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Implementation of The Internet of Things on Monitoring and Control Tools Hydroponic System

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ABSTRACT

This Hydroponics is a way of growing crops without using soil. Soil that is actually a place for plants to grow can be supported with sand, husk charcoal and rockwool. In a hydroponic system, nutrients and the pH value of water are absolutely necessary for plant development, every plant that requires different levels of nutrients and pH values of the air, if the nutrient levels are lacking then the plant will not grow as well as if the nutrient content is more then the plant will be poisoned. nutrients, water nutrients will continue to decrease along with the development of the plant itself. Therefore, a measuring tool for nutrient levels in hydroponic plant irrigation systems with android monitoring is made so that humans can monitor hydroponic plants. The tool used by Arduino nano as a microprocessor that is integrated into the TDS sensor works to measure nutrient levels and the pH sensor works to measure the pH value of the air, ESP8266 wifi module on NodeMCU as a gateway that aims to be a liaison from Arduino nano to the web server, Using websites and android applications that act as remote controls for nutrient pumps, pH up, pH down and hydroponic water pumps.

INTRODUCTION

The hydroponic plant monitoring and control system that works using a microprocessor in this case using Arduino nano which is integrated into all existing sensors such as the TDS sensor which detects nutrient levels and the pH sensor detects the acidity of the water in the hydroponic plant water reservoir and is connected using Node MCU which aims to connect the website with the microprocessor in real time in this case hydroponic plants require nutrients and a neutral pH value for maximum results.

Hydroponics is a way of growing plants without using soil, usually done using a water medium containing nutrients. Hydroponics is a way of growing crops using water that has been given nutrient content or nutrients as a growing medium, the hydroponic method itself is a very efficient method at this time considering that this method does not require a large area of land (Siska Handayani et al., 2024).

Water quality in hydroponic plants greatly affects the growth and development process of these plants, in this system using spinach plants, these plants require nutrient levels with a range of 600 to 900 ppm with a pH value of 6.0-7.0. In this system, real time monitoring can be done and control the nutrient pump and pH pump if the TDS sensor reading is less than the minimum limit value of nutrient levels and the pH sensor is less than the minimum limit or more than the maximum pH value (Gregoryan et al., 2019)(Assa et al., 2022).

By implementing IoT in monitoring and controlling nutrient pumps and pH of hydroponic plants where this makes it easier for plant owners to monitor water quality at any time without having to see the plants directly and can be done remotely using an android application.

Based on the problems and background above, the authors make the final project with the title "Implementation of Internet of Things (IoT) on Hydroponic System Monitoring and Control Tools".

LITERATURE REVIEW

Research that has been conducted by previous researchers, both researching monitoring and control of hydroponic plants and research on the use of PH sensors or TDS sensors, includes the following: Monitoring Smart Applications for Monitoring and Controlling of IoT-Based Strawberry Hydroponic Plants (Willi Bianyosa Arif Wibiya & Aris Nasuha, 2023). Design and Implementation of IoT-Based Monitoring Battery and Solar Panel Temperature in Hydroponic System (Rahmatullah et al., 2023). Smart Hydroponic Design Based on Internet of Things (IoT) with

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Android Application (Siska Handayani et al., 2024). Monitoring System and Hydroponic Plant Automation Using Microcontroller Internet of Things Based (IoT) (Ramsari & Hidayat, 2022). Design and Implementation of IOT-Based Monitoring System on Nanobubble-Based Hydroponics Farming (Safira et al., 2023). Control and Monitoring System for Water Ph and Nutrient Concentration in Hydroponic Cultivation of Vegetables Using the Deep Flow Technique (Gregoryan et al., 2019). IoT-Based Hydroponic Plant Monitoring and Control System to Maintain Plant Fertility (Untoro & Hidayah, 2022). Internet Of Things (Iot) In Water Quality Monitoring Systems And Nutrition In Hydroponic Plants (Irawati et al., 2021). IoT-based Monitoring and Control System for Hydroponic Cultivation: A Comprehensive Study (Thakur et al., 2023). Internet of Things-Based Hydroponic System Monitoring Design (Assa et al., 2022). Development Of Hydroponic System Monitoring Applications (Kereh et al., n.d.). Internet of Things (IoT) Based Water Nutrition and PH Monitoring System for Hydroponic Plants (Rivana et al., 2023). Reliable IoT-Based Monitoring and Control of Hydroponic Systems (Tatas et al., 2022).

