Design and Implementation of a LabVIEW-Based Real-Time Temperature Monitoring and Communication System Using MAX6675 Thermocouple

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ABSTRACT

This research aims to design and implement a temperature monitoring system that utilizes the Thermochouple Max6675 sensor, Arduino Nano, as well as communication modules, namely RS485 to TTL and RS485 to USB. This system is equipped with a Solid State Relay to control the device based on the detected temperature measurements. The Max6675 sensor is used to measure temperature accurately and then sends the data via RS485 communication to the user's device. To ensure the accuracy of the measurement results, the temperature obtained from this system is compared with temperature data obtained from the Hygrothermometer application as a standard reference for the surrounding environmental temperature. In this circuit, the data measured by the sensor is sent via RS485 to TTL and forwarded using RS485 to USB to the computer user. The received temperature data is then processed and displayed in real time via the Labview application, providing a bright graphical interface for users to integrate temperature changes. In the tests carried out, the results obtained from the Max6675 sensor compared with the Hygrothermometer application showed a fairly high level of accuracy, namely around 90%. Which shows that the system developed is able to provide temperature measurements with a low error rate. Using the Labview application as a platform for displaying monitoring results makes it easy to visualize temperature data directly and allows further processing for real-time temperature analysis. This system has great potential to be applied in various industrial fields, such as temperature monitoring in manufacturing processes or environmental control, with a sufficient level of accuracy and easy integration with other software for analysis and control purposes. The success of this research opens up opportunities for more efficient, cost-effective temperature monitoring and also a higher level of accuracy.

Keywords: Temperature Monitoring, Arduino Nano, Thermocouple MAX6675, Labview, RS485

ABSTRAK

Penelitian ini bertujuan untuk merancang dan mengimplementasikan sistem pemantauan suhu dengan memanfaatkan sensor Thermochouple Max6675, Arduino Nano, serta modul komunikasi RS485 ke TTL dan RS485 ke USB. Sistem ini dilengkapi dengan Solid State Relay untuk mengontrol perangkat berdasarkan pengukuran suhu yang terdeteksi. Sensor Max6675 digunakan untuk mengukur suhu secara akurat dan kemudian mengirimkan data melalui komunikasi RS485 ke perangkat pengguna. Untuk memastikan keakuratan hasil pengukuran, suhu yang diperoleh dari sistem ini dibandingkan dengan data suhu yang diperoleh dari aplikasi Hygrothermometer sebagai referensi standar untuk suhu lingkungan sekitar. Pada rangkaian ini, data yang diukur oleh sensor dikirim melalui RS485 ke TTL dan diteruskan menggunakan RS485 ke USB ke komputer pengguna. Data suhu yang diterima kemudian diproses dan ditampilkan secara real-time melalui aplikasi Labview, menyediakan antarmuka grafis yang menarik bagi pengguna untuk mengintegrasikan perubahan suhu. Dalam pengujian yang dilakukan, hasil yang diperoleh dari sensor Max6675 dibandingkan dengan aplikasi Hygrothermometer menunjukkan tingkat akurasi 90%. Hal ini menunjukkan bahwa sistem yang dikembangkan mampu memberikan pengukuran suhu dengan tingkat kesalahan yang rendah. Penggunaan aplikasi Labview sebagai platform untuk menampilkan hasil pemantauan memudahkan visualisasi data suhu secara *real-time*. Sistem ini memiliki potensi besar untuk diterapkan di berbagai bidang industri, seperti pemantauan suhu dalam proses manufaktur atau pengendalian lingkungan, dengan tingkat akurasi yang memadai dan integrasi yang mudah dengan perangkat lunak lain untuk tujuan analisis dan pengendalian. Keberhasilan penelitian ini membuka peluang untuk pemantauan suhu yang lebih efisien, hemat biaya, dan juga tingkat akurasi yang lebih tinggi.

Keywords: Pemantauan Suhu, Arduino Nano, Termokopel MAX6675, Labview, RS485

1. INTRODUCTION

The rapid development of modern technology, significant advancements have provided numerous conveniences in daily human life. One notable area of technological progress is in the field of electronic components and devices that can be integrated with microcontrollers [1]. Examples of such technologies include sensors and microcontroller-based systems. A microcontroller is an integrated component that combines a microprocessor, memory, and input–output devices within a single chip [2]. Sensors are devices used for measurement and data acquisition purposes [3].

