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A Multi-impact Frequency Up-converted Magnetostrictive Transducer for Harvesting Energy from Finger Tapping

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Abstract

Vibration energy harvesting has been a research subject of growing interest over the past few years, and is envisaged as a remedy to the unsatisfactory battery issue in low-power electronic devices. In this study, we propose a new magnetostrictive transducer to harvest energy from finger tapping. Galfenol is selected as the transducing material due to its high piezomagnetic coefficient and excellent machinability. To effectively harness energy in low-frequency conditions, we develop a frequency up-conversion mechanism that succeeds in converting vibration below 10 Hz from finger tapping up to the system's resonance of a few hundred Hz. Furthermore, multiple impacts are induced in each working cycle deliberately to boost the efficiency. A comprehensive model is built and solved to analyze the mechanical-magnetic-electrical coupling system. Based on the model, we elucidate the design criteria for high-performance magnetostrictive transducers. A prototype is fabricated with a Galfenol beam of $0.5 \times 5 \times 25\ mm^3$ and, under finger tapping, it generates 5.3 mW power and instantaneously lights up 10 commercial LEDs and a numeric LCD.

Keywords: Energy harvesting, Frequency up-conversion, Galfenol, Magnetostrictive, Nonlinear vibration .

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