AUTOMATIC PROGRAMMABLE AIR OZONIZER

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In this paper we describe a compact, economical, easy to manage auto air ozonator developed at the Institute of Plasma Physics of the NSC KIPT. It is designed for sanitation, disinfection of premises and cleaning the air from foreign odors. A distinctive feature of the developed device is the generation of a given concentration of ozone, approximately 0.7 maximum allowable concentration (MAC), and automatic maintenance of a specified level. This allows people to be inside the processed premises during operation. The microprocessor controller to control the operation of the ozonator was developed.

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INTRODUCTION

In recent years in many countries an increase of interest to use ozone technologies is observed, and Ukraine is not exclusion in this regard. The antiseptic properties of ozone allows to process objects five times more effectively than ultraviolet disinfection. Besides, ozone can penetrate cavities closed for UV radiation. Particularly relevant are devices based on air ozonators. Earlier in the IPP NSC KIPT the air ozonator was developed based on the principle of barrier discharge [1]. The disadvantages of that device were the lack of automatic mode and program control. Continuing the work on perfection of the device, a new air ozonator with program control was designed, which has no disadvantages mentioned above. Below the work of device is described in detail. It can be used for cleaning of air in clinics and hospitals, where there are a large number of infected patients, and also in surgical premises for continuously maintaining sterility of air during surgery. Maximum continuous cycle operation of the device is 2 hours and is does not have a time limit of use. The photo of ozonator is shown in Fig. 1.

Fig. 1. Photo of ozonator

HARDWARE AND SOFTWARE PRINCIPLES OF AIR OZONATOR

Ozonator has the following specifications:

1. Ozone productivity – 6 mg / min.
2. Maximum area of treated premise – 99 m^2.
3. Supported ozone concentration – 0.7 MAC.
4. Power – 5 watts (generation regime).
5. Power consumption – 0.5 watts (ventilation).
6. Weight – 0.5 kg.
7. Dimensions 170x100x50 mm.

The control of the ozonator operation is realized by means microprocessor controller developed in IPP NSC KIPT. It is implemented on the basis of microcontroller PIC18F series designed by Microchip company [2, 3]. The controller provides control of the ozone generator, the operational configuration of the application of the working gas injection, selection of work modes and timing of the process. The input value of the premise area is indicated on the dynamic display. The device structural scheme is shown in Fig. 2.

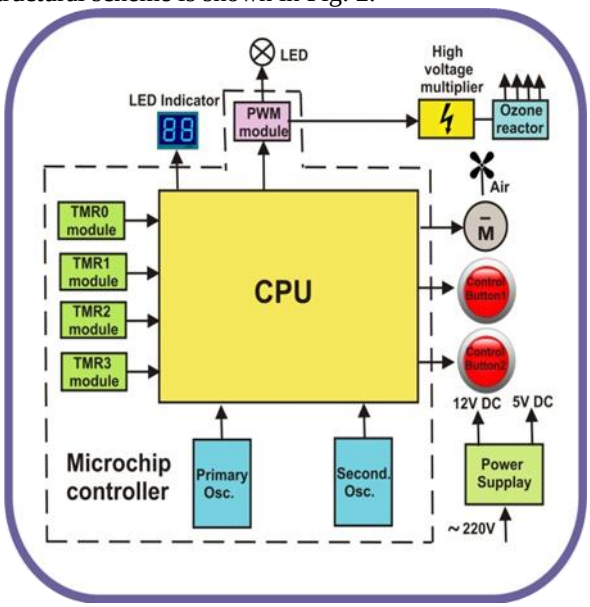

Fig. 2. The device structural scheme:

CPU – central processing unit;
TMR0…TMR3 – timer module;
Primary Osc. – Primary Oscillator;
Second Osc. – Secondary Oscillator;
PWM – Pulse Width Modulation Module;
M – Motor

Ozonator operates in a cyclic mode. The period of continued operation of the device is 2 hours. The number of two-hour cycles is unlimited.

The device can operate in two modes:

- the continuous ozone injection (with a ozone generator productivity of 6 mg/min) without automatically aintain the concentration ofozone gas to stop after 2 hours;

- automatic maintenance of the ozone concentration on the given level in the room 0.7 maximum allowable concentration (MAC).

