

MICROPROCESSOR OCM-003 DEVICE FOR OZONE CONCENTRATION MEASURING

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In the paper, the OCM-003 type meter of ozone concentration operated in a gaseous environment with microprocessor control unit has been developed. Such device belongs to spectroscopic type meters. The measuring principle is based on the absorption of ultraviolet (UV) light at a wavelength of 254 nm. It was shown that the measurable ozone concentration range comprised 0.1...100 mg/l. The ozone meter is controlled by the PIC18F25K80 microprocessor-based controller produced by Microchip Technology Inc. The original software was developed. The possibility to developing a simple low-cost meter of ozone has been shown.

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INTRODUCTION

Ozone has been used in dozens of industries for many years to improve sanitation of surfaces, raw water purification, air treatment and odor control, wastewater treatment, and much more. Ozone is used primarily for disinfection purposes and the concentration needs to be accurately measured and monitored since it is considered a hazardous material.

Stationary spectrometers are rather expensive for laboratory tests, therefore portable devices for the detection of high, low and medium MAC levels (maximum admissible concentration) ozone concentrations are of great interest. 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.

Widely used meters for ozone measuring concentration, such as OZONE-5 (JSC "Angarsk - OKBA", Russia), analyzer UVOZON 200.50 (Trailigaz Instruments, France) [1-3] and others provide measuring of the mass-volume ozone concentrations in ozone-air, ozone-oxygen and ozone-nitrogen gas mixtures. Along with the indisputable advantages of these devices there are a number of drawbacks. For example, the device OZONE-5 has a large weight (12 kg), whereas the device UVOZON 200.50 is very expensive.

At the Institute of Plasma Physics NSC KIPT, there was designed portable ozone meters operated in gaseous environment, including those based on the principle of measuring the absorption of ultraviolet radiation at 254 nm wavelength.

The present article describes the device for measuring the ozone concentration of OCM-003 type (Fig. 1.).

1. MAIN PART

The measurement system consists of a dual channel analyzer of differential signal value containing information about ozone concentration in gas.

The structural scheme of the device is shown in Fig. 2.



Fig. 1. OCM-003 ozone concentration meter

In the double-beam photometer the light from an extended source of UV radiation passes through two identical lines (channels). The light flow from one channel passes through the cuvette with the measured gas, and from the other channel - through a cuvette with "zero" gas (air or oxygen containing no measurable component). Then, each beam of light has been directed at the individual photodetectors. Signals from the photodetectors come to the current-voltage converter, logarithmic and differential amplifiers, and further - to an analog-digital converter (ADC) of the microcontroller.

With this scheme of construction of ozone concentration meter the requirement for identity characteristics of both photodetectors is not a strict and variation of sensitivity can be compensated by changing the electric circuit parameters, or by an optical method: the weakening of one of the light beams (diaphragming).

Temporary change of ultraviolet radiation also has no significant effect on the measurement accuracy.

Thermal gradients between the cuvettes are decreased due to placing them on the common metal plate made of aluminum alloy. All elements of the meter, including ultraviolet lamp must be screened.

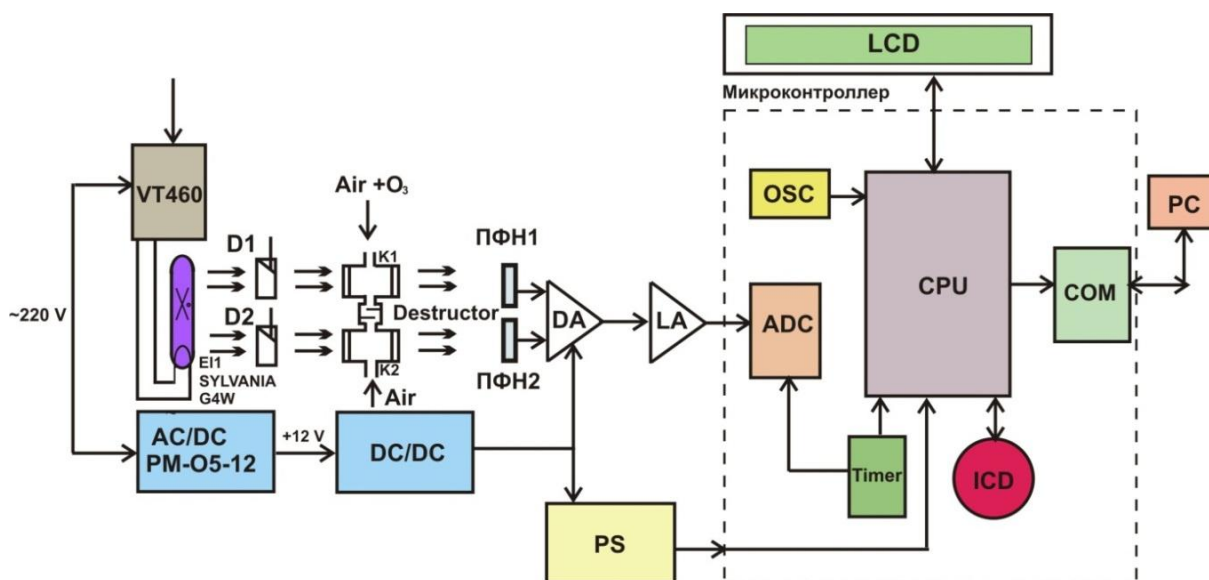


Fig. 2. The device's structural scheme

Control of meter operation is realized by microprocessor controller designed at the Institute of Plasma Physics NSC KIPT. It is implemented on the base of the PIC18F25K80 microcontroller produced by Microchip Company Inc. [4]. The controller provides a control function of the operation of the ozone meter, mode selection and timing of the process. The analog signal from the differential amplifier is converted by an analog-digital converter ADC module into a digital code. Further, the value of the current concentration is calculated by the microprocessor according to the formula (1). To reduce measurement errors, microprocessor performs converting and reading of the incoming signal for 200 times for further averaging of the obtained data. Minimum and maximum values are removed from the resulting array; the remaining data is summarized and calculated the average value of the converted data. To visualize the data the LCD WH2002 indicator is used. It contains two lines of twenty characters.

