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DIAGNOSTIC DEVICE FOR GAS-FILLED DEVICES FOR VISUAL REPRODUCTION OF THE INFORMATION

The discovery of the phenomenon of glow discharge in gases led to active scientific research and gave rise to a large number of technical means that are based on the application of the phenomenon of glow discharge in gases. This type of discharge is used in gas light tubes, daylight lamps, plasma panels, and voltage stabilizers, as well as for obtaining electron and ion beams. Gas-discharge means of visual reproduction of information have also become widely used. A constant high voltage (about 180 V) is required to power them, which can be obtained in various ways, for example, using a classic scheme – a step-down transformer, a diode bridge, and a smoothing filter. Or a circuit with a voltage multiplier on diodes and capacitors. The disadvantage of these options is the need for alternating voltage, which can be obtained either from an alternating current network or by converting a source of direct voltage into alternating voltage using additional electronic circuits. These problems limit the use of the mentioned methods and are not suitable for a mobile and compact version of the device that would provide a quick check of gas-filled devices and preventive restoration of «poisoned» cathodes immediately after their detection. But after the rapid development of chip technology, there are many options for solving these problems, for example, STEP-UP DC voltage converters using microcircuits that operate at high frequencies and can control the charge/discharge process of the choke through power switches. The paper presents the results of the development of a device that uses several STEP-UP converters for powering the indicators and a microcontroller that controls the decoder (which ensures fast scanning of the cathodes of the sign indicators), the power switch (for changing the indicators) and the power supply time. A study of the power change of gas-filled devices with an increase in the power supply voltage of the converter was carried out, and the possibility of restoring «poisoned» cathodes of sign indicators was checked. Experimentally obtained oscillograms of alternating voltage at the control points of the device's electrical circuit.

Key words: *gas-filled devices, gas-discharge indicator, glow discharge, poisoned cathodes, voltage booster.*

Formulation of the problem. Due to the fact that gas-filled devices could be stored or used in conditions harmful to them, they may not work (gas leakage, disconnection with the cathode, burnout of output pins, «poisoning» of cathodes) [1, 2]. Structural diagrams of diagnostic devices for gas-filled devices for visual reproduction of information can consist of one block (which includes a diode and a limiting resistor, powered directly from an alternating current network), from two or three blocks, they include a step-down transformer, a diode bridge, filters, and a limiting resistor. But these options do not differ in compactness and functionality because they require an alternating current network; also, the functions of the proposed schemes end on the power supply of the indicators, but the problem with «poisoned» cathodes and the speed of inspection remain. The provision of fast and mobile testing of gas-filled devices with a recovery function is possible only when using a structural circuit with a microcontroller, which accelerates the speed of testing indicators and the user's work with it and the use of step-up DC-DC converters.

Analysis of recent research and publications. There are already a large number of power supplies for gas-filled devices based on STEP-UP converters, for example [3], a development based on the NE555 timer is proposed, but the timer does not have a temperature-compensated reference voltage source and a generator with an active peak current limiting circuit, unlike the MC34063 microcircuit. There are options based on the classic converter [4, p. 913], but these devices do not offer any functions other than power (for example, increasing the current).

Task statement. The work aims to develop a diagnostic device for gas-filled visual information display devices, both for stationary use and for portable use, which can provide high output voltage and the function of restoring «poisoned» cathodes. To achieve the goal, the following tasks must be solved: 1) propose a compact schematic solution of the voltage converter and the control mechanism; 2) check the layout of the device for compliance with the requirements; 3) draw conclusions about the possibility of reducing the oxide layer by increasing the power of gas-filled devices.

Methods. Figure 1 shows the structural diagram of the diagnostic device.

The electrical diagram of the diagnostic device is shown in Figure 2.

For stationary use, it is advisable to power the diagnostic device from pulsed power supply units, the voltage of which is equal to 9 V DC or higher (up to 12 V). When it is necessary to use the device far from power supply networks, it is advisable to use a built-in power source, for example, a «Krona» battery. To power the decoder and the microcontroller, you need to use the LM7805 stabilizer.

