MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN
Non-commercial joint-stock
company
ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATIONS
named after Gumarbek Daukeyev
Institute of Space Engineering and Telecommunications
Department of Electronics and Robotics

Head of the
Department associate professor
Chigambaev T. O.
_____"___"_____2021.

DIPLOMA WORK

On the topic: “Design of the "SMART OFFICE" system”
Specialty: “5B071600-Instrument Engineering”
Completed by: Tolepov D.A. Group: PSa-17-4
Scientific supervisor: Balbayev G.K. PhD, associate professor
Consultants:
on an economic side:

Tuzelbaev B. I., associate professor
_____"___"_____2021.
(signature)

on a life safety:

Begimbetova A. S., associate professor
_____"___"_____2021.
(signature)

Normcontroller:

Fazylova A.R., senior lecturer
_____"___"_____2021.
(signature)

Reviewer:

Imanbekova T.D., candidate of Technical Sciences, docent, SC “IITU”
_____"___"_____2021.
(signature)

Almaty, 2021

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Department of Electronics and Robotics
Specialty “5B071600-Instrument Engineering”

TASK

to complete a graduation project (work)

Student Tolepov Dauren Adilbayevich

Topic of work (project) “Design of the "SMART OFFICE" system”

Approved by University order № 217 of 27.10.2020.

Deadline for delivery of the completed work (project) «30» June 2021.

Initial data for work (required parameters of research (design) results and initial data of the object):

1 Bluetoth HC-06;
2 ArduinoATmega328;
3 RTC;
4 Buttons;
5 Laptop.

The list of graphic materials (with exact indication of required drawings): this project contains 19 figures and 21 tables.

Basic recommended literature:

1. Mike Railey «Programming Your Home Automate with Arduino, Android, and Your Computer» - « The Pragmatic Bookshelf Dallas, Texas Raleigh, North Carolina ».: LLC, 2012 г. 216.

2. Goldsmith, Mike. "A Beginner's Guide to Measurement" (PDF). National Physical Laboratory. Archived (PDF) from the original on 29 March 2017.

3. Arhipov G.V. «Systems for the smart building», № 45 .:Госэнергоиздат 1999 г. 218 с..

Consultants for work with indication of the relevant section

Section	Consultant	Date	Sign
Life safety	Begimbetova A.S	23.05.2021	
Economic part	Tuzelbayev B.I	21.05.2021	

SCHEDULE

Of degree project preparation

№	Title of section, list of issues to be developed	Deadline for submission to instructor	Note
1	Technological overview	01.03	
2	Selecting of appropriate hardware	01.04	
3	Programming part	01.05	
4	Work conditions analysis and life safety calculations	23.05	
5	Project costs calculations	21.05	
6	Conclusion	21.05	

Date of issue of the task «____»_____2021

Head of the Department_____(T. O. Chigambayev)

(signature)

Scientific supervisor of

the work (project)_____ (G. K. Balbayev)

(signature)

The task was accepted by

the student_____(D. A. Tolepov)

(signature)

Abstract

In the diploma work, a “Smart Office” system was created to control lighting and office networks. The resulting model of the system is able to receive data from sensors and control lighting and power supply regardless of an external power source.

In this thesis the following tasks were solved:

- Analysis of existing systems and ready-made solutions;
- Comparison with ready-made solutions;
- Design and development of a system management program.

The practical significance of the hardware and software complex developed on the base can be used in private homes and offices to promote LED office and energy saving office. The system is easily replaceable and expandable, which makes it possible to use this software and hardware complex as a laboratory table during practical exercises.

Аннотация

В дипломной работе создана система «Умный офис» для управления освещением и офисными сетями. Полученная модель системы способна получать данные от датчиков и управлять освещением и электроснабжением независимо от внешнего источника питания.

В данной дипломной работе решены задачи:

- Анализ существующих систем и готовых решений;
- Сравнение с готовыми решениями;
- Дизайн и разработка программы системного управления.

Практическая значимость программно-аппаратного комплекса, разработку можно использовать в частных домах и офисах для продвижения офиса со светодиодами и энергосберегающего офиса. Система легко заменяется и расширяется, что позволяет использовать этот программно-аппаратный комплекс в качестве лабораторного стола во время практических занятий.

Аңдатпа

Дипломдық жұмыста жарық пен кеңсе желілерін басқару үшін «Smart Office» жүйесі құрылды. Жүйенің пайда болған моделі датчиктерден мәлімет алуға және сыртқы қуат көзіне тәуелсіз жарық пен қорек көзін басқаруға қабілетті.

Осы тезисте келесі міндеттер шешілді:

- қолданыстағы жүйелер мен дайын шешімдерді талдау;
- дайын шешімдермен салыстыру;
- жүйені басқару бағдарламасын құру және әзірлеу.

Аппараттық-бағдарламалық кешеннің практикалық маңызы, оны жеке

үйлерде және кеңселерде жарық диодты кеңсе және энергияны үнемдейтін кеңсе арқылы ілгерілету үшін қолдануға болады. Жүйе оңай ауыстырылады және кеңейтіледі, бұл практикалық жаттығулар кезінде осы аппараттық-бағдарламалық кешенді зертханалық үстел ретінде пайдалануға мүмкіндік береді.

Content

Introduction

We currently live in a world where most of our daily tasks are automated or simplified to the greatest extent possible, and this trend is increasing year by year. Modern man has developed the technology of automatic and remote control so much that these technologies not only save time and money, but also allow him not to worry about the safety of his home. The growing popularity of automated systems, such as "smart homes", is due to the desire to live comfortably and comfortably. Safety is an additional factor in the attractiveness of these systems, from fire protection systems to remote signals.

“Smart office” is a modern tool to increase the level of comfort and human life, and since most processes are done automatically, this makes it relevant for study and development.

1 Literature review

1.1 Theoretical grounds for ensuring security

Security is one of the most important needs of a person, society, state, and humanity. The essence of security can be revealed as the ability to prevent, reflect, eliminate the dangers that threaten the existence of these entities, as well as destroy their fundamental interests, without which life, well-being, progress and development are unthinkable.

Safety conditions are referred to as comfort, since buildings and the surrounding area cannot be considered favorable for life by a person if they pose a potential danger. Poor planning of the house plot, poorly executed vertical layout, insufficient fire resistance and structural strength, or not well-established systems of engineering equipment can cause accidents. Mechanical equipment malfunctions can lead to injuries, systems with hot heat carriers-burns, and gas and electric utilities-cause fires or explosions.

The stability and strength of the elements standing on the territory plays an important role in ensuring security. The strength properties of the structure are created by the error-free design, accuracy of execution and quality of operation.

The basis of the probability of natural hazards in the area of the functioning of the planning system (earthquakes, hurricanes, etc.) is of particular importance. If you do not take into account the additional loads that occur in these cases, do not perform anti-seismic or anti-wind measures, this can lead to irreversible consequences. In areas that are traditionally not classified as seismic and located in the middle zone of Kazakhstan, Tatarstan and Bashkiria, buildings sometimes collapse. According to scientists, at the junctions of the earth's crust, local seismic manifestations took place, due to the fact that all possible movements of tectonic plates were not taken into account during the construction [1].

For safety, both the conditions of maintenance of structures, the susceptibility of structures and materials to wear and aging are important.

Explosion safety, first of all, depends on the reliability of engineering equipment. As a rule, gas explodes, the leakage of which the technical operation services did not eliminate in a timely manner. To reduce the probability of explosions, it is most often decided to take out intersectional gas pipelines from the basements of old structures to the street, lay them along the outer walls, which improves their daily inspection.

Often, the cause of the explosion may be overloaded or faulty electrical equipment and wiring. Many electrical systems of the housing stock work at the limit, because they are not designed for such loads and constant monitoring is necessary here.

Most often, the means of passive protection are needed for people to feel comfortable. In the genes of every person, the instinct of self-preservation is stored and the willingness to protect yourself from unforeseen situations is natural.

Reinforcement of the structure, emergency exits in case of blockages, fires and other situations when it is necessary to leave the room urgently.

Another aspect of security is the protection against unauthorized persons entering the premises, which is often left out of the attention of builders. Now the issue of ensuring the protection of both the territory and the premises is very relevant. The impenetrability of potential passages to the building must be addressed during the renovation of the building or the initial construction.

The security of planning decisions is a special part of building design. It consists of comparing the elements of landscaping, developing the concept of planning and selecting every detail of the functional.

Coordination of building elements is basically the organization of space, parts of which are subject to the scenario of life on the territory. It is also necessary to identify the features of the expected behavior of people and on the basis of this to ensure the safety of stay and movement. In the planning solution of the security system, the following techniques are laid down. Passageways are traced taking into account their use by fire equipment. Machines with retractable ladders are the only means of fighting fire in multi-storey buildings. Due to the installation the latest equipment, they increase in size and are not able to drive up to a burning building through an inconvenient passage or a narrow arch.

Fire safety in buildings depends on properly organized escape routes, malfunctions of possible sources of ignition, engineering networks and the degree of fire resistance of various parts of the building. There are several types of evacuation: normal and emergency. Normal evacuation is due to the calm flow of processes related to the daily functioning of the facility.

Forced evacuation is characterized by short duration, as it is caused by a situation in which it is necessary to urgently leave the building. At this time, panic is not excluded. A person guided by the instinct of self-preservation tends to force the evacuation process. Subsequently, there is a compaction of the flow of people and a decrease in the speed of movement.6

During an emergency evacuation, it is difficult to ensure the necessary safety, so the layout of the paths is based on the creation of the best conditions during an emergency evacuation.

Under the concept of "escape route", they combine such elements as corridors, stairs, passageways, vestibules and doorways. The dimensions of these elements are selected based on the knowledge of the physiological characteristics of the human flow. The width of corridors and doors is assigned to the aliquot width of a single stream. The width of the stream is greater than or equal to 0.5 meters, since the maximum width of a person's shoulders is 0.48—0.5 meters. The evacuation process is also characterized by the duration of the evacuation, taking into account the maximum density of the human flow. Data the indicator also evaluates the length of the evacuation routes. These values are normalized according to the degree of fire resistance of the building.

In the design practice, the fire hazard of the equipment and the fire load of the premises are considered. Fire load is the amount of combustible material that is used

in the construction of a building and installed in the premises.

The degree of fire hazard is related to the processes for which the installed equipment in the building is intended. The more flammable these processes are, the more serious the protective measures. Areas that are characterized by high danger are implemented in the form of sealed compartments that are protected by fire-resistant structures. They are equipped with emergency exits and fire doors with emergency locks that can be easily opened from the inside, but not from the outside.

Fire alarm systems are installed in crowded areas. They implement the functions of fire detection, alerting the fire brigade and giving an alarm.

The installation of fire fighting equipment is also an important part of human safety in the building. The simplest of them are fire extinguishers, installed in easily accessible places according to a certain scheme. The buildings provide fire-fighting water supply with hydrants on each stairwell. The kit includes fire hoses with hoses. In particularly fire-hazardous areas, sprinkler systems are installed - automatic water collection systems. The channels of their nozzles are filled with a low-melting alloy. In case of fire, they melt and distribute water jets over the entire area of the room [2].

1.2 Description of the security system in the “smart office”

A system is a set of elements that are connected to each other and form a certain integrity, unity.

A security system is a set of interrelated and ordered elements that includes legal, socio-economic, technical, organizational, methodological, therapeutic and preventive, sanitary and hygienic and other means and measures to ensure security.

Complex security system-a specialized complex organizational and technical open system designed for a specific object (allowing for subsequent expansion of the structure and functions), consisting of algorithmically combined (integrated) target functionally independent technical subsystems and technical means designed for complex protection of the object from standardized threats of various nature of occurrence and nature of manifestation.

Integrated security system - a specialized complex technical system being developed that combines (integrates) on the basis of a single software and hardware complex with a common information environment and a single database target functional technical subsystems and technical means designed for complex protection of an object from standardized threats of various nature of occurrence and nature of manifestation.

Passive security is the management of the state of the entire office with the function of autonomous response to situations. The passive safety system receives information from sensors of water leakage, gas (response to the detection of carbon monoxide), smoke, flame detection, overvoltage of the supporting structure of the building, data on meteorological precipitation, air temperature fluctuations, wind speed.

The actuating device here is an electric valve that regulates the supply of water or gas to the leak area, an alarm siren when the level of carbon monoxide increases, an autonomous fire extinguishing system when an uncontrolled fire source is

detected, an anti-ice system on the roof, steps and entrance to the garage when ice appears [3].

1.3 Analysis of initial data and finished solutions

Lights and power. The most popular block among users. In addition to the use of lighting controls, the main and essential characteristic of this unit is the transition from the control of each lighting group to the control of the level of illumination in different rooms of the house or lighting scenarios. For each room of the house, three levels of Illumination are often enough: minimum, average, maximum, as well as the deactivation function.

Climate control. Air conditioning. In the past, in order to reach the desired temperature in the room, the user had to use several controls, and when the weather conditions changed, the user manually adjusted all systems to reach the desired climate parameters within the House. Sometimes the user had to perform such operations daily, sometimes several times a day. When air conditioning is used, the owner of the house sets the required parameters for the micro address of the room, followed by the monitoring system itself, monitor the operation of all engineering subsystems, giving preference to equipment whose work is currently more advantageous for the user [4].

Figure 1.1 – Z-Wave Light sensor.

Figure 1.2 – thermostat Z-wave.

Security. Ensuring security means the implementation of three large groups of solutions: preventing entry into the House, preventing human-caused accidents, and video surveillance. Geographically, the areas of responsibility of the security system are divided into lines: from the perimeter of the house to in-house security. At each border, the security system has its own tasks.

Electric Drives. This section is used to control gates, shielding, sun visors and other equipment.

