Piezo Bending Actuator Controlled Variable Inductor

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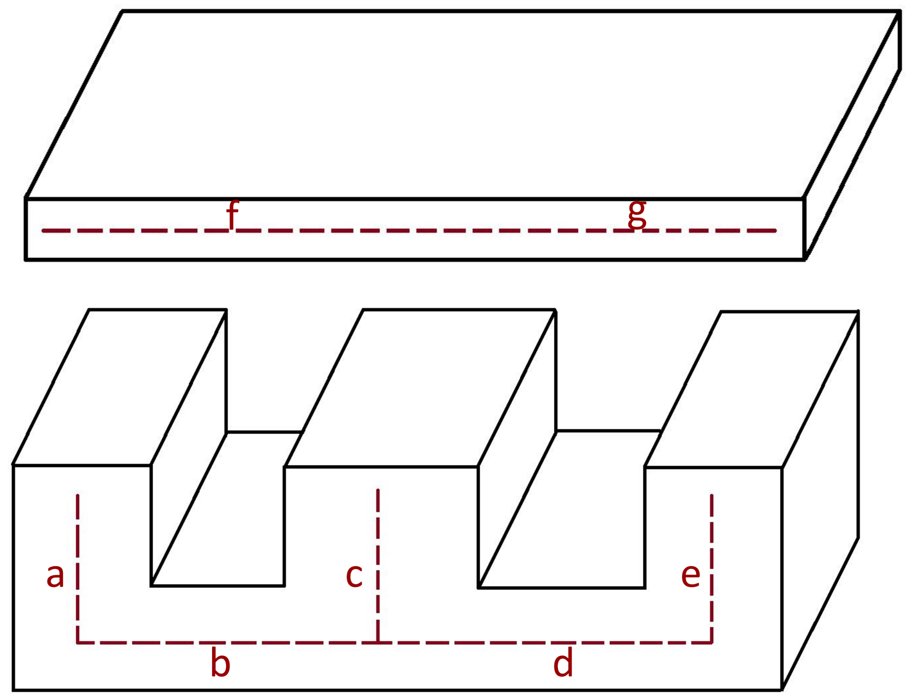
Is There an Application for Piezoelectric Bending Actuators in Variable Inductors?

Design

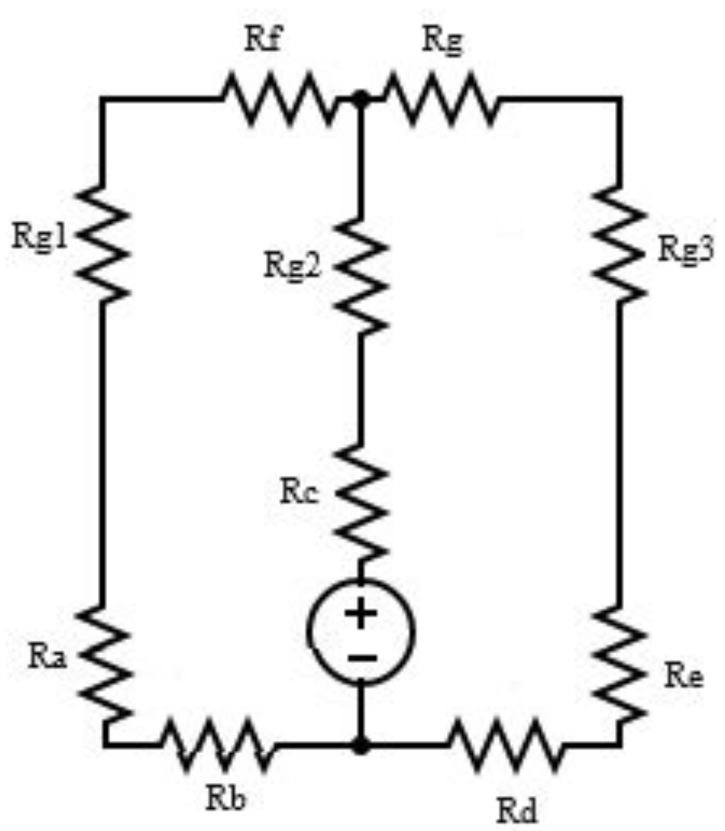
MAGNETIC CIRCUIT



Flux Path

- Magnetic circuit of the ferrite ELP and I Cores used in this research.
- This model provides intuition on how flux is guided through the system. It also helped in the development of the magnetic circuit model below.

