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Lab Notes

IEEE Consultants' Network of Silicon Valley

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Audio & Electroacoustics

- *Consulting*
- *Design / Testing*
- *Training*

Volume 6, Issue 1 **March 2013**

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Inside this issue:

ANSI/ASA Hearing Aid Test Standards in Anaheim, CA

ANSI/ASA Working Group S3-48 on Hearing Aid Measurements will meet on 3 April 2013 at the Hilton Hotel in Anaheim, CA in conjunction with the Audiology NOW! Conference. I will be attending as a member of the working group and also in my capacity as Chair of Subcommittee 3 on Bioacoustics. There will also be a meeting of a newly formed subcommittee to discuss measurements of feedback cancelation systems in hearing aids.

Please contact us if you plan to attend Audiology Now! 2013 in Anaheim in April and would like to set up a meeting.

ALMA Winter Symposium 2013 Wrap

The ALMA Winter Symposium took place in Las Vegas 6-7 January 2013 at the Tuscany Suites. I gave a presentation entitled, *"An Introduction To Headphone and Headset Acoustics"*. The lecture was well attended, with an open discussion with several of the attendees afterwards.

News & Recent Developments

ANSI/ASA S3.36-2012

S3.36-2012 "American National Standard Specification for a Manikin for Simulated in-situ Airborne Acoustic Measurements" is now published. This standard is the culmination of a 16-month effort by the S3WG67 working group which I chair to revise and update the 1985 version of the standard. My thanks to all of the members for their efforts in making this happen.

The standard is available for purchase through ASA:

http://asastore.aip.org/shop.do?cID=9&pID=677

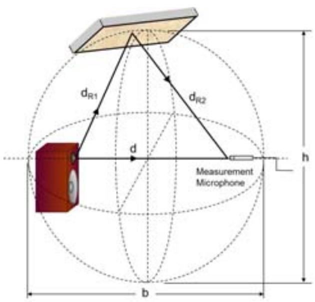
Please contact us and let us know how we can be of service to you and your organization.

Christopher J. Struck

CEO & Chief Scientist

CJS Labs

1-Day Electroacoustics Measurements Seminar



Materials for the one-day Electroacoustics Measurements seminar have been extensively revised and updated with additional slides on new topics. This seminar is available as an in-house or off-site format. A course outline is available on our website:

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Please contact us for more information.

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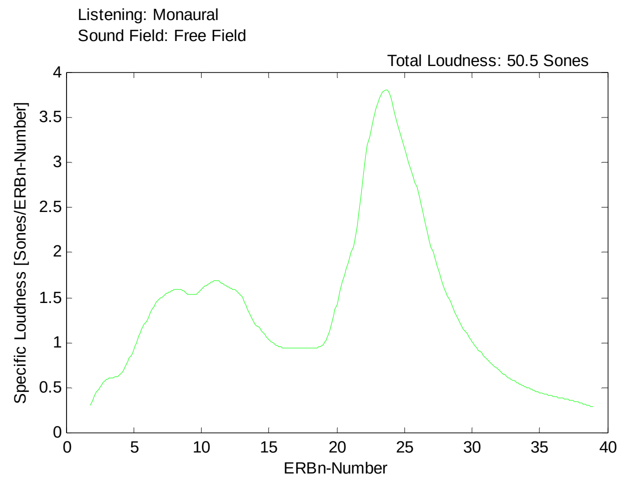
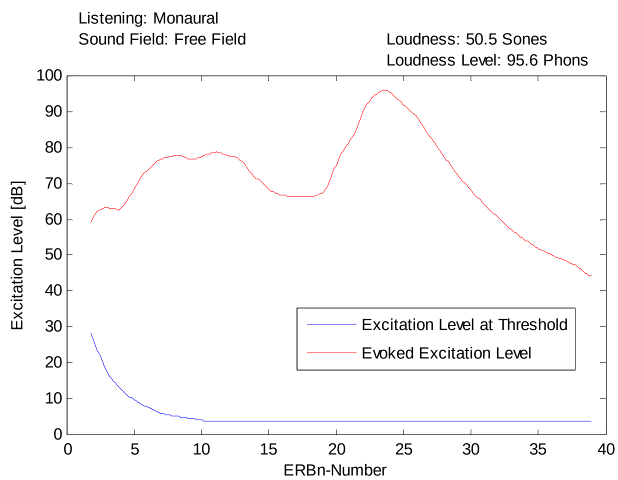
ANSI S3.4-2007 Loudness Calculation

