Design And Development of a Pond Water Quality Monitoring Device Using the GSM SIM-800L Module

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Abstract –The current pond water monitoring systems are still lacking, necessitating innovations in efficient and effective monitoring technology. This study aims to design and develop a pond water monitoring system using SIM800L and ESP32 modules. The method used in this research is development research, which includes the stages of design, creation, and testing of the device. This monitoring system is equipped with TDS sensors, temperature sensors, and pH sensors to measure pond water quality in real-time. The test results show that the developed device can accurately monitor pond water quality and transmit data to a server via the GSM network. In conclusion, this device is effective and can be used by users to practically and efficiently monitor pond water, thereby helping to maintain pond water quality and support better aquaculture. .

Keywords: SIM800L, Fish Pond, ESP32, Water Monitoring.

I. INTRODUCTION

Managing pond water quality monitoring systems is a crucial aspect of the aquaculture industry. Poorly monitored water quality can lead to various problems, such as reduced fish quality, increased mortality rates, and significant economic losses. Currently, many pond water monitoring systems are still performed manually and are ineffective in providing the real-time information needed by fish farmers. In recent years, the Internet of Things (IoT) technology has shown its potential in improving the efficiency and effectiveness of monitoring systems across various sectors, including aquaculture [1].

The SIM800L and ESP32 modules are IoT components that can be used to build a more advanced pond water monitoring system. The SIM800L functions as a GSM communication module that enables remote data transmission via cellular networks, while the ESP32 is a microcontroller that supports Wi-Fi and Bluetooth connectivity and has high processing capabilities[2]. The combination of these two modules allows for the creation of a monitoring system that is not only accurate but also accessible from remote locations, providing greater flexibility to users [3].

This study aims to design and develop a pond water monitoring system using the SIM800L and ESP32 modules. The system is equipped with TDS sensors, temperature sensors, and pH sensors to monitor critical water quality parameters in real-time[4]. The method used is development research, which involves the stages of designing, creating, and testing the device. The results of this study are expected to provide a practical solution for fish farmers to monitor the quality of their pond water more effectively and efficiently, thereby supporting increased productivity and sustainability in the aquaculture industry [5].

II. METHODS

A. System Block Diagram

The pond water monitoring system in this study operates as explained in Figure 1. The stages of this research include analyzing material requirements, testing each device, and testing the entire system. The primary function of this tool is to measure the quality of pond water with several parameters such as TDS, temperature, and pH level. For monitoring, the tool is equipped with a SIM800L module that is connected via GPRS and a 16x2 LCD integrated into the device box. In this study, an ESP32 DevKit V1 microcontroller is used to handle multiple sensors.

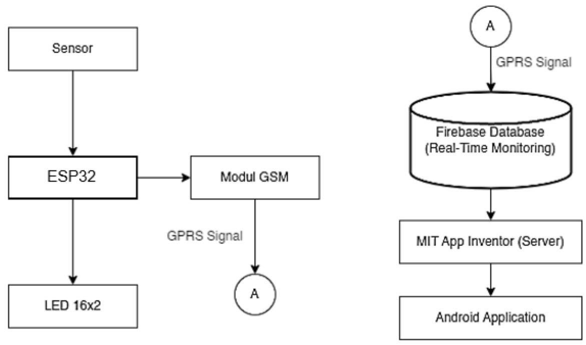

Figure 1 System Block Diagram

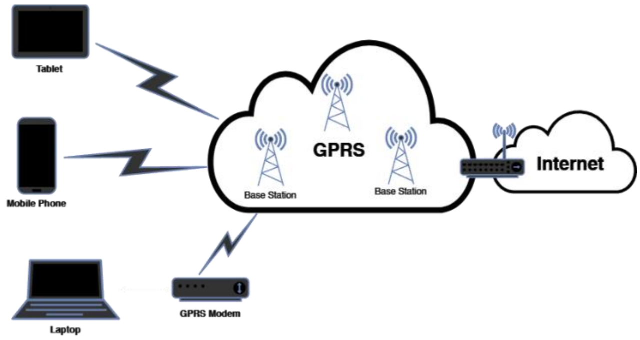

Figure 2 GPRS Work's

B. Hardware Design

The hardware design in this study can be seen in Figure 2. This figure shows the wiring diagram integrated with all device units. Figure 2 aims to facilitate the cable configuration for all the electronic components used. Some of the components used include the ESP32, SIM800L, 16x2 LCD, RTC DS3231, Gravity TDS Sensor, DS18b20 Sensor, pH4502C Sensor, and 2 DC Converter units.

