Indonesian Journal of Electrical Engineering and Computer Science
Vol. 34, No. 2, May 2024, pp. 848~860
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v34.i2.pp848-860

An internet of things-based pump and aerator control system

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Article Info

Article history:

Received Nov 29, 2023
Revised Jan 8, 2024
Accepted Feb 16, 2024

Keywords:

Aerator control
IoT-based prototype
Pump control
Shrimp pond
Water quality

ABSTRACT

Small-scale shrimp farmers in Hamparan Perak District, Deli Serdang Regency, Indonesia, conduct direct water quality supervision and manually use aerators and water pumps. Thus, it is inefficient in meeting the water quality required for shrimp farming and using production costs. This study aims to test the performance of an internet of things (IoT)-based prototype in supervising and controlling the aerator and pump in a shrimp pond. This prototype comprises an ESP32, three sensors: the DS18B20 sensor, MLX90614 sensor, and JSN-SR04T sensor, and two relays to control the aerator and pump automatically. Prototype testing is done directly on shrimp ponds by placing the prototype in an electrical panel connected to a power circuit. Based on the study's results, it is known that the prototype can measure water temperature. The water level and temperature of the aerator motor are pretty accurate. In addition, the prototype can also control the aerator and water pump well and send notifications to users automatically via smartphones.

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1. INTRODUCTION

Supervision and control of water quality in shrimp ponds are needed to avoid spreading disease or cannibalization that can reduce crop yields [1]. Small-scale shrimp farmers usually do not use technology-based water quality monitoring and control tools because they are expensive. Technology-based water quality monitoring and control tools are needed to maintain water quality to suit shrimp needs. Generally, small-scale shrimp farmers in Hamparan Perak District, Deli Serdang Regency, Indonesia, only supervise water quality directly by paying attention to watercolor and knowing the water temperature using hand skin. Furthermore, farmers also control water levels manually using water pumps and control water quality by using chemicals and activating aerators according to the age of shrimp seedlings. Thus, the water quality for shrimp farming cannot be known, and improper use of aerators can reduce water quality or increase energy consumption costs. It can also accelerate the service life of the aerator motor. Thus, monitoring and controlling aerator tools for internet of things (IoT)-based shrimp farming at affordable prices are needed to increase crop yields and cost efficiency of energy use and aerator motors [2]–[4]. In this study, the problem was overcome by automatically controlling the aerator motor based on the temperature of the shrimp pond water. The aerator motor is governed to work if the shrimp pond water temperature reaches 33 °C and stops if the temperature has reached 28 °C.

This research develops the author's previous research [2]. In previous studies, the prototype produced has not been able to be applied directly in the field, while in this study, the prototype developed has been tested for performance now in the field. To be tested now, this prototype has been equipped with a buoy used by

DS18B20 sensors to measure water temperature. The output of the sensor DS18B20 is a digital signal because it has been equipped with an analog-to-digital converter (ADC). In addition, the sensor has a low price and relatively good accuracy [5], [6]. Then, this prototype has also been placed in a panel and integrated with a power circuit to control the aerator and water pump automatically. That is necessary so that the aerator and pump can work for a long time stably. In addition, other developments that have been carried out include the JSN-SR04T sensor to measure water levels and an infrared-based MLX90614 sensor to measure the temperature of the aerator motor. The JSN-SR04T sensor is preferred over other ultrasonic sensors because it is a waterproof type of sensor [7]. The MLX90614 sensor is selected over the DHT 11 or DHT 22 sensor because the sensor is contactless-type, making it easier to install [8], [9]. The output of the JSN-SR04T sensor is used as a reference to control the water pump automatically, and the output of the sensor MLX90614 is used to monitor changes in the temperature of the aerator motor to prevent overheating. Processor replacement has also been carried out in the previous prototype using Wemos D1 R2, while in the prototype of this development, the ESP32 module was used. ESP32 module has the advantage of more general-purpose input-outputs (GPIOs) and data transfer rates [10].

Previous researchers have conducted relevant research on water quality monitoring and control systems for shrimp farming. Orozco-lugo *et al.* [11] research, a water quality monitoring system for shrimp ponds has been produced using a flying ad-hoc network (FANET). The FANET system is applied to overcome the weaknesses of wireless sensor network (WSN) systems that require many sensors to monitor water quality in different shrimp ponds. In the FANET system, all sensors that monitor water quality, including temperature, PH, salinity, and dissolved oxygen (DO), are installed on an unmanned aerial vehicle (UAV). Furthermore, UAVs are connected to each radio point placed on each shrimp pond so that UAVs can be used alternately to measure the water quality of each shrimp pond. Research conducted by Uddin [12] has resulted in an IoT-based monitoring system for freshwater shrimp farming in Bangladesh. Water parameter monitoring includes temperature, PH, DO, salinity, and turbidity. The system allows users to monitor water parameters using a web application and receive notifications automatically if water parameters exceed predetermined limits. In Fithrotul's research [3], a water quality monitoring system for shrimp ponds based on temperature, potential hydrogen (PH), salinity, and DO information has been developed. The sensor readings are sent to the internet network using IoT technology and then classified by a fuzzy logic system so that farmers can easily find the quality of shrimp pond water. The classification results of shrimp pond water quality are based on the four sensor information used: good, medium, poor, and inferior water quality. Research conducted by Chuyen *et al.* [4] has produced a system that can monitor temperature, DO, PH, salinity, and oxygen reduction potential (ORP) based on IoT. In addition, the system can also control water pumps and oxygen generators automatically with inverter technology. The power source is obtained through solar panels that are used to supply monitoring systems, water pumps, and oxygen generators.

