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Automated Control System of Greenhouses

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Abstract **– To control the microclimate in the greenhouse it is suggested to use a programmable controller. Aprobation of the proposed solutions has been chosen to become with a programmable controller ARDUINO MEGA 2560. The automatic control system has been tested on a greenhouse laboratory model.**

To control the microclimate in the greenhouse sensors and actuators are offered. A greenhouse software product has been developed for the selected programmable controller. The automatic control system is tested on a greenhouse laboratory model.

Keywords **– Control, Automation, Programmable Logic Controller, Microcontroller, Greenhouse.**

I. Introduction

Greenhouse production in Bulgaria is constantly growing. In cultivating plants in cultivation facilities, the management of the process of vegetation requires reliable control of temperature, humidity, ventilation, illumination and other factors. One of the main components that increase the productivity of the plants grown in the greenhouses is the maintenance of an optimal microclimate in them. Optimizing the conditions in the greenhouses is a prerequisite for increasing the yield of the facilities used. Moreover, the efficient and economical use of energy resources provides an additional opportunity to reduce production costs.

The main parameters to be maintained in the greenhouse are temperature and humidity. The need to change them at different times of the day and keep them within certain limits requires more precise control and management.

In some places in Bulgaria and especially for smaller cultivation facilities, climate control is done manually.

As this indicator, heating air in the greenhouse uses hot water produced in boiler stations. As a fuel they use mainly natural gas, but there are also cases of fuel oil and solid fuel.

Normally medium and large greenhouses are built on several plots with different areas for greater mobility. This requires the temperature to be measured and adjusted for each section. Beyond the subject of this article, the need to measure it at several points can also be commented and the management of each section is performed at the average value.

Major problems in developing and implementing such a system are high humidity and long distances.

For many years, various automated systems have been introduced in this industry for this purpose. It is estimated that about 20% are reduced energy costs for an industrial greenhouse from its use. An opportunity to solve this problem with Bulgarian low cost automation is described in [2].

II. Main Factors Determining the Microclimate in Industrial Greenhouses

The microclimate in an industrial greenhouse is mainly determined by temperature, humidity, ventilation, lighting and other factors.

A. Temperature

Maintaining a suitable temperature in the greenhouse is a major factor for the proper vegetation of plants and the good fertility, i.e. achieving high results [6, 7]. This is done by choosing a suitable heating system. In order to stabilize (maintain) the desired temperature in the greenhouse (Θ_{opaH}) today, integrated solutions are implemented that combine natural and energy-efficient solutions with different methods of artificially supporting heating. Water heating with boilers for gas, liquid and less solid fuel is most often used.

B. Humidity

The plants in the greenhouse transpirate large amounts of water, which leads to an increase in the humidity of the air in it [6]. High humidity (80-85 %) is unfavorable and should be avoided. Stabilization is achieved by appropriate ventilation, evaporative or fogging cooling systems, etc.

C. Ventilation

In the absence of an adequate ventilation, the plants grown in the greenhouse become susceptible to various diseases. That's why it's one of the most important aspects of the microclimate, providing clean air, unifying the temperature and the humidity field in the greenhouse.

D. Illumination

The use of an artificial lighting in the production of greenhouses leads to an increase in the productivity of plants.

III. Control of Microclimate in a Greenhouse

It is not possible an industrial greenhouse to operate without a reliable automatic control system (ACS). The main parameter which has to be stabilized is Θ_{opaH}. A major problem with the development of such a ACS is high humidity and long distances. At [2] a remote ACS of the temperature regime was designed and implemented in an industrial greenhouse divided into three sections. A modern microprocessor technology and a personal computer for reading, display and archiving were used. The same system can also be used for thermal disinfection of the soil in the greenhouse by solariuming [1].

However, when the purpose of the ACS is to manage the microclimate in the greenhouse and maintain it at optimal levels for the particular crops of the greenhouse, besides Θ_{opaH}, the other major factors should be stabilized or changed with a programme - humidity, ventilation, lighting and more. Using local automation for the aid, in our opinion, is not a rational solution. A much more effective proposal is to use a programmable controller.

Purpose of the work: The purpose of the work is to develop ACS of the microclimate in a greenhouse based on a programmable controller.

IV. Programmable Microcontroller Arduino

The programmable microcontroller ARDUINO is compact, large-capacity and open code [5]. It uses powerful AT MEGA microcontroller. Its development started in 2005. ARDUINO consists of an 8-bit Atmel AVR microcontroller with complementary components that facilitate programming and integration into other circuits. An important aspect of the ARDUINO platform is the availability of standard connectors that allow users to connect the CPU board to a wide range of different interchangeable peripheral modules (PMs). Some PMs communicate with ARDUINO directly via different pin ports. Thanks to the I^{2}C split, several PMs can be attached and used in parallel. The ARDUINO microcontroller is equipped with a bootloader that simplifies the program's upload to the flash drive of the device. This makes using ARDUINO considerably simpler by allowing computer programming. At the conceptual level, using the ARDUINO software stack, all boards are programmed using the RS 232 serial port, but the way it is executed varies according to the hardware features of the device.

