THE TAA ACOUSTIC LABORATORY

by **GIULIANO NICOLETTI**

The main objective of every researcher dedicated to the study of audio reproduction devices is undoubtedly that of establishing direct relations between instrumental measurements and subjective listener perceptions.

This is an extremely complex task for various reasons: above all one has to make the results of subjective listening tests reliable in order to build a valid track to act as a referral point during technical analysis. The measurements, on the other hand, must be able to describe the qualitative aspects that are seen in different spheres. Common technical terms in the language of the acoustic reviewer, such as the breadth of the image, sensations of naturalness, contrast, dynamics, and tones, all refer to phenomena that are shown in different analysis domains: the system transfer function for different radiation angles (and thus sound power response), acoustic and mechanical resonance, nonlinear distortions, interfacing with the amplifier and listening environment. That which the ear – and the brain – perceives as "one," a sensation which develops when one is listening in a natural spontaneous way, has to be broken down by technical analysis into different subgroups – relating to the mixed nature of the event – and successively reintegrated to furnish an overall picture that can identify coherent and repeatable evaluation parameters (the basis of technical analysis). In the case of a measurement setup to be published on the pages of a magazine with a wide circulation (rather than in a te-

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"...bearing in mind always that evidence that offends the eye may or may not indicate the presence of a problem that is offensive to the ear."
Floyd E. Toole

chnical, highly specialized paper), everything needs to be clear and easy to understand, in order to supply the utmost support to the reader who, we have to bear in mind, must not be required to possess the specific competences of a specialized technician.
Last but not least, **The Absolute Audiophile**'s graphic presentation is profoundly different from that of a printed magazine and this will therefore allow the breaking away from the limitations and restrictions typical of a rigid layout, to resolve in a creative and dynamic manner, the various demands that may arise every time.

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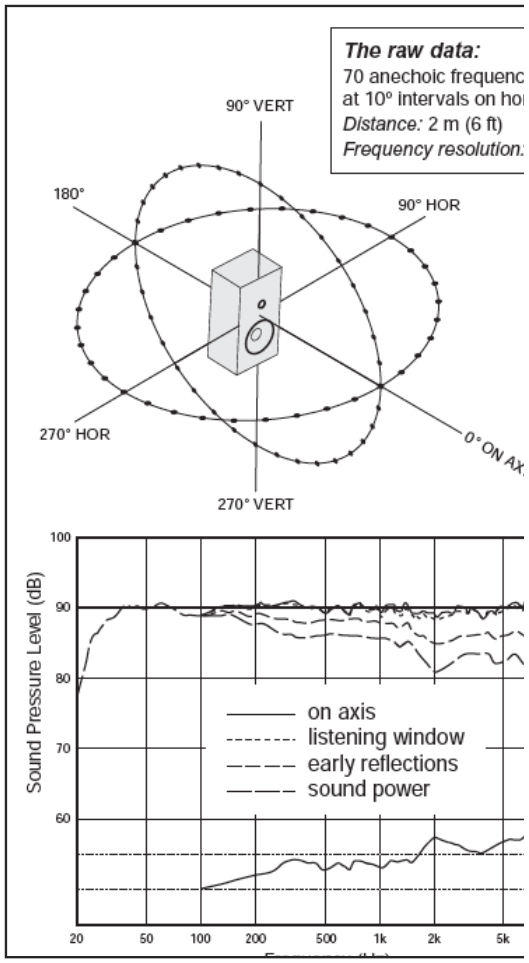
Standard measurements setup

The analysis of the loudspeakers' transfer functions – the classic frequency response, is the starting point for the analyses to which the loudspeakers will be subjected to and which will be passed under the tools of the measuring section. The most widespread setup in sector magazines usually consists in the measurement of on-axis response, in some (rare) cases equipped with measurements at various vertical and horizontal angles: this type of analysis is completely insufficient to correctly valuate the transfer function of loudspeakers, and to establish a useful relationship with subjective perception during the listening phase.
As highlighted in the precious research work of Floyd Toole in [1], Sean Olive in [2] and Allan Devantier in [3], to obtain coherent indications on the transfer function of an loudspeakers the analysis of the polar emission diagram has to be deepened, mapping out the emission areas and calculating the spatial mean of the results.
We shall therefore present an average response of the di-

