PROTOTYPE OF AN INTERNET OF THINGS (IoT) BASED SHRIMP POND WATER MANAGEMENT SYSTEM

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Abstract - ***The Fourth Industrial Revolution has driven the development of Internet of Things (IoT) technology, playing a crucial role in various sectors, including aquaculture. This article reviews the development and testing of an IoT-based pond water management prototype system for monitoring temperature, pH, and water level automatically. The system employs a DS18B20 sensor for temperature, a DFROBOT V1 pH sensor, and a JSN-SR04T ultrasonic sensor, as well as an ESP32 module for data communication. The system development method follows the Waterfall model, encompassing the stages of planning, modeling, implementation, and testing Testing results indicate that the DFROBOT V1 pH sensor has an average error of 2.06%, the DS18B20 temperature sensor has an average error of 1.714%, and the ultrasonic sensor has an average error of 3.36%. Notifications regarding pond water conditions are sent via the Blynk application, providing ease of monitoring for pond farmers. The conclusion from this testing is that the developed prototype can function effectively in monitoring and managing the water quality of shrimp ponds, although there are some error levels that remain within the tolerance limits.***

Keywords - **Internet of Things (IoT), Water quality monitoring, DS18B20 temperature sensor, DFROBOT V1 pH.**

I. INTRODUCTION

Technological developments mark the Industrial Revolution 4.0; one example of this technological development is the Internet of Things (IoT) [1]. IoT is a concept in which an object or object is embedded with technology such as sensors and software to communicate, control, connect, and exchange data through other devices as long as it is still connected to IoT, which has a close relationship with the term machine-to-machine or M2M [2]. All devices with M2M communication capabilities are often called smart devices [3]. These smart devices are expected to help humans complete various tasks or affairs.

One of the impacts of this IoT development is the fisheries sector [4]. Automation of tilapia feeding with the IoT system is an example of the impact of IoT development in the fisheries sector. Based on the results of observations made at one of the shrimp ponds in Katapiang village, Batang Anai, the pond water monitoring process is carried out to maintain the temperature and pH levels in the water so that they do not exceed the safe threshold for shrimp growth. When the cycle age has reached three weeks or the biomass content in the water is high, the water conditions must be checked at least twice daily at 04.00 and 20.00. A tool is needed to read water quality, namely a sensor, to find out all these parameters. Many farmers still use manual temperature, pH, and water level measurement instruments, meaning all instruments are inserted into the water, and the readings obtained will be recorded. Manual measurements are prone to errors when observing the data displayed using temperature, pH, and height measurement instruments.

In general, the growth rate of shrimp will increase when the water temperature is in the range of 28 - 30˚C [5], but mortality will also increase along with increasing temperature [6]. Making a pond with sufficient depth is one way to ensure that the water temperature is not too hot. The optimal acidity (pH) of water for shrimp life is 7.5 - 8.5 (neutral) because, in this range, it shows an optimal balance between oxygen and carbon dioxide, and various harmful microorganisms have difficulty growing [7]. The ideal depth for cultivating vannamei shrimp is 50-70 cm [8]. The depth of the pond depends on the species of shrimp being grown, the topographic area and climate conditions [9].

To overcome these problems, it is necessary to have a tool in the form of a shrimp pond water management system that makes it easy for shrimp farmers to monitor the quality of shrimp pond water. The prototype of an IoT-based shrimp pond water management system can help shrimp farmers monitor the quality of pond water from a distance based on the internet if the farmer is not in the shrimp pond area and can also monitor the quality of shrimp pond water via the LCD installed on the tool if the farmer is in the shrimp pond area, making the work of shrimp farmers more efficient.

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II. METODE

The waterfall method is a system development process with a progress process that looks like water flowing through the stages of planning, modelling, implementation (development), and testing [10]. This model was chosen because it involves a gradual process from system planning to maintenance, showing a structured linear approach to system development. The waterfall model makes it easier to control and schedule the system development process [11].

