



Exercise D: Loudspeaker Exercise

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Introduction

In the first part of this exercise, the frequency response of a 3-inch driver was measured under different mounting conditions of freely mounted, circular screen and IEC screen. The aim was to illustrate how the frequency response and directivity of a loudspeaker unit depends on the mounting.

The frequency response of the loudspeaker units which will be used in the project was measured in the second part of the exercise. The frequency response was measured for each driver. The data will be applied in the future loudspeaker design project.

Methodology

The surroundings of the loudspeaker can significantly affect its radiation pattern. Therefore the measurement conditions are just as important as the driver itself. The ideal condition for measuring a loudspeaker driver is when mounted in an infinite baffle. This is normally not possible and some approximation to this is used. The IEC screen is a standardized approximation to the infinite baffle. Due to its finite size reflections (diffraction) will occur at the edges, but as the driver is placed asymmetrically the effects of the diffraction is minimized.

In the Pulse SSR Analyzer, the generator was set to stepped sine signal. The frequency range was set to 50-20kHz in the analyzer, and the frequency resolution to R80(1/24 octave).

The frequency response of the loudspeaker unit was measured in an anechoic chamber. Three different mountings were applied, which are freely mounted, circular screen and IEC screen. For each mounting, the direction of the loudspeaker was changed. In this way, the directivity of the loudspeaker could be measured. Similar measurement was done to the loudspeaker, which includes the measurement of tweeter, midrange and woofer.

Results and Analysis

3-inch driver

Figure 1 shows the frequency response of both freely mounted driver and circular screen mounted driver in 0 degree.

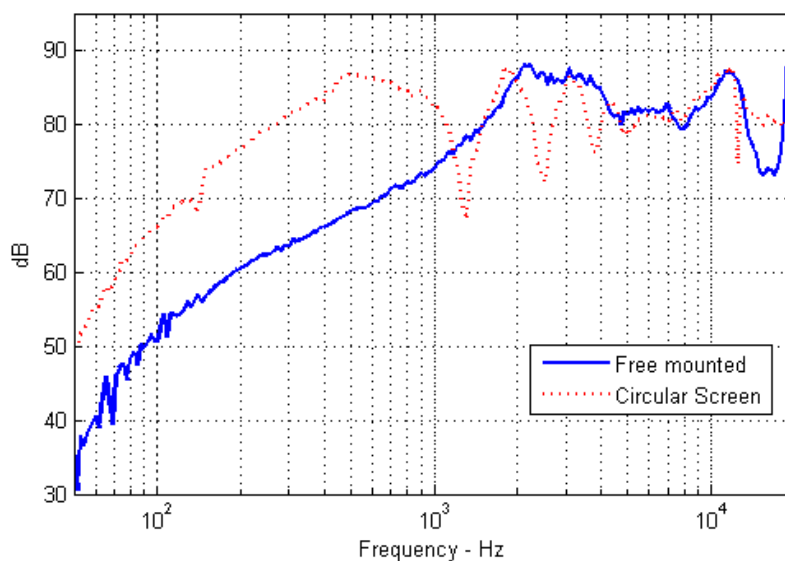


Figure 1. Frequency response of free mounted and circular screen mounted driver

Compared to the response of circular screen mounted driver, the free mounted one has a much lower level in low frequencies. The reason is that, when the membrane is vibrating, it moves back and forth and the sound propagates into opposite direction. If the driver is free mounted, the sound towards opposite direction will cancel by each other. The screen is used to reduce this effect. Thus, the level of the response is much lower.

Figure 2 shows the frequency response of the driver mounted on a circular screen. The blue curve shows the frequency response at 0 degree, and red one stands for the response in direction towards 30 degree. Compared with the response of freely mounted driver, the one of the driver mounted on a circular screen has more ripples. The circular screen does have a great influence on the frequency response of the loudspeaker. These drops are corresponding to the diameter of the screen and the wavelength. When the direction is changed to 30 degree, the response drops a lot at high frequency, but ripple reduces at medium frequencies as distance from edge of screen is not any more the same around it.