This research uses the ESP32 module to implement IoT technology. Several relevant studies are using the ESP32 module to implement IoT technology. Jasim *et al.* [13] have proposed an IoT-based innovative waste system that can monitor the level and humidity of waste in baskets. Another purpose of such systems is to prevent the accumulation of waste by integrating each wastebasket on one rubber conveyor. The converter carries garbage from each wastebasket to the landfill automatically. Ahmed *et al.* [14] designed and implemented a robotic arm to lift and place objects through web page commands. The ESP32 module is applied to the robotic arm to control four servo motors that move and connect it to the internet network. In addition, ultrasonic sensors (HC-SR04) are also used to measure the distance between the robotic arm and the object to be picked up and placed and tighten the screwdriver connected to the object. Megantoro *et al.* [15] have produced two devices that measure weather parameters and gas concentrations in the air. Weather parameters include wind speed and direction, precipitation, air humidity, air pressure, ambient temperature, and ultraviolet (UV) index. The measured gas concentrations include ammonia, hydrogen, methane, ozone, carbon monoxide, and carbon dioxide. Sensors and the results from each parameter measurement are processed by the ESP32 module to be displayed on the LCD [16] and sent to the server.

Thus, the user's device can receive real-time measurement data from the sensor. Salman *et al.* [17] have produced a solar panel cleaning robot with simple, portable, independent, low-cost, self-sufficient features connected to the internet network. The robot cleans the surface of solar panels from dry dust, which can reduce the efficiency of solar panels in producing electrical energy. The robot has six free wheels, a gearbox, and two rolling brushes that aim to remove dust. The robot will move to clean dust along the solar panels using an ESP32 module via the internet network. Kusuma *et al.* [18] have designed an IoT-based touchless parking system using ESP32-CAM. The system was created to overcome the spread of the COVID-19 virus. The system automatically opens and closes the gate based on the rider's arrival. The system is equipped with passive infrared (PIR) sensors, HC-SR04 ultrasonic sensors, and servo motors as components to control the gate. Meanwhile, ESP32-CAM is used on this system to take pictures of riders automatically and send them over the Internet. Talbi *et al.* [19] have produced a low-cost IoT-based monitoring system to observe transformer network performance. The system uses an ESP32 module and is equipped with various sensors that are used as a reference to determine the performance of transformers. These sensors include temperature and humidity sensors (DHT22 sensor), oil level sensors (HC-SR04 sensor), vibration sensors (SW-420 sensors), and voltage and current sensors (R100kohm and R1kohm).

Hasan *et al.* [20] have designed an intelligent irrigation system supplied by photovoltaics. The system uses multiple sensors controlled by an ESP32 module. The system applies fuzzy logic to control the water discharge passed based on sensor data collected by the ESP32 module. Hutabarat *et al.* [6] have produced an Internet of Things-based aquascape environmental control system using the ESP32 module. The system controls the light and temperature of the water. Light control is carried out using light-emitting diodes (LEDs) of high power led (HPL) type. Meanwhile, temperature control is carried out using fans and heaters. The temperature sensor is a DS18B20 sensor, while the light sensor is a BH1750FVI sensor. Roslina *et al.* [21] have produced an intelligent detection system and electrical energy control to save energy consumption. The system works to control the electric current supply in the room automatically based on human presence. PIR sensors are used to detect human presence. An ESP32 module and WSN are components to detect and control electrical energy consumption.

This research has some uniqueness from previous relevant studies [3], [11], [12], [22]–[25]. The uniqueness is that this prototype is equipped with sensors for water temperature and level and aerator motor temperature. Sensors for aerator motor temperature are used to monitor changes in motor temperature due to prolonged use in lowering water temperature and increasing DO levels in shrimp ponds. Suppose the temperature of the aerator motor is more than 65 °C. In that case, the prototype sends a notification of the temperature of the aerator motor so that the impact of overheating on the aerator motor, which can shorten the service life of the motor, can be avoided. In addition, the temperature sensor for the aerator motor is infrared-based, so it is easier to use. Another uniqueness is that this study designed water quality monitoring and quality control systems tested directly on shrimp ponds. This prototype has been integrated with the power circuit and placed in an electrical panel box to automatically control the aerator motor and water pump.