Lab Notes Volume 2, Issue 3 described the ISO 532b Zwicker method for calculation of objective loudness. Although still in use, it has been largely superseded by the newer ANSI S3.4-2007 calculation, based upon the work of Moore, Glasberg, and Baer. The basic principles in the method are generally similar, however, a number of the intermediate computations and conversions have been modified to correlate more closely with more recent psychoacoustic data. Notable differences include a modified calculation of sones and phons at very low levels. Also, the Bark scale, the psychometric critical band frequency scale, is replaced by the ERB_N (equivalent rectangular bandwidth number) scale. The ANSI 3.4 calculation is indeed different from the ISO 532b method and should not be expected to yield the same results.

The ANSI S3.4 standard is accompanied by a DOS program (loud2006a.exe) for the calculation of loudness according to the standard along with several example scripts. CJS Labs has created a MATLAB script, which runs loud2006a.exe in batch mode, and provides a somewhat friendlier user interface that does not require the creation of formatted text input script files of command line data entry to run the program. Results are imported into MATLAB and plotted rather than returned to the DOS command line. In addition, the MATLAB script can take a calibrated *.wav file and perform the necessary 1/3 octave band analysis and feed the results to the loudness calculation. The MATLAB script can also take a 1/3 octave analysis file in Excel or ASCII (*.csv) or read a loud2006a script file. The user is prompted for any additional information, as needed (e.g., Free Field, Diffuse Field, or Headphone listening, headphone response correction file, Binaural, or Monaural listening). The batch mode of loud2006a has an option for providing the excitation and specific loudness data versus frequency or ERB_N. The MATLAB script plots this information.





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Volume 6, Issue 2 **June 2013**

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Inside this issue:

IEEE Test Standards in Santa Cruz, CA

The IEEE Subcommittee on Telephone Instrument Testing met 29 April—2 May 2013 at Plantronics in Santa Cruz, CA. The meeting was held in conjunction with TIA TR-41. The weather was excellent and the meetings were productive. We also had an interesting tour of the Plantronics facility.

Revision work on IEEE 269 is on-going, with a massive re-working of the entire document. The majority of the test methods will be retained, however, the document structure, references, and sub-clauses are all being re-written for improved clarity and readability. In addition, some obsoleted material and annexes have been removed.

The committee also decided to postpone integrating IEEE 1329 (Loudspeaking Telephones) until the next revision of IEEE 269 in 2014-15. The target is to have a document ready for ballot by the end of the year.

The TIA TR-41 group is also working on a major revision, combining the TIA 810 and TIA 920, standards (narrowband and wideband wireless, respectively) into a single unified document. Working is also on-going for this project and the completion date is not yet known.

If you are working in the telecom area and have questions about these or any other standards or test methods, please do not hesitate to contact us for further information.

News & Recent Developments

ANSI/ASA S3WG48

The ANSI/ASA Working Group S3-48 on Hearing Aid Measurements met at the Hilton Hotel in Anaheim in April in conjunction with the Audiology NOW! Conference. In addition to revision work on the S3.22 standard, there was also a meeting of the newly formed subcommittee on measurement of feedback cancelation systems in hearing aids.

ASA S3 Vice Chair Search

As Chair of ASA Subcommittee S3 on Bioacoustics, I am responsible for overseeing 24 working groups developing standards in this field. Our Vice Chair, George Frye, recently retired, so I am actively seeking someone qualified to serve out his term and possibly continue on in this role for an additional term. Persons interested in this position or wishing to nominate a qualified person are encouraged to contact myself or ASA for more information.

