Design and Implementation of Automatic Fan Control System Based on Room Temperature Using Microcontroller-Based LM35 Sensors

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Abstract

Room temperature control is an important aspect in maintaining user comfort and ensuring the efficient performance of electronic devices in enclosed spaces. Manual fan operation is considered ineffective because it cannot respond promptly to temperature changes and may lead to energy inefficiency. Therefore, this study aims to design and implement an automatic fan control system based on room temperature using an LM35 temperature sensor and an Arduino Uno microcontroller. The control method applied is threshold-based control, in which the fan automatically turns on or off according to a predefined temperature limit. The system consists of an LM35 sensor for temperature sensing, a microcontroller for data processing, a relay module as the actuator controller, a DC fan as the cooling device, and an I2C-based LCD as the display unit. System testing was conducted in an enclosed room with naturally varying temperature conditions. The experimental results show that the system is capable of reading room temperature stably and in real time, displaying temperature data clearly, and controlling the fan automatically and consistently according to the room temperature conditions. Based on its performance, the proposed system can be considered a simple, efficient, and easily applicable solution for room temperature control in small- to medium-scale enclosed environments.

Keywords: temperature control, automatic fan, LM35 sensor, microcontroller, embedded system.

1. Introduction

The development of embedded system technology and microcontrollers has encouraged the use of automation systems in various fields, especially in controlling the environment with the help of sensors. One of the environmental factors that greatly affects human comfort and the efficiency of electronic devices is room temperature. If the temperature is not properly managed, it can cause discomfort and potentially impair the performance of electronic devices in enclosed spaces such as workspaces and laboratories [1].

In practice, the setting up of the cooling fan is still often done manually by relying on the user to set it up themselves. This method is considered less effective because it cannot respond to temperature changes directly, and can lead to energy waste because the fan is operated without regard to the actual environmental conditions [2]. Therefore, an automatic fan control system is needed and can work based on the room temperature directly.

The LM35 temperature sensor is a type of analog sensor that is widely used in measuring temperature because it has linear properties, a fairly good level of accuracy, and is easily connected to a microcontroller [3]. Previous research has shown that LM35 sensors can be used in room temperature monitoring systems, generating stable temperature data and facilitating integration into microcontroller-based control systems [4].

Combining a temperature sensor with a microcontroller allows for the creation of a simple and inexpensive temperature control system. By adding components such as relays as electrical controllers and LCDs as information display tools, the system becomes easier for users to understand and use [5]. Systems like these are commonly used in a variety of small to medium-scale applications, especially for regulating temperature in enclosed rooms.

A commonly used control method in automatic fan systems is one based on threshold temperature, in which the fan moves or stops depending on the specified temperature [6]. The advantage of this method is that the algorithm is simple and the response is fast to temperature changes, although it is not good at regulating the fan speed slowly [7].

Several studies on automatic fan control systems based on temperature have been carried out with various methods. However, many studies still focus on simulations or limited trials, without directly testing the effectiveness of the system in an enclosed environment with noticeable temperature changes [8]. In addition, further research is still needed to evaluate the reliability level of the ON/OFF control method in maintaining stable fan performance under a variety of temperature conditions [9].

Based on this explanation, this study aims to create an automatic system that regulates the fan based on room temperature. The system uses LM35 sensors and microcontrollers. This research also focuses on the application of temperature control methods with the threshold method. In addition, the system is tested directly in an enclosed room to find out how effective it is. It is hoped that the results of this research can be a simple, efficient, and easy-to-use solution in daily life [10].

2. Research Methodology

2.1 Types and Approaches to Research

This study uses an engineering research approach with an experimental method. This approach was chosen because the study focused on the manufacture, installation, and direct testing of an automatic fan control system that works at room temperature. The experimental method allows for real-time testing of the system's performance in an enclosed environment [11].

2.2 System Planning

The automatic fan control system is designed using an embedded system consisting of a temperature sensor, a processing unit, an actuator, and a display screen. The LM35 sensor acts as an input to measure the room temperature, while the microcontroller acts as a data processing and decision-making center. The output of the system is in the form of a cooling fan controlled through a relay and an LCD that displays the temperature and fan status figures.

The system starts with a temperature reading by the LM35 sensor, then the analog signal is converted into digital data by the ADC on the microcontroller.
The data is compared with the predetermined limit temperature values to determine whether the fan should be turned on or off [12].

