Selection of Microphones for Diffusion Measurement Method

Jan Karel, Ladislav Zuzjak, Oldřich Tureček

Department of Technologies and Measurement, University of West Bohemia, Univerzitní 8, 304 14 Plzeň, Czech Republic

Summary

In this work, the selection of appropriate microphones for the microphone frame is described. The selection was based on the measurement of complex information about the microphones (in addition to parameters specified by producer). The relative frequency response of various microphones were measured in an anechoic chamber. The next effects that affect the frequency response were measured and evaluated with them. The microphone Shure MX 150 B/O was found as most suitable microphone for the diffusion measurement method according to obtained data. It exhibits the greatest immunity against the various influences which are critical for this method.

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1. Introduction

A civil engineering uses very often the diffuse structures, such as the diffusers, for a room acoustics treatment. Thus, reproducible and reliable characterization of these structures is very important. The main parameter of these structures is the amount of the scattering of an incident sound [1]. For this purpose, newly designed measurement system was developed [2]. One of the most important parts of this measurement system are the microphones used for measurement of the scattering of an incident sound. This work focus on the selection of appropriate microphones for the microphone frame in the measurement system. The selection of the microphones was based on the measurement of complex information about the microphones (in addition to parameters specified by producer). In order to get the complex information about microphones the microphones were measured along with the reference microphone B&K 4190 in an anechoic chamber in laboratories at University of West Bohemia.
The selection considered measurement microphones and microphones for audio technic. Microphones for audio technic bring a complicated mechanical solution but dramatically lowering price of the method with acceptable parameters.

Based on the measured data the microphone Shure MX 150 B/O was found as a suitable microphone for the installation in the measurement system.

2. Selection of the microphones

2.1. The microphone frame

The microphone frame has a shape of the semicircle with radius corresponding to the method and the dimensions of the diffuser. In the case of commercially used diffusers with the size of 600 x 600 mm, the radius of the microphone frame should be 5 m. The diffuser is situated in the center of the semicircle. 47 microphones is located in the microphone frame with central microphone in the axis of the diffuser. The microphone frame is made of the Medium Density Fibreboard with the surface treatment. In order to easy transport,

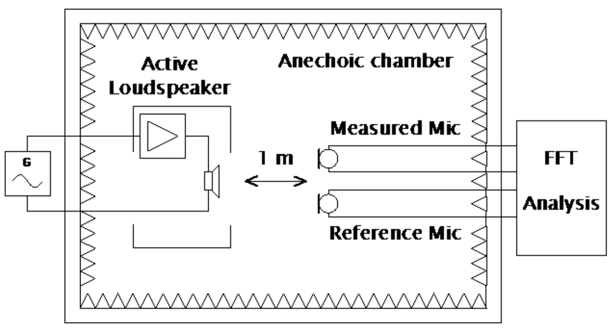

Figure 1 The arrangement of the microphones during the comparative method

the microphone frame can be separated into the 16 parts. Each part contains 3 microphones.

2.2. Criteria for the selection of the microphones

For this application the omnidirectional microphones are necessary in order to eliminate the deviation in the frequency response of the microphone in the direct and the reflected sound direction. The total elimination is required in the horizontal plane in the frequency range from 100 Hz to 10 kHz. The balanced frequency response in the range of the interest is required in the horizontal plane. The value of the sound pressure level (SPL) has to be >120 dB. The high number of the microphones in the measurement system specifies the demand on the acceptable price of the microphones. Due to the placement of the microphones in the microphone frame, the next important parameters are the size and the mechanical endurance. The last but not negligible parameters are the long term stability of the parameters and the availability of the microphones on the market.

2.3. Preselected microphones

The properties of the preselected microphones, which are in accordance with the criteria listed in paragraph 2.2 are shown in table 1. Because of the size criteria, all microphones are the lavalier microphones. Moreover, the cylindrical shape of these microphones is suitable for the placement into the microphone frame.

2.4. Testing room and the equipment

In order to get the complex information about microphones (in addition to the parameters specified by producer in table 1) the microphones were measured along with the reference microphone B&K 4190 (comparative method) in an anechoic chamber in our laboratories. The size of the anechoic chamber is 5.0 m x 4.0 m x 6.4 m and the total volume is 128.3 m^3. The equipment for the comparative method was:

- Analyzer & generator: B&K PULSE 3560C, SW v10.3, 4 Channels
- Reference microphone: B&K 4190
- Active loudspeaker: Event 20/20 BAS v2

The figure 1 shows the arrangement of the microphones during the comparative method. Evaluation of the frequency response of the reference and measured microphone was performed by the FFT analysis (6400 spectral line/ 25.6 kHz/1000 averages). Active loudspeaker with the similar dimensions as the loudspeakers used in the measurement system was used as a source of the sound. The white noise generated by the analyzer B&K 3560 was used as the signal for this measurement.

