Measurement of acoustic transmission properties of a handset with a piezoelectric vibrator using a head and torso simulator

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This paper clarifies the difference between the acoustic transmission properties of the pinna simulator and a real pinna by a subjective assessment of the sound produced by vibration of the handset with a piezoelectric vibrator using a head and torso simulator (HATS). Recently, a piezoelectric vibrator that vibrates a pinna to produce and transmit sounds was adopted as a receiver on cell-phones and smartphones to improve perceived sound quality in noisy environments. The HATS, used for handset testing in accordance with ITU-T recommendations, has a silicone-rubber pinna simulator to realistically reproduce natural acoustic properties with its human-like shape and stiffness. However, the handset with the piezoelectric vibrator is beyond the scope and was not tested on the HATS. In this paper, we conducted a subjective assessment test that adjusted the gain of pure tones through the pinna simulator to make them auditorily equal to those through the real pinna. We used the HATS, B&K Type 4128-D. The results showed an effect resembling that of a low-pass filter with an approximate cutoff frequency of 1.5 kHz. This allows an actual sound to be simulated from the sound measured by HATS, using the known difference in frequency response.

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INTRODUCTION

Recently, a piezoelectric vibrator that vibrates a pinna to produce and transmit sounds was adopted as a receiver on cell-phones and smartphones to improve perceived sound quality in noisy environments and also to increase users’ convenience. The head and torso simulator (HATS), used for handset testing in accordance with ITU-T recommendations [1], has a silicone-rubber pinna simulator to realistically reproduce natural acoustic properties with its human-like shape and stiffness.

However, the handset with the piezoelectric vibrator is beyond the scope and was not tested on the HATS. This paper clarifies the difference between the frequency characteristics of the pinna simulator and a real pinna by vibrating the handset with a piezoelectric vibrator and using a subjective assessment test that adjusts the gain of pure tones through the pinna simulator to make them auditorily equal to those through the real pinna.

MEASUREMENT

Figure 1 shows the experimental setup of the subjective assessment test. The handset was a prototype of a cell-phone that was made in Japan, in 2012. The receiver was a multi-layer piezoelectric bimorph vibrator measuring approximately $5 \times 20 \times 0.5$ mm. We used the HATS, Brüel & Kjær Type 4128-D with the pinna simulator DZ-9759 [2]. The headphone was a Sony MDR-CD900ST.

In a soundproof room with a reverberation time of 0.1 s, a seated subject heard pure tones, alternately from the handset and a normal headphone. We adjusted the gain of the pure tones through the pinna simulator to be auditorily equivalent to those through the real pinna based on responses from the subject. The pure tones were 0.3, 0.5, 0.8, 1.0, 1.5, 2.0, 2.5, 3.0, and 3.4 kHz.

![Figure 1: The experimental setup.](image-url)
RESULT

Figure 2 shows the frequency characteristics and their difference. The effect resembled that of a low-pass filter with an approximate cutoff frequency of 1.5 kHz.

CONCLUSION AND FUTURE WORK

This paper clarified the difference in frequency response between the pinna simulator and a real pinna by a subjective assessment of the sound produced by vibration of the handset with a piezoelectric vibrator using a head and torso simulator (HATS). The results showed an effect resembling that of a low-pass filter. This allows an actual sound to be simulated from the sound measured by HATS, using the known difference in frequency response.

However, we should increase the number of subjects to provide a more reliable answer to the questions addressed, and also consider various conditions such as the contact pressure in the future.

REFERENCES