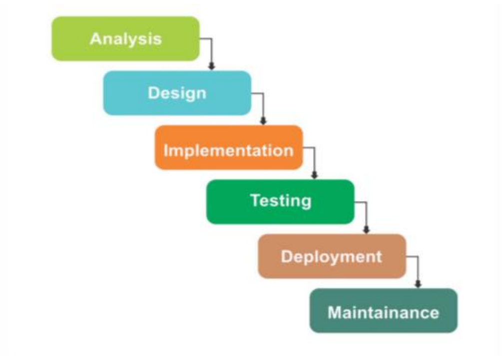

Fig. 1 Model Waterfall

A. *Analysis*

The initial manufacturing process identifies the sensor and output requirements needed in making this tool [12]. The results of the needs analysis in the design of a prototype tool for managing shrimp ponds based on the Internet of Things (IoT) are as follows:

1) ESP32 module as a receiver and sender of data to a smartphone.

2) DS18B20 Sensor Module as a sensor to measure temperature parameters.

3) pH V 1.1 sensor to detect water pH levels.

4) Ultrasonic waterproof JSN-SR04T sensor as a sensor to detect water levels.

5) LCD as a medium to display data read by the sensor

6) Relay as a regulator of the voltage entering the pump.

7) Pump as a medium to move liquid from one container to another.

8) Heater as a tool to increase water temperature.

9) Power or power supply functions as a voltage source for the sensors and pumps.

B. *Design*

After conducting the analysis, the interface and system design stages are carried out based on the functional requirements of the tool. At this stage, determine the form of the prototype [13]. This stage includes several points as follows:

1) Block Diagram

A block diagram is a series of blocks connected by lines that explain the diagram of manufacture and planning. The following image shows the block diagram of the tool's design made in this Final Assignment. In the block diagram, there is a Power Supply, ESP 32, DFROBOT v1.1 pH Sensor, Ultrasonic Sensor, DS18B Temperature Sensor, Push Button, I2C Module, 16 X 2 LCD Display, 4 relays, 4 pumps, and a heater.

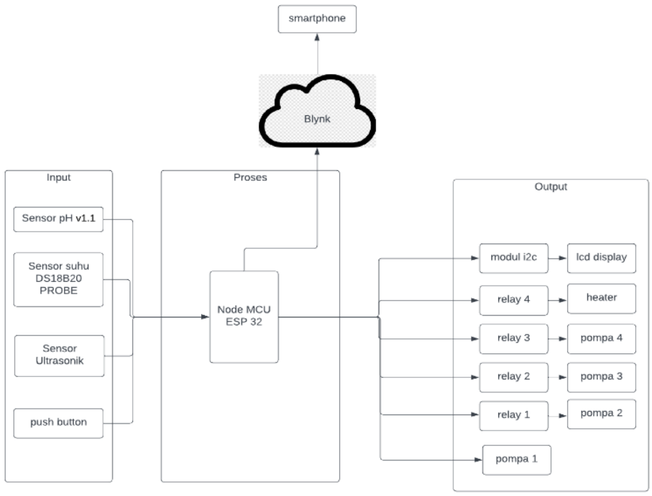

Fig. 2 Block Diagram

2) Hardware Design

Hardware design is essential in making this prototype. This design aims to reduce the error rate in the prototype-making prototype-making process to obtain optimal results [13]. Because of the hardware design, the system can be tested in real terms to determine whether the tool works properly.

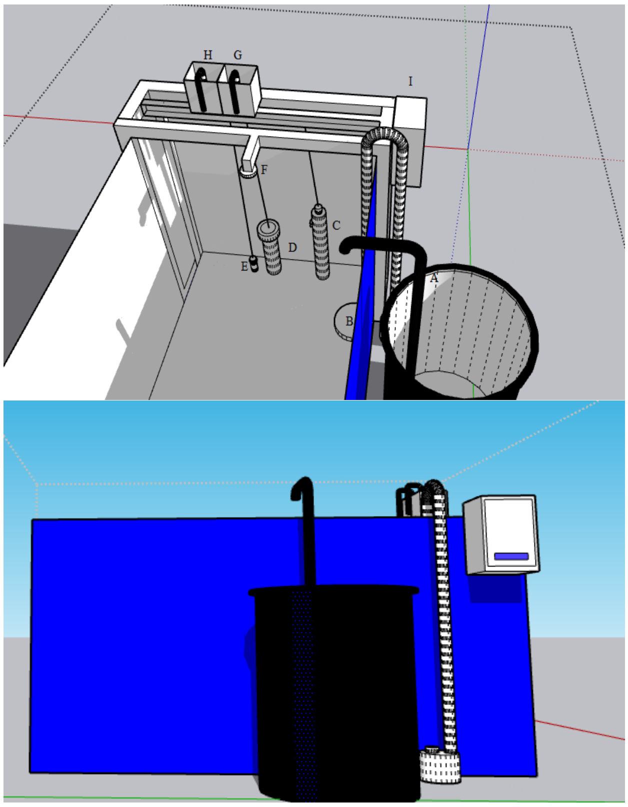

Fig. 3 Top view of Prototype Design

Image description above:

