continue this in Amplifier 4 to improve further the sound.

### Amplifier 4—Introducing 300B-TRANS

As you might know, I have written a book about valve amplifiers with transconductance<sup>[9]</sup>. It describes a study where a voltage controlled current source and the final power tube are combined. This results in extra low impedance drive of the output transformers. So, I am going to apply this Trans-concept in Amplifier 4.

My idea was as follows: Suppose I change the first FET into a voltage controlled current source.



The second FET can stay in place. It is a mandatory source follower to suppress the influence of the grid capacitance of the 300B. Only one connection needs to be changed. At the first FET, the 330 kΩ resistor from drain to B+ shall now be connected to the anode of the 300B (see **Figure 9**). The correct operation point can be trimmed with Rs1, as in the previous amplifier.

The more I apply this very simple schematic, the better it pleases me. You can linearize the voltage controlled current source even further by measuring the AC-music-voltage over Rs1. Next, compare this voltage with the input signal, by means of a

Figure 9: For Amplifier 4, van der Veen experiments with transconductance.

# ALL ELECTRONICS CORPORATION

**Thousands of Electronic Parts Available Today!**

LEDs · CONNECTORS · RELAYS  
SOLENOIDS · FANS · ENCLOSURES  
MOTORS · WHEELS · MAGNETS  
PC BOARDS · POWER SUPPLIES  
SWITCHES · LIGHTS · BATTERIES  
and many more items...

**We have what you need for your next project.**

**www.allelectronics.com**  
Discount Prices · Fast Shipping

## Spiral Air<sup>tm</sup> Interconnects

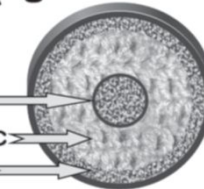
# Coax Is Cool Again!

Cardas Golden Strand

Air Filled Cotton Dielectric

Unique Spiral Litz Shield

ETI Tellurium Copper Connectors



**Affordable Litz Interconnects and Bulk Wire**  
Tonearm - Phono - Line - Loudspeaker

**KAB**  
Preserving The Sounds Of A Lifetime

**www.kabusa.com**



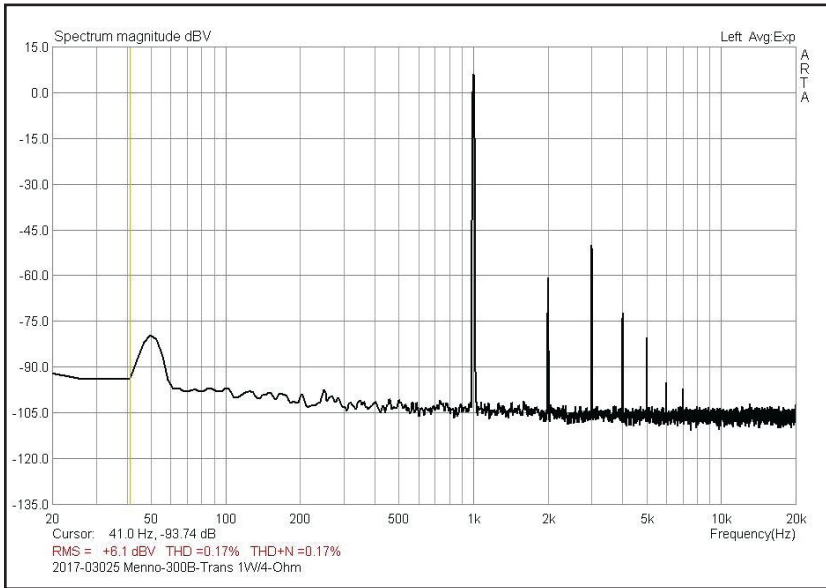


Figure 10: Amplifier 4 is shown with 300B-Trans 1 kHz spectrum.

## About the Author

Menno van der Veen studied engineering physics at the university. He taught physics at an upper secondary school and teacher trainings college. At the age of 40, he founded his engineering firm with a focus on tube amplifiers and toroidal output transformers. He wrote many articles and books about these subjects. About 12 years ago, he also started his TubeSociety academy. Tube-amp research, consultancy, design, teaching and playing the guitar are the main activities of his present work.

differential op-amp circuit and let the op-amps output drive the gate of the first FET. This local feedback approach will produce better measurements, but subjectively I hardly noticed improvements. So, I did not apply this more complex approach.

Before studying the measurement results, let me be honest. The 300B is a legend, the best creation ever. Now I come along and apply transconductance, and this technique creates negative feedback over this famous tube. Have I gone crazy? I will be killing all the specialties of the 300B by applying feedback!

I know, I humbly bend my head. But maybe you will allow me some defense. It really was not my goal to provide feedback to the 300B, because transconductance works optimally when you use a good pentode instead of a 300B. However, the 300B was already on the chassis and the current source was there, as the source follower. The challenge was irresistible. I couldn't stop myself from doing this. **Figures 10–13** show the measurement results.

Figure 10 clearly shows that the second harmonic is largely suppressed. Now we don't see the regular harmonic decline under the masking curve. Understanding this is not difficult: the 300B-Trans is internally feedback, creating almost equal distance and constant slopes of the more vertical gridlines of the Ia-Vak-Vgk characteristics. The standard curved characteristics are straitened, also in the limiting range at low anode currents. Consequently, the second harmonic distortion gets less.

Figure 11 shows that the frequency range is almost flat, because of the much smaller plate resistance of the 300B-Trans configuration, suppressing the influence of  $L_p$  and  $C_{ip}$  and the  $L_{sp}$  of the OPT.

Figure 12 shows many interesting results. At very low frequencies (below 20 Hz) the OPT-steel-core distortions are dominant. Going from 20 Hz to 1 kHz, the second harmonic decline is caused by the lesser influence of the primary inductance  $L_p$  of the OPT on the effective load line (less oval). Above 1 kHz and higher you see the second harmonic increasing again because of decreasing impedance of the effective primary capacitor  $C_{ip}$  inside the OPT, making the load line oval again. The third and higher harmonics are smaller than in earlier trials, suppressed to a lesser extent than the second, which can be understood from the famous research by Peter Baxandall and Douglas Self<sup>[10]</sup>.

Figure 13 clearly shows the internal Trans-feedback on the 300B. The output impedance is almost  $(\mu - 1)$  times smaller than in earlier trials. At highest frequencies the influence of the leakage inductance  $L_{sp}$  of the OPT again is visible.

