

Smart Structures Project 2

Lecturer: Morteza Karamooz

Problem: Consider a cantilevered bimorph beam shown in Fig. 4. The properties of the bimorph are shown in tables I and II.

- Develop the finite element model of this beam in Comsol and compute the short circuit and open circuit natural frequencies when the applied voltage is $v = 5 \text{ volts}$
- Simulate the direct or converse effect by applying a sinusoidal voltage or load at the tip of the beam.

TABLE I

PHYSICAL PROPERTIES OF THE BIMORPH CANTILEVER USED IN THE THEORETICAL ANALYSIS

Piezoelectric layer dimension $L \times b \times t_p$ (mm ³)	$50 \times 6 \times 1$
Brass dimension $L \times b \times t_s$ (mm ³)	$50 \times 6 \times 0.3$
1-stiffness of substrate, $C_{33,s}$ (GPa)	100
5-stiffness of substrate, $C_{55,s}$ (GPa)	40
1-stiffness of piezo, C_{33}^E (GPa)	53
5-stiffness of piezo, C_{55}^E (GPa)	21
Substrate density, ρ_s (kg·m ⁻³)	7630
Piezoelectric density, ρ_p (kg·m ⁻³)	7750
Piezoelectric constant, e_{15} (C·m ⁻¹)	12.3
Permittivity, ϵ_{11}^S (F·m ⁻¹)	$1500 \epsilon_0$
Poisson's ratio, ν	0.3
Mechanical damping ratio, ζ_1	0.01

TABLE II

PZT-5A MATERIALS PARAMETERS USED IN THE FEM SIMULATION TENSOR (IN ORDER OF x, y, z, yz, zx , AND xy)

Permittivity, ϵ (F·m ⁻¹)	Piezoelectric constant, d (pm·V ⁻¹)
$10^{-9} \times \begin{bmatrix} 916 & 0 & 0 \\ 0 & 830 & 0 \\ 0 & 0 & 830 \end{bmatrix}$	$\begin{bmatrix} 374 & -171 & -171 & 0 & 0 & 0 \\ 0 & 0 & 0 & 584 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 584 \end{bmatrix}$
Stiffness, c (N·m ⁻²)	
$10^{10} \times \begin{bmatrix} 11.1 & 7.52 & 7.54 & 0 & 0 & 0 \\ 0 & 12.1 & 7.54 & 0 & 0 & 0 \\ 0 & 0 & 12.1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.11 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2.26 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2.11 \end{bmatrix}$	

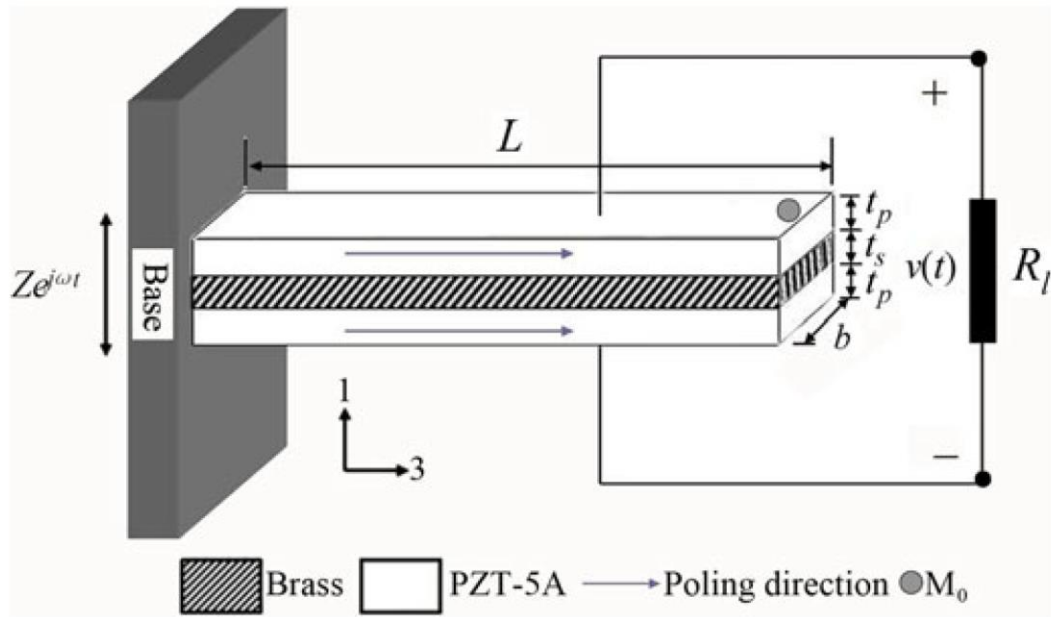


Figure 4. Schematic of the cantilevered beam for problem 5