SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU-572103

(An Autonomous Institute under Visvesvaraya Technological University, Belagavi)

Project Report on

"DEPLOYMENT OF WATER MONITORING SYSTEM"

submitted in partial fulfillment of the requirement for the completion of V semester of

BACHELOR OF ENGINEERING

in

ELECTRONICS & TELECOMMUNICATION ENGINEERING

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DEPARTMENT OF ELECTRONICS & TELECOMMUNICATION ENGINEERING

2025-26

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU-572103

(An Autonomous Institute under Visvesvaraya Technological University, Belagavi)

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the mini project work entitled "DEPLOYMENT OF WATER MONITORING SYSTEM" is a bonafide work carried out by Ananya.V (1SI23ET004), Jayadixitha.S.P (1SI23ET019) and Nagapriya.K.G (1SI23ET031) in partial fulfillment for the completion of V Semester of Bachelor of Engineering in Electronics & Telecommunication Engineering from Siddaganga Institute of Technology, an autonomous institute under Visvesvaraya Technological University, Belagavi during the academic year 2025-26. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the department library. The Mini project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering degree.

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2.

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We offer our humble pranams at the lotus feet of **His** Holiness, **Dr. Sree Sree Sivakumara Swamigalu**, Founder President and **His** Holiness, **Sree Sree Siddalinga Swamigalu**, President, Sree Siddaganga Education Society, Sree Siddaganga Math for bestowing upon their blessings.

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Course Outcomes

CO1: To identify a problem through literature survey and knowledge of contemporary engineering technology.

CO2: To consolidate the literature search to identify issues/gaps and formulate the engineering problem

CO3: To prepare project schedule for the identified design methodology and engage in budget analysis, and share responsibility for every member in the team

CO4: To provide sustainable engineering solution considering health, safety, legal, cultural issues and also demonstrate concern for environment

CO5: To identify and apply the mathematical concepts, science concepts, engineering and management concepts necessary to implement the identified engineering problem

CO6: To select the engineering tools/components required to implement the proposed solution for the identified engineering problem

CO7: To analyze, design, and implement optimal design solution, interpret results of experiments and draw valid conclusion

CO8: To demonstrate effective written communication through the project report, the one-page poster presentation, and preparation of the video about the project and the four page IEEE/Springer/ paper format of the work

CO9: To engage in effective oral communication through power point presentation and demonstration of the project work

CO10:To demonstrate compliance to the prescribed standards/ safety norms and abide by the norms of professional ethics

CO11: To perform in the team, contribute to the team and mentor/lead the team

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO-1											3		
CO-2		3											
CO-3											3		
CO-4						3	3					3	
CO-5	3	3											2
CO-6					3								
CO-7			3	3								3	
CO-8										3			
CO-9										3			2
CO-10								3					2
CO-11									3			3	

Attainment level: - 1: Slight (low) 2: Moderate (medium) 3: Substantial (high)

POs: PO1: Engineering Knowledge, PO2: Problem analysis, PO3: Design/Development of solutions, PO4: Conduct investigations of complex problems, PO5: Modern tool usage, PO6: Engineer and the world, PO7: Ethics, PO8: Individual and collaborative team work, PO9: Communication, PO10: Project management and finance, PO11: Lifelong

DECLARATION

We hereby declare that the Mini Project work entitled **"Deployment of Water Monitoring System"** submitted to the **Siddaganga Institute of Technology, Tumakuru**, is a record of an original work done by us under the guidance of **Dr. K. C. Narasimhamurthy**, of **Electronics & Telecommunication Engineering** and this project work is submitted in the partial fulfilment of the requirements of V semester in Electronics and Telecommunication Engineering. The results embodied in this Mini Project have not been submitted to any other university or institute for the award of any degree.

Place: Tumakuru
Date:

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Abstract

Efficient monitoring of water storage systems is essential in large buildings to avoid overflow, pump dry-running, and unnecessary power consumption. On the Siddaganga Institute of Technology campus, water tanks and sumps are distributed across multiple floors, making manual supervision difficult and unreliable. To overcome these challenges, this project implements a long-range wireless water monitoring and control system with minimal human intervention.

The proposed system continuously monitors water levels in both the tank and the sump and communicates their status wirelessly using LoRa technology. Two transmitter nodes are installed at the tank and sump, while a receiver node is placed near the motor control unit. Each transmitter uses an ESP32 microcontroller interfaced with a Ultrasonic(JSN-SR04T) waterproof ultrasonic sensor to measure water levels. The measured data is transmitted using the RYLR890 LoRa module. At the receiver end, the ESP32 evaluates the received information and controls the water pump through a relay module based on predefined operating conditions.

Prototype testing across multiple rooms and floors demonstrated reliable LoRa communication and accurate automated motor control. The developed system effectively reduces manual monitoring and is suitable for deployment in multi-floor institutional environments.

