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ACOUSTICAL SOLUTIONS IN MODERN ARCHITECTURE

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Abstract
Acoustic properties of spaces are pretty hard to achieve in modern architecture. In 21st century buildings with open plan workspace and with emphasis on glass surfaces room acoustic is sometimes neglected part of design. Something like that can not happen in one broadcast studio where intelligibility of voice is important.

The idea of this paper is to present the result of the integration of modern workplace and technology with the acoustic design of one inadequate room in use of broadcast studio.

INTRODUCTION

The paper will present how to achieve suitable acoustical shaping results of inadequate space which is used as an audio studio for broadcasting and the results achieved with two different sound equipments in the control room with the idea of presenting the possibilities of sound shaping compensation or to show how architectural acoustic can not be much changed no matter how good audio equipment we use.

IMPLEMENTING ACOUSTICAL AREA IN INADEQUATE ENVIRONMENT

Having in mind trends in modern architecture multimedia center is build in Zagreb, Croatia, two years before. Part of the multimedia center is a news agency. The agency is organised as a big newsroom. It is organised as an open plan workspace, mostly made of glass surfaces. The conception of the work place is that all the journalists work together in the same room, separated by organising tables in different shapes and directions.

After some time it was realised that the agency must contain it's own audio broadcasting studio for distributing news via satellite. Broadcasting it's own news improves agency's work in the most transparent way.

Broadcasting requires at least audio studio, control room and soundlock, like one small radio broadcasting station. In this very case that meant that the environment has to be neglected. Any kind of architectural changing of the agency neglected architect's vision and the idea of wide open space. The solution is accomplished with a lot of compromise.

The only closed space in the agency was the archive room, shaped as a rectangular parallelepiped with the ground area of about 8 square meters and the height of 2.7 m. The archive itself has been moved out of this space, which was then converted into an audio broadcasting studio. A double-glass window has been built in one of the studio walls, making this wall the bulkhead between the studio and the control room, which was built next to the studio itself. The building of the control room was a delicate process, due to the fact that the original concept of the space and the original idea of the architect were not to be compromised. Therefore, the control room has been made of glass, occupying minimal required area and was sized to match the size of the studio. Glass walls have been mounted from the floor to the ceiling, perpendicular to both of these faces, and held by metal frames. No acoustic treatment of the control room was possible because the purity of the control room form would be compromised.

ACOUSTICAL CHARACTERISTICS OF THE IMPROVISED AUDIO BROADCASTING AREA

When a studio space is well planned and designed in advance, then such planning and design represents a complex multidisciplinary task which yields optimal technical solutions by viewing the problems through the prisms of architectural acoustics, electro-acoustics, environmental control, lighting and ceiling systems. The result of such approach is an integrated system in which the architectural acoustics yields favourable conditions for program production by limiting the noise levels and providing the optimal reverberation time and diffuse properties; environmental controls provide the exchange of air in the space, as well as optimal heating, cooling and humidity of air; the artificial lighting complements or completely replaces the daylight, while the ceiling enables the incorporation of elements of environmental control, the lighting, the acoustics and electro-acoustics into a harmonious whole.

Since the architectural conditions could not be changed, it was not possible to subject the architecture itself to yielding the adequate solutions of acoustics and sound insulation of the studio. The environmental control of the studio was not realized, so the studio space uses an indirect heating and cooling system, through the existing newsroom, thereby overriding the engineering part of studio design. To be precise, there was no need for damping the non-existent environmental system, as it would be if such system were to pass through the studio.

The impossibility of subjecting everything to the acoustics of the studio has made it impossible to define the space mathematically in the optimal manner. This particular studio is treated as a small acoustic space, so the reverberation times recommended for large acoustic spaces cannot be applied here.

One of the mitigating circumstances is that only one microphone is to be used at the time, so there was no need to perform the intermicrophone isolation.

The positioning of the studio in the existing space within the news agency made it impossible to solve the problems of noise in the studio itself and the noise flow between the control room and the studio in an optimal manner.

The walls of the studio have been built out of gypsum-cardboard panels. A double-glass window has been built into the wall separating the studio and the control room, but not as an element of acoustic treatment. The noise flow between the control room and the studio has been minimized by using the headphones for monitoring in the control room. The acoustic treatment of walls has been solved by mounting a wooden construction to the walls, followed by mounting the gypsum-cardboard panels to that construction and filling the empty space behind the panels with appropriate quantities of mineral wool. The gypsum-cardboard panels have different perforation percentages, or can even be imperforated. The wooden construction elements have been mounted at different slopes in order to achieve optimal diffusion. The ceiling has also been mounted to a wooden construction of different depths, using a combination of imperforated and perforated gypsum-cardboard panels. The blueprint of implemented acoustic treatment is shown in Figure 1.

