

Abstract No: PS-21

Design and characterization of a parametric speaker using Pulse Width Modulation method

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This study focuses on designing and characterization of a parametric speaker. It is used to convert sound waves that spread out in all directions emitted from a sound source into a narrow sound beam to reduce noise pollution. The designed parametric speaker consisted of a parametric acoustic array. The operation of the device is based on nonlinear acoustic characteristics of sound in air. An ultrasound wave that can be modulated by any audio signal is radiated from a transducer array into the air. As a result, an audio signal is produced by the self-demodulation effect of the modulated sound in the air due to the nonlinearity of the air. Typical parametric speakers use different amplitude modulation methods to produce the parametric acoustic array. There is a high cost to produce parametric speakers using those methods. In this work, a method is proposed to produce the parametric acoustic array using the pulse width modulation method (PWM). PWM techniques were used for modulating the input signal. Mainly TL494 IC was used to realize the modulate system. In that process, input audible sound waves were converted to digital high frequency sound (ultrasound) waves which contains information of the audible sound. The proposed design consists of an array of ultrasound transducers each with 8 mm radius that produces ultrasound wave of 40 kHz frequency as the carrier frequency and a class D power amplifier to amplify the sound level of the modulated output sound. The operation of the proposed parametric speaker was tested by changing the carrier frequency and audio signal and measuring the sound pressure level of the parametric speaker for the different distances. It is identified that this method will be a suitable and cost effective method to produce the parametric speaker. Further the directness of the parametric sound beam depends on the carrier frequency and slightly on the input signal. Hence, the parametric sound beam can be more narrowed by using the (30 kHz – 80 kHz) high-frequency range ultrasound emitters and carrier frequencies for the parametric speaker array. It is concluded that the pulse width modulation method based parametric array used for this research is cost effective method and has a great potential to be further developed for designing commercial scale parametric speakers.

Keywords: Nonlinear acoustic characteristics, Parametric Speaker, Pulse Width Modulation