LABORATORY OF ELECTROACOUSTICS

EXERCISE 5.

Measurements of frequency characteristics and directional characteristics of microphones and speakers.

The purpose of the exercise:

The exercise consists of two parts. The aim of the first part of the exercise is to get acquainted with the methodology of measuring the characteristics of the directivity and frequency of the speakers and calculating these parameters.

The aim of the second part of the exercise is to learn the basic properties and parameters of microphones with switchable directional characteristics and methods for measuring these parameters.

I. Measurements of speaker characteristics

1 Laboratory tasks

Before starting the measurements, the measuring microphone should be calibrated using a pistonphone or an electroacoustic calibrator. The microphone should be placed on the reference axis of the speaker set at a distance of 1 m; input power 1 W.

1.1. Measurements of the directional characteristics of the speaker set

The „CHAK" program is used for measurements. Please read its instructions.

Measure the efficiency of the speaker set for 1 kHz (this is the value of the sound pressure level measured on the reference axis of the speaker system at a distance of 1 m with 1 W input power). The measuring system is shown in Fig.1.

Measurements of directional characteristics of the speaker set should be carried out in the measurement system as in Fig. 1, for the frequencies: 250 Hz, 1 kHz and 4 kHz. To eliminate possible interference in the reception path, activate an octave filter with a center frequency equal to the frequency put in to the speaker.

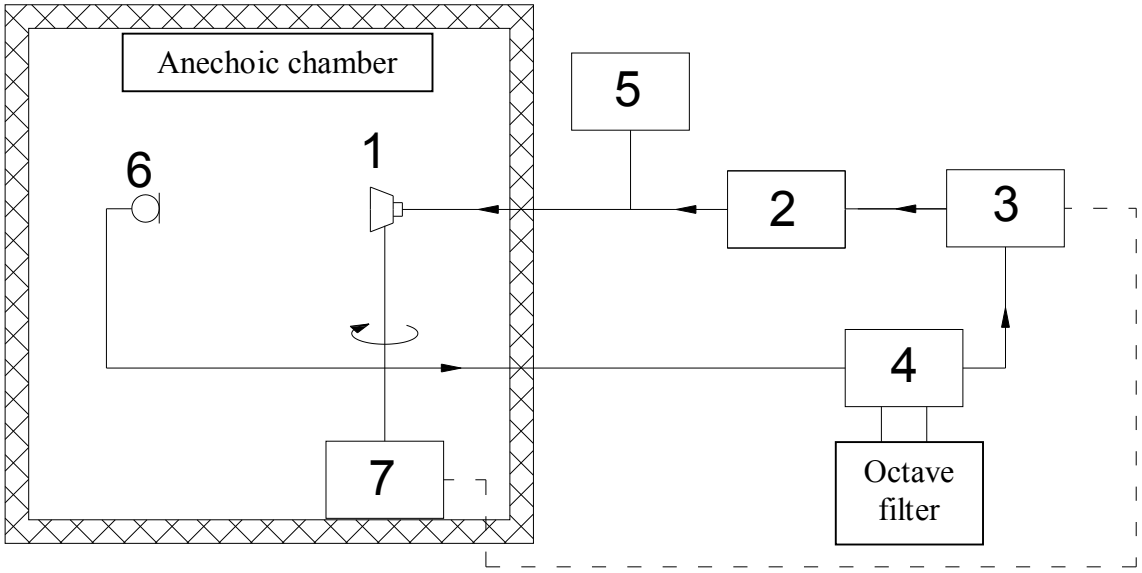


Fig. 1. The system for measuring the directional characteristics of the speaker system:
1 – tested speaker set, **2** – power amplifier typ LV101 RFT, **3** – PC,
4 – acoustic pressure level meter type PSI 202 + octave filter OF 101, RFT,
5 – voltmeter, **6** – measuring microphone, 7 - B & K rotary table.

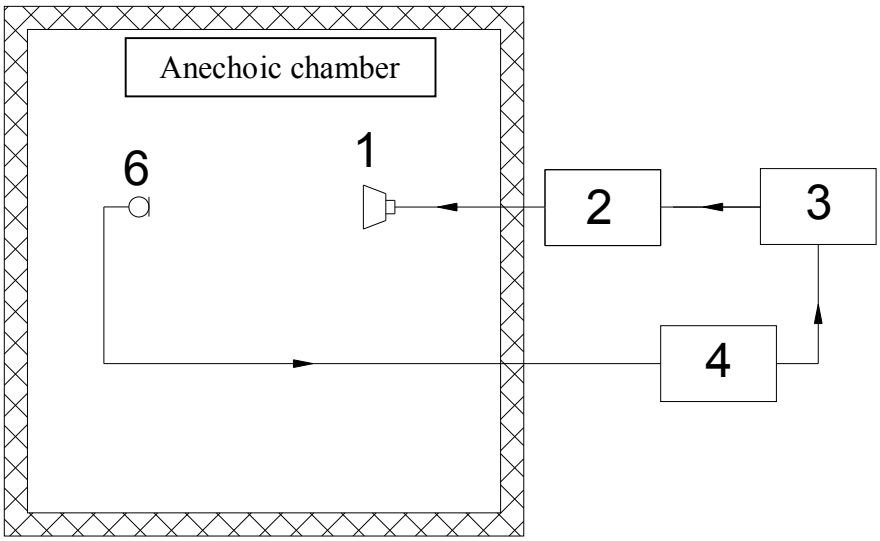
Caution!

