MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Nonprofit Joint Stock Corporation
«ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATION NAMED AFTER GUMARBEK DAUKEEV»
Institute of Space Engineering and Telecommunications
Department of Electronics and Robotics

«APPROVED»
Head of department ass.prof, Chigambaev T.O.
_______________ «___» __________________20__y.
(signature)

SENIOR THESIS

On the topic: «Automated fire alarm and fire warning system»
Specialty «5B071600 – Instrumentation engineering»
Performed by Babakhanova R.I.
Scientific adviser c.e.s., ass.prof Chigambaev T.O.

_______________ «___» __________________20__y.
(signature)

Consultants:
by the economic part: c.e.s. ass. prof. Tuzelbaev B.I.

_______________ «___» __________________20__y.
(signature)

By life safety: PhD, ass.prof., Begimbetova A.S.

_______________ «___» __________________20__y.
(signature)

Norm controller: sen.lec., Fazylova A.R.
_______________ «___» __________________20__y.
(signature)

Reviewer: c.e.s., Pya D.R.
_______________ «___» __________________20__г.
(signature)

Almaty 2020

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THE TASK
for the implementation of the thesis project

student Babakhanova R.I.

Work topic: «Automated fire alarm and fire warning system» approved by order of the rector № ___ от ___ september 2020 y.

Deadline for completion of work «__» may 2020y.

Initial data for the project (required parameters of the design results) and initial data:

On the basis of arduino uno, implement a fire alarm and fire warning system with sending SMS to the phone.

The list of issues to be developed in the diploma project or a summary of the diploma project:

1) a review of existing management systems;
2) a description of the process;
3) selection of necessary equipment;
4) development of a user program and imitation of the system;
5) a business plan;
6) life safety (calculation of artificial lighting and air conditioning).

The list of graphic material (with an exact indication of the mandatory drawings): this work contains 30 figures and 9 tables.

Recommended basic literature:

1. SP 3.13130.2009. Fire protection systems. Warning and evacuation management system in case of fire. Fire safety requirements: approved. by order of the Ministry of Emergencies of the Russian Federation of March 25, 2009 № 173; enter 05/01/2009. - M.: FGU VNIIPO EMERCOM of Russia, 2009.
2. Arduino [Electronic resource] - Free Encyclopedia - 2018 - Access Mode: https://ru.wikipedia.org/wiki/Arduino.

3. The use of GSM / GPRS - technologies for building effective process control systems // http://genisys.ge. [Electronic resource]. - Access mode: http://genisys.ge/ru/news/применение-gsmGPRS-технологий-для-построения-эффективных-асу-тп.
4. Knyazevsky B.A. Occupational Safety and Health. - M .: Higher school, 2002. – 365 с.
5. Website: https://www.arduino.cc/en/Guide/ArduinoGSMShield.

Project consultants specifying related work areas.

Section	Consultant	Lead time	Signature
System Overview	Chigambaev T.O.	20.02.20	
Equipment selection	Chigambaev T.O.	15.03.20	
Software development and simulation of work in the program	Chigambaev T.O.	7.04.20	
Life safety	Begimbetova A.S.	29.04.20	
Technical-economic rationale	Tuzelbaev B.I.	04.05.20	

SCHEDULE
preparation of the thesis project

№	Name of sections, list of issues to be developed	Lead time	Note
1	2	3	4
1	Overview of existing management systems	20.02.20	
2	Process description	15.03.20	
3	Selection of necessary equipment	30.03.20	
4	User program development and system simulation	7.04.20	
5	Life safety (calculation of artificial lighting and air conditioning)	29.04.20	
6	Business plan	04.05.20	

Date of assignment «___» __________ 2020 y.

Head of department ________________ Chigambaev T.O..

Scientific adviser ___________________ Chigambaev T.O.

Task accepted for execution
student ________________________ Babakhanova R.I.
(signature)

Summary

This graduation paper addresses issues about the fire alarm system used in residential facilities, in workrooms, in industry and in other environments. The Arduino UNO microcontroller, the GSM module SIM900, fire detectors and other modules related to this project are described, and a fire alarm system and fire warning with the sending of SMS to the phone were developed on these devices.

The issues of life safety were considered, a business plan was drawn up and the payback period of the developed project was calculated.

Аннотация

В данной выпускной работе рассмотрены вопросы о системе пожарной сигнализации, используемых в жилых объектах, в рабочих помещениях, в промышленности и в других средах. Описаны микроконтроллер Arduino UNO, GSM модуль SIM900, пожарные извещатели и другие модули относящиеся к данному проекту, и на данных устройствах был разработан система пожарной сигнализации и оповещение о пожаре с отправкой смс на телефон.

Рассмотрены вопросы безопасности жизнедеятельности, составлен бизнес-план и рассчитан срок окупаемости разработанного проекта.

Аңдатпа

Бұл дипломдық жұмыста тұрғын үйлерде, жұмыс бөлмесінде, өнеркәсіпте және басқа ортада қолданылатын өрт дабылы жүйесі туралы мәселелер қарастырылған. Arduino UNO микроконтроллері, SIM900 GSM модулі, өрт детекторлары және осы жобаға қатысты басқа модульдер сипатталған, бұл құрылғыларда телефонға SMS жіберу арқылы өрт дабылы және өрт туралы ескерту жүйесі жасалды.

Тіршілік әрекетінің қауіпсіздігі мәселелері қаралды, бизнес-жоспар жасалды және жасалған жобаның өтелу мерзімі есептелді.

Content

Introduction

In modern society, technologies are very well developed, new devices appear that are being intensively introduced into people's lives, are actively used and beneficial, and at the same time pose a fire hazard, cause a fire.

In general, fire, as the cause of the simultaneous death of a large number of people, is second only to dangerous natural phenomena in the number of claimed lives.

The fire alarm system is a complex set of technical tools that serve for the timely detection of fire.

In some situations, the time of arrival of firefighters depends on the human factor, which may fail.

In the case of connecting fire control services, the fire service receives a signal automatically, which reduces the possible consequences of the incident and save lives.

Using the fire control service, you can organize round-the-clock monitoring of installed equipment. In the event of a malfunction, the owner will be promptly notified of this fact.

Fire safety is an important requirement for facilities and structures. High-rise buildings belong to the category of especially dangerous objects, since in case of danger it is very difficult to evacuate people from there. The installation of a fire alarm is an effective way to timely detect a fire source in order to take appropriate measures.

The relevance of designing a fire alarm system, the development of a warehouse warning system is determined by the fact that it is much easier to prevent a fire than to eliminate an existing one, which can lead to irreversible consequences. The adverse effects of a fire can be significantly reduced by preventing them by timely notification of a fire to the public.

The relevance of designing a fire alarm system, the development of a warehouse warning system is determined by the fact that it is much easier to prevent a fire than to eliminate an existing one, which can lead to irreversible consequences. The adverse effects of a fire can be significantly reduced by preventing them by timely notification of a fire to the public.

Purpose: to develop a project for automatic fire alarms and warning systems for a warehouse.

Tasks:

- study the statistical data of the situation with fires in the world; in the oil and gas industries
- analyze the fire hazard in the warehouse;
- design a fire alarm system, develop a warehouse warning system to prevent a fire;
- evaluate the cost-effectiveness of the fire alarm project by analyzing the effectiveness of protection at facilities similar to the object of study on industrial objects.

1 Technological part

1.1 The purpose and objectives of the graduate work

The aim of the diploma project is to design a fire alarm system and alert people about a fire, designed to detect signs of a building fire and to promptly inform people about the occurrence of these signs. The fire alarm is intended for round-the-clock monitoring of the guarded object, and in particular for early detection of fire detection using one of the most likely signs for this object and issuing signals about its detection.

1.2 Fire alarm

A fire alarm system is a set of jointly operating fire alarm systems installed on a protected facility for detecting a fire, processing, presenting in a given form a fire notification at that facility, special information and (or) issuing commands to turn on automatic fire extinguishing installations and technical devices.[1]
Currently, there are three main types of fire alarms:

1 Addressable fire alarm. Addressable fire alarm systems allow you to determine not only the zone, but also the exact address of the triggered sensor. When activated, the sensor sends a loopback address in a serial code, which is displayed on the control panel display. Each sensor or mounting base has an address setting circuit. Thus, the system determines a specific place for generating a signal about TI, which increases the responsiveness of special services. In the figure 1.1 was shown addressable alarm scheme.

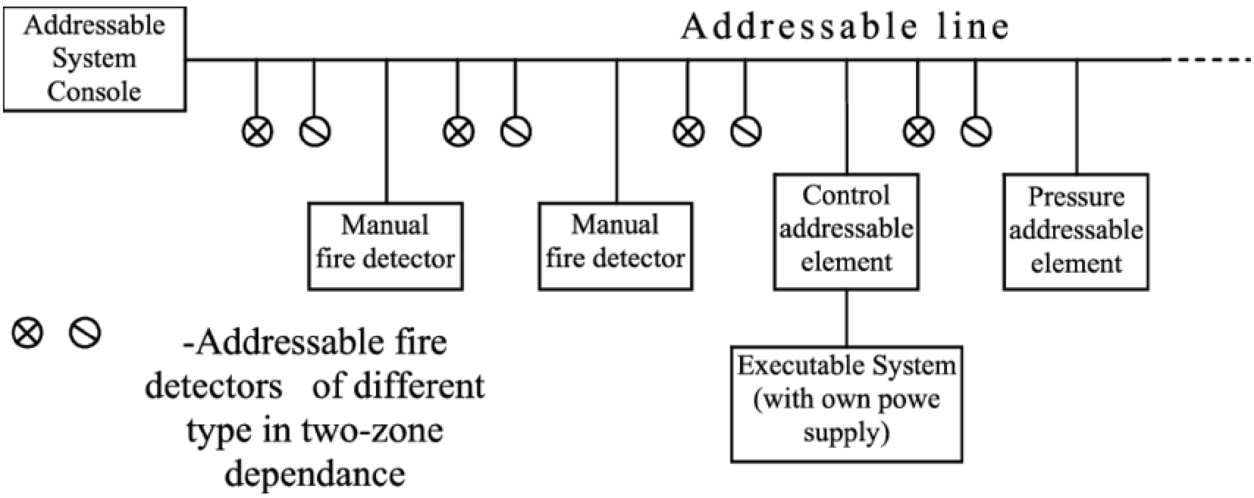


Figure 1.1 – Addressable alarm scheme

Addressable fire alarm systems are divided into non-interrogative and interrogative. In intelligent address systems, an arbitrary loop type can be used: ring, branched, star, and any combination of them; no terminal elements of the loop are required. In the polling address systems, the presence of the sensor is confirmed by its answers to the control panel requests (at least 5-10 s). If the control panel does not receive a response from the sensor at the next request, its address is displayed with a corresponding message. In this case, there is no need to use the loop break function, and when one sensor is disconnected, the functionality of all the others remains.[1]

2 Addressable analogue fire alarm. Address-analog systems of the PS, have the most developed functional capabilities, reliability and flexibility, are the center for collecting telemetric information from sensors. In a modern building, equipped with expensive telecommunication, automation and life support systems, the use of address-analog equipment is the right decision. An important difference between the address-analog systems of the substation is that in them the detector is only a parameter meter and transmits its value and its address to the control panel, and the control panel estimates the magnitude and rate of change of this parameter, and also controls the indication of the PI, including the corresponding mode. Those all decisions on monitoring and managing the fire situation at the facility are made by the control panel.[1] The modern address-analog analog system PS is a specialized computer complex that allows you to control a whole set of parameters - and evaluate the state of an object using several PIs located in one or different rooms, change the sensitivity of PIs depending on operating conditions and operating time (day / night modes), working day / day off). The address-analog system also allows you to flexibly organize the work and interaction of all engineering life support systems of the building (Figure 1.2).

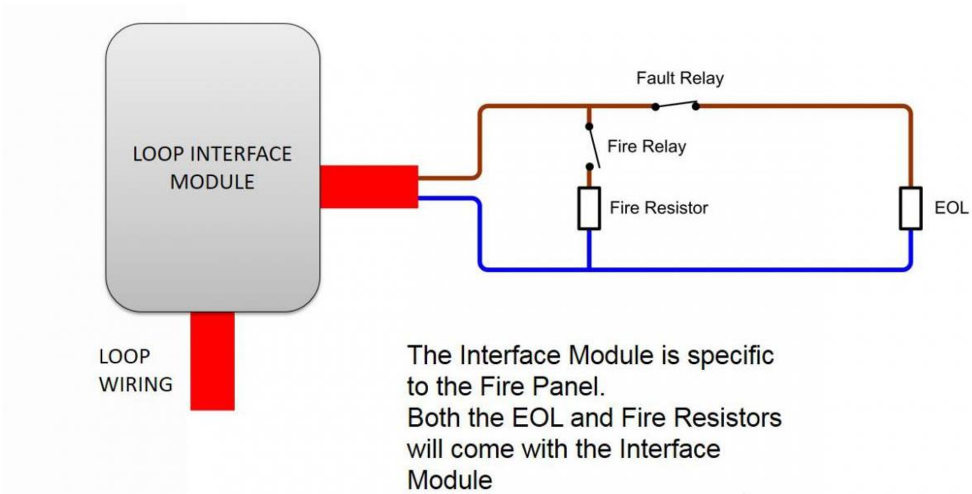


Figure 1.2 – Connection to addressable fire panels

3 Fire warning and evacuation control systems. In the event of a fire, it is important not only to detect it at an early stage, but also to notify about the dangers of people in the building and prevent a possible panic. For this purpose, depending on the category of the object, in accordance with the requirements of fire safety standards, various types of alerts are used: sound, light-sound, speech, speech with separate switching zones. In the figure 1.3 was shown plan evacuation of working area.

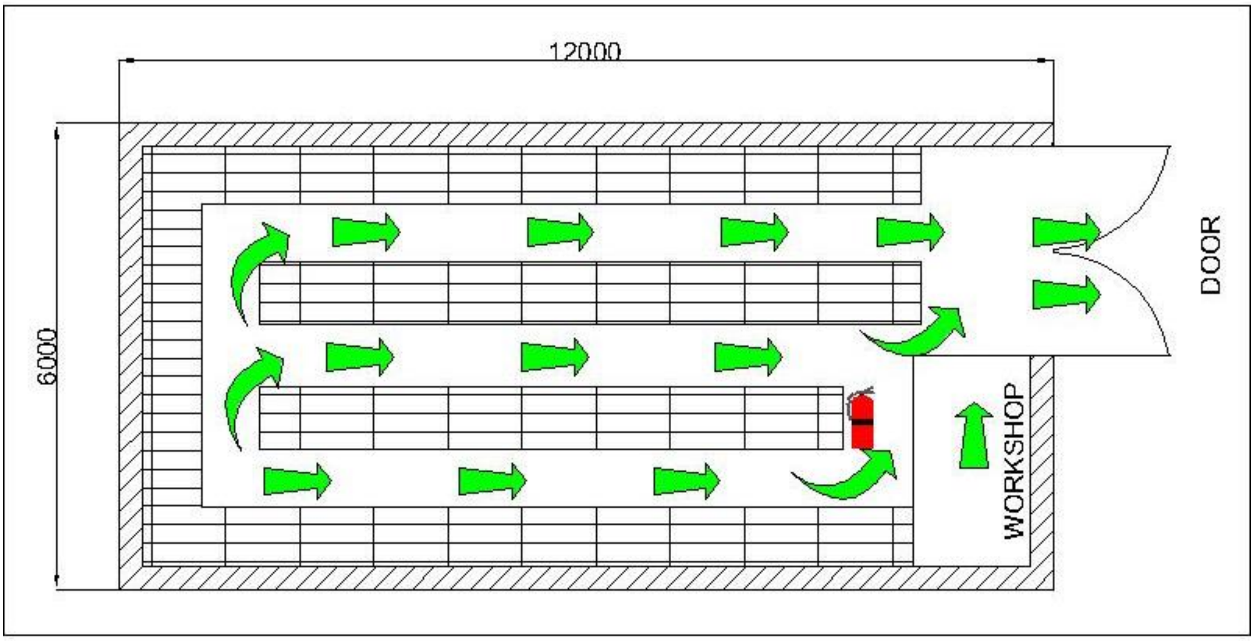


Figure 1.3 – Plan evacuation of working area

Successful evacuation of people and material assets is facilitated by guidelines transmitted through a fire warning system. Such systems are especially needed in public buildings, where in addition to the constantly working staff there is a significant number of visitors. Voice notification systems are used to broadcast fire warning signals or to any other danger with specified priority over other operating modes (sending short messages, advertisements, background music, radio programs, etc.) to specified zones.

The basis of the warning system is a radio-electronic unit, which is connected to the building's general broadcasting system, and, receiving an alarm from the fire system or any other alarm system, then automatically switches to the warning mode. In the notification mode, the system determines the priority, and the place of origin of the signal then starts to reproduce information previously recorded for this case with the simultaneous inclusion of sirens and strobes.

