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

Faculty of Computer Information Systems and Software Engineering
(full name of faculty)
Computer Science Department
(full name of department)

QUALIFYING PAPER

For the degree of

Bachelors degree
(degree name)

topic: **Information support system comfort and energy efficiency of living spaces**

Submitted by: fourth year student _____, group ICH-42
specialty Computer Science
Computer Sciences 122
(code and name of specialty)

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Ternopil
2021

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ASSIGNMENT
for QUALIFYING PAPER

for the degree of Bachelor
(degree name)

specialty 122 Computer Sciences
(code and name of the specialty)

student Rudolph Augustus Wilson III
(surname, name, patronymic)

1. Paper topic Information support system comfort and energy efficiency of living spaces

Paper supervisor Hromiak Roman, PhD, Assoc. Prof.
(surname, name, patronymic, scientific degree, academic rank)

Approved by university order as of «*01*» *01* 2021 № *4/7-62*

2. Student's paper submission deadline 26.06.2021

3. Initial data for the paper

4. Paper contents (list of issues to be developed)
Annotation. 1. Climatology, meteorology and existing systems for data analysis and visualization
2. Selection of software and development of the server part
3. Development of the client part of the system of analysis and visualization of climate data
4. Life safety
Conclusion. Bibliography.

5. List of graphic material (with exact number of required drawings, slides)

6. Advisors of paper chapters

Chapter	Advisor's surname, initials and position	Signature, date	
		assignment was given by	assignment was received by
Life safety, fundamentals of labor protection			

7. Date of receiving the assignment January 25, 2021

TIME SCHEDULE

LN	Paper stages	Paper stages deadlines	Notes

Student _____ Rudolph Augustus Wilson III
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ANONOTATION

Information support system comfort and energy efficiency of living spaces. // Qualification work of the educational level "Bachelor" // Rudolph Augustus Wilson III // Ivan Pulyuy Ternopil National Technical University, Faculty of Computer Information Systems and Software Engineering, Department of Computer Science, ICH-42 group / / Ternopil, 2021 // P., fig. -, table. -, chair. -, added. -, bibliogr -.

Key words: CONTROLLER, REMOTE CONTROL, MICROCLIMATE, INFORMATION SYSTEM.

Thesis is devoted to methods and means of automatic regulation of parameters of air environment in premises. The decision on automation of management of the climate parameters which are subject to control in a service room is offered.

The object of detailed study are the processes of climate supply in the human environment. The technical documentation for this object was studied: general information; characteristics of microclimate in living quarters, structural interaction of climate control system with its main subsystems. Elements for subsystems of parameter management subsystems were also selected and calculated, the functional scheme of automation was developed. Software for the controller was written and a human-machine interface was created, which is a component of the SCADA system, which provides visualization of the climate control system in the office.

The main task of the thesis is to develop an information system for remote control of the parameters of the microclimate of residential premises with optimal reliability and reduced cost.

In the first part of the work the methods of realization of automated control in microclimate control systems were considered.

The second part of the work described the characteristics of microclimatic conditions to ensure human comfort.

The third part considers the main choices of equipment for the implementation of the information system.

The fourth part describes the general characteristics of the MQTT protocol.

Object of research: information system of microclimate of living quarters.

Subject of research: automated system based on hardware platform ESP 8266.

The aim of the work is to study the hardware platform and their capabilities for the implementation of remote climate control.

Main results: an automated system for remote control of microclimate parameters of residential premises based on the hardware platform ESP 8266. This development will allow remote monitoring and control of microclimate parameters in the room both manually and automatically.

LIST OF SYMBOLS

ESP - Espressif Systems (Chinese microcontroller)

SRAM - Static random access memory (Static random access memory)

UART - Universal asynchronous receiver / transmitter (Universal asynchronous receiver / transmitter)

GPIO - General-purpose input / output (General-purpose input / output interface)

DHT - Distributed hash table

LCD - Liquid crystal display (Liquid crystal display)

FBD - Function Block Diagram (Function Block Diagrams)

MQTT - Message Queue Telemetry Transport (Simplified Network Protocol)

ISO - International Organization for Standardization (International Organization for Standardization)

IEC - International Electrotechnical Commission

IoT - Internet of Things

STOMP- Simple Text Oriented Message Protocol

HTTP - Hyper Text Transfer Protocol (Hyper Text Transfer Protocol)

TCP - Transmission Control Protocol

OIC - Open Interconnect Consortium

CES - Consumer Electronics Show

CONTENT

INTRODUCTION

Ensuring optimal regimes of thermal, humid and air regimes of residential and public buildings is associated with significant costs of fuel and energy resources. This problem is especially relevant for regions that have a cold climate in winter.

The analysis of heat consumption in the premises shows that there is almost always a discrepancy between the thermal characteristics in the buildings that are operated and subject to reconstruction, the values that were laid down in the projects.

This discrepancy is caused not only by deviations from the design decisions during construction, but also due to changes in the thermal characteristics of building structures over time. The peculiarity of the approach is that after the installation of heating and ventilation systems it is necessary to adjust the design decisions based on the results of field inspections of the actual thermal characteristics of enclosing structures and microclimate parameters. As a result, it is important to develop remote control systems for indoor climate with the ability to collect data over a long period of time, which will analyze the change in indoor climate depending on changes in weather conditions and building parameters.

In this regard, the development of systems for monitoring the microclimate of the premises remotely is an urgent task today. The introduction of such systems will ensure a comfortable state of housing, speed up the response to emergencies, automatically respond to changes in parameters in order to save resources and provide remote control.

1 METHODS OF IMPLEMENTATION OF AUTOMATED CONTROL IN MICROCLIMATE CONTROL SYSTEMS

At the present stage of development of science and technology there is a significant increasing the level of load on the environment of the premises, which are characterized by different volume, microclimatic parameters, gas composition of air, the number of people and the nature of the work performed, therefore creation and maintenance of these indicators in the workspace in normalized limits are one of the most important tasks.

INdeviation from normative parameters of the microclimate causes unpleasant sensations in organs of vision, unsatisfactory condition of the respiratory organs, frequent colds and chronic diseases, and at low concentrations of the lungs air ions functional disorders of the nervous, respiratory and cardiovascular system, which leads to malaise, increased fatigue, shortness of breath and headache, while optimal concentrations of light air ions have a stimulating effect.

Except moreover, the aeroionic composition of air is a variable and depends on complex of natural, man-made and physicochemical factors. But on currently there is no mechanism that would take into account the formation of air ions depending on the chemical composition of the room air and allowed to conduct assess and establish patterns of formation and disintegration of complexes "Air ion-chemical substance". Equally important is the effect of constant and alternating electric fields on working. Recent studies have convincingly proven the negative impact electromagnetic fields on people even at their low intensity, but the imperfection of the mathematical modeling of the spatial distribution magnetic fields significantly reduces the effectiveness of implemented labor protection measures to minimize the impact of electromagnetic fields on humans.

Scientific data of recent years indicate the gradual development of areas research on optimization and assessment of the impact of physical factors of the microclimate on humans not from the standpoint of assessing thermal comfort, but from the point of view view of studying the quality of indoor air space. But there is

still no systematic approach to this theoretical substantiation and carrying out of experimental researches and formation of scientific bases of monitoring, management and modeling spatial distributions and temporal changes in the levels of physical factors by degrees their influence on psychophysiological indicators of the person and sanitary and hygienic characteristics of production facilities in order to create favorable conditions labor.

Previous research has shown convincing results concerning the combined influence of physical factors of the production environment on human health, and the quantitative change of one factor leads to changes of others. Therefore, information systems, methods and techniques need to be developed at present monitoring and control of quantitative characteristics of physical factors in areas of human habitation [1].

The modern "smart home" embodied many innovative developments that made it unique in terms of safety and comfort. The presence of all these development allows today to realize dreams, now the homeowner at all it is not necessary to worry about your house, because it is always under control equipment that does not fail and works around the clock all year round, even when no one not in the house.

There are many companies on the market now that offer their services in the field of designing "smart homes", when choosing a company, it is necessary to be confident in the professionalism of employees, so as not to continue experience problems with technology.

In every modern house in one way or another operates a large number of equipment that provides life, comfort, comfort, connection and security, which helps to relax and creates a full working environment.

Ease of management of these systems, their integration is one of one, the ability to work harmoniously together, thereby increasing the functionality of each of them separately - all this makes it possible to call such house - Smart home.

In the absence of a person the Smart Home will support optimally constant microclimate, thereby maintaining comfort, houseplants and furniture. It will turn

off unnecessary light or vice versa create visibility of your presence by turning the lights on and off this or that room from time to time.

A smart home will allow you to be calm and carefree rest. A smart home will constantly monitor all engineers systems in the house and prevent a flash or explosion associated with a leak gas or damaged furniture due to water leakage. Also, intrusion into a stranger's house will not go unnoticed.

The Smart Home system will try to implement it itself, creating unpleasant conditions of his stay in the house and, of course, he will inform you and to the security panel about this event, using a mobile connection or by email.

To ensure high-quality system development and implementation, it is necessary to consider the basic principles of building automated systems for monitoring the parameters of indoor air, as well as the parameters of the microclimate.

The system of automated provision of the optimal microclimate of the production room should perform the following functions: information, managing, auxiliary. The information function of the system is to collect, store and issue information about the state of the parameters of the air environment of the working production room. The work area is space two meters above floor level or the site where the jobs are [2].

The content of the control function is the development of decisions and implementation of control effects on the technical means of ensuring the parameters of the microclimate.

The control functions of the system include:

– determination of the rational mode of regulation of microclimate parameters;

– formation and transmission to the inputs of the executive devices of the control effects, which ensure the implementation of the selected mode. Auxiliary functions include those that provide the solution of internal system tasks and purpose for maintenance of own functioning (maintenance of the set algorithm of functioning, control of a condition, etc.).

The system of automated provision of the optimal microclimate of the production room with taking into account the functional requirements consists of two modules: design and, in fact, the system itself in Figure 1.1 [2].

The design module is responsible for calculating the number of ionizers that must be installed in a given room or work area.

The input parameters in this block are the geometric parameters of the room (A - width, m; B - length, m) and radiation power of the source of negative air ions (n0, ion / cm3). The source information of the design unit is the number of ionizers N. The measuring unit is responsible for measuring the parameters of the microclimate of the production room - the temperature and concentration of negative air ions. The information here is obtained from the measuring devices: the temperature is measured using temperature sensors, and the level of concentration of negative air ions - ionometers. Information from the measuring unit is fed to the control unit, which outputs control signals to the execution unit. To the unit includes air conditioning and air ionizer.

The system of automated provision of the optimal microclimate of the production room operates on the basis of software and information software. Software and information software system is a set of interconnected software that must provide in accordance with the requirements, automatic solution of collection problems information, its primary processing in a form convenient for registration, development of control influences.

