CJS Labs

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Lab Notes

NCAC National Council of Acoustical Consultants Member

Volume 11, Issue 1 **March 2018**

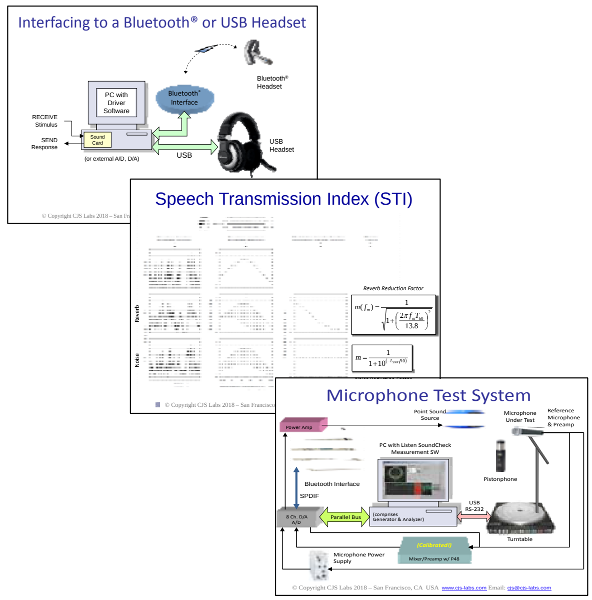
Electroacoustics & Audio

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

Inside this issue:

New & Updated Training Seminar Materials

Several of the classic CJS Labs training seminar modules have been updated with new material in order to keep up with emerging technology trends, including "Microphone Measurements" and "Headset Testing". In addition, we are now offering a seminar module for "Introduction to Speech Intelligibility Measurements" featuring all new material and focused on the IEC 60268-16 Speech Transmission Index (STI) method. Contact us for details.



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http://www.cjs-labs.com/training_seminars.html

Contact us to schedule a training course for your organization.

News and Upcoming Events

ASA 175th Meeting in Minneapolis

The Acoustical Society of America will meet in Minneapolis 7-11 May 2018. ASACOS and the ASA Standards committees will meet on Monday and Tuesday.

I'm chairing a Special Interdisciplinary Session on Thursday, 10 May entitled ***"Acoustical Standards In Action: Realization, Application, and Evolution"***, Session 4aID.

In this session, I will also be presenting *"An overview of the Standards Program of the Acoustical Society of America"*.

The session is 8:00 - 11:40 CDT and will be live streamed and recorded. Go to the ASA website for more information.

If you plan on attending the ASA Meeting in Minneapolis and would like to set up a time to meet, please contact us.

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

Christopher J. Struck

CEO & Chief Scientist

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Equalization of Sound Sources for Microphone Measurements

The response of a sound source used for microphone testing is not generally flat at all frequencies. Therefore, measurements must ensure that the response of the source does not appear in the response of the device under test. The most straightforward method is to perform a 2-channel measurement that simultaneously measures the output of the sound source and the output of the device under test. The desired frequency response is then the sound source channel divided by the reference microphone channel.

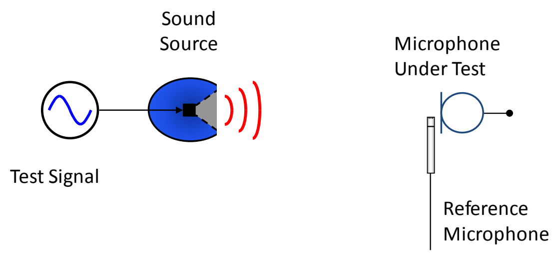

Fig. 1. Simultaneous 2-ch. comparison method.

This works with any signal, and handles changes in the source response. However, the test spectrum is not controlled and the reference mic and mic under test cannot occupy the same position. An alternative is to measure the response of the source and store it, substitute the device under test, and then divide the reference measurement out using post-processing.

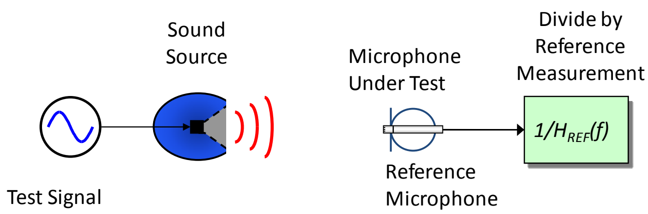

Fig. 2. Two-pass substitution method.

