Ministry of Education and Science of Ukraine
Ternopil Ivan Puluj National Technical University

Faculty of Applied Information Technology and Electrical Engineering
(full name of faculty)
Department of Biotechnical Systems
(full name of department)

QUALIFYING PAPER

For the degree of

Bachelor
(degree name)

topic: Network Unit of the Medical Laboratory Thermostat

Submitted by: fourth year student 4, group IRB-43
specialty 163 Biomedical engineering
(code and name of specialty)

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Ternopil
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ASSIGNMENT
for QUALIFYING PAPER

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(degree name)

specialty 163 Biomedical engineering
(code and name of the specialty)

student Ekong Victor Willie
(surname, name, patronymic)

1. Paper topic Network Unit of the Medical Laboratory Thermostat

Paper supervisor Dozorska O.F., PhD, Assistant Professor
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Introduction, Temperature modes of bacterial development; Use of thermostats in laboratories; Overview of thermostat analogues; Analysis of the technical task; Construction of a mathematical model; Structural and functional analysis of the adopted decisions; Analysis of the basic electrical diagram and the choice of the method of modernization; Construction of the electrical diagram; Verification analysis of the electrical diagram; Construction of the network block; Electromagnetic compatibility; Labor protection; Security in emergency situations

6. Advisors of paper chapters

Chapter	Advisor’s surname, initials and position	Signature, date	
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TIME SCHEDULE

LN	Paper stages	Paper stages deadlines	Notes
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	Writing section 1		
	technical task analysis		
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	design of the product		
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Student ____________________ (signature) Ekong Victor Willie (surname and initials)

Paper supervisor ____________________ (signature) Dozorska O.F. (surname and initials)

SUMMARY

Theme of qualification work: "Network Unit of the Medical Laboratory Thermostat". Qualifying work of a bachelor // TNTU, ATF, group IRB-43. // Ternopil, 2024 //p.- , fig.- , table- , bibliog.- , appendix- .

Key words: thermostat, network unit, circuit unit.

In the qualification paper, an analysis of the stages of the network unit of the medical laboratory thermostat's life cycle was carried out, as well as its modernization. An overview of thermostat analogs and analysis of their characteristics was conducted. An analysis of the use of the thermostat in laboratory research was carried out. The analysis of the technical task was carried out. Modeling of the measuring converter was carried out and the function of the network unit was derived. An analysis of the structural, functional and electrical diagram of the basic network unit was carried out and a method of its modernization was proposed. In particular, it is proposed to use a pulsed power supply based on the TOP223Y chip instead of a transformer power supply. At the same time, the size and weight of the network unit have decreased. The functional and electrical scheme of the modernized network unit was drawn up, electro-radio elements were selected, and the printed circuit board and the printed unit of the modernized network unit were developed.

CONTENT

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INTRODUCTION

Temperature maintenance during serological, bacteriological and other laboratory tests is important in medicine. Thermostats are used for this. A thermostat is a device designed to maintain a constant temperature in the working chamber. According to the principle of operation, thermostats can be passive or active. Passive thermostats maintain the temperature due to the fact that the object is isolated from the environment. Active thermostats use thermostats to maintain the required temperature level.

According to the type of working medium, air, liquid and solid thermostats are distinguished.

By purpose, thermostats are divided into industrial, research, laboratory and metrological ones. Industrial thermostats include drying cabinets, incubators, pressure chambers, etc. Research thermostats are used in chemical or physical studies of materials.

Thermostats of the latest generations have a high class of temperature regulation accuracy, and also have great control capabilities.

To date, an extremely large number of thermostatic equipment has been developed. However, the most common are thermostats of the TS series. The aim of the thesis is the analysis and modernization of the network unit of laboratory thermostat.

SECTION 1
MAIN PART

1.1 Temperature modes of bacterial development

Temperature is the most important factor influencing the growth of processes occurring in microorganisms. The oxygen regime, the intensity of oxidation-reduction processes, the activity of microflora, etc., largely depend on the temperature. The temperature and redox conditions of the environment have a particularly significant influence on the growth, development, and biochemical activity of microorganisms, on which the intensity of the organism's biosynthetic activity also depends. One of the important conditions for regulating the growth of microorganisms is the temperature of the environment. Affecting the speed of reproduction, temperature affects the speed of biosynthetic processes in cells.

The vital activity of each microorganism is limited by certain temperature limits. This temperature dependence is usually expressed by three points: the minimum (min) temperature - below which reproduction stops, the optimal (opt) temperature - the best temperature for the growth and development of microorganisms, and the maximum (max) temperature (growth or cell slows). For the first time in the history of science, Pasteur developed methods of destroying microorganisms by exposing them to high temperatures. The optimum temperature is usually equated to the ambient temperature.

Microorganisms don`t regulate their temperature, their existence is determined by the temperature of the surrounding environment. There are three main temperature zones that are crucial for the development of bacteria: minimum, optimum and maximum. The lowest temperature at which these microbes can develop is called the minimum. Highest temperature when these same organisms can still live is called the maximum. Between the two extremes is the temperature at which prokaryotes develop best. This temperature was called optimal. Although the cardinal temperature points for some microorganisms are characteristic for each type of microbe, they can change under the influence of other environmental factors.

All microorganisms in relation to temperature can be conditionally divided into 3 groups:

The first group: psychrophiles are cold-loving microorganisms that grow at low temperatures: min t — 0°C, opt t — from 10-20°C, max t — up to 40°C. Such microorganisms include inhabitants of northern seas and water bodies. Many microorganisms are very resistant to low temperatures. For example, cholera vibrio can be stored in ice for a long time without losing its viability. Some microorganisms can withstand temperatures up to -190°C, and groups of bacteria can withstand up to -250°C. The action of low temperatures stops putrefaction and fermentation processes, that is why we use refrigerators in everyday life. At low temperatures, microorganisms fall into a state of anabiosis, in which all vital processes occurring in the cell slow down.

The second group includes mesophiles — this is the largest group of bacteria, which includes saprophytes and almost all pathogenic microorganisms, because the opt temperature for them is 37°C (body temperature), min t = 10°C, max t = 45°C. Mesophiles include the vast majority of both saprophytic and pathogenic bacteria.

Among the bacteria - inhabitants of the depths of the oceans, there are saprophytic bacteria - psychrophiles, which multiply at temperatures below 20°C. Thermophilic microorganisms inhabiting, for example, the waters of hot springs, are capable of multiplying at temperatures above 70°C.

Mesophilic bacteria in the vegetative state are sensitive to temperature rise up to 50-55°C. At the same time, the enzyme proteins of the bacterial cell are denatured, which leads to the death of the organism.

Spore-forming bacteria are more resistant to temperature rise, many of them can withstand heating up to 100-110°C for several hours. However, the sensitivity to elevated temperature varies in bacteria depending on the cultivation conditions, the composition of the nutrient medium, the duration of exposure to temperature and other factors.

At a temperature below the optimum by 5-10°C, bacteria do not die, however, their reproduction is delayed due to inhibition of metabolism. To preserve the vegetative forms of bacteria at a low temperature, substances with high viscosity are used, which protect the cytoplasm of the bacterial cell from destruction by ice crystals. Such substances are called cryoprotectors. These include gelatin, albumin solution, glycerin, 40% sucrose solution. Cryoprotectors are used for long-term storage of bacterial cultures at minus temperatures, as well as for lyophilic drying of microorganisms. Lyophilic drying involves the transition of a substance from a frozen state to a dry state, bypassing the liquid phase. This is achieved by heating frozen cultures of bacteria under vacuum conditions and is used in the preparation of immunobiological preparations.

The third group includes thermophiles — thermophilic bacteria that develop at t above 55°C, min t for them = 30°C, max t = 70-76°C. These microorganisms live in hot springs. Many spore forms are found among thermophiles. The effect of high temperatures on microorganisms is the basis of sterilization.

Important factor determining the growth and development of thermophilic microorganisms is the rate of oxygen supply and its concentration in the culture medium. The degree of restriction of the growth of aerobic organisms in the absence of oxygen depends on the growing temperature. The solubility of oxygen in water increases with decreasing temperature, so the growth of microorganisms at lower temperatures is not limited by the oxygen content to the same extent as in the case of incubation at high temperatures. This explains the fact that the total yield of organisms grown at low temperatures is often higher than that of microorganisms grown at higher temperatures, although the growth rate may be greater in the latter case.

Metabolic processes in the cells of thermophiles proceed at a much faster rate than in the cells of mesophiles. Therefore, the concentration of oxygen dissolved in the environment can become a factor that limits the growth of thermophilic microorganisms. However, when cultivating thermophilic microorganisms in rich natural environments under conditions of intensive aeration, organisms may not experience a lack of dissolved oxygen. But when growing thermophiles on synthetic media, the amount of dissolved oxygen begins to act as a decisive factor.

The need for thermophiles in nutrients depends on the temperature of their growth. According to this feature, thermophilic spore-forming bacteria can be separated on three groups. The first group includes thermophilic bacteria, the need for nutrients does not depend on temperature. The bacteria of the second group need additional nutrition when the growing temperature increases, and the bacteria of the third group - when the temperature decreases.

1.2 Use of thermostats in laboratories

In laboratories, you can find devices with different purposes. One of the universal devices that can be found almost everywhere is a thermostat. It is designed to create certain conditions that are necessary for the full implementation of reactions.

A laboratory thermostat allows you to create an environment with certain parameters necessary for one or another study. The device is designed to maintain the set temperature and evenly distribute it over the entire area of the device's chamber. Devices are of different types, but they are united by one common property: the ability to maintain the conditions that are necessary in each specific case.

The design of the device is designed in such a way that it makes it possible to maintain a certain temperature in its working space. The range can be quite wide and depends on the model. At the same time, its level will be uniform over the entire area of the camera. Thus, it is possible to provide the necessary conditions for the study of solutions, chemicals and biological preparations.

The thermostat ensures uniform air circulation inside the working space. This allows you to get ideal parameters for work. A wide temperature range allows you to use the devices in a wide range of research. These indispensable devices can be found in various laboratories. Neither medical nor chemical research institutions can do without them.

Modern thermostats, regardless of the technology implemented to create the desired environment, are equipped with automation. The devices are computerized and can maintain the working temperature without human intervention. The alarm system and automatic protection ensure safe use of this equipment.

Laboratories use these devices for various researches. This is irreplaceable and reliable equipment, without which it is difficult to carry out some experiments.

Manufacturers of modern thermostats do everything to ensure that the equipment can work efficiently and conduct any research that requires maintaining a certain temperature. Convenient design and increased functionality, a large number of additional options and ease of use - these are the features that distinguish modern laboratory equipment for research activities.

1.3 Overview of thermostat analogues

1.3.1 TSvL-160 thermostat

In fig. 1.1 shows the appearance of TSvL-160 thermostat.

Figure 1.1 – TSvL-160

Advantages of the TSvL-160:

- 10-program microprocessor control unit with an individual timer for each program;
- high-quality engine ensures silent forced convection of air in the chamber;
- new design, long-lasting powder coating of the body;
- the chamber is made of stainless steel;
- lighting inside the camera;
- automatic regulation and maintenance of temperature;

1.3.2 CO2 thermostat

Figure 1.2 shows the appearance of the CO2 thermostat.

Figure 1.2 - CO2 thermostat

The CO2 thermostat is designed to create an optimal environment for cells.

A thermostat with the ability to maintain the CO2 concentration meets the requirements for creating absolutely stable, reproducible conditions for growing and researching cell and tissue cultures.

The latest CO2 measurement technology - an infrared gas sensor provides continuous, accurate and reliable data on the level of CO2 concentration in the chamber.

Uniformity of heat distribution throughout the volume of the chamber equipped with double doors (glass inside and stainless steel outside) provides exceptionally soft heating. This ensures excellent isothermality in the chamber even without forced air circulation (which can cause unwanted drying).

The surfaces of the chamber are fully accessible for disinfection. The design of the thermostat is specially developed to minimize sources of possible contamination. There is no fan or piping inside the camera.

Advantages of the CO_2 thermostat:

- CO_2 concentration: 0 - 5%;
- Concentration maintenance accuracy - 0.2%;
- The inner chamber is of special steel;
- Microprocessor control device;
- Continuous display of current values of temperature, CO_2 concentration;
- Acoustic and visual signaling;
- Infrared gas sensor;
- RS 232 interface for connecting a printer or PC;
- Protection against overheating;

Specifications:

- Chamber volume, l 160;
- Overall dimensions, mm, no more than 779x782x881;
- Internal dimensions, mm, no more than 615x515x615;
- Power, kW, no more than 0.3;
- Weight, kg, no more than 85;
- Temperature regimes are set, ºC Tos + 5 ... 50;
- The time to reach a steady state at a temperature of + 37 º C, hours, no more than 1.5;
- Accuracy of maintaining the set temperature value, ºC ± 0.2;
- Discreteness of temperature, ºC 0.1;
- CO_2 concentration, % 0 ... +5;
- Accuracy of maintaining CO_2 concentration, % ± 0.2;
- Discreteness of CO_2 concentration, % 0.1;
- Time of continuous work, hours, no more than 500;
- Power supply, V / Hz 220/50.

1.3.3 Air thermostat TV-20 PZ-K

Fig. 1.3 shows the appearance of the TV-20 PZ-K air thermostat

Figure 1.3 – Air thermostat TV-20 PZ-K

Thermostat TV-20 PZ-K made for obtaining and maintaining stable temperature for carrying out different biochemical studies.

Advantages of thermostat TV-20 PZ-K:

- Excellent operational characteristics, low energy consumption, highly effective heating control and operational safety;
- The presence of additional glass doors allows you to visually observe the processes taking place inside the chamber, without violating its tightness;
- Lighting inside the camera;
- Modern design, pleasant color range;
- Digital indication of the current temperature in the working chamber.