Please contact us and let us know how we can be of service to you and your organization.

Christopher J. Struck

CEO & Chief Scientist

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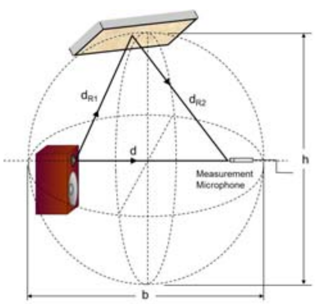
Electroacoustics Measurements Seminar



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Time Response Magnitude, the Hilbert Transform and Delay Measurements

Lab Notes Volume 3, Issue 4 introduced the Hilbert Transform and demonstrated its use for deriving the phase response from the magnitude response of a minimum phase system. A more common application of the Hilbert Transform is calculation of the magnitude of the impulse response of system.

Recall that the Hilbert Transform is a -90° phase shift to a signal. It can applied in either time or frequency domains, so the result remains in the same domain as the original signal. In the time domain

$$H[a(t)] = \tilde{a}(t) = \frac{1}{\pi}\int_{-\infty}^{\infty} a(\tau)\frac{1}{t-\tau}\,d\tau$$

$$= \frac{1}{\pi}\,a(t) \;*\; \frac{1}{t}$$

In general, this is easier to implement in the frequency domain as

$$\mathscr{F}\left[\tilde{a}(t)\right] \equiv A(f)(-j\,\mathrm{sgn}\; f)$$

where the *sgn* function changes an even function to an odd function (and vice versa). This in turn enables calculation of the so-called 'analytic signal' and envelope function

$$\overset{\nabla}{a}(t) = a(t) + j\,\tilde{a}(t)$$

$$= \left|\overset{\nabla}{a}(t)\right| e^{-j\theta t}$$

The impulse response magnitude is then easily calculated as

$$\left|\overset{\nabla}{a}(t)\right| = \sqrt{a^2(t) + \tilde{a}^2(t)}$$

This effectively creates a complex response from a real-valued signal. Without the negative values, the impulse or time response magnitude can be plotted on a logarithmic ordinate vs. time, for increased dynamic range, just like its frequency response counterpart. For a loudspeaker impulse response plotted in dB vs. *t*, this is sometimes referred to as the 'Energy Time Curve' or ETC. The peak in this response is the arrival time of the sound and can be used to set up a measurement or to align the delay between drivers in a multi-way system.

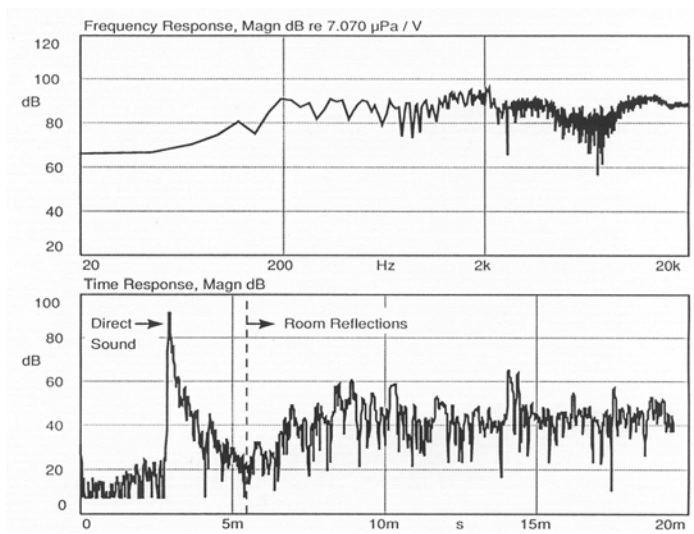

Fig. 1 Frequency and Time response of a loudspeaker measured in an ordinary room, with reflections.

