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EXPERIMENTAL VERIFICATION OF SQUARE ROOTING ALGORITHM FOR PARAMETRIC LOUDSPEAKER WITH A PVDF FILM TRANSDUCER

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Abstract. *In this paper, a novel polyvinylidene fluoride (PVDF) film transducer is proposed to improve the performance of parametric loudspeaker. In terms of the self-demodulation principle, the theoretical self-demodulation models of the square rooting algorithm for parametric loudspeaker are established. Further theoretical analysis on these models shows that there is no harmonic component existing in the self-demodulated signal, but a 12dB frequency response slope per octave exists in it. Experiments have been done to verify these theoretical results, and the experimental results show that the measured self-demodulated signals are composed of fundamental and harmonic components, and the total harmonic distortion (THD) decreases when the frequency of input signal increases. Moreover, it is also proved by the experiments that the self-demodulated signal is inclined to agree with the 12dB frequency response slope per octave predicted by Berktay's Far-Field Solution only when input signal is at low frequency and high voltage, but it is inconsistent with the theoretical result when the frequency of input signal is high.*
Keywords: PVDF film transducer, Parametric loudspeaker, Self-demodulation principle, Square rooting algorithm, Total harmonic distortion, Berktay's Far-Field Solution

1. **Introduction.** Parametric loudspeaker is also referred to as audio spotlight, hypersonic sound system, audio beam loudspeaker or audio directional loudspeaker. Actually, it is a novel loudspeaker which can generate an audible sound with high directivity by utilizing the nonlinear propagation effect of ultrasonic in the air. Compared with traditional loudspeaker, it can produce a controllable audible sound to propagate within a certain spatial region. The sound can be heard within the region. Out of the region, it can not be heard, or only a very weak sound can be heard.

The research on parametric loudspeaker stemmed from the parametric acoustic array theory. Parametric acoustic array was for the first time defined by Peter Westervelt in 1962 [1]. A more accurate and complete theoretical explanation of parametric acoustic array was given by H. O. Berktay in 1965 [2]. A so-called Berktay's Far-Field Solution was derived from Berktay's parametric acoustic array theory, in which the demodulated signal is predicted to be proportional to the second time-derivative of the squared envelope of modulated signal. To date, almost all the developed algorithms for the signal process of parametric loudspeakers originate from it. The earlier application of parametric acoustic array was only in the water. It was not until 1975 when M. B. Bennet and D. Blackstock did an experiment to demonstrate that parametric acoustic array did exist in the air [3], which confirmed that it is possible to develop a parametric loudspeaker.

The early efforts directed at creating a practical device of parametric loudspeaker were based in Japan. In 1983, M. Yoneyama and J. I. Fujimoto made an attempt at fabricating