Development of a system for measurement of carbon monoxide and smoke detection

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***Abstract* — carbon monoxide is a colorless and odorless gas that is lighter than air; it can cause symptoms of poisoning to varying degrees, which can lead to serious consequences. The aim of the report is to develop a system for measuring the concentration of carbon monoxide and smoke. An electro-chemical sensor MQ-2 and an Arduino platform were used for the development of the system. A series of experiments were performed to test the system – in the city park, in underground parking, garage, indoor. The obtained results are analyzed.**

***Index Terms* — carbon monoxide, MQ-2, Arduino Uno**

I. Introduction

Carbon monoxide (CO) is a colorless and odorless gas that is lighter than air. Carbon monoxide is obtained from the incomplete combustion of substances that contain carbon in the absence of sufficient oxygen. When exposed, depending on the amount in the air and the sensitivity of the person, it can cause symptoms of poisoning to varying degrees, which can lead to serious consequences. A person is at risk of carbon monoxide poisoning even in their ordinary daily lives - sources of carbon monoxide can be a heating stove, cooker, clothes dryer, barbecue or grill and even a clogged chimney or flue. In addition to the familiar human routine, carbon monoxide can also be found in the workplace.

Carbon monoxide is one of the main greenhouse gases that lead to rising global temperatures and global warming. Its concentrations in the air are normatively subject to continuous monitoring. The maximum permissible concentrations of carbon oxides in the ambient air of the settlements are regulated by Ordinance 14 (adopted on September 23, 1997) of the Ministry of Health and the Ministry of Environment and Water [1]. It is also stated in [2] that the limit value for CO concentration must not exceed 10 mg/m^3. The procedure and manner of measuring emissions (concentrations of harmful substances in waste gases) released into the atmosphere from sites with stationary sources is regulated by Ordinance № 6 of March 26, 1999 of the Ministry of Environment and Water [3].

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In the sense of this ordinance, the measurements can be control and own. The purpose of this article is to develop a system for measuring the concentration of carbon monoxide in ambient air. An electrochemical sensor MQ-2 and an Arduino Uno platform are used to develop the system. Various experiments were conducted to verify the effectiveness of the developed system.

II. Development of the Measuring System

The developed measuring system consists of MQ-2 electrochemical semiconductor gas sensor, detecting the presence of smoke and flammable gases, Arduino Uno microcontroller board and LCD screen. Breadboard and a set of connecting wires are also used.

MQ-2 is a semiconductor gas sensor that detects the presence of smoke and flammable gases. The sensitive part of the sensor is made of SnO2 [4]. This is a metal oxide semiconductor (MOS) gas sensor, also known as a chemical resistor, as the detection of the desired substance is based on a change in the resistance of the sensor material when the gas comes in contact with the material. The MQ-2 sensor operates with a supply voltage of 5V DC and consumes about 800mW. It can measure propane-butane, smoke, carbon monoxide, propane, hydrogen. MQ gas sensors use a small heater that is located inside the sensor along with an electrochemical sensor. Figures 1 and 2 show the front and back of the sensor.

The output signal from the sensor is an electrical voltage that changes its magnitude depending on the presence of gas or smoke in the air. The higher the gas concentration, the higher the output voltage; when the gas concentration is lower therefore the output voltage will also be low.

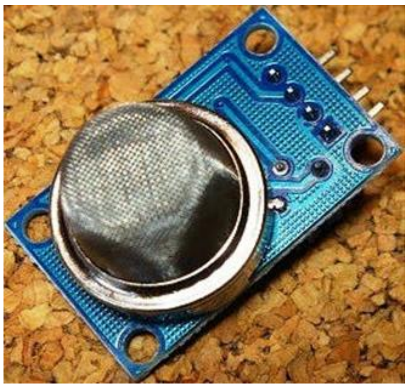

Fig. 1. The front side of MQ-2

The sensor is characterized by high speed, and its sensitivity can be adjusted using the built-in potentiometer (Fig. 2).

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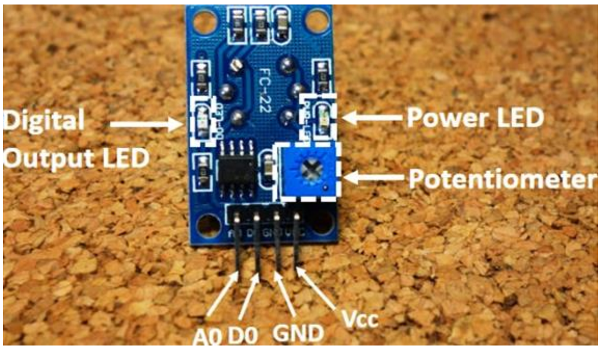

Fig. 2. MQ-2 sensor - back side

The sensor is characterized by high speed, and its sensitivity can be adjusted using the built-in potentiometer (Fig. 2).

The Arduino Uno board consists of an 8-bit Atmel AVR microcontroller with complementary components that facilitate programming and integration into other circuits [5]. An important aspect of the Arduino platform is the availability of standard connectors that allow users to connect the CPU board to a large set of different, interchangeable modules.

The DFRobot Gravity I2C LCD1602 display with RGB backlight, which supports 16 million types of color combinations, is used to visualize the measured values. The IIC (I2C) communication interface mode allows only two communication lines or these are communication with the microcontroller board and the backlight control. The display is two-line and supports up to sixteen characters per line. The operating voltage is from 3.3V to 5V.

The developed system is shown in Figure 3. The connection between the individual components is made with connecting wires and breadboard.

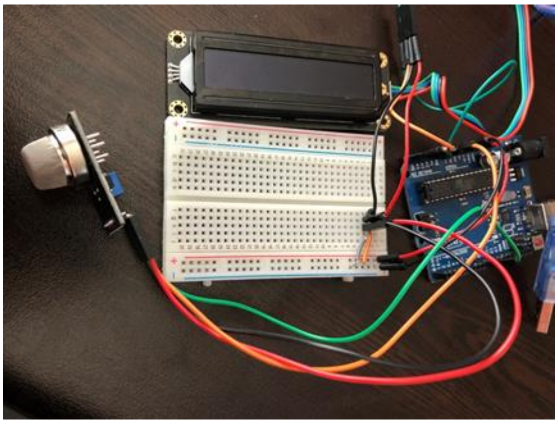

Fig. 3. A system for measurement of carbon monoxide and smoke detection

III. Experimental Results

Before starting the measurements, it is necessary to adjust the sensor transducer. Once the system has been developed and set up, the sensor is left for 24 hours for preheating. After this period, the sensitivity of the sensor is adjusted. For this purpose, it is placed near a source of carbon monoxide and with the help of a screwdriver rotate the potentiometer, which is located on the rear panel of the sensor. The potentiometer rotates clockwise until the model's red LED lights up more intensely. With this action, the sensor is ready for operation.

Various experiments have been performed with the ready system to verify its effectiveness and applicability.

A. City park

The first series of experiments were performed in a city park in the hours before noon, where there are many trees and lawns. The measuring device is placed on a bench in the park, away from city traffic and other sources of air pollutants. Five measurements were performed with an interval between each of the measurements. The results obtained are shown in Table 1. As can be seen, the values obtained for CO are below the maximum allowable concentration.

TABLE I
MEASUREMENT OF CARBON MONOXIDE CONCENTRATION IN A CITY PARK

№	CO, ppm	CO, mg/m^3
1	2	2,29
2	8	9,16
3	4	4,58
4	3	3,45
5	1	1,15

B. Underground parking

The second series of experiments were conducted in an underground parking lot. The underground parking is at level "-2" and is located in a shopping center (mall). The parking lot is not full. The device is placed relatively in the center of the parking lot on the ground. The nearest car at the moment of starting the measurement is through two parking lots. Ten measurements were made. The results are given in Table 2. At the beginning of the experiment, cars do not pass, but while the measurements are running, cars pass close to the measuring point, which can be read by the higher measured values of CO. In general, based on the results obtained, it can be concluded that the sensor has a very good sensitivity and that this underground car park has adequate ventilation.

TABLE II
MEASUREMENT OF CARBON MONOXIDE CONCENTRATION IN UNDERGROUND PARKING

№	CO, ppm	CO, mg/m^3
1	8	9,16
2	6	6,85
3	9	10,31
4	7	8,02
5	18	20,61
6	8	9,16
7	11	12,6
8	9	10,31
9	16	18,32
10	8	9,16

C. A garage

The third series of experiments was performed in a closed garage and a working car. The measuring device is placed on the ground behind the car, and the sensor is 70 cm from the muffler. Ten measurements were performed. After each measurement is ventilated to ensure the independence of the measurements, the results are shown in Table 3. The obtained values are many times higher than 10 mg/m^3. Therefore, a long stay in a closed garage without ventilation can cause unpleasant sensations in the human body.

TABLE III
MEASUREMENT OF CARBON MONOXIDE CONCENTRATION IN GARAGE

№	CO, ppm	CO, mg/m^3
1	56	64,13
2	33	37,79
3	31	35,5
4	38	43,52
5	59	67,57
6	90	103,07
7	6	71
8	112	128,26
9	54	61,84
10	75	85,89

D. Indoor

The fourth series of experiments involved measuring of CO and smoke indoors. For this purpose, an incense stick is lit in the room. The measuring device is placed on the table, at a distance of 60 cm from the lighted rod. Ten measurements were made, and before each measurement the room was thoroughly ventilated and then a new stick was lit. Wait for half of the stick to burn and then make the measurement. The results are given in Table 4. The values obtained are quite high, which means that prolonged exposure to smoke from incense sticks for more than 8 hours can cause disease in humans.

TABLE IV
MEASUREMENT OF CO AND SMOKE FROM INCENSE STICK

№	CO, ppm	CO, mg/m^3	smoke, ppm
1	173	198,12	32
2	117	133,99	44
3	148	169,49	39
4	181	207,28	58
5	152	174,07	42
6	123	140,86	35
7	133	152,31	38
8	139	159,18	40
9	128	146,59	31
10	161	184,37	50

IV. CONCLUSION

A measuring system for measuring the concentration of carbon monoxide and smoke has been developed. The main components of the system are the electrochemical sensor MQ-2 and the Arduino Uno platform. A series of various experiments were conducted to verify the operability of the system. Based on the results obtained, it can be concluded that the developed system is suitable for measuring both low and higher concentrations of carbon monoxide and smoke. The proposed system is a convenient method for monitoring the human environment. It can be used both indoors and outdoors.

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