In Fig. 1, the loudspeaker is clearly at 1m (2.92ms) and the room reflections corrupt the result starting at ca. 6ms, leaving a time window for the measurement of approximately 3ms, or an equivalent resolution of 333 Hz, without reflections.

Please contact us for more information.

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Volume 6, Issue 3 **September 2013**

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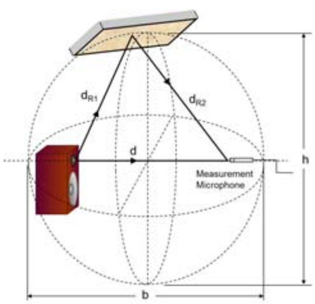
Inside this issue:

Electroacoustics Measurements Seminar



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Contact us to schedule an in-house training course for your organization.

AES 135th in New York City

The AES 135th takes place 17-20 October 2013 at the Jacob Javitts Center in New York City.

On 19 October 2013, at 9:00am, I will be giving a tutorial lecture in the Product Design session PD3 entitled "*Telephony: An Introduction to the Acoustics of Personal Telecommunications Devices* "

http://www.aes.org/events/135/productdesignsessions/?ID=3694

In addition, I will be Chairing the "P14 - Transducers - Part 2: Headphones and Loudspeakers" papers session on Saturday, 19 October from 2:30-6:00pm.

http://www.aes.org/events/135/papers/?ID=3603

At 5:00pm in this same session, I will also be giving a paper entitled:

"*Free Plus Diffuse Sound Field Target Earphone Response Derived from Classical Room Acoustics Theory*".

If you will be at the AES 135th in New York and would like to set up a meeting, please do not hesitate to contact us. Information about the AES 135th convention is available at:

http://www.aes.org/events/135/

We look forward to seeing you there.

News and Recent Developments

ASA 166th San Francisco

The 166th Meeting of the Acoustical Society of America will take place 2-6 December 2013 at Hilton Hotel, Union Square, right here in San Francisco, CA.

The program and technical sessions are widely varied, across many different fields in acoustics. There will also be tours of Berkeley and the newly relocated Exploratorium on the Embarcadero.

As Chair of ANSI Subcommittee 3 on Bioacoustics, I will be attending the plenary, accredited subcommittee, and ASACOS standards meetings the first three days of the conference.

If you will be attending the ASA 166th here in San Francisco and would like to set up a meeting, please do not hesitate to contact us.

Information about the ASA 166th Meeting is available at:

http://acousticalsociety.org/meetings/san_francisco

Please contact us and let us know how we can be of service to you and your organization.

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Intermodulation and Difference Frequency Distortion Measurements

In addition to traditional measurements of harmonic distortion, it is often advantageous to perform two-tone distortion testing when evaluating band-limited systems, particularly those incorporating electroacoustic transducers. **Intermodulation Distortion** is a two-tone test using a fixed low frequency tone (f_2) and a stepped or swept higher frequency tone (f_1). The level of f_2 is usually +12 dB relative to f_1 (SMPTE). For a non-linear system, the test produces distortion products at sum and difference frequencies as shown in Fig. 1.

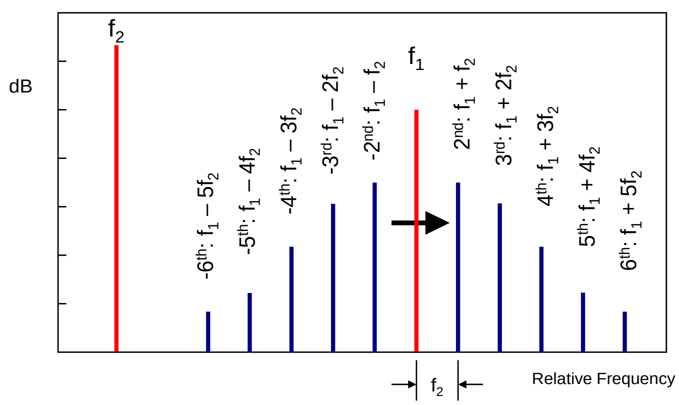

Fig. 1 Intermodulation Distortion products.