The device OCM-4 (Ozon Concentration monitoring) has been used for the calibration of the new ozonator. The OCM-4 is a modification of the OCM-3 device [4] constructed on the basis of a semiconductor sensor MQ-131 and calibrated by means of 2 methods:

- chemical;
- spectrometric.

Chemical calibration of the ozone generator was performed in IPP NSC KIPT by experts of Sanitary Epidemiological Station of specialized medical unit №13 of Kharkov city. A series of measurements was conducted of ozone concentration in the air; the ozone was produced by the test generator. The spectrometer calibration was performed by the use of the software developed in IPP and the hardware complex [5]. The measurement results are decorated by protocol.

For correct operation of the device OCM-4 it is necessary to obtain such parameters as ozone decay rate and the purge time of ozonated premises. With that end in view, an experiment was conducted and some results are presented graphically in Fig. 3.

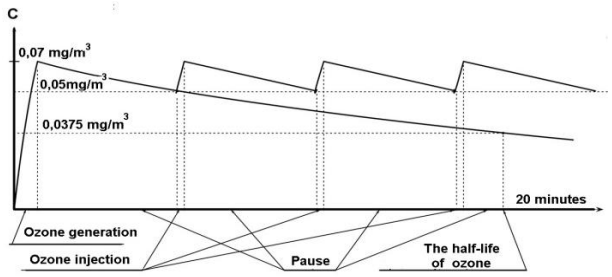

Fig. 3. Graph of the ozone decay rate in the room in different modes (with a purge premises without purging and at different ozone concentrations)

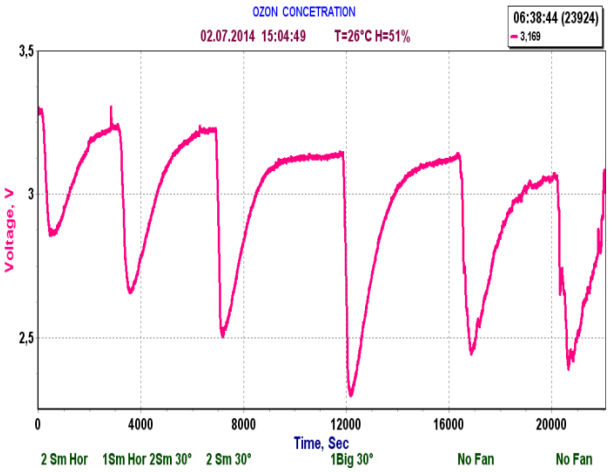

Fig. 4. Theoretical graph of the ozone concentration changes at ozonator work in automatic mode

The times of ozone half-life and purge obtained from the experiment are used to construct a theoretical graph of the ozone concentration change indoors at ozonator operating in automatic mode (Fig. 4).

Fig. 5 presents the experimental graph of the ozone concentration changes, measured by the device OCM-4. The device operates in the mode of automatic maintenance of the ozone concentration.

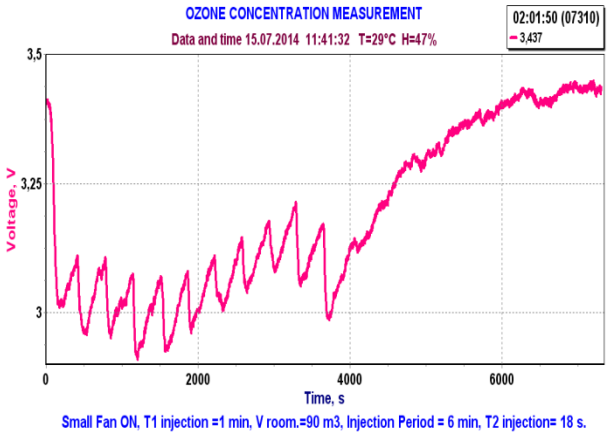

Fig. 5. Experimental graph of the ozone concentration changes at ozonator work in automatic mode

The operational mode is selected by entering the values of the ozonated premise area S (m^2). If S = 0, the device will operate in a mode of continuous ozone injection. If S> 0, the device will operate in the automatic mode to maintain the constant concentration of ozone. The period of continued operation of the device does not depend on the selected mode and equals 2 hours. For the countdown of time the module "Timer 0" is used.