1.3 Establishment and development of a fire warning system in the 19th century

Most attention is paid to the galvanized service and the evolution of its use in the specified period. The history of human society has been and continues to be accompanied by fires, because of which whole civilizations, cities, and villages have perished. The cause of the fires was some natural phenomena, and more often the person himself - his carelessness or deliberate actions. Therefore, at all stages of the development of human society, a fire department was built to ensure the fire safety of society. The successful activity of the fire brigade is determined by several components, one of which - fire warning - as a result of development has become a fire warning system for firefighters and the public, and later on as a whole, a fire protection communication system. From time immemorial, the ringing of a bell in Russia has warned the people of the imminent danger of fire, the raid of enemies or called for rebellion. When a fire occurred, the random ringing of bells made a mess, people ran out into the street, not knowing where the fiery attack was coming from, where to run with fire-fighting tools, performing fire service. Probably, it was precisely these circumstances that led in 1668 to the appearance of an audible alarm, establishing the procedure for signaling a fire in Moscow. By bell ringing people were gathered for fires in other cities and settlements. Until 1719, in the newly laid capital of St. Petersburg, fires were reported using rattles and sticks to planks. In 1719, the first St. Petersburg police general A.E. Devier replaced this method with drumming. In 1740, a special detachment of drummers was formed for fire alarm at the Senate. Later, in 1748, in St. Petersburg, there was an order to cast the bell at 50 pounds and hang it at the main police office. For a better view, it was customary in some cities to put guardians in an elevated place. In the XVIII century, in Moscow, to observe the fires, “special towers” were arranged on the moving huts, of which police officers on duty observed the surrounding area. With the construction of moving houses in St. Petersburg, towers appeared at a considerable height, called the "tower". It is characteristic that the towers were built so that those on duty on each of them could see the raised “warning signals” from each other. With the growth of cities, it became increasingly difficult to accurately determine the place of the fire, especially at night and in bad weather. In this regard, to increase the accuracy of information, they began to build square rooms on the towers with four windows - one on each side. The initiative was made in Vienna. Here, windows began to place tables with a detailed description of the area. The spyglasses went on course. If the Vienna observers went around with one pipe, then the firemen of Wismar (Germany) installed spyglasses stationary in all directions.[2]

In the 19th century, special instruments, toposcopes, replaced the telescopes. The device was uncomplicated: an astronomical pipe mounted on a stand, goniometric scales, indicators. When the pipe is rotated in a vertical or horizontal plane, the countdown according to the signs gave the coordinates of the fire. The first such toposcope was installed in 1837 on the tower of St. Stephen in Vienna. Next, it was necessary to find a way to quickly transfer the coordinates of the fire to the firewall. How to quickly go down from a tower more than 50 meters high? We decided not to go down, but to lower the coordinates of the fire along the pipe laid along the contour of the tower from the observation post to the barracks. In the upper part of the pipe was funnel-shaped and hermetically closed. The sentinel put the exit address into the capsule, inserted it into the funnel, closed the lid and began to swing the manual fur. So, in the 70s. XVIII century pneumatic mail was born in the fire department, which later became widespread. Fundamental transformations in fire warning are related to the invention of the Russian scientist P. Schilling. In 1832, he, and five years later by the American S. Morse, created a telegraph apparatus, which they began to successfully use for warning of fires. In 1851, the Berlin fire brigade first began to use the apparatus of the Werner-Siemens system for calling fires, in which the Morse telegraph apparatus entered as the receiving station. Devices for calling fire brigades were installed in crowded places - theaters, institutions, etc. In Russia, the first street detector was installed in St. Petersburg in 1858, the construction of the St. Petersburg city telegraph, which was used to communicate between the fire brigades of the city. Since that time, information about the fire came to all parts of the city after 3 minutes. after the signal. The formation and development of fire warning as a system in St. Petersburg begins with the creation of a professional fire department. On November 29, 1802, Alexander I, by decree, established a fire brigade under the Metropolitan Police, consisting of 1602 people from soldiers incapable of front-line service. This was an important step in creating a professional fire department in St. Petersburg, and indeed in Russia. On June 24, 1803, a decree "On the duties of the inhabitants of the city of St. Petersburg" was issued, which exempted residents of the capital from compulsory arrival to extinguish fires. This date is considered the time of the formation of the city, professional fire department of St. Petersburg. According to the same decree, the fire brigade of St. Petersburg was to consist of 11 fire brigades, following the example of Western European fire brigades.[3]

The graph shows that at the beginning of the XX century, there was a sharp decrease in the number of fires detected from the tower in comparison with the total number of fires. Thus, notification of fires using the Kalanova service with the emergence and development of professional fire protection in St. Petersburg has become the main component of the warning system, both of individual fire units and the fire brigade of the capital as a whole. The principle of the fire warning system was the visual transmission of conditional signals ("visual telegraph") between the fire departments and the tower of the city council. The dynamics of changes in the number of fires detected from the tower. The Kalanch service was constantly improved both in the material and technical direction, and in the normative. In the first half of the 19th century there was no alternative to the Kalanha service and with its help a large number of fires were detected and, accordingly, there was a warning about them. In the second half of the 19th century, new technical communications equipment appeared that were successfully used for warning of fires. As they developed, the role of the Kalanova service in the fire warning system began to decrease and at the beginning of the 20th century it became negligible. The Kalanch service could not compete with progressive electrical equipment at that time, and therefore, starting in 1911, the Kalanova fire service began to abolish the Kalanch service as far as fire departments and their areas of exit were equipped with electric fire alarm calls and telephones, in the required quantity.[3]

1.4 Gas leaks

Gas, as a source of air pollution, during the operation of the gas pipeline can manifest itself during scheduled and emergency repairs of the gas pipeline with the emptying of the gas pipeline.

During the operation of the gas pipeline, the main impact arises from possible leaks of natural gas through microdamage to pipes and leaks in linear fittings.

The maximum possible gas leakage from the planned gas pipeline laid on flat terrain through micro fistula and not linear reinforcement density, m3 / year, is determined according to the "Methodological guidelines for calculating gross hydrocarbon emissions in the gas industry" according to the formula:

$$Q_l = 1113.5 \times \frac{D \times L \times P_{av} \times t}{T_{av} \times Z_{av} \times m}, \quad (1.1)$$

where, 1113.5 – conversion factor, deg / kg × day;
D – gas pipe diameter;
L – gas pipeline length;
P_{av} – average pressure;
t – gas pipeline operating time;
T_{av} – average gas temperature in the gas pipeline;
Z_{av} – average compressibility factor;
m – initial tightness degree
Decision:

$$Q_l = 1113.5 \times \frac{0.2 \times 5 \times 3 \times 365}{288 \times 0.92 \times 1.2} \approx 3835\ m^3/year$$

Considering the fact that odorized natural gas (with an odorant content of at least 16 mg / m^3) enters the gas pipeline from the gas distribution station, therefore, about 0.16 kg of odorant can be released into the atmosphere together with natural gas in a year. The indicated number of leaks is evenly distributed along the entire length of the pipeline route. It should be noted that the maximum amount of leaks is possible only after prolonged and careless operation (more than 10 years) due to the appearance of microdamage in pipes and worn out glands of shut-off valves.

To prevent leaks on the linear part, an inter-settlement high-pressure gas pipeline is tested for leaks before commissioning.

1.5 Fire protection

Fire protection - a set of technical measures aimed at increasing fire resistance and reducing the risk of fire, its development in buildings, as well as preventing the collapse of load-bearing structures. This is achieved due to: special fire-retardant impregnation of wood, coating with fire-retardant materials of loaded frame elements of buildings made of metal or reinforced concrete, which, under fire, heat, can catch fire or lose bearing capacity. The use of such passive fire protection can reduce the risk of fire spread, increase the period of elimination of a fire in buildings without the risk of collapse. The fire protection of the facilities includes a set of the following measures: Calculation, selection of fire retardants at the stage of building design using rafters made of wood roofs, supporting metal structures of unprotected metal or precast concrete of a small cross section with insufficient fire resistance limit. Preparatory work on drying, degreasing and cleaning wood, as well as structures made of metal alloys and reinforced concrete products from pollution. Trial application of fire-resistant materials on a small area of the protected surface to control adhesion, peeling of the coating after drying. Work carried out by representatives of specialized enterprises licensed by the Ministry of Emergencies. Quality control after complete drying of coatings, especially multilayer ones, if necessary, is carried out by both test firefighters and independent accredited laboratories, the conclusion of which is applied to the acts of fireproofing. Fire protection measures should be carried out in accordance with the requirements of regulatory documentation, as well as with the work procedures set forth in the instructions for the use of materials that increase the fire resistance of metal or reinforced concrete structures; translating wood into a combustible state. Fire protection means Mastics, pastes. These are the oldest fire-retardant materials with a high density, a significant expense for creating a heat-insulating layer on the surface of a metal structure. The disadvantage is a large load on the supporting elements of buildings, the advantage is low cost.[2]

The merger of human flows. The design situation diagram is presented in Figure 1.1. To the border of section $i + 1$ from the sections i and j preceding it, human flows with parameters q_i = 10,23 m/min, V_i = 68,2 m/min, D_i = 0,15 m^2/m^2 и q_j = 3 m/min, V_j = 100 m/min, D_j = 0,03 m^2/m^2 , respectively. All sections of the path are horizontal. It is required to determine the motion parameters human flow q_{i+1}, V_{i+1}, D_{i+1} in the subsequent section of the path $i + 1$ (Figure 1.4).

Decision:

The traffic intensity on the site i + 1 taking into account the merger of human flows is determined by the formula:

$$q_{i+1} = \frac{\sum qb}{b_{i+1}} = \frac{q_i b_i + q_j b_j}{b_{i+1}} \quad (1.2)$$

$$q_{i+1} = \frac{10 \cdot 2 + 3 \cdot 1.5}{2} = 12.25\ m/min$$

$$q_{i+1} = 12.25\ m/min < q_{max} = 16.5\ m/min$$

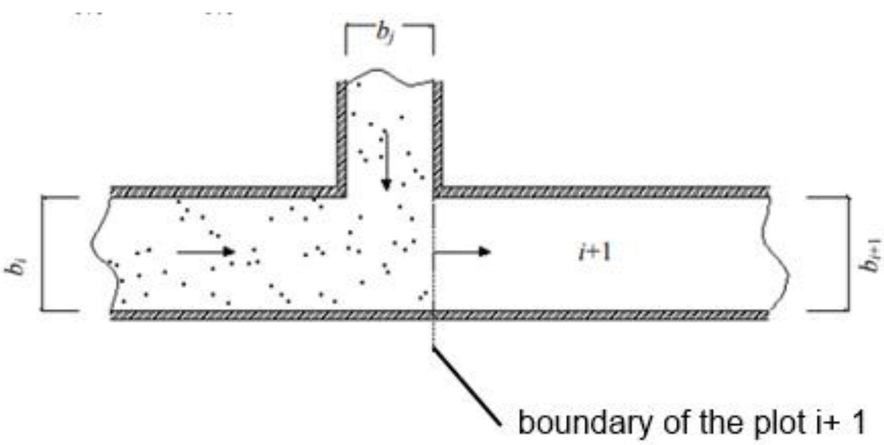


Figure 1.4 – The merger of human flows

Consequently, movement occurs unhindered. Traffic value q_{i+1} = 12.25 m/min corresponds to the value of the density of human flow D_{i+1} = 0.21m^2/m^2, and to him is the speed value V_{i+1}=58.3m/min.

Fire retardant impregnation. Used for surface coating on wooden elements of roofs of buildings, as well as for fire protection of fabrics. Fireproof plasters of various compositions. From traditional clay-based to modern formulations containing vermiculite. If the former are mainly used to seal openings at the intersection of fire barriers with communications, when installing fire-resistant filling openings in them; then the latter are in demand for the protection of supporting metal structures, as well as transit ducts. Paints or coatings. They are used in the same way as modern types of fire-resistant plasters for application to metal structures. Fire retardant varnishes. Used as a top coat, as a rule, they protect a multilayer coating made of fire-retardant paint from moisture, cracking. Other types of such varnishes are used for fire protection of wooden elements of the interior decoration of architectural monuments. Fire protection methods Fireproof impregnation by dipping or brushing, but spraying water formulations is most commonly used. Fireproof plaster is applied with a spatula or high pressure spray pumping stations.[2]

Application of fire-retardant multilayer coatings - with a brush or also by spraying, depending on the viscosity, the size of the particles of the material. Thermal insulation or structural fire protection is carried out by facing with ceramic tiles or fire-resistant cardboard, the voids under which are most often filled with fire-resistant basalt material, which allows you to achieve the required limit of resistance to fire. And also for these purposes fibrous fire-resistant materials are used in the form of rolls or dense mats, with which protected metal structures are wrapped or wrapped over the entire surface. There is a difference between the fire protection of building structures made of metal and wood both in the choice of materials used for these purposes and in the methods of its implementation. Fire protection of wooden structures is carried out both in assembled form, and in the form of individual elements of the rafter system by impregnation with aqueous solutions; thermal insulation of metal structures is carried out by applying fire-resistant multilayer coatings that reliably protect them after complete drying; or methods of structural fire protection not suitable for wood.

1.5.1 Firefighting

These are simple substances and mixtures based on them, which due to their natural properties make it possible to create conditions for localization, as well as the complete suppression of the combustion process. The process of such an experimental selection of substances for the needs of fire fighting, and then a more focused scientific study, has led to the fact that today among fire-extinguishing liquids there are several types of substances in various states of aggregation, which are effectively used in both primary and stationary and mobile fire extinguishing agents. Types and methods of supplying to the fire source Main types of extinguishing agents: Water. Still the most common substance, most often used to suppress fires, is usually extinguished by compact or sprayed jets in pure form from combined networks of household, drinking water supply with external or internal fire water supply to territories, buildings, enterprises, and settlements (Figure 1.5). It is more efficient to use water with wetting agents, that is, surfactants, or to supply it by spraying under high pressure of air or an inert gas.[2]

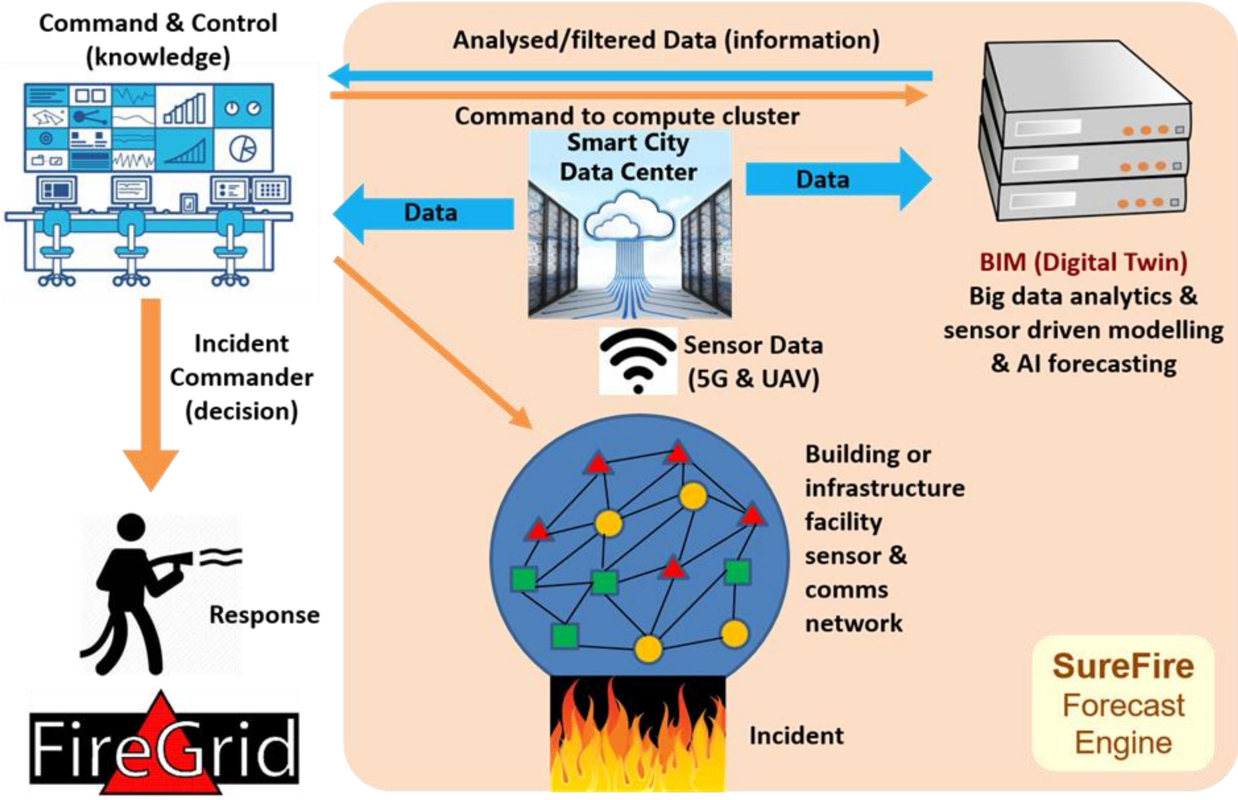


Figure 1.5 – Department of building services engineering

Foam of various multiplicity. Developed by special spray guns with for example GPS-600 or SVP-4 with foam-generating devices from aqueous solutions of fire blowing agents - this is an even more effective solution for combating many types of fires that cannot be extinguished with water without additives; and / or petroleum products. Water extinguishing compositions, including foams, are used to stop the combustion process of solid, liquid materials and are not intended to extinguish electrical installations, most gaseous substances.[2]

Powder. This is a mixture of finely ground, refined fractions of several types of mineral salts, enriched with additives, to reduce the caking process of the substance and the formation of lumps during long-term storage. Such a powder is a universal means for extinguishing foci of fire classes from A to E, and special types for extinguishing metals.

Extinguishing aerosols. This is a fairly new type of extinguishing agent, unusually active, since an aerosol cloud is formed as a result of burning a specially selected mixture of chemical components. Given this specificity, the scope of extinguishing aerosols is limited. Firstly, due to the high temperature of the extinguishing agent at the outlet of the feed device, and secondly, due to the unsuitability, as in the case of powders, of the air environment of the protected breathing rooms. Inert gases, carbon dioxide, freons. They are a very effective means to stop the processes of smoldering, burning, sharply reduce the ambient temperature in the protected premises, but usually only in small areas - due to the high cost of equipment, installation, service (for example, server ones). Combined mixtures, compositions. Usually including two extinguishing agents, supplied simultaneously or in turn to enhance the effect of localization and elimination of fire, in practice are quite rare, used in combined fire extinguishing systems.

Extinguishing powders, mixtures for producing extinguishing aerosols are supplied from the enclosures of the fire extinguishing modules, storage tanks for powder, aerosol fire extinguishing systems. Freons, carbon dioxide, inert gases are stored under pressure in cylinders, releasing into the protected premises through distribution pipelines, after the signal from the control device of the gas fire extinguishing installation from the triggered fire detectors. All existing methods of supplying extinguishing agents are inextricably linked with the types of supply devices listed above. The Basics of Cessation of Burning The choice of a particular type of extinguishing agent for each specific building or facility to be protected, as well as the method for its quick delivery to the fire source and to the combustion zone, is carried out according to the requirements of regulatory documents that take into account both their physicochemical parameters and properties, characteristics of the fire load explosion hazard categories. Important factors are also the construction dimensions of the objects and the nature of how the main fire extinguishing substances will interact with the materials in the fire load.[2]

The fundamentals of the cessation of combustion by fire extinguishing substances in many respects depend on the nature of their impact on the combustion process when it enters the reaction zone, changing its heat release and heat transfer. According to this effect on extinguishing fires, extinguishing agents are conditionally divided into 4 groups: Substances that sharply cool materials in the combustion zone. These include water, carbon dioxide, freons. Thus, the effectiveness of water, chladonic, carbon dioxide fire extinguishers in extinguishing primary foci of ignition is based on this physical factor.