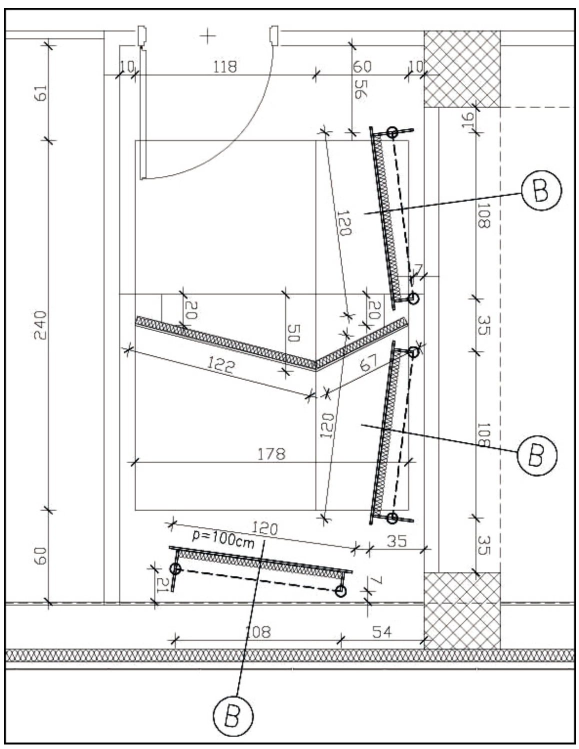

Figure 1 – Blueprint of implemented acoustic treatment of the studio

Since the studio did not have adequate environmental control, the studio door, mounted in the gypsum-cardboard wall, could not be acoustically treated because a ventilation opening had to be left in them in order to enable the circulation of air. The door conjunction could not be dealt with appropriately because the foundation on which the studio has been built is laminate laid on concrete.

The control room space is enclosed with metal-framed glass and is acoustically untreated. The monitoring in the control room is performed using the headphones in order to reduce the noise flow between the studio and the control room, as said before. The soundlock has not been implemented due to the impossibility to incorporate it into the existing architectural concept. The sound insulation that would have been provided by building such soundlock had to be neglected. The noise flow from the newsroom is minimised just with the journalists' discipline of whispering or no speaking at all during news production in the studio.

All the circumstances were endurable because the maximum news production is only five minute in one hour. Besides, we are talking about studio made just for speaking and that only one microphone is to be used at the time. Of course, the right choice of microphone, actually microphone pattern, can highly contribute to solve this problem.

ACOUSTICAL ANALYSIS

Considering all the circumstances of production in this case, we observe the acoustical component together with the contribution of chosen audio equipment that sound passes through.

As we already mentioned, only one microphone is to be used at the time and only speech is to be transmitted. Therefore speech intelligibility is the most important thing that must be accomplished here.

Acoustical measurements we have done with TEF analyse. Analyse gave us reverberation time, the value of RASTI index and articulation losses of consonants in speech ($\%AL_{CONS}$). Our system under test was audio chain which audio signal from studio microphone must pass on the way to the satellite uplink.

This paper is supposed to present the results achieved with two different sound equipments in the control room with the idea of presenting the possibilities of sound shaping compensation or to show how architectural acoustic can not be much changed no matter what we change in audio equipment chain. The main difference between measurements is in dynamic processing.

The first measurement has been done with the minimum of the audio equipment, without any additional dynamic processor. The block diagram is shown in Figure 2.

Sound signal passes through the microphone, mixing console and the output from the mixing console goes to TEF analyzer. Condenser microphone and an average analog mixing console were used in measurements. The optimal reverberation time for small studio is maximum 0.2s.

