Design of a Growing Media Control System on IoT-Based Vanda Douglas Orchids

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Abstract— **In the era of rapid technological development, the need for systems or tools that facilitate daily activities and support human life is becoming increasingly urgent. One application that can assist humans in efficiently controlling their environment is a plant monitoring system. This research implements this concept in the context of agriculture and the environment to monitor the quality of the plant ecosystem through the utilization of smartphones and internet connectivity. By leveraging smartphones equipped with specialized applications, users can easily control and obtain sensor readings. This study employs pH soil sensors, DS18B20, and YL-69 to measure pH, temperature, and humidity values of the growing media. The use of a water pump regulated based on humidity levels is a crucial component of this system. Data generated are processed by NodeMCU ESP32 and sent to smartphones. The results of this research yield a device capable of detecting plant media conditions and controlling watering both automatically and manually. Consequently, users can conveniently monitor the health of their plants. This system holds significant potential for enhancing agricultural efficiency and environmental management through the utilization of digital technology and internet connectivity.**

Keywords— DS18B20, Orchid, pH Sensor, Sensor YL-69, Water Pump.

I. INTRODUCTION

Currently, technology is rapidly advancing. It's not difficult to imagine that in our daily lives, we require systems or tools to simplify activities and assist human life. Especially when such a system is integrated, allowing someone to conceive and create a system that can efficiently help humans control their surroundings. One of the ways to achieve this is by creating a system for monitoring the condition of plants [1].

Orchid plants are now starting to be widely cultivated in Indonesia as commercial ornamental flower plants. According to the Balitbang Ministry of Agriculture, orchid plants experience an increase in interest every year, because they have various shapes, patterns, colours and sizes [2]. One type of soil orchid that is widely cultivated is Vanda Douglas, because the requirements for growing vanda orchids are not difficult so it is much favoured by beginners who like to grow crops. This type of orchid can be used as a cut flower because it has a relatively long durability and has many florets in one stalk. Vanda orchids can be planted in polybags with planting media such as top soil, compost, sawdust and so on [3]. However, differences in planting media will have a fairly different influence on their growth, so that the influence of media on orchid growth and better planting media for orchid plants can be known.

Orchid plants have a relatively slow growth speed so special care is needed to grow well [1]. Dry soil and lack of nutrients can cause plants to become infertile and inhibit growth. Fertile soil is soil that has a crumbly loose structure and has high microscopic body activity [4]. The deposition of nutrients with the addition of nutrients provides a planting pH quality of 5 – 6. From this explanation, it can be implemented in the field of agriculture and environmental management to control the quality of a plant ecosystem using pH sensors, temperature sensors, and humidity sensors. These sensors collect data from the planting medium, which is then processed by a microcontroller. With this system in place, it can make it easier for people to determine the condition of the planting medium used, ensuring that plants can thrive and grow.

II. METHOD

A. Research Stages

The design stage is the phase where the tools and systems are tested and designed in accordance with the design. The end result can be both hardware and software. The entire circuit can be used after it has been programmed using the Arduino Software IDE.

The testing method involves testing pH sensors, temperature sensors, humidity sensors, a water pump, and a monitoring application. The purpose of testing this system is to determine whether the sensors can function properly and according to the initial plan. During the monitoring process, data is collected from the sensors in real-time, stored in Firebase, and displayed in the application.

B. Blok Diagram

In Figure 1, there is a block diagram illustrating the system's use of the NodeMCU ESP32 microcontroller as a data processor for input from sensors in order to generate the desired output. This type of NodeMCU is also equipped with a Wi-Fi module, enabling it to connect to the internet. In this system, several sensors are employed, including: a pH sensor, a temperature sensor, and a humidity sensor. The pH sensor is responsible for measuring the pH level of the planting medium, the temperature sensor measures air temperature and humidity, and the humidity sensor measures the humidity level of the planting medium.

The sensor readings, once processed by the NodeMCU, are sent to Firebase and automatically linked to a smartphone. The sensor readings are also displayed on an LCD screen. A Water Pump is included in the system, which automatically irrigates the plants based on predefined parameter values. The relay is utilized to control the automatic on/off operation of the water pump.

