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Development of Smart Life Support and Monitoring System for Indoor Plants

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A robotic system is a microcontroller with a set of sensors that register external changes (humidity, lighting, temperature, etc.), a data exchange module, and an execution mechanism that begins to act when the user sends a command to the microcontroller from an Android device. Creating robotic systems is one of the main tasks of industrial automation, which is closely related to the IoT (Internet of Things) technology. There are a lot of variations in the development of robotic systems in synergy with IoT: "Smart Home", driverless car, cleaning robot, etc. In most cases, a smart home is a home automation system – a system that helps save time on managing all other engineering and entertainment devices. And the more devices, the more necessary it is to use automation systems. For a large number of IoT systems, a mobile phone or tablet based on the Android or iOS operating system is often used as a control device. This is due to the mobility in managing and monitoring messages through a handheld device. The purpose of this article is to develop a Smart system for life support and monitoring the condition of indoor plants.

The Smart system being developed provides for the creation of not only a plant life support system, but also the creation of a mobile application for managing and monitoring plant life support. In the course of writing the article, the existing automated control systems were investigated and a block diagram of the Smart system was constructed, taking into account its interaction with the mobile application. The article uses a decentralized automation system in which the main elements are the ESP8266 microcontroller (as a transmitter) and the Atmega328 microcontroller (as a data processing element). An application for a mobile device that acts as a remote control has also been developed. Within the framework of the article, an electrical schematic diagram of the Smart system has been developed. The article also provides detailed instructions and recommendations for both hardware and software parts.

Keywords: indoor plants, monitoring, smart house, mobile app, sensors, microcontroller, Internet of things.

Introduction

Today, growing plants at home is an increasingly popular occupation. But large greenhouses, as well as mini greenhouses of an Amateur nature and just indoor plants require a lot of time to care for them. For full growth and development, as well as photosynthesis processes, sufficient light and moisture are needed. An important factor is the support of the temperature regime of the environment of plants, which in turn are natural air purifiers and bring aesthetic pleasure. Modern technologies allow you to automate the care of not only greenhouses, but also indoor or office plants, taking into account their individual characteristics. A number of existing Smart systems are an excellent solution in the situation for large offices and home use for frequent long business trips or vacations of flower growers.

State of the art

There are many automatic watering systems for indoor plants. One of these representatives is the Smart Dripping Pro system, which syncs with your smartphone via Bluetooth technology, and allows you to simultaneously water up to 8 vases.

Automatic irrigation systems are offered by the manufacturer GreenHelper. Such systems are equipped with a timer and watering is carried out with a certain frequency. A simpler way out of this situation is to use designer planters with automatic watering of indoor plants. Among the manufacturer LECHUZA. The listed examples of automatic irrigation systems can be found in the offers of online stores.

One of these smart systems for watering indoor plants, under the guise of the TechKit Flower project, was implemented by a Ukrainian specialist. This device automatically adapts the watering mode to the needs of the plant. This irrigation management can be performed using a smartphone. TechKit Flower connects to the Internet via Wi-Fi and transmits its performance statistics to the server. The user tracks data using a mobile app for Android and iPhone. The system can report problems or adverse changes to the owner. All analytical information is periodically sent to the cloud storage [1].

The purpose of research [2] is to design, build and test the system to be able to do the watering, hydroponic nutrients drain automatically, and to fog the plant environment, also to monitor the environmental temperature in the plant house. The method used in the research of Automatic Watering System in The Plant House – Using Arduino Board is experiment technique. Some of the steps that need to be considered, namely the design stage, the stage of development/manufacture, and installation phase. Next is the testing of the product that has been made by testing some variables that have been previously specified. As a result, the system can do the watering, drain hydroponic nutrients, and perform automatic misting with a working voltage of 208-214 VAC and 15 VDC, as well as a constant Arduino pin voltage of 4.8 VDC. The system can also display the current state of the soil moisture status and the temperature of the greenhouse. By performing tests on crops, showed growth of plants in the hydroponic method is faster than with conventional cultivation methods.

Based on the implementation of automatic opto-hydroponics it was created system is capable of healthiest growth of plants with minimum resources and maximum output. Aim of the system was to build cost effective and efficient setup to provide the best environmental conditions in an artificial setup [3]. High-cost is a major drawback in technology.

This paper proposes a new approach in utilizing IoT technology as a remote monitoring system to control the indoor climatic conditions via light emitting diode (LED) parameters which include spectrums, photoperiod and intensity in order to increase yields as well as to reduce the turnaround time. In order to capture real-time data and monitor the environmental parameters of the plant experiment, an intelligent embedded system was developed to automate the LED control and manipulation. [4]

This research paper describes designing of a greenhouse system to control climate, soil moisture, lighting using fuzzy logic. The proposed model consists fuzzy logic to control GHS parameter such as temperature, Humidity, light, soil moisture and watering system to the plant. In this proposed system temperature controlling controller is used to take current temperature as input by using temperature sensor and its deviation from user set data. Simulation using MATLAB is used to achieve the designed goal. [5]

The purpose of the work [6] is to develop a device for automatic watering of plants. The advantage of this development is the simplicity of the design, the ability to change the parameters of watering depending on the requirements of plants for humidity, compact placement, as well as a system to prevent waterlogging of the plant and the use of more durable materials during Assembly. Irrigation control is performed using the Arduino Pro Mini. The proposed design does not involve control from a mobile device.

This project aims to develop dual axis solar tracker with IOT monitoring system using Arduino. With the help of this system, solar panels can improve the way of sunlight detection so that more electricity can be collected as solar panels can maintain a sunny position. Two servo motors have been used to rotate the solar panel according to the sun's light source detected by the LDR. Next a WIFI ESP8266 device is used as an intermediary between device and IOT monitoring system. The IOT monitoring system is a website that functions to store data. [7]

Projects to create automated systems for irrigation or monitoring are very popular. Existing automated systems have certain disadvantages, both of a constructive nature and related to the purchasing power of the end user. Thus, the development of automated systems for life support and monitoring of indoor plants is an urgent scientific and applied task.