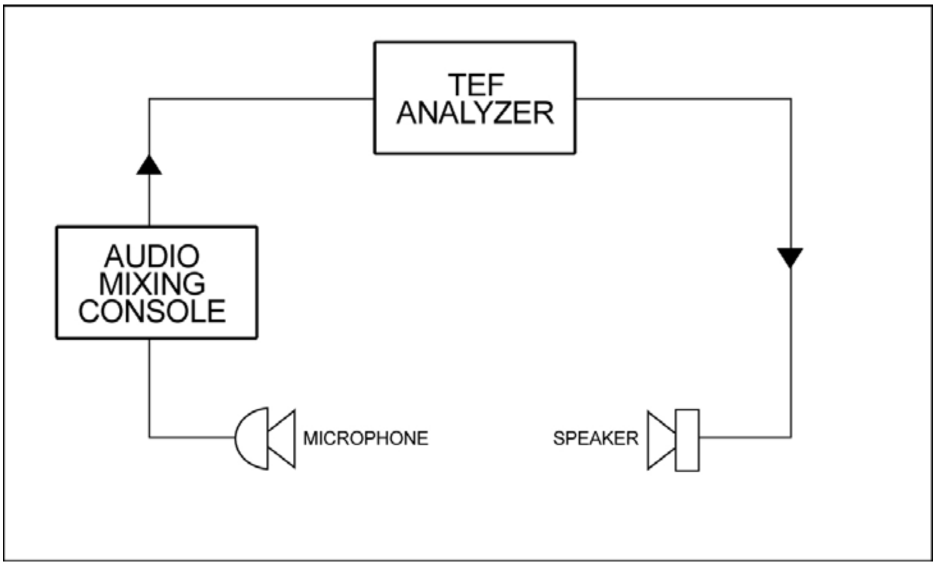

Figure 2 – Block diagram of the measurement without additional dynamic processing

Our first measurement showed the reverberation time of 0.13s, RASTI index 0.81 and %AL_{CONS} 2.11. RASTI index of 0.81 is considerable as excellent. The results are shown in Figure 3.

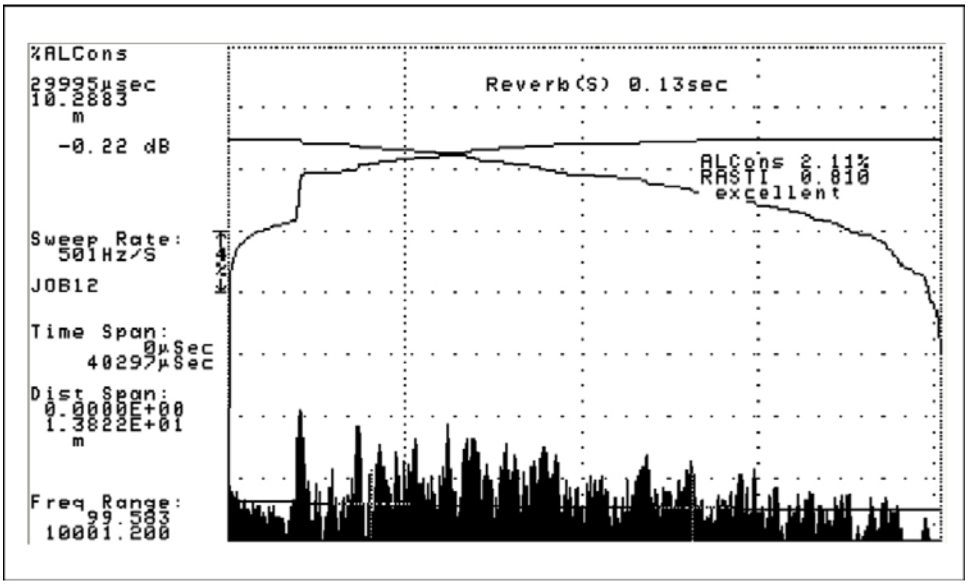

Figure 3 – Results of the measurement without additional dynamic processing

The second measurement has been done with some additional audio equipment. The block diagram is shown in Figure 4. Microphone preamplifier between the microphone and mixing console and dynamic processor at the end of the audio chain were added. Some frequencies which come to microphone can be masked with microphone preamplifier and that is the way we can try to affect frequency response of the studio. Dynamic processor, among other purposes, is designed to amplify, or suppress, the signal level within particular portions of the audio frequency range. It means that frequencies can be masked again and that frequency response of the studio can be affected also in this way. At least we aspected so.