Extinguishing agents that quickly dilute the concentration of flammable vapors and oxygen in the area of the fire, to those values when the continuation of the combustion reaction becomes impossible. These include gases, water vapor, finely dispersed water. Substances that isolate the combustion zone - powders, foam, sand, as well as sheet non-combustible materials, including specially made fire cloths. They also include earth, sand, gravel, which can be used to fill mineralized strips between combustible buildings and forests. Substances chemically slowing the rate of the combustion reaction. These are fire extinguishing aerosols, chladones and other halide hydrocarbons. Of course, not only these parameters will dictate the conditions for the cessation of burning in a fire, but also the actual availability of fire extinguishing means and methods that can be immediately applied to eliminate it. Nevertheless, when designing fire extinguishing installations and calculating the required number of fire extinguishers, such characteristics of fire extinguishing substances must be taken into account for optimal selection. Intensity of supply an important factor in successful extinguishing is also the intensity of the supply of extinguishing agents, defined as their weight quantity, which is supplied per unit time by area or volume of the fire source. It is no coincidence that this factor, together with the period of fire development, the linear velocity of the combustion process, are the main indicators of the fire extinguishing process necessary for the calculations. Determining the supply rate of extinguishing agents also includes the concepts of the lower and upper limits that limit the extinguishing area: So, the lower limit is understood as such a minimum value of the supply, when if it is even slightly reduced, the combustion process will not stop, how long it has not been fed into the fire zone , that is, until the fire load is completely burned out. Accordingly, the upper limit is the value of the supply of extinguishing materials, beyond which the period of elimination of the fire will not change. If you use the values of the flow rate, which are between the upper / lower limit, then you can successfully eliminate it by a different ratio of means, forces. It is clear that increasing the supply rate, one should take into account the inevitability of attracting many times more equipment, people, as well as fire extinguishing substances, which is not only often not advisable, but also not always possible in practice. You can find out the optimal intensity values and calculate the necessary amount of forces and means according to the data given in the tables of the reference books for fire extinguishing managers. You should not think that they are close to the critical lower values, on the contrary, as a rule, they significantly exceed them, allowing you to perform the calculation necessary for a particular situation. In such summary reference tables you can find out the intensity of the supply of: Water, including finely dispersed, to extinguish the most common, typical objects, which also indicates that the elimination of fires at sites with fire in buildings, open areas for storing cotton, peat, other fibrous materials should be kept only with water and wetting agents. And when extinguishing other objects with such aqueous solutions, it is recommended to halve the intensity.[2]

1.6 GSM alert system

The global standard for digital mobile communications GSM (from the name of the group Groupe Special Mobile, later renamed Global System for Mobile Communications) was developed under the auspices of the European Telecommunication Standardization Institute (ETSI) back in the late 1980s. But it became widespread and used only in the last couple of decades. But now, thanks to the high density of coverage cards of various operators, it is possible to use GSM communication almost anywhere in the world.[7]

High reliability and security of GSM communication channels allow them to be used for receiving and transmitting data from automated systems, for example, to inform about events at distribution network substations that do not have permanent duty personnel.[11] In the figure 1.6 was shown circuit diagram of the module.

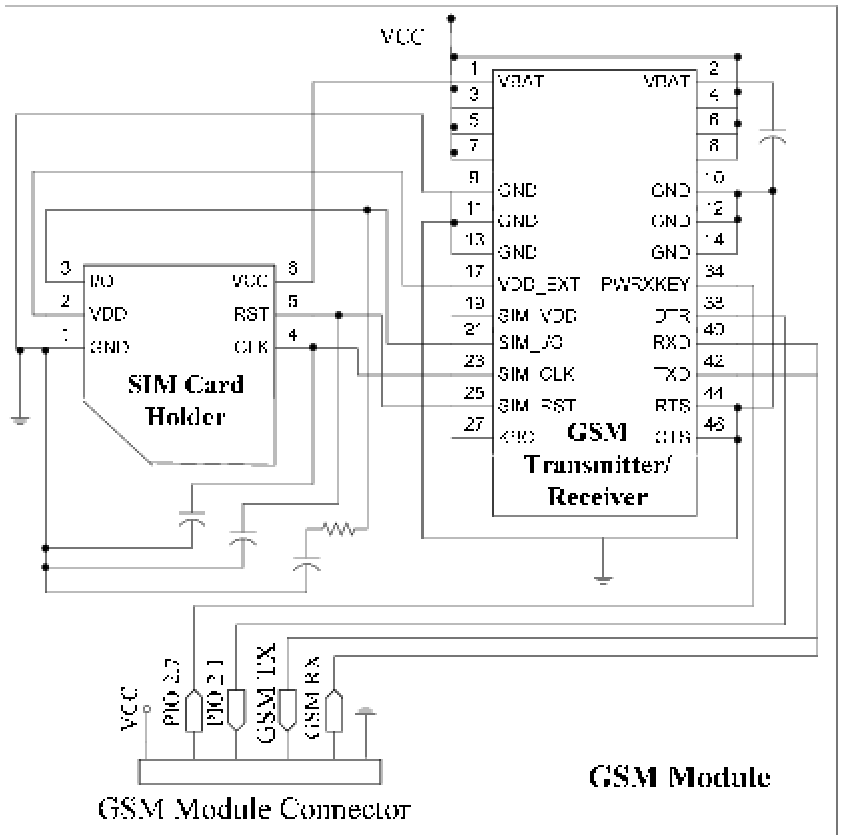


Figure 1.6 – Circuit diagram of the module

GPRS is a packet switching technology that stands for General Packet Radio Service. It can provide idealized data rates between 56-114 kbit per second.

A number of technologies such as SMS rely on GPRS to function. With the GSM shield, it is also possible to leverage the data communication to access the internet. Similar to the Ethernet and WiFi libraries, the GSM library allows the Arduino to act as a client or server, using http calls to send and receive web pages.
To access a network, you must have a subscription with a mobile phone operator (either prepaid or contract), a GSM compliant device like the GSM shield or mobile phone, and a Subscriber Identity Module (SIM) card. The network operator provides the SIM card, which contains information like the mobile number, and can store limited amounts of contacts and SMS messages.[11]

To use GPRS for internet access, and for the Arduino to request or serve webpages, you need to obtain the Access Point Name (APN) and a username/password from the network operator. See the information in Connecting to the Internet for more information about using the data capabilities of the shield.

SIM cards. In addition to the GSM shield and an Arduino, you need a SIM card. The SIM represents a contract with a communications provider. The communications provider selling you the SIM has to either provide GSM coverage where you are, or have a roaming agreement with a company providing GSM coverage in your location.[11]

It's common for SIM cards to have a four-digit PIN number associated with them for security purposes. Keep note of this number, as it's necessary for connecting to a network. If you lose the PIN associated with your SIM card, you may need to contact your network operator to retrieve it. Some SIM cards become locked if an incorrect PIN is entered too many times. If you're unsure of what the PIN is, look at the documentation that came with your SIM.

Using a PUK (PIN Unlock Code), it is possible to reset a lost PIN with the GSM shield and an Arduino. The PUK number will come with your SIM card documentation.

Look at the PIN Management example in the "tools" folder, bundled with the GSM library for an example of how to manage your PIN number with the PUK.

There are a few different sizes of SIM cards; the GSM shield accepts cards in the mini-SIM format (25mm long and 15mm wide) (Figure 1.7).[11]

To upload sketches to the board, connect it to your computer with a USB cable and upload your sketch with the Arduino IDE. Once the sketch has been uploaded, you can disconnect the board from your computer and power it with an external power supply.

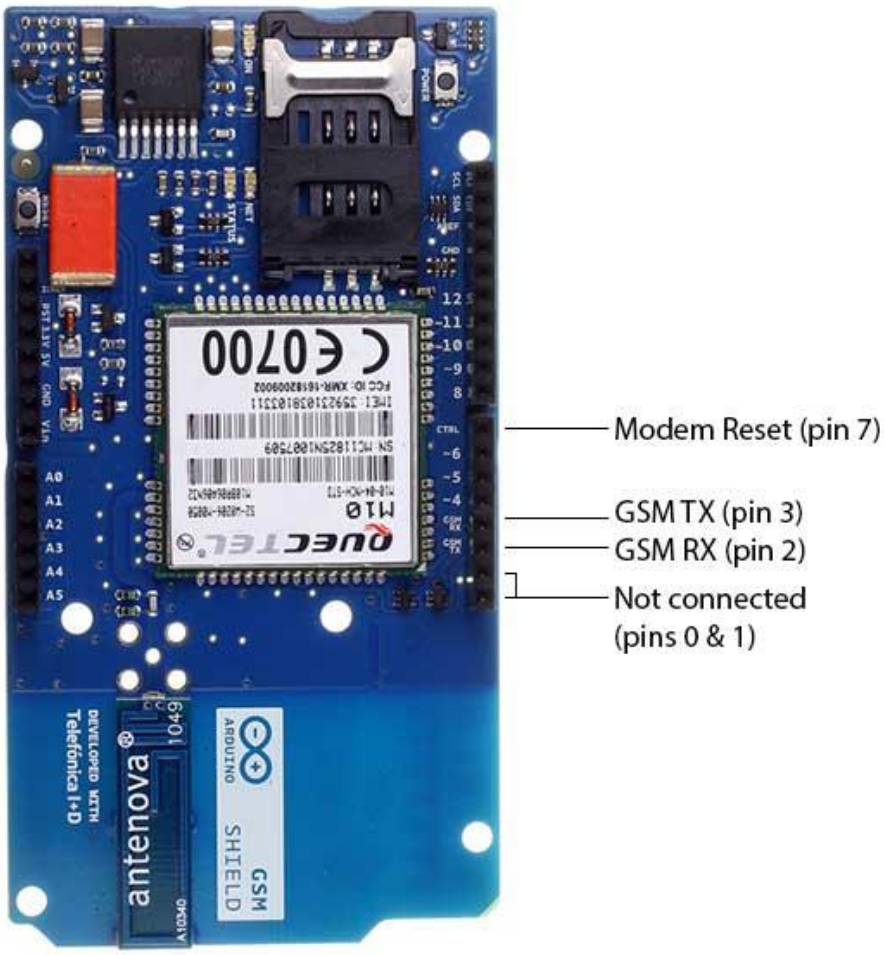


Figure 1.7 – GSM module

Digital pins 2, 3 and 7 are reserved for communication between the Arduino and modem and cannot be used by your sketches. Communication between the modem and Arduino is handled by the Software Serial library on pins 2 and 3. Pin 7 is used for the modem reset.

When the yellow status LED turns on, it means the modem is powered, and you can try connecting to the network.

Developer versions of the GSM shield required you to press press the Power button on the shield for a few moments to turn the modem on. If you have an early version of the shield, and it does not turn on automatically, you can solder a jumper to the CTRL/D7 pad on the reverse side of the board, and it will turn on when an attached Arduino receives power.[11]

GSM Library. The GSM library handles communication between Arduino and the GSM shield. The majority of functions are for managing data, voice, and SMS communication. There are also a number of utilities for managing information about the modem and the SIM card's PIN.[11]

2 Design part

2.1 Atmel Microcontrollers AVR Architecture

AVR microcontrollers have a Harvard architecture (the program and everything else are in different address places) and a command system closest to the R.I.S.C. ideology. The AVR processor has 32 general-purpose 8-bit registers integrated into a register file.[4] Unlike the “ideal” RISC, registers are not completely orthogonal:

- different teams work only with the r16-r31 registers. Commands that work with a specific operand are related to them: ANDI / CBR, ORI / SBR, CPI, LDI, LDS (16-bit), STS (16-bit), SUBI, SBCI, and also SER and MULS;
- commands increasing and decreasing a 16-bit value (where available) with a specific operand (ADIW, SBIW) work only with one of the pairs r25: r24, r27: r26 (X), r29: r28 (Y), or r31 : r30 (Z);
- the command to copy a pair of registers (where there is access) works only with the nearest registers that start with odd (r1: r0, r3: r2- r31: r30);
- the product report (in those models in which the multiplication module is present) should always be placed in r1: r0. And yet, only this pair is used for operands for a self-programming instruction (where it is available);
- some versions of the product commands accept only registers from the r16-r23 range (FMUL, FMULS, FMULSU, MULSU) for arguments (Figure 2.1).[4]

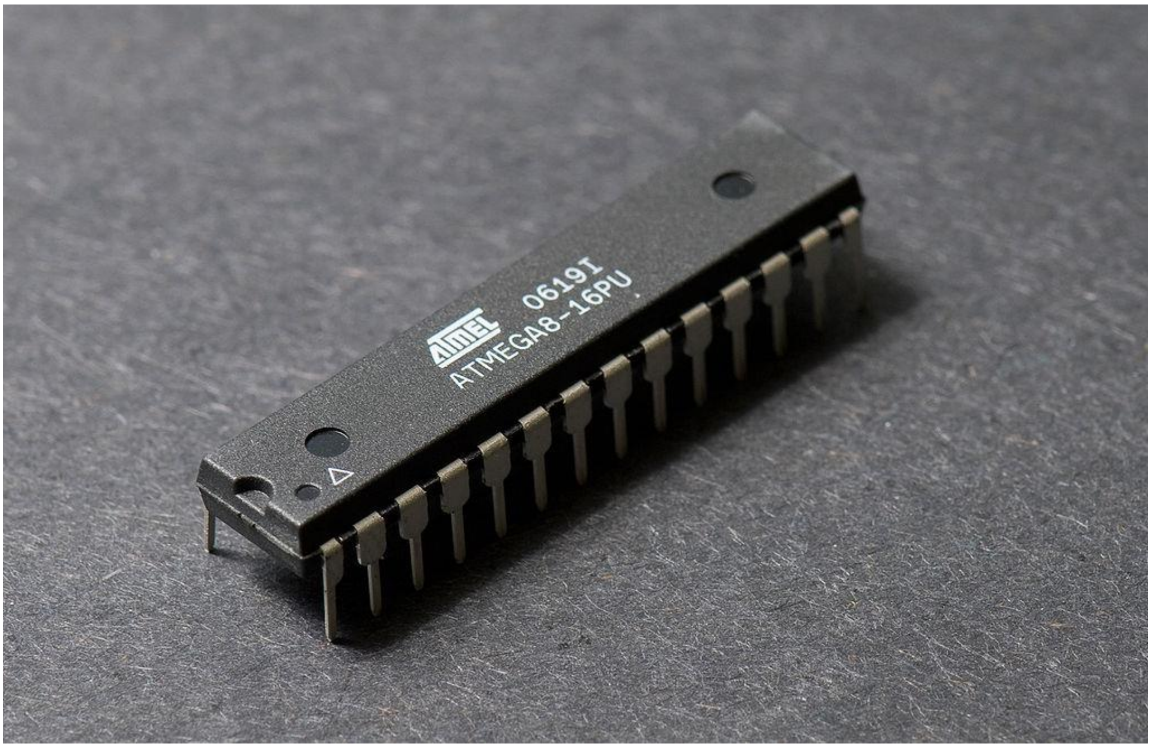


Figure 2.1 - Microcontroller AVR

The organization of the A.V.R microcontroller teams is very developed and counts from 90 to 133 different instructions in various models.

Most commands occupy only one memory location (16 bits). Most of the commands are executed in 1 cycle.

We divide the total number of A.V.R microcontroller teams into a number of groups:

- teams of logical operations;
- teams of arithmetic operations as well as shift commands;
- bits operation commands;
- data transfer commands;
- control transfer commands;
- process control teams.

Peripheral devices are managed using the address data space. To make it convenient to have “abbreviated commands” IN / OUT (Figure 2.2).[4]

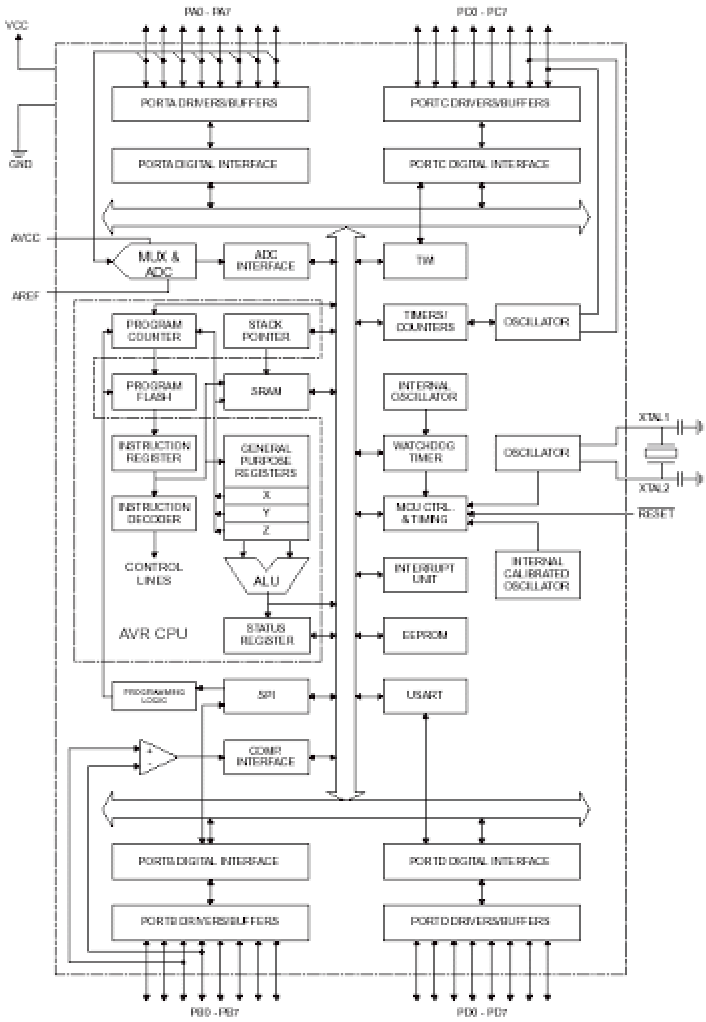


Figure 2.2 - Block diagram of a typical AVR microcontroller

AVR microcontrollers have developed peripherals:

- up to 86 functional, bidirectional GPIO I / O ports. In connection with the software-predetermined configuration of the registers, there are all chances, regardless of each other, to function in the order of a “powerful” driver, issuing or receiving (to ground) current up to forty milliamps, which is sufficient to turn on the LED indicators. Each of the ports conclusions is capable of being configured in an “introduction” or in an independent stay or with the use of an integrated pull-up (to an advantage) resistor[4];

- up to three external sources of interruptions (along the front, cut, or level) and up to thirty-two according to the change in the input level;

- as a source of clock pulses it can be selected:

a) ceramic or quartz resonator;

b) external clock signal;

c) a calibrated internal RC generator (frequency 1, 2, 4, 8 MHz, and
for some ATtiny models - 4.8, 6.4, 9.6 MHz and 128 kHz).