METHOD

The stages of the method carried out in this study are as follows:
1. Tool design and manufacture
2. Testing of tool parts or components
3. Implementation of the System in Hydroponics

The stages of these stages are explained as follows

Tool design and manufacture

Hardware design is depicted on a block diagram with the aim of being a reference for making hardware to make it easier to assemble and become an integrated.

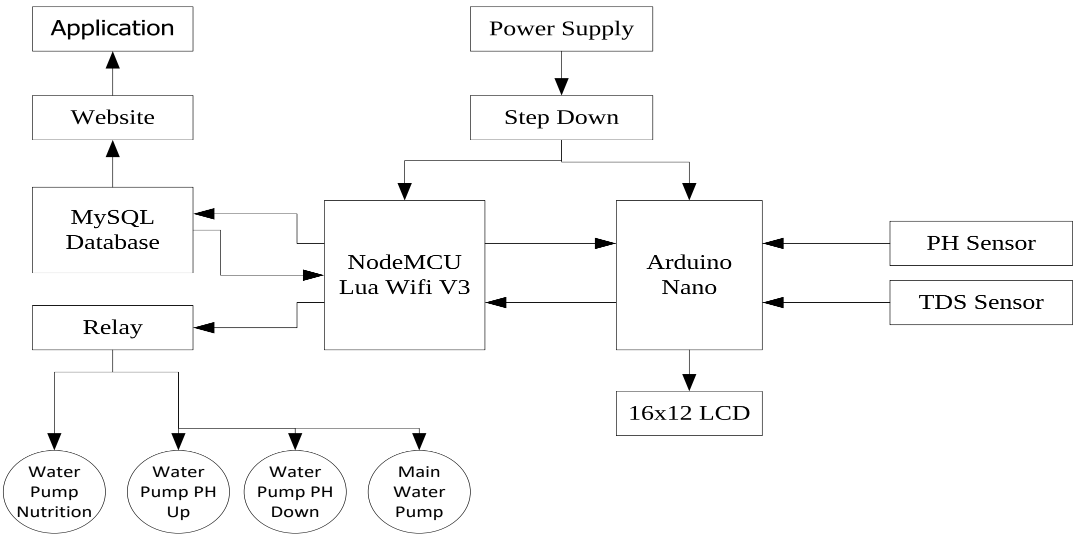

Figure 1. Block Diagram

The block diagram of hydroponic monitoring and control system hardware design can be seen in figure 1. Arduino is the controlling center. The input from the system is a pH sensor as a sensor measuring acid and alkaline levels in hydroponic water, and a TDS sensor as a measure of nutrient levels in flowing hydroponic water.

PH sensors and TDS sensors that function as inputs will send data forwarded to the Arduino. The data will be processed on the Arduino chip so that it can be received by the output. The relay functions as an automatic switch to activate the pump according to the readings of pH and TDS sensor values with specified limits. Node MCU ESP8266 used as a Wi Fi module which is also used to send data to and from users. LCD displays characters in the form of pH values and nutritional values in ppm units.

The data sent by Node MCU is received by the website via HTTP protocol, with the GET data delivery method. Sensor data received by the website will be stored into a database. Then the data will be displayed through website media in the form of graphs or tables. The application is an output that can display, control and monitor through an unlimited distance as long as the internet connection is on.

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Hardware Design

Mechanical design aims to plan something that will be made in mechanical form. Mechanical design is needed because mechanical design is used as a reference to make the overall system.

Hydroponic Plant Design

For the mechanical design of hydroponic tanman can be seen in the picture below. For the size of the backrest of this hydroponic system measuring 90 cm long and 70 cm high, using wood measuring 2.5X7 cm. The plant laying section uses a 2inch paralon pipe with a length of 2 m and has 2 levels, each level has 5 potted holes for the plant later. The results of the mechanical design of component boxes and hydroponic systems can be seen in figure 2.

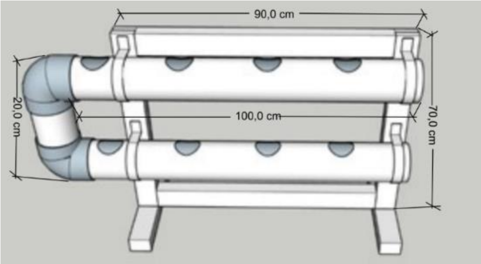

Figure 2. Design of Hydroponic System Front View

Software Design

Next, design is carried out on the software part of this device. Software is used to control the work of hardware in a system. The software design has been carried out as explained as follows:

Flowcharts and Algorithms on Arduino Nano

In the Arduino section, it functions to collect data on pH and TDS sensor readings, then send it to the Node MCU ESP8266. For flowchart can be seen in figure 3 below.

