Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 1 (2024)

Wireless Liquid level indicator Using LORA and ESP32

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Abstract. The proposed method is an innovative solution to address the demand for effective, economical remote monitoring system of liquid levels in diverse industrial, agricultural, and environmental settings. By leveraging the ESP32 microcontroller and Long-Range (LoRa) communication technology, the system enables real-time data acquisition and transmission over long distances. Its key components include an ESP32 development board, adaptable ultrasonic or pressure sensors for liquid level measurement, and LoRa modules such as SX1278 for wireless data communication. The system's adaptability to different sensor types ensures versatility across various liquid types and container shapes. Programming the ESP32 using the Arduino IDE or Platform IO, along with relevant sensor libraries and LoRa communication protocols, facilitates continuous data collection, processing, and secure transmission via LoRa, ensuring data reliability. Noteworthy features include long-range communication capability, low power consumption for extended battery life, real-time data accessibility for prompt decision-making, scalability for monitoring multiple containers simultaneously, customizable alerts and notifications, and data logging for historical analysis. This system finds applications in monitoring liquid storage environments, flood detection, irrigation management, and ensuring the safe operation of industrial processes, providing a comprehensive solution for liquid-level monitoring needs.

Keywords*: Wireless Liquid Level Monitoring System, ESP32, LoRa, real-time data accessibility, and data logging.*

I. Introduction

An essential component of many industrial, agricultural, and environmental applications is liquid-level monitoring. For effective resource management, process control, and environmental protection, precise and up-to-date information about the liquid levels in storage tanks, reservoirs, and other containers is crucial. Installing traditional cable monitoring systems in remote or large areas can be costly and difficult. This is where the ESP32 microcontroller and LoRa (Long-Range) technology come into play for wireless solutions. They provide a creative solution that gets beyond the drawbacks of wired systems to meet the demand for efficient liquid level monitoring. A complete solution for liquid level monitoring needs is the Wireless Liquid Level Monitoring System with ESP32 and LoRa. It enables the real-time acquisition and long-distance transmission of liquid level data via the use of the ESP32 microcontroller and Long-Range (LoRa) communication technology. The main parts of the system are an ESP32 development board, flexible pressure, or ultrasonic sensors for measuring liquid level, and LoRa modules like the SX1278 for wireless data transfer. This flexibility in sensor types guarantees adaptability to various liquid kinds and container geometries. Continuous data collection, processing, and secure transmission over LoRa are made possible by programming the ESP32 with the appropriate sensor libraries and LoRa communication protocols through the Arduino IDE or Platform IO. This ensures data reliability. The system is the perfect answer for liquid level monitoring demands because it has a few important functions. Its long-range communication capabilities, which permit real-time data capture and transfer across large distances, even in off-grid conditions, is one of its most important advantages. The system is an affordable option for long-term monitoring requirements because of its low power consumption, which guarantees a longer battery life. Quick decision-making is made possible by real-time data accessibility, and monitoring of several containers at once is made possible by scalability. Users are kept informed of any changes in liquid levels by customizable alerts and notifications, and data logging allows for historical analysis.

The Wireless Liquid Level Monitoring System with ESP32 and LoRa is a flexible system that may be used for flood detection, irrigation control, monitoring different liquid storage settings, and making sure industrial processes run safely. Its versatility across various liquid types and container forms is ensured by its sensor types of adaptability. The system's low power consumption guarantees a longer battery life, making it an affordable option for long-term monitoring requirements. Its long-range communication capability makes it a great alternative for monitoring liquid levels in remote or expansive places. Quick decision-making is made possible by real-time data accessibility, and monitoring of several containers at once is made possible by scalability. Users are kept informed of any changes in liquid levels by customizable alerts and notifications, anddata logging allowsforhistoricalanalysis.Inthecity, its longrange communication range, low power consumption, and realtime data a ccessibility make it an economical and effective solution for liquid level monitoring requirements.Users can improve o verall operational efficiency in their respective domains, avoid resource waste, and make wellinformed decisions by put ting this system into practice. In conclusion, a complete solution for liquid level monitoring needs is provided by the Wireless Liquid Level Monitoring System with ESP32 and LoRa. It is the perfect option for monitoring liquid levels in a variety of industrial, agricultural, and environmental applications because it has several important features. Its ability to accommodate various liquid types and container shapes is ensured by its sensor types of adaptability.