- internal Flash memory commands up to 256 KB (10,000 rewriting cycles);

- Project setup is performed with support for JTAG or debugWIRE interfaces: JTAG signals (TMS, TDI, TDO, and TCK) are multiplexed to the input-output port. The operating mode - JTAG or port - is set by the corresponding bit in the fuses register. AVR MKs come with JTAG enabled;

- Internal EEPROM data memory up to 4 KB (ATmega / ATxmega) / 512 bytes (ATtiny) (up to 100,000 rewriting cycles);

- Internal SRAM up to 32 KB (ATxmega) / 16 KB (ATmega) / 1 KB (ATtiny) with 2 clock access;

- External memory up to 64 KB (ATmega8515, ATmega162, ATmega640, ATmega641, ATmega1280, ATmega1281, ATmega2560, ATmega256) [6];

- Timers with a resolution of 8, 16 bits;

- PWM modulator (PWM) 8, 9, 10, 16 – bit;

- Analog comparators;

-ADC (ADC) with differential inputs, bit 8 (ATtiny) / 10 (ATtiny / ATmega) / 12 (ATxmega) bits:

a) programmable gain before the ADC 1, 10 and 200 (in differential mode);

b) in the property of the main effort they will be able to represent: supply voltage, external voltage, or internal reference voltage of 2.56 V / 1.1 V (in some ATtiny).

- various serial interfaces, including:

a) two-wire TWI interface compatible with I²C;

b) universal synchronous / asynchronous UART;

c) synchronous serial port Serial Peripheral Interface (SPI).

- USB series AT90USBxxxx;

- CAN series AT90CANxxx;

- LCD series ATmega169 and ATmega329;

- temperature sensors ATtiny25, ATtiny45, ATtiny85;

- almost all (individual premature modifications of ATtiny, for which reprogramming will go through a special interface) support in-circuit programming (ISP) via the serial SPI interface[4];

- Support for self-programming, in which the main program will change part of its code;

- Support for loading the main program using a rewriting-protected subroutine (bootloader). Listing of the main program is usually received through one of the ports of the microcontroller using one of the standard protocols;

- a number of low power modes.[4]

2.2 Arduino UNO Board on ATmega328

General Information:

Arduino Uno control device created in ATmega328. The platform has fourteen digital inputs / outputs (6 of which can be used exactly as PWM outputs), 6 analog inputs, a 16 MHz piezoelectric crystal oscillator, a USB micro-connector, a power micro-connector, an ICSP micro-connector and a reset button. To work, you must connect the platform to the PC using a USB cable, or give power with the support of an AC / DC adapter or battery. Unlike absolutely all previous boards that used the FTDI USB controller for USB interconnection, the newest Arduino Uno uses the ATmega8U2 controller. "Uno" translates as 1 from Italian and the creators thus allude to the upcoming Arduino 1.0. The latest payment is accepted by the flagship Arduino board line (Figure 2.3).[5]

Parameters:

Table 2.1 – Summary Parameters of Arduino uno Board

Microcontroller	ATmega328
Working voltage	5 V
Input voltage (recommended)	7-12 V
Input voltage (limit)	6-20 V
Digital I/O	14 (6 from which can be used as PWM outputs)
Analog Outputs	6
DC input / output	40 mA
DC output 3.3 V	50 mA
Flash-memory	32 Kb (ATmega328) from which 0.5 Kb used for downloader
RAM	2 Kb (ATmega328)
EEPROM	1 Kb (ATmega328)
Clock frequency	16 MHz

Power:

Arduino Uno is able to extract power through a USB connection or from an external power source. The power source is knocked out automatically. External power (not USB) is capable of being transmitted via an AC / DC voltage converter (power supply) or a battery. The voltage converter is connected using a 2.1 mm connector with a central positive pole. The battery cable connects to the Gnd and Vin pins of the power connector. The program is capable of operating the presence of external power supply from 6 V up to twenty V. When the supply voltage is lower than 7 V, the 5V output is able to provide less than 5 V, while the program is capable of functioning unstable. When applying a voltage greater than 12 V, the voltage regulator is able to burn out and ruin the board. The proposed range is from 7 V to 12 V.

Figure 2.3 – Arduino UNO

Power Leads:

VIN. The input is used to supply power from an external source (in the absence of 5 V from the USB connector or other regulated power supply). The supply voltage is supplied through this pin.

5V. An adjustable voltage source used to power the microcontroller and parts on the board. Power can be supplied from the VIN pin through a voltage regulator, or from a USB connector, or other custom 5V voltage source.

3.3VThe voltage at terminal 3.3 V is generated by an internal regulator in the circuit. Maximum current consumption 50 mA.

GND. Grounding leads

Memory:

The ATmega328 microcontroller has 32 kB of flash memory, which 0.5 kB are used to store the bootloader, and another 2 kB of RAM (SRAM) and 1 kB of EEPROM. (Which is read and written using the EEPROM library).

Inputs and outputs

All of the fourteen Uno digital pins are configured as input or output using the pin Mode (), digital Write (), and digital Read (), functions. The pins operate at a voltage of 5 V. All pins have a load resistor (disabled by default) 2 0-5 0 kOhm and can pass up to 40 mA. Certain findings include special features:

Serial bus: 0 (RX) and 1 (TX). The pins are used to read (RX) and transmit (TX) TTL data. These pins are connected to these pins of the ATmega8U2 USB-to-TTL serial bus chip.

External interrupt: 2 and 3. These outputs can be configured to trigger an interrupt either at a low value, at a rising or falling edge, or to change a value. Detailed instructions are provided in the attach Interrupt () function description.

PWM: 3, 5, 6, 9, 10, and 11. All of the pins provide PWM with a resolution of 8 bits using the analogWrite () function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). Through these conclusions, an SPI connection is made, for which the SPI library is used.

LED: 13. An internal LED that is connected to digital pin 13. If the value on the pin has high potential, the LED lights up.

There are six analog inputs (labeled A0 .. A5) on the Uno platform, all with a resolution of ten bits (that is, they can take 1024 different values). Accordingly, the outputs have a measuring range of up to five V, but it is possible to change the upper limit by means of the AREF output and the analog Reference () function. Certain conclusions have special functions:

I2C: 4 (SDA) and 5 (SCL). Using the pins, I2C (TWI) communication is used by the Wire library.

An additional pair of platform conclusions:

AREF. Reference voltage for analog inputs. Used with analogReference () function.

Reset A low output signal restarts the microcontroller. As a rule, it is used to connect the reset button on the expansion board, which blocks access to the button on this Arduino board.

Pay attention to the connection between the Arduino pins and the ATmega328 ports.[5]

Communication:

A number of devices are used on the Arduino Uno platform to create communication with a computer, other arduino devices, or microcontrollers. The ATmega328 supports the subsequent UART TTL (5 V) interface used by pins 0 (RX) and 1 (TX). The ATmega8U2 chip used on the board sends this interface via USB, the programs "communicate" with the board through the virtual COM port to the computer. The ATmega8U2 firmware uses standard USB COM drivers, no other drivers are needed, but on Windows you need the ArduinoUNO.inf file to connect. Monitoring the serial bus (Serial Monitor) of the arduino program makes it possible to send and receive text when connected to the platform. The RX and TX LEDs on the platform should blink when transmitting data via the FTDI chip or USB connection (but not when using serial transmission through terminals 0 and 1).

The SoftwareSerial library can be used to serialize data through any of the Uno digital pins.

ATmega328 can support I2C (TWI) and SPI interfaces. The Wire library has been added to Arduino for the convenience of using the I2C bus.

Programming:

The platform is programmed using Arduino software. From the Tools> Board menu, “Arduino Uno” is configured (according to this microcontroller). All information is written in the manual or instructions.

The ATmega328 microcontroller is delivered with an existing bootloader, making it easy to record the latest programs without using external programmers. Communication is performed by the original STK500 protocol.

It is possible not to use the bootloader and program the microcontroller through the outputs of the ICSP (in-circuit programming). All information is provided in this manual.

Automatic (software) reboot:

Uno is designed so that before writing new code, the reboot becomes the program itself on the computer, and not by pressing a button on the platform. One of the DTR lines of the ATmega8U2 chip controlling the data stream (DTR) is connected to the reset pin of the ATmega3.28 microcontroller via a 100nF capacitor. The activation of this line, that is, the supply of a low level signal, restarts the microcontroller. The Arduino program, using this function, downloads the code with one click of the Upload button in the programming environment itself. DTR low-level signal supply is coordinated with the beginning of code writing, this reduces the bootloader time.

The function may have 1 more application. Uno is rebooted every time you connect to the arduino program on a computer running Mac X or Linux (via USB). For the next half second after the reboot, the bootloader functions. During the programming period, a delay of some first bytes of code is applied in order to avoid the platform receiving incorrect data (all but the code of the new program). When one-time debugging of code written to the platform, or input of some other data during the first run, takes place, you need to understand what the program on the computer waits for a second before transmitting the data.[6]

On Uno, you can disconnect the automatic reload line by breaking this line. The contacts of the microcircuits at both ends of the line are connected for recovery. The line is marked "RESET-EN". You can turn off automatic restart by connecting a 110 Ohm resistor between the 5 V source and this line.[6]

2.3 GSM module SIM900

The GSM / GPRS module SIM900 is the representative of a new generation of low-cost GSM / GPRS modules from SIMCOM.

When developing the module, the wishes of consumers of modules of previous generations were taken into account, the reliability of embedded software was carefully worked out, new energy-saving modes were introduced, and the dimensions were significantly reduced. At the same time, key advantages were retained: the popular form factor with end rations, which allows not to use expensive mounting and soldering control technologies, a convenient built-in TCP / IP stack, and low price.

All this allows the module to be used in a wide range of products, including personal and automotive trackers, security systems and industrial automation, and other areas.

The Arduino GPRS / GSM Shield board (Figure 2.4) provides us with the ability to use GSM-mobile data for remote reception and transmission of data. There are three ways to do this:

- using sending / receiving short text messages (SMS);
- sending voice (audio) commands based on CSD technologies (standard GSM data transmission technology) and / or DTMF (two-tone multi-frequency analog signal used to dial a telephone number);
- using packet data transmission based on GPRS technology.

The board is based on the SIMCom SIM900 module.

Also located on it:

- SIM card slot;
- 3.5 mm jack for audio input and output;
- connector for an external antenna.

Figure 2.4 – GSM module SIM900

Communication with the board is done through a serial connection using a set of AT commands. Using jumpers on the board, it is possible to set the contacts used for communication: hardware 0-1 or 2-3 (on some boards) 7-8 for working through SoftwareSerial.

2.4 Relay module

In my thesis, I used a 2-section relay device for the arduino platform. And so we will understand what it is (Figure 2.5). Relay - a device specialized for closing / opening electric circuits Turning a relay on and off, we can control whether a current flows through it or not at all. Adjusting the micro relay with Arduino support is as easy as LED.

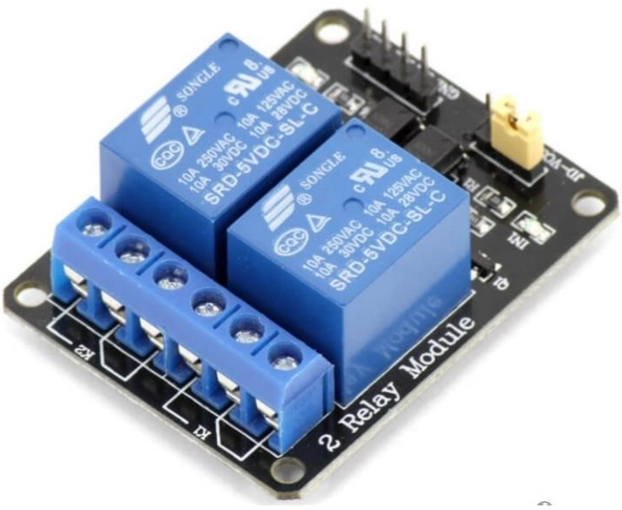


Figure 2.5 – Relay module

If the relay contacts close when a control voltage is applied, then such a relay is called a closing relay. If, when a control voltage is applied, the relay contacts open, and in the normal state the contacts are closed, then the relay is called opening. Also, relays are direct and alternating current, single-channel, multi-channel and switching. The principle of operation is the same for everyone. And in figure 2.6 was shown wiring diagram.

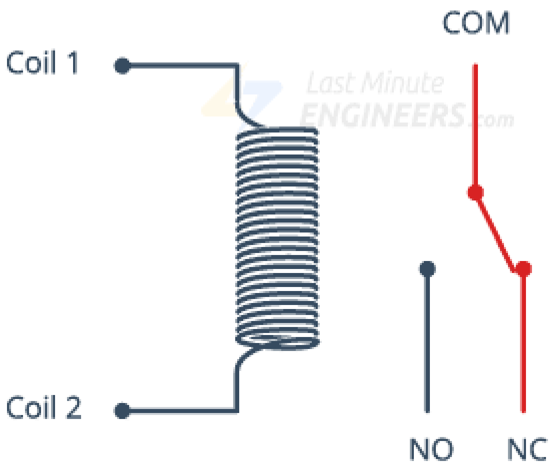


Figure 2.6 – Relay scheme

The Arduino relay module has total of six pins: three on one side and three on other side.On the bottom side, there are three pins which are signal, 5V and ground. We will connect these pins with the Arduino. While on the other side, there are NC (Normally close), C (Common) and the NO (normally open) which are the output pins of the 5V relay. There, we will connect the output device.

The Arduino relay module can be used in two states which are:

- Normally open state (NO)
- Normally closed state (NC)

In the normally open state, the initial output of the relay will be low when it will be powered. In this state, the common and the normally open pins are used.

In the normally closed state, the initial output of the relay will be high when it will be powered. In this state, the common and the normally close pins are used.

2.5 Fire detector

Fire detector - a technical tool that is installed directly on the protected object to transmit an alarm notification of a fire to a fire alarm control panel and / or warning and display information about the detection of fires. Most often, detectors transmit information about their condition to the loop of a fire alarm control panel. The detector detects a fire by monitoring changes in the physical parameters of the environment caused by the fire. Unlike "sensors", fire detectors are not measuring instruments. Technical means that are designed to determine fire hazard use non-metric scales of names or order. Detectors are the most important elements of fire alarm systems and automation. They mainly determine the capabilities and characteristics of the system as a whole.

1. Gas sensor MQ-2.The MQ-2 sensor is a semiconductor device (Figure 2.7). The principle of operation of the sensor is based on a change in the resistance of the thin-film layer of tin dioxide SnO2 in contact with the molecules of the gas being detected. The sensor element consists of a ceramic tube coated with Al2O3 and a sensitive layer of tin dioxide deposited on it. A heating element passes inside the tube, which heats the sensitive layer to a temperature at which it begins to respond to the gas being detected. Sensitivity to different gases is achieved by varying the composition of impurities in the sensitive layer.

2. Heater power mode selection. The sensor has two operating modes, switchable by a jumper:

1) The sensor heater is always on. Thus, you can do with one three-wire loop;
2) Heater control software.

Figure 2.7 – Gas sensor MQ-2

3. Flame detector. The flame detector is used in modern fire alarm models, along with thermal, optical, smoke and gas sensors. The fire detector is designed to detect a source of ignition at the initial stage. The sensitive device is triggered earlier than the traditional thermal sensor, until the temperature in the controlled zone reaches a critical value. Flame sensors are used indoors and in large open areas (Figure 2.8).

The response of the sensors of the device depends on the spectrum of electromagnetic radiation of the flame arising from the ignition of various materials, and the range of spectral sensitivity of the fire detector. All parameters and characteristics are presented in the technical documentation for the products.

Figure 2.8 – Flame detector

4. Temperature sensor (thermistor). This module is a digital temperature sensor. The module allows you to register the achievement of a given temperature by changing the signal at the digital output DO. The threshold temperature is set by a potentiometer. An NTC thermistor is used to measure the temperature, and an LM393 comparator is used to obtain a digital signal. The sensor is easy to use and in your device (Figure 2.9).

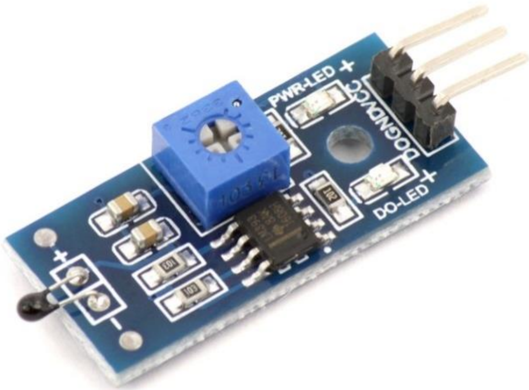


Figure 2.9 – Thermistor

5. DC DC Convertor. DC/DC converters are electronic components in a design that provide a specific voltage and isolation between input and output (Figure 2.10).

They can be used for many different reasons and provide, in a simple way, all different voltages used by electronic components in one single board. The isolation within the DC/DC converter allows the design engineer to comply with the safety regulations and solve issues such as interferences and failure protection. DC/DC converters also offer a flexible and clean solution to Distributed Power Architecture systems.

The function of a DC/DC converter module is to meet at least one of the following requirements:

- to match the secondary load to the primary power supply;
- to provide isolation between primary and secondary circuits;
- to provide protection against the effects of faults, short circuit or overheating;
- to simplify compliance with safety, performance or EMC legislation.

Figure 2.10 – DC DC Convertor

3 Software

3.1 Arduino board

Arduino - is a trademark of hardware and software used to create simple automation and robotics systems, and is aimed at non-professional users. The software part consists of a free software shell (IDE) for writing programs, compiling them, and programming hardware. The hardware consists of a set of mounted printed circuit boards, which are sold by official and third-party manufacturers. In the Arduino system, architecture is completely open architecture, which makes it possible to freely copy or complement the Arduino product line.
Arduino is used to form autonomous automation objects, as well as to connect to software on a computer with standard wired and wireless interfaces (Figure 3.1).[5]

The Arduino concept does not include a cabinet or mounting construct. The developer can choose the installation method and mechanical protection of the boards. Third-party manufacturers produce sets of robotic electromechanics oriented to work together with Arduino boards.[5]

Programming takes place entirely through its own software shell (IDE), available free of charge from the Arduino website. This shell has a text editor, project manager, preprocessor, compiler and tools for downloading the program to the microcontroller (Figure 3.2). It is written in Java based on the Processing project, runs on Windows, Mac OS X and Linux.

The Arduino programming language is standard C ++ (using the AVR-GCC compiler) with some distinguishing features that make it easy for beginners to write their first working program.[5]

Programs written by the Arduino programmer are called sketches (or sometimes sketches) and are saved in files with the ino extension. The Arduino preprocessor processes these files before compilation. Plus, there is the opportunity to create and connect standard C ++ files to the project.

The Arduino preprocessor itself can create the main () function, which is required in C ++, and insert the required initial operations.

The programmer must write two mandatory functions for Arduino setup () and loop (). The first is executed once at startup, the second is called in an infinite loop.

In the program listing, the programmer is not required to enter header files that are used by standard libraries. The Arduino preprocessor will add these header files according to the project configuration. But user libraries must be designated.