The first units to which the voltage from the power source is supplied are the unit for increasing the supply voltage (it can be implemented using the MT3608 module) and the microcontroller. This module is a step-up converter on the MT3608 microcircuit; this microcircuit has short-circuit protection, overheating protection, output current limitation, and acts as a key. The regulator on the converter board allows you to select the required output voltage level up to 28 V, which is what this module is useful for, with a load current of up to 2 A from a low-voltage power source [5].

The diagnostic device's operation principle is based on the cyclic accumulation and return of energy to the load. At the first moment, when the power transistor is open (it is located in the microcircuit), the choke accumulates energy, then the transistor closes, and through the diode, thanks to the accumulated energy on the choke, voltage is applied to the load and the charge of the capacitor, the transistor opens again, the diode closes, the choke again accumulates potential, and the capacitor at this time feeds the load. When the cycle is repeated, the capacitor is not yet fully discharged, and the output voltages are added. The power transistor opens and closes at high frequencies, resulting in the effect [3]; the maximum output voltage of this module is 28 V DC; in addition to increasing the voltage, we increase the current that we supply to the indicators. This block can be disabled using a toggle switch, then the maximum current recovery mode of the indicators will be smaller.

The next DC-DC step-up converter unit is a power supply unit for indicators. This converter is similar in principle to the previous one but uses a powerful n-channel MOSFET as a control element. The 34063 series of microcircuits is not usually used to control

