CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

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Project Number

S0903

Project Title

Design and Optimization of a Novel Flexure-Enhanced Piezoelectric Wind Power Generator for Remote Wireless Sensors

Abstract

Objectives/Goals

There is a growing demand for small on-site electricity generators to power wirelessly networked sensor nodes that are suitable for monitoring the built and natural environments. Though wind is ubiquitous, research on milliwatt-scale wind power has just begun. Miniaturized windmills are not suitable for these applications because they require frequent maintenance. In this context, I investigate the wind energy harvesting performance of a low-maintenance mechanism, and demonstrate novel methods to boost its performance by 50-100x.

Methods/Materials

The core element of my power generator is a piezoelectric transducer that is laminated on to a fin. As the fin bends, the piezo will bend with it, and as the piezo bends, charges in the crystal will redistribute. The flowing charge will in turn deliver power to an electrical load connected across the piezo. I used the root-mean-square (RMS) power delivered to a resistor as the figure of merit to assess the optimality of the design variations, described below. I studied the electrical performance of this core setup when cylindrical obstacles (bluffs), sized to shed turbulent vortices at typical wind speeds, are placed in the vicinity of the fin. The materials consisted of several piezoelectric transducers, rectangular brass fins, pieces of cylindrical tubing, an oscilloscope, and an anemometer.

Results

I discovered that the performance of the system can be improved dramatically (>50x) when two bluff objects are placed within whisking distance of the fin. I investigated the performance of this system as wind speed, load resistance, fin length, and bluff separation are varied. I then showed that the wind power extracted by the device per unit volume can be enhanced further by affixing a T-shaped "nose" to the front of the fin.

Using follow-on experiments, I studied two alternative hypotheses to explain my results, and found evidence that the observed improvement in power production is most plausibly attributed to non-linear self-excitations, rather than to the resonant transfer of energy from the vortices to the vibrational modes of the harvester.

Conclusions/Discussion

I demonstrated a novel family of energy harvesters that can yield in excess of 1mW of power under modest wind conditions of < 5 m/s. This is sufficient to power many useful remote sensing applications that utilize emerging ultra low power wireless and CMOS technologies.

Summary Statement

I demonstrated a small-scale device (active volume ~ 0.002 m^3) that can generate over 3mW of power at modest wind speeds of U ~5m/s.

Help Received

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