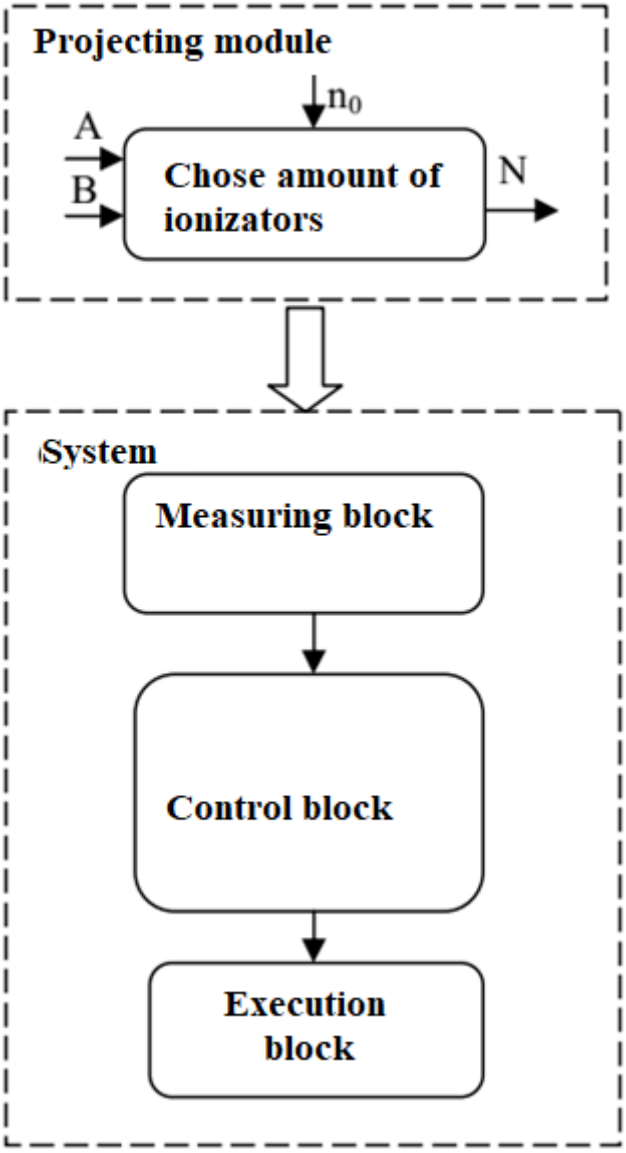

Figure 1.1 - Functional structure of the automatic microclimate control system

The software of the system of automated maintenance of the optimal microclimate of the production room implements the following main functions:

– analysis and processing of information about geometric the size of the production room and the strength of the radiation of the air ionizer;

– issuing recommendations on the number of installed air ionizers;

– input of information from the temperature sensor and ionometer;

– analysis and processing of entered information;

– providing special programs required heat from heating appliances and concentrations of negative air ions from air ionization equipment to maintain a given mode microclimate;

– user connection with the information collection and processing system;

– decision-making according to a given algorithm;

– output of control influences in the control channel;

– output of the message on the display of the terminal;

– organization of dialogue with the operator.

Figure 1.2 shows the algorithm for determining the number of air ionizers that must be installed in given room or work area, and in Figure 1.3 - algorithm of functioning of the system of automated provision of the optimal microclimate of the production room in the form of a block diagram.

The choice of the number of air ionizers is by such an algorithm. Current geometric values the size of the room and the radiation power of the ionizer are compared with the tabular values [2].

In accordance with the obtained results of the calculation, the issuance of recommendations on the number of air ionizers of a given radiation power, which is necessary to install in the set room or a working zone.

Algorithm of functioning of the system of automated maintenance of an optimal microclimate contained in the following. First determined normalized indicators of working room temperature and normalized indicators of air ionization.

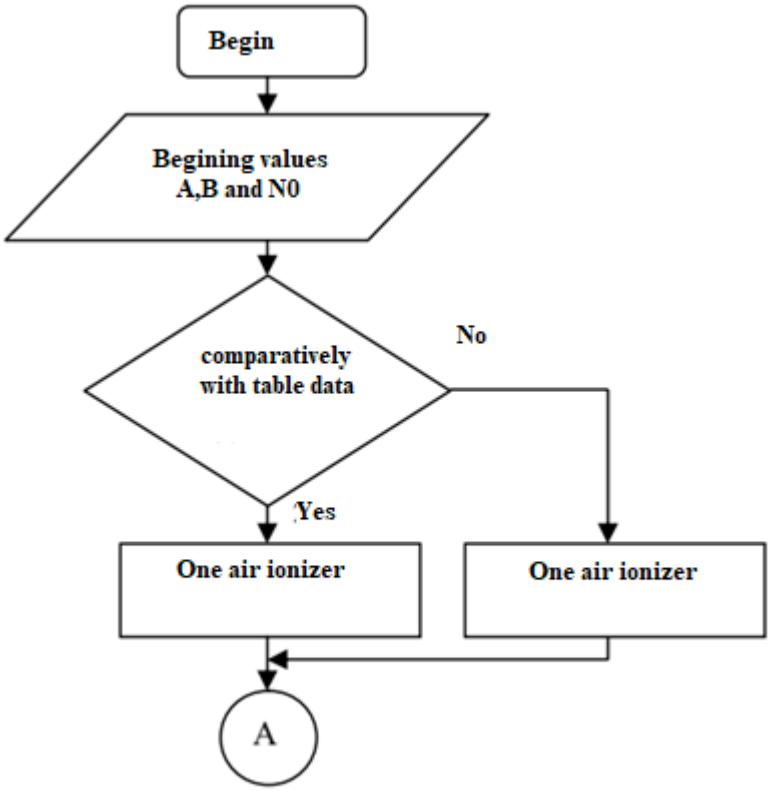

Figure 1.2 - Example of implementation of the algorithm of the automated control system for determining air parameters.

Next, these figures are compared with the current values of temperature and air ionization, which were received from measuring instruments. Depending on the obtained results of comparison the control unit gives out the operating influence: to include (in case of decrease temperature below the allowable) or turn off air conditioning (in case of temperature rise above permissible), to include (in case of decrease of level of concentration of air ions below admissible) or to exclude the air ionizer (in case of increase of level of concentration of air ions above admissible). Current status microclimate parameters and actuators (on / off) is fixed on the board.

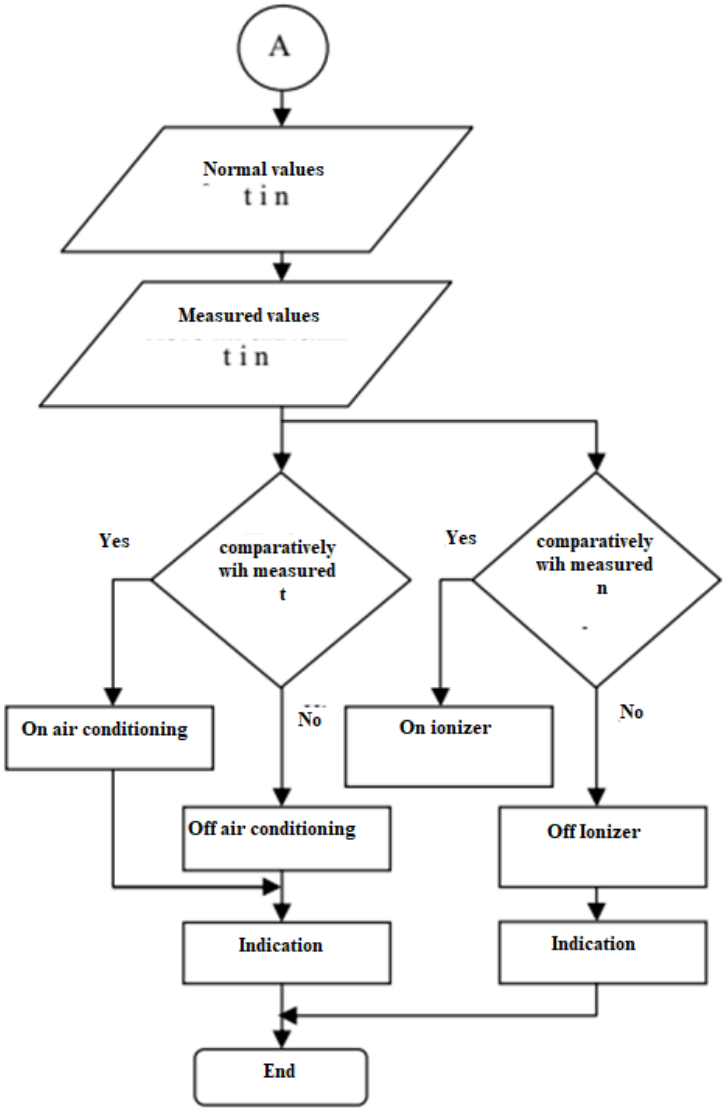

Figure 1.3 - Block diagram of the automatic control system

2 ANALYSIS OF HARDWARE PLATFORMS FOR IMPLEMENTATION OF INFORMATION SYSTEM

The development of information systems for remote control of the parameters of residential premises is an urgent task today. At the moment, the cost of energy resources is constantly growing, and the issue of providing comfortable conditions in the premises where people live and work is becoming increasingly important. This raises the question of improving the efficiency of such systems, the ability to store and analyze previous data, as well as reduce the cost of their implementation at the required level of reliability.

It should be noted that the operating conditions of the devices in residential areas are not difficult compared to industrial. As a result, most platforms are able to work reliably in such conditions. Also, the presence of certain errors or false positives is also not critical in the general case.

2.1 Characteristics of microclimatic conditions to ensure human comfort

Microclimate is a set of indoor environmental factors, such as air condition, humidity and temperature. It depends on many components. First of all, it is significantly affected by the weather conditions of the area where the building is located, what is the peculiarity of its design in terms of protection against external factors (ambient temperature, relative humidity, precipitation, wind speed, etc.). Also important are the internal parameters of the building, in particular, the presence and strength of air flows, the presence of heat sources, their location and efficiency, the amount of moisture released, the ability to absorb moisture. Also additional factors may be the presence of dust, carbon dioxide content, various aerosols, etc.[3].

The presence of a certain amount or increased concentration of harmful substances (leakage of natural gas into the gas supply system) also has a negative impact on the well-being of residents and their health.

However, creating isolated buildings that provide maximum protection from the environment (cold, heat, wind, noise) there is a problem of ensuring air quality, its purity inside the room. Air conditioning, ventilation and heating systems can solve this problem. However, the availability of air conditioning or ventilation systems does not always fully solve the problem of providing quality air, as the ventilation ducts can collect numerous microbes and bacteria that contaminate the air entering the room, which can increase the morbidity of people living in it.

At the present stage of development of automation systems, there are a large number of solutions that allow you to create favorable conditions for life and work of people in any type of premises. After all, their ability to work and health significantly depends on them.

Therefore, one of the main conditions for the operation of air conditioning, heating and ventilation systems is to provide optimal parameters for a beneficial effect on the thermoregulation of the human body, the most important physiological process that determines comfort. The presence of optimal and comfortable conditions in the room allows to increase, in fact, the efficiency of human work by maintaining health, increasing the working period of time, increasing activity during this period[3].

Comfortable or optimal microclimate parameters are such conditions under which, due to their simultaneous impact on people for a certain period of time, heat is stored by the human body. In such conditions, the person does not feel discomfort, the thermoregulatory load is minimal, this, in fact, and provides high efficiency.

The allowable norms of the parameters of the microclimate include those at which the human body may have a thermal imbalance, ie they can lead to changes in thermal state. Such conditions can lead to a partial decrease in productivity, but do not harm health, a person may feel local heat. The main factor in establishing the limits of admissibility is to ensure the permissible thermal state of the organism.

Harmful or unacceptable parameters of the microclimate are the conditions under which the thermal state of a person during a certain period of time changes significantly, a pronounced discomfort. At the same time, the efficiency is

significantly reduced due to the operation of thermoregulation mechanisms in critical conditions. Preservation of health in such conditions is impossible to guarantee, I to and, as a matter of fact, thermal stability of an organism.

Extreme parameters of the microclimate are dangerous values of the main characteristics of climatic conditions, in which even during short-term exposure there is a critical load on the mechanisms of thermoregulation, significantly changes the thermal state of the organism. This can lead to serious illness and in some cases death[4], [5].

Provided a comfortable microclimate in the room, a person feels comfortable in it, efficiency is maintained at a high level, there is thermal comfort and good mood. When designing comfort systems, it is necessary to take into account the nature of life in certain rooms for a comfortable temperature in them. It should be noted that, for example, in bedrooms the temperature should be slightly lower than in rooms where people are more active. In certain rooms, the activity of different members may be different, so it is necessary to take into account which of the activities has more than 50% of people in the selected room. However, it is not desirable to provide a sharp difference in parameters between rooms, as well as sudden temperature jumps. This causes discomfort to the body.

All parameters of microclimatic conditions can be divided into 2 types:

- controlled or adjustable, ie those that can be provided by the construction of the building (insulation, etc.), heating devices, humidifiers, dehumidifiers, air conditioners;
- uncontrollable, ie those that exist independently of man. These include climatic conditions and features of the area.

To ensure comfort, people mainly use ventilation, heating and air conditioning systems. At the same time, such systems work more efficiently when uncontrolled factors are taken into account.

