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Research Article

USING MODERN AUTOMATION IN THE GREENHOUSE

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ABSTRACT

Work was carried out to study separately existing smart greenhouse systems, during the consideration of which their advantages and disadvantages were identified. Having considered all possible options for smart greenhouse systems, we determined the best ways of development. Based on the data obtained, the relevance of the chosen project topic was substantiated. He developed an electrical circuit diagram, the elements of which were selected in accordance with the necessary parameters, which were also indicated in the list of elements.

KEYWORDS

Automation of greenhouses, modern greenhouse complexes, microclimate: heating, irrigation, ventilation and air circulation, automatic lighting, automated control.

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INTRODUCTION

The use of automated microclimate control systems in greenhouses is promising [1-4]. Greenhouse automation [5,6] implies the management and monitoring of climate parameters that can be adjusted. Automation of climate control promotes better growth and higher yields, as well as reduces manual labor costs. There is a need for a high degree of automation and mechanization of technological processes [7].

Modern greenhouse complexes are built multi-span according to standard designs, they are equipped with the necessary engineering systems for maintaining the microclimate: heating, irrigation, ventilation and air circulation, drainage, water supply and sewerage, lighting. All these systems are designed for large enterprises. They are difficult to install and operate, and also have a high cost. These systems are not applicable to private or small farms [8].

The use of an automatic system for greenhouses makes it possible to greatly facilitate the work on your garden plot and increase the yield up to several times. By installing an automatic machine for a greenhouse with your own hands, it is achievable to create favorable conditions for the development and growth of plants without human intervention. Autonomous irrigation systems will save time spent on watering, especially in summer cottages, when watering is required even on weekdays. The amount of water and fertilizer used is also significantly reduced. Automatic lighting and heating allow you to grow vegetables and herbs in greenhouses all year round. Automation systems will significantly simplify all technological operations in the greenhouse.

Figure 1. Control of sensors using a special block

Depending on the needs of farmers, any combination of sensors is possible: temperature sensors, humidity sensors, light meter sensors, soil composition sensors (acidity, chemical composition), dew point sensors, irrigation water quality sensors, etc.

The sensors are connected via wired or wireless networks. In remote areas, LPWANs such as LoRaWAN, RF, NB-IoT, etc. can be used. As a rule, networks of an unlicensed range are used for communication, which in many cases reduces the cost of using equipment, subscription fees for services, etc.

To build such a solution and achieve the desired result, three main components are required: a set of sensors that read certain parameters; a hardware-software complex, or HSC, for collecting and processing this information, as well as data transmission technologies designed to link the other two components. The above is enough for high-quality monitoring of the state of air.

Automated control is carried out as follows: the agricultural producer has a certain device - a computer, laptop, tablet or smartphone, through which he can access the taken parameters.

For example, the system signals that soil moisture in a greenhouse has fallen below a threshold value, as a result of which watering is necessary. In this case, the farmer can give an appropriate instruction to the maintenance personnel and, after a while, monitor changes in the humidity parameters. The main advantage of the data obtained as a result of monitoring is accuracy and reliability. For example, a weather forecast may have serious errors and not reflect the real picture. The assessment is given for the settlement as a whole, and the situation in some part of it may be very different from what is happening in another.

Like any modular structure, an intelligent control system can be upgraded and improved. For example, it is possible to introduce monitoring of the state of technological equipment into the monitoring loop.

If the complex gives a command to turn on the heating, and the device is faulty, the action will not be performed, which can lead to crop losses.

