

Compressive Axial Preload Expands the Usable Range of Piezoelectric Generators

Vision

To develop vibration energy scavenging devices that can be adjusted to generate useful amounts of power from a variety of vibration sources with differing peak frequencies.

By contrast, most vibration energy scavenging devices can only operate effectively using vibrations that precisely match a device's resonance frequency.

The development of variable-frequency energy scavenging technology is vital to designing a suitable power source for wireless sensor networks and other applications.

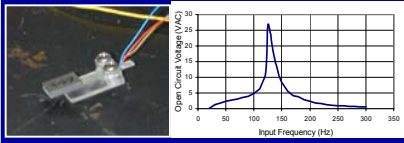
Research Questions

- Can the resonance frequency of a piezoelectric vibration energy scavenger be altered using compressive axial preload?
- How much power is generated by a piezoelectric energy scavenger whose resonance frequency has been thus altered?
- How can a resistive load be used to optimize such a generator's power output?

Findings

- Compressive axial preload can reduce resonance frequency up to 30%
- 50-90% of initial power available at frequencies 20% below nominal (no preload) resonance, compared with 2-5% initial power from non-tunable generator

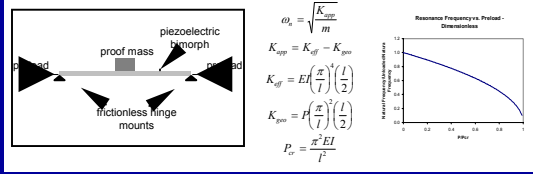
Conventional designs work best at a single frequency...



...but source vibrations vary widely

| Vibration Source | Frequency of Peak (Hz) | Peak Acceleration (m/s ²) |
|--|------------------------|---------------------------------------|
| Clothes dryer | 121 | 3.5 |
| Door frame just after door closes | 125 | 3 |
| Small microwave oven | 121 | 2.25 |
| NVAC vents in office building | 60 | 0.2-1.5 |
| Woods dock with people walking | 385 | 1.3 |
| External windows (size 28" x 34") near a busy street | 180 | 0.7 |
| Notebook computer while CD is being read | 75 | 0.6 |
| Washing machine | 109 | 0.5 |
| Second story of wood frame office building | 100 | 0.2 |
| Refrigerator | 240 | 0.1 |
| Class 3-axis milling machine in operation | 8.3 | 10-30 |
| Food deposition molding machine in operation | 200 | 2.5 |

Will compressive axial preload expand the usable range of piezoelectric generators?



Methods

- A custom-fabricated steel vise was used to apply compressive preload to a simply-supported piezoelectric bimorph
- Resonance frequency for each level of preload was determined by using a variable-frequency vibration generator
- Optimal power output was determined by varying load resistance