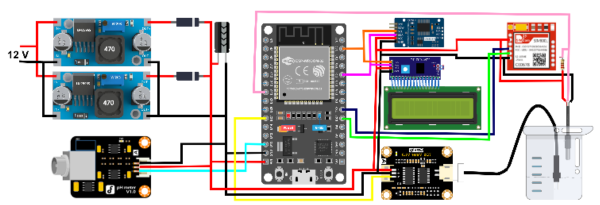

Figure 1 Wiring Diagram

C. GPRS

GPRS is a mobile communication standard that operates on 2G and 3G networks, enabling high-speed data transfer using packet-based technology. GPRS facilitates Internet Protocol (IP)-related connections, allowing for both commercial and enterprise applications. Data is transmitted by breaking it into multiple packets, which are then reassembled on the receiving side. GPRS adds important features for end-to-end IP-based packet data transmission, enabling packet communication services at speeds of up to 114 kbit/s. Users can stay connected without additional costs, as charges are based on the volume of data exchanged.[6]

With GPRS, network operators can distribute data to customers more effectively without using voice channels. The average speed of dial-up services is 9.6 kbps, while GPRS ranges from 40 to 172.2 kbps. GPRS has three main characteristics: always-online functionality that eliminates the need for dial-up, a system that can be implemented on existing equipment, and a crucial role as a foundation for future 3G networks such as EDGE and WCDMA. [7]

D. SIM800L

The SIM800L module is a GSM/GPRS module frequently used in various electronic projects due to its small size and reliable capabilities. This module supports quad-band network frequencies of 850/900/1800/1900 MHz and GSM/GPRS class 12. For communication, it uses a serial interface (UART) with a configurable baud rate of up to 115200 bps[8].

Figure 3 SIM800L Module

The SIM800L module operates at a voltage range of 3.4V to 4.4V with a power consumption of 0.7mA in sleep mode, 1mA in standby mode, and 200mA during calls. Its features include support for AT (Attention Command) commands for control, SMS (Short Message Service) in both text and PDU mode, GPRS (General Packet Radio Service) for class 12 data transfer, voice calls, caller ID recognition, and TCP/IP capabilities for internet communication. Connectivity options include an external antenna via an IPX connector or solder pad, and a slot for a Micro SIM card.[9]

The module has dimensions of approximately 25mm x 23mm and operates within a temperature range of -40°C to +85°C, with a storage temperature range of -45°C to +90°C. Additional features include GPRS multi-slot class 12/10 with up to 12 slots for faster upload and download times, Mobile Station Class B, and compliance with GSM phase 2/2+ with class 4 (2 W @ 850/900 MHz) and class 1 (1 W @ 1800/1900 MHz). It also supports SMS point to point MO and MT, cell broadcast, coding schemes CS 1, 2, 3, 4, and has a DTMF detector[10].

With these features, the SIM800L module is highly versatile and widely used in applications such as security systems, IoT projects, vehicle tracking, and remote control. Its flexibility in communication and low power consumption make it suitable for various projects requiring GSM connectivity.

E. ESP32

The ESP32 is a dual-mode Wi-Fi and Bluetooth module from Espressif Systems, designed for Internet of Things (IoT) applications with high performance and low power consumption. This module integrates a dual-core Xtensa® 32-bit LX6 processor with speeds up to 240 MHz, 520 KB SRAM, and external Flash memory up to 16 MB. Its connectivity features include Wi-Fi (IEEE 802.11 b/g/n) with speeds up to 150 Mbps and Bluetooth v4.2 BR/EDR as well as BLE. This board has two versions: 30 GPIO and 36 GPIO. Both have the same functionality, but the 30 GPIO version was chosen because it has two GND pins. All pins are labeled on the top of the board, making them easy to identify. This board features a USB to UART interface, which is easy to program with application development tools such as the Arduino IDE [11]. The ESP32 also comes with various peripheral interfaces such as GPIO, SPI, I2C, I2S, UART, PWM, ADC, and DAC, along with built-in sensors like a touch sensor, Hall sensor, and temperature sensor[12].