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Chapter 1

Introduction

1.1 Motivation

Water management in institutional buildings often relies on manual observation and operator-dependent motor switching. At the Siddaganga Institute of Technology (SIT) campus, water tanks are typically located on higher floors, while sumps and motors are placed at ground level, making frequent monitoring inconvenient. This often results in delayed motor operation, overflow of tanks, dry running of pumps, and increased electricity consumption.

With the availability of low-power microcontrollers and long-range wireless communication technologies, automated water-level monitoring has become practically feasible. LoRa communication is particularly suitable for this application because it offers reliable data transmission across multiple floors with very low power consumption. By combining ultrasonic water-level sensing with LoRa-based communication and automated motor control, a dependable and efficient water monitoring system can be implemented.

The need to conserve water, reduce operational effort, and improve system reliability forms the primary motivation for developing this project.

1.2 Objective of the Project

The primary objective of this project is to design and deploy a real-time water monitoring system using ESP32 microcontrollers, JSN-SR04T waterproof ultrasonic sensors, and LoRa RYLR890 modules. The system aims to:

- Measure water levels in tank and sump using ultrasonic sensing.
- Transmit level information wirelessly over long range using LoRa communication.
- Automate water pump control based on predefined tank–sump conditions.
- Demonstrate phase-wise motor evaluation using a relay module integrated at the receiver end.

- Provide a reliable, low-power, long-range solution suitable for institutional deployment.

The system replaces manual monitoring with automated, accurate, and remote decision-making, ensuring operational reliability and preventing dry-run or overflow conditions.

1.3 Organisation of the Report

The report is organized into seven chapters. Chapter 2 presents the literature survey on existing wireless water monitoring technologies, with relevance to LoRa-based communication systems. Chapter 3 describes the overall architecture of the proposed system, including transmitter and receiver block diagrams. Chapter 4 discusses the design methodology, working principle, motor control logic, and implementation flow. Chapter 5 explains the hardware implementation, including details of ESP32, LoRa modules, ultrasonic sensors, and relay integration carried out during the final deployment phase. Results and system performance are presented in Chapter 6. Chapter 7 provides conclusions and outlines the possible future enhancements of the system.

Chapter 2

Literature Survey

This chapter presents a review of existing research related to wireless water-level monitoring systems and long-range communication technologies used in Internet of Things (IoT) applications. The literature survey was carried out to understand current methodologies, identify limitations in conventional systems, and select suitable technologies for the proposed implementation.

Callebaut et al. [1] conducted an extensive evaluation of the LoRa physical layer by performing point-to-point communication tests in various indoor and outdoor environments. The study highlighted that LoRa provides reliable long-distance communication with low power consumption, even in environments with obstacles such as walls and floors. These findings indicate that LoRa is well suited for applications where sensors and control units are separated by large distances, such as water tanks located on upper floors and motors placed at ground level.

Gutiérrez-Gómez et al. [2] analyzed the propagation characteristics of LoRa-based point-to-point links for IoT applications. Their experimental results showed that LoRa communication remains stable in obstructed and multi-building environments. The authors concluded that LoRa can maintain consistent data transmission across floors without significant packet loss. This makes LoRa an effective solution for indoor water-level monitoring systems deployed in large buildings and institutional campuses.

Gaitán et al. [3] studied the behavior of LoRa communication in environments affected by humidity and reflective surfaces. The research demonstrated that LoRa modulation performs reliably under varying environmental conditions and maintains robust connectivity for sensor-based monitoring systems. This observation supports the use of LoRa in water-related applications, where moisture and environmental variations can influence wireless performance.

Natividad et al. [4] proposed an IoT-based model for monitoring and controlling water distribution systems. Their work emphasized the importance of automation in reducing water wastage and improving overall system efficiency. However, the implementation relied on short-range communication technologies, which limits scalability in multi-floor or large-area deployments.

From the literature review, it is evident that LoRa technology offers significant advantages in terms of communication range, power efficiency, and reliability compared to conventional wireless methods. Most existing systems focus either on sensing or communication, whereas the proposed project integrates water-level sensing, long-range wireless communication, and automated motor control into a single system. This integration addresses practical challenges faced in institutional water management and forms the basis for the design of the proposed water monitoring system.

Chapter 3

System Overview

This chapter describes the overall architecture and functional organization of the proposed water monitoring system. The system is designed to automatically monitor water levels and control the pumping operation with minimal human involvement. It consists of two transmitter units and one receiver unit that communicate using long-range wireless technology.

One transmitter unit is installed at the overhead tank and the other at the sump. Each transmitter continuously measures the water level and sends the processed status information to the receiver unit. The receiver is positioned near the motor control panel and is responsible for evaluating the received data and operating the motor through a relay module. This distributed arrangement ensures reliable monitoring and control even when the tank, sump, and motor are located at different floors.

The complete system architecture is optimized to provide accurate sensing, dependable wireless communication, and safe motor operation, making it suitable for deployment in multi-floor institutional buildings such as the SIT campus.