Weather and watering of plants. Installing a local weather station will provide you with up-to-date information about the temperature, humidity, pressure, wind speed and direction outside your window, as well as the amount of precipitation for the day and the past week. In case of prolonged absence of precipitation, the automatic irrigation system will water the lawn and plants according to the specified schedule.

Figure 1.3 – automatic watering timer.

Control of opening of windows and doors. Opening sensors monitor the opening/closing of windows and doors in the office. First of all, wireless sensors for opening windows and doors perform security functions. If after the office closes. there will be an unauthorized attempt to open the door or any of the windows, this will lead to the opening of the circuit and the alarm signals from the sensor will be instantly sent to the security console (and, if necessary, to the phone of the manager). Thus, the control system for opening office doors and windows ensures that no one can get into offices or other premises unnoticed, thereby protecting the business from robbers and intruders. At the same time, security will be notified if any of the windows remain open during the departure of the last person from the office.

Uninterruptible power supplies. In the event of network interference or a short-term power outage, the power supply in the office is provided by uninterruptible power supplies (UPS/UPS). The popularity of such devices is explained by their relatively low cost and ease of use. When the UPS receives current, its internal battery is charged, and as soon as the current supply stops, the equipment connected to it continues to work from the battery power. The uninterruptible power supply time is usually 5-15 minutes, this time should be enough for the correct shutdown and shutdown of all office equipment [5].

1.4 Choosing a Smart home hardware Architecture

There are two architectures for managing the Smart office system, centralised and decentralised.

The centralised system shall consist of a programmable central control to which the modules are connected.

Advantages of centralised systems:

- In a centralised system, build complex control programs based on time, temperature and user status. The central control is sufficient performance and information on the modules attached to it that allow the whole system to be managed on a single interface;

- Centralised systems have a higher rate of processing of information, as it collects information from central control modules without requiring modular processing;

- The modules used in such systems are compact, cheap and have a simple technical design that allows almost any equipment to be connected to the controller.

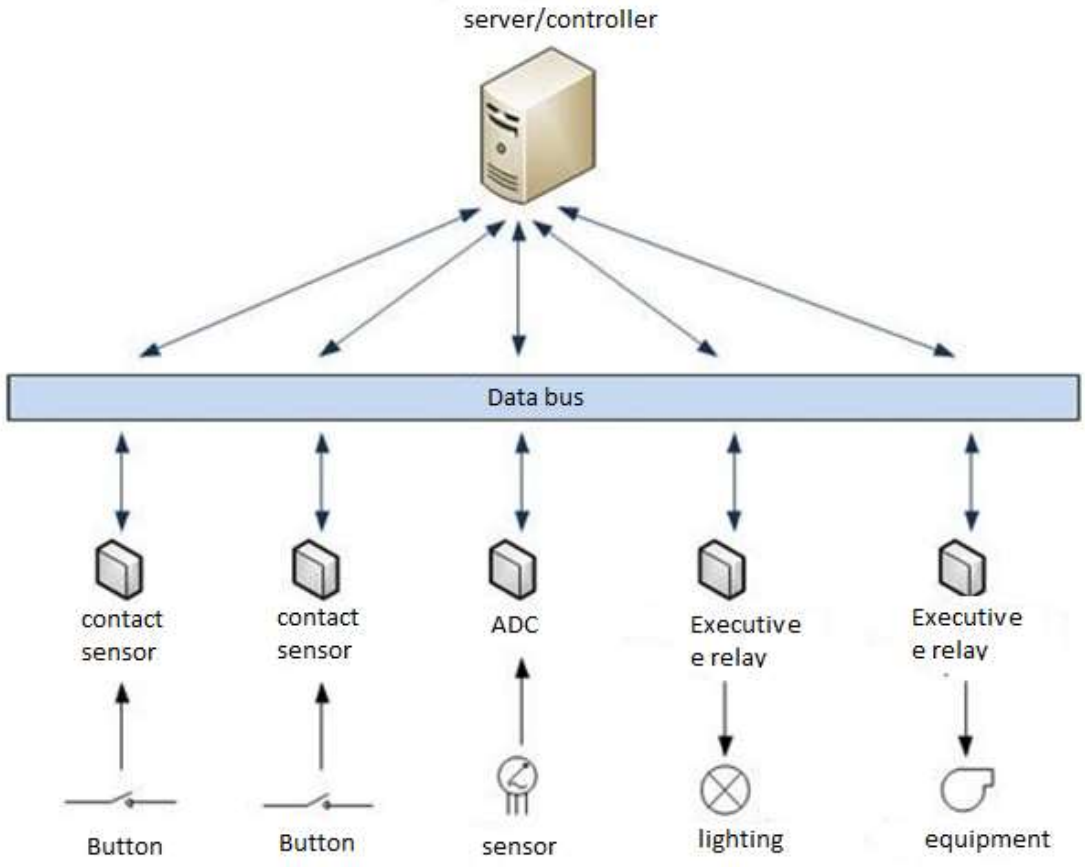


Figure 1.4 - graphical depiction of centralized architecture management.

Disadvantages of centralized systems:

- High price of central control;

- Uncertainty. If the central control fails, the entire system will cease to function;

- The human factor. If the central connection is lost to the programmer who has completed the setting and programming, the reprogramming shall, if necessary, rewrite the entire program.

Decentralised “Smart Offce” control system, devices independent of each other, as each module contains a microprocessor with Non-Volatile Memory. This architecture is building systems for the bus.

Advantages of decentralised systems:

- Reliability. Due to the absence of a central controller, failure of one or more modules will not significantly affect the operation of the system as a whole. From which it follows that a decentralized system has increased reliability;

- Decentralized systems are easy to expand. New modules can be easily added to the existing bus, which support the data transfer protocol of the used bus.

Disadvantages of decentralized systems:

- Sensors have their own data processing controllers, which is why they have a high cost, and also become technically complex;

- The speed of the system is lower due to the processing of data in different modules [6].

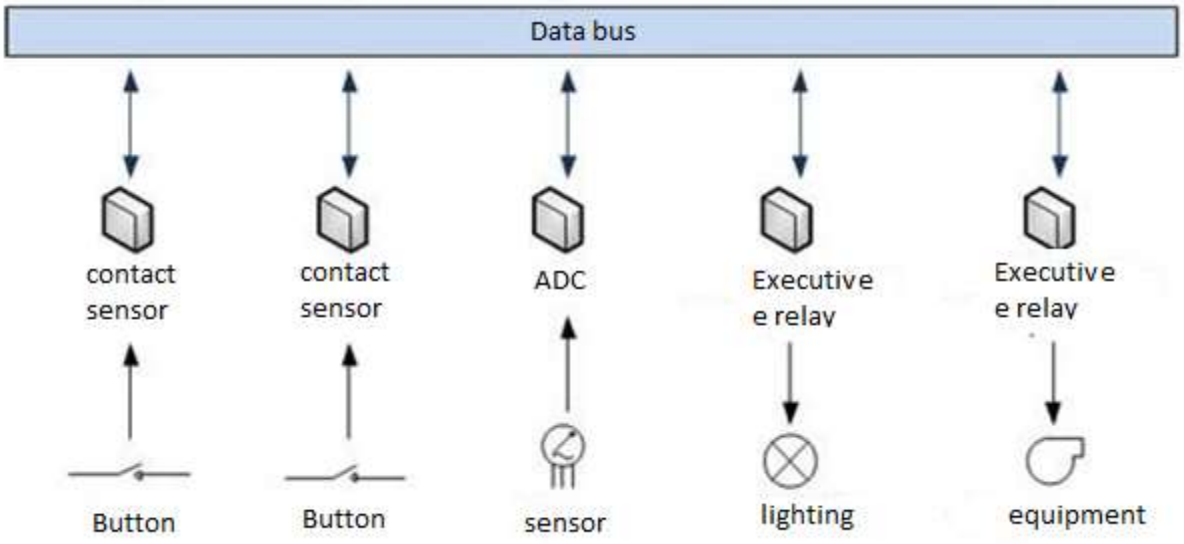


Figure 1.5 - graphical depiction of a centralized management architecture.

1.5 Automated Technologies for combining and managing “smart office” systems

LanDriver - The lanyard is a universal "smart office" system for controlling all electronic devices in the building. The LanDriver system consists of centralised modules linked to central control and buses. Controlled equipment is connected to the modules. In this system, only the main controller must be programmed.

EIB system is decentralised and the management is carried out within the assets. Devices exchange information through the bus according to their own protocol. The EIB bus system is autonomous and therefore does not depend on the central control.

Figure 1.6 - Central controller" SPIDER2 " used in the LanDriver system.

AMX 11 - software and hardware for remote control, video surveillance system, media system, as well as a wide range of sensors. Initially, it used its own data transfer bus, but the updated equipment uses standard Ethernet and Wi-Fi protocols.

Z-wave wireless data transmission technology, designed to provide maximum comfort to residents, is based on a net topology in which all node receivers and transmitters, which means that when an obstacle occurs, the signal is redirected to adjacent network nodes that are within range. Its great advantage compared to other systems is the low power consumption, which makes it possible to integrate Z-wave into different household appliances due to its small size.

Figure 1.7 - Central control controller with control panel and sensors.

Figure 1.8 - The NI-700 central control controller used in the AMX system.

Figure 1.9 - Central control controller "Z-wave Plus" used in the Z-wavesystem.

NetPing is a family of devices developed by the Home Company Alentis Electronics to control the environment. Used for remote control and supervision of home and office equipment. NetPing performs the following functions:

- Power management;
- Monitoring of the security system and monitoring of emergencies;
- Microclimate check;
- Change settings remotely under different circumstances;
- Send System Notifications via SMS and e-mail;
- Real-time access to the system via HTTP or SNMP;
- Regular monitoring of household appliance.

Of the considered ready-made software and hardware solutions, the Z-wave system is most suitable, since it is elementary in setting up and installing additional equipment. But due to the high price this system does not suit us.

Z-Wave is designed to create low-cost and energy efficient consumer electronics, including battery-powered devices such as remote controls, smoke, temperature, humidity, motion, and other security sensors.

As of 2018, Z-Wave is supported by over 700 manufacturers worldwide and

covers a wide range of consumer and commercial products in the US, Europe and Asia. The lower protocol layers, MAC and PHY, are described by ITU-T G.9959 and are fully backward compatible. Z-Wave radio chips are supplied by Sigma Designs and Mitsumi. A distinctive feature of Z-Wave is that all these products are compatible with each other. Compatibility is confirmed by the Z-Wave or Z-Wave Plus certification process.

The Z-Wave solution is based on a mesh network, in which each node or device can receive and transmit control signals to other network devices using intermediate neighboring nodes. Mesh is a self-organizing network with routing that depends on external factors - for example, if an obstacle occurs between two nearby network nodes, the signal will go through other network nodes that are in range [7].

Table 1.1 – comparison of the advantages and disadvantages of smart home control systems

	LanDriver	EIB	AMX	z-wave	Fibaro	NetPing	Arduino
Easy to install and configure	+	-	-	+	+	+	+
System openness	-	-	-	+	-	-	+
Reliability	+	+	+	+	+	+	+
Readily available	-	-	-	+	-	+	+
Price	24600	14000	1500000	10000	25000	90000	35000

1.6 Choosing an alternative power source

Among the options for natural sources of private energy supply, it should be noted:

- Solar panels;
- Wind turbines;
- Micro hydroelectric power plant.

A solar cell is a device that converts sunlight into electricity. It consists of a film made of a polymer active layer, aluminum electrodes, an organic flexible

substrate and a special protective layer.

Light falls on the p-n junction, and a voltmeter connected to it begins to record insignificant values of electric current. With an increase in the area of the p-n junction, the amount of electricity received will increase.

Benefits of solar panels:

- Can be installed wherever the sun is shining;
- Silence;
- Generation of electricity comes from a renewable source;
- Abundance.

Disadvantages of Solar Panels:

- High cost;
- Low power density;
- Unstable source of energy.

Figure 1.10 - The solar panel

A wind generator is a device that converts wind energy into electrical energy. Consists of a generator, high tower, blades, battery and electronic control system.

Operating principle.

Rotation causes three types of physical impact on the propeller blades - impulse force and lifting force, as a result of which the flywheel starts to move, and braking force. Two forces against one overcome the resistance, and the flywheel spins, the rotor creates a magnetic field on the stationary part of the generator. This is enough for an electric current to flow through the wires.

Benefits of wind turbines:

- Generation of electricity comes from a renewable source;
- Simple maintenance, fast installation, low maintenance and service costs;
- Can be installed anywhere in the world.

Disadvantages of wind turbines:

- Unstable source of energy;
- High installation cost;
- Creation of noise;
- Large dimensions of wind turbines.

The monitoring of the state of the object is checked by sensors and transmitted to the central controller at regular intervals. The central controller consists of a comparison unit and an acceptance unit

solutions. The comparison unit contains the difference between the effective and reference values of the controlled parameter. Based on the magnitude and sign of this difference in the corresponding block, a decision is made to carry out the action, the implementation of which is carried out by the executive device.

Figure 1.11 - Wind generator

Of the alternative sources of power considered, solar panels are the most suitable for us, as they can easily be placed on top of the building, but at the same time they cost less than the wind generator.

The micro-power plant is a small power plant that produces small amounts of electrical energy. May consist of axial microturbines and generators mounted on the same axle

The power of micro-electric power plants does not exceed 100 kW. A significant difference between low power hydropower plants and large hydropower plants is that there are no dams in place. It is almost impossible to obtain a permit from the supervisory authorities to block the sewers of any reservoir in order to raise the water level.