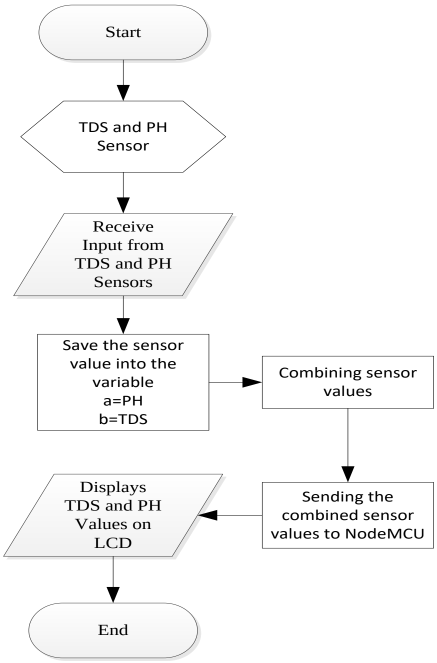

Figure 3. flowchart on Arduino Nano

The algorithm of this Arduino is: first the pH sensor module, TDS takes data on the condition of the hydroponic system water reservoir, then the sensor values are sent to the Node MCU ESP8266. The sensor value will also be

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displayed on the LCD module.

Flowcharts and Algorithms on Node MCU

Node MCU functions to send data to the server via wifi communication using the http protocol and move4 water pumps using relays.

The algorithm of the NodeM CU module is as follows:

First the mcu node will net wifi, then connect with the wifi network, and connect with the website server with this link, https://hidroponikfahreza.000webhostapp.com.

After the mcu node connection is successful, the mcu node will receive data from the Arduino nano module. The mcu node will select whether the data has it from the tds sensor or from the pH sensor, if the data sent by the tds sensor then the data will be sent to the input.php page, using a GET Request. However, if the data is from the pH sensor, the data will be sent to the input.php page using the GET Request method.

Furthermore, the mcu node will activate the pump from the input.php reply, where if the value of the tds pump is 1 (one) sent from the database, the tds pump relay will be active with a value of LOW, besides that the value of the tds pump is inactive with a value of HIGH. If the pH UP pump value is 1 (one) sent from the database, the pH UP pump relay will be active with a value of LOW, besides that the value of the pH UP pump is inactive with a value of HIGH.

If the pH Pump Down value is 1 (one) sent from the database, the pH Down pump relay will be active with a value of LOW, besides that the value of the pH UP pump is inactive with a value of HIGH. if the main pump value is 1 (one) sent from the database, the main pump relay will be active with a value of LOW, otherwise the value of the main pump is inactive with a value of HIGH. Where the relay on the active mcu node is HIGH. Figure 4 is a flowchart of the MCU nodes.