1 Hardware components of a smart system

The article defines the main hardware components of a smart system. Let's look at them in detail:

1. The ESP8266 microcontroller. The ESP8266 is all about Wi-Fi. If you are eager to connect your new ESP8266 module to a Wi-Fi network to start sending and receiving data, this is a good place to start. ESP8266 is designed with advanced power management technologies and intended for mobile devices, wearable electronics and the Internet of Things applications [8].

2. The Atmega328 microcontroller. The ATMega328 microcontroller is an 8-bit CMOS microcontroller with low power consumption based on the advanced AVR RISC architecture.

3. Sensors.

3.1. Humidity sensor FC-28. This module (see Fig. 1) is designed to determine the amount of water in the soil.

The principle of operation of this module is based on measuring the soil resistance between two plates. The higher the soil humidity, the less its resistance. The LM393 comparator is used to convert the resistance to volts. The sensor has two types of outputs. One of them is analog, the other is digital. From the first output, you can find out how wet the soil is, and from the digital output, you can get information about passing a certain saturation threshold. The module has a potentiometer for setting this limit.

3.2. Sensor ultraviolet (UV) radiation is shown in Fig. 2. the Gy-8511 Module is assembled on the ML8511 chip. The UV sensor has an analog signal output. UV Sensor is designed to detect the intensity of ultraviolet radiation. The principle of its operation: the value of the output voltage is higher, the stronger the intensity of UV radiation, directly proportional to the current passing through the built-in UV led. The Gy-8511 sensor is able to work with UV radiation in the range of: 1) UV-A from 315 to 400 nm and 2) UV - B from 280 nm to 315 nm.

A photoresistor is used as a light sensor.

4. Silicone led light strip is shown in Fig. 3. Sealed led strip is designed for illumination in areas with high humidity and dust. The degree of protection of led strips ip54 (ip64) and ip65 allows the led sealed tape to work without problems and

for a long time in conditions of high dust and moisture. This tape in this article will be used as additional lighting for the system.

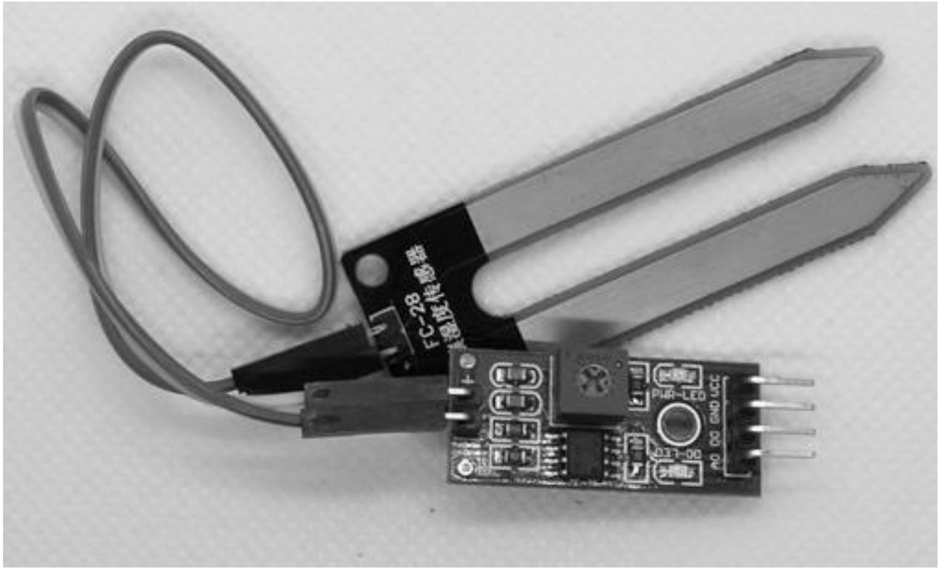


Fig. 1. The Soil Moisture Sensor FC-28

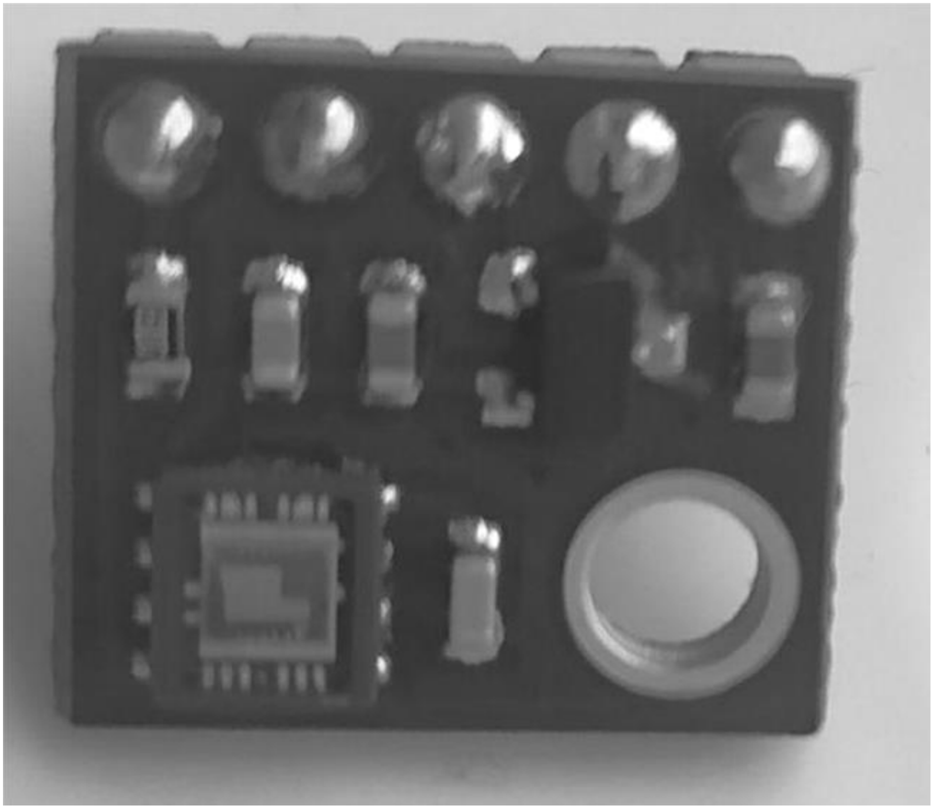


Fig.2. UV Radiation Sensor GY-8511

5. Submersible pump. In this project, the QR30E submersible water pump was used as a mechanism (see figure 4). This choice is due to the fact that this pump has the best quality for its price. The pump is easy to use and suitable for home use. The height of the water rise can be from 0.4 meters to 1.5 meters.

