Modeling and Optimization of an Electrostatic Energy Harvesting Device - DTU Orbit
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Modeling of energy harvesting devices is complicated by the coupling between electrical and mechanical domains. In this paper, we present a coupled electromechanical model for electret-based resonant energy harvesters where the two output pads are placed on the same device side (single-sided). An analytical analysis is complemented by 2-D finite element method simulations, where the fringing field effect on a plane capacitor is studied and accounted for by an effective area that is well fitted by a sinusoidal function of the displacement of the proof mass. From analytical calculations, we prove that the electrostatic transducer force is related to the voltage output and cannot be approximated by viscous damping or a Coulomb force as reported previously. The coupled model with two simultaneous differential equations is numerically solved for the voltage output and transduction force with given parameters. The model was verified both by practical measurements from our own fabricated device and results from a reference. An optimization study is carried out using this model to achieve the maximum output power by tuning the allowable movement (XM) of the proof mass. Finally, the effect of a standard power-conditioning circuit is investigated for both continuous and burst power supply applications.

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