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CHARACTERISTICS OF A HIGH-PERFORMANCE OMNIDIRECTIONAL SOUND SOURCE

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1. Introduction

This publication describes the procedure leading to the manufacture of a high-performance omnidirectional sound source, with innovative characteristics and operating flexibility.

2. Description of the source

For many acoustic applications, it is useful to have a sound source that is ideally able to emit sound with both a high pressure level and in an isotropic manner in the surrounding area, with precise, repeatable and flexible test signals. These requirements can only be met by electroacoustic sound diffusion systems [1].

The specification that were at the basis of the design of the sound source described in this publication were deduced from the normative on the issue of testing the acoustic requisites of construction elements and the need to have a suitably flexible instrument for architectural acoustic applications, not yet available on the market at the time the product described in this publication was realized. For these reasons, the basic characteristics for which the source was conceived had to be high acoustic power, low weight and an operating frequency range extending from 40 Hz to over 10 kHz, which had to be compatible with the indispensable need to ensure high omnidirectional characteristics even at high frequencies and the ability to maintain maximum performance through time.

Starting out from these requirements, the first problem that occurred was that of establishing the minimum dimensions of the enclosure in which the compact but high-powered loudspeakers were to be mounted. It was decided to opt for a dodecahedral shape, able to make the most of available internal space. The loudspeakers mounted in the omnidirectional enclosure are 133 mm. diameter “extended range” units with dual Neodymium magnets: one internal, the other external, where the aluminium plug is fitted, with the twin purpose of ensuring linear response and more effective heat dispersion. At the executive design stage, it was decided - for the very first time in this type of professional enclosure - to use reflex type acoustic loading, with the dual purpose of achieving maximum heat dispersion for lengthy operating periods on one hand, and ensuring the utmost possible natural mechanical. protection for the loudspeakers used on the other. The adoption of this solution also gave the added advantage of having a higher sound level in the tuning frequency band of the reflex system, useful for use along with an additional optional enclosure for low frequencies [2]. Overall, the solution of the aluminium plug on the loudspeakers, the distributed holes in the box (calculated and cut to obtain the reflex tuning decided for maximum protection below 90 Hz) and the special loudspeaker circuit with twin Neodymium magnets enabled to achieve a high degree of operating safety at maximum power without any limit on running time and with absolutely steady performance conditions. To give an example of this issue: the internal temperature measured is 45°C, with just 0.3dB power compression. Figure 1 shows a close-up of the dodecahedral enclosure and a view of a complete system (outboard power amplifier, subwoofer and dodecahedral enclosure), but there is also a digital 4-channel amplifier that can be placed in the enclosure’s transport case, or in a special compartment in the subwoofer).


Figure 1: Close-up of the omnidirectional enclosure and a view of the complete system.

3. Normative references.

For the realization of the omnidirectional source, reference must be made to UNI EN ISO 140 and ISO 3382 standards. In particular, to measure reverberation time in any given room, it is necessary to have a source able to simultaneously saturate the surrounding space acoustically and have sufficient power output in the range of frequencies that are to be generated. The aforementioned standards specify the maximum admissible values of a fundamental parameter, known as the directivity index. In the case in question, it was decided to opt for the various faces meeting without any sharp edges, in order to eliminate diffraction effects at the edges. Lastly, to establish power handling, technical standard AES 2-1984-(1997) was used, as it seemed the most suited to assessing the source.

4. Specific performance of the source

ISO 3382 and ISO 140 standards specify the directivity characteristics the source must have and propose the comparison curves for analysis in octave and 1/3-octave bands. Figure 2 shows the line segments that indicate admissible limit values and the histograms of the average and maximum values measured for the omnidirectional source according to the aforementioned standards' specifications.

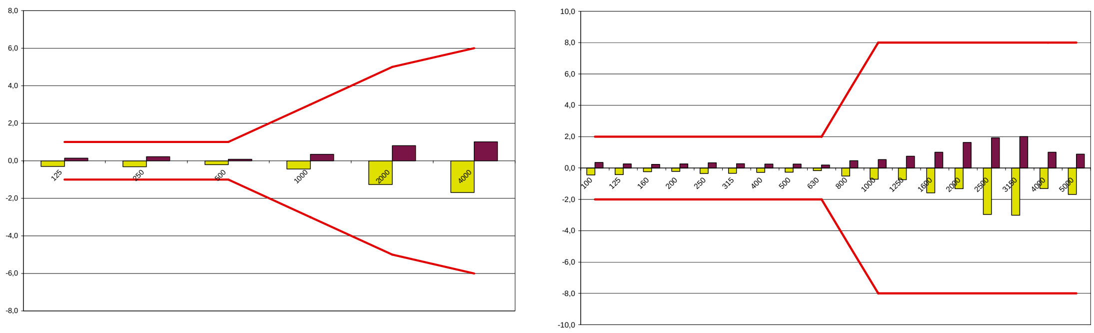

Figure 2: Directivity characteristics of the source according to ISO 3382 and ISO 140 standards

As far as dynamic response range is concerned, in order to facilitate transport, again bearing in mind the objective of achieving high acoustic output, extended range loudspeakers specially manufactured for the device in question were used. This type of loudspeaker has the closest frequency response to the type of response decided at the design stage (Figure 3a). The definitive prototype was obtained after the construction and analysis of numerous laboratory samples. The overall acoustic response of the loudspeakers used together in the box is shown in Figure 3b. It can be seen that fitting the loudspeakers in the box considerably changed the frequency response, with a rise in frequencies between 100Hz and 1250Hz. The choice of the individual loudspeakers at the design stage therefore seems justified.