Figure 4 ESP32 Devkit V1

F. PH4502C Sensor

The pH4502C sensor from Diymore is a device used to measure the acidity or alkalinity (pH) of a solution. This sensor consists of two main components: the pH probe and the pH module. The pH probe, usually made of glass, performs the pH measurement by being immersed in the solution. The pH module connects the probe to a microcontroller, such as an Arduino, and converts the analog signal from the probe into a digital signal that the microcontroller can read.

This sensor has a measurement range from pH 0 to pH 14 and operates at a 5V DC voltage. The output voltage from this sensor correlates with the pH value of the measured solution. The working principle of this sensor begins when the pH probe is immersed in the solution, where it generates a voltage proportional to the hydrogen ion concentration in the solution. This voltage is then read by the pH module and converted into a pH value[13].

Figure 5 PH4502C Sensor

Figure 6 Gravity TDS Sensor

It's specifications include an operating voltage of 3.3V to 5V DC, a measurement range of 0-1000 ppm (up to 5000 ppm on some models), an accuracy of +/- 10%, and an analog signal output. The sensor operates at temperatures from 0-60°C with humidity levels of 10%-90% without condensation. Manual calibration can be performed using a potentiometer, and it connects via a Gravity interface, making it compatible with microcontrollers like Arduino[14].

G. DS18B20

The DS18B20 sensor is a digital temperature sensor renowned for its accuracy and ease of integration with microcontroller systems. This sensor can measure temperatures in the range of -55°C to +125°C, with an accuracy of ±0.5°C within the range of -10°C to +85°C. The DS18B20 uses a 1-Wire communication interface, allowing multiple sensors to be connected to a single data pin on a microcontroller, simplifying setup and reducing wiring requirements[15].

The measurement resolution is selectable between 9-bit and 12-bit, with a default resolution of 12-bit, offering flexibility in the desired level of precision. The sensor operates at a voltage range of 3.0V to 5.5V and can function with power supplied from the data line via its parasite power feature[16].

Figure 7 DS18B20 Sensor

III. RESULT AND DISCUSSION

I. Power Supply

In the initial testing, the design for the pond water monitoring system used an Arduino Nano as the microcontroller. Thus, the PCB board used consisted of two voltage supplies from the LM2596 DC converters, set at 5 volts and 3.7 volts. The use of these two DC converters is to power the TDS sensor, pH sensor, temperature sensor, and Arduino Nano. The DC converter with a voltage of 3.7 volts is used to power the SIM800L module.

During the testing for GET/POST data using the TinyGSM library for the SIM800L module, the Arduino Nano could not handle the program being executed due to its limited 32 KB flash memory. The significant memory requirement necessitated using a larger Arduino, so it was decided to use the ESP32 module as the microcontroller, as it can handle the operations of the module and sensors.

The ESP32 has a working voltage range with a maximum of 4.5 volts, so the circuit on the old board could not be used because the reference voltage was still using 5 volts. Modifications were made to the LM2596 DC converter by making both DC converters have a single output voltage in parallel using a 2-watt diode and an electrolytic capacitor as a rectifier and voltage stabilizer. Both DC converters were set at a voltage of 4.6 volts to produce an output voltage of 3.9-4.0 volts.

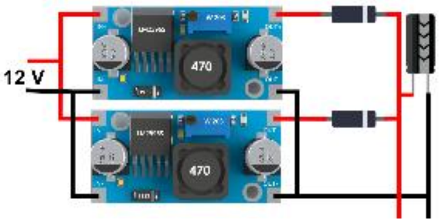

Figure 8 Power Supply Unit

Table 1 GPIO List Used

GPIO	Function
13	PH4502C (pH Sensor)
16	RX SIM800L Modem
17	TX SIM800L Modem
21	SDA (LCD, RTC)
22	SCL (LCD, RTC)
27	TDS Gravity V1.0 (TDS Sensor)
33	DS18B20 (Temperature Sensor)

II. ESP32

In the hardware assembly, some GPIOs cannot be used. The selection of ports, as shown in Table 1, represents several ports on the ESP32 that can be used directly. Examples of ports that cannot be used include GPIO2 and GPIO12. The reference voltage used to power and operate all the hardware comes from a power supply with a voltage of 3.9-4.0 volts.