In addition, this prototype is designed for small farmers farming shrimp so that this prototype has an affordable price. A reasonable price is obtained because this prototype does not use DO sensors and contactors, which are relatively expensive. DO sensors can be dispensed with because water temperature affects DO levels, so they can be predicted using the Benson-Krause equation [26]. Thus, maintaining the temperature of the pond water between 28 °C and 33 °C can provide water quality with DO levels that are good enough for shrimp farming [23], [27], [28]. The contactor to control the aerator motor and water pump was replaced with two 10 A relays. It can be done because small-scale shrimp farming farmers generally use electric motors with specifications of 1 horsepower (HP), 1 phase, and an electric current consumption of no more than 6A. Thus, use contactors that can be replaced with 10A relays. Another advantage of this prototype is that it has a man-off-manual switch. The aerator and water pump can still be controlled under certain circumstances even though the water quality is still appropriate.

2. METHOD

The author carried out three stages to develop this prototype: the design stage, the hardware assembly stage, and the programming stage. The prototype design stage is carried out using the Fritzing Simulator. The hardware installation stage is equipped with a black box to protect the prototype and a panel box to protect the power circuit. And the programming stages are carried out using the Arduino IDE simulator.

2.1. Prototype design

Figure 1 is a block diagram of the prototype that has been developed. The working principle, namely the DS18B20 sensor functions to measure water temperature [29], [30], the JSN-SR04T sensor acts to measure water level [31]–[33], and the MLX90614 sensor functions to measure the temperature of the aerator motor [34]–[36]. The measurement results taken by each sensor are processed by the ESP32 module to be displayed on the LCD and sent to the internet network via a microstrip antenna on the ESP32 board [37], [38]. Furthermore, users can view such data through the Blynk IoT platform [39]. Through it, users also receive notifications if the water temperature, aerator temperature, and water level do not meet predetermined limits. The ESP32 module also controls the work of the aerator motor and water pump according to the predetermined water quality [40], [41]. The schematic circuit and prototype diagram series are shown in Figures 2 and 3, respectively. Based on the two drawings, the prototype's cooling fan has been installed [42]. The cooling fan was needed for a long time due to the prototype.