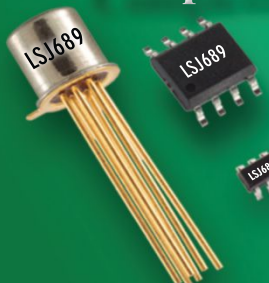
In general: Rather drastic changes compared to earlier amps are observed. Fortunately, these

A New Part Introduction for 2016

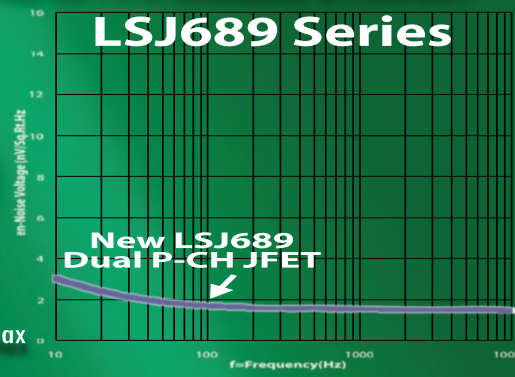
## 1.8 nV Low Noise Dual P-Channel JFET

### 4pf Low Capacitance

### Complement to N-Channel LSK489



### LSJ689 Series



New LSJ689  
Dual P-CH JFET

- Low Noise < 1.8nV
- Low Capacitance: 4pf max
- Low Offset: 20mV max
- Complement to Dual N-Channel JFET - LSK489
- Ideal for Differential Amplifier Applications when uses with the LSK489
- Ideal for Voltage Controlled Resistor Applications
- TO71, SOIC-8, SOT23-6, ROHS Packages
- Contact the Factory or Visit the LIS Website for Data Sheets/Pricing/Samples

[www.linearsystems.com](http://www.linearsystems.com)

1-800-359-4023

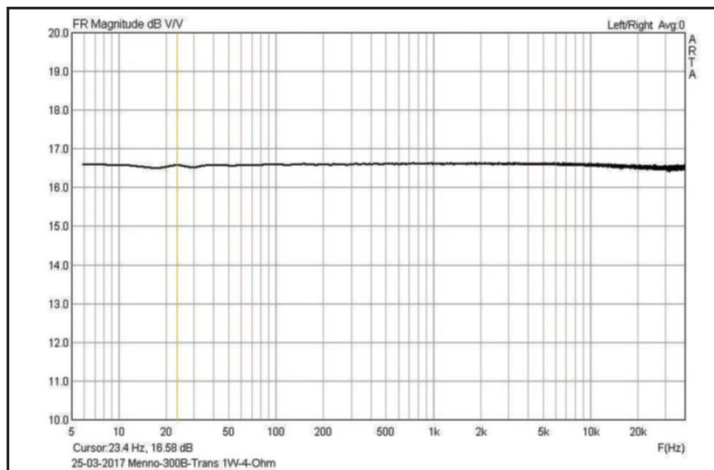


Figure 11: Amplifier 4 is shown with a 300B-Trans frequency range.

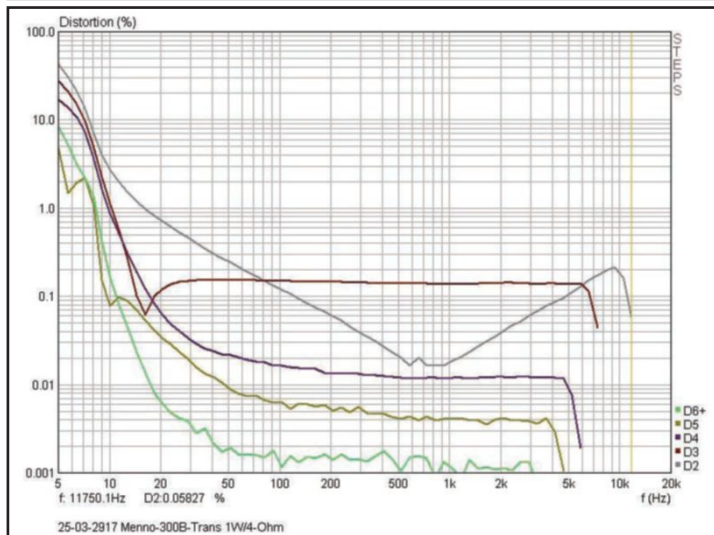


Figure 12: These are the 300B-Trans distortions for Amplifier 4.

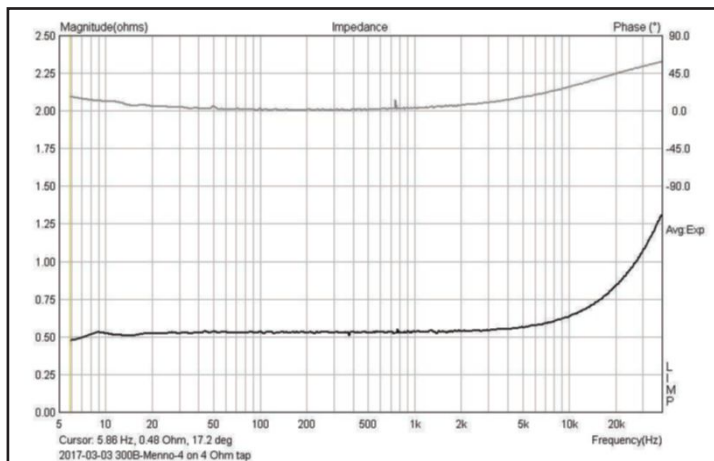


Figure 13: This is the Trans output impedance (lower curve) at 4  $\Omega$  tap for Amplifier 4. The upper curve is the phase of the impedance (right hand scale).

changes are fully described in my Trans book. The “power” of transconductance is large; don’t underestimate this technique for several reasons:

- You can use pentode power tubes with their 50% efficiency (instead of 25% with triodes)
- You get better linearity than with triodes (smaller THD)
- The effective plate resistance with Trans (around 100  $\Omega$  to 300  $\Omega$ ) is smaller than with good 300B triodes (around 800  $\Omega$ )
- Consequently the magnetic distortions in the OPT decline at least a factor 2 to 3 (6 to 9 dB)
- The local Trans feedback is only around the power tube and does not include the fog and smear creating hysteresis of the core of the OPT. This feedback loop is intrinsic linear.

