Integrated deflection measurement for electrostatically actuated MEMS

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Modern surface micromachined optical MEMS devices commonly use electrostatic means to achieve mechanical actuation. Two electrostatic actuation modes are generally used: bistable mode (for example, MEMS optical switches) and continuous tuning mode (for example, MEMS microspectrometers [1]). While operation in bistable mode can be accomplished with high confidence using an open-loop driver, continuous tuning requires a closed feedback loop to maximize tuning accuracy and eliminate drifts.

The proposed approach is depicted schematically in Fig. 1(a) and allows for measuring MEMS membrane displacement without device modifications as it uses the existing MEMS actuation electrodes. The MEMS structure is actuated by an amplitude-modulated alternating current (AC) high-frequency signal (100 kHz). The drive signal is used to control the MEMS displacement and, simultaneously, to measure the displacement. The displacement signal can be used as a feedback to maintain and fine-tune the actuated membrane position. The measurement circuit's response is depicted in Fig. 1(b). The capacitance change is directly related to the presented voltage signal and was measured for both fixed capacitor (as a reference) and MEMS, where capacitance increases with actuation voltage.

The main benefits of this measurement approach are that it does not interfere with the MEMS actuation and can facilitate the displacement measurements needed for use within a feedback loop.

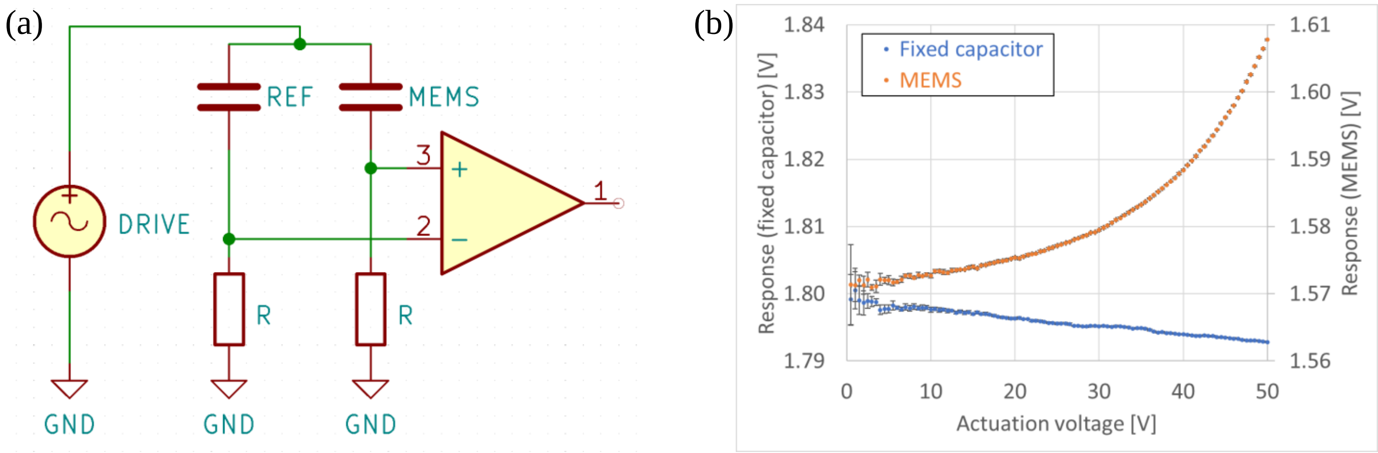

Fig. 1. (a) Simplified schematic of the MEMS displacement measurement system, (b) measured circuit response with sine wave actuation (100 kHz) for reference capacitor (fixed) and actuated MEMS.

[1] H. Mao et al., "Large-Area MEMS Tunable Fabry–Perot Filters for Multi/Hyperspectral Infrared Imaging," IEEE Journal of Selected Topics in Quantum Electronics, vol. 23, no. 2 (2017)