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Design Of Air Conditioning Control Equipment Using Arduino Microcontroller

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ABSTRACT
Indonesia is a developing country with many people working in the agricultural and small industry sectors. Therefore, it is necessary to develop technology in small industries in order to create various new innovations. One example is the development of digital device technology, such as microcontrollers. The use of microcontrollers can have a positive impact on work ease and efficiency. For example, the design of a room temperature control system can provide significant benefits in supporting efficient work activities in the medium-sized industrial and office sectors. This study proposes a simulation design of a temperature control system along with its implementation in the form of a prototype of a room temperature control system based on an Arduino microcontroller. This system is equipped with the ability to display room temperature via an LCD screen. The system design stages start from system architecture analysis, and temperature control system planning, to prototype creation. The result of this study is a prototype of a temperature control system with a temperature display feature on the LCD; if the room temperature exceeds the maximum limit, the cooler will be active, and conversely, the cooler will turn off if the temperature is below the minimum limit. This system uses several devices, including Arduino, temperature sensors, coolers, and LCD screens to display temperature.

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INTRODUCTION

The need for electricity in Indonesia continues to increase, triggered by high electricity consumption in buildings, industries, and factories. In addition, people's electricity usage is still wasteful, often without considering the power capacity (watts) of the electrical equipment used. This condition affects the office building sector, which mostly relies on electricity supplies from PLN. Building managers need to address this problem carefully to reduce energy consumption. One of the simplest ways is to implement an energy-saving program to maximize electricity usage.

Energy saving means using energy efficiently and rationally without reducing essential energy needs. If applied systematically in buildings and industries, these savings can significantly reduce electricity consumption. However, in practice, this effort still faces several obstacles. One of them is the control of electrical equipment in buildings that still use

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conventional methods, such as manual switches. For example, air conditioners in some buildings are still activated by remote control.

In buildings with many rooms, air conditioners often remain on outside of working hours, even until morning. This is due to the negligence of users and officers who have to check each cooling device in each room. This condition can cause electricity waste if it continues to repeat itself. Therefore, a more practical and efficient temperature control system is needed. This system can be set automatically using a temperature sensor that reads the room temperature, combined with microcontroller technology.

Several efforts and studies related to temperature control systems have been carried out, including research by Asrofi and Bambang Eka Purnama entitled "Design and Construction of an Automatic Computer Cooling Control Device Based on the ATMEGA8L Microcontroller". This research utilizes the ATMEGA8L microcontroller to replace the manual switch on the additional cooler (fan). This tool automatically controls the computer temperature and maintains temperature stability to ensure optimal hardware performance. This research uses main components such as a power supply circuit, minimum system, IC LM35 temperature sensor, and other devices, with the support of Code Visio Evaluation and AVR Studio software. The result is a prototype of an automatic temperature control system placed inside the computer casing.

The research conducted by Masruchin entitled *Room Temperature Control System Based on the AT89S51 Microcontroller* aims to design a prototype of a room temperature control system using the AT89S51 microcontroller. This microcontroller has quite limited features. The way the system works is when the switch is turned on, the components in the heating system based on the LM35 temperature sensor with the AT89S51 microcontroller will be active both in hardware and software. The temperature data detected by the sensor is converted into an analog voltage, with every 1°C increase in temperature resulting in a voltage increase of 10 mV.

Research conducted by Luthfi Hendra Lukmana entitled Design and Construction of Room Light Controllers Using Remote Control and Real Time Clock Based on ATMega8535 [3]. This research uses a remote control to control the room lights. The use of this remote control is certainly one of the practical and flexible work principles to make it easier to return the room lights. Data sent by the remote will be received by the infrared receiver sensor to be forwarded to the microcontroller. In the microcontroller, the data will be processed and executed to control the entire working system of the circuit. Programming using assembler language is generally small in size so it is efficient in memory usage and can be executed quickly. The real-time clock will store data for timing references on the room light control so that automation and turning off the lights can function.