a) A is a water pump that increases the volume of prototype water.
b) B is an aerator that creates air bubbles in the water in the prototype.
c) C is a heater, namely a water temperature heater.
d) D is a pH sensor.
e) E is a DS18B20 temperature sensor.
f) F is an ultrasonic sensor.
g) G is a DC pump for pH-up liquid.
h) H is a DC pump for pH-down liquid.
i) I am a toolbox.

3) Flowchart

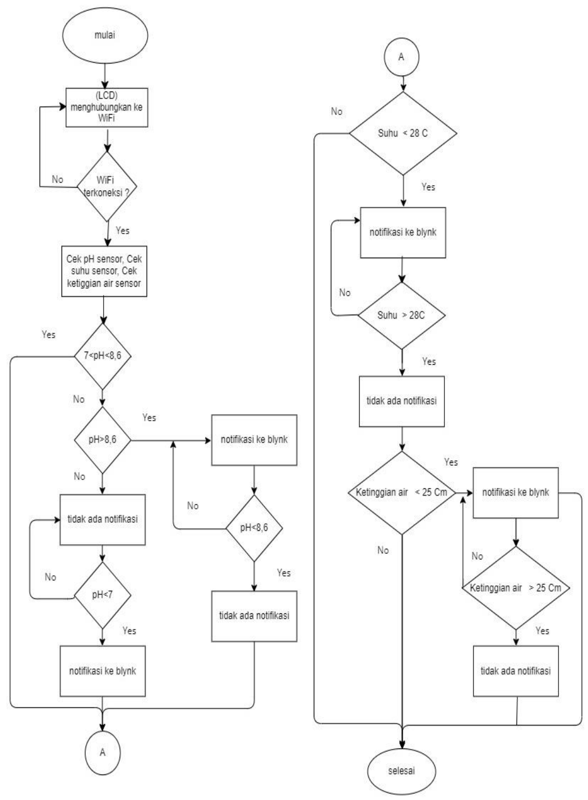

Fig. 4 Flowchart

Flowchart Description:

a) Start means the beginning of the program starting or running
b) (LCD) connecting WiFi means the condition of the device after the program is executed is a program to connect the ESP 32 to the registered WiFi network by displaying its condition via the 16 X 2 LCD Display.
c) WiFi connected? This means that if the WiFi network is not detected by the ESP 32, the program executed at the beginning will continue to be repeated until the network is detected by the ESP 32. If WiFi is connected, the device will perform the following program.
d) Check the pH Sensor, the sensor temperature, and the sensor water level. This means that all sensors read pH, temperature, and water level, and then the data is sent to the esp 32.
e) 7> pH <8.6 means that if the pH value read by the sensor is more significant than seven and less than 8.6, the device will execute the following program.
f) pH> 8.6 means that if the pH value read by the sensor is greater than 8.6, the device will activate pump 2 to enter the pH-down liquid. If not, pump 3 turns off.
g) pH<8.6 means if the pH value read by the sensor is less than 8.6, then the device will deactivate pump 2.
h) pH<7 means if the pH value read by the sensor is less than seven, the device will activate pump 3 to insert pH-up fluid. If not, pump three turns off.
i) Temperature <28 ℃ means if the temperature is less than 28℃, then the heater is active.
j) Temperature> 28 ℃ means if the temperature is greater than 28℃, then the heater is inactive. If not, then the heater is active
k) Water height <50 cm means if the pool water height is less than 50 cm, the device activates pump 4. If not, the device deactivates the pump.