The Arduino IDE Project Manager has a custom library adding mechanism. They are added as source code in standard C ++ to a specific folder in the IDE working directory. And the library name is added to the library list in the IDE menu. In order for them to be included in the compilation list, the programmer must mark the necessary libraries.[5]

Arduino IDE does not have any compiler settings and other settings are minimal, making it easier for beginners to get started and reduce the risk of problems.

The simplest Arduino program consists of two functions:
setup (): the function starts once when the microcontroller starts. loop (): the function runs after setup () in an infinite loop all the time microcontroller operation.[6]

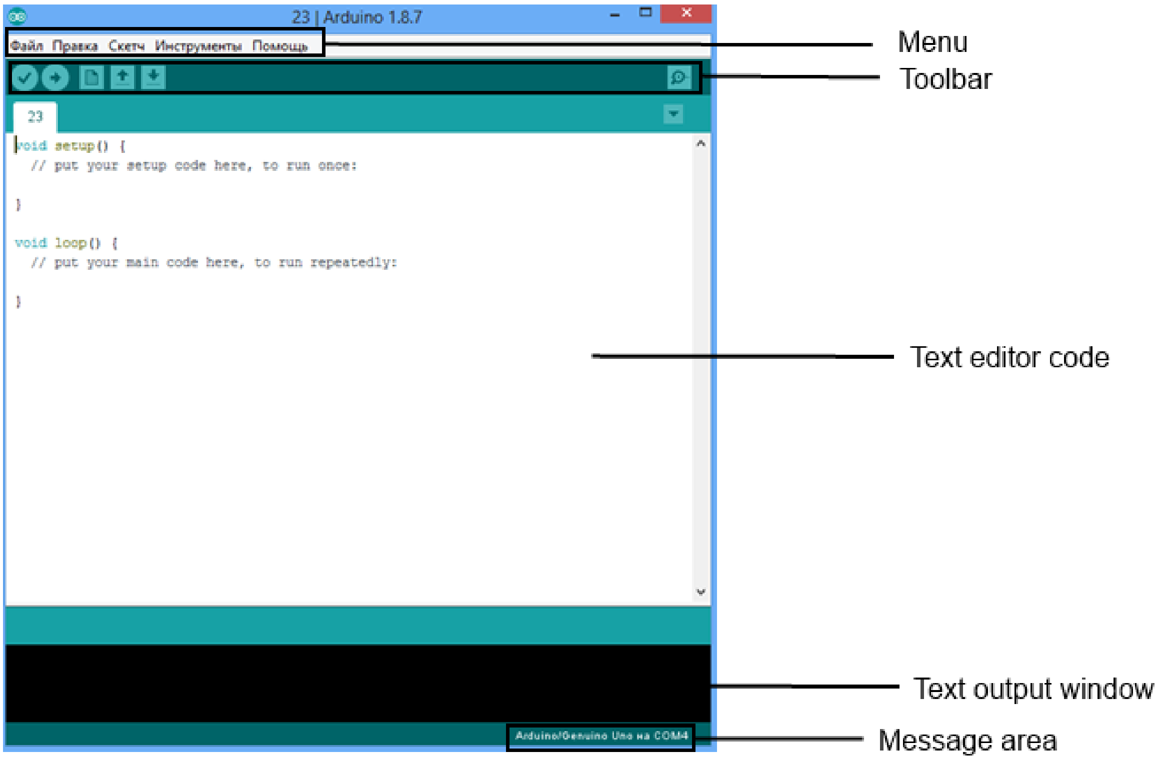


Figure 3.1 - Window of the standard Arduino IDE

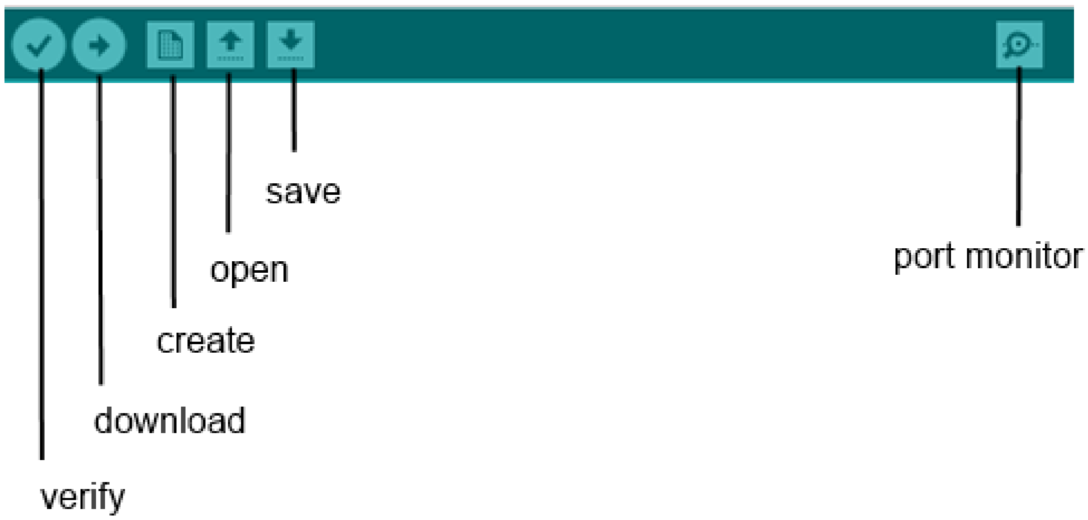


Figure 3.2 - Arduino IDE Toolbar

This is the full text of the simple fire alarm program (sketch) with two gas sensors:

int buzzer = 8; // Determine the pin used to connect the buzzer

```
int smoke = A0; // Declare a variable for smoke-sensor1, specify a pin
int Count = 0;
int ssmoke = A1; // Declare a variable for smoke-sensor2, specify a pin
// In this function, we determine the initial settings
void setup() {
  Serial.begin(9600);
pinMode(buzzer, OUTPUT); // Declare a buzzer pin as a way out
void loop() {
  int smokeVal = (analogRead(smoke) >= 100) ? 1 : 0; // Read the value from the smoke sensor1
int ssmokeVal = (analogRead(ssmoke) >= 100) ? 1 : 0;// Read the value from the smoke sensor2
  if (smokeVal + ssmokeVal == 1) {
tone(buzzer, 1900); // Give a Piezo signal
    delay(200);
    tone(buzzer, 1800);
    delay(500);
}
  else if (smokeVal + ssmokeVal >= 2) {
tone(buzzer, 2100); // Give a Piezo signal
    delay(500);
    tone(buzzer, 1900);
    delay(200);
  }
  else {
noTone(buzzer); //Turn off the Piezo signal
  }
  delay(100); // Checking values once per second
}
```

The functions shown in the example are library functions. The Arduino IDE bundle provides a large number of sample programs, and there is also Arduino documentation translated into Russian.

The program is downloaded to the Arduino microcontroller thanks to a pre-programmed special bootloader (all microcontrollers from Arduino are bundled with this bootloader). It is based on the Atmel AVR Application Note AN109. The loader performs work via RS-232, USB or Ethernet interfaces, depending on the composition of the periphery of a particular processor board.[6] In other types, such as the Arduino Mini or the unofficial Boarduino, a separate adapter is required for programming.

Due to the fact that the IDE includes support for a programmer based on AVRDude, the user has the opportunity to program the bootloader himself in a clean microcontroller. And also other types of fairly common and not expensive programmers are supported.

Recently, a large number of extensions have appeared for this program. One of the most significant is the support of the ESP8266 module, because it is considered a self-sufficient product, and is used as an independent microcontroller.

3.2 Program Listing

For using an auto fire alarm was chosen a storage room where the measuring instruments are stored. Three types of sensors are installed in the room, such as gas sensor, flame detector and thermistor. And if one sensor is triggered, the blue LED lights up and a warning signal is given, and when two or more sensors are triggered and the red LED lights up, an alarm signal is given and a message is sent through the GSM-channel. So on the figure 3.3 was shown wiring scheme of automated fire alarm without GSM shield.

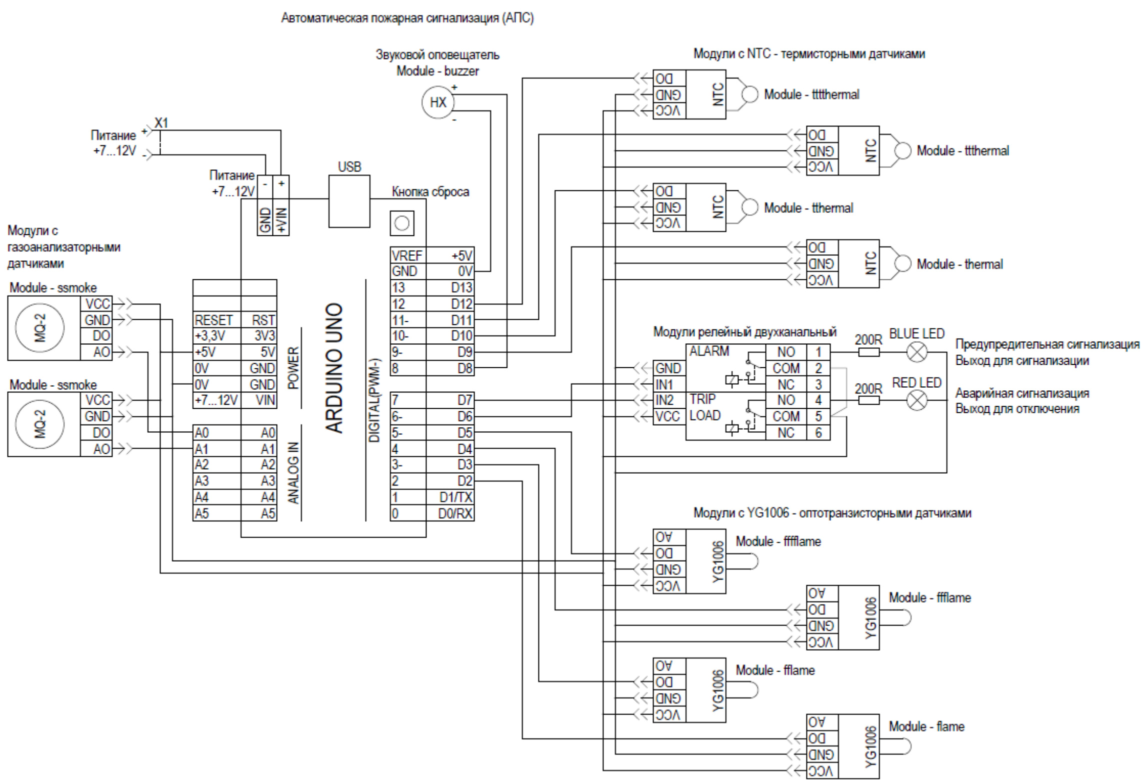


Figure 3.3 – Wiring scheme

/* Auto Fire Alarm Sketch (AFA)

```
*/
#include <GPRSk_Shield_Arduino.h>  // library for working with a GPRS device
#include <SoftwareSerial.h>  // library for emulating a serial port
SoftwareSerial mySerial(0, 1);  // create the mySerial object and pass the numbers of the control pins RX and TX
#define PHONE_NUMBER  "+77473058085"  // number to which we will send a message
GPRSk gprs(mySerial);     // create an object of the GPRS class and pass the mySerial object to it
unsigned long millissend;
#define flame 2 // declare a variable for flame sensor 1 and indicate the pin
#define fflame 3 // declare a variable for flame sensor 2 and indicate the pin
#define ffflame 4 // declare a variable for flame sensor 3 and indicate the pin
#define fffflame 5 // declare a variable for flame sensor 4 and indicate the pin
#define thermal 9 // declare a variable for thermal sensor 1 and indicate the pin
#define tthermal 10 // declare a variable for thermal sensor 2 and indicate the pin
#define ttthermal 11 // declare a variable for thermal sensor 3 and indicate the pin
#define ttttthermal 12 // declare a variable for thermal sensor 4 and indicate the pin
int relay = 6; // determine the pin used to connect the alarm relay 1
int zrelay = 7; // determine the pin used to connect the relay2 emergency shutdown
int buzzer = 8; // determine the pin used to connect the tweeter
int smoke = A0; // declare a variable for smoke-sensor1, we specify a pin
int Count = 0;
int ssmoke = A1; // declare a variable for smoke-sensor2, we specify a pin

// In this function, we determine the initial settings
void setup() {
  Serial.begin(9600);
mySerial.begin(9600);   // open Serial connection with GPRS Shield
  pinMode(relay, OUTPUT); // Declare pin relay1 as an output
  pinMode(zrelay, OUTPUT); // Declare pin relay2 as an output
  pinMode(buzzer, OUTPUT); // Declare pin buzzer as an output
  digitalWrite(relay, HIGH); // Turn off the relay - send a high signal
  digitalWrite(zrelay, HIGH); // Turn off the relay - send a high signal
  pinMode(flame, INPUT);
  pinMode(fflame, INPUT);
  pinMode(ffflame, INPUT);
  pinMode(fffflame, INPUT);
  pinMode(thermal, INPUT);
```

```
  pinMode(tthermal, INPUT);
  pinMode(ttthermal, INPUT);
  pinMode(tttthermal, INPUT);
// wait until the serial port monitor opens
  // in order to track all the events in the program
  while (!Serial) {
}
Serial.print("Serial init OK\r\n");
gprs.powerOn();    // turn on the GPRS shield
  // check if there is a connection with the GPRS device
  while (!gprs.init()) {
    // if there is no connection, wait 1 second
    // and display an error message
    // the process repeats in a cycle
    // until a response from the GPRS device appears
    delay(1000);
    Serial.print("GPRS Init error\r\n");
  }
Serial.println("GPRS init success");     // conclusion about successful initialization of GPRS Shield
}

void loop() {
  int flameVal = (digitalRead(flame) == LOW) ? 1 : 0;
  int fflameVal = (digitalRead(fflame) == LOW) ? 1 : 0;
  int ffflameVal = (digitalRead(ffflame) == LOW) ? 1 : 0;
  int fffflameVal = (digitalRead(fffflame) == LOW) ? 1 : 0;
  int thermalVal = (digitalRead(thermal) == LOW) ? 1 : 0;
  int tthermalVal = (digitalRead(tthermal) == LOW) ? 1 : 0;
  int ttthermalVal = (digitalRead(ttthermal) == LOW) ? 1 : 0;
  int tttthermalVal = (digitalRead(tttthermal) == LOW) ? 1 : 0;
  int smokeVal = (analogRead(smoke) >= 100) ? 1 : 0; // Read the value from the smoke sensor1
  int ssmokeVal = (analogRead(ssmoke) >= 100) ? 1 : 0;// Read the value from the smoke sensor2
  if (flameVal + fflameVal + ffflameVal + fffflameVal + thermalVal + tthermalVal + ttthermalVal + tttthermalVal + smokeVal + ssmokeVal == 1) {
    digitalWrite(relay, LOW);
    digitalWrite(zrelay, HIGH); // Turn on the relay - send a low signal level
```

```
    tone(buzzer, 1900); // give a Piezo signal
    delay(200);
    tone(buzzer, 1800);
    delay(500);
Serial.println("Send SMS: ");           // send SMS
char message[16] = "FIRE";      // preparing a message to send
Serial.println("Start to send message ...");        // inform about the beginning of sending SMS to the specified number
if (gprs.sendSMS(PHONE_NUMBER, message))        // send a message to the specified number with the specified text
Serial.println("Success");
 else
Serial.println("Error");
  }
  else if (flameVal + fflameVal + ffflameVal + fffflameVal + thermalVal + tthermalVal + ttthermalVal + tttthermalVal + smokeVal + ssmokeVal >= 2) {
    digitalWrite(relay, LOW);
    digitalWrite(zrelay, LOW); // Turn on the relay - send a low signal level
    tone(buzzer, 2100); // give a Piezo signal
    delay(500);
    tone(buzzer, 1900);
    delay(200);
  }
  else {
    digitalWrite(relay, HIGH);
    digitalWrite(zrelay, HIGH); // Turn off the relay - send a high signal level
    noTone(buzzer); // Turn off the piezo signal
  }

  delay(100); // Checking values once per second.
}
```

On the figures 3.4, 3.5, 3.6 were shown screenshots of program code and on the next figure 3.7 was screen of coming message to phone.