2.5. Methodology

Following characteristics of all four preselected microphones were measured:

2.5.1. The frequency response in the free field

Relative frequency responses in the range from 100 Hz to 20 kHz were measured using comparative method (see figure 1) in order to obtain the precise data.

Table 1 The preselected microphones with the suitable parameters

Producer	Type	Sensitivity	Background noise	Max SPL	Diameter	Installation depth	Price
		[mV/Pa]	[dBA]	[dB]	[mm]	[mm]	[€]
DPA [3]	4060	20	23.0	123	5.4	17	250
Shure [4]	MX 150 B/O	19	34.5	130	5.8	12	150
Sennheiser [5]	MKE 2-P-C	10	28.0	130	4.8	12	330
AKG [6]	C 417 PP	10	32.4	126	7.5	15	130

2.5.2. The influence of the microphone frame

Despite of the very low profile, the total height of the microphone frame could negatively affect the frequency response of the microphones. Thus, the frequency response of the microphones in the microphone frame was measured.

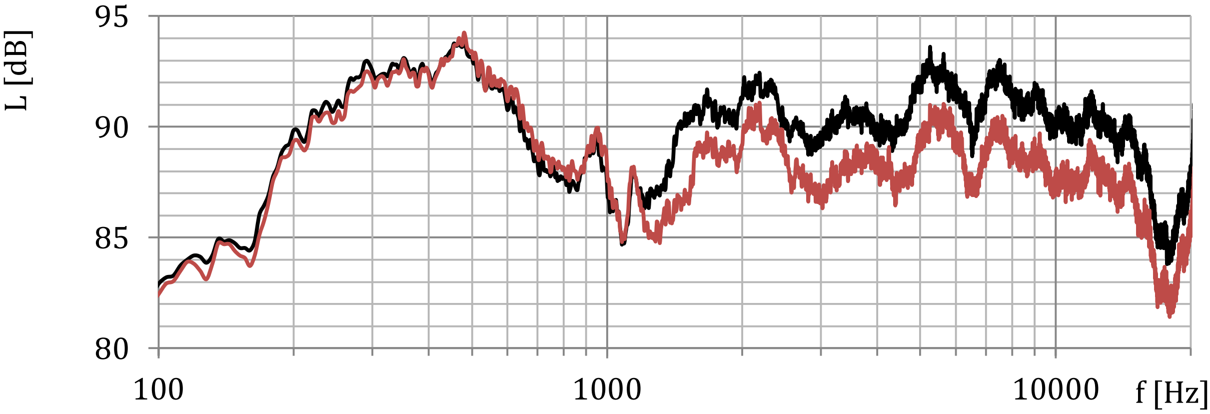

Figure 2 The relative frequency response of the microphone in the free field (red curve) and the frequency response of the fully imbedded microphone in the microphone frame (black curve) (Shure MX 150 B/O)

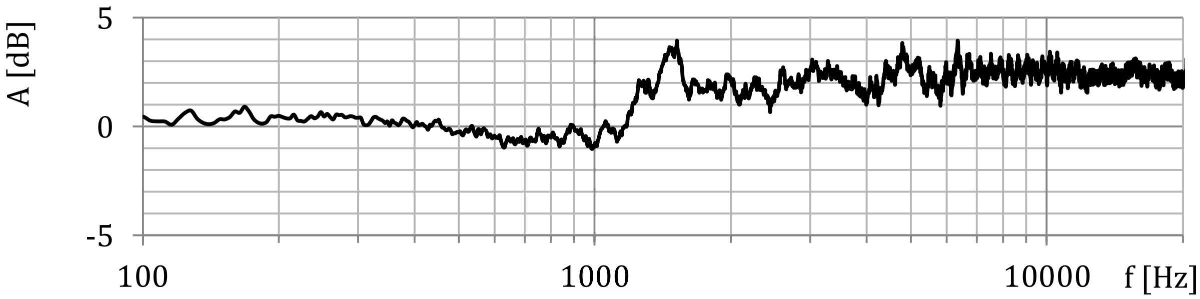

Figure 3 The difference between the frequency responses of the microphone in the microphone frame and in the free field (Shure MX 150 B/O)

2.5.3. The influence of the protrusion

To enhance the mechanical endurance of the measurement system, the minimal protrusion with minimal effect on the frequency response of the microphone was determined. Three different positions of the protrusion of the microphone were selected: 0 mm, 2.5 mm and 5 mm. To avoid the mechanical damage of the microphones, they should be imbedded as much as possible. This measurement was performed with the prototype of one segment of the microphone frame.