Specifications:

- Chamber volume, *l* 20;
- Overall dimensions, mm, no more than 360x430x535;
- Internal dimensions, mm, no more than 250x300x286;
- Power, kW, no more than 0.3;

- Weight is less than 21 kg;

- Temperature regimes are set, ºC from a temperature that is 5 ºC higher than the ambient temperature, to +70 ºC;

- Discreteness of temperature, ºC 0.1;

- Emergency disconnection from the network in case of overheating in the chamber, C, no more than +85;

- Time of continuous work, hours, no more than 500;

- Power supply, V / Hz 220/50.

1.3.4 ShS-80 N dry-air thermostat

In fig. 1.4 shows the appearance of the SHS-80 N dry-air thermostat.

Figure 1.4 – ShS-80 N dry-air thermostat

Designed for drying and dry-air sterilization of glass and metal dishes, heat-resistant syringes, surgical and other instruments.

ShS-80 H has the following advantages: High accuracy of set temperature mode (± 0.5 ^{0}C at the reference point). A wide range of temperature regulation (from 36 to 200 ^{0}C), which expands the functionality of the device. Complete information about the sterilization process (display of the set and current temperature, set and current time and emergency situations on the display). ShS-80 H operates from a single-phase alternating current network with a frequency of 50 Hz, a nominal voltage of 220 V ± 10%.

Specifications:

- Chamber volume *l.* 80;
- Consumed power no more than 2200 W;
- Overall dimensions, mm 680x615x1500;
- Weight of the product, no more than 75 kg.

1.4 Analysis of the technical task

The work considers the TS-1/80 MD thermostat. This thermostat is intended for use in medical and preventive facilities, epidemiological laboratories, pharmacies, research and medical facilities.

The network unit of thermostat TS-1/80 MD must provide control of the power elements of the thermostat, which include the power switching element - triac, and heating elements - shades. The formation of the power triac switch-on signal is performed by the microcontroller control unit based on the signal about the temperature inside the thermostat chamber. This signal is formed in the network unit with the help of a comparator that compares the signal from the output of the sensitive element with the specified value of the reference voltage.

The thermostat should be operated in rooms with artificially regulated climatic conditions in the range of ambient air temperature from +10 to +35 ºC and atmospheric pressure (84-107) kPa.

Technical requirements related to the network unit:

1. Supply voltage – (220±10%) V, frequency (50±5%) Hz;
2. Power consumed by the unit in W, no more than 20;

The network block must provide the following:

1. Switching of heating elements to the power supply network;

2. Maximum switched power W, no more than 500;

3. Operating switched power, W – 250;

4. Formation of a signal about the value of the temperature inside the chamber.

1.5 Construction of a mathematical model

Consider the operation of semiconductor sensor used in thermostat as a measuring element.

Semiconductor sensors uses to measure temperatures from -55° to 150°C. A huge number of tasks fall into this range, both in domestic and industrial applications. Due to their high performance, ease of use and low cost, such temperature sensors are very attractive for use in microprocessor-based measurement and automation devices.

The physical principle of operation of a semiconductor thermometer is based on the temperature dependence of voltage drop on p-n junction, biased in the forward direction. This dependence is close to linear. In practice, diodes or transistors connected according to a diode circuit are used as sensitive elements. To carry out measurements, a stable current must flow through the sensing element. The output signal is the voltage drop on sensor.

Circuits using a single pn junction are characterized by low accuracy and a large scatter of parameters associated with the manufacturing and operation of semiconductor devices. Therefore, the industry produces many types of specialized sensors based on the principle described above, but additionally equipped with circuits that eliminate negative features and significantly expand the functionality of the devices

Simple analog semiconductor sensors almost in their pure form implement the idea of measuring temperature by determining the voltage drop across the p-n junction. To eliminate all the negative phenomena associated with the operation of such a transition, a special circuit is used that contains two sensitive elements (transistors) with different characteristics. The output signal is generated as the difference in voltage drop on sensitive elements. When subtracting, negative aspects are significantly reduced. Further improvement of measurement accuracy is achieved by calibrating the sensor using external circuits.

The main characteristic of a temperature sensor is its measurement accuracy. For semiconductor models it ranges from ±1°C to ±3.5°C. The most accurate models rarely provide accuracy better than ±0.5°C. Moreover, this parameter strongly depends on temperature. As a rule, in a narrowed range from -25° to 100°C, the accuracy is one and a half times higher than in the full measurement range -40°C to +125°C. Most analog temperature sensors, otherwise called integrated sensors, contain three terminals and are connected using a diode circuit. The third pin is usually used for calibration purposes. The sensor output is a voltage proportional to the temperature. The magnitude of the voltage change is different and, for example, is 10 mV/degree. To accurately determine the temperature value, it is necessary to know the voltage drop at any fixed value. Typically, the value of the beginning of the measurement range or 0°C is used as such.

Unlike metals, many semiconductors and oxides have negative TCR. The relationship between the value of resistance and temperature for such thermoresistors is often strongly nonlinear.

The appearance of the germanium (Ge) resistance thermometer is shown in Figure1.5.

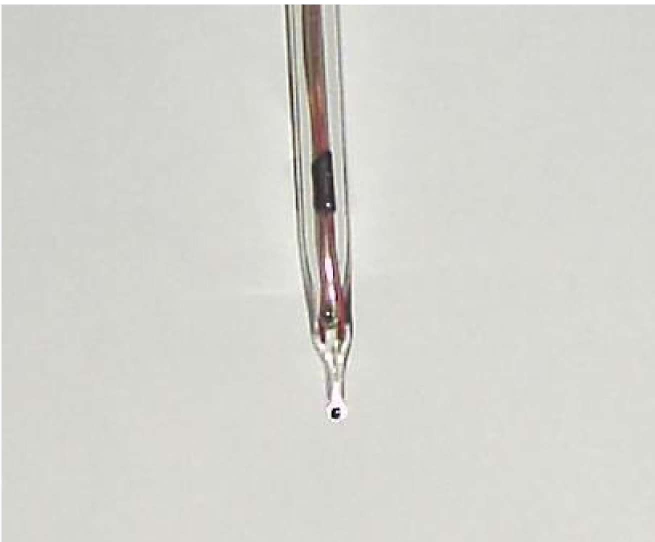

Figure 1.5 - Semiconductor germanium resistance thermometer

Semiconductor thermoresistors (composite carbon, doped germanium, etc.) are widely used for low temperatures estimation (0.1-100 K) due to their high sensitivity. They are semiconductor wafers (films) of various dimensions and shapes with welded metal terminals, often placed in a protective shell. In the temperature range of 4.2-13.8 K they are used as particularly accurate germanium thermoresistors. At temperatures above 100 K, the use of semiconductor thermoresistors is limited due to their instability and scatter of individual characteristics.

The specific electrical conductivity of its own semiconductor is determined by the ratio:

$$\sigma = n_o \mu_n q + p_o \mu_p q , \tag{1.1}$$

where n_0, p_0 - equilibrium concentration of electrons and holes, μ_n, μ_p – movability.

For doped semiconductors, the concentration of the main carriers is always significantly higher than the concentration of non-basic carriers, so the conductivity of such semiconductors will be determined only by the conductivity component of the main carriers.

The movability of the carriers when heated changes relatively weakly (according to the power law, $\sim T^{3/2}$), and the concentration is very strong (exponentially). For its own semiconductor, the concentration of charge carriers is determined by the following dependence:

$$n_0 = p_0 = n_\mathrm{i} = \sqrt{N_\mathrm{C} \cdot N_\mathrm{V}} \exp\left(-\frac{E_\mathrm{g}}{2kT}\right). \qquad (1.2)$$

Since the conductivity of a semiconductor directly depends on the number of free charge carriers, the temperature dependence of the specific conductivity of the semiconductor is similar to the temperature dependence of the concentration of the main carriers.

Thus, the resistance of the semiconductor will depend on the temperature according to the following law:

$$R = N_o \cdot e^{\frac{\Delta E}{kT}} = N_o \cdot e^{\frac{B}{T}}, \qquad (1.3)$$

where N_o – coefficient depending on the type and geometric dimensions of the semiconductor; ΔE – impurity activation energy, k – Boltzmann constant.

Constant $B=\Delta E/k$ is called the coefficient of temperature sensitivity and is given in the passport data on the thermistor. Experimentally, the coefficient of temperature sensitivity is determined by the formula:

$$B = \frac{T_1 T_2}{T_2 - T_1} \cdot \ln\frac{R_1}{R_2}, \qquad (1.4)$$

where T_1 and T_2 – output and final temperatures of the working temperature range, R_1 and R_2 – the resistances of the thermistor at a temperature T_1 and T_2, respectively.

Semiconductor thermoresistors, also called posistors, which have positive TCR in a relatively narrow temperature range, are also available. When heated, the resistance of semiconductor thermistors decreases, and posistors - increases.

The function of the network block can be written by the following expression:

$$f(x)=f(K(t^o), G_p(t)); \quad (1.5)$$

where $K(t^o)$ – function of heating and temperature maintenance, it can be represented as a function of the form:

$$K(t^o) = \begin{cases} 1, & at \quad t^o < t_k \\ 0, & at \quad t^o \geq t_k \end{cases} \quad (1.6)$$

it describes the permission of heating inside the thermostat when temperature value to is lower than temperature tk formed by the comparator, *Gp(t)* is a function that describes the provision of time modes.

1.6 Structural and functional analysis of the adopted decisions

The function of the network unit is reflected in its structural diagram (fig. 1.6).

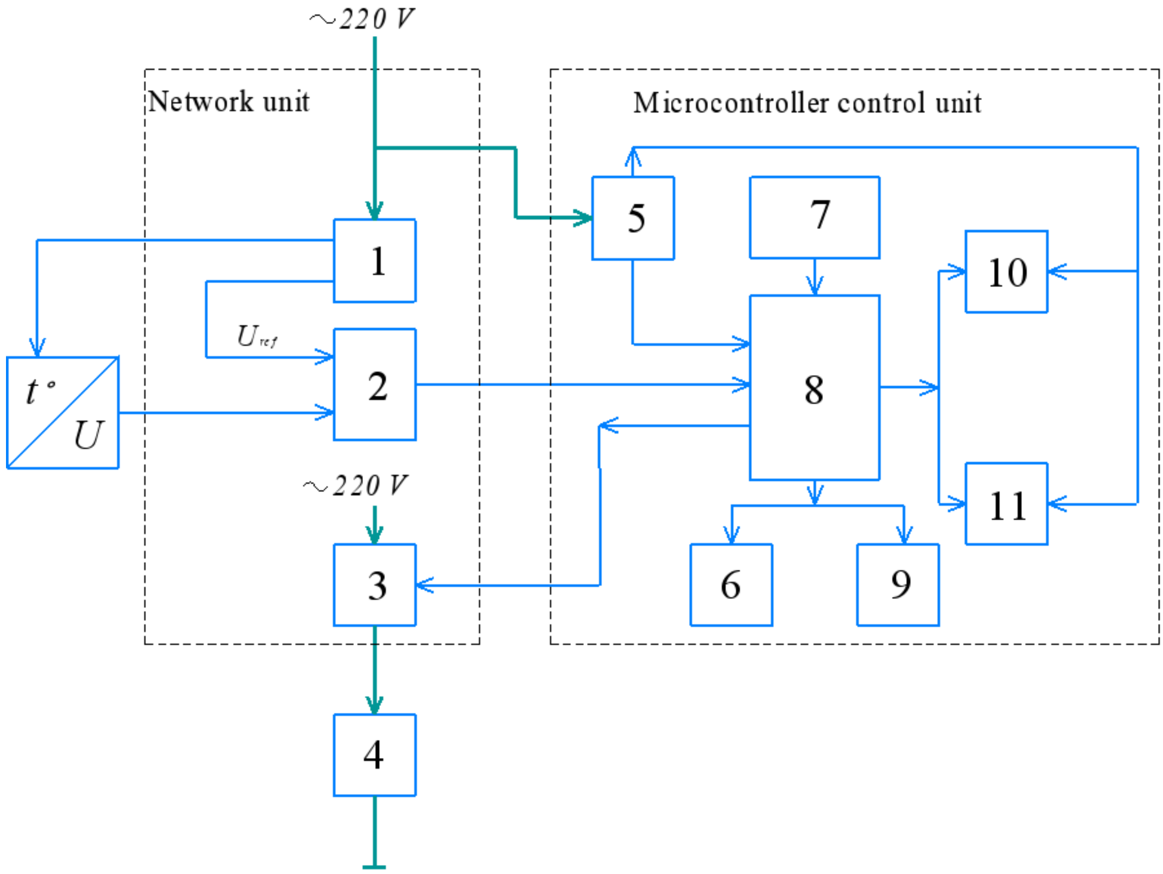

Figure 1.6 – Structural diagram of the network block

The signal from the sensor, which is a temperature-to-voltage converter, enters the input of comparator 2, which compares it with the value of the reference voltage and forms a signal characterizing the temperature inside the chamber. From the output of the comparator, the signal enters the microcontroller control unit, which includes a microcontroller 8 and means of indicating modes 6, a reading and light indication (6, 9), an indication of temperature and time of thermostating (10, 11), organization 7. The microcontroller generates a signal permission of heating or its prohibition, which enters the network unit and turns on the power switch 3, which in turn switches the heating elements 4 to the power supply network.

The structure of the network unit is displayed in its functional diagram and is intended to explain the processes that take place in the product in various foreseen modes.

The functional diagram of the network base unit is shown in Fig. 1.7.