Based on the described sensors, climate parameters of the environment and executive mechanisms, a block diagram of a Smart system for life support and monitoring of indoor plants has been developed, which is shown in Fig. 5.

Fig. 3. Silicone Led Strip

Fig. 4. QR30E Pump

Currently, there are the following types of smart home systems: wired, wireless, centralized, decentralized, open protocol, closed protocol.

In this article, the smart system is managed using wireless information transfer technologies.

Wireless technologies are a subclass of information technologies that serve to transfer information between two or more points at a distance, without requiring a wired connection. Radio waves, as well as infrared, optical, or laser radiation can be used to transmit information.

GPRS is similar to the Internet: data is divided into packets and sent to the recipient, where it is collected. When setting up a session, each device is assigned a unique address, which essentially turns it into a server. The GPRS Protocol is transparent for TCP/IP, so the integration of GPRS with the Internet is invisible to the end user. Packets can be in the IP or X.25 format, and it does not matter which protocols are used over IP, so you can use any standard transport and application layer protocols used on the Internet (TCP, UDP, HTTP, HTTPS, SSL, POP3, XMPP, etc.).

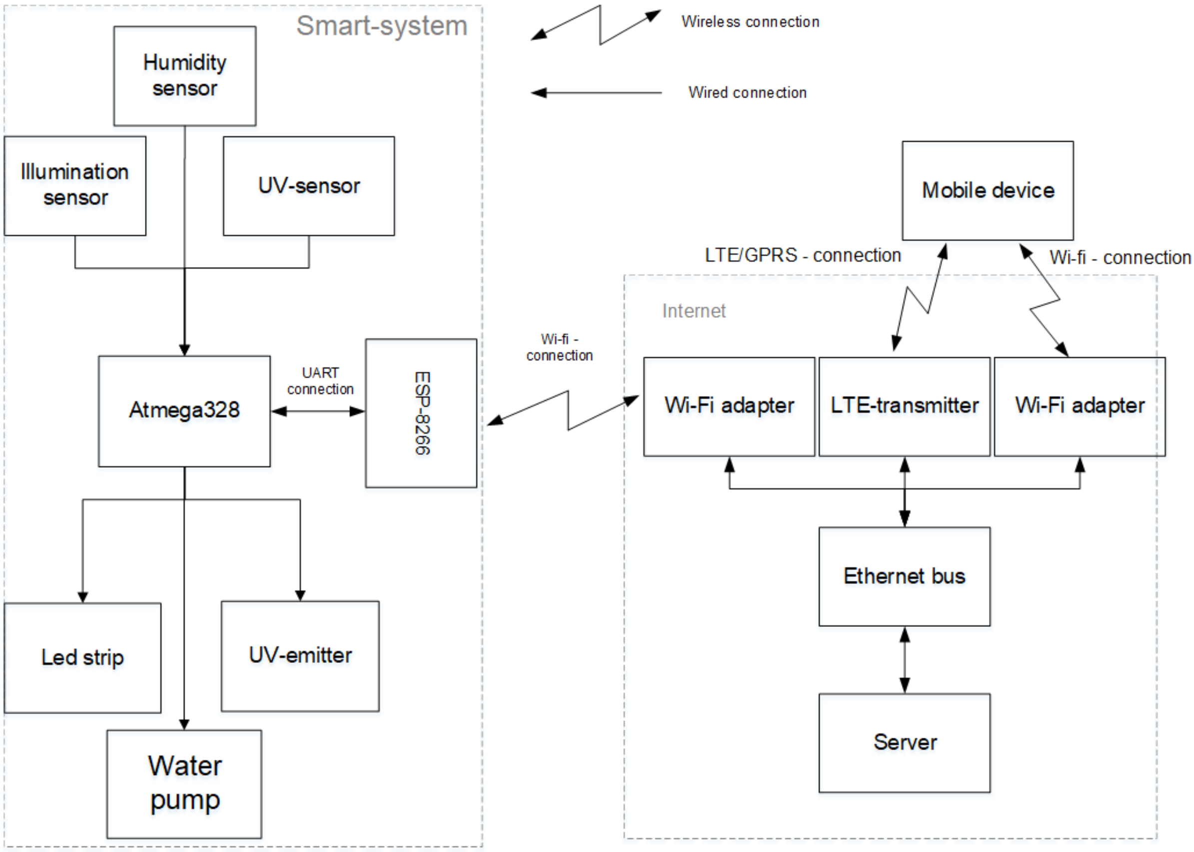


Рис. 5 – Block diagram of Smart life support and monitoring system for indoor plants

The Smart system serves as a smart plant life support system. According to the purpose of the smart system, its appearance was modeled. The hardware implementation of the smart system was modeled in the SCADA Trace Mode program. The simulation result is shown in Fig. 6.

Consider the symbol in the figure:

1 – water tank;
2 – Atmega328 microcontroller;
3 – submersible pump;
4 – water supply tube;
5 – light sensor;
6 – reservoir with soil;
7 – humidity sensor;
8 – UV radiation sensor;
9 – tube output;
10 – UV emitter;
11 – lighting.