When one selects a continuous ozone injection mode (S = 0) and press the start button, the "Timer 0", ozone generator and fan will start automatically and will be continuously running throughout the period of operation of the device (2 hours), and then will be automatically turned off. Further the device will wait for one of the following user action:

- entering the new value of premise area and start of the ozonation process;
- next start of ozonation process (without changing the value of the ozonated premise area).

If the mode of automatically maintaining the concentration of ozone in the room (S> 0) is selected and the start button is pressed, the "Timer 0", ozone generator and fan will start as well as in continuous ozone injection mode. However ozone generator will be turned on for the time T_f (minute), equals to the time of filling the room with ozone. After this time the ozone generator and the fan will be turned off automatically and will remain off during 6 minutes.

Then ozone generator and the fan will be turned on at the time of the ozone injection T_i. Such actions will be repeated periodically until the set time of the device work (2 hours) has elapsed. Further all operations will stop automatically and the program will wait for user directives. The work of ozone generator is provided by the Pulse Width Modulation module output signal. Parameters of the output signal (the period and duty cycle) are given by setting the corresponding registers of the programmable "Timer 2". The "Timer 2" module incorporates the readable and writable (both registers) 8-bit timer and period registers. The module also includes:

- software programmable prescaler (1:1, 1:4 and 1:16);
- programmable postscaler (1:1 through 1:16).

The fan is activated by setting of high level on the appropriate port of the controller PIC18F2550.

Times of filling the room with ozone T_f and ozone injection T_i depend on an area of ozonated premise and were calculated by the formulas (1) and (2):

$$T_f=\frac{h\cdot C_0}{P}\cdot F(S), \quad (1)$$

$$T_i=\frac{h\cdot C_0\cdot T_{pi}}{P}\cdot F(S). \quad (2)$$

Concentration of ozone in the mode of continuous ozone injection is defined by the formula (3):

$$C=\frac{P\cdot T_{hl}}{S\cdot h}, \quad (3)$$

where :

S - area of premise (m^2); H - height of the room (m); C_0 - allowable concentration of ozone for long-term stay (0.07 mg / m^3); P - productivity of ozone generator (6 mg / min); T_{pj} - ozone injection period (6 min); T_{hl} - the half-life of ozone.

CONCLUSIONS

The use of a microcontroller allowed to create a compact and easy-to-use air ozonator for industrial and domestic purposes. When operating, the device is not a threat to life and health of people being in the room. A sophisticated algorithm for inclusion of the ozonizer eliminates any unauthorized exploitation of the device.

The use of such kind microcontroller can significantly improve the safe application of ozone technology within human-aided activity.

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АВТОМАТИЧЕСКИЙ ВОЗДУШНЫЙ ПРОГРАММИРУЕМЫЙ ОЗОНАТОР

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Описан разработанный в Институте физики плазмы ННЦ ХФТИ малогабаритный, экономичный, простой в управлении автоматический воздушный озонатор. Он предназначен для санации, дезинфекции помещений и очистки воздуха от посторонних запахов. Отличительной особенностью разработанного прибора является генерация озона заданной концентрации (порядка 0,7 ПДК) и автоматическое поддержание заданного уровня. Это позволяет людям безопасно находиться внутри обрабатываемых помещений во время работы прибора. Управление работой озонатора осуществляется с помощью разработанного в Институте физики плазмы ННЦ ХФТИ микропроцессорного контроллера.

АВТОМАТИЧНИЙ ПОВІТРЯНИЙ ПРОГРАМОВАНИЙ ОЗОНАТОР

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Описано розроблений в Інституті фізики плазми ННЦ ХФТІ малогабаритний економічний, простий в управлінні автоматичний повітряний озонатор. Він призначений для санації, дезинфекції приміщень і очищення повітря від сторонніх запахів. Відмінною особливістю розробленого приладу є генерація озону заданої концентрації (порядку 0,7 ГДК) та автоматична підтримка заданого рівня. Це дозволяє людям перебувати безпечно всередині оброблюваних приміщень під час роботи приладу. Управління роботою озонатора здійснюється за допомогою розробленого в Інституті фізики плазми ННЦ ХФТІ мікропроцесорного контролера.