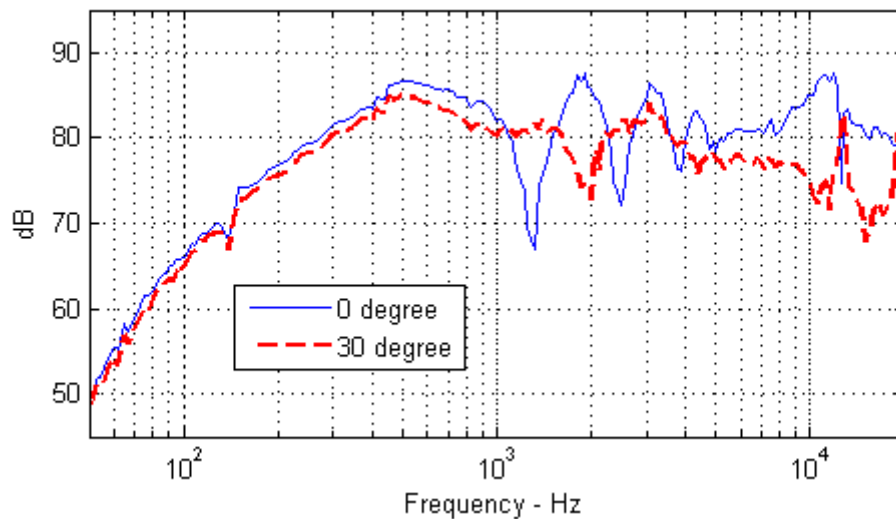


Figure 2. The frequency response of the loudspeaker unit mounted on a circular screen

Figure 3 shows the frequency response of the driver unit mounted on IEC screen. As can be seen from the plot, when the direction is on axis, the response curve is quite flat, which is expected. The sudden increase at the higher frequency should come from the speaker itself as same effect is visible in figure 2. Ripple is much smaller than in circular baffle because of asymmetrical shape of the IEC baffle.

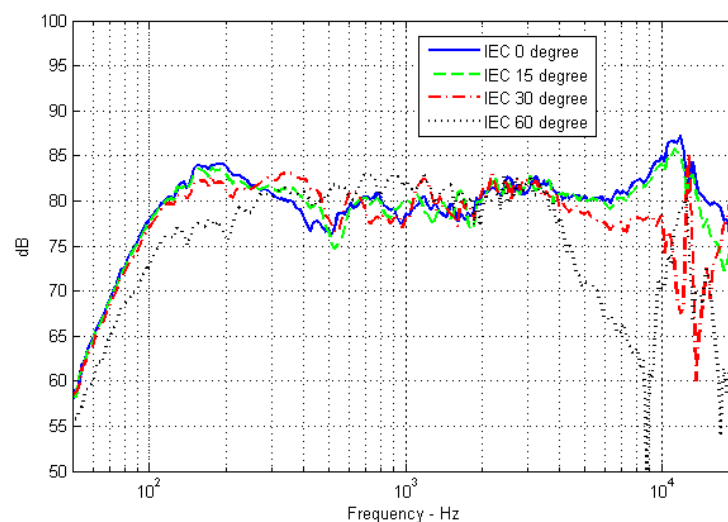


Figure 3. The frequency response of the loudspeaker mounted on IEC screen

Figure 4 shows the off axis response normalized with the on axis measurement. The drops of the responses increase as the angle increases. At the direction towards 15 degree, the curve does not change a lot. However, when the angle exceeds 30 degrees, the drops at high frequency become apparent. Thus, at higher frequencies, the sound produced by the driver propagates towards limited directions.

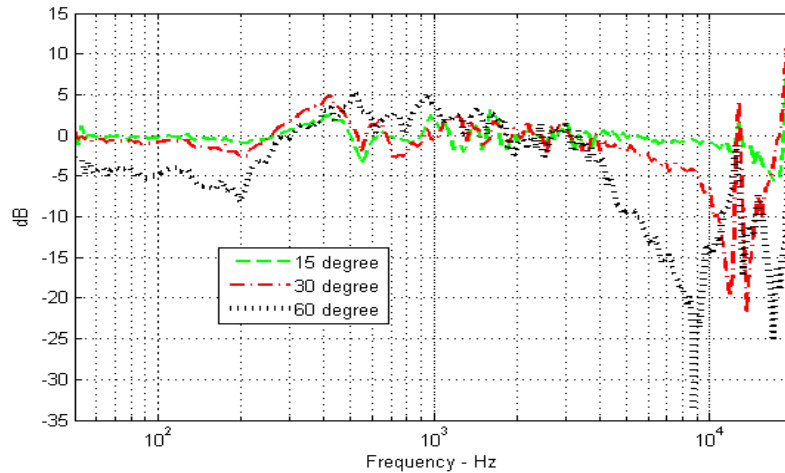


Figure 4 .The normalized response of the loudspeaker mounted on IEC screen

Loudspeaker in project

The diameters were measured as 21 cm for the woofer, 10.5 cm for the midrange and 2.5 cm for the tweeter.