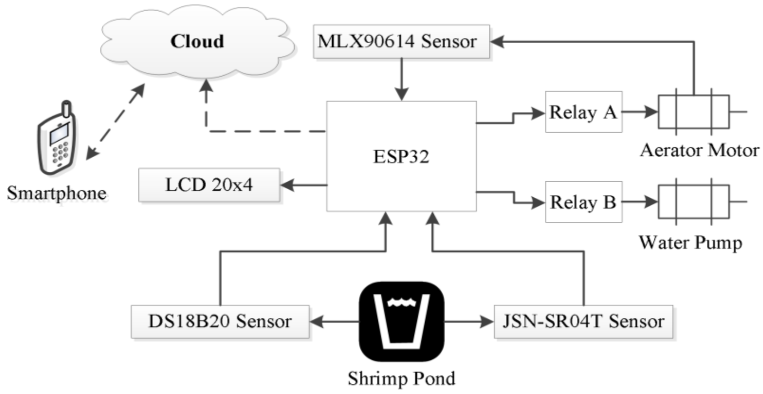


Figure 1. Prototype block diagram

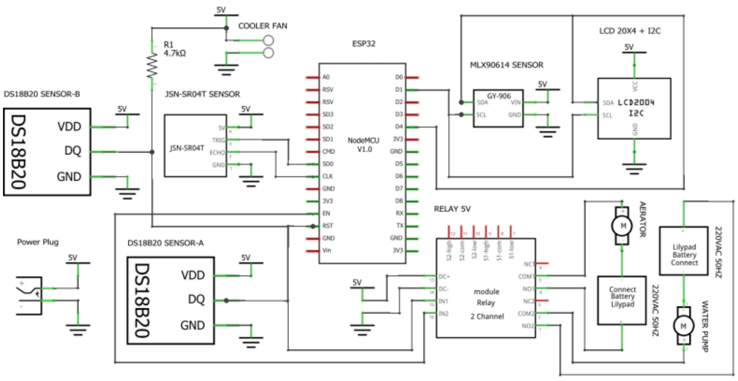


Figure 2. Prototype schematic series

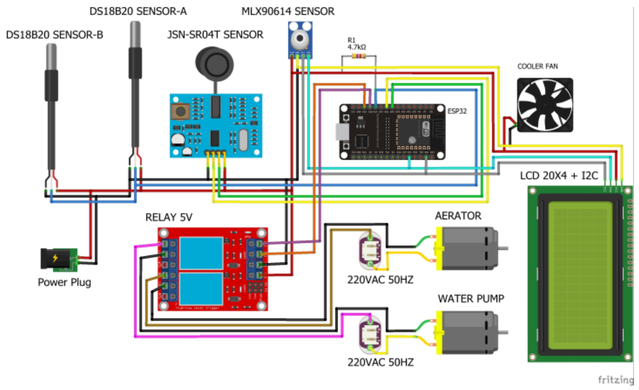


Figure 3. Prototype diagram series

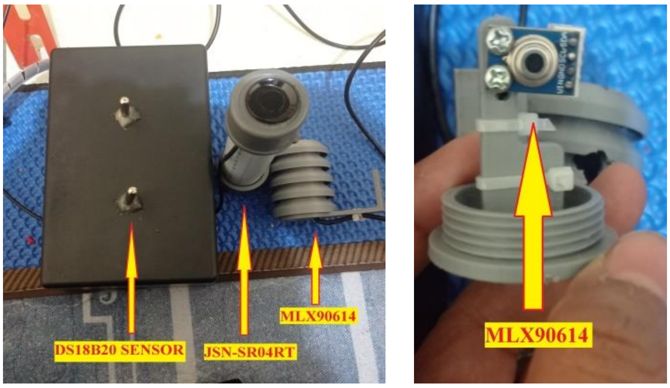
2.2. Hardware assembly

The entire assembled prototype is shown in Figure 4. The prototype features a circuit that serves as a connector port for the power source and each sensor used. It aims to make it easier for farmers to repair if the prototype is damaged. The connector port is shown in Figure 4(a). The connector port is designed using electronic design automation software (EDA), namely Eagle Software. In Figure 4(a), a connecting board for the ESP32 module is used to make the power supply and cable connection to the ESP32 GPIO more efficient. The extension board has an adapter with a supply voltage specification of 12V and a supply current of 3A. Meanwhile, the relay, LCD, and each sensor have a working voltage 5V with a total current consumption of almost 200 mA. Therefore, an LM2596 Module is used as a voltage regulator with a current capacity of 3A to supply power to these devices because the maximum output of the ESP32 GPIO is 200 mA [41], [43].

Figure 4(b) is a prototype integrated with the power circuit in a 40x30x20 cm^3 outdoor panel box. In the picture, 4 MCBs have functions, namely 2 MCBs for the main power supply switch and two other MCBs, each used to control the aerator and water pump in manual operation. Furthermore, in the picture, there are also three relays with a capacity of 10A that have functions, namely two relays, each of which is used to control the aerator and water pump in auto operation, and one other relay is used to supply power. The power is for 2 MCBs or two previous relays to control aerators and water pumps. The relay provides power based on man-off-auto (MOA) switch commands. Figure 5 is a view of the sensors used in the prototype. Based on Figure 5(a), there are three sensors used in this study, namely the DS18B20 sensor used to measure water temperature, the JSN-SR04T sensor used to measure water level, and the MLX90614 sensor used for aerator motor temperature. Each sensor is equipped with a shield to withstand the environment. Figure 5(b) is the position of the MLX90614 sensor inside its shield.

(a) (b)

Figure 4. Prototype final results (a) prototype series and (b) prototype integration with power circuits



(a) (b)

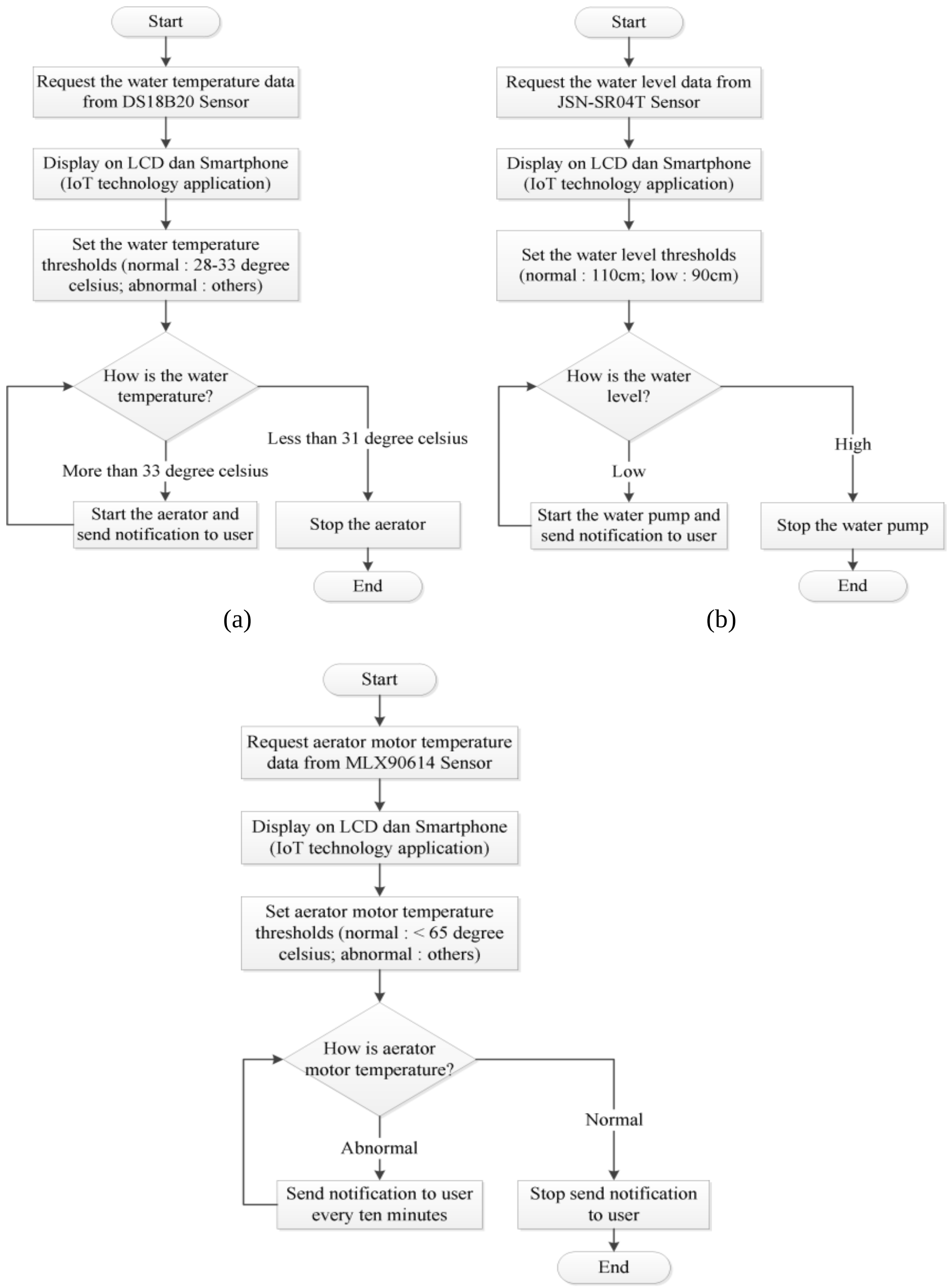
Figure 5. Sensors used (a) entire sensor and (b) MLX90416 sensor