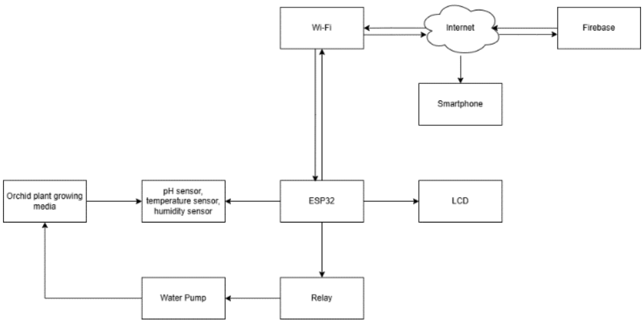

Figure 1. System block diagram

C. NodeMCU ESP32

Figure 2 explain about ESP32. ESP32 is a microcontroller introduced by Espressif System, the successor of ESP8266 microcontroller. In this microcontroller there is already a WiFi module on the chip so that it is very supportive for making Internet of Things application systems. There is a pin out of ESP32 that can be used as input or output to turn on the LCD, lights, even to drive the DC motor [5].

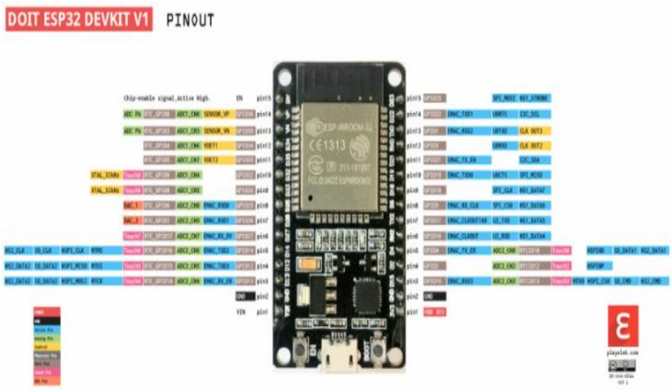

Figure 2. NodeMCU ESP32

D. Soil pH sensor

Figure 3 explain about soil pH sensor. Soil pH sensor is a sensor that detects acidity or alkalinity in the soil. The pH scale that can be measured by this sensor is a range of 3.5 to 15. The pH sensor works at a DC voltage of 5 Volts and has a measurement range of 6 cm from the tip of the sensor into the ground. This sensor can be directly connected to the analog pins of the microcontroller without using an amplifier module [6].

Figure 3. Soil pH sensor

E. Temperature sensor DS18B20

Figure 4 explain about DS18B20 sensor. DS18B20 sensor is a temperature sensor that has an output in the form of a digital signal. This sensor has a similar appearance to the LM35 sensor, except that the sensor DS18B20 is waterproof so the sensor is waterproof and has an internal 12-bit ADC. In the event of a temperature change the sensor DS18B20 can sense the smallest change of 5212-1=0.0012, in a temperature range of -10°C to 85°C, and has an accuracy of ± 0.5% [7].

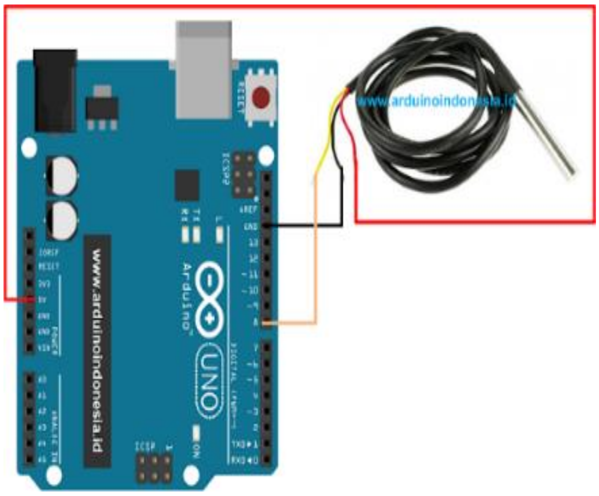

Figure 4. Temperature sensor D6S18B20

F. Humidity sensor YL-69

Figure 5 explain about YL-69 sensor. YL-69 Sensor is a moisture sensor for measuring moisture content in the soil. Soil moisture sensors measure volumetric moisture content indirectly by using electrical resistance, dielectric constant or interaction with neutrons for moisture content [8]. This sensor consists of two probes to pass current through the soil, then the sensor reads its resistance value to get the soil moisture value. If the water content in the soil is increasing, the resistance will be smaller. Vice versa, if the water content in the soil is small, the resistance will be greater [7].

