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AIR HEATING CONTROL SYSTEM BASED ON MICROCONTROLLER

This article discusses a technological solution developed on the basis of an Arduino-type microcontroller with automatic control of air heating in production.

Currently, microcontrollers have a large range (more than 10,000), which differ among themselves in terms of application, parameters and other properties. Dozens of manufacturers are engaged in the release of microcontrollers.

Increasing reliability, speed and functional saturation, as well as reducing the amount of modern computer technology and electricity consumed have led to its widespread use to control complex technological objects with a large number of physical quantities and controlled installations.

The result of this article will be the development of a block diagram, drawing up a schematic diagram of a control system, block diagrams, writing a program for a microcontroller, developing an operation algorithm and a set of elements that can be used in any production, production process (for example, drying systems, heating installations, etc.), where an air heating control system is deemed necessary. Also, the main conclusions, concepts of this research work can be used in production processes, household appliances and as a teaching aid.

Keywords: microcontroller, system, controls, air heating, Arduino.

Introduction

Due to the rapid development of microelectronics, the computing power of modern microcontrollers has increased significantly. This has led to lower prices for microcontrollers and the use of the proposed capabilities of microcontrollers in circuits that were previously economically unprofitable.

Microcontrollers are found in all spheres of human life, in all the devices that surround him. Easy connection and extensive work opportunities. With the help of programming microcontrollers, it is possible to solve practical problems of hardware technologies. All production processes that need to be cost-effective and safe require a management system. It is a programmable logic controller that has spread rapidly in recent years and radically change control methods, which, along with its effective price, adds computing power and considerable flexibility [1].

In the research work [1] describes the developed model of a universal thermostat on an ATmega8 microcontroller; the devices used and how to connect them to the microcontroller. The algorithm of the program operation in a special CodeVisionAVR environment has been developed. The article [2] describes the technology of preparing and debugging the Arduino IDE environment and the method of connecting Arduino to LabVIEW. The errors that occur during saving and exporting the project in the message area are shown and corrected; the program of work with the description of the front panel and the schematic diagram of the device. A program for finding coefficients for thermistors has been written. In the article [3] an experimental circuit for determining the gas content in the air and a control program were developed using an Arduino microcontroller.

Materials and methods

A microcontroller is an integrated system consisting of memory, processor and I/O ports. The microcontroller is programmed to perform a specific task. If it is necessary to change or supplement its activities, it is necessary to re-download the program to the chip [4].

The main purpose of the microcontroller is its use in automatic control systems, even in various structures (credit card, mobile phones, music centers, washing machine, alarm system, nuclear reactors, production processes, etc.). It is used from industrial automation to household appliances, from controlling nuclear power plants to children's toys, from secret military systems to replacing the channels of your radio receiver. It is easier to list those areas in which they are not used [5–7].

The widespread use of software-controlled machines and equipment in industry, thermal power engineering, transport medicine, communication industries, electronics and microelectronics creates the need for a microcontroller.

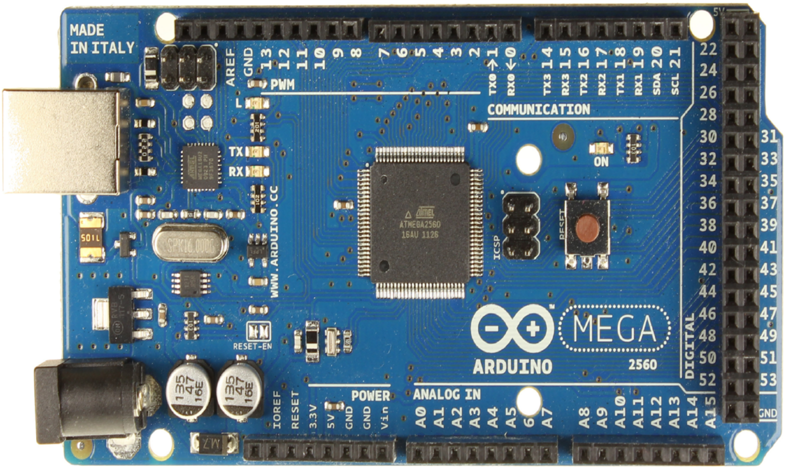

Figure 1 – Arduino Mega 2560 microcontroller

Microcontrollers differ from conventional computers in the following ways:

- all functions are located only in one small and convenient volume;
- programmed to perform a specific task;
- it is powered by energy in a smaller volume, since, depending on the physical parameters, the energy reserve is provided only in a smaller amount;
- it is efficient because it has a unidirectional I/O port and connects to peripheral devices [8–10].

Microcontroller design: core, registers, memory, cache, common I–O, timers, interrupt (stop), watchdog, peripherals, ordering capability.