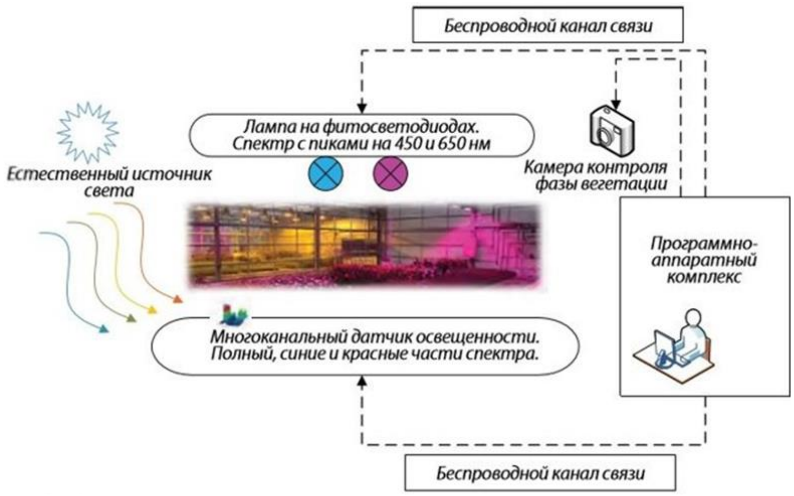

Figure 2. The control scheme of the lighting system in the greenhouse

The solution to this problem lies in the implementation of monitoring of hardware nodes and the early elimination of damage. There are methods that help to read additional parameters of the greenhouse biosystem, for example, to control the level of nitrogen in the soil by the color of the leaves. It is possible to install cameras that recognize diseases of various crops, which are evidenced by the appearance of spots and plaque on the leaf surface.

All these measures bring the control of growing vegetables to a new level of quality. At the stage of fruit formation, the level of CO_2 concentration becomes an important parameter. To monitor it, an appropriate sensor can be integrated into the system and procedures for maintaining the required level can be added. This option requires external sources of carbon dioxide and optimization of ventilation control algorithms, while it is advisable that the number of visits to greenhouses by employees is minimal. The fewer people walking and opening doors, the more stable the system and the better the maintenance of CO_2 levels. Thus, when developing algorithms, one also has to take into account the human factor. The introduction of additional options requires certain costs, but most often such actions are justified. In this case, the economy is simple: when there is a question of preserving the crop, then the costs are acceptable, because if ventilation is not opened in time, lighting, heating, etc. are turned on, the agricultural producer risks losing part, and sometimes the entire crop. At the same time, there is no need to directly perform all actions and control them in the greenhouse itself, since the monitoring and control system allows you to do all operations automatically, quickly and remotely.

Previously, automating the operation of a greenhouse was an expensive, and sometimes irredeemable procedure, but at the moment the solution to this problem is not so expensive and fully pays off, and in the future, besides, it brings even greater benefits.

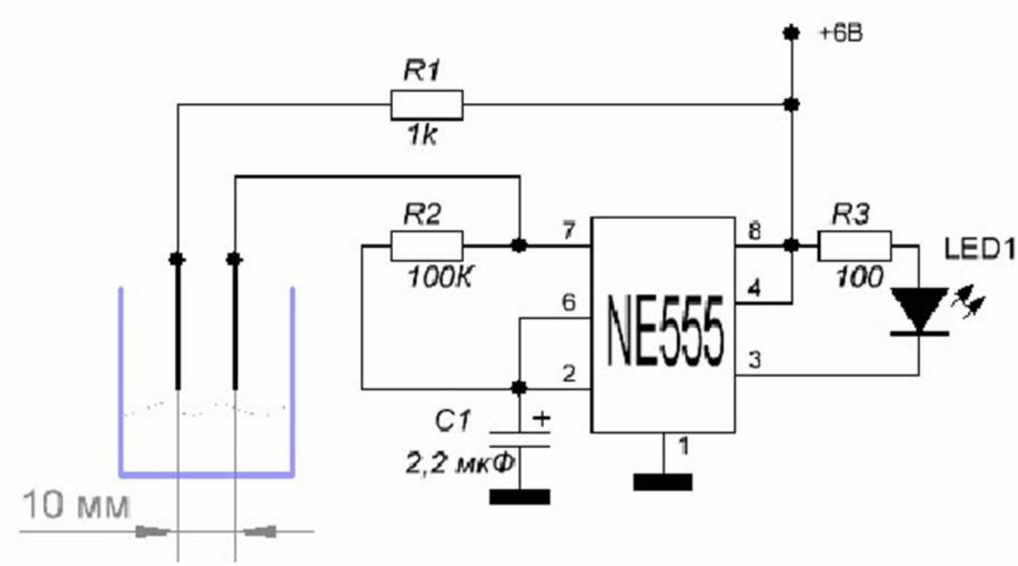

Figure 3. Soil moisture sensor on a chip NE555

It is important to know the required water consumption per day (which will depend on the area greenhouses, the needs of grown plants in water, their planting density, etc.), then it is enough to control irrigation using water flow sensors over time, and use humidity sensors as overflow alarms.