One important example is a temperature sensor, which measures a physical quantity indicating the degree of hotness or coldness of an object. Temperature serves as a critical indicator in many research activities that require stable thermal conditions. Periodic temperature measurements are necessary to obtain data on temperature variations over time. Temperature is a fundamental parameter present in almost every system, and due to its importance, temperature measurement is widely required in research, automation control, industrial applications, and daily life.

Along with technological advancements, real-time measurement has been facilitated by the emergence of data acquisition techniques. Arduino can be used as a reliable data acquisition system when the sensors are properly calibrated. Arduino platforms offer stable connectivity, high reliability, good durability, and can function as control systems for various levels of complexity at a relatively low cost. When using a Type-K thermocouple with Arduino for temperature data acquisition, a module that provides cold junction compensation is required. The MAX6675 is one of the compatible modules for Arduino that performs cold junction compensation for Type-K thermocouples. The MAX6675 is selected due to its wide measurement range, capable of measuring hot junction temperatures from 0 °C to 1024 °C.

A thermocouple is one of the most commonly used types of temperature sensors [4]. It is classified as an active transducer, consisting of two different metals joined together, producing an output at their junction. The working principle of a thermocouple is based on converting temperature differences into voltage changes due to differences in electron density between the metals, which depend on their material properties [5]. Thermocouples are widely used because they are relatively inexpensive, accurate, and capable of operating over both high and low temperature ranges. This sensor measures temperature through direct contact with the object.

Type-K thermocouples combined with the MAX6675 module have been widely utilized by researchers to measure temperature values; however, ensuring accurate temperature measurement remains a challenge. Thermocouples operate based on the Seebeck effect, where an electromotive force is generated when two dissimilar conductive materials are joined at both ends and a temperature difference exists between the junctions. The magnitude of this electromotive force is proportional to the temperature difference and the Seebeck coefficient of the thermocouple materials [6].

Temperature conditions in machinery or industrial environments are critical parameters that must be monitored and managed effectively. For example, in an extruder machine, temperature is used to melt raw materials and force them into molds to form products. The temperature of an extruder machine has a significant impact on performance and operational safety. Therefore, temperature monitoring is essential to maintain machine stability and prevent potential failures caused by overheating.

Currently, many temperature monitoring processes are still performed manually by visiting each location, measuring the temperature, and recording the data [7]. Therefore, the purpose of designing this system is to support accurate and efficient temperature monitoring [8]. In this study, an Arduino Nano is used as the main controller, a MAX6675 thermocouple as the temperature sensor, RS485 communication modules for long-distance data transmission, and the LabVIEW application as the system output interface.

RS485 is utilized in this system due to its various advantages, including the ability to connect up to 32 devices using only two wires without requiring a common ground reference between devices, and its long transmission range of up to 1.2 km [9]. In addition, RS485 provides reliable data transmission. LabVIEW is a programming

environment widely used in industrial applications, making it an essential programming skill for engineering students to master [10].

2. RESEARCH METHOD

In this study, an experimental method is employed, in which the research involves the design and development of a prototype system. The design methodology is conducted through several stages, consisting of: (1) hardware design, which includes the development of circuit schematic designs and the assembly of components in accordance with the constructed block diagrams or flowcharts; and (2) microcontroller programming design, which involves the development of software and its implementation on the Arduino microcontroller.
In the hardware design of the control system, a Solid State Relay is controlled by the sensor and the Arduino, which is programmed using an Arduino Nano, as illustrated in Figure 1.