Under normal conditions, the human body temperature is maintained at 36.6 °C due to thermoregulatory mechanisms. Depending on the activity of the person, the body releases heat. The processes of its return occur due to the microclimatic

parameters of the environment. At more active work more heat is allocated. A large amount of heat is mainly due to the mechanism of sweating. The higher the moisture content in the air, the worse the heat transfer due to evaporation. If the moisture content in the air is reduced, this, in turn, will increase the efficiency of the heat transfer process due to better evaporation. At too low humidity there is a reverse process - excessive drying of mucous membranes in humans, the body does not have time to generate as much mucus. It should be noted that the intensity of heat transfer is affected not only by moisture content, but also the movement of air, the more intense it is, the better the heat transfer process. The limiting value of the temperature at which cooling of the organism is possible is approximately 35 ℃.

At low temperatures, on the contrary, the process has the opposite value and causes hypothermia. Air movement at low temperatures is not desirable. The presence of drafts in general can lead to serious diseases, as it creates a strong temperature difference to which the human body is unable to adequately respond. This process can cause severe hypothermia or local overheating due to the fact that the body, although it can adjust body temperature, but in a narrow range. The upper value of the temperature at which thermoregulation is still possible is 31 ℃ (humidity 85%) or 40 ℃ (humidity 30%). When a person works, the critical temperature values are much lower. As for low temperatures, if there is hard work, then at 12 ℃ human heat generation is stable.

Based on the above, for a comfortable stay in the room for a person important factors are a combination of optimal relative humidity, in fact, temperature, carbon dioxide content and air movement.

According to the standards, if the average daily temperature is less than 10 ℃, it is a cold period, at temperatures above this value - warm. The optimal parameters of the microclimate are, in fact, a combination of environmental factors, which due to long-term exposure to the human body ensure the normal functioning of thermoregulatory mechanisms and the presence of comfortable thermal sensations.

As for ventilation systems, they also play an important role. The ventilation system must provide access to all air in the room. It is known that in the process of

life a person inhales oxygen and emits CO2. Increasing its concentration leads to a deterioration in the parameters of comfort and productivity due to the fact that it is more difficult for humans to conduct oxidative reactions to generate energy. Although there is no heat load, the body is tired, working in a loaded state. Therefore, the supply of fresh air is important. The process of fresh air supply is entrusted to air conditioning and ventilation systems. They can simply carry out the fence from the outside, as well as carry out its heating or cooling according to the external environment.

"Air conditioning is a phenomenon of directed occurrence and automatic maintenance indoors of some or all available parameters, such as: temperature, cleanliness, air velocity, humidity at a given level in order to ensure, in fact, optimal weather conditions, most favorable for comfort. people "[6],[7].

This process is provided by a system of technical means of various types, which are called air conditioning system. It includes devices for air intake, purification, heating, mixing, humidification and dehumidification, which can be remotely controlled. The main task for an automated system that deals with the air conditioning process is to maintain a given condition in the room, regardless of how the climate changes outside. As a rule, all means of ventilation try to be executed in one case for simplification of processes of repair and its service. It is also important to monitor the condition of the filters for ventilation processes, as they can often develop large numbers of microorganisms, which can lead to many diseases in people living indoors.

Currently, air conditioning systems are divided into:

– for the purpose of use - comfortable and technological;

– according to the established principle of work - combined, recirculation and direct flow;

– in the presence of equipment for raising and lowering the temperature - autonomous and non-autonomous;

– by location of the main elements - local and central;

– by the method of parameter control - one-pipe (qualitative) and two-pipe (quantitative).

– on the quality of air supply in accordance with the norms - first, second and third class;

– by the number of available premises that the system is able to cover - single-zone and multi-zone.

2.2. Problem statement for information system development

The system to be developed must control the comfort devices according to a pre-programmed logic depending on the signals from the sensors. According to the norms and requirements, the parameters of the microclimate should be as follows: humidity 40-60%, and temperature 18-20 ℃. If the user wishes, it should be possible to change the limits of these parameters. This is especially true if residents leave the building for a while. The temperature can be lowered, which will lead to savings.

The system must adjust the microclimate value in case of any deviation from the established norms. The aim of the work was to develop an information system that will automatically control the actuators (ventilation, humidifier, fuel boiler) to ensure comfort in the room. The system must have flexibility, ie if necessary, control algorithms can be modified or replaced. The system also has the ability to easily expand and add new modules. In addition to these parameters, the system will also monitor the level of CO2 in the room and turn on the ventilation systems, and in their absence to issue a signal to the control device. Requirements for the microclimate required in the premises are given in Table 2.1.

Analyzing the table, you can see if the temperature value is lower than 18 ℃, you need to turn on the heating system. Similarly, in the summer at temperatures above 27 ℃ it is necessary to turn on the coolers.

The efficiency of cooling systems for ukraine is determined according to the schedule shown in table 2.1.

Table 2.1 - Values of living space temperature depending on their type to ensure comfortable conditions

Тип будівлі / приміщення Type of building / space	Категорія Category	Робоча температура, °C Operative temperature °C	
		Мінімум для опалення (зимовий період) ~ 1,0 кло Minimum for heating (winter season), ~ 1,0 clo	Максимум для охолодження (літній період) ~ 0,5 кло Maximum for cooling (summer season), ~ 0,5 clo
Житлові приміщення: спальні, вітальні, кухні тощо Сидяча діяльність ~ 1,2 мет Residential buildings: living spaces (bed rooms, drawing room, kitchen etc) Sedentary ~ 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	18,0	27,0
Житлові приміщення: інші приміщення (кладові, холи тощо) Стояння-ходьба ~ 1,6 мет Residential buildings: other spaces: storages, halls, etc) Standing-walking ~ 1,6 met	I	18,0	
	II	16,0	
	III	14,0	

It should be noted that in order to avoid the phenomenon of overheating of certain parts of the building and to prevent the formation of hotter and less hot zones, it is also necessary to ensure sufficient air movement.[8].

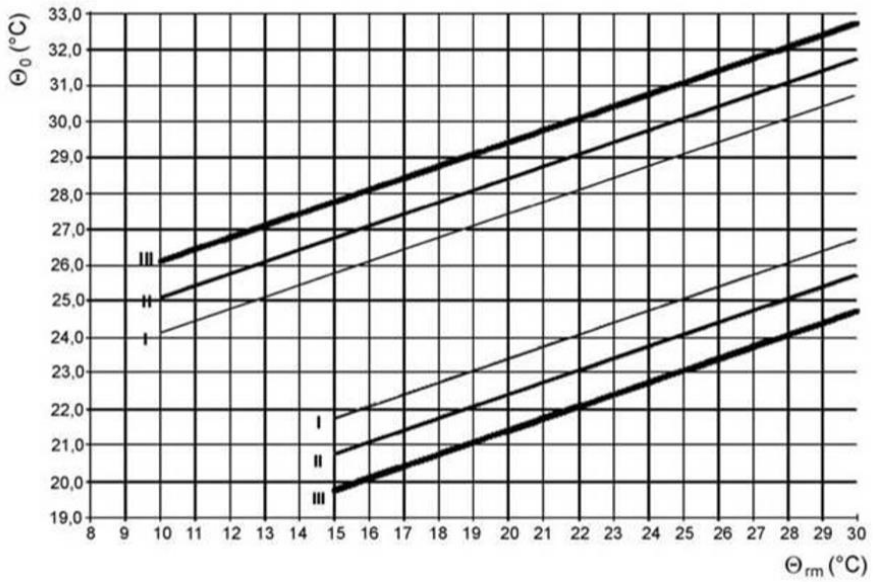

Figure 2.1 - Schedule for determining the operating temperature for buildings, depending on the ambient temperature:

Θ0 - value of operating temperature; Θrm is the average temperature outside the room.

The equations for constructing curves for category III buildings are as follows:

upper border

$$\Theta_{i\,max} = 0{,}33 \cdot \Theta_{rm} + 18{,}8 + 43 \quad „ \tag{2.1}$$

lower limit

$$\Theta_{i\,max} = 0{,}33 \cdot \Theta_{rm} + 18{,}8 - 4 \quad „ \tag{2.2}$$

These parameters can be used to implement the law of temperature control in the premises[9].

The normalized required value of ventilation and CO2 content in the living space is given in Tables 2.2 and 2.3.

Table 2.2 - Ventilation rate for sparse emissions from humans

Категорія Category	Очікувана відсоткова невдоволеність Expected Percentage Dissatisfied	Повітряний потік на особу, л/с/особу Airflow per person l/s/per
I	15	10
II	20	7
III	30	
IV	> 30	< 4

Table 2.3 - Normalized concentration of CO2

Категорія Category	Відповідна концентрація CO_2 вище зовнішньої у PPM для енергетичних розрахунків Corresponding CO_2 above outdoors in PPM for energy calculations
I	350
II	500
III	800
IV	<800

It should be noted that when normalizing the humidity in living spaces, the humidification process must be started when its value is <30%, as low humidity leads to a deterioration of airway comfort. Dehumidification of air should be carried out at increase in value of humidity over 50%. The values of the normalized indicators of these parameters are given in table 2.4.

If these parameters are within the set limits, the system should not adjust anything.

One of the tasks of the developed information system is to display controlled values in real time on the screen of a mobile device with the ability to adjust them and change the control limits. Another task of the systems is to collect statistics over a long period of time for possible data analysis in order to optimize when working in automated mode. Also, this tool can help the user to plan the cost of resources for a certain period (heating season, etc.).

Table 2.4 - Normalized indicators of the beginning of humidification and dehumidification at the established corresponding systems

Тип будівлі/приміщення Type of building/space	Категорія Category	Розрахункова відносна вологість для осушування, % Design relative humidity for dehumidification, %	Розрахункова відносна вологість для зволоження, % Design relative humidity for humidification, %
Приміщення, де показник зволоження встановлюється мешканцями. Спеціальні приміщення (музеї, церкви тощо) можуть потребувати інших меж Spaces where humidity criteria are set by human occupancy. Special spaces (museums, churches etc) may require other limits	I	50	30
	II	60	25
	III	70	20
	IV	> 70	< 20

Therefore, based on the above, the developed information system of remote control should provide the following functions, namely:

– read the measured parameters from the sensors that are installed in the room;

– to carry out optimization of regulation for the maintenance of the set parameters within regulated limits;

– display and store graphs of the main indicators of the microclimate;

– display the basic parameters to the user in real time;

– model and select optimal equipment operation plans for different time periods[10], [11].

Also, the developed system should be flexible and inexpensive to implement. Strictly speaking, today's market of controllers allows to realize it.

To implement the control system, it is necessary to choose technical means that will collect data on the microclimate of the environment, as well as provide control of basic devices for effective control of control means, such as heating, air conditioning, humidification and dehumidification. It should also be borne in mind that the selected equipment must provide flexibility, ie the ability to change the parameters of regulation, laws and parameters of optimal conditions. This process should take place through the user's actions, as well as depending on the time of day, season and environment. The system must also be able to expand and increase the controlled parameters, add new modules and more.

The main parameter of choosing the hardware of the system is reliability (in fact, the requirements for residential premises are not very high, because the systems will actually be in optimal conditions) and cost. Additional parameters are ease of implementation, functionality, speed, the ability to support different types of platforms. So, let's look at the basic hardware implementations and controllers for creating systems of this type.

2.3 Hardware platforms for system implementation

2.3.1 Arduino

To date, there are several platforms for the development of a system of remote control of the elite parameters of the room. Consider the most popular - Arduino[12].

Arduino is a type of microcontroller that is based on the Atmega microcontroller. There are many types of implementation of this platform. Consider its properties on the example of ArduinoUno Figure 2.2.

This device is quite cheap and has good functionality in combination with good reliability, its estimated cost is 150 UAH. It consists of 14 digital inputs / outputs, the mode of operation of which can change.

This platform is quite popular today. First of all, this is due to the fact that it has good functionality and has a pleasant taste. In terms of implemented functions, it can be equated to powerful industrial controllers. also, this platform has a convenient implementation of the programming language and is easy to learn, while allowing you to create automated systems of complex level.

The only disadvantage of such a system, in our opinion, is the need to install additional modules for communication and data transmission over mobile or Internet networks. Another disadvantage is the inability to work in extreme conditions. Since the system will work in residential areas, they will not have critical extreme conditions, so the last drawback can be ignored.

