Technical University of Denmark

Popular science summary of the PhD thesis

PhD student	Jakob Kenn Toft
Title of the PhD thesis	Integrated Circuits for High-Voltage Servo-Loop in a MEMS Microphone
PhD school/Department	DTU Electrical Engineering – Electronics Department

Science summary

* Please give a short popular summary in Danish or English (approximately half a page) suited for the publication of the title, main content, results and innovations of the PhD thesis also including prospective utilizations hereof. The summary should be written for the general public interested in science and technology:

Micro-Electromechanical Systems (MEMS) based microphones are a type of microphone that is widely used in smartphones, smartwatches, tablets, and laptops. When MEMS microphones were first introduced to the market in 2003, one of the attractive attributes of MEMS microphones was the small physical size (2.75 mm x 1.85 mm x 0.90 mm) rather than the sound quality. Ever since commercialization, electronics manufacturers have pushed for a higher Signal-to-Noise Ratio (SNR) in MEMS microphones to get a better sound quality. The SNR is especially desired for the smart assistant features of electronics, where a higher SNR can improve the performance and user experience. The SNR is limited by a physical phenomenon called squeeze film damping, where noise is generated by air-molecules being squeezed.

A MEMS microphone manufacturer has proposed a new MEMS structure for a microphone where a vacuum is used to reduce the noise from the squeeze film damping. However, with a vacuum, the ambient pressure will exert a force on the diaphragm that is large compared to the force exerted by acoustic waves making it difficult to achieve a high sensitivity and thereby difficult to achieve a high SNR.

This project proposes a servo-loop configuration that can compensate for the ambient pressure and thereby make it possible to achieve a high sensitivity and SNR in the new MEMS microphone. The servo-loop consists of a controller, a High-Voltage (HV) bias generator, and an Analog-to-Digital Converter (ADC). To implement the servo-loop two prototype integrated circuits were designed, fabricated, and evaluated. The implemented HV bias generator is capable of boosting 1.4 V to an adjustable voltage in the range 41.0 to 188.8 V, with a voltage resolution of 20 mV. The implemented ADC features a 10-bit resolution and a sample-rate of 971 samples/second. A servo-loop with the implemented circuits and a digital controller is capable of achieving a 25.1 Hz bandwidth, and the implementation area of the circuits is 0.710 mm^2, which is small enough to fit inside a MEMS microphone. The implemented servo-loop does not reach the targeted specifications for the next generation MEMS microphone, but future work is suggested to bring the servo-loop within specifications.

Please email the summary to the PhD secretary at the department