The same point in sound field is used for measurement and calibration, but again the test spectrum is not controlled and the calibration may need to performed frequently if the source is not stable. The most common method of regulating the sound source response is to perform a serial point-by-point measurement of the sound source and then use this data (inverted) to adjust its response during the measurement of the test object.

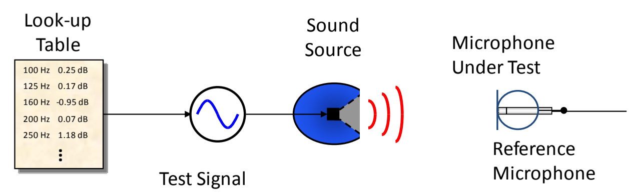

Fig. 3. Serial point-by-point compensation method.

This method only works for sinusoidal signals, but otherwise is the same as the substitution technique, except that the test spectrum is controlled. If it is necessary to the keep sound pressure constant, a compensating equalization (EQ) network with the inverse response of the sound source can be used.

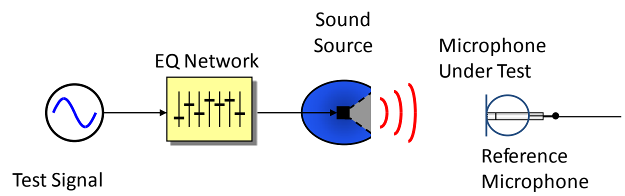

Fig. 4. Inverse filter method.

This method controls the test spectrum and can be used with any other technique, but the EQ may need to be adjusted if the source is unstable.

Please contact us for more information.

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Member

Volume 11, Issue 2 **June 2018**

Electroacoustics & Audio

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Inside this issue:

Christopher Struck Receives the ASA Fellowship Award

On May 9th, 2018, at the Acoustical Society of America 175th Meeting in Minneapolis, I was honored to be presented with the ASA Fellowship Award. The accompanying citation read: "For contributions to acoustical standards development and instrument design." Since standards work is necessarily a collaborative effort, I wish to thank the members of ASACOS as well as everyone participating in the ASA Standards Program.

Christopher Struck receiving the Fellowship Award from ASA President Marcia Isakson at the Minnesota meeting.

News and Upcoming Events

ASA 175th Meeting in Minneapolis podcasts of streamed sessions

Many of the sessions at the recent Acoustical Society of America meeting in were live streamed and recorded. The session I chaired on Thursday, 10 May (4aID) entitled *"**Acoustical Standards In Action: Realization, Application, and Evolution**"*, was recorded, including *"An overview of the Standards Program of the Acoustical Society of America"*. Please visit the

ASA streaming webpage

JOB OPENING: ASA Standards Manager

The Acoustical Society of America seeks qualified candidates for the position of Standards Manager to run the operational activities of the ASA Standards Office.

Details are available at:

https://acousticalsociety.org/standards-manager/

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

Christopher J. Struck

CEO & Chief Scientist

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CJS Labs is a consulting firm based in San Francisco, CA. We specialize in audio and electroacoustics applications. With over 30 years of industry experience in engineering and technology management, our areas of expertise include transducers, acoustics, system design, instrumentation, measurement and analysis techniques, hearing science, speech intelligibility, telephonometry, and perceptual coding. We also offer project management, technology strategy, patent & IP evaluation, and training services

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Microphone Proximity Effect as a function of Type and Distance & Noise Cancelling S/N

The 'Proximity Effect' manifests itself as a boost in the low frequency response of a directional microphone for sources close to the microphone. The polar equation of a first-order directional microphone is:

$$\rho = \alpha + \beta \cos \theta$$

with $$\alpha + \beta = 1$$

where α is the omnidirectional component, β is the dipole or bidirectional component, and θ is the angle of sound incidence. The omnidirectional element senses sound pressure equally from all directions while the dipole element senses pressure gradient and is therefore directionally dependent. Thus, all first order directional patterns can be created by a scaled sum of omnidirectional and dipole elements.

