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Lab Notes

IEEE CNSV

NCAC National Council of Acoustical Consultants Member

Electroacoustics & Audio

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

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Inside this issue:

ISEAT 2017—Shenzhen, China

In November, I presented a Master class on loudspeaker design and the closing keynote lecture entitled ***"Why Is Headphone Audio So Poor, and What Can Be Done About It?"*** at the ISEAT 6th International Symposium on Electroacoustic Technologies in Shenzhen, China. Both presentations were well received. I had excellent support from the organizer, Prof. Yong Shen, of Nanjing University, his student, Hongyi Zhu, and the ISEAT staff.

News and Recent Developments

AES 143rd New York

In October, I attended the AES 143rd Convention October in New York City. In addition to the exhibition and papers, I presented a tutorial entitled "***Headphones, Headsets & Earphones: Electroacoustic Design & Verification***". I included new material on testing wireless devices. Not surprisingly, there were a lot of questions afterwards.

ASA 174th Meeting in New Orleans

The Acoustical Society of America met in New Orleans in December. I chaired 2 standards meetings and co-chaired a Special Session entitled ***"Standards: Practical Applications in Acoustics"***. I also made two presentations: *"An overview of ANSI/ASA S3.7-2016: Method for measurement and calibration of earphones"* and *"Measurement uncertainty and its application to standards in acoustics"*. The session was live streamed and recorded. The recorded presentations are available at:

https://attendee.gotowebinar.com/register/3937864997797067522

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

Happy New Year!

Christopher J. Struck

CEO & Chief Scientist

CJS Labs

Training Services

CJS Labs offers customized in-house training. Our design experience, proven processes, and measurement expertise will make your product development more efficient. Learn how to optimize both your designs and test routines. Having a thorough understanding of fundamentals, correct terminology, and proper techniques will also enable you to make more informed decisions and communicate more effectively with your customers and vendors as well as within your own organization. Understand why certain failure modes are problematic, even if they are not obvious or audible. Sample course outlines and details are available on our website:

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

Contact us to schedule a training course for your organization.

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Efficiency Bandwidth Product for Loudspeaker Drivers

Richard Small, in his seminal JAES papers laid out the mathematical foundation in engineering terms for the design of closed box, ported, and passive radiator systems. The parameters of the simplified lumped parameter electro-mechano-acoustic circuit model bear his name along with that of Neville Thiele, who's work Small's papers is based upon. These have long been a *de facto* industry standard.

The parameters may be measured on a given driver using a variety of methods (e.g., added volume, added mass, SPL sensitivity plus electrical impedance, or laser velocity plus electrical impedance). Many manufacturers provide this data on their specification sheets as well with their samples (see Fig. 1).

Parameter	Symbol	Value	Unit
Driver Surface Area	S_D	83.32	cm²
Voice Coil DC Resistance	R_E	3.71	ohms
Resonant Frequency	f_S	87.22	Hz
Impedance Maximum at Resonance	Z_{MAX}	36.34	Ω
Impedance Minimum	Z_{MIN}	3.75	Ω
Mechanical Quality Factor	Q_{MS}	7.526	
Electrical Quality Factor	Q_{ES}	0.857	
Total Quality Factor	Q_{TS}	0.769	
Equivalent Compliance Volume	V_{AS}	3.17	liters
Mechanical Compliance	C_{MS}	0.3261	mm/N
Mechanical Effective Moving Mass	M_{MS}	10.21	grams
Mechanical Damping	R_{MS}	0.7435	N·s/m
Magnetic Flux Density · Coil Length Product (Force Factor)	Bl	4.93	T·m
Voice Coil Inductance	L_E	0.058	mH
Efficiency	η_0	0.237	%
Sensitivity		89.2	dB SPL at 1m

Fig. 1. Thiele-Small parameters for a driver.

In addition to modeling the small signal behaviour of the loudspeaker system, the suitability of a particular driver for use in a closed or ported system can be determined by its parameters.

The Efficiency Bandwidth Product (EBP) is calculated as

$$EBP = \frac{f_s}{Q_{ES}}$$

or, simply the quotient of the resonant frequency and the electrical quality factor.

In general, drivers with an EBP < 60 are best suited for use in a closed box system. The more compliant suspension is supplemented by the stiffness of the air in the enclosure to provide additional restoring force — the force required to bring the driver back to its zero displacement rest position when the input voltage crosses through zero.

Drivers with an EBP > 90 are best suited for use in a ported box (or band pass) system. In this case, since the enclosure is open to the outside, a stiffer suspension is required, as the driver must supply its own restoring force.

Drivers with an 60 < EBP < 90 provide flexibility with respect to the choice of closed box vs. ported / band pass enclosure, but are not optimum for either.

If the EBP is not provided with the other parameters, it is usually the first step in the design process in order to evaluate the driver, particularly if a particular system design is required.

Please contact us for more information.