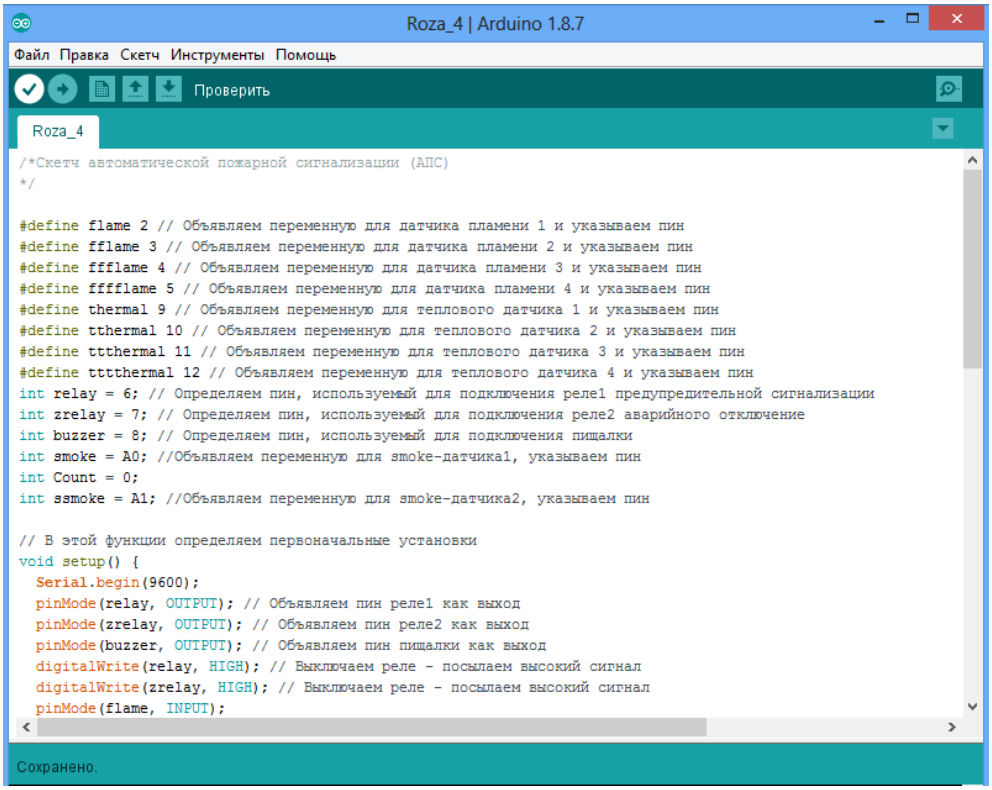


Figure 3.4 – Program code screenshot

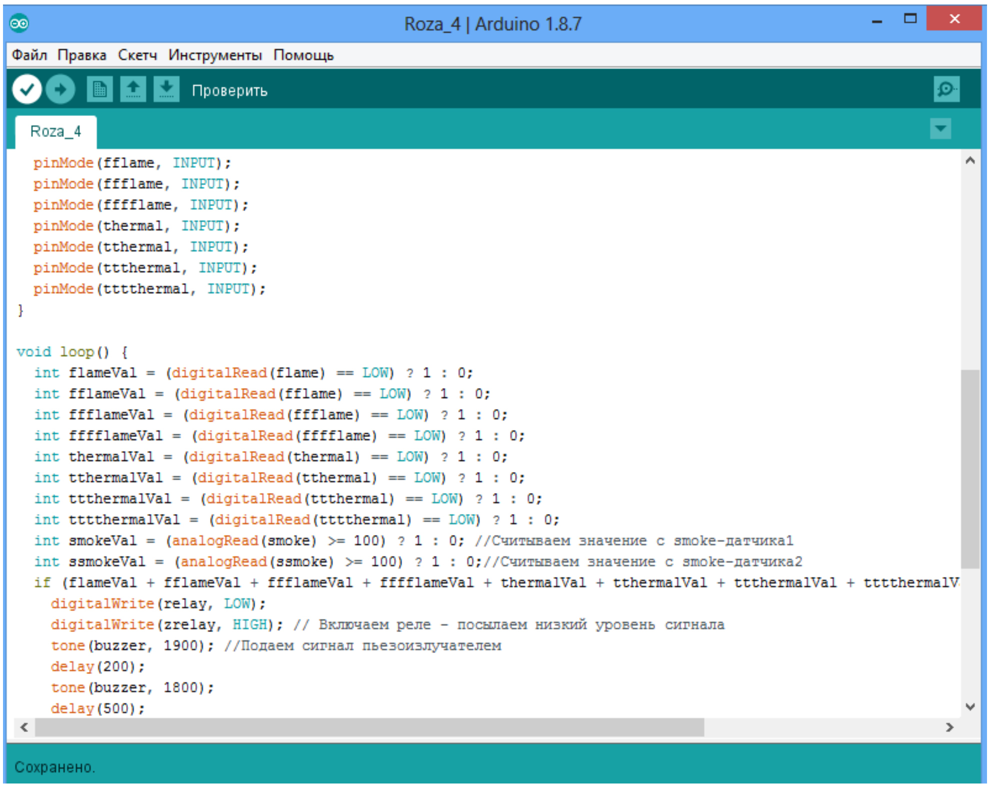
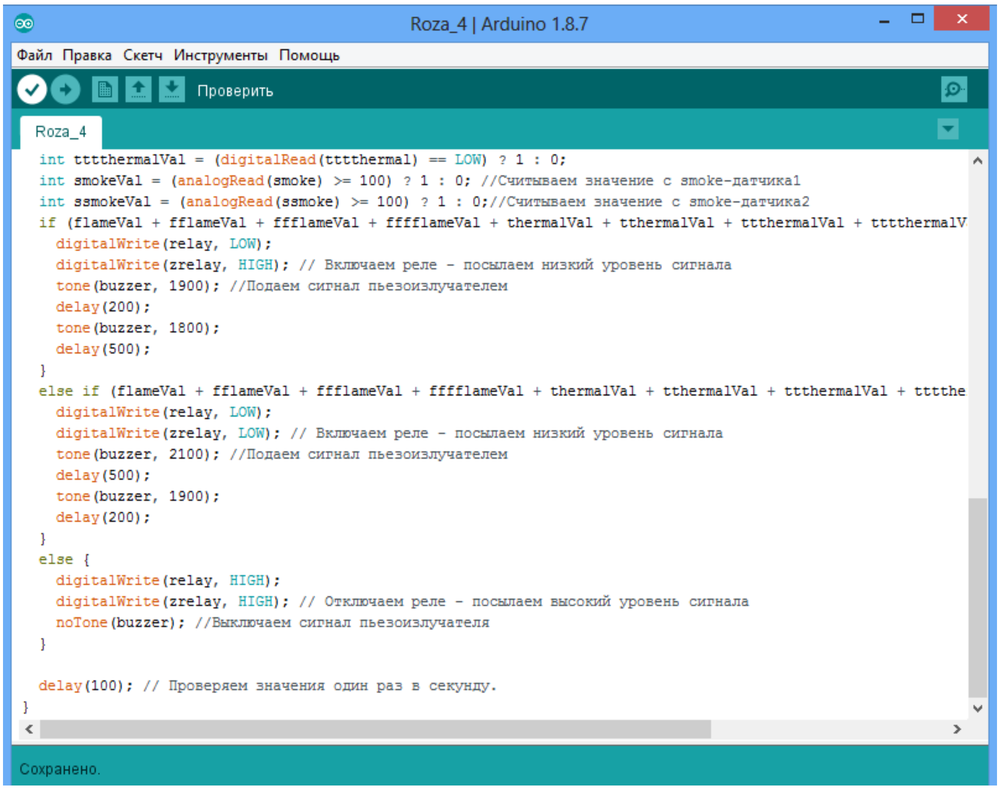


Figure 3.5 – Program code screenshot



Roza_4 | Arduino 1.8.7

Файл Правка Скетч Инструменты Помощь

Проверить

Roza_4

```
  int ttttthermalVal = (digitalRead(ttttthermal) == LOW) ? 1 : 0;
  int smokeVal = (analogRead(smoke) >= 100) ? 1 : 0; //Считываем значение с smoke-датчика1
  int ssmokeVal = (analogRead(ssmoke) >= 100) ? 1 : 0;//Считываем значение с smoke-датчика2
  if (flameVal + fflameVal + ffflameVal + fffflameVal + thermalVal + tthermalVal + ttthermalVal + ttttthermalV
    digitalWrite(relay, LOW);
    digitalWrite(zrelay, HIGH); // Включаем реле - посылаем низкий уровень сигнала
    tone(buzzer, 1900); //Подаем сигнал пьезоизлучателем
    delay(200);
    tone(buzzer, 1800);
    delay(500);
  }
  else if (flameVal + fflameVal + ffflameVal + fffflameVal + thermalVal + tthermalVal + ttthermalVal + tttthe
    digitalWrite(relay, LOW);
    digitalWrite(zrelay, LOW); // Включаем реле - посылаем низкий уровень сигнала
    tone(buzzer, 2100); //Подаем сигнал пьезоизлучателем
    delay(500);
    tone(buzzer, 1900);
    delay(200);
  }
  else {
    digitalWrite(relay, HIGH);
    digitalWrite(zrelay, HIGH); // Отключаем реле - посылаем высокий уровень сигнала
    noTone(buzzer); //Выключаем сигнал пьезоизлучателя
  }

  delay(100); // Проверяем значения один раз в секунду.
}
```

Сохранено.

Figure 3.6 – Program code screenshot

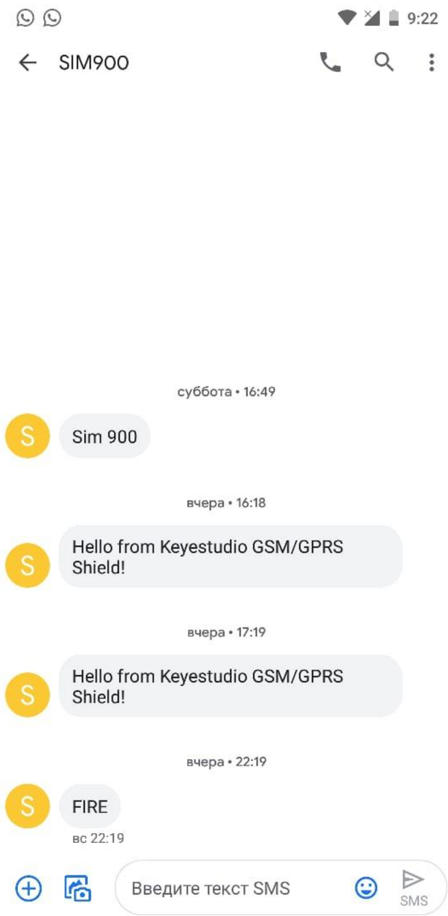


Figure 3.7 – Coming message to phone

3.3 Port Monitor

Port Monitor is a small utility included with the Arduino IDE. It is designed to communicate using a serial port, most often with an Arduino. Since the Arduino IDE does not have built-in tools for debugging firmware, the port monitor is the only tool available for this.[10]

The utility consists of one window and at the same time can work with only one serial port, the number of which was selected in the Arduino IDE. Conventionally, this window can be divided into three parts:

- in the upper part there will be an input field. With it, you can send data to the serial port;
- in the central part, data received from the serial port will be displayed;
- in the lower part is the settings menu (Figure 3.8). When auto-scrolling is on, the received data will always scroll down and you will see the latest information received. Here you can also choose the format of the postfix (more about them below), added after the sent line, and the data transfer rate.[10]

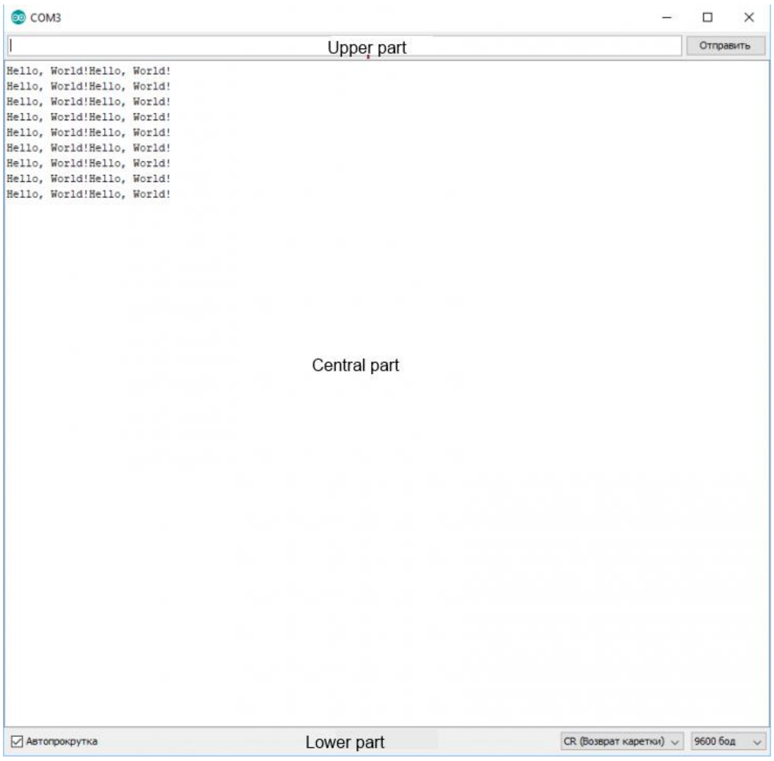


Figure 3.8 – Port monitor parts

Now about working with the Arduino serial port. In order to establish a connection in the sketch, namely in the setup function, you need to call the begin method of the Serial class and specify the connection speed:

Serial.begin (9600);

Also, during initialization, you can declare additional settings: the number of information bits in a byte (8 by default), stop bits (1 by default), and the presence of a parity bit (no default).

The following baud rates (including service characters) are available for correct operation with the port monitor: 300; 1200; 2400; 4800; 9600; 19200; 38400; 57600; 74880; 115200; 230400; 250000. For intensive work I chose 19200 bps. Send data with Arduino using the print (no line break) and println (line break) methods of the Serial class.[10] On the figure 3.9 was shown port monitor feedback.

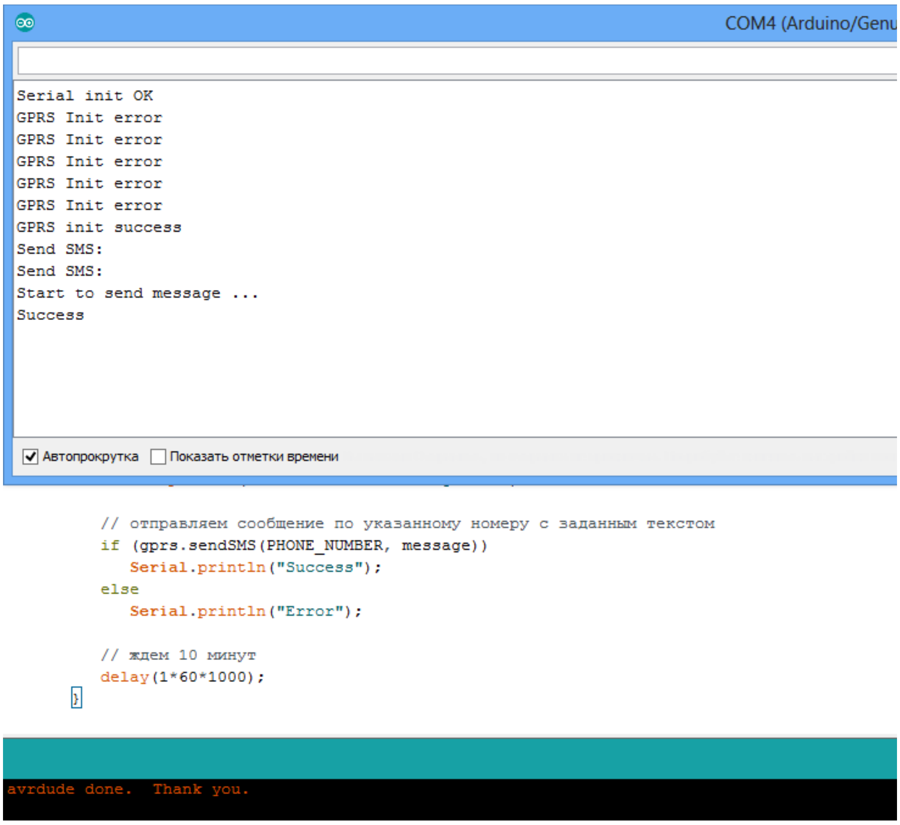


Figure 3.9 – Port monitor output

4 Life safety

In this section, such calculations were made as the calculation of artificial lighting, the calculation of air conditioning, fire safety. As lighting, we used fluorescent lamps in a room with no windows.

We determined the required number of air conditioners to create comfortable working conditions in the room. Significant excesses of heat (the difference between the heat dissipation in the room and the heat dissipation through walls, doors, etc.) can occur in the room due to the heat generated by the production equipment, the removal of which, first of all, should be ensured by the ventilation system.

The possibility of a fire situation at communication facilities is not very large. OU-5 hand-held carbon dioxide fire extinguishers are installed in the room, in the courtyard of the building there is a shield with the equipment necessary for extinguishing.

4.1 Fire forecast

The fire situation is understood as the totality of the consequences of natural disasters, accidents (catastrophes), primary and secondary damaging factors of nuclear weapons, other modern weapons and, most of all, incendiary weapons, as a result of which fires occur that affect the stability of the national economy and the vital functions of the population.[9]

Fire assessment includes:

- determination of the scale and nature (type) of the fire (individual foci, continuous fires, fires in the rubble, ground, top, underground, steppe (field) fires;
- speed and direction of the fire; areas of smoke zones and the time of smoke and others);
- analysis of their influence on the stability of the work of individual elements and the object as a whole, as well as on the vital activity of the population;
- conclusions about the stability of individual elements and the object as a whole to fire and recommendations for its improvement;
- proposals on the selection of the most appropriate actions of fire departments and civil defense units to localize and extinguish a fire, evacuate workers if necessary, people, population and material values from the zone (center) of fire, etc.

Assessment of the fire situation is based on a combination of forecast data and fire intelligence.

The initial data for forecasting the fire situation are: information on the most likely natural disasters, accidents (catastrophes), data on the fire and explosion hazard of the object and its elements, the environment, especially forests and settlements, weather conditions, terrain, the presence of various obstacles, water sources, etc., as well as about the enemy, his intentions and capabilities for the use of nuclear weapons and incendiary weapons.

4.2 Assessment of the fire situation

Assessment of the fire situation in the center of nuclear damage is divided into a preliminary assessment of the fire situation and assessment of the fire situation after a nuclear strike.

A preliminary assessment of the fire situation is carried out in advance in peacetime in order to develop and implement, in the prescribed manner, civil defense engineering and technical measures to increase the fire resistance of the city (facility), as well as to calculate the forces and means for the fire support of rescue and emergency emergency restoration work (REERW).[9]

Preliminary fire assessment includes:

- identification of urban areas in which the formation of separate, continuous fires and fire storms is possible;
- determination of a possible fire situation on the civilian defense forces entry routes and at the facilities of the conduct of the REERW;
- determination of the possible boundaries of localization of continuous fires;
- determination of the security of the city (facility) with water for extinguishing fires;
- Calculation of forces and means for firefighting REERW.

Identification in urban areas of plots on which the formation of separate, continuous fires and fire storms is possible, is carried out on the plan of the city (object) by highlighting them using established symbols. Each building plot is assigned a serial number. The numbering of sections is carried out from the geometric center of the city in a spiral clockwise direction.[9]

The density of urban development, the degree of fire resistance and the number of storeys of buildings and structures are determined according to the architectural and planning department of the executive committee of the city council of people's deputies directly on the ground or using the topographic plan of the city.

The determination of a possible fire situation on the routes of the introduction of civil defense forces and at the facilities of the REERW is carried out in the following order:

- along the routes for introducing civil defense forces and at REERW facilities, areas are specified where continuous fires and fire storms may occur;
- the possibility of the passage of civil defense forces through building plots without protecting people and equipment from thermal radiation is being specified;
- using symbols on the city plan, explosive and fire hazardous objects, sources of fire water supply and their entrances, as well as routes for entering civil defense forces are applied.

Data on the possible fire situation on the routes for the introduction of civil defense forces and at the facilities of the REERW are used in the calculation of forces and means for the fire support of the REERW and the development of a card for fire-fighting support for the route for the introduction of the forces of civil defense.

The determination of the possible boundaries of localization of continuous fires in urban buildings (at the facility) is carried out with the aim of preventing their spread to the objects of REERW and organization of fire fighting.

The determination of the security of a city (facility) with water for extinguishing fires should be made taking into account the requirements of the Design Standards for civil defense engineering measures.

As a result of a preliminary assessment of the fire situation, the following should be developed:

- a city plan with the drawn (raised) borders of urban areas, routes for introducing civil defense forces, the location of fire hazardous facilities, city shelters, fire departments, fire reservoirs with a capacity of 300 m or more, natural reservoirs, rivers and entrances to them, building sites where it is possible formation of zones of continuous fires and fire storms, as well as a table with the results of a preliminary assessment of the fire situation in urban areas and a list of objects;

- cards for the fire support of the city, facilities and routes of deployment of civil defense forces.