3.1 Block Diagram

Transmitter Block Diagram

The transmitter node consists of the following major functional modules:

1. Sensing Module: The JSN-SR04T waterproof ultrasonic sensor measures the distance between the sensor and the water surface. This distance corresponds to the water level in the tank or sump(Refering to Figure 3.1).

2. Processing Module: The ESP32 microcontroller processes the ultrasonic sensor output and classifies the water level as FULL or EMPTY based on predefined threshold values.

3. Communication Module: The RYLR890 LoRa module is interfaced with the ESP32 using UART communication mode, as illustrated in Figure 3.1. The ESP32 sends

encoded water-level status messages to the LoRa module through UART, enabling long-range wireless transmission to the receiver node.

Together, these modules ensure continuous measurement and reliable wireless transmission of tank and sump conditions.

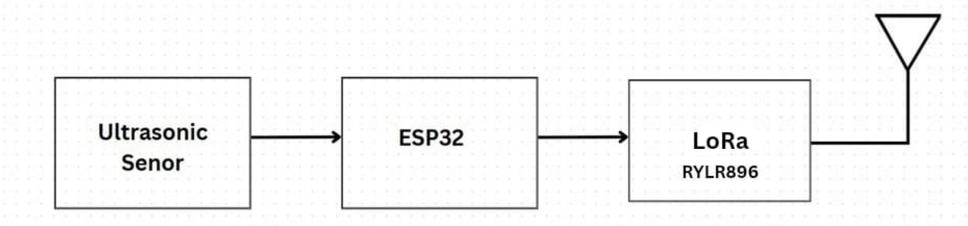

Figure 3.1: Transmitter Block Diagram (Tank/Sump Node)

Receiver Block Diagram

The receiver node architecture is shown in Figure 3.2 and is responsible for receiving water-level data from both transmitter nodes and controlling the motor accordingly. It consists of the following modules:

1. Communication Module: The RYLR890 LoRa module receives wireless data packets from the transmitter nodes , the LoRa module operates in UART mode, where the received data is forwarded to the ESP32 microcontroller via serial communication.
2. Processing Module: The ESP32 processes the received UART data, identifies whether the message corresponds to the tank or sump node, and stores the latest water-level status. It then evaluates the tank–sump conditions using predefined decision logic.
3. Actuation Module: Based on the evaluated conditions, the ESP32 controls a relay module to switch the water pump ON or OFF. The relay provides electrical isolation between the low-voltage control circuitry and the high-voltage motor supply.

This arrangement ensures reliable reception, intelligent decision-making, and safe motor operation, preventing dry running and water overflow.

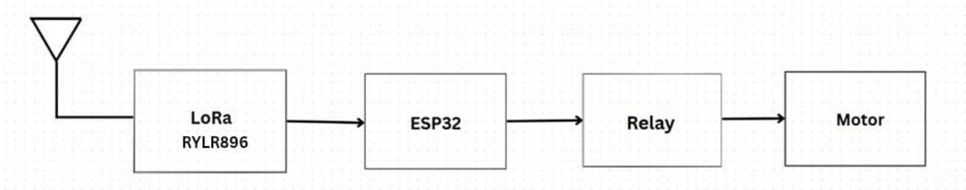

Figure 3.2: Receiver Block Diagram

Chapter 4

Design Methodology

The design methodology outlines the complete workflow followed to develop the water monitoring system. It includes sensing, data processing, wireless transmission, reception, decision-making and motor control.

4.1 Schematic View

4.1.1 Transmitter Schematic View

The transmitter schematic is shown in Figure 4.1 which illustrates the interconnection between the JSN-SR04T sensor, ESP32 microcontroller and RYLR890 LoRa module. The sensor's TRIG and ECHO pins interface with ESP32 GPIOs for time-of-flight measurement. ESP32 processes this measurement, determines the water-level condition, and sends encoded data to the LoRa module using UART communication. The entire transmitter is powered through a regulated 5V (VIN) supply ensuring stable operation.