Lighting control. Automatic lighting is most easily implemented using a simple photoresistor. When the light decreases, its resistance increases and thus a control signal is formed to turn on the lamps in the greenhouse.

Soil heating Automatic soil heating is carried out in the same way as air, but instead of actuators, heating elements or a heating cable are used to control the temperature.

Automation control devices

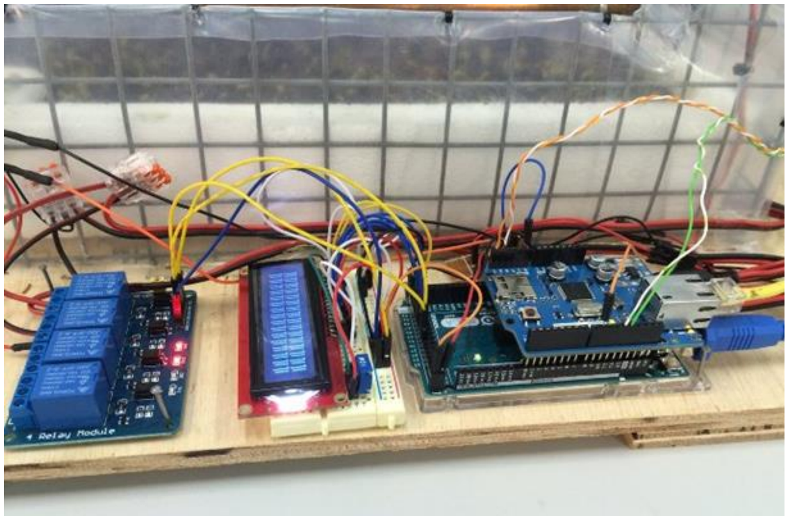

Figure 4. An example of using Arduino to automate a greenhouse

Separately, it should be said about devices that receive information from sensors, analyze and issue control signals to actuators, heating elements, water supply valves, etc. On the Internet, you can find a lot of articles on such a platform as Arduino, on the basis of which it is proposed to create automation for small greenhouses.

Arduino is a hardware and software tool with a preloaded bootloader that allows you to upload your program to the microcontroller without using separate hardware programmers. The microcontroller on the board is programmed using the Arduino language, which is based on the Wiring language (C-like).

All the results of the operation of the equipment in an automated greenhouse, if necessary, can be visually tracked on a computer. The web interface can make it possible not only to monitor the readings of temperature, humidity and lighting sensors, but also to manage these very readings. It can also be implemented to monitor the greenhouse through a webcam.