Assessment of the fire situation after a nuclear strike is carried out in order to determine the scope and timing of work on fire safety REERW, restoration of fire sources; water supply, as well as calculating forces and means and preparing a decision on their use.

The initial data for assessing the fire situation in the center of nuclear damage are:

- type of explosion, ammunition power, epicenter coordinates and time of the explosion;

- speed and direction of the middle and surface winds;

- materials for a preliminary assessment of the fire situation.

Assessment of the fire situation in the center of nuclear damage is carried out in the following order:

- on the city plan, on which the data of preliminary assessment of the fire situation are plotted, the type, power, center (epicenter) and date (hours, minutes, day, month) of the explosion are shown;

- depending on the power of the ammunition.

4.3 Plan of warehouse

Warehouse - territory, premises (also their complex), designed to store material assets and provide warehouse services. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport companies, customs, etc.

The measuring instruments warehouse consists of two containers 12 meters long and 6 meters wide, 3 meters high, and an area of 72 m^2. It is located on the premises of the company. There is one large entrance door and there is not a single window in the warehouse (Figure 4.1).

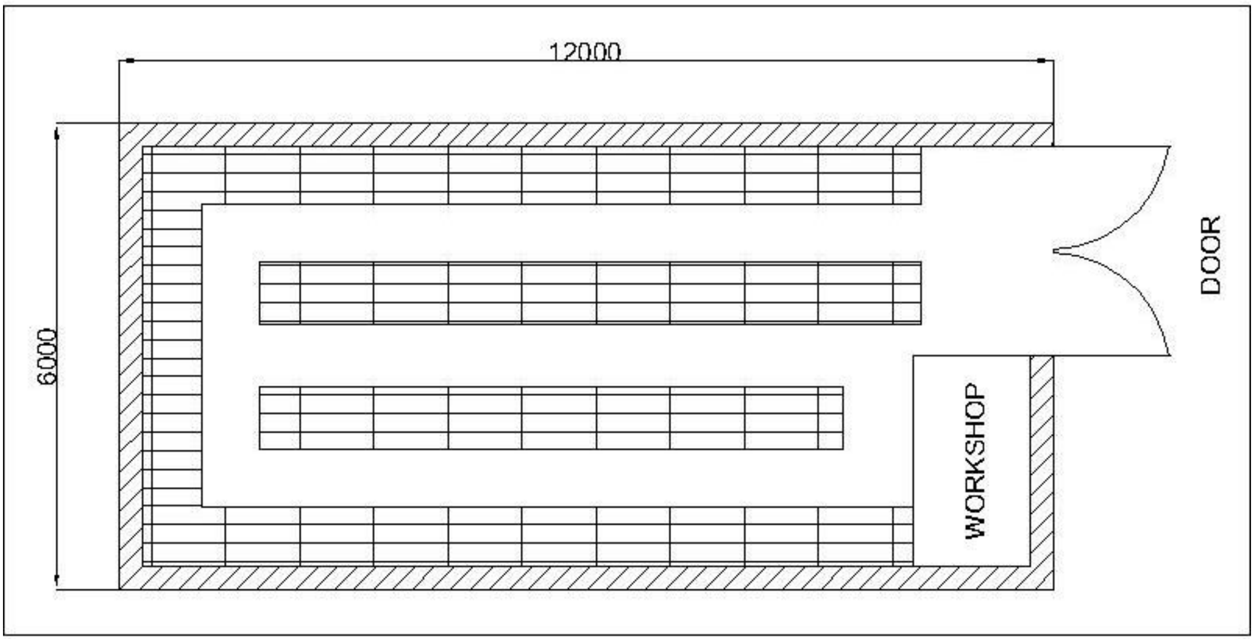


Figure 4.1 – Plan of warehouse

Indoors, measuring instruments are stored in several rows and there is a workshop for technical inspection (fixing and soldering) of instruments. There work two shift workers.

4.4 Calculation of artificial lighting using the spot method

The point method is used to calculate uneven lighting: general localized, local, inclined surfaces, external. The necessary luminous flux of the lighting installation is determined on the basis of the condition that at any point on the illuminated surface the illumination must be at least normalized, including at the end of the life of the light source. Reflection from walls, ceiling and work surface does not play a significant role.[8] For point emitters, the calculation is as follows:

1) the minimum normalized illumination for the room is determined (when calculating the general lighting) or the required illumination of the working surface (when calculating the local lighting);

2) select the type of light source and lamp;

3) the placement of the fixtures in the room is calculated or the location of the local lighting fixture relative to the working surface is specified;

4) when calculating the total illumination, control points are outlined on the floor plan with the location of the lamps;

5) the conditional illumination in each control point is calculated as the sum of the conditional illumination from the nearest lamps. The concept of “conditional” illumination implies that the lamp that creates it has a luminous flux of 1000 lm;

6) eference data selects safety factors and additional illumination (for example, due to the reflected color $\mu = 1.1$);

7) The required luminous flux of the lamp is calculated by the formula:

$$\Phi = \frac{1000 \cdot E_{íîð} \cdot K_{Ç}}{\mu \cdot \Sigma e} \quad (4.1)$$

8) the nearest standard lamp is selected from the reference tables, the luminous flux of which differs from that obtained by no more than –10% ... + 20%, and its power is determined.

There are 8 luminescent lamps in this warehouse. The distances between them are shown below in the figure 4.2.

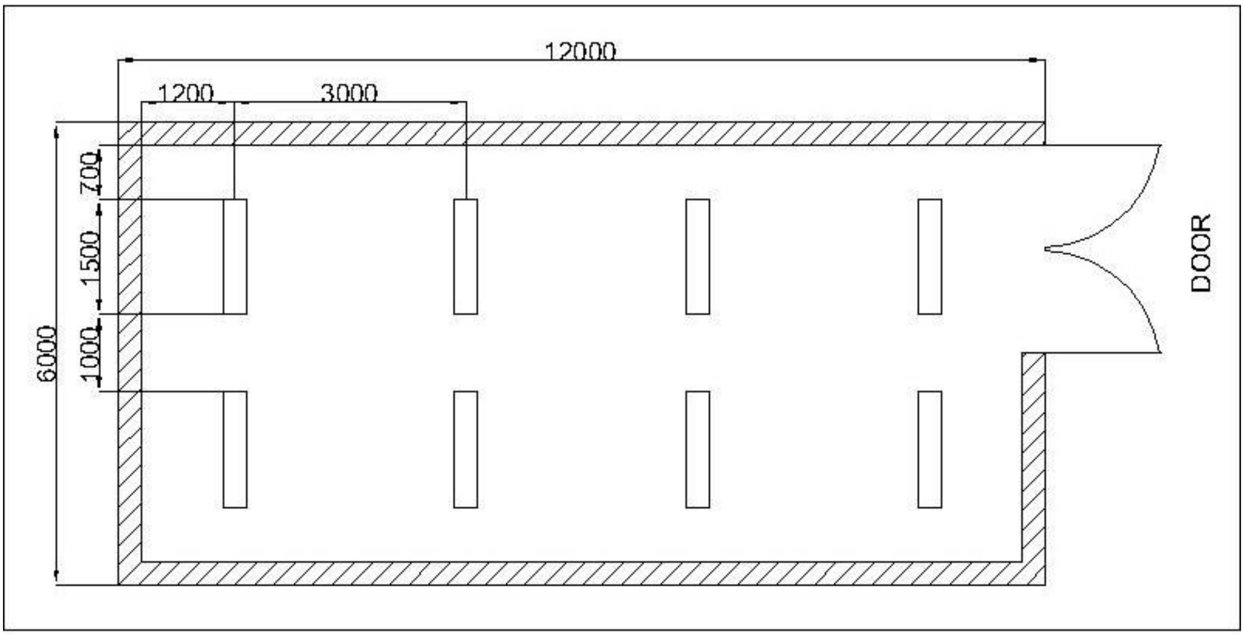


Figure 4.2 – Location of lamps

Table 4.1 - Calculation of values by formulas

Initial data		
The name of a room	Warehouse	
Room dimensions, m: length × width × height	A × B × H	12 × 6 × 3
The area of the illuminated surface, m^ 2	S	72 m^2
Regulatory illumination, of the total as part of the combined, lx	$E_{íîð}$	400
Safety factor	$K_{Ç}$	1.2
Type of lamp (preliminary)	LCP, type LIC D	
The distance from the ceiling to the lamp (overhang), m	$h_{ñ}$	0.1m

Continuation of table 4.1

The distance from the floor to the working surface, m	$h_{\text{ð}}$	0.7m
Lamp suspension height, m: $H_{\text{Ð}} = H - h_{\text{ñ}} - h_{\text{ð}}$	$H_{\text{Ð}}$	2.2m
Coefficient of uneven lighting	Z	1.1
Reflection coefficients: ceiling, walls, floor	$\rho_{\text{п}}, \rho_{\text{с}}, \rho_p$	70, 30, 30
Preliminary selection of the location of the fixtures		
The optimal distance (between rows), m: $\lambda_{\text{ñ}} \cdot H_{\text{Ð}} \leq L \leq \lambda_{\text{ý}} \cdot H_{\text{Ð}}$	L (L_B)	1·2.2=2.2; 3·2.2=6.6 L = L_B = 2.2
The distance from the wall to the row of lamps, m: (desirable l_B =(0,7…1,2)·L_B)	l_B	l_B = 1.54 – 2.64 accepting l_B=1.276
The number of rows of fixtures N_2 = (B – 2 · l_B) / L_B + 1	N_2	N_2= (6 – 2 · 1.276) / 2.2 + 1 = 2.57; accepting N_2 = 2
Lamp preselection		
Type of luminescent lamp	ЛБ40-4	
Luminous flux of the selected lamp, lm	$\Phi_{\text{Ë}}$	2850
The power of the selected lamp, W	$P_{\text{Ë}}$	40
The choice of the number of lamps and fixtures, the location of the fixtures		
Room Index: i = A · B / (h · (A + B))	i	1.33
Light flux	η	1.66
The number of lamps in the room $N = \frac{K_{\text{Ç}} \cdot Z \cdot E_{\text{íîð}} \cdot S}{\Phi \cdot \eta}$	N	N = 8.08 accepting N = 8
Type of lamp; dimensions, mm	ЛПО01-2х40, type КСС – Д; 1250 × 165 × 75	
The number of lamps in the selected fixture	$N_{\tilde{n}}$	2

Continuation of table 4.1

The number of fixtures in the room $N_{\Sigma} = N/N_{\tilde{n}}$	N_{Σ}	8
The number of fixtures in a row $N_1 = N_{\Sigma}/N_2$	N_1	4
Total length of fixtures, m: $L_{\Sigma} = N_1 \cdot l_{\tilde{n}}$	L_{Σ}	4; L_{Σ} < A, tear line
The distance from the wall to the lamp in a row, m:	l_A	1.5m
Distance between fixtures, m: $L_{Đ} = (A - N_1 \cdot l_{\tilde{n}} - 2 \cdot l_A)/(N_1 - 1)$	$L_{Đ}$	1.66
Parameters of high pressure gas discharge lamps	1УБИ-40/220-ВПП	
Lighting system power, W: $P_i = N \cdot P_{\tilde{E}}$	P_i	320
Specific Power, W / m^2: $P_{óä} = P_i/S$	$P_{óä}$	4.44
The preliminary choice of the lamp and the location of the lamps are taken as final.		

4.5 Air conditioning calculation

In this chapter we will calculate the required number of air conditioners, this will create comfortable working conditions. The cabinet has a large amount of equipment that generates significant heat and creates excess heat (the difference between the heat generated in the room and the heat dissipation through walls, windows, doors, etc.), a normal ventilation system should eliminate this heat. Excessive heat is determined by the formula:

$$Q_{ИЗБ} = Q_{ОБ} + Q_{ОСВ} + Q_{Л} + Q_{Р} - Q_{ОТД}, \qquad (4.2)$$

where, $Q_{ОБ}$, $Q_{ОСВ}$, $Q_{Л}$ – this heat, which is released due to production equipment, artificial lighting systems for the cabinet and workers, respectively, kcal/h;
$Q_{Р}$ – it is the heat that appears due to sunlight (solar radiation), kcal/h;
$Q_{ОТД}$ – heat transfer, which manifests itself naturally, kcal/h.

Heat generated by production equipment is determined by the formula:

$$Q_{ОБ} = 860 * P_{ОБ} * \eta, \qquad (4.3)$$

where, 860 is thermal equivalent of 1 kW/h;
$P_{ОБ}$ – power consumption of equipment, kW/h;
η – coefficient determining the transfer of heat into the building.

For equipment we have:
$Q_{ОБ}$ = 860*8.6*0.95 = 7026.2 kcal/h.

The value η = 0.95 is the rate of loss of power consumption for heat dissipation of equipment.

The heat generated by lighting systems is calculated:

$$Q_{ОСВ} = 1000*N, \quad (4.4)$$

where, N – power consumption of lamps:
$Q_{ОСВ}$ = 1000*0.24 = 240 kcal/h

The heat generated by people is calculated by the formula:

$$Q_{Л} = К_{Л}*(q-q_{ИСП}), \quad (4.5)$$

where, $К_{Л}$ – number of workers;
q – heat dissipation of one person in this category of work I-III, kcal/h;
$q_{исп}$ – heat expended on heat evaporation, kcal / h.

Work performed indoors belongs to the 1st category of work.

q = 200 kcal/h; $q_{исп}$ = 130 kcal/h
$Q_{Л}$ = 1*(200 – 130) = 70 kcal/h

Heat introduced by solar radiation:

$$Q_{P} = m*F*q_{ОСТ}, \quad (4.6)$$

where, m – the number of windows in the building;
F – the area of one window, m^2;
$q_{ост}$ - solar radiation that passes through a glazed plane, i.e. heat penetrated in 1 hour through a glazed plane of one m^2.
Q_{P} = 0, because there are no windows in my warehouse.

For winter:

$$Q_{ОТД} = q_0*V_n8(t_{ВН}-t_{НАР}), \quad (4.7)$$

where, q_0 – the approximate specific heat consumption for the heating and ventilation system, $kcal/m^3 \cdot h \cdot °C$;
V_n - the volume of the building, m3;
$t_{ВН}$ and $t_{НАР}$ - internal and external air temperature for a given period, °C.
$Q_{ОТД}$ = 0.42 · 216 · (20 − (-25)) = 4082.4 kcal/h.

For FHHE, the calculation of the excess heat looks like this:

$Q_{изб}$ = 7026.2 + 240 + 70 + 0 = 7336.2 kcal/h.

For FHR, it is obvious that the excess heat is much less than in FHHE:

$Q_{изб}$ = 7026.2 + 240 + 70 + 0 - 4082.4 = 3253.8 kcal/h.

It is obvious that the excess heat in the FHHE is superior to the excess in the FHR, and for this we will calculate the amount of air that needs to be isolated from the building using the FHHE:

$$L_b = Q_{изб}/C_b*t*y_b, \quad (4.8)$$

where, $Q_{ИЗБ}$ – it is excess heat, kcal/h;
C_b – heat capacity of air (0.24 kcal/kg°C);

$\Delta t = t_{вых} - t_{вх}$;

$t_{ВЫХ}$ – the temperature of the air leaving the building,°C;

$t_{ВХ}$ – temperature of the air entering the building,°C;

$\gamma b = 1.206\ kg/m^3$ – specific gravity of supply air.

The value Δt in the calculations is selected due to the heat intensity of the air:

$$Q_H = Q_{изб}/V_п, \qquad (4.9)$$

If the heat intensity of the airspace $Q_H < 20\ kcal/m^3$, then apply $\Delta t = 6°C$, and when $Q_H > 20\ kcal / m^3$, $\Delta t = 8°C$.

$L_b = 7336.2/0.24*8*1.206 = 3168.3\ m^3/h$;

We apply a precision air conditioner with an upward flow, air flow 1.500 m^3/h. The number of air conditioners will be:

N = 3168.3/1500=2 air conditioners (Figure 4.3).

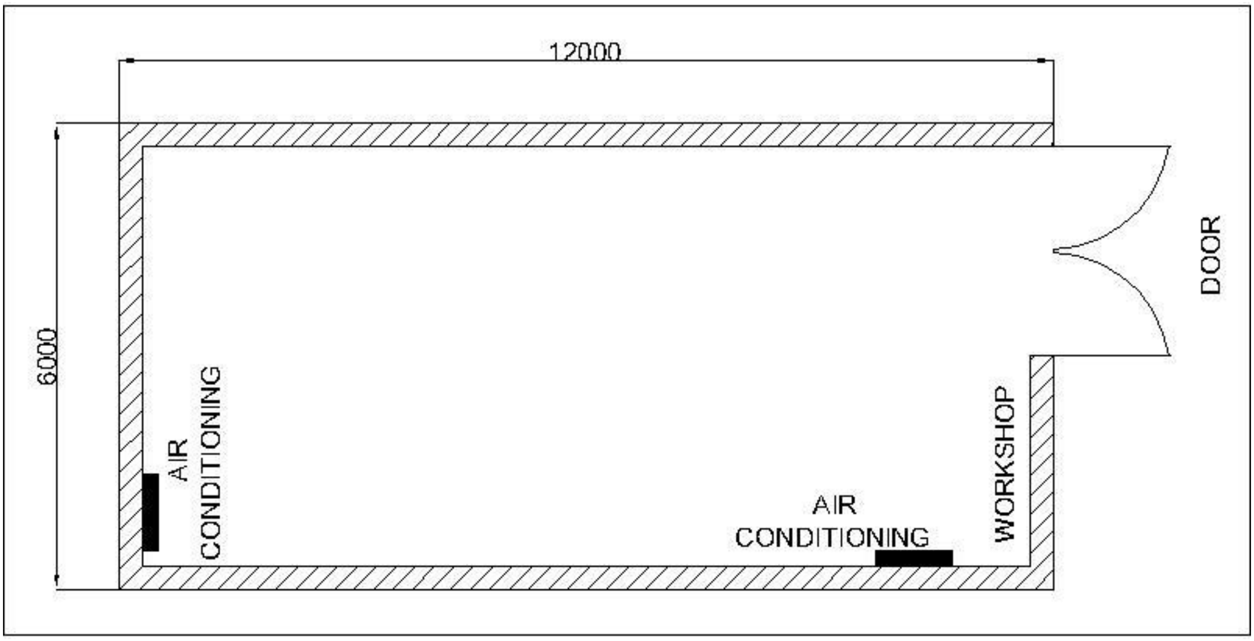


Figure 4.3 – Location of air conditioning

4.6 Fire safety

A fire at my facility is almost impossible. An automated fire alarm was carried out in the room and an OU-5 carbon dioxide fire extinguisher is located, there is a shield on the street with the necessary equipment.

Absolutely every employee passes a safety exam once a year, and of course other safety measures are also applied: stands mentioning the caution of handling fire, there are smoking areas, etc.