III. Sensors

The sensors used in this research include a TDS sensor, temperature sensor, and pH sensor. During testing, the TDS sensor and pH sensor interfered with each other. This interference is caused by the way both sensors operate, which involves providing a reference voltage to one of the probes while the other probe reads the resulting voltage. To overcome this, two methods can be employed. The first method involves permanently programming the TDS meter library for calibration so that the program can run alternately with the pH sensor. However, the first solution is more complicated when the TDS sensor needs recalibration. Therefore, the second solution is to place the two interfering sensor probes far apart to avoid interference.

Figure 9 Top view of the tool

IV. Testing

During the testing phase, the device was placed in two different locations. The first location was an aquarium with an active aerator system, and the second location was a simple fish pond. In the first test, the results showed that the device worked well. The readings were normal and could be viewed on the 16x2 LCD display on the device box. In the second test at the fish pond, the device continued to function properly without any issues. It is important to note that in both test locations, the TDS sensor and the pH sensor were placed far apart to avoid interference.

Figure 10 Testing equipment in Pond Fish

A. Data Result

The data obtained from two tests at different locations are considered the same. The tests were conducted over a 24-hour period with a time limit from 07:00 to 22:00. In the aquarium with an aerator system, the measurement data is as shown in Table 2:

Table 2. Measurement data with TDS 300-304 ppm

Time	TDS (ppm)	PH (pH)	Temperature (°C)
11/6/2024 – 08.00	300	7,73	28,56
11/6/2024 – 09.30	301	8,14	28,56
11/6/2024 – 10.00	301	7,76	28,56
11/6/2024 – 11.30	302	6,78	28,56
11/6/2024 – 13.30	302	7,45	28,62
11/6/2024 – 15.00	303	6,85	29,08
11/6/2024 – 17.00	303	7,94	29,12
11/6/2024 – 18.30	304	8,01	29,15
11/6/2024 – 20.00	304	7,43	29,12
11/6/2024 – 22.00	304	6,25	29,12

In a simple fish pond, the data obtained is as shown in Table 3:

Table 3. Measurement data with TDS 442-445 ppm

Time	TDS (ppm)	PH (pH)	Temperature (°C)
11/6/2024 – 08.00	442	8,56	30,88
11/6/2024 – 09.30	442	8,35	30,12
11/6/2024 – 10.00	438	6,55	29,12
11/6/2024 – 11.30	441	7,40	30,88
11/6/2024 – 13.30	441	8,12	30,94
11/6/2024 – 15.00	442	8,83	30,95
11/6/2024 – 17.00	446	8,56	32,44
11/6/2024 – 18.30	446	8,90	32,44
11/6/2024 – 20.00	445	8,56	32,38
11/6/2024 – 22.00	445	9.09	32,31

From this data, it can be seen that the aquarium with an aerator system has a stable pH level ranging from 6.76 to 8.14, with no significant changes. Changes in water temperature affect the TDS meter readings because the electrical conductivity (EC) values are influenced by temperature at normal temperature (25°C). In the second measurement at the simple fish pond, similar results were obtained by the test instrument. The pH measurements ranged from 6.55 to 9.09. The TDS values were also affected by temperature, similar to the first measurement.

V. CONCLUSION

This study presents real-time monitoring of pond water quality. The system used for monitoring includes TDS sensors, pH sensors, and temperature sensors, with the SIM800L module used for data transmission. Data is sent to and received from the Firebase RTDB server using GET/POST commands on the SIM800L module. Experiments were conducted in an aquarium with an aerator system and in a freshwater fish pond in Tambaksari, Waru. The design and construction of the tested device were successfully implemented and tested. In the future, this research can be developed to meet the needs of the fish farming industry.