	α	β
Bidirectional	0.000	1.000
Hypercardioid	0.250	0.750
Supercardioid	0.366	0.634
Cardioid	0.500	0.500
Sub-cardioid	0.700	0.300
Omnidirectional	1.000	0.000

For sound sources in the far field, the driving force on the dipole is proportional to frequency. However, for sound sources close to the microphone, there is an added inverse square pressure difference which is constant with frequency that adds to the frequency-dependent pressure gradient. The inverse square component dominates at low frequencies and causes a rise in the output of the dipole element for decreasing frequencies. Figs. 1 and 2 show the on-axis response at several source distances for a bidirectional ('Figure of 8') and a cardioid microphone, respectively. The effect is primarily at low frequencies.

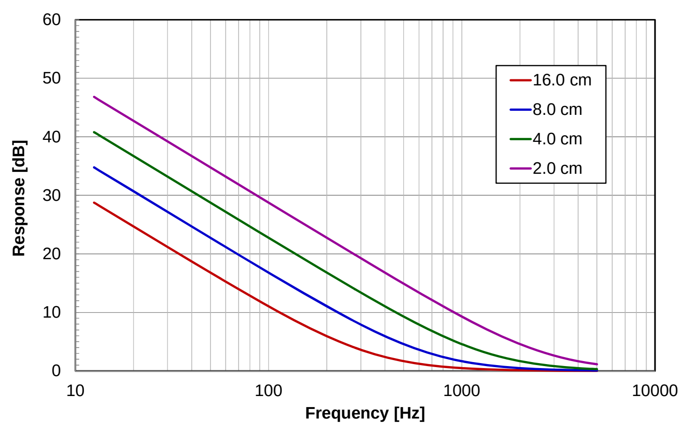

Fig. 1. Proximity effect—Bidirectional mic.

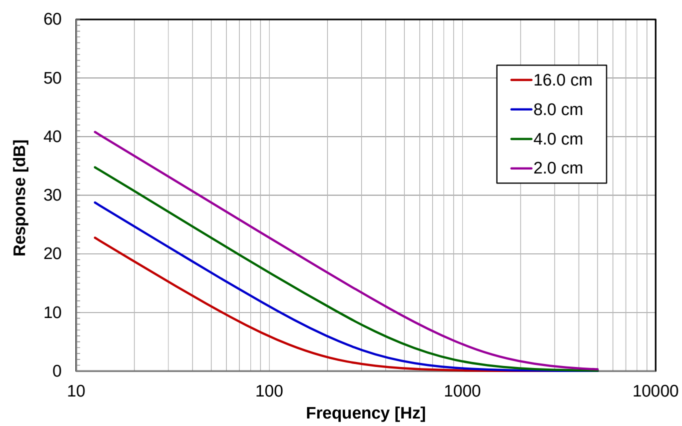

Fig. 2. Proximity effect—Cardioid mic.

This effect is leveraged in close-talking noise cancelling headsets. In fact, the signal-to-noise ratio improvement (close talking voice vs. far field noise) for a noise cancelling microphone is the same as the proximity effect plotted here.

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Volume 11, Issue 3 **October 2018**

Inside this issue:

IEC TC-29 Meets in Ottawa

IEC TC-29 met in Ottawa 24-28 September 2018. More than 60 delegates from 13 countries participated. I was Head of the US Delegation and participated in 4 working group meetings: WG5 on Microphones; WG13 on Hearing Aids; WG21 on Ear simulators; and WG on Modular Instrumentation. I was also named Convenor of MT25 to revise IEC 60263.A Joint *ad hoc* group was formed to align the Microphone, Calibrator, and Sound Level Meter standards.

News and Upcoming Events

AES New York

The AES 145th Convention takes place 17-20 October 2018 in New York City.
http://www.aes.org/events/145/

I will be presenting a tutorial entitled "**Telephonometry: The Practical Acoustics of Handsets, Headsets, and Mobile Devices**", Session AP02 on Thursday 18 Oct. at 4:30pm.
http://www.aes.org/events/145/acoustics/?ID=6220

Let us know if you will be there and would like to set up a meeting.

ASA Meeting in Victoria, BC—CANADA

The Acoustical Society of America will meet in Victoria, British Columbia 5-9 November. ASACOS, which I chair, will meet on Tuesday 6 November at 7:30am.

Please contact us if you are planning on attending, and would like to meet.