II. Literature Review

The subject of Water Level Indicator has been extensively researched. As evident by the reference list, there are numerous articles available. [1] to [7].In [1] Muhammad Ahmad Baballe,et.al., proposed an Automatic Water Level Indicator.These days, Africa's drinking water situation is getting alarmingly worse. For this reason, protecting water for both people and animals is crucial. A common cause of needless water waste in homes is overflowing above tanks. One way to solve such issues is using an automatic water level indicator and controller. The water level controller operates based on the principle that water conducts electricity because it contains minerals. Thus, a circuit can be opened or closed based on the water level. Different controller circuits transmit different signals in response to changes in the water level. These signals are employed to turn the motor pump on or off in accordance with our needs. An estimated 2 billion cubic kilometres of water are accessible on our planet, which is sufficient to produce a protective barrier of three miles thick to cover the earth. As theoceans contain around 95% of the water on Earth, which is unfit for human use. The remaining 1% makes up all the fresh water that can be found in rivers, streams, and lakes and is fit for human use, with the other 4% being trapped in the polar ice caps.In [2]Anikka Pendimethalin. proposed an Automatic water level indicator and controller.The primary goal of this methodis to maximize water usage. Water conservation has gained importance because water waste has now emerged as a significant worldwide concern. The overflow of water is one of the frequent causes of waste that we come across. This project aims to stop water overflow by using an Arduino Uno to help detect the water level in the water tank and show it on the screen in the proper manner. The Arduino Uno receives the water level information from the ultrasonic sensors that help measure it, and an LCD linked to it shows us the level. Depending upon the water level in the tank, the Arduino allows to toggle on or off the servo. In this fashion, by implementing an automated the water control system, we have a desire to help safeguard energy and natural resources. In [3] Chandrakant Naikodi,et.al. proposed water level indicator using smart Bluetooth.One of the main issues facing large cities worldwide is water scarcity, with transmission waste being identified as a major contributing factor. This is one of the incentives for this research's positions of computational approaches to build a barrier against junk, which can benefit the environment and water cycle while enhancing financial advantages and energy savings and promising that water gets stored for future generations. We discussed our research on the integration of several technologies in the design and development of an automatic water pump controller to incorporate a control system. In [4] Anirudh Kodavatiganti,et.al., proposed tracking of water levels.Despite an oil level indicator, the fluid level of any kind of container, notably overhead tanks, can be precisely located and shown. In this research, we examined how to engineer a liquid level sensor for a liquid storagesystem using an Arduino UNO. Ultrasonic waves are produced by an ultrasonic sensor, water levels are detected by a water sensor, the significance of various water levels is indicated by LEDs, and water levels are monitored by a PC. Three different LEDs to show the water level: one red LED for when it is almost at the maximum, and two red LEDs for when it was at the maximum. Any application involving the levels of any liquid can employ this effective circuit. In [5] Chawalit Panya-isara,et.al., proposed the LORA Technology-powered Internet of Things water quality monitoring system.The quality of water is a critical factor that affects human existence. Water quality tests usually need to be done on-site. There will need to be multiple test sites if the area under investigation is extensive. It will be challenging and time-consuming to do routine water quality evaluations. Therefore, to safeguard and keep an eye on the water and take preventative action in case of pollution, we need a system to check water quality in real time.The purpose of this project is to establish environmental sensors that deploy the Node-RED application and LoRa technology to monitor and display the state of the water.Measurement and data capture on water quality variables which involve temperature, electric conductivity, pH, air quality, and turbidity, are done based on the region that requires examination. When the microcontroller is done processing the sensor data, it is sent to the database via the wireless network and viewed on the dashboard of Node-RED .The trial's findings demonstrated that in certain where LoRa technology encounters difficulties, information can be sent up to 2.0 kilometers. In [6] Pawar Vikrant