The Arduino platform is used to simulate the air heating control system based on the Arduino Mega 2560 microcontroller.

Arduino is an electronic constructor and a convenient platform for quick preparation of electronic devices. The platform is known worldwide for the convenience and simplicity of its programming language, as well as its open architecture and code. The device is programmed via USB without the help of a programmer [11].

Arduino is built on the Mega Atmega2560 microcontroller. The board includes 54 digital inputs/outputs (14 of which can be combined as EIM outputs), 16 analog inputs, 4 UART serial ports, a 16 MHz quartz oscillator, a USB connector, a power connector, an ICSP connector and a reset button. To work, you must either connect the platform to a computer via a USB cable, or supply power via an AC/DC adapter or a battery. The Arduino Mega can get power by connecting it to USB, or via an external power supply. The power supply is removed automatically [12–13].

Results and discussions

General characteristics of the air heating control system project

Below is a diagram of an air heating control system assembled on a breadboard that operates via an Arduino Mega 2560 microcontroller.

1 – temperature of the output air flow D2, 2 – LED indicating the operating mode, 3 – field transistor, 4 – LED indicating compensation mode, 5 – input air flow temperature D1, 6 – Arduino Mega platform with Arduino Mega 2560 microcontroller, 7 – ventilator. The specification of the elements is presented in table 1.

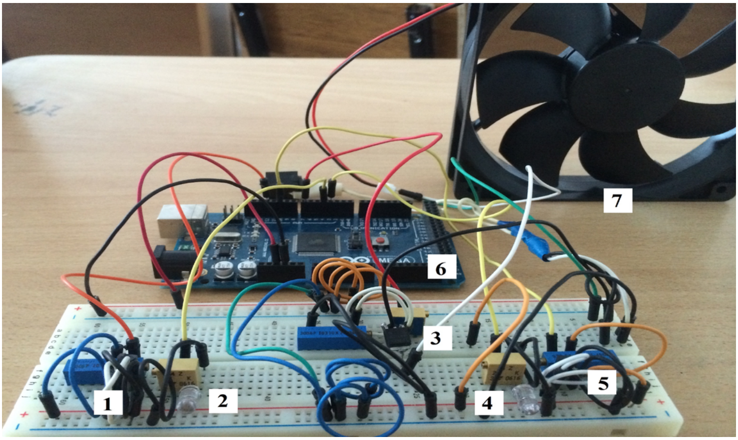

Figure 2 – Project diagram of the air heating control system

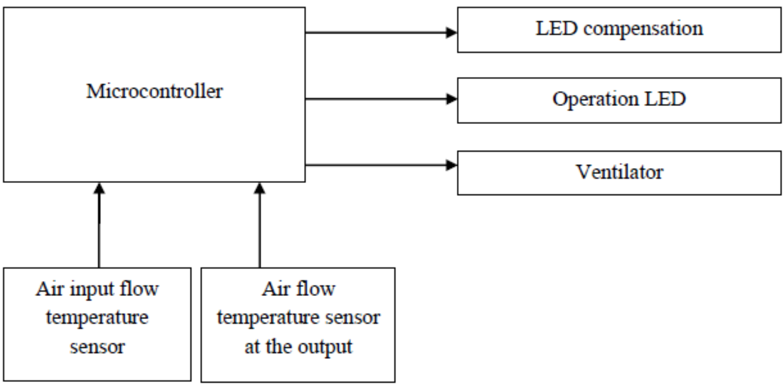

Figure 3 – Structural scheme of the air heating control system

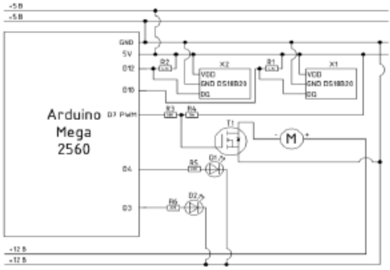

Figure 4 – Assigning scheme of the air heating control system

Table 1 – Specification of elements to a scheme

Designations	**Element**	**Note**
R1, R2	Resistor 4.7 kOhm	
X1	DS18B20 Temperature sensor	Air flow temperature sensor at the output
X1	DS18B20 Temperature sensor	Air flow temperature sensor at the input
R3	Resistor 500 Ohm	
R4	Resistor 10 kOhm	
T1	Field-effect transistor IRLR7843	
M	Ventilator motor	
R5, R6	Resistor 220 Ohm	
D1, D2	Light emitting diode (LED)	

Go to the input process of the Aruduino Mega 2560 microcontroller. The process of the Aruduino Mega 2560 microcontroller is performed in the Arduino programming environment.

- The program (sketch) is recorded on Arduino 1.6.9 (new version of Arduino, freely available on the Internet, free).

