3P6-5

Advanced study on Self-focusing effect of polarization inverted transmitter with up-chirp signal driving for sub aperture array

分極反転型配列送波器を用いた周波数変調及び開口分割による集束効果

Kazuki Abukawa[1†], Tomoo Sato[1], Takenobu Tsuchiya[2], Nobuyuki endoh[2], Sayuri Matsumoto[1], Kageyoshi Katakura[1] ([1]Port and Airport Research Institute; [2]Kanagawa Univ.)

蛇川和紀 [1†]，佐藤智夫 [1]，土屋健伸 [2]，遠藤信行 [2]，松本さゆり [1]，片倉景義 [1] ([1]港湾空港技術研究所, [2]神奈川大学)

1. Introduction

The four-dimensional acoustic video camera realizes a simple transmit system configuration using polarization inverted transmitter. [1)] We have already reported that the self-focusing without giving a delay to the driving signal of each element of the polarization inverted array and convergence improves by dividing the aperture.[2)] However, it is not enough to discuss about the number of the sub aperture and beam width of the self-focusing.

Therefore, divided polarization inverted array was made, and evaluation the relation of number of sub aperture and self-focusing effect was experimentally examined. In addition, we compare the simulation with measured beam profile and report it.

2. Experiment

This experiment was done in a 3 m × 3 m × 1 m (length × width × depth) tank of water. The experimental setting was shown in Fig.1. Hydrophone with a diameter of 1 mm was used for sound pressure measurement. The position of hydrophone was performed with the automatic positioning stage. The specification of transmitter was shown in Table 1. The transmitter constructed by 64 elements and electrically bound in unit of 4 elements to form 16 channels, and each channel was connected to an arbitrary signal generator. Using up-chirp signal was shown Fig.2. The duration of the driving waveform was 32 cycles, additionally sound velocity was 1447.6 m/s.

3. Simulation method

The beam pattern was simulated in two-dimensions considering the following.

(1) Time of flight between each element and focusing plane.

(2) Polarization direction of the elements

abukawa-k@pari.go.jp

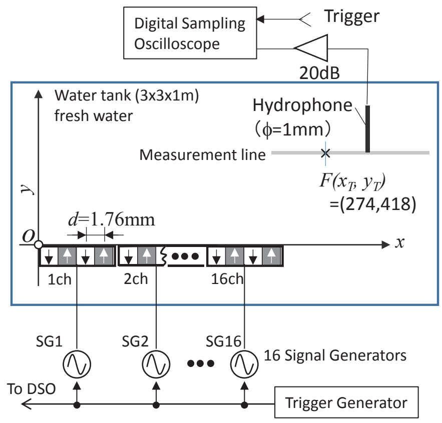

Fig. 1 Experimental setting.

Table1 Transmitter specification

Element number N	64 elements
Polarization	Inverted
Electrical channel	16ch
Element pith d	1.76mm
Aperture width w	$w=N*d=64\times1.76=112.64$mm

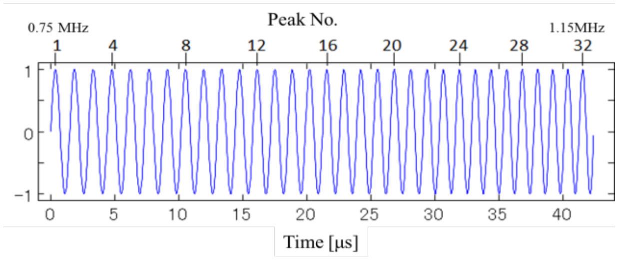

Fig.2 Driving waveform

(3) 1/r attenuation when considering the wavefront of a cylinder

The calculation of quantum time used 40 MHz and phase rotation at complex plane was no considering. This simulation was an approximation with a point sound source, the directivity of elements and hydrophone were not calculated. In addition, various conditions were the same as those in the experiment.

4. Result ＆ Discussion

Fig.3 illustrates comparison of beam patterns of the measured on focal axis. The pattern of beam evaluated by using the peak to peak of the received waveform. X-axis shows measurement position, and Y-axis shows the normalized amplitude. As shown in this figure, the self-focusing effect was confirmed by increasing the divisions of the sub aperture. On the other hand, when the number of divisions in 8 divisions or more, the self-focusing effect is hardly reflected on the beam width.

Fig.4 shows the two-dimensional beam patterns of measured and simulation. As shown in Fig.4, the left images illustrates result of measured, right images illustrates result of simulation, and number of upper left corner shows the divisions of the sub aperture. Result of measured and simulation are in good agreement in the range up to 8 divisions, and almost plot lines overlap. In the evaluation of beam profiles, the simulation well reflects the actual phenomenon. However, in 16 divisions, the result of measured became thicker than the result of simulation. The possible causes are that the influence of the directivity and characteristics of the element becomes large as approaching the focusing limit.

