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Electromagnetic Resonant Generator

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Authors

Waterbury, Andrew
Koplow, Mike
Wright, Paul

Publication Date

2008

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Electromagnetic Resonant Generator

Andrew Waterbury
Mike Koplow
Paul Wright

Vision

Small scale resonant generators harvesting ambient vibrations in the 60-200 Hz frequency range

Use an optimized electromagnetic circuit to convert the mechanical vibrations to electrical energy

Vibration Source	Peak Acc. (m/s^2)	Frequency of Peak (Hz)
Base of 5 HP 3-axis machine tool with 36" bed	10	70
Kitchen blender casing	6.4	121
Clothes dryer	3.5	121
Door frame just after door closes	3	125
Small microwave oven	2.25	121
HVAC vents in office building	0.2 – 1.5	60
Wooden deck with people walking	1.3	385
Breadmaker	1.03	121
External windows (size 2 ft X 3 ft) next to a busy street	0.7	100
Notebook computer while CD is being read	0.6	75
Washing Machine	0.5	109
Second story floor of a wood frame office building	0.2	100
Refrigerator	0.1	240

S. Roundy, Energy Scavenging for wireless sensor nodes with a focus on vibration to electricity conversion

Table 1: Characterization of harvestable vibrations

Methods

Beam Structure:

Beam structures were characterized that resonate in 60-200 Hz range while having a footprint on the order of 1 cm^2. Longer thinner multi-turn beams best met the size and frequency requirements.

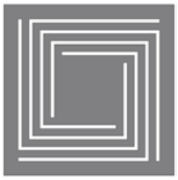

Figure 1: Top view of multi-turn beam structure

Frequency matching is very important due to the narrow power bandwidth of resonant devices. Frequency matching can be done using an analytic expression of the stiffness of the beam structure and classical optimization techniques.

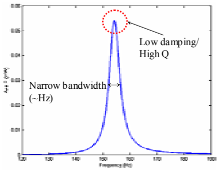

Figure 2: Typical power bode plot for resonant devices

Power Conversion:

The voltage generated from electromagnetic induction is essentially equal to the number of coil turns, N, and the change in magnetic flux, ϕ.

$$V = N\frac{\partial \phi}{\partial t}$$

The greatest change in flux can be achieved using amplified vibration and a toothed steel magnetic circuit

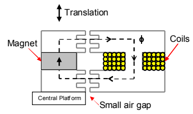

Figure 3: X-section of magnetic circuit

The toothed geometry is the same as that for variable reluctance stepper motor and the same design principles can be used.

Research Questions

What is the theoretical power potential of the design predicted by FEM?

What is the optimum tooth geometry, and does passing by multiple teeth in a quarter vibration cycle increase the power output?

What is the Power Bandwidth of the device?

Findings

Small structures can be designed to resonate between 60 and 200 Hz.

Figure 4: 10 x 10 x 0.09 mm Silicon beam structure that Resonates at 110 Hz

The beams amplify the input vibration amplitude 20 times, meaning the teeth in the magnetic circuit can be larger and more easily fabricated.

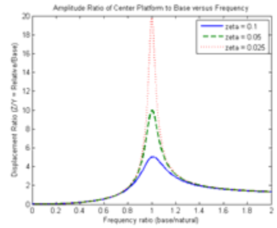

Figure 5: Plot of relative amplification versus input to natural frequency ratio