- The program (sew up) is introduced into the memory of the board, which ensures the exchange of information between the microcontroller and software by the COM port (Fig. 5).

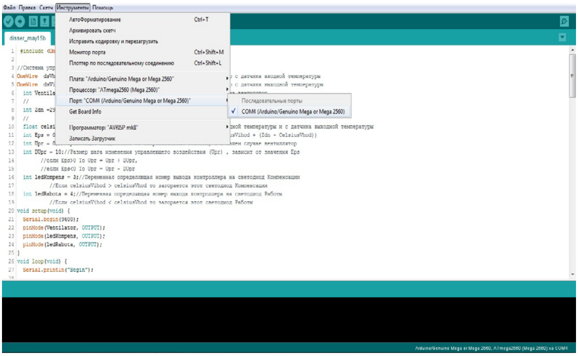

Figure 5 – COM port selection

The introduced sketch is checked and, after completing the compilation, press the download button. The interaction of a personal computer and MK can be seen by flashing LEDs RX and TX. You can try to open the monitor port to track temperature changes, that is, temperature sensors data.

The system works in the cycle (Fig. 6).

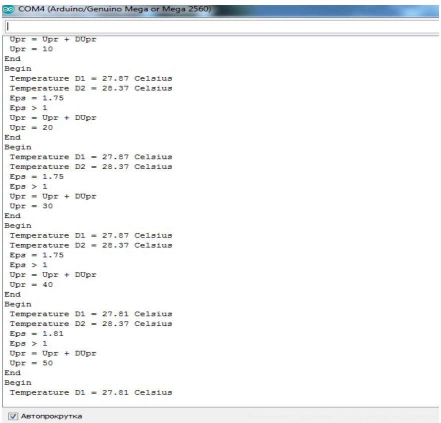

Figure 6 – Temperature change (port of the Arduino 1.6.9 monitor)

The code of the “Air heating control system” written in Arduino 1.6.9

// Air heating control system

OneWire dsVhod(10); // Variable defining the input number from the input temperature sensor to the controller

OneWire dsVihod(12);// Variable defining the input number from the output temperature sensor to the controller int Ventilator = 7;// A variable determining the exit number of the controller to the ventilator

//

int Zdn =25;// The task of the temperature that should be obtained as a result In this case, the task is 25 degrees Celsius

//

float celsiusVhod, celsiusVihod;// The temperature obtained from the input sensor of the temperature and the output temperature sensor

int Eps = 0;// This is how the mismatch signal is calculated

Eps = (Zdn - CelsiusVihod + (Zdn - CelsiusVhod))

int Upr = 0;// Control action on the heating element, in this case – on the fan

int DUpr = 10;// The step size of the control effect depends on the value Eps

// if Eps>0 then Upr = Upr + DUpr,

// if Eps<0 then Upr = Upr - DUpr

int ledKompens = 3;// A variable that determines the output number to the LED compensation of the controller

//If celsiusVhod > celsiusVihod then the compensation LED will light up

int ledRabota = 4;// Variable that determines the number of output to the working LED of the controller

//Если celsiusVihod >= celsiusVhod then the work LED lights up

2) Example from the window of the monitor port

Conducted action

Begin Begin

Temperature D1 = 23.50 Celsius The input temperature is measured

Temperature D2 = 23.00 Celsius The output temperature is measured

Eps = 1.50 Eps is calculated

Eps>0 The increase mode is displayed

or reduce the effect of control

Upr = 10 The control effect is calculated,

dependent on Eps value

End End

Begin

Temperature D1 = 23.50 Celsius

Temperature D2 = 23.00 Celsius

Eps= 1.50

Eps>0

Upr = 20 Calculating Eps

Upr started to rise

End

```
Begin
Temperature D1 = 23.50 Celsius
Temperature D2 = 23.00 Celsius
Eps= 1.50
Eps>0
Upr = 30            Calculating Eps
Upr started to rise
End
Begin
Temperature D1 = 23.50 Celsius
Temperature D2 = 23.00 Celsius
Eps= 1.50
Eps>0
Upr = 40            Calculating Eps
Upr started to rise
End
```

The program is built from blocks. The Begin and End blocks represent the beginning and end of the loop. The temperature of the input temperature sensor and the temperature of the output temperature sensor are also displayed. Then the *Eps* value is calculated

$$Eps = Zdn - D_2 + (Zdn - D_1) \quad (1)$$

Eps always tends to zero. Eps – D1 shows how much the temperature of the input air flow and D2 shows how the temperature of the output air flow corresponds to the task Zdn. The variable Eps changes depending on the value. Upr – variable, providing a fan speed from 0 to 250. Experimentally, the number of steps equal to 10 units was chosen. The permissible range of control actions is from 0 to 255. Since the step is equal to 10 units, the range of control actions is from 0 to 250, that is, 25 steps. If $Eps \prec 0$, then $Upr = Upr - DUpr$.

