Self-powered Wireless Monitoring System Using MEMS Piezoelectric Micro Power Generator

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A thin-film lead zirconate titanate Pb(Zr,Ti)O₃ (PZT), MEMS Piezoelectric Micro Power Generator has been integrated with a commercial wireless sensor, Telos, to simulate a self-powered RF temperature monitoring system (Figure 1). Such a system has many important applications, ranging from structure to rotary system monitoring. Telos consumes 2270 µJ for 221 ms per measurement. The PMPG and power management module are designed to satisfy such power requirements.

The first prototype of PMPG provides an average 1 µW, with a natural frequency of 13.9 kHz (Figure 2). It has an energy density of 0.74 mW-h/cm², which compares favorably to lithium ion batteries [1]. The second generation PMPG is designed to provide 0.173 mW of power at 3 V with a natural frequency of 150 Hz and maximum strain of 0.12% [2]. We increased the effective mass of the PMPG by adding a Si substrate with thickness of 525 µm to the beam structure. The increase in the effective mass increases the energy store in the device and its power output. The beam length is also increased to achieve a low resonant frequency. The third generation PMPG will use a serpentine structure, which can achieve a low frequency with minimum volume.

Since PMPG offers limited power, a storage capacitor and a power management module are implemented to power the sensor node at discrete time intervals [3]. The PMPG is first connected to a rectifier that converts AC to DC voltage. Each cycle consists of a charging interval, in which PMPG charges the capacitor, and operation intervals, in which Telos uses the energy from capacitor. We developed a test bed, which mimics that of a liquid gas pipe used in the Alaska where the PMPG device will be used to generate power for temperature sensors. Scaling/dimension factors as well as cost and robustness are considered in the design.

REFERENCES