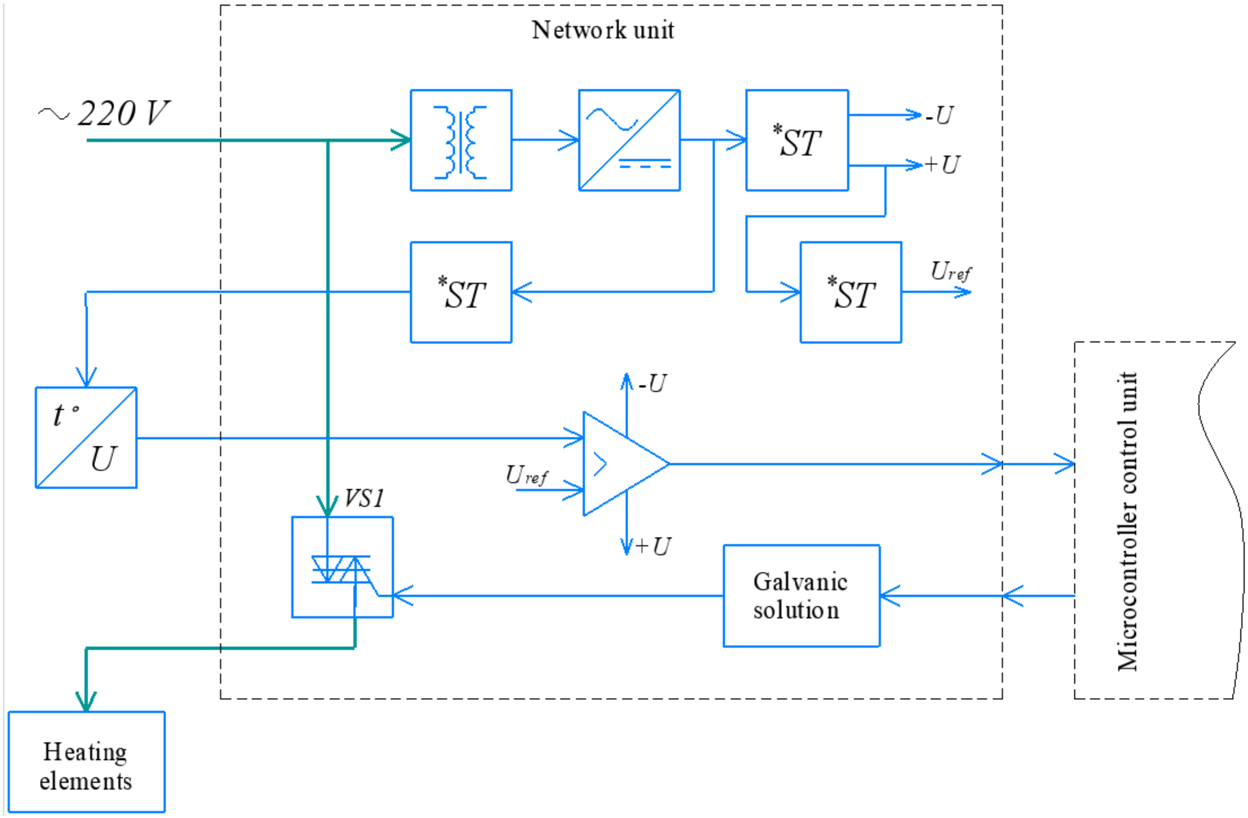

Figure 1.7 – Functional diagram of the basic network unit

According to the functional diagram, the network unit includes a stabilized power source of the sensitive element and comparator 6 (corresponding units 1-5) and triac switch VS1. The power source contains a step-down transformer 1, a rectifier with a filter 2, a bipolar supply voltage stabilizer 3, a sensitive element supply voltage stabilizer 4 and a reference voltage stabilizer 5.

1.7 Analysis of the basic electrical diagram and the choice of the method of modernization

Let's analyze the basic electrical diagram. It is shown in fig. 1.8 According to it, the power source includes a fuse FU1, a varistor RU2, designed to protect against sudden changes in the voltage on the primary winding of the transformer T1 when the heating elements are turned on and off. Fuse FU2 protects the output of the rectifier made on diodes VD1-VD4 from short circuit. Capacitors C4-C7 emit a constant component at the output of the rectifier. On DA1, DA2 microcircuits, stabilizers of positive and negative supply voltage of comparator DA5 are made. The sensor power supply voltage stabilizer is made on the DA3 microcircuit. A reference voltage source is made on the DA4 microcircuit. The triac VS1 switches the heating elements to the power supply network. The RU1 varistor additionally protects the VS1 triac from voltage drops. The triac VS1 is switched using the optocoupler U1. The optocoupler is switched with the help of a transistor key made on the transistor VT1. Resistor R6 limits the current through the optocoupler LED. Resistor R7 limits the base current of transistor VT1. Resistor R5 prevents spontaneous opening of transistor VT1.

The voltage divider made on resistors R8-R10 is designed to set the required value of the reference voltage.

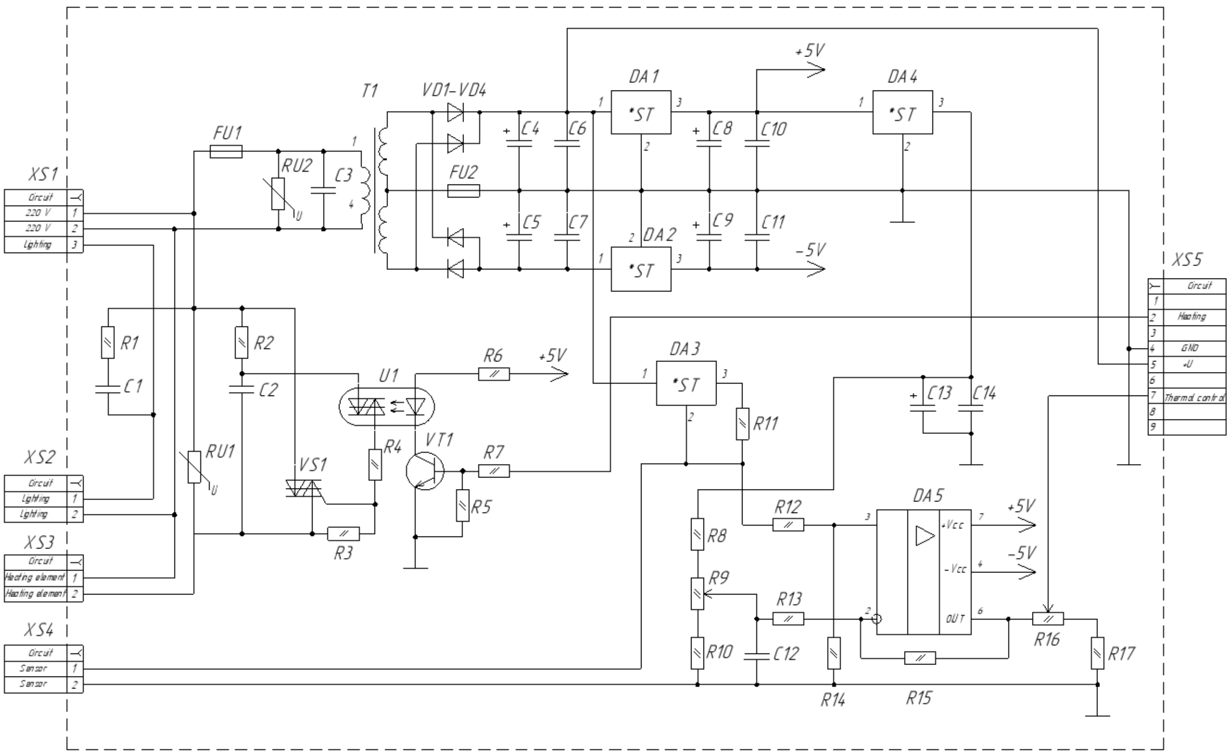

Fig. 1.8. The basic electrical diagram

In the work, it is proposed to modernize the schematic solutions for the construction of the power source of the network unit, namely, instead of the overall network transformer (1) and the rectifier with filters (2), use a low-power pulse power supply unit.

A typical functional diagram of a pulsed power supply unit with galvanic isolation of the primary and secondary circuits is shown in Fig. 1.9.

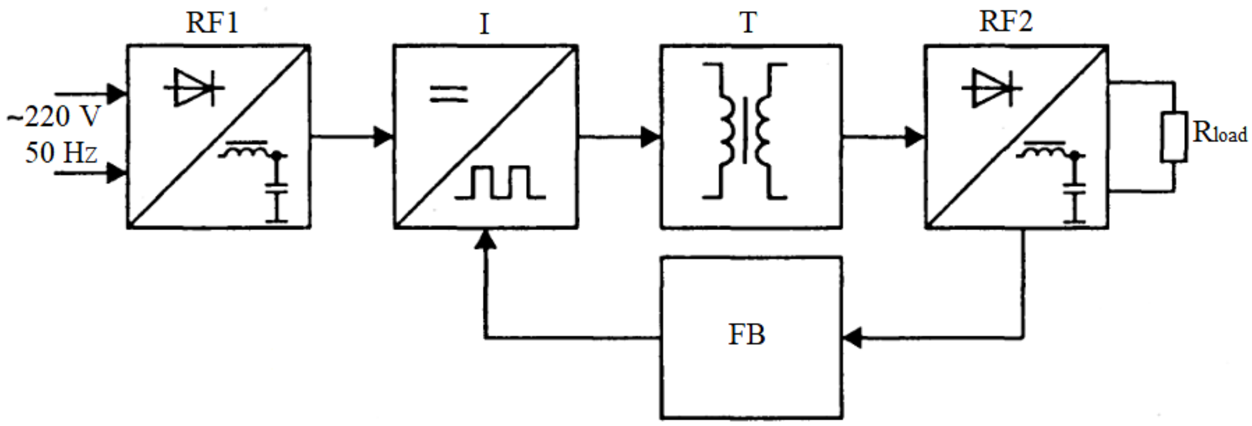

Figure 1.9 – Functional diagram of a converter with galvanic isolation

The alternating mains voltage with a frequency of 50 Hz is rectified on diode bridge and smoothed by a filter (node RF1). Then the received constant voltage will be converted into a pulsed alternating voltage of increased frequency with the help of an inverter (node I). A pulse transformer (node T) converts this voltage into the required value for powering the equipment. The rectifier and filter (node RF2) smoothes the high-frequency voltage ripples and feeds the R_{load}. Thus, by varying the width of the high-frequency pulses, it is possible to control the voltage on the load or introduce stabilizing feedback (node FB).

Most often in practice there are three main circuits of single-cycle converters with galvanic isolation: flyback circuit, forward single transistor circuit and forward two transistor circuit. Forward/reverse circuits difference is in the method of transferring energy to the load - if the energy transfer occurs when the power transistor switch is open, they are called forward converters; if the load is replenished with electrical energy at the moment of the open state of the key element - this is a flyback converter.

The diagram of flyback converters is the most important. The vast majority of modern televisions and VCRs are equipped with such mains voltage converters. Many control microcircuits for flyback converters have been developed. There are both microassemblies that use an external power transistor, and microcircuits that include a power element in their composition, which reduces the dimensions of the converter.

The reverse circuit is very similar to the forward circuit, with the only difference that the "beginnings" and "ends" of the secondary windings of the transformer T are included with reverse phasing, as shown in Fig. 1.10. In this case, the phases of the converter are called differently: the energy storage phase and the energy transfer phase to the load. These phases are separated in time, therefore, by and large, transformer T cannot be called a transformer. Rather, it is a two-winding choke that stores energy with one winding and transfers it to the load with the other. But, since energy conversion is carried out in this case, according to established terminology, element T is called a storage transformer.

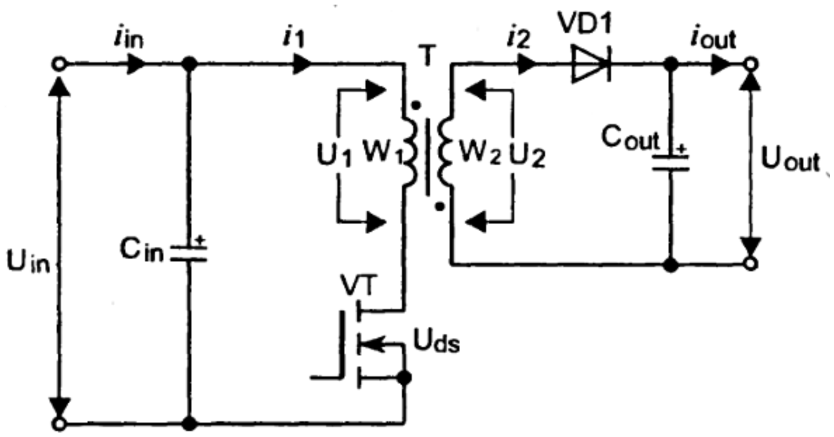

Figure 1.10 - Flyback converter diagram

In the energy storage phase, the transistor VT1 is open, current i1 flows in the primary winding T, the transformer stores energy.

The search for ways to simplify the circuitry of equipment power supply units led Power Integration to create a series of network flyback microcircuits that have only three outputs.

Table 1.1 - Nomenclature of three-terminal pulse stabilizers of the company Power Interation

Chip brand	Maximum power, W	Internal protection activation current, A	Drain resistance in the open state, Ohm
TOP221Y	7	0.25	31.2
TOP222Y	15	0.5	15.6
TOP223Y	30	1	7.8
TOP224Y	45	1.5	5.2
TOP225Y	60	2	3.9
TOP226Y	75	2.5	3.1
TOP227Y	90	3	2.6

These microassemblies have the following main parameters:

- maximum drain-leakage voltage - 700 V;
- control voltage range - 0 ... 9 V;
- crystal operating temperature 65 ... +125 °C;
- thermal resistance "crystal-medium" - 70 °C/W;
- thermal resistance "crystal-case" - 2 °C/W;
- conversion frequency - 100 kHz;
- range of change of filling factor - 0.02 ... 0.67;
- switch-on time - 100 ns;
- shutdown time - 50 ns;
- restart when the supply voltage drops to 5.7 V;
- blocking when the supply voltage drops to 4.7 V;
- the lower limit of blocking - 1 V;
- restart frequency 1.2 Hz;

- Efficiency up to 90%.

All these microcircuits are made in the TO-220 case.

In the project, it is proposed to use the TOP223Y network microcircuit and its typical switching circuit for the construction of the power supply unit of the network unit.

The functional diagram of the modernized network unit is shown in fig. 1.11.