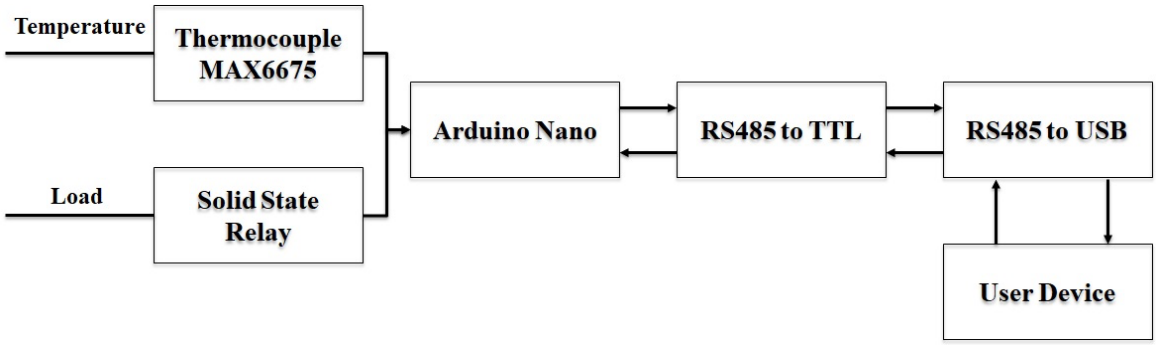


Figure 1. Block Diagram of temperature monitoring system

As illustrated in the figure, the temperature is measured by the MAX6675 thermocouple sensor and subsequently processed by the Arduino Nano to determine whether it exceeds a predefined temperature threshold. The temperature data are then transmitted via the RS485 to TTL and RS485 to USB communication interfaces and displayed on the user's device. When the measured temperature exceeds the threshold set in the Arduino program, the Solid State Relay (SSR) is activated to disconnect the power supply to the load, thereby turning the load off. Once the temperature returns to within the normal operating range, the SSR is deactivated and the load resumes normal operation.

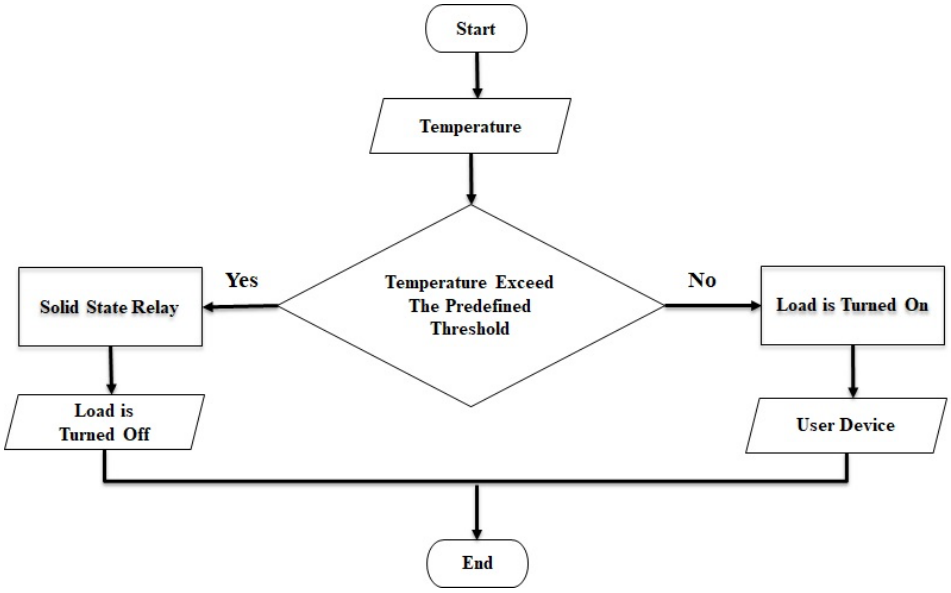


Figure 2. Flowchart of the system operation

Figure 2 presents the flowchart of the proposed circuit operation. The sensor inputs the detected temperature, which is then processed by the Arduino. If the measured temperature exceeds the predefined threshold, the Solid State Relay (SSR) functions as a switch to disconnect the power supply to the applied load. If the temperature does not exceed the specified limit, the load remains turned on. Afterward, the temperature data are transmitted to the user device, where the temperature is displayed through an application named LabVIEW.

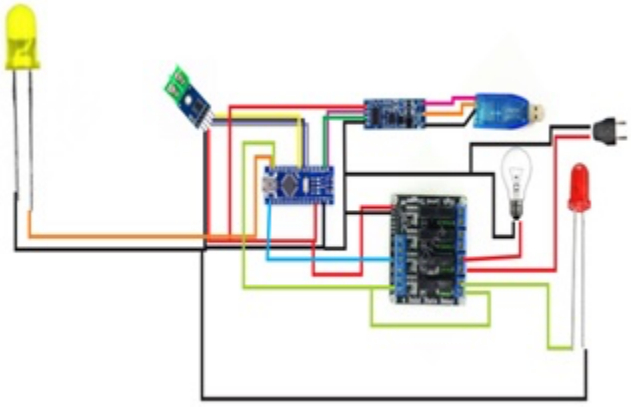


Figure 3. Wiring Diagram

Figure 3 illustrates the wiring diagram of the developed temperature monitoring system. The Arduino Nano serves as the main controller for the output control, while the input is provided by the MAX6675 thermocouple sensor, which is connected to the Arduino. The system output utilizes an RS485 to USB module that is connected to a computer or laptop for data communication.