The appearance of a board ARDUINO MEGA 2560 is shown in Fig. 1.

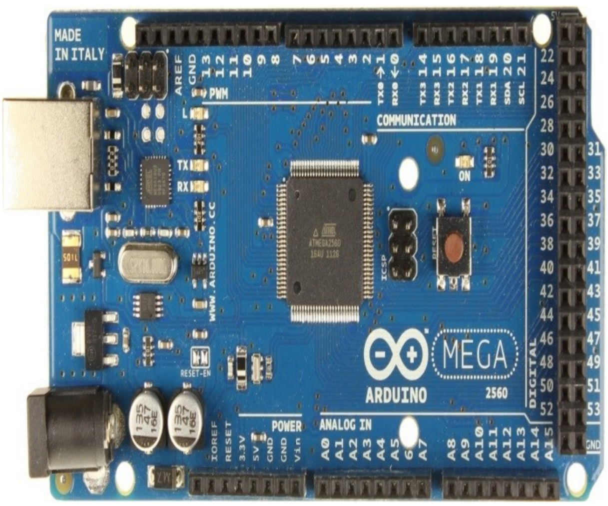


Fig.1. The appearance of the board type ARDUINO MEGA 2560

It is created for cases requiring a greater number of inputs and outputs and greater processor power. ARDUINO MEGA 2560 is a microcontroller development board with AT 2560 MEGA AVR microcontroller. There are 54 digital input / output (I/O) ports, 16 analog inputs, 4 UARTs ports (hardware serial ports), 16 MHz resonators, four LEDs (one user's), etc.

V. Development of a Microprocessor System for Control of the Microclimate in a Greenhouse Laboratory Model Based on a Programmable Controller Arduino Mega 2560

The hardware part of the development includes the choice of a programmable microcontroller, but also the choice of suitable sensors and mechanisms of performance.

For measurement $\Theta_{opaн}$ and the humidity in the laboratory model, the DHT family sensor is selected. It contains two sensors - a temperature thermistor and a capacitive humidity sensor. It is equipped with a chip to convert the analogue signal to digital. For the DHT 22 sensor, the temperature is measured in the range -40 ÷ 125 ˚C with an accuracy ± 0.5 ˚C and the humidity in the range 0-100 % with an accuracy of 2 – 5 %. To determine the humidity in the soil, a LM 393 conductive sensor was selected. LDR photoresistor was selected to measure the luminance in the laboratory greenhouse. A module of 4 relays operating at 5 V and switching voltages of 250 V and 10 A is selected for actuators. Two 200 W LED lamps are used for lighting. For industrial irrigation a 4SUM100 submersible pump is available and a fog fan is used for cooling.

VI. Development of a Program Product for Control of Microclimate in a Greenhouse Laboratory Model Based on a Programmable Microcontroller Arduino Mega 2560