Several previous studies still use old microcontrollers that are now difficult to find on the market. Therefore, this study uses Arduino Uno, a microcontroller with newer and more accessible technology. With this background, this study aims to create a prototype of a room temperature control system based on the Arduino Uno microcontroller. This system will read the room temperature, and if the temperature exceeds the recommended limit, the air conditioner will automatically turn on. Arduino was chosen because it has advantages,

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including low power consumption and wide availability on the market, making it easy to obtain the required components.

Literatur Riview

To realize a temperature control system using a temperature sensor, this section will explain the steps and tools used in the research.

Research Steps

The steps taken in this research are presented in the flow diagram in Figure 1.

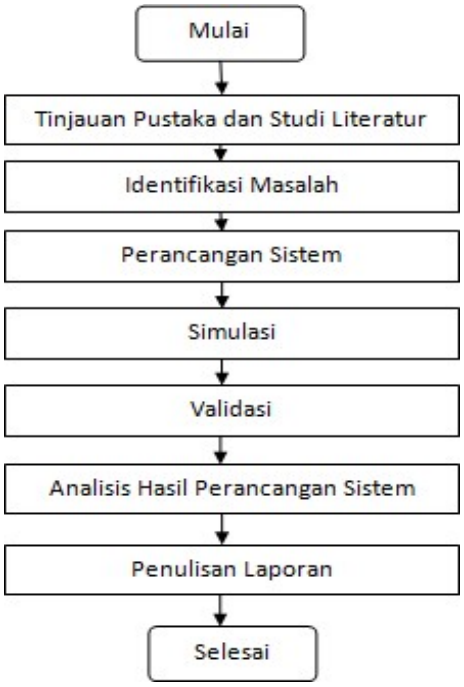

Figure 1. Flowchart of Research Steps

A literature review and literature study were conducted to find relevant references related to this research topic. The references referred to include studies on control systems on microcontrollers and various methods used. Based on these references, the identification of problems to be solved in this research was carried out. This stage also involves a study of the differences between this research and previous studies, the results of which will be the formulation of problems to be solved in this research.

The design of this system was carried out based on a study and trial of various theories and methods relevant to the research topic. The study includes (1) system architecture, (2) design with simulation using Proteus software, (3) design of a temperature control system, and (4) selection of equipment to be used in the design. After all these aspects have been determined, the system design steps are carried out by referring to the problems previously identified.

The next step is to conduct a simulation to test the system design in software, using Proteus Professional 8 software. In addition, validation is also carried out to ensure that the system design can be applied in real terms, namely by implementing it on the Arduino circuit and ensuring that the system functions properly.

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The system design produces a system that is not yet stable and requires testing to optimize its overall performance. Testing is carried out on important parts of the system, including (1) the room temperature control system and (2) a comparison between this system and a manual room temperature measuring device. Testing is carried out until the best results are achieved based on the analysis and evaluation carried out. After testing and analyzing the system, the next step is to compile a research report that includes the results and findings obtained during the process, resulting in a better system overall.

Tools and Materials

The developed system requires several hardware devices. This hardware plays a major role in system design. The hardware used in designing this system is as follows:

a. Arduino
b. LM35DZ Temperature Sensor
c. FAN
d. LCD

The software used in designing and building the system consists of:

a. Notepad++ is a tool used to create scripts used to program microcontrollers.
b. Proteus 8 Professional is an application used to simulate the design of a temperature control system.
c. Sketch Arduino is an application to compile and upload programs into the Arduino microcontroller.

System Workflow

The design of a room temperature control system based on the Arduino Uno microcontroller uses the waterfall method, which is a one-way flow. The process begins with a literature review and literature study to collect data and references that will be used in the design. Furthermore, the identification of problems to be solved and researched is carried out. After that, the system design is carried out through various studies on system architecture and design, followed by simulation and validation. After the circuit is validated and implemented on the Arduino Uno hardware, the next step is to conduct testing to obtain results that can be analyzed. Finally, all findings and research results will be compiled in the form of a research report.