C. *Implementation and Unit Testing*

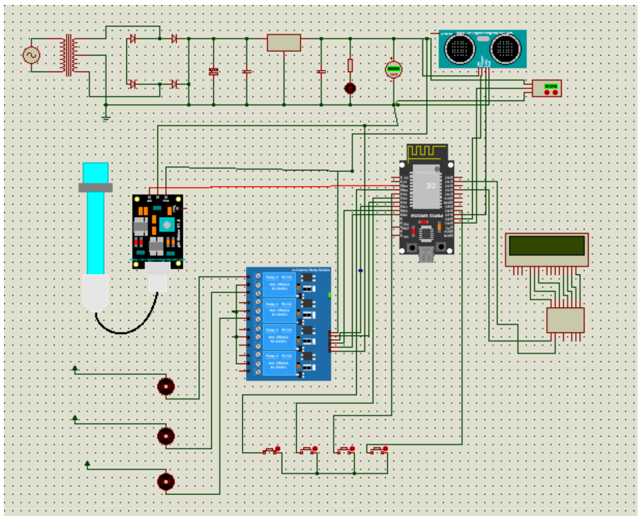

Fig. 5 prototipe

If not, this series combines all the components used to make a prototype of IOT-based shrimp pond management. The design is made to simplify the process of assembling the tools to be made. In hardware design, components must be appropriately arranged so that the wiring or wiring process between components can be done more efficiently [14].

D. Operation and Maintenance

This section aims to maintain the system to remain optimal in its performance and meet the needs of users and organizations. The waterfall model tends to be linear, where the operational and management stages follow the stages. pH Sensor Periodic calibration is needed to maintain sensor accuracy. This system is also designed to be outdoors, so routine checks are required in order to prevent system damage [15].

III. RESULTS AND DISCUSSION

In this stage, whether the developed system runs as planned will be explained. This system is designed using the Waterfall model approach. The next stage includes implementation and testing. The implementation aims to assess the extent to which the initial design and the prototype assembly results match. This stage also functions as a trial step for the system that has been built. A more detailed explanation of the implementation of this system is as follows Font of Entire Document

A. Results

1) DFROBOT V1 pH Sensor Testing

Testing on the DFROBOT V1 pH sensor was carried out by creating a program for the pH sensor on the ESP32 and then measuring the pH value of the pH buffer solution. The sample used was a buffer powder solution. The buffer powder solution samples varied in pH 4.01, pH 7.01, and pH 9.18. Each sample was measured with the DFROBOT V1 pH sensor and meter so that the pH value of the water sample was obtained. Furthermore, the DFROBOT V1 pH sensor reading on the prototype can control the relay.

Fig 6.pH buffer

TABLE 1 RESULTS OF WATER PH SENSOR TESTING WITH A PH METER

No	**pH buffer**	**pH DFROBOT V1**	**pH meter (pH)**	***Error* (%)**	***Relai 1***	***Relai 2***
1	4,01	4,06	4,00	1,5	aktif	nonaktif
2	6,86	6,85	6,83	0,29	aktif	nonaktif
3	9,18	9,21	9,17	0,43	aktif	nonaktif
Rata-rata *error*				2,06 %		

Fig. 7 pH testing

In the DFROBOT V1 sensor test shown in Table 1 above, the DFROBOT V1 sensor has an error compared to the pH meter. The calculation of the error percentage when the DFROBOT V1 is 4.06, and the pH meter is 4.00 is as follows:

$$Error\ (\%) = \frac{(\text{Value pH} - \text{Value pH meter})}{\text{Value pH meter}} x100\%$$

$$Error\ (\%) = \frac{(4{,}06 - 4{,}00)}{4{,}00} x100\%$$

$$Error\ (\%) = 1{,}5\ \%$$

The average error when testing the DFROBOT V1 sensor is as follows:

$$Average\ Error\ (\%) = \frac{\sum error}{\sum uji\ coba} x100\%$$

$$Average\ Error\ (\%) = \frac{2.29}{3} x100\%$$

$$Average\ Error\ (\%) = 1{,}29\ \%$$

Based on the DFROBOT V1 pH sensor test results by measuring three types of water samples with different pH based on the buffer powder solution sample, an error percentage of = 2.06% was found. This error occurs because the PH Meter measuring instrument must be calibrated at pH 7 to maintain accuracy. The reading value of the DFROBOT V1 pH sensor and measuring instrument is 0-14. The pH from 0-7 is acidic, and from the range 7-14 is alkaline. The reading of the sensor and measuring instrument takes a few seconds to get a stable value.