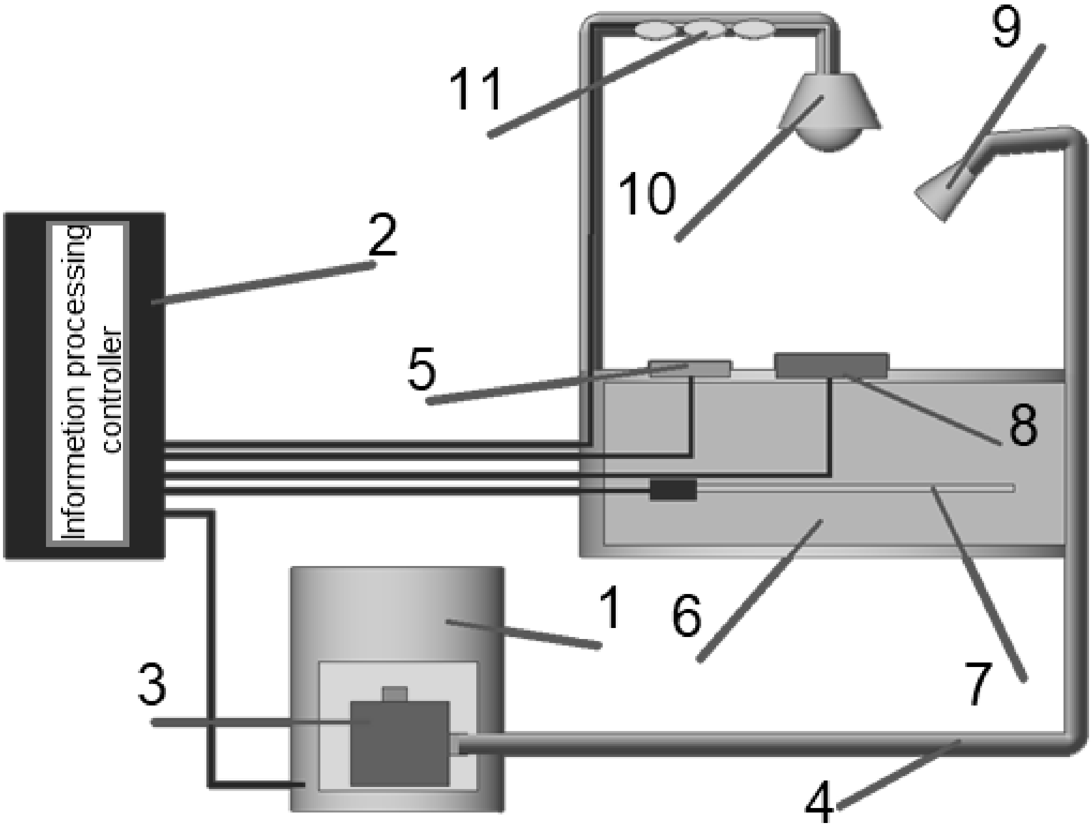


Fig. 6 – Smart system model

The controller (2) receives a signal from the sensors of normal (5) and ultraviolet (8) lighting. If the coefficients are not satisfactory, the controller sends a signal to turn on the lighting (11 – if there is no lighting, 10 – if there is no UV lighting). The controller also receives a signal from the humidity sensor (7), which checks the soil moisture in the tank (6). If this sensor receives a coefficient that does not meet the norm, then the controller sends a signal to the pump (3), which is submerged in the water tank (1). Then a portion of water is passed through the pipe (4) to the funnel (9).

As part of the work, an electrical circuit diagram was developed, shown in Figure 7.

The electrical circuit diagram shows:

- communication between microcontrollers using UART;
- power conversion for Atmega328 from 12V to 5V;
- power conversion for ESP8266 from 5V to 3.3 V;
- connection of sensors and executing mechanisms.

The diagram has the following designations:

R1, R2 – resistor 1 kOm;

R3 – resistor 2 kOm;

R4, R5, R6, R7, R8, R9 – resistor 10 kOhm;

R10, R11, R12 – resistor 220 Om;

X1 – bus for connecting sensors;

X2 – bus for connecting the DA2 circuit;

S1, S2, S3, S4 – key;

VT1, VT2, VT3 – transistor IRL3705;

VD1 – diode;
C1, C2 – 22 μF capacitor;
C3, C4 – 22 pF capacitor;
DA1 – linear voltage regulator;
DA2 – induction voltage regulator;
DD1 – Atmega328 microcontroller;
DD2 – ESP8266 microcontroller.