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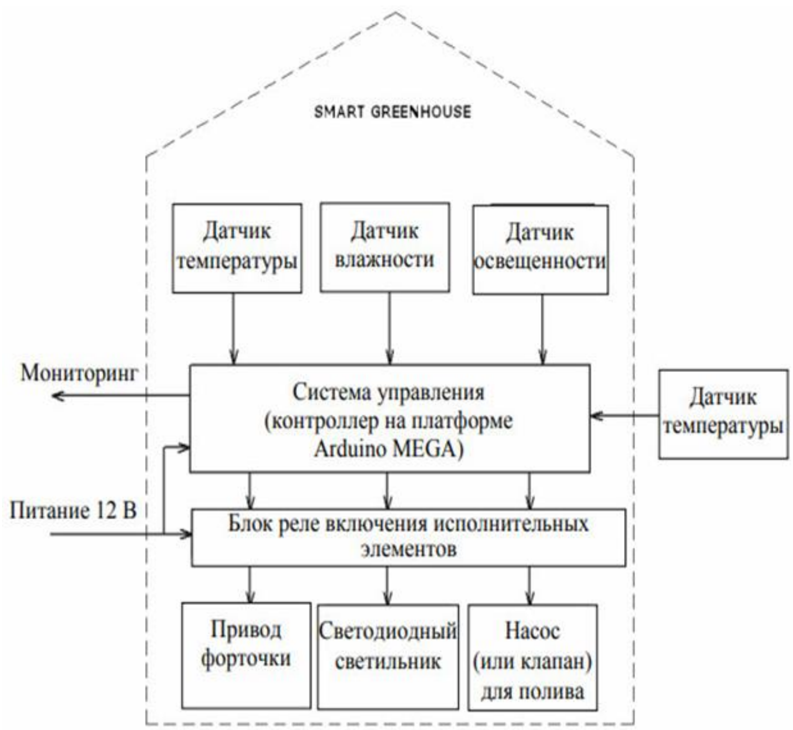

Figure 5. An example of a greenhouse automation circuit on Arduino

The greenhouse control system is controlled by the Arduino central board, it works as follows: the received environmental data, the air temperature, humidity or lighting sensor is transmitted to the central controller (Arduino) which compares the current values with the set ones. If any of the values does not match, then the actuator is activated to restore the optimal state. Next, the Arduino sends the data to a remote server for monitoring over the Internet.

By means of a special programmable block, such parameters are controlled as:

- Heating of the internal space of the greenhouse;
- Water heating;
- Frequency and duration of irrigation;
- Start and stop forced ventilation;
- Lighting.

Air temperature control is determined by two threshold limits: upper limit and lower limit. When the upper limit is exceeded, the vents open, the fan is activated to cool the greenhouse environment, curtains can be used to oppress, and when the temperature drops below the lower limit, the fan turns off, the heater turns on to heat the air to a predetermined level.

Humidity control is determined by a threshold set by the user. when the humidity in the greenhouse falls below the set threshold, the automatic watering system turns on and then turns off when the optimum condition is restored.

The lighting condition is controlled by two preset points: upper limit and lower limit. The upper limit determines when the light is activated while the lower limit determines when it is turned off. This strategy is mainly used to increase daylight or compensate for insufficient natural light according to the user's desire. Despite the ease of programming and connection, as well as the low cost, in my opinion, the implementation of such projects on Arduino is difficult.

Figure 6. Controllino PLCs: MINI (left), MAXI (middle) and MEGA (right)

The Raspberry Pi 2 microcomputer can also be used as a master control device, combining the advantages of Arduino and a personal computer, as it is able to run a separate operating system and has input / output ports for connecting slave devices and receiving signals from sensors.

But the easiest way is to buy a ready-made device in the form of a programmable relay or a programmable logic controller. Of the domestic manufacturers of such products, the most well-known companies are OWEN, Segnetiks, and others. An alternative for those who have learned to program Arduino can be the Controllino PLC.

The only disadvantage of this PLC is the relay outputs with a current of up to 6 A. But if the greenhouse uses electrical equipment with less current consumption, then this PLC is the best fit.

Thus, the creation of an automated greenhouse today is a simple and relatively inexpensive task for small farms.

CONCLUSION

In the process of developing this article, work was carried out to study separately existing smart greenhouse systems, during the consideration of which their advantages and disadvantages were identified. Having considered all possible options for smart greenhouse systems, we have identified the best ways to develop this article. Based on the data obtained, the relevance of the chosen project topic was substantiated. He developed an electrical circuit diagram, the elements of which were selected in accordance with the necessary parameters, which were also indicated in the list of elements. He also developed and designed an assembly drawing of the stand, which was used to further place the elements of the project's schematic diagram. Algorithms for the program parts of the dissertation work were developed separately for each of the subsystems. He assessed the safety of the dissertation project. Compiled a brief manual for the operation of the design layout.

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