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REFERENCE

[1] A. W. Al-Mutairi and K. M. Al-Aubidy, “IoT-based smart monitoring and management system for fish farming,” *Bulletin of Electrical Engineering and Informatics*, vol. 12, no. 3, pp. 1435–1446, Jun. 2023, doi: 10.11591/eei.v12i3.3365.

[2] A. H. Kelechi *et al.*, “Design and Implementation of a Low-Cost Portable Water Quality Monitoring System,” *Computers, Materials and Continua*, vol. 69, no. 2, pp. 2405–2424, 2021, doi: 10.32604/cmc.2021.018686.

[3] F. Hawari and M. A. Hazwan, “Development of Iot Monitoring System For Aquaculture Application,” *2022 International Conference on Green Energy, Computing and Sustainable Technology (GECOST)*, p. 456, 2023.

[4] F. Alfaeru, A. Boedi Setiawan, and R. S. Hidayat, *IMPLEMENTATION OF ACCELEROMETER SENSOR AND GPS MODULE FOR SMART BIKE DESIGN*.

[5] J. Duangwongsa, T. Ungsethaphand, P. Akaboot, S. Khamjai, and S. Unankard, “Real-Time Water Quality Monitoring and Notification System for Aquaculture,” in *2021 Joint 6th International Conference on Digital Arts, Media and Technology with 4th ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunication Engineering, ECTI DAMT and NCON 2021*, Institute of Electrical and Electronics Engineers Inc., Mar. 2021, pp. 9–13. doi: 10.1109/ECTIDAMTNCON51128.2021.9425744.

[6] A. Zola, “DEFINITION GPRS (General Packet Radio Services),” https://www.techtarget.com/searchmobilecomputing/definition/GPRS#:~:text=General%20Packet%20Radio%20Services%20(GPRS,of%20packets%20isn’t%20guaranteed. Accessed: Mar. 18, 2024. [Online].

[7] H. Andrianto and G. Intan Saputra, “Smart Home System Berbasis IoT dan SMS Smart Home System Based on IoT and SMS,” *TELKA*, vol. 6, no. 1, pp. 40–48, 2020.

[8] O. Onyango and S. Kamau, “Send GPS Location to Firebase Using GPS Neo 6M and SIM800L”, doi: 10.13140/RG.2.2.10230.47685.

[9] F. M. Dahunsi, S. O. Eniola, A. A. Ponnle, O. A. Agbolade, C. N. Udekwe, and A. O. Melodi, “A Review of Smart Energy Metering System Projects,” *Jurnal Elektronika dan Telekomunikasi*, vol. 21, no. 1, p. 70, Aug. 2021, doi: 10.14203/jet.v21.70-78.

[10] Khairun Nisa Meiah Ngafidin, A. Arista, and R. Nisa Sofia Amriza, “Implementasi Firebase Realtime Database pada Aplikasi FeedbackMe sebagai Penghubung Guru dan Orang Tua,” *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, vol. 5, no. 2, pp. 327–334, Apr. 2021, doi: 10.29207/resti.v5i2.2909.

[11] M. Nizam, H. Yuana, and Z. Wulansari, “MIKROKONTROLER ESP 32 SEBAGAI ALAT MONITORING PINTU BERBASIS WEB,” 2022.

[12] L. M. Engineers, “ESP32 Pinout Reference,” https://lastminuteengineers.com/esp32-pinout-reference/.

[13] ecadio.com, “Sensor pH larutan untuk Arduino PH4502C,” https://ecadio.com/sensor-ph-meter-untuk-arduino.

[14] F. Chuzaini, P. Studi Fisika, J. Fisika, and U. Negeri Surabaya, “IoT MONITORING KUALITAS AIR DENGAN MENGGUNAKAN SENSOR SUHU, pH, DAN TOTAL DISSOLVED SOLIDS (TDS),”

2022.
[15] T. Suryana, “Implementation DS18B20 1-Wire Digital Temperature Sensor with NodeMCU IDEAL TEMPERATURE FOR BREWING COFFEE.”
[16] Maxim Integrated, “DS18B20 Programmable Resolution 1-Wire Digital Thermometer,” 2019, Accessed: Jan. 13, 2024. [Online]. Available: www.maximintegrated.com