According to the requirements of fire safety rules, the building is equipped with OU-5 carbon dioxide fire extinguishers, taking into account one fire extinguisher per 110 m^2. The total area of the building is 72 m^2, so we need to use 1 OU-5 fire extinguisher (Figure 4.4).

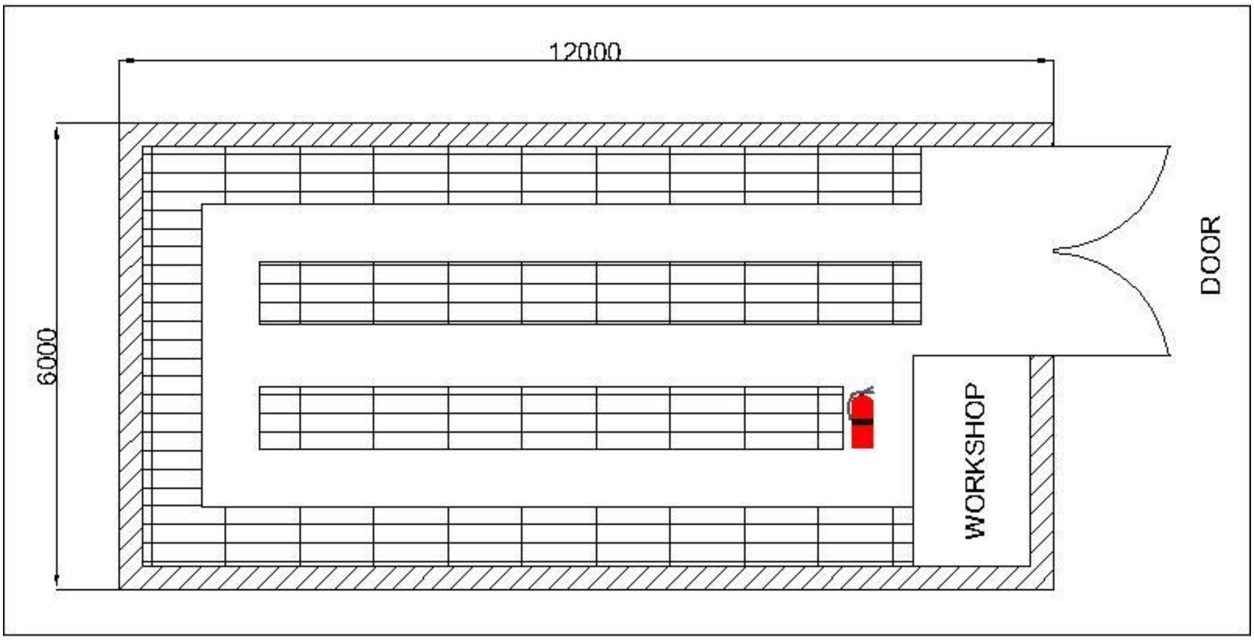


Figure 4.4 – Location of fire extinguisher

5 Technical-economic rationale

In my graduation project, I created an automated fire alarm and fire alarm alerts, which will be used in different areas. Residential and industrial premises will be automated, i.e. wherever industry is. Currently, automated fire alarms are very widespread and are used very often, since according to the standards of any workroom, warehouse or industrial site, etc. fire safety required.

This section discusses the components of the implementation of this project, which reflect the time, labor and financial costs of the project. In order to calculate the initial cost of development, it is necessary to find and include all the costs that are aimed at research work.

1. Materials;
2. Remuneration of the employee;
3. Additional costs for wages;
4. Social security contributions;
5. Payment of electricity;
6. Expenses for overhead needs.

5.1 Calculation of equipment investment

The capital investments required for the implementation of this project consist of capital investments for equipment and for the creation of a software product:

$$I_{pr} = I_{eq} + I_{sp}, \quad (5.1)$$

where, I_{pr} – the investment required for the project;

I_{eq} – equipment investments;

I_{sp} – investment in a software product.

Equipment capital investments are calculated using the following formula:

$$I_{eq} = C_{eq} + C_{tr} + C_{i}, \quad (5.2)$$

where, I_{eq} – equipment investment;

C_{eq} – the cost of equipment;

C_{tr} – transportation costs;

C_{i} – installation costs.

Transportation costs cost about 5-10% of the cost the equipment itself and is calculated by the formula:

$$C_{tr} = C_{eq} * 0.05, \quad (5.3)$$

Recommended installation costs must be taken from the interval from 4 to 6% of the cost of equipment and they are determined by the formula:

$$C_{i} = C_{eq} * 0.04, \quad (5.4)$$

Calculation of capital investment for equipment for the first version of the project.

The total cost of equipment necessary for the implementation of the project is 17360 tenge. The list of necessary equipment and their cost are given in the following table 5.1.

Table 5.1 – Cost of equipment for project implementation

Name	Cost, tg.
Relay module	1400
Arduino Uno	7300
smoke detector MQ-2	1560
temperature sensor module	1920
flame detector	880
board	500
bread board	800
wires	1600
buzzer	400
resistors	600
LED diodes	400
GSM module	16000
DC DC Convertor	1000
Total	34360

From formulas (5.3) and (5.4) it is clear that the cost of transportation and installation will be:

$$C_{tr} = 34360 * 0.05 = 1718 \text{ tenge},$$

$$C_i = 34360 * 0.04 = 1375 \text{ tenge},$$

From this it follows that the investment in the formula (5.2) is:

$$I_{eq} = 34360 + 1718 + 1375 = 37453 \text{ tenge}.$$

5.2 Calculation of investment in software development

The calculation of the investments required for the development of the software product PPC are calculated by the formula:

$$I_{sp} = C_{prf} + D_{st} + C_m + E_s + E_{dep} + E_{el} + E_{oh}, \quad (5.5)$$

where, C_{prf} – payroll fund necessary for developers of software, tenge;

D_{st} – deductions for social tax, tenge;

C_m – costs of materials, tenge;

E_s – expenses for special software tools that are needed to develop a design solution, tenge;

E_{dep} – expenses for depreciation of equipment, tenge;

E_{el} – electricity costs, tenge;

E_{oh} – overhead, tenge

The volume of the wage fund intended to pay the services of developers C_{prf} is determined by the formula:

$$C_{prf} = S_{bas} + S_{ad}, \quad (5.6)$$

where, S_{bas} - basic salary, tenge;

S_{ad} - additional salary, tenge.

The main payment for the work of software developers is calculated by the formula:

$$S_{bas} = t_{com} * S_{dai}, \quad (5.7)$$

where, t_{com} – is the complexity of software product development (person / day);

S_{dai} – daily salary of the developer (tenge).

Salary costs depend on the complexity of the work. Labor input (t_{com}) is calculated by adding labor costs for individual development periods:

$$t_{com} = S_{des} + S_{alg} + S_{bl} + S_{pr} + S_{deb} + S_{doc}, \quad (5.8)$$

where, S_{des} – is the preliminary preparation of the task description, person / hour;

S_{alg} – development of an algorithm for solving the problem, person / hour;

S_{bl} – drawing up a block-scheme of the algorithm, person / hour;

S_{pr} – programming, person / hour;

S_{deb} – debugging of a computer program, person / hour;

S_{doc} – preparation of documentation, person / hour.

When determining the complexity, a key indicator is needed, such as the approximate or conditional number of operator teams that are used in the developed software. With this indicator, it is possible to preliminarily evaluate the complexity of the program and the amount of work necessary in the process of its development and time for debugging. This affects the final cost of the software product, is indicated by the symbol "Q" and is found by the formula:

$$Q = q * c, \quad (5.9)$$

where, Q – is the conditional number of operators;

q – the estimated number of operators depends on the type, the values of this coefficient are given in table 5.2;

c – is a coefficient taking into account the complexity of the program and its novelty (table 5.3).

According to the degree of novelty, SP are divided into four groups:

a) the development of fundamentally new tasks (group A);

b) development of original programs (group B);

c) development of programs using standard solutions (group C);

d) a one-time standard task (group D).

Table 5.2 – Estimated number of operators «q»

Task type	The limits of the coefficient
Accounting Tasks	1400 to 1500
Operational management tasks	1500 to 1700
Planning tasks	3000 to 3500
Multivariate tasks	4500 to 5000
Complex tasks	5000 to 5500

Table 5.3 – The coefficient of complexity and novelty «c»

Programming language	Difficulty group	Degree of novelty			
		A	B	C	D
High level	1	1,38	1,26	1,15	0,69
Low level	2	1,30	1,19	1,08	0,65
	3	1,20	1,10	1,00	0,60
	1	1,58	1,45	1,32	0,79
	2	1,49	1,37	1,24	0,74
	3	1,38	1,26	1,15	0,69

The software that is discussed in this project is written in a high-level language using standard solutions.

The conditional number of teams of operators is calculated by the formula (5.10):

$$Q = 1700 * 1,08 = 1734 \text{ (commands)}, \quad (5.10)$$

Next, you need to determine the time required at each stage of software development.

The time spent on preliminary preparation of the task description top (actual time) on average from 3 to 5 days for 8 hours:

$$S_{des} = 32 \text{ person / hour},$$

The required time for the development of an algorithm for solving the Salg problem is calculated by the formula:

$$S_{alg} = Q / (50 *k), \tag{5.11}$$

where, k – is the coefficient characterizing the qualification of the programmer according to the experience of his work, is selected from table 5.4.

Table 5.4 – Coefficient characterizing the qualification of a programmer

Experience	Qualification ratio
Up to two years	0,8
2-3 years	1
3-5 years	1,1-1,2
5-7 years	1,3-1,4
More 7 years	1,5-1,6

The time required to create the algorithm is calculated by the formula (5.11):

$$S_{alg} = 1734/ (50 * 0.8) =43 \text{ person / hour},$$

The time required to develop a block of the S_{bl} circuit is defined in the same way as S_{alg} in accordance with formula (5.11):

$$S_{bl} = 1734/ (50 *0.8) = 43 \text{ person / hour},$$

Time spent directly on writing a program in a high-level language S_{pr}:

$$S_{pr} = Q *1,5 / (50 * k), \tag{5.12}$$

The time spent writing a program according to the formula (5.12) is equal to:

$$S_{pr} = 1734 *1,5 / (50 *0.8) = 65 \text{ person / hour},$$

Time for debugging and testing the program S_{deb}:

$$S_{deb} = Q *4,2/50 * k, \tag{5.13}$$

Having calculated the time using the formula (5.13), the following result was obtained:

$$S_{deb} = 1734 *4,2/50 *0.8 = 182 \text{ person / hour},$$

Documentation time required S_{doc}, withdrawn upon delivery and ranges from 3 to 5 working days for 8 hours:

$$S_{doc} = 24 \text{ person / hour},$$

Based on this, according to formula (5.9), the complexity of developing a software product is:

$$t_{com} = 32 + 43 + 43 + 65 + 182 + 24 = 389 \text{ person / hour or } 48 \text{ person / day},$$

Daily wages can be calculated in accordance with the monthly salary and the number of working days (an average of 22 working days). Table 5.5 shows the salary of specialists who are involved in creating the software product. Figure 5.1 shows a chart of development periods and labor intensity.

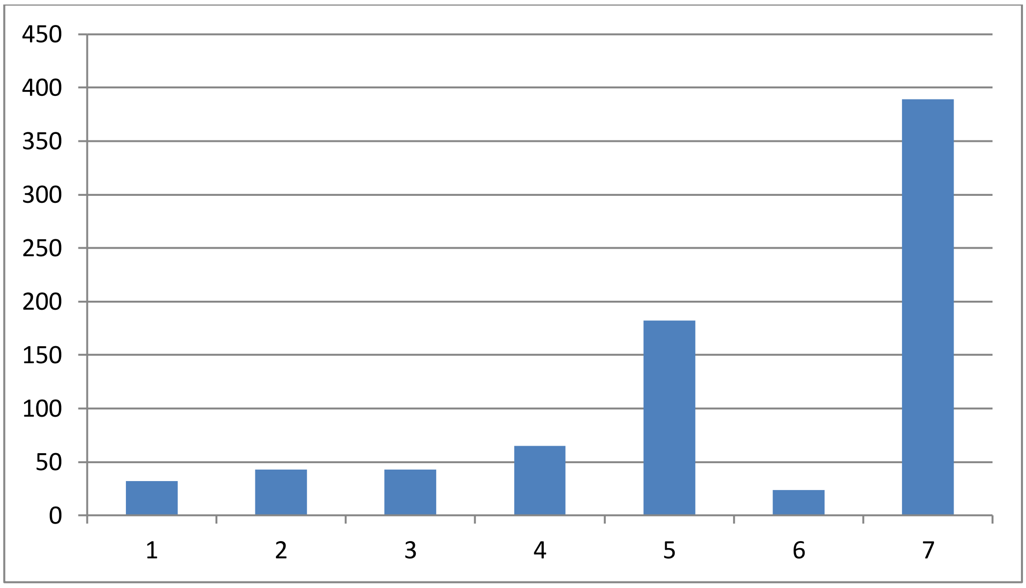


Figure 5.1 - Development periods and laboriousness

Table 5.5 – Salaries of specialists

Executive Specialist	Amount, hm.	Monthly salary, tg.
Programmer	1	180000
Total		180000

Based on this, the daily wage of the programmer is:

$$S_{dai} = 180000/22=8182 \text{ tg},$$

The basic salary according to the formula 5.8 will be:

$$S_{bas} = 48*8182 = 392736 \text{ tg},$$

Additional salary is 10% of the main and is calculated by the formula:

$$S_{ad} = S_{bas} * 0.1, \tag{5.14}$$

And consists:

$$S_{ad} = 392736 * 0.1 = 39273 \text{ tg},$$

Thus, the payroll will be:

$$C_{prf} = 392736 + 39273 = 432009 \text{ tg},$$

According to Art. 358 p. 1 of the Tax Code of the Republic of Kazakhstan, the social tax is 9.5% of the employee's income, and is calculated by the formula:

$$D_{st} = (C_{prf} - S_{pc}) * 0.095\%, \tag{5.15}$$

where, S_{pc} - pension contributions that are not taxed by social tax, and their share of the wage fund is 10%:

$$S_{pc} = C_{prf} * 0.1, \tag{5.16}$$

Pension contributions calculated by the formula (5.16) are equal:

$$S_{pc} = 432009 * 0.1\% = 43200 \text{ tenge},$$

Based on the above calculations and using formula (5.15), the social tax will be:

$$D_{st} = (432009 - 43200) * 0{,}095\% = 36936 \text{ tenge},$$

Based on the information obtained from the source data, the cost of materials is calculated:

$$C_m = (S_{bas} * R_{ems}) / 100\%, \tag{5.17}$$

where, R_{ems} - the rate of expenditure of materials from the main salary on average is from 3 to 5%.

According to this formula (5.17), the costs of materials are equal:

$$C_m = (392736 * 5\%)/100\% = 19637 \text{ tenge},$$

This project uses the Arduino IDE programming environment, which is in free distribution, it follows that the cost of special software tools (E_s) is 0.

Depreciation expenses include depreciation deductions from the cost of equipment used to create the software; for this, the formula is used:

$$E_{dep} = \frac{Ceq * Rd * N}{100 * 12 * t}, \tag{5.18}$$

where, R_d – is the depreciation rate of 25%;

C_{eq} – the initial cost of equipment, tenge;
N – is the time of use of personal equipment,
t – the number of working days in a month, days.

According to the formula (5.18), depreciation expenses amount to:

$$E_{dep} = \frac{34360 * 0,25 * 48}{100 * 12 * 22} = 15.6 \text{ tg.},$$

Type of depreciation charge: write-off of the value in proportion to the number of products sold.

The cost of electricity can be calculated by the formula:

$$E_{el} = M*F_l*T* C \text{ kWh}, \quad (5.19)$$

where M - is the power of the computer, kW;
F_l - load factor (0.8);
C kWh - the cost of 1 kWh of electricity, tenge / kWh;
T - operating time, hour (299 hours).

Using the formula (5.19), you can determine the cost of electricity, they are shown in table 5.6:

$$E_{el} = 0.12*0.8*299*16.65 = 477 \text{ тенге}.$$

Table 5.6 - Electricity Costs

Name of equipment	Nameplate power, kW	Load factor	Operating time of equipment for the development of software, hours	Price of electric power, tenge / kWh	Amount, tg
A laptop	0,12	0,8	299	16,65	477
Total electricity costs					477

Overhead costs, (E_{oh}) and make up from 40 to 60% of the basic salary:

$$E_{oh} = S_{bas} * R_{oc}/100\%, \quad (5.20)$$

where, E_{oh} - overhead costs for PP (tenge);
R_{oc} - overhead charge ratio of -40%.

$$E_{oh} = 392736 * 0.4 = 157094 \text{ tenge},$$

Capital investment in software product development is:

$$I_{sp} = 432009 + 36936 + 19637 + 15.6 + 477 + 157094 = 646169 \text{ tenge.}$$

The summary results of the calculation of costs for the development of software are shown in table 5.7.

In general, the total amount of investment in my project according to formula (5.2) is:

$$I_{pr} = 34360 + 646169 = 680529 \text{ tenge.}$$

Table 5.7 – Summary table of software development costs

Expenditures	Amount, tg.
Payroll	432009
Social tax	36936
Materials	19637
Depreciation	15.6
Electric power	477
Overhead	157094
Total	646169

Conclusion

As a result of the graduation project, a fire alarm system and a fire warning were developed with sending SMS to the phone using wireless information transfer technologies. The system is based on the Arduino UNO board in which the Atmega328 microcontroller is implemented, as well as on the SIM900 GSM module and relay module. The technical task of the project is fully completed.

The first chapter examined the existing systems of fire detectors, the principle of their operation and the possibility of application. The characteristics of each system, the characteristics and method of application are very different between competitors, although they use the same mathematical and statistical models to implement the fire alarm. An in-depth analysis of modern systems was made and the appropriate option was chosen.

In the second chapter, the basic elements of the system, their structural characteristics and the electrical circuit of the devices were considered. Features of the design and implementation of modules with working basic functions with provided sketches of printed circuit boards.

The third chapter is devoted to software and writing a correctly working microcontroller firmware code in a C ++ -based language with the possibility of upgrading and debugging in the Arduino IDE program.

In the fourth chapter, labor protection issues were considered, namely: analysis of working conditions, identification of dangerous and harmful production factors, analysis and calculation of the air conditioning system and the grounding system of the room in which the device will be manufactured, as well as testing of finished devices.

In the fifth chapter, the cost of the project is calculated, as well as the economic effect of the introduction of the new system. The estimated payback period for an industrial scale of production is also calculated. The benefits of introducing a new system can be estimated by the following criteria: Low price of devices, ease of implementation, the ability to change configurations, and measurement accuracy sufficient for most technological processes.

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