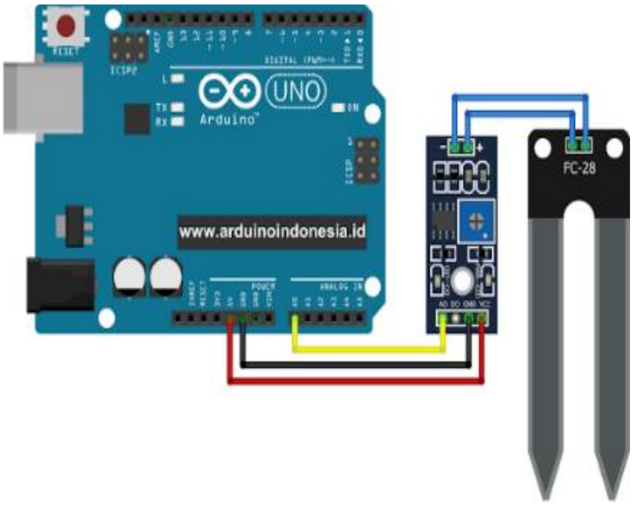

Figure 5. Humidity sensor6 YL-69

G. Relay

Figure 6 explain about The working principle of a relay is a switch that operates electronically using the electromagnetic principle to disconnect and connect electricity. By using a small electric current that can conduct high-voltage electricity. There are two types of relay point contacts, namely Normally Close (NC) and Normally Open (NO). In the event that the coil is not electrified, the COMM leg will be connected to the NC leg. When the coil is electrified, the COMM leg will be connected to the NO Foot [9].

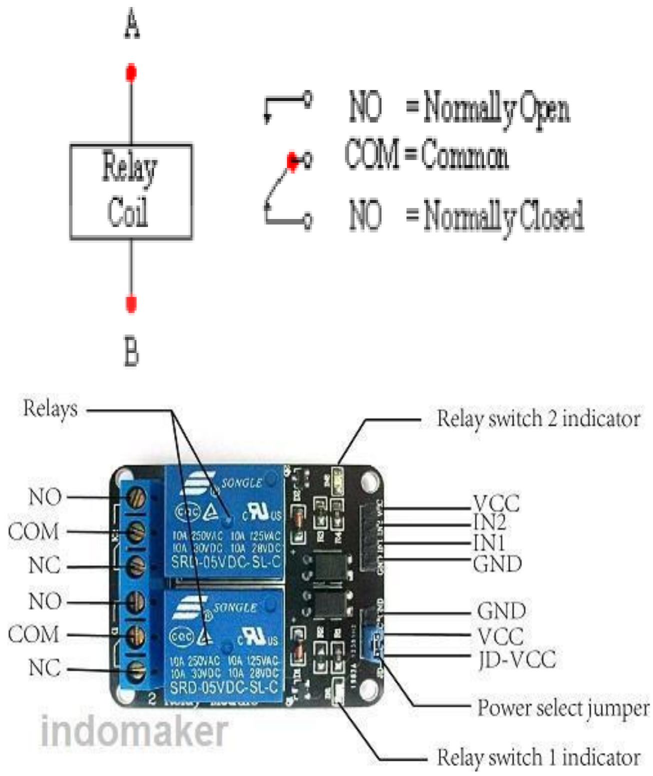

Figure 6. Relay

H. Water Pump

Figure 7 explain about pump, is a device used to move fluids from one place to another through pipes by adding energy to the fluid that is moved and takes place continuously. The pump functions to convert mechanical power from a power source (drive) into kinetic power (speed). The pump also serves to increase the speed, pressure, and height of the liquid [10].

