MOEMS Accelerometer Evaluation Regarding Resolution And Comparison With ADXL203

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Abstract

This work presents the results of the characterization of two innovative MOEMS accelerometers [1] (Fig. 1) in comparison to the high-end commercial sensor ADXL203 from Analog Devices. The focus hereby mainly lies on the discussion of the respective noise spectral densities.

The characterization setup for the MOEMS sensors is schematically depicted in Fig. 2. The sinusoidal excitation of the devices which was supplied by a customized piezoelectric shaker unit was measured by a laser-Doppler-vibrometer (Polytec MSA400). The sensor output is recorded with a Lock-In amplifier (Stanford Research SR830). measurements were conducted for frequency ranging from 1 Hz up to 10 kHz (Fig. 3). The resulting sensor characteristics obtained for different acceleration amplitudes are depicted in a normalized diagram in Fig. 4. The noise densities for the MOEMS sensors were determined with the Lock-In amplifier revealing an improvement in the sensors' resolution of more than two orders of magnitudes.

Motivation

Micro-machined accelerometers and inclinometers become increasingly important in modern life, which is, among other things, due to an expanding consumer market, wearable devices and autonomic operating drones and robots. Since the accelerometers become smaller, cheaper and more sensitive, they become more and more applicable for medical applications [2], security sensitive applications like automated tilt-control in trains [3], on-the-fly vibration analysis of vehicles [3] or surveillance of the seismic activity of the earth. Nevertheless, further improvement of the noise performance and the sensitivity of these devices is still necessary for most applications. The presented MOEMS sensors reveal a dramatically enhanced resolution compared to commercial high end products allowing for completely new fields of application.

Results

Fig. 3 depicts the transfer characteristics of all three sensors. In the depicted case, an acceleration magnitude of 10 µg was applied via the piezoelectric shaker. The amplitude of the applied acceleration is kept constant between the two dashed lines. Since the dynamic range of the amplitude of the power-supply is limited to three orders of magnitude, the applied acceleration shows variations in case of strong shaker resonances. The sensitivity and noise density were, therefore, evaluated only within the flat region of the transfer function. Outside this range, the acceleration is increasing with the frequency. The two discussed sensors are referenced in the figures as M18 and E0. They exhibit low resonance frequencies of 196 Hz and 340 Hz for M18 and E0, respectively. Both values are much lower compared to the one of the ADXL of 5.5 kHz. The values of the respective sensitivities were determined for different acceleration amplitudes, yielding the individual noise densities.

As depicted in Fig. 4, the MOEMS sensors are able to measure accelerations down to 1 µg/√Hz, whereas the ADXL203 is limited to 110 µg/√Hz. Here g is the earth's gravitational acceleration (1 g=9.81 m/s²).

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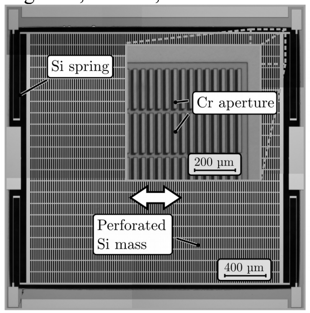

Figure 1. Micrographs of the fabricated MEMS components of the MOEMS prototype M18. The perforated seismic mass is ~2.5x2.5 mm² and was fabricated into a 20 µm thick device layer of an SOI wafer. The inset shows the Cr layer on glass bonded to the SOI chip forming a light modulation aperture.

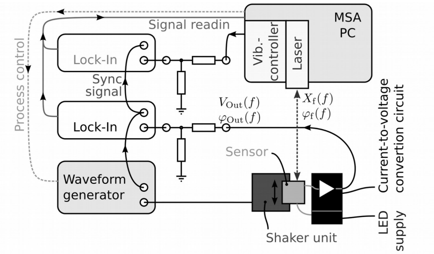

Figure 2. Schematic drawing of the MOEMS characterization setup. The sensors are mounted onto the shaker unit. In the depicted case of the MOEMS, an external circuit for supplying the LED and amplifying the output signal is located next to the shaker system.

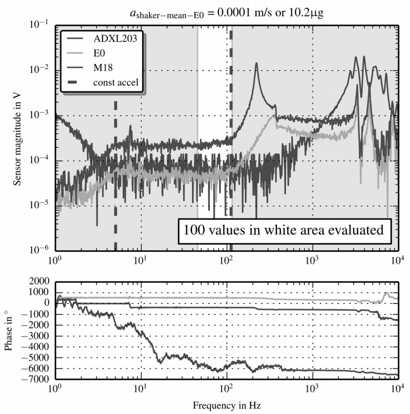

Figure 3. Sensor output of all three sensors for 1 Hz to 10 kHz. A constant acceleration was controlled between 5 Hz and 110 Hz. The values in the white region in the upper plot were used to determine the sensor output. The phase information reveals that the ADXL203 can not measure the applied 10.2 µg/√Hz.

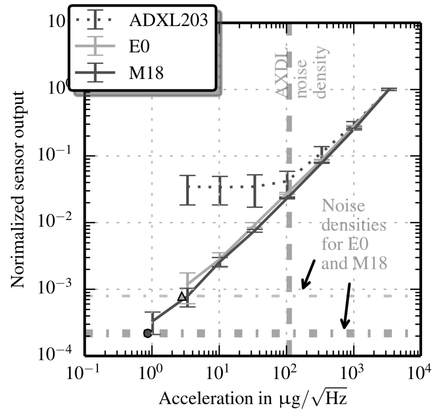

Figure 4. Comparison of the different sensors in terms of the normalized transfer characteristics over the applied input acceleration. The stated noise density of the high end ADXL203 from analog devices of 110µg/√Hz was proven, while the noise density of prototype M18 is 126 times lower.