The electricity generation of small hydroelectric power plants is carried out in accordance with the same principle as megawatt others-the water from the tank is directed and rotated to the Blades of the hydraulic turbine and the mechanical work is transferred to the hydrogenerator rotor, which generates electricity.

The power characteristics of the turbine are slightly higher than those of a hydroelectric generator combined to a hydroelectric unit. The choice of the hydroelectric generator for small hydroelectric power plants depends on the type of electricity consumption produced. If the network has active load devices that convert incoming electricity to full light, heat and the like, the asynchronous generators will do so. But in the case of reactive load electrical devices, pumps or electric motors that lead part of the electrical energy back to the generator, only a synchronous generator can cope with this.

The advantages of small hydroelectric power plants:

- Electricity is produced from renewable sources that are more stable than sunlight and wind;

- Proximity to the end-user, energy loss of transport is minimal or absent;

- Low electricity cost, taking into account the zero cost of initial fuel;

- Absence of total emissions to the atmosphere, minimal impact on water basins;

- Small hydropower plants take less time to reach their full capacity than other generators;

- Away from the Central Power Grid, Small hydropower plants can provide electricity to consumers without interference, as they are not dependent on regular fuel supply.

Disadvantages of small hydroelectric power plants:

- In winter, rivers can freeze up to several meters, which will interfere with the receipt of energy;

- With a weak water pressure, the mini hydroelectric power station has a low productivity;

- The construction of a full-fledged, small hydroelectric power plant is quite expensive;

- The energy consumer of a small hydroelectric power plant should be located near the water, since otherwise the operation of the installation is impossible [8].

1.7 "Smart Ofiice" autonomous power supply system

The home autonomous power supply system is a system that allocates the amount of power required for the operation of all intelligent components without any power loss or power loss.

The general scheme of the autonomous power supply system consists of successive elements:

- Primary power source-solar panels or various generators can be used for this source;

- A charger is a device that converts the voltage from the primary power source to the values necessary to ensure the stable operation of the battery;

- A device for storing and releasing rechargeable battery energy;

- Inverter-a device that creates the required voltage.

These elements form an integral part of the home autonomous power system.

A smart office is needed in an autonomous power supply system for the following reasons:

- Inability to connect individual components to an existing power supply network;

- Instability of the applied voltage;

- Protection of smart home components from power outages.

Smart homes are highly dependent on the availability of electricity and therefore the energy needed for full operation must be continuously generated independently of external factors. Renewable and user-friendly options should be preferred when selecting the power source.

The self-supply of electricity to the smart home depends on the total power and the nature of their 'needs'. Most often, energy consumers are:

- The House heating system;

- Refrigeration units and other equipment;

- Air conditioners;
- Household electrical appliances;
- Pumping equipment.

Each type of electricity consumer has its own capacity. The requirements of the power supply network shall in particular be the stability of the voltage and frequency supplied.

It is very important to determine the technical characteristics that are the basis for building the House's autonomous power supply system. The factor that determines what function the autonomous power supply system will perform, whether it is a fully independent power supply or only serves as a backup power source. If the system plays a role.

The “safety net” for the supply of energy sources should be defined as the duration of the autonomous power supply system in the absence of centralised power supply.

The financial possibilities of the user are an important factor in the design of the smart home's own power supply system.

Benefits of autonomous power supply systems:

The main advantage of the autonomous power supply system is financial savings, as the user does not have to pay for energy consumption. Home autonomous power supply has no social standards for energy consumption.

The quality of the energy depends on the proper calculation of the performance design at the design stage of the system and the installation of the necessary equipment. Due to the calculations, there is no risk of voltage surges, power outages, and there is no need to fear that a live current will block equipment or smart home systems.

The installation of the autonomous power supply system is fairly reliable and rarely fails. This advantage is maintained by the proper care and proper operation of all elements of the system.

The smart home's autonomous power supply system can be completely independent. Whatever state the power supply is in, the user will always have his own power source.

Disadvantages of smart home independent power supply system:

Despite the many advantages, the autonomous power supply system has many disadvantages, including:

- High cost of equipment;
- High operating costs.

For this reason, everything must be calculated carefully before the equipment and materials are selected so that the equipment does not fall to failure before it has time to recover. If the autonomous power supply of a smart home ceases for some reason, the user has to figure out the reasons for the problems on his own. To understand the reasons, to make repairs or to call specialists and to pay for the repair services of the autonomous power supply system. To prevent this from happening and the equipment has served as long as possible, regularly check and maintain the home self-supply system.

In the Smart Home layout, parameters are monitored based on motion sensors. The sensors are installed indoors. The information from the sensors is transmitted to the central controller, which processes it and, based on the received data, performs the action in accordance with the action that occurred.

The layout has several modes of operation, switching between which is carried out by entering a key registered in the system into the RFID reader. If a key is found that is not registered in the system, the system locks the reader for a programmed time, without changing the mode in which it is located.

Security mode. The mode in which the system supplies power to the security system: motion sensors and alarms. If there is movement in the room during operation of this mode, the system will respond to this by turning on the alarm.

Power consumption and lighting mode. The mode in which the system supplies power to the electrical network of the room, as well as turns on and off the lighting in the room when the user appears. The room is also viewed by sensors and if there is no movement during the programmed time. This mode allows you to save energy when the user is away from the room for a long time.

The layout is powered by both a permanent power source and an alternative power source consisting of a battery, a charger, and a solar panel.

A smart office is a format of a room equipped with integrated engineering systems, intelligent multimedia complex and information systems for efficient and comfortable work of the company.

This format of the room is relevant for companies of various industries that strive for comfort in the company's work and rational use of material resources.

With the rapid development of scientific and technological progress, building automation systems are becoming more and more frequently used, including due to the positive economic effect. This is not only due to the creation of improved working conditions for the company's employees. The problems of energy efficiency and energy saving, which are solved by using this system, lie much deeper, therefore, they solve the issues of economic feasibility.

Developments in the field of creating “smart offices " have reached a level where the building reaches an almost zero energy balance, established through the improvement of renewable energy systems and microclimate.

Investment in this area of construction in Russia has only just begun to be noticed by the authorities in the form of tax cuts. Complex automated systems can be adapted to the needs of office buildings, which, therefore, increases the class and energy efficiency of the office and the building as a whole. Lighting control in optimal mode is improved the comfort and safety of people, as well as contributes to energy savings, which is a significant factor. According to OSRAM, having a lighting system that depends on daylight and the presence of people in the room accounts for up to 80% of the energy savings. In large projects with a large number of fixtures, lighting control systems are mainly aimed at both saving resources and ensuring manageability. A modern lighting control system can do a lot. The following functions have become common: switching and smooth address adjustment of the luminaire brightness; accounting for the presence of people in a

lighted room; maintaining a constant set level of illumination in the room; scenario management of groups of lamps in accordance with preset parameters; accounting for the level of natural illumination of the room; providing a control interface for a PC/PLC, the ability to integrate it into the dispatching system of the object; work on a schedule.

Electric blinds and roller shutters can be closed and opened and closed: individually, in groups, centralized, or decentralized. The control is carried out manually by means of a push-button switch of the radio remote control or automatically depending on the time of day or outdoor lighting. In addition, awnings and external blinds are automatically raised at the signal of the rain or wind sensor, which protects against damage.

Possible combination with: lighting, heating, ventilation and air conditioning systems. This approach helps to increase the individual comfort of the user, while reducing energy costs. Control and adjustment of the temperature in individual rooms is carried out through temperature controllers installed in the premises: with individual temperature control, the desired temperature and heat demand of each room in the office is recorded (taking into account time and other parameters), which continues to be maintained at a given level in the future.

This increases not only comfort, but also provides additional energy-saving opportunities: when the temperature in the room is lowered by 1°C, energy consumption is reduced by about 6 %. In addition to room temperature control, other features can be used, such as the integration of window contact systems. When the window is open, the room temperature controller is set to the frost protection mode. this mode guarantees a minimum temperature of + 7°C, which saves energy when the window is open and prevents the pipes from deforming in winter. In special-purpose buildings, it is often necessary to display data coming from devices in various sectors of the system. Such as: the state of the switching elements of the lighting system; the duration of operation of lighting devices; the position of doors, windows and gates; the alarm status; the position of blinds, roller shutters and awnings; internal and external temperature; operating mode and notification of malfunctions of heating and air conditioning equipment; notification of malfunctions in operation elevators; liquid level monitoring and leak alarm; gas, electricity, and water meter readings; and various other operational indicators and data.

The automation system can perform not only the functions specified by the standards, which are difficult or almost impossible to perform without using this system, for example: by pressing the button at the exit, you can turn off unnecessary consumers, close roller shutters and windows, lower the temperature in the premises. As a warning measure to protect the building, the function of simulating presence is effective, as a result of which an outsider gets the impression that someone is in the room: the office lights are turned on unevenly, the brightness of the lighting is adjusted, and after dusk the blinds or/and roller shutters are activated. Connecting all systems to the communication systems via the proper interfaces demonstrates additional possibilities for monitoring and changing the settings of the connected systems and devices. In the event of an emergency or malfunction of the building

automation systems, they are notified of the incident by SMS or voice mail. Components of the automated system "Smart Office" allows you to: prevent cases of theft of material and intellectual values; increase the efficiency of employees; prevent cases of theft of material and intellectual values; pay for the time actually worked; prevent cases of theft of material and intellectual values; ensure the efficient use of electrical and thermal energy; reduce the cost of repairing engineering systems; create comfortable working conditions.

Equipping with the "Smart Office" system, in comparison with the construction and repair costs, is a relatively small increase to the total budget amount. Also, unjustified costs are reduced, labor productivity increases, which will help the business become more productive, efficient and more profitable.

An automated system is a complex of electronic equipment that controls engineering systems, creating a comfortable environment. The creation of the concept of an intelligent building during the reconstruction of existing facilities and new construction will allow to achieve a large reduction in energy consumption and facilitate the implementation of standards in terms of ensuring the necessary energy efficiency classes with unconditional compliance with safety requirements. The use of a smart building system in private construction is less appropriate, due to the cost of equipment, installation of the system and a long payback period, unlike large office buildings. The payback period of these intelligent systems in this case is reduced and gives greater savings in resources and increases the company's profit

Smart office is based on integrated engineering systems and their centralized management. The software and technical support of the smart office includes a variety of integrated engineering systems [9].

1.8 “Smart office” autonomous Power Supply System»

The system of autonomous power supply of the house is a system that allocates the necessary amount of electricity to operate all components of the smart home without power outages and power supply interruptions.

The general scheme of the autonomous power supply system consists of sequentially arranged elements:

- Primary source of electricity – solar panels or various generators can be used as this source;
- Charger-a device that converts the voltage from the primary source of electricity to the values necessary to ensure the stable operation of the battery;
- A rechargeable battery is a device used to store and release energy;
- Inverter-a device that creates the desired voltage.

These elements are an integral part of the autonomous power supply system.

The high demand of a smart office for an autonomous power supply system arises for the following reasons:

- The inability to connect individual components to an existing power supply network;
- Instability of the supplied voltage;
- Protection of smart home components from power outages.

A smart home is highly dependent on the availability of electricity, so the

energy needed for full operation must be produced non-stop, regardless of external factors. When choosing a source of electricity, preference should be given to a renewable and user-friendly option.

Requirements for the autonomous power supply system:

The autonomous power supply of a smart home depends on the total power of electricity consumers and the nature of their "needs". Most often, the number of energy consumers includes:

- The heating system of the house;
- Refrigeration units and other equipment;
- Climate control systems;
- Home electrical appliances;
- Pumping equipment.

Each type of electricity consumer has its own capacity. The requirements for the power supply network are, first of all, the stability of the supplied voltage and its frequency.

It is very important to determine the technical characteristics that will serve as the basis on which the system of autonomous power supply at home will be built. They are determined by the factor of what function the autonomous power supply system will perform, whether it will be a fully autonomous power supply or serve only as a backup power source. If the system plays a role

1.9 “Smart office” as an implementation of the human and technical safety system.

Smart office is a format of a room equipped with integrated engineering systems, intelligent multimedia complex and information systems for efficient and comfortable work of the company.

This room format is relevant for companies in various industries that strive for comfort in the company's work and rational use of material resources.

With the rapid development of scientific and technological progress, building automation systems are becoming more and more frequently used, including due to the positive economic effect. This is not only due to the creation of improved working conditions for the company's employees. The problems of energy efficiency and energy saving, which are solved by using this system, lie much deeper.

All over the world, the construction of buildings equipped with modern automation systems and management of the engineering infrastructure of buildings has begun to actively develop. With the revival in the construction industry, interest in smart buildings has also grown. Smart office is a highly automated building, a single management system that manages the entire engineering and technical complex of the building, monitors the state of all engineering systems and, in the event of a deviation, edits the parameters so that this deviation is eliminated. Building automation has a serious competitive advantage in the market.

Savings on the repair and restoration of the efficiency of engineering systems reduce the cost of utility bills, about 20-30%.According to American experts, the intellectual component pays off in 3-5 years. At the Russian facilities, the process is still underway [10-12].

2 System Description

The Arduino was chosen as the central controller because it is an inexpensive printed circuit board with an open architecture microcontroller. The Arduino platform is capable of reading input data in the form of voltage on its analog pins. If sensors are connected to certain inputs of the device, it programmatically reads the information from these contacts.

The Arduino platform is designed to create electronic devices that work according to a given algorithm and with the ability to respond to external signals. Arduino is an open concept platform. This platform is available both for connecting other devices, and for changing the electrical circuit of the device itself.

