

Design of an Energy Harvester

Project 3C

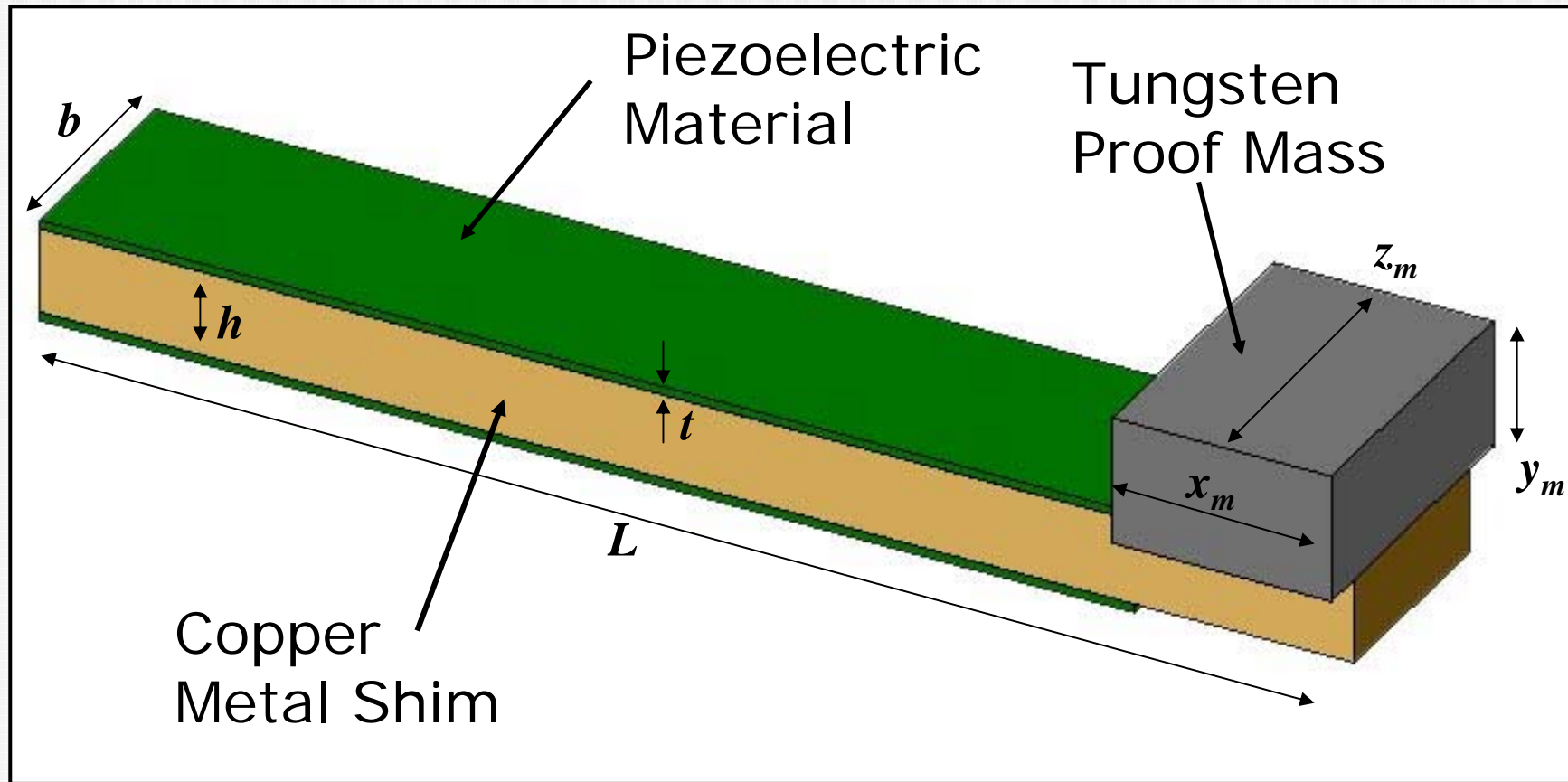
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ME 128, Spring 2006