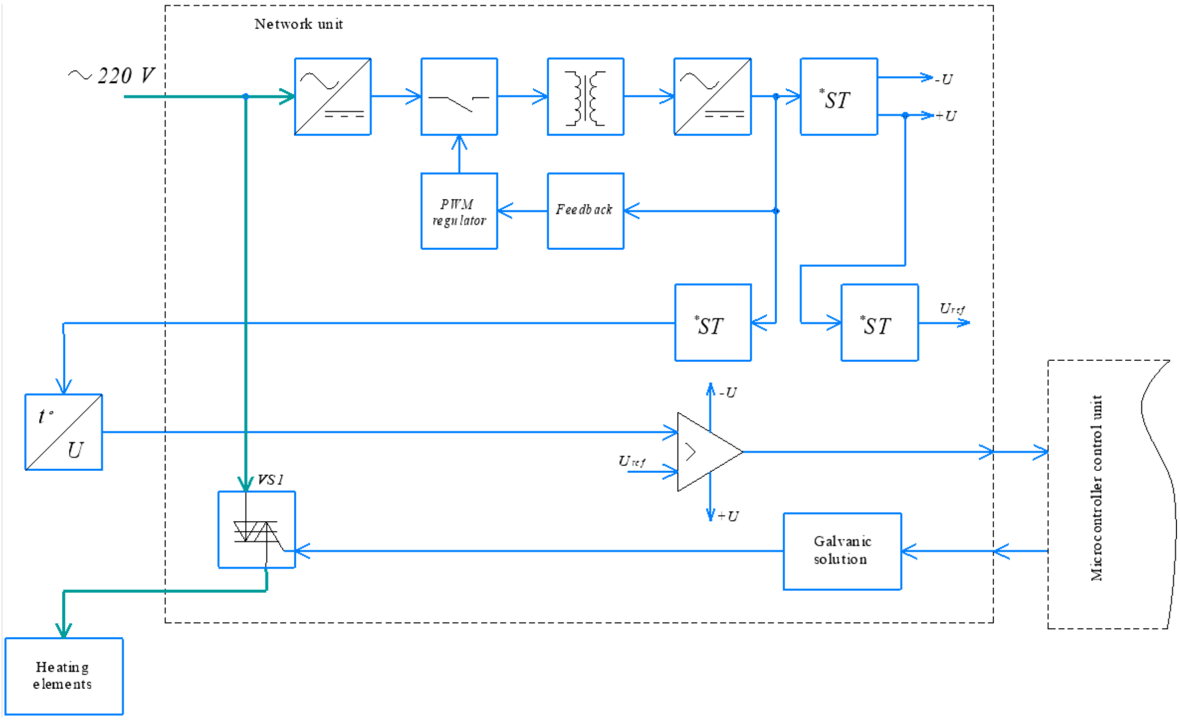

Figure 1.11 – Functional diagram of the modernized network unit

1.8 Construction of the electrical diagram

On the basis of the functional diagram, we build the electrical diagram. It is shown in fig. 1.12. According to it, the power source includes fuse FU1, rectifier VD1 and capacitive filter C2, C4. From it, a constant voltage with an amplitude of about 310 V is supplied to the pulse transformer T1, in the circuit of the primary winding of which the microcircuit DA1 is included. Elements VD3, C6, C9 and

VD4, C7, C10 are designed to obtain a supply voltage of ±5 V. Microcircuit DA4, capacitors C13 and C14 are designed to obtain a stabilized reference voltage.

The sensor power supply voltage stabilizer is made on the DA5 microcircuit. The triac VS1 switches the heating elements to the power supply network. The RU1 varistor additionally protects the VS1 triac from voltage drops. The VS1 triac is switched using the DA2 optocoupler. The optocoupler is switched with the help of a transistor key made on the transistor VT1. Resistor R8 limits the current through the optocoupler LED. Resistor R9 limits the base current of transistor VT1. Resistor R7 prevents spontaneous opening of transistor VT1.

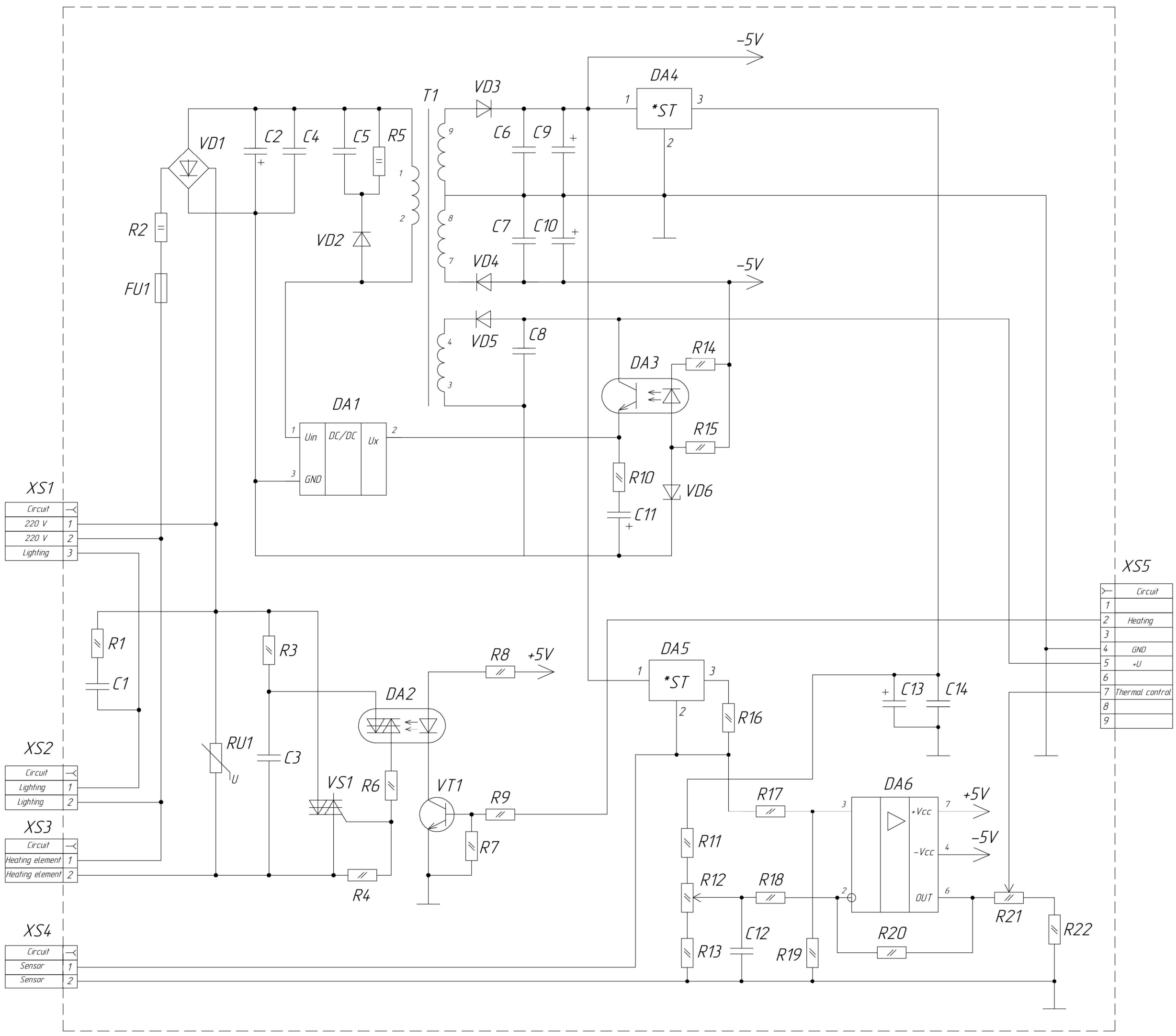

Figure 1.12 – The modernized electrical diagram

The voltage divider made on resistors R11-R13 is designed to set the required value of the reference voltage.

1.9 Verification analysis of the electrical diagram

We will calculate the nominal values of some elements of the electrical diagram.

The VD1-VD4 diode bridge rectifies the voltage from the low-voltage power supply transformer, so the reverse voltage of each diode must be greater than the amplitude value of the voltage on the secondary winding of the transformer, that is, more than 11 V. We choose diodes of the 1N5819 type, for which the maximum reverse voltage is equal to 40 V, direct current – $i_d = 1$ A, maximum direct current (at $\tau_m < 10ms$) $i_{d.m} = 25$ A.

The capacity of the capacitor C2 is found by the formula:

$$C = \frac{P_{load}}{200 \cdot K_{load} \cdot U^2} \quad (1.7)$$

where P_{load} - nominal power consumption (25 W),

K_{load} - coefficient of pulsations (2%),

U - supply voltage (220 V),

$$C2 = \frac{20}{200 \cdot 0{,}02 \cdot 220^2} \approx 45\text{u}F \quad (1.8)$$

Let's take C2=47 μF.

Capacitor C4 suppresses high-frequency interference, its capacity is assumed equal to 0.01 μF, capacitors C5-C8 – 0.1 μF.

Integrated stabilizers DA1 and DA2 type 78L05 and 79L05, respectively, with a maximum direct current of up to 1A were used to implement bipolar supply voltage and stabilize it. For them, according to expression (1.8), we choose the capacities of capacitors C8 and C9 equal to 470 µF, and capacitors C10 and C11 - 0.1 µF, respectively. We choose a DA3 stabilizer of the LM317 type. The DA5 microcircuit is selected as the MSR1541-I/OT type.

Let's calculate the ratings of the elements of the power commutator shown in Fig. 1.13.

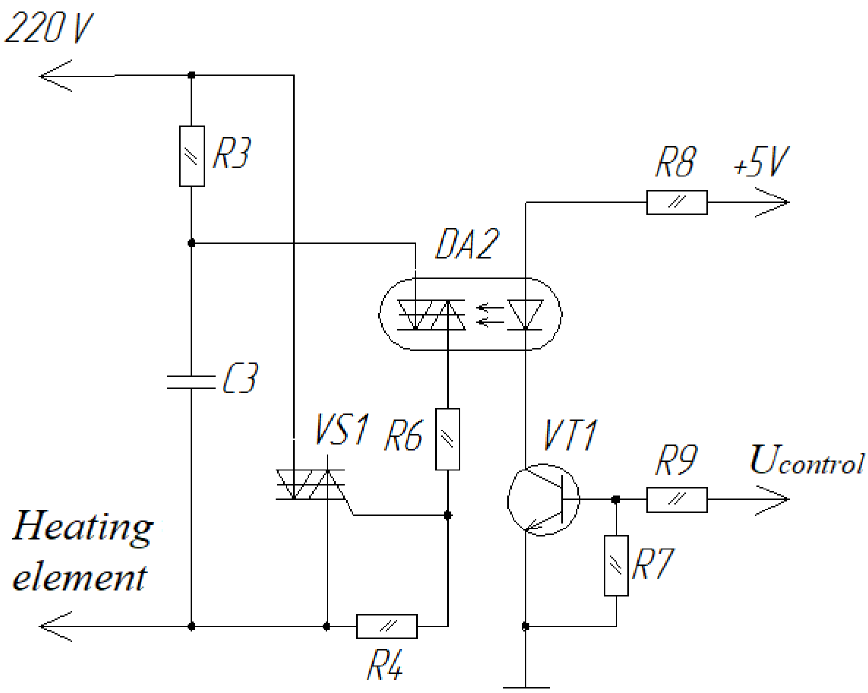

Figure 1.13 – Diagram of the power switch

For the DA2 optocoupler LED, the voltage drop should be 1.3 V, the maximum forward current is 6.5 mA. Let's calculate the resistance of the limiting resistor R8.

$$U_{R8}=5V-U_{VD}-U_{VT1},$$

where U_{VD} – voltage drop to light diode optocouplers - 1.3V, U_{VT1} – the voltage drop at the emitter-collector transition of transistor VT1 in the open state is 0.9V. Then:

$$U_{R8}=5V-1,3-0,9=2,8\ V$$

Then the resistance of the resistor will be:

$$R=U/I=2,8/6,5\cdot 10^{-3}=430\ Ohm$$

Let's find the power dissipated on it:

$$P=U\ I=2,8\cdot 6,5\cdot 10^{-3}=0,0182\ W \quad (1.9)$$

Accordingly, you can use resistors with a power of 0.125 W with a margin of power.

Let's find the rating of resistor R9. We will use the KT315 transistor to switch the optocoupler LED. To enter the transistor VT1 into the open state, it is necessary that the voltage drop at the base-emitter junction is 1 V and the current is 1 mA. Then:

$$U_{R9}=5-1=4\ V$$

$$R=U/I=4/1\cdot 10^{-3}=4\ kOhm$$

We take R9 equal to 4.3 kΩ.

In a similar way, calculations of the remaining elements of the electrical principle scheme are carried out.

1.10 Construction of the network block

1.10.1 Selection of element base

Selection of types of resistors and capacitors. The following components were selected for the product, taking into account economy, versatility, miniaturization and simplicity:

From a large number of resistors, C2-23 resistors were chosen because they are the best according to their parameters (dissipation power, overall dimensions, working time before failure, operating temperature), they are the most common and cheaper compared to their counterparts.

Resistors C2–23 are permanent with a metal-dielectric conductive layer, general purpose, non-insulated.

Noise level 1; 5 μV/V. Series E96.

The main technical characteristics of C2-23-0.125 type resistors:

- nominal power: 0.125 W
- range of nominal resistances: 1 – $3.01 \cdot 10^6$ Ω (intermediate values of nominal resistances for tolerance ±0.5%÷±5% correspond to the E96 series);
- operating temperature range: from -60^0C to $+70^0$C;
- inherent noise level: 5 μV/V;
- maximum operating voltage of direct/alternating current: 100 V;
- minimum working time before failure: 15,000 hours;
- mass: no more than 0.05 g.

From the existing and available nomenclature of capacitors, I chose K10-17 and K50-35 capacitors because they are the best according to their parameters (tolerance, temperature coefficient of capacity, overall dimensions, working time to failure, operating temperature).

Capacitors K10–17. Protected isolated capacitors of constant capacity are designed for operation in circuits of direct/alternating/pulsating current. They are characterized by high insulation resistance and relatively high temperature stability of parameters. Design: rounded with epoxy compound, have one-sided arrangement of terminals for printed mounting. Capacitors can be manufactured using materials that do not contain environmentally hazardous substances.