Over the last years we have been witnessing an alarming race towards the lowering of impedance in commercial speakers

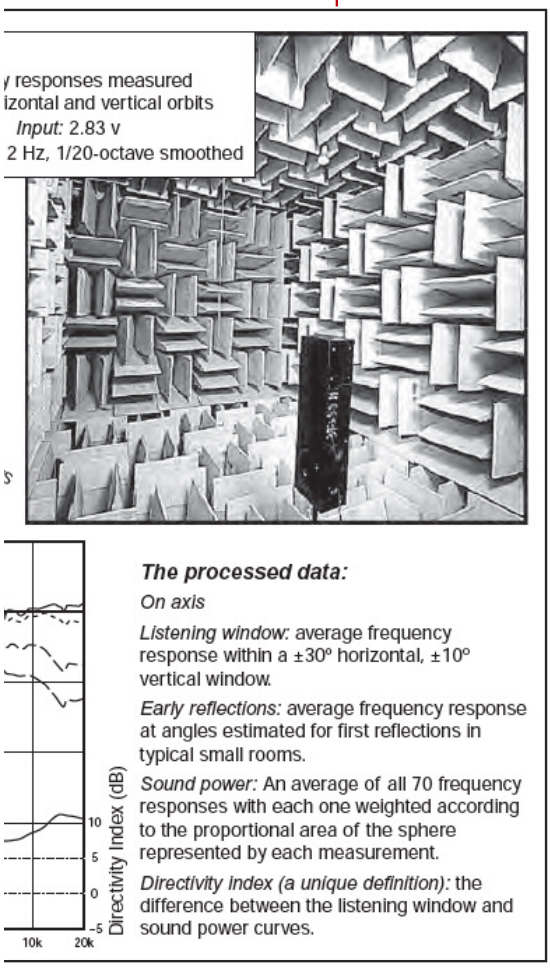
rect sound perceived by the listener, mapping out a relative zone of about +/- 20 emission degrees on the horizontal axis, and e +/-10 degrees on the vertical one: this mean – reasonably representative of the listening window – makes less evident the response fluctuations due to acoustic interactions of the paths and to the diffractions on the edges of the panel, and shows a trend directly comparable to the basic tone characteristics perceived subjectively.
This analysis will moreover be deepened by the measurement of the mean of emissions representing the first reflections in the ambient and of the response in sound power. The difference between the response in the listening window and the sound power will ultimately allow the obtaining of the directivity index of the diffuser being tested, one of the more interesting indicators of the homogeneity of emissions in the ambient, the system's resonances and the spatiality characteristics perceived subjectively.

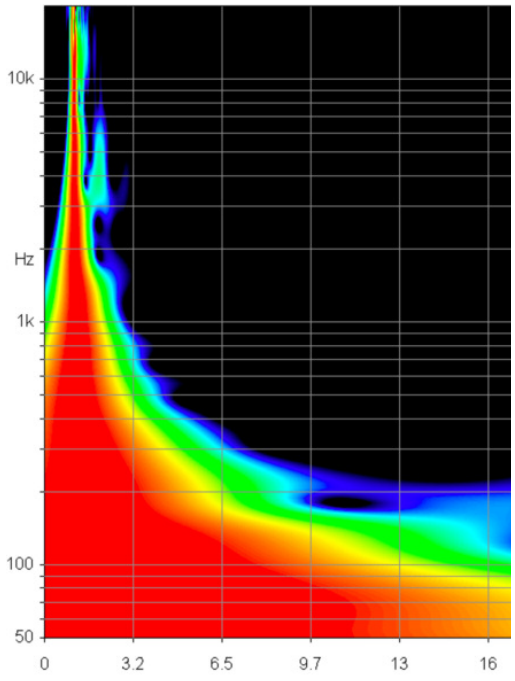
Devantier's analysis in [3] was performed with 70 response tests in an anechoic chamber with extensive response up to 20 Hz and an acquisition window of 500 ms (Figure 1, courtesy of Harman International); in The Absolute Audiophile's technical labs we are completing a procedure that will allow us obtain important comparative results in face of the need to simplify the setups. The first results are very encouraging, and urge us to carry on in this direction.