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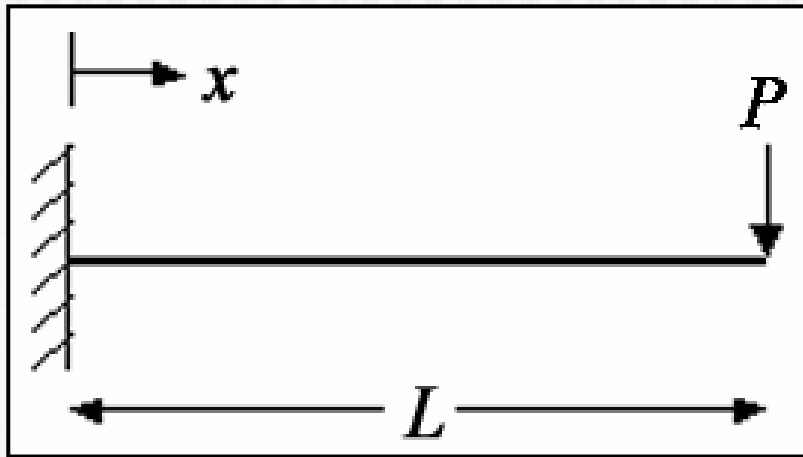
May 1, 2006

Proposed Design



Theoretical Approach

■ Simplify the problem



- Cantilever Beam
- Single Material
- Point Force

Governing Equation

$$M(x) = EI \frac{d^2 u}{dx^2} = P(x - L)$$

Boundary Conditions

$$y(x=0) = 0 \quad \theta(x=0) = 0$$

Equation of Elastic Curve

$$u(x) = \frac{P}{6EI} (x - L)^3 - \frac{PL^2}{2EI} x + \frac{PL^3}{6EI}$$

Analytical Model

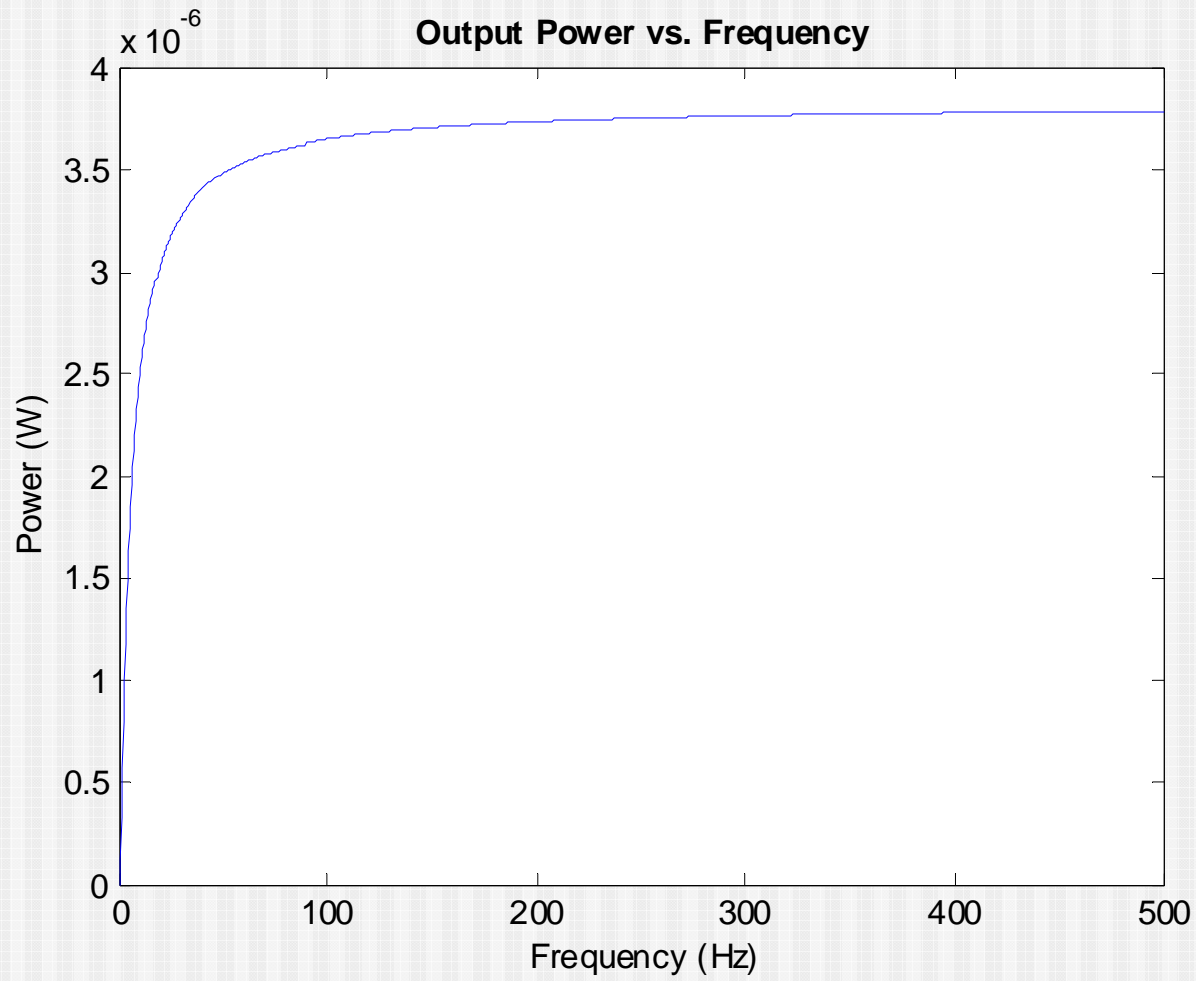
$$\left. \begin{aligned}
 & Power = \frac{\omega^2 b^2 h^2 e_{31}^2 A^2}{4(1 + bL\varepsilon_{33}\omega R / t)^2} R \\
 & R_P^* = \frac{t}{bL\varepsilon_{33}\omega} \qquad \sigma = \frac{M \cdot b}{2 \cdot I} \\
 & u(x = L) = \frac{PL^3}{3EI} \qquad A = \frac{\sigma}{E}
 \end{aligned} \right\}$$