RESULTS AND DISCUSSION

Simulation

For simulation and validation, Proteus Professional 8 software is used, which is specifically made for simulating electronic circuits. The results of the simulation are shown in Figure 2 below:

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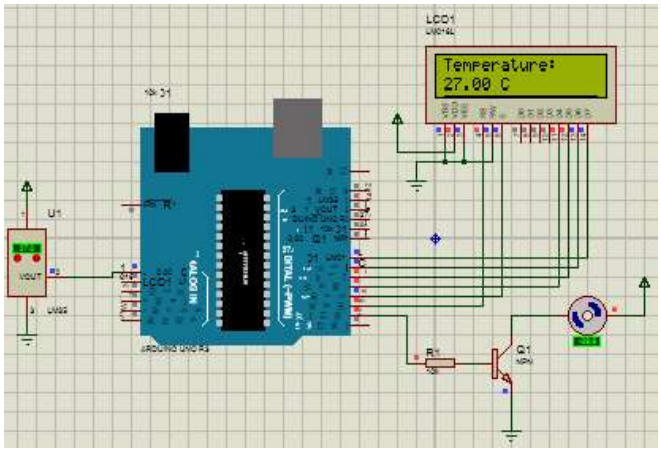

Figure 2. Room temperature controller circuit

The output of the LM35 temperature sensor is connected to the Analog In (A0) pin on the Arduino microcontroller, making it an input. Meanwhile, the output of the Arduino consists of a 16 x 2 LCD and a fan. The fan is connected to digital pin 1, while the LCD is connected to digital pins 2, 3, 4, 5, 6, and 7. This temperature sensor reads real-time analogue data that represents the room temperature, then the data is sent to pin A0 on the Arduino microcontroller. The Arduino will convert this analogue data into digital data for further processing, producing an output in the form of a fan that turns on to cool the room and a real-time temperature display on the LCD. The comfortable room temperature is set in the range between 25°C to 28°C. If the temperature read by the sensor exceeds 28°C, the fan will automatically switch on to cool the room until it reaches 25°C. Conversely, if the temperature drops below 25°C, the fan will automatically switch off. With this setting, the main goal is to save on the consumption of electrical energy used in the room.

From Figure 2, it can be seen that the circuit has functioned as expected, with the temperature displayed is 27°C and the fan is still on to cool the room until it reaches the lower limit temperature of 25°C. If the temperature drops below 25°C, the fan will automatically switch off. This circuit has been simulated repeatedly and the results show consistent stability. This is the basis for system validation. Based on the simulation results, it can be concluded that the circuit has been validated and is ready to be manufactured into an electronic hardware circuit.

Temperature Control Testing

After the circuit is simulated and validated, the next step is designing the hardware circuit and testing the system. The results of the design of the temperature control system hardware circuit are as follows:

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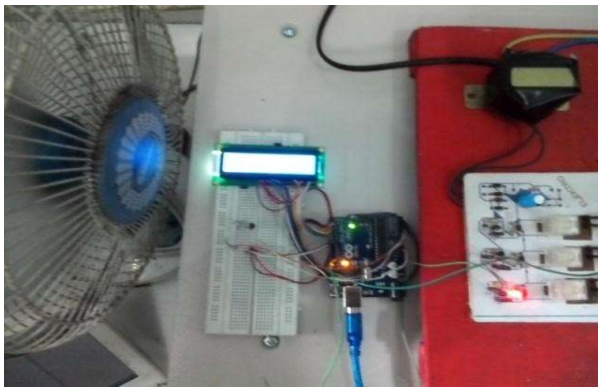

