Increasing Electrical Power Generation for a Piezoelectric Power Harvester

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The usefulness of most high technology devices such as PDAs, cell phones, computers, and sensors is limited by the storage capacity of batteries. In the future, these limitations will become more pronounced as the demand for wireless power outpaces battery development which is already nearly optimized. Thus, new power generation techniques are required for the next generation of wearable computers, wireless sensors, and autonomous systems to be feasible.

Piezoelectric materials are excellent power generation devices because of their ability to couple mechanical and electrical properties. For example, when an electric field is applied to piezoelectrics a strain is generated and the material is deformed. Consequently, when a piezoelectric is strained it produces an electric field; therefore, piezoelectric materials can convert ambient vibration into electrical power. A few researchers have used single off-the-shelf piezoelectric devices to harvest electrical power, yet little has been done to overcome the main weaknesses associated with piezoelectric power harvesting. This research seeks to systematically overcome the weaknesses associated with cantilever-mounted piezoelectric used for mobile power harvesting.

To maximize the power from a piezoelectric device the load impedance must match the impedance of device. This is problematic for frequencies between 10-100 Hz because a single piezoelectric may have impedance in the range of several hundred thousand ohms to ten million ohms. Thus, little current can be produced, and battery charging is diminished due to low current production. To reduce the impedance and increase electrical current, two off-the-shelf actuators (8 piezoelectrics total) are connected electrically in parallel and tuned to resonate in the frequency range of an ambient vibration similar to that produced by a person walking. A picture of the experimental setup may be seen in Figure 1.

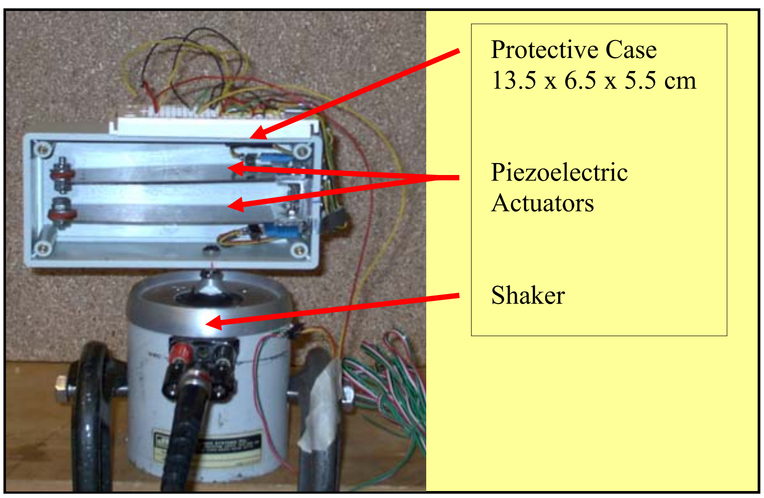

Figure 1: The mobile power harvester attached to a shaker for experimental testing.

To demonstrate the power harvesting advantage, 40 and 80 mAhr Nickel Metal Hydride batteries are charged with each individual actuator then charged with both actuators connected in parallel. For a 1.4 Hz frequency (a brisk walking pace), the parallel combination charges two 40 mAhr batteries in 3.09 hours, and two 80 mAhr batteries in 5.64 hours. The individual actuators require 16.1 hours to charge a 40 mAhr battery, and 22.7 hours to charge an 80 mAhr battery. Clearly, the parallel combination of multiple off-the-shelf piezoelectric actuators increases battery charge times, and adding more parallel devices could increase power production so long as the total voltage exceeds the charged voltage of the battery. Since most production piezoelectrics devices are designed as actuators, research is being conducted to optimize piezoelectrics for power harvesting. Specifically, the locations of each piezoelectric on the cantilevered structure is being studied and designs that reduce electrical cancellation due to out of phase motions are ongoing.