Mini Project Report On

Water Quality Monitoring Buoy

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Applied Electronics & Instrumentation Engineering

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CERTIFICATE

This is to certify that the mini project report entitled ***"Water Quality Monitoring Buoy"*** *is a bonafide record of the work done by* ***Dheeraj S Dharman (U2102025)****,* ***Kalyani N Shenoy (U2102038)****,* ***Neha Binukumar Nair (U2102049)****,* ***Neha Nice (U2102050)*** *and* ***P Simran Sureshkumar (U2102053)*** *submitted to the Rajagiri School of Engineering & Technology (RSET) (Autonomous) in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in "Applied Electronics & Instrumentation Engineering" during the academic year 2023-2024.*

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Last but not least, we would like to express our sincere gratitude towards all other teachers and friends for their continuous support and constructive ideas.

Abstract

This project proposes a novel and cost-effective solution for real-time water quality monitoring: a compact, self-contained buoy equipped with low-cost and accessible sensors like Arduino UNO and probes for temperature, pH, and Total Dissolved Solids (TDS). Unlike traditional labor-intensive methods, this buoy offers real-time data transmission flexibility through both WiFi (facilitating long-range communication near established networks) and Bluetooth Low Energy (BLE) for prioritizing lower power consumption in remote locations. This eliminates the need for frequent manual testing, saving time and resources. Prioritizing affordability with readily available components, the technology is accessible to a wider range of users compared to expensive traditional systems, making it valuable for researchers, environmental agencies, and even smaller aquaculture operations. The compact size further expands its applicability by enabling deployment in diverse freshwater and saltwater environments.

Contents

List of Abbreviations

1. WQMB- Water Quality Monitoring Buoy
2. TDS- Total Dissolved Solids
3. BLE- Bluetooth Low Energy
4. WiFi- Wireless Fidelity
5. pH- Potential of Hydrogen
6. OLED- Organic Light-Emitting Diode
7. PLED- Polymer Light-Emitting Diode
8. WRM- Water Resource Management
9. WFD- Water Framework Directive
10. CWA- Clean Water Act
11. WSN- Wireless Sensor Network
12. IoT- Internet of Things
13. LCD- Liquid Crystal Display
14. LED- Light Emitting Diode
15. DAC- Digital to Analog Converter
16. CAN- Controlled Area Network
17. OP AMP- Operational Amplifier
18. HID- Human Interface Device
19. I2C- Inter-Integrated Circuit

20. RTC- Real-Time Clock
21. VRTC- Virtual Real-Time Clock
22. RAM- Random Access Memory
23. SPI- Serial Peripheral Interface
24. MCU- Microcontroller Unit
25. IDE- Integrated Development Environment

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Chapter 1

Introduction

Water pollution remains a significant global issue with various sources contributing to its degradation. Industrial waste, agriculture runoff, sewage discharge, and plastic waste are among the primary culprits. These pollutants contaminate water bodies, harming aquatic ecosystems, endangering wildlife, and threatening human health.

Figure 1.1: Buoy Type Monitoring System

Water quality monitoring devices Figure 1.1 play a crucial role in safeguarding human health and protecting the environment. Monitoring devices can detect pollutants in water bodies at an early stage, allowing prompt action to mitigate the spread of contamination and prevent adverse health effects. By continuously monitoring water quality parameters like temperature, pH, and dissolved solids, these devices help to ensure that drinking water meets safety standards. They can also help to track changes in water quality that can affect aquatic ecosystems including fish populations, biodiversity, and overall ecosystem.

Many industries are required by law to monitor and report their wastewater discharge to ensure compliance with environmental regulations. Water quality monitoring devices help industries meet these requirements and avoid penalties for non-compliance.

Several regulatory frameworks and international agreements drive the need for improved water quality monitoring like the the Clean Water Act(CWA) and the European Union Water Framework Directive(WFD).CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The WFD sets out a framework for the protection and improvement of water quality across the European Union.

1.1 Problem Definition

This project aims to create a compact, self-contained device that can check the quality of the water once deployed into lakes, ponds, rivers, oceans, and other types of water bodies. Several health issues due to poor water quality were the main reason behind the selection of this project.

1.2 Scope and Motivation

The scope of this device typically involves assessing various parameters like pH levels, dissolved solids, and temperature. This device can be used in various settings like for monitoring, in agricultural processes and for ensuring safe drinking water.

Need for a device that checks the water purity levels of water bodies and water storage facilities that favors remote checking of water quality, continuous monitoring of water quality, gives rapid response and that is cost effective

1.3 Objectives

The main objectives of this project are :

1. Integrate the TDS Meter with Arduino to measure Total Dissolved Solids (TDS) in the water. Integrate a TDS meter with an Arduino for water quality measurement

by connecting the meter's analog output to an Arduino analog input (e.g., A0), or use the appropriate communication protocol (UART or I2C) for digital output. Write Arduino code to read and process TDS data: use 'analogRead' and 'map' for analog output, or implement specific protocols for digital meters. Ensure the TDS meter is calibrated per its specifications. Provide stable 5V power, and optionally add a display or data logging for real-time monitoring. Adapt code and connections for accurate measurements based on your specific TDS meter and Arduino model

2. Connect the DS18B20 temperature sensor to Arduino for monitoring water temperature. To monitor water temperature using a DS18B20 sensor with an Arduino, connect VCC to 5V, GND to GND, and Data (DQ) to a digital pin (e.g., pin 2) with a 4.7k pull-up resistor to 5V. Add the OneWire and DallasTemperature libraries in Arduino IDE, initialize the sensor in setup(), and continuously request temperature readings in loop(). Use serial communication for debugging and adjust delays as needed for timing. View temperature in Celsius or Fahrenheit via Serial Monitor for accurate monitoring of water temperature.

3. Interface the SSD1306 OLED Display with Arduino to provide a real-time display of water quality parameters. Interface the SSD1306 OLED display with Arduino by connecting VCC to 5V, GND to GND, SCL to A5 (or SCL pin), and SDA to A4 (or SDA pin). Use the Adafruit SSD1306 library to initialize and update the display in the Arduino code's setup() and loop() functions, showing real-time water quality parameters like temperature and TDS values for continuous monitoring.

4. Utilize 3D modeling software to design a waterproof buoy housing. Design a waterproof buoy housing in Autodesk Fusion 360 or SolidWorks by sketching dimensions and internal structures for electronics and sensors. Ensure seals, gaskets, secure closures, ventilation holes, and drainage channels are incorporated for waterproofing. Validate structural integrity and waterproofing virtually, then export the final design in STL or STEP format for manufacturing, documenting details for future reference and modifications.