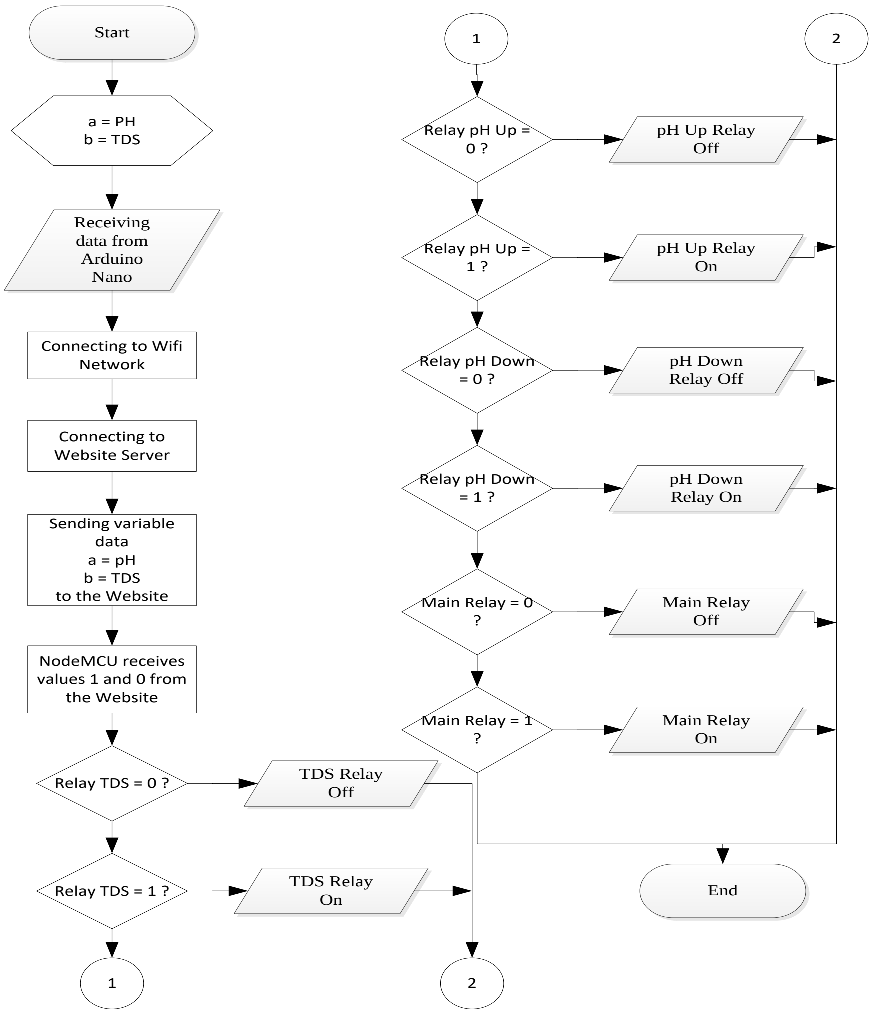

Figure 4. Flowchart on NodeMCU

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Testing tool parts or components

Testing is a way that can be done to find out whether the tool that has been designed and made can work well and as expected. After the tools and systems can work well, then each circuit block and system created is tested and measured.

The tools used in this testing process are:

1. Laptops: To carry out testing of device components and device data communications.
2. Digital Multimeter: To test the output voltage of the sensor components
3. Oscilloscope: To see the shape of the pulse signal sent via serial communication

Implementation of the System in Hydroponics

Arduino nano and Node MCU series that have been compiled

In the network can be seen Node MCU, relay, LCD, pH sensor and TDS sensor that have been connected based on the network contained in the hardware design and in figure 5 is the manufacture of the network that has been compiled.

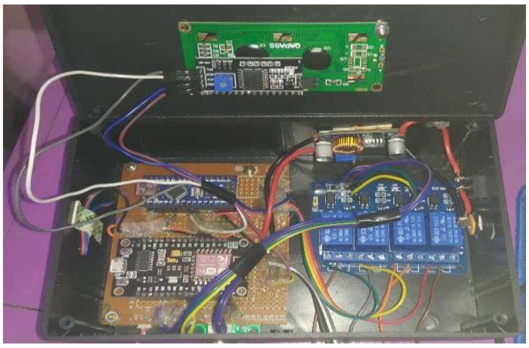

Figure 5. Complete Tool Suite

RESULT AND DISCUSSION

From the results of testing the components of this tool, the following results were obtained:

Sensor Testing

Sensor testing is carried out to find out whether the sensor installed on the tool can operate properly and can measure the environmental conditions of the Hidroponic. The sensors that will be tested in this research are:

Sensor pH

pH sensor testing is carried out to find out whether this sensor can work properly and is able to read the condition of the acidity value in hydroponic system water, pH sensors have analog outputs, so this sensor can be measured the output voltage from the sensor and compare it with the value displayed on the serial monitor.

The way a pH sensor works is that it measures the ADC value of a solution when the sensor tip touches the solution. In order for these results to be obtained, it is necessary to calibrate the output voltage on this sensor. To calibrate the sensor, the following steps are performed:

1. The probe in this circuit is removed first from the circuit.
2. The circuit is connected on a 5V power supply.
3. BNC pin on probe is connected
4. Voltage measurement is carried out on pin P0 of the PH Sensor circuit
5. The trimpot adjust on the circuit is rotated so that the measured output voltage shows 2.5 V DC.

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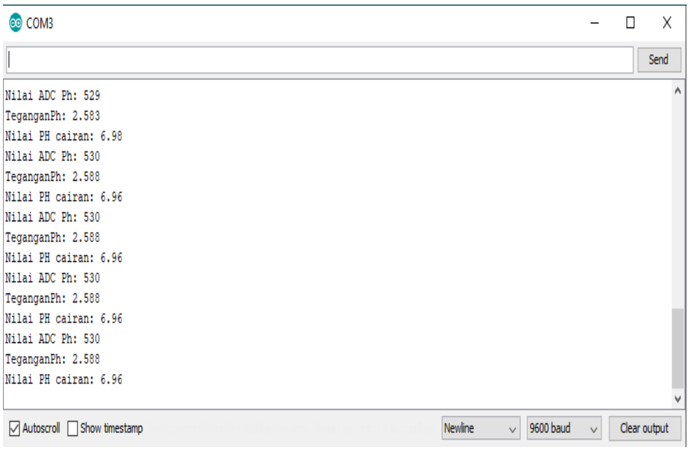

Figure 6. pH Sensor Readings With a buffer of 6.86

Figure 6 is the result of testing a pH sensor using a pH buffer (standart) with a value of 6.86. A pH buffer is a pH solution whose value is known, at the time of testing the pH value read on the serial monitor is 6.96.

Table 1. pH sensor voltage output measurement results

Display pH Sensor Value	Rated Output Voltage (V)
6,98	2,58
6,96	2,58
6,96	2,58
6,96	2,58
6,96	2,58
6,90	2,60
6,87	2,61
6,89	2,60
6,92	2,60

In table 1 is the result of measuring the pH sensor output voltage, voltage measurement using an analog multimeter obtained a voltage value with an average of 2.59 V at the time of reading the pH value of 6.94 in the serial monitor.

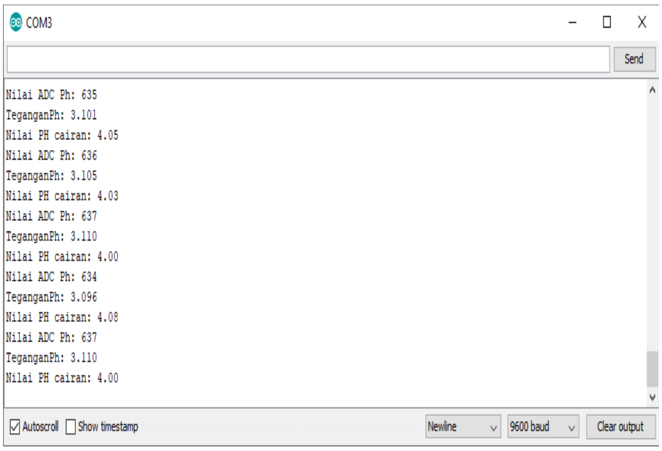

Figure 7. pH Sensor Readings With buffer 4

Figure 7 is the result of testing a pH sensor using a pH buffer (standart) with a value of 4. At the time of testing, the pH value that was read was with an average of 4.05

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Table 2. Output Measurement Results pH Sensor Voltage With buffer 4

Display pH Sensor Value	**Rated Output Voltage (V)**
4,05	3,10
4,03	3,10
4,00	3,10
4,08	3,10
4,00	3,10
4,00	3,10
4,08	3,10
4,08	3,10

In table 2 is the result of measuring the pH sensor output voltage, voltage measurement using an analog multimeter obtained a voltage value of 3.1 V at the time of reading the pH value with an average of 4.04 in the serial monitor.

Sensor TDS

TDS sensor serves to measure TDS (Total Dissolve Solid) levels in water, TDS itself is the concentration level of solid objects dissolved in water. The higher the TDS value, the more turbid the water, and vice versa. The lower the TDS value, the clearer the water. In hydroponic systems, it is used to measure nutrient levels in water reservoirs to drain hydroponic plants.

TDS sensors are analog data outputs as well as pH sensors, so the output voltage can be measured with a multimeter, by attaching a multimeter probe to the output of the TDS sensor and then the voltage output value is compared with the value displayed on the serial monitor display. From the test results the value of the TDS sensor when the TDS sensor probe before being put into a hydroponic water reservoir or not exposed to water.

Table 3. Output Measurement Results TDS sensor voltage when probe is not exposed to water

Tampilan Nilai Sensor TDS (ppm)	**Rated Output Voltage (V)**
0	0
0	0
0	0
0	0
0	0
0	0
0	0

In table 3, the output voltage is obtained from the test results of figure 8 where the voltage is 0V or there is no voltage. Voltage measurement using an analog multimeter.