2) Testing the DS18b20 Temperature Sensor

The temperature sensor is tested by creating a program for the DS18b20 temperature sensor on the ESP32. The DS18b20 temperature sensor measures the temperature of hot water in the aquarium, mineral water stored in an air-conditioned room, mineral water stored in the refrigerator, and water mixed with ice cubes, then compared with the measurement results of the digital thermometer type. The results of testing the DS18b20 temperature sensor and digital thermometer are below.

TABLE 2RESULTS OF TESTING TEMPERATURE SENSORS AND DIGITAL THERMOMETERS

No	DS18b20 (°C)	Termometer digital(°C)	*Error* (%)	*Relai 3*
1	43.13	43.1	0,07	nonaktif
2	28.37	28,9	1.83	nonaktif
3	24,37	24,6	0.93	aktif
4	13,63	13,1	4,04	aktif
5	11.50	11.7	1,70	aktif
Rata-rata *error*			1,714 %	

Fig. 8 DS18b20 sensor testing

In the test results of the DS18b20 temperature sensor listed in Table 2, it can be seen that this sensor still shows an error compared to a thermometer. Calculations need to be made to determine the level of sensor accuracy. The percentage of error when the DS18b20 sensor measures a temperature of 43.13 °C and the digital thermometer of 43.1 °C was calculated.

$$Error\ (\%) = \frac{(\text{Value DS18b20} - \text{Value Termometer})}{Nilai\ Termometer} x100\%$$

$$Error\ (\%) = \frac{(43{,}23 - 43{,}1)}{43{,}1} x100\%$$

$$Error\ (\%) = 0{,}069\%$$

The average error when testing the DS18b20 sensor is as follows:

$$Average\ Error\ (\%) = \frac{\sum error}{\sum uji\ coba} x100\%$$

$$Average\ Error\ (\%) = \frac{87{,}5}{5} x100\%$$

$$Average\ Error\ (\%) = 1{,}714\ \%$$

Based on the DS18B20 temperature sensor test results with five types of water samples at different temperatures, the percentage of error obtained was 1.714%. This error occurs because the digital thermometer can only read one number behind the decimal point. The sensor and digital thermometer readings require 1-3 seconds to obtain a stable temperature measurement.

3) Ultrasonic Sensor Testing

TABLE 3ULTRASONIC SENSOR TESTING RESULT DATA

No	Ultrasonik(cm)	penggaris(cm)	Error %	Relai 4
1.	11	12	8,3	aktif
2.	13	13	0,0	aktif
3.	14	14,8	5,4	aktif
4.	15	15,7	4,5	aktif
5.	16	16,4	2,4	aktif
6.	17	17,6	3,4	aktif
7.	18	18,5	2,7	aktif
8.	19	19,5	2,6	aktif
9.	21	20,8	1,0	non aktif
Rata-rata *error*			3,36 %	

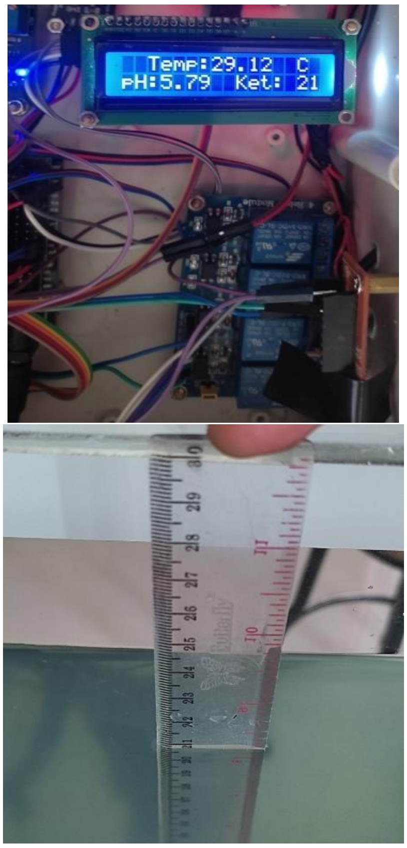

Fig. 9 Ultrasonic testing

Ultrasonic sensor testing is carried out to calculate the accuracy of the ultrasonic sensor used. Testing is done by creating an ultrasonic sensor program on ESP32 and comparing the water height value read from the ultrasonic sensor with a ruler. The value read by the ultrasonic will be displayed on the LCD and the Blynk application. The results of testing the ultrasonic sensor and ruler show that the ultrasonic sensor still has an error. Calculations need to be made to determine the level of sensor accuracy. Calculate the percentage of error when the ultrasonic sensor reads the water height with a value of 21 cm and the ruler with a value of 20.8 cm.