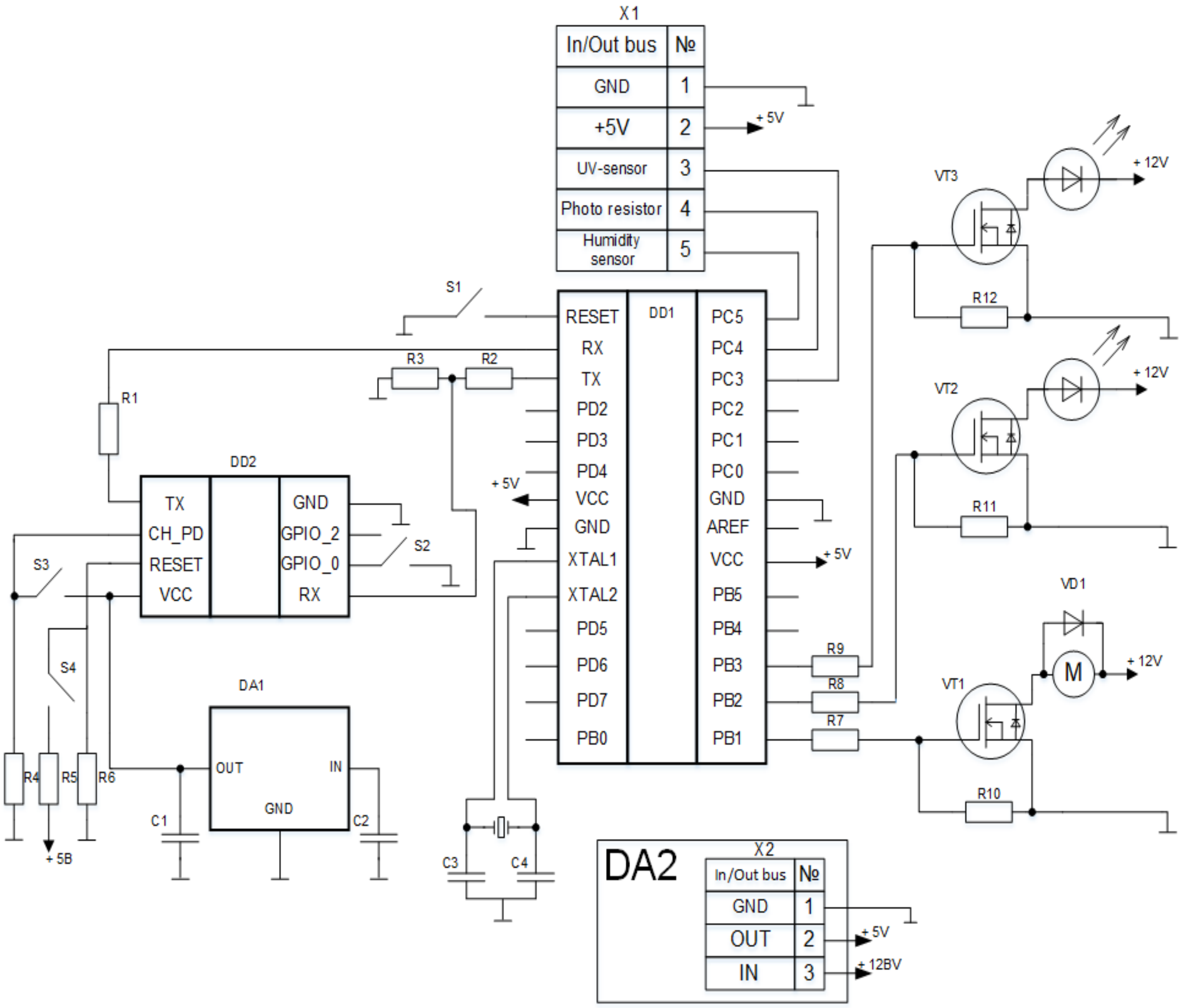


Fig. 7 – Electrical schematic diagram of the Smart system

The soil enclosure was designed and drawn in the Solidworks 2019 program (Fig. 8). The case includes:

- the hole for the watering tube;
- the hole for the soil moisture sensor;
- the holes for the light sensors;
- water tank;
- reservoir for soil.

The hull was printed on a 3D printer (see Fig. 9).

As a result of the preparatory procedures, the control board shown in Fig. 10 was created.

Obtained in the result of the work of the Board has certain characteristics:

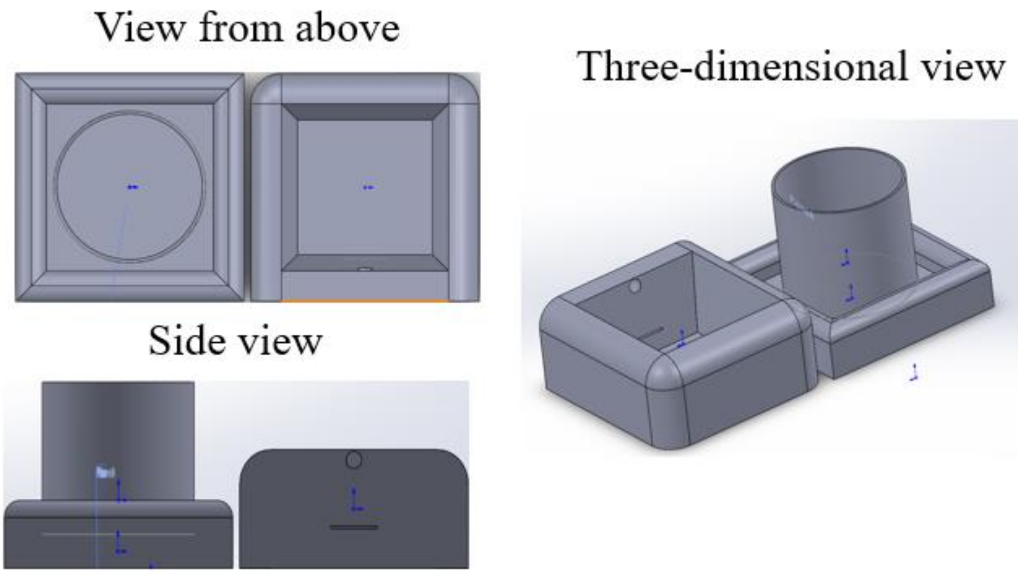


Fig. 8. Drawing of the Hull

Fig. 9. The Hull

- it is allowed to flash controllers on the Board;
- thanks to the inductive voltage stabilizer, the available voltage conversion from 12 V to 5 V (5 V is required for Atmega328);
- a linear voltage stabilizer mounted to the Board converts the voltage from 5 V to 3.3 V (3.3 V is required for ESP8266);

- available connection and control of the pump, led strip and other means that require a voltage of 12 V.

