A Report on

Clear Stream Guardian

For

Mini Project-2A Embedded System Project (ECM-501) of Third Year (Semester-V)

Submitted by

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in partial fulfillment for the award of the degree

BACHELOR OF ENGINEERING

in

Department of Electronics & Telecommunication Engineering

under guidance of
Ms. Savita Kulkarni

St. Francis Institute of Technology, Mumbai

University of Mumbai

2024-2025

CERTIFICATE

This is to certify that Hitesh Chandanshive, Kaushik Karkera, Om Kulkarni and Shreyansh Mahadik are the bonafide students of St. Francis Institute of Technology, Mumbai. They have successfully carried out the project titled "Clear Stream Guardian " in partial fulfilment of the requirement for the award of Mini project 2A of third year (Semester-V), in Electronics and Telecommunication Engineering of Mumbai University during the academic year 2024-2025. The work has not been presented elsewhere for the award of any other degree or diploma prior to this.

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ACKNOWLEDGEMENT

We are thankful to a number of individuals who have contributed towards our third year project and without their help; it would not have been possible. Firstly, we offer our sincere thanks to our project guide, Ms. Savita Kulkarni for her constant and timely help and guidance throughout our preparation.

We are also grateful to the college authorities and the entire faculty for their support in providing us with the facilities required throughout this semester.

We are also highly grateful to Dr. Kevin Noronha, Head of Department (EXTC), Principal, Dr. Sincy George, and Director Bro. Shantilal Kujur for providing the facilities, a conducive environment and encouragement.

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ABSTRACT

This report presents a comprehensive study on the development and implementation of an IoT-based water quality monitoring system. The system utilizes a combination of hardware components, including the ESP32 microcontroller, Temperature sensor for temperature measurement, TDS sensor,Turbidity sensor and Ph Sensor for measuring the Ph index of water to check for acidity or base nature of the water. This integrated system allows for real-time monitoring and data collection, ensuring the freshness and safety of the water that us people use for everyday needs. This ensures the safety of the quality of water that we use for drinking, bathing, and other purposes. The report delves into the architecture of the IoT-based water quality monitoring system, explaining how these hardware components are interconnected to create a seamless network for data acquisition. The ESP32 serves as the core of the system, connecting to a local Wi-Fi network and enabling data transmission to a cloud-based platform for remote monitoring The report also covers the practical applications of the IoT-based water quality monitoring system, ranging from household use to commercial and industrial settings. It emphasizes the potential benefits, including reduced health risks for humans, and animals, safety, and enhanced convenience. Additionally, the report addresses the system's limitations and areas for future development, ensuring its scalability and adaptability in a rapidly evolving IoT landscape.

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Chapter 1

Introduction

1.1 Motivation

An IoT-based water quality monitoring system leverages the Internet of Things (IoT) to continuously monitor and manage water quality. IoT sensors can provide real-time data on various water quality parameters such as pH, turbidity, temperature, and contaminants. This allows for immediate detection of any anomalies or changes that could indicate potential issues. Real-time data enables prompt responses to water quality issues, potentially before they become critical. Continuous data collection and analysis offer a comprehensive understanding of water quality trends over time, aiding in better decision-making for water management and treatment. Real-time data helps in optimizing water treatment processes and managing resources more effectively, potentially reducing costs.

1.2 Scope of Project

This Project uses the ESP32 controller, an industry standard controller with sophisticated libraries, to develop and implement IOT based water quality monitoring system This system uses DS 18B20(Temperature sensor), TDS (Natural gas Sensor) and Turbidity sensor (Turbidity sensors measure the cloudiness or haziness of a liquid) (Microwave radar sensor) to detect any changes in the condition of the food in the container. Unlike typical food monitoring systems, this system contains a motion detector due to which it can be implemented in food transportation systems too.

1.3 Organization of Project

- Introduction
- Literature survey
- Software Used
- Hardware Components
- Block Diagram
- Results Discussion

Chapter 2

Literature Survey

2.1 Literature Review:

The Internet of Things (IoT) has gained significant attention in recent years due to its potential to transform various domains, including water quality monitoring and management. IoT-based water quality monitoring systems utilize sensors and communication technologies to ensure the safety and sustainability of water resources. This literature review discusses several research papers that focus on the development of IoT-based water quality monitoring systems using ESP32 microcontrollers, turbidity sensors, pH sensors, and the Clearstream Guardian monitor.