Subhashet.al.,proposed water level monitoring system. Using containers as an example, the method measures the liquid level and compares it to the container's depth using ultrasonic sensors that are positioned over the containers. The Raspberry Pi, an LCD screen, an AV family microcontroller, a buzzer, and a Wi-Fi modem are all used in the system. A 12 Transformer serves as the power supply in this configuration. The LCD panel displays the current liquid level status in each container. The user may see how much liquid is in the container by using a web page to highlight and colour the liquid level. When the liquid reaches its predetermined limit, the buzzer begins to sound. Therefore, this technique aids in preventing this is one of the driving forces for the research's use of computer techniques to build a barrier against waste, which will not only result in increased financial advantages but additionally serve the ecosystem and the aquatic cycle, ensuring that we ensure resources for coming generations. This clever device, an IOT-based water level monitoring system, will alert people to the liquid's level and keep it from overflowing. In [7] Ramon Lawrence et.al.,envisioned real-world agriculture with precision using a networkof wireless sensors based on Lora. By managing environmental variables, measuring performance to improve upon past seasons, and performing predictive analysis to make better-growing decisions, real-time data facilitates precision agriculture and leads to higher production yields at reduced production costs. The environmental data collection and analysis process is costly and time-consuming, despite its benefits. Many of the current wireless sensor network (WSN) solutions are based on protocols like 802.11x (WLAN) and 802.15.4 b (LR-WPANs), however, they have a high-power consumption, a short transmission range, and complicated data management and communication stacks. Furthermore, a lot of the services that are now in place have problems with data residency and ownership.Growers have a significant obstacle to entry because of these considerations. The cost of implementing and maintaining sensor networks is too great to be justified. The method presented in this study makes use of readily set up and maintained, low-cost, and functional hardware. Using open-source hardware lowers the implementation costs of the network. By adopting long-range (LoRa) radio transceivers, transmission ranges and power consumption are increased. Farmers will be more able to adopt new technology if these barriers are removed, which will ultimately increase agriculture's viability, sustainability, quality, and profit margins.

III. Proposed Work

A.Problem Statement

In city, its long-range communication range, low power consumption, and real-time data accessibility make it an economical and effective solution for liquid level monitoring requirements.Users can improve overall operational efficiency in their respective domains, avoid resource waste, and make well informed decisions by putting this system into practice. Conclusion, a complete solution for liquid level monitoring needs is provided by the Wireless Liquid Level Monitoring System with ESP32 and LoRa. It is the perfect option for monitoring liquid levels in a variety of industrial, agricultural, and environmental applications because it has several important features. Its ability to accommodate various liquid types and container shapes is ensured by its sensor types of adaptability.

B. Block Diagram

The block diagram of the proposed system is shown in figure 1 and figure 2. The figure 1 shows the transmitter flow for a cordless volume tracking system with ESP32 and LORA. The figure 2 shows the receiver flow for a remote liquid level tracking system that uses esp32 and Lora.

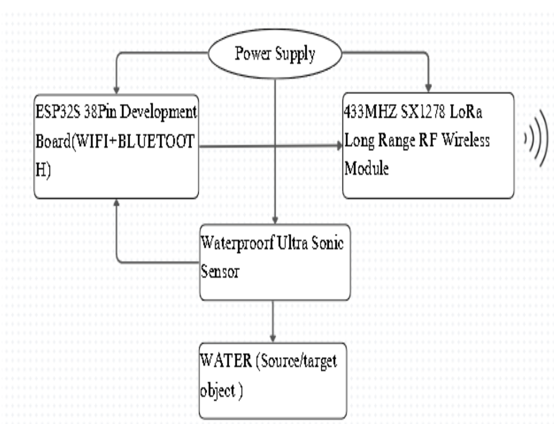

Fig 1 Transmitter

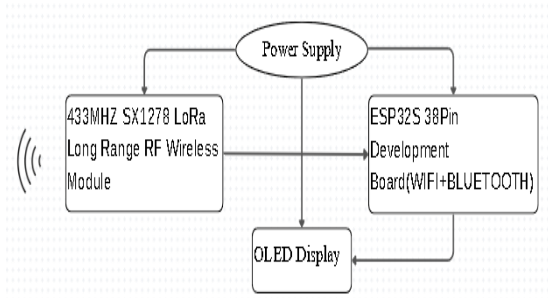

Fig 2 Receiver

The construction of the water level indicator is depicted in Figure 1. The parts that follow go over both the equipment and programs.

The Wireless liquid level monitoring system consists of the following components.

- 433MHz SX1278 LoRa Long Range RF Wireless Module
- ESP32S 38Pin Development Board(WIFI BLUETOOTH)
- OLED Display 0.96 Inch I2C Interface / 6 Pin Blue SSD130
- Waterproof Ultra Sonic Sensor
- Jumping wires.
- Transmitter and receiver side
- Components used.

