

# Modeling And Simulation Of Magnetolectric Materials In COMSOL For Vibration Energy Harvesting

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## Abstract

Recent studies for smart materials have found promising results in terms of vibration energy harvesting using piezoelectric effect. Previous research has demonstrated a potential for broadband piezoelectric energy harvesting solutions for small scale electronic devices using various optimizations of the geometry and materials. When coupled with magnetolectric effect (ME), i.e. a magnetic field inducing electric polarization of the material, the device can tap into not only utilizing piezoelectric effect but also magnetolectric effect for enhanced voltage or charge generation. In this research, a magnetolectric sandwich composite made of lead-zirconate-titanate doped with zinc and niobium (PZT-PZN) and nickel as shown in the attached figure. COMSOL Multiphysics was used to model and simulate magnetolectric composite beams. First, the natural frequency of the beam was determined using eigen function followed by simulating the structure at this frequency to harvest energy from mechanical vibrations. A series bimorph piezoelectric transducer was designed and was further sandwiched between nickel plates to induce ME effect. A simple rectangular geometry with dimensions of 60 X 2 X 0.825 mm<sup>3</sup> was chosen to form a baseline model with a tip mass of 0.4 grams to tune the resonance frequency to 143.6 Hz. A time dependent convergence study for 2 mm displacement of the free end of the bimorph resulted in the device generating 47.2 V<sub>rms</sub> at 0.5 M-Ohm optimum resistance and an average electric power of 3.69 mW in two mechanical cycles. The magnetolectric coefficient was recorded as 1180 V/cm.Oe. The rectangular geometry was further modified to a trapezoidal shape with a longer width of 40 mm and a shorter width of 4 mm. At a natural frequency of 383 Hz, this device produced average voltage output of 14.69 V<sub>rms</sub> at 13.9 k-Ohm resistance and average power of 16.89 mW in COMSOL simulations. These results show promising trends in researching new geometry and new mechanisms to efficiently harvest energy from ambient resources. Experimental validation would further strengthen these findings for on-board energy harvesting applications.

## Reference

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