Efficient and Sensitive Energy Harvesting Using Piezoelectric MEMS Compliant Mechanisms

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Piezoelectric energy harvesters typically perform poorly in the low frequency, low amplitude, and intermittent excitation environment of human movement. In this paper, a piezoelectric compliant mechanism (PCM) energy harvester is designed, modeled, and analyzed that consists of a PZT unimorph clamped at the base and attached to a compliant mechanism at the tip. The compliant mechanism has two flexures that amplify the tip displacement to produce large motion of a proof mass and a low frequency first mode with an efficient (nearly quadratic) shape. The compliant mechanism is fabricated as a separate, relatively rigid frame with flexure hinges, simplifying the fabrication process and surrounding and protecting the PZT unimorph. The bridge structure of the PCM also introduces an axial tensioning nonlinearity that self-limits the response to large amplitude impacts, improving the robustness of the device. Comparing the time domain performance based on realistic wrist acceleration data, the PCM produces 6 times more average power than a proof mass cantilever with the same unimorph area and natural frequency.