Table 2.1 - Technical specifications

Microcontroller Type	ATmega328P
Microcontroller supply voltage	5 V
Recommended board power supply voltage	7 – 12 V
Maximum permissible power supply voltage of the board	6 – 20 V
Digital inputs and outputs	14
PWM modulation outputs	6
Analog inputs	6
Permissible current of digital outputs	20 mA
Permissible output current 3.3 V	50 mA
Flash memory capacity	32 kB
Amount of RAM	2 kB
Non-volatile memory capacity	1 kB
Clock frequency	16 mGz
Board Length	68,6 mm
Board width	53,4 m
Weight	25 g

The following sensors were used in the work: Bluetooth HC 6 designed to transmit data to a smartphone. There are also two LED stands for displaying information, namely with the help of LEDs. We can manage with a smartphone as we like, also naturally manually. I also added a lot of modes. The main thing is that you can draw on your smartphone and transmit information directly to the LEDs using Bluetooth. This module operates at frequencies from 2.40 GHz to 2.48 GHz

and supports the bluetooth specification version 2.1 + EDR: lower power consumption, increased data security and easy connection of Bluetooth devices. Stable reception with the module is guaranteed within 10 meters. VCC and GND "plus" and "minus" of the module power supply, voltages from 3.6 to 6 volts are supported. TX and RX transmitter and receiver of the module. Reset and restart of the module, in this case it is carried out by a low logic level.

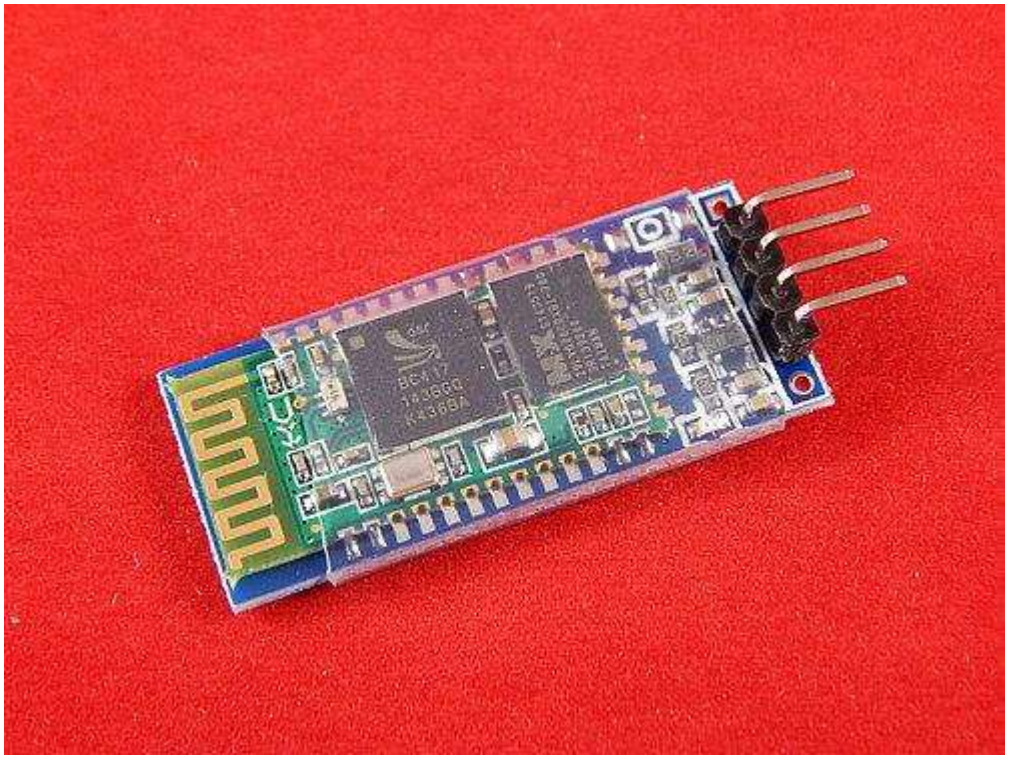


Figure 2.1 – Bluetooth HC-06

The Real Time Clock (RTC) is an electronic circuit specifically designed to keep track of the current time, date, day of the week, and other time and calendar data. They are widely used in data logging systems, when creating electronic clocks, alarms, timers, control devices operating on a schedule. As a rule, such a scheme, in addition to the metering device, also includes an autonomous power source in order to continue to work even when the main system is turned off. Real-time clocks keep records in time units that are more familiar to humans (hours, minutes, years, etc.), in contrast to clock generators and counters, which create and count just “ticks”. We can say that the real time clock is a clock generator specially designed for timing.

Often times, microcontrollers, including the Arduino, have timekeeping functions like millis () and hardware timers that can track longer time intervals like minutes and days. So why do we need separate real-time clock circuits?

The main reason is that millis () keeps track of the time elapsed since the last time the Arduino was turned on, when turned on, the millisecond timer is set to zero. The Arduino doesn't know "Tuesday" today or "February 23rd", all it knows is that 14763 milliseconds have passed since the last power-on.

What if we want to set the time on the Arduino? In the program, it would be necessary to set some point of reference, from which to count the time and dates. But

if you turn off the power, the time would be reset. This is exactly what happens in inexpensive models of alarm clocks, when “12:00” starts flashing when the power is turned off. For some tasks, this is quite acceptable, but in some cases it is important to keep timing even if power is lost. In this case, specialized RTC microcircuits, which have an autonomous power source, come to the rescue.

Most real-time clock circuits use a crystal resonator operating at 32768 Hz. 32768 = 215 ticks per second, which is very convenient for simple binary counters.

Figure 2.2 - RTC sensor

LED panel with Arduino. Used to output data using LEDs. Semiconductor material is used for data transmission. Also I used two LED display myself.

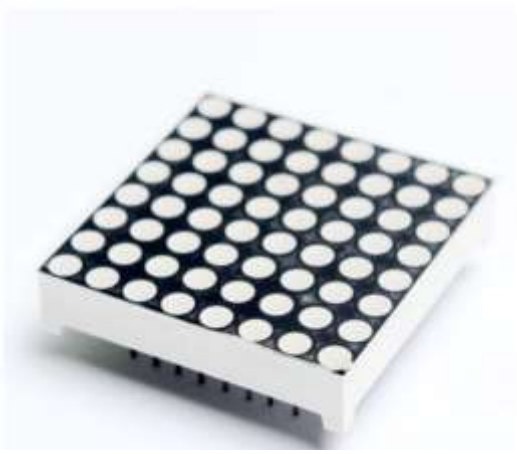


Figure 2.3 - 8x8 LED display

Before assembling the system. We need a schematic diagram. You can see the schematic diagram in Figure 3.4. What is very important, you can assemble this circuit on any Arduino board. But I built it on ArduinoATmega328P. You can see on the diagram there are buttons that serve to control the system. You can see on the diagram there are buttons that serve to control the system. I programmed this whole system using C ++. Since the programming language is the most popular and convenient.

What if we want to set the time on the Arduino? In the program, it would be necessary to set some point of reference, from which to count the time and dates. But if you turn off the power, the time would be reset. This is exactly what happens in inexpensive models of alarm clocks, when “12:00” starts flashing when the power is turned off. For some tasks, this is quite acceptable, but in some cases it is important to keep timing even if power is lost. In this case, specialized RTC microcircuits, which have an autonomous power source, come to the rescue.

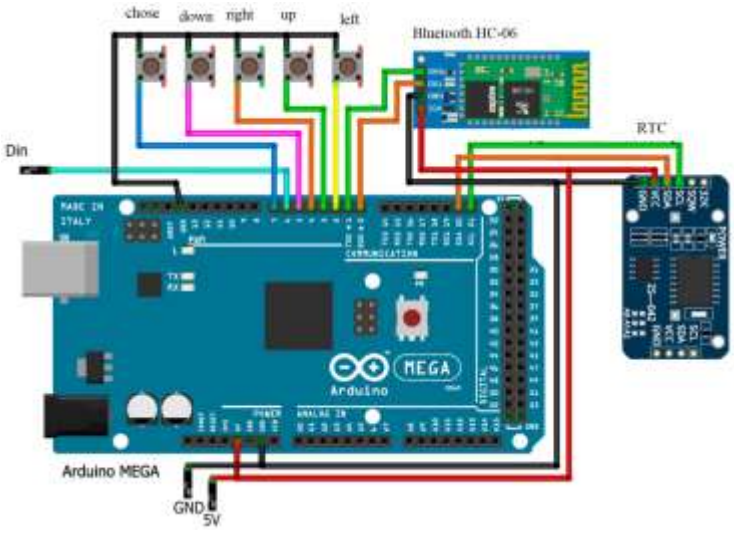


Figure 2.4 - Schematic diagram

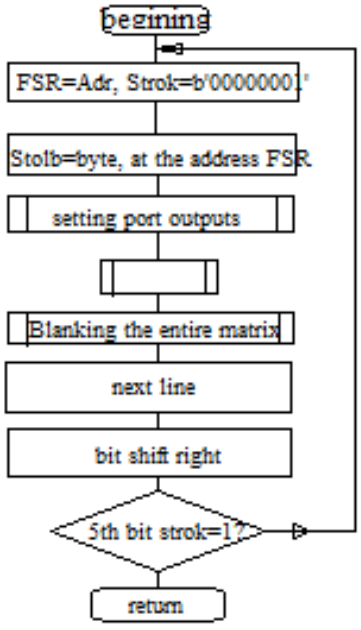


Figure 2.5 - Program algorithm

This whole system had to be programmed. The LED screen needed a different mode. For example, what could show the clock. Or the company logo, etc.

I also made different effects. Like a rainbow, flame, snow, etc. Through

random value integration and brightness monipulation.

I did this whole system using Proteus. You can see my diagram in the picture 2.6. To get started, of course, you need to click on the triangular button in the lower left corner. Then we wait until the system turns on. Then we can connect from any smartphone via bluetooth.

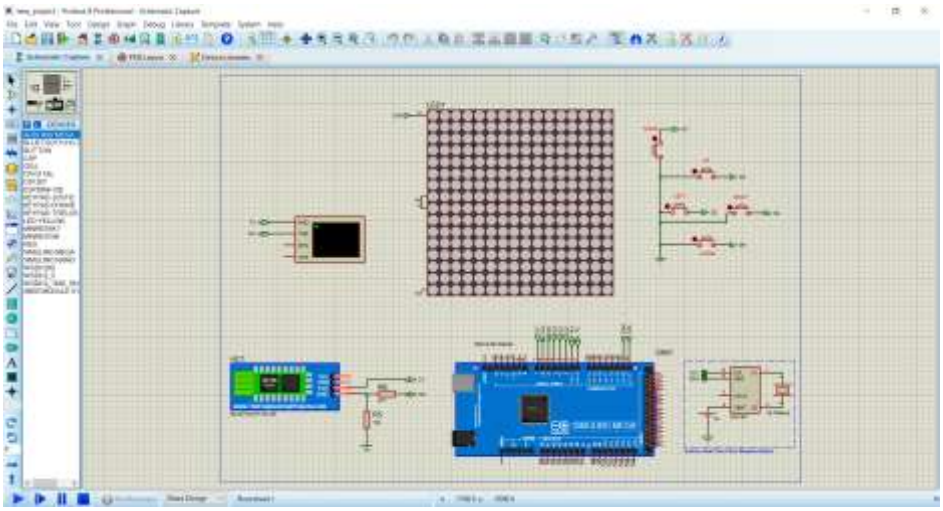


Figure 2.6 – My scheme

Turn on bluetooth on pc and smorphone. Next, we connect and go to the control interface. And we can control what effect we need.

By pressing the buttons, we can control which mode we need. As well as an add-on, you can add so that you can draw right on the phone. Then a person who wants to advertise his office can change it very quickly and easily and easily.

The automation system can perform not only the functions specified by the standards, which are difficult or almost impossible to perform without using this system.

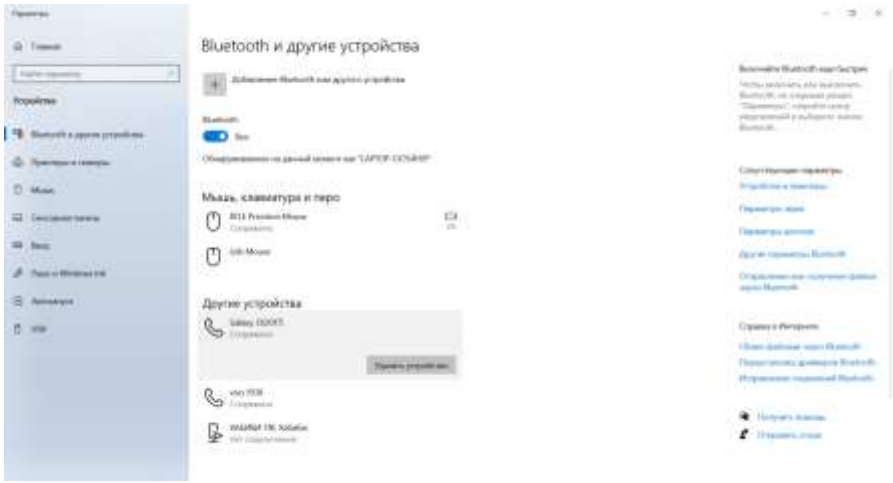


Figure 2.7 - Bluetooth connection

Figure 2.8 - Bluetooth connection

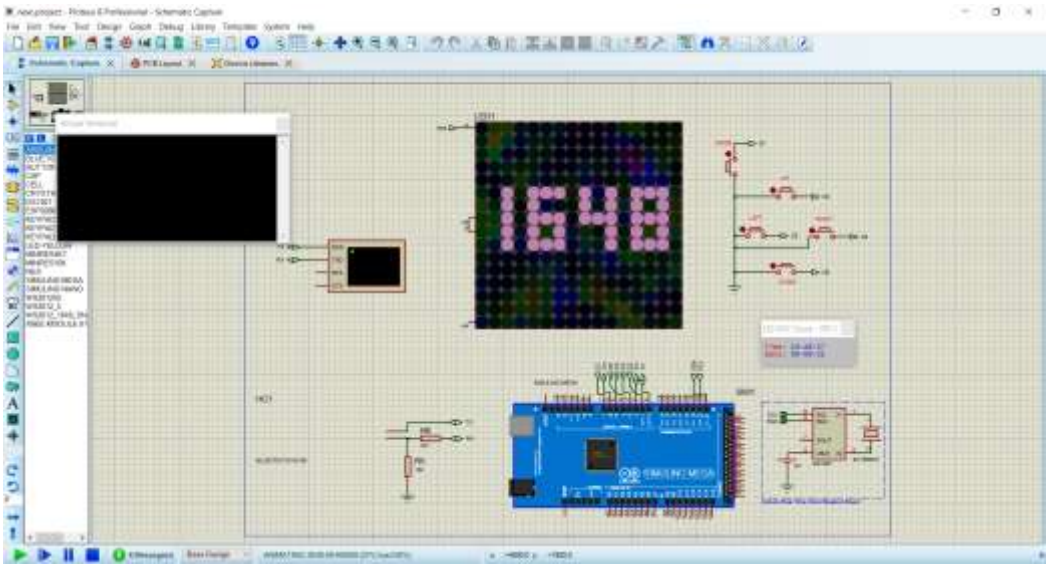


Figure 2.9 - the result of my work

3 Software part

My program was programmed with C ++ in Arduino. There are a lot of modes in my system and for this I will select a few examples for review. Clock mode. I need to show the exact time of the clock on the LED screen. To do this, see how I programmed arduino.