2.5.4. The influence of the position of the microphone against the loudspeaker

The loudspeakers generate the source of the sound. In order to design transportable measurement system, the number of the required loudspeakers should be reduced as much as possible. Thus, it was measured, how the position of the microphone off-axis of the loudspeaker affects the frequency responses.

The selected angle of the displacement was 30 °.

2.5.5. The influence of the existence of the reflective surface

The measurement system will be always placed on a reflective surface (e.g. floor, ground). This placement always affects the frequency response of the microphones. The reflective surface in the anechoic chamber was simulated by sufficiently large board. The measurement was not performed in 1 m (as shown in fig. 1), but in the maximum allowed distance limited by the dimension of the anechoic chamber (2.26 m).

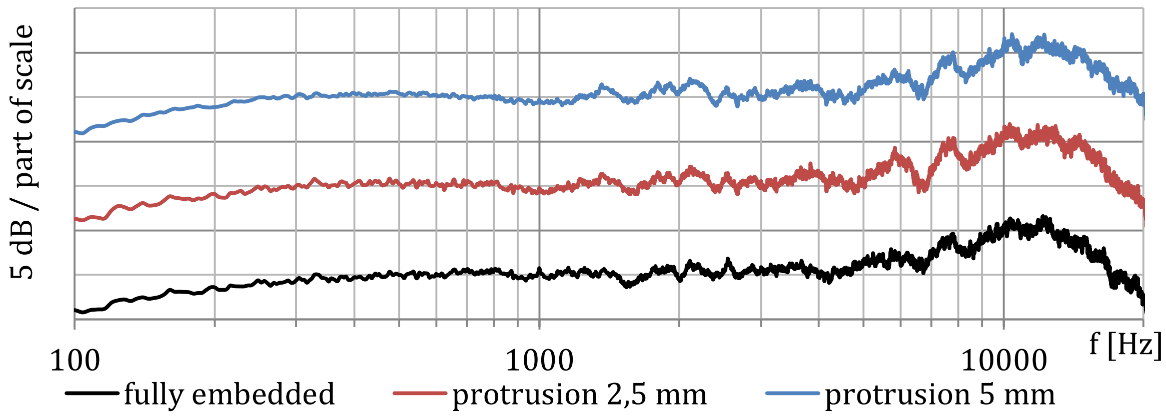

Figure 4 The effect of the protrusion in three different positions (Shure MX 150 B/O)

3. Measured frequency responses

3.1.1. Frequency response in the free field

The frequency responses of all preselected microphones in parallel with the frequency responses of the microphone B&K 4190 were measured. The relative frequency responses were consequently calculated from obtained data. The relative frequency responses were used as references for evaluation of the appropriate microphone.

3.1.2. The influence of the microphone frame

The relative frequency responses of the microphone Shure MX 150 B/O in the free field and the frequency response of the fully imbedded microphone in the microphone frame are shown in the figure 2. The figure 3 shows the difference of these two curves. The microphone Shure MX 150 B/O was selected as the representative example and the other measured data are not shown in the graphs.

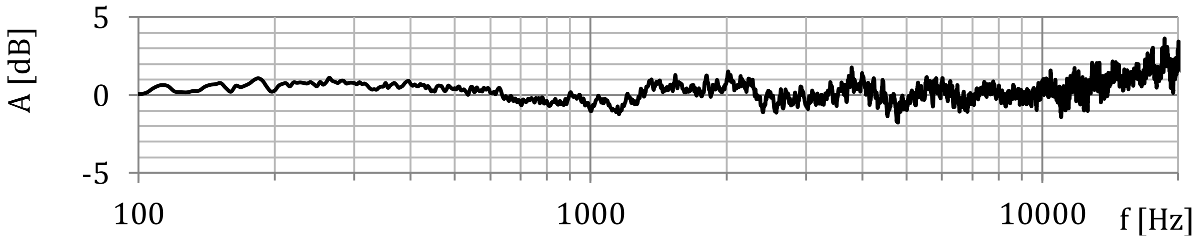

Figure 5 Effect of the protrusion (the difference between 5 mm and fully imbedded characteristics)

3.1.3. The influence of the protrusion

The figure 4 shows the frequency response of the microphone Shure MX 150 B/O in three different positions of the protrusion. The individual curves are vertically shifted for better visibility.
The difference between the frequency response of the microphone Shure MX 150 B/O with 5 mm

