Study of Capacitance in Electrostatic Comb-Drive Actuators

P. Hanasi[1], B. G. Sheeparamatti [1], V. Abbigeri [1], N. Meti[1]

[1]Visvesvaraya Technological University, Belagavi, Karnataka, India

Abstract

The objective of this work is to study capacitance in electrostatic comb-drive actuators. The proposed work is carried out by selecting the electrostatic physics domain in COMSOL Multiphysics software. In the electrostatic physics domain, select terminals option to give voltage and ground to the movable comb fingers and fixed comb fingers respectively. Due to the applied voltage and ground, capacitance is established between the comb fingers. Further to enhance the capacitance and power handling capacity, increase in the number of comb fingers from 1 to 150. Capacitance values are obtained from the simulated results. The range of the capacitance value obtained is 3.0524×10-14 F to 6.1674×10-12 F as the comb fingers increased from 1 to 150. Multiple numbers of comb fingers are modeled and simulated using copy option in the geometry. In this way, COMSOL Multiphysics helps to compute the capacitance between comb fingers. These capacitance values are compared with the theoretical values. Fringe capacitance is accounted in the theoretical calculation using the Palmer formula. This type of MEMS-based electrostatic comb drive actuators are used in micro switches and micro grippers.

Reference

[1] Chang Liu, “Foundations of MEMS” , Pearson International Edition 2006, ISBN 0-13-199204-X.
[2] Vitaly Leus and David Elata, “Fringing field effect in electrostatic actuator”, Technical report ETR-2004-2 may2004.
[3] Mehran Hosseini , Guchuan Zhu , Yves-Alain Peter,” A new formulation of fringing capacitance and its application to the control of parallel-plate electrostatic micro actuators”, Analog Integr Circ Sig Process (2007) 53:119–128.
[4] S. Mukhopadhyay and N. Majumdar, “Use of the neBEM solver to Compute the 3D Electrostatic Properties of Comb Drives”, Proceedings of ICCES'05, TechScience Press (2005).
[5] Nitaigour Premchand Mahalik, “MEMS”, Tata McGraw-Hill publishers, Third edition 2007, ISBN-13:978-0-07-063445-9.
[6] Ndu Osonwanne and Jason V. Clark “MEMS Comb Drive Gap Reduction beyond Minimum Feature Size:A Computational Study” Excerpt from the Proceedings of the COMSOL Conference 2010 Boston
[7] Prime Faraday Technology Watch “An Introduction to MEMS” January 2002.
[8] M. Steven Rodgers, Sridhar Kota, Joel Hetrick, Zhe Li, Brian D. Jensen. “A New Class Of High Force, Low-Voltage, Compliant Actuation Systems” Intelligent Micromachine Department, Sandia National Laboratories Albuquerque, New Mexico 87185-1080.
[9] Tai-Ran-Hsu “MEMS & Microsystems: Design, Manufacture, and Nanoscale Engineering” Tata McGraw Hill Publishers, 2004 Edition, ISBN 007048709X.
[10] Sam Jebar Kumar1, Enoch Amoatey Tetteh2, E. Paul Braineard, “A study of why electrostatic actuation is preferred and a simulation of an electrostatically actuated cantilever beam for mems applications” Volume 6, Issue 5, pp: 441-446 ©IJESET.