The distortion product "Order" is the sum of the absolute values of the coefficients. The sign (positive or negative) designates above or below f_1, respectively. The interval between the products is equal to f_2 and the IM distortion products follow f_1 as a group. The use of a very low f_2 can be used to force the distortion products to be within the pass-band of a band-limited system.

Difference Frequency Distortion is another two-tone test using two sinusoids at a fixed interval, stepped or swept in frequency. The level of f_1 and f_2 are usually equal. For a non-linear system, the test produces distortion products as shown in Fig. 2.

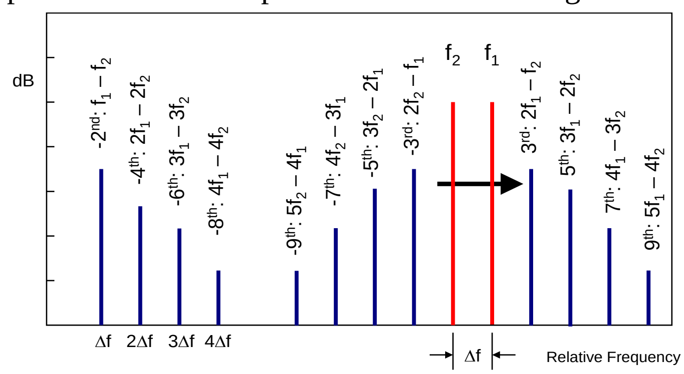

Fig. 2 Difference Frequency Distortion products.

The distortion product "Order" is the sum of the absolute values of the coefficients for odd orders and one-half the sum of the coefficients for even orders. Positive or negative designates products above or below f_2 and f_1. The interval between the products is Δf (the fixed or relative difference in frequency between the test tones). The odd order products follow f_1 and f_2 as a group, while the even order products are fixed at low frequencies. Some standards required a fixed Δf (e.g., 125 Hz). Otherwise, Δf may be set to force the even order products to be above the low frequency cutoff of the system.

A two-tone stimulus is, in some ways, a better approximation of speech, music, or other complex signals the system is likely to encounter in real use. Another advantage of Intermodulation and Difference Frequency Distortion measurements is that the generator and sinusoidal signals do not have to be of very high quality (i.e., low THD). Note that these tests are NOT time selective, so an anechoic chamber or near field techniques must be employed.

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Volume 6, Issue 4 **December 2013**

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Inside this issue:

Telephony & Headphones in New York

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I presented a tutorial lecture in the Product Design session entitled:

"*Telephony: An Introduction to the Acoustics of Personal Telecommunications Devices* "

There was a lot of interest in this topic, particularly for VoIP, Bluetooth and USB devices.

I also Chaired the Transducers - Headphones and Loudspeakers" papers session in which I also gave a paper entitled:

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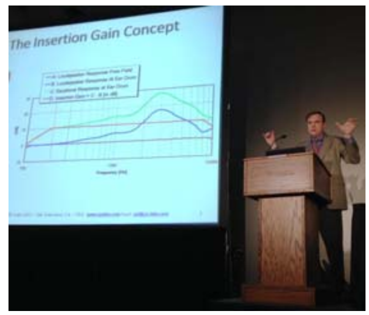
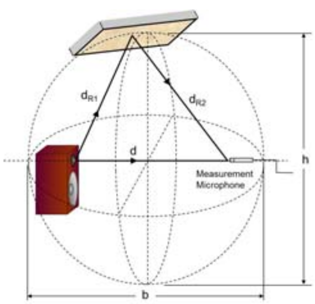


The paper and the lecture are posted to the secure area of our website. Contact us for log in information if you are interested in obtaining a copy.