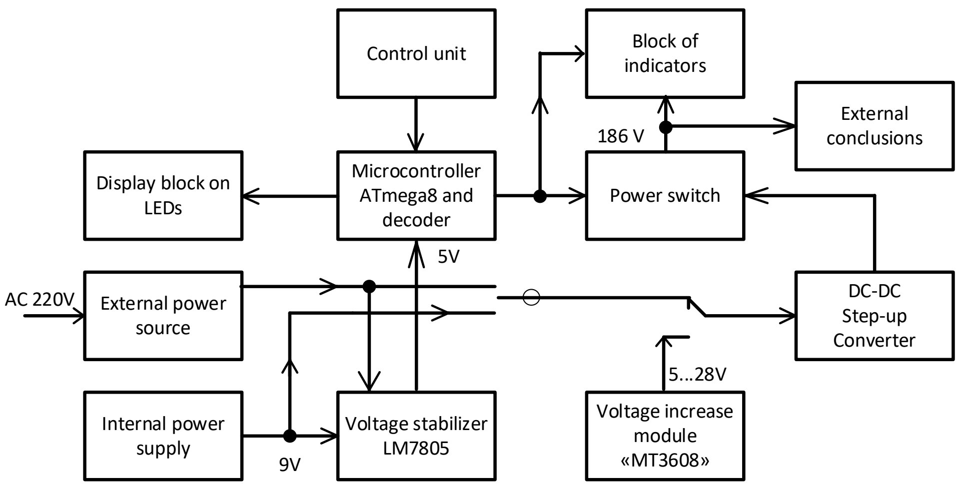

Fig. 1. Structural diagram of the diagnostic device

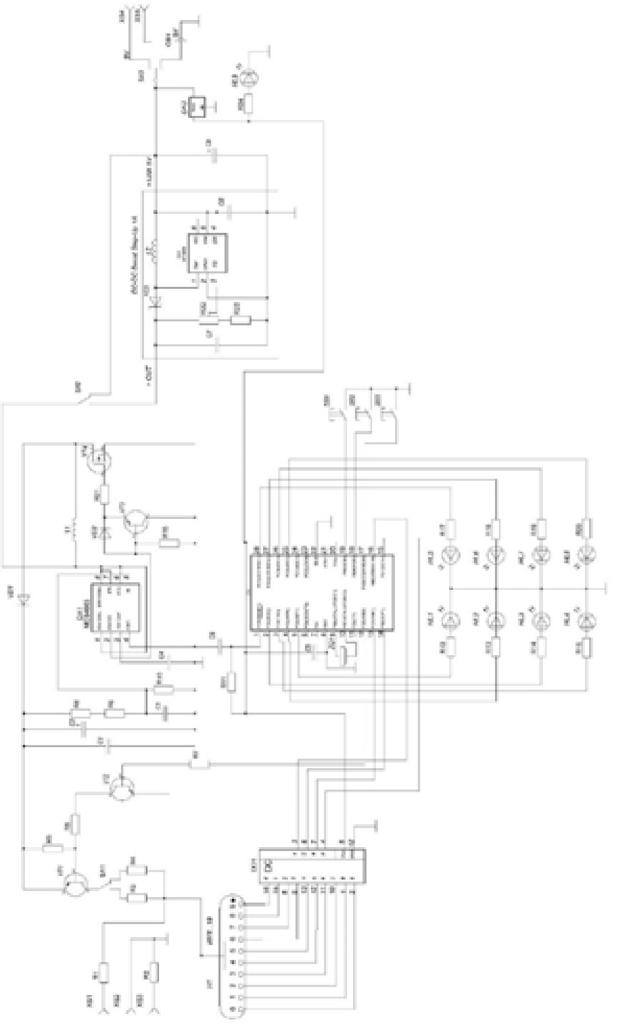

Fig. 2. Electrical diagram of the diagnostic device for gas-filled devices

field-effect transistors because the circuit does not provide for the possibility of discharging the gate of the transistor, but if you add to it a special driver for controlling the field-effect transistor, which consists of a bipolar p-n-p transistor (VT3) with a diode (VD2) and resistors (R16, R21), then this function appears. The scheme is one of the most effective solutions for reducing the turn-off time of the field-effect transistor. With the help of the transistor VT3, capable of conducting large pulse currents, the input capacitance of the MOSFET gate is discharged to its drain [6, pp. 20-21].

MC34063 controls the key; the frequency with which it will open/close the key depends on the divider R8, R9, and capacitor C4. The output voltage is calculated according to the manufacturer's documentation [7, c. 8-14].

Next is the block of the power key on the elements – VT1, VT2, R5, and R6 [8]. They are needed to ensure the function of turning off the device at the user's request or after the restoration of the indicators is complete. To conditionally control the current that will flow through the indicators, it is necessary to apply two resistors with a small (100 Ohm) and a large (10 kOhm) resistance after VT1. You can connect the resistor using the toggle switch SA1.

The next one is a block with a microcontroller, which, by executing a program programmed into it using AVR Studio [9, c. 46-48], controls the LEDs HL1...HL8 (modes to do – the speed of the cathode bulkhead and the recovery time), the K155ID1 decoder, and the VT2 transistor. Control is carried out by switching one of the buttons SB1, SB2, and SB3 with a common wire. In order to ensure the sequential selection of cathodes, the K155ID1 decoder is used. This decoder is used to convert the binary-decimal code into decimal.

The last block is a block of indicators, which is ten parallel buses, nine of which go to the number depending on the bus number and which the decoder switches in series with the ground when the code is fed to it from the microcontroller and the tenth is the common anode for the lamps, i.e., it is a +186 VDC power bus.

In the Proteus 8 simulator, the operation of the converter was simulated, and oscillograms were recorded (Fig. 3 a, c, d), which confirmed the correctness of the performed electrical calculations and the selected ratings of the radio components of the electrical circuit. A timing capacitor is connected to pin 3 of the microcircuit, which determines the conversion frequency. A semi-driver and a field-effect transistor are connected to pin 2 of the microcircuit. Oscillograms from pin 3 and pin 2 of the chip are shown in Fig. 3, a, c. The duration of the voltage pulses is 27 µs; the frequency is 37 kHz; that is, the microcircuit works without failures.