5. Conclusion

The self-focusing effect of the polarization inverted transmitter was experimentally examined. We showed that beam width can be reduced by using up-chirp signal driving for sub aperture array. By this experiment, it is confirmed that the proposed methods provides almost comparable spatial resolving power to the diffraction limit.

Acknowledgement

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References

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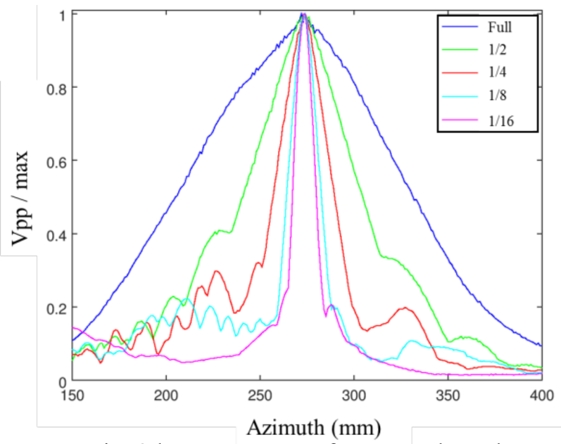
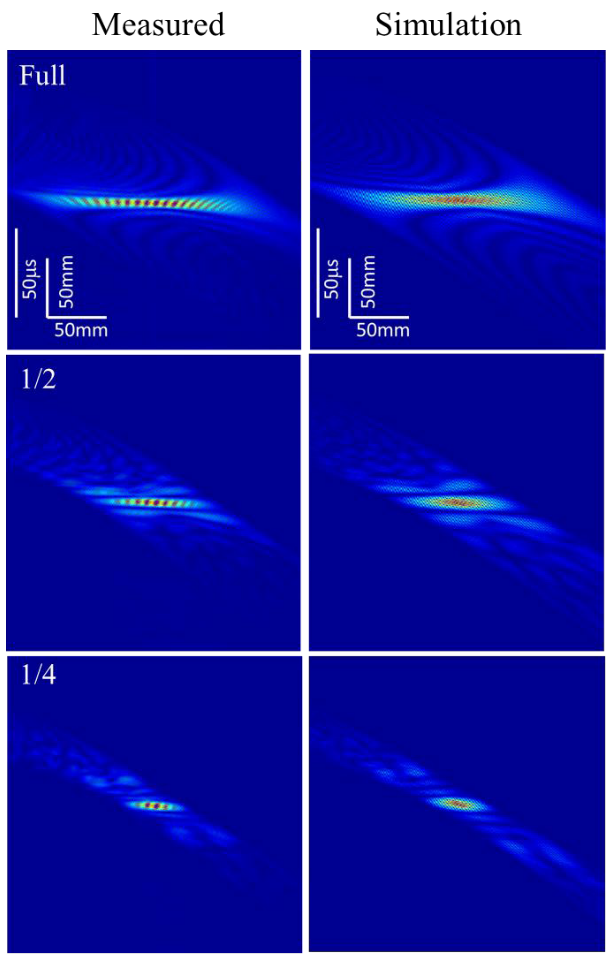


Fig. 3 beam patterns of measured result



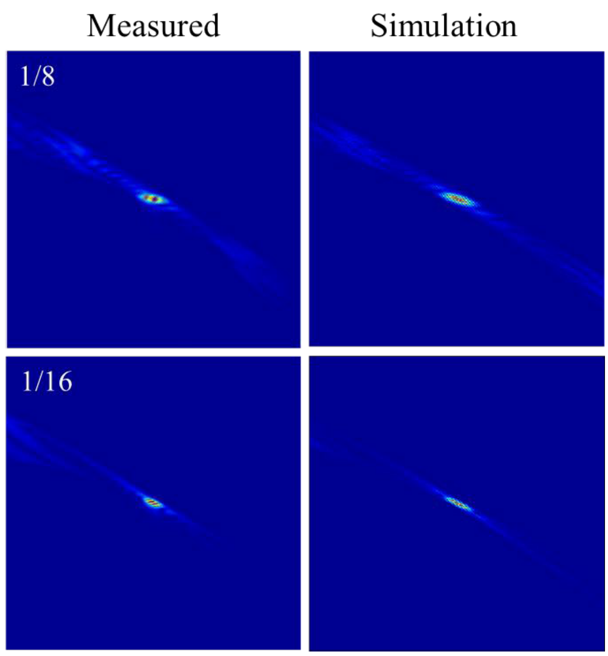


Fig.4 2D beam patterns.