Electroacoustics Measurements Seminar



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At the ASACOS meeting, I received an award from ASA Standards Director Paul Schomer for chairing Working Group 67, which published S3.36-2012: *Manikin for Simulated in situ Airborne Acoustic Measurements.*

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Happy New Year!

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Anechoic Chamber vs. Time Selective Measurements

In Vol. 4, Issue 2 (May 2011), we discussed correlated and uncorrelated noise errors as well as methods for mitigating these problems. For transducer testing, one of two methods is typically employed: Testing in an anechoic chamber or the use of time selective methods. In order to measure to sufficiently low frequencies, an **anechoic chamber** must be quite large – size being directly related to cost (see Fig. 1). The constraints are:

$$f_{MIN} = \frac{1.5c}{h} \Rightarrow h_{MIN} = 1.5\lambda$$

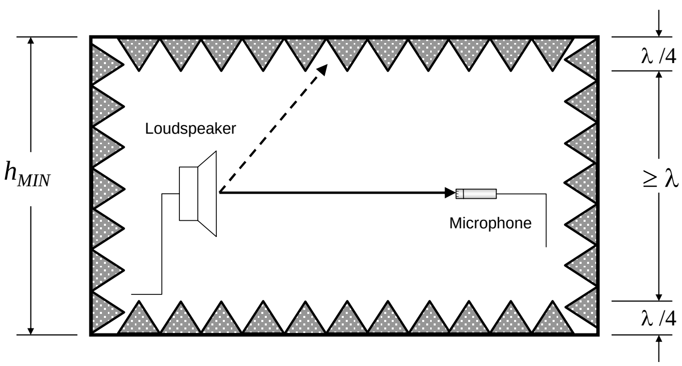

Fig. 1 Anechoic Chamber minimum dimensions.

For example, the minimum floor to ceiling height to measure down to 100 Hz is 5.1m, without wedges. In order to measure down to 20 Hz, the minimum floor to ceiling height would be 25.8m, and the depth of the absorptive wedges in this case is 4.3m! One advantage of a properly constructed isolated anechoic chamber is its very low noise floor, enabling very low level measurements to be performed. This is quite useful for two-tone distortion tests and microphone self-noise.

Time Selectivity is based upon the constant speed of sound. The direct sound always follows the shortest path and arrives at the measurement microphone first. Time delay and distance are therefore directly related: $\tau = d/c$. A Simulated Free Field is created by completing the measurement before the arrival of the first reflection. The *path length difference* between the direct sound and the first reflection is the available measurement time (Time Window). The reciprocal of the Time Window, *T*, is the Frequency Resolution, Δf.

$$f_{MIN} = \Delta f = \frac{1}{T}$$

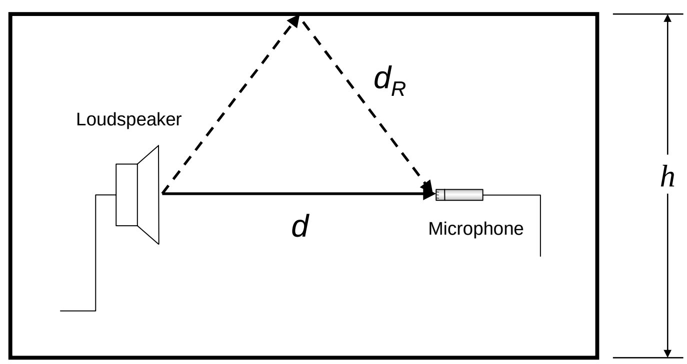

Fig. 2 Time selective test in an untreated room.

In the typical case where $d_R = 2\,d$, using the geometry of an ellipse, $d \approx 0.58h$, or *nearly the same as the anechoic chamber without wedges!* A detailed proof can be found in Struck & Temme, JAES 1991. Keep in mind that the frequency resolution is both the narrowest Q feature that can be resolved as well as the lowest frequency measured. But this is limited by either the time window or by the wedge absorption (unsuppressed reflections) - ultimately the *room size*.

Please contact us for more information.