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Investigation of Unusually High Ultrasonic Signal Attenuation in Water Observed in Various Combinations of Pairs of Lead Zirconate Titanate Pb(ZrxTi1-x)O3 (PZT) Piezoelectric Ceramics Positioned Adjacent to One Another Separated by an Intermediate Gap

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Abstract : Lead zirconate titanate (PZT) piezoelectric ceramics are widely used in ultrasonic applications due to their ability to effectively convert electrical energy into mechanical vibrations and vice versa. This paper presents a study on the behaviour of various combinations of pairs of PZT piezoelectric ceramic materials positioned adjacent to each other with an intermediate gap submerged in water, where one piezoelectric ceramic material is excited by a cyclic electric field with constant frequency and amplitude displacement. The transmitted ultrasonic sound propagates through the medium and is received by the PZT ceramic at the other end, the ultrasonic sound signal amplitude displacement experiences attenuation during propagation due to acoustic impedance. The investigation focuses on understanding the causes of extremely high amplitude displacement attenuation that have been observed in various combinations of piezoelectric ceramic pairs that are submerged in water arranged in a manner stipulated earlier. by examining various combinations of pairs of these piezoelectric ceramics, their physical, electrical, and acoustic properties, and behaviour and attributing them to the observed significant signal attenuation. The experimental setup involves exciting one piezoelectric ceramic material at one end with a burst square cyclic electric field signal of constant frequency, which generates a burst of ultrasonic sound that propagates through the water medium to the adjacent piezoelectric ceramic at the other end. Mechanical vibrations of a PZT piezoelectric ceramic are measured using a double-beam laser Doppler vibrometer to mimic the incident ultrasonic waves generated and received ultrasonic waves on the other end due to mechanical vibrations of a PZT. The measured ultrasonic sound wave signals are continuously compared to the applied cyclic electric field at both ends. The impedance matching networks are continuously tuned at both ends to eliminate electromechanical impedance mismatch to improve ultrasonic transmission and reception. The study delves into various physical, electrical, and acoustic properties of the PZT piezoelectric ceramics, such as the electromechanical coupling factor, acoustic coupling, and elasticity, among others. These properties are analyzed to identify potential factors contributing to the unusually high acoustic impedance in the water medium between the ceramics. Additionally, impedance-matching networks are investigated at both ends to offset the high signal attenuation and improve overall system performance. The findings will be reported in this paper.

Keywords : acoustic impedance, impedance mismatch, piezoelectric ceramics, ultrasonic sound
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