As we can see in the picture, in order for the line to be oriented horizontally, I wrote “#define CLOCK_ORIENT 0”. If we want vertical we need to correct 0 by 1. In order to show values on the LED screen, you need to indicate the origin of the coordinate along the x axis and along the y axis. For this I need to write in the program “#define CLOCK_X 0” and #define “CLOCK_Y 6”. “#define CLOCK_X 0” for x axis. “CLOCK_Y 6” for y axis (figure 3.1). Next, you will need to assign a color for the minute, hours and for two-dot. For this are the commands “#define

MIN_COLOR CRGB::White", "#define HOUR_COLOR CRGB::White" and "#define DOT_COLOR CRGB::Red".

```
#define OVERLAY_CLOCK 1
#define CLOCK_ORIENT 0
#define CLOCK_X 0
#define CLOCK_Y 6
#define COLOR_MODE 0
//
//
//

#define MIN_COLOR CRGB::White
#define HOUR_COLOR CRGB::White
#define DOT_COLOR CRGB::Red

#define HUE_STEP 5
#define HUE_GAP 30


byte overlayList[] = {
  MADNESS_NOISE,
  OCEAN_NOISE,
};
```

Figure 3.1 - Clock settings

```
#define BRIGHTNESS 250
#define CURRENT_LIMIT 2000

#define WIDTH 16
#define HEIGHT 16
#define SEGMENTS 1

#define COLOR_ORDER GRB

#define MATRIX_TYPE 0
#define CONNECTION_ANGLE 1
#define STRIP_DIRECTION 0
// при неправильной настрйоке


#define MCU_TYPE 0
//
//
//


#define D_TEXT_SPEED 100
#define D_EFFECT_SPEED 80
#define D_GAME_SPEED 250
#define D_GIF_SPEED 80
#define DEMO_GAME_SPEED 60

boolean AUTOPLAY = 0;
int AUTOPLAY_PERIOD = 10;
#define IDLE_TIME 10
```

Figure 3.2 - show settings

The most important thing will be to customize the LED screen. Such as width, length, speed, brightness, how many diodes there will be in one pixel, etc.

For the brightness of the screen, I used the command “#define BRIGHTNESS 250” (Standard maximum brightness from 0 to 255 values). “#define CURRENT_LIMIT 2000” to set the current limit. So that there are no loads for the power supply. In this case, I put 2000 this value in mill amperes.

“#define WIDTH 16”, “#define HEIGHT 16” #define HEIGHT 16 for the width and for the length of the matrix. Since we have a 16x16 LED, the value is all 16. You also need to indicate how many diodes in one pixel to serve for this “#define SEGMENTS 1” (figure 3.2).

I need to make sure that I have zig-zag matrices. Since it has faster response time and less noticeable interpixel mesh. For this I wrote #define MATRIX_TYPE 0”.

It is necessary to indicate the connection pins you can see in the picture 3.3.

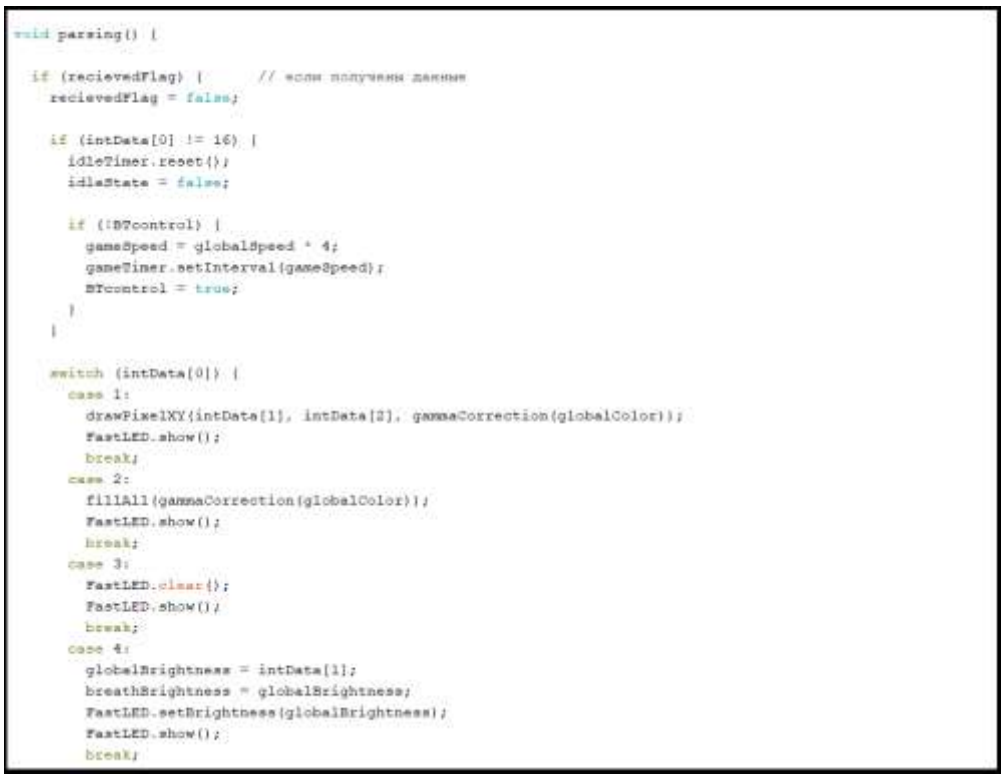
```
// Arduino (Nano, Mega)
#if (MCU_TYPE == 0)
#define LED_PIN 6           // пин ленты
#define BUTT_UP 3           // кнопка вверх
#define BUTT_DOWN 5         // кнопка вниз
#define BUTT_LEFT 2         // кнопка влево
#define BUTT_RIGHT 4        // кнопка вправо
#define BUTT_SET 7          // кнопка выбор/игра
```

Figure 3.3 - connecting pins

```
#include "timerMinim.h"
timerMinim effectTimer(D_EFFECT_SPEED);
timerMinim gameTimer(DEMO_GAME_SPEED);
timerMinim scrollTimer(D_TEXT_SPEED);
timerMinim idleTimer((long)IDLE_TIME * 1000);
timerMinim changeTimer(70);
timerMinim halfsecTimer(500);

#if (USE_CLOCK == 1 && (MCU_TYPE == 0 || MCU_TYPE == 1))
#include <Wire.h>
#include "RTClib.h"

RTC_DS3231 rtc;
// RTC_DS1307 rtc;
#endif

void setup() {
#if (BT_MODE == 1)
  Serial.begin(9600);
#endif

#if (MCU_TYPE == 1)
  WiFi.setSleepMode(WIFI_NONE_SLEEP);
#endif

#if (USE_CLOCK == 1 && (MCU_TYPE == 0 || MCU_TYPE == 1))
  rtc.begin();
  if (rtc.lostPower()) {
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
  }
  DateTime now = rtc.now();
  secs = now.second();
  mins = now.minute();
  hrs = now.hour();
#endif
```

Figure 3.4 – Settings for RTC

Figure 3.4 shows that if we give the command to show the time, the RTC receives a command to exit sleep mode and transmits the data to the display time (seconds, minutes and hours) and date “DateTime now = rtc.now(), “secs = now.second(), mins = now.minute(), hrs = now.hour();”.



```
void parsing() {

  if (recievedFlag) {      // если получены данные
    recievedFlag = false;

    if (intData[0] != 16) {
      idleTimer.reset();
      idleState = false;

      if (!BTcontrol) {
        gameSpeed = globalSpeed * 4;
        gameTimer.setInterval(gameSpeed);
        BTcontrol = true;
      }
    }

    switch (intData[0]) {
      case 1:
        drawPixelXY(intData[1], intData[2], gammaCorrection(globalColor));
        FastLED.show();
        break;
      case 2:
        fillAll(gammaCorrection(globalColor));
        FastLED.show();
        break;
      case 3:
        FastLED.clear();
        FastLED.show();
        break;
      case 4:
        globalBrightness = intData[1];
        breathBrightness = globalBrightness;
        FastLED.setBrightness(globalBrightness);
        FastLED.show();
        break;
```

Figure 3.5 – settings for Bluetooth

4 Safety of life part

4.1 Calculation of natural lighting

Premises with permanent residence of people should have natural light.

The sun is the source of natural light. The lighting conditions in a room are determined mainly by the diffuse light of the sky, as well as by the reflected light created by radiation reflected from the earth's surface.

Natural lighting is divided into side, top and combined (top and side).

Since natural light is unstable, it can change dramatically even within a few minutes, then natural lighting is normalized not by illumination, but by the coefficient of natural illumination (KEO). The natural illumination coefficient e is the ratio of natural illumination at a given point inside the room Ev to the simultaneous value of the external horizontal illumination Eh, created by the light of a completely open sky. KEO is expressed by the formula:

$$e = \frac{E_B}{E_H} * 100\%, \quad (4.1)$$

Thus, the coefficient of natural illumination shows what proportion of the external illumination of the diffuse light of the sky is the illumination at the calculated point inside the room.

Construction norms and rules SNiP 23-05-95 establish the minimum KEO values depending on the category of visual work, lighting system (side, top). The normalized values of KEO are determined according to the table in Appendix 1.

The category of visual work is determined by the smallest the size of the object of discrimination, for example, line thickness, thread, scratch, etc.With one-sided side illumination, the minimum KEO value is normalized at the point located at the intersection of the vertical plane of the characteristic section of the room and the conditional working surface at a distance of 1 m from the wall farthest from the light openings.

With two-sided side lighting, the minimum KEO value is normalized at a point in the middle of the room.

With upper and combined natural lighting, the average value of KEO is normalized at the points located at the intersection of the vertical plane of the characteristic section of the room and the conditional working surface. The first and last points are taken at a distance of 1 m from the surface of the walls or the axes of the columns.

The normalized value of KEO for buildings located in different areas should be determined by the formula:

$$e_N = e_H * m_N, \quad (4.2)$$

N - The number of the group of provision with natural light according to the table. 2.2;

e_H - KEO value according to the table in Appendix 1;

m_N - Light climate coefficient according to the table. 4.1.

The values obtained according to the formula should be rounded to tenths.

A simplified method for calculating the area of light openings is to determine the area of light openings, at which the normalized value of KEO is provided. With side lighting of premises:

$$S_0 = \frac{Sn * En * K_3 * \eta 0}{100 * \tau 0 * r1}, \quad (4.3)$$

Overhead lighting:

$$S_\phi = \frac{Sn * En * K_3 * \eta_\phi * K}{100 * \tau 0 * r1}, \quad (4.4)$$

S_0 - area of light openings with side lighting;

S_n - floor area of the room;

E_n - normalized KEO value for buildings located in different areas;

$K_з$ - the safety factor is selected according to the table in Appendix 7;

n_0 - light characteristic of the window, determined according to table 2.3;

r_1 - coefficient taking into account the increase in KEO with side illumination due to light reflected from surfaces premises and the underlying layer adjacent to the building, taken according to table. 2.12;

S_ϕ - area of skylights under overhead lighting;

η_ϕ - light characteristic of the lantern, determined according to the table. 2.11;

r_2 - factor that takes into account the increase in KEO under overhead lighting due to light reflected from surfaces premises, taken according to the table. 4.10;

K_ϕ - coefficient taking into account the type of lamp, determined according to table 2.8;

$\tau 0$ - total light transmittance, determined by the formula

$$\tau 0 = \tau 1 * \tau 2 * \tau 3 * \tau 4 * \tau 5, \quad (4.5)$$

4.1.1 Purpose and procedure for calculation of natural lighting

The purpose of calculating natural illumination is to determine the glazing area at which the value of the normalized coefficient of natural illumination will be provided. In this case, the type of bindings (lanterns), the position of the glazing, the number of light openings, etc. are determined.

Calculation procedure:

- Choice of a natural lighting system.

The choice is made depending on the purpose of the production facility, taking into account the specifics of the technological process.

Lighting can be side (one-sided or two-sided), top - through aeration lights, combined (top and side).

- The choice of the normalized value of the coefficient of natural illumination is made according to SNiP 23-05-95 or according to the table in Appendix 1. For this, it is necessary to determine the category of visual work depending on the

smallest size of the object of discrimination.