5. Employ 3D printing technology to manufacture the waterproof buoy, ensuring it can withstand immersion in water bodies while protecting internal electronics. Design

a waterproof buoy in Autodesk Fusion 360 or SolidWorks with seals, gaskets, and secure closures for water resistance. Choose ABS or PETG for 3D printing material. Print the buoy with precise settings, ensuring a smooth finish and effective waterproofing. Assemble electronics, test in water for integrity, iterate on design based on results, and document the process for future improvements, ensuring it meets aquatic operational needs.

1.4 Challenges

Deploying the WQMB into diverse water bodies presents challenges such as ensuring sensor accuracy and reliability amidst varying environmental conditions and water chemistry. Additionally, maintaining data transmission stability and buoy stability against currents, waves, and potential vandalism or damage are critical challenges for sustained and effective water quality monitoring.

1.5 Assumptions

In the WQMB project, it is crucial to assume that the sensors employed are highly reliable and capable of accurately measuring essential water quality parameters, including pH levels, temperature, and conductivity, across a range of water bodies such as rivers, lakes, and water tanks. This reliability ensures that the data collected reflects true environmental conditions, providing a solid foundation for subsequent analysis. Additionally, it is assumed that the WQMB system is environmentally robust, able to function effectively and endure the diverse conditions encountered in these aquatic environments without compromising the accuracy of the data or the functionality of the buoy. This durability is vital for maintaining consistent and long-term monitoring operations. Furthermore, the assumption extends to the data transmission process, where it is expected that a stable and reliable means of transmitting data from the buoy to a centralized database or monitoring station is in place. This consistent data transmission is essential for enabling real-time analysis and informed decision-making in water quality management, allowing for prompt and effective responses to any detected issues.

1.6 Societal / Industrial Relevance

The Water Quality Monitoring Buoy (WQMB) holds significant relevance in both societal and industrial applications. It protects public health by monitoring drinking water sources in rivers and lakes, and facilitates environmental conservation by identifying pollutants in aquatic ecosystems. Additionally, it enhances safety for recreational activities in swimming pools and beaches, and optimizes water usage while maintaining product quality standards in manufacturing and agriculture. The WQMB also supports sustainable aquaculture practices by monitoring water quality for aquatic organisms, and ensures compliance with environmental regulations for wastewater treatment plants and industrial facilities.

1.7 Organization of the Report

The report on the water quality monitoring device is meticulously structured to provide a comprehensive understanding of its function and effectiveness. It begins with Chapter 1, the Introduction, highlighting the critical importance of water quality monitoring and outlining the specific objectives of the device. Chapter 2, the Literature Review, delves into existing research and technologies relevant to the field, providing context and supporting the development of the current device. Chapter 3, Methodology, details the specifications of the monitoring device, including the types of sensors employed and their calibration procedures. Chapter 4, Results, presents the data collected by the device for analysis. Finally, Chapter 5, the Conclusion, summarizes the key findings, evaluates the device's performance, and offers recommendations for further enhancement. To complement the main report, appendices will include supplementary technical details and raw data to support the findings presented throughout the document.

Chapter 2

Literature Survey

Maintaining healthy water resources requires effective monitoring, but traditional methods often fall short due to limited scope, cost, and accessibility. Water quality monitoring buoys offer a compelling solution. These self-contained systems provide continuous data collection, real-time monitoring capabilities, and remote deployment options. This literature survey delves into the current state of water quality monitoring buoys, examining sensor technologies, data transmission methods, power management strategies, and recent advancements. By exploring existing research, this survey aims to identify key trends and opportunities for even more effective buoys, ultimately contributing to improved water resource management.

2.1 Related work

Several systems have been developed that address some of the issues with the commercially available water quality monitoring systems. The projects "RiverCore"[1] and "CavePearl"[2] are two examples of projects that have done so and have similarities to WQMB. However, RiverCore monitors water levels as part of a real-time flood warning system, while CavePearl is a water quality datalogger, being used in submerged cave systems. CavePearl does not report data in real time and requires manual extraction of data.

Piyush Agade *et.al*[3] shows utilisation of low-cost sensors to deliver accurate, high-frequency water quality data. This real-time information empowers WRMs with a more comprehensive understanding of water quality, enabling faster response times to pollution events and improved water resource management.

B. O'Flynn *et.al* [4] has given a a multi-sensor system designed to meet the requirements set by the water quality regulations in Europe (WFD). It measures key water quality parameters like temperature, phosphate, oxygen levels, conductivity, pH, turbidity, and water level. The system leverages a "plug and play" wireless sensor network (WSN) for easy sensor integration and the development of custom sensors within the project.

A water quality monitoring system based on wireless sensor network and solar power supply [5] introduces a water quality monitoring system that leverages wireless sensor network (WSN) technology and solar power. To achieve real-time monitoring across diverse field locations, the system employs a novel architecture comprised of distributed sensor nodes and a central base station. Communication between these nodes and the base station is facilitated by WSN technology. A prototype system was designed and implemented, utilizing a single node powered by a solar cell and connected via WSN. This prototype collects data from various sensors, including those measuring pH, turbidity, and dissolved oxygen, and transmits it to the base station through the WSN. This novel system offers several advantages, including a minimal carbon footprint, reduced power consumption, and enhanced deployment flexibility.

A smart water quality monitoring system using four sensors and an IoT platform is propsed in [6]. It focuses on real-time analysis of key parameters (temperature, pH, TDS, turbidity) in various water sources (tap, filtered, river, pond, lake) to determine if they meet drinking water standards. The system uses sensors to collect data, transmits it to an Arduino Uno microcontroller, and displays real-time results on a mobile app and LCD screen. This approach allows users to quickly assess water quality for safe drinking.

2.2 Summary and Gaps Identified

Our project "Water Quality Monitoring Buoy (WQMB) leverages successful methods from prior research [6], [3] in sensor selection, communication protocols, power conservation, and data management. It integrates proven electronic components, water quality sensors, and best practices to create a cost-effective, customizable, open-source, portable, and robust monitoring buoy. The WQMB offers real-time reporting and visualization of water quality data.

While existing water quality monitoring buoys offer valuable data collection capabilities, several limitations hinder their effectiveness. These limitations create gaps in our ability to comprehensively monitor water quality across diverse environments. Here, we explore some key areas for improvement:

- Cost: High costs associated with commercial buoys can restrict deployment, particularly for research and citizen science initiatives.
- Sensor Capabilities: Current sensor limitations include potential accuracy issues due to reliance on commercially available options and limited scope, potentially missing crucial contaminants.
- Deployment Challenges: Depth limitations caused by housing materials and difficulty reaching certain areas restrict data collection in some critical zones.
- Data Transmission: Complexity of managing wireless sensor networks and potential limitations in data transmission range or reliability can hinder real-time monitoring efforts.