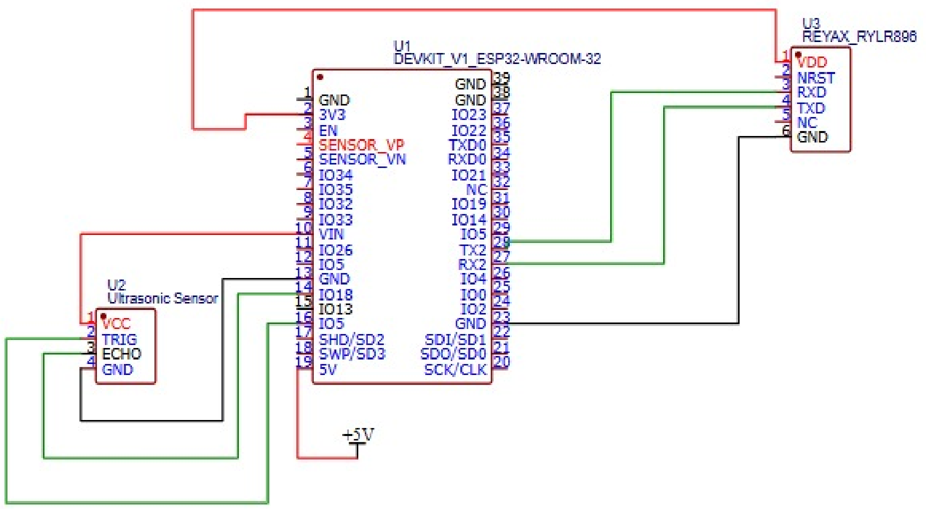

Figure 4.1: Schematic View of Transmitter

4.1.2 Receiver Schematic View

The receiver schematic shown in Figure 4.2 demonstrates the interfacing between ESP32, LoRa module and relay module. The LoRa module forwards received messages to ESP32 via UART. ESP32 executes logic to determine the motor state and triggers the relay accordingly. The relay provides isolation between low-voltage control signals and the motor's AC power line.

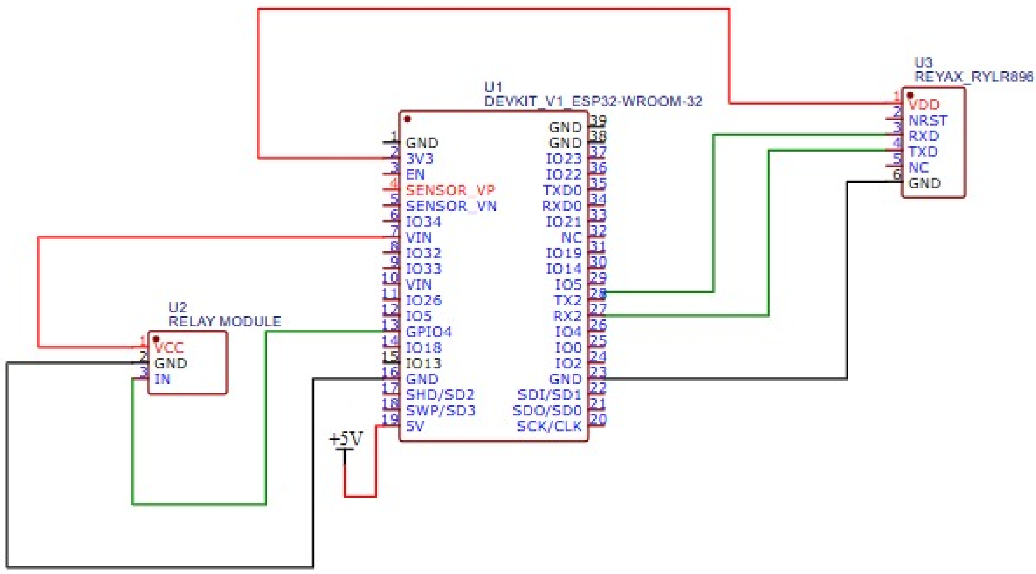

Figure 4.2: Schematic View of Receiver

4.2 Working

The working of the system is divided into sensing, wireless transmission, and motor control logic.

1. Sensing

At both the tank and sump locations, the JSN-SR04T waterproof ultrasonic sensor measures the distance between the ultrasonic sensor and the water level. The ESP32 processes this measurement and classifies the water level as FULL or EMPTY based on predefined threshold values as shown in Figure 4.3.

- **FULL** — when distance is less than lower threshold
- **EMPTY** — when distance is greater than upper threshold

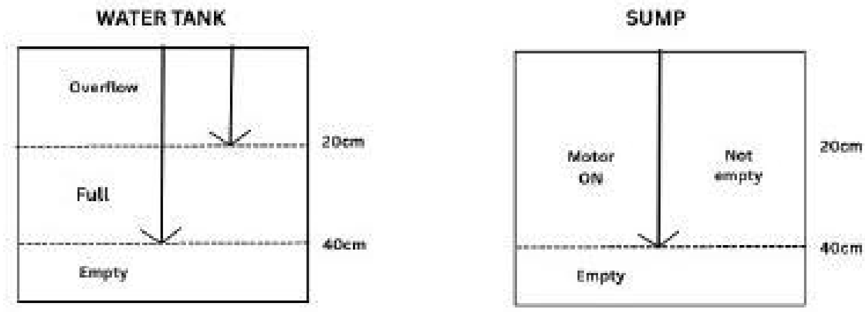

Figure 4.3: Ultrasonic water level detection levels

2. Wireless Transmission

After classification, the ESP32 transmits the water-level status along with node identification to the RYLR890 LoRa module using UART communication. The LoRa module wirelessly sends this information to the receiver node, ensuring reliable long-range communication.

3. Motor Control Logic

At the receiver node, the LoRa module operating in UART mode forwards the received data to the ESP32. The ESP32 evaluates the tank and sump conditions using predefined logic and determines the appropriate motor operation(Refer Figure 4.3 and table 4.1).

Flow Chart

The flowchart represents the complete decision-making (Refering to Table 4.1 and Figure 4.3) sequence used to operate the motor.