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

Christopher J. Struck

CEO & Chief Scientist

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Condenser Microphone Diaphragm Displacement

The typical condenser microphone consists of a thin metallic diaphragm, usually made of nickel or stainless steel, in close proximity to a rigid, charged metal back plate (see Fig 1). This forms an air dielectric

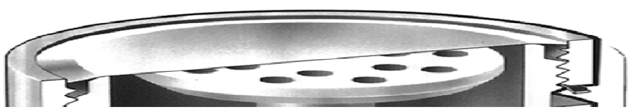

Fig. 1. Cross section of a condenser microphone showing the diaphragm and back-plate.

capacitor with a variable capacitance proportional to the (varying) distance between the diaphragm and the back plate. The tension on the diaphragm affects the microphone sensitivity and frequency response. For an omnidirectional microphone, the cavity behind the diaphragm is sealed and under constant pressure. A very small equalization vent prevents the diaphragm from rupturing due to large variations in ambient pressure. Sound energy impinging upon the diaphragm creates a pressure difference from front (outside) to back (inside) and causes the diaphragm to move in relationship to the fixed back plate.

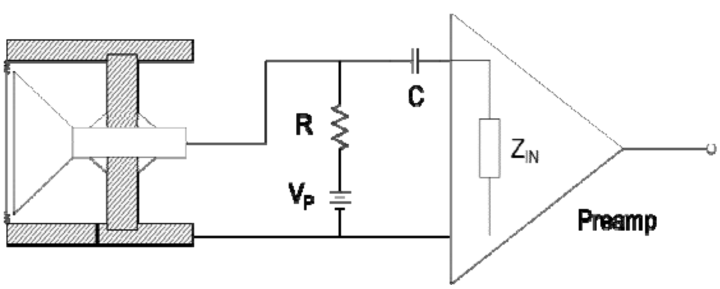

Fig. 2. Condenser microphone functional diagram

Diaphragm movement is converted into a varying voltage signal as

$$V = \frac{Q}{C} = \frac{Q}{\varepsilon\, S} \cdot d$$

$$\therefore \quad \Delta V = \frac{Q}{\varepsilon\, S} \cdot \Delta d$$

where

V = voltage
Q = charge on back plate
C = microphone capacitance
ε = dielectric permeability
A = surface area of diaphragm
d = distance between back plate and diaphragm

The linear relationship is valid as long as the movement of the diaphragm is small and the charge is constant, i.e., no current flow. Constant charge is obtained with a high polarization voltage (V_P = 200V) connected through a very high resistance. A coupling capacitor blocks the DC polarization voltage, leaving only the AC acoustic signal, which is linearly proportional to the input. The preamp must be located very close to the mic capsule, due to the extremely high output impedance of the mic. The preamp also transforms the output to low impedance, so a long cable can be used.

For an input of p = 1 Pa, the diaphragm displacement of a 1/2 inch microphone with a sensitivity of S = -38.5 dB V/Pa can be calculated as

$$\Delta d = \frac{S \cdot p \cdot d}{V_P} = \frac{12.5\,\mathrm{mV/Pa} \times 1\,\mathrm{Pa} \times 20\,\mu\mathrm{m}}{200\,\mathrm{V}} = 1.25\,\mathrm{nm}$$

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AES Headphone Technology Conference San Francisco, CA — 27-29 August 2018

I am co-chairing the AES Headphone Technology Conference which will be held 27-29 August 2019 here in San Francisco at Golden Gate Club in the historic Presidio .

The Paper and Workshop submission sites are now open. More information is available at:

http://www.aes.org/conferences/2019/headphones/

News and Upcoming Events

Fundamentals of Electroacoustics—Santa Clara, CA

In conjunction with Listen, Inc., I will be presenting the 1-day ***Fundamentals of Electroacoustic Measurements*** training course on

Monday 4 February 2019

in Santa Clara, CA. Spaces are still available.
Info and registration details are available at:

https://www.listeninc.com/west-coast-training-extravaganza-feb-4-8-2019/

History of ASA Standards

A paper I co-authored about the ASA Standards program was just published in JASA. The history of the ASA Standards program going back to the formation of the Society in 1929 is detailed, including the contributions of my venerable Standards Director predecessors. It is freely available on-line, including PDF download:

https://asa.scitation.org/doi/10.1121/1.5080329

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Probability Density Functions of Common Audio Test Signals

In addition to RMS level, peak, and crest factor, a signal may also be described by its statistics. The Probability Density Function (PDF) specifies the relative likelihood of the instantaneous time signal being within a particular range of values. PDFs for several common signals are shown.