If $Eps \geq 1$, than control action on the Upr heating element increases. If $Eps \leq 1$, than Upr the control effect on the heating element is reduced. The more the ventilator rotates, the more the heating element heats up.

The LED acts as an indicator, that is, it shows in which mode the system is operating. There are two modes in this system: compensation and working.

If the temperature of the output airflow is greater than the temperature of the input airflow D2>D1, the LED will light up on it and the operating mode status will be displayed. If the temperature of the input air flow is greater than the temperature of the output air flow D1>D2, the LED will light up on it, indicating the operation of the compensation mode.

Conclusion

As a result of this work: an air heating control system has been assembled on a breadboard with a circuit. The proposed system is based on the Arduino Mega 2560 microcontroller. A block diagram of the air heating control system has been developed. Based on the block diagram, a microcontroller, temperature sensors, indicator LEDs and an actuator, that is, a fan, were selected. The basis is the Arduino Mega 2560 microcontroller and the DS18B20 temperature sensor.

In addition, a schematic diagram of the control system was drawn up. It reflects all the elements used and shows the principle of operation between them.

The recording of the program for the microcontroller began with the development of a block diagram of the operation of the air heating control system. After writing the code for the microcontroller, a circuit was assembled on the breadboard and its correctness was checked.

As a result, an algorithm of operation and a set of elements that can be used in any production, production process (for example, grain drying, heating system, air conditioning, etc.), where an air heating control system is considered necessary, are obtained.

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МИКРОКОНТРОЛЛЕРГЕ НЕГІЗДЕЛГЕН АУАНЫ ЖЫЛЫТУДЫ БАСҚАРУ ЖҮЙЕСІ

Мақалада өндірістегі ауаны жылытуды автоматты түрде реттейтін Arduino типті микроконтроллер негізінде жасалған технологиялық шешім қарастырылады.

Қазіргі уақытта микроконтроллерлерде қолдану аясы, параметрлері және басқа қасиеттері бойынша бір-бірінен ерекшеленетін үлкен номенклатура бар (10 000-нан астам). Микроконтроллерлерді шығарумен ондаған өндірушілер айналысады.

Сенімділіктің, жылдамдықтың және функционалдық қанықтылықтың жоғарылауы, сондай-ақ тұтынылатын заманауи есептеу техникасы мен электр энергиясының азаюы оның физикалық *шамалары мен басқарылатын қондырғылары көп күрделі технологиялық объектілерді басқару үшін кеңінен қолданылуына әкелді.*

Бұл мақаланың нәтижесі құрылымдық схеманы әзірлеу, басқару жүйесінің схемалық схемасын, блок-схеманы құру, микроконтроллерге арналған бағдарламаны жазу, жұмыс алгоритмін әзірлеу және кез-келген өндірісте, өндіріс процесінде қолдануға болатын элементтер жиынтығы болады (мысалы, кептіру жүйелері, жылыту қондырғылары және т.б.), мұнда ауаны жылытуды басқару жүйесі қажет деп саналады. Сонымен қатар, осы зерттеу жұмысының негізгі тұжырымдары мен тұжырымдамаларын өндірістік процестерде, тұрмыстық техникада және оқу құралы ретінде пайдалануға болады.

Кілтті сөздер: микроконтроллер, жүйе, басқару элементтері, ауаны жылыту, Arduino.

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СИСТЕМА УПРАВЛЕНИЯ НАГРЕВА ВОЗДУХА НА ОСНОВЕ МИКРОКОНТРОЛЛЕРА

В статье рассматривается технологическое решение, разработанное на базе микроконтроллера типа Arduino с автоматической регулировкой нагрева воздуха в производстве.

В настоящее время микроконтроллеры имеют большую номенклатуру (более 10 000), которая различается между собой по области применения, параметрам и другим свойствам. Выпуском микроконтроллеров занимаются десятки производителей.

Повышение надежности, скорости и функциональной насыщенности, а также уменьшение количества потребляемой современной вычислительной техники и электроэнергии привели к ее широкому использованию для управления сложными технологическими объектами с большим количеством физических величин и управляемых установок.

Результатом этой статьи будет разработка структурной схемы, составление принципиальной схемы системы управления, блок-схемы, запись программы для микроконтроллера, разработка алгоритма работы и набор элементов, которые можно использовать *в любом производстве, производственном процессе (например, сушильные системы, отопительные установки и т.д.), где система управления нагрева воздуха считается необходимой. Так же, основные выводы, концепции данной исследовательской работы могут быть использованы в производственных процессах, бытовой технике и в качестве учебного пособия.*

Ключевые слова: микроконтроллер, система, управления, нагрев воздуха, Arduino.

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