Harman International data collection system

The sensitivity value of the loudspeaker under analysis will be measured from the mean value of the SPL ranging between 200 Hz and 12 kHz shown on the response graph of the listening window, more representative of the SPL sensation perceived when listening. This data will obviously be compared with the classic mesurament of impedance module and phase of the loudspeaker system. Over the last years we have been witnessing an alarming race towards the lowering of impedance in commercial diffusers: we shall reserve in-depth studies on this issue, analyzing the relationships and the interfacings between power amplifiers and loudspeakers, and clarifying notions regarding Ohm, Watt, dB SPL and distortions in voltage and electricity.
As an offshoot to the transfer function analysis of the complete diffuser, the Wavelet Transformation on impulse will be performed, obtained from the measurement on the emission's main axis. Unlike the classic Cumulative Spectral Decay measurement shown through the Waterfall chart, the Wavelet Transformation gives important information on the entire development of the impulse with a compromise between temporal and frequential resolution very much like the behavior of the human ear with respect to the fixed windows of the Waterfall. The resulting chart gives a clear view of the system's capacity to dispose of the energy furnished by the impulse and the possible resonances that may be prolonged with time.



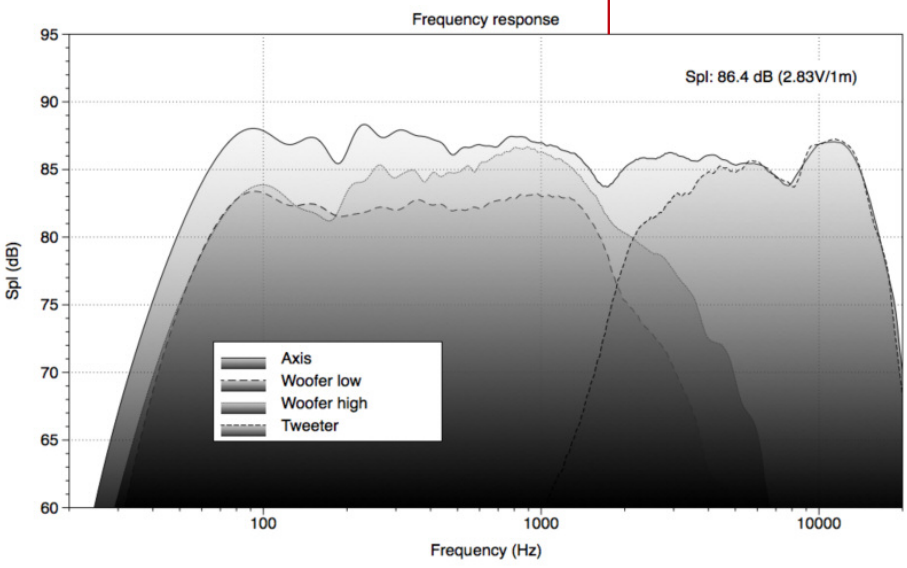


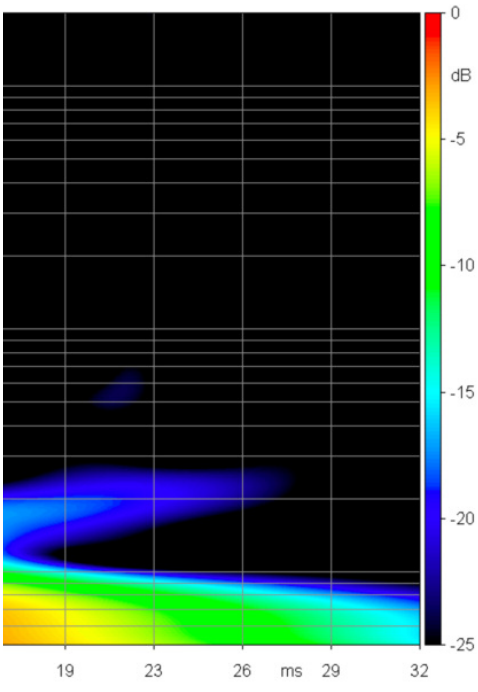
Wavelet Chart