This board has such a constructive form factor that allows you to create implementations of various control information systems in a fairly small case, which also has a significant advantage. By the way, it should be noted that the constant size of the board, regardless of the type of Arduino system allows you to unify the requirements for other manufacturers of third-party elements for connection.

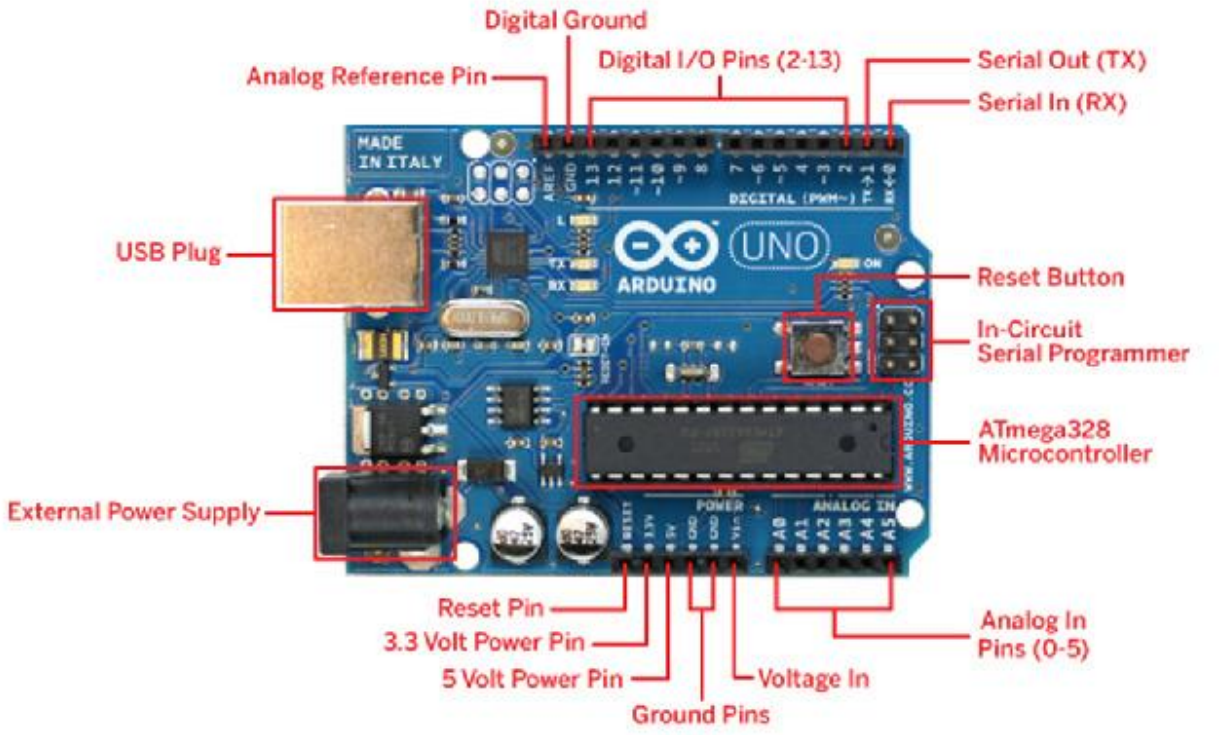

Figure 2.2 - General view of the ArduinoUno controller

Also a significant advantage is the implementation of such boards in the form of modules. That is, their implementation in a modular form allows you to easily integrate such platforms into other systems, to connect several modules through standard interfaces.

As for programming, the environment for developing control programs, as well as the syntax of the code itself is similar to C ++, which has now become generally accepted and known in the world. This reduces the training of professionals to create programs and projects.

In itself, the Arduino is a platform for the development of open source electronics, in particular. This platform is based on easy-to-learn software and easy-to-use hardware.

The platform helps to analyze the environment, explore the object, its parameters, to manage it. The systems implemented on this platform can be both stand-alone and connected to other such systems, a personal computer or cloud technology. For such a system, all components, boards, you can create your own,

buy ready-made solutions. Ready-made software solutions for certain systems, perhaps not always the most perfect or insufficiently optimized, can be obtained free of charge under an open license.

The Arduino platform itself is built on the principle that developers (engineers, scientists, teachers, students) can use standard basic components to start creating projects, conducting the first implementation. In the future, the program and hardware can be improved using existing tools.

The main advantages of systems based on such a controller are:

– openness and cross-platform. The environment works on all Windows, Linux, Mac systems, and the system code is completely open, based, in fact, on a good, functional and well-supported server part, supports many platforms, is easily portable, and errors as they occur can be easily eliminated [thirteen];

– drivers that ensure the correct operation of the system are also executed on most existing platforms, are open source, can be adapted with certain skills and time to any needs and with error correction;

– all the generated program code is run and executed on a well-tested implementation, with a well-thought-out compiler, it runs without interpreters, resulting in a fairly decent performance parameters;

– the platform includes analog inputs and digital inputs outputs with variable parameters, which provides high flexibility in work and implementation. There are ready-made solutions for the use of several sensors on one line, if there is no high need for speed (I2C, SPI, etc.). This provides the ability to connect almost all types of available sensors.

However, all the benefits are valid at the initial stage of implementation. When implementing serious projects, the platform itself needs to be modified with additional modules (so-called "signs"), which expand the functionality, but reduce the reliability of the system as a whole. However, the use of such signs, connections, settings is very simple and does not require a very large specialty of Figure 2.3.

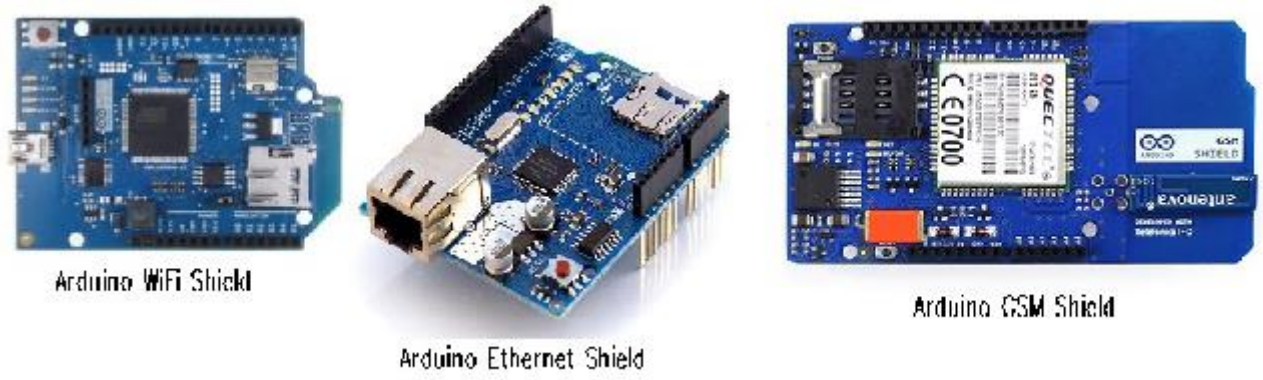

Figure 2.3 - Examples of modules (shields) for the Arduino platform.

The platform itself was not designed for certain specific elements or chips, as the manufacturers of the latter are trying to gain an advantage in buying their products. They privately make them unique, adding certain specific implementations and functions. Arduino itself, on the other hand, tries to be open and without any complex specifics, which allows you to easily transfer developments to other controller platforms. In fact, if the project is implemented on an Arduino, it can be transferred to any other platform.

Another significant advantage is, of course, low cost. Somewhere around UAH 150 per platform is very little. Low cost, especially for masters and students, removes the "fear of breaking" some elements in the development, which increases the breadth of the plane of creativity and raises confidence and skills.

Also a significant advantage of such systems is the openness of the code, which can be fully used for commercial purposes. This adds flexibility and appeal to developers. This provides a wide range of created libraries, functions and additional elements, which reduces development time and code generation. Also, the openness of the code allows you to create your own function, library, module with little time and skill.

Another advantage is that this brand continues to develop, new developments and systems are introduced.

Among the latest developments, in particular, Arduino Mega 2560 - in fact, based on ATmega2560 microcontroller board. This platform carries 16 analog

inputs, in particular, 54 digital I / O pins (15 PWM capability), 4 comprehensive hardware progressive ports (SARS), a clock frequency of 16 MHz in Figure 2.4.

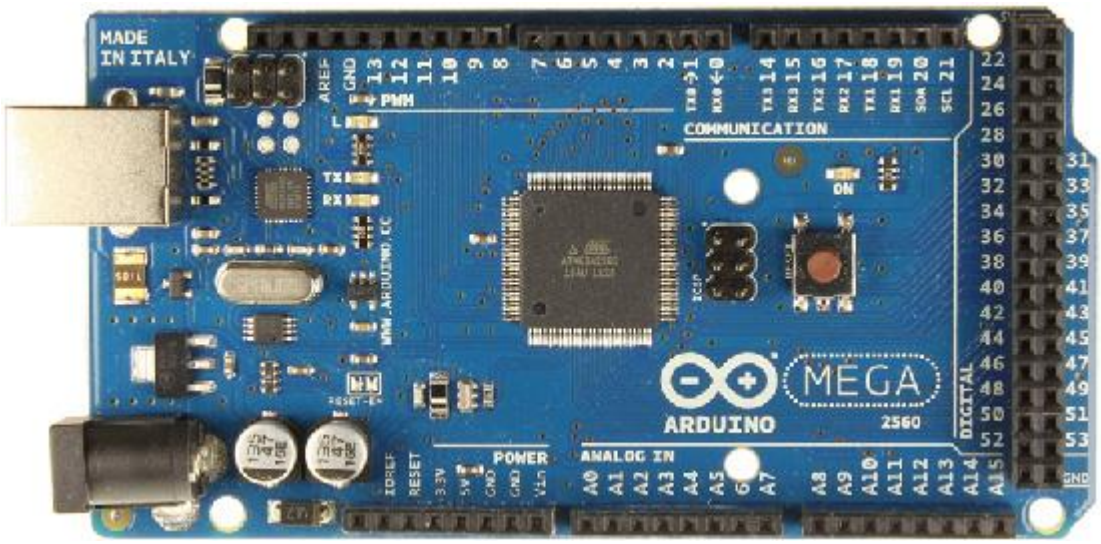

Figure 2.4 - Arduino Mega platform

The Arduino Due implementation, for example, uses the SAM3X8E Atmel ARM Cortex-M3, an unknown AVR microcontroller. This is a new board that uses a 32-bit ARM core processor at full capacity. The platform has 12 analog inputs, 54 digital I / O pins (12 pulse-width modulations), 4 South Africa, a conduction frequency of 84 MHz, also has the ability to connect 2 DACs, in fact, USB, including 2 TWI, SPI connectors and JTAG and more in Figure 2.5.

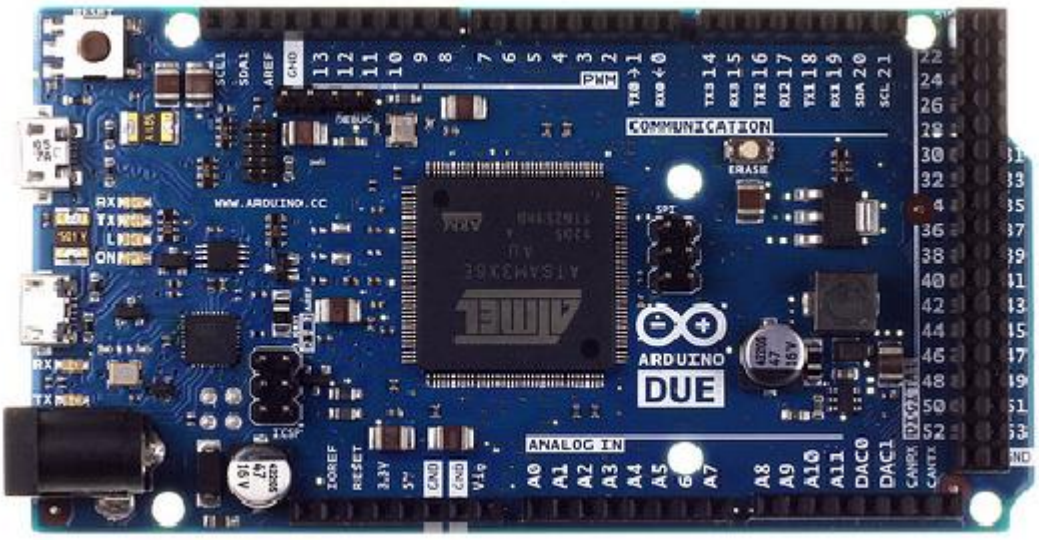

Figure 2.5 - Arduino Due platform.

