Determining the Material Constants from Impedance Resonance in Piezoelectric Stacks

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Abstract - A derivation of the impedance equation for a zero bond length stack resonator is presented. The model is based on the effective elastic, dielectric and piezoelectric constants of the stack, which allows for the determination of the average piezoelectric and dielectric constant of the stack material. For the number of layers in the stack n = 1,2 it is shown that the wave speed in the stack is determine by the open circuit elastic constant s^D_{33}. In the limit of many layers n it is shown that wave speed is controlled by the short circuit elastic constant s^E_{33}. In the limit of n large an equation for the impedance is derived which is found to be equivalent to the impedance equation previously derived using network theory [G.E. Martin, JASA, **36**, pp1496-1506, 1964]. Techniques to invert the impedance data to determine complex material constants are presented for all values of n. The error associated with using the impedance equations derived from fully short and fully open electrical boundary conditions is investigated. Since the model is based on the material properties rather than circuit constants it allows for the evaluation of specific aging or degradation mechanisms in a direct fashion.