Correct the values of en depending on the area of the building, taking into account the light climate according to the formula (2.2). In this case, the light climate coefficient is determined depending on the number of the group of administrative districts according to the light climate resources (Table 2.2) according to Table 2.1. The skylights are oriented to the north.

- The choice of the safety factor Kz, which takes into account the reduction of KEO due to contamination of the glazing, is made according to the table in Appendix 7. For this, it is necessary to establish the category of the room according to the conditions of air pollution and the location of the light-transmitting material in relation to the horizon.

- The determination of the light characteristics of light openings is carried out:

- with side lighting according to the table. 2.3 depending on the value of the ratio of the length of the room Ln to its depth B (Ln / B), as well as the value of the ratio of the depth of the room B to its height from the level of the conventional working surface from the top of the window h1 (B / h1);

- with overhead lighting according to the table. 2.11 depending on the type of lantern, as well as the values of the ratio of the length of the room to the width (Ln / B) and the height of the room to the width (H / B).

The determination of the total coefficient of light transmission is carried out according to the formula (4.5), as well as using the table. 4.5, 4.6, 4.7.

- Determination of coefficients. R1 - for side lighting according to the table.

- To do this, you need to determine. the ratio of the depth of the room to the height from the level of the conventional working surface to the top of the window - B / h1;

the ratio of the distance between the design point and the outer wall to the depth of the room - L / B;

the ratio of the length of the room to its depth - Ln / B;

the value of the weighted average reflection coefficient P_{cp} of the ceiling, walls and floor, which is determined by the formula:

$$P_{cp}=\frac{P1*S1+P2*S2+P3*S3}{S1+S2+S3}, \qquad (4,6)$$

P_1,P_2,P_3 - Reflectance coefficients of ceiling, walls and floor respectively, determined from the table 4.9;

S_1,S_2,S_3 - The surface area of the ceiling, walls and floor, respectively.

It is determined depending on the value of the ratio of the height of the room, taken from the conditional working surface to the lower edge of the glazing to the width of the room (Hф / B), as well as on the weighted average reflection coefficient of the ceiling, walls and floor P_{cp} which is calculated by formula (4.6).

- The value of the coefficient Kf is selected according to the table 4.8 depending on the type of flashlight;

- Determination of the area of light openings is carried out:

a) with side illumination according to the formula (4.3);

b) with overhead lighting according to the formula (4.4).

The dimensions of the light openings established by the calculation may be changed by + 5%, -10%.

Table 4.1 - Light climate coefficient values

Light openings	Orientation light openings on	Light climate coefficient, mN				
		Administrative districts group number				
		1	2	3	4	5
In the outer walls of buildings	N	1	0,9	1,1	1,2	0,8
	NE, NW	1	0,9	1,1	1,2	0,8
	W, E	1	0,9	1,1	1,1	0,8
	SE, SW	1	0,85	1	1,1	0,8
	S	1	0,85	1	1,1	0,75
In rectangular and trapezoidal lamps	N – S	1	0,9	1,1	1,2	0,75
	BE - NW SE – SW	1	0,9	1,2	1,2	0,7
	E – W	1	0,9	1,1	1,2	0,7
In lanterns like "Shed"	N	1	0,9	1,2	1,2	0,7
In anti-aircraft Lanterns	-	1	0,9	1,2	1,2	0,75

Table 4.2 - The value of the light characteristic of the windows with side illumination

The ratio of the length of the room to its depth	The value of the light characteristic with the ratio of the depth of the room to its height from the level of the conventional working surface to the top of the window B / h1							
	1	1,5	2	3	4	5	7,5	10
4	6,5	7	7,5	8	9	10	11	12,5
3	7,5	8	8,5	9,6	10	11	12,5	14
2	8,5	9	9,5	10,	11,	13	15	17

				5	5			
1,5	9,5	10,5	13	15	17	19	21	23

Continuation of table 4.2

1,0	11	15	16	18	21	23	26,5	29
0,5	18	23	31	37	45	54	66	-

Table 4.3 - The values of the coefficient Кзд, taking into account the shading of windows by opposing buildings

The ratio of the distance between the considered and the opposing building to the height of the position of the eaves of the opposing building above the window sill of the window in question (Lзд / Nзд)	Кзд
0,5	1,7
1,0	1,4
1,5	1,2
2,0	1,1
3	1,0

Table 4.4 - Light transmittance values

Type of light-transmitting material	τ
Sheet glass:	
- single	0,9
- double	0,8
- triple	0,75
Reinforced sheet glass	0,6

Table 4.5 - Coefficient value

Binding type	$\tau 2$
a) wooden:	
- single	0,75
- double	0,7
- double separate	0,6
b) steel:	
- single opening	0,7

	5
- double opening	0,6

Table 4.6 - Coefficient value

Bearing structures of coatings	$\tau 3$
Steel trusses	0,9
Reinforced concrete and wooden trusses and arches	0,8

Table 4.7 – $K_ф$ coefficient values

Flashlight type	$K_ф$

Continuation of table 4.7

Lanterns with sloped double-sided glazing (trapezoidal)	1,15
Lanterns with vertical double-sided glazing (rectangular)	1,2
Lanterns with one-sided tilted glazing (Sheds)	1,3
Lanterns with one-sided vertical glazing (Sheds)	1,4

Table 4.8 - Approximate reflectivity values

The nature of the reflective surface	P, %
Whitewashed ceiling; whitewashed walls with curtains windows	70
Whitewashed walls with not curtained windows; clean concrete and light wood ceiling	50
Concrete ceiling in dirty rooms; concrete walls with windows; walls covered with light wallpaper	30
Red brick not plastered; walls with dark wallpaper	10

Table 4.9 - Coefficient values r2

The ratio of the height of the room, taken from the conditional working	Weighted average reflectance of ceiling, walls and floor

surface to the lower edge of the glazing, Nf to the width B	P_{cp}=0,5	P_{cp}= 0,4	P_{cp}= 0,3
2	1,7	1,6	1,4
1	1,5	1,4	1,3
0,75	1,45	1,35	1,25

Table 4.10 - The value of the luminous characteristics of lanterns

Lantern type	The ratio of the length of the room Lp to the width B								
	from 1 to 2			from 2 to 4			more than 4		
	The ratio of the height of the room H to the width B								
	from 0.2 up to 0.4	from 0.4 up to 0.7	from 0.7 up to 1.0	from 0.2 up to 0.4	from 0.4 up to 0.7	from 0.7 up to 1.0	from 0.2 up to 0.4	from 0.4 up to 0.7	from 0.7 up to 1.0

Continuation of table 4.10

With vertical double-sided glazing (one span)	5,8	9,4	16	4,6	6,8	10,5	4,4	6,4	9,1
Sloped double-sided glazing (one span)	3,5	5,2	6,2	2,8	3,8	4,7	2.7	3,6	4,1
With vertical single-sided glazing (one span)	6,4	10, 5	15	5,1	7,6	10	4,9	7,1	8,5
Sloped single-sided glazing (one span)	3,8	4,5	6,8	2.9	3,4	4,5	2,5	3,2	3,9

Calculate natural illumination in the planning and economic department. Determine the required area of the skylights (glazing).

Given: The planning and economic department of the airline is located in Almaty. Geometrical dimensions of the room: length of the room Lp = 10 m; depth B = 12 m; height H = 5 m. Height from the working surface to the top of the window h1 = 4 m. Distance from the outer wall to the design point A - L = 6 m. Reflection

coefficients of the ceiling, walls and floor: 50%, 30%, 10%. The opposing building is located at a distance of Ld = 30 m; Nзд = 30 m.

Design side, one-sided natural lighting. Provide for the use of double glass panes in double vertically arranged wooden sashes. The smallest size of the object of discrimination is 4 mm.

Decision:

Determine the normalized value of the coefficient of natural illumination for the location area.

We find from the table in Appendix 1 $e_N = 1$.

For Almaty, when the windows are oriented to the north - eN = 1 * 1.1 = 1.1 The safety factor according to the table in Appendix 7 is Kз = 1.6.

We find the light characteristic of the light openings according to the table. 2.3 at Lp / B = 10: 12 = 0.8; B / h1 = 12: 4 = 3 $\eta_0 = 18$

Determine the overall coefficient of light transmission:

$$\tau 0 = \tau 1 * \tau 2 * \tau 3 * \tau 4 * \tau 5;$$

$$\tau 1 = 0{,}8;\ \tau 2 = 0{,}7;\ \tau 3 = 1;\ \tau 4 = 1;$$

$$\tau 0 = \tau 1 * \tau 2 * \tau 3 * \tau 4 * \tau 5 = 0{,}8 * 0{,}7 * 1 * 1 = 0{,}56.$$

Determine the coefficient r1 - for side lighting

To do this, we find:

the ratio of the depth of the room to the height from the level of the conventional working surface to the top of the window - B / h1 = 12/4 = 3;

the ratio of the distance between the design point and the outer wall to the depth of the room - L / B = 6/12 = 0.5;

the ratio of the length of the room to its depth - Ln / B = 10/12 = 0.8;

value of the weighted average reflectance $P_{ср}$ ceiling, walls and floor, with a ceiling area S1 = 10 * 12 = 120 m2; wall area S2 = 2 * 12 * 5 + 10 * 5 = 170 m2; floor area S3 = 10 * 12 = 120 m2:

$P_{ср}$ = (50 * 120 + 30 * 170 + 10 * 120)/ (120 + 170 + 120) = 30 (%).

$r_1 = 1{,}15$.

We find the coefficient Kzd, taking into account the shading of the opposing building according to table. 2.4 with the ratio Lzd / Nzd = 30/30 = 1 and $P_{ср}$ = 30%

Кзд = 1,4

Determine the area of light openings by the formula 1.3

$S_0 = \frac{120*1{,}1*1{,}5*18*1{,}4}{100*0{,}56*1{,}15} = 77{,}5 м^2$

Relative area of skylights

$$\sigma = \frac{77{,}5}{120} * 100 = 64{,}6\%$$

4.2 Zeroing calculation

Brief theoretical information

The term electrical safety is understood as a system of organizational and technical measures and means that ensure the protection of people from the harmful and dangerous effects of electric current, electric arc, electromagnetic field and static

electricity.

Electrical protection measures can be divided into the following three main groups:

- Organizational measures, including registration of work with a permit-permit.

- Organizational and technical measures: fencing of current-carrying parts of electrical equipment, safe modes of network operation, the use of interlocks, protective equipment, alarms, portable earthing switches, safety posters.

a) Technical protection measures, including:
b) protective grounding;
c) protective grounding and protective shutdown;
d) potential equalization;
e) conductor insulation (working, double, reinforced);
f) control and prevention of insulation, detection of its damage;
g) low voltage;
h) electrical separation of networks;
j) protection against voltage transition from the higher side to the lower one;
k) lightning protection.

One of the most effective electrical protective equipment against non-current-carrying parts is: automatic shutdown of the power source (including protective neutralization and protective shutdown), which protects a person from injury in the event of a malfunction of the electrical installation - in case of damage or breakdown of the insulation of the electrical installation to the case. This method provides a high level of electrical safety when operating electrical installations in networks up to 1000V.

Zeroing is used in networks with a dead-grounded neutral voltage up to 1000V.

The purpose of zeroing is to eliminate the risk of electric shock in the event of touching metal non-conductive parts (equipment housing) that are under voltage.

The principle of operation of the protective zero is to automatically turn off the damaged area and at the same time to reduce the contact voltage on the equipment body, until the maximum current protection (MTZ) or automatic shutdown is triggered.

The task of the protective zeroing is a fast and reliable automatic shutdown of electrical equipment in the event of a violation of the insulation and the appearance of dangerous voltage on the housings of electrical equipment.

To solve this problem, metal non-conductive parts of electrical equipment (housing), which may be energized, are connected by conductors to the grounded neutral point of the current source winding or its equivalent (deafly grounded neutral).

Calculate the system of protective zeroing for a three-phase four-wire line with a voltage of 380/220 V, feeding the electric motor.

The initial data for the calculation are given in Table 3.1

Table 4.11 - Initial data

Initial data	Option number				
		2	3	4	5
transformer power, Str, kVA	100	250	1000	400	600
electric motor power, P, kW	48	65	55	60	30
metal type of conductors	Cu	Al	Cu	Al	Cu
line length, L, m	100	150	200	130	180
electric motor efficiency,$\eta_{эд}$, %	0,85	0,86	0,87	0,88	0,90
power factor, cos φ	0,86	0,84	0,89	0,88	0,85
Resistance of the main ground conductor, Ro, Ohms		4	4	4	4

Decision:

An electrical circuit for grounding a three-phase electric motor with voltage up to 1 kV is drawn up. The four-wire circuit with zero protection is adopted wire.

$$I_{н.эл.дв} = \frac{1000P}{\sqrt{3U} * cos\ \varphi}, \quad (4.7)$$

where P - the rated power of the engine, kW;

Uн - rated voltage, V;

cos φ - the power factor.

Calculation of the starting current of the electric motor

$$I_{пус} = I_{н}, \quad (4.8)$$

where $I_{н.эл.дв}$ - rated operating current of the electric motor, A;

β = 5… 8 - overload factor ($I_{пус}$ / $I_{н}$).

Fuse-links of fuses are selected according to the calculated value

rated current $I_{н}$ in this case, condition (1) must be met.The value of the rated current is determined by the expression:

$$I_{пл.вст} = \frac{Iпус}{\alpha}, \quad (4.9)$$

Where

$I_{пл.вст}$ - starting current of the electric motor, A;

α - the operating mode coefficient.

