LOW-COST SENSOR MODULE FOR GAS MEASUREMENTS

Stefan Ivanov[1], Todor Todorov[1], Toshko Nenov[1]
[1] *Technical University of Gabrovo*

Abstract
The paper presents the development of low-cost module for gas measurements which can be used for classification of food quality and conditions of living. The data from sensor module are acquired by interface board and can be stored and processed in personal computer.

Keywords: gas sensors; air quality monitoring; data acquisition.

INTRODUCTION

The use of gas sensors is becoming more common today. This is due to the continuous progress in the production of new types and generations of gas sensors, as well as in the development of new techniques for data processing and classification. One of the main applications of gas sensors is in the field of monitoring of air quality, both outdoors and indoors. Another major application of gas sensors is food quality control.

The monitoring of atmospheric air is a very important aspect of environmental control. By monitoring of various air pollutants, as well as the meteorological factors that affect their spread, such as temperature, humidity and atmospheric pressure, some measures for environmental control can be taken. Various methods for monitoring of gases are used to control air pollution [1]. In addition to analytical instruments, measuring modules based on gas sensors are also used. They have a low cost and allow achievements of quick measurements [2]. As often harmful chemicals in the air cannot be identified with the help of a single gas sensor, it is necessary to use multiple sensors combined in a sensor module.

Traditionally the methods used for determining the quality of food products, such as visual, gustatory, olfactory and the like (by a team of tasters) are definitely subjective, relatively expensive and time consuming. In addition, the reliability of these methods progressively decreases with increasing complexity of the studied samples.

Consumers need an objective and accurate assessment of the food they buy. They must receive information and a guarantee that the food they buy is manufactured from the specified products and is stored correctly by the traders (according to the prescriptions and requirements of the manufacturer and the control bodies). Last but not least is the accurate detection of contamination both in the various foods and in the raw materials used for their preparation. This increasingly necessitates the development of fast and accurate methods and devices through which it will be possible to determine the quality of various food products, as well as to determine the change in their condition during storage.

Therefore, research is being conducted to find methods for rapid assessment of product quality. One of the directions of these researches is the use of a set of gas sensors, united in the so-called "Electronic nose". The "electronic nose" makes it possible to quickly determine the quality of products with great accuracy, objectivity and productivity [3]. The use of gas sensors is suitable for testing various food products in solid or liquid state. They are suitable for detecting differences in milk diluted with different amounts of water [4]. They are also used to detect dairy products infected with Escherichia coli [5], as well as they are used in the study of yogurt [6]. Studies of contaminated sheep's milk with toxins [7], which are carcinogenic and extremely dangerous for human health, have also been performed.

The results obtained in these studies are particularly indicative of the capabilities of gas sensors in their use for the classification of various food products.

The aim of this paper is to present the development of a module with gas sensors that can be used in monitoring environmental parameters, as well as it can also find its application for food control.

SENSOR MODULE

To measure the parameters of the air, as well as to determine the gas footprint of various foods, it is developed a sensor module for monitoring three main types of gases - Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ammonia (NH_3) (Fig. 1).

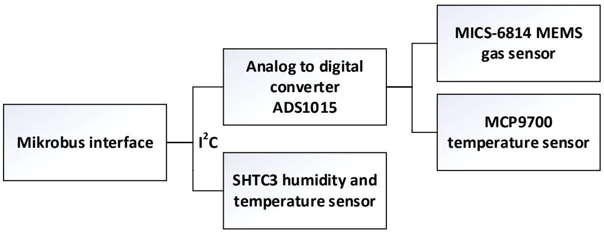


Fig. 1. *Block diagram of sensor module*

The module uses MICS-6814 gas sensor [8], which is able to detect the mentioned above gases.

The sensor type is metal oxide sensor which means that the sensing elements are resistive and their resistances change with the changes of measured gases. The oxidizing gases (such as ozone or nitrogen dioxide) make the resistance of sensing elements to increase while the reducing gases such as carbon monoxide or VOC's cause the resistance to decrease.

The signals from the sensor are discretized with the help of ADS1015 analog to digital converter. The ADS1015 also converts the signal coming from MCP9700 temperature sensor.

Other sensor used in the proposed system is SHTC3 for measurement of temperature and humidity. Its construction includes a capacitive humidity sensor and a temperature sensor in a single package which communicates via I2C interface. The sensor can measure humidity from 0 to 100% RH and temperature in the range of -40°C to 125°C. The low energy consumption of the sensor makes it suitable for battery powered devices.

