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Rebuilding a Prototype System for Ambient Noise Imaging with Acoustic Lens
音響レンズを用いた周囲雑音イメージングのためのプロトタイプシステムの再構築

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1. Introduction

Buckingham *et al.* developed a revolutionary idea, which views ambient noise as a sound source rather than a hindrance, and which is neither a passive nor an active sonar. [1] This method is often called ambient noise imaging (ANI), and an acoustic lens system would be a suitable choice for realizing ANI, because such a system would not require a large receiver array and a complex signal processing unit for 2-D beam forming, which could reduce the size and cost of the system. We already designed and made an aspherical lens with an aperture diameter of 1.0 m for ANI. It was verified that this acoustic lens realizes directional resolution, which is a beam width of 1° at the center frequency of 120 kHz over the field of view (FOV) from -7 to +7°. [2] Using the 1st prototype system with the lens and a 1-D receiver array on a part of the image surface, the silent target was successfully detected under only ocean natural ambient noise, which is mainly generated by snapping shrimps on the 2010 sea trial conducted at Uchiura Bay. [3] Recently, we estimated the spatial distribution of noise sources using a pair of tetrahedron arrays, and some results and discussions of relationship between noise source positions and target scatterings were reported. [4]

Our final goal is to create a pictorial image of a target under ocean natural ambient noise. It is necessary to arrange a 2-D receiver array to cover onto the image surface fully. Now, we are rebuilding the 2nd prototype ANI system with the 2-D receiver array. In this report, the outline of the systen is presented.

2. 2nd Prototype System for ANI

For convenience to manufacture the 2-D array, the image surface of the designed lens approximated to a spherical surface. Figure 1 shows the comparison between the original design and the spherical approximation of the image points for the incident angles of -7, -6, … , +7°. Although the maximum difference of both image points is formed at 0°, it was verified that the difference of the both received pressures is lower than 0.05 dB using the numerical analysis of the 3-D FDTD method. Figure 2 shows the arrangement of the sensor elements for the 2-D array. The 127 elements are arranged under the spherical approximation of the image surface for the horizontal FOV from -7 to +7°, and for the vertical FOV from -4 to +4°. Each element is a square with 10×10 mm^2. This array was manufactured with a piezocomposite technique by Materials Systems Inc. The illustration of the array is shown in Fig. 3. The piezocomposite receiver array with the polyurethane encapsulation attaches to the preamplifier housing directly. It is possible to select the gains of 20 or 30 dB in the 127 preamplifiers. The receivers' sensitivity with the gains of 30 dB is shown in Fig. 4. The average sensitivity increases gradually from -180 to -172 dB at the frequency band from 60 to 200 kHz. The sensitivity variation of all receivers is within ±3 dB.

The whole of the 2nd prototype ANI system is shown in Fig. 5. The acoustic lens and the 2-D receiver array are arranged under the water, and the 2nd preamplifiers with the selectable gains from 0 to 40 dB and the data acquisition (DAQ) system are arranged in the sea surface. The DAQ system has 128 A/D converters with the sampling rate of 1.0 MS/s and the quantization bit rate of 16 bit, and has two SSD RAIDs with total size of 2.4 TB. It is possible to record the 127 output signals of the 2-D array continuously. Now, using this system, we are planning a second sea trial in November of 2014. The main objective is to verify whether the target can be successfully imaged under various conditions involving the direction of the imaging system and the noise distributions.

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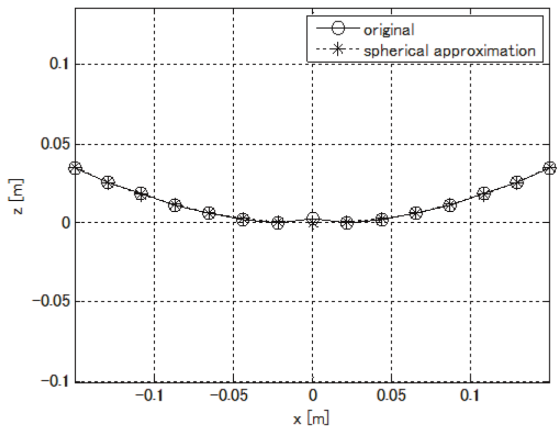
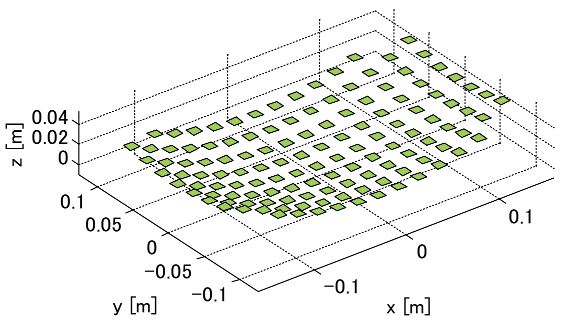
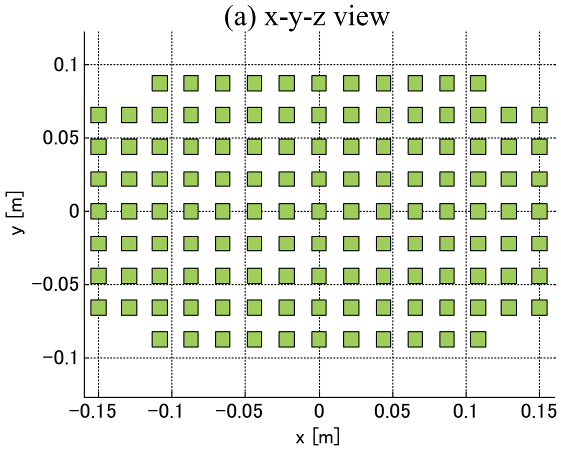