Subjective observations: Yep, here we go! Lots of details and embracement, the depth picture is excellent. No curtain anymore. This is how I like the natural open sound



**FREE**  
Software

## FRONT PANELS & ENCLOSURES

**YOU DESIGN IT  
WE MACHINE IT**



**NEW**  
DIGITAL PRINTING



**FRONT PANEL  
EXPRESS**

☎ 1-800-373-9060  
[www.frontpanelexpress.com](http://www.frontpanelexpress.com)



# CINE GEAR EXPO 2018

**LOS ANGELES**

MAY 31 - JUNE 3, 2018

EXHIBITS: JUNE 1-2

THE STUDIOS AT PARAMOUNT  
HOLLYWOOD, CA



FOR FULL DETAILS GO TO:

**[WWW.CINEGEAREXPO.COM](http://WWW.CINEGEAREXPO.COM)**

EXHIBITS • SEMINARS • DEMONSTRATIONS • FILM SERIES COMPETITION  
NEW PRODUCT INTRODUCTIONS • TECHNICAL AWARDS • NETWORKING • SPECIAL EVENTS



character. Let's have a bottle of wine and listen for hours into the late night. I have had this experience before. But usually the next day, with some headache, the joy slowly disappears. However, with Amplifier 4, my appreciation remained, even grew. Students and friends were invited for listening. In my opinion, I approached the holy grail a little bit. I consider this amplifier as a very good design, I am proud of it.

I could have stopped my supportive research for my TubeSociety students at this moment. But one day I accidentally connected a faulty device with a lot DC-offset voltage to the input of the amplifier and misfortune struck me. Flash, a spark rain, severe hum, smoke, and other bad things. I had red 300B anodes and a broken filament because I plugged in the precious hot tubes too hastily. I easily could have prevented all that by adding a high-quality input capacitor (1  $\mu$ F non polar) before the volume control (see the red in Figure 9). But I actually broke the amplifier, so I had to build a new one. I decided to offer my students another challenging alternative.

I will describe Amplifier 5 in Part 2 of this article series for the May issue of *audioXpress*. 

## Resources

[1] M. van der Veen, "TS-2016: 2A3/300B-SE AMPLIFIER," TubeSociety 2016 project (in English), [http://mennovanderveen.nl/nl/tube\\_2016.html](http://mennovanderveen.nl/nl/tube_2016.html)

[2] M. van der Veen, TS-2106 Starting concepts and schematics, [http://mennovanderveen.nl/nl/download/ts2016/2A3-300B\\_concepts.pdf](http://mennovanderveen.nl/nl/download/ts2016/2A3-300B_concepts.pdf)

[3] M. van der Veen, Toroidal Output Transformer T2: VDV-2512-SEE or PAT-13473-00, <https://mennovanderveen.nl/eng/download/vatsea/Transformers-specs.pdf>

[4] Ivo Mateljan, Audio Measurement and Analysis Software, [www.artalabs.hr](http://www.artalabs.hr).

[5-1] M. van der Veen, "How to make your own Arta-2 calibrated measurement device," [https://mennovanderveen.nl/nl/download/arta/ARTA-2\\_manual-ijken-meten-schema-pcb-boormal.zip](https://mennovanderveen.nl/nl/download/arta/ARTA-2_manual-ijken-meten-schema-pcb-boormal.zip)

[5-2] M. van der Veen, Arta-2 demonstration (in Dutch), [www.youtube.com/watch?v=LLpPy5oPCBY](http://www.youtube.com/watch?v=LLpPy5oPCBY)

[6] Quintafila Niagara MSR, [www.quintafila.it](http://www.quintafila.it)

[7] M. van der Veen: "Signal level and frequency dependent losses inside audio signal transformers and how to prevent those," 130<sup>th</sup> Audio Engineering Society (AES) Convention paper, May 2011, [http://mennovanderveen.nl/nl/download/download\\_5.pdf](http://mennovanderveen.nl/nl/download/download_5.pdf)

[8] M. van der Veen, H. van Maanen: "Non linear distortions in capacitors," 124<sup>th</sup> Audio Engineering Society (AES) Convention paper, May 2008, [http://mennovanderveen.nl/nl/download/download\\_4.pdf](http://mennovanderveen.nl/nl/download/download_4.pdf)

[9-1] M. van der Veen, *Vanderveen Trans Tube Amplifiers*, Elektor, [www.elektor.com/vanderveen-trans-tube-amplifiers](http://www.elektor.com/vanderveen-trans-tube-amplifiers), ISBN: 978-94-9109-875-8

[9-2] M. van der Veen, *Vanderveen Trans Tube Amplifier*; Elektor, [www.elektor.de/trans-roehrenverstaerker](http://www.elektor.de/trans-roehrenverstaerker), ISBN: 978-3-89576-307-6

[9-3] M. van der Veen, *Vanderveen Trans Valve Amplifiers*; Elektor, [www.elektor.com/vanderveen-trans-tube-amplifiers](http://www.elektor.com/vanderveen-trans-tube-amplifiers), ISBN: 978-1-907920-34-9

[10] P. Baxandall and D. Self, *Baxandall and Self on Audio Power, Linear Audio*, [www.linearaudio.net](http://www.linearaudio.net), ISBN 978-94-90929-03-9

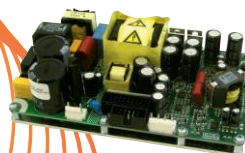
# hypex NCxxxMP series

## overview

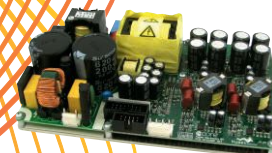
The NCxxxMP amplifier module incorporates a low power standby power supply (meets 2013 ERP Lot 6 0.5W requirements), a highly efficient switch mode power supply and a high- performance Class D amplifier in one compact and easily applicable power brick.



NC122MP



NC250MP



NC252MP



NC500MP



NC502MP

**Add-on Module NC100HF**  
The NC100HF is a dedicated tweeter-amplifier which fits the NCxxxMP series.



**ncore**  
audio power conversion

**hypex electronics**  
[www.hypex.nl](http://www.hypex.nl)

# A DIY HRTF Binaural Microphone HEAD

Ron Tipton explains how to build an economical head-related transfer function (HRTF) binaural microphone head by starting with a Styrofoam wig holder.