Addressing these gaps is crucial for comprehensive water quality monitoring. By developing more affordable, versatile buoys with advanced sensor capabilities and reliable data transmission methods, we can gain a complete understanding of water quality across various aquatic ecosystems.

Chapter 3

Methodology

This chapter outlines the methodology employed to design and develop the water quality monitoring buoy. It details the specific steps taken to achieve the project's objectives, including hardware selection, sensor integration, software development, and system testing. By understanding the methodology, readers gain insight into the decision-making process and the technical approach used to create the final product.

This chapter will delve into the following key aspects:

The hardware selection for the buoy system involves careful consideration of sensors, microcontrollers and communication modules based on their specific functionalities and compatibility with the project requirements. Sensors are chosen for their ability to accurately measure relevant environmental parameters, such as temperature, humidity, and water quality indicators. These sensors are integrated with the microcontroller using appropriate interfacing methods to ensure reliable data acquisition. Calibration procedures are implemented to guarantee the accuracy and consistency of sensor measurements over time. In terms of software development, programming languages and libraries are selected to facilitate efficient data acquisition, processing, and transmission functionalities. Testing procedures are rigorously conducted to validate the buoy's overall functionality and ensure the accuracy of collected data. Additionally, CAD software is utilized for 3D modeling, enabling the design of the buoy's structure, which is then realized through 3D printing for physical implementation.

3.1 Hardware Selection

Choosing the right hardware components is very important for the proper functioning of the device. The following hardware was chosen based on the needs of the buoy.

3.1.1 Arduino Uno R4 WiFi

The Arduino UNO R4 WiFi[7] is a powerful development board that combines the best of both worlds: the processing muscle of a Renesas RA4M1 microcontroller and the wireless capabilities of an ESP32-S3 chip from Espressif. This makes it ideal for projects that need both brains and brawn, whether you're a seasoned maker or just starting. On top of that, it throws in a bunch of useful features like a built-in LED matrix, a Qwiic connector for easy prototyping, and more, making it a great all-in-one package for your next project. With the UNO R4 WiFi, you can easily add wireless connectivity to your existing projects or use it as a starting point for something entirely new.

The Arduino UNO R4 WiFi development board shown in Figure 3.1 represents a significant advancement within the Arduino product line. This report details the key improvements incorporated into the UNO R4 WiFi compared to its predecessor, the UNO R3.

The UNO R4 WiFi is designed to offer enhanced compatibility, performance, and functionality for project development compared to its predecessor, the UNO R3. It maintains compatibility with existing projects and shields by adhering to the established UNO form factor, pin configuration, and 5V operating voltage, minimizing the need for modifications during migration. Performance improvements include increased memory and a faster clock speed, enabling more precise calculations and efficient handling of complex tasks. The board introduces expanded onboard peripherals such as a DAC, CAN bus interface, and OP AMP, providing developers with greater flexibility in project design. It also supports a wider input voltage range up to 24V, simplifying integration with various components like motors and LED strips. The integration of an ESP32-S3 module enables wireless connectivity with WiFi and Bluetooth, facilitating remote monitoring and control through the Arduino IoT Cloud platform. Additional features include a Qwiic I2C connector for easy sensor and actuator integration, dedicated pins for power management and RTC support, an integrated LED matrix for visual displays, and an error-detection mechanism for streamlined debugging. These features collectively enhance the UNO R4 WiFi's utility and versatility in creating innovative and robust electronic projects.

In conclusion, the Arduino UNO R4 WiFi development board offers a compelling array of enhancements over its predecessor. These improvements encompass increased performance, expanded functionality, broader power compatibility, wireless connectivity options, simplified integration with various components, and enhanced debugging capabilities. These advancements make the UNO R4 WiFi a highly versatile and powerful platform for a wide range of project applications.

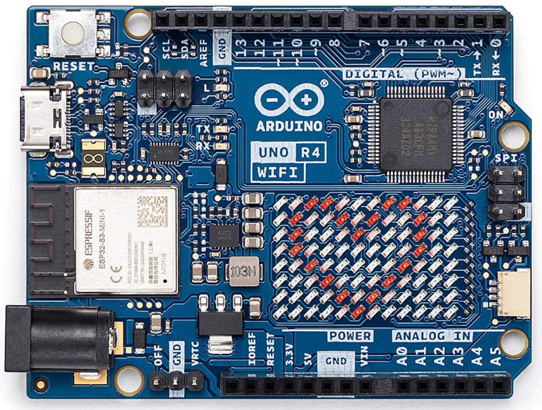

Figure 3.1: Arduino Uno R4 WiFi

3.1.2 DS18B20

DS18B20[8] follows single wire protocol and it can be used to measure temperature.in the range of -67°F to +257°F or -55°C to +125°C with +-5% accuracy.The DS18B20 as shown in Figure 3.2 is one type of temperature sensor and it supplies 9-bit to 12-bit readings of temperature. These values show the temperature of a particular device. The communication of this sensor can be done through a one-wire bus protocol which uses one data line to communicate with an inner microprocessor. Additionally, this sensor gets the power supply directly from the data line so that the need for an external power supply can be eliminated. The applications of the DS18B20 temperature sensor include industrial systems, consumer products, systems which are sensitive thermally, thermostatic controls, and thermometers.

The specifications include a versatile programmable digital temperature sensor that communicates using the 1-Wire method. It operates within a wide power supply range of 3.0V to 5.5V and measures temperatures from -67°F to +257°F (equivalent to -55°C to +125°C) with an accuracy of ±0.5°C. The sensor provides output resolutions ranging from 9-bit to 12-bit, converting a 12-bit temperature to a digital word in 750 ms. It can be powered through the data line and offers programmable alarm options. Each sensor has a unique 64-bit address enabling multiplexing in systems. The sensor is available in various packages including SOP, To-92, and waterproof versions, catering to different application needs from general electronics to harsh environmental conditions.

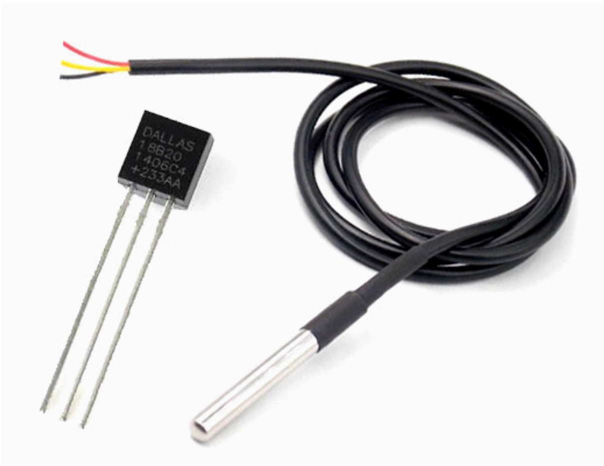

Figure 3.2: DS18B20 Temperature Sensor

The working principle of this DS18B20 temperature sensor is like a temperature sensor. The resolution of this sensor ranges from 9-bits to 12-bits. But the default resolution which is used to power-up is 12-bit. This sensor gets power within a low-power inactive condition. The temperature measurement, as well as the conversion of A-to-D, can be done with a convert-T command. The resulting temperature information can be stored within the 2-byte register in the sensor, and after that, this sensor returns to its inactive state.