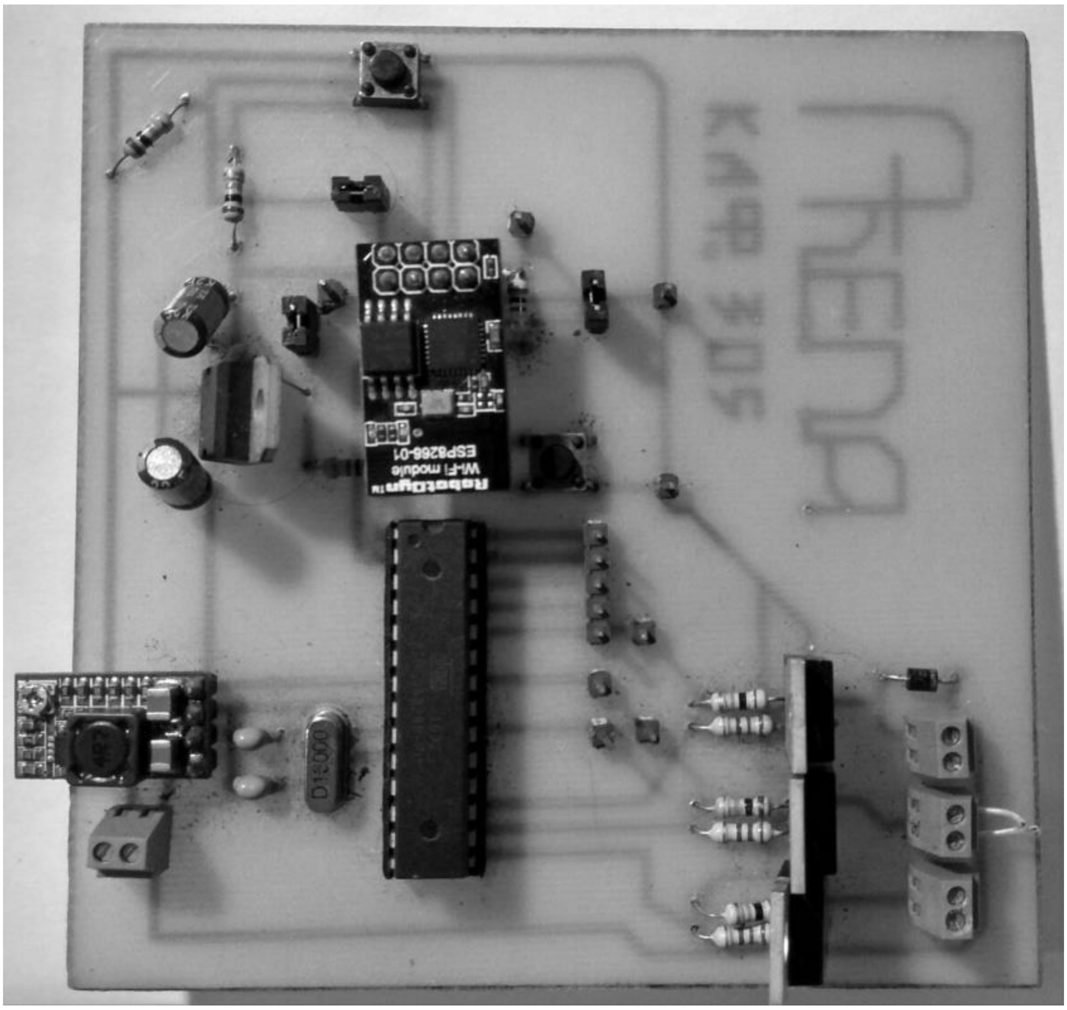


Fig. 10. The Control Board

2 Creating smart system software modules

An algorithms for processing data received from sensors was developed. The algorithm is shown in Fig. 11.

Software modules include firmware for ESP-8266 and Atmega328 microcontrollers. To get data from the server, use the JSON packet transfer library. In the Arduino Ide (the environment where the firmware for ESP8266 and Atmega328 will be registered), there is a corresponding library for this purpose called "Arduino JSON by Benoit Blanchon". The "ESP8266HTTPClient" library is used for transmitting data using Get requests.

To connect the microcontroller to a Wi-Fi adapter, use the "ESP8266Wifi" library, which has a set of methods that search for adapters specified by the user.

The Atmega328 microcontroller acts as a control microcontroller that receives data from sensors and gives commands to the executing mechanisms. This firmware consists of the setup and loop methods. The setup method initializes the inputs and outputs. The loop method retrieves data, manages executing mechanisms, and sends data to ESP8266.