1. *Measurements of directional characteristics of the loudspeaker set should be made in the range of angles 0^0 – 180^0. After the measurement has been made for a given frequency, the table should be returned to position 0^0 by means of the RESET command in the table control panel.*
2. *We assume that the directionality characteristic of the tested speaker system is symmetrical with respect to the axis passing through points 0^0 and 180^0.*

Using the measured characteristics, the radiation angle of the speaker set should be determined (angle measured relative to the reference axis at which the sound pressure level measured at a fixed measuring distance within this angle is less than 10 dB compared to the sound pressure on the reference axis).

1.1. Measurements of frequency response characteristics

Specify the dependence of the sound pressure level as a function of the frequency measured on the reference axis of the speaker system under free field conditions. The measurements should be carried out in the system as in Fig. 2. Measurements are made in the anechoic chamber using the Level Recorder program (on the computer desktop it is called as "LevRec")."LevRec").



Rys. 2. The system for measuring the frequency characteristics of the speaker system playback:
1 – tested speaker set, **2** – power amplifier typ LV101 RFT, **3** – PC,
4 – sound pressure level meter type PSI 202,
6 – measuring microphone.

Using the measured characteristics should be determined:

- usable frequency range of the tested speaker set (the frequency range in which the frequency response characteristic does not drop by more than 10 dB from the average sound pressure level in the one octave band in the highest sensitivity range).

II. Microphones with switchable directional characteristics

2. Laboratory tasks

2.3. Determining the effectiveness of the microphone

The effectiveness of the microphone is the voltage ratio at the microphone terminals to the acoustic pressure acting on the microphone. The effectiveness measurements should be made as shown in Figure 3, for all types of microphone directionality, for the frequency of 1000 Hz and perpendicular incidence of the acoustic wave.

1. Create at the place of placing the tested microphone a certain value of the sound pressure level, e.g. 94 dB (1 Pa); The pressure is determined by measuring the sound pressure level in the system with the reference microphone. The sound pressure level is expressed by the following relationship:

$$L_p = 10\log\left(\frac{p}{p_o}\right)^2 = 20\log\left(\frac{p}{p_o}\right) dB$$

where: p - effective value of sound pressure [Pa];

p_0 - a reference pressure of $2 \cdot 10^{-5}$ Pa (the threshold pressure value for the 1000 Hz tone is taken as the reference pressure), therefore the pressure level corresponding to the reference pressure is 0 dB.

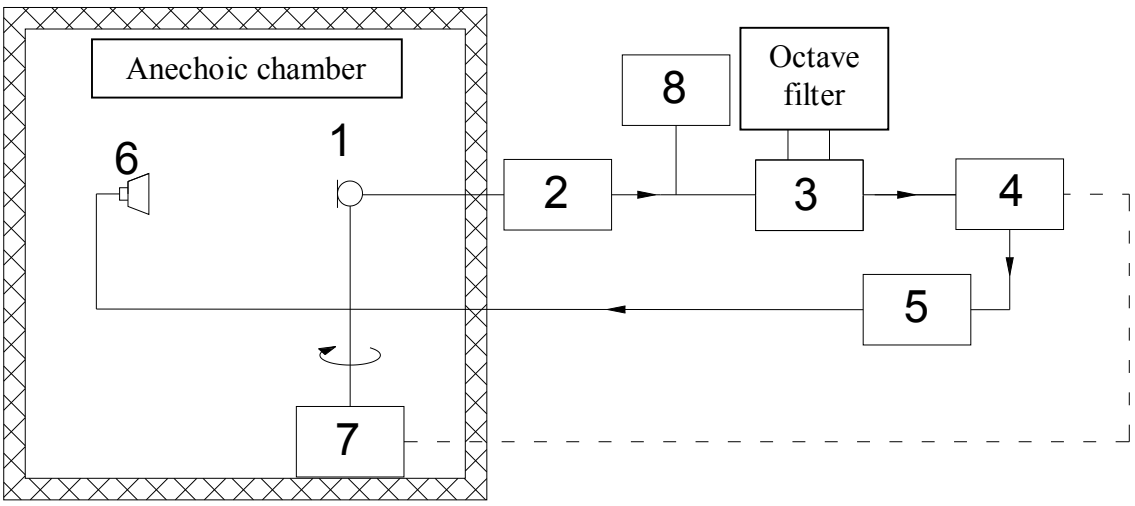
2. Read on the voltmeter the voltage value at the output of the tested microphone.
3. Calculate the value of the microphone's effectiveness by considering the amplification of the voltage amplifier.