2.3. Creating programs

The prototype program is built using the Arduino IDE Software. The program includes programs for monitoring and controlling water temperature and shrimp pond water levels and monitoring aerator motors' temperature. The surveillance system is built to apply IoT technology through the Blynk IoT platform on smartphones. Figure 6 is a surveillance and controller flowchart for water temperature, water level, and aerator motor temperature [44].

In Figure 6, a program is created to collect data on water temperature, water level, and aerator motor temperature obtained from each sensor, namely the DS18B20 sensor, JSN-SR04T sensor, and MLX90416 sensor. Furthermore, data from each sensor is displayed on an LCD and sent to the internet network so that users can view the data through smartphones and the Blynk IoT platform [40], [45]. Figure 6(a) is the water temperature control flowchart, Figure 6(b) is the water level control flowchart, and Figure 6(c) is the aerator motor temperature monitoring flowchart. The temperature of shrimp pond water for normal conditions is set at 28 °C – 33 °C. The average water level of the shrimp pond is set in the 90 cm – 100 cm range. And the average aerator motor temperature is less than 65 °C [3], [27].

Controlling the temperature of the shrimp pond water is carried out as follows: namely, if the water temperature is more than 33 °C, then the aerator is activated, but if the temperature has dropped to less than 28 °C, then the aerator is stopped automatically. It is done to avoid excessive energy consumption of the aerator [46] and shorten the service life due to activating and repressing the aerator in a short time. Likewise, controlling the water level of the shrimp pond, that is, if the water level is less than 90 cm, the water pump is operated and stopped automatically if the water level has reached 100 cm. Then, controlling the automatic delivery of notifications is carried out if the water temperature reaches more than 33 °C, the water level is less than 90 cm, and the temperature of the aerator motor is more than 65 °C [36].



(c)

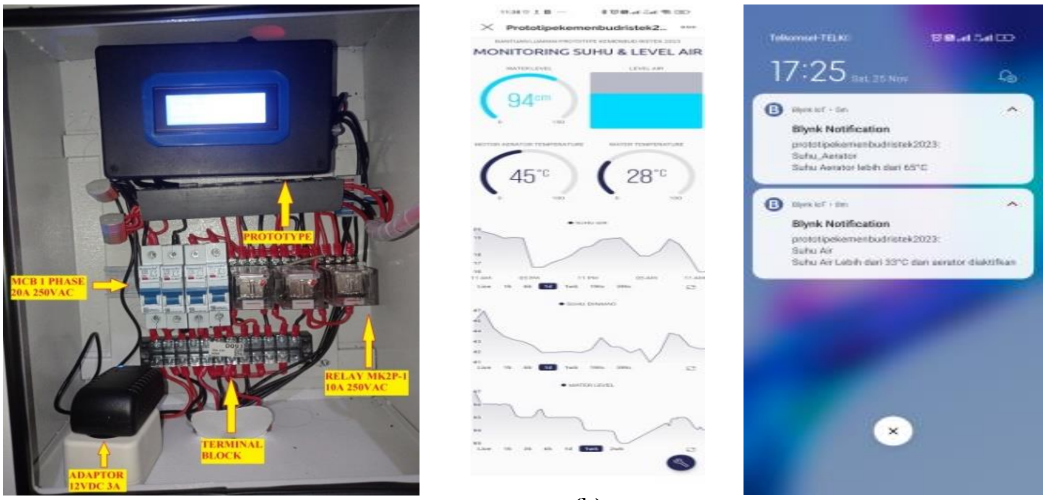
Figure 6. Programming flowchart; (a) water temperature control flowchart, (b) water level control flowchart, and (c) aerator motor temperature monitoring flowchart

