Design and Development of Ultrasonic Wave Generator Using Piezoelectric Ceramics

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Ultrasonic transducers using piezoelectric materials are popular among researchers because of the efficiency, ease handling, low weight, and small size. In this research, an ultrasonic wave generator using piezoelectric ceramics was designed using mathematical modelling and finite element analysis. Then a prototype was fabricated to compare the performance. Piezoelectric constitutive equation for converse effect and differential equation of spring-mass system with a forcing function were used for mathematical calculation in thickness mode to determine resonant frequency, dimensions of the design and acoustic impedance of matching layer and backing layer. The matching layer transmits the mechanical vibration as ultrasonic wave.

To identify optimum parameters of the design, finite element analysis was done. The design resonant frequency and parameters of layers were calculated from solid mechanics and electrostatics for Eigen frequency and Frequency domain studies using 3D model. Transmitting wave frequency in water and air was calculated from acoustic pressure variation, which was obtained as a results of simulation using 2D axisymmetric model. Arduino software was used to feed controlled electric signals to piezoelectric material. Finally a prototype device was developed using Lead Zirconate Titanate (d_{33} = 400 $\times 10^{-12}$ m/V) as piezoelectric ceramics, Aluminum as matching material and Steel as backing material. Thickness of them are respectively 1.5 mm, 3 mm, and 10 mm. Terminal wires were soldered and all three were merged together using glue gun with polymer binder.

Prototype testing was performed with Oscilloscope. The resonance was observed at 75 kHz, 182 kHz, and 232 kHz. Resonance was also confirmed by Impedance - Frequency and Phase - Frequency analysis using LCR measurements.

Keywords: Ultrasonic wave, Piezoelectric, Wave Generator, Finite Element Analysis.