Mode selection, configuration, installation of "0" is carried out by two buttons located on the front panel.

The measuring device is equipped with RS-232 serial port. This option provides visualization and archiving of ozone concentration measurement results on the computer.

For the convenience of making changes to program of the microcontroller without disassembling the device was provided a connector for in-circuit debugging (ICD).

Specifications:

- Overall dimensions: length – 160 mm
- Width – 180 mm
- Height – 85 mm
- Weight – 1.15 kg
- Power consumption – 7 W.

The original software was developed. Software module is created in the environment of development MPLAB IDE in a specialized language C18, designed to program the microcontrollers.

Debugging and calibration of the device was carried out at the Institute of Plasma Physics (IPP) on a special stand [5]. Ozone generator produces ozone concentration in the range from 0 to 100 mg/l. As reference standard, an American ozone meter M454 produced by Teledyne Advanced Pollution Instrumentation Inc. was used. It provides a measurement accuracy of $\pm 1\%$ of full scale. The response time is 2 seconds. Measurement range is $0.1 \dots 400 \text{ g/m}^3$. Ozone meter M454 was set in series with described apparatus OCM-3 in the pipeline with ozone air mixture. As a result, series of ADC codes from each device at different values of the ozone concentration were obtained. The graph of ozone concentration values registered by devices OCM-003 and M454 versus ADC codes are shown in Fig. 3.

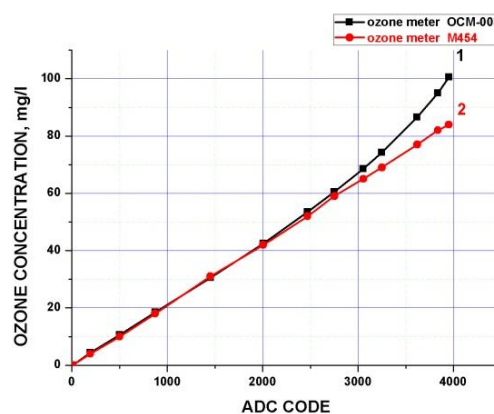


Fig. 3. Graph of ozone concentration values registered by devices OCM-003 and M454 versus ADC codes

The graph shows that the calibration curve 1 is composed of two parts. If the ADC code value $x < 2000$, the ozone concentration value is calculated by a linear function $C_{\text{ozone}} = K \cdot x$, where $K = 0.021255$. If the ADC code value is $x \geq 2000$, so the value of the ozone concentration is calculated according to the formula:

$$C_{\text{озон}} = A1 \cdot e^{\left(\frac{-x}{t1}\right)} + y0,$$

where

$$\begin{aligned} A1 &= 24.54673; \\ t1 &= -2643.85574; \\ y0 &= -9.45805. \end{aligned}$$

These formulas are stored in the memory of the microprocessor.

CONCLUSIONS

A domestic meter of ozone concentration in a gaseous environment with microprocessor control unit was developed. The measuring principle is based on the absorption of ultraviolet (UV) light at a wavelength of 254 nm. It was shown that the measurable ozone concentration range comprised 0.1...100 mg/l. The ozone meter is controlled by the PIC18F25K80

microprocessor-based controller produced by Microchip Technology Inc. The original software was developed. The possibility to developing a simple low-cost meter of ozone has been shown.

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МИКРОПРОЦЕССОРНОЕ УСТРОЙСТВО ОСМ-003 ДЛЯ ИЗМЕРЕНИЯ КОНЦЕНТРАЦИИ ОЗОНА

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Разработан измеритель концентрации озона в газовой среде с микропроцессорным управлением типа ОСМ-003. Устройство относится к измерителям спектроскопического типа на основе поглощения ультрафиолетового излучения на длине волны 254 нм (диапазон измеряемой концентрации от 0,1 мг/л до 100 мг/л). Управление измерителем озона осуществляется контроллером на основе микропроцессора PIC18F25K80 производства фирмы Microchip Technology. Было разработано оригинальное программное обеспечение. Показана возможность разработки простого и недорогого измерителя концентрации озона.

МИКРОПРОЦЕССОРНИЙ ПРИСТРІЙ ОСМ-003 ДЛЯ ВИМІРЮВАННЯ КОНЦЕНТРАЦІЇ ОЗОНУ

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Було розроблено вимірювач концентрації озону в газовому середовищі з мікропроцесорним управлінням типу ОСМ-003. Пристрій відноситься до вимірювача спектроскопічного типу на основі поглинання ультрафіолетового випромінювання на довжині хвилі 254 нм (діапазон вимірюваної концентрації від 0,1 до 100 мг/л). Управління вимірювачем озону здійснюється контролером на основі мікропроцесора PIC18F25K80 виробництва фірми Microchip Technology. Було розроблено оригінальне програмне забезпечення. Показана можливість розробки простого й недорогого вимірювача концентрації озону.