For asynchronous motors α = 1.6 ... 2.5; for engines with frequent starts (crane motors) α = 1.6 ... 1.8; for motors driving mechanisms with rare starts (conveyors, fans), α = 2 ... 2.5.

Selection of the rated current of the fuse-link Inom.pl from the following row - with $I_{н.пл.вст}$ <10 (A) - a larger value is selected with rounding to the nearest integer, with $I_{н.пл.вст}$ ≥10 (A) - the larger value is selected, rounded to the nearest 5 or 10.

$I_{н.пл.вст}$ = 380/220 V

Selection of the approximate current density in the phase conductors:

j = 3 A / mm2 - for copper wires, j = 2 A / mm2 - for aluminum wires. Calculation of the approximate section of the phase wires s f = I ed / j mm2.

The choice of the standard section of the phase conductors Sf is carried out from the following row: 1; 1.5; 2; 2.5; four; 6; eight; 10; sixteen; 25; 35; fifty; 70; 95; 130; 150; 170 mm2. Is selected section according to the calculated sf rounded to the nearest larger value from this series. For Al wires, the minimum cross-section is 2.5 mm.

The cross-section of the neutral conductor and its material are selected from the condition that the admittance of the neutral conductor is at least 50% of the admittance of the phase conductor, that is, the condition is met

$$\frac{1}{(R_н+X_н)} \geq \frac{1}{2(R_н+X_н)}, \tag{4.10}$$

Calculation of active resistance of phase and neutral wires

$$R_ф = \frac{p*L_ф}{S_ф}, \tag{4.11}$$

where ρ - the resistivity of the conductor (for copper (Cu) ρ = 0.018 Ohm mm2 / m, for aluminum (Al) ρ = 0.028 Ohm • mm2 / m);

L - conductor length, m;

S - section, mm2.

Calculation of inductive resistance of phase and neutral wires Values of inductive resistances Xϕ and Xн for copper and aluminum

conductors are small (about 0.0156 Ohm / km) and, as a rule, they are neglected in calculations.

The external inductive reactance of 1 km of the "phase - zero" loop is taken

$$Xp = 0.6 \text{ Ohm / km, so } Xp=0.6*L, \tag{4.12}$$

Calculation of the impedance of the "phase-zero" loop

$$Z_п = [(R_f + X_н) 2 + X_{п2}] 0.5, \text{ Ohm}, \tag{4.13}$$

The value of the Gtr (Ohms) depends on the power of the transformer, the voltage and the

connection scheme of its windings, as well as the design of the transformer.

When calculating zeros, the value of the $Z_{тр}$ is taken from Table 3.2.

Approximate values of the calculated total resistances Ztr (Ohms), windings of oil three-phase transformers connected according to the scheme Δ/Y.

Table 4.12 - Data in the calculation of zeroing

$N_{тр}$, кVA	100	160	250	400	630	1000
$Z_т$ /3 , Ohm	0,226	0,141	0,09	0,056	0,042	0,027

Checking the condition for the reliability of the breaking capacity

$$I_{к.з} \geq k*I_{н.эл.дв}, \quad (4.14)$$

If the current $I_{к.з}$ is less than the above conditions, then large values of the cross-sections of the phase and zero wires $S_ф$ and $S_н$ are taken for one stage (or several) from a number of cross-sections in paragraph 9 and the calculation is repeated from paragraph 11 to paragraph.

4.3 Conclusion on the life safety section

In this section of the degree project, the requirements for the workplace of an engineer-programmer were set forth. The created conditions must ensure comfortable work. On the basis of the studied literature on this problem, the optimal dimensions of the desktop and chair, the working surface were indicated, as well as the choice of the system and the calculation of the optimal lighting of the production room, as well as the calculation of the noise level at the workplace. Compliance with the conditions that determine the optimal organization of the 43 workplace of the engineer-programmer will allow maintaining good performance throughout the working day, will increase both quantitatively and qualitatively the productivity of the programmer, which in turn will contribute to the fastest development and debugging of the software product.

I made a natural light calculation and calculated the zeros for my “smart office”. So that in the future my employees can work without harm to their health. Since the health of my future employees is very important.

5 Economic part

5.1 Business plan

A feasibility study of the theses related to the development of a software product (SP) was made.

The feasibility study of the development should contain:

– determination of the complexity of the development of the SP;

– calculation of the costs for the development of the SP;

– determination of the possible price of the developed SP.

5.2 Determination of the complexity of the development of the SP

The complexity of developing a software product for a specific task (t_p) can be considered as the sum of labor costs for the stages of development:

– preparation of the task description – t_d, man/hour;

– development of the algorithm for solving the problem – t_a, man-hour ;

– drawing up a flowchart of the algorithm – t_f, man/hour;

– programming – t_p, man/hour;

– debugging the program on a computer – t_{deb}, man/hour;

– preparation of documentation for the task – t_{doc}, man/hour.

The basic indicator for determining the complexity is the conditional number of operator commands in the developed software (software). The conditional number of operators in the task program is determined by the formula:

$$Q = q \times c, \tag{5.1}$$

where Q is a conditional number of operators;

q is an estimated number of operators depending on the type of task;

c is a coefficient taking into account the novelty and complexity of the program.

Let us select the coefficient q according to table 5.1.

Table 5.1 - The values of the coefficient q

Further, in order to determine the coefficient c, the first thing is to choose a group according to the degree of novelty:

– group A – the development of fundamentally new tasks;

– group B – development of original programs;

– group B – development of programs using standard solutions;

– group D – a one-time standard task.

The system is designed using Raspberry single-board computer and JSON keys. The Raspberry Pi is an ultra-low-cost ($20-$35) credit-card sized Linux computer which was conceived with the primary goal of teaching computer programming to children. It was developed by the Raspberry Pi Foundation, which is a UK registered charity. The foundation exists to promote the study of computer science and related topics, especially at school level, and to put the fun back into learning computing. The device is expected to have many other applications both in the developed and the developing world. JSON, or JavaScript Object Notation, is a minimal, readable format for structuring data. It is used primarily to transmit data between a server and web application, as an alternative to XML. Square space uses JSON to store and organize site content created with the CMS [35].

Now, based on table 5.2, we determine the coefficient c equal to 1.26.

Table 5.2 - Labor calculation factors

Thus, the (5.1) formula is used to define Q:

$$Q = 1500 \times 1{,}26 = 1890.$$

After this, it is necessary to determine the time spent on creating the software at each stage:

a) t_d is taken upon the fact:

$$t_d = 24\ man - hour, \qquad (5.2)$$

b) we find t_a by the formula:

$$t_a=Q/(50*K), \qquad (5,3)$$

where K is a coefficient taking into account the qualifications of a programmer (table 5.3).

Table 5.3 - Programmer qualification factors

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 than 7 years	1,5-1,6

Hence, according to the formula (5.2.3), t_a is equal to:

$$t_a = \frac{1890}{50 \times 1} = 37{,}8 \quad man/hour;$$

3) t_f we find by the formula:

$$t_f = \frac{Q}{50 \times K}, \tag{5.4}$$

where K is a coefficient of programmer qualification factors.
So the t_f is:

$$t_f = \frac{1890}{50 \times 1} = 37{,}8 \quad man/hour;$$

4) t_p is determined by the formula:

$$t_p = Q \times \frac{1{,}5}{50 \times K}$$

where Q is a conditional number of operators;

K is a coefficient that takes into account the programmer's qualifications.

$$t_p = 1890 \times \frac{1{,}5}{50 \times 1} = \frac{2835}{50} = 56{,}7 \; man/hour;$$

5) t_{deb} is determined by the formula:

$$t_{deb} = Q \times \frac{4{,}2}{50 \times K}$$

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where Q is a conditional number of operators;
K is a coefficient that takes into account the programmer's qualifications.

$$t_{deb} = 1890 \times \frac{4{,}2}{50 \times 1} = \frac{7938}{50} = 158{,}76\ man/hour;$$

6) t_{doc} is taken on the fact and is (from 3 to 5 days for 8 hours):

$$t_{doc} = 24\ man/hour.$$

The total labor costs are calculated as the sum of the composite labor costs according to the formula (man/hour):

$$t_p = t_d + t_a + t_f + t_p + t_{deb} + t_{doc}, \qquad (5.7)$$

where t_d - preparation of the task description, man/hour;

t_a – development of the algorithm for solving the problem, man/hour;

t_f – drawing up a flowchart of the algorithm, man/hour;

t_p – programming, man/hour;

t_{deb} – debugging the program on a computer, man/hour;

t_{doc} – preparation of documentation for the task, man/hour.

$$t_p = 24 + 37{,}8 + 37{,}8 + 56{,}7 + 158{,}76 + 24,$$

$$t_p = 339{,}06\ man/hour\ or\ 42\ man/day.$$

5.3 Calculation of the costs for the development of the SP

In works that require the development of a software product (software), the costs (C_{sp}) are determined by the following formula:

$$C_{sp} = G_f + S_t + \mathrm{M} + C_s + C_d + C_e + C_o, \qquad (5.8)$$

where S_f – the general fund of remuneration of developers, tenge;

S_t – social tax deductions, tenge;
M – cost of materials, tenge;
C_s – the cost of special software tools necessary for the development of the project solution, tenge;

C_d – the cost of depreciation of equipment, tenge;

C_e – electricity costs, tenge;

C_o – overhead costs, tenge.

The size of the developer's salary fund (G_f) is calculated using the formula:

$$G_f = S_b + S_a, \tag{5.9}$$

where S_b is a basic salary, tenge;

S_a is an additional salary, tenge.

The basic salary of performers for a specific software is calculated using the formula:

$$S_m = t_p \times S_d, \quad (5.10)$$

where t_p is a complexity of software development, man/day;

S_d – the daily salary of the developer, the i-th performer, (tenge).

The daily salary is determined based on the monthly salary of the developer and the number of working days in the month (on average, you can take 22 working days). Information on the employees involved in the development should be presented in table (table 5.4).

Table 5.4 - Salaries of specialists

Specialist	Number, person	Salary, tg.
Programmer	1	200 000
Total		200 000

Thus, the daily salary of a programmer is:

$$S_d = \frac{200000}{22} = 9090\ tenge.$$

The basic salary's formula is:

$$S_b = t_p \times S_d, \quad (5.11)$$

$$S_b = 42 \times 9090 = 381780\ tenge.$$

The additional salary is 10% of the basic salary and is calculated according to the formula:

$$Sa = Sb * \frac{Ca}{100}, \quad (5.12)$$

where C_a is the coefficient of additional salary for developers.

$$S_a = 381780 \times \frac{10}{100} = 38178\ tenge.$$

Thus, the general fund of remuneration of developers will be:

$$G_f = S_b + S_a, \quad (5.13)$$

$$G_f = 381780 + 38178 = 419958\ tenge.$$

The social tax is 9,5% (Article 358 p. 1 of the Tax Code of the Republic of Kazakhstan) of the employee's income, and is calculated according to the formula:

$$St = (Gf + Pc), \quad (5.14)$$

where P_c is a pension contributions, which make up 10% of the FOT and are not subject to social tax:

$$P_c = G_f \times 0{,}1 = 419958 \times 0{,}1 = 41995\ tenge.$$

Based on the above calculations and using the formula (5.15) for the social tax is equal to:

$$St = (Gf - Pc) \times 9{,}5\%, \quad (5.15)$$

$$S_t = (419958 - 41995) \times 0{,}095 = 35906\ tenge.$$

The value of the cost of materials based on the source data is determined by the formula:

$$M = \frac{(S_b \times R_{mc})}{100\%}, \quad (5.16)$$

where R_{mc} is a rate of material consumption from the basic salary (3-5%).

$$M = \frac{381780 \times 5\%}{100\%} = 190000\ tenge.$$

This project uses the API "Google Cloud Platform" and JSON objects/keys which are freely distributed for 60 days, therefore, the cost of special software tools (Pc) is 0.

Depreciation costs include depreciation deductions from the cost of the equipment used for the development of the software product and are calculated using the formula:

$$C_d = \frac{C_{eq} \times R_d \times N}{100 \times 12 \times t},$$

(5.17)

where R_d is the depreciation rate (25%);

C_{eq} – initial cost of equipment;

N – personal computer usage time;

t – the number of working days in the month.

$$Cd = \frac{10000 * 0{,}25 * 42}{100 * 12 * 22} = 3{,}9$$

The cost of electricity is calculated using the formula:

$$C_e = \text{M} \times l_f \times T \times C_{\text{kWt*h}}, \quad (5.18)$$

where M is a computer power, kW;

l_f – load factor (0.8);

$C_{\text{kWt*h}}$ – cost of 1 kWh of electricity, tenge/kWh;

T – working time, hour.

Using the formula (5.3.11), the energy costs were determined and shown in table (table 5.5):

$$C_{e1} = 0{,}12 \times 0{,}8 \times 339 \times 17{,}79 = 579,$$

$$C_{e2} = 0{,}1 \times 0{,}8 \times 339 \times 17{,}79 = 482.$$

Table 5.5 - Electricity costs

Equipment name	Passport power, kW	Load factor	Operating time of the equipment for the development of SP, hour	Price of el., tenge/kW-hour	Amount, tenge
Laptop	0.12	0.8	339	17.79	579
Lamp	0.1	0.8	339	17.79	482
Total electricity costs					1061

Overhead costs, (C_o) and account for 40 to 60% of the basic salary:

$$C_o = O_{ss} \times S_o \times 100\%, \quad (5.19)$$

where C_o is an overhead for a specific software (tenge);

S_o – the standard of overhead costs, (%).

$$C_o = 381780 \times 50\% \times 100\% = 19000\ tenge.$$

Thus, the cost of developing the software product is given by formula:

$$C_{sp} = G_f + S_t + \text{M} + C_s + C_d + C_e + C_o, \quad (5.20)$$

$$C_{sp} = 419958 + 35906 + 19000 + 0 + 3.9 + 1061 + 190000,$$

$$C_{sp} = 980000\ tenge.$$

The estimated cost of developing a software product is presented in table (table 5.6).