3.1.3 Gravity Analog TDS Sensor

Analog TDS Sensor for Arduino[9] is an Arduino-compatible TDS Meter Kit for measuring TDS value of the water, to reflect the cleanliness of the water. TDS meter can be applied to domestic water, hydroponic and other fields of water quality testing.

TDS meter shown in Figure 3.3 indicates that how many milligrams of soluble solids dissolved in one liter of water. In general, the higher the TDS value, the more soluble solids dissolved in water, and the less clean the water is. Therefore, the TDS value can be used as one of the references for reflecting the cleanliness of water.

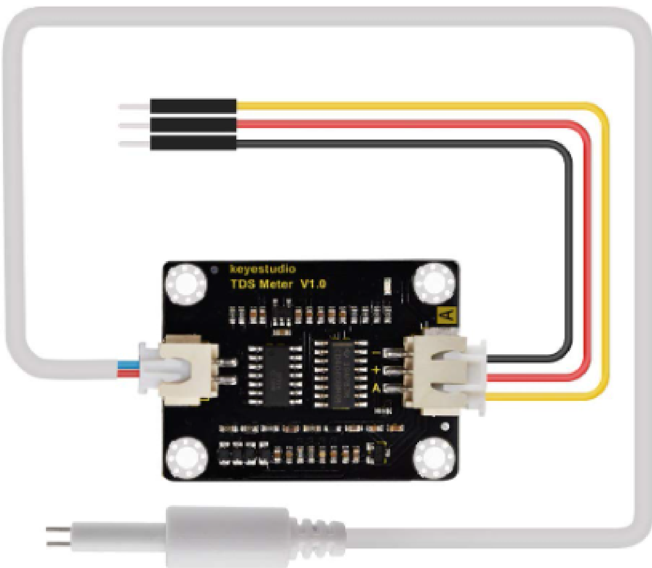

Figure 3.3: TDS Meter

TDS meters work by measuring the electrical conductivity of water. Dissolved solids in water can conduct electricity, so by measuring the conductivity of the water, the TDS meter can determine the concentration of dissolved solids. TDS meters typically use two electrodes that are placed in the water. An electrical current is passed between the electrodes, and the meter measures the resistance to the current. The greater the resistance, the higher the concentration of dissolved solids in the water.

The Gravity analog TDS meter features professional manufacturing quality and operates effectively within a wide voltage range of 3.3V to 5.5V. It outputs a 0-2.3V analog signal compatible with both 5V and 3.3V control systems, ensuring versatility in various electronic setups. The meter utilizes an AC signal source to prevent probe polarization effectively, enhancing its longevity and reliability during prolonged immersion in water, facilitated by its waterproof probe design. Its compatibility and ease of connection allow for plug-and-play installation without the need for soldering, making it straightforward to integrate into water quality monitoring systems and other applications requiring accurate TDS measurements.

3.1.4 Adafruit SSD1306

The SSD1306 [10] is a highly integrated single-chip driver designed for organic light-emitting diode (OLED) and polymer light-emitting diode (PLED) displays. This versatile chip offers a complete solution for controlling dot-matrix graphic displays, eliminating the need for numerous external components.

The SSD1306 shown in Figure 3.4 is optimized for common cathode type OLED panels, typically featuring a resolution of 128 segments by 64 commons.

It features a comprehensive array of capabilities designed to optimize display performance. These include integrated contrast control, allowing for precise adjustment of display brightness. Internal display RAM enhances efficiency by facilitating efficient storage of image data, ensuring smooth and responsive operation. The on-chip oscillator generates essential display control signals, contributing to seamless functionality. Additionally, the 256-step brightness control offers fine-grained adjustments, enabling users to tailor the display to their exact preferences with accuracy and ease. These combined features make it a versatile choice for applications requiring reliable and customizable display solutions.

The SSD1306 offers flexible communication interfaces, supporting industry-standard protocols like the 6800/8000 series compatible parallel interface, I2C interface, and Serial Peripheral Interface (SPI). This versatility simplifies integration with various microcontrollers (MCUs) within a project.

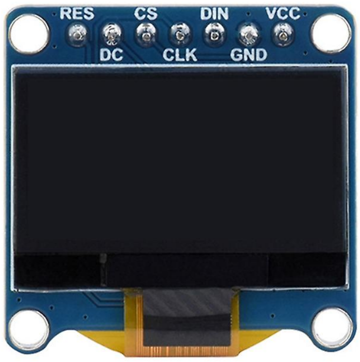

Figure 3.4: Adafruit SSD1306

Due to its compact size, low power consumption, and comprehensive feature set, the SSD1306 is ideally suited for a wide range of portable applications. These include mobile phone sub-displays, MP3 players, calculators, and other space-constrained devices requiring high-quality graphic displays.

3.2 Sensor Integration

Integrating the chosen sensors with the Arduino Uno involved carefully connecting them based on their specifications and communication protocols.

The buoy system integrates several key components to enable comprehensive functionality. The DS18B20 temperature sensor utilizes the Dallas Temperature library, simplifying communication via the One Wire protocol for accurate temperature readings. The Gravity Analog TDS Sensor provides an analog output pin that connects directly to an Arduino Uno's analog input, with power and ground connections made to corresponding Arduino pins (5V, 3.3V, or GND). Specific libraries may vary depending on the sensor model. An OLED display is integrated for real-time data visualization on the buoy, managed by the Adafruit SSD1306 library. This setup allows for the display of text, graphs, and other visual elements, facilitating intuitive and user-friendly representation of data collected by the sensors in the buoy system.

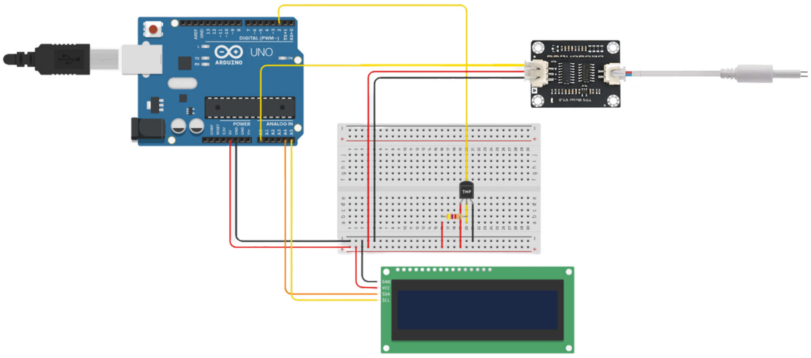

Figure 3.5: Wiring Diagram

By utilizing these libraries and following the recommended connection protocols, the sensors were successfully integrated with the Arduino Uno as shown in Figure 3.5, enabling them to collect and transmit water quality parameters and other data.