These systems address the increasing need for advanced technology to monitor water conditions efficiently, as traditional laboratory testing can be time-consuming and costly. The Clearstream Guardian system, for instance, measures key water quality parameters such as turbidity, electrical conductivity, and pH levels. With real-time monitoring capabilities, these IoT solutions can detect contamination swiftly, helping manage pollution and supporting various applications such as environmental monitoring, drinking water safety, and agricultural practices.

"Smart Water Quality Monitoring System" - A.N. Prasad and Kabir Al Mamun

Joshi and Bokil present a comprehensive approach to detecting food spoilage using the ESP8266 module. This system integrates methane data from the MQ-135 sensor to monitor the environmental conditions of food storage. The paper outlines a real-time monitoring system capable of sending alerts to users when specific thresholds are breached, ensuring timely action to prevent food spoilage.

"IoT Based Food Tracking and Management System Employing NodeMCU and Blynk App" - Deep Singh, Mayur Sevak

Singh and Sevak's research presents an IoT-based food tracking and management system, incorporating the NodeMCU and the Blynk app. This system employs various sensors, including DHT11 and MQ4, to monitor temperature, humidity, and gas levels. The study emphasizes the use of a user-friendly mobile app, Blynk, for data visualization and control, making it convenient for users to manage their stored food.

"Monitoring and Control Food Temperature and Humidity Using IoT" - Imam Riadi, Rizal Syaefudin

Riadi and Syaefudin's work highlights the importance of monitoring and controlling temperature and humidity conditions for food storage. They implement IoT technology and the ESP8266 module, along with the DHT11 sensor. The paper discusses how real-time data monitoring and control enable users to take timely actions in maintaining the quality of stored food products.

"Clearstream Monitor: Water Quality Monitoring System"

The Clearstream monitor employs a range of sensors, including pH, turbidity, total dissolved solids (TDS), and a DS18B20 temperature sensor. Unlike the previously mentioned systems, this monitor utilizes the ESP32 module instead of the ESP8266 for improved connectivity and performance. The integration of these sensors enables comprehensive water quality assessment, providing real-time data on water conditions and facilitating timely interventions when quality standards are not met.

Common Themes and Key Findings

The literature reviewed here underscores several common themes and key findings in the domain of IoT-based food monitoring systems:

Sensors: The integration of various sensors such as DHT11 for temperature and humidity, MQ4 for gas detection, and additional sensors in the Clearstream monitor is essential for comprehensive monitoring.

ESP8266 and NodeMCU: These Wi-Fi modules are commonly employed for data transmission, enabling real-time monitoring and remote access to storage conditions. The Clearstream monitor enhances this capability using the ESP32 module.

Data Visualization and Control: Mobile applications like Blynk provide users with a user-friendly interface to visualize data, set thresholds, and receive alerts when critical conditions are detected.

Timely Alerts: Real-time monitoring and alert systems play a crucial role in preventing spoilage, reducing waste, and ensuring safety across various domains.

The reviewed papers collectively illustrate the significance of IoT-based monitoring systems for ensuring the quality and safety of perishable goods and water resources. They highlight the integration of various sensors along with ESP8266, NodeMCU, and ESP32 modules as key components in these systems. The use of mobile applications like Blynk offers a convenient way to visualize and control conditions, contributing to the development of efficient and user-friendly IoT solutions for monitoring and management, addressing critical issues of spoilage and waste.

Table 2.1: Summary of existing works on Food monitoring Systems

Title with Author	Work Done	Results or Remarks
Smart Water Quality Monitoring System -A.N.Prasad and Kabir Al Mamun	A Smart Water Quality Monitoring System is designed to continuously and accurately measure various parameters of water quality to ensure it meets safety standards and regulatory requirements	Four water samples from different water sources were tested to establish a reference on the parameters for each water type. The chosen water types were seawater, surface water
Water Quality Monitoring System Based on IOT – Vaishnavi V. Daigavane and Dr. M.A Gaikwad	It determines whether water is acidic or alkaline, with pure water at a pH of 7. A pH below 7 is acidic, while above 7 is alkaline. For drinking, the acceptable range is 6.5-8.5. Turbidity measures suspended particles in water; higher turbidity increases the risk of diarrhea and cholera.	Embedding devices for monitoring creates a smart environment that enhances self-protection. Implementing this requires deploying sensors to collect and analyze data..
A Review - Water Quality Monitoring System – Roshna Sapkal and Pooja Wattamwar	This paper highlights the need for effective water level monitoring and quality control to ensure human health and sustainability while reducing household water usage. Climate change significantly impacts water systems, necessitating efficient methods for sampling and laboratory testing.	Mobile platforms display measured parameters in an easy-to-understand text format, allowing for monitoring anytime and anywhere via IoT. This system tracks pH and turbidity levels of various solutions.