The frequency response of the loudspeaker used in the project is shown in Figure 5 to 7 for each driver. The microphone position was chosen as 1.2m high which is a height between the midrange driver and the tweeter.

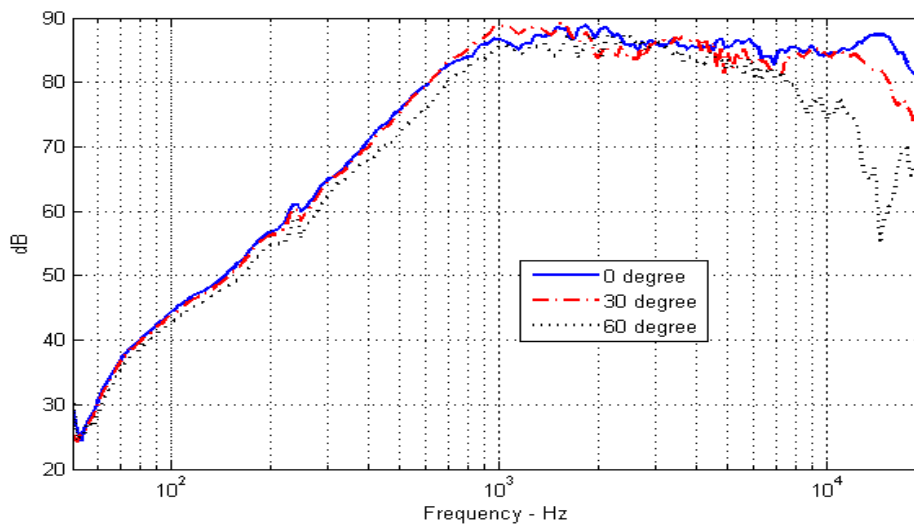


Figure 5 .Frequency response of the tweeter

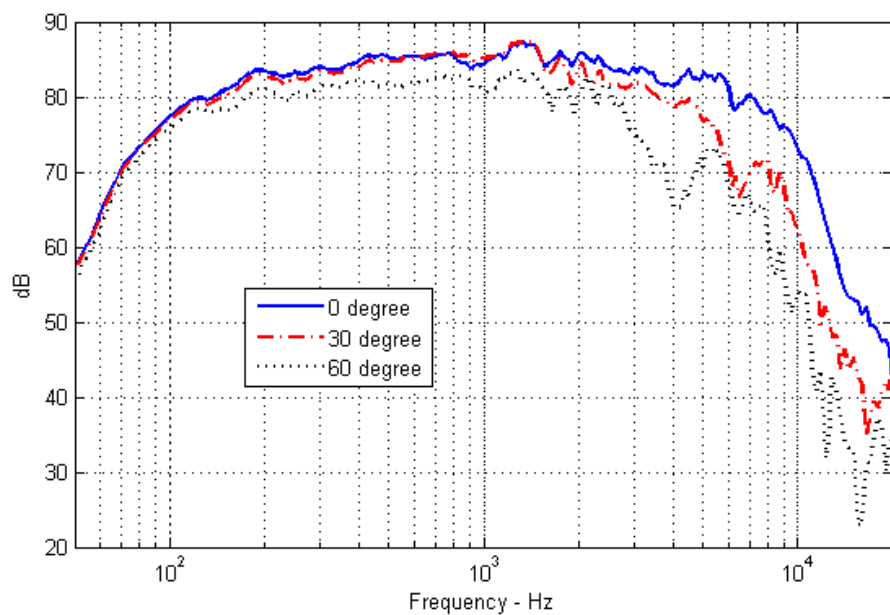


Figure 6 .Frequency response of the midrange

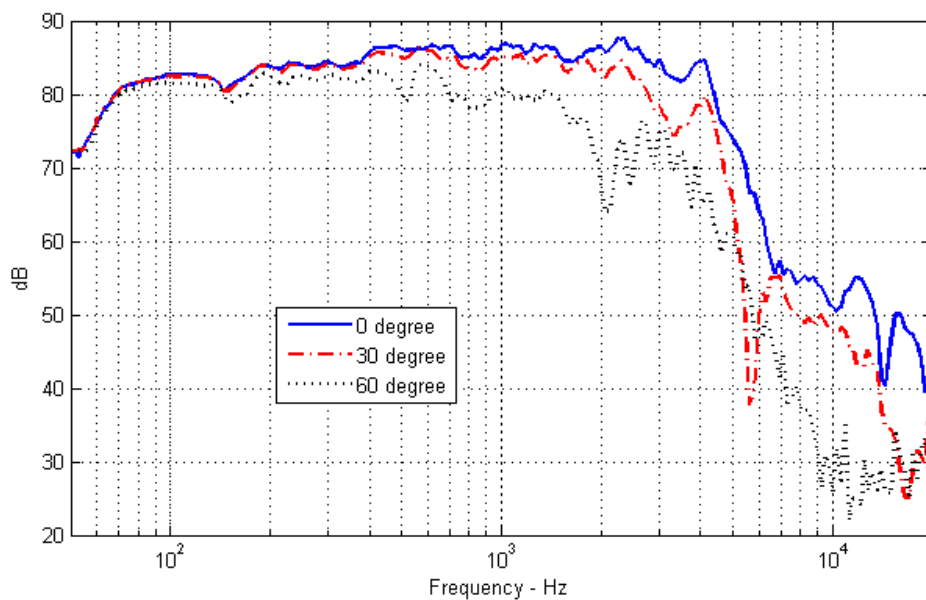


Figure 7 .Frequency response of the woofer

The following figure shows the phase of each driver when the direction was 0 degree.

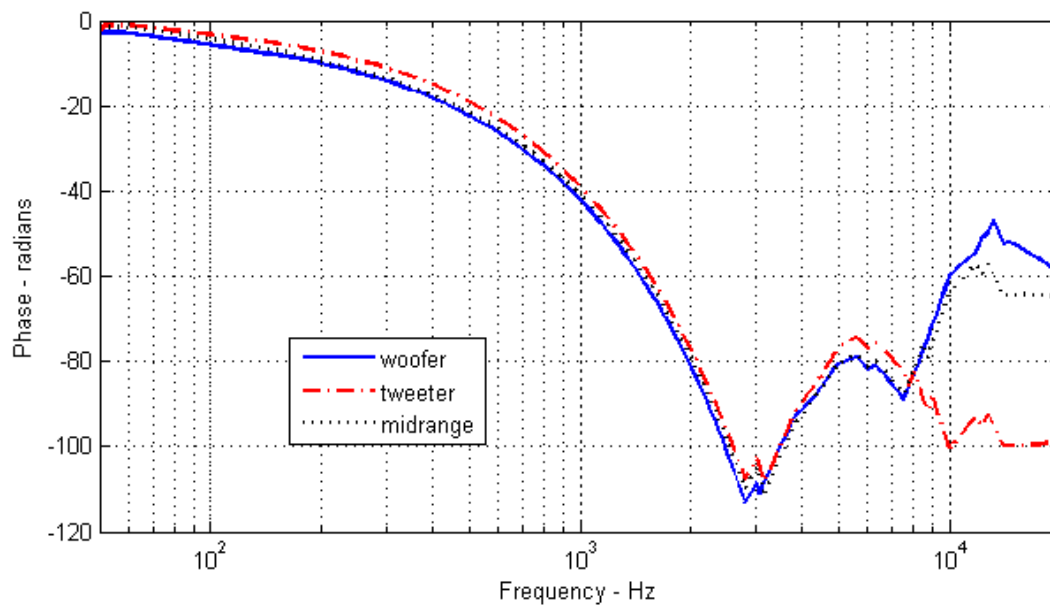


Figure 8. The phase response of each driver

The phases of the three drivers are quite similar at low and middle frequencies. The deviation between these three curves is due to the difference in the distance between the driver and the microphone. However, the dip at approximately 1.8 kHz is unexpected and difficult to explain. At high frequencies, the phases show the different characteristics of the three drivers.

Conclusion

The mounting has an important role in the performance of the loudspeaker driver. The frequency responses are quite different under various mounting conditions. The screen can help to increase the level in low frequencies. In order to achieve a flat response, the influence of the mounting screen should be avoided. The circular screen affects the responses at some frequencies due to equal distance from speaker to all points of edge, while the IEC screen gives a quite flat response because it has asymmetrical distance from speaker to edges.

The directivity of the loudspeaker driver measured in this exercise illustrated by the figure which shows the normalized responses. The sound produced by the driver propagates towards limited direction, especially at high frequency.

Absolute phase of drivers of three way speaker system is similar up to medium frequency range. It starts to differ at higher frequencies because there is distance difference from speakers to microphone and signals arrive with different delay. This data should be considered while designing crossover networks.

Reference

1. **W. Marshall Leach, Jr.** *Introduction to electroacoustics and audio amplifier design, third edition.* Georgia Institution of Technology. 2003.