Article

FPGA-based readout of an extended array of SAW sensors for the detection of volatile organic compounds

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Version July 21, 2020 submitted to Journal Not Specified

Abstract: Development of a high quality digital electronic instrumentation system. The FPGA processing speed up to 900MHz for the functionalization of Surface Acoustic Wave is proposed.

Keywords: matrix, sensor, voc, saw, fpga

1. Introduction

In addition to the conventional methods used in laboratory, the analysis of volatile organic compounds has have a wide variety of applications and recent research works have developed new techniques to provide real-time analysis. The measurement of enzyme activity provides important phenotypical information in medicine, where the breath measurement provides a thorough approach to the disturbances of human exposure and can be interpreted as preclinical signs of a diagnosis adverse [1].

The aim of this work is to develop an instrumentation system for multiple surface acoustic wave (SAW) sensors in a matrix array for the detection of volatile organic compounds, by measuring the phase, delay and frequency changes detection for each sensors. Certain materials oscillate when driven by SAWs. SAWs were first explained in 1885 by Lord Rayleigh, who described the surface acoustic mode of propagation and predicted its properties. A surface acoustic wave (SAW) is an acoustic wave that travels along the surface of a material that exhibits elasticity, with an amplitude that typically decays exponentially with depth within the material.

IoT will soon be driven by field-programmable gate array (FPGA)-like devices, because these devices can interface with the outside world very easily and provide lowest power, lowest latency and best determinism. IoT would interface with temperature, pressure, position, acceleration, analogue-to-digital converters (ADCs), digital-to-analogue converters (DACs), current and voltage, among others. Arduino and Raspberry Pi could also be used. An FPGA can be considered a programmable special-purpose processor as it can handle signals at its input pins, process these and drive signals on its output pins.

In [2], a novel, portable and innovative eNose composed of a surface acoustic wave (SAW) sensor array based on zeolitic imidazolate frameworks, ZIF-8 and ZIF-67 nanocrystals (pure and combined with gold nanoparticles), as sensitive layers has been tested as a non-invasive system to detect different disease markers, such as acetone, ethanol and ammonia, related to the diagnosis and control of diabetes mellitus through exhaled breath. The sensors have been prepared by spin coating, achieving continuous sensitive layers at the surface of the SAW device. Low concentrations (5 ppm, 10 ppm and 25 ppm) of the marker analytes were measured, obtaining high sensitivities, good reproducibility, short time response and fast signal recovery.

[3] In the present work a novel, portable and innovative eNose composed of a surface acoustic wave (SAW) sensor array based ZIF-8, and ZIF-67 nanocrystals (pure and combined with gold

nanoparticles) as sensitive layers has been tested as a non-invasive system to detect and differentiate disease markers, such as acetone, ethanol and ammonia, related with early diagnosis of diabetes mellitus through exhaled breath. The sensors have been prepared by spin coating, achieving continuous and homogenous sensitive layers. Low concentrations (5 ppm, 10 ppm and 25ppm) of the marker analytes were measured, obtaining high sensitivities, good reproducibility, short time response and fast signal recovery.

[4] An E-nose based on surface acoustic wave (SAW) sensors has been developed, and sensitive polymer coatings have been optimized to detect simulants of chemical warfare agents (CWAs). The polymers selected have allowed to discriminate among simulants and classify them at low concentrations in air through Pattern Recognition Methods. Good detection responses have been achieved for very low concentrations, such as 0.05ppm for Dimethyl methylphosphonate (DMMP) and 0.5ppm for dipropylene glycol monomethyl ether (DPGME)

[5] The distributed surface acoustic wave (SAW) strain sensing system based on FPGA was presented in this paper. Equal strength beam SAW strain sensor was adopted. Through special device sealing, it not only protected the surface electrode but also did not influence the sensitivity of the sensor. Equal precision frequency meter based on FPGA realized the frequency measurement of measuring signal. Equal precision frequency meter had high measuring precision. It can keep constant measuring precision during the whole frequency domain. Measuring frequency ranged from 0.1 to 100MHz. Relative error was 1 ppm.

SENSORS ARRAY [6]

2. System Model

we use frequency change for detection of sensitivity and resolution of different concentrations within the extended SAW matrix. The time resolution can reach up to 1.05ns. The main goal os to functionalize different gases for a single measurement in real-time analysis.

The main requirement to have a device or instrument capable of detecting changes frequency or phase with respect to the excitation signal is the opertive frequency of 82MHz,

A general purpose processor is used with a FPGA technology from Xilinx model Spartan 6 XC6SLX9 for the measurement of the phase, delay and frequency with a matrix of sensors. A preliminary time base of 350MHz, can be scalable up to 950MHz.

This electronic board allows us to make ad-hoc designs for future modifications. The board provides 103 pins available for digital programming of inputs and outputs, as well as a 64MHz oscillator clock model LO7-64.000- WTL's CMOS capable of delivering a time of up to 3.125ns. It can be modified by a LVDS type oscillator clock of 400MHz model BB-4000.000MBE-T from the manufacturer TCX commits us to a time base of up to 625ps.

3. Results

We generate pulses with characteristics suitable for SAW-type translators, that have a working frequency of between 10MHz to 100MHz, it was possible to reproduce the excitation and phase of these signals within the FPGA

The frequency changes detection in a high-speed programmable FPGA device allows us to do iterations important before the actual analysis of the data and the digital signal processing.

We generate a 10us period, Vpp of 3.32V 100KHz frequency and 100ns pulse width For this signal we have two additional features important. First, the frequency or time delay typical for the SAW type sensors to be used, such as 10us at 100KHz. Second, the excitation time for 82MHz transducers, represented by a pulse width of 12ns (to be checked).

4. Conclusion

4.1. Subsection

be added as an appendix.

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Sample Availability: Samples of the compounds ...... are available from the authors.