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APPLICATION NOTE

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Recommendations for Sealing Analog Devices, Inc., Bottom-Port MEMS Microphones from Dust and Liquid Ingress

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INTRODUCTION

This application note describes a seal, made of rubber, silicone rubber, or similar soft material, designed to protect bottom-port PCB-mounted microphones from dust and liquid. The described approach creates minimal performance side effects while allowing a watertight system design.

This application note describes the following:

- Theory behind the design
- Design parameters and materials
- Experimental results

DESIGN CONCEPT

Analog Devices bottom-port MEMS microphones are designed to be reflow soldered directly onto a PCB. A hole in the PCB is required to admit the sound into the microphone package. In addition, the PCB with the microphone is placed in a housing equipped with an opening connecting the microphone to the outside environment.

In a traditional implementation, microphones are exposed to the outside environment. In a harsh outside environment, water or other liquids may enter the microphone cavity, affecting the microphone performance and sound quality. Liquid ingress can also permanently damage the microphone. This application note describes how to protect the microphone from such damage, enabling its use in wet and dusty environments, including full immersion.

DESIGN DESCRIPTION

It is easy to provide protection: place a soft rubber-like seal in front of the microphone. The seal is designed to minimize its acoustic impedance, compared to that of the microphone's sound port. When done correctly, the seal has no impact on the microphone sensitivity and only a minimal influence on its frequency response, confined to the treble range.

The bottom-port microphone is always mounted on a PCB. In this design, the outside-facing side of the PCB is covered with a layer of silicone rubber or similar flexible waterproof material. The flexible material layer can be a part of a keyboard or a keypad or otherwise integrated into the industrial design. This layer should form a cavity in front of the sound hole in the PCB, as shown in Figure 1, to increase the membrane's mechanical compliance. The flexible membrane protecting the microphone should be made as thin as possible. The combination of a large (relative to the sound port in the microphone and the hole in the PCB) diameter cavity and the thin soft flexible membrane forms an acoustic circuit with relatively low impedance. This low impedance (relative to the input impedance of the microphone) minimizes signal loss. The cavity diameter should be about 2× to 4× that of the sound port.

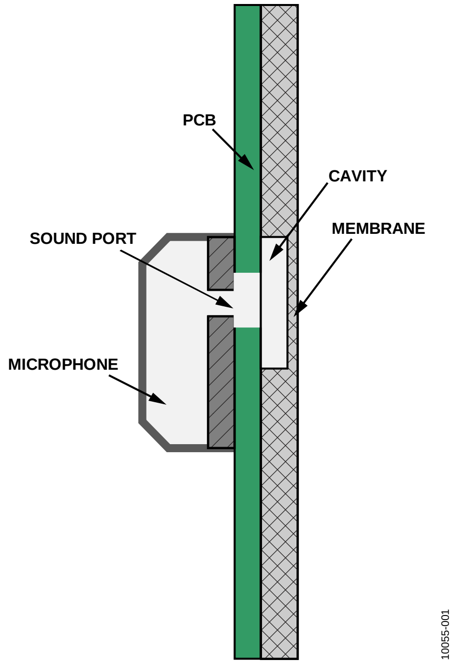

Figure 1. Cross-Section of Bottom-Port Microphone Seal Structure

Membrane Materials

The membrane material should be selected to present as little impediment to sound as possible. A thin layer of soft flexible rubber material is the most suitable for this application. Most measurements described in this application note were performed with a layer of 0.01 inch thick, 35A durometer silicone rubber (McMaster-Carr Part Number 86435K31) used as a seal. Some measurements were also completed with 0.002 inch thick, clear, low density polyethylene (LPDE) film.

EXPERIMENTAL DATA

A number of experiments were performed to test the impact of the seal on bottom-port microphone performance. The microphone was housed in a contactor allowing easy change of the seal materials and a direct comparison with the unsealed condition.

Establishing Baseline Response

A bottom-port MEMS microphone was mounted in a contactor, allowing it to be tested under normal test conditions to establish a baseline sensitivity, shown in Figure 2. A difference in sensitivity between different MEMS microphones only shifts the line on this plot up or down; its shape remains the same.

