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Consideration of SH-wave fundamental modes in piezoelectromagnetic plate: electrically open and magnetically open boundary conditions

A.A. Zakharenko*

Department of Physics, International Institute of Zakharenko Waves (IIZWs), Krasnoyarsk, Russia

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This report studies the dispersive wave propagation in the transversely isotropic (6 mm) piezoelectromagnetic (PEM) plate when the mechanical, electrical, and magnetic boundary conditions for both the upper and lower free surfaces of the plate are as follows: the mechanically free, electrically open, and magnetically open surfaces. This study follows some original results obtained in book. The fundamental modes' dispersion relations are graphically shown for the following well-known PEM composite materials: $BaTiO_3$–$CoFe_2O_4$ and PZT-5H–Terfenol-D. It is natural that for large values of the nondimensional parameter kd (k is the wave number and d is the plate half-thickness), the velocities of both the fundamental modes approach the surface shear-horizontal wave called the piezomagnetic exchange surface Melkumyan wave. It is well known that plate waves are usually utilized in the nondestructive testing and evaluation, for instance, in the airspace industry. Also, PEM materials are used as smart ones in various technical devices such as dispersive wave delay lines, (biochemi)sensors, lab-on-a-chip, etc.

1. Introduction

According to the most general definition of the magnetoelectric effect, it is possible to state that this effect denominates the coupling between electric and magnetic fields in matter. In the last decade, there is a growing interest in different materials possessing the magnetoelectric effect. Refs. [1–3] review research activities on the (linear) magnetoelectric effect for the last several decades, of which Ref. [1] provides a comprehensive list of review works on the subject. The magnetoelectric effect is characterized by induction of magnetization caused by an electric field or of polarization caused by an applied magnetic field. In composite materials, the magnetoelectric effect is generated as a product property of a magnetostrictive (piezomagnetic) phase material and a piezoelectric phase material. A linear magnetoelectric polarization is induced by a weak AC magnetic field oscillating in the presence of a strong DC bias field. The magnetoelectric effect is large if the magnetoelectric constant α coupling the magnetic and electric fields is large.

*Email: aazaaz@inbox.ru