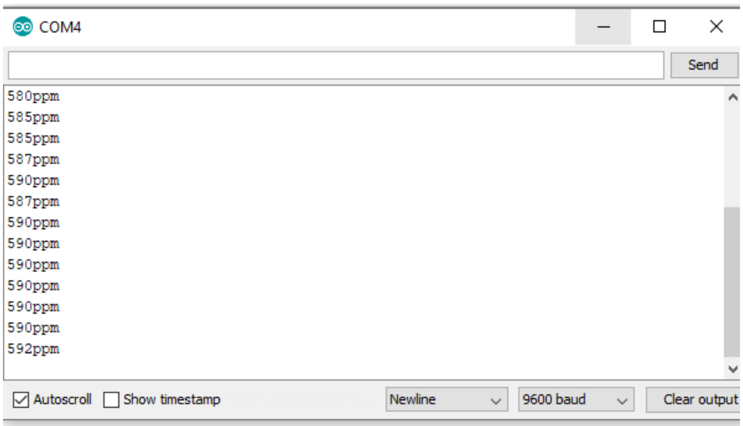

Figure 8. TDS Sensor Measurement Results with Hydroponic Nutrient Liquid

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From the test results in figure 8 is the value of the TDS sensor When the TDS sensor probe is inserted into the hydroponic water reservoir in which there is already nutrient fluid and an average value of 588 ppm is obtained.

Table 4. Results TDS sensor voltage output measurement with hydroponic nutrient liquid

TDS Sensor Value Display (ppm)	Rated Output Voltage (V)
580	1,3
585	1,3
585	1,3
587	1,3
590	1,3
587	1,3
590	1,3
590	1,3

Table 4 is the result of voltage measurement when the TDS sensor probe reads a value with 580 obtained a voltage value of 1.3 V. Voltage measurement at the time of testing using an analog multimeter.

Testing Node MCU

The MCU node acts as a sensor data transmission module from Arduino to the website, it can be referred to as a wifi module. To test the NodeMCU wifi module, it is done by looking at the data sent by Arduino on the COM 4 serial monitor and the data received by NodeMCU on the COM 3 serial monitor, can be seen in figure 9.

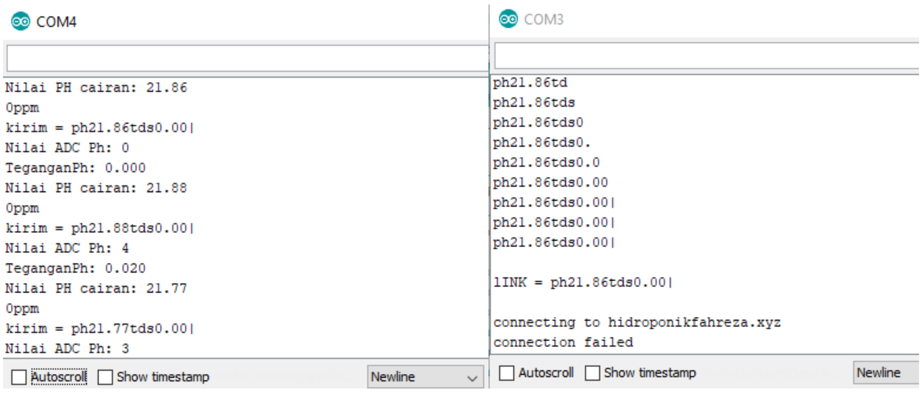

Figure 9. Data sent by Arduino (left) and data received on NodeMCU (right)

From the test results shown in figure 9 it is concluded that the wifi module is well connected to Arduino. So that the process of sending Arduino sensor data can go to websites and android applications properly.

Table 5. Data Sending Response from Arduino to NodeMCU

No	Data from Arduino	Data received by NodeMCU	*Delay* (Second)
1	pH21,86 tds0.00	pH21,86 tds0.00	1
2	pH21,88 tds0.00	pH21,88 tds0.00	1
3	pH21,77 tds0.00	pH21,77 tds0.00	1
4	pH21,77 tds0.00	pH21,77 tds0.00	1
5	pH21,86 tds0.00	pH21,86 tds0.00	1
6	pH21,88 tds0.00	pH21,88 tds0.00	1
7	pH21,88 tds0.00	pH21,88 tds0.00	1
8	pH21,88 tds0.00	pH21,88 tds0.00	1
9	pH21,77 tds0.00	pH21,77 tds0.00	1
10	pH21,77 tds0.00	pH21,77 tds0.00	1

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In table 5 is the response to sending Arduino data to NodeMCU, the data sent is pH sensor data and TDS sensor, in sending the data there is a delay of 1 second.