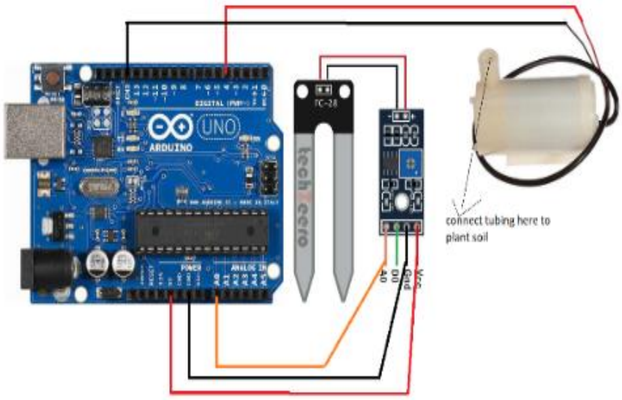

Figure 7. Water pump

I. LCD 16×2

Figure 8 explain about LCD 16×2 (Liquid Crystal Display). LCD is a data viewer module that uses liquid crystals as material for data display in the form of writing and images. Applications in everyday life that are easily found include calculators, gamebots, television, or computer screens [11].

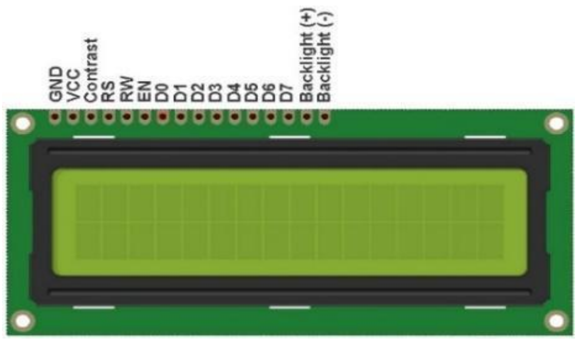

Figure 8. LCD 16×2

J. Android Studio

Figure 9 explain about Android studio is the official IDE (Integrated Development Environment) for Android app development and is open source or free. The launch of Android Studio was announced by Google on May 16, 2013 at the Google I/O Conference for 2013. Since then, Android Studio replaced Eclipse as the official IDE for developing Android apps. Android Studio itself is developed based on Intel IDEA which is similar to Eclipse accompanied by ADT plugin (Android Development Tools) [12].

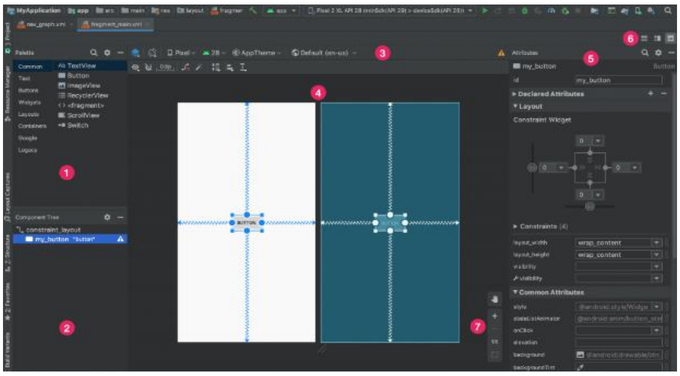

Figure 9. Editor Layout View

K. Arduino IDE

Figure 10 explain about IDE (Integrated Development Environment) is a software application that provides functions to facilitate software development. In general, an IDE is installed on a computer and can only be used on that computer. Arduino's open-source environment makes it easy to write code and upload it to the Arduino board. It runs on Windows, Mac OS X, and Linux. Based on Processing, avr-gcc, and other open-source software [13].

Figure 10. Arduino IDE View

L. Firebase

Figure 11 explain about Firebase is a mobile platform that helps developers develop high-quality apps quickly, user-driven, and earn more money. Firebase aka BaaS (Backend as a Service) is a solution offered by Google to speed up the work of developers. Firebase consists of complementary features that can be combined according to needs (Google). Firebase is used because it has features that are capable enough to be used in some applications [14].

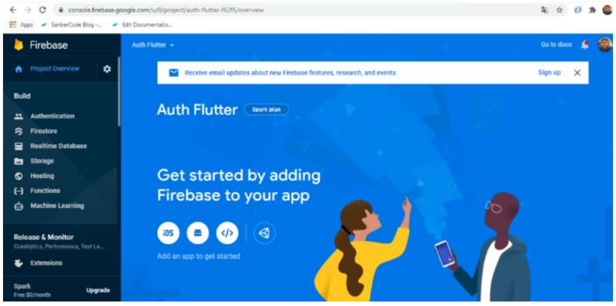

Figure 11. Firebase View

M. Smartphone

Figure 12 explain about Smartphone is a device that is useful for communication, on smartphones there is a PDA function (Personal Digital Assistant) and is capable like a computer. A characteristic of smartphones is having application software, application software aimed at increasing productivity and supporting daily activities. Because smartphones can connect to the internet, they can be used to access the web or content and applications that require the internet [15].