Also in this aspect you need to know about such a platform as Raspberry Pi. Unlike the Arduino, which is a full-fledged controller, the Disassemble is a full-fledged HRC. Implementations on it are a bit more complicated, the cost is a bit higher, but the possibilities are also wider in Figure 2.6.

This platform was developed primarily for effective computer science training with the ability to program on a large number of implementations. This platform has a broader support for a wide range of programming languages, application applications, and more.

For starters, the Arduino is usually offered. It has the largest number of users, training textbooks, various projects and the simplest interaction with external equipment.

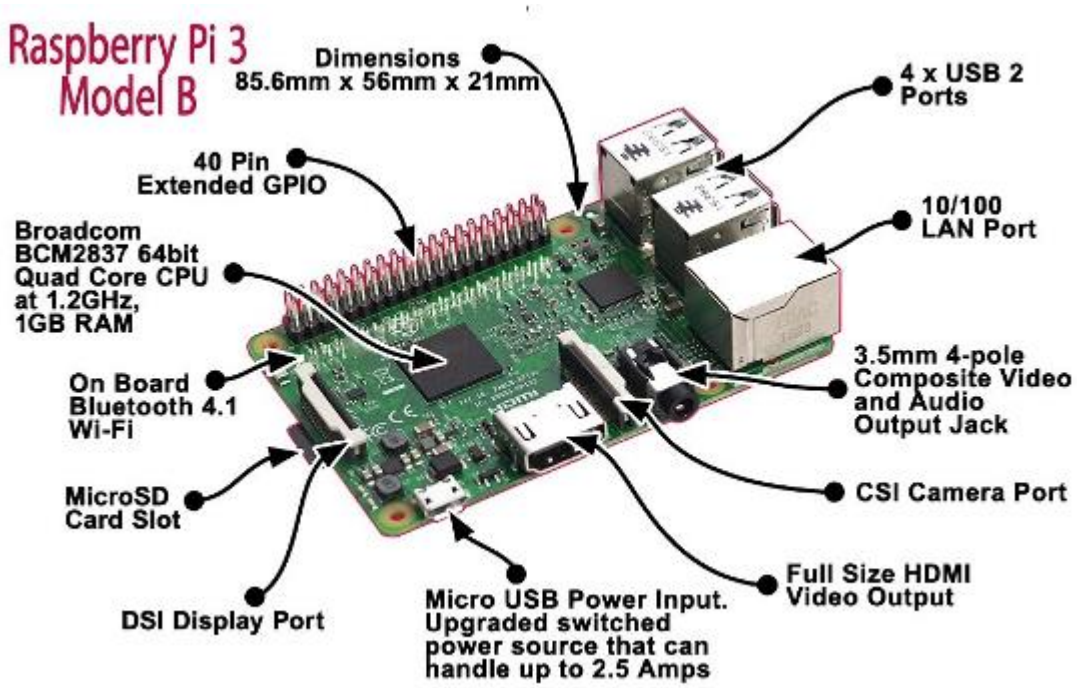

Figure 2.6 - Rasbery Pi platform

To date, for a hardware project, the Arduino is considered the best choice.Typically, the output of the PWM (pulse-width modulation) add a full series

of compatibility. It is also allowed to connect several feedback users and various components via ports.

If you plan to implement large software tools for the project, ie the main part is still a software part, then we offer Raspberry Pi. Providing a wide range of opportunities for use and access to the Internet, video, audio makes it much easier to implement certain applications.

For minimal applications, it is usually a much better solution to use an Arduino. The advantage is undeniable, because Arduino has inexpensive built-in high-speed systems and does not consume a lot of resources for easy implementation.

Arduino is also suitable for the implementation of automated systems that work with sensors in real time. If it is necessary to analyze statistics using the methods of mathematical analysis, forecasting, statistics, modeling - it is better to use Rasbery Pi [14].

One of the class of small programs is the Raspberry Pi. Simply put, Linux is a computer with wireless internet that you get by connecting a wireless module. The Arduino platform supports applications for peripheral devices, so-called shields, which also allow you to connect to the Internet, but with limited access.

When working with programs for the interface, Arduino is also recommended. There is a large selection of boards of different versions on the market, which are able to work with different output voltages, which makes it easier to connect to devices. It is also important that many sensors are able to have digital interfaces - I2C or SPI, which provide support and communicate with them effortlessly.

When used in implementations that require autonomous power supply due to low power consumption, the most appropriate is the use of Arduino. This platform, unlike the Disassemble, can operate in a wide voltage range, which allows you to use a wide range of batteries and circuit solutions.

If the project uses an application based on a graphical interface, then Rakhberie is more efficient due to the presence of HDMI and PC capabilities.

Analyzing our task and the advantages and disadvantages of both platforms in our case, it is better to use platforms of the controller class.

2.3.2 ESP 8266

Although the Arduino and Rasbery have a host of significant advantages, in some cases there are certain platforms that are much easier to use when there are specific implementations. In our case, the emphasis is on remote control and monitoring of microclimate parameters with the ability to control the actuators. At the same time high requirements to reliability and work in extreme conditions are not required. Therefore, it is also advisable to consider cheaper platforms that have the functionality we need (number of inputs, outputs) and the presence of a built-in module that can transmit data to the Internet without additional devices.

Such a platform, in our opinion, is ESP 8266 [15].

This device is a development of Espressif Systems. This is a stand-alone controller with a built-in Wifi module, which connects to the Internet without any additional settings. In our implementation, such a module is just the most suitable, because it has a lower cost with all the same advantages compared to the Arduino. As a basic data transmission environment - Wifi is the most optimal, because in any building where you need to control the parameters of the microclimate there is wireless internet. This implementation of the system ensures its implementation without the need to install additional cables, boxes, wall drilling, rearrangement of furniture, etc. That is, the process of remote control and the information system itself is greatly simplified, and the cost is much lower.

The ESP 8266 platform has a built-in USB connector, which makes it easy to set up, connect to a PC, and more.

The platform also contains a 32-bit processor based on SRAM Tensilica L106 Diamond series. This makes the system fast in relation to the tasks.

There is 36 kilobytes of memory, which is clearly not enough for large projects, but for our tasks this is enough, because the platform must know the

microclimate readings from the sensors, make a control effect by simple logic and transfer the sensor values to the cloud service. Therefore, the amount of memory is quite sufficient.

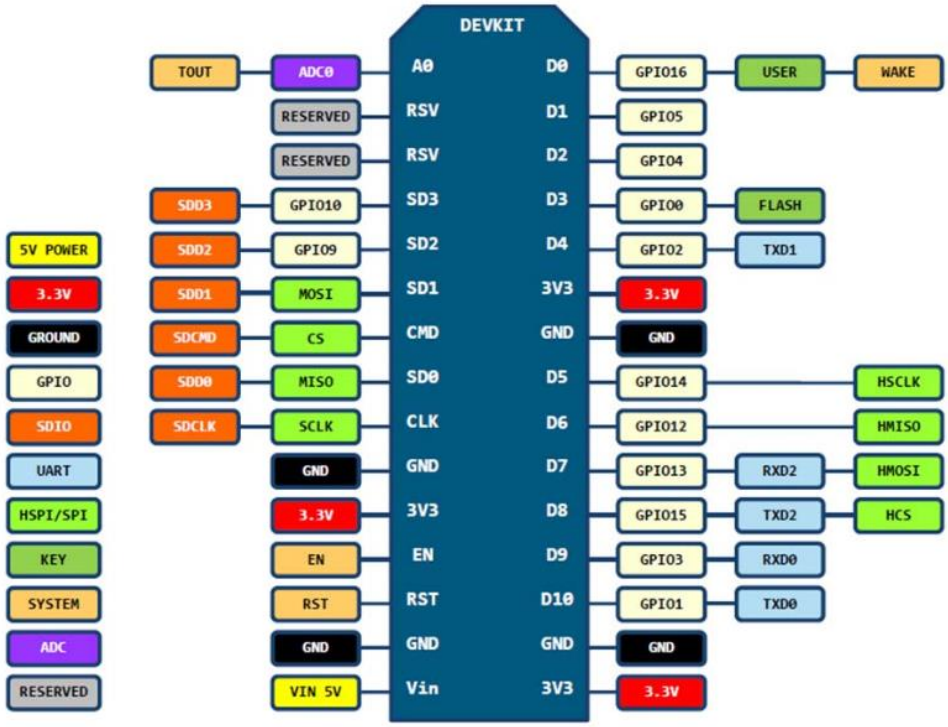

Figure 2.7 - Pinout and logic value of ESP 8266 Node MCU pins.

Module features:

– built-in WiFi standard 802.11 b / n / g;

– Support of STA / AP / STA + AP operating modes;

– there is a stitched stack of TCP / IP protocols with support for 5 client connections (which in our case is quite enough);

– The output current value is 15 mA;

– Power supply range: 4.5 - 10 V or 5 V USB power supply;

– Non-regurgical consumption: when working with data exchange - from 70 to 200 mA, when waiting <70 mA;

– Data transfer rate: 110 - 460800 bps;

– Support for data transmission interfaces such as UART / GPIO;

– the ability to change the firmware via USB or from cloud services;

- platform dimensions: 48x26 mm;
- Weight: about 18 g

Therefore, it should be noted that this module is best suited for our implementation. However, the review would be incomplete if we did not consider the features of the use of industrial logic controllers.

2.3.3 Industrial controllers

Unlike open systems such as Arduino, industrial controllers have a certain guarantee of performing the necessary operations and requirements for the safety and security of automated information systems. Failure of the controller to work in industry can lead to significant financial losses and, in some cases, human casualties. Therefore, controllers and sensors of industrial systems have greater protection against open systems and, consequently, more cost.

Also in such industrial implementations there are high requirements for the protection of transmitted data and signals, as even communication channels can be in extreme operating conditions and under the influence of various types of mechanical and electromagnetic interference. All these indicators affect the cost. Therefore, the use of industrial controllers is reliable, but very expensive. The implementation of such systems is guaranteed by the system integrator for a certain period of time [16], [17].

In industrial performance, the system integrator, due to increased security, rarely allows modifications of some elements of the software implementation. Does not disclose the principles of operation and implementation of individual modules or data transmission protocols. At the moment, there is a trend in the industry to move to open systems, more and more manufacturers are disclosing the principles of selling their products. However, this process is time-consuming, as it involves high liability of industrial equipment, and large-scale errors, if any.

Well-known brands that manufacture lines of controllers and products include such as: Emerson, Honeywell, Wago, Siemens, Schneider, Aries, etc.

The cost of one controller ranges from $ 300 to $ 50,000. The cost is directly proportional to the functionality, flexibility and reliability of such a device.

Based on all the above in the master's thesis, the use of industrial controllers will not be considered, but if the customer wants to use such systems, the implementation procedure is no different.

2.4 Conclusions to the second section

During the work on the second section, the hardware platforms for the implementation of the information system were analyzed. A system has been built that will automatically control the ventilation and humidifier to ensure comfort in the room.

3 CHOICE OF METHODS AND EQUIPMENT FOR IMPLEMENTATION OF THE INFORMATION SYSTEM

3.1 Hardware implementation of the system

When implementing your own remote control system, you can use any high-level programming language in combination with additional software to implement certain content and functionality. However, such an implementation requires a highly qualified developer and in-depth knowledge of methods for implementing data transmission, creating interfaces and mobile applications. At the present stage of development of information technologies, of course, it is more profitable to use already created software implementations of remote control, which allow you to easily create a customizable server architecture with feedback and optimization.