3.3 Software Development

The software development process for the water quality monitoring buoy relied heavily on the Arduino Integrated Development Environment (IDE) and the Arduino Cloud platform.

The development of the buoy system leverages Arduino C/C++ as its primary programming language within the Arduino IDE. This language enables interaction with connected sensors via specific libraries such as the Dallas Temperature library for the DS18B20, the Gravity Analog TDS Sensor library, and Adafruit SSD1306 for the OLED display. These libraries facilitate communication, data acquisition, and real-time visualization on the buoy. Sensor data, including temperature from the DS18B20 and TDS readings from the Gravity Analog TDS Sensor, is processed within the Arduino IDE. This involves tasks like scaling to desired units, applying calibration factors, and performing necessary calculations for accurate data interpretation. The processed data is formatted and transmitted using the built-in WiFi or BLE capabilities of the Arduino Uno R4 WiFi. Additionally, integration with Arduino Cloud libraries establishes a secure connection to the Arduino Cloud platform. This enables uploaded sensor data to be accessed via a cloud dashboard for remote monitoring of water quality parameters in real-time, accessible through web browsers or mobile applications.

The final code for the project was uploaded to GitHub[11]

3.4 System Testing

Rigorous system testing was conducted to ensure the accuracy and functionality of the water quality monitoring buoy.

The buoy system underwent rigorous testing and calibration procedures to ensure the accuracy and reliability of its sensor readings and data transmission capabilities. For the temperature sensor, comparisons were made between readings from the DS18B20 and a reference thermometer in a controlled temperature bath. Discrepancies were addressed through software adjustments to achieve precise temperature measurements. Similarly, the TDS sensor underwent calibration using known TDS solutions, aligning sensor readings with established values through calibration factors embedded in the software code. During testing in controlled environments, data displayed on the OLED screen, if utilized, was cross-referenced with reference measurements to detect and correct any anomalies. Integration with the Arduino Cloud platform was thoroughly tested to simulate data transmission and visualization on the cloud dashboard. This involved uploading processed sensor data and verifying its accuracy and reliability on the dashboard interface. Any issues identified during testing were resolved through iterative code refinements and adjustments within the Arduino Cloud libraries, ensuring seamless data transmission and accurate representation on the remote monitoring platform.

3.5 3D Modeling and Printing

Having explored the intricate details of the electronic components and software development, we now shift our focus to the physical embodiment of the water quality monitoring buoy as shown in Figure 3.6. This section delves into the fascinating realm of 3D modeling and printing, the processes used to create a robust and watertight enclosure for the sophisticated technology within.

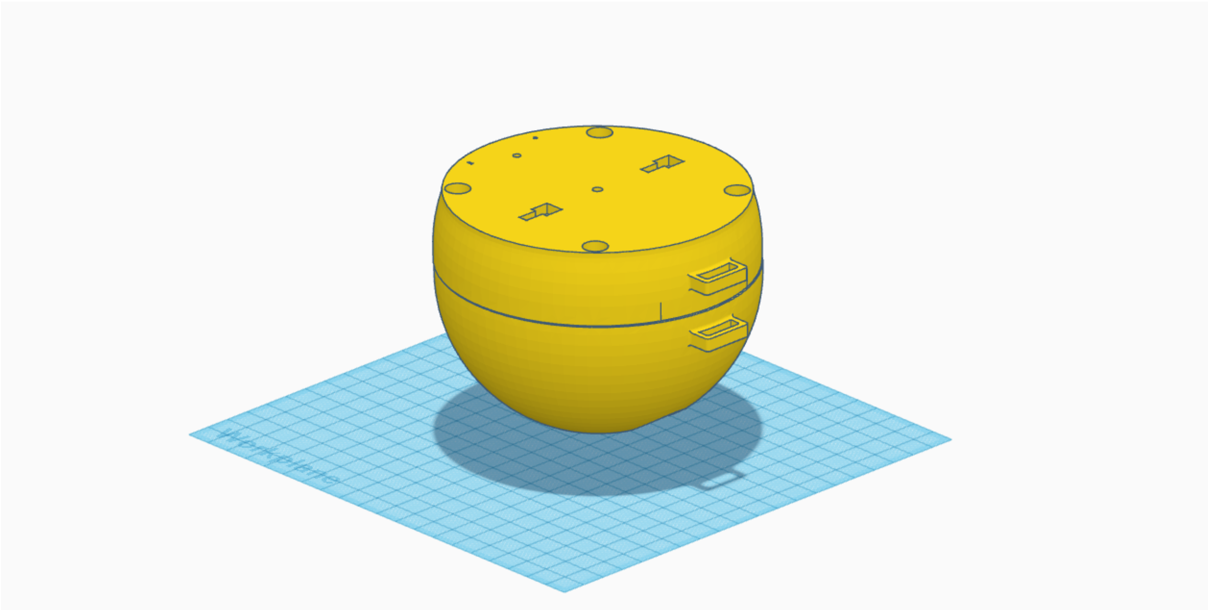

Figure 3.6: 3D Model of Buoy

3.6 Summary

This chapter has outlined the methodology employed to design, develop, and test the water quality monitoring buoy. By detailing the hardware selection, sensor integration, software development, and system testing procedures, this chapter provides a transparent and replicable approach for building such a system. The utilization of readily available libraries and the Arduino environment enables ease of use for researchers, hobbyists, or anyone interested in replicating or building upon this project. The successful implementation of these methodologies resulted in a functional and reliable water quality monitoring buoy, paving the way for real-time water quality assessment.

Chapter 4

Results

Our project successfully developed a compact and cost-effective water quality monitoring device. The device utilizes a TDS meter to measure total dissolved solids and a DS18B20 temperature sensor to provide precise readings displayed on an SSD1306 OLED display. An algorithm based on these values determines water quality (safe or unsafe) for user awareness.

Beyond the on-site display, the system can be integrated with the Arduino Cloud platform, allowing for remote monitoring through a user-friendly dashboard as show in Figure 4.1. This facilitates real-time data access from any location, enhancing the overall monitoring capabilities.