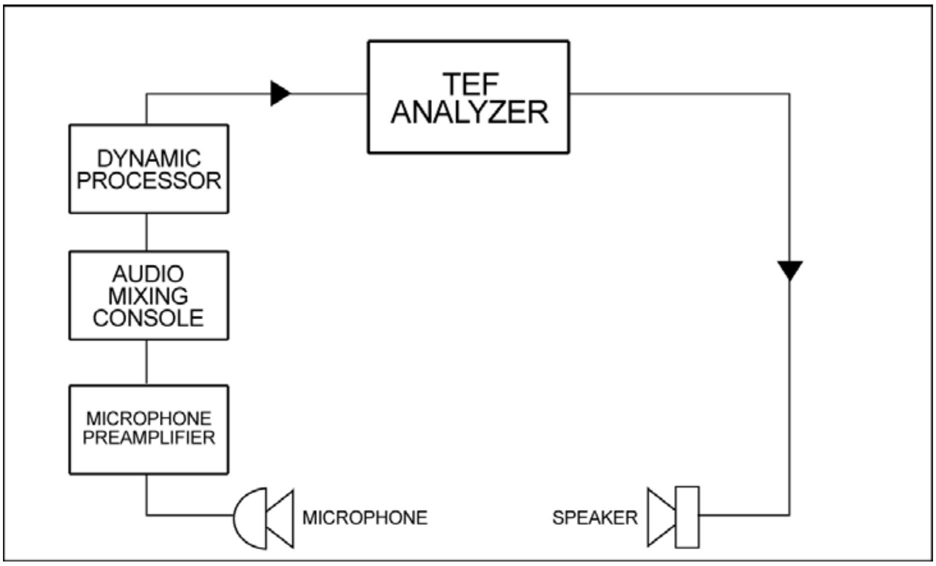

Figure 4 – Block diagram of the measurement with additional dynamic processing

The second measurement gave us mathematically pretty similar results as we had in the first measurement. The results are shown in Figure 5.

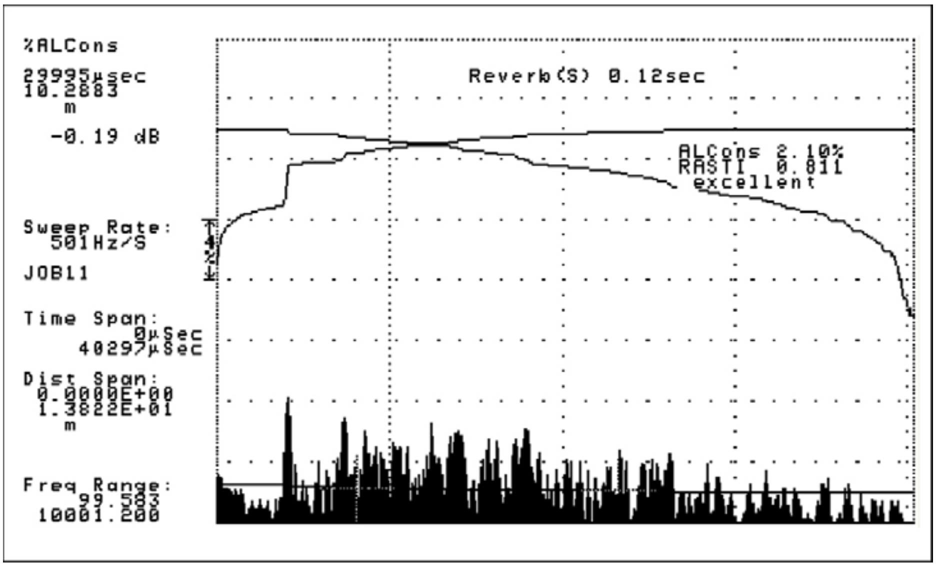

Figure 5 – Results of the measurement with additional dynamic processing

The measurement showed the reverberation time of 0.12s, RASTI index 0.81 and $\%AL_{CONS}$ 2.10. The difference is shown in energy-time curve which confirmed our prediction that dynamic processing should suppress some frequencies.

CONCLUSIONS

Due to the chosen measurement method, it was expected that the results would be similar in both investigated cases. Prior to conducting the objective measurements, the subjective impression was that the dynamic signal processing affects the final sound image by making it more balanced and contributes to speech intelligibility, thus serving the elementary purpose of this improvised studio. This subjective impression has been confirmed with the changes in the shape of the energy-time curve after the measurement conditions had been altered. The results have confirmed the hypothesis that proper choice of equipment can somewhat compensate for flaws exhibited in an acoustically inadequate space. The differences between the results are fairly small, in relation to the choice of equipment, so adequate acoustic treatment of spaces used for audio production must not be neglected, but should be of primary concern. It is important to mention once again that this studio is intended solely for speech broadcasting using only one microphone at a time. Therefore, these results must not be taken for valid should the studio be used for any other purpose in the process of audio production.

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