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Modeling and numerical simulations of MEMS shutter devices

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We investigate the acoustic behaviour of Micro-Electro-Mechanical-Systems (MEMS) with a focus on shutter devices. These shutter devices can be used for a new method of sound generation – which we call Advanced Digital Sound Reconstruction (ADSR) – where a redirection mechanism for sound pulses is incorporated [1]. With the help of this redirection mechanism, sound pulses can be generated which are superimposed to form an audio signal.

At MEMS-scales viscous effects can play a major role regarding sound transmission. Therefore, we utilize the linearized flow equations in time domain in order to solve for the acoustic pressure while incorporating effects caused by viscous boundary layers. Furthermore, the movement of the shutter itself contributes to the overall generated sound in a negative manner. Since the generation of the sound pulses is in the ultra sound range, the generated noise by the shutter might lead to adverse effects on the human body [2]. Hence, modeling the shutter noise and understanding its generation process can help to improve the design. To model the noise generated by the shutter, we apply the arbitrary Lagrangian-Eulerian (ALE) framework to the linearized flow equations to be able to compute the noise generation on the moving geometry. The geometry update itself is governed by an artificial quasi-static mechanical problem which is solved in each step to get the new element deformation [3].

Assuming that the impact of the acoustic pressure is negligible, a simple forward coupling from the quasi-static mesh-smoothing to the the linearized flow equations is employed. Furthermore, we use a direct coupling approach to couple the acoustic wave equation to the linearized flow equations. The final coupled system is then used to characterize the impact of the shutter movement on the overall system behaviour of a certain embodiment.

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