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56 Topology optimization of electro-mechanical-acoustic micro devices

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Structural optimization methods applied to the design of micro-electro-mechanical systems (MEMS) has been studied with successful outcome for the past two decades. To extend the capabilities of the density based topology optimization methodology, we explore the possibility of designing MEMS devices for specific acoustic pressure properties. Adding acoustics to the already multiphysical problem paves the way to study design problems including transducers, hearing aid receivers/transmitters and other audio based MEMS devices e.g. sensors and mobile phone components.
The proposed methodology is based on a monolithic mechanical-electrical model. The mechanical and electric problems are coupled through the Maxwell stress tensor which in turn depends on the intensity of the electric field, which in return depends on the deformation. To incorporate the acoustic pressure field into the design problem we apply a mixed u-p formulation for the mechanical problem using a stable Q9Q4 2d discretization. As we want to solve the electro-mechanical-acoustic problem in the frequency domain, we first solve for the static state of the mechanical-electrical system. This is followed by a linearization of the dynamic equations about the deformed equilibrium, which is then perturbed by a mechanical, time-harmonic load. We demonstrate the capabilities of the proposed design formulation by solving the following model problem: Based on a mechanical time-harmonic excitation, we seek to find the material distribution consisting of solid/conductor and acoustic media/insulator materials that minimizes (or maximizes) the acoustic response, i.e. the sound pressure pressure level, in a specified region of the modeling domain.

57 Layout optimization of cable-suspended membrane structures for wrinkle-free design

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Cable-suspended membrane structures have been widely used in many large gossamer structures and architectural engineering problems, such as solar sails, sun shields, large-aperture spacecraft antennas, and fabric tension structures. These structures may be tens or even hundreds of meters in size, and characteristically contain a limited boundary cables and large areas of thin membranes. Compared with pure membrane structures that are easily subject to wrinkles under external loads, a cable-suspended membrane design may be more structurally efficient because the boundary cables in tension can make the membrane as uniformly as possible without increasing the structural mass significantly.