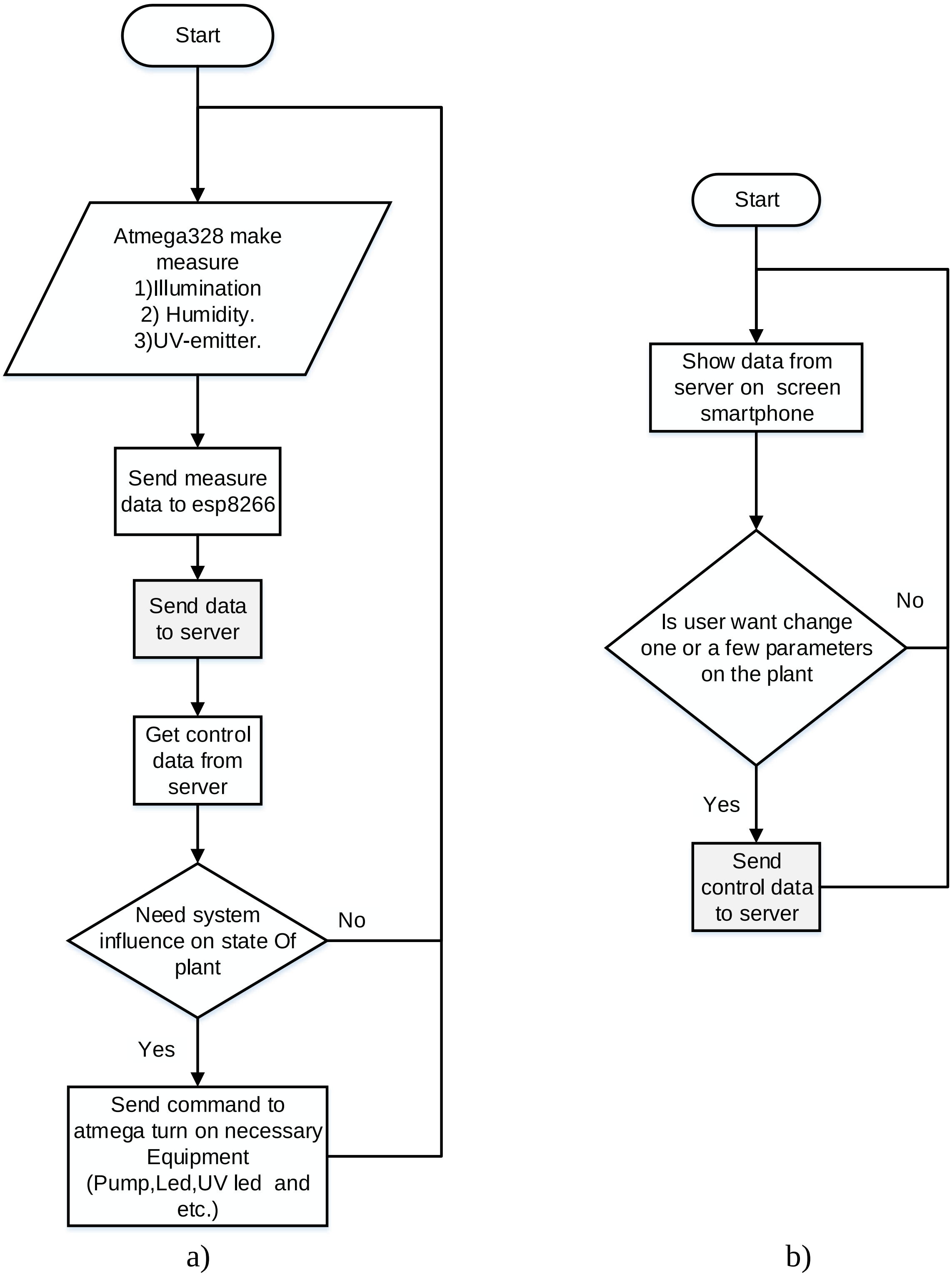


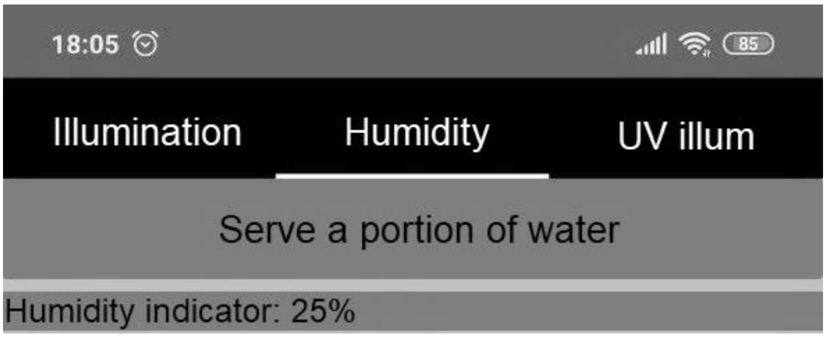
Fig. 11. The algorithms of operation of smart system software modules:
a) the program algorithm for control unit;
b) the mobile app algorithm

2.1 Creating a mobile app

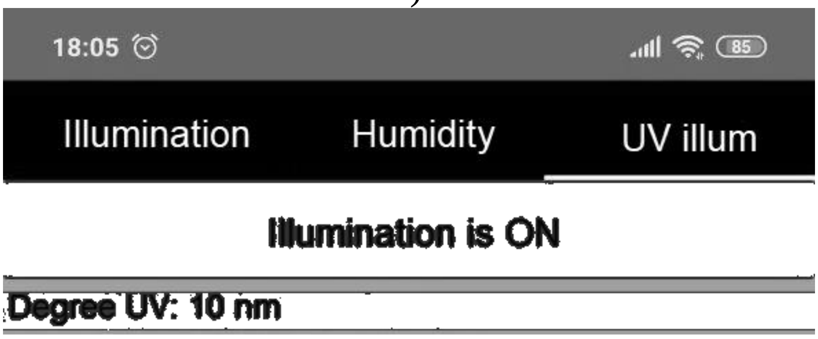
The mobile application in this project acts as a monitoring tool and a remote control for the Smart system. The main functionality that the application should have is to read parameters from the server in real time and allow the user to send their management commands to the same server.

In this article, Android is considered as the main platform for developing a mobile app. The mobile app was created using the C # programming language and technology. NET Framework Xamarin.Forms.

The mobile app interface is represented by three tabs. Pages have been developed for each indicator: lighting, humidity, and UV radiation (see fig. 12). This text field is used for viewing data from the server.



a)



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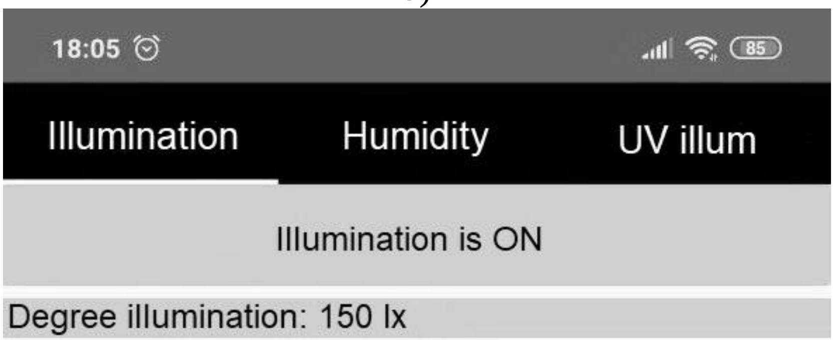

c)

Fig. 12. Functionality of mobile app tabs:
a) humidity tab; b) UV lighting tab; c) lighting tab

The presented graphical interface was written using XAML code.

For the interface to function, the ServerRequest class was created, the implementation of Which is associated with requests to the server.

The ServerRequest class consists of the following methods:

Hum_on-method-procedure that sends a Get request to the server with the changed value of the plant watering command. The implementation of the method is shown below:

```
public static void Hum_on() {
var json = new WebClient().DownloadString("http://desp.zzz.com.ua");
Resp r = JsonConvert.DeserializeObject<Resp>(json);
string l = Convert.ToString(r.light);
string ul = Convert.ToString(r.ulight);
string str;
using (StreamReader strr =
 new StreamReader(HttpWebRequest.Create(@"http://desp.zzz.com.ua/?" + CSS() + "&param_h=1" + "&param_l=" + l + "&param_ul=" + ul).GetResponse().GetResponseStream()))
str = strr.ReadToEnd();}
```

UltLightOn_Off – method-procedure for enabling and disabling UV lighting.

LightOn_Off – method-procedure for turning on and off the main lighting.

CSS – method that is used to fill in Get requests in the Hum_on, UltLightOn_Off, and LightOn_Off methods. This architecture was created because the Get request must be filled with all the parameters in the correct sequence. This method reads the unchanged parameters from the server, after which the above methods access the CSS method in order to fill in the Get request data before the main parameter being changed is written.

CS – method that reads the lighting parameter from the server. After that, the read parameter will be written in the field on the "lighting" tab.

CS2 – method is similar to the CS method, which reads the humidity parameter.

CS3 – method is similar to the CS and CS2 methods, which reads the UV parameter.

SizeStateLight – method reads data about the state (enabled/excluded) of lighting.

SizeStateUltLight – method reads data about the state (enabled/disabled) of UV lighting. In order to interact with the server, two namespaces were used: System. Web (for sending Get requests) and Newtonsoft.Json (for getting data from the server). To enable Newtonsoft.JSON to the visual studio project, enter the following in the package Manager console: install-package Newtonsoft.Json.