Table 5.6-Summary table of costs for the development of the SP

Cost items	Amount, tenge
Payroll fund	419958
Social tax	35906
Materials	19000
Depreciation	3.9
Electricity	1061
Overhead costs	190000
Total:	980000

5.4 Determination of the possible price of the developed SP

The value of the possible (contractual) price of the SP should be set taking into account the efficiency, quality and timing of its implementation at a level that meets the economic interests of the customer (consumer) and the contractor.

The contract price (C_p) is calculated using the formula:

$$C = [C \times (\text{P})] + VAT, \quad (5.21)$$

p sp $\overline{100}$

where $C_{sp}$is a cost of developing the SP, tenge;

P – the average level of profitability (accepted in the amount of 20-30%);
VAT – value added tax,%.

The value added tax rate in the Republic of Kazakhstan for 2021 is 12% of the selling price of R&D and is calculated according to the formula:

$$VAT = [C_{sp} \times (\frac{P}{100})] \times 12\%, \quad (5.22)$$

$$C_p = [980000 \times (1 + \frac{20}{100})] + [980000 \times (1 + \frac{20}{100})] \times 12\%,$$

$$C_p = 1317120\ tenge.$$

5.5 Conclusion on the economic section

Summing up all calculations, it can be clearly seen that development of this products has an average cost and it is more efficient than other types of development of an object detecting and classification system, because there is a Raspberry Pi single-board computer and Google Cloud Platform API which is affordable due to program complex objectives of whole project and it need only 1 employer for relevant cost of general project. Additionally, thus project affordable to employ in industry because of available cost.

Conclusion

The diploma project was aimed at developing a "smart office" system. Concepts such as arduino board, smart office alternatives have been thoroughly researched and disclosed.

The system has been configured to connect via bluetooth and buttons. Three programs for recognizing faces, labels and logos have been developed. The complete program codes are presented in three appendices A, B, and C.

At the next stage of life safety, working conditions were created. It includes requirements for production facilities, microclimate parameters. Also, calculations of artificial lighting and safe grounding were carried out. The economic part estimates the cost of the project.

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Application A

```
#define BRIGHTNESS 250
#define CURRENT_LIMIT 2000
#define WIDTH 16
#define HEIGHT 16
#define SEGMENTS 1
#define COLOR_ORDER GRB
#define MATRIX_TYPE 0
#define CONNECTION_ANGLE 1
 #define STRIP_DIRECTION 0
#define MCU_TYPE 0
#define D_TEXT_SPEED 100
#define D_EFFECT_SPEED 80
#define D_GAME_SPEED 250
#define D_GIF_SPEED 80
#define DEMO_GAME_SPEED 60
boolean AUTOPLAY = 0;
int AUTOPLAY_PERIOD = 10;
#define IDLE_TIME 10
#define GLOBAL_COLOR_1 CRGB::Green
#define GLOBAL_COLOR_2 CRGB::Orange
#define SCORE_SIZE 0
#define FONT_TYPE 1
#define USE_BUTTONS 1
#define BT_MODE 1
#define USE_NOISE_EFFECTS 1
#define USE_FONTS 1
#define USE_CLOCK 1
#define USE_SNAKE 1
#define USE_TETRIS 1
#define USE_MAZE 1
#define USE_RUNNER 1
#define USE_FLAPPY 1
#define USE_ARKAN 1
#if (MCU_TYPE == 0)
#define LED_PIN 6
#define BUTT_UP 3
#define BUTT_DOWN 5
#define BUTT_LEFT 2
#define BUTT_RIGHT 4
#define BUTT_SET 7
#elif (MCU_TYPE == 1)
#define LED_PIN 2
```

```
#define BUTT_UP 14
#define BUTT_DOWN 13
#define BUTT_LEFT 0
#define BUTT_RIGHT 12
#define BUTT_SET 15
#elif (MCU_TYPE == 2)
#define LED_PIN PB12
#define BUTT_UP PA1
#define BUTT_DOWN PA3
#define BUTT_LEFT PA0
#define BUTT_RIGHT PA2
#define BUTT_SET PA4
#endif
#define DEBUG 0
#define NUM_LEDS WIDTH * HEIGHT * SEGMENTS
#define RUNNING_STRING 0
#define CLOCK_MODE 1
#define GAME_MODE 2
#define MADNESS_NOISE 3
#define CLOUD_NOISE 4
#define LAVA_NOISE 5
#define PLASMA_NOISE 6
#define RAINBOW_NOISE 7
#define RAINBOWSTRIPE_NOISE 8
#define ZEBRA_NOISE 9
#define FOREST_NOISE 10
#define OCEAN_NOISE 11
#define SNOW_ROUTINE 12
#define SPARKLES_ROUTINE 13
#define MATRIX_ROUTINE 14
#define STARFALL_ROUTINE 15
#define BALL_ROUTINE 16
#define BALLS_ROUTINE 17
#define RAINBOW_ROUTINE 18
#define RAINBOWDIAGONAL_ROUTINE 19
#define FIRE_ROUTINE 20
#define IMAGE_MODE 21
#if (MCU_TYPE == 1)
#define FASTLED_INTERRUPT_RETRY_COUNT 0
#define FASTLED_ALLOW_INTERRUPTS 0
#include <ESP8266WiFi.h>
#endif
#include "FastLED.h"
CRGB leds[NUM_LEDS];
```

```
String runningText = "";
static const byte maxDim = max(WIDTH, HEIGHT);
byte buttons = 4;
int globalBrightness = BRIGHTNESS;
byte globalSpeed = 200;
uint32_t globalColor = 0x00ff00
byte breathBrightness;
boolean loadingFlag = true;
byte frameNum;
int gameSpeed = DEMO_GAME_SPEED;
boolean gameDemo = true;
boolean idleState = true;
boolean BTcontrol = false;
int8_t thisMode = 0;
boolean controlFlag = false;
boolean gamemodeFlag = false;
boolean mazeMode = false;
int effects_speed = D_EFFECT_SPEED;
int8_t hrs = 10, mins = 25, secs;
boolean dotFlag;
byte modeCode;
boolean fullTextFlag = false;
boolean clockSet = false;
#if (USE_FONTS == 1)
#include "fonts.h"
#endif
uint32_t autoplayTime = ((long)AUTOPLAY_PERIOD * 1000);
uint32_t autoplayTimer;
#include "timerMinim.h"
timerMinim effectTimer(D_EFFECT_SPEED);
timerMinim gameTimer(DEMO_GAME_SPEED);
timerMinim scrollTimer(D_TEXT_SPEED);
timerMinim idleTimer((long)IDLE_TIME * 1000);
timerMinim changeTimer(70);
timerMinim halfsecTimer(500);
#if (USE_CLOCK == 1 && (MCU_TYPE == 0 || MCU_TYPE == 1))
#include <Wire.h>
#include "RTClib.h"
RTC_DS3231 rtc;
// RTC_DS1307 rtc;
#endif
void setup() {
#if (BT_MODE == 1)
  Serial.begin(9600);
```

```
#endif
#if (MCU_TYPE == 1)
  WiFi.setSleepMode(WIFI_NONE_SLEEP);
#endif
#if (USE_CLOCK == 1 && (MCU_TYPE == 0 || MCU_TYPE == 1))
  rtc.begin();
  if (rtc.lostPower()) {
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
  }
  DateTime now = rtc.now();
  secs = now.second();
  mins = now.minute();
  hrs = now.hour();
#endif
FastLED.addLeds<WS2812, LED_PIN, COLOR_ORDER>(leds,NUM_LEDS).setCorrection( TypicalLEDStrip );
  FastLED.setBrightness(BRIGHTNESS);
  if (CURRENT_LIMIT > 0) FastLED.setMaxPowerInVoltsAndMilliamps(5, CURRENT_LIMIT);
  FastLED.clear();
  FastLED.show();
  randomSeed(analogRead(0) + analogRead(1));
}
void loop() {
  customRoutine();
  bluetoothRoutine();
}
```

Application B

```
#define TEXT_DIRECTION 1
#define MIRR_V 0
#define MIRR_H 0
#define TEXT_HEIGHT 0
#define LET_WIDTH 5
#define LET_HEIGHT 8
#define SPACE 1
#if (USE_FONTS == 1)
int offset = WIDTH;
void fillString(String text, uint32_t color) {
  if (loadingFlag) {
    offset = WIDTH;
    loadingFlag = false;
    modeCode = 0;
    fullTextFlag = false;
  }

  if (scrollTimer.isReady() || (!BTcontrol && !gamemodeFlag)) {
    FastLED.clear();
    byte i = 0, j = 0;
    while (text[i] != '\0') {
      if ((byte)text[i] > 191) {           i++;
      } else {
        drawLetter(j, text[i], offset + j * (LET_WIDTH + SPACE), color);
        i++;
        j++;
      }
    }
    fullTextFlag = false;

    offset--;
    if (offset < -j * (LET_WIDTH + SPACE)) {    // строка убежала
      offset = WIDTH + 3;
      fullTextFlag = true;
    }
    FastLED.show();
  }
}
void drawLetter(uint8_t index, uint8_t letter, int16_t offset, uint32_t color) {
  int8_t start_pos = 0, finish_pos = LET_WIDTH;
  CRGB letterColor;
  if (color == 1) letterColor = CHSV(byte(offset * 10), 255, 255);
```

```
      else if (color == 2) letterColor = CHSV(byte(index * 30), 255, 255);
      else letterColor = color;
      if (offset < -LET_WIDTH || offset > WIDTH) return;
      if (offset < 0) start_pos = -offset;
      if (offset > (WIDTH - LET_WIDTH)) finish_pos = WIDTH - offset;
      for (byte i = start_pos; i < finish_pos; i++) {
        int thisByte;
        if (MIRR_V) thisByte = getFont((byte)letter, LET_WIDTH - 1 - i);
        else thisByte = getFont((byte)letter, i);
        for (byte j = 0; j < LET_HEIGHT; j++) {
          boolean thisBit;
          if (MIRR_H) thisBit = thisByte & (1 << j);
          else thisBit = thisByte & (1 << (LET_HEIGHT - 1 - j));
          if (TEXT_DIRECTION) {
            if (thisBit) leds[getPixelNumber(offset + i, TEXT_HEIGHT + j)] = letterColor;
            else drawPixelXY(offset + i, TEXT_HEIGHT + j, 0x000000);
          } else {
            if (thisBit) leds[getPixelNumber(i, offset + TEXT_HEIGHT + j)] = letterColor;
            else drawPixelXY(i, offset + TEXT_HEIGHT + j, 0x000000);
          }
        }
      }
    }

    uint8_t getFont(uint8_t font, uint8_t row) {
      font = font - '0' + 16;
     if (font <= 90) return pgm_read_byte(&(fontHEX[font][row]));
      else if (font >= 112 && font <= 159) {
        return pgm_read_byte(&(fontHEX[font - 17][row]));
      } else if (font >= 96 && font <= 111) {
        return pgm_read_byte(&(fontHEX[font + 47][row]));
      }
    }
    #elif (USE_FONTS == 0)
    void fillString(String text, uint32_t color) {
      fullTextFlag = false;
      modeCode = 0;
      return;
    }
    #endif
```

Application C

```
#pragma pack(push,1)
typedef struct {
  bool holdedFlag: 1;
  bool btnFlag: 1;
  bool pressF: 1;
  bool clickF: 1;
  bool holdF: 1;
} buttonMinimFlags;
#pragma pack(pop)

class buttonMinim {
  public:
    buttonMinim(uint8_t pin, boolean type);   // type true - pullDOWN, false - input pullUP
    boolean pressed();
    boolean clicked();
    boolean holding();
    boolean holded();
  private:
    buttonMinimFlags flags;
    void tick();
    uint32_t _btnTimer;
    byte _pin;
    boolean _type;
};
buttonMinim::buttonMinim(uint8_t pin, boolean type) {
  _pin = pin;
  _type = type;
  if (!_type) pinMode(_pin, INPUT_PULLUP);
  else pinMode(_pin, INPUT);
}
void buttonMinim::tick() {
  boolean btnState = digitalRead(_pin) ^ _type;

  if (!btnState && !flags.btnFlag && ((uint32_t)millis() - _btnTimer > 90)) {
    flags.btnFlag = true;
    _btnTimer = millis();
    flags.pressF = true;
    flags.holdedFlag = true;
  }
  if (btnState && flags.btnFlag && ((uint32_t)millis() - _btnTimer < 350)) {
    flags.btnFlag = false;
```

```
    _btnTimer = millis();
    flags.clickF = true;
    flags.holdF = false;
  }
  if (flags.btnFlag && ((uint32_t)millis() - _btnTimer > 600)) {
    if (!btnState) {
      flags.holdF = true;
    } else {
      flags.btnFlag = false;
      flags.holdF = false;
      _btnTimer = millis();
    }
  }
}
boolean buttonMinim::pressed() {
  buttonMinim::tick();
  if (flags.pressF) {
    flags.pressF = false;
    return true;
  }
  else return false;
}
boolean buttonMinim::clicked() {
  buttonMinim::tick();
  if (flags.clickF) {
    flags.clickF = false;
    return true;
  }
  else return false;
}
boolean buttonMinim::holding() {
  buttonMinim::tick();
  if (flags.holdF) {
    return true;
  }
  else return false;
}
boolean buttonMinim::holded() {
  buttonMinim::tick();
  if (flags.holdF && flags.holdedFlag) {
    flags.holdedFlag = false;
    return true;
  }
  else return false;
```

```
}
```