$$Error\ (\%) = \frac{(\text{Value ultrasonik} - \text{Value penggaris})}{Nilai\ penggaris} x100\%$$

$$Error\ (\%) = \frac{(21 - 20{,}8)}{20{,}8} x100\%$$

$$Error\ (\%) = 1{,}0\%$$

The average error when testing the ultrasonic sensor is as follows:

$$Average\ Error\ (\%) = \frac{\sum error}{\sum uji\ coba} x100\%$$

$$Average\ Error\ (\%) = \frac{30{,}3}{9} x100$$

$$Average\ Error\ (\%) = 3{,}36\%$$

The results of this ultrasonic sensor test, which measured nine water level samples, concluded that there was an error of 3.36%. This error occurs because the LCD does not display numbers behind the decimal. Sensor readings take 2 seconds to get a stable measurement value.

4) Blynk Notification Testing

The blynk notification test determines whether the system works according to the device's program. The testing method is to create a program on ESP32. The results of the Blynk notification test are in the following table:

TABLE 4 NOTIFICATION TEST TABLE

No	Sensor	Notification
1	pH < 7	PH AIR KOLAM < 7 !!!
	7> pH<8,6	Tidak ada notifikasi
	pH > 8,6	PH AIR KOLAM > 8.6 !!!
2	Suhu < 28	suhu air < 28 C!!!
	Suhu > 28	Tidak ada notifikasi
3	Ketinggian air < 25 cm	air kolam < 25 cm!! !
	Ketinggian air > 25 cm	Tidak ada notifikasi

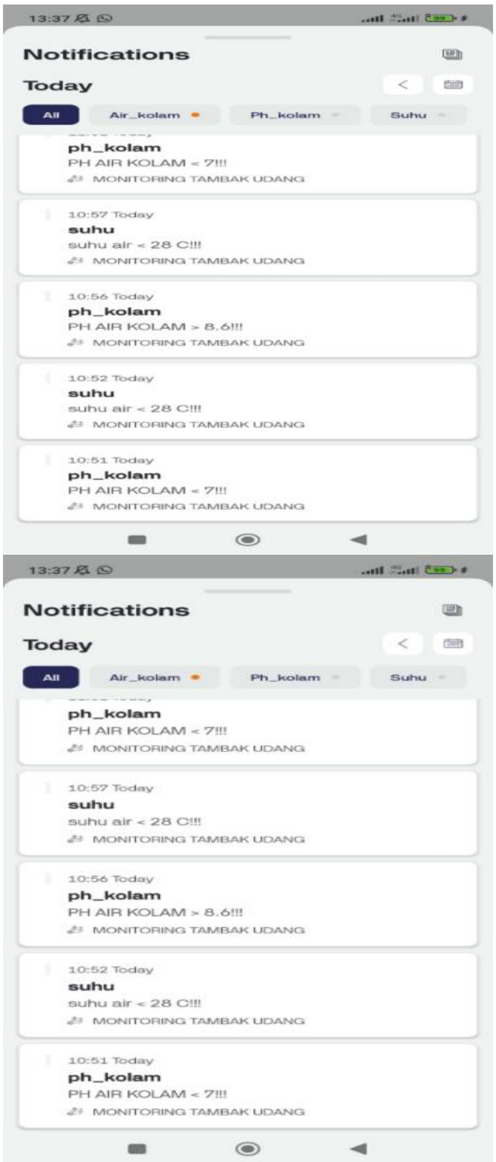

Fig. 10 notifikasi blynk

From the results of this blynk notification test, it can be concluded that the system is running well. The system can respond quickly when the temperature, pH, and water level parameters are abnormal. Notifications can be sent directly to smartphones.