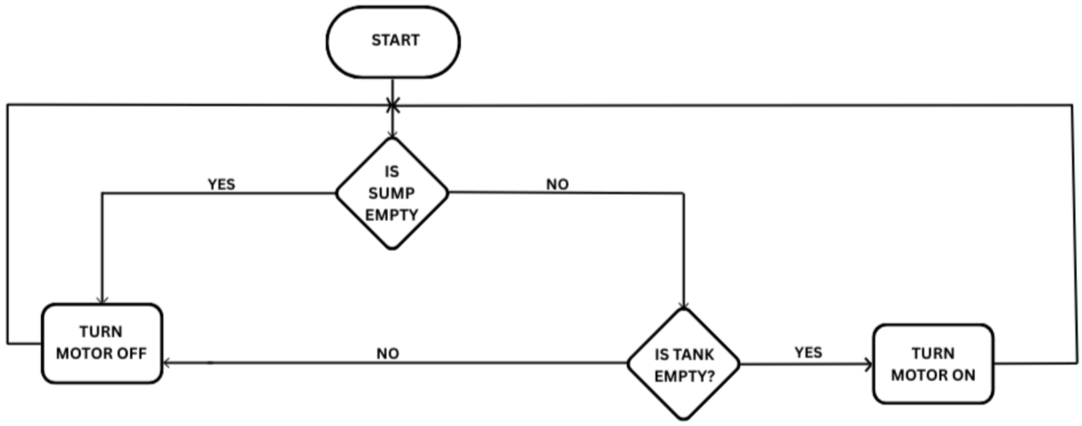

Figure 4.3: Flow Chart of System Working

Decision Table

The motor action is determined using the conditions shown in Table 4.1.

Table 4.1: Tabular Column of Motor Operation

Case No.	**Tank**	**Sump**	**Motor Condition**
Case 1	TE	SE	OFF
Case 2	TE	SNE	ON
Case 3	TF	SE	OFF
Case 4	TF	SF	OFF

Where: TE = Tank Empty TF = Tank Full SE = Sump Empty SF = Sump Full SNE = Sump Not Empty

Explanation of Cases

- **Case 1 (TE + SE → Motor OFF):** Both tank and sump are empty; motor must remain OFF to prevent dry running.

- **Case 2 (TE + SNE → Motor ON):** Tank requires water and sump contains sufficient water; hence motor is turned ON.
- **Case 3 (TF + SE → Motor OFF):** Tank is full and sump is empty; thus motor remains OFF.
- **Case 4 (TF + SF → Motor OFF):** Both tank and sump are full; pumping is unnecessary.

The ESP32 activates the relay based on the evaluated condition, ensuring reliable and automated motor operation.

Chapter 5

Results and discussions

This chapter presents the results obtained through prototype-level evaluation and functional testing of the proposed water monitoring system. Since real-time multi-floor deployment has not yet been executed, the results correspond to laboratory testing, controlled experiments, and logical validation of sensing, communication, and motor-control subsystems. The outcomes confirm the correctness of the design and the suitability of LoRa-based communication for long-range water-level monitoring.

- The performance of the ultrasonic sensing module and LoRa wireless link was evaluated during prototype trials.
- These evaluations were conducted to verify whether the system reliably detects tank and sump water levels and transmits status updates to the receiver node without errors.

I **Verification of Water-Level Classification Logic**

Distance thresholds were configured to simulate real tank and sump depths. The system correctly classified the water level as FULL or EMPTY based on these distance readings. This confirmed the accuracy of the sensing and thresholding algorithm implemented on the ESP32.

II **Communication Reliability Using LoRa**

LoRa-based transmission was tested across multiple rooms and floors within the laboratory environment. Message reception remained stable, demonstrating the suitability of LoRa for multi-floor communication. Latency was minimal, and no message corruption was observed during repeated trials.

i The transmitter successfully measured distances at regular intervals and converted them into discrete FULL/EMPTY status values. This verified the integrity of the sensing pipeline—from ultrasonic echo measurement to classification.

ii Stable results were obtained because JSN-SR04T produced consistent readings in the 25–200 cm range and the RYLR890 LoRa module reliably delivered encoded data to the receiver, matching the intended design behavior presented in the mini-project slides.

1. Parameters evaluated during bench testing included:
    - accuracy and repeatability of ultrasonic distance measurements,
    - reliability and range capability of LoRa communication indoors,
    - correctness of the motor ON/OFF decision logic.
2. The experimental setup consisted of ESP32–JSN-SR04T transmitter units and an ESP32-LoRa receiver unit powered through USB supplies, as demonstrated in the presentation. Threshold distances were varied manually to emulate rising and falling water levels. These experiments confirmed that the decision logic behaves exactly as intended.

a Communication between ESP32 and LoRa modules was validated by monitoring the transmitted and received status frames. No data loss or interference was observed during testing, highlighting LoRa's robustness compared to the previously used RF system.

b The motor-control logic was verified by manually applying all four tank–sump combinations (TE, TF, SE, SNE, SF). In each case, the relay output matched the predefined truth table, confirming the correctness of the control algorithm.