Figure 12. Smartphone

N. System Flowchart

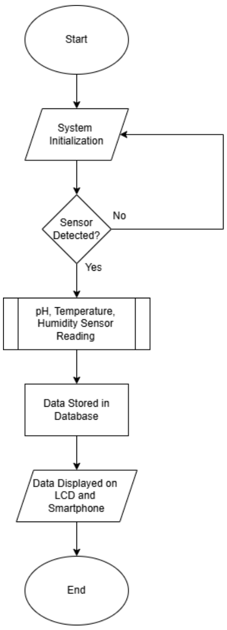

Figure 13. System Planning Flowchart

In Figure 13 shows the process in this study, when the tool is turned on, the initial step taken is to initialize the system, then detect the sensor, if the sensor is not detected then calibrate and return to the initial step. If a sensor is detected, the next step is to take sensor readings, which then the results of those readings will be managed by the microcontroller and stored in a database. After that, the data that has been obtained will be displayed on smartphones and LCDs.

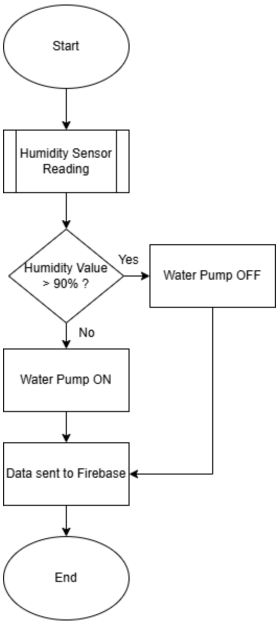

Figure 14. Watering Automation Flowchart

In Figure 14 shows that checking the moisture value of water, if the humidity value is more than 90% then the water pump is off / off. If not, whether the humidity value is less than 60%, if the humidity value is less than 60% then the water pump is on. Otherwise, the data obtained will be sent to firebase.

O. Mechanical Design

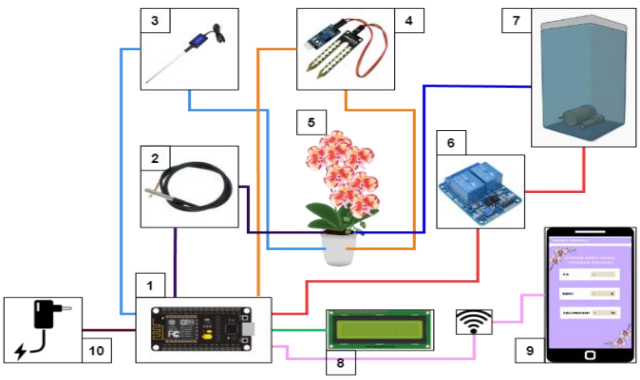

Figure 15. Mechanic design

In Figure 15 shows the entire circuit of each port cable connected to each sensor and other electronic components that will be used in the design of the growing media control system on the IoT-based Vanda Douglas orchid species. The testing process begins with sensor readings, from the readings will be processed by the microcontroller so as to produce output values that have been synchronized.

III. RESULTS AND DISCUSSION

A. Hardware Design Result

The results of hardware planning are the result of combining component components to form a whole circuit in accordance with the plans that have been made before. Figure 16 shows the result of the overall form of mechanical design planning in the form of acrylic boxes is useful as a place for a series of components that have been combined. The bottle is useful as a water reservoir for automating watering plants.

The acrylic box contains a series of components to detect pH, temperature and humidity values in IoT-based orchid growing media. The acrylic box is divided into 2 parts. The closed part is where the components are assembled and the exposed part is where the pH, temperature and humidity sensors are stored. then on the inside of the bottle there is a water pump which is useful for pumping water to water plants automatically.

Figure 16. Hardware Design Results

B. Application Design Result

Android application design is made using android studio software. Figure 17 shows the page display when the application is opened, which is in the form of a splash screen page and continued with the display of the results of application planning, on this page in the form of information on pH, temperature and humidity values read by sensors.

Figure 17. Application Design Result

C. Database Design Results

Database design is created using the Firebase platform. Firebase contains data stored in the real time database and menu. Figure 18 shows that the stored data will be displayed on the smartphone application in real time.