$$Power = \frac{9E^{1/2} e_{31}^2 \rho^{3/2} a^2}{8\varepsilon_{33} E_{11}^{3/2}} \cdot \frac{tx_m^{3/2} y_m^{3/2} z_m^{3/2}}{L^{1/2} b^{1/2} h^{1/2}}$$

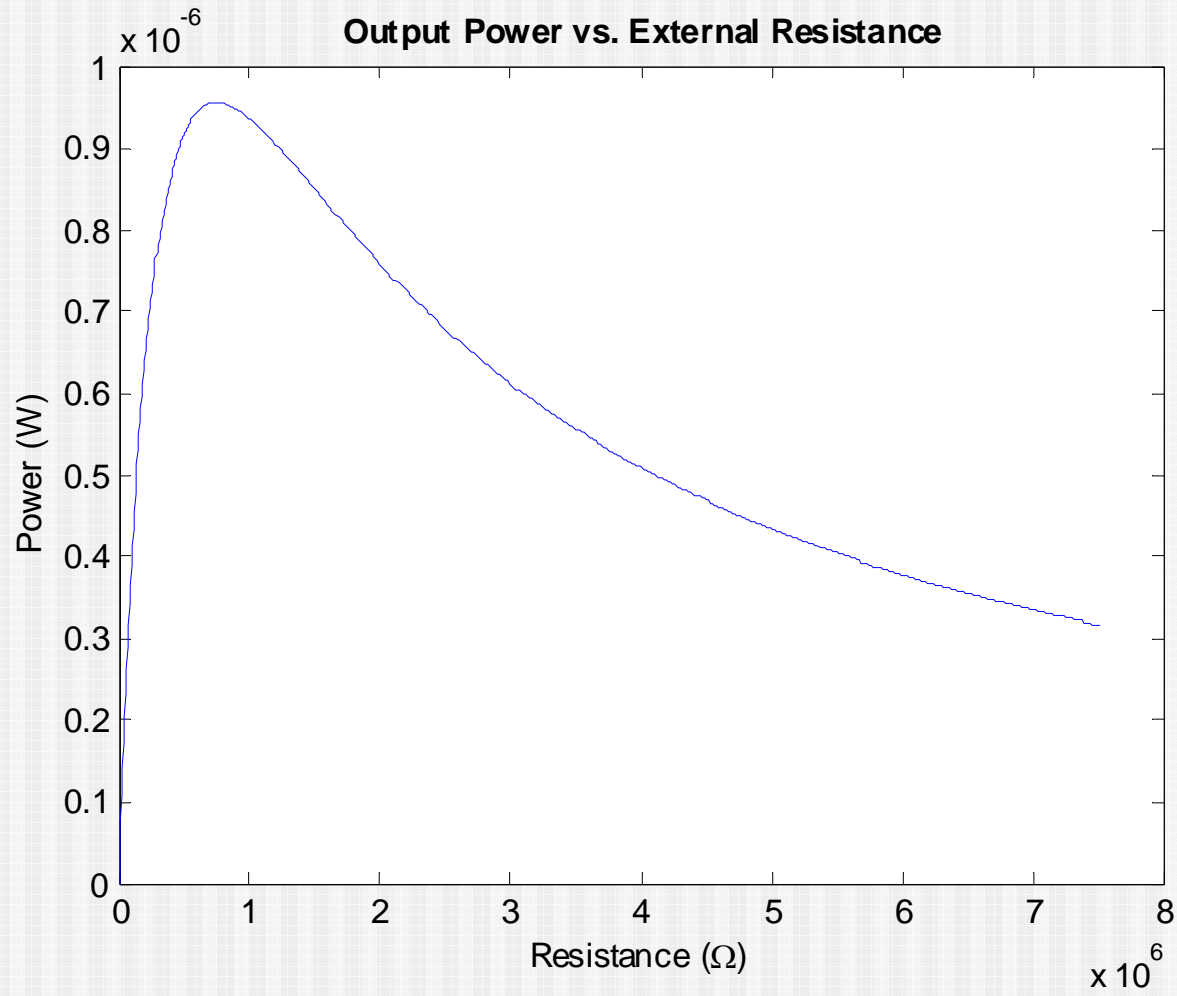
L	↓
b	↓
t	↑
h	↓
x_m	↑
y_m	↑
z_m	↑

* F Lu et. al., "Modeling and Analysis of Micro Piezoelectric Power Generators for Micro-electromechanical-systems Applications", Smart Mater. Struct. 13(2004) 57-63.