5.1 Data analysis

Each evaluated parameter was analyzed to ensure correct subsystem behavior:

- **Sensor Data Analysis:** The ultrasonic sensor consistently measured the distance between the ultrasonic sensor and the water level. Distance values decreased proportionally as water level increased, and the ESP32 accurately classified the levels as FULL or EMPTY based on thresholds.
- **LoRa Communication Analysis:** The RYLR890 LoRa modules transmitted and received water-level status via UART without packet loss or corruption. Received

data matched transmitted values, confirming reliable long-range communication suitable for multi-floor monitoring.

- **Motor Logic Analysis:** The ESP32 evaluated all tank and sump condition combinations and controlled the relay correctly in each case. The motor operated only when required, preventing overflow, dry running, and unnecessary operation.

Overall, the results demonstrate that the sensing, communication, and control subsystems function reliably in prototype form. The system is ready for real-time deployment once physical installation in the building is carried out.

Serial Monitor Observations

During prototype testing, the Arduino IDE Serial Monitor served as the primary tool for validating the sensing output, transmission frame format, reception correctness, and final relay actuation. Although screenshots are not included, the essential outputs observed during testing are summarised below.

1. Transmitter Node Output

Both tank and sump transmitter ESP32 nodes continuously printed real-time sensing and transmission details. The Serial Monitor displayed the following:

- Real-time ultrasonic distance measurements obtained from the JSN-SR04T sensor (e.g., `Distance = 37.59 cm`, `Distance = 31.04 cm`, etc.).
- Threshold comparison results indicating whether the tank or sump was classified as *FULL* or *EMPTY* (e.g., `State: F`, `State: E`).
- The encoded LoRa message string sent to the RYLR890 module (e.g., “TANK_FULL“, “TANK_EMPTY“, “SUMP_EMPTY“ , “SUMP_FULL“ , “SUMP NOT_EMPTY“).
- LoRa transmission acknowledgements from the module, such as `+OK`, confirming successful data delivery.
- Encoded messages including node identity (tank or sump) and measured readings.

The readings were stable across repeated measurements, and the distance values consistently decreased when the water level was simulated to rise, validating the sensing pipeline.

2. Receiver Node Output

At the receiver side, the Serial Monitor displayed detailed information for every packet received from both transmitter nodes. Observations included:

- Identification of sender node, such as `Sender: 2` or `From: TANK` / `From: SUMP`.
- Incoming LoRa messages and decoded tank/sump status after parsing the received frame.
- The decision output generated by the ESP32 after evaluating the tank and sump statuses using the predefined logic table.

The receiver correctly differentiated between tank and sump packets and stored them independently before evaluating motor control.

3. Relay Switching Behaviour and Logic Evaluation

The relay module connected to the receiver ESP32 toggled ON or OFF exactly as per the four-case truth table. The Serial Monitor clearly printed the conditions and final action.Additionally, the relay LED and the audible clicking sound verified physical switching whenever ON/OFF conditions were satisfied. The system updated the motor state immediately when new tank or sump readings were received.

Summary of Observations

- Ultrasonic readings, LoRa transmissions, receiver decoding, and relay responses were fully consistent with the expected design.
- No corrupted packets or missed transmissions were recorded during testing.
- The real-time messages printed on the Serial Monitor provided clear evidence that each subsystem—sensing, wireless communication, and decision control—functioned reliably.

These observations validate that the system behaves correctly under prototype conditions and is ready for real-world deployment.

Chapter 6

Conclusion

This project successfully demonstrates the design and prototype implementation of an automated water monitoring system using ESP32 microcontrollers, JSN-SR04T ultrasonic sensors, and RYLR890 LoRa modules. The system effectively monitors the water levels of both tank and sump and controls the motor based on predefined logical conditions.

Experimental testing confirmed accurate water-level detection, reliable long-range LoRa communication, and correct relay operation for all possible tank–sump combinations. Although real-time installation has not yet been carried out, the prototype results indicate that the system is technically sound and ready for deployment in multi-floor buildings such as the SIT campus.

The proposed solution minimizes manual intervention, prevents overflow and dry-running conditions, and offers a practical approach to automated water management in institutional environments.

6.1 Scope for future work

Several enhancements can be explored to extend the capabilities of the proposed system:

- **Real-time deployment:** Installing the system at the actual tank and sump locations to evaluate long-range LoRa performance under real environmental conditions.
- **Mobile application integration:** A smartphone app or web dashboard can be developed to remotely monitor water levels and motor status.
- **Battery-powered transmitters:** Using low-power modes of ESP32 to enable battery-operated transmitter nodes for improved reliability.
- **Solar-powered operation:** Incorporating solar charging for transmitter units to make the system fully autonomous.
- **Multiple tank–sump scalability:** Extending the system to monitor multiple tanks and sumps using additional transmitter nodes.