3. RESULTS AND DISCUSSION

The results of each sensor implemented by the prototype are shown on the LCD and Blynk IoT application in Figure 7. Figure 7(a) displays the prototype's components in an electrical panel with a 20x4 liquid crystal display (LCD). The LCDs are the results of measuring water temperature, aerator motor temperature, and water level. Figure 7(b) displays the results of each sensor on a smartphone through the Blynk IoT platform. Figure 7(c) shows notifications on a smartphone sent automatically from the prototype. Four prototype parts are tested for performance: the DS18B20 sensor, JSN-SR04T sensor, MLX90416 sensor, relay, and notification delivery.

3.1. Sensor testing

Performance testing of each sensor is shown in Figure 8. Tests for DS18B20 sensors are performed on water heated in a stainless container, as shown in Figure 8(a), so variations in water temperature are obtained. Furthermore, the data from the readings of the DS18B20 sensor are compared with the fabricated waterproof-type temperature sensor. Figure 8(b) is a JSN-SR04T sensor test using a measuring meter instrument attached to a 3/4-inch polyvinyl chloride pipe. Variation of water levels is done using a water pump and two buckets. A buoy is placed above the water surface for the JSN-SR04T sensor to work optimally by eliminating the deviation effect on clear water. Figure 8(c) is an MLX90416 sensor test compared with measurement results using a manufactured thermogun. The temperature increase of the working aerator motor is used as a measurement object by the MLX90416 sensor and infrared thermometer measuring instrument. Furthermore, sensor test result data is obtained using the camera for the comparison measuring instrument and simultaneously displays sensor results in the Blynk IoT platform. The test data retrieval of each sensor is 50 data. Based on the test results of each sensor on the prototype, data were obtained by comparing measurement results using sensors to measurement results using measuring instruments, as in Table 1.



(a) (b) (c)

Figure 7. Display of the readings of each sensor; (a) display of sensor results on LCD, (b) display sensor results on blynk IoT, and (c) display of notification on smartphone

(a) (b) (c)

Figure 8. Prototype testing; (a) testing on DS18B20 sensors, (b) testing on JSN-SR04T sensor, and (c) testing on MLX90416 sensor

Table 1. Comparison of measurement data using sensors and measuring instruments

Measurement	Water temperature (ºC)		Water level (Cm)		Aerator motor temperature (ºC)	
	DS18B20	Measuring instruments	JSN-SR04T	Measuring instruments	MLX90416	Measuring instruments
1	25.00	25.00	10.00	10.00	25.10	25.00
2	25.81	26.00	11.20	11.00	26.30	26.00
3	27.18	27.00	12.10	12.00	27.25	27.00
4	28.00	28.00	13.00	13.00	28.13	28.00
5	29.20	29.00	14.20	14.00	28.92	29.00
6	30.00	30.00	15.30	15.00	30.05	30.00
7	31.44	31.00	16.20	16.00	30.90	31.00
8	32.30	32.00	17.10	17.00	32.15	32.00
9	33.00	33.00	18.10	18.00	33.02	33.00
10	33.93	34.00	19.00	19.00	34.21	34.00
11	35.00	35.00	20.00	20.00	35.14	35.00
12	36.00	36.00	21.30	21.00	35.88	36.00
13	37.10	37.00	22.10	22.00	37.10	37.00
14	38.00	38.00	23.00	23.00	38.10	38.00
15	39.00	39.00	24.10	24.00	38.88	39.00
16	40.22	40.00	25.10	25.00	40.30	40.00
17	41.00	41.00	26.00	26.00	41.30	41.00
18	42.20	42.00	26.96	27.00	42.31	42.00
19	43.12	43.00	28.20	28.00	43.33	43.00
20	44.00	44.00	29.20	29.00	43.85	44.00
21	45.40	45.00	30.00	30.00	45.30	45.00
22	46.25	46.00	31.00	31.00	46.35	46.00
23	46.90	47.00	32.00	32.00	47.34	47.00
24	47.80	48.00	33.20	33.00	48.36	48.00
25	49.24	49.00	34.20	34.00	48.89	49.00
26	50.36	50.00	34.89	35.00	50.10	50.00
27	51.10	51.00	36.30	36.00	51.42	51.00
28	52.00	52.00	37.10	37.00	52.41	52.00
29	53.00	53.00	38.50	38.00	52.98	53.00
30	54.30	54.00	39.60	39.00	54.44	54.00
31	55.10	55.00	40.10	40.00	55.42	55.00
32	56.22	56.00	41.10	41.00	56.50	56.00
33	57.30	57.00	41.90	42.00	57.51	57.00
34	58.31	58.00	43.30	43.00	58.51	58.00
35	59.00	59.00	44.30	44.00	59.44	59.00
36	59.88	60.00	45.00	45.00	60.20	60.00
37	61.40	61.00	46.20	46.00	61.27	61.00
38	62.00	62.00	47.40	47.00	62.13	62.00
39	63.28	63.00	48.20	48.00	63.56	63.00
40	64.27	64.00	48.95	49.00	63.97	64.00
41	64.78	65.00	50.10	50.00	65.40	65.00
42	66.46	66.00	51.20	51.00	66.23	66.00
43	67.15	67.00	52.20	52.00	67.45	67.00
44	68.23	68.00	53.00	53.00	68.48	68.00
45	69.27	69.00	54.20	54.00	69.17	69.00
46	70.20	70.00	55.10	55.00	70.23	70.00
47	71.00	71.00	55.95	56.00	71.43	71.00
48	72.43	72.00	57.20	57.00	72.26	72.00
49	73.40	73.00	58.20	58.00	72.97	73.00
50	74.00	74.00	59.10	59.00	74.21	74.00