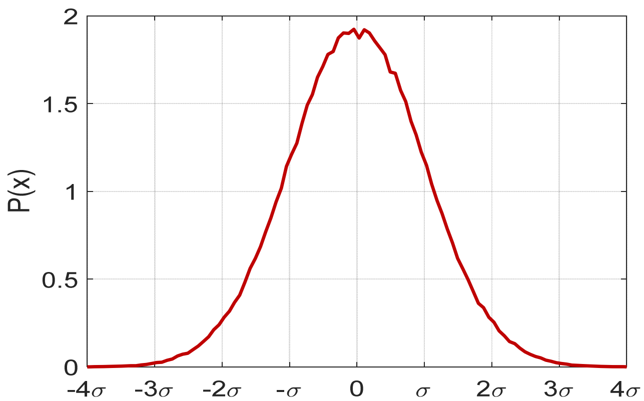

Fig. 1 Pink noise.

This is a random signal and exhibits the familiar Gaussian distribution. Pseudo random noise has the same distribution, as it is composed of short repeated segments of random noise.

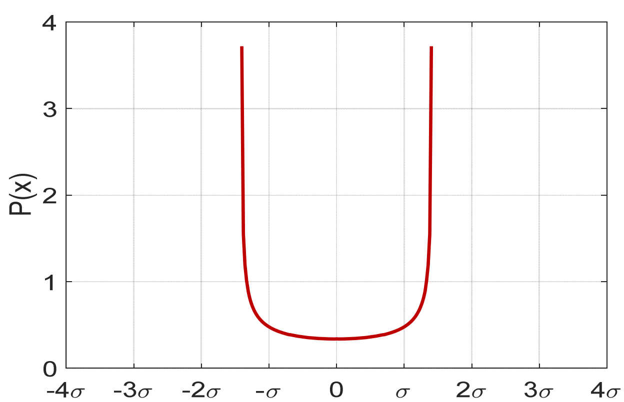

Fig. 2 Sine wave.

In contrast, the sine wave probability is highest at the positive and negative peaks (sometimes called 'bimodal').

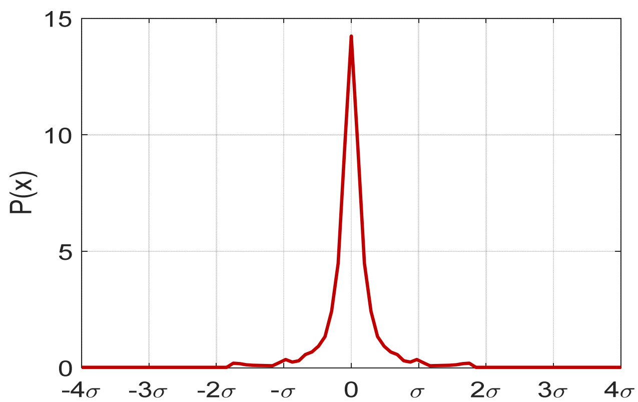

Fig. 3 32-frequency multi-tone signal.

For this signal, the distribution is narrow about zero.

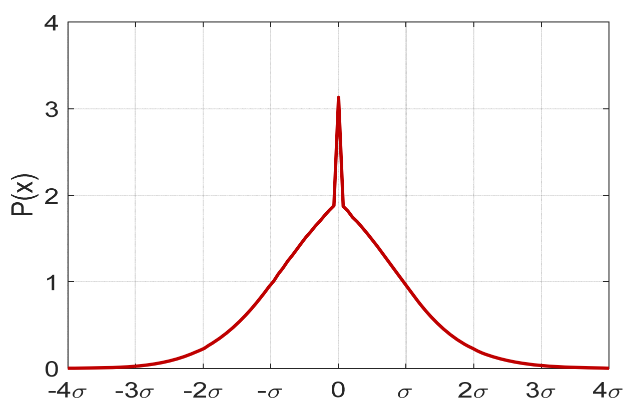

Fig. 4 Music signal (One After 909—The Beatles).

The height of the flanks of the music PDF can vary depending upon the specific signal, but the overall shape always appears similar.

Please contact us for more information.