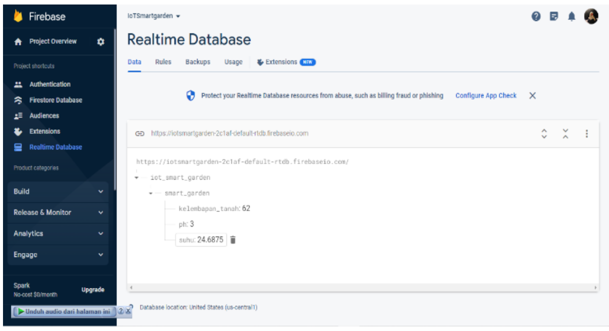

Figure 18. Realtime Database View

D. Soil pH Sensor Test Result

Soil pH sensor testing was carried out on orchid plants with planting media in the form of moss and coconut husk. Testing is carried out 5 times a day using a pH meter as a comparison of the sensor output value. The test results can be seen in Table I and II.

TABLE I
SOIL PH SENSOR TEST RESULT

Moss Planting Medium		
pH sensor value (pH)	**pH meter value (pH)**	**Error (%)**
4	4	0
4	4.06	1.5
3	3.1	3.2
5	5.03	0.6
4	4.1	2.5
Average Error (%)		1.56

TABLE II
COCONUT COIR PLANTING MEDIUM

pH sensor value (pH)	pH meter value (pH)	Error (%)
3	3.15	4.7
3	3	0
3	3.1	3.2
2	2.13	6.1
3	3.1	3.2
Average Error (%)		3.44

E. YL-69 Moisture Sensor Test Results

YL-69 moisture sensor testing was carried out on Orchid Plants with planting media in the form of moss and coconut husk. Testing is carried out 5 times a day. The test results can be seen in Table III.

TABLE III
YL-69 MOISTURE SENSOR TEST RESULTS

Moss Planting Medium	Coconut Coir Planting Medium
Moisture Value (%)	
70	62
61	64
60	65
59	70
62	63

F. DS18b20 Temperature Sensor Test Results

Testing of the DS18b20 temperature sensor was carried out using a thermometer as a comparison. DS18b20 temperature sensor testing was carried out on orchid plants with planting media in the form of moss and coconut husk. The test was carried out 5 times a day using a thermometer as a comparison of the sensor output value. The test results can be seen in the Table IV.

TABLE IV
DS18B20 SENSOR TEST RESULTS

Moss Planting Medium		
DS18B20 (°C)	**Thermometer (°C)**	**Error (%)**
24.13	24	0.54
24.06	24	0.25
24	24	0
24.19	24	0.79
24.3	24.2	0.41
Average Error (%)		0.39

TABLE V
COCONUT COIR PLANTING MEDIUM

DS18B20 (°C)	Thermometer (°C)	Error (%)
24.25	24.2	0.2
24.81	24.8	0.04
24.75	24.8	0.2
24.81	24.9	0.4
24.57	24.5	0.3
Average Error (%)24.9		0.22

G. Water pump Testing results

Water pump testing was carried out on orchid plants with planting media in the form of moss and coconut husk. Testing is carried out 5 times a day. The test results can be seen in Table VI.

TABLE VI
WATER PUMP TEST RESULT

Moss Planting Medium		Coconut Coir Planting Medium	
Moisture on LCD (%)	**Water Pump**	**Moisture on LCD (%)**	**Water Pump**
70	OFF	62	OFF
61	OFF	64	OFF
60	OFF	65	OFF
59	ON	70	OFF
62	OFF	63	OFF

H. QoS Test Results

Quality of Service (QoS) is the ability to provide computer network performance in providing services to applications. QoS testing is the process of testing and evaluating the quality of service of a network, application or system. Computer network performance is caused by several problems, such as bandwidth, latency and jitter problems. In this QoS Test using Wireshark software, testing is carried out using wifi and different providers. With the distance of the tool with a smartphone ranging from 3m.

