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Proposal for the final project in Computational Physics course

Calculation of capacitance between two doubly clamped beams with arbitrary form functions

Electrostatic excitation is the main method of mechanical actuation of microelectromechanical systems (MEMS). The exciting mechanical force results from the attraction of two conductive surfaces/bodies, to which a non-zero voltage difference is applied. This force strongly depends on the mutual capacitance between the two conductors.

We plan to numerically investigate the effective capacitance between two parallel doubly clamped micromechanical beams or plates. Such devices are widely used in MEMS as mechanical resonators, mass detectors, parts of optical grids, mechanical switches, etc. In general, analysis of the behavior of such devices requires using the full continuous elasticity model. However, description of doubly clamped beams (as well as cantilevers) as single degree of freedom systems is adequate in many engineering applications.

The effective one-dimensional excitation force that exists between two charged beams can be shown to be proportional to the total capacitance between the beams and to the voltage difference squared. If the voltage is constant, the beams' bend is static. Otherwise, if the voltage is time dependent, the beams may oscillate. In order to take the static or dynamic bending of the beams into account, one may use an appropriate form function describing the geometrical form of each bending beam. Such form function has to satisfy several border conditions. For example, a sine form function assumption is widely used for doubly clamped beams.

In the proposed project, we will create a computer program for numerical calculation of the total capacitance between two doubly clamped beams with given dimensions and form functions. The algorithm will use the method of moments to find the electrical charge distribution on the beams, and calculate the resulting total capacitance. The results for several typical beams' configurations will be fitted to approximate analytical models, such as the inverse distance squared law of parallel plate capacitor. We will also compare the results for not bent (straight) beams with exact analytical solutions found in literature.

The program will be written in Fortran programming language, and will run on Windows and Linux platforms. The analytical fits and results presentation will be done in Matlab.

Possible expansions:

1. Additional configurations of mechanical beam oscillators may be analyzed, most importantly - cantilever configuration.

2. Electrostatic force distribution on the surface of each beam may be calculated. Such force distribution may be consequently plugged into more elaborate continuous elastic model (not as part of this project, however).