Figure 3. Hardware circuit design

This temperature control system is designed to automatically collect room temperature data using an LM35 temperature sensor, which is then displayed on the LCD. The system also regulates the room temperature by switching the fan on and off. When the room temperature exceeds the threshold, the fan will switch on until the temperature reaches the lower threshold; once the temperature drops below the threshold, the fan will automatically switch off. Tests were conducted by comparing the temperature read by the sensor with the temperature indicated by the thermometer. Three tests were conducted in the temperature range of 25°C to 38°C, and the results obtained were then averaged. The average reading of the temperature sensor is compared with the temperature measured using a thermometer to find the difference. This difference shows the error value that occurs during measurement. The error value can be calculated using the following formula:

$$\frac{\text{Selisih Pengukuran Thermometer dengan Sensor}}{\text{Suhu Thermometer}} \text{ X } 100\ \%$$

The results of the temperature sensor measurements can be seen in Table 1:

Table 1. Room Temperature Measurement Results

Thermometer Temperature (Celsius)	temperature sensor(celcius) Testing I	Testing II	Testing III	Average	Differences	Error
25	25,7	25,7	25,5	25,63	0,63	2,53
26	26,6	26,3	26,4	26,43	0,43	1,67
27	27	27,2	27	27,07	0,07	0,25
28	28,8	28	28,6	28,47	0,47	1,67
29	29,6	29,5	29,8	29,63	0,63	2,18
30	30,6	30,6	30,8	30,67	0,67	2,22
31	31,8	31,8	31,65	31,75	0,75	2,42
32	32,7	33	32,8	32,83	0,83	2,60
33	34	34,2	33,8	34,00	1,00	3,03
34	34,5	34,5	34,8	34,60	0,60	1,76
35	35,6	35,8	36	35,80	0,80	2,29

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Thermometer Temperature (Celsius)	temperature sensor(celcius) Testing I	Testing II	Testing III	Average	Differences	Error
36	36,4	36,6	36,8	36,60	0,60	1,67
37	37,8	37,8	37,8	37,80	0,80	2,16
38	38,8	39	38,5	38,77	0,77	2,02
	Average				0,65	2,03

The test results presented in Table 1 show satisfactory measurement performance. The average error recorded is 2.03%. This measurement discrepancy is caused by the rounding process performed by the sensor as well as calibration that may not be optimal. Therefore, it is necessary to perform a more accurate calibration to improve the reliability of measurement results in the future. The measurement results are then graphed as follows:

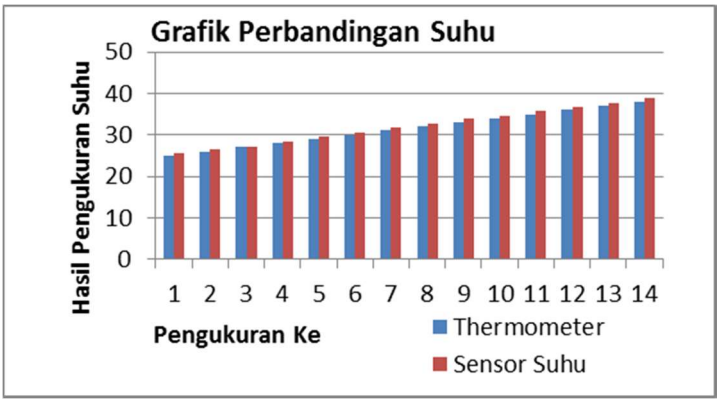

Figure 4. Temperature Comparison Chart

CONCLUSIONS

From the research that has been done, there are several conclusions, among others, are as follows: The research produces a Room Temperature Control System that can be used to control room temperature automatically using a temperature sensor; LM35 temperature sensor is a good temperature sensor and is suitable for monitoring room temperature; Arduino Uno microcontroller is an open source microcontroller that can be used to process analogue data from sensors and Design and Implementation of Arduino Uno Microcontroller-Based Room Temperature Controller with LM35 temperature sensor is feasible to use and apply as a room temperature control system.

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