In our case, to implement the system, we use the following elements:

Hardware modules:

- ESP8266 NodeMcu;
- DHT-22;
- LCD 1602-I2C;
- MQ-135;
- Relay.

Humidity and temperature sensor DHT22 [18], [19].

It uses a technique of collecting digital signals and moisture sensing technology, which allows to ensure the reliability and stability of information. Its sensitive elements are connected to an 8-bit single-chip computer. Each sensor of this model is calibrated in an accurate calibration chamber, and the calibration factor is stored in the program type in OTP memory, when the sensor detects, it will quote the factor from memory. Small size, low consumption and long transmission distance (20 m) make DHT22 suitable for all types of abrupt applications. The most important characteristics are listed in the DHT22 technical specification in Table 3.1.

Table 3.1- Technical specification DHT22

Model	DHT22
Nutrition	3.3 - 5 V DC
Output	On the One-wire bus
Measuring element	Polymer capacitor
Permissible limits	Humidity: 0 - 100%; Temperature: -40 - 80 ° C
Sensitivity	Humidity: 0.1%; Temperature: 0.1 ° C
Error	Humidity: ± 1%; Temperature: ± 0.2 ° C
Minimum measurement period	2 seconds

Figure 3.1 - Humidity and temperature sensor DHT22.

The controls will be connected as follows to the inputs of ESP 8266:

- D0 - Air conditioning;
- D1- D2 - lcd1602_i2c;
- D3 - DHT22;
- D4 - Boiler;
- D5 - Humidifier;
- D6 - Dehumidifier;
- D7 - Fan;
- A0 - CO2 sensor;

The connection diagram is shown in Figure 3.2.

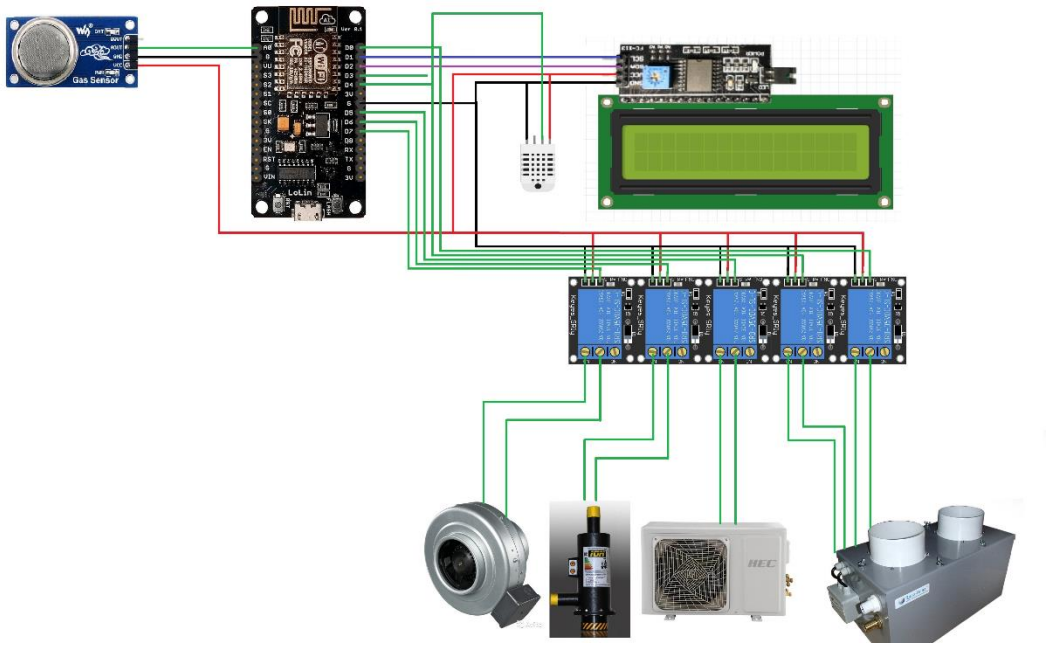

Figure 3.2 - Scheme of connections of the hardware of the information system

3.2 Algorithm of information system operation

To implement the information system of remote control and management of the parameters of the microclimate of the premises, it is necessary to determine the main indicators that will be supported and spill the algorithm.

Therefore, based on the information mentioned above, to ensure human comfort, the temperature should be within> 18 ℃ in winter and within <27 ℃ in summer. At temperatures below 18, the system must turn on the fuel boiler, which will heat the building, when operating in automatic mode. If the summer temperature is higher than 27, it is necessary to turn on the cooling device, such as air conditioning.

To manufacture and use a system for monitoring the climatic parameters of the greenhouse, you need to create a device on a microcontroller.

The ESP8266 microcontroller will be used to solve this problem. The structure of the device itself will include auxiliary units, humidity sensor, carbon dioxide sensor, LCD display, power supply and relay kit.

FLprog software will be used to create the main program of the ESP8266 controller. In FLprog, we choose the FBD programming language. The FBD programming language belongs to the IEC 61131-3 standard. The FBD programming language is the iron logic of the microcontroller, and in the process of executing the program the question of the human factor is removed. Blocks of the program are pieces of code which concerning various programming algorithm are compared in one cycle of the program of execution by the controller. In this program, very important attention is paid to the knowledge of the programmer of the logic of discrete electronics.

To write a program for the controller, you need to make a task. The task is to monitor, display and control the actuators of the greenhouse. We need that, depending on the temperature and humidity, the actuators are turned on and off [20],[21], [22].

In the FLprog program we choose the programming language FBD. The program consists of several areas of Fig.1. The "project tree" area, in this area we select the controller. The "tag" area, here we declare the registers of the controller and create if necessary changes. Area "library of functional blocks", here are the main blocks and macros of the components of the FBD program. And the main one is the workspace for creating the program. Area "library of functional blocks". In this area there is a library of blocks. The library contains design blocks, basic elements, scaling, triggers, timers, counters, math, algebra, mapping, switches, motors, real-time clocks, displays, strings, infrared control, arrays, structures, sensors, type conversion, extension chips, bit operations, communications.

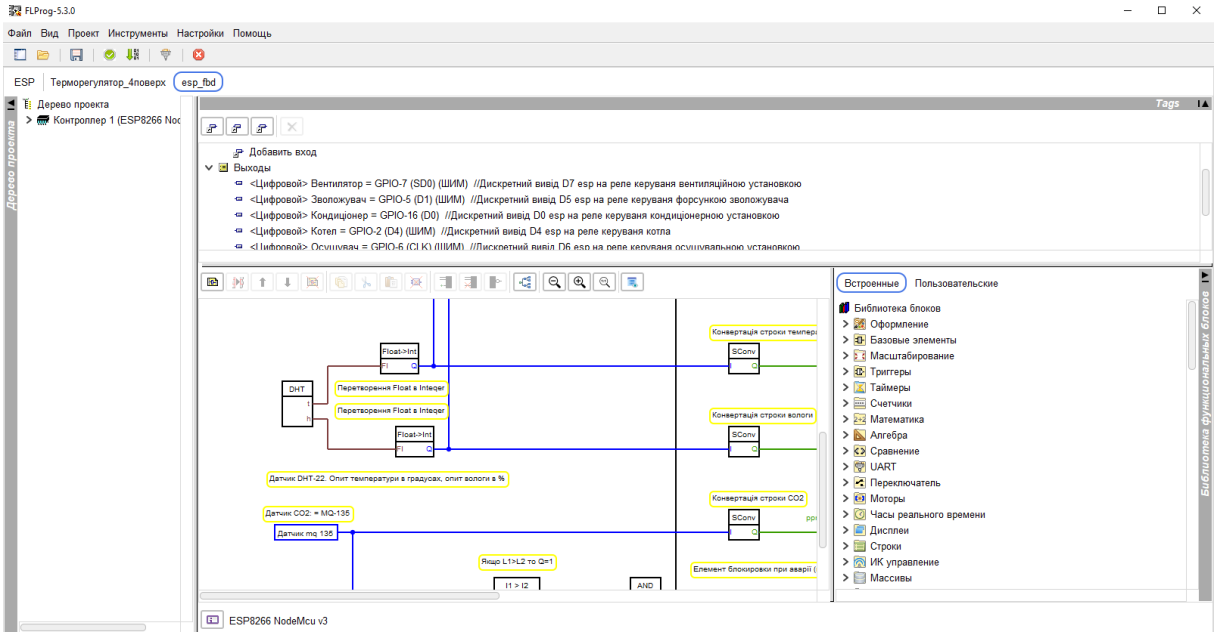

Figure 3.3 - Type of program

Design blocks are used to design the project itself, ie the design of the programming workspace. The basic elements include the OR element, the AND element, the XOR element.

The OR element is a logical OR operation

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

The AND element is a logical operation AND

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

The XOR element is a logical operation exclusive OR

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

The scaling block uses the scale block. This block is designed to scale the input values and output from the scaled values.

The trigger block uses the SR trigger, the TT trigger, the Rtrig trigger, and the RS trigger [23].

SR trigger element

	SRQ	
0	1	0
1	0	1
1	1	1

Element TT trigger

	SQ
0	0
1	1
1	0

Element Rtrig trigger

	RQ
0	0
1	1
1	1

Structure and principle of operation of the MQ135 gassing sensor. The electronic circuit of the sensor is shown in Figure 3.4.

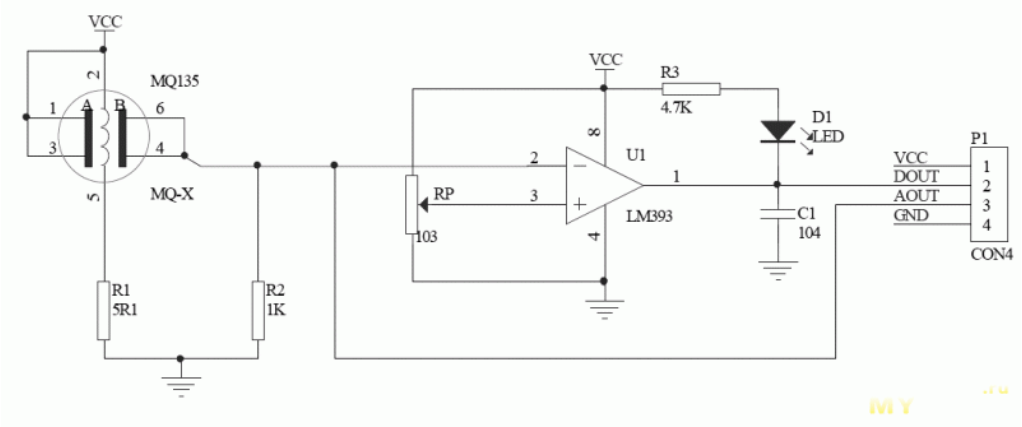

Figure 3.4- Scheme of the MQ135 sensor

The sensor works as follows. At start-up, the MQ-X heats up. The comparator U1 compares the inputs 2, 3, relative to the unit rp. In our case, the comparator will not be used, the signal will be removed from the MQ-X element itself.

We pass to writing of the program, in the top part of the program we assign discrete inputs and outputs fig.3. Discrete output D7 esp to the relay of control of ventilating installation, discrete output D5 esp to the relay of management of a nozzle of a humidifier, discrete output D0 esp to the relay of management of the conditioner, discrete output D4 esp to the relay of management of a copper, discrete output D6].

First, select the macros of the components. Macro of DHT-22 sensor, macro of carbon dioxide sensor, LCD display. In the macro of the DHT-22 sensor (DHT-22 sensor. Temperature test in degrees, humidity test in%) we put the number of the discrete input from which the signal will be removed, select the GPIO-0 input (D3). We put in the macro of the sensor labels of an output of humidity and temperature, then we put time of interrogation of the sensor. DHT-22 sensor configuration is complete.

