Computation exercise 2(b): Actuator

Mechatronic systems
376.050
2016W

Important: Answers must be a hard copy and submitted to the office in CA0421 by December 6, 2015 at 4pm. The work must be original.

Fig. 1 shows a lumped mass model of a mass *m* mounted on a piezoelectric actuator, as a positioning system. The power is provided by a voltage amplifier. The parameter values are given in the following table. Answer the following questions.

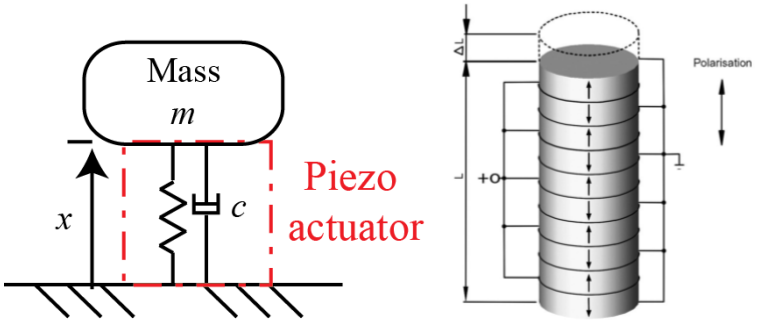

Fig. 1: (Left) a lumped mass model of a positioning system and (right) the stacked piezo actuator

Parameter	Value	Unit	Description
Y	$53 \cdot 10^9$	N/m^2	Young's modulus of piezo material
m	100	g	Weight mass (Load)
ρ	$7.85 \cdot 10^3$	Kg/m^3	Density of piezo material
c	50	N/(m/s)	Damping of piezo actuator
r	5	mm	Radius of piezo actuator
D	195×10^{-12}	m/V	Piezoelectric coefficient
ε	1.68×10^{-8}	F/m	Dielectric coefficient, Permittivity
n	50	-	Number of stacks
l	1	mm	Length of piezo per stack
R	75	Ω	Amplifier's output impedance
V_{max}	150	V	Amplifier's maximum output voltage

i. Determine the mass, the stiffness and the capacitance of the piezo. [25%]

ii. Determine the transfer function from voltage of the piezo to displacement and the impedance of the electrical circuit. [25%]

iii. Determine the maximum displacement of the piezo, as well as its natural frequency. [25%]

iv. When the number of stacks is doubled, determine the maximum displacement and the natural frequency. By assuming that the control bandwidth is restricted by the natural frequency, discuss the design trade-off between the achievable displacement and control bandwidth. [25%]