Modeling Losses of a Piezoelectric Resonator : Analytical vs Finite Elements Analysis

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Ferroelectric ceramics and crystals are the main component of many acoustic transducers based on piezoelectric effect. These materials exhibit different types of losses which may have strong effect on the resonances of its impedance. Losses have different sources, may be purely dielectric, mechanical or coupled, piezoelectric "losses".

The frequency, the amplitude, the width, damping and the general shape of the resonances are influenced by these losses. It is well known that calculation of material parameters of a piezoelectric resonator from resonance frequencies has to take into account the glossy nature of the resonator material.

In resonators that have simple geometrical shapes, one can in general have an analytical expression for impedance, and losses can then be determined using several standard or other methods (for example, by fitting the resonance curve with an analytical equation). One may also use an electrical equivalent circuit to achieve the same goal.

If the resonator has a complex shape, the analytical expression for impedance is usually not available and the description of the resonator is made using Finite Element Analysis (FEA). The question is then raised how to implement losses in FEA analysis and whether standard approach of adding losses in FEA adequately describes the resonator.

In this work we approach the problem by modelling impedance of a piezoelectric bar resonator (d31 mode), with known values of elastic and dielectric losses and piezoelectric phase angle, using analytical expression for admittance and FEA. We compare those results with experimentally determined admittance. We show that this description is not a trivial problem and that FEA, in its simple implementation, generally does not describe losses well.