2.1. Measurements of the microphone's directionality characteristics:

- unidirectional,
- bi-directional,
- omnidirectional.

Measurements of microphone direction characteristics, in the range of angles 0^0 – 360^0, should be carried out in the measurement system as in Fig. 3, for two frequencies: 250 Hz or 500 Hz and 2 kHz or 4 kHz for each directional characteristic.

To eliminate possible interference in the reception path, activate an octave filter with a center frequency equal to the frequency fed to the loudspeaker. The CHAK program is used for measurements. Please read its instructions. Measurements are made in a free field in an anechoic chamber.



Rys. 3. A system for measuring the microphone's directionality characteristics:
1 – tested directional microphone + power supply, **2** – voltage amplifier type M60T,
3 - sound pressure level meter type PSI 202 + octave filter OF 101 RFT,
4 - PC,**5** - power amplifier type LV101 RFT, **6** – speaker, **7** – rotary table,
8 - voltmeter.

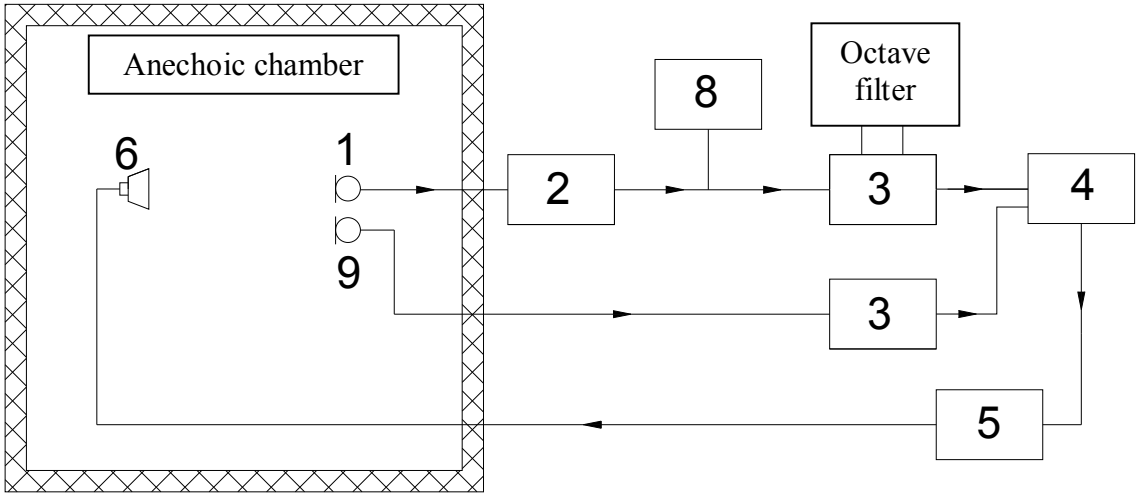
Using the measured characteristics:

- determine the performance indicators of the tested front-to-back microphone (0^0 – 180^0) expressed in dB;

- determine the angles for which there is a minimum of effectiveness of the tested microphone for a particular directional characteristic;
- specify the angular ranges for which the effectiveness in relation to the effectiveness on the reference axis (0^0) does not decrease by more than 6 dB;
- compare the obtained results with theoretical results.

2.2. Measurements of the frequency characteristics of the microphone's effectiveness

The measurements should be carried out in the system as in Fig. 4, for all types of microphone directivity characteristics and perpendicular incidence of the acoustic wave (0^0). Before starting the measurements, it is necessary to calibrate the reference microphone reference path by means of a pistonphon or an electroacoustic calibrator. The measurements are performed in the anechoic chamber using the Level Recorder program (on the computer desktop it is called as "LevRec").



Rys. 4. A system for measuring the frequency characteristics of the microphone's effectiveness:
1 – tested directional microphone + power supply, **2** – voltage amplifier type M60T,
3 - sound pressure level meter type PSI 202 + octave filter OF 101 RFT,
4 - PC, **5** - power amplifier type LV101 RFT, **6** – speaker, **8** – voltmeter,
9 – measuring microphone.

3. Issues to prepare

3.1. The principle of operation of microphones with adjustable directivity characteristics.
3.2. Microphone properties and parameters.
3.3. Features and parameters of speakers.

Literature

[1] Dobrucki A., Electroacoustics, Lecture
[2] Urbański B., Electroacoustics in Questions and Answers, WNT W-wa 1984, pp. 57-80
[3] Żyszkowski Z., Sound Measurement, WNT W-wa 1987, pp. 182-209
[4] Dobrucki A., Electroacoustic transducers, WNT W-wa 2007, chapter 9
[5] PN-EN 60268-4 Equipment for electroacoustic systems - Part 4: Microphones
[6] PN-EN 60268-5 Electroacoustic equipment devices - Part 5: Loudspeakers