B. *Discussion*

1) DFROBOT V1 pH Sensor Testing

The results of the DFROBOT V1 water pH sensor test that has been carried out show that the pH sensor readings are more or less the same as those of the pH meter. Based on the test results, it was found that the DFROBOT V1 water pH sensor had an average error of 1.29% from 3 trials. In general, the sensor can work well and can control relays 1 and 2 well when there is a change in pH Value. To maintain the accuracy of the sensor reading, periodic calibration is needed.

2) DS18b20 Temperature Sensor Testing

The DS18b20 water temperature sensor test results showed that the sensor worked well. When the temperature sensor was dipped into the sample water, the output value was close to the measurement results of a digital thermometer as a comparison. This sensor has a small average error of around 1.714% from 5 trials, so the sensor can be used in the prototype of shrimp pond water management based on IoT. The system can respond to temperature changes by activating relay 3 to turn on the heater to increase the temperature to> 28 C.

3) Ultrasonic Sensor Testing

The ultrasonic sensor works normally when the pond water level increases. It can measure the water level that is getting higher. This sensor has a small average error of around 3.36% from 9 trials, so it can be used in the prototype of shrimp pond water management based on IoT. The system can respond to changes in water level by activating relay 4 to turn on the pump to increase the water level.

4) Blynk notification testing

Based on testing the notification system on Blynk, it works well. The notification system has a data-sending interval of 5 minutes. Notifications only provide warnings when the system reads abnormal temperature, pH, and water level parameter values; when the water parameters return to normal, there is no notification.

C. *Physical Image of the Tool*

The physical form of the finished tool prototype, using glass material for the aquarium, is 1 cm thick, 50 cm long, 30 cm wide, and 30 cm high. The assembly box is made of plastic, 24 cm long, 9 cm high, and 16 cm wide. The pH solution container is made of plastic glass.

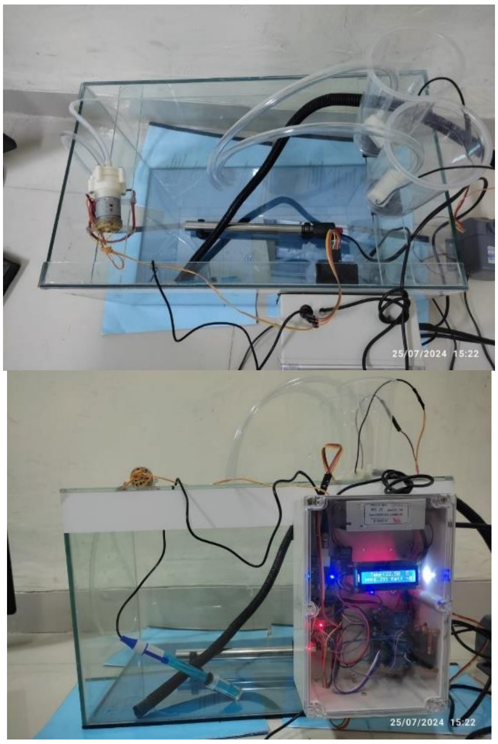

Fig. 11 Physical Image of the Tool

IV. CONCLUSIONS

After carrying out all stages of design and assembly of the IoT-based shrimp pond water management prototype, which was continued to the testing stage, the following conclusions can be drawn:
1. Control and monitoring testing using the Blynk webserver. The application can display temperature data, pH values, water levels, and notifications from the test data and send commands to the system remotely. It can also inform the quality of shrimp pond water in normal or abnormal conditions based on the internet.
2. DS18b20 temperature testing obtained an average percentage error from the temperature sensor test of 1.714%. So, the temperature error rate of the Internet of Things (IoT)-Based Shrimp Pond Water Management Prototype for temperature parameters below 2%. So, the DS18b20 temperature sensor is very suitable for this system, where it is supported by a waterproof feature.
3. DFROBOT V1 pH testing obtained an average percentage error from the pH sensor test of 1.29%. So, the error rate of the Prototype of Internet of Things (IoT) Based Shrimp Pond Water Management for pH parameters is still within the tolerance limit. 4. Ultrasonic sensors have a principle based on ultrasonic wave reflection; sometimes, the ultrasonic wave reflection becomes non-periodic, causing the measurement results to have an error of 3.36%. In addition, measurement errors occur due to rounding of calculations when creating the program.example of a standard in [12]

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