We made an experimental sample of the device and examined the voltage oscillograms at the control points. The sawtooth voltage from pin 3 of the microcircuit is shown in Fig. 3.b (cell scale on the X axis is 10 µs, on the Y axis is 0.5 V), and the repetition frequency is 43 kHz. The shape of the signal that enters the gate of the field capacitor is shown in Fig. 3.g (cell scale on the X axis – 5 µs, on the Y axis – 1 V), frequency 43kHz. The form of the inductance discharge voltage (Fig. 3, e), at the output of the field-effect transistor, was investigated using a probe-divider 1:10 (one cell along the X axis – 5 µs, along the Y axis – 5V), frequency 43 kHz.

During the simulation, the frequency was lower than the calculations made according to the manufacturer's documentation (37 kHz); on the model, the frequency is 43 kHz. Also, the voltage forms are slightly different. This is due to the parasitic capacitances of the experimental layout, as well as the spread of the nominal values of the radio components.

An important function of the device was the introduction of restoration of «poisoned» cathodes of indicators by supplying increased power. The voltage measurement results on the experimental layout in different modes of the diagnostic device are shown in Fig. 4.

The change in power of different types of gas discharge indicators in normal mode and recovery mode with and without using the Step-UP converter module is considered (the values of currents and voltages are taken from the average indicator, and the converter increases the voltage by 3 V). The voltage in the idle mode is 186.3 V. Figure 5 shows the graph of the obtained results for increasing the power of various types of indicators. The obtained results indicate that the mode of operation with the previous Step-UP converter is in good working order. An example of restoring part of the «poisoned» cathode of the indicator is shown in Figure 6.

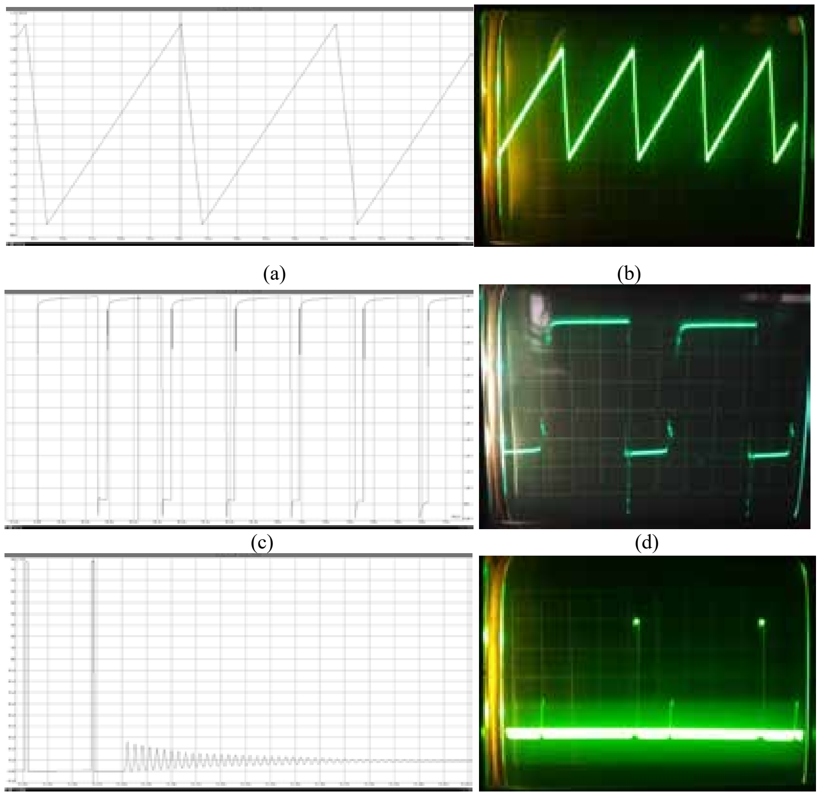

Fig. 3. Oscillogram from pin 3 of the microcircuit (a, b), the pulses from which are sent to the gate (c, d), and the oscillogram of the inductance discharge when the field-effect transistor is closed (e, f)