C. Hardware Description

An ESP32 and LoRa are used in the wireless liquid-level monitoring system to facilitate communication. Figure 3 shows the schematic of the transmitter section. A liquid-level sensor interfaced with the GPIO pins of the ESP32 is part of the circuit. Using SPI pins, attach the LoRa module to the ESP32 and supply the necessary power. To maintain power supply stability, use a voltage regulator. Install the appropriate firmware on the ESP32 to enable it to read sensor data and send it over LoRa. Make sure the LoRa module's antenna connections are made. For stability, use the proper decoupling capacitors. Long-distance real-time liquid level monitoring is made possible by this circuit, which makes it perfect for uses like industrial processes ortank monitoring.

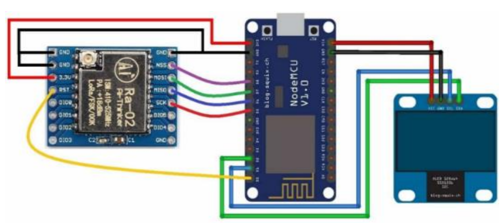

Fig 3 Schematic diagram of Liquid level transmitter in a wireless system that employs ESP32 and Lora.

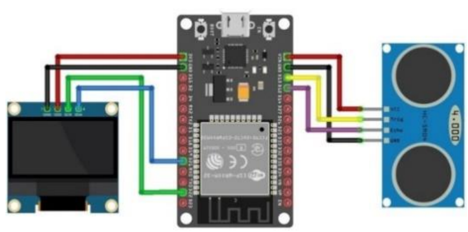

Fig 4 Schematic diagram of Liquid level receiver in a wireless system that employs Esp32 and Lora.

When using wireless communication, always abide by local rules.In figure 4 the schematic diagram of the transmitter used in the proposed system. In the city, and its long-range communication range, low power consumption, and real-time data accessibility make it an economical and effective solution for liquid level monitoring requirements. Users can improve overall operational efficiency in their respective domains, avoid resource waste, and make well-informed decisions by putting this system into practice. ESP32 with LoRa can be used to make a wireless liquid level monitoring system through two LILYGO TTGO LoRa32 modules and a submersible ultrasonic sensor.The LoRa SX1276 chip, ESP32 Wi-Fi + Bluetooth, and a 0.96-inch OLED display module with I2C support are the foundation of the TTGO LoRa32. Since the LoRa and OLED display module are already connected, the receiver side circuit diagram is not needed. The receiver schematic diagram is shown in figure [4]. Popular ultrasonic sensors that are frequently utilized in distancemeasurement applications are the JSN SR04T and the HC-SR04. ·. With an accuracy of roughly 3mm, the HC-SR04 is a cheap ultrasonic sensor that can measure distances between 2cm and 4 meters.

Its purpose is to offer low-power, long-range wireless connectivity. Up to 10,000 meters can be reached by using LoRa modulation and 433 MHz operation for this module1. Applications requiring low data rates and low range can benefit from the module's high sensitivity of -136dBm and high-power output of 20dBm. When paired with any microcontroller that supports SPI1, the module can communicate via the SPI protocol. Only 3.3V1 should be used to power the module since it needs an antenna to work correctly. Arduino and other platforms can communicate with standard libraries.

The ESP32S 38-Pin Development Board is an affordable and adaptable option for Internet of Things projects that need wireless communication. It has an ESP32-WROOM-32 microcontroller inside of it, which is a 32-bit dual-core CPU that can communicate via Bluetooth and Wi-Fi12. There are 38 pins on the board in total, including power and analog pins, which offer a variety of input and output options3. The board may be programmed using the Lua programming language and supports three modes of operation: AP, STA, and AP+STA1. Additionally, the board can be programmed in C++ using the Arduino IDE1. The board can operate at a frequency of up to 240 MHz and consumes little power2. The board's wireless connectivity makes it perfect for Internet of Things applications.

A small and adaptable display module, the OLED Screen may interface via SPI/IIC protocols with any microcontroller1. The module boasts a viewing angle of more than 160 degrees and a resolution of 128x64. OLED display technology is perfect for low-power applications since it doesn't need a backlight and emits light on its own1. With its SSD1306 driver IC, the module only needs two I/O ports to control1. A 6-pin male header that is soldered to the board1, a display board, and a display are included in the box. The module offers an input voltage range of 3.3V to 6V1 and is compatible with both 3.3V and 5V I/O levels.

A multipurpose tool that uses sound waves to detect and measure distances is the Waterproof Ultra Sonic Sensor. It is made especially to resist challenging climatic factors including moisture, dust, and humidity12. The transducers used by the sensor can operate at ultrasonