

Study of Capacitance in Electrostatic Comb-Drive Actuators

B. G. Sheeparamatti, P. Hanasi , V. Aibbigeri, N. Meti
Visvesvaraya Technological University, Belagavi, Karnataka, India

Introduction: The objective of this work to study capacitance in electrostatic comb-drive actuators. In Micro Electro Mechanical Systems (MEMS), comb-drives are used as both sensors and actuators. Normally these comb drives have two sets of fingers, one is fixed and other is moving.

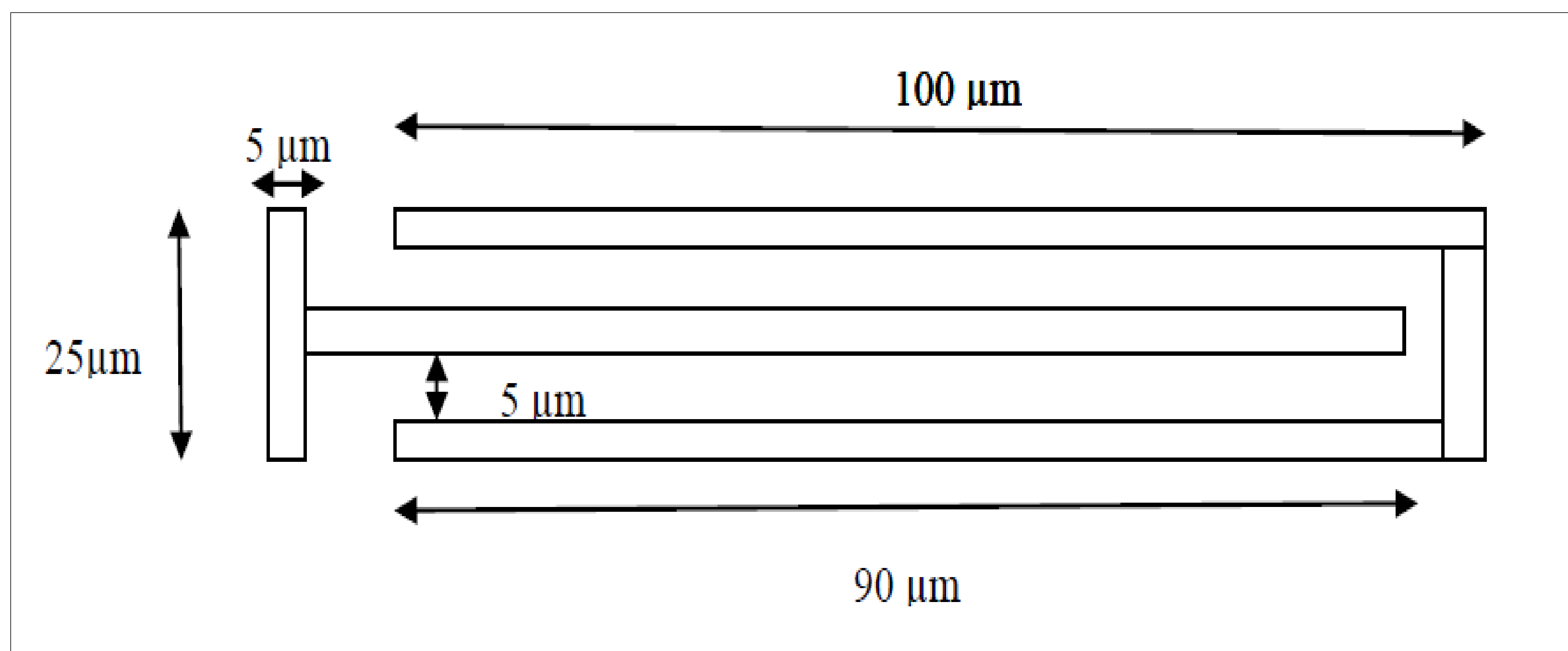


Figure 1. Schematic diagram of MEMS comb-drive actuator

Modeling and simulation: In case of parallel plates, capacitance is given by the equation 1.

$$C = \frac{\epsilon_0 \epsilon_r A}{d} \dots (1)$$

In case of comb-drives, capacitance for a single finger is given by the equation 2.

$$C = \frac{\epsilon_0 \epsilon_r l_0 t}{d} \dots (2)$$

Fringe capacitance is given by equation 3.

$$C_f = \epsilon \frac{WL}{G} \left(1 + \frac{G}{\Pi W} \left(1 + \ln \left(\frac{2\Pi W}{G} \right) \right) \right) \times \left(1 + \frac{G}{\Pi L} \left(1 + \ln \left(\frac{2\Pi L}{W} \right) \right) \right). (3)$$

For the N number of comb fingers, capacitance is given by equation 4.

$$C = N \frac{\epsilon_0 \epsilon_r l_0 t}{d} + C_f \dots (4)$$

Results:

Voltage is applied to movable comb fingers and ground is applied to fixed comb fingers. Due to the applied voltage and ground, capacitance is established between the comb fingers.

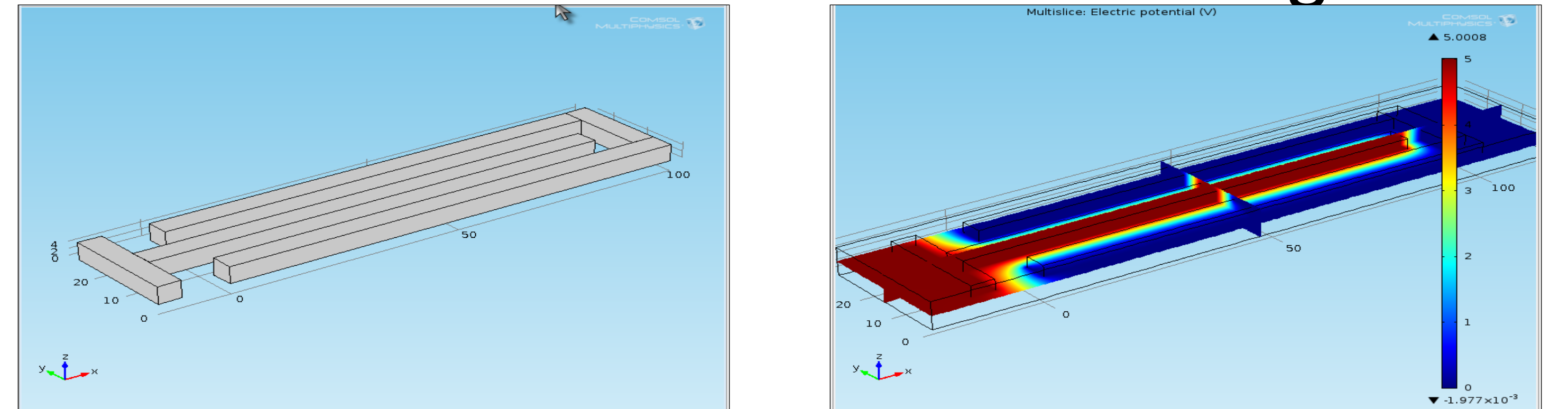


Figure 2 and 3.