The developed sensor module uses mikroBUS™ [9] interface for connection with other devices. The mikroBUS™ socket comprises a pair of 1×8 female headers. The pinout of headers consists of three groups of communications pins (SPI, UART and I2C), six additional pins (PWM, Interrupt, Analog input, Reset and Chip select), and two power groups (+3.3V and 5V).

The mikroBUS™ interface is selected for this sensor module, because it makes possible the sensor module to be used with different platforms from various manufacturers.

The developed sensor module is presented on Fig.2.

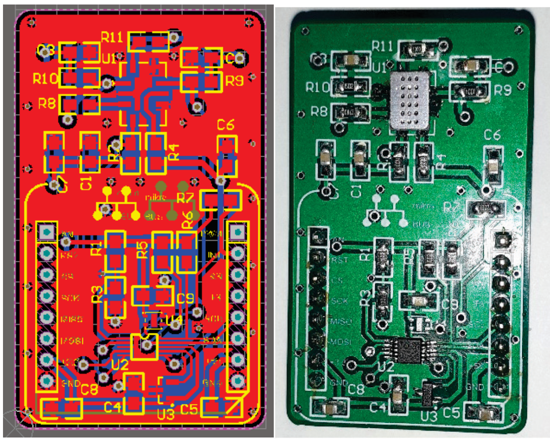


Fig. 2. *Sensor module – PCB and final device*

For data acquisition from the sensor module, it is developed an interface board which allows the data from the sensor module to be sent to personal computer (PC). The interface board uses USB interface for communication with the PC and with the help of FT230XS chip a virtual COM port is realized (Fig.3).

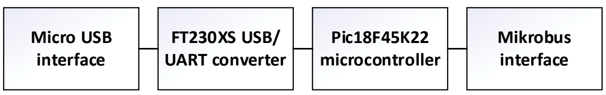


Fig. 3. *Block diagram of interface board*

The core of interface board is Pic18F45K22 microcontroller. Its task is to read the measurements from the sensor module via I2C interface. The communication with the personal computer is realized as message-based transfer of data. The protocol of data exchange is very simple but very reliable. The command parser in the microcontroller software detects the received message from PC and after that the microcontroller reads the sensor module and sends the received data to PC.

The interface board has compact dimensions and it is presented on Fig.4.

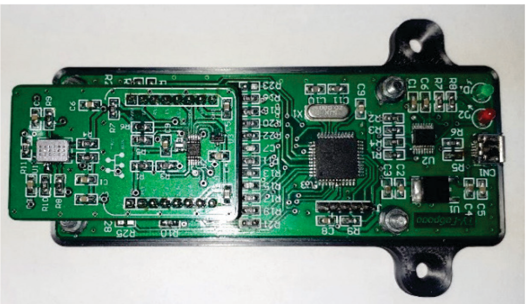


Fig. 4. *Interface board with installed sensor module*

DATA ACQUISITION

For reading and storing the data on PC side, it is developed a program for data acquisition. The program is developed with LabVIEW and it is compiled as stand-alone application (Fig.5).

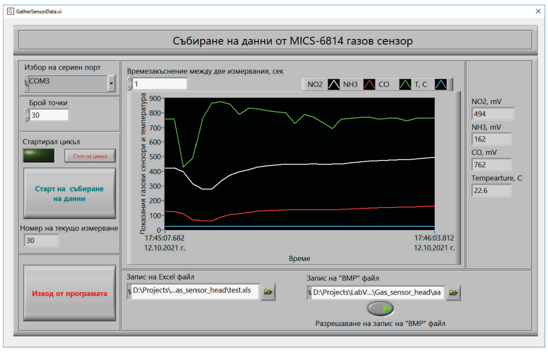


Fig. 5. *Data acquisition program*

The main properties of the program are intuitive user interface, graphical representation of acquired data and possibilities for storing the data in Excel file. The program also enables the data to be plotted into BMP image and stored locally (Fig.6).

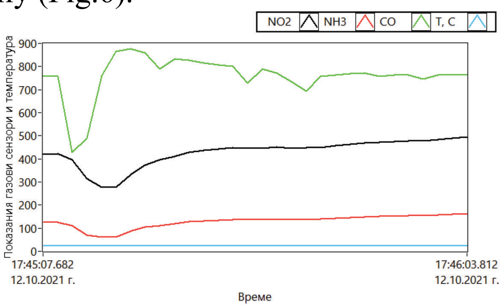
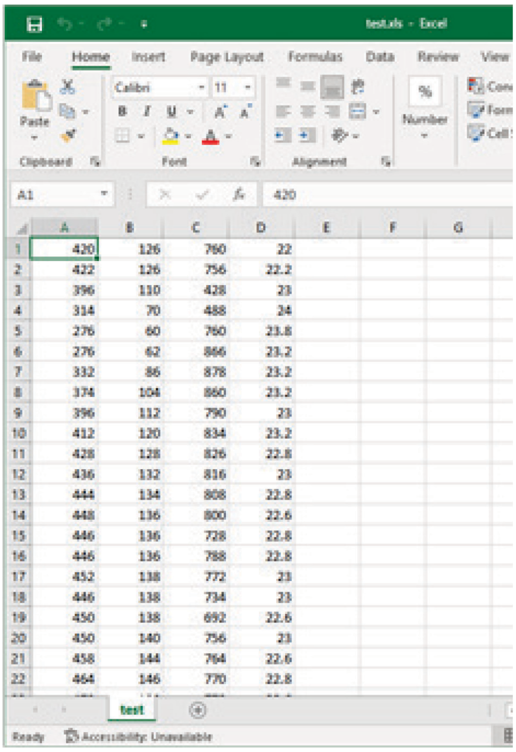


Fig. 6. *BMP picture of acquired data*

The data from MICS-6814 gas sensor is stored in the Excell file as mV values, while the temperature is stored as values in °C with resolution of 0.1 °C (Fig.7).



	A	B	C	D
1	420	126	760	22
2	422	126	756	22.2
3	396	110	428	23
4	314	70	488	24
5	276	60	760	23.8
6	276	62	866	23.2
7	332	86	878	23.2
8	374	104	860	23.2
9	396	112	790	23
10	412	120	834	23.2
11	428	128	826	22.8
12	436	132	816	23
13	444	134	808	22.8
14	448	136	800	22.6
15	446	136	728	22.8
16	446	136	788	22.8
17	452	138	772	23
18	446	138	734	23
19	450	138	692	22.6
20	450	140	756	23
21	458	144	764	22.6
22	464	146	770	22.8

Fig. 7. *Excel file with acquired data*

All data can be after that easily read and processed. One of typical data processing techniques can be the utilization of Deep Neural Network (DNN) for data evaluation and classification.

CONCLUSION

The presented device uses a combined gas sensor, with the help of which the values of three types of gases can be monitored - NO_2, NH_3, CO. It can be used to collect data about the state of the environment with arbitrary duration and arbitrary interval between individual measurements. It can also be used as a basis for creating systems for quality control of various food products and for monitoring the indoor air quality.

REFERENCE

[1] R. D. Down, J. H. Lehr. Environmental instrumentation and analysis handbook. WILEY-INTERSCIENCE, Noboken, New Jersey, 2005.

[2] Nart J.K., K. Martinez. Environmental sensor networks: a revolution in the earth system science? Earth-Science Reviews, Vol. 78, 2006, 177-191.
[3] H. Swatland. Effect of connective tissue on the shape of reflectance spectra obtained with a fibre-optic fat-depth probe in beef. Meat Sci. 2001, 57, pp.209–213.
[4] H. Yu, J.Wang, Y.Xu. Identification of Adulterated Milk Using Electronic Nose. Sens. Mater., 2007, 19, pp. 275-285.
[5] Z. Ali, W. T. O'Hare, B. Theaker. Detection Of Bacterial Contaminated Milk By Means Of A Quartz Crystal Microbalance Based Electronic Nose. Journal of Thermal Analysis and Calorimetry, 2003, Vol. 71, pp.155–161.
[6] G. Green, A.Chan, R.Goubran. Tracking Food Spoilage in the Smart Home Using Odour Monitoring. In Proceedings of the 2011 IEEE International Workshop on Medical Measurements and Applications (MeMeA), Bari, Italy, 30–31 May 2011, pp. 284–287.
[7] S. Benedetti, F.Bonomi, S.Iametti, S. Mannino, M.Cosio. Detection of aflatoxin M1 in ewe milk by using an EN. In Proceedings of the 2nd Central European Meeting 5th Croatian Congress of FTBN, Opatija, Croatia, October 17–20, 2004, pp. 101-105.
[8] Data Sheet. MiCS-6814. (https://www.sgxsensortech.com/content/uploads/2015/02/1143_Datasheet-MiCS-6814-rev-8.pdf).
[9] The World's Faster Growing Add-On Board Standard (https://www.mikroe.com/mikrobus)