MAGNETIC CIRCUIT MODEL



- Using the magnetic circuit model, the total reluctance of the system can be equated and simplified. This equation was the basis for developing python codes to solve for key design metrics, like the number of turns on the core and the inductive range of displacement.

$$R_a = R_e$$

$$R_b = R_d$$

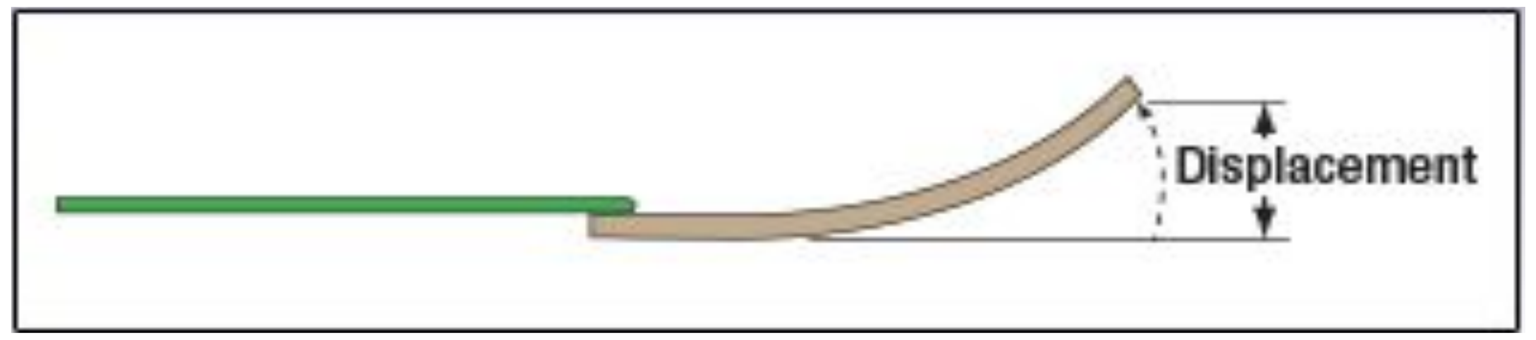
$$R_f = R_g = R_p * 0.5$$

$$R_{tot} = \frac{R_f + R_{g1} + R_a + R_b}{2} + R_{g2} + R_c$$

$$L = \frac{N^2}{R_{tot}}$$

Testing

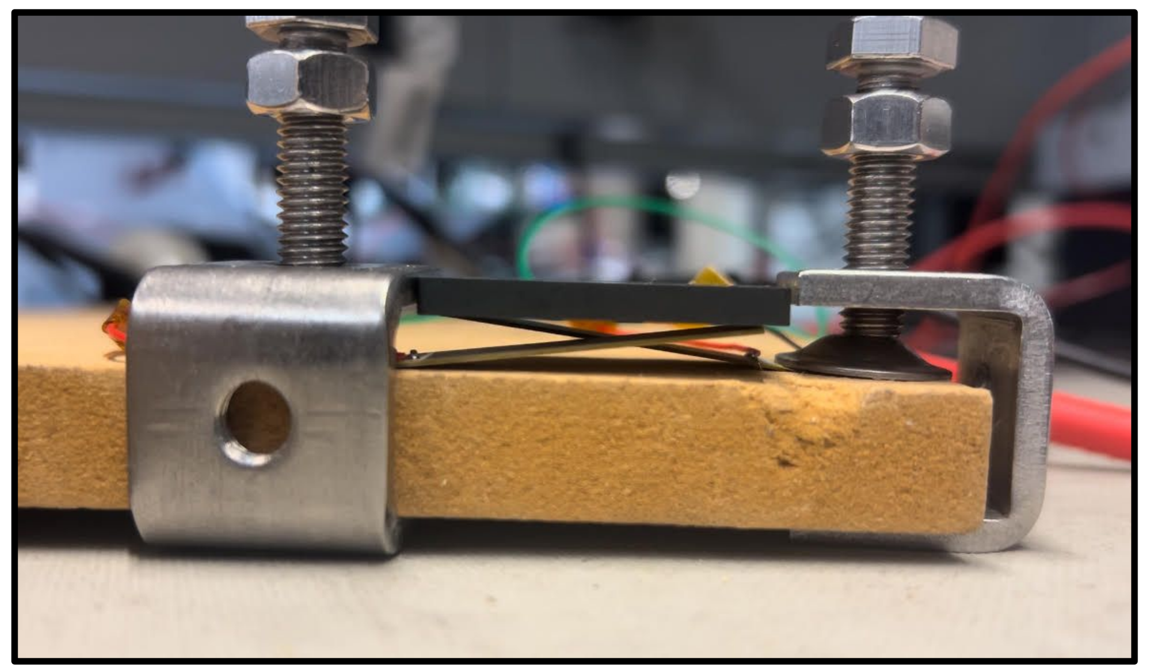
DISPLACEMENT



[1] "Piezoelectric benders," Thorlabs, Inc. - Your Source for Fiber Optics, Laser Diodes, Optical Instrumentation and Polarization Measurement & Control, https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=10958 (accessed Nov. 5, 2024).

- The actuators produce a displacement when a DC voltage is applied to them. The promising aspect of this relationship is that the displacement force is relative to the voltage applied, meaning that it can theoretically be precisely controlled.

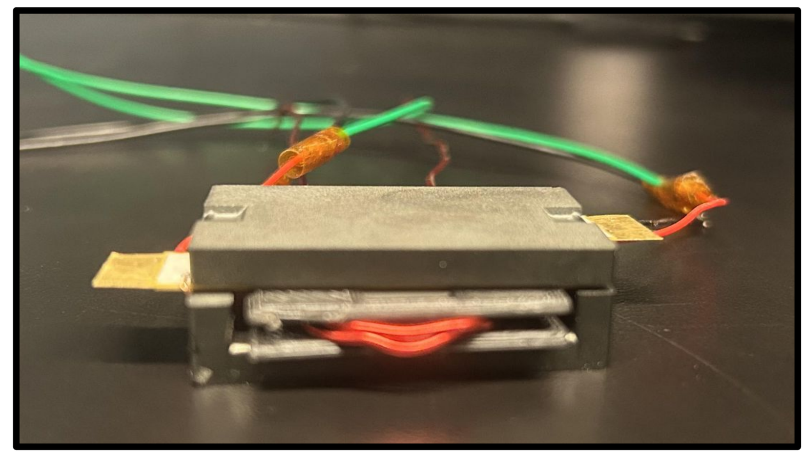