Comb drive actuator and applied electric potential

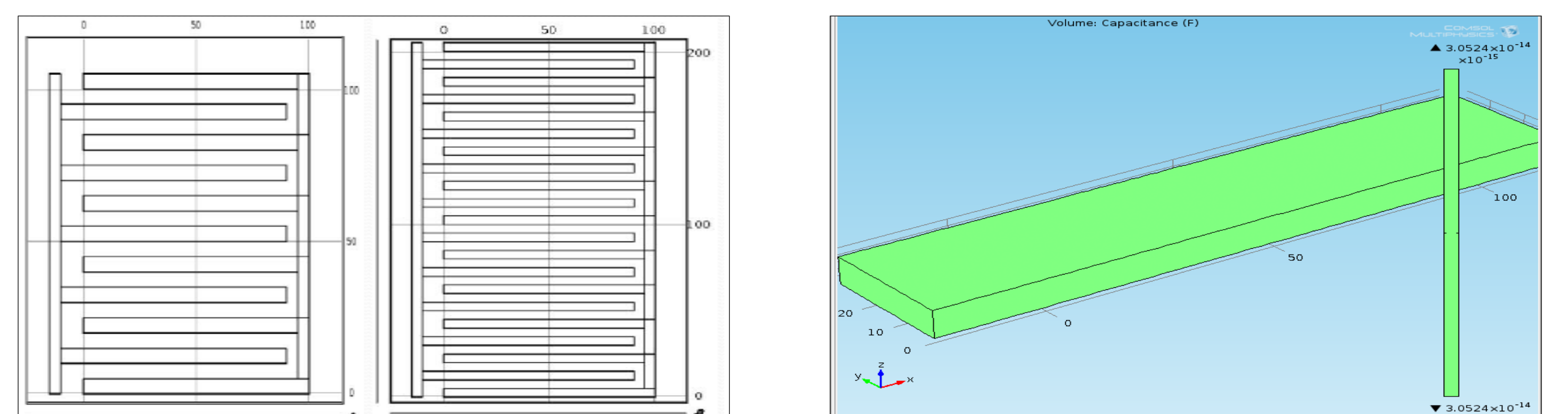


Figure 4 and 5. Comb drive actuator with multiple comb fingers and capacitance

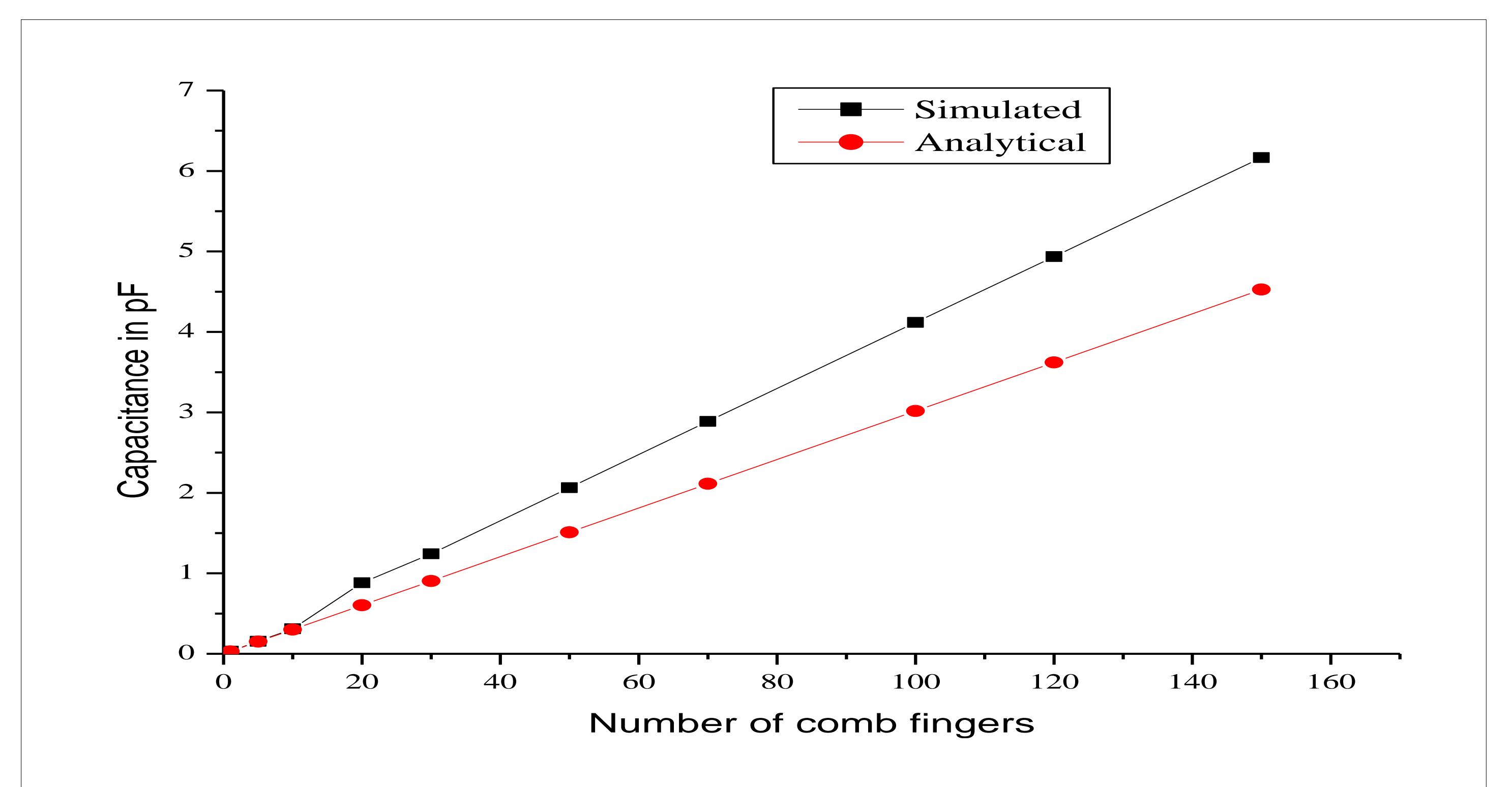


Figure 6. Variation of capacitance w.r.t. comb fingers

Conclusions: number of comb fingers up to 150 is done. 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. This type of MEMS based electrostatic comb drive actuators are used in micro switches and micro grippers.

References:

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 may 2004.