In addition to the ServerRequest class, the Hmm, Ilum, and UltFiolet classes were also written, which link tabs to the ServerRequest class.

All the classes listed above represent the basic logic of the mobile app. They are linked to the page interfaces. In General, classes are intended for receiving information, processing it, and sending information to the server.

Conclusions

Internet of Things closely connects various types of devices and mobile communications. Therefore, IoT is constantly used to create intelligent monitoring systems. The Internet of Things has been integrated in various applications such as smart homes and smart cities. IoT in agriculture such as in monitoring indoor climatic conditions can help to improve the plant growth. [4]

In this article, we have studied the existing automation systems for watering indoor plants. Based on the results obtained, the need to create an automated system of life support and monitoring of indoor plants was determined.

The article offers a block diagram of the created automated system. The life support of plants is realized through the possibility of watering and providing illumination, as well as ultraviolet lighting of plants. The development of the smart system involved the creation of a mobile application that acts as a remote control for the plant life support system.

In addition to the structural and basic electrical diagrams, a model of hardware implementation of the smart system is proposed, which takes into account the design requirements for the life support system.

The Smart system includes two microcontrollers: Atmega328 and ESP8266. The task of the smart system is to read indicators from sensors and send this data to the server. The Smart system receives commands for the execution mechanisms from the server.

The mobile app, in turn, receives indicators for the server. The user can send commands to the Smart system via the server. Thus, monitoring and automated management of plant life support is implemented.

The information was transmitted using the following communication technologies:

UART – for communication between controllers;

Wi-Fi – for communication between the Smart system and the adapter, and for communication between the mobile app and the server (this is how WiMAX is used);

Ethernet – for accessing the server.

The mobile app was written using Xamarin.Forms in the C# programming language for a mobile device running on the Android operating system.

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Розроблення Smart-системи життєзабезпечення і моніторингу кімнатних рослин

Під роботизованною системою розуміється мікроконтролер з набором датчиків, які реєструють зовнішні зміни (рівень вологості, освітлення, температури і т. ін.), модуль обміну даними, та виконуючий механізм, який починає діяти, коли користувач відправляє команду на мікроконтролер з Android-пристрою. Створення роботизованих систем є однією з основних завдань автоматизації промисловості, яка тісно зв’язана з технологією IoT (Internet of Things). Варіацій розробки роботизованих систем в синергії з IoT велика кількість: «Smart Home», безпілотний автомобіль, робот-прибиральник і т. ін. У більшості випадків «розумний будинок» це система домашньої автоматизації – система, яка допомагає заощадити часові ресурси на управління всіма іншими інженерними та розважальними пристроями. І чим більше пристроїв, тим потрібніше використання систем автоматизації. Для великої кількість IoT-систем в якості пристрою управління часто використовується мобільний телефон або планшет на базі операційної системи Android або iOS. Цей факт зумовлений мобільністю в управлінні і моніторингу повідомлень через кишеньковий пристрій. Метою даної статті є розроблення Smart-системи життєзабеспечення та моніторингу стану кімнатних рослин.

Розроблювальна Smart-система передбачає створення не тільки системи життєзабезпечення рослини, а й створення мобільного додатку для управління та моніторингу життєзабезпечення рослин. У ході написання статті були досліджені існуючі системи автоматизованого управління та побудована структурна схема Smart-системи з урахуванням її взаємодії з мобільним додатком. У статті була використана децентралізована система автоматизації у якій в ролі головних елементів виступають мікроконтролер ESP8266 (в якості передавача) та мікроконтролер Atmega328 (в якості елементу обробки даних). Також розроблено додаток для мобільного пристрою, який виступає у ролі пульту управління. В рамках статті розроблена електрична принципова схема Smart-системи. Також в статті представленні докладні інструкції та рекомендації як апаратної, так і програмної частин.

Ключові слова: кімнатні рослини, моніторинг, smart house, мобільний додаток, датчики, мікроконтролер, Інтернет речей.

Разработка Smart-системы жизнеобеспечения и мониторинга комнатных растений

Под роботизированной системой понимается микроконтроллер с набором датчиков, регистрирующих внешние изменения (уровень влажности, освещения, температуры и т. д.), модуль обмена данными, и исполняющий механизм, который начинает действовать, когда пользователь отправляет команду на микроконтроллер с Android-устройства. Создание роботизированных систем является одной из основных задач автоматизации промышленности, которая тесно связана с технологией IoT (Internet of Things). Вариаций разработки роботизированных систем в синергии с IoT большое количество: «Smart Home», беспилотный автомобиль, робот-уборщик и т. др. В большинстве случаев «умный дом» это система домашней автоматизации – система, которая помогает сэкономить временные ресурсы на управление всеми другими инженерными и развлекательными устройствами. И чем больше устройств, тем нужнее использования систем автоматизации. Для большого количество Ивт-систем в качестве устройства управления часто используется мобильный телефон или планшет на базе операционной системы Android или iOS. Этот факт обусловлен мобильностью в управлении и мониторинга сообщений через кпк. Целью данной статьи является разработка Smart – системы жизнеобеспечения и мониторинга состояния комнатных растений.

Разрабатываемая Smart-система предусматривает создание не только системы жизнеобеспечения растения, но и создание мобильного приложения для управления и мониторинга жизнеобеспечения растений. В ходе написания статьи были исследованы существующие системы автоматизированного управления и построена структурная схема Smart-системы с учетом ее взаимодействия с мобильным приложением. В статье была использована децентрализованная система автоматизации в которой в качестве главных элементов выступают микроконтроллер ESP8266 (в качестве передатчика) и микроконтроллер Atmega328 (в качестве элемента обработки данных). Также разработано приложение для мобильного устройства, который выступает в роли пульта управления. В рамках статьи разработана электрическая принципиальная схема Smart-системы. Также в статье представлены подробные инструкции и рекомендации как аппаратной, так и программной частей.

Ключевые слова: комнатные растения, мониторинг, smart house, мобильное приложение, датчики, микроконтроллер, Интернет вещей.

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