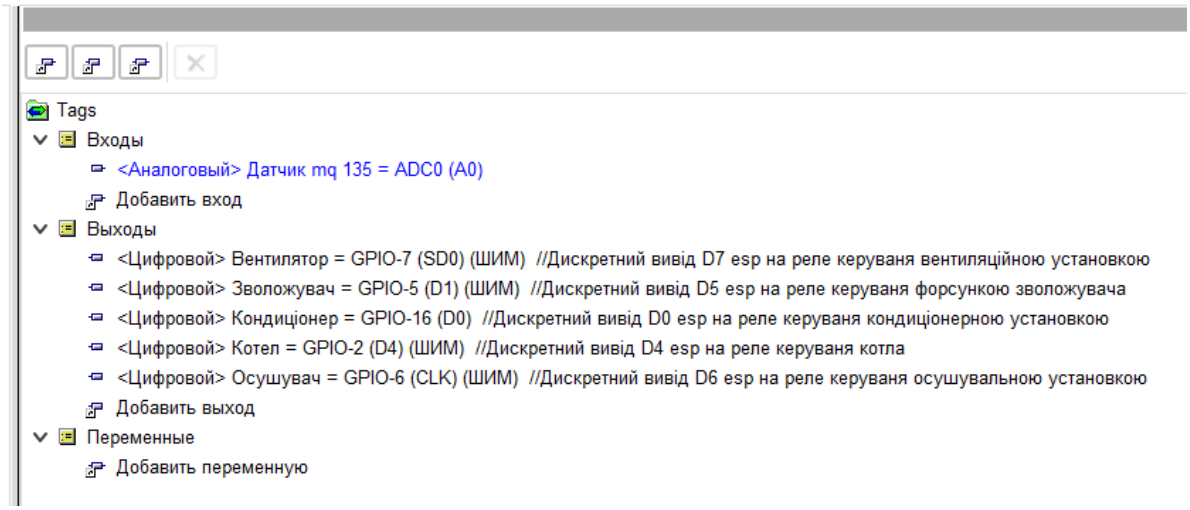

Figure 3.5 - Scheme of assignment of discrete inputs outputs.

Next, configure the carbon dioxide sensor (CO2 sensor: = MQ-135). In the configuration window, select the analog input ADC0 (0), the configuration is complete. Next, we put on the macro outputs of the sensor DHT-22 Float-> Integer

conversion units for moisture and temperature outputs, this is done to optimize the characters on the LCD display. We create four blocks of comparison.

On the first block of comparison in the configurator we put a condition L1 <L2, further L1 we connect to the block of transformation on a temperature conclusion and on L2 we put a constant 18. That is if on L1 there will be less than 18 degrees on a conclusion Q the logical unit will appear. This unit hits the ANA unit, the unit has two inputs and one output. When two units are applied to the block, one will appear on the Q output, if one of the outputs has a logical zero, then the Q output will have zero. The boiler will be switched on only if a logical unit and a unit for the second input from the gassiness sensor are fed to the input of the comparison unit output.

On the second block of comparison in the configurator we put a condition L1 <L2, further L1 we connect to the block of transformation on a moisture output and on L2 we put a constant 20. That is if on L1 there will be less than 20 percent on a conclusion Q the logical unit will appear. This unit hits the ANA unit, the unit has two inputs and one output. When two units are applied to the block, one will appear on the Q output, if one of the outputs has a logical zero, then the Q output will have zero. The humidifier will only switch on if a logic unit and a unit for the second input from the carbon dioxide sensor are fed to the input of the comparison unit.

On the third comparison block in the configurator we set the condition L1> L2, then L1 is connected to the conversion unit for moisture output and on L2 we set the constant 50. That is, if L1 will be more than 50 percent, then the output Q will have a logical unit. This unit hits the ANA unit, the unit has two inputs and one output. When two units are applied to the block, one will appear on the Q output, if one of the outputs has a logical zero, then the Q output will have zero. The dehumidifier will only switch on if a logic unit and a unit for the second input from the carbon dioxide sensor are fed to the input of the comparison unit.

On the last fourth block of comparison in the configurator we put a condition L1> L2, further L1 we connect to the block of transformation on a temperature conclusion and on L2 we put a constant 27. That is if on L1 there will be more than

27 degrees then on a conclusion Q the logical unit will appear. This unit hits the ANA unit, the unit has two inputs and one output. When two units are applied to the block, one will appear on the Q output, if one of the pins has a logical zero, then the Q output will have zero. The air conditioner will turn on only if a logical unit and a unit for the second input from the carbon dioxide sensor are fed to the input of the comparison unit.

So we made a configuration for the sensor and set the inclusion conditions for the output registers of the value Bool. Next, connect the comparison element to the output of the gas sensor. In the comparison element in its configurations we expose the condition L1> L2, L1 is connected to the gas sensor and L2 we set the constant 800. That is, when the constant 800 is exceeded at the output Q there will be a logical unit. These above elements are designed to block the actuators in excess of carbon dioxide. Compared to locking, the AND element turns on the hood.

We create macros to display data on the LCD display. In the first macro of the display component, select the display number, specify the display address in the I2C network, then set the constant "AVARIYA" and put a column and a row to display the constant. Then after configuring the macro we put the AND element.

At one input of the AND element we put an inversion to ensure when you turn on the gas sensor. That is, when the humidity sensor is triggered, the generator starts, which flashes with the constant "AVARIYA". In the second macro of the display component, select the display number, specify the display address in the I2C network, then put a column and a row to display temperature data. At the input EN we set the constant true for constant display of data. Next, the input D is fed to the line assembly unit and immediately set the constant "T" for visual perception of temperature on the display.

On the second input of the converter we put the block for conversion of integer in a line. In the third macro of the display component, select the display number, specify the display address in the I2C network, then put a column and a row to display moisture data. At the input EN we set the constant true for constant display of moisture data.

Next, input line D is fed to the input unit D and immediately set the constant "H" for the visual perception of moisture on the display. On the second input of the converter we put the block for conversion of integer in a line. In the fourth macro of the display component, select the display number, specify the display address in the I2C network, then put a column and a row to display the gas content data. At the input EN we set the constant true to constantly display the gas content of the greenhouse. Next, input line D is fed to the line assembly unit and immediately set the constant "ppm" for the visual perception of moisture on the display. On the second input of the converter we put the block for conversion of integer in a line.

To display information on the LCD display, we will use an array of information for each word in the display line. This is not due to the support of the Cyrillic display.

The program in run mode works as follows. When you turn on the controller from the discrete water D3 data is removed from the sensor DHT-22. Data of the Float type are removed from the DHT-22 sensor, for convenience of displays and optimization of the data on the display by means of the converter we transfer data to Integer. Next, the temperature data is transmitted to two communication lines, one line goes to the converter integer in a row, after the converter goes to the converter folding rows that are folded and displayed on the LCD. The second line is transmitted and divided into two lines for comparison comparators. Regarding these temperatures, one of the comparators works, which in turn turns on the air conditioner or boiler.

In the second cycle of the DHT-22 sensor data of type Float are removed, for convenience of displays and optimization of the data on the display by means of the converter we transfer data to Integer. Next, the moisture data is transmitted to two communication lines, one line goes to the converter integer in a row, after the converter goes to the converter folding lines that are folded and displayed on the LCD. The second line is transmitted and divided into two lines for comparison comparators. Regarding the moisture data, one of the comparators works, which in turn turns on the air conditioner or boiler [25],[26].

The circuit of the device consists of a temperature-humidity sensor, a gas sensor, a relay line and a display. When you turn on the device, the priority of the program is allocated to the gas sensor, then the temperature and humidity data are removed. When the temperature is greater than 27 degrees, the air conditioner is turned on, when the temperature is less than 18, the boiler is turned on. This is how the hygrometer works. At moisture 30 the humidifier is switched on, at moisture 50 the dehumidifier is switched on.

The algorithm of the developed information system is shown in Figure 3.6

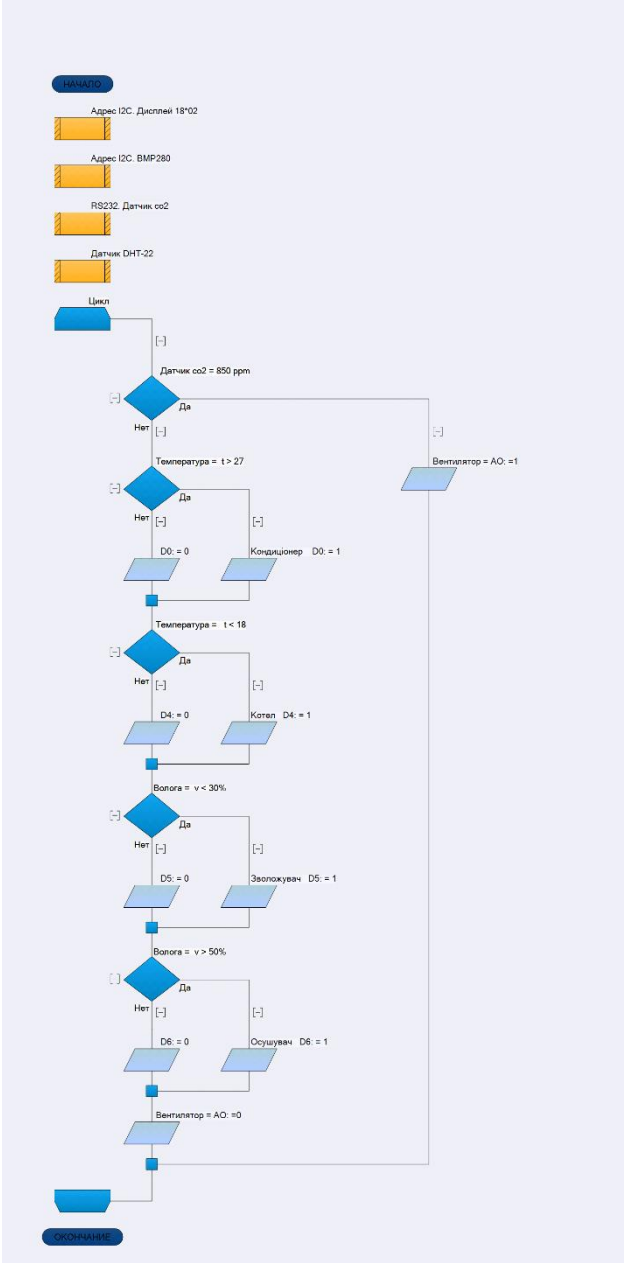

Figure 3.6 - Algorithm of the control program.

3.3 Conclusions to the third section

During the development of this section, sensors and a microprocessor controller were selected, and the expediency of their use was considered. Also the program for control and realization of system is developed, the algorithm of the managing program for information system is created.

4 LIFE SAFETY

4.1 Occupational safety management system.

Occupational safety management system (OSMS) is a set of management bodies of the enterprise, which on the basis of a set of normative documentation carry out purposeful, planned activities to implement tasks and management functions to ensure healthy, safe and highly productive working conditions. Creation of OSH is carried out by consistent definition of the purpose and object of management, tasks and actions concerning labor protection, functions and methods of management, construction of organizational structure of management, drawing up of normative and methodical documentation. The main purpose of occupational safety management is to create healthy, safe and highly productive working conditions, improve working life, prevent injuries and occupational diseases [43].

Labor protection is based on legislative, directive and normative and technical documents. When managing labor protection, no decisions should be made and measures taken that contradict the current legislation, state regulations on labor protection, labor safety standards, rules and norms of labor protection.

The main functions of labor protection management include:

— forecasting and planning of works, their financing;
— organization and coordination of works;
— accounting indicators, analysis and assessment of working conditions and safety;
— control over the state of labor protection and the functioning of OSH;
— stimulating labor protection activities.

The planning function, which is based on prognostic analysis, is crucial in OSH. Occupational safety planning is divided into long-term, current and operational.

Long-term planning covers the most important, time-consuming and long-term measures of labor protection, the implementation of which, as a rule, requires

the joint work of several divisions of the enterprise. The possibility of implementing the measures of the long-term plan must be confirmed by a reasonable calculation of the necessary logistics and financial costs, indicating the sources of funding. The main form of long-term planning of work on labor protection is the development of a comprehensive plan of the enterprise (for 3-5 years) to improve the state of labor protection.

Current planning is carried out within a calendar year by developing and including appropriate measures in the section "Labor protection" of the collective agreement.

Operational planning of work on labor protection is carried out on the basis of control of a condition of labor protection in structural divisions and at the enterprise as a whole or checks of bodies of the state supervision. Prompt measures to eliminate the identified shortcomings are specified in the order of the employer.