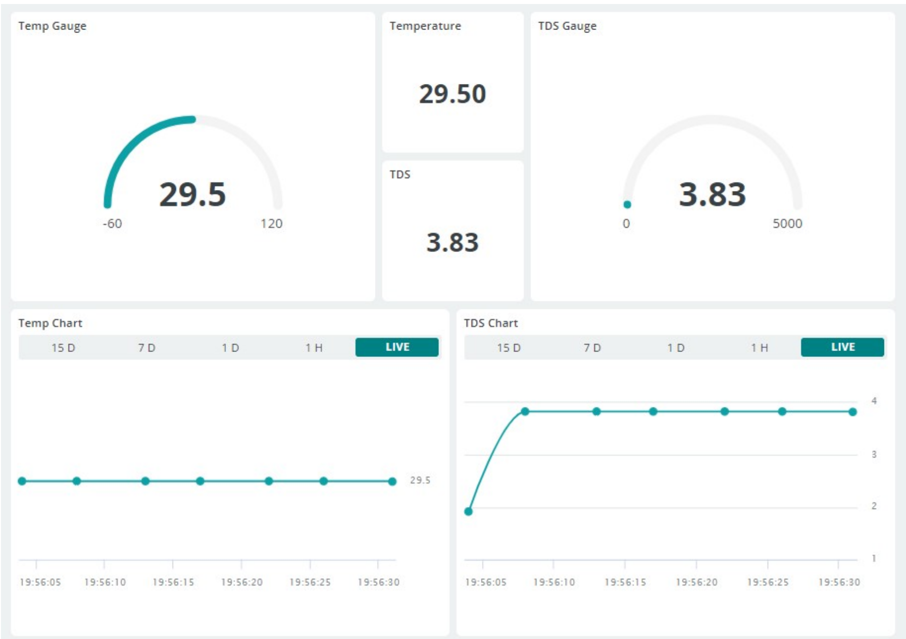

Figure 4.1: Dashboard

Rigorous testing with controlled samples of known TDS and temperature values ensured the accuracy and reliability of the device. This comprehensive approach verifies the system's effectiveness in assessing water quality.

The project's potential applications extend beyond basic water quality checks. Its suitability for aquaculture and agriculture highlights its ability to play a critical role in maintaining optimal water conditions for these vital sectors. Furthermore, by providing users with a clear indication of water safety, the device can directly improve lives by ensuring access to clean drinking water. The combination of cost-efficiency and ease of use makes this water quality monitoring device a valuable tool for various applications.

Chapter 5

Conclusion

This project was driven by the fundamental need for high-quality water, a cornerstone of a healthy life. The developed device addresses this need by providing a user-friendly and cost-effective solution for water quality monitoring. By measuring temperature and total dissolved solids (TDS), the device empowers users to assess water safety for various purposes.

The project's success lays the groundwork for exciting future advancements. Integration of a pH sensor is planned to further enhance the accuracy of water quality assessments. Additionally, incorporating a callback feature will provide a new level of user convenience. Imagine receiving a notification on your phone when water quality parameters exceed preset thresholds, allowing for immediate action. GSM modules or LoRaWAN capabilities could be explored to facilitate these automated alerts, ensuring users stay informed even when away from the monitoring location.

This project represents a significant step towards ensuring cleaner water for all. Its potential applications extend beyond personal use, offering valuable tools for industries like aquaculture and agriculture. By empowering users with real-time water quality data and fostering responsible water management practices, this technology has the potential to improve lives and safeguard our precious water resources.

References

[1] "Rivercore: Iot device for river water level monitoring over cellular communications," January 2019. [Online]. Available: https://doi.org/10.3390/s19010127

[2] "Cave pearl data logger: A flexible arduino-based logging platform for long-term monitoring in harsh environments," February 2018. [Online]. Available: https://doi.org/10.3390/s18020530

[3] E. B. Piyush Agade, "Gatorbyte– an internet of things-based low-cost, compact, and real-time water resource monitoring buoy," *Volume 14, HardwareX*, 2023.

[4] B. O'Flynn, R. Martinez-Catala, S. Harte, C. O'Mathuna, J. Cleary, C. Slater, F. Regan, D. Diamond, and H. Murphy, "Smartcoast: A wireless sensor network for water quality monitoring," in *32nd IEEE Conference on Local Computer Networks (LCN 2007)*. IEEE, 2007, pp. 815–816.

[5] R. Yue and T. Ying, "A water quality monitoring system based on wireless sensor network & solar power supply," in *2011 IEEE International Conference on Cyber Technology in Automation, Control, and Intelligent Systems*. IEEE, 2011, pp. 126–129.

[6] S. A. Binti Makhtar, N. Binti Burham, and A. B. Abdul Aziz, "Design and implementation of real-time approach for the monitoring of water quality parameters," in *2022 IEEE 12th Symposium on Computer Applications & Industrial Electronics (ISCAIE)*. IEEE, 2022, pp. 311–316.

[7] "Arduino® uno r4 wifi." [Online]. Available: https://store.arduino.cc/products/uno-r4-wifi

[8] "Ds18b20 temperature sensor." [Online]. Available: https://www.elprocus.com/ds18b20-temperature-sensor/

[9] "Gravity: Analog tds sensor/ meter for arduino." [Online]. Available: https://www.dfrobot.com/product-1662.html

[10] *128 x 64 Dot Matrix OLED/PLED Segment/Common Driver with Controller*, Solomon Systech, April 2008, rev 1.1.

[11] "Wqmb github repository." [Online]. Available: https://github.com/captPh03nix/WQMB/blob/WQMB_Arduino_Cloud/WQMB_Arduino_cloud.ino

Appendix A: Presentation

S6 AEI – May 2024



Mini Project Final Presentation

Presented by:
- Dheeraj S Dharman
- Kalyani N Shenoy
- Neha Binukumar Nair
- Neha Nice
- P Simran Sureshkumar

Guided by: Dr. Hari C V

Project Title

WATER QUALITY MONITORING BUOY (WQMB)

Outline

- Introduction
- Literature Review
- Motivation
- Objectives
- System Block Diagram
- Wiring Diagram
- Methodology
- Results
- Work Plan
- Conclusion
- References

Introduction

- Water Quality Monitoring Buoy (WQMB) is a project based on water quality checking.
- This project is executed using various sensors such as temperature sensor, pH sensor and Total Dissolved Solids (TDS) sensors.
- This project is deployed into water bodies, and the pH level, the temperature and conductivity is measured.
- This project can be deployed inside rivers, lakes, water tanks etc.