By  
**Ron Tipton**  
(United States)



The HRTF is a response that characterizes how an ear receives a sound from a point in space. As sound strikes the listener, the head's size, shape, and density as well as the ears, ear canal, and size and shape of nasal and oral cavities, all transform

the sound and affect how it is perceived, boosting some frequencies and attenuating others. For my DIY HRTF head, I chose a life-size male head model (see the Parts List for details) because the ears are acoustically important and I could not find a lady's head model with ears. In fact, one online vendor complained about this. The vendor markets ladies' hats and explained ears are needed for a proper display.



Photo 1: In this photo, "Fred" has had two coats of water-based acrylic paint with a light sanding (220 grit sandpaper) between coats.

## Prepping the Head

This head model was formed in a two-part mold, front and rear, and the two halves did not perfectly fit. A small ridge remains and it should be removed with a light sanding using 150-grit sandpaper. The ridge is probably not an acoustic problem but its removal looks nicer. Next, give the head model at least two coats of water-based acrylic paint to help stabilize the rather delicate surface. The color is not an acoustical factor, so take your pick. It is important to test the paint on the head's bottom surface to make sure there is no adverse reaction (e.g., dissolving the Styrofoam). I had some Glidden flat matte interior paint tinted "tan suede glove," which worked fine (see **Photo 1**).

When the paint is dry, you need to make holes for the microphone wiring. The head I chose had



a “carrot-shaped” hole extending from the bottom center to about an inch below the line between the center of the ears (see **Photo 2**). Having this hole saves a lot of work, but if your head lacks this feature, you must make one. Use a small spoon or hobby knife. It doesn’t need to be very large in diameter but you do need room to work on it. The hole in my model started at about a 1” diameter at the base and tapered to about a 1/2”. As I mentioned, my center hole was not “deep” enough so I had to extend it about 1” with an iced-tea spoon, which I made narrower with a belt grinder. The depth needs to be opposite a line between the centers of the two ears to accommodate the microphone wiring. I found it convenient to hold the head upside down in a soft, fluffy towel in my lap while doing this “excavation.”

Great care is needed for this next step and the soft towel may help. You need to drill a small hole from the center of each ear into the center hole. Conventional drill bits do not work well on Styrofoam so don’t try it. Make the two holes with a length of thin-wall brass tubing, 3/16” outside diameter (see the Parts List, which can be found in the Supplementary Materials section of the audioXpress website). Even though it’s thin-wall tubing, it needs to have a cutting edge. Use a file or belt grinder to “sharpen” one end and then use a small, round jeweler’s file to remove the burr from the inside of the tube. This will leave a sharp cutting edge.

Starting at the center of each ear, twirl the tubing with your fingers, pushing gently, until it has penetrated about a 1/2”. Remove the tubing from the hole and push out the piece of Styrofoam with a length of stiff wire or small dowel rod. Continue in this manner until you have made both holes. It’s really easy and the holes have surprisingly smooth walls—however...Styrofoam is a peculiar material. It is composed of fairly small “pellets” that are pressed together to form the molded object so the finished product is not necessarily homogenous.

A firm surface is needed for the microphone cartridge to seat properly so using a small artist’s brush carefully paint the inside of the ear holes to a depth of a 1/4” or so with the same paint you originally used on the head. Continue to apply paint coats until you have a smooth surface for the microphones. This will save a lot of grief later on!

## The Microphones

Next, you will need to make up the microphones using the parts listed in the Parts List and shown in **Figure 1** and **Photo 3**. Place a 1/4” diameter colored adhesive “dot” from an office supply store over each microphone face before putting them into the model. This is helpful in case there is some leakage of the



Photo 2: This head was made with a center hole that simplifies the project because the microphone cable will exit here. If your head does not have this feature, you will have to provide it (see text). I tested the paint on the bottom before painting the entire head.

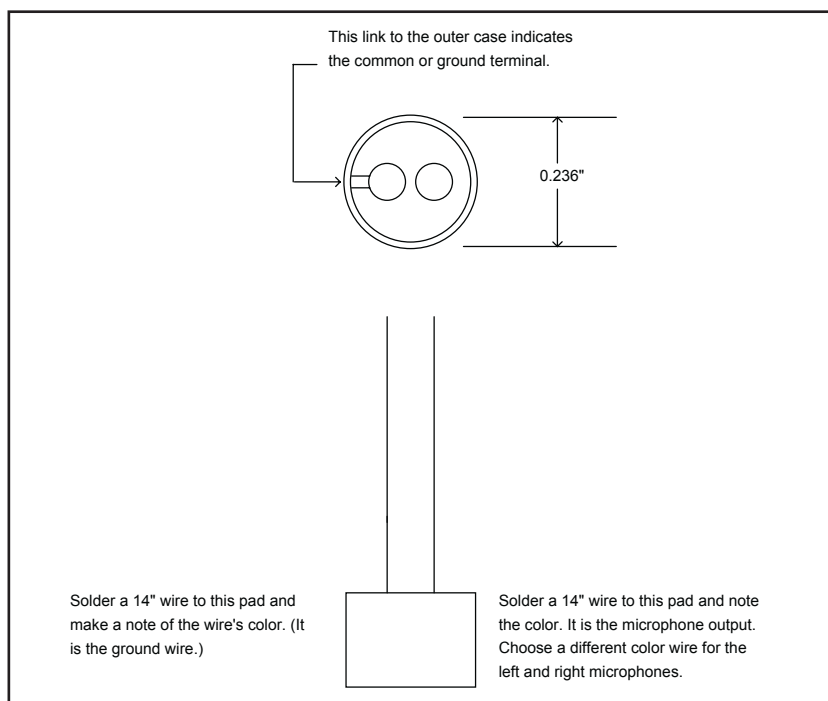


Figure 1: This shows how to connect the wires to the Panasonic WM-61A microphone cartridge for use in the HTRF head.