2.3 Hardware Design

The hardware on this system consists of:

- Sensor suhu LM35

  LM35 sensors are a type of temperature sensor that works with analog signals. Its main function is to measure the ambient temperature in units of degrees Celsius. This sensor has a straight nature, meaning that every 1°C increase in temperature will cause an increase in output voltage by 10 mV. The advantages of the LM35 sensor are that it is easy to use in microcontroller systems, its accuracy is quite high, and it does not require complicated calibration. In this system, the LM35 sensor acts as a component that receives room temperature data directly, then sends an analog signal to the microcontroller for further processing.
- Arduino Uno Microcontroller

  The Arduino Uno microcontroller serves as the main controller of the system that receives temperature information from the LM35 sensor, processes that data, and makes decisions to control the actuator. The Arduino Uno board uses an ATmega328P microcontroller equipped with an Analog to Digital Converter (ADC) feature, allowing the

conversion of analog signals from the LM35 sensor into a digital format. In addition, the selection of the Arduino Uno is based on ease of programming, large community support, and good compatibility with a wide range of sensors and additional modules. In this system, the Arduino Uno runs a temperature control algorithm to determine whether the fan should be active or not.

- Module relay

  The relay module functions as an electronic switch that controls the DC fan based on the signal from the microcontroller. By using relays, microcontrollers operating at low voltages and currents can regulate loads that have higher voltages and currents in a safe manner. In this system, the Arduino Uno activates or deactivates the relay module according to the results of the temperature data processing. The relay application provides protection between the control circuit and the power circuit, thereby improving the overall safety and reliability of the system.
- DC Fan

  DC fans act as drives in room temperature control systems. This fan starts working when the room temperature reaches or exceeds a certain preset limit and will stop operating when the temperature drops below that limit. DC fans were chosen because of their fairly efficient power usage, easy to set up with relays, and commonly used as cooling devices in enclosed environments. With fan automation, this system can help lower the room temperature effectively without the need for manual intervention.
- I2C-based LCD

  LCDs that use I2C serve as a display tool to show the room temperature and fan state directly. The implementation of the I2C interface saves the use of pins on the microcontroller, which makes the circuit more compact and effective. This LCD helps users to keep an eye on the room temperature situation and see the operational status of the system immediately. With the visual display available, the system becomes easier to understand and operate.

The LM35 sensor is connected to an analog input pin on the microcontroller, while the relay module is connected to a digital output pin to regulate fan work.
The circuit design is made with the voltage stability and safety of the components in mind so that the system can run continuously [13].

2.4 Software Designing

The software is created using the C language inside the Arduino IDE. The program is tasked with reading data from the LM35 sensor, converting the data into temperature numbers in degrees Celsius, and then comparing it to a certain temperature limit.

The control method used is temperature threshold-based control, with logic like this:

- If the temperature reaches or exceeds the temperature threshold, then the fan will be switched on.
- If the temperature is below the temperature threshold, then the fan will be turned off.

This method was chosen because the algorithm is simple, the response is fast, and it is easy to apply to systems that use microcontrollers [14].

2.5 System Testing Methods

The system test is carried out in a closed room with naturally occurring temperature variations. The purpose of this test is to determine the system's capabilities in several ways, namely: reading the room temperature directly and in real-time, responding to temperature changes according to the specified threshold values, and controlling the fan automatically and consistently. The parameters observed in the test include the temperature values read by the sensor, the status of the fan (on or off), and the extent to which the system's response corresponds to the temperature conditions in the room. Repeated testing was carried out to ensure the system was reliable and stable [15].

3. Results and Discussion

Testing of the automatic fan control system was carried out to ensure that the LM35 sensor was working properly, the data processing process by the microcontroller was reliable, and the actuator could respond appropriately to changes in the temperature in the room. This test is performed in a closed room with a slowly changing temperature. During the testing process, the system is run continuously to ensure that the readable temperature remains stable and the fan's response to temperature changes remains consistent.

The test results show that the LM35 sensor is able to measure the temperature in the room in a stable and consistent manner. Temperature changes in the room can be detected clearly, as can be seen from the temperature values that are constantly updated and displayed on the LCD screen directly. There was no drastic change in the measurement results during the test, which indicates that the LM35 sensor works well in measuring temperature. This also proves that communication between sensors, microcontrollers, and screens runs smoothly without any hindrances.