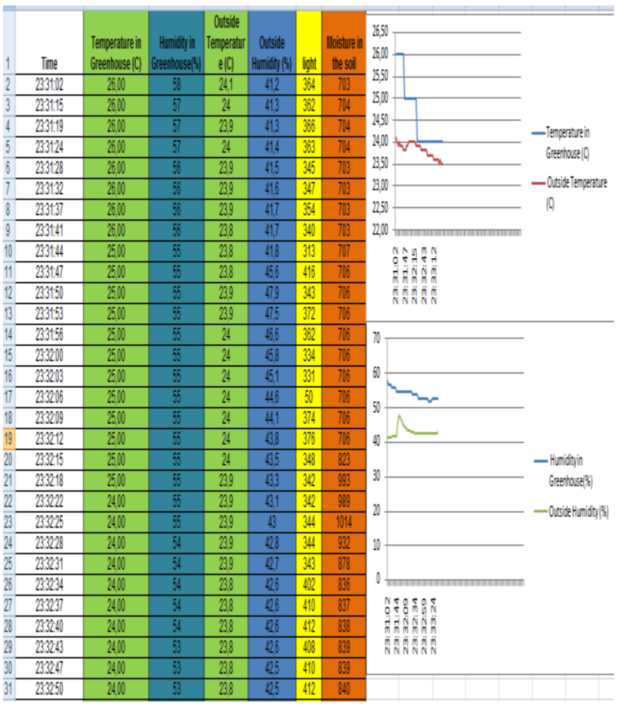
Program products for the ARDUINO MEGA 2560 programmable microcontrollers use a special programming environment based on the Processing language. The code is translated to C and is passed to the avr-gcc compiler (open code software that makes the translation understandable for the microcontroller). The microclimate control program in a laboratory greenhouse model based on the ARDUINO MEGA 2560 microcontroller program is as follows:

```
#include "DHT.h" // Library Sensor DHT
#include <Servo.h> // Servo Library
#include <LiquidCrystal.h>
#define RELAY1 4 // Relay Channel On irrigation
#define RELAY2 5 // Relay Channel On heating
#define RELAY3 6 // Relay Channel On cooling
#define RELAY4 7 // Relay Channel On. Lighting
#define LED1 9 // LED Lighting On
#define LED11 31 // LED Lighting Off
#define LED2 32 // LED irrigation On
#define LED22 33 // LED irrigation Off
#define LED3 34 // LED Heating On
#define LED33 35 // LED Heating Off
#define LED4 36 // LED Cooling On.
#define LED44 37 // LED Cooling Off
#define DHT1PIN 2 // Temperature and humidity sensor in the greenhouse (DHT11)
```

```
#define DHT2PIN 3 // Outdoor temperature and humidity sensor (DHT22)
-------------------------------------------------------------------
-------------------------------------------------------------------
-------------------------------------------------------------------
float h1 = dht1.readHumidity (); // Humidity in the greenhouse
float t1 = dht1.readTemperature (); Temperature in the greenhouse
float h2 = dht2.readHumidity (); // Humidity outside the greenhouse
float t2 = dht2.readTemperature (); // Temperature outside the greenhouse

if (isnan (t1) || isnan (h1)) {
Serial.println ("Failed to read from DHT # 1");
} else {
-------------------------------------------------------------------
-------------------------------------------------------------------
-------------------------------------------------------------------
Serial.print ("DATA, TIME,"); // Monitoring for Excel
Serial.print (t1); Serial.print (";"); Serial.print (h1);
Serial.print (";");
Serial.print (t2); Serial.print (";"); Serial.print (h2);
Serial.print (";");
Serial.print (analogRead (sensePin)); Serial.print (";"); Serial.print (analogRead (A0));
}
Serial.println (); }
```

A personal computer was used to monitor the basic parameters in tabular and graphical form. A printout of the variation of the main factors forming the microclimate in the laboratory model of the greenhouse and the graphs built on these data is shown in Fig. 2.



1	Time	Temperature in Greenhouse (C)	Humidity in Greenhouse(%)	Outside Temperature (C)	Outside Humidity (%)	light	Moisture in the soil
2	23:31:02	26,00	58	24,1	41,2	364	703
3	23:31:15	26,00	57	24	41,3	362	704
4	23:31:19	26,00	57	23,9	41,3	366	704
5	23:31:24	26,00	57	24	41,4	363	704
6	23:31:28	26,00	56	23,9	41,5	345	703
7	23:31:32	26,00	56	23,9	41,6	347	703
8	23:31:37	26,00	56	23,9	41,7	354	703
9	23:31:41	26,00	56	23,8	41,7	340	703
10	23:31:44	25,00	55	23,8	41,8	313	707
11	23:31:47	25,00	55	23,8	45,6	416	706
12	23:31:50	25,00	55	23,9	47,9	343	706
13	23:31:53	25,00	55	23,9	47,5	372	706
14	23:31:56	25,00	55	24	46,6	362	706
15	23:32:00	25,00	55	24	45,8	334	706
16	23:32:03	25,00	55	24	45,1	331	706
17	23:32:06	25,00	55	24	44,6	50	706
18	23:32:09	25,00	55	24	44,1	374	706
19	23:32:12	25,00	55	24	43,8	376	706
20	23:32:15	25,00	55	24	43,5	348	823
21	23:32:18	25,00	55	23,9	43,3	342	993
22	23:32:22	24,00	55	23,9	43,1	342	989
23	23:32:25	24,00	55	23,9	43	344	1014
24	23:32:28	24,00	54	23,9	42,8	344	932
25	23:32:31	24,00	54	23,9	42,7	343	878
26	23:32:34	24,00	54	23,8	42,6	402	836
27	23:32:37	24,00	54	23,8	42,6	410	837
28	23:32:40	24,00	54	23,8	42,6	412	838
29	23:32:43	24,00	53	23,8	42,6	408	839
30	23:32:47	24,00	53	23,8	42,5	410	839
31	23:32:50	24,00	53	23,8	42,5	412	840

Fig. 2. Printout of the change of the main factors forming the microclimate in the laboratory model of the greenhouse

VII. Conclusion

In the work is analyzed the main factors forming the microclimate in the greenhouse. Some aspects related to its control have been considered. The programmable microcontroller ARDUINO MEGA 2560 is described. Sensors and executive mechanisms for controlling the microclimate in a greenhouse laboratory model are proposed. A laboratory model of a greenhouse was constructed. A program product for its control has been developed for the selected programming controller. The system has been tested and showed good results and high reliability.

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