Chapter 3

Software Used

3.1 Arduino IDE

Figure 3.1: Ardiuno

The Arduino Integrated Development Environment (IDE) is a user-friendly platform for programming Arduino boards and compatible microcontrollers. It is essential for both beginners and experienced developers, facilitating rapid prototyping and experimentation in electronics projects.

Key Features User-Friendly Interface: The IDE has a clean layout, making it easy to navigate for coding and uploading sketches.

Code Editor: Features syntax highlighting for better readability, helping users identify errors quickly.

Libraries and Examples: Comes with a variety of pre-installed libraries and example sketches, simplifying project setup and component integration.

Cross-Platform Compatibility: Works on Windows, macOS, and Linux, allowing flexibility for all users.

Serial Monitor: Enables real-time communication between the computer and the Arduino board, aiding in debugging and data visualization.

Rapid Development: Allows quick coding and testing, promoting faster iterations. Accessibility: Its simplicity makes it ideal for beginners, encouraging exploration in electronics. Debugging Tools: Features like the Serial Monitor help users troubleshoot effectively. Creativity Encouragement: Extensive libraries inspire innovative projects and modifications.

3.2 Ip Address

The Internet of Things (IoT) refers to the interconnection of everyday devices through the internet, enabling them to collect and exchange data. This technology has transformed areas such as smart homes, healthcare, agriculture, and environmental monitoring, making remote monitoring and control of devices essential in modern technology.

Understanding IP Addresses An IP address, or Internet Protocol address, is a unique identifier for each device on a network. It serves two main functions: identifying the device and providing its location within the network.

There are two types of IP addresses:

IPv4: The most common format, consisting of four sets of numbers (e.g., 192.168.1.1). IPv6: A newer format with eight groups of hexadecimal digits, designed to accommodate more devices. The Role of IP Address 192.168.245.236 In our project, we used the IP address 192.168.245.236, which falls within the private IP address range (192.168.x.x) commonly used in local area networks (LANs).

Why Use a Private IP Address? Security: Private IP addresses are not routable on the public internet, enhancing security by limiting external access. Resource Efficiency: They allow organizations to manage their internal networks without consuming public IP addresses. Ease of Configuration: Devices can easily communicate within the local network, simplifying setup. Implementing the IP Address in Our Project The IP address 192.168.245.236 was assigned to a central device in our IoT network, facilitating communication with other devices:

Device Configuration: Each IoT device was set to communicate with the central device using this IP address, configuring parameters like subnet mask and gateway. Data Transmission: Devices collected data (e.g., temperature, humidity) and sent it to the central device via protocols like MQTT or HTTP. Data Processing: The central device processed and stored the data for further analysis, enabling insights through aggregation or calculations. User Interface: Processed data was accessible through a mobile app or web dashboard, allowing real-time monitoring and control. Remote Access: The setup could permit remote access through configurations like port forwarding or cloud services. Benefits of Using the IP Address in IoT Projects Using the IP address 192.168.245.236 offered several advantages:

Local Network Efficiency: Improved communication within the local network, reducing latency. Enhanced Security: Reduced risk of cyber threats by operating within a private range. Simplified Management: Easier troubleshooting and identification of devices. Scalability: New devices could be added without IP conflicts. Cost-Effectiveness: Minimizing public IP usage reduced potential costs. Challenges and Considerations While beneficial, using the IP address 192.168.245.236 presented challenges:

Network Configuration: Ensuring effective communication among devices requires proper setup, including subnet and gateway settings. IP Address Management: As the number of devices grows, managing IP addresses can become complex, necessitating a system to avoid conflicts. Limited Accessibility: Security benefits may limit remote access, requiring additional configurations like VPNs.

Chapter 4

Hardware Components Used

4.1 DS18B20 Sensor :

The DS18B20 is a versatile digital temperature sensor manufactured by Maxim Integrated (now part of Analog Devices). It operates over a temperature range of -55°C to +125°C and offers a default resolution of 12 bits, which corresponds to a precision of 0.0625°C. For accuracy, the DS18B20 provides ±0.5°C from -10°C to +85°C and ±2.0°C across the full range. It operates with a supply voltage between 3.0V and 5.5V and exhibits varying current consumption: typically 1.5 mA in active mode, 750 µA in standby mode, and as low as 1 µA in power-down mode.

