

## Design of Outseal PLC-Based Temperature and Humidity Regulator for Oyster Mushroom Cultivation Rooms Using Node-RED

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| Article Information                                                                                                                            | ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| <b>Article History</b><br><br><b>Received</b> : December 01, 2024<br><b>Revised</b> : December 11, 2024<br><b>Published</b> : January 04, 2025 | <p>Oyster mushroom is one type of exotic plant that has high economic value and great potential to be developed commercially. The current economic condition of mushroom cultivation is not supported by the availability of adequate investment capital and limited human resources in the oyster mushroom sector. In addition, oyster mushroom cultivation requires special skills and supporting technology. Increasingly developing technology provides more choices in technology development, especially in the field of oyster mushroom cultivation. PLC Outseal is one alternative in the development of oyster mushroom cultivation technology. PLC Outseal was chosen because it is cheap and has been proven reliable in the industrial world. Controlling room temperature 22 - 28 °C and humidity 60 - 80% in oyster mushroom cultivation is very important for the success of oyster mushroom cultivation. In this study, the use of the LM35 sensor with ladder plc outseal programming has an error of 1.3% when compared to the HTC-1 digital thermometer and the humidity sensor has an error of 0.69% when compared to the SM150T. The use of RS 485 in communication up to 110 m between slaves has no obstacles and is very stable in testing between slave plc outseal. Node RED as an IoT (Internet of Things) platform is very good for monitoring the temperature and humidity of the growing media in mushroom cultivation.</p> |
| <b>Keywords:</b><br><br><i>PLC Outseal;</i><br><i>Oyster Mushroom;</i><br><i>Temperature;</i><br><i>Soil Moisture;</i><br><i>RED Node;</i>     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## INTRODUCTION

The goal of development in the agricultural sector by the current government is national food self-sufficiency. The development of the agricultural sector is also accompanied by the development of technology in agriculture. The technology used to achieve maximum results has been used in several agricultural researches such as smart gardens that have been developed in oyster mushroom cultivation (Dani et al., 2022). The development of oyster mushroom cultivation technology is very easy because it requires little land but has quite a lot of results and can be developed as an alternative additional income for the community (Az-Zahra et al., 2021).

The benefits of oyster mushrooms that can be used as nutritious food and have low prices can be developed by several community PKM to increase income (Putra et al., 2021). Good sales and marketing distribution will increase the income of mushroom farmers (Fauzan et al., 2020). The biggest challenge in oyster mushroom cultivation is controlling the temperature and humidity of the oyster mushroom cultivation room. The technology needed for oyster mushroom cultivation to regulate the environmental conditions of oyster mushrooms so that oyster mushrooms can grow

optimally. Maximum oyster mushroom development will result in abundant and good quality oyster mushroom production. The selection of technology used should have reliable and long-lasting performance, namely using PLC (Aziz et al., 2021). PLC (Programmable Logic Controller) used in oyster mushroom cultivation to regulate the provision of water in the oyster mushroom cultivation room environment to maintain the temperature and humidity to suit the needs of oyster mushrooms to grow optimally, namely 22 - 28 °C and humidity 60 - 80% (Ponimat et al., 2021).

PLC which has reliability in long-term and continuous work has a weakness, namely it is expensive and difficult to afford for small home industry level entrepreneurs (Putri et al., 2021). Based on the weakness of the high price of the PLC, the use of PLC Outseal is an alternative for use in oyster mushroom cultivation because it has a cheap price and can be programmed easily and reliably (Yudha et al., 2022).

PLC Outseal is used to control the room temperature and humidity of the growing media in the oyster mushroom cultivation room. The LM 35 sensor is used to determine the temperature in the environment of the eastern mushroom cultivation room. LM 35 is used because it has an analog output that can be input from the PLC Outseal. The soil moisture sensor is used to determine the humidity of the growing media in oyster mushrooms. Soil moisture is used because it has an analog output that is entered into the growing media of oyster mushrooms. Inappropriate sensor point placement causes oyster mushroom cultivation results to be less than optimal (Tanadi et al., 2020). Based on this research, this study uses several PLCs with master slave architecture to overcome the weaknesses of the sensor placement.