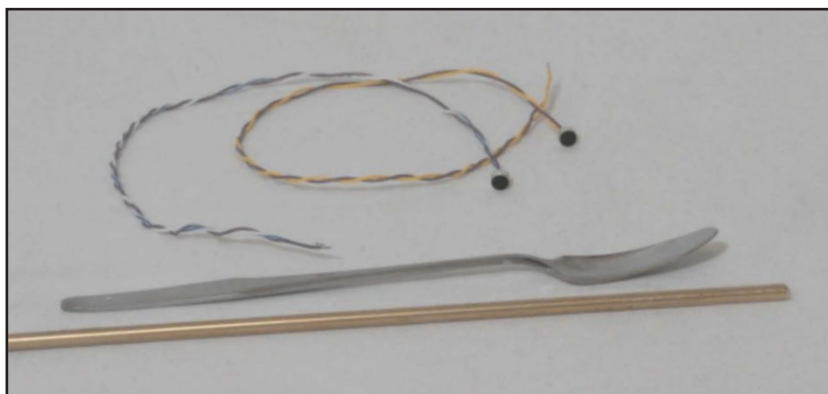


Photo 3: Panasonic WM-61A microphone cartridges with 14" twisted wires attached. Also shown are the modified iced-tea spoon used to extend the head's center hole and the sharpened 3/16" OD brass tube used to "drill" the ear holes for the microphones. The wires must be shortened before splicing them to the microphone cable but the 14" length makes it easier to fish them out through the center hole.



Photo 4: With the head upside down, slowly pour the liquid rubber mixture into the center hole until the level is about an inch from the top. This leaves space for the splices connecting the microphone wires to the shielded microphone cable. The rubber takes about 6 hours to cure. Part A is pink and Part B is blue so it's fairly easy to get them well mixed.



Photo 5: This photo shows the groove for the microphone cable easily made with a small, round jeweler's file. To get the size right, just lay the cable in the groove. The long microphone wires made it easier to fish them out through the center hole, but they must be cut to about a 2" length before splicing them to the microphone cable.

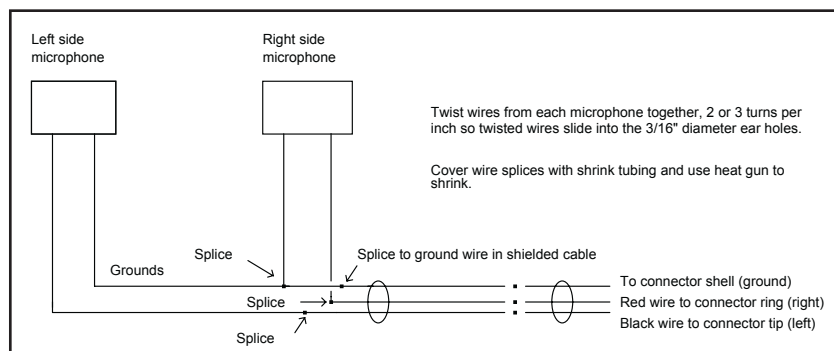


Figure 2: Connect the microphone wires to the shielded cable and the cable to the stereo phone connector.

liquid rubber in a later step. The painted Styrofoam in my model was soft enough to push each microphone assembly into the 3/16" diameter hole from outside each ear and also firm enough to hold it in place. The outer microphone surface should be flush with the Styrofoam surface or slightly indented but it should not protrude. (A later step will further stabilize the microphones and wiring with the liquid rubber.)

When the microphone assemblies are in place in the ears, carefully fish the four wires out through the central hole with a hooked piece of solid wire. Drape the free ends over the head base and secure them with a bit of masking tape. Leave them a bit loose so they don't pull the microphones any deeper into the Styrofoam. Check to make sure the microphones are still properly positioned.

## Adding the Liquid Rubber

For the next step, choose a bowl you can line with a soft towel that will hold the head upside down (see **Photo 4**). You will also need a disposable measuring cup. Refer to the Parts List and combine 2 oz. each of Liquid Rubber Parts A and B in the measuring cup. Put in 2 oz. of Part A and then add Part B for a total of 4 oz. Stir until well mixed. Then SLOWLY pour the mixture into the head's center hole. Pour about a half ounce and allow time for it to settle. Then another half ounce and wait... and so on until its level leaves about 1" of space for the wire splices. The mixed life of the liquid rubber is supposed to be 30 minutes but try to finish in 15 minutes or so because it does start to thicken. (You won't need all of the liquid rubber mix but it's difficult to accurately mix a smaller amount. As another indication of this dysfunctional world—you mix the two Parts by volume but the container contents are given in weight! Dow-Corning has some excellent flexible potting material but it's much more expensive than the suggested liquid rubber.)

Wait for the rubber to set, at least 6 hours, so leave the head upside down in the bowl. Check for leakage around the microphones. If you find any, carefully remove it and the protective "dot" with a hobby knife. (You might also have to retouch the paint in the ear when the rest of the project is completed.) Using a small, round jeweler's file, make a groove in the Styrofoam base from the center hole to the rear edge. The groove should be just large enough for the microphone cable, a 1/8" diameter if you use the cable listed in the Parts List (see **Photo 5**).

## Connecting the Wires

Refer to the **Figure 2** and connect the two ground wires together and to the ground wire in the microphone cable. Connect the two "hot" microphone wires to the microphone cable using shrink tubing



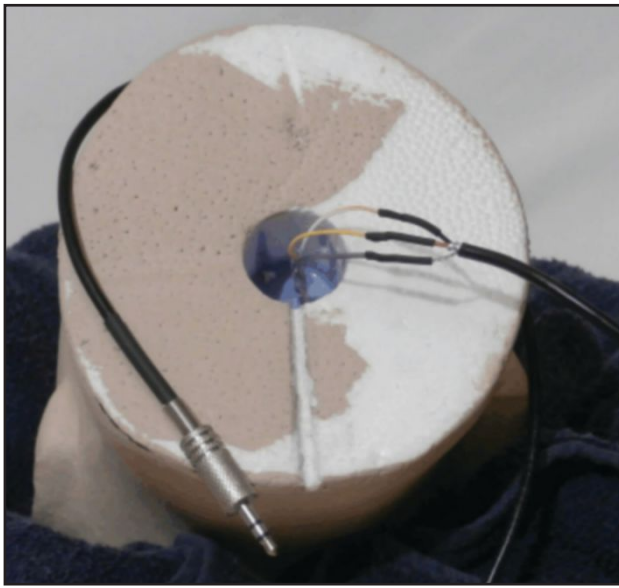


Photo 6: Strip about a 1/2" of insulation from both microphone ground wires and twist them together, then apply a light solder coat to the joint. Strip about a 1/4" from the other two microphone wires and from the two wires in the microphone cable. Tin all the bare ends. Slide three lengths of 3/32" shrink tubing over the microphone wires and solder the connections. Make sure the right-hand mic wire connects to the red wire in the cable and the left-hand mic wire goes to the black. Slip the tubing pieces over the joints and shrink them with your heat gun. Try to not melt any of the Styrofoam! This photo also shows the 3.5 mm stereo phone connector attached to the other end of the microphone cable. The suggested cable has a foil shield with a bare ground wire. The bare ground wire is soldered to the connector shell. The red wire goes to the connector ring (Right) and the black wire goes to the tip (Left).

