G-Tech : Jurnal Teknologi Terapan
Vol. 9, No. 4, October 2025, p. 2259-2270
E-ISSN: 2623-064X | P-ISSN: 2580-8737

Implementation of Outseal PLC with RS-485 as a Multi Node in Chicken Farming Using Raspberry Pi and Node RED

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Article Information

Article History

Received: September 29, 2025
Revised: October 22, 2025
Published: October 30, 2025

***Keywords*:**

Raspberry Pi;
Node RED;
RS-485;
Ammonia Gas;
Temperature.

ABSTRACT

Chicken farming is one of the important sectors in meeting food needs, but still faces challenges related to the ideal quality of the chicken coop environment, especially high levels of ammonia gas (NH_3) and non-ideal temperatures. Ammonia levels that exceed the threshold can harm chicken health and reduce productivity and result in chicken death. RS-485 as an industry standard communication is used as a Multi Node implemented in the Outseal PLC as an automatic control in chicken farming. Node-RED, as a browser-based visual programming platform, makes it easy for users to create IoT applications, including monitoring and control systems. The use of the Outseal PLC is used to control ammonia gas levels (NH_3) below the permissible threshold of below 20 ppm and the cage temperature below 35°C. The reading of the LM 35 sensor with the Outseal PLC ladder has an error percentage of 1.71% and the reading of the MQ 135 ammonia gas sensor with the Outseal PLC ladder has an error percentage of 1.303%. Raspberry Pi and Node are used to display ammonia gas levels and temperature in chicken farming. By implementing PLC Outseal with RS-485 as a Multi Node in chicken farming using Raspberry Pi and Node RED, it is hoped that it can increase productivity and achieve maximum results from chicken farming.

INTRODUCTION

Chicken farming is a crucial sector in the livestock industry, contributing significantly to food security and the local economy. In recent years, demand for chicken products, both meat and eggs, has continued to increase in line with population growth and changing consumption patterns (Amam et al., 2022). Many previous studies still used the Arduino Nano, programming in C, and an LCD display to monitor ammonia gas and temperature. The weakness of previous systems was that they only monitored activity per cage without an integrated system like SCADA or PLC..To meet this demand, farmers are required to increase efficiency and productivity in their farming processes. One way to achieve this is by adopting automation technology in control and monitoring systems, such as the use of Programmable Logic Controllers (PLCs) and SCADA systems (Aziz et al., 2021).

However, the increasing number of chicken farms is often accompanied by environmental quality issues within the coops, particularly high levels of ammonia gas (NH3) produced by chicken manure. High levels of ammonia gas can cause respiratory problems in chickens, reduce productivity, and even potentially lead to death (Murad et al., 2022). The standard safe level of

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ammonia gas in chicken coops is between 20 and 35 ppm (Nugroho et al., 2021). Therefore, an effective control system is needed to detect and reduce ammonia gas levels.

PLC-based control systems offer an efficient and automated solution for monitoring and regulating environmental conditions inside chicken coops. Using temperature and ammonia gas sensors, these systems can provide real-time data necessary for rapid and accurate decision-making (Surahman et al., 2021). Furthermore, research shows that automated control systems can improve time and labor efficiency, as well as reduce the risk of human error in coop management (Wahyudi et al., 2020). Outseal PLCs are an affordable alternative to PLCs and offer the same functionality as industry-standard PLCs (Cahyono et al., 2023).

A SCADA system integrated with a PLC enables automated data collection and in-depth analysis of chicken coop conditions. The collected data can be used to identify patterns and trends that can help farmers optimize their farming processes (Hadi et al., 2021). Using SCADA, farmers can monitor and control the system in real time through a user-friendly interface, facilitating quick and accurate decision-making (Zare et al., 2020). This study demonstrated the development of SCADA using Node RED integrated with a Raspberry Pi.

The Raspberry Pi Foundation is developing a credit-card-sized minicomputer. Software development, learning, and the Internet of Things (IoT) are among the projects that will utilize this device (Arhandi et al., 2021). The Raspberry Pi has USB ports, HDMI, and a microSD card slot, and can run operating systems like Raspbian, which is based on Linux. The Raspberry Pi is a controller with many advantages, such as requiring less power and being easier to connect to a web server compared to a microcontroller (Das et al., 2024).

Node-RED is a browser-based software used to create Internet of Things (IoT) applications. Its visual programming environment is a flow. This flow consists of a number of interconnected nodes, each performing a specific function (Kamarozaman et al., 2021).

RS485 offers advantages in long-distance communication with a master-slave architecture. The master-slave architecture can be expanded to 32 nodes/slaves with a distance of up to 1.2 km. The combination of Raspberry Pi and Node RED provides an affordable and reliable alternative for creating a low-cost and reliable SCADA system (Arigela et al., 2024).

With this background, this study aims to implement PLC Outseal with RS-485 as a Multi Node in chicken farming using Raspberry Pi and Node RED which is effective for chicken farming, with a focus on reducing ammonia gas levels and optimal temperature regulation, which is expected to improve chicken health and overall farm productivity.

RESEARCH METHODS

This study conducted research and development to design monitoring and control of temperature and ammonia gas using Raspberry Pi and Node RED. The use of RS 485 as a means of communication with the master and slave architecture in the designed system. PLC Outseal is an alternative to PLC with the advantages of being affordable and reliable. Ideal temperature and ammonia gas settings in the chicken coop will affect the success of chicken farming. Data collection of 10 temperature and ammonia gas sensor data to calibrate the designed sensor with sensors on the market. This was done to see the extent to which the accuracy of the sensor designed with ladder language can match the sensors that have been certified in the field. The research method used can be explained as follows:

1. Literature Study

Literature review at this stage, a literature study was conducted to learn what influences chicken farming, such as the ideal temperature and ammonia gas levels in chicken farming. The use of the latest technologies such as the Internet of Things (IoT), namely Raspberry Pi and Node RED in chicken farming, is an alternative use of technology in the livestock sector. Furthermore, the reliability of Outseal PLC technology, which has been used in the industrial world, is a good alternative in designing a reliable and affordable system. The implementation of RS-485, which has one of the reliable solutions in long-distance communication, is one of the most interesting studies in this research. The LM 35 and MQ 135 sensors are used as input from the Outseal PLC

to monitor temperature and ammonia gas in this study. The literature study also includes a review of previous relevant studies to understand and identify research gaps being studied.

2. Needs Analysis

This needs analysis phase involved gathering and analyzing the requirements for a temperature and ammonia gas monitoring and control system using a Raspberry Pi and Node RED for chicken farming. This research included interviews with stakeholders (such as farm operators and technicians in the study area), field observations, and an analysis of all possible scenarios.

a. Raspberry Pi

Raspberry Pi is used as an inexpensive and low-power alternative to PCs with the Raspberry Pi operating system. In this study, the Raspberry Pi was used to install Node RED as an inexpensive and reliable SCADA alternative (Zamani et al., 2023). This study used Node RED installed on the Raspberry Pi, and then the Node RED dashboard displays several sensors such as temperature sensors and ammonia sensors. The Raspberry Pi has several advantages, such as requiring only an SD card to install the OS and can work like a mini PC (Lin et al., 2024).

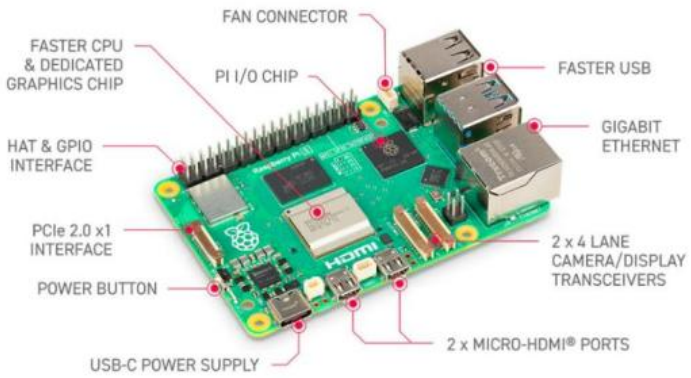

Figure 1. Raspberry Pi

b. Node RED

In this study, Node RED is used to display a dashboard for monitoring and controlling temperature and ammonia gas in the chicken farming room. Node RED was chosen because it has the advantage of having a MODBUS protocol that can communicate with PLCs or other devices that have the MODBUS protocol (Musrianto et al., 2021). Node RED programming with a flow system makes it easy for programmers to create a system that is easy for novice programmers. In this study, Node RED communicates with two slaves, namely PLC Outseal, using RS-485 as a serial UART. Figure 2 shows one of the Node RED implementations used on a Raspberry Pi with a PLC that can be accessed on a PC or smartphone.

Figure 2. Node – RED

c. PLC OUTSEAL

The Outseal PLC is an Indonesian-developed open-source PLC, offering a low cost without compromising on its reliability (Rachman et al., 2023). This study uses the Outseal PLC version 5 with the Arduino Nano as its main board. The Outseal Nano PLC has 8 inputs, S1 through S8, and 8 outputs, R1 through R8. Furthermore, the Outseal Nano PLC has 2 ADCs, A.1 and A.2 (Risfendra et al., 2023). These two ADCs receive analog data from the LM35 temperature sensor and the MQ135 ammonia sensor. Figure 3 illustrates the Outseal Nano v5 PLC, which is available on the market.

Figure 3. PLC Outseal V5

d. UART to RS 485 Serial Module

This study uses RS485 to communicate between a Raspberry Pi and two Outseal PLCs with a master and slave architecture. RS485 is used because it has the advantage of a long communication distance of up to 1200 meters (Kwon et al., 2024). Resistance to electrical interference is due to differential transmission and the use of twisted pair cables. Figure 4 shows the master-slave architecture of multi-point communication (up to 32 slave points) with high data transmission speeds and low implementation costs (Wang et al., 2021). The Outseal PLC as a slave uses an RS485 UART to communicate with the master over long distances. The use of two cables can save on communication time between the slave and master.

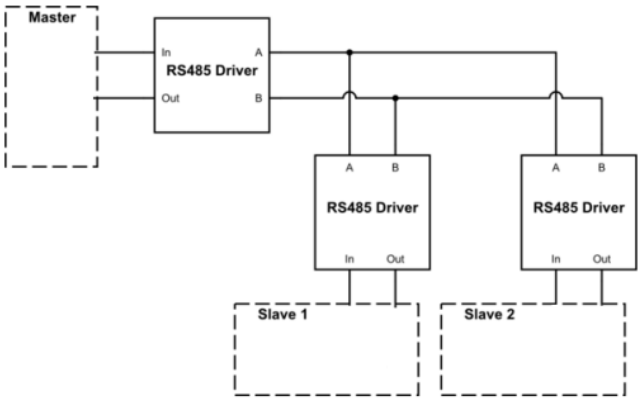

Figure 4. Master and slave architecture in RS 485

e. LM 35 Sensor

The LM 35 sensor is used to detect the temperature around chicken coops for monitoring and control (Lestari et al., 2020). The LM 35 sensor has an accuracy of 1°C / 10 mV with a maximum temperature of 150°C. The LM 35 can be used as an input sensor for the Outseal PLC because it has an analog output that is linear with temperature increases (Hamzah et al., 2021).

Figure 5. LM 35 Temperature Sensor

f. Sensor MQ 135

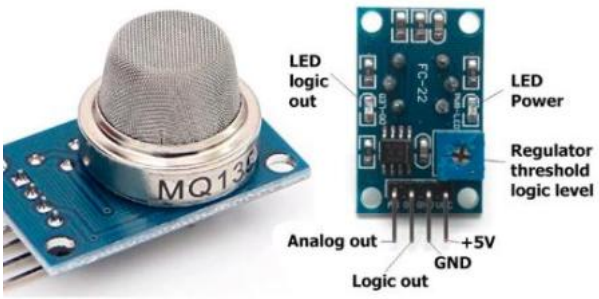

Figure 6. MQ135 Ammonia Sensor

The MQ135 sensor is used to detect ammonia gas around the chicken coop so that it can be monitored and controlled in the designed system (Kristiawan et al., 2021). The MQ 135 sensor has an output that is linear with the monitored ammonia levels. Increasing ammonia levels will result in an increasing output voltage. The output response from the MQ 135 sensor will be input to the Outseal PLC to control and monitor the condition of the chicken coop.

3. System Design

Figure 7 shows a block diagram of a system designed using a Raspberry Pi as a mini PC running Raspberry Pi OS. Node RED is installed on the Raspberry Pi as a PC replacement so that it can communicate with two Outseal PLCs. Using the MODBUS protocol, the Outseal PLC acts as a slave and Node RED can communicate to display temperature and ammonia sensor data. Node RED is used on the Raspberry Pi to create a low-cost and reliable system that requires low power consumption and supports the MODBUS protocol, which is widely used in industry (Muhammad et al., 2020). The Outseal PLC, which has two ADC sensors, A.1 and A.2, will receive temperature sensor data (LM 35) and ammonia gas data (MQ 135), which will then be sent to the Raspberry Pi using USB to RS 485. The output from the relay connected to the fan is fed to R2 of the Outseal PLC. The Raspberry Pi with Node RED will display monitoring data from several sensors and can then be accessed using IoT technology (Bharath et al., 2021). The combination of Raspberry Pi with Node RED can create an industry-standard SCADA because it can be accessed by PC or smartphone, making it an inexpensive solution for creating SCADA with IoT technology.

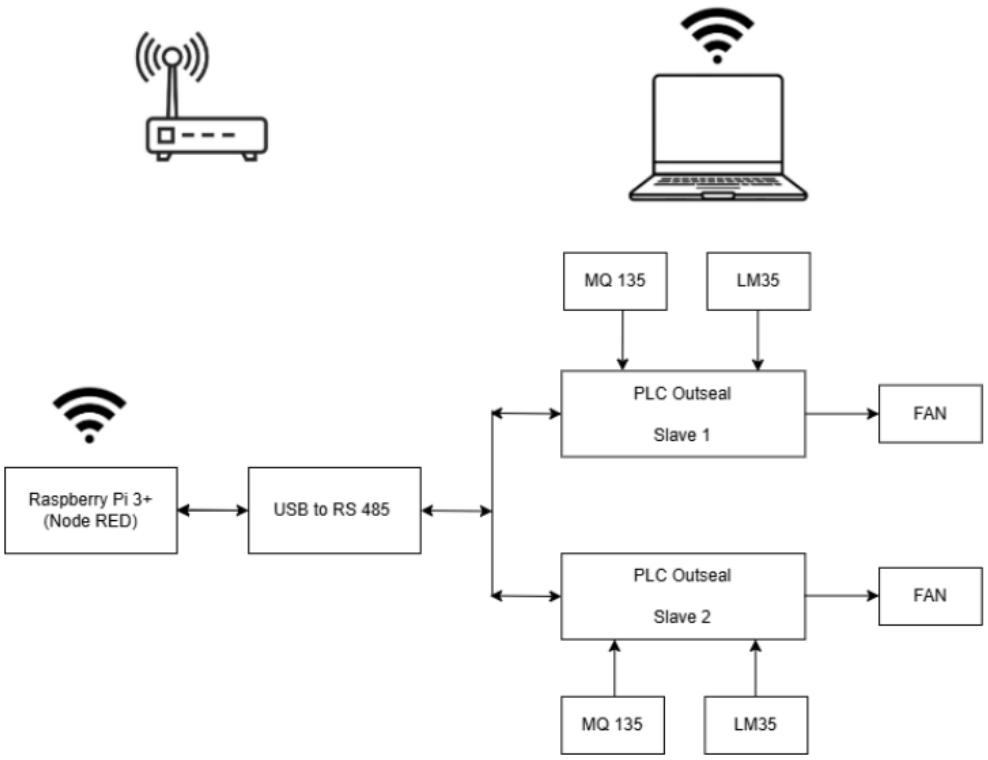

Figure 7. Block diagram of the system being designed

Hardware Design

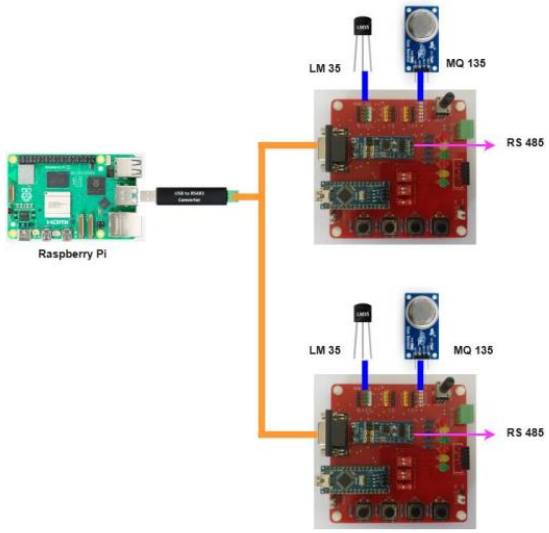

Figure 8. Designed system hardware design

Figure 8 shows the hardware design designed for a temperature and ammonia gas monitoring and control system using Raspberry Pi and Node RED in chicken farming. This study aims to implement the Outseal PLC with RS-485 as a Multi Node in chicken farming using Raspberry Pi and Node RED. Raspberry Pi, with the help of RS 485, communicates with the Outseal PLC. The use of RS 485 in this system is because the Outseal PLC supports RS 485 with Modbus RTU as its protocol. The use of Node RED simplifies communication between the Outseal PLC and the Raspberry Pi as its master controller so that it can be accessed via a PC or cellphone via the Internet of Things.

Software Design

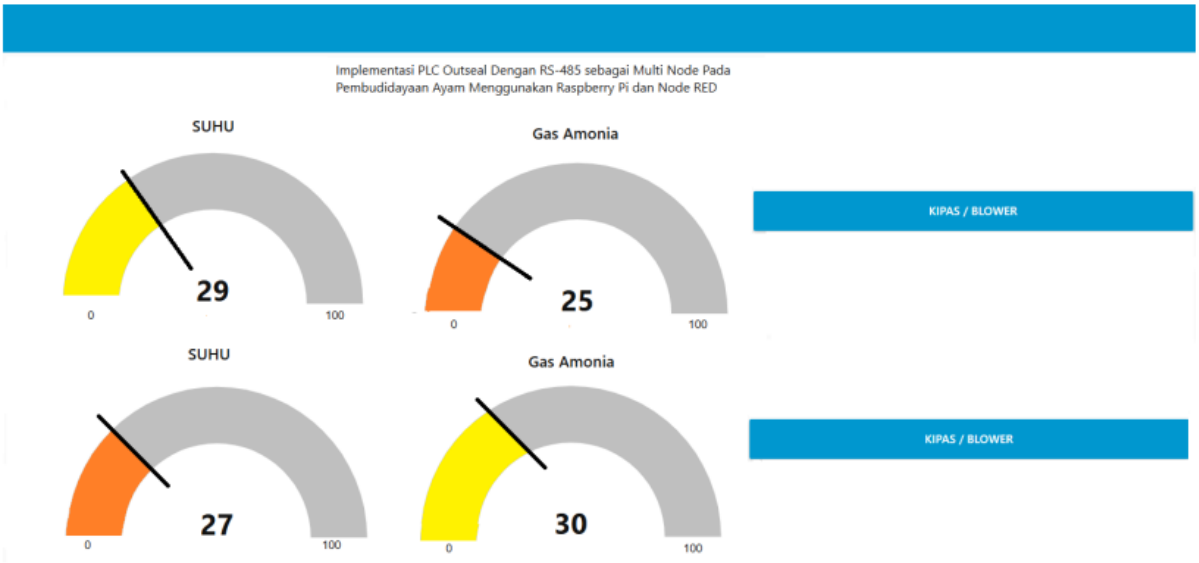

Figure 9. Node RED view on Raspberry Pi

Figure 9 shows the results of the designed Node RED display. Changes in temperature and ammonia will be displayed on the Node RED dashboard. To control the fan/blower, press the fan

or blower button on the Node RED for the manual version. In addition to being able to control whether the blower is active or not based on ammonia gas levels or the temperature of the chicken coop, the use of the Node RED dashboard also makes it easier for chicken farm operators to monitor coop conditions by viewing temperature and ammonia sensors on each plant in the chicken farm.

System Work Process

Figure 10 shows the flowchart of the system that has been created. In this study, the system uses two slaves, namely two Outseal PLCs with two IDs, namely slave ID 1 and slave ID 2. The use of two different IDs to prevent incorrect data transmission between the slave and master. Data transmission between slave and master uses the Modbus protocol. Raspberry Pi as the master will receive data from each slave in the form of temperature sensor data and ammonia sensors from each slave. If the temperature is more than 35 ℃ then the blower will turn on and if the ammonia gas is more than 20 ppm then the blower will also turn on. Every change in temperature and ammonia gas data on each slave will be sent to the dashboard from Node RED.

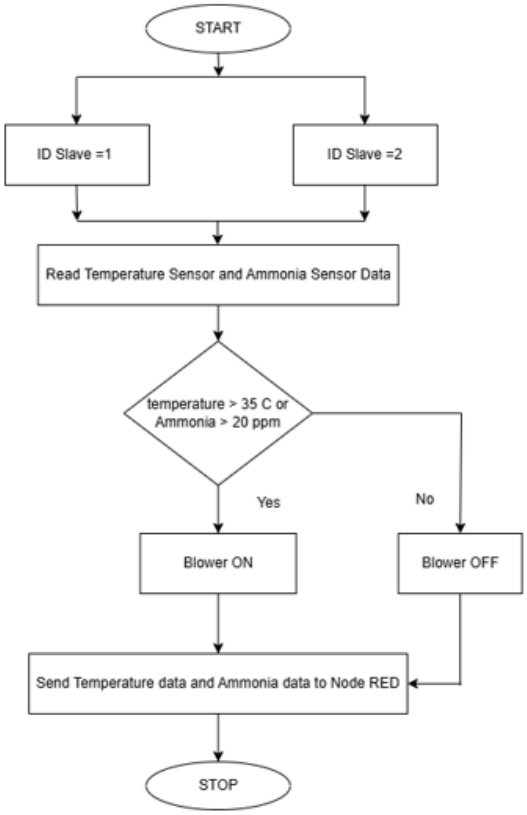

Figure 10. Flowchart of the system created

RESULTS AND DISCUSSION

After designing the system, the next step is for researchers to test the system that has been created. The initial test is to compare the LM 35 temperature sensor with a temperature measuring instrument that is already on the market, namely the Fluke 724. After that, comparing the MQ 135 ammonia gas sensor with a measuring instrument that is on the market, namely the AR 8500. Next, the system will test the entire system whether it can run according to its function and can send temperature and ammonia gas data in real time which can be seen on the Node RED dashboard on the Raspberry Pi.

Whole system testing

The overall system testing begins with the calibration of the LM 35 temperature sensor and then the MQ 135 ammonia gas sensor. This temperature test was carried out to calibrate the temperature sensor programmed with the Outseal PLC with industry standard tools such as the Fluke 724. Table 1 shows the results of the temperature test with the Fluke 724, obtaining a percentage error of 1.71%. With a percentage error of 1.71%, the LM 35 sensor programmed with the Outseal PLC ladder is considered suitable for use. The next test is the ammonia gas calibrated with the Smart Sensor AR 8500. The measurement results of the MQ 135 ammonia gas sensor programmed with the Outseal PLC ladder and the Smart Sensor AR 8500 are as shown in table 2. Table 2 shows a percentage error of 1.303%, so the MQ 135 sensor can be used to read ammonia gas in this study. The error percentage between the sensors available on the market and the use of temperature sensors and ammonia gas sensors is due to changes in the calculation scale of the Outseal PLC ladder language and the limitations of arithmetic calculations using PLC. Figure 11 shows a system that has been designed to view the results of temperature and ammonia gas sensors on each slave. The test results show that communication between slaves using RS485 does not experience significant obstacles. Data from the LM 35 temperature sensor and the MQ 135 ammonia gas sensor is displayed on the Node RED dashboard. The Node RED dashboard display on the Raspberry Pi makes it easy for chicken farm staff to monitor and control temperature and gas sensors in the chicken coop.

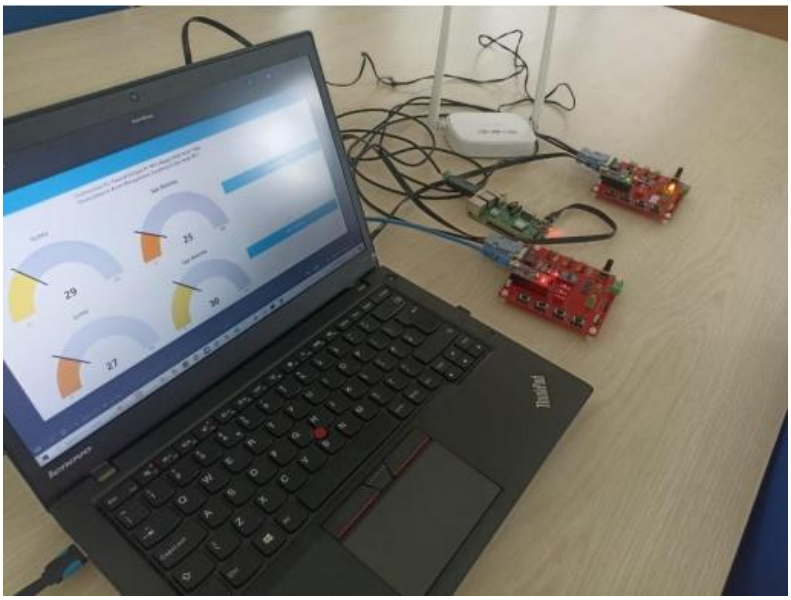

Figure 11. overall system testing

Table 1. Temperature sensor test results using Fluke 724.

No	LM35	Fluke 724	% error
1	30	31	3,2 %
2	31	31	0 %
3	28	28	0 %
4	30	30	0 %
5	25	26	3,8 %
6	27	27	0 %
7	26	27	3,7 %
8	24	25	4 %
9	40	41	2,4 %
10	31	31	0 %
	% average error		1,71 %

Table 2. Ammonia gas sensor test results using AR 8500.

No	MQ135	AR8500	% error
1	20	21	4,7 %
2	26	26	0 %
3	28	28	0 %
4	30	30	0 %
5	45	46	2,1 %
6	48	48	0 %
7	50	51	1,9 %
8	60	61	1,63 %
9	70	71	1,4 %
10	75	76	1,3 %
	% average error		1,303 %

Table 1 shows the testing of the LM 35 temperature sensor with the Fluke 724. This test was carried out by providing different heat responses to the LM 35 and Fluke 724 sensors simultaneously and then observing the results. This experiment was carried out for 10 trials with different temperatures. The results of the 10 trials produced an error of 1.71%. Table 2 shows the testing of the MQ 135 ammonia sensor with the AR 8500. This test was carried out by providing different ammonia gas responses to the MQ 135 and AR 8500 sensors simultaneously and then observing the results. This experiment was carried out for 10 trials with different ammonia gases. The results of the 10 trials produced an error of 1.303%. The error percentage occurs due to differences in the calculation scale on the ladder PLC with sensor instrumentation available on the market as validation of the tool made.

CONCLUSION

From several tests conducted, it can be concluded that Raspberry Pi can be used as an alternative to PC to install Node RED and create SCADA easily and cheaply. The use of Node RED on Raspberry Pi makes it easy to create a monitoring and control system for temperature and ammonia gas in chicken farming. Programming temperature and ammonia gas sensors with a ladder using PLC Outseal has an error percentage of 1.71% when compared to Fluke 724 for temperature and ammonia gas sensors MQ 135 has an error percentage of 1.303% when compared to AR 8500. So the monitoring and control system for temperature and ammonia gas using Raspberry Pi and Node RED is in accordance with the researcher's expectations. As a further development, the researcher suggests that the system can be developed with Grafana dashboard so that the display is better and more informative and the use of Modbus TCP IP will make it easier to integrate Raspberry Pi into SCADA than using RS 485. This research is expected to be implemented to increase productivity and achieve maximum results from broiler farming.

ACKNOWLEDGEMENTS

I express my sincere gratitude to my parents and my supervisor who have helped and supported me in the preparation of this paper. I also extend my gratitude to G-Tech, the applied technology journal that published my research findings.

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