In (1) is used to determine the percentage of error in the reading of each sensor against the measuring instrument used [47]–[49].

$$Error\ (\%) = \frac{Sensor\ Results - Measuring\ Instrument\ Results}{Measuring\ Instrument\ Results} x100\% \quad (1)$$

After using (1), it is known that the average error percentage for each sensor, namely the DS18B20 sensor, is 0.26%, the JSN-SR04T sensor is 0.46%, and the MLX90416 sensor is 0.44%. The error percentage of each sensor still meets manufacturing standards; namely, the rate of the DS18B20 sensor is a maximum of 0.5% for measurements at -10 °C – 85 °C. The maximum error percentage of the JSN-SR04T sensor for the 30–600 cm measurement range is 1.0%. The total error percentage of the MLX90419 sensor for measurements at 0 °C – 50 °C is 0.5%.

3.2. Relay and notification testing

Testing prototype relays or control aerators and water pumps uses two electric motors with 1 HP 1 Phase specifications. They are equipped with indicator lights for each electric motor, as in Figure 8(c). Testing of sending notifications to users' smartphones through the Blynk IoT platform was also carried out in conjunction with relay testing. Based on the experiment results, test result data are obtained in Table 2.

Based on Table 2, the aerator or relay is controlled automatically with the determination to work if the water temperature reaches 33 °C and stop if it has dropped to 28 °C. The water pump is also controlled automatically with the condition that it works if the water level reaches 90 cm and stops working if it goes 100 cm. Notification to users is sent if the water temperature is 33 °C, the water level is 90 cm, and the motor temperature is 65 °C, especially for sending temperature notifications to the aerator motor every 10 minutes if the temperature is > 65 °C.

Table 2. Test results of aerator control, water pump, and notification

Parameters	Aerator conditions	Water pump condition	Notification
Water Temperature 33 °C	Run	-	Sent
Water Temperature 28 °C	Stop	-	not sent
Water Level 90cm	-	Run	Sent
Water Level 100cm	-	Stop	not sent
Aerator motor temperature > 65 ºC	-	-	Sent every 10 minutes
Aerator motor temperature ≤ 65 ºC	-	-	not sent

3.3. Prototype implementation

This prototype has been implemented in shrimp ponds, as shown in Figure 9, for 13 days from December 9 to 21, 2023. Figure 9(a) is the installation position of the MLX 90614 sensor on the aerator motor. Figure 9(b) is the installation position of the JSN-SR04T sensor and DS18B20 sensor on the shrimp pond. The electrical panel is placed with an aerator motor because the length of the MLX90416 sensor cable and the JSN-SR04T sensor cable is 2 m each. Based on the results of implementing the prototype in the shrimp pond, it is known that the prototype is reliable against environmental influences. That is evidenced by a prototype that can provide sensor data through the user's smartphone. In addition, the prototype is also able to control the water pump and aerator motor automatically.

(a) (b)