In the evaluation of the more interesting cases, we shall proceed with the analysis of the single emissions of the loudspeaker's components, measuring the transfer function, relative acoustic phase, and acoustic interaction modes in relation to the diffuser's polar emission graph and the characteristics perceived subjectively. It will moreover be interesting to deepen the design modes of the crossover filters (through the study of the implemented schematics) which will show us a bit more with regard to the intention of designers and the way of interpreting this particular discipline which is so complex and fascinating.

Transfer functions of the single components of three-way loudspeaker system.

In a standard measurement setup there will certainly be also a measurement of distortion, carried out through a multi-tone signal at two different SPL levels. The multi-tone signal is very much like the musical signal, generating harmonic distortions and intermodulations and giving important, easily read information on the behavior of the system during tests. Our reference for this type of analysis is the

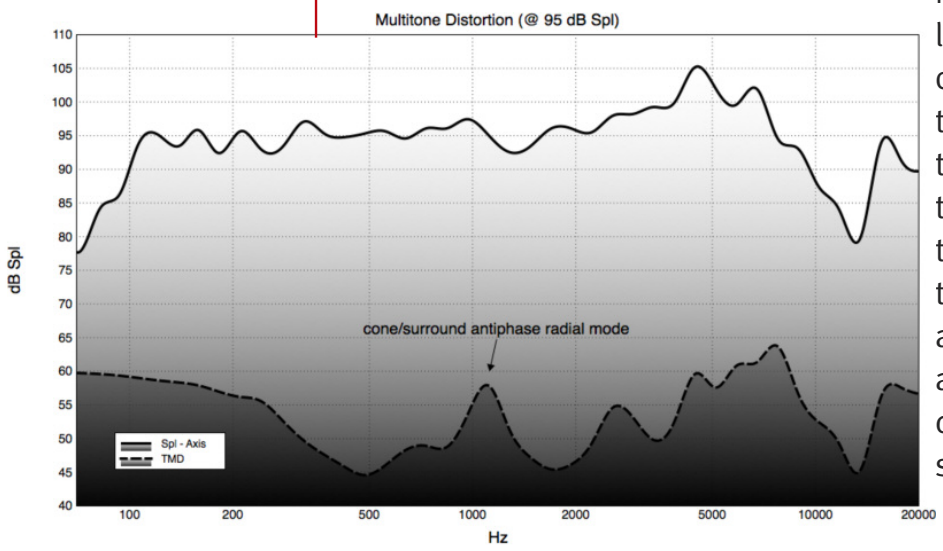




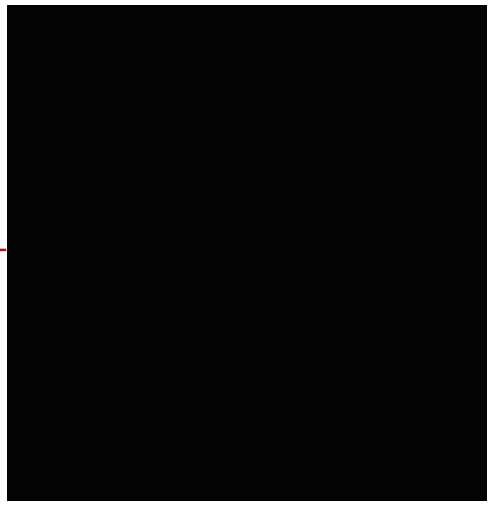
work achieved by Eugene Czerwinski, Alexander Voishvillo, Sergei Alexandrov and Alexander Terekhov in [5]; as of now we are developing a simple, comparable graph which can give us an immediate indication of the signal-to-noise ratio of the loudspeaker being tested, and to set it in direct relation with other products analyzed. The use of the LPM module of Klippel's Distortion Analyzer will allow us furthermore to identify the factors of the more classic non-linear distortion, such as those produced by the factor Bl(x), the Cms(x) compliance, the Le(x)inductance, the Doppler effect and the system's break-up resonance, as described by Wolfgang Klippel himself in [6] and [7].

