Study on Pulse Compression Ultrasonic Transducer Made with Piezoelectric Copolymer Films

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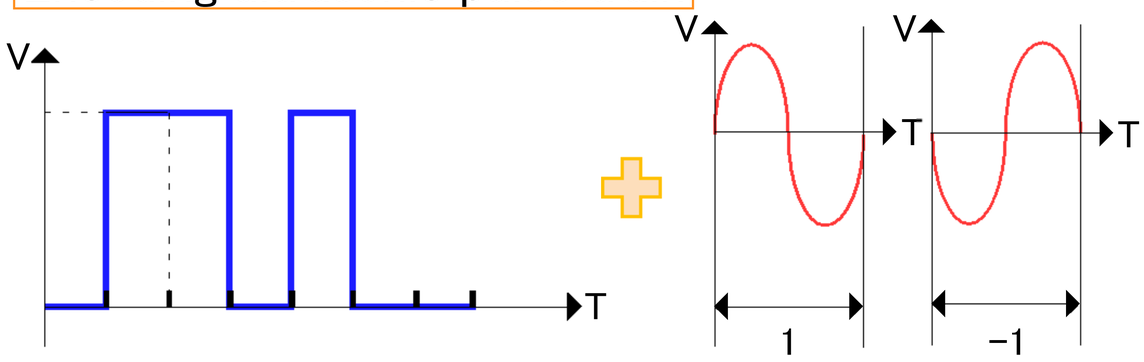
Introduction

In ultrasonic testing, in order to raise the ability in flaw detection, it is necessary to use an ultrasonic probe with a broadband and high sensitivity. The pulse compression techniques using M-sequence and LFM (linear frequency modulation) wave have been reported as a method improving the SN ratio and resolution in ultrasonic testing. However, in order to generate M-sequence or LFM wave, a special hardware like an arbitrary waveform generator is needed, and a power amplifier must be also prepared.

In this study, it aimed to develop a novel ultrasonic transducer which can generate M-sequence wave by only a general pulser without such a special device.

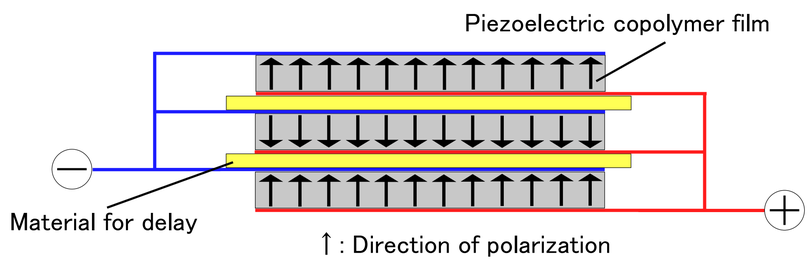
Principle

Encoding ultrasonic pulse train



An ultrasonic pulse train according to the M-sequence of 7 bits length

M-sequence pulse compression transducer

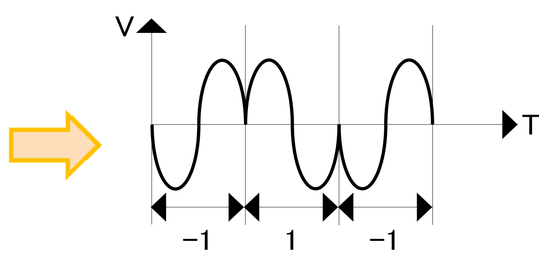


Piezoelectric copolymer film
・PVDF film(52 μm・10MHz)

Material for delay
・Polyimide(175 μm)

・The polarity of generated ultrasonic wave is determined by the polarization direction.

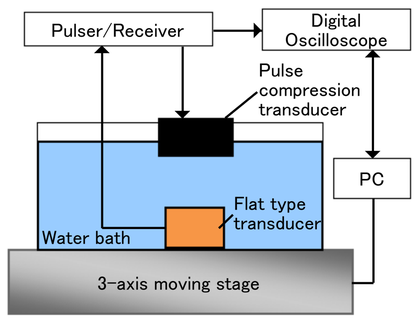
・In order to delay the phase for one wavelength, a delay layer was inserted between each piezoelectric film.



Waveform of M-sequence of 3 bits length

Experiments

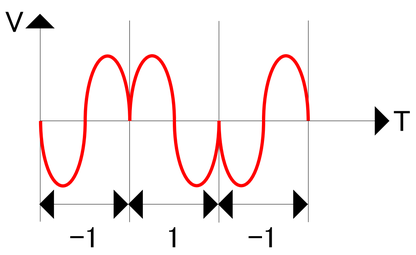
Pulse compression



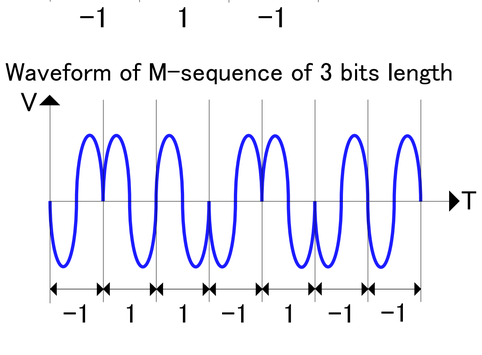
Experimental system

The performance of the transducers was evaluated by autocorrelation received wave by the transducers.