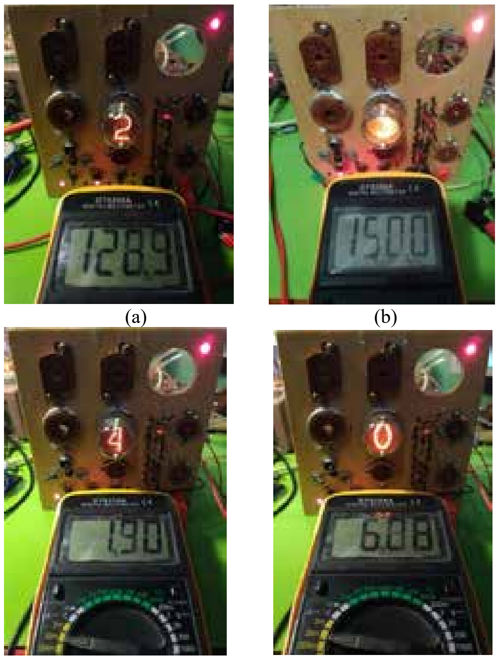

Fig. 4. Results of voltage measurement on the experimental layout in different modes of the diagnostic device: voltage at load 128.9 V (a), the voltage at load in a recovery mode 150 V (b), current not in recovery mode 1.9 mA (c), current in recovery mode 6.08 mA (g)

Conclusions. Powering the indicators is implemented using DC-DC step-up voltage converters, which with small dimensions and input voltages, can provide a voltage sufficient to create a glow discharge in the indicator.

Device control is implemented on the Atmega8 8-bit microcontroller, which made it possible to develop a fairly large number of tester functions, in particular, the ability to control the speed or time of operation of the device in recovery and testing modes. The operating mode can be determined using a panel of LEDs controlled by a microcontroller. The microcontroller unit is controlled using three buttons: Start/Stop, Changing the frequency, and Changing the working time. In addition to the microcontroller, a pair of toggle switches was used to switch the device to high voltage and high current mode (cathode recovery mode).

Practical studies show that the recovery mode works correctly in two modes (increased power