TMD Distortion Chart

Still with the use of the Distortion Analyzer we shall have the chance to focalize our attention on the typical characteristics of the speakers used in loudspeaker tests, as described by Wolfgang Klippel himself in [7], [8]. This inalienable measuring instrument allows for the identification of the most classic distortions of the nonlinearity typical of electrodynamic transducers, to establish the parameters that limit the dynamic performances and verify the correctness and functionality of the choices made in the design phase. The different



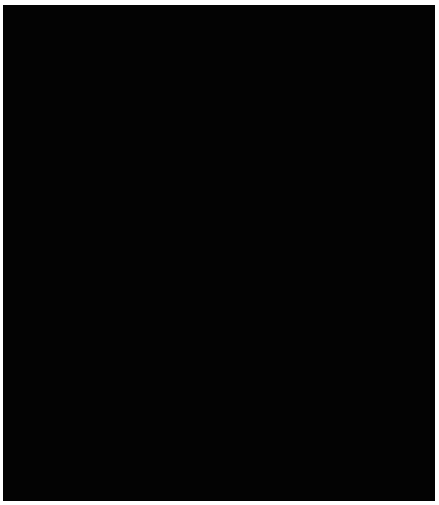
speakers that make up the complete system are the first elements responsible for the most important sonic characteristics – the sensation of dynamics, emission fluidity, grain refinement, signal reactivity – and a deep analysis of their qualities will give us qualifying information.
As we approach the issue of speakers under tests, we can point the membranes with the laser of the newest Scanning Vibrometer also produced by the tireless Wolfgang Klippel, presented in 2006 in [9]. This analysis will allow us to reconstruct with precision the vibration modes of the cones and the specific contribution to acoustic pressure; the Scanning Vibrometer utilizes decomposition techniques which separate the radial modes from the circular ones, visualizing the components of the emission in phases, antiphases and squaring, and allowing the identification of the dynamics responsible for the alterations in the overall acoustic response. The software generates very clear and intuitive animations that will be given particular attention in the hypertext of the TAA pages.



Vibration mode in antiphase at 890 Hz of a 16 cm midwoofer, in correspondence with a cone/surround resonance.

From the overall picture achievable with diverse instruments and analysis modes, we will be able to identify with extreme precision the cause-effect relationships between technical-design parameters and the subjective listener sensations, identifying that which we consider as the concept of quality. Quality – this is our conviction – is not an abstract nor subjective parameter: there are objectives – which every loudspeaker manufacturer aims to

produce – and today there is an objective and serene way of evaluating the results obtained, without giving way to doubts, perplexities, or skepticism. The task of the technical diagrams published on The Absolute Audiophile is to establish the most reliable and objective quality classification index possible – every time in relation with the type and commercial category of products being tested - making it easy to read and archive, so as to allow future comparisons and the generation of a data base that will be available to readers and producers to whom we refer with particular willingness and spirit of cooperation. We are eagerly awaiting your impressions – suggestions and criticisms – saying that we shall make it a point to meet at the first technical tests to be published in the next editions. To close, I would like to thank Mattia Cobianchi for the precious advice he gave during the evolution of this project, and also to Elettromedia for its development and research acoustic laboratory where most part of the measurement tests were performed.



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