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Design and Development of an IoT-Based Water Acidity Monitoring System Using ESP8266 Module

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Abstract

This research discusses the design and development of an Internet of Things (IoT) based monitoring system for the acidity of tofu water. The background of the research is based on the importance of maintaining water quality in the tofu production process, particularly the pH parameter, which directly affects the taste, texture, and safety of the product. This system is designed using the ESP8266 as the microcontroller, E-201C pH sensor to measure acidity levels, DS18B20 temperature sensor, a 16x2 LCD as a local display, and the Blynk application as a medium for remote monitoring. Test results show that the system can display pH and temperature values of the water in real-time and send automatic notifications to the Blynk application when the pH value is outside the standard threshold.

***Keywords**: Internet of Things, ESP8266, pH Sensor, Monitoring, Tofu.*

1. Background

In Indonesia, tofu is popular as a staple food, and the tofu industry is a very important sector. The process of making tofu, particularly the control of the quality of water used, plays a crucial role in the final product. Poor water quality, especially acidity levels (pH), can affect the taste, texture, and safety of the tofu produced. However, many tofu manufacturers still monitor water quality manually, which is prone to errors and time-consuming. The presence of Internet of Things (IoT) technology opens up opportunities to develop automated systems that can monitor water quality in real time and provide notifications. This paves the way for improved efficiency and quality in the tofu industry.

The selection of this issue is based on the importance of maintaining water quality standards in tofu production as one of the key successes in the tofu production process. Integrating IoT technology into the water quality monitoring system aims to provide a more modern, efficient, and reliable solution compared to traditional methods. The ESP8266 module was chosen because it is a low-cost microcontroller, has internet connectivity capabilities, and can monitor water acidity (pH) data in real-time through an application. This technology can also directly notify users if the water parameters do not meet standards, allowing them to quickly take corrective actions to maintain product quality.

Monitoring water pH levels using the Telegram application as a user where users can monitor the water pH levels and control whether the system is working properly or not. Users can interact with the Bot by sending command messages through private or group messages. The Telegram Bot account does not require adding a phone number during its creation. This account serves only as an interface for the code running on a Server. In addition to the automatic monitoring of water pH levels conducted through smartphones, manual monitoring of pH solutions is also carried out, with the degree of acidity more commonly known as pH, which indicates the concentration of H ions (Mailoa, 2020).

2. Literatur Review

2.1. Design Build

Design and Build is the first phase where photos and sketches that have never been created before are made, forming photos or creating sketches with your selected function. Designing or Building a system is a process of translating the system's results into programming language. The definition of building a structure or system is the activity of creating a new system and replacing or improving all or parts of the existing system. Design and Build refers to a unit for designing and building systems and designing and constructing systems (Syahputra, Aji Tyo, 2024).

2.2. Monitoring

Monitoring is an effort to collect ongoing information aimed at providing program managers and stakeholders with insights into early indications of progress and shortcomings in program implementation to enhance program objectives (Nasihi, 2022). Monitoring is an act of oversight that can be defined as awareness of the information one wishes to know. High-level monitoring is conducted with the aim of measuring progress over time, whether moving closer to or further from objectives. In carrying out monitoring, we obtain information regarding status and trends that can aid in the repeated measurement and evaluation over time. Generally, monitoring is performed for specific purposes, such as monitoring the processes of objects or evaluating conditions and developments towards management results arising from various types of actions, including actions aimed at maintaining the continuity of ongoing management (Sari, 2022).

2.3. Tofu

Tofu is one of the most favorite foods for Indonesians. It is a food that is always present in their daily meals, whether as a side dish with rice or as a snack, either unprocessed or modified into other food forms based on tofu. Whether they are aware of it or not, as a product of soybean processing, tofu is a staple food for nutrition improvement because it has the best quality of plant-based protein due to its complete amino acid composition and is believed to have a high digestibility rate (between 85%-98%).

2.4. ESP8266

ESP8266 is a WLAN module that acts as an additional microcontroller like Arduino, allowing you to connect directly to WLAN to create a TCP/IP connection. Additionally, this module is based on SOC (System on Chip). This means you can use this device without the help of other microcontrollers. This module requires an output of about 3.3 V and has three WLAN modes: station, access point, and more. This module also has a processor, memory, and GPIO, which allows for a varying number of pins depending on the type of ESP8266 used (Nouval, 2024).

2.5. Internet of Things

IoT is communication between machines (M2M) with internet connectivity and humans as users and managers. Generally, IoT operations have key elements, namely physical goods with IT modules, devices connecting to the internet, and a cloud data center for storage. The working concept of IoT is that all uses of physical goods connected to the internet will store all collected data as Big Data, which is processed in such a way for analysis and utilized for specific purposes (Sawitri, 2023).