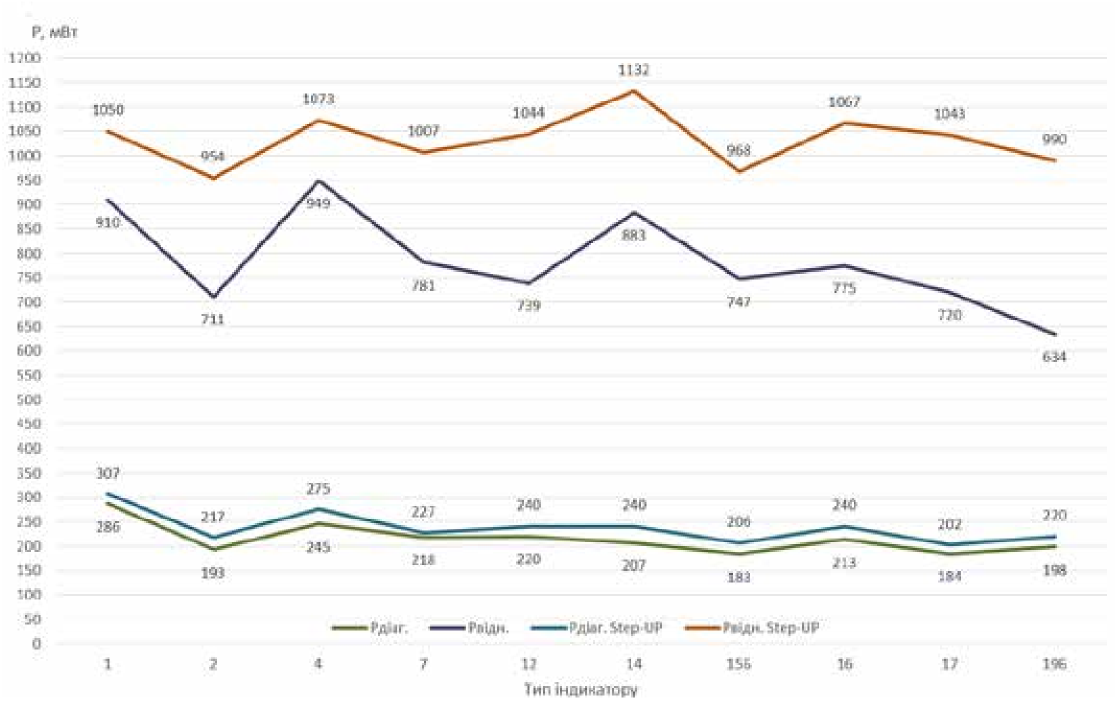

Fig. 5. Power change graph in different operating modes of the diagnostic device

(a) (b)

Fig. 6. Partially «poisoned» cathode (a), cathode of the indicator after recovery with increased current (b)

compared to the normal diagnostic mode). A slight increase in the voltage on the Step-UP converter gives a power increase of 250 mW. A further increase in voltage will lead to many times exceeding the allowable current through the indicator, so it is suggested to leave the supply voltage at most 12 V.

With the diagnostic device proposed in work, it is possible to check not only the types of gas-filled devices for which there are panels on the body but also various types of indicators, the supply voltage of which is in the range from 160 to 200 V direct current. This is implemented with the help of three output wires – anode, cathode, and auxiliary cathode.

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ДІАГНОСТИЧНИЙ ПРИСТРІЙ ДЛЯ ГАЗОНАПОВНЕНИХ ПРИЛАДІВ ВІЗУАЛЬНОГО ВІДТВОРЕННЯ ІНФОРМАЦІЇ

Відкриття явища тліючого розряду у газах привело до активних наукових досліджень та породило велику кількість технічних засобів, які ґрунтуються на застосуванні явища тліючого розряду у газах. Цей тип розряду використовується в газосвітних трубках, лампах денного світла, плазмових панелях, стабілізаторах напруги, а також для отримання електронних та іонних пучків. Широкого використання набули також газорозрядні засоби візуального відтворення інформації. Для їх живлення необхідна висока постійна напруга (порядку 180 В), яку можна отримати різними способами, наприклад використовуючи класичну схему – понижувальний трансформатор, діодний міст, згладжуваний фільтр. Або схему з помножувачем напруги на діодах і конденсаторах. Недоліком цих варіантів є потреба в змінній напрузі, яку можна отримати або від мережі змінного струму, або перетворивши джерело постійного напруги в змінну напругу використовуючи додаткові електронні схеми. Ці проблеми обмежують використання зазначених способів і не підходять для мобільної та компактної версії приладу який би забезпечив швидку перевірку газонаповнених приладів та профілактичне відновлення «отруєних» катодів відразу після їх виявлення. Але після бурхливого розвитку мікросхемотехніки з'явилося багато варіантів вирішення цих проблем, наприклад STEP-UP перетворювачі постійної напруги з використанням мікросхем, які працюють на високих частотах і можуть керувати процесом заряду/розряду дроселя через силові ключі. У роботі наведено результати розробки пристрою що використовує декілька STEP-UP перетворювачів для живлення індикаторів і мікроконтролер, який керує дешифратором (що забезпечує швидкий перебір катодів знакових індикаторів), ключом живлення (для зміни індикаторів) та часом подачі живлення. Було виконано дослідження зміни потужності газонаповнених приладів при збільшенні напруги живлення перетворювача, перевірена можливість відновлення «отруєних» катодів знакових індикаторів. Експериментально отримані осцилограми змінної напруги у контрольних точках електричної схеми приладу.

Ключові слова: *газонаповнені прилади, знаковий індикатор, тліючий розряд, отруєні катоди, STEP-UP перетворював.*