I CORE DISPLACEMENT



- Lab Testing of the displacement force on the I Core using the piezo bending actuators.
- Important note is that the actuators must be clamped down to a surface on one end to achieve displacement.

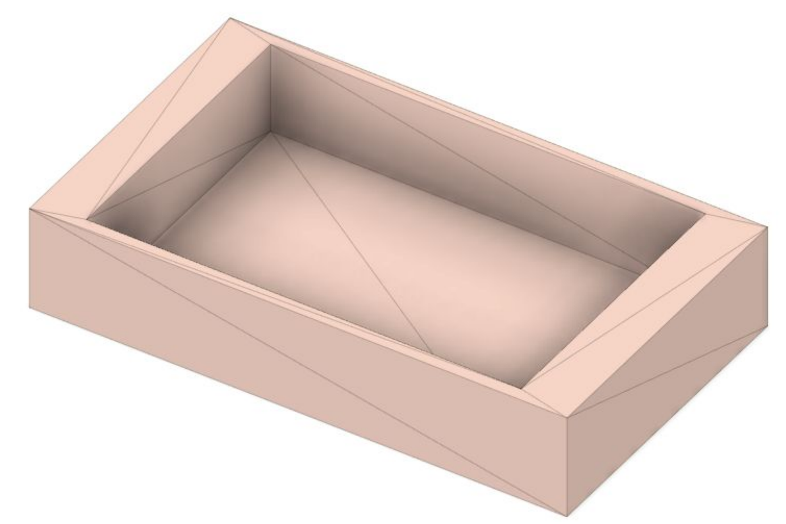
Development

EARLY INDUCTOR DESIGN



- Test system for measuring the initial core inductance and for proof of concept of variable inductance produced by piezo actuator displacement.
- Important design characteristic is the overhang of the piezo actuators off of the cores. This accommodates for the clamping requirement of the actuators.

ELP CORE HOUSING



- 3D Fusion model of the ELP core housing.
- Made to solve the obstacle of clamping the piezo actuators outside of the core.
- The design prevents any extra initial displacement between the bottom ELP core and the I core, which would alter the initial inductance values.
- Future improvements include opening for windings, sloped clamping surfaces, increased clamping surface area, and horizontal place holder for I Core..

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