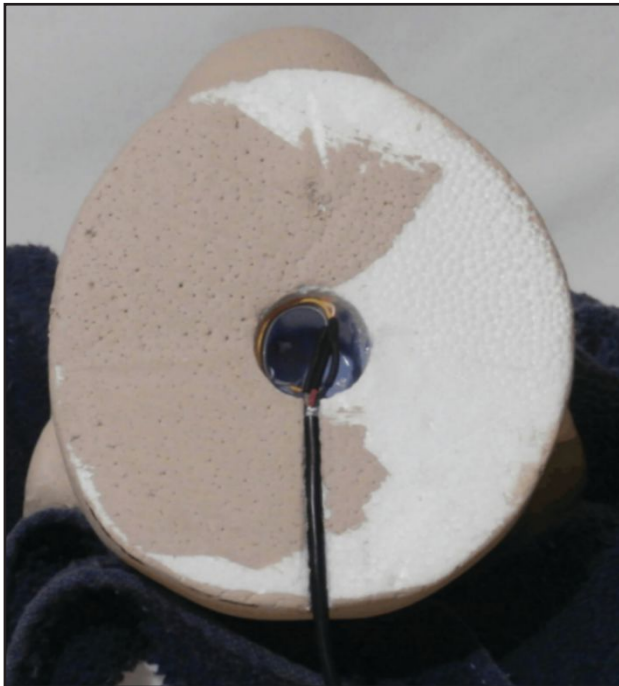


Photo 7: When the wires have been spliced, tuck them into the center hole and lay the microphone cable in its groove. The bottom plate, shown in Photo 8, is drilled and tapped and then cemented in place with construction caulking compound.

# MIC CAPSULES ALL TYPES

STOCK + CUSTOM  
Mic Capsules  
Housings + Mounts  
Lead Attachment  
Connectorizing  
Waterproofing  
Wind Screens  
Circuitry  
PCB Assembly  
Testing

Mic Assemblies  
For Any Purpose

Low Minimums

HOW MAY WE  
HELP YOU?

JLI ELECTRONICS  
215-256-3200

[www.jlielectronics.com](http://www.jlielectronics.com)

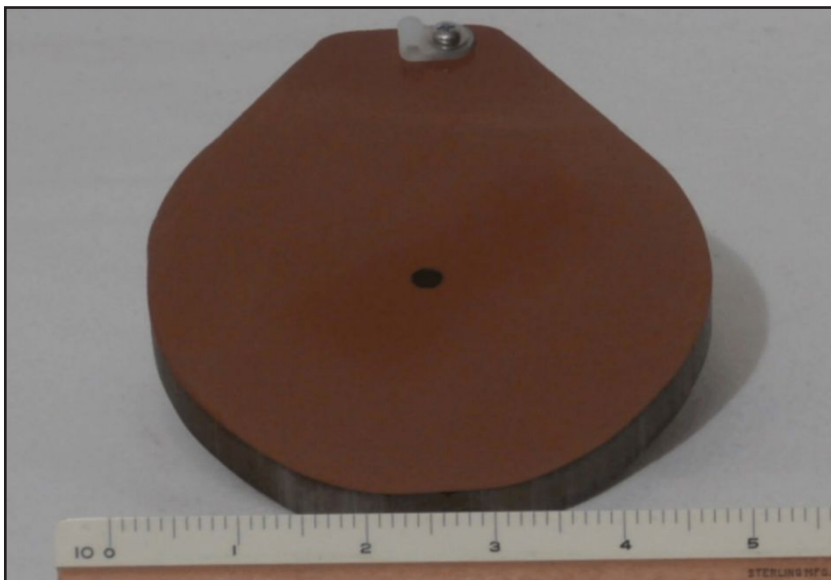
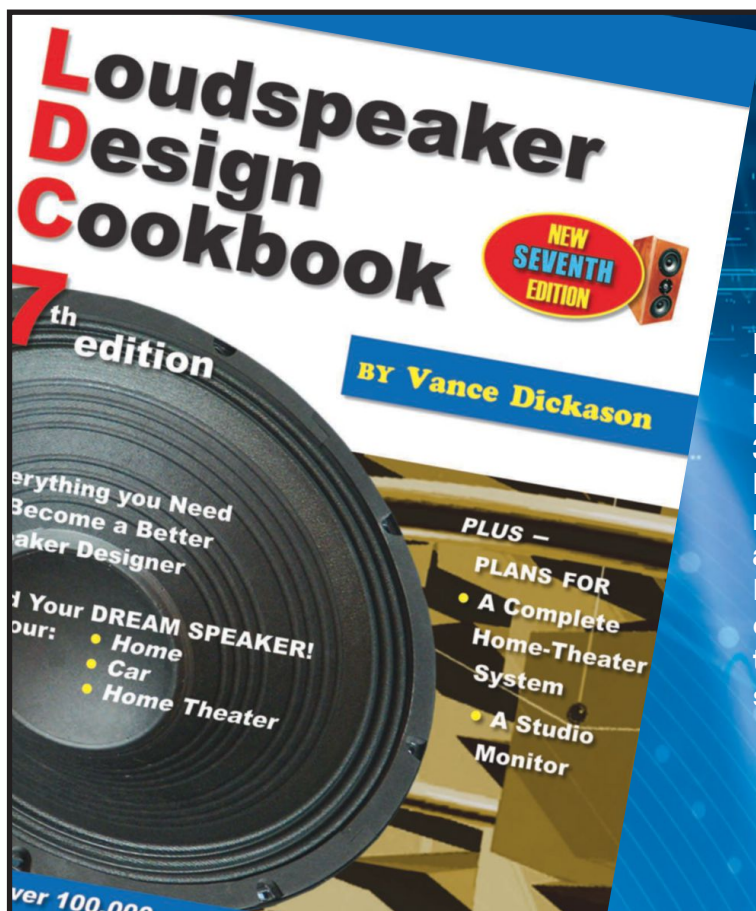


Photo 8: Place the nearly completed head on the Bakelite base and trace around the model with a fine-line marker. Cut to the line and smooth the saw cuts with a belt sander or file. As shown, leave a "projection" at the rear side for attaching the nylon clamp to anchor the microphone cable. Locate the base center (about 2-1/2" from each side and 2-3/4" from the front center), drill a # 7 hole and tap 1/4"-20 for a tripod mount. Drill and tap the hole for the nylon clamp as shown, for a 6-32 x 3/8" machine screw. The Bakelite surface is very smooth so lightly sand it for better adhesion.

on the wire splices (see **Photo 6**). Leave a bit of slack in the center hole wiring and lay the microphone cable in the groove you prepared in the step above (see **Photo 7**).