The main technical characteristics of K10-17 type capacitors:

- nominal voltage: 63, 100, 160, 250, 400, 630 V
- range of nominal capacities: 0.001 - 4.7 μF
- limit operational data:
- operating temperature range: from -60^0C to $+125^0$C;
- minimum working time before failure: 40,000 hours;

K50-35 capacitors are oxide polar. There are three variants: 1 – for automated assembly, 2 and 3 – for manual assembly.

The main technical characteristics of K50-35 type capacitors:

- maximum voltage: 25; 50 V
- range of nominal capacities: 10–100 μF (intermediate values of nominal capacities for tolerance ±20% correspond to the E24 series)
- limit operating data:
- operating temperature range: from -60^0C to $+85^0$C;
- minimum working time before failure: 40,000 hours;
- mass: no more than 0.05 g

The selected types of resistors and capacitors have good parameters, so their use is justified.

1N5819 diodes were chosen as diodes.

Diodes 1N5819 Schottky limiting diodes.

The main technical characteristics of diodes:

- direct voltage at a current of 1A - 600 mV;
- reverse voltage - 40 V;
- rectified current - 1A;
- reverse leakage current 1mA at 40V;
- fast recovery <500ns> 200mA.

The KT315 transistor is an n-p-n silicon transistor in a plastic case for low-frequency devices.

The following microcircuits were selected: 78L05, 79L05, LM317LZ, MPC1541-I/TO, OP-07DP.

Microcircuits 78L05, 79L05 are three-output integrated voltage stabilizers +5V and -5V with current to 1.4A.

The LM317LZ microcircuit is an adjustable +12 V integrated stabilizer.

The MPC1541-I/TO microcircuit is a precision voltage stabilizer.

The OP-07DP chip is a precision operational amplifier.

Optocoupler MOS3063. Specifications:

- number of channels – 1;
- constant direct input voltage Uin., V – 1.3;
- at input current Iin., mA – 30;
- maximum input current Iin.max., MA – 60;
- the maximum input reverse voltage Uin.arr.max., V – 6;
- output stage – triac + ZeroCrossing;
- maximum switching output voltage, V – 600;
- maximum insulation voltage, V – 7500;
- operating temperature range, ^{0}C – -40 ... 85;
- case – PDIP6.

MAS9M thyristors. The main technical characteristics of thyristors:

- the maximum value of the amplitude of the operating voltage of the thyristor in the closed state is 600 V;
- the maximum rms value of the current through the thyristor at a conduction angle of 180° – 8 A;
- maximum average dissipated power of the control electrode – 0.35 W;
- the maximum pulse dissipated power of the control electrode – 16 W;
- the maximum voltage drop across the thyristor during the passage of a short current pulse, the value of which is indicated in parentheses, is 1.6 (11 A);

Technical characteristics of varistors TVR14 391:

- classification voltage, V – 390;
  at current, mA – 1;
- working temperature, ^{0}C -40 ... +85;
- rms activation voltage, V – 250;
- DC trigger voltage, V – 320;
- maximum absorbed energy, J – 100;
- maximum pulse current (pulse 8/20 μs), A – 4500;

TOP223Y is a pulse microcircuit with a built-in pulse generator and PWM control.

NES2501 is an optocoupler for implementing feedback.

1.10.2 Development of the layout and installation of the printed circuit board of the product

Let's take a closer look at the design features of the product under development. In the design of the printed unit, only radio elements with pin terminals are used.

As a result of the calculation of the printed circuit board, the dimensions of the elements of the conductive pattern are determined: the nominal dimensions of the diameters of the mounting holes, the minimum diameters of the contact pads, the minimum distances for laying a given number of conductors between two holes.

The nominal values of the diameters of mounting holes (2nd class of accuracy) are determined by formula (1.10):

$$d = d_e + |\Delta d_{н.в}| r, \tag{1.10}$$

where d_e – the maximum diameter of the output of the element;

$\Delta d_{н.в.}$ – the lower limit value of the deviation from the nominal value of the diameter of the mounting hole;

r is the difference between the minimum diameter of the hole and the maximum diameter of the output (based on the soldering conditions, choose within 0.1…0.4 mm).

The use of mounting, transitional and mechanized holes from the 0.4 series is allowed; 0,5; 0,6…3,0 mm.

The value of the maximum diameters of the terminals:

- for resistors C2–23:

$$d_e = 0,6\ mm;$$

- for capacitors K10–17:

$$d_e = 0,5\ mm;$$

- K50–35:

$$d_e = 0,5\ mm;$$

- for 1N5819 diodes:

$$d_e = 0,6\ \mathrm{mm};$$

- for the MAC9M thyristor:

$$d_e = 0,6\ mm;$$

- for microcircuits

$$d_e = 0,5\ mm.$$

We choose the value of r equal to 0.2 mm, choose $\Delta d_{н.в.} = 0,1 mm$. Then, according to formula (1.4), we obtain the following values of the nominal diameters of the mounting holes:

- for resistors $d_1 = 1 mm$;

- for capacitors $d_2 = 0,8 mm$; $d_3 = 0,8 mm$;

- for the diode $d_4 = 1 mm$;

- for triac $d_5 = 1 mm$; $d_6 = 1 mm$; $d_7 = 1,1 mm$; – we accept 1.3 mm;

- for microcircuits $d_8 = 0,8 mm$;

The value of the minimum diameters of the contact pads around the mounting holes is determined by formula

$$D = \left(d + \Delta d_{в.в.}\right) + 2в + \Delta t_{в.в.} + 2\Delta d_{тр} + \sqrt{\delta d^2 + \delta p^2 + \Delta t_{н.в.}}, \quad (1.11)$$

where d is the nominal diameter of the mounting hole,

$\Delta d_{в.в.}$ – upper limit deviation of the hole diameter;

$в$ – guaranteed belt on the outer layer;

$\Delta t_{в.в}$ – upper limit deviation of the width of the conductor,

$\Delta d_{тр}$ – dielectric etching tolerance;

δd – tolerance for placement of holes;

δp – permission to place contact areas;

$\Delta t_{н,в,}$ – the lower limit deviation of the width of the conductor.

For holes of d= 0.8 mm, 1 mm:

δd=0,3 *mm;* δp=0,2 *mm;* $d_{в.в.}$=0,1 *mm*; $\Delta t_{в.в}$= 0,1 *mm;* $\Delta t_{н,в,}$=0,1 *mm;*

$\Delta d_{тп}$=0,03 *mm;* $в$=0,2 *mm.*

Then the minimum diameter of the contact pad D around the mounting hole of d=0.8 mm, calculated by (1.11), will be equal to

$$D_1 = (0.8 + 0.1) + 2 \cdot 0.2 + 0.1 + 2 \cdot 0.03 + \sqrt{0.2^2 + 0.3^2 + 0.1^2} = 1.8mm,$$

and for holes with a diameter of d=1mm

$$D_2 = (1 + 0.1) + 2 \cdot 0.2 + 0.1 + 2 \cdot 0.03 + \sqrt{0.2^2 0.3^2 0.1^2} = 2mm.$$

For holes with a diameter of d=1.3 mm:

δd=0,2 *mm;* δp=0,3 *mm;* $d_{в.в.}$=0,15 *mm;* $\Delta t_{в.в}$= 0,1 *mm;* $\Delta t_{н,в,}$=0,1 *mm;*

$\Delta d_{тр}$=0,03 *mm;* $в$=0,2 *mm..*

Then the minimum diameter of the contact pad around the mounting hole with a diameter of d=1.3mm, calculated according to formula (1.12), will be equal to

$$D_3 = (1{,}3 + 0{,}15) + 2 \cdot 0{,}2 + 0.1 + 2 \cdot 0{,}03 + \sqrt{0{,}2^2 \cdot 0{,}3^2 \cdot 0{,}1^2} = 2.4mm.$$

The nominal value of the conductor width t is determined by the formula:

$$t = t_{м.д.} + \left|\Delta t_{н.о}\right|, \qquad (1.12)$$

where $t_{м.д.}$ – the minimum permissible width of the conductor, which is determined by the accuracy class and the possible current load,

$\Delta t_{н.о.}$ – tolerance on the width of the conductor, $\Delta t_{н.о.}$ = 0.1 *mm.*

We take t=0.3 mm. According to the selected 2nd accuracy class of the printed circuit board, we choose $t_{м.д.}$=0,45 *mm*, then:

$$t = 0{,}45 + 0{,}1 = 0{,}55(mm)$$

The nominal value of the distance between adjacent elements of the conductive pattern is determined using the formula:

$$S = S_{м.д.} + \Delta t_{в.в.} \delta \ell, \qquad (1.13)$$

where $S_{м.д}$ – the minimum permissible distance between adjacent elements of the leading pattern;

$\delta \ell$ – permission to place conductors.

We choose $\delta\ell - 0.1mm, \Delta t_{в.в.}, S_{м.д.} = 0,45mm$. Then, using the formula, we will find the nominal value of the distance between adjacent elements of the leading pattern:

$$S = 0,45 + 0,1 + 0,1 = 0,65(mm)$$

To find the minimum distance ℓ for laying n conductors between two holes with contact pads in diameter D_1 and D_2 are determined by the formula:

$$\ell = \frac{D_1 + D_2}{2} + t_n + S(n+1) + \delta\ell, \qquad (1.14)$$

where n – the number of conductors,

t_n – the minimum value of the nominal width of the conductor;

$\delta\ell$ – permission to place conductors;

S – the nominal value of the distance between adjacent elements of the conductor pattern.

For D_1=1,8 *mm* and D_2=2 *mm*.

$$\ell = \frac{1,8 + 2}{2} + 0,45 + 0,45 \cdot 2 + 0,1 = 3.35(mm)$$

For holes D_1=2 *mm* and D_2=2,4 *mm*.

$$\ell = \frac{2 + 2,4}{2} + 0,45 + 0,45 \cdot 2 + 0,1 = 3,65(mm)$$

For holes of the same diameter:

$$D_1 = D_2 = 1,8mm : \ell_{11} = 3,25(mm), \quad D_1 = D_2 = 2mm : \ell_{22} = 3,45(mm),$$

$$D_1 = D_2 = 2,4 : \ell_{33} = 3,85(mm),$$

Knowing all the structural parameters of the elements of the printed circuit board, the design of the topology of the printed circuit board and the actual printed circuit of the product was carried out with the help of CAD P-CAD 2006.

1.11 Electromagnetic compatibility

It is the ability of radio-electronic means and radiating devices to simultaneously function with the specified quality in real operating conditions, taking into account the influence of unintentional radio interference and not to create unacceptable radio interference to other radio-electronic means.

Since there is an electromagnetic compatibility filter in the product, and its elemental base is quite resistant to external influences, electromagnetic compatibility calculations are not performed.

SECTION 2
LABOR PROTECTION AND SAFETY IN EMERGENCY SITUATIONS

2.1 Labor protection

Electrical safety measures when working with the product

When working with the product, it is necessary to observe the general safety rules. Depending on the method of protecting service personnel from electric shock, the network unit can be classified as I or II class in accordance with the current standard.

Safety rules:

- if a malfunction is suspected during the preparation of the unit for work, it is necessary to disconnect it from the power supply network (disconnect). It is strictly forbidden to operate a defective unit. A malfunction is suspected due to the occurrence of suspicious noises, crackling, smells, and the like.
- grounding on the heating and water supply pipes cannot be considered satisfactory, since there is always a possibility that in another room a block with a significant current leakage, which can spread to the service personnel, is grounded on the same pipe.
- if several blocks are used at the same time, they must have one grounding point. It is not possible to connect the blocks to the ground in series, in this case a grounding "loop" is formed through which leakage currents circulate.
- replacement of cartridges, forks and other connectors should be done only by specialists, although at first glance the work seems very simple.

Providing first aid for electric shocks

First aid to a victim of electric shock must be provided as quickly and correctly as possible. It is necessary, first of all, to free the injured person from the current, since the duration of the action affects the severity of the electric injury.

First of all, it is necessary to turn off the electricity supply to the scene using a circuit breaker or switch. If there is no switch nearby, and the voltage of the supply line does not exceed 1000 V (the voltage in household electrical networks does not exceed 220 V), then free the victim with the help of a dry non-conductive object: a stick, a board, a dry part of clothing, for example, the floor of a jacket or a jacket collar . When pulling the victim by his clothes, you need to take care of your own insulation. For this purpose, a dry scarf worn on the arm, a cloth or leather cap is suitable; you can stand on a rubber car mat or grab the victim with it; you can cut the wires with an ax with a dry wooden handle. It is necessary to rework or cut the wires individually, each phase separately. When the voltage in the network is higher than 1000 V, you should wear dielectric gloves and boots, act with an insulating rod or short-circuit the wires by throwing a flexible wire with a large cross-section over them, so as not to burn out in the event of a short-circuit current. In other words, special equipment is required.

In all cases of electric shock, emergency medical assistance should be called. If the victim is conscious, but was unconscious, or if he is in an unconscious state, but his breathing and pulse are preserved, then he should be laid down, unbutton his clothes, warm his body and create a calm environment around him. To prevent the victim from choking on vomit, the head must be turned to the side. When the victim regains consciousness, he is forbidden to get up and walk until the arrival of an ambulance. Usually, such victims are taken to the inpatient department and their condition is monitored for several days.

If, after release from the effect of electric current, the victim does not breathe or his breathing is thin, shallow, and the skin gradually turns blue, then it is necessary to carry out artificial respiration. Breathing from the mouth to the mouth or from the mouth to the nose ensures that the required amount of air, suitable for breathing, enters the lungs of the rescued person. Air is blown through gauze or a handkerchief. With this method of artificial respiration, it is visible whether air enters the lungs of the rescued person, his ribs rise during inhalation, and exhalation occurs passively, due to the natural elasticity of the chest.

