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Numerical Simulation and Experimental Verification of Mechanical Displacements in Piezoelectric Transformer

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Abstract : Since its invention, by virtue of its remarkable features, the piezoelectric transformer (PT) has drawn the attention of the scientific community. In past years, it has been extensively studied and its performances have been continuously improved. Nowadays, such devices are designed in more and more sophisticated architectures with associated models describing their behavior quite accurately. However, the different studies usually carried out on such devices mainly focus on their electrical characteristics induced by direct piezoelectric effects such as voltage gain, efficiency or supplied power. In this work, we are particularly interested in the characterization of mechanical displacements induced by the inverse piezoelectric effect in a PT in vibration. For this purpose, a detailed three-dimensional finite element analysis is proposed to examine the mechanical behavior of a Rosen-type transformer made of a single bar of soft PZT (P191) and with dimensions 22mm×2.35mm×2.5mm. At the first three modes of vibration, output voltage and mechanical displacements ux, uy and uz along the length, the width and the thickness, respectively, are calculated. The amplitude of displacements varies in a range from a few nanometers to a few hundred nanometers. The validity of the simulations was successfully confirmed by experiments carried out on a prototype using a laser interferometer. A good match was observed between simulation and experimental results, especially for us at the second mode. Such 3D simulations thus appear as a helpful tool for a better understanding of mechanical phenomena in Rosen-type PT.

Keywords : piezoelectricity, gain, dispalcement, simulations
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