Fig. 1 Spherical approximation of image surface.



(a) x-y-z view



(b) x-y view

Fig. 2 Arrangement of sensor elements of receiver array.

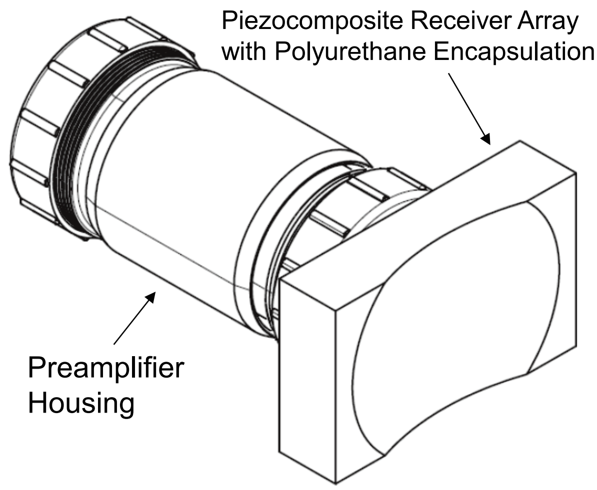


Fig. 3 Illustration of receiver array.

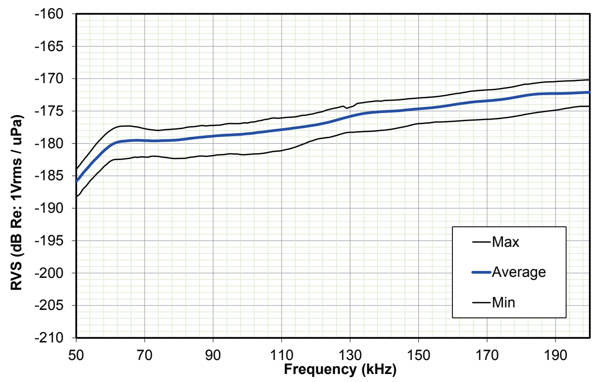


Fig. 4 Sensitivity of receiver array

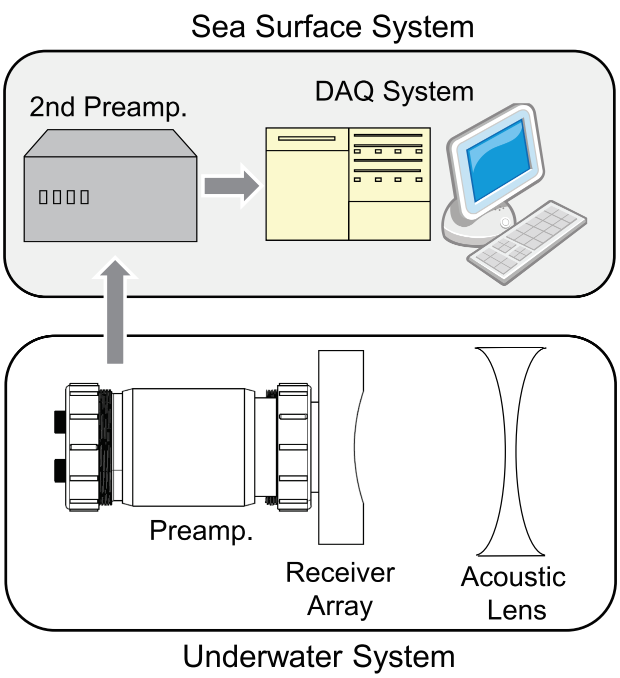


Fig. 5 2nd prototype system