Operational planning of work on labor protection is carried out following the results of control of a condition of labor protection in structural divisions and at the enterprise as a whole. Operational measures to eliminate the identified shortcomings are indicated directly in the order of the owner of the enterprise, which is issued based on the results of control, or in the action plan as an appendix to the order.

The function of OSH for the organization and coordination of work involves the formation of labor protection management bodies at all levels of management and all stages of the production process, defining responsibilities, rights, responsibilities and interaction of persons involved in the management process, .

Control over the state of labor protection. Effective management of labor protection can be carried out only in the presence of complete, timely and reliable information about the state of labor protection. It is possible to obtain such information, identify possible deviations from safety standards, as well as check the implementation of plans and management decisions only on the basis of regular and objective control.

The main forms of control over the state of labor protection include: operational control; control carried out by the labor protection service of the

enterprise; public control; administrative and public three-level control; departmental control of higher bodies. It should be noted that in addition to control, labor protection is supervised by state and trade union inspections.

The administration (employer) for the creation of safe and harmless working conditions for employees and for their own safety must be guided by a list of the following basic regulations and documents on labor protection:

- Law of Ukraine "On labor protection";
- Standard regulations on labor protection service;
- Regulations on the procedure for investigating accidents that occurred during the educational process in educational institutions (Order of the Ministry of Education and Science of Ukraine № 616 of 31.08.2001):
- Procedure for Investigation and Accounting of Accidents, Occupational Diseases and Accidents at Work (Resolution of the Cabinet of Ministers of Ukraine № 1112 of August 25, 2004);
- Typical provision on labor protection training;
- Regulations on the development of instructions on labor protection;
- List of works with increased danger;
- Limit norms for lifting and moving heavy objects by women;
- Limit norms for lifting and moving heavy objects by minors;
- Regulations on medical examination of employees of certain categories;
- The list of positions of officials who are obliged to pass preliminary and periodic check of knowledge on labor protection;
- The procedure for development and approval by the owner of regulations on labor protection in force at the enterprise;
- Regulations on the procedure for providing employees with special clothing, special footwear and other personal protective equipment (Order of Derzhgirpromnahlyad dated 24.03.2008 № 53);
- Procedure for attestation of workplaces under working conditions (Resolution of the Cabinet of Ministers of Ukraine No. 442 of September 1, 1992);
- Standard regulations on the commission on labor protection;

- Typical provision "On the office of labor protection" [44].

Stimulation of labor protection activities is aimed at creating the interest of employees in ensuring healthy and safe working conditions. Incentives include both moral and material incentives, as well as penalties for non-compliance with a person's obligations regarding occupational safety or breach of cancer protection requirements. The latter include: bonuses, rewards for specific work performed, inventions and innovation proposals on labor protection. The source of stimulation of labor protection activities are labor protection funds.

4.2 Requirements for the working environment of the computer user: microclimate, lighting, noise level, electromagnetic radiation

Premises with computers must be equipped with an automatic fire alarm system in accordance with the requirements of the list of similar objects to be equipped with automatic fire extinguishing and fire alarm systems, approved by order of the Ministry of Internal Affairs of Ukraine and registered with the Ministry of Justice of Ukraine. fire extinguishers at the rate of 2 pcs. for every 20 square meters. m of floor space, taking into account the maximum allowable concentrations of fire-extinguishing liquid in accordance with the requirements of the Rules of fire safety in Ukraine [45].

The rules of computer operation establish safety requirements and sanitary and hygienic requirements for the equipment of workplaces of computer users and employees performing maintenance, repair and adjustment of computers, and work with the use of computers, in accordance with current technology and research in the safe organization of operation. Computers and taking into account the provisions of international regulations on these issues.

Hygienic requirements for the parameters of the production environmentinclude requirements for microclimate parameters, lighting, noise level and electromagnetic radiation.

In production premises at workplaces optimum values of parameters of a microclimate should be provided: temperature, relative humidity and air mobility.

Premises with computers must have natural and artificial lighting. Natural light must penetrate through the side apertures, usually oriented to the north or northeast, and provide a coefficient of natural light of not less than 1.5%. In case of production needs, it is allowed to operate computers in premises without natural light in coordination with the bodies of state supervision over labor protection and bodies and institutions of the sanitary-epidemiological service.

General lighting should be in the form of continuous or intermittent lines of lamps, placed on the side of the workplace (preferably on the left) parallel to the line of sight of workers.

Noise levels at workplaces of persons working with video terminals and computers are defined by DSanPiN 3.3. 2-007-98.

To ensure normalized noise levels in production facilities and workplaces, sound-absorbing means are used, the choice of which is justified by special engineering and acoustic calculations.

Levels of electromagnetic radiation and magnetic fields must meet the requirements of GOST 12.1. 006 "SSBT. Electromagnetic fields of radio frequencies. Permissible levels at workplaces and requirements for control", SN N 3206-85 "Maximum permissible levels of magnetic fields with a frequency of 50 Hz" and DSanPiN 3.3. 2-007-98.

4.3 Establishment and operation of an environmental monitoring system for the integration of environmental information systems covering certain areas

The state system of environmental monitoring is a system of observation, collection, processing, transmission, storage and analysis of information on the state of the environment, forecasting its changes and development of scientifically sound recommendations for decision-making on the prevention of negative changes in the

state of the environment and compliance with environmental safety requirements. It The Regulation defines the procedure for the establishment and operation of such a system in Ukraine.

The monitoring system is an integral part of the national one information infrastructure compatible with similar systems other countries [46].

The monitoring system is an open information system, the priorities of which are the protection of vital environmental interests of man and society; preservation of natural ecosystems; prevention of crisis changes in the ecological state of the environment and prevention of environmental emergencies.

Establishment and operation of a monitoring system to integrate environmental information systems covering certain territory, based on the principles of:

– consistency of regulatory and legal and organizational and medical support, compatibility of technical, information and software of its components;

– systematic observations of the state of the environment and man-made objects that affect it;

– timeliness of receipt, complexity of processing and use of information on the state of the environment, which is received and stored in the monitoring system;

– objectivity of primary, analytical and forecast information on the state of the environment (environmental information) and its efficiency bringing to public authorities, local authorities self-government, public organizations, the media information, the population of Ukraine, interested international institutions and the world community.

Environmental monitoring is carried out by:

– Ministry of Environment - soils in protected areas (content CL, including radionuclides); state ecological mapping of the territory of Ukraine to assess its condition and its changes under the influence of economic activity; terrestrial ecosystems (background number of CLs, including radionuclides); species of endangered flora and fauna and species under special protection.

– Ministry of Economy - soils for agricultural use (radiological, agrochemical and toxicological determinations, residual amount of pesticides, agrochemicals and heavy metals); agricultural plants and products thereof (toxicological and radiological determinations, pesticide residue, agrochemicals and heavy metals).

– State Forest Agency - soils of forest lands (radiological determinations, pesticide residue, agrochemicals and heavy metals); forest vegetation (condition, productivity, damage by biotic and abiotic factors, biodiversity, radiological determinations); hunting fauna (species, quantitative and spatial characteristics);

– State Geocadastre - soils and landscapes, irrigated and drained lands (secondary flooding and salinization, etc.); shorelines of rivers, seas, lakes, reservoirs, estuaries, bays, hydraulic structures (dynamics of change, damage to land resources);

– Ministry of Regional Development - drinking water of centralized water supply systems (CL content, consumption volumes); sewage of the city sewer networks and treatment facilities (CL content, revenues);

– Gosgeonadra - groundwater (resources and use); endogenous and exogenous processes (species and spatial characteristics, activity of manifestation).

Funding for the establishment and operation of the monitoring system and its components is carried out in accordance with the procedure for financing environmental measures at the expense of funds provided in the state and local budgets in accordance with the law.

Reimbursement of a certain part of the costs for the establishment and operation of the components and components of the monitoring system may be carried out at the expense of innovation funds within the funds provided for environmental measures, international grants and other sources of funding.

4.4 Organization of civil protection at industrial facilities and implementation of measures to prevent emergencies of man-made origin

Based on the principles of building civil protection in Ukraine, it should be emphasized that the territorial - production principle is embodied in the organization of civil protection in the economy, as well as in regions, cities and districts, including urban and rural.

In accordance with Article 16 of the Civil Protection Code of Ukraine and in order to prevent emergencies of man-made nature (hereinafter - emergencies), ensuring the sustainable operation of facilities in a special period, the Cabinet of Ministers of Ukraine.

Provides to establish that the effect of this resolution extends to the civil defense authorities, namely the central executive authorities, the Council of Ministers of the Autonomous Republic of Crimea, regional, Kyiv and Sevastopol city, district, district in mm. Kyiv and Sevastopol, state administrations, military-civil administrations, local self-government bodies and facilities, regardless of the form of ownership, the violation of which may harm vital national interests and which operate and provide services in energy, chemical industry, are subject to protection and defense in a state of emergency and a special period, are objects of increased danger [47].

To guide the current work on civil protection at the object of the economy, the main governing body is created - the headquarters of civil protection. The Civil Defense Staff consists of: the Chief of Staff and his deputies (assistants) from the operational and reconnaissance unit, combat training, and the housing sector.

The position of Chief of Staff of Civil Defense is provided by the staffing schedule of the facility. The Chief of Staff is the first deputy chief of civil defense of the facility and has the right to give orders and instructions on civil defense on his behalf. He is the direct organizer of the management of civil protection and notification of the threat or fact of emergency, intelligence, dosimetric and chemical

control, conducts current and future planning, training of formations and production personnel for civil protection and control over all civil protection measures.

Heads of functional and territorial subsystems of the unified state system of civil protection and enterprises, institutions, organizations, regardless of ownership, to which this resolution applies, to ensure:

– clarification of emergency response plans and plans for localization and elimination of the consequences of accidents, implementation of measures to prevent their occurrence;

– readiness to notify the authorities and civil defense forces, the population of the threat or occurrence of an emergency situation and inform them about the limits of spread, consequences, methods and techniques of protection, as well as actions in the area of a possible emergency situation;

– monitoring and control of the situation at the facilities covered by this resolution, the territories of these facilities and / or outside them, as well as the implementation of constant forecasting of the possibility of emergencies, their scale;

– readiness of available forces and means of civil protection, possibility of attraction of additional forces and means in case of emergencies;

– creation and use of material reserves to prevent emergencies and eliminate their consequences.

Summarize analytical materials to the State Emergency Service and submit them for consideration to the State Commission on Technogenic and Ecological Safety and Emergencies to ensure coordination of measures to prevent emergencies at the state level.

The final decision on the level of the emergency situation with its subsequent reflection in the statistics, including in the absence of sufficient information on the development of the emergency situation, is made by a specially authorized central executive body, which is responsible for protecting the population and territories from man-made and natural emergencies. nature, in agreement with the ministries and other central executive bodies concerned, if necessary. The expert opinion of

the regional commission on technogenic and ecological safety and emergency situations on the level of the emergency situation must be taken into account (if any).

4.5 Conclusions to the sixth section

This section addresses current safety issues in emergencies. Knowledge was gained regarding the operation of computer rules and requirements, which are approved by the committees for the supervision of labor protection and other bodies responsible for safety. Also prevent negative changes in the environment and prevent the elimination of emergencies that threaten human life and health.

GENERAL CONCLUSIONS FOR THE THESIS

The paper develops an automated system for remote control of microclimate parameters of residential premises based on the hardware platform ESP 8266. Data transmission and remote control is implemented with the help of a modern protocol for Internet of Things MQTT using the broker Mosquitto.

Hardware platforms and their capabilities for remote climate control have been studied. The optimal hardware platform for system implementation is selected.

Implementation of the software part using MQTT made it possible to optimally develop a mobile application for remote control to record the obtained parameters of the microclimate in the cloud for further analysis.

The developed system has the necessary stability in operation and reduced cost compared to analogues, which is sufficient for residential premises.

Carrying out this development will allow you to remotely monitor and control the parameters of the microclimate in the room both manually and automatically.

The developed system is flexible, can be easily expanded and has versatility in terms of connection to integrated IoT systems.

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