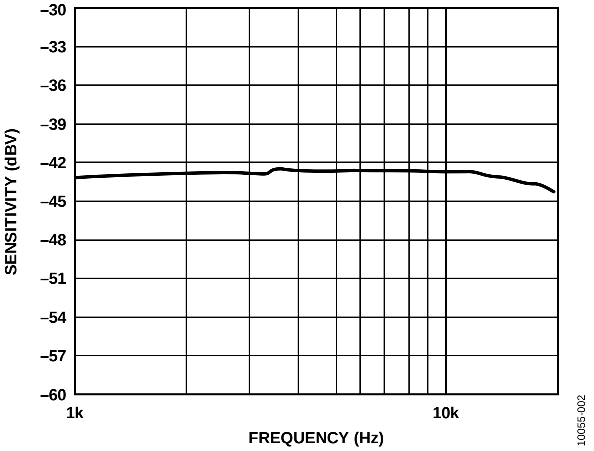

Figure 2. Baseline Response of a Bottom-Port MEMS Microphone

Response with Spacers Added

Two different spacers (washers) were then placed in front of the microphone to create the cavity (see Figure 1) without the sealing film. This was done to test the effect the cavity itself had on the response. The influence of cavities with no film was shown to be minimal. Figure 3 shows that the cavities formed by the washers had the effect of only slightly increasing the high frequency response.

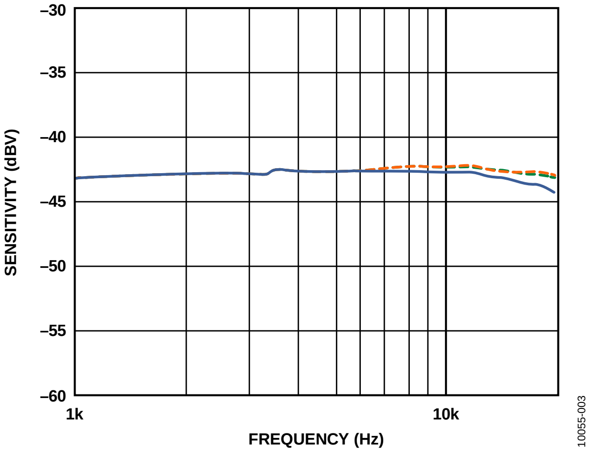

Figure 3. Microphone Response with Added Washer and No Seal (Dotted Lines)

Response with Protective Seals

Two different protective seal materials and two different washer sizes were used to imitate various design options. All demonstrated no sensitivity change and some variations of response at high frequencies. Figure 4 shows the original microphone response overlaid with the response of the four different washer/seal combinations (dashed lines). The actual response in a given application is influenced by the microphone placement, the size of the cavity between the membrane and the microphone, and the membrane material. Figure 5 shows a cross-section of the experimental setup. The only difference between Figure 5 and Figure 1 is that Figure 5 shows the washer and membrane as two separate pieces of the seal assembly, rather than the membrane encompassing all components of the seal.

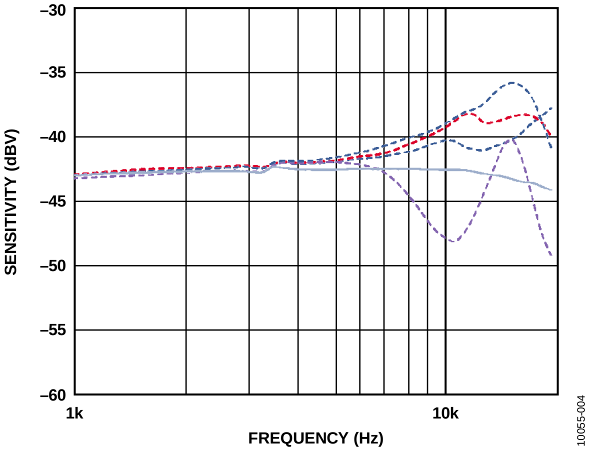

Figure 4. Microphone Response with Different Protective Seal Materials

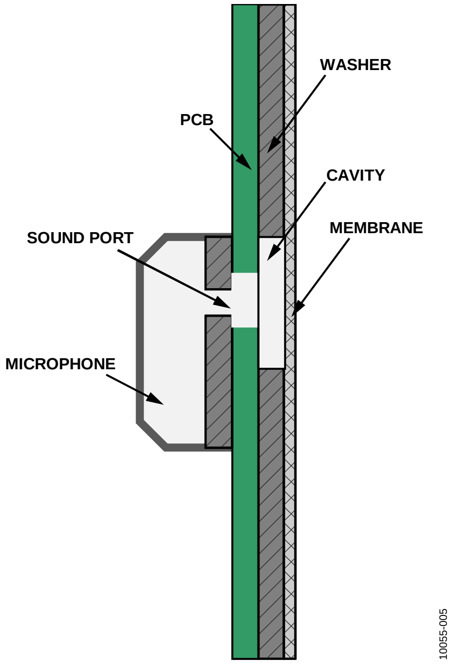

Figure 5. Cross-Section of Experimental Seal Structure

CONCLUSIONS

A simple and effective low cost dust and liquid ingress protection solution for bottom-port microphones is described. Test results show no negative effects on microphone sensitivity and only minimal changes to high frequency response. For many applications where microphones need complete protection from dust and liquids, the high frequency response variations are outside of the frequency band of interest and, thus, have no effect on the overall sound quality.

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