The system testing consists of evaluating the constructed temperature monitoring circuit. This testing involves the collection of relevant environmental temperature data to assess the accuracy and reliability of the MAX6675 thermocouple sensor. The testing procedure includes the simulation of ambient temperature conditions to evaluate the sensor's capability to accurately detect temperature variations and consistently transmit data to the Arduino Nano.

3. RESULTS AND DISCUSSION

3.1. Result

The following research results demonstrate the performance of the temperature monitoring system that has been designed and implemented. The testing was conducted to evaluate the accuracy, reliability, and real-time monitoring capability of the system by comparing the temperature readings obtained from the MAX6675 thermocouple sensor with a reference measuring instrument. The collected data were analyzed to assess the effectiveness of the system for temperature monitoring applications.

Table 1. Testing of the Type-K MAX6675 Thermocouple Sensor

Parameter	Result	Descriptiom
THERMOCOUPLE MAX6675	Operating properly; data transmission successful	The MAX6675 thermocouple sensor accurately detects temperature and successfully transmits data to the Arduino Nano.

The circuit testing is not only conducted by collecting data from the sensor installed in the system, but also by comparing the measured sensor data with temperature readings obtained from a Hygrometer application, which serves as the reference temperature. The primary objective of this testing is to compare the data generated by the MAX6675 thermocouple sensor with the Hygrometer application. The comparison results are then evaluated to determine the accuracy of the MAX6675 thermocouple in monitoring ambient temperature conditions.

Table 2. Testing of the Type-K MAX6675 Thermocouple Sensor and Hygrometer Application

No.	Thermocouple Measurement Results (℃)	Hygrometer Measurement Results (℃)	Error (%)
1	27℃	28℃	3,57
2	30℃	25℃	16,6
3	29,25℃	26C℃	11,1
4	28,75℃	24,5℃	14,7
5	27,25℃	29℃	6,42

The testing was conducted to validate the developed system. Table 1 shows the difference between the temperature readings obtained from the Type-K MAX6675 thermocouple sensor and those from the hygrometer, which is used as the standard measuring instrument. The accuracy percentage of the sensor used in this study is approximately 90%.

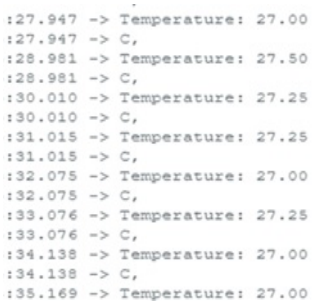


Figure 4. Temperature output from the thermocouple displayed on the Arduino serial monitor

In this figure, temperature measurements are obtained using the MAX6675 thermocouple sensor to measure the ambient environmental temperature. The temperature readings acquired by the sensor range from approximately 27.0 °C to 27.5 °C. These measured values are then compared with temperature data obtained from a Hygrometer application. Figure 10 illustrates the temperature readings provided by the Hygrometer application.

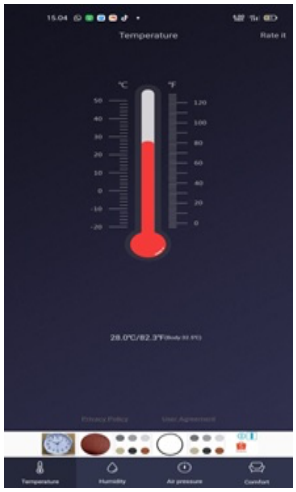


Figure 5. User Interface of the Hygrometer Application as a Temperature Reference

In the figure above, the image was captured using a smartphone on which a Hygrometer application was used as the reference for the current temperature. The reference temperature obtained from the application was then compared with the temperature measured by the thermocouple sensor. After the circuit was constructed and operated, testing was conducted to evaluate the accuracy of the developed temperature monitoring system. This testing involved a comparison between the temperature readings from the MAX6675 sensor and those measured

using the Hygrometer application as a reliable reference. In this experiment, five measurement trials were conducted, and the results showed an average error of 10.47%.

3.2. Discussion

Based on the results of the conducted experiments, the temperature monitoring system based on the Type-K MAX6675 thermocouple sensor demonstrates satisfactory performance in monitoring ambient temperature in real time. The evaluation was carried out by comparing the temperature readings obtained from the sensor with those provided by a Hygrometer application used as a reference instrument. This comparison aimed to assess the accuracy and reliability of the developed system.

