A single-axis accelerometer with differential capacitances made by inkjet printing technology

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In the past few years, flexible accelerometers have been widely developed, and they are based on significantly different readout concepts. These types of sensors are not expected to have very high accuracy or a wide measuring range. Instead, they should be easy to manufacture, cheap, easily implemented, and compatible with the IoT objects. Such acceleration sensors could be used, for example, in the monitoring of earth seismic activity [1], smart packaging or activity monitoring for seniors [2,3]. The paper reports a single-axis accelerometer exploits capacitive sensors, where the variation of the electrical capacitance is produced by a seismic mass movement. The sensor is compatible with printed electronics technology and is part of the broader concept of the Internet of Things.

The made sensor consists of two fixed electrodes attached to the housing, and the third one, as a movable membrane suspended elastically between them. The fixed electrodes and the membrane were made of FR4 laminate and PET foil, respectively. The membrane geometry was defined with the use of laser, while the conductive layer on it was deposited by means of inkjet printing technology. The principle of operation and construction scheme of the acceleration sensor is shown in Fig. 1. In the project, a pair of capacitors were obtained, which capacitances C_1 and C_2 are mutually dependent. For an applied acceleration, the membrane (seismic mass) moves towards one of the fixed electrodes and away from the other. This move simultaneously causes a decrease and an increase in the gaps d_1 and d_2 between outer electrodes. Hence, an adequate increase and decrease in the capacitance value of both capacitors are observed. This concept enables differential capacitance measurement, which increases sensor sensitivity and reduces susceptibility to interference.

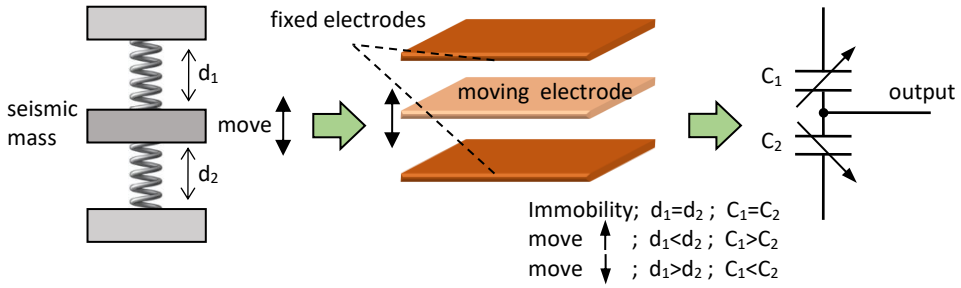

Fig 1. Mechanical and electrical diagram of a differential capacitive accelerometer

The performed tests have shown, that the obtained measuring range was ±4 g, the sensitivity has been determined to be 1.03 pf/g and resonant frequency as high as 27 Hz. The mechanical design of the membrane and the material from which it was made result in membrane elasticity around 1.18 N/m. In conclusion, the printed single-axis accelerometer could successfully replace classical silicon MEMS structure, especially is some applications. Its properties are noticeable worse comparing to typical accelerometer, however, the technology is significantly cheaper.

[1] B. Andò, S. Baglio, C. O. Lombardo, V. Marletta, A. Pistorio, A Low-Cost Accelerometer Developed by Inkjet Printing Technology. IEEE Transactions on Instrumentation and Measurement. 65, 1242–1248 (2016).
[2] Zhang, Yuanfeng, Kim, Woo Soo. “Highly Sensitive Flexible Printed Accelerometer System for Monitoring Vital Signs”, Soft Robotics. 1. 132-135. 10.1089/soro.2014.0003. (2014)
[3] J. S. Park, S. Robinovitch, W. S. Kim, A Wireless Wristband Accelerometer for Monitoring of Rubber Band Exercises. IEEE Sensors Journal. 16, 1143–1150