2.2 Safety in emergency situations

Emergency environmental situations and environmental risk

Emergency situations that arise during natural disasters or man-made disasters play a special role in human life. Along with social and economic losses, emergency situations also cause environmental damage, which is reflected in the destruction and degradation of natural systems, air, water and soil pollution. As a result, emergency environmental situations arise. Emergency environmental situations are those situations that arise as a result of sudden natural disasters or man-made accidents and are accompanied by large losses. Characteristic features of these situations are the acuteness of the manifestation, significant deviations of environmental indicators from the norm (exceeding the maximum permissible concentrations (MPC) of pollutants by hundreds, thousands, and even tens of thousands of times); hurricane wind speeds; flooding of residential areas (settlements); occurrence of catastrophic mudflows, etc.

Of course, such deviations do not last long - hours, days, tens of days, sometimes more. Then the degree of severity of the environmental condition decreases, although it can remain quite high. So, the concepts of an emergency environmental situation and a catastrophic environmental situation differ in that the first one lasts for a relatively short time, but occurs suddenly and is characterized by exceptionally high deviations from the state of the environment from the norm, while the second one is quite long (usually years), but has a less acute manifestation.

An emergency situation can turn into a catastrophic one under certain circumstances. For example, the situation in the Chernobyl zone. For almost a month, the radiation situation in Chernobyl was extraordinary. After the construction of the sarcophagus, the emissions of radioactive elements decreased dramatically, but by then the contamination had covered large areas. Such high radiation pollution has been going on for more than two decades. According to experts, the ecological situation in the Chernobyl zone is catastrophic.

Thus, emergency environmental situations are reflected in the disruption of the normal functioning of natural and natural-anthropogenic systems associated with sudden natural or man-made impacts (natural disasters, catastrophes, accidents), which are accompanied by social, economic and ecological damage and require special management measures to eliminate solutions (Fig. 1.2). Damages are manifested in the death and injury of people, the deterioration of their health, the destruction of material objects, the structure of natural and natural-anthropogenic systems, the loss of their natural resource and ecological potential. A long-term emergency situation leads to the formation of an ecological disaster zone or ecological disaster.

Emergency environmental situations arise as a result of the action of three main groups of factors:

— deliberate destruction of the natural environment, the origin of technology, deterioration of economic objects during wars and acts of sabotage;

— devastating disasters that occur due to incompetent and erroneous technical decisions (for example, the Chernobyl accident);

— natural phenomena. Specialists attribute the fact that their frequency and intensity have increased sharply in recent decades to anthropogenic stimulation, which causes increased deviations of natural processes from the normal level of oscillations.

Economic losses caused in connection with adverse and dangerous natural processes and phenomena have increased significantly. According to some estimates, they are growing faster than the indicators of the world gross product, that is, the limit of the spatial and technological development of production may be reached in terms of its ability to compensate for the increasing losses from adverse and dangerous phenomena. Primary processes arising in the natural environment as a result of these factors will intensify or weaken depending on the natural situation (stability of landscapes, weather conditions, phase of ecosystem fluctuations, etc.) and socio-economic conditions (psychological readiness and unreadiness of the population to eliminate the consequences of an emergency, technical equipment of special services, economic opportunities, etc.). Thus, emergency environmental situations in most cases have a complex nature.

Measures to prevent environmental emergencies or overcome their consequences can be grouped into three classes:

— organizational, among which there are planning and operational ones;

— engineering and technical;

— technological.

Therefore, measures aimed at preventing and overcoming environmental emergency situations can be divided into two types: measures aimed at reducing the susceptibility of objects to hazardous effects, and measures aimed at reducing the sensitivity of objects to hazardous effects. In the first case, measures are taken for the purpose of external protection of objects, exclusion of certain territories from use for industrial purposes, etc. Reducing the sensitivity of objects to dangerous influences is achieved, first of all, due to more advanced technologies, by regulating technological regimes in connection with natural cycles, creating a system of duplication of objects, information systems and rapid response systems.

The main functions of preventing environmental emergencies and overcoming them at the state level are performed by the Ministries of Emergency Situations.

Risk is an objective concept, it is connected with almost any human activity. The ability to be aware of the degree of risk allows a person to assess his own capabilities and choose directions of behavior in this case. The essence of the term risk is understood as the probability, first, of any dangerous event; secondly, the negative consequences of it and the amount of expected losses. Some risks are specific, others do not have such a definition. There are occupational risks (for example, the risk of occupational diseases) and those experienced by the entire population (ecological, economic, geological, political risks).

The subject of our research is environmental risk, which still does not have a clear definition. M.F. Reimers believes that this is the probability of the consequences of any (specific or random, gradual or catastrophic) anthropogenic changes in natural objects and factors. The concepts of environmental safety and danger are related to environmental risk. These alternative categories refer to the population as a recipient of environmental action in its respective unfavorable or favorable status.

Environmental risk is associated with the following groups of factors: 1) man-made; 2) natural; 3) military; 4) socio-economic; 5) political; 6) terrorism.

Man-made ecological risk arises in connection with accidents at LES, tanker accidents, at dangerous chemical productions, during the destruction of reservoir dams, etc. The causes of accidents are the intensity of technological processes and connections, high concentration of production, resource-intensive and high-waste technologies, poor equipment of cleaning and disposal devices.

Natural environmental risk is associated with the probability of occurrence of many adverse natural phenomena, such as earthquakes, volcanism, mudslides, floods, tsunamis, etc. It is necessary to take into account the peculiarities of the geological structure (properties of rocks, presence or absence of fractures, etc.), relief (for example, increased risk of pollution in basins), landscapes (the degree of their resistance to man-made loads). It is also worth considering the neighborhood of valuable and unique natural objects, territories of special protection regime. Environmental risk increases with high population density, and also depends on the nature of the population's perception of the events taking place. It is known that the catastrophic consequences of accidents and natural phenomena increase dramatically as a result of the psychological unpreparedness of the population for such events.

A special group of environmental risk factors is military actions that cause various changes in the environment and directly affect people and other subjects. Environmental risk is also related to socio-economic factors. It is about the probability of occurrence of adverse ecological situations in the case of decisions on the construction of certain dangerous objects in connection with the social and economic needs of such construction. This category includes the construction of many nuclear power plants, the creation of hazardous chemical industries, and transport systems. In some cases, similar decisions are related to political factors.

Currently, there are and are being developed a large number of scientifically based resolutions, regulations, rules, state standards, according to which economic activity is regulated, maximum permissible concentrations of harmful and toxic components in soils, underground and surface waters, etc. are established. On the basis of these documents and environmental legislation, a system of measures was developed at the state, departmental and object levels, which regulate the conduct of environmentally safe economic activities, the construction of various structures, the limits of pollution of the natural environment within the framework of not only individual local systems, but also large regions, the state in general. Such measures can be grouped into three main groups — social-organizational, evaluation-prognostic, and technical. All types of measures are interrelated and are the basis for the organization of safe life activities. If they are followed correctly, it is possible not only to preserve the state of the environment, but also to improve it, to avoid ecologically dangerous phenomena and disasters caused by anthropogenic and man-made activities.

CONCLUSIONS

In the thesis, the stages of the life cycle were considered and modernization of the network unit of medical laboratory thermostat TS-1/80 MD was carried out.

In the first section of the thesis, an analysis of the technical task was carried out, the purpose of which is to clarify the requirements set by the customer, an overview of the technical characteristics of thermostat prototypes was carried out, an analysis of the structural, functional and electrical diagram of the base unit was carried out, and the ways of modernization were substantiated, and the expediency of using a pulse-type power supply unit instead of a transformer power supply unit in the structure of the unit is justified. Such solutions led to a reduction in the mass and dimensions of the network block. Based on this, the functional diagram of the modernized network unit of the TS-1/80 MD thermostat was developed. An analysis and modernization of the electrical diagram was also carried out and its calculations were carried out.

The selection of the element base was also carried out, the design of the printed circuit board and the printed unit was developed. When developing the device, automated design systems were used. They include the P-Cad 2006 program packages. Using the P-Cad environment, the printed circuit board was traced and the assembly drawing of the printed unit was obtained.

The section on labor protection and safety in emergency situations has also been completed.

LIST OF USED SOURCES

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3. "Thermostat Maker Deploys Climate Control Against Climate Change". America.gov. Archived from the original on April 18, 2009. Retrieved October 3, 2009.

4. Paul Horowitz and Winfield Hill (1989), The Art of Electronics (Second ed.), Cambridge University Press, ISBN 978-0-521-37095-0

5. Electrical circuit theory and technology / John Bird. — 5th edition – Routledge, 2014. – 782 p. – ISBN: 978-0-415-66286-4 (pbk)

6. Electrical circuit theory and technology / John Bird. — 2th edition – Routledge, 2001. – 1005 p. – ISBN 0 7506 5784 7

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9. Electronic circuits / James W. Nilsson, Susan A. Riedel. – 9th edition – Prentise Hall, 2011. – 822 p.

APPLICATIONS

Marking	Name	numb	
	Capacitors		
	К50-35		
	К10-17		
C1, C3	К10-17-630V-0,1 uF ±5%	2	
C2	К50-35-400V-47 uF ±20%	1	
C4,C5	К10-17-630V-0,01 uF ±5%	2	
C6-C8	К10-17-63V-0,1 uF ±5%	3	
C9,C10	К50-35-16V-470 uF ±20%	2	
C11	К50-35-16V-100 uF ±20%	1	
C12	К10-17-400V-0,1 uF ±5%	1	
C13	К50-35-16V-10 uF ±20%	1	
C14	К10-17-400V-0,1 uF ±5%	1	
	Microcircuits		
DA1	TOP223Y	1	
DA2	MOC 3063	1	
DA3	TL431	1	
DA4	MPC1541-I/TO	1	
DA5	LM317LZ	1	
DA6	OP-07DP	1	
	Resistors		
	C2-23		
	3296W		
R1,R3,R10	C2-23-0,25-91 Ohm±5%	3	
R2	C2-23-2-4,7 Ohm ±5%	1	
R4,R6,R14	C2-23-0,25-360 Ohm ±5%	3	

		Signature	Date	EVW 2.893.001
Developed	Ekong V.W.			Network unit of the medical laboratory thermostat List of elements
Chekced	Dozorska O.F.			ATF, group IRB-43

Marking	Name	numb	
R5	С2-23-2-100 kOhm ±5%	1	
R7, R9	С2-23-0,25-4,7 kOhm ±5%	2	
R8,R13,R15	С2-23-0,25-430 kOhm ±5%	3	
R11	С2-23-0,25-18 kOhm ±5%	1	
R12	3296W-0,5-100 Ohm ±10%	1	
R16	С2-23-0,25-560 Ohm ±5%	1	
R17, R18	С2-23-0,25-2 kOhm ±5%	2	
R19, R20	С2-23-0,25-220 kOhm ±5%	2	
R21	3296W-0,5-1 kOhm ±10%	1	
R22	С2-23-0,25-2,7 kOhm ±5%	1	
RU1	TVR14 391	1	
T1	T EVW4.11	1	
	Diodes		
VD1	W10M	1	
VD2	КД226Б	1	
VD3-VD5	1N5819	3	
VD6	КС133А	1	
VS1	MAC9M	1	
VT1	КТ315Г	1	
XS1-XS4	PLS-40	4	
XS5	DRB-9MB	1	

EVW 2.893.001

			Name	Name	numb.	
				Documentation		
A1			EVW 2.893.001	Assembly drawing		
A2			EVW 2.893.001 E3	Electric diagram		
A2			EVW 2.893.001 E1	Structural diagram		
				Details		
		1	EVW 7.180.001	Bushing	2	
		2	EVW 7.103.001	Printed board	1	
		3	EVW 7.800.001	Gasket	8	
		4	EVW 7.800.002	Gasket	2	
		5	EVW 7.180.002	Radiator	1	
				Standard products		
		6		Nut M3	2	
		7		Screw M3	3	
		8		Screw 3	1	
		9		Puck 3.02	8	
				Other products		
				Diodes		
		10		W10M	1	VD1
		11		КД226Б	1	VD2
		12		1N5819	3	VD3-VD5
		13		КС133А	1	VD6

