MEMS Energy Harvesters with a Wide Bandwidth for Low Frequency Vibrations

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ABSTRACT

We have designed and built macro-scale wideband electrostatic and electromagnetic power harvesters for low frequency vibration. Initially, MEMS capacitive plates for power harvesting have been designed, modeled and fabricated, and characterized. It was designed with a 2×2 mm^2 movable metallic plate with a thickness of 10 µm suspended by four straight beams above a fixed electrode with a gap of 10 µm to form a variable capacitor. The suspension beams are made with a width, thickness and total length of 20 µm, 10 µm and 1500 µm, respectively. It was found that the single cavity device can harvest almost 180 nW peak power across a 100 kΩ load resistor at 5g. The harvested power was dependent on excitation amplitude and supplied DC voltage.

The MEMS capacitive energy harvester was integrated with two impact oscillators at 18 Hz and 25 Hz for transferring energy from low frequency structural vibration with varying mechanical spectra to high frequency vibration of a high resonance frequency cantilever at 605 Hz. The results demonstrate that the device was able to harvest power on a wide range from 14 to 39 Hz at 1g excitation. The harvested power was 96 nW on a 100 kΩ load resistor.

We also studied a macro-scale electromagnetic power harvester with multi-impact oscillations to achieve a broad bandwidth at low frequency vibrations. The device consists of three low frequency cantilever designed to resonate at 12 Hz, 19 Hz and 40 Hz, a high frequency cantilever with resonance frequency of 210 Hz and a pick-up coil fixed at the tip of the high frequency cantilever. This results in a wide bandwidth response from 11-62 Hz at 1 g. A maximum output power of 23.5 µW can be harvested at 1 g acceleration on an optimum load resistor of 22 Ω.