2.6. Sensor PH E-201C

The Blue PH Sensor Kit E-2010 is also a pH sensor module equipped with a probe and a converter module with an analog data interface output. It allows you to connect to Arduino boards, STM32, Raspberry Pi Pico, and other microcontroller cards with an analog interface.The specifications of the PH E-201C sensor are as follows:

1. Heating Voltage: 5 ± 0.2V (AC · DC)
2. Current Consumption: 5 ~ 10mA
3. Detectable Concentration Range: pH 0-14
4. Detection Temperature Range: 0 ~ 80°C
5. Response Time: 55s
6. Settling Time: 60s
7. Component Power: 0.5W
8. Interface: Analog
9. Operating Temperature: -10 ~ 50°C
10. Humidity: 95% RH
11. Dimensions: 42 x 32 x 20mm

2.7. LCD

LCD (Liquid Crystal Display) is a type of display technology with CMOS logic that does not emit light but reflects light from the front and transmits light from memory. LCD acts as a data artist for both characters, letters, numbers, or graphics. LCD is a mixed organic layer between a transparent glass layer and transparent indium oxide electrodes in the form of seven segments and an electrode layer on the back glass. When the electrodes are activated by an electric field (voltage), long cylinders and cylindrical organic molecules are arranged to the segment electrodes.

2.8. Adaptor

An adaptor is an electronic circuit that can generate power, or serve as a source of energy for other electronic circuits. The current source of energy is alternating current (AC) from power plants, which is then converted into direct current (DC). To do this, the power supply requires a device that can convert AC flow to DC (Wildan, 2020).

3. Design And Analysis

3.1. Research Methodology

The method used in this research is the design method (prototyping). This method includes several main stages, namely:

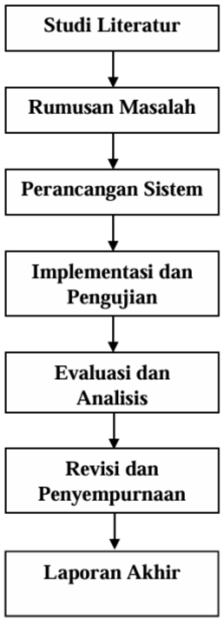

Fig. 1: Research Methodology

3.2. Control System Flowchart

The design of this tool begins with the creation of a flowchart to facilitate the planning and development of the program on the microcontroller. The creation of a flowchart is useful for simplifying the understanding of the working process of the tool. The program flowchart from this research includes the control system of the tool's operation, which can be seen in Figure III.2:

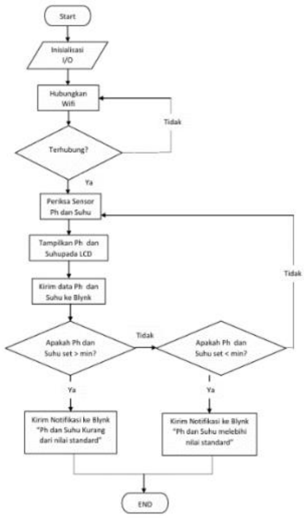

Fig.2 : Flowchart Monitoring System

The following is an explanation of the Flowchart for the Tofu Water Acidity Control System as follows:
1. Start.
2. Initialize Input/Output.
3. Connect the hardware to the internet such as wifi, etc.
4. Check if the pH is active or if there are any issues with the sensor.
5. Display pH on the LCD.
6. This process is done manually by inserting the pH sensor into the tofu water.
7. Next, if the pH is below standard, the notification received will be "pH is less than standard value."
8. End.

3.3. Block Diagram Series

The design of the block diagram circuit is the design of electronic components in such a way that it has the desired function. Generally, the planning of the tool design is as follows:

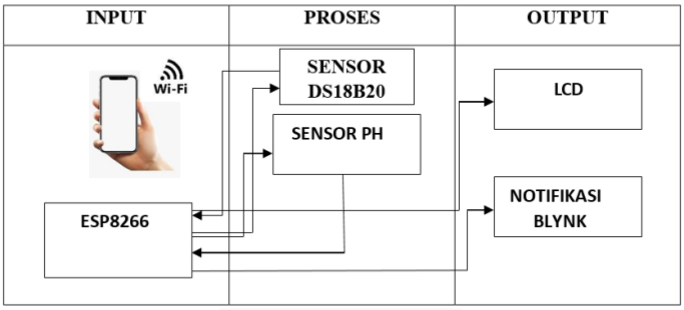

Fig.3 : Blok Diagram Series

The block diagram series in image III.2 shows that the first process is to connect the hardware used, such as a smartphone or computer, to Wi-Fi. In the next process, the pH water sensor is activated. Then, the data from the sensor is sent to the ESP8266, which will then instruct Blynk to display notifications, and the LCD will show the pH in real-time.

3.4. Electronic Circuit Scheme

Schematic of the electronic circuit using ESP8266 as a microcontroller that receives data from the pH sensor. The design of the ESP8266 serves as a connection between the hardware and the internet. The output of the ESP8266 will be connected to an LCD to display the detected pH results. Below is an illustration of the electronic circuit scheme for monitoring the acidity of tofu water in IoT:

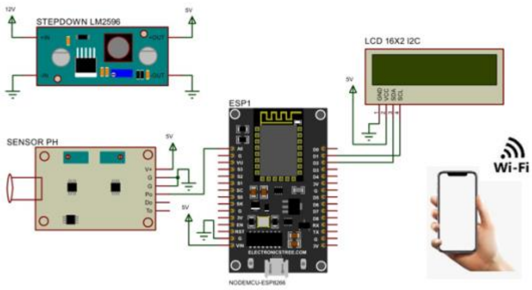

Fig.4 : Electronic Circuit Scheme

4. RESULTS AND DISCUSSION

In this chapter, the author outlines and explains the research results by conducting tests. The tests to be conducted are software and hardware tests. Here is the explanation:

4.1 Software Testing

To conduct the program test, the initial steps in this experiment are as follows:

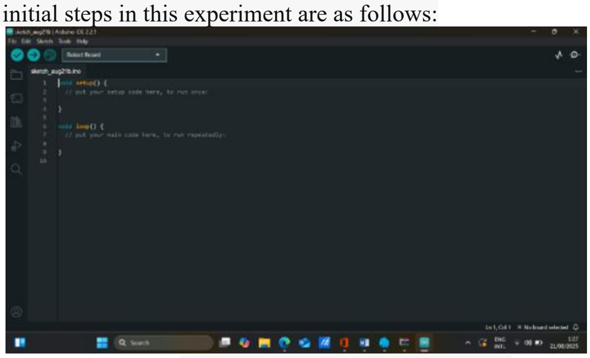

Fig. 5 : Initial Display of Arduino IDE

4.2 Hardware Testing

After all the programs are typed, design the hardware as shown in Figure IV.2.

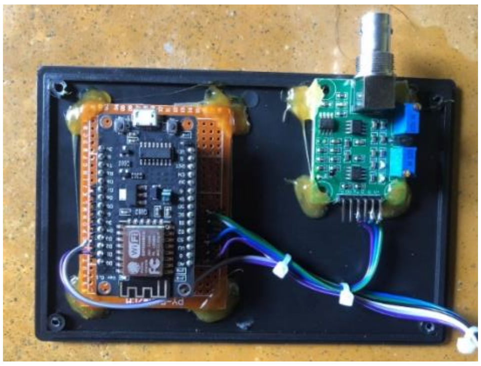

Fig. 6 : The ESP8266 Hardware Design is connected to the pH Sensor

Next, the test for the device's activity, based on the display on the LCD showing its pH value:

Fig. 7 : Position of the tool when active

4.3 Blynk Testing

In this Blynk testing, we create a new template with widgets as shown in the image below:

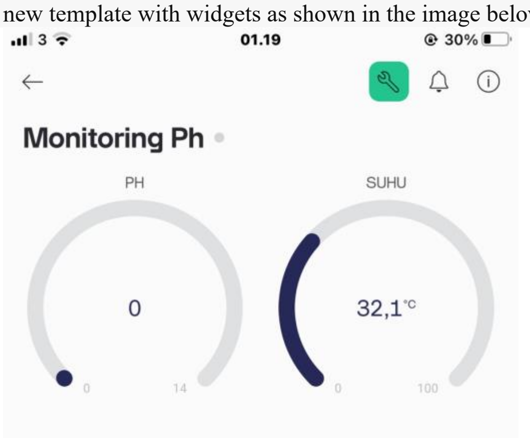

Fig. 8 : Blynk Display

After the program has been fully typed, the next step is to input the program code into the circuit by clicking the Bar menu on the Arduino IDE and then clicking upload, with the note that the Board and Port in the Arduino IDE Bar menu are already set. Next, wait a moment until the upload process is complete, then the program that has been uploaded will automatically be saved to the microcontroller.

4.4 Implementation of Overall Testing Using RTC and ESP32 Connected with Blynk

The implementation of this test is conducted to determine the performance of the components that will be used in this thesis, with the output being Blynk, which will monitor the pH level of tofu water and the water temperature by sending the sensor data generated on the acidity level and temperature with notifications sent in Real-Time. By being connected to the internet, Blynk can receive data sent by the microcontroller. The experiment is carried out by dipping the sensor into the tofu water that will be monitored for its acidity and temperature levels; as a trial, the next step is to check the notifications received in the Blynk application. After all circuits have been designed in the 'Design and Development of the Tofu Water Acidity Monitoring System Using the IoT-Based ESP8266 Module', below is the image of the successful testing of monitoring the pH acidity level of tofu water using IoT in Figure IV.5 below:

Fig. 9: Overall Circuit Results

5. Conclusion

Based on the results of the research and implementation of "Design and Build of a Monitoring System for Tofu Water Acidity Using IoT-Based ESP8266 Module", several conclusions can be drawn as follows:

1. This research successfully designed and built a monitoring system for tofu water acidity using the E-201C pH sensor, DS18B20 temperature sensor, and ESP8266 microcontroller that is integrated with the Blynk application.
2. The system is capable of displaying pH and temperature values in real-time through an LCD and providing automatic notifications to the Blynk application if the pH value is outside the standard limits (less than 6.0 or more than 8.0).

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