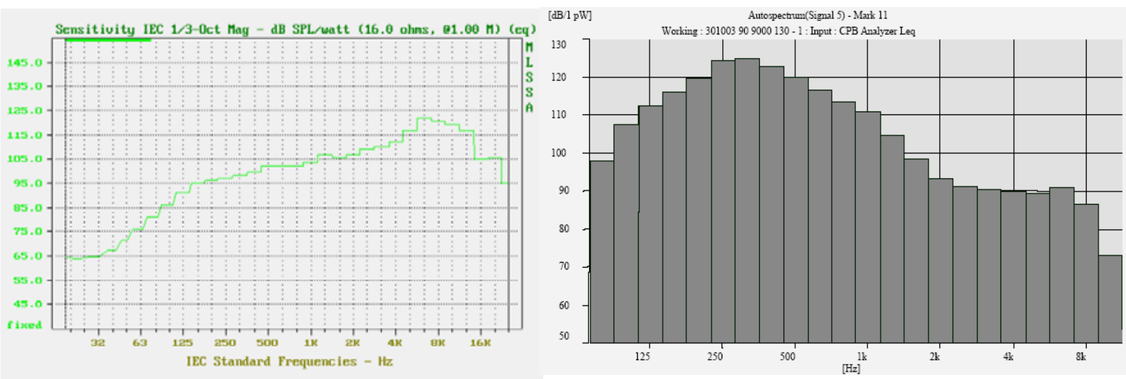

Figure 3: **a**) Frequency response of the individual loudspeaker **b**) Frequency response of the complete system in 1/3-octave bands.

It was then decided to integrate the diffusion system with a device specialized in reproducing low frequency sounds (below 80 Hz) and an equalization filter introduced to compensate the high frequencies fed out. Figure 4 shows the positive result achieved by introducing these choices. In particular, in Figure 4a, regarding the application of equalization, the response curve is flattened, whereas in Figure 4b, regarding the end result with equalization and subwoofer, the curve is considerably flattened with sufficiently high low frequency values. These curves characterize a device with high technological value, which has some unusual features that – when suitably exploited – enable it to achieve excellent performance, above all in terms of linear response and directivity control.

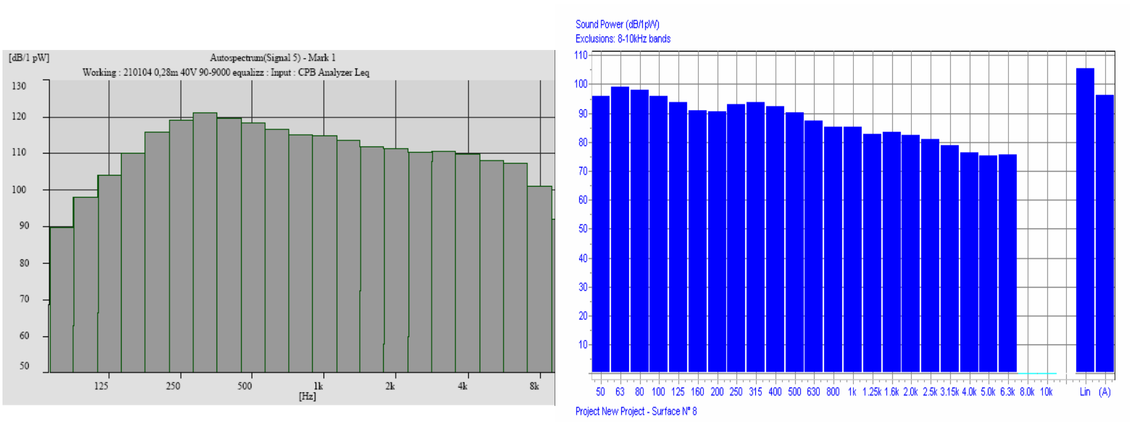

Figure 4: **a)** Sound pressure levels emitted by the omnidirectional source alone **b)** Sound pressure levels emitted by the omnidirectional source along with the subwoofer.

In detail, this involves: the possibility of powering groups of loudspeakers separately; the possibility of inverting the phase of the signal fed out by the amplifier; the possibility of setting the delay between channels' outputs. Lastly, Table 1 shows the main characteristics of the sources that make up the system.

Table 1: Characteristics of the sound sources that make up the system

Dodecahedral System	**12 Outline S5WM16NPP** loudspeakers. *Frequency response*: 90÷12500Hz; *Diameter:* 133 mm; *Weight*: 800 gr. *PWL@maximum*: 130.3dB re 1pW with equalized response.
Extension range Subwoofer	**1 Outline 15**" loudspeaker. *Frequency response*: 39÷150 Hz (max sugg.); *Weight:* 25 kg. *PWL@maximum:*129 dB re 1pW. 135 *dB Peak*

5. Conclusions

The source described suitably satisfies the needs of the three main sectors for which it was designed: finding reverberation time, assessing passive acoustic requisites in building construction and research in the architectural acoustics field. As far at the last field of application is concerned, the device was also used for measurements taken in the Sinopoli hall of Rome's Parco della Musica complex, with excellent results.

6. Bibliography

John Borwick, "Loudspeaker and Headphone Handbook", Butterworth 1988.

Harry F. Olson "Acoustical Engineering", D. Van Nostrand Company, Inc., 1957.