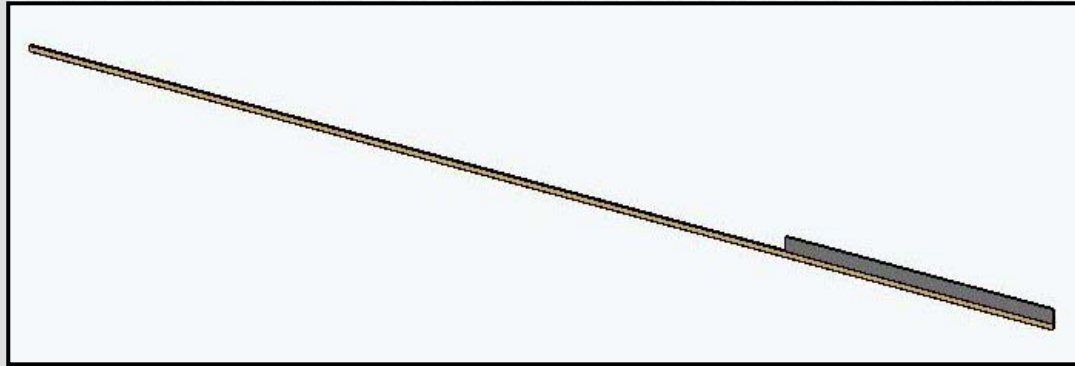
Ext. Resistance vs. Power



Frequency vs. Power



FEM Results



Genetic Algorithm

$$L = 19\text{mm}$$

$$b = 1\text{mm}$$

$$t = 0.5\text{mm}$$

$$h = 5\text{ mm}$$

$$x_m = 3584\text{mm}$$

$$y_m = 101\text{mm}$$

$$z_m = 1.3\text{mm}$$

Maximum Displacement: 11.55mm

Maximum Stress: 5.6 Mpa

Power : 0.61 mW

Natural Frequency: 160 Hz