The use of IoT (Internet of Things) technology as remote monitoring and control is an added value of the designed system. The IoT platform from Node RED was chosen because it has a protocol that supports PLC Outseal, namely MODBUS. From this research, it is expected to be an effective solution to increase the production of cheap oyster mushrooms and is used for mushroom farmers in oyster mushroom cultivation.

## RESEARCH METHODS

The following research method contains hardware and software planning and system requirements analysis in the development of research tools or systems. The system design uses a master and slave architecture. Node RED is used as a master and PLC Outseal as a slave. In this study, 2 slaves were used, namely PLC Outseal with several sensors, namely the LM35 sensor and the soil moisture sensor.

### System Design

This study uses a master and slave architecture. For slaves, PLC Outseal is used, each slave is tasked with controlling and monitoring the temperature and humidity of the growing media of the oyster mushroom cultivation room. Figure 1 shows the hardware planning using two slaves, namely PLC Outseal 1 and PLC Outseal 2. Each slave will provide information on the temperature and humidity data of the growing media of the oyster mushroom cultivation room to the master, namely Node RED. The communication protocol used is the MODBUS protocol with RTU (Remote Terminal Unit) mode. The temperature and humidity data will be displayed on the Node RED dashboard.

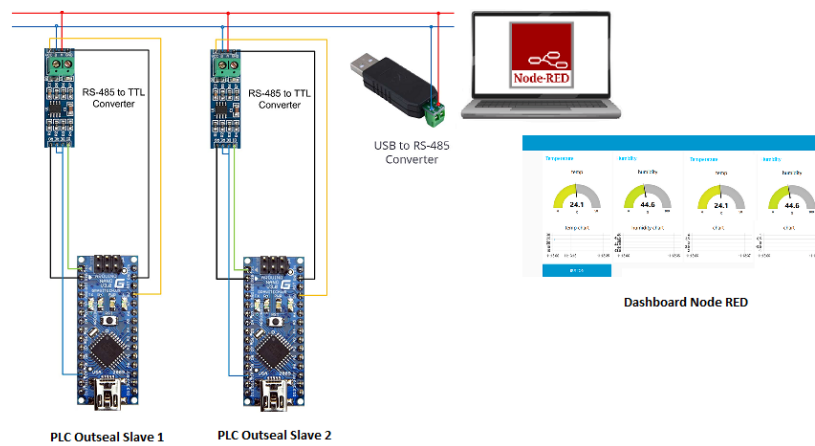


**Figure 1.** Hardware design with master and slave architecture

## Hardware Design

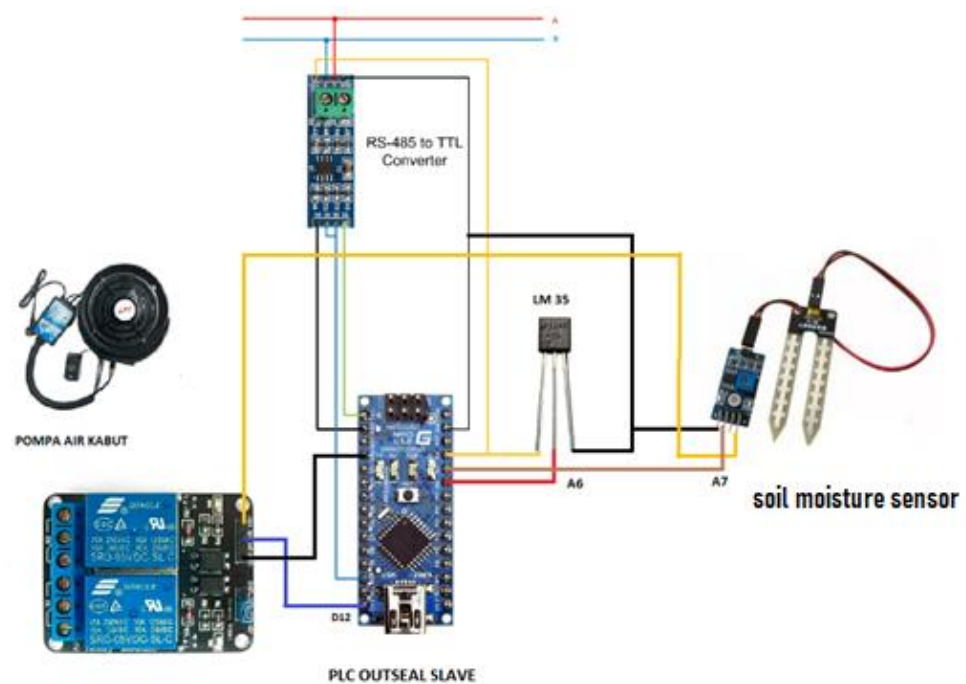


**Figure 2.** PLC Outseal hardware design for each slave

From Figure 2 shows the hardware design that will be used in this study. PLC Outseal has 2 analog input channels with analog voltage as input and with ADC resolution of 10 bits with a maximum value of 1023. The two channels are A.1 and A.2 which are on the Arduino Nano pins A6 and A7. In this study, the LM 35 temperature sensor is inserted into the Arduino Nano pin at A6 and the soil moisture sensor is inserted into A7. The output is R2 from the outseal or pin D12 from the Arduino Nano which will provide a control signal to the relay to activate the mist water pump to control the desired temperature and humidity, namely a temperature of 22 - 28 °C and humidity of 60 - 80%. The prototype of the tool designed is as shown in Figure 3.

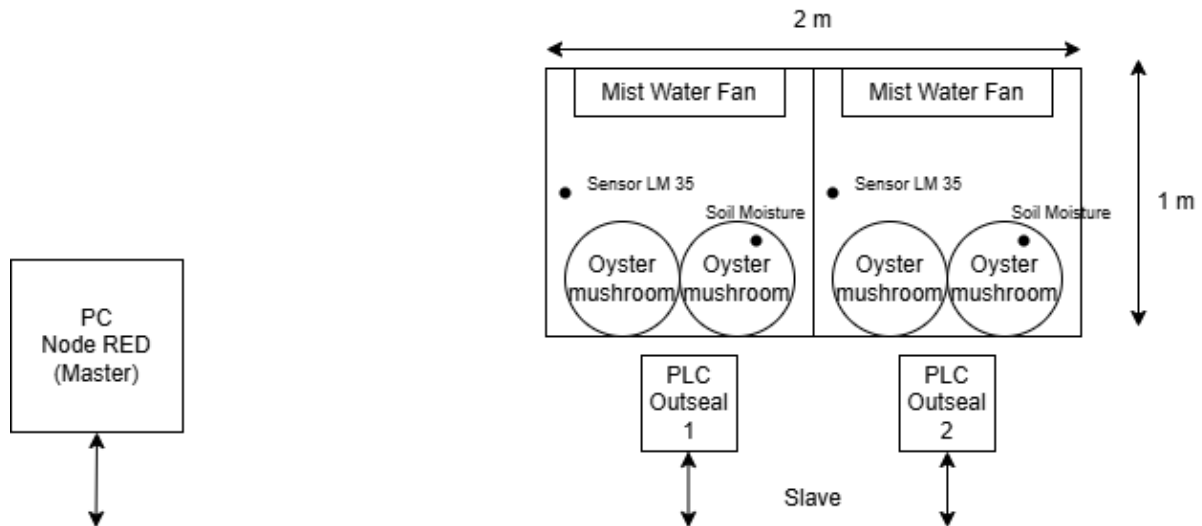


Figure 3. Design of tool prototype

### Node RED Dashboard Design

In this study, software design begins with PLC Outseal programming on each slave with a ladder program, then each ladder will have a modbus protocol which then the modbus address will communicate with the designed Node-Red. Generally, the ladder program used is the same for each PLC, only the naming of the input address and output address is different. The master uses the Node RED program with the MODBUS protocol to communicate with the slave, namely the Outseal PLC. The flow structure designed in Node-Red can be seen in Figure 4 and the dashboard display designed is as in Figure 5.

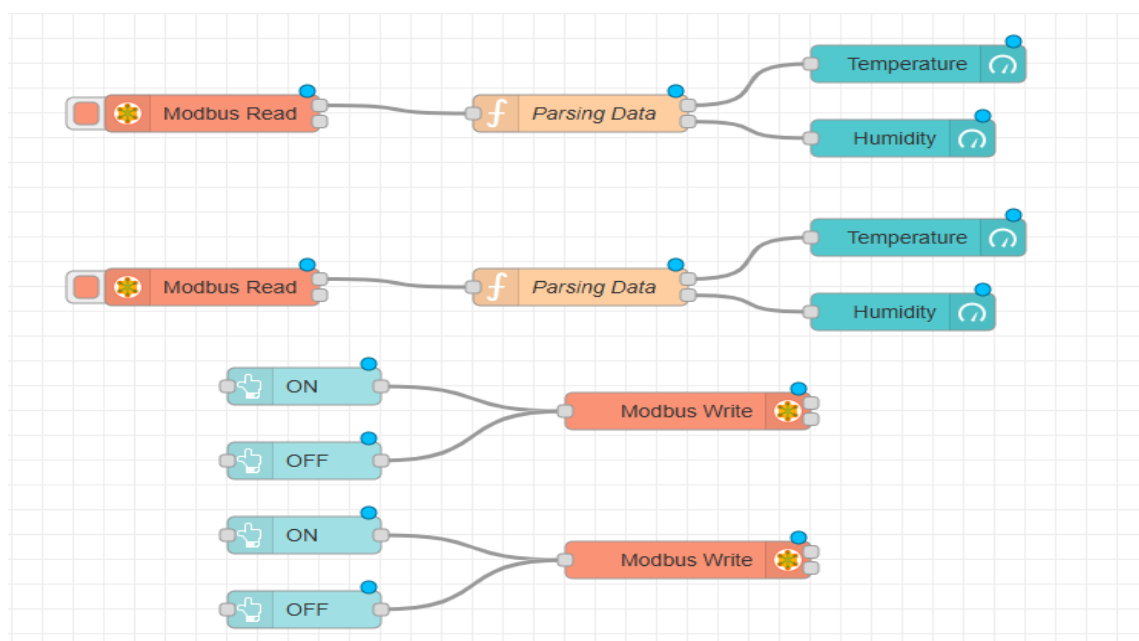


Figure 4. Designed flow structure in node red

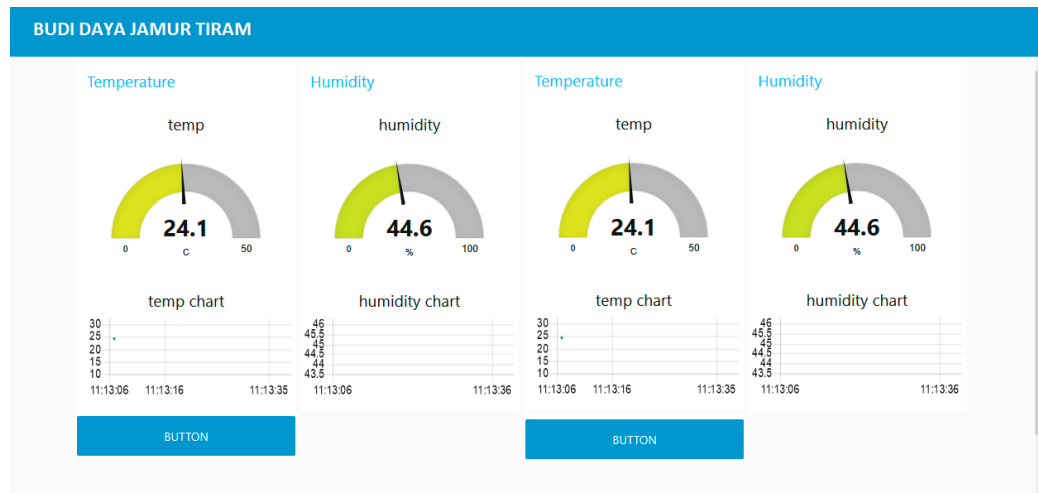


**Figure 5.** Software design on the Node RED dashboard

### System Work Process

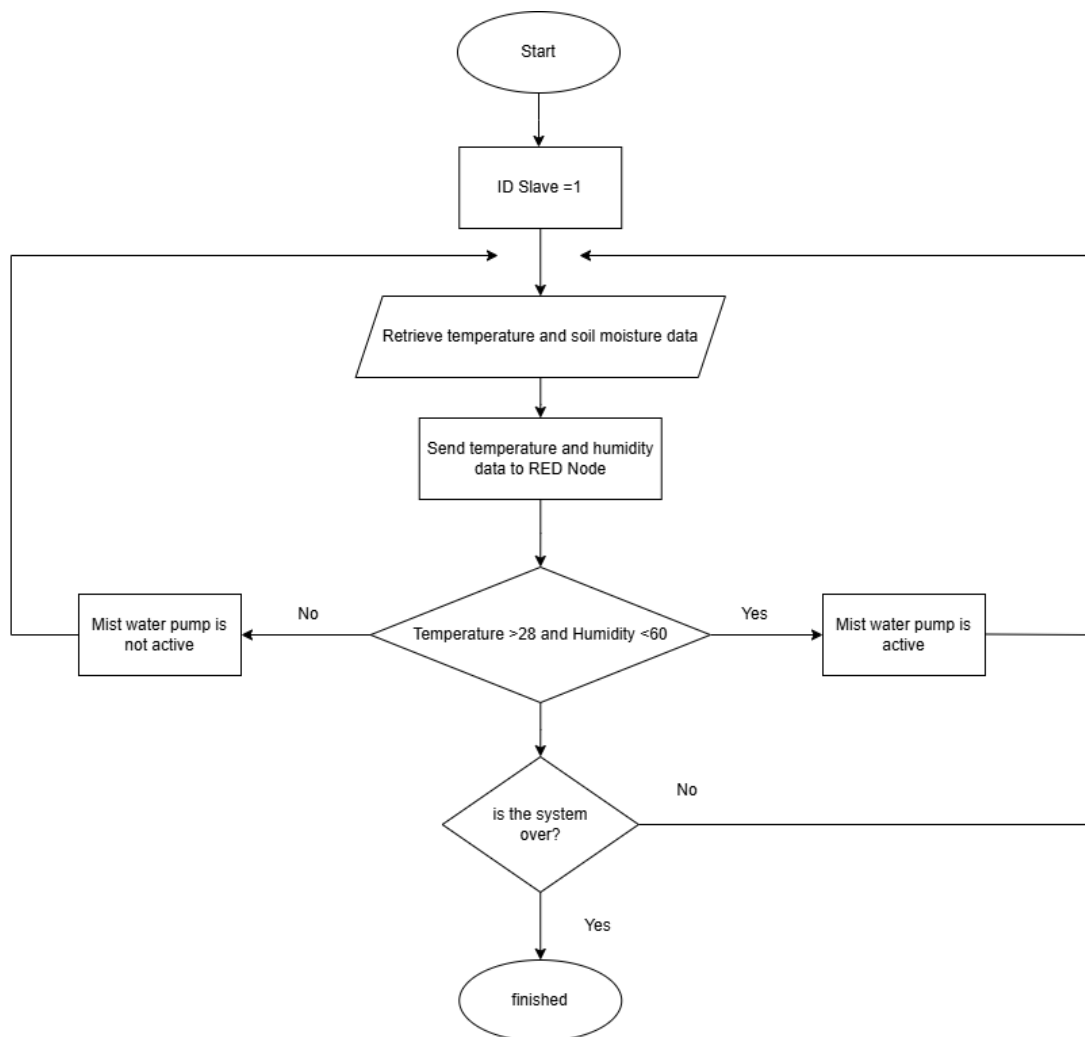


**Figure 6** LC Outseal slave 1 and slave 2 work flowchart

Figures 6 and 7 show the working system of the Outseal PLC implementation as a temperature and humidity regulator for the growing media in the oyster mushroom cultivation room based on Node RED. The working process of the Outseal PLC on slave 1 and slave 2 is shown in Figure 5. In Figure 5, the difference is the ID of the slave because with the master slave architecture with multi slaves, it can be distinguished from the ID of each slave. PLC Outseal slave 1 is declared with ID = 1 and PLC Outseal slave 2 is declared with ID = 2. Each slave will take soil temperature and humidity data and then send the temperature and humidity data to the RED node with the identifier being the ID address of each slave. The RED node will distinguish the ID of the data sent and then it will be sent to the dashboard that has the same ID so that the data sent will not be misplaced. The Node RED flowchart will be shown in Figure 7. The controlled temperature and humidity are temperature if it is more than 28 °C and humidity is less than 60% then the mist water pump will turn on and will turn off if the temperature and humidity have reached the desired set point, which is less than 28 °C and humidity is more than 60% (Ponimat et al., 2021).

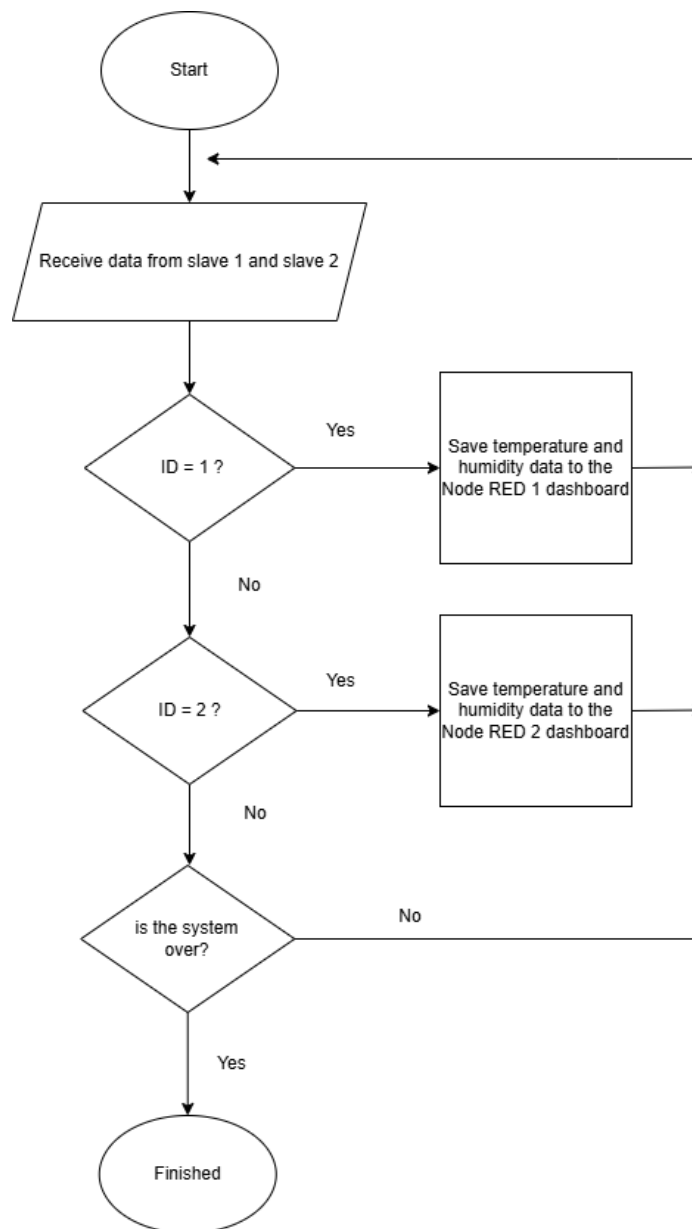


**Figure 6.** Node RED work flowchart

## RESULTS AND DISCUSSION

After designing the system, the next step is to calibrate the sensor and test the entire system that has been created. The design of the temperature and humidity controller for oyster mushroom cultivation rooms based on PLC Outseal using Node-RED conducted initial testing and calibration of the LM 35 temperature sensor by comparing it with a sensor available on the market, namely the HTC-1 digital thermometer. The next test is the soil moisture sensor which is compared with the SM 150T soil moisture available on the market. The test aims to see the differences and percentage of errors between the sensors we designed and sensors that are already on the market. Then the entire system is tested with two sensors and a pump. PLC Outseal and master slave architecture are also tested to determine the communication of sensor data between PLCs. The Node RED dashboard test is carried out by looking at the response of the temperature and soil moisture sensors that are monitored.

### LM 35 sensor testing

This test was conducted to calibrate the LM 35 sensor with the HTC-1 digital thermometer available on the market. The test results can be seen in table 1. Table 1 shows that the average error of the LM 35 test against HTC-1 is 1.3% with a total of 10 data tests so that the LM 35 in the designed system is appropriate and can be used as a temperature sensor to monitor the temperature in mushroom cultivation areas.

**Table 1.** Test results of the LM 35 sensor with the HTC-1 digital thermometer

| No              | LM 35 | HTC-1 | % error |
|-----------------|-------|-------|---------|
| 1               | 32    | 32    | 0 %     |
| 2               | 30    | 29    | 3,3 %   |
| 3               | 29    | 29    | 0 %     |
| 4               | 30    | 30    | 0 %     |
| 5               | 29    | 28    | 3,4 %   |
| 6               | 28    | 28    | 0 %     |
| 7               | 31    | 30    | 3,22 %  |
| 8               | 35    | 35    | 0 %     |
| 9               | 33    | 33    | 0 %     |
| 10              | 32    | 31    | 3,12%   |
| % average error |       |       | 1,3 %   |

### Soil Moisture Testing

For further testing, the soil moisture sensor used using the Outseal PLC program will be compared with the soil moisture sensor on the market, SM150T. Table 2 is the test result of the soil moisture sensor designed with SM150T with a total of 10 data tests. From table 2 it can be concluded that the difference in average error between soil moisture used in the system with SM150T has an error of 0.69 %.

**Table 2.** Soil Moisture sensor test results with SM150T

| No | Soil Moisture | SM150T | % error |
|----|---------------|--------|---------|
| 1  | 70            | 69     | 1,4 %   |
| 2  | 80            | 80     | 0 %     |
| 3  | 60            | 59     | 1,6 %   |
| 4  | 66            | 66     | 0 %     |
| 5  | 75            | 74     | 1,3 %   |

| No              | Soil Moisture | SM150T | % error |
|-----------------|---------------|--------|---------|
| 6               | 84            | 83     | 1,1 %   |
| 7               | 81            | 81     | 0 %     |
| 8               | 70            | 70     | 0 %     |
| 9               | 67            | 67     | 0 %     |
| 10              | 63            | 62     | 1,5%    |
| % average error |               |        | 0,69 %  |

### Outseal PLC Testing with Master-Slave Architecture



**Figure 7.** Slave distance testing with master slave architecture

Slave distance testing was conducted to see the reliability of the master slave architecture using RS 485 which in theory can be up to 1 km and up to 32 nodes. The first test was given a distance between nodes / slaves of 1 m then given 2,3,10,20 m to 110 m. Testing was not carried out up to 1 km considering the limited research funds. Table 3 shows that testing up to 110 m was very successful and reliable. From this test it was found that RS 485 can be developed up to 32 nodes and the cable length of 110 m is very good in its data communication.

**Table 3..** Testing between slaves regarding distance and success of data transmission

| No | Distance Between Slaves (m) | Condition |
|----|-----------------------------|-----------|
| 1  | 1                           | succeed   |
| 2  | 2                           | succeed   |
| 3  | 3                           | succeed   |
| 4  | 10                          | succeed   |
| 5  | 20                          | succeed   |
| 6  | 30                          | succeed   |
| 7  | 40                          | succeed   |
| 8  | 50                          | succeed   |
| 9  | 100                         | succeed   |
| 10 | 110                         | succeed   |

### Testing with the whole system

The overall system testing is carried out to determine whether the system works as intended. Table 4 shows the results of the system testing of one slave. Temperatures above 28°C will activate the mist water pump and will turn off if below 28°C, as well as the humidity of the mushroom planting media being monitored. If the humidity of the mushroom planting media is less than 60%, the mist water pump will be activated. Likewise, if the temperature is more than 28°C and the humidity is less than 60%, the mist water pump will turn on.

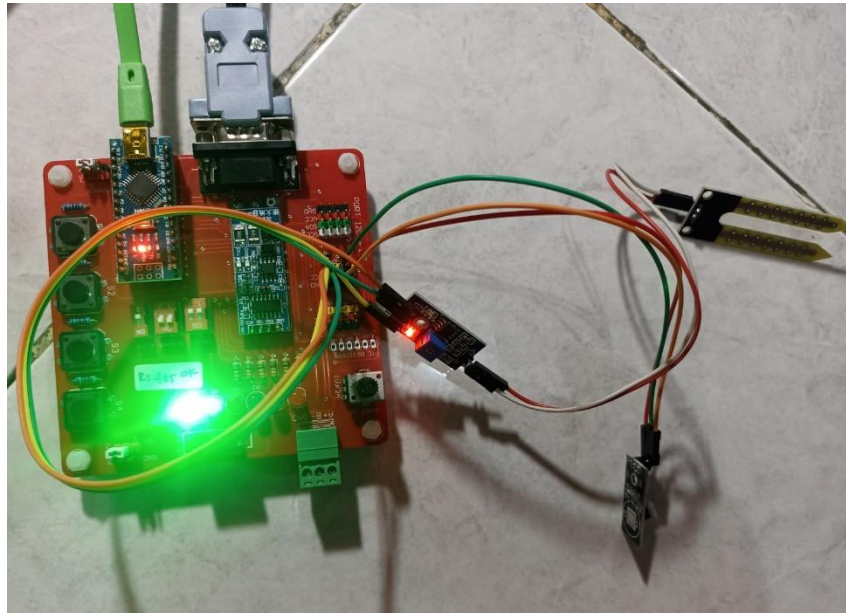


**Figure 8.** Tool testing on 1 slave

Figure 8 shows the tools to test each slave of the system being tested. The test uses a soil moisture sensor and an LM 35 temperature sensor, the test is carried out by providing several conditions to see the response of the sensor and the reaction of the actuator in the form of a mist water pump.

**Table 4.** Overall testing on 1 slave

| No | LM35 | Soil Moisture | Mist water pump  |
|----|------|---------------|------------------|
| 1  | 30   | 69            | pump is working  |
| 2  | 28   | 80            | pump not working |
| 3  | 27   | 59            | pump is working  |
| 4  | 27   | 66            | pump not working |
| 5  | 30   | 74            | pump is working  |
| 6  | 31   | 83            | pump is working  |
| 7  | 25   | 81            | pump not working |
| 8  | 26   | 70            | pump not working |
| 9  | 29   | 67            | pump is working  |
| 10 | 28   | 62            | pump not working |

### CONCLUSION

From several tests conducted, it can be concluded that the LM35 sensor with PLC Outseal programming compared to sensors on the market, namely the HTC-1 digital thermometer, has an error of 1.3%. So the LM 35 sensor can be used on the PLC Outseal as well as the soil moisture

sensor that has been tested with an error of 0.69%. RS 485 as a multidrop or multinode communication can be used up to a distance of 110 m without obstacles and obstacles by using two slaves in monitoring the temperature and humidity of the mushroom cultivation media using Node RED. Data communication between the two slave PLC Outseal with Node RED did not experience any obstacles and so monitoring the temperature of oyster mushrooms and the humidity of oyster mushrooms could be done properly, as well as the control system of each slave PLC Outseal running according to plan.

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