I suggest a bottom plate made from a 1/2" thick sheet of Bakelite, drilled (# 7) and tapped (1/4"-20) for tripod mounting and drilled and tapped for a 6-32 machine screw to anchor the microphone cable. Place the head model on the base plate and trace around it with a fine-line marker. Saw around the line and then smooth the saw cut with a file or, better, a belt grinder. Lightly sand the side of the bottom plate that will attach to the head's base for better adhesion (see **Photo 8**). I chose 1/2" thick Bakelite for the weight, the head model is very light, but 3/8" or even 1/4" thick would be okay and would cost a little less.

With the head still upside down in the bowl, apply some ordinary construction caulking compound to the head's base (as an adhesive) and then lightly press the base plate into position. Let it stand upside down for about 24 hours. Remove the head from the bowl and trim away any caulk that oozed out. Put the cable clamp on the microphone cable, position the clamp over its tapped hole and



## The "Must Have" reference for loudspeaker engineering professionals.

Back and better than ever, this 7th edition provides everything you need to become a better speaker designer. If you still have a 3rd, 4th, 5th or even the 6th edition of the Loudspeaker Design Cookbook, you are missing out on a tremendous amount of new and important information! **Now including: Klippel analysis of drivers, a chapter on loudspeaker voicing, advice on testing and crossover changes, and so much more!**

A \$99 value!  
Yours today for just \$39.95.

[www.cc-webshop.com](http://www.cc-webshop.com)



secure with a 3/8" 6-32 machine screw and #6 flat washer (see **Photo 9**).

Again referring to Figure 2, add a 3.5 mm, stereo phone plug to the free end of the microphone cable. The microphone cartridges in the head need 2 to 10 VDC for operation. This is supplied by portable digital recorders (e.g., the Tascam models) or by a stereo microphone preamplifier designed for electret condenser microphones (e.g., the TDL model 432 or a pair of model 411 mono preamps).

## Final Thoughts

Styrofoam is a bit difficult to work with but the steps can be successfully completed with patience. I have built two of these heads and the second one was easier because of what I learned from making the first one. I have tried to describe each step completely enough to make your project go well.

For best results, the microphone cartridges should be matched for sensitivity so you have a balanced output from the head. You can do this by purchasing at least 10 cartridges and measuring their sensitivity. For details on making the measurements, take a look at the articles available in the Supplementary Material on the *audioXpress* website. 



Photo 9: Allow 24 hours for the caulk to set, then trim off any leakage and attach the microphone cable to the base plate. Your HRTF head is ready for testing and use. Enjoy!

## Project Files

To download the Parts List and additional material, visit  
<http://audioxpress.com/page/audioXpress-Supplementary-Material.html>



### SB21SDC-C000-4

21 mm Large Surround Dome Tweeter

- Large surround dome for increased acoustic output.
- Dual balanced compression chamber for improved dynamics.
- Copper cap for reduced voice coil inductance and minimum phase shift.
- Saturation controlled motor system for low distortion.
- Non-reflective rear chamber with optimized damping for improved dynamics.
- Flow optimized vented pole piece for optimum coupling to rear chamber.
- CCAW voice coil for low moving mass.
- Long life silver lead wires.
- Low resonance frequency.



Find Us on :  
  SBACOUSTICS  
info@sbacoustics.com  
[www.sbacoustics.com](http://www.sbacoustics.com)

 Engineered in Denmark  
 Manufactured in Indonesia

## Ready, willing and Avel



**offering an extensive range of ready-to-go  
toroidal transformers  
to please the ear, but won't take you for a ride.**

 **Avel Lindberg Inc.**  
47 South End Plaza, New Milford, CT 06776  
p: 860.355.4711 / f: 860.354.8597  
[sales@avellindberg.com](mailto:sales@avellindberg.com) • [www.avellindberg.com](http://www.avellindberg.com)





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

**April 7–8, 2018**

**CanJam SoCal 2018**

**The JW Marriott Los Angeles,  
L.A. Live, Los Angeles, CA**

[www.head-fi.org](http://www.head-fi.org)

[www.canjamglobal.com/SOCAL2018](http://www.canjamglobal.com/SOCAL2018)

CanJam is a network of headphone and personal audio shows, produced by Head-Fi.org, the world's largest community for headphone and personal audio enthusiasts. Since 2006, CanJam SoCal has been a well-established event for one of the fastest growing segments of the audio industry, and is dedicated to everything that goes on and around our ears. CanJam's not only about headphones and in-ears, but also increasingly about all the audio players, preamps, and electronics that complete the experience. Featuring more than 100 leading brands in over 25,000 sq ft. of exhibition space, CanJam SoCal 2018 will showcase the latest products and innovations in headphones and personal audio electronics in all price ranges—from inexpensive earbuds to the world's finest headphone audio systems.



**April 9–12**

**NAB Show 2018**

**Convention: April 7–13**

**Las Vegas Convention Center (LVCC), Las Vegas, NV**

[www.nabshow.com](http://www.nabshow.com)

The NAB Show is where ground-breaking technology is unveiled, innovative solutions are displayed and game-changing trends are exposed. Prepare to explore aisle after aisle of awesome tech, cool gear, smart software, capable cloud solutions and limitless ideas and inspiration. Only here can you roll-up your sleeves and be hands-on with the products, services and people driving the future of content.