- **Predictive analytics:** Implementing machine-learning based water-usage prediction for optimizing motor operation.
- **Leakage and overflow detection:** Adding flow sensors or pressure sensors to detect pipe leakage or unusual consumption.

These enhancements would make the system more robust and user-friendly, enabling widespread adoption in residential, institutional, and industrial water management applications.

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Appendices

Appendix A

LoRa RYLR890 Module

Figure A.1: LoRa RYLR890 Transceiver Module

Description

The RYLR890 LoRa module enables long-range wireless communication using LoRa modulation. It operates in the 868/915 MHz ISM band and supports UART-based AT command communication. It is used in this project to transmit tank and sump water-level data reliably over long distances.

Specifications

Operating Voltage (VDD)	2.0 – 3.6 V
Typical Operating Voltage	3.3 V
RF Output Power	–4 to +15 dBm
RF Sensitivity	–148 dBm
Frequency Range	862 – 1020 MHz
Frequency Accuracy	±2 ppm
Communication Range	4.5 – 15 km (environment dependent)
Transmit Current	49.7 mA @ +14 dBm
Receive Current	16.5 mA
Sleep Current	0.5 µA
Baud Rate	300 – 115200 bps (default 115200)
Operating Temperature	–40°C to +85°C
Weight	3.07 g

Appendix B
Waterproof Ultrasonic Sensor (JSN-SR04T)

Figure B.1: JSN-SR04T Waterproof Ultrasonic Sensor

Description

The JSN-SR04T is a waterproof ultrasonic distance sensor used for measuring water levels in tanks and sumps. It operates by transmitting ultrasonic waves and measuring the time taken for the echo to return. Its waterproof construction makes it suitable for harsh and humid environments.

Specifications

Operating Voltage	5V DC
Operating Current	30 mA (max)
Ultrasonic Frequency	40 kHz
Measuring Range	25–450 cm
Accuracy	±1 cm
Trigger Pulse Width	10 μs
Echo Output	5V TTL
Waterproof Rating	IP66
Interface Pins	VCC, TRIG, ECHO, GND

Appendix C

ESP32 Development Board

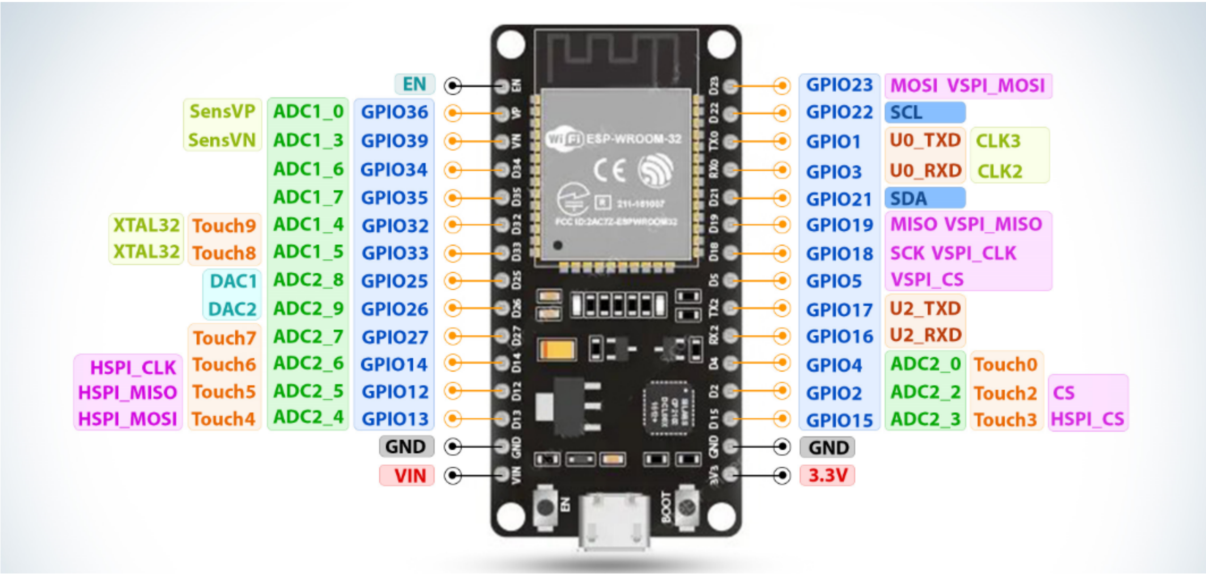

Figure C.1: ESP32 Development Board

Description

The ESP32 is a dual-core Wi-Fi and Bluetooth-enabled microcontroller widely used in IoT systems. It integrates ADC, UART, SPI, I2C, PWM, and other interfaces, making it highly suitable for sensor nodes and wireless data processing. In this project, ESP32 performs sensing, LoRa communication, and motor control logic.

