Vibration-to-Electric Energy Harvesting Using a Mechanically-Varied Capacitor

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To become a feasible alternative to electrochemical cells, energy harvesting circuits require an energy flyback mechanism that can send harvested energy into a storage node for future use. We present simulated and experimental data for a charge-constrained circuit topology containing an inductive energy flyback that periodically transfers energy harvested from a vibrational source back into a reservoir capacitor. Using a mechanical spring steel variable capacitor with capacitance variation from 415.16 pF to 884.84 pF and an out-of-plane resonant mode of 1560 Hz, the system delivers 1.8 µW at 6 V steady-state voltage to a resistive load. Because the circuit contains only one active device used for controlling the energy flyback rate, timing signal generation is greatly simplified. Unlike previous works, a source-referenced timing scheme was explored in order to prevent unwanted energy injection into the harvesting circuit, which would artificially inflate experimental results. Finally, the system exhibits a startup voltage requirement below 89 mV, indicating that it can potentially be turned on using just a piezoelectric film.

In a typical harvesting cycle, charges are delivered onto a parallel plate capacitor while the capacitance is at its maximum value. As the plates are mechanically pulled apart, vibrational energy performs positive work on the charges, which are momentarily constrained from leaving the plate. When the capacitance reaches its minimum value, the charges are moved off the parallel plate capacitor and harvested through an optimized power electronics network.

REFERENCES: