DEVICES FOR OZONE CONCENTRATION MONITORING

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This paper describes three types of ozone concentration meters working on different principles: spectroscopic-based ultraviolet absorption at a wavelength of 254 nm (measuring range of 0.1 to 80 mg/l), based on a corona discharge (measuring range of 0.1 to 40 mg/l) and on the basis of semiconductor ozone sensor (measuring range of 0.2 to 10 maximum admissible concentration – MAC). All ozone meters are controlled by the PIC18F2550 microcontrollers, produced by Microchip Technology Inc.

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INTRODUCTION

Ozone technologies used in the industry, medicine, agriculture and households will require the development and production of instruments for the measurement of ozone concentration. However along with the undeniable positive effects of these technologies there's a high risk of impact of elevated concentrations of ozone on human health [1]. If the laboratory studies can use an expensive stationary spectrometers, mass use required a portable devices for the detection of high, medium and small (at the MAC) concentrations of ozone. The most common portable meters available on the market are based on the principle of absorption by ozone of ultraviolet radiation, the accuracy and reliability of which are constantly being improved.

At the Institute of Plasma Physics KIPT developed portable ozone meters based on the ultraviolet absorption at a wavelength of 254 nm, on the corona discharge and on the semiconductor ozone sensor.

1. OZONE MEASURING

1.1. SPECTROSCOPIC METER

This device is a microprocessor ozone meter for medium and high ozone concentrations (Fig. 1). The measuring principle is based on the absorption of ultraviolet (UV) light at a wavelength of 254 nm.

Brief description of the device.

In the two-beam photometers light from an extended source of UV radiation passes through two identical lines (channels). One of them passes through a cell with sample gas, and the other - through a cell filled with a gas (air or oxygen) that contains no measurable component ("zero gas").

Then each beam of light is directed to separate photodetectors. The signals from the photodetectors are directed to the current-voltage converter, and to the logarithmic differential amplifier and to the analog-to-digital converter of the microcontroller.

In this construction of the ozone meter requirement to identity the characteristics of both photodetectors is not rigid and the spread in their sensitivity can be compensated by changing the parameters of electrical circuits or optical method: the weakening of one of the light beams. The fluctuations of the UV radiation also does not have much impact on the correctness of measurements. Temperature gradients between the cuvettes can be reduced by installing them on a common metal plate made of aluminum alloy. All elements of the meter, including the UV lamp must be shielded.

Main technical characteristics:

1.1. Range of the measured ozone concentration from 0.1 to 80 mg/l.

1.2. Accuracy of the measured ozone concentration is not more than 3 %.

1.3. Power source is AC 220 B ± 15 %. Power Consumption is less than 11 Wt.

1.4. Warm-uptimemeter, min – 20.

1.5. Overall dimensions - 246x235x127 mm.

1.6. Massof meter, kg – 2.4.

Fig. 1. Spectroscopic meter

1.2. METER BASED ON CORONA DISCHARGE

This device is a microprocessor ozone meter for medium and high ozone concentrations (Fig. 2).

The operation principle of the device is based on the properties of the corona discharge in a coaxial chamber (Zener mode).Coaxial discharge chamber can be successfully used as an indicator of the gas analyzer. In order to stabilize the measurement of several parameters of instability (temperature, humidity, pressure, etc.), the scheme has been applied differential measurement with two identical coaxial chambers, flushed sequentially through the destructor. Current outputs cameras are connected to the differential current amplifier with adjustable gain. Amplifier outputis connected to the microprocessor. To not use the complicated scheme stabilized high voltage power supply was used the method of pulsed measurements.

When you run the power supply, high voltage gradually increases until it reaches the comparator value. After that, the last trigger signal comes to the

microprocessor to read analog values from differential amplifier. After analog-to-digital conversion the numerical value of the concentration is displayed on the LCD display. The measurement time is about 5 seconds.

Main technical characteristics:

1.1. Range of the measured ozone concentration of 0.1 to 40 mg /l.
1.2. Accuracy of the measured ozone concentration is not more than 4 %.
1.3. Power source is AC 220 V ± 15 %. Power consumption is less than 7 watts.
1.4. Warm-up time meter, min μ – 5.
1.5. Dimensions, mm - 180x150x100.
1.6. Meter Weight, kg – 2.5.

Two-channel measurement circuitry.Heat setting. Liquid crystal display.

Fig. 2. Meter based on corona discharge

1.3. SEMICONDUCTOR MAC OZONE METER OCM-3

Ozone concentration meter is designed for detection and measuring of low ozone concentrations in the gas phase (Fig. 3). It has high stability and service life. The principle of the meter is to use ozone type semiconductor sensor MQ-131.

Main technical characteristics:

1.1. Range of the measured ozone concentration from 0.02 to 20 mg/m^3.
1.2. Accuracy of the measured is not more than 3 %.
1.3. Power meter is AC 220 V + / - 15 %. Power consumption is less 2 watts.
1.4. Serial interface RS-232 (RS-485) or USB.
1.5. Dimensions, mm – 160x140x60.
1.6. Weight – 0.5 kg.

Fig. 3. Semiconductor MAC ozone meter

A lot of companies produce instruments for measuring and recording dangerous to humans ozone concentrations near or above the MAC. Widely used instruments for ozone measuring concentration, such as Ozone-MAC, produced OKBA Angarsk (Russia) [2], the analyzer 3-02.P-R (Smolenskpribor, Russia) [3], Ozone Monitor Model 205 (2B Technologies, USA) [4], etc. The principle of operation of most devices based on detection of selective absorption of ultraviolet radiation by ozone.The instrument measures the difference between the intensities of ultraviolet radiation passing through the analyzed and reference gas mixtures. Comparison in the device 3-02.P-R is realized between a model of the gas mixture and analyzed by gas glow as a result of heterogeneous chemiluminescence. The applied methods of measurement require the creation of complex, expensive and bulky designs.

The task of developing low-cost domestic measuring device and indicators of ozone concentration due to the high cost of these devices (up to $ 4,000) and the lack of their production in Ukraine is put. The Institute of Plasma Physics National Science Centre "Kharkov Institute of Physics and Technology" along with the development of new types of ozone sterilizers has been actively working to develop technical means for controlling the maximum permissible concentrations of ozone in order to ensure safety of personnel.

2. DESIGN AND OPERATION OF DEVICE FOR OZONE CONCENTRATION MONITOR OCM-3

As the analysis shows of existing solutions in the measurement of ozone concentrations in the range of maximum permissible concentration now in Ukraine does not solve the problem of availability of such equipment. The high cost of existing devices due to their complexity associated with the principle of work. Recently have appeared small-sized low-cost semiconductor detectors such as ozone sensor MQ-131 [5].Their application creates the possibility to developing a simple low-cost meter of ozone.

Device for ozone concentration monitoring OCM-3, a block diagram of which is shown in Fig. 4, is designed for permanent monitoring the situation for the safe work conditions.

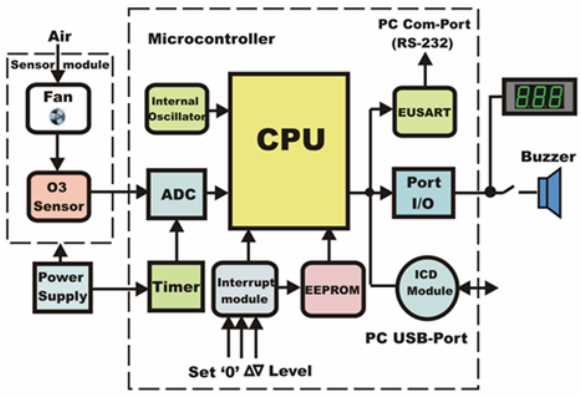

Fig. 4. The device's structural scheme

Device provides automatic measuring of ozone concentration, its indication, setting threshold and turning on of audio alarm, transferring data to a central computer via serial connection (RS-232), possibility of storage the calibration parameters for specific instance of ozone sensors. Device includes a microcontroller, a communication with a computer, indicator, alarm function and controlling unit. The microcontroller is implemented on the base of an integrated circuit PIC18F2550 produced by Microchip Technology Inc. [6]. In this device was used solid-state semiconductor sensor of MQ-131 series produced by HENANHANWEI ELECTRONICS CO., LTD.

Analog output signal of the sensor is converted into digital code by an analog-digital converter (ADC) of the microcontroller, which is clocked by the internal oscillator (Osc). The microprocessor (MCU) produces consistent comparing of the results with hard-wired to convert non-volatile memory data (EEPROM) in the form of a table of values for the given sub-ranges of measured concentrations. The table is the result of a preliminary calibration of each instance of the sensor using special equipment [7]. An integrated transceiver MAX-232used to convert the signal unipolar 5-volt TTL / CMOS level serial port EUSART into bipolar standard signals TIA/EIA-232-F (a standard PC COM-port). The power supply (PS) provides energy to the device.

Button "Set 0" is used for compensation of the effect of temperature drift in a room. Response threshold for the beep is set with buttons "↑ Level" and "↓Level".

Firmware and reprogramming of the microcontroller can be made by means of in-circuit debugger (ICD).

Operation of the device is supported by a set of the developed software, including the work program of the microcontroller, and a set of individual calibration characteristics of the ozone sensors.

The program provides the transfer of information from the device OCM-3 to a central computer, its visualization and archiving processes, including alarms if necessary. Fig. 5 illustrates the operation of the device OCM-3, watch on the monitor of the central computer. The graph showing the response of sensor to the periodic puffing ozone concentration of 0.2 mg/m^3 every 800 seconds.

Fig. 5. Graph of ozone concentration

All software modules are created in the environment of development MPLAB IDE in a specialized language C18, designed to program the microcontrollers.

CONCLUSIONS

The ozone meters are low-cost, simple device which allows to use it in a wide sphere of ozone technologies to ensure the safety of personnel. The application of microcontroller devices can significantly improve the safe use of ozone technology involving human contact with ozonized environment.

The serial digital channel with computer is realized for possibility of the remote control of ozone concentration in working area.

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ИЗМЕРИТЕЛИ КОНЦЕНТРАЦИИ ОЗОНА

С.П. Губарев, Г.П. Опалева, В.С. Таран, М.И. Золототрубова

Описаны разработанные микропроцессорные измерители концентрации озона в газовой среде, построенные на различных принципах действия: спектрометрический измеритель, использующий поглощение ультрафиолетового излучения на длине волны 254 нм, прибор на коронном разряде (диапазон измерения от 0.1 до 40 мг/л) и полупроводниковый измеритель (диапазон измерения находится в области предельно допустимых концентраций (ПДК).

ВИМІРЮВАЧІ КОНЦЕНТРАЦІЇ ОЗОНУ

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Описано розроблені мікропроцесорні вимірювачі концентрації озону в газовому середовищі, побудовані на різних принципах дії: спектрометричний вимірювач, що використовує поглинання ультрафіолетового випромінювання на довжині хвилі 254 нм, прилад на коронному розряді (діапазон вимірювання від 0.1 до 40 мг/л) і напівпровідниковий вимірювач (діапазон вимірювання знаходиться в межах гранично допустимих концентрацій (ГДК).