

# A New System for Acoustoelectronic Gas Sensors Analysis

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Typical approach to the surface acoustic waves sensors response analysis is based on the use of self-oscillating circuits with surface acoustic wave device working inside positive feedback loop of an amplifier. Such kind of parametric measurement allows to track the center frequency of the sensor changes in particular. The method is widely used mainly due to their relative simplicity. Unfortunately, it has many disadvantages like frequency (phase) instability, sensitivity to unwanted factors, surface acoustic wave substrate mass-load limit etc. A new system to the analysis of surface acoustic wave gas sensors response as well as an exemplary measurement results are described in the paper. The presented system make the first step to the more complex conception realization.

DOI: [10.12693/APhysPolA.124.445](https://doi.org/10.12693/APhysPolA.124.445)

PACS: 43.35.Pt, 46.35.+z, 68.35.Ja

## 1. Introduction

The common approach to the surface acoustic wave (SAW) sensors response measurement is based on tracking of center frequency changes using self-oscillating circuits. Such method of measurement was presented in many papers concerning the topic [1–6]. The main reason of such solution application is relative simplicity of the measurement set. However, the simplicity seems to be the only advantage of the approach. Unfortunately, it has much more disadvantages like frequency (phase) instability, oscillation fading, significant limitations of SAW surface load, strong dependence on environment parameters changes etc. The most important drawback of the previous system lies in the possibility of monitoring only its frequency changes. Numerous experiments concerning the SAW sensors show that many interesting information about the sensor response to environment parameters change can be obtained by monitoring other parameters like overtones shifts [7, 8], amplitude and phase characteristic etc.

The eight-channel system presented in the paper enable to observe the center frequency and amplitude changes close to the center frequency of the SAW sensors.

## 2. General description of the new system

In the new approach the positive feedback loop conception was given up and replaced by the linear system with short-term ultra-stable frequency source with stepped frequency continuous wave (SFCW) modulation. The comparison of the block diagrams of commonly used and proposed method is shown in Fig. 1.

The linear system proposed here is shown in Fig. 1b. The system is fully digital. High stability signal from SFCW source passes through SAW sensor structure and it is converted into digital form using analog/digital converter (ADC). Finally, it is processed in the digital signal

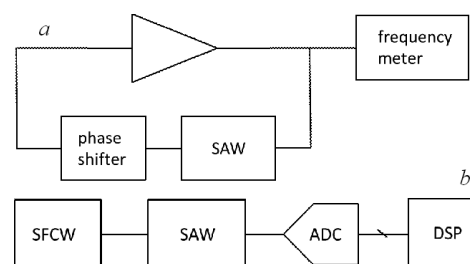


Fig. 1. The comparison of the block diagrams of commonly used (a) and proposed (b) new method of SAW sensor response measurement.

processing (DSP) unit. The main task of the unit is accurate power change measurement at the SAW output for each frequency steps. As a result a sensor characteristic change is obtained. From the characteristic one can extract the amplitude, frequency,  $Q$ -factor and other parameters changes. The analysis of the changes ultimately provides an information about environment state influence on the sensor. The method is well known in radar technology and many DSP algorithms may be taken from this domain of knowledge. The approach may be considered as excessive complicated but actually is not thanks to the modern FPGA systems features.

The hardware part of the system was built using field-programmable gate array (FPGA) circuits. Its functional blocks scheme is shown in Fig. 2.

Signal generated in direct digital synthesis (DDS) block is transmitted through the phase locked loop (PLL) and demultiplexer (DMUX). After that it excites chosen (one of the eight) SAW sensors located inside gas chamber. The signal after pass-through the sensor (i.e. SAW delay line, filter or resonator) and multiplexer (MUX) is detected using quadrature method (QAD block utilising reference signal from vector multiplier V-MULT). The power of the signal at a fixed frequencies is next measured inside PM block. The results of the measurement are converted into the digital form, pre-processed inside microcontroller and at the end sent via RS232 interface to PC.

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Small amplitude fluctuations visible in the magnified part of characteristic (Fig. 4b) are an effect of finite resolution of the measurements.

It can be observed that both resonant frequencies and peaks amplitudes are changing and changes of amplitudes are bigger than of frequencies. Moreover, each of visible peaks is changing their position in a different way and it goes show that the mechanisms of SAW device interaction with the gas in the environment is complex. Both qualitative and quantitative observations confirm the theoretical predictions described in [8]. It shows that the system can be also useful as a research tool for different surface phenomena observation.

#### 4. Conclusions

The measurement system described here allows to precise monitoring of SAW devices characteristic changes in a some frequency range surrounding their resonant frequency. As a matter of fact it is narrow band precise spectrum analyser with tracking generator adapted to SAW sensors response observations. Because of digital signal processing application it is possible to extract an additional data from the raw results.

Finally, instead of commonly observed frequency change one can obtain a data vector consisting of information concerning changes, beside mentioned above fre-

quency, also phase, amplitude, slope,  $Q$ -factor etc. Such system gives much more comprehensive characterisation of the interactions of SAW sensor with environment than typical method.

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