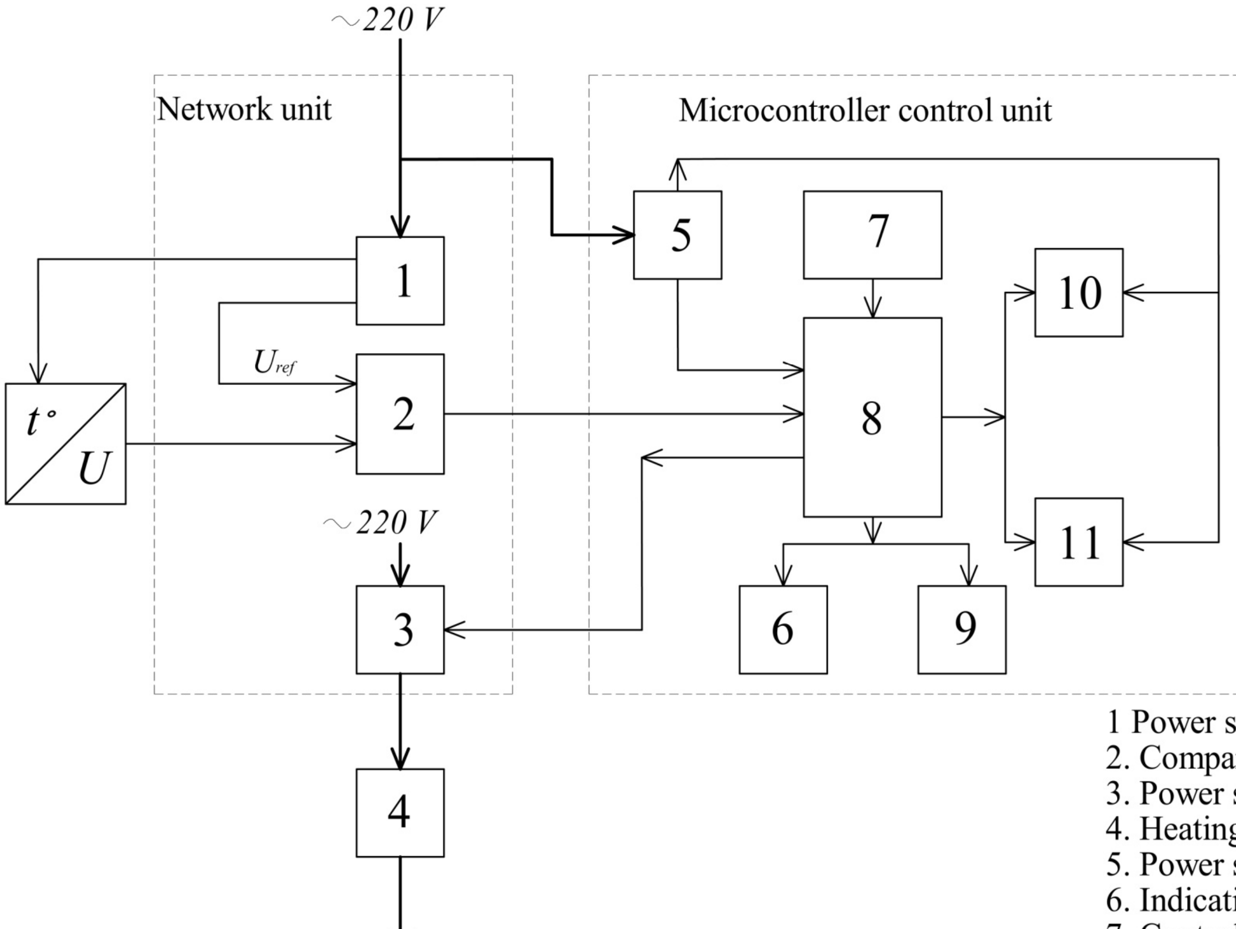
		Signature	Date	EVW 2.893.001
Developed	Ekong V.W.			Network unit of the medical laboratory thermostat
Chekced	Dozorska O.F.			ATF, group IRB-43

			Name	Name	numb.	
		14		_PLS-40	4	XS1-XS4
		15		DRB-9MB	1	XS5
				Capacitors		
				К50-35		
				К10-17		
		16		К10-17-630V-0,1 uF ±5%	2	C1, C3
		17		К50-35-400V-47 uF ±20%	1	C2
		18		К10-17-630V-0,01 uF ±5%	2	C4,C5
		19		К10-17-63V-0,1 uF ±5%	3	C6-C8
		20		К50-35-16V-470 uF ±20%	2	C9,C10
		21		К50-35-16V-100 uF ±20%	1	C11
		22		К10-17-400V-0,1 uF ±5%	1	C12
		23		К50-35-16V-10 uF ±20%	1	C13
		24		К10-17-400V-0,1 uF ±5%	1	C14
				Microcircuits		
		25		TOP223Y	1	DA1
		26		MOC 3063	1	DA2
		27		TL431	1	DA3
		28		MPC1541-I/TO	1	DA4
		29		LM317LZ	1	DA5
		30		OP-07DP	1	DA6
				Resistors		
				C2-23		
				3296W		
		31		C2-23-0,25-91 Ohm±5%	3	R1,R3,R10
		32		C2-23-2-4,7 Ohm ±5%	1	R2
		33		C2-23-0,25-360 Ohm ±5%	3	R4,R6,R14
		34		C2-23-2-100 kOhm ±5%	1	R5

EVW 2.893.001

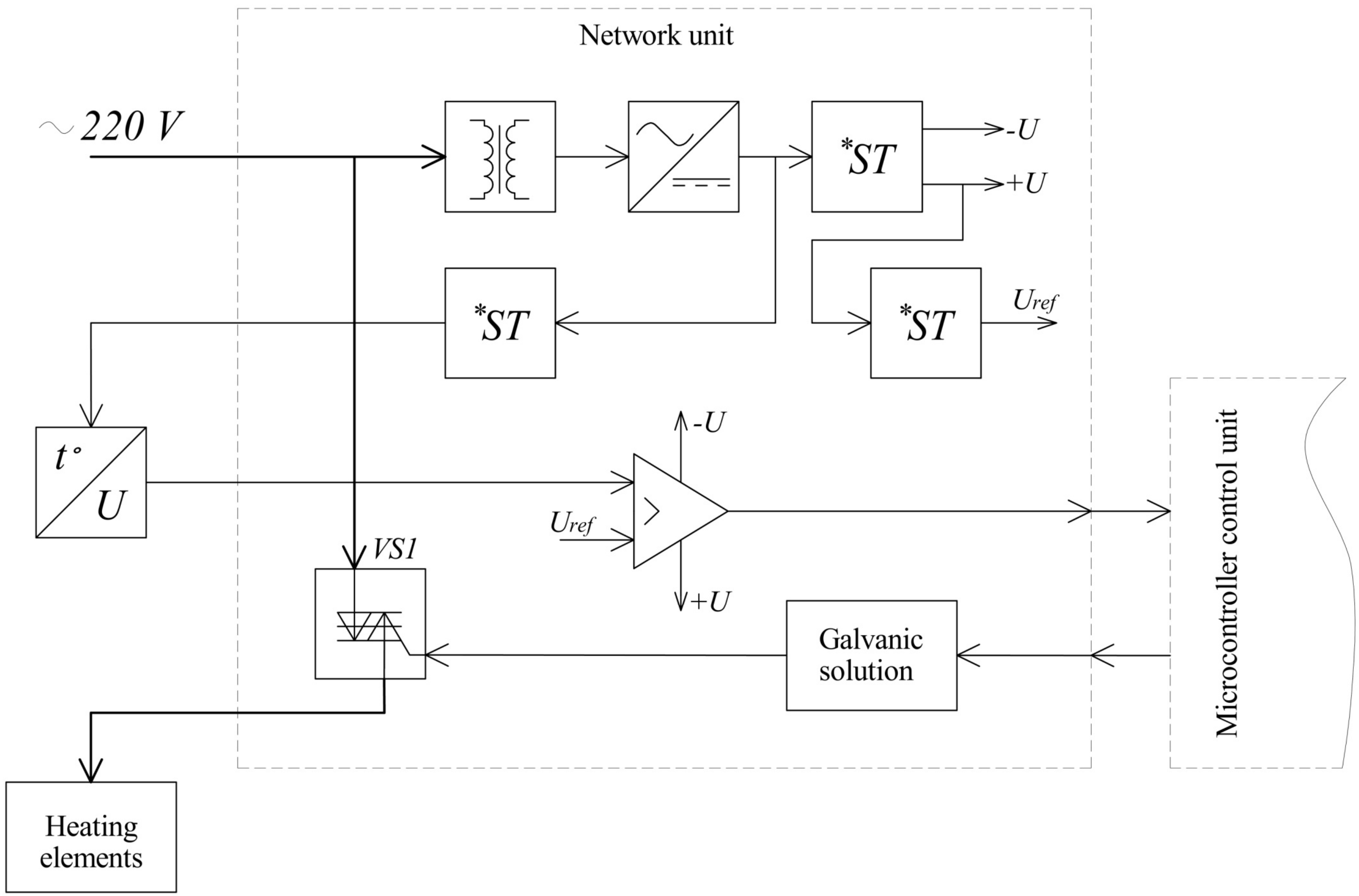
			Name	Name	numb.	
		35		C2-23-0,25-4,7 kOhm ±5%	2	R7, R9
		36		C2-23-0,25-430 Ohm ±5%	3	R8,R13,R1
		37		C2-23-0,25-18 kOhm ±5%	1	R11
		38		3296W-0,5-100 Ohm ±10%	1	R12
		39		C2-23-0,25-560 Ohm ±5%	1	R16
		40		C2-23-0,25-2 kOhm ±5%	2	R17, R18
		41		C2-23-0,25-220 kOhm ±5%	2	R19, R20
		42		3296W-0,5-1 kOhm ±10%	1	R21
		43		C2-23-0,25-2,7 kOhm ±5%	1	R22
		44		TVR14 391	1	RU1
		45		T EVW4.11	1	T1
		46		MAC9M	1	VS1
		47		КТ315Г	1	VT1

1. STRUCTURAL DIAGRAM OF THE THERMOSTAT

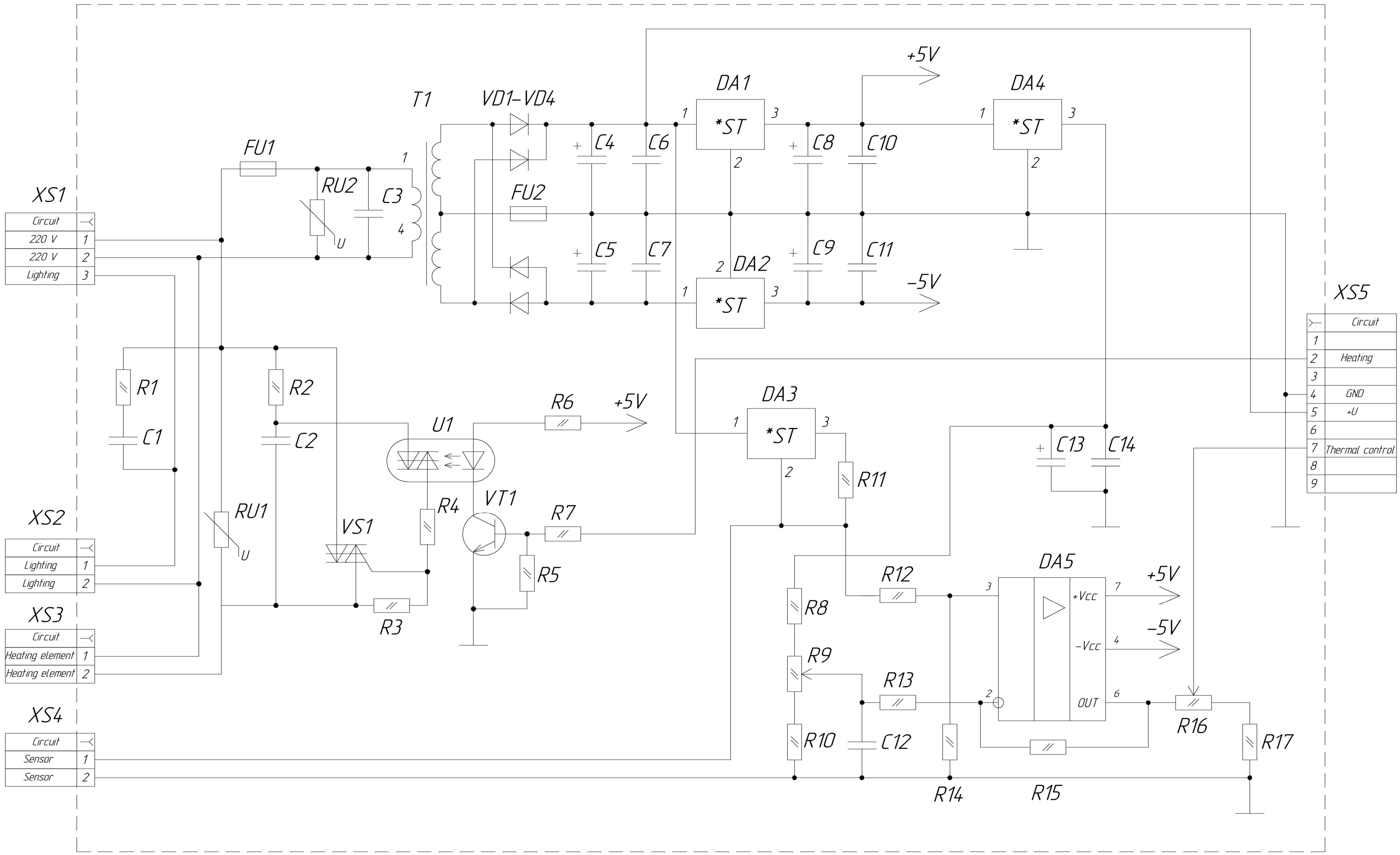


1 Power supply unit;
2. Comparator;
3. Power switch;
4. Heating elements;
5. Power supply unit;
6. Indication of modes;
7. Control elements;
8. Microcontroller;
9. Sound alarm;
10. Temperature indication;
11. Indication of the time of thermostating.