Literature Review

Author's name	Project/ Journal Details	Inference
Carlos Moreno,Raúl Aquino, José Ibarreche	RiverCore: IoT device for river water level monitoring over cellular communications	Monitors water levels as part of a real-time flood warning system
Piyush Agade, Eban Bean	GatorByte– An Internet of Things-Based Low-Cost, Compact, and Real-Time Water Resource Monitoring Buoy	Utilizes low-cost sensors to deliver accurate, high-frequency water quality data.
Binti Makhtar, Siti Aishah and Binti Burham, Norhafizah and Abdul Aziz, Anees Bt	Design and Implementation of Real-Time Approach for The Monitoring of Water Quality Parameters	Focuses on real-time analysis of key parameters in various water sources

Motivation

Need for a device that checks the water purity levels of water bodies, water storage facilities, etc that favours:

- Remote checking of water quality
- Continuous monitoring
- Small scale availability of device
- Rapid response
- Cost effective

Objectives

To design and develop a compact, self-contained water quality monitoring buoy that:

- Interfaces TDS Meter with Arduino
- Interfaces DS18B20 with Arduino
- Interfaces SSD1306 OLED Display with Arduino

3D Modeling and printing the waterproof Buoy.

System Block Diagram

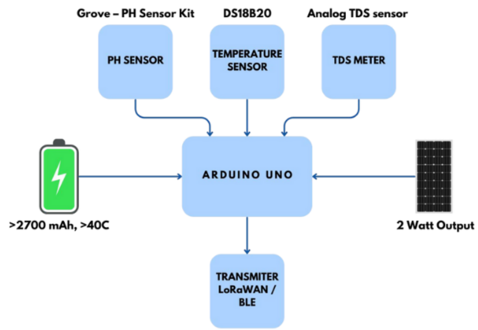

Figure 1 : System Block Diagram

Wiring Diagram

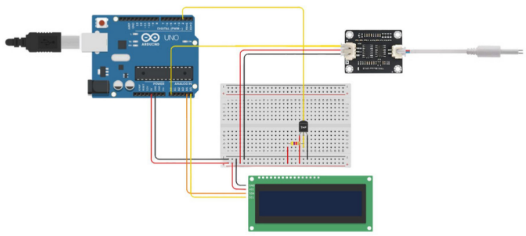

Figure 6 : Wiring Diagram

Methodology

TDS METER

- TDS stands for Total Dissolved Solids, which is basically a measure of all the solids dissolved in water.
- This can come from minerals, salts, metals, and even organic matter.
- You can find TDS in everything from natural springs to your tap water.

Methodology

TDS METER FEATURES

- Professional manufacturing, wide voltage working: 3.3-5.5V.
- 0-2.3V analog signal output, compatible 5V, 3.3V two control system.
- Motivate source of AC signal, effectively prevent probe from polarization.

Methodology

- Waterproof probe, can long time immersion in water.
- Compatible, easy to connect, plug and play, no welding required

TDS METER WORKING

- The meter reads this flow and estimates the total amount of dissolved stuff (TDS) in your water.

Methodology

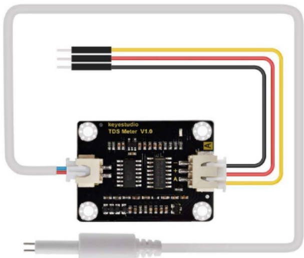

Figure 2: TDS Meter

Methodology

DS18B20 TEMPERATURE SENSOR

DS18B20 follows single wire protocol and it can be used to measure temperature.

SPECIFICATIONS

- Programmable and digital temperature sensor.
- Communication can be done with the help of a 1-Wire method.
- Range of power supply is 3.0V – 5.5V
- Accuracy of this sensor is ±0.5°C
- Output resolution will range from 9-bit to 12-bit.

Methodology

- Changes 12-bit temperature to digital word within 750 ms time.
- Can be power-driven from the data line.
- The temperature can be calculated from -55°C to +125°C.
- It is a waterproof sensor.

WORKING PRINCIPLE

- It is like that of a temperature sensor.
- This sensor gets power within a low-power inactive condition.

Methodology

WORKING PRINCIPLE

- The temperature measurement and conversion of Analog-to-Digital is done with a convert-T command.

- The resulting temperature information is stored within the 2-byte register in the sensor, and after that, this sensor returns to its inactive state.

- The sensor will react by supplying 0 when the temperature change is in the improvement and reacts by supplying 1 when the temperature change is done.

Methodology

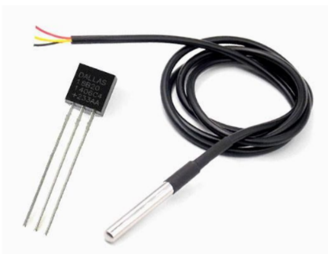

Figure 3 : DS18B20 Temperature Sensor

Methodology

Adafruit SSD1306 OLED Display

- SSD1306 is a single-chip CMOS OLED/PLED driver with controller for organic / polymer light emitting diode dot-matrix graphic display system
- It uses Adafruit_GFX and Adafruit_SSD1306 libraries to communicate with the Arduino UNO

Methodology

Adafruit SSD1306 OLED Display

- **The SSD1306 offers flexible communication interfaces, supporting industry-standard protocols like the 6800/8000 series compatible parallel interface, I2C and Serial Peripheral interfaces**
- **This versatility simplifies integration with various microcontrollers (MCUs) within a project.**

Methodology

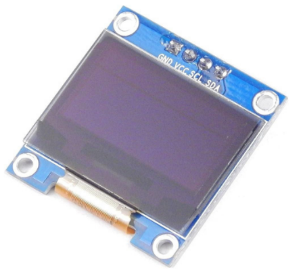

Figure 4 : Adafruit SSD1306 OLED

Methodology

Arduino UNO R4 WiFi

- **The Arduino UNO R4 WiFi is a powerful board that merges the RA4M1 microcontroller from Renesas with the wireless capabilities of the ESP32-S3 from Espressif**
- **The RA4M1 microcontroller is a product line from Renesas Electronics Corporation. It's part of their RA (Renesas Advanced) Family of microcontrollers, which are designed to provide scalable performance and features suitable for a wide range of embedded applications.**

Methodology

Arduino UNO R4 WiFi

- **The UNO R4 WiFi offers an on-board 12x8 LED matrix, Qwiic connector, VRTC, and OFF pin.**

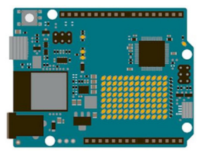

Figure 5 : Arduino UNO R4 wifi

Methodology

Code

https://github.com/WQMB.ino

Methodology

Algorithm

1. Include all the required libraries for the sensors

2.Connect to the given WiFi using SSID and password

3.Read Temperature and TDS from the sensors

4. Display the values on the OLED Display

5. Send the data to the dashboard

6. Repeat Steps 3 to 5

Results

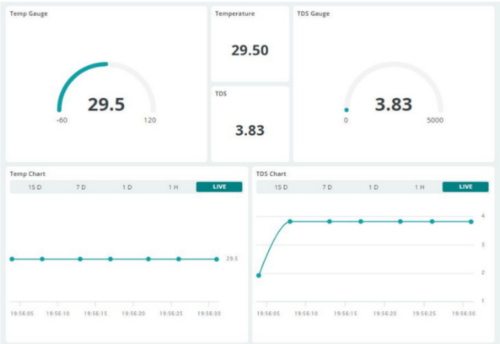

Figure 7 : Dashboard

Results

Features:

- **Hardware compatibility with UNO form factor**
  The UNO R4 WiFi maintains the same form factor, pinout, and 5 V operating voltage as its predecessor, the UNO R3, ensuring a seamless transition for existing shields and projects.

- **Expanded memory and faster clock**
  The UNO R4 WiFi boasts increased memory and a faster clock speed, enabling more precise calculations and effortless handling of complex projects.

- **Extended 24V tolerance**
  The UNO R4 WiFi supports a wider input voltage range, allowing seamless integration with motors, LED strips, and other actuators using a single power source

Results

- **Wi-Fi® and Bluetooth®**
  The UNO R4 WiFi hosts an ESP32-S3 module, enabling makers to add wireless connectivity to their projects. Combined with the Arduino IoT Cloud, makers can monitor and control their projects remotely.

- **Diagnostics for runtime errors**
  The UNO R4 WiFi includes an error-catching mechanism that detects runtime crashes and provides detailed explanations and hints about the code line causing the crash.

Results

```
21:19:37.546 -> Temperature : 31.50°C  TDS Value:1414ppm
21:19:38.745 -> Temperature : 31.50°C  TDS Value:1414ppm
21:19:40.020 -> Temperature : 31.50°C  TDS Value:1414ppm
21:19:41.251 -> Temperature : 31.50°C  TDS Value:1414ppm
21:19:42.455 -> Temperature : 31.50°C  TDS Value:1414ppm
21:19:43.703 -> Temperature : 31.50°C  TDS Value:1409ppm
21:19:44.935 -> Temperature : 31.50°C  TDS Value:1409ppm
21:19:46.136 -> Temperature : 31.50°C  TDS Value:1409ppm
```

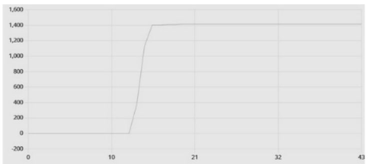

Figure 8 : Serial Monitor

Results

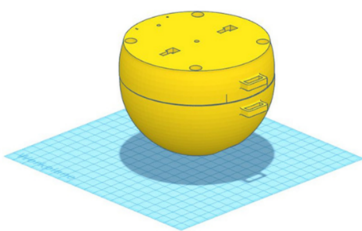

Figure 9 : 3D Model of Buoy

Work Plan

Description	March		April		May	
Literature Review and Components Finalization						
Testing and Calibration of TDS Meter						
Testing and Calibration of Temperature Sensor						
Interfacing with Arduino						
3D Modelling and Casing						
Final Assembly						
Report writing						

Conclusion

- Following components have been calibrated:
  - TDS meter
  - DS18B20 Temperature Sensor
  - Adafruit SSD1306 OLED Display
- Arduino has been coded using Arduino IDE.
- The casing for the buoy has been 3D modeled
- Dashboard has been configured to display the data
- Future developments planned for the project include
  - Recall / Call back feature
  - GSM module for long range deployment
  - IoT based application (IoW and IoA)

References

- "ArduinoUNOR4 wifi."Available:https://store-usa.arduino.cc/products/uno-r4-wifi?selectedStore=us (accessed april 2, 2024)
- "Adafruit SSD1306." Adafruit Available : https://www.adafruit.com/product/326
  - (accessed april 10, 2024)
- "DS18B20 Temperature Sensor". Available:https://www.elprocus.com/ds18b20-temperature-sensor/ (accessed april 2, 2024)
- "UNDERSTANDING TDS METERS". Osmotics. Available:https://www.osmotics.co.uk/blog/post/tds-meters-explained-osmotics(accessed march 27, 2024)

References

- Rivercore: Iot device for river water level monitoring over cellular communications," January 2019. [Online]. Available: https://doi.org/10.3390/s19010127
- Cavepearl datalogger: A flexible arduino-based logging platform for long-term monitoring harsh environments,"February 2018.[Online].Available:https://doi.org/10.3390/s18020530
- B. Piyush Agade, "Gatorbyte– an internet things-based low-cost, compact, and real-time water resource monitoring buoy," Volume 14, HardwareX, 2023.

References

- B. O'Flynn, R. Martinez-Catala, S. Harte, C. O'Mathuna, J. Cleary, C. Slater, F. Regan, D. Diamond, and H. Murphy, "Smartcoast: A wireless sensor network for water quality monitoring," in 32nd IEEE Conference on Local Computer Networks (LCN2007). IEEE, 2007, pp. 815–816.
- S. A. Binti Makhtar, N. Binti Burham, and A. B. Abdul Aziz, "Design and implementation of real-time approach for the monitoring of water quality parameters," in 2022 IEEE 12th Symposium on Computer Applications Industrial Electronics (ISCAIE). IEEE, 2022, pp. 311–316.
- R. Yue and T. Ying, "A water quality monitoring system based on wireless sensor network solar power supply," in 2011 IEEE International Conference on Cyber Technology in Automation, Control, and Intelligent Systems. IEEE, 2011, pp. 126–129.

Thank you

Appendix B: Vision, Mission, Programme Outcomes and Course Outcomes

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To evolve into a centre of academic excellence, developing professionals in the field of electronics and instrumentation to excel in academia and industry.

Department Mission

Facilitate comprehensive knowledge transfer with latest theoretical and practical concepts, developing good relationship with industrial, academic and research institutions thereby moulding competent professionals with social commitment.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

- PSO 1: Involves efficient management of time and money.
- PSO 2: Project management is efficiently done.
- PSO 3: Methods of designing the experiments are understood clearly.

Course Outcomes (CO)

Course Outcome 1: Students will be able to practice acquired knowledge within the selected area of technology for project development.

Course Outcome 2: Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.

Course Outcome 3: Reproduce, improve and refine technical aspects for engineering projects.

Course Outcome 4: Work as a team in development of technical projects.

Course Outcome 5: Communicate and report effectively project related activities and findings

Appendix C: CO-PO-PSO Mapping

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO.1	3	3	2	2	2	2	2	3	3	3	2	3
CO.2	3	3	3	3	3	3	3	3	3	3	3	3
CO.3	3	3	3	3	3	3	3	3	3	3	3	3
CO.4	3	3	3	3	3	3	3	3	3	3	3	3
CO.5									3	3	3	3

CO - PSO Mapping

	PSO1	PSO2	PSO3
CO.1	3	3	3
CO.2	3	3	3
CO.3	3	3	3
CO.4	3	3	3
CO.5			3