Testing device communication with Web Server

This test is carried out to test whether the hydroponic system device is able to send data to the server, through the MCU Node. So that testing the connection of NodeMCU with the internet network was carried out.

To be able to connect NodeMCU to a network, NodeMCU must be connected to Wifi. When the Node is connected to wifi, the NodeMCU will automatically get an ip address.

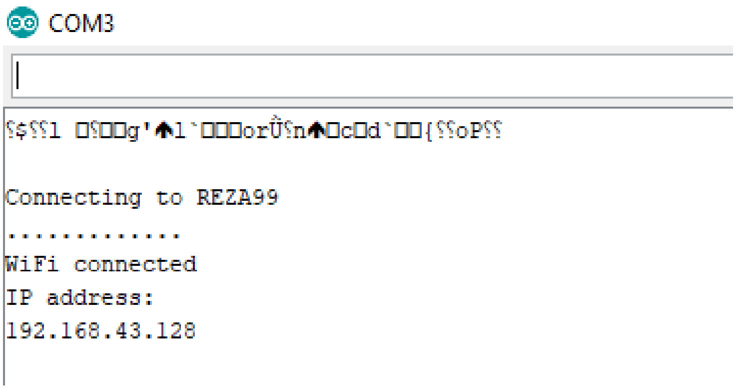

Figure 10. Nodemcu Connection with Wifi Successful

Figure 10 is the connection of NodeMCU with wifi,In this test NodeMCU is connected to a portable hotspot that has SSID "REZA99", and password "aaaaaaaa". When

NodeMCU connects with a portable hotspot, NodeMCU gets the IP address 192.168.43.128.

Figure 11. Data transfer process to server successfully

Then after testing the NodeMCU connection with the network, testing the transmission of data from NodeMCU to the server was carried out. In figure 11 is the test result if NodeMCU successfully sends data to the server.

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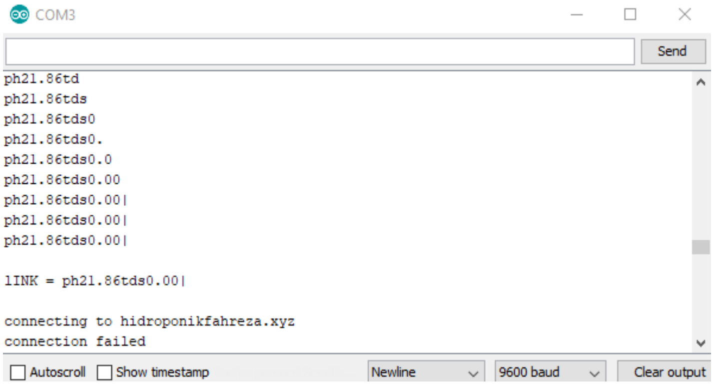

Figure 12. Conection failed when connection with server fails

In the process of sending data to a website whose server is on a web hosting server, if NodeMCU is not connected to internet access, the serial monitor will appear the words connection failed, as in figure 12.

Data Communication Process Between Device and Server

To test device and server communication, the wireshark application is used to capture the process of exchanging data between mcu nodes and servers. In the testing process this time the server used is a local server created using the xampp application, so it is in the process of retrieving and acting as a server.

Figure 13. ip config in cmd to check server ip

The server is connected to a portable wifi hotspot network so that the server gets an IP address of 192.168.43.170 can be seen in figure 13.

CONCLUSION

1. Based on the results of this preparation and discussion, conclusions can be drawn in accordance with the objectives of the study.
2. TDS sensors are capable of reading nutrient levels and pH sensors are capable of reading pH values in hydroponic plant water. Sensor data is displayed in real time on websites and android applications. In monitoring and controlling this hydroponic system in controlling the pH value of water has worked as expected, the pH up distribution pump works if the pH value is below the minimum limit and the pH down distribution pump will work if the pH value is above the maximum limit. The pump will activate when the relay is given a HIGH input and will turn off when given a LOW input.
3. In monitoring and controlling this hydroponic system controls nutrient levels for the hydroponic system as expected, where the nutrient distribution pump works based on the minimum limit of nutrient levels on the sensor set. On the website and application an

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