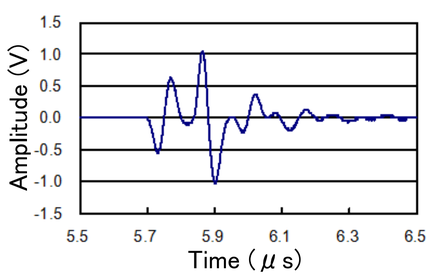
It was verified that M-sequence pulse train could be generated by the proposed method. It was confirmed that the effect in pulse compression could be improved depending on the bit length in a pulse compression transducer with M-sequence.



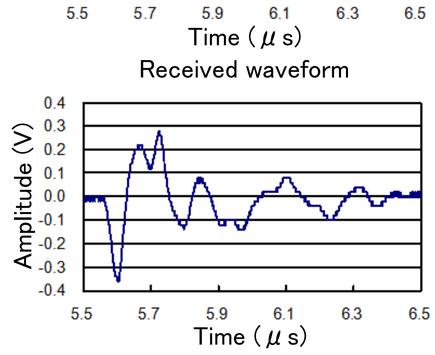
Waveform of M-sequence of 3 bits length



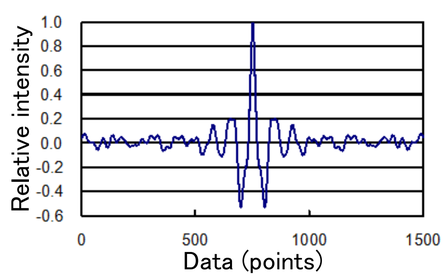
Waveform of M-sequence of 7 bits length



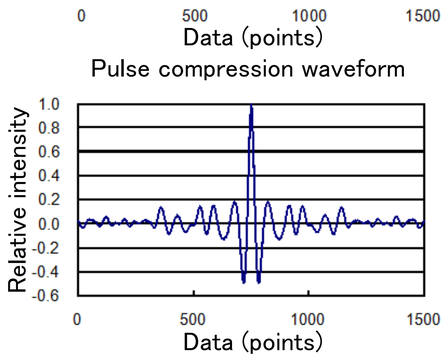
Received waveform



Received waveform



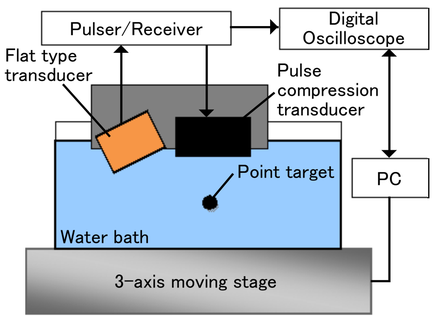
Pulse compression waveform



Pulse compression waveform

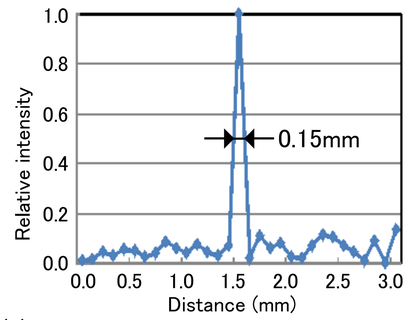
Received waveform and Pulse compression waveform

Performance of this transducer

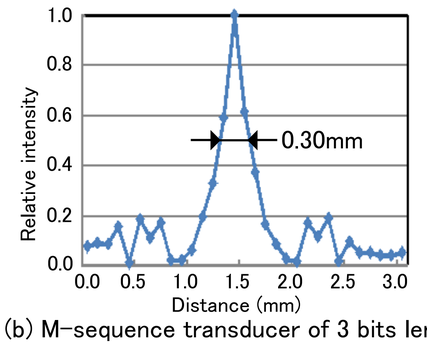


Experimental system

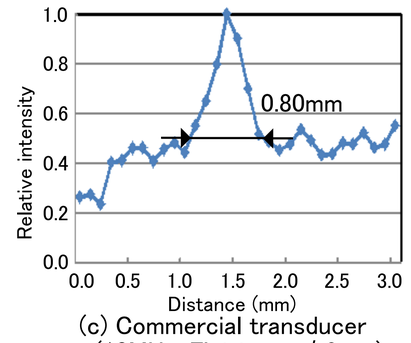
The performance of the transducers was evaluated by 1-D PSF on the acoustic axis of the transducers. A pulse compression processing was carried out by calculating cross-correlation in received waves.



(a) M-sequence transducer of 7 bits length



(b) M-sequence transducer of 3 bits length



(c) Commercial transducer
(10MHz, Flat type, φ6mm)

1-D PSF by each transducer

It was confirmed that the resolution along the acoustic axis could be improved depending on the bit length in a pulse compression transducer with M-sequence. Furthermore, it was demonstrated that the SN ratio in M-sequence pulse compression transducer could be higher than the commercial transducer.

Conclusions

In this study, a pulse compression ultrasonic transducer was developed in order to improve, the performance in ultrasonic measurements . The transmission of M-sequence pulse train was observed in the experiment using only a conventional pulser apparatus. It was confirmed that the developed pulse compression ultrasonic transducer with M-sequence has the performance which corresponds to a general pulse compression method and was improved depending on the bit length in M-sequence. It will be expected that the pulse compression ultrasonic transducer is useful for the ultrasonic testing because of its simple system.