Specifications

Processor	Tensilica LX6 Dual-Core
Clock Frequency	Up to 240 MHz
Operating Voltage	3.0V – 3.6V
Flash Memory	4 MB
GPIO Pins	34
ADC Resolution	12-bit
Communication Interfaces	UART, SPI, I2C, Wi-Fi, BLE
Typical Operating Current	80 mA

Appendix D

Relay Module

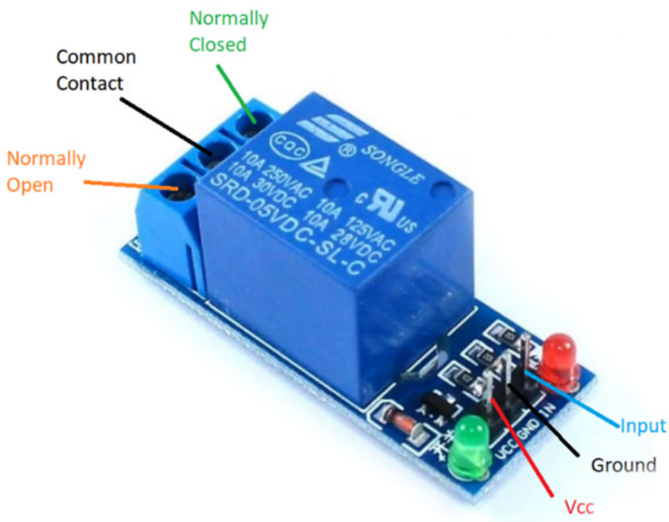

Figure D.1: 5V Relay Module

Description

The relay module provides electrical isolation and allows switching of AC motors using low-voltage control signals from ESP32. It is used in the receiver node to turn the motor ON or OFF based on tank and sump water levels.

Specifications

Coil Voltage	5V DC
Trigger Voltage	3.3V
Contact Rating	10A @ 250VAC
Isolation Type	Optocoupler Isolation
Switching Output	NO / NC
Indicator LEDs	Power and Status LEDs

Sustainable Development Goals Addressed

SDG No.	Sustainable Development Goal	Level
1	No Poverty	–
2	Zero Hunger	–
3	Good Health and Well-being	–
4	Quality Education	–
5	Gender Equality	–
6	Clean Water and Sanitation	3
7	Affordable and Clean Energy	–
8	Decent Work and Economic Growth	–
9	Industry, Innovation and Infrastructure	2
10	Reduced Inequalities	–
11	Sustainable Cities and Communities	2
12	Responsible Consumption and Production	2
13	Climate Action	–
14	Life Below Water	–
15	Life on Land	–
16	Peace, Justice and Strong Institutions	–
17	Partnerships for the Goals	–

Level: Poor = 1 Good = 2 Excellent = 3

Self-Assessment of the Project

This section presents the self-assessment of the project with respect to Program Outcomes (POs) and Program Specific Outcomes (PSOs), based on the design, implementation, and analysis of the water monitoring system using LoRa communication technology.

SDG 4 – Quality Education

Level: 2 (Good): The proposed water monitoring system supports quality education by providing hands-on experience in embedded systems, wireless communication. The use of ESP32, ultrasonic sensors, and LoRa modules strengthens practical understanding and bridges the gap between theoretical concepts and real-world engineering applications.

SDG 9 – Industry, Innovation and Infrastructure

Level: 2 (Good): The project demonstrates innovation by implementing a LoRa-based wireless monitoring system for efficient water management. It highlights practical system design and infrastructure automation, with scope for further enhancement towards large-scale deployment.

Levels: Poor = 1, Good = 2, Excellent = 3

PSO Contribution from the Project

PSO No.	Program Specific Outcome Description	Level
1	Apply and analyze the concepts of electronic circuits, embedded systems, and communication systems for real-time challenges using ESP32 and LoRa technology.	3
2	Identify, design, and develop solutions for complex engineering problems related to wireless monitoring and automation using analytical techniques and hardware implementation.	3

PO Contribution from the Project

PO No.	Program Outcome	Contribution from the Project	Level
1	Engineering Knowledge	Applied embedded systems, sensing, and LoRa communication principles in system design and analysis.	3
2	Problem Analysis	Identified limitations of manual water monitoring and evaluated automated wireless solutions.	3
3	Design / Development of Solutions	Designed and implemented a functional water monitoring and motor control system.	3
4	Investigation of Complex Problems	Analyzed system performance, wireless range, and operational reliability.	2
5	Modern Tool Usage	Used Arduino IDE and embedded development tools for programming and testing.	3
6	The Engineer and Society	Addressed efficient water usage and prevention of wastage in buildings.	2
7	Ethics	Followed ethical practices in system design, testing, and documentation.	3
8	Individual and Team Work	Worked collaboratively in design, hardware integration, and analysis.	3
9	Communication	Documented methodology, results, and analysis in a structured report.	2
10	Project Management and Finance	Managed time, components, and workflow efficiently.	2
11	Life-long Learning	Explored IoT-based monitoring and long-range wireless communication for future enhancements.	3