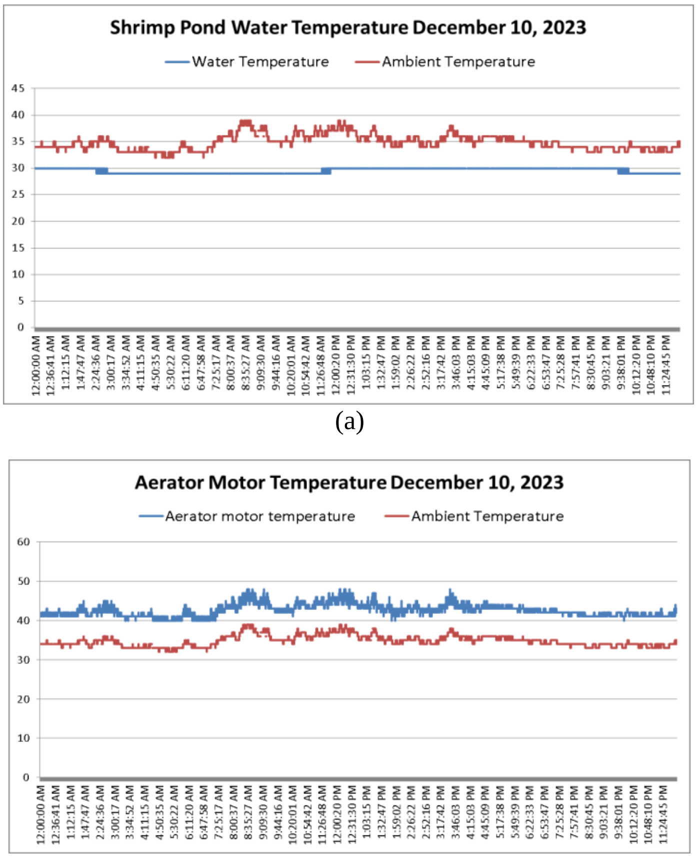
Figure 9. Prototype implementation in shrimp ponds (a) electrical panel box position and (b) sensor placement

Figures 10 and 11 are curves of the results of each prototype sensor on December 10, 2023. Each sensor has 44,858 measurement data. Figure 10(a) is the curve of the DS18B20 sensor result. On the curve, it is known that the water temperature is lower than the ambient temperature (ambient air) obtained from the MLX90614 sensor. The water temperature is 29 °C – 30 °C while the ambient temperature is 32 °C – 39 °C. It is because the aerator always works to reduce the temperature of the shrimp pond water. Figure 10(b) is a curve of the measurement results taken by the MLX90614 sensor. On the curve, it is known that the temperature of the aerator motor is higher than the ambient temperature.

The temperature of the aerator motor is 40 °C – 48 °C. That is because the aerator motor works all day. After all, the temperature of the shrimp pond water does not reach 28 °C. The test results of the JSN-

SR04T sensor in the shrimp pond are shown in Figure 11. Based on the picture, it has been seen that there has been an increase in the water level of the shrimp pond from 96 cm to a stable level of 100 cm. That happens because the water pump will work if the shrimp pond water level recedes to 90 cm and stops if the water level has reached 100 cm.

Based on the results of measurements made by each prototype sensor from 12:00:00AM – 11:59:58PM, 44,858 data on the performance of each sensor has been obtained. The measurement data taken by each sensor is obtained from the Blynk IoT application. The DS18B20 sensor was able to produce successful measurement data of 43,538 data (97.06%). The JSN-SR04T sensor has 44,391 successful measurement data (98.96%). The MLX90614 sensor has 43,266 successful measurement data (96.45%).



(a)

(b)

Figure 10. Temperature sensor measurement result curve (a) the DS18B20 sensor and (b) the MLX90614 sensor

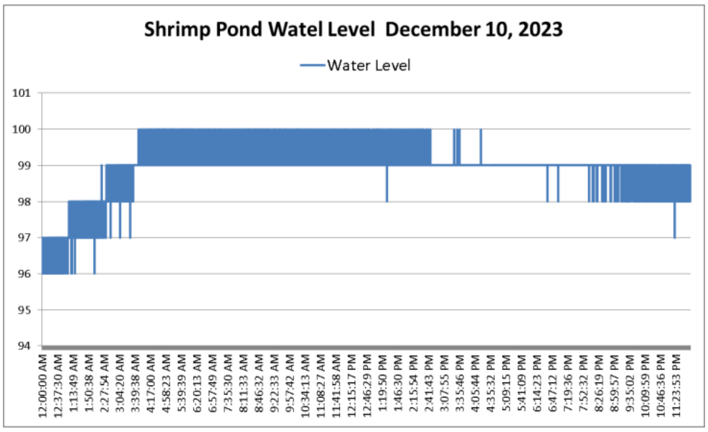


Figure 11. JSN-SR04T sensor test results curve in shrimp pond

4. CONCLUSION

Based on the prototype testing results, it can be seen that the prototype can accurately measure changes in water temperature, water level, and aerator motor temperature. In addition, the prototype is also able to control the aerator and water pump according to the desired water parameters. This prototype can also display sensor readings on the LCD and send the data to the internet network. So, users can monitor shrimp farms in real-time and receive notifications automatically. This prototype is designed to control an aerator or several aerators simultaneously. Based on the conditions in the field, the aerator does not work simultaneously but is adjusted to the age of the shrimp, which is proportional to the need for DO. Thus, further research can be developed to control several aerators to work according to shrimp needs.

ACKNOWLEDGEMENTS

The author would like to thank the Indonesian Ministry of Culture and Technology for funding this research. This research is fully supported by the Kemenbudristek 2023 Prototype Output Assistance Program.

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