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Analytical Modelling of a Plucked Piezoelectric Bimorph for Energy Harvesting

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Energy harvesting (EH) is a multidisciplinary research area, involving physics, materials science and engineering, with the objective of providing renewable sources of sufficient power to operate targeted low-power applications. Piezoelectric transducers are often used for vibrational, inertial and direct movement EH. One problem is that, due to the stiffness of the most common material (PZT) and typically useful sizes, intrinsic resonant frequencies are normally high, whereas the available power is often concentrated at low frequencies. The aim of the plucking technique of frequency up-conversion, also known as "pizzicato" excitation, is to bridge this frequency gap. In this paper, the technique is modelled analytically. The analytical model is developed starting from the Euler-Bernoulli beam equations modified for piezoelectric coupling. A system of differential equations and associated initial conditions are derived which describe the free vibration of a piezoelectric bimorph in the last part of the plucking excitation, i.e. after release. The system permits the calculation of the mechanical response and the time evolution of the power generated and represents a ready-to-use modelling tool which will be specially useful for optimisation work.

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