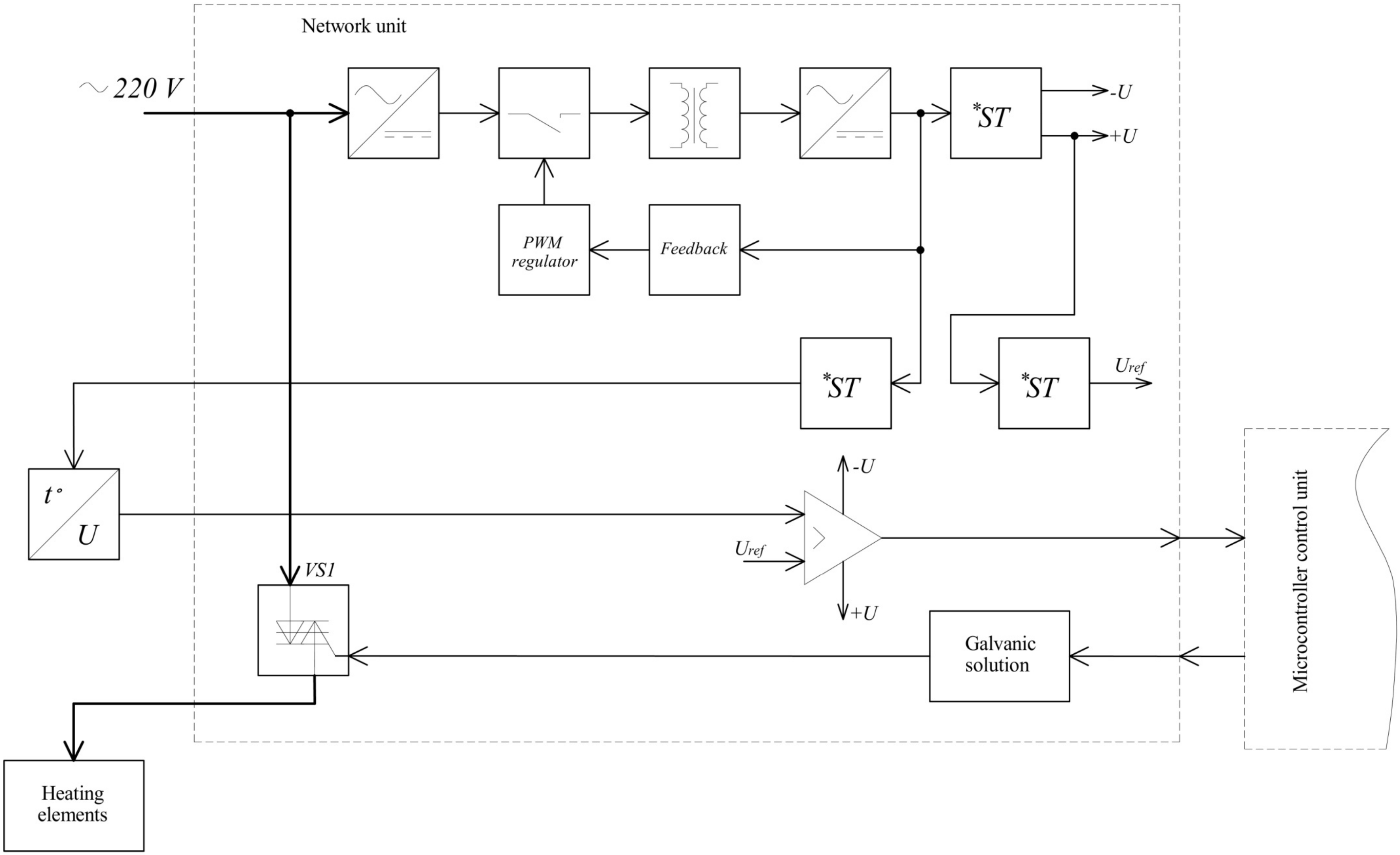
2. FUNCTIONAL DIAGRAM OF THE BASIC NETWORK UNIT



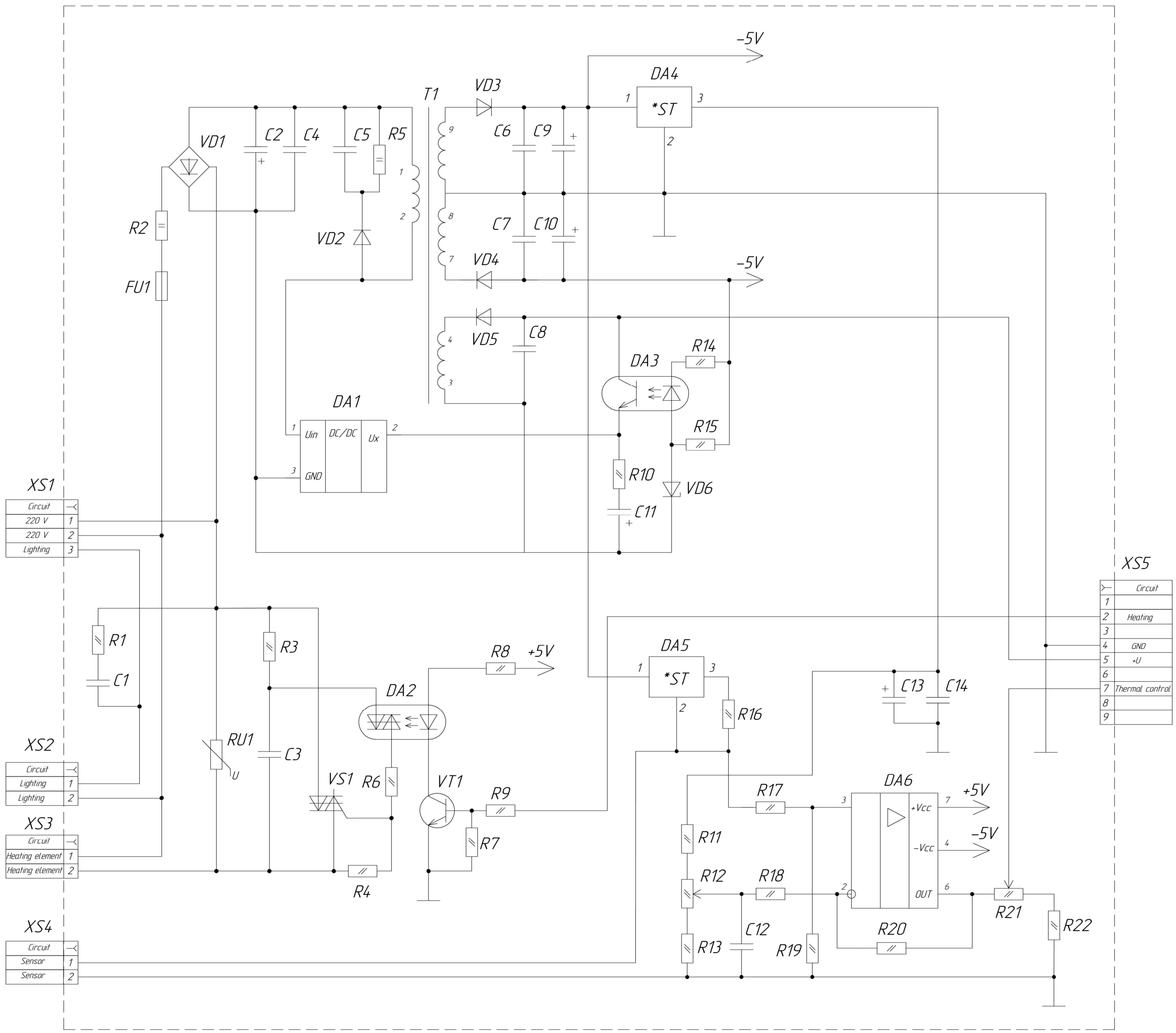
3. ELECTRICAL DIAGRAM OF THE BASIC NETWORK UNIT



4. FUNCTIONAL DIAGRAM OF THE MODERNIZED NETWORK UNIT



5. ELECTRICAL DIAGRAM OF THE MODERNIZED NETWORK UNIT



6. PRINTED CIRCUIT BOARD

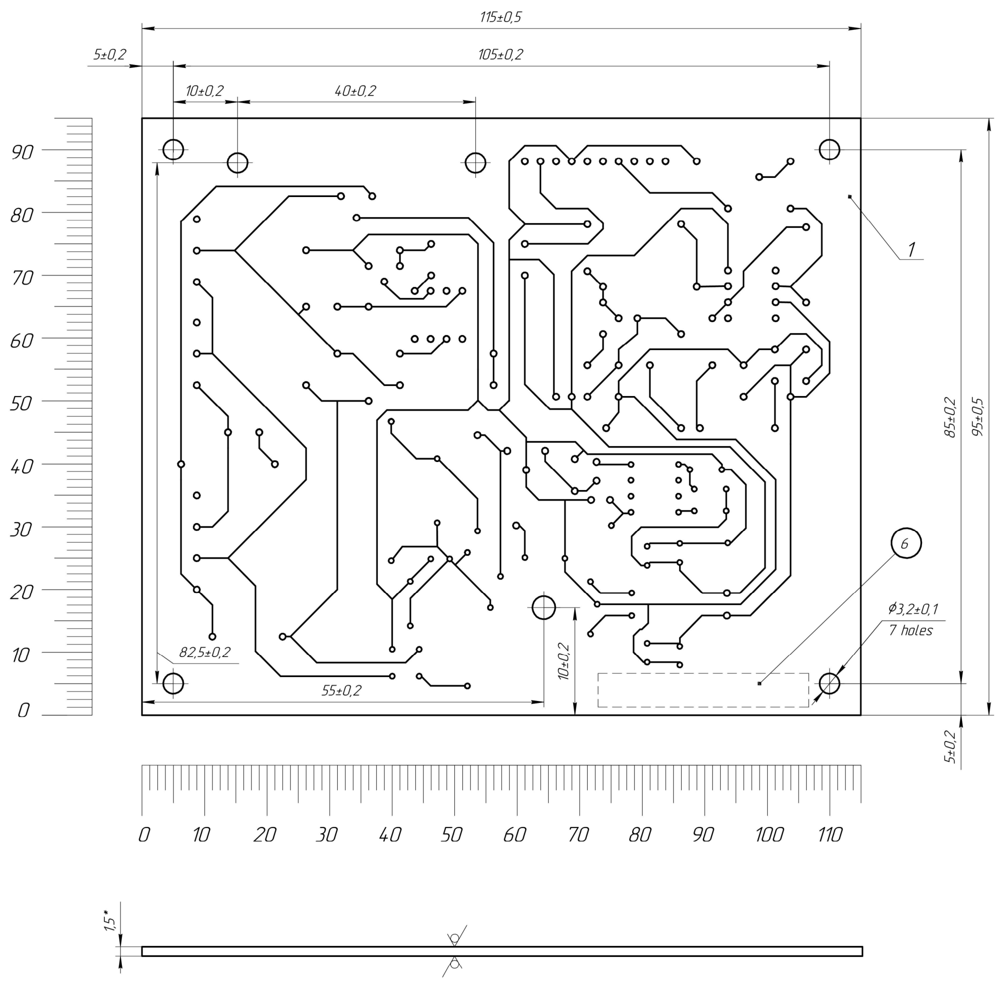
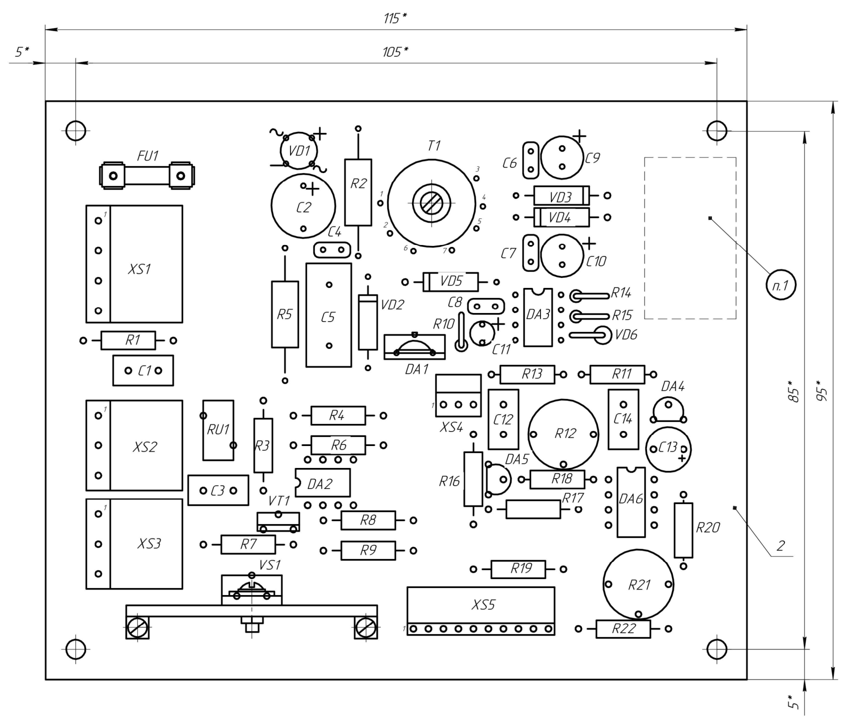


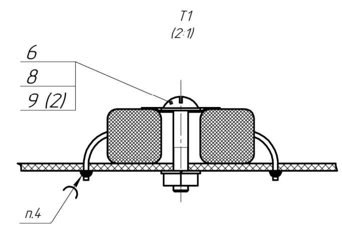
Table 1.

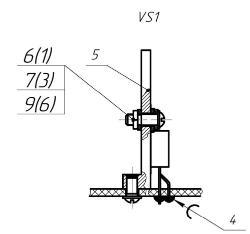
Conventional designations of holesУ	Hole diameter, mm	The size of the contact pads	Presence of metallization	Number
⌖	0,8±0.08	1,7±0,1	+	166
⊕	3,2±0,1	–	–	7

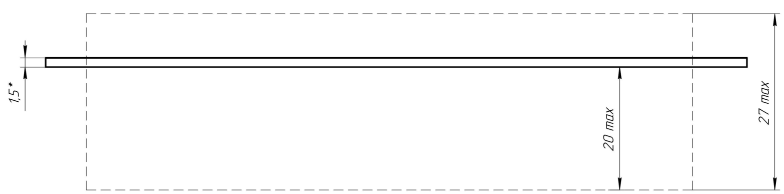
1. * Dimensions for reference.
2. The board must meet the requirements of standards, rigidity group 2. Accuracy class 2
3. Configuration of printed conductors according to the drawing. The step of the coordinate grid is 1.25 mm.
4. Permissible deviations between the axes of any mounting holes are 0.1 mm.
5. Make the board using the combined positive method.
6. Mark the decimal number with marking paint, font 2.5

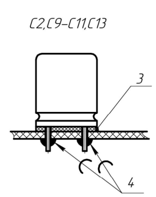
7. CIRCUIT UNIT

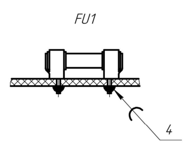


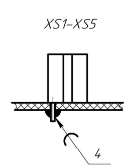












1. *Dimensions for reference.
2. Prepare for installation according to standards
3. Install elements according to standards.
Elements C1, C3, C6, C7, C10–C12, C14, RU1, RU2 set according to option IIa; resistors (except R9 and R16) and diodes – according to option Ia; DA1–DA4, VT1 – according to option IIv; DA5 – according to option VIIIa; other elements – according to the drawing.
The step of the coordinate grid is 1.25 mm.
4. Solder with solder.
6. Stop the threaded connections with enamel.
7. Mark the number, date, letter of the change – font 2.5 with black marking paint.
8. Cover the printed unit with varnish
9. Elements with a schematic designation are shown conditionally.