Figures used in the abstract

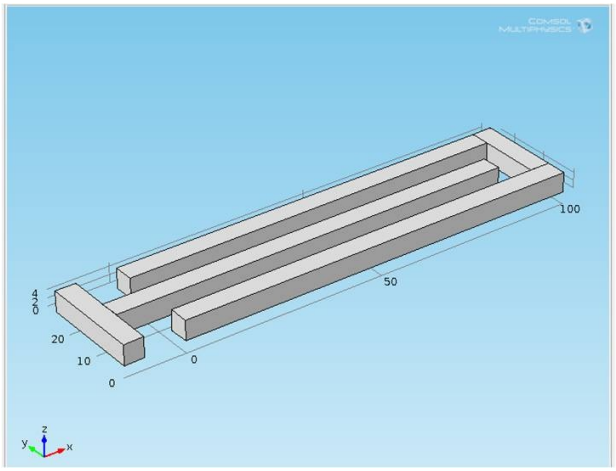

Figure 1: Geometry of MEMS Comb-Drive Actuator

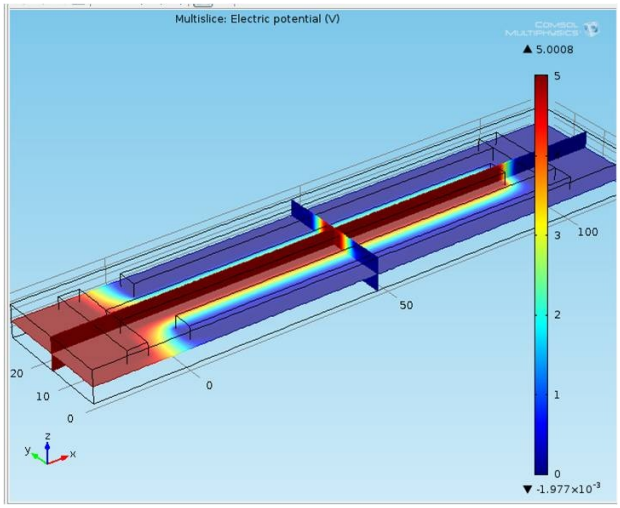

Figure 2: Electric Potential Distributions in the Model

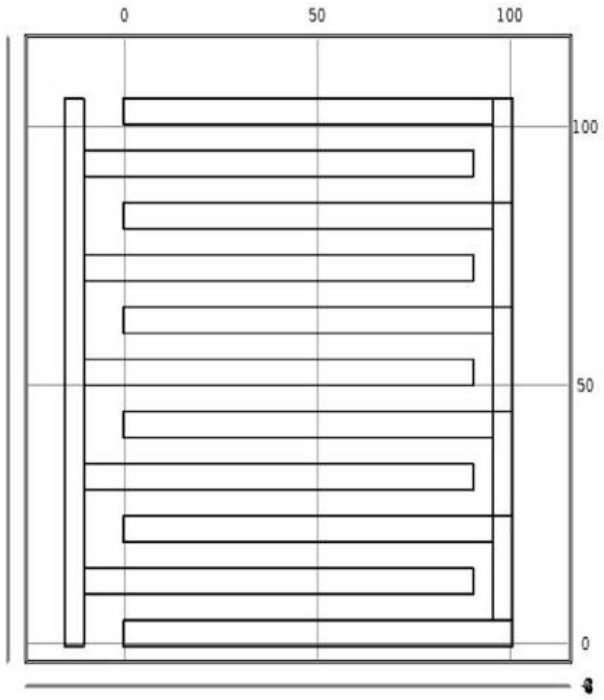

Figure 3: Comb-Drive Actuator with 5 Comb Fingers

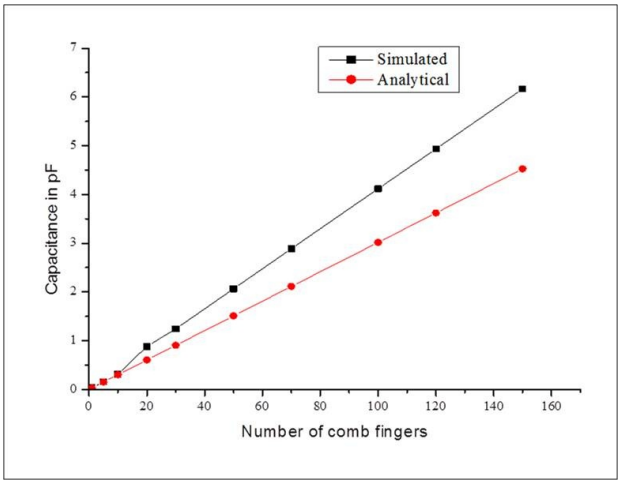

Figure 4: Comparision of the Simulated and Theoretical Capacitance Values