At the stage of the system response test, when the temperature in the room reaches or exceeds the preset limit, the microcontroller automatically sends a signal to the relay module to turn on the fan. The fan runs according to the temperature control rules set in the software. If the room temperature is lower than the specified limit, the system will automatically turn off the fan. These results show that the system is able to make informed decisions based on the temperature data obtained from the sensors**.**

The threshold-based temperature control method used in this system is good enough to regulate the temperature of a small room. Its main advantage is that the algorithm is easy to understand and the system can respond quickly to temperature changes. Because it does not require complex calculations, this method is ideal for use on microcontrollers that have limited power and memory. In addition, the ON/OFF method also makes the process of creating and writing system code simpler.

However, the test results also show that the system still has limitations. How to set the fan with ON/OFF only makes the fan run at a fixed speed, so it cannot adjust the cooling slowly according to the temperature rise. This can cause the temperature to be unstable to a certain extent, especially when the room temperature fluctuates around the threshold value. However, for simple use and basic needs in regulating the room temperature, this method is still acceptable and works quite well.

Overall, the test results showed that the automatic fan control system using the LM35 sensor and microcontroller was running well and in accordance with the original purpose. This system can detect the room temperature directly, display temperature data clearly, and adjust the fan automatically according to the existing temperature conditions. With such performance, this system can be used as a simple, efficient, and easy solution to control the temperature in various enclosed rooms.

4. Conclusions and Suggestions

4.1 Conclusion

Based on the results of the design, manufacture and testing of an automatic fan control system using LM35 temperature sensors and based on microcontrollers, it can be concluded that the system was successfully built and ran according to the research objectives. The system is able to read the room temperature directly and stably, as well as display the temperature data continuously on the LCD screen. This shows that the communication between the LM35 sensor, microcontroller, and display screen is good and effective.

Using a certain temperature setting can make the cooling fan run on its own. This system will turn on the fan when the room temperature reaches or exceeds the predetermined limit, and turns off the fan when the temperature is below that limit. This system can respond appropriately and continuously to temperature changes, reducing the need to operate the fan manually. In this way, this system can help use energy more efficiently and keep the room comfortable conditions.

From a technical point of view, the use of LM35 sensors and microcontrollers provides an easy, cheap, and workable solution to control room temperature on a small to medium scale. The algorithm used does not require too complicated calculations, making it suitable for use on microcontrollers that have limited power. In addition, the use of the relay module as an actuator

regulator and LCD to display information also makes the system more convenient and more reliable to use.

Although the system is already running smoothly, the study still has some weaknesses. The way to set the fan only on or off makes the fan only rotate at a constant speed, so it cannot adjust the cooling slowly according to the change in room temperature. This can cause the ambient temperature to fluctuate, especially when the room temperature is close to a certain limit. Therefore, the system can still be improved to improve in terms of performance and temperature control.

4.2 Suggestions

Based on the results of the research and the limitations that have been found, there are several suggestions that can be given for the development of the system in the future. First, a fan control system can be developed by applying a more responsive control method, for example by adjusting the fan speed based on Pulse Width Modulation (PWM). In this way, the fan can operate slowly according to the rising temperature in the room. This approach is expected to improve temperature stability and cooling efficiency.

Second, a feature can be added to record temperature data so that the system is better and can be analyzed more deeply. By storing existing temperature data, users can see the pattern of temperature changes in the room over a period of time and evaluate the system's performance in more detail.

Third, the next step is to combine the system with Internet of Things (IoT) technology. By utilizing a network connection, the fan control system can be monitored and changed remotely using a web-based device or mobile app. This incorporation makes the system more flexible and practical, especially for use in smart homes or smart buildings.

Fourth, to make the system more accurate and reliable, future research can use more precise digital temperature sensors or calibrate the sensors regularly. In addition, the system must also be tested in various environmental conditions and different types of rooms in order to know its performance more completely.

With this development, it is hoped that an automatic fan control system that utilizes room temperature can provide better benefits in the application of automation technology and intelligent systems. In addition, this system can also be an example or reference for further research in the field of interfacing engineering and control systems that use microcontrollers.

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