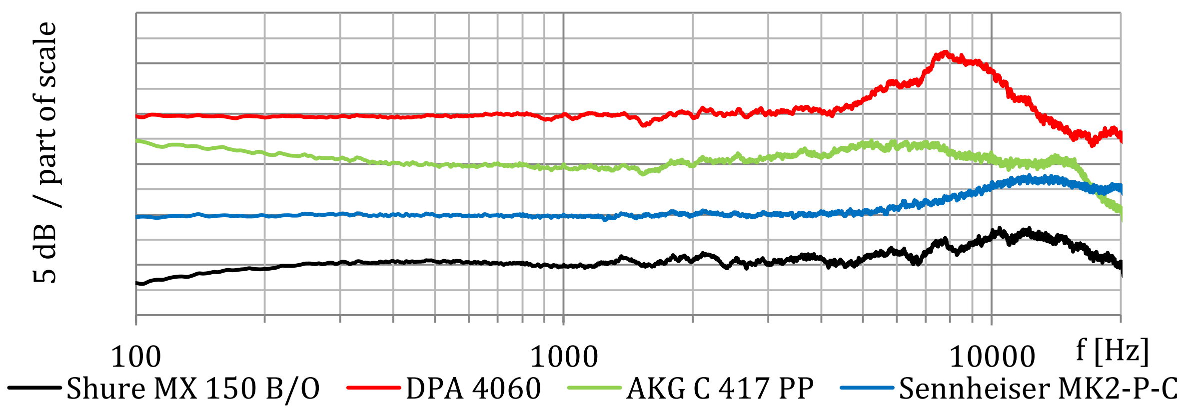

Figure 6 The relative frequency responses of all preselected microphones fully imbedded in the microphone frame

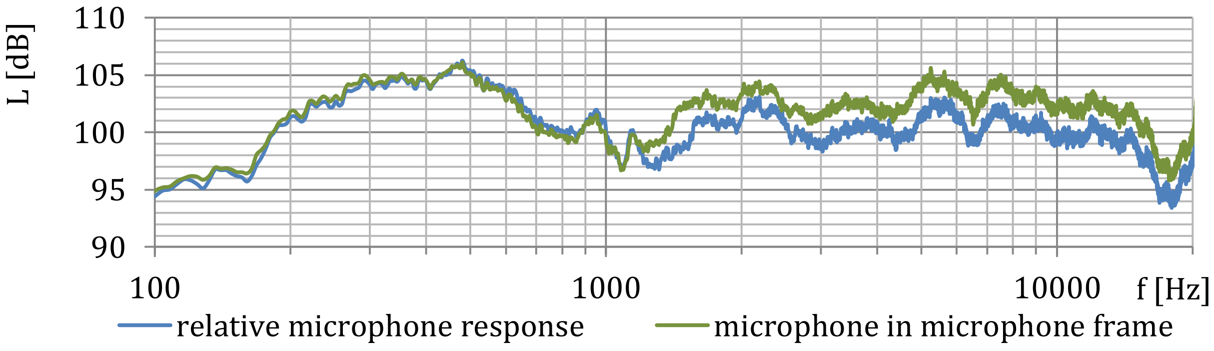

Figure 7 The influence of the existence of the reflective surface

protrusion and the frequency response of the fully imbedded microphone in the microphone frame is shown in the figure 5. The figure 6 shows the relative frequency responses of all four preselected microphones fully imbedded in the microphone frame.

The figure 8 shows the frequency responses of the microphone Shure MX 150 B/O axis and off axis of the loudspeaker in the free field. The figure 9 shows the influence of the angle of the displacement 30°.