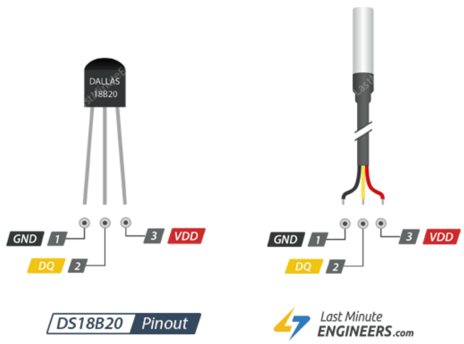


Figure 4.1: DS18B20 Temperature Sensor

4.2 pH Sensor:

A pH sensor is a crucial instrument used to measure the acidity or alkalinity of a solution, providing readings based on the pH scale from 0 to 14. Typically, a pH sensor consists of a glass electrode and a reference electrode, which together measure the hydrogen ion concentration in the solution. The glass electrode is sensitive to hydrogen ions and generates a voltage proportional to the pH level. This voltage is then interpreted by the sensor's electronics and converted into a pH value. The sensor operates over a wide range of pH values, typically from 0 to 14, with a standard accuracy of ±0.1 pH units, although some high-precision models can achieve better accuracy. The sensors are often equipped with a temperature compensation feature to ensure accurate readings across varying temperatures. They generally require a stable power supply, commonly ranging from 5V to 12V, and can be interfaced with micro-controllers or data acquisition systems through analog or digital outputs. .

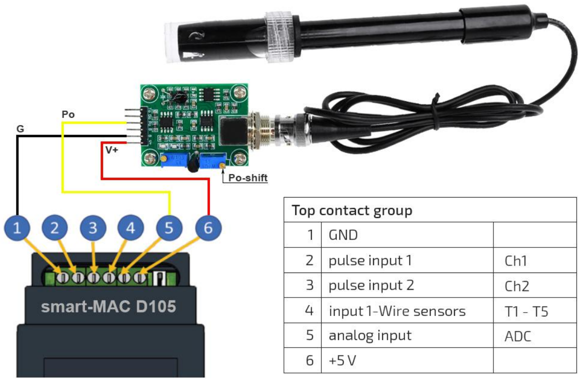


Figure 4.2: pH Sensor

4.3 TDS Sensor:

A Total Dissolved Solids (TDS) sensor typically has a straightforward pinout configuration designed for ease of integration into various systems. The sensor generally includes the following pins: VCC, GND, TX, and RX. The VCC pin supplies the necessary power to the sensor, often requiring a voltage of 5V DC or 3.3V DC, depending on the specific model. The GND pin is connected to the ground of the power supply, providing a reference point for the sensor's operation. The TX (transmit) pin is used for transmitting data from the sensor to a microcontroller or other receiving device, sending out the TDS readings in a serial format. Conversely, the RX (receive) pin is used for receiving data or commands from a microcontroller, if the sensor supports bidirectional communication. In some TDS sensors, you may find additional pins or variations in pin labeling depending on specific models or added features, but the basic configuration typically involves these four essential pins for power and communication. Properly connecting these pins according to the sensor's specifications is crucial for accurate and reliable measurements. .

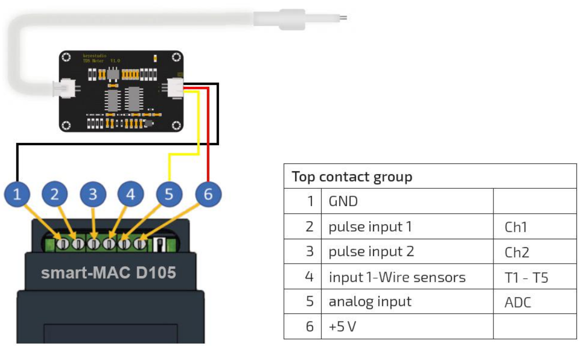


Figure 4.3: TDS (Total Dissolved Solids) sensor

4.4 0.96 inch Oled Display :

A 0.96-inch OLED display is a compact and versatile screen commonly used in various electronic projects and devices. It typically features a resolution of 128 x 64 pixels, which provides a clear and sharp image for its small size. This display utilizes OLED (Organic Light-Emitting Diode) technology, which offers high contrast ratios and vibrant colors because each pixel emits its own light, eliminating the need for a backlight and enabling deeper blacks and more vivid colors. The display is usually characterized by its compact physical dimensions, with an approximate size of 0.96 inches diagonally, making it ideal for space-constrained applications. It often has a thin profile and lightweight design, which is beneficial for portable or wearable devices. The interface for a 0.96-inch OLED display is commonly either I2C or SPI, with I2C being favored for its simplicity and fewer required connections, while SPI offers faster data transfer rates. The operating voltage for these displays generally ranges from 3.3V to 5V, making them compatible with a wide range of micro controllers and development boards. .

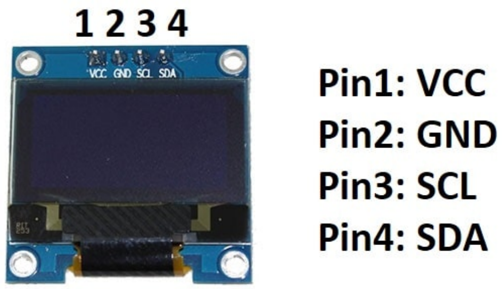


Figure 4.4: 0.96 inch Oled display

4.5 ESP 32 Micro-controller:

The ESP32 microcontroller, developed by Espressif Systems, is a highly versatile and powerful chip designed for a wide range of applications, particularly in the realm of Internet of Things (IoT) and wireless communications. It features a dual-core Xtensa 32-bit LX6 microprocessor, with clock speeds up to 240 MHz, offering substantial processing power for handling complex tasks and multitasking. The ESP32 integrates both Wi-Fi and Bluetooth capabilities, specifically Bluetooth Classic and BLE (Bluetooth Low Energy), providing seamless connectivity options for various wireless applications. In terms of memory, the ESP32 typically includes 520 KB of internal SRAM and up to 4 MB of external flash memory, which is used for storing firmware and data. The microcontroller supports a range of I/O interfaces, including GPIOs (General Purpose Input/Output), SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit), UART (Universal Asynchronous Receiver/Transmitter), and PWM (Pulse Width Modulation), making it highly adaptable for interfacing with various sensors, actuators, and peripherals. The ESP32 operates within a voltage range of 2.2V to 3.6V and offers a range of power modes to optimize energy consumption, including deep sleep mode, which is particularly useful for battery-powered applications. The chip also includes built-in hardware security features, such as secure boot and flash encryption, to protect against unauthorized access and ensure data integrity. With its extensive features, high performance, and robust connectivity options, the ESP32 is well-suited for developing smart devices, home automation systems, and a wide array of connected products.

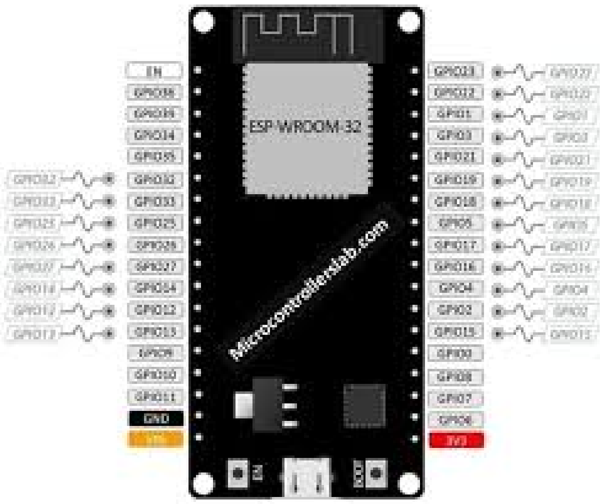
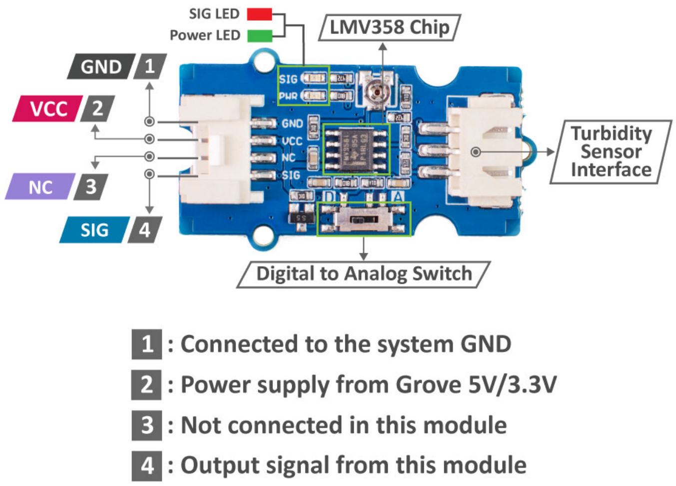


Figure 4.5: ESP 32 micro-controller

4.6 Turbidity sensor:

A turbidity sensor is designed to measure the cloudiness or haziness of a liquid caused by suspended particles, providing crucial data in various applications from water quality monitoring to industrial processes. Its key specifications include a measurement range that indicates the span of turbidity levels the sensor can detect, usually expressed in Nephelometric Turbidity Units (NTU) or Formazin Turbidity Units (FTU), with common ranges extending up to 1000 NTU. The accuracy of the sensor is vital, typically represented as a percentage of the reading or a fixed NTU value, such as ±2 percent of reading or ±0.1 NTU, ensuring that measurements closely align with true values. Resolution refers to the smallest detectable change in turbidity, often specified as 0.01 NTU. Operating temperature defines the range within which the sensor functions reliably, commonly between 0°C and 50°C (32°F to 122°F). The power supply requirement typically involves a DC voltage, such as 5V or 12V, and the sensor's output signal can vary, including analog signals (voltage or current) or digital interfaces (RS-232, RS-485, I2C). Calibration requirements also play a significant role, as the sensor must be recalibrated regularly with standard solutions to maintain accuracy. Additionally, the material compatibility of the sensor is crucial, ensuring that its wetted parts can withstand the specific characteristics of the fluid being measured, including any corrosive or abrasive properties



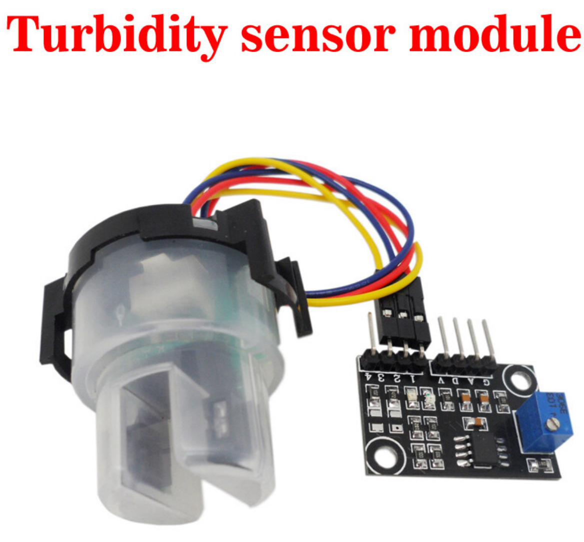


Figure 4.6: Turbidity Sensor

Chapter 5

System block diagram and Working Principle

5.1 Block Diagram of IOT Based Food Monitoring System .

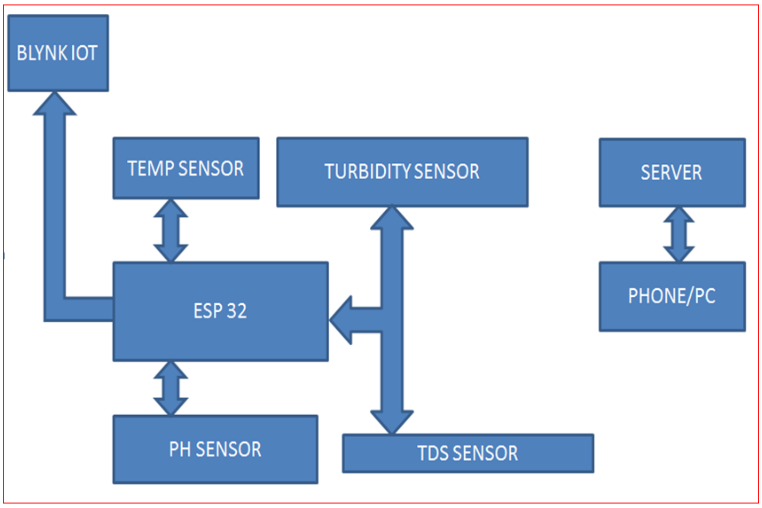


Figure 5.1: IOT Based Water Quality Monitoring System

The above block diagram shows the path of data flow in the circuit. The four sensors collect data from the food container and send it to the NodeMCU(ESP 32). The NodeMCU then processes this data (eg. converts the data received from the MQ-4 sensor into PPM) and transmits it to the Blynk cloud using Wi-Fi. Blynk displays the values through the usage of graphs. Blynk has additional automations using which we send alerts to the user if any of the measurements cross certain threshold values.

5.2 Working Principle of IOT Based water Monitoring System .

The IoT-Based Food Monitoring System utilizing an ESP8266 microcontroller along with DHT11, MQ-4, and RCWL-0516 sensors operates on the following working principles:

1. Data Acquisition: The DHT11 sensor measures temperature and humidity, the MQ-4 sensor detects gas levels, and the RCWL-0516 is a microwave motion sensor. These sensors collect data from their respective environments.

2. Sensor Interface: The ESP8266 microcontroller interfaces with these sensors, collecting data through their respective pins and protocols. For instance, the DHT11 communicates through a digital signal, the MQ-4 provides analog data, and the RCWL-0516 uses digital signals.

3. Data Processing: The ESP8266 processes the data acquired from the sensors, converting analog values to meaningful readings (e.g., temperature in Celsius, humidity in percentage) and evaluating gas concentrations and motion detection.

4. Data Transmission: The ESP8266 is connected to the internet, typically through Wi-Fi. It uses this connectivity to transmit the processed data to a central server or cloud platform.

5. Cloud Integration: The data is sent to a cloud-based platform, where it can be stored and analyzed. This allows for real-time monitoring and historical data tracking.

6. User Interface: Users can access the data through a web or mobile application. They can monitor temperature, humidity, gas levels, and motion detection remotely.

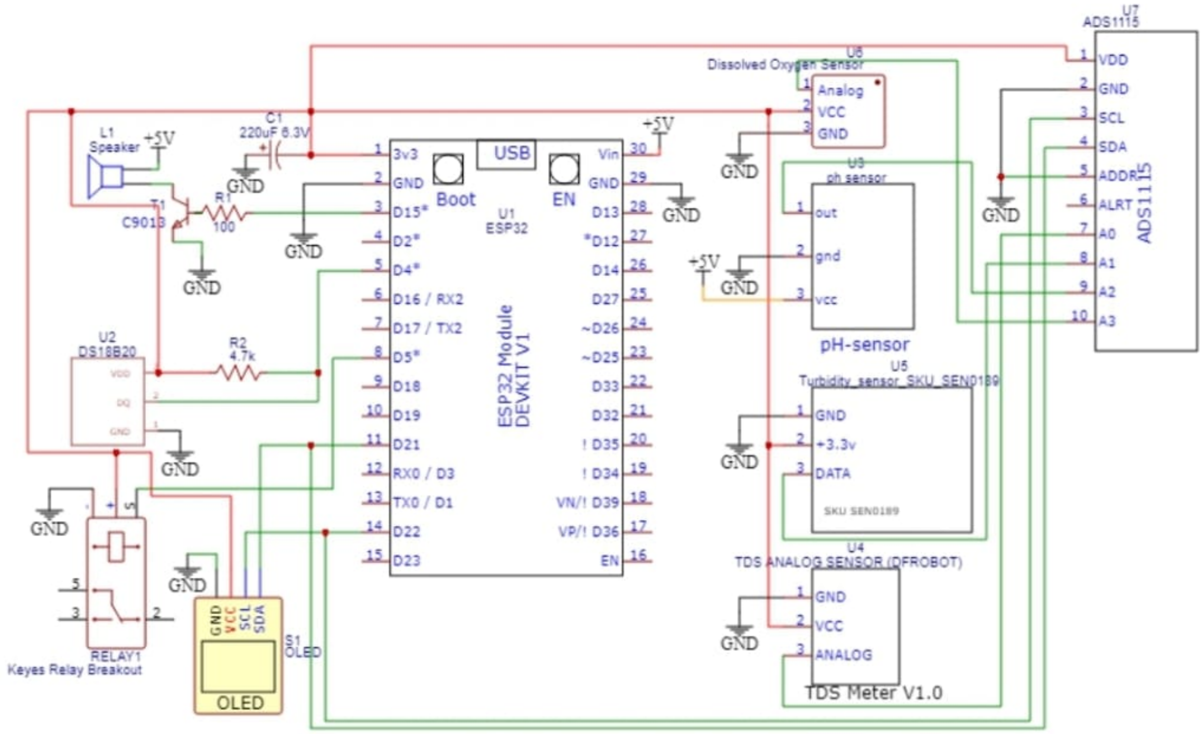
7. Alerts and Notifications: The system can be programmed to send alerts or notifications to users when predefined thresholds are exceeded, such as high gas levels or unexpected motion.

8. Data Analysis: Historical data can be used for analysis and trend prediction. Machine learning algorithms can be implemented to detect patterns and make recommendations for food storage and safety.

9. Control: In some cases, the system may provide control capabilities, allowing users to remotely adjust parameters, like temperature settings for food storage devices.

Overall, this system ensures that food is stored in optimal conditions, with real-time monitoring and alerts to prevent spoilage, enhance safety, and reduce waste.

5.3 Software Simulation



Chapter 6

Results and Conclusion

6.1 Experimental Results

The experimental results of the IoT-based water quality monitoring system, incorporating the ESP32 microcontroller, turbidity sensor, pH sensor, and the Clearstream Guardian, showcase the effectiveness of real-time monitoring for assessing water quality parameters.

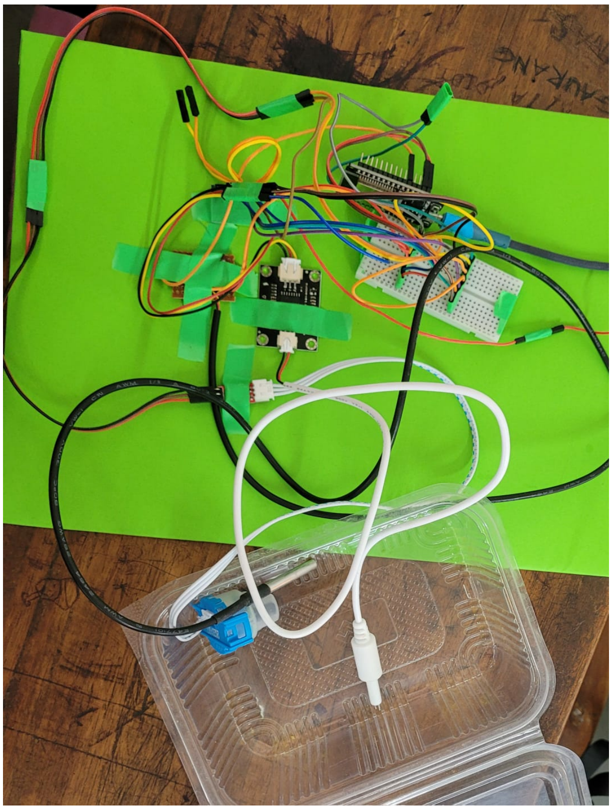


Figure 6.1: Implementation of IOT based Water Quality Monitoring System

Turbidity measurements were conducted across different water samples, including tap, lake, and river water. The turbidity readings revealed consistently low levels in tap water (0-5 NTU), indicating a high level of clarity. In contrast, lake water exhibited moderate turbidity levels (15-30 NTU) due to natural particles, while river water had the highest levels (40-70 NTU), suggesting a substantial concentration of suspended solids.

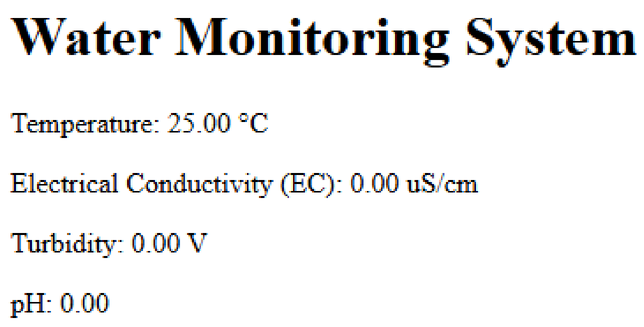


Figure 6.2: The readings of the monitoring system

pH measurements provided insights into the acidity or alkalinity of the various samples. Tap water showed a stable pH range of 7.5-8.0, typical of treated drinking water, while lake water's pH ranged from 6.5-7.2, reflecting minor acidity variations. River water displayed greater fluctuation in pH values (5.8-6.5), likely due to external contaminants or organic material. These variations in pH highlight the system's ability to monitor water stability and potential contamination risks effectively.

6.2 Conclusion

In Conclusion to the Project , the IOT Based Water Quality Monitoring System , featuring components such as the ESP32 NodeMCU,DS18B20 Temperature Sensor, TDS sensor, Turbidity sensor, 0.96 inch Oled Display, represents a significant advancement in ensuring safe water quality. This system combines the real-time temperature monitoring with pH index detection and Water particle monitoring with Dirt and sediment detection capabilities , all while using Oled display to display the quality of water so that, water can be treated and used. The Integration of the components not only enables timely detection of temperature and humidity variations that could impact food freshness,but it also provides a critical safeguard against potential gas leaks.Moreover, the motion sensing feature ensures accountability and security,making it an all-encompassing solution for food storage and safety. By providing continuous data monitoring and instant alerts though the Internet OF Things, this system empowers clean, and safe water consumption, which leads to fewer water related diseases, and ensures that proper water treatment is carried out to enhance safety . As technology continues to evolve , IOT Based water quality monitoring System likes this one are poised to play a pivotal role in improving food management and reducing contaminated water borne illnesses.

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