Explore niche solutions, emerging tech and like-minded professionals all in one-place with the Must-Visit Pavilions. The Innovation Pipeline Destinations are located in a dedicated area in North Hall. The three destinations spotlight future-focused technologies and solutions—from concept to prototype. And, with more than 1,700 exhibitors, don't miss the on-floor experiences. There are also dedicated theaters and stages on the show floor providing open-to-all education sessions on topical tech and trends.



**April 10–13**

**Prolight+Sound Frankfurt**

**April 11–14**

**Musikmesse**

**Frankfurt Messe Exhibition Center, Frankfurt Germany**

[www.musikmesse.com](http://www.musikmesse.com)

[www.prolight-sound.com](http://www.prolight-sound.com)

[www.messefrankfurt.com](http://www.messefrankfurt.com)

Prolight+Sound is four days fully packed with product launches, events, inspiration, and networking in two minutes: the new Prolight + Sound image film shows how exhibitors and visitors turned Frankfurt into the global hotspot for event and media technology in April. The event runs in conjunction with Musikmesse in Frankfurt, an international trade fair for musical instruments, sheet music, music production, and marketing.

For the first time, A3E (Advanced Audio + Application Exchange) is organizing an exciting professional-development program within the framework of the trade-fair duo. The "Future of Audio + Music Technology" conference on Friday, April 13, and illuminate subjects that are impacting decisively on the global music industry. A3E is a leading industry resource dedicated to the future of advanced audio applications and new music technologies. The conference will be held in English and admission is free of charge for all Musikmesse and



Prolight + Sound visitors.

Also, new for 2018, MerchDays, the meeting place for the entertainment merchandising sector, will be held for the first time within the framework of next year's Musikmesse and Prolight + Sound in Frankfurt. In cooperation with Aka Merch & Textil GmbH, the organizers of MerchDays, Messe Frankfurt will integrate the forum for the merchandising sector into its trade-fair duo for musical instruments and event technology. Thus, merchandising and fan-article suppliers will present their products and services in the Galleria 1 on April 12 and 13. MerchDays will be open to all visitors of Musikmesse and Prolight + Sound free of charge. Most recently, the two-day event was held concurrently with the c/o pop Convention in Cologne in August 2017.



**April 13–15**

**Audio Expo North America (AXPONA)**

**Renaissance Schaumburg Hotel &  
Convention Center, Schaumburg, IL**

[www.axpona.com](http://www.axpona.com)



AXPONA is the largest high-end audio show in North America. The three-day experience features multiple hotel floors packed with listening rooms, the Exhibit Hall featuring Ear Gear Expo and the Record Fair, seminars and live musical performances. The event also features more 150 high fidelity listening rooms, providing guests the enviable opportunity to experience the newest technology in high-end consumer audio products.

The success of AXPONA 2017 has created a high demand for exhibit space. The personal audio and headphone area, Ear Gear Expo, was previously sold out and AXPONA attendees have an insatiable appetite for vinyl and accessories.

To accommodate growing demand, Audio Expo North America is expanding the exhibit area for the 2018 show. The Marketplace and Ear Gear Expo will combine into one large Expo Hall within AXPONA's new venue, the Renaissance Schaumburg Hotel & Convention Center.

AXPONA is also introducing a new pavilion, The Record Shop within the Expo Hall. The Record Shop will be a centrally located pavilion where fans can shop for new and vintage vinyl, CDs, SACDs, and downloads and discover new artists.

AXPONA is known for featuring world-renowned companies and manufacturers, showcasing the most innovative products and services in the high-end audio industry. It is the place where manufacturers and dealers unveil their latest offerings, in a wide variety of price points and mediums. 60 new and innovative exhibitors will gather at AXPONA 2018 to introduce their newest offerings.

The following is a summary of first-time exhibitors that will be at AXPONA 2018, representing a number of product categories including amplifiers, cables, headphones, speakers, turntables, and much more:

Accent Speaker Technology, ACE Computers, Acoustic Research, ADVANCED, Asona, Bandwidth Audio, Bending Wave USA, Bluewave, Boenicke, Caprice Audio, Cayin, Clarus Cable, Clear Tune Monitors, Creative Sound Solutions, Dekoni Audio, Dynamique Audio, Earsonics, EarzAudio, Effect Audio, EINSTEIN Audio Systems, Eikon by Gayle Martin Sanders, Elite Audio Systems, Elite AV Distribution, EMU Systems, Fern & Roby, Gobel High End, HighEnd by Oz, iFi Audio, Kanto Audio, KirmussAudio, Kole Digital Systems, KRC Professional Audio, Lenbrook, Lindemann Audio, M&Co Electronics, Merging Technology, Orinda Acoustics, Parasound Products, Perfect Seal, Perfect Vinyl Forever, pNeuance Audio, Prana Distribution, PranaFidelity, Pro-Ject, Rainbow Audio, Reckless Records, Refined Audio, Rubert Neve Designs, SOTm, Stereo Haven, Studio Electric, Swan Song Audio, The Sound Environment, Timbre & Lucus USA, TRIANGLE Speakers, Western Electric and Zavfino 1877Phono.



Engineering Consulting for the Audio Community

Celebrating  
**35 YEARS**  
1983-2018

# MENLO SCIENTIFIC



- Liaison Between Materials, Suppliers, & Audio Manufacturers
- Technical Support for Headset, Mic, Speaker & Manufacturers
- Product Development
- Test & Measurement Instrumentation
- Sourcing Guidance

MENLO  
SCIENTIFIC

USA • tel 510.758.9014 • Michael Klasco • [info@menloscientific.com](mailto:info@menloscientific.com) • [www.menloscientific.com](http://www.menloscientific.com)



# NEW

## 2018 CATALOG

**SIGN UP  
TODAY!**

**FREE CATALOG**

parts-express.com  
or call  
1-800-338-05321

### The 2018 Parts Express Catalog is Here

Completely redesigned with a sleek new look and feel, you'll find the 2018 Parts Express catalog packed with the latest and greatest in audio solutions. Whether you're an integrator, OEM, speaker builder, or electronics enthusiast, let us be the single source for your next speaker project. Visit [parts-express.com](http://parts-express.com) or simply call 1-800-338-0531 to order your free copy today! **Plus SAVE \$5 off your next \$50+ order!** Use promo code: AXP28D. Offer expires 4/30/2018.

Parts Express – Making the World Sound Better Since 1986.

**Custom OEM  
inquiries welcome!**



725 Pleasant Valley Dr. Springboro, OH 45066