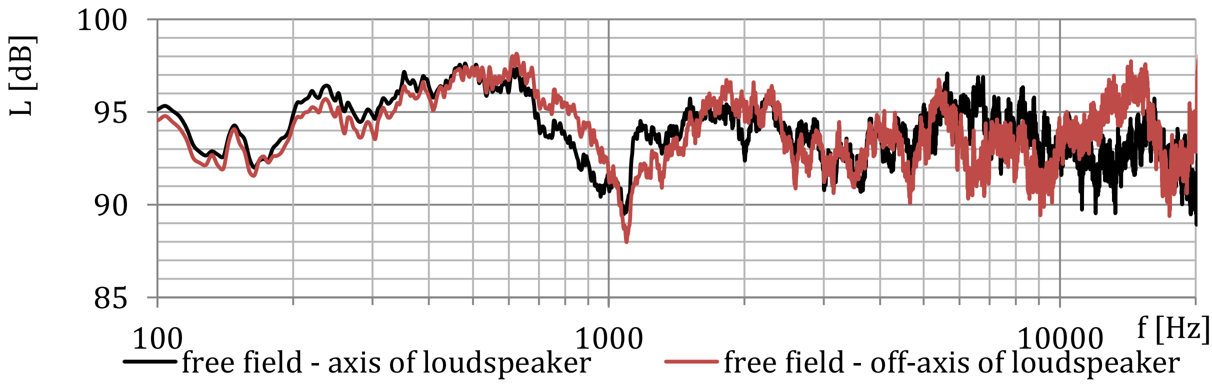

Figure 8 Frequency responses in axis and off axis of the loudspeaker

3.1.4. The influence of the existence of the reflective surface

The relative frequency response of the microphone and the frequency response of the microphone fully imbedded in the microphone frame both with the presence of the reflective surface are shown in the figure 7.

3.1.5. The influence of position against the loudspeaker

4. Discussion

The selection of the suitable microphone for the measurement system is based on the fulfillment of the criteria listed in paragraph 2.4.

The data showed in figure 3 proved that the influence of the height of the microphone frame is minimal. The difference between the frequency responses of the microphone in the microphone frame and in the free field is less than 3 dB. Such low difference can be neglected.

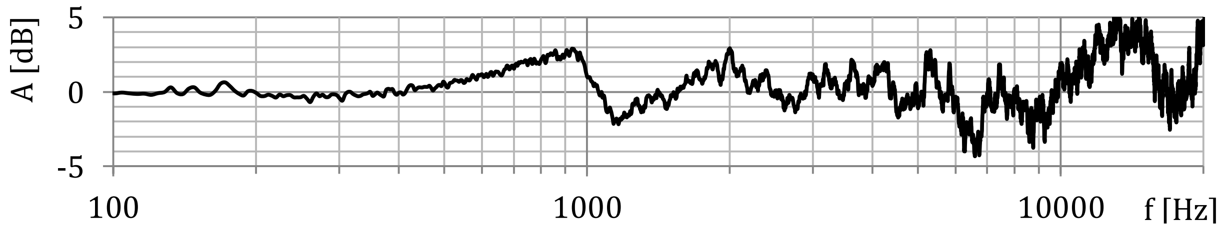

Figure 9 The influence of the angle displacement 30°

As it was expected, the presence of the reflective surface affects the frequency response. Based on the measured data (not shown), it was found that there is great difference between the frequency responses measured in the free field and in the microphone frame with the presence of the reflective surface. On the other hand, there is no such big difference between relative frequency response of the microphone and frequency response the microphone imbedded in the microphone frame both in the presence of the reflective surface. These two facts prove that the microphone frame has minimal effect to the frequency response of the microphones.

The influence of the protrusion was also tested. The difference between the frequency responses of the microphone with the protrusion of 5 mm and fully imbedded microphone is lower than 3 dB in the measured frequency range. This fact allows the installation of the microphone in the microphone frame without the protrusion. This possibility highly improves the mechanical endurance of the measurement system.

Based on the figure 6, it can be seen, that the microphone DPA 4060 has sharp rise in the frequency response from the 5 kHz to 10 kHz. The microphone Sennheiser MK2-P-C has lower increase above the 5 kHz with lower peak at 10 kHz (in comparison with the microphone DPA 4060). The microphone Shure MX 150 B/O has slight decrease at frequencies under 300 Hz and low peak at 10 kHz. The microphone AKG C 417 PP has little growth at low frequencies up to 300 Hz, but there is imbalanced in frequency response from 2 kHz.

At the angle displacement of 30° the effect of off-axis measurement is lower than 4 dB in the measured frequency range (100 Hz to 10 kHz) (see figure 9). Independence of the placement of the microphone off-axis of the loudspeaker (up to 30°) allows to reduce the total number of the loudspeaker needed for the measurement system from 47 to 5.

5. Conclusions

Based on the measured data the microphones Sennheiser MK 2-P-C, Shure MX 150 B/O or AKG C 417 PP are all suitable for the designed measurement system. All these microphones have balanced frequency response and the influence of the protrusion in the microphone frame can be considered as negligible. The microphone DPA 4060 was found as inappropriate because of the sharp peak around the 10 kHz at the frequency response.

The price, the mechanical endurance and dimensions were decisive criteria for the selection. The microphone Shure MX 150 B/O was selected as the suitable microphone for this method because of:

1. Lower price against the Sennheiser MK 2-P-C.
2. High quality of mechanical design compared to AKG C 417 PP
3. Smaller dimensions compared to the price competitive AKG C 417 PP
4. Small dimension of cable with really small bending radius (necessary for easy installation in microphone frame)

Acknowledgement

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