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Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 329-330
6-8 December, 2010

Measurement of sound field (ultrasonic and audio waves) radiated from parametric speaker by optical wave microphone

光波マイクロホンによるパラメトリックスピーカーの放射音場（超音波と可聴音波）の計測

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1. Introduction

Microphones are widely used for detecting sound waves. It has high sensitivity, but itself disturbs the sound field to be measured. In contrast, the optical wave microphone with no diaphram, which is based on wave-optics and uses a laser beam to detect sounds, can measure sounds without any disturbance to a sound field. In this method, diffracted light waves, which are generated from phase modulation by sound waves, are conducted optical information processing and converted into an electric signal. As the sensor section is a light beam, it can measure wideband sound waves from audible to ultrasonic frequencies. Furthermore, it is also excellent in measuring waves with very high sound pressure.

In this study, it is applied to measurement of the sound field radiated from a parametric speaker, where very strong ultrasonic waves and audible sound coexist.

2. Experiment and method

Figure 1 shows the experimental setup. The laser source is a diode laser (670nm, 6mW). The radius of the beam (w) at the sound field is about 2mm. In this experimental condition, sensitivity of the system is theoretically predicted to be max at about 35kHz. A sound transmitter is the parametric speaker ((1)Tristate Co.: 40kHz, 10mmφ, 100 elements kit; size; 100mm*100mm, FM/ (2)Nippon Ceramic Co. ; AS-050C1, 40kHz, 10mmφ, 50 elements, AM). This report mainly shows the results for the former. The surface of the parametric speaker is set parallel to a laser beam. Therefore, the emitted sound vertically traverses the laser beam. A signal sound is the music or the 5kHz signal. The output signal from the photo-detector isn't proofed with absolute sound pressure.

Therefore, a single test sound (20kHz, 90dB) is emitted to the laser beam for comparison. These sound sources are set in a anechoic box (1m*1m*1.2m H) and a laser beam injected through a quartz optical window (30mmφ). Consequently, the distance of the surface of the speaker to the laser beam is limited to about 50～300mm and the present experiment is conducted in the area near the surface of the speaker.

After diffracted light waves are conducted optical information processing by the Fourier optical system, they are converted into electric signal by a photo-detector. After the output signal is amplified by a preamplifier and is through band-pass filter, input into and analyzed in a digital oscilloscope or a FFT analyzer.

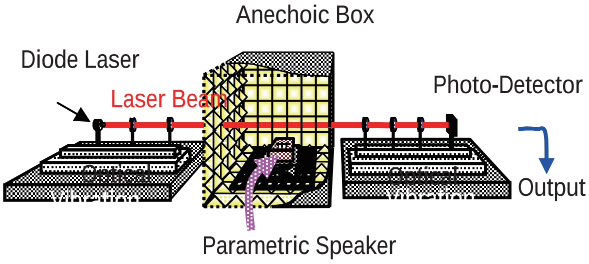

Fig. 1　Experimental Apparatus.

3.　Experimental result and discussion

Figure 2 shows an example of the frequency spectrum obtained by inputting a music by MD as a signal source to the parametric speaker. The output signal isn't proofed with absolute sound pressure. Therefore, a single test sound (20 kHz, 90dB) is emitted to the laser beam for comparison. From Fig.2, it is found that 40kHz carrier component, modulated components and audible sound generated by nonlinear effect are clearly detected. The ultrasonic carrier component is

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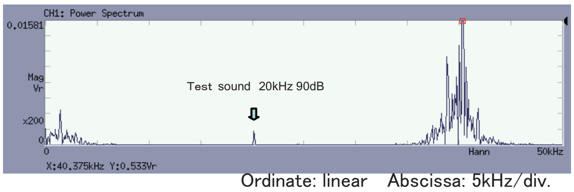
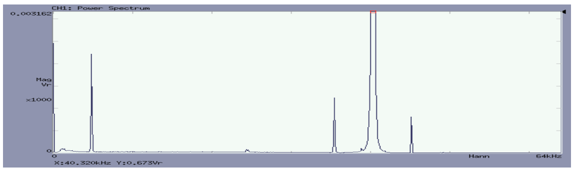
roughly estimated about 140～150dB. Further quantitative evaluation is to be performed hereafter.



Ordinate: linear Abscissa: 5kHz/div.

Fig. 2 Frequency spectrum for music signal input with test sound (25kHz, 90dB).

Next, the single signal sound is input to the parametric speaker and we measure the frequency spectrum. The distance from the parametric speaker surface to the laser beam is changed from 50mm to 300mm. The speaker is also scanned to horizontal (or radial) direction. An example of frequency spectrum is shown in **Figure 3**, where the carrier component and the generated audible sound are observed.



Ordinate: linear Abscissa: 10kHz/div.

Fig. 3 Frequency spectrum for single sound input (5kHz).

Figure 4 (at 100mm from speaker surface) and **Figure 5** (at 300mm) shows the radial change of the signal intensity of audible sound (5kHz) and the ultrasonic sound waves (35kHz, 40kHz, 45kHz), respectively. The origin of the coordinate is the center of the parametric speaker. The spatial point of maximum intensity is shifted about 20mm from the center of the speaker,
The reason of the spatial shift is not clear now.

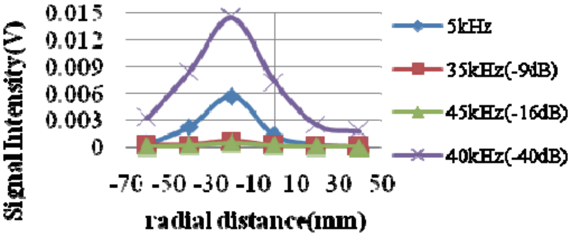


Fig. 4 Radial distribution of each sound wave (at 100mm)

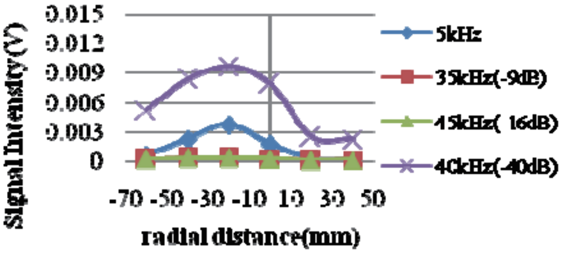


Fig. 5 Radial distribution of each sound wave (at 300mm).

On the other hand, **Figure 6** shows the axial change of the signal intensity. It is found that the signal intensity of 5 kHz has maximum value at about 100 mm from the speaker surface.

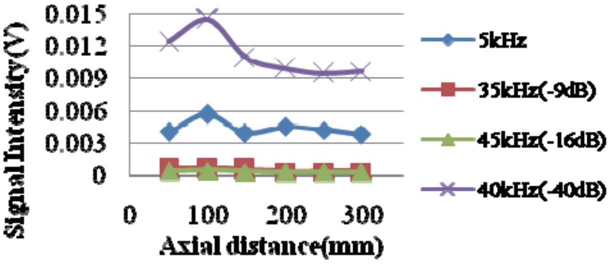


Fig. 6 Axial distribution of each sound wave (at 20mm from center axis).

4. Conclusions

The optical wave microphone is applied to measurement of sound field radiated from a parametric speaker. It is found that this optical method is effective to measure special sound field where the ultra-strong supersonic wave and the audible sound wave coexist. The quantitative estimation of such sound field is to be carried out in the next experiment.

Acknowledgment

This work was supported by the Grant–in-Aid for Scientific Research (C; 22560429) from Japan Society for the Promotion of Science.

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