The experimental results indicate that the temperature values measured by the MAX6675 thermocouple sensor show relatively small deviations when compared to the reference Hygrometer readings. From five experimental trials, an average error of 10.47% was obtained, corresponding to an overall system accuracy of approximately 90%. These results suggest that the MAX6675 sensor is capable of providing sufficiently accurate and consistent temperature measurements.

The observed differences between the sensor readings and the reference measurements may be influenced by several factors, including sensor sensitivity to environmental changes, sensor placement, surrounding environmental conditions, and the inherent limitations of the Hygrometer application used as a comparison tool. Additionally, sensor response time and data processing through the Arduino microcontroller may also contribute to measurement discrepancies.

Nevertheless, with an accuracy level of approximately 90%, the developed temperature monitoring system can be considered reliable for real-time temperature monitoring applications. The system successfully displays temperature data through the Arduino serial monitor and the LabVIEW application, enabling users to monitor environmental temperature conditions effectively.

Overall, the results of this study indicate that the temperature monitoring system based on the MAX6675 thermocouple sensor has strong potential for further development, particularly in improving measurement accuracy and expanding its application to industrial-scale systems or automation environments that require continuous temperature monitoring.

4. CONCLUSION

The temperature monitoring system implemented in this study is capable of providing sufficiently accurate results, with an accuracy level of approximately 90%. This indicates that the developed circuit is able to monitor and measure temperature with good precision, although several factors may still influence the measurement results. With an accuracy of 90%, the system can be considered reliable for applications that require real-time temperature monitoring; however, there remains potential for further improvements to achieve a higher level of accuracy.

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REFERENCES

[1] T. Hadyanto and M. F. Amrullah, “Sistem Monitoring Suhu dan Kelembaban pada Kandang Anak Ayam Broiler Berbasis Internet of Things,” *JTST*, vol. 03, no. 02, pp. 9–22, 2022.

[2] D. Sabran; Yasser Abd, “Perancangan Modul Pembelajaran Berbasis Projek pada Matakuliah Dasar Mikrokontroler,”

J. MEKOM (Media Komun. Pendidik. Kejuruan), vol. 5, no. 1, pp. 23–31, 2018.
[3] I. Rokhim, A. F. Rifai, and A. S. Sunarya, "Rancang Bangun Multisensor Sistem Proses Menggunakan Komunikasi I2C Berbasis Labview," *Cybernetics*, vol. 5, no. 01, pp. 38–48, 2021.
[4] A. Setiyoko and D. E. Yuliana, "Kendali Suhu Minyak Goreng pada Penggorengan Sosis menggunakan Kontrol PID," *J. Appl. Sci. Electr. Eng.*, vol. 3, no. 1, pp. 52–62, 2022.
[5] A. Pradipta, Y. B. A. Apatya, and H. Krismastuti, "Temperature Control on Hostia Baking Oven Machine Using Type K Thermocouple Sensor," *J. Elektro Luceat*, vol. 8, no. 1, pp. 1–8, 2022.
[6] A. Riantono, B. Teguh, and A. Koestoer, "Kalibrasi Sensor Temperatur Termokopel Tipe K dan DS18B20 Pada Temperatur Es Mencair dan Air Mendidih Sistem Dengan Akuisisi Data (DAQ) Berbasis Arduino," in *SNTTM XVIII*, 2019, pp. 9–10.
[7] U. Khairat *et al.*, "Monitoring Suhu Ruang Budidaya Jamur Tiram Menggunakan Android Berbasis Arduino," *Technomedia J.*, vol. 7, no. 1, pp. 1–10, 2022.
[8] R. M. Abdurrohman, K. Barriyah, and K. Nursuciliyat, "Prototipe Monitoring Suhu Dan Kelembapan Secara Realtime," *J. ICTEE*, vol. 4, no. 2, pp. 29–36, 2021.
[9] I. H. Mulyadi, R. Mahdaliza, A. Gautama, and S. Prayoga, "Modul Komunikasi Modbus RTU over RS485 Berbasis Arduino," *J. Appl. Electr. Eng.*, vol. 5, no. 1, pp. 26–29, 2021.
[10] M. I. Hadikusuma and S. A. Salim, "Rancang Bangun Modul Praktikum Pemrograman Labview," *Elit J. (Electrotechnics Inf. Technol.*, vol. 1, no. 1, pp. 35–44, 2020.