Throughput testing as shown in Figure 19 below:

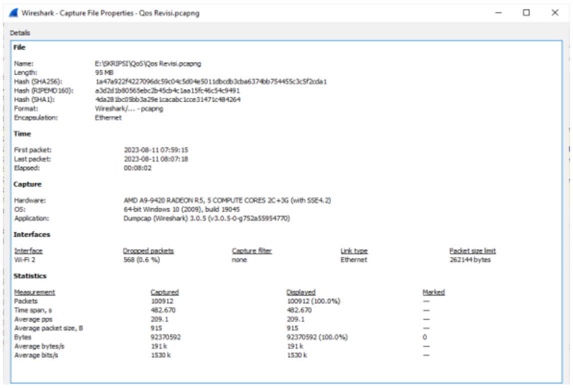

Figure 19. Network Information Details on Wireshark

Throughput= Amount of data sent/Delivery time
Throughput= 92370592/482.670
Throughput= 191k byte×8
Throughput= 1530 k bit/s

Packet loss Testing as shown in Figure 20 below:
Packet loss= (packets sent-packets received)/packets sent×100
Packet loss= (100912-95431)/100912×100
Packet loss= 5481/100912×100
Packet loss= 0,054 ×100
Packet loss= 5,4 %

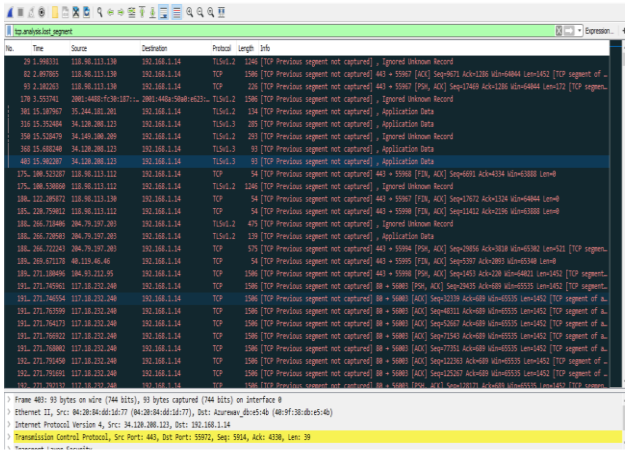

Figure 20. Filtered Packet Loss

Delay testing as shown in Figure 21 below:

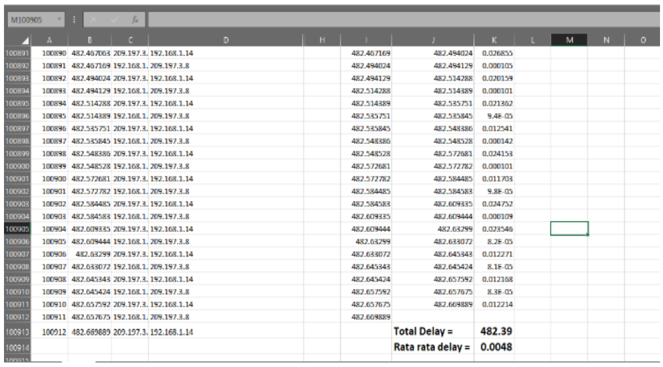

Figure 21. Data View in Excel Application

Average Delay= Total delay/Total number of packages
Average Delay= 482,39 s/100912
Average Delay= 0,0048 s
Average Delay= 4,8 ms

IV. CONCLUSION

Based on the results of this research, it can be concluded that the designed and implemented system demonstrates good overall performance. The system successfully integrates a soil pH sensor, YL-69 sensor, and DS18B20 sensor to identify pH values in the range of 2–5, humidity values between 62%–64%, and temperature values around 24°C. Sensor data are processed effectively by the ESP32 microcontroller and displayed both on an LCD and through a smartphone application, while the water pump regulation system operates in accordance with predefined parameters. Testing on Vanda Douglas Orchid plants using moss planting media resulted in pH values ranging from 3–5, an average humidity of 62.4%, and temperature values between 23.69°C and 24.3°C. Meanwhile, tests conducted on Vanda Douglas Orchid plants with coconut husk planting media showed pH values of 2–3, an average humidity of 64.8%, and temperature values ranging from 24.25°C to 24.81°C. Furthermore, users are able to monitor sensor information in real time through a smartphone application as long as the system is in operation. The Quality of Service (QoS) testing results indicate satisfactory performance, with an average index of 3.3, a throughput of 1530 kbps from the database to the application, packet loss of 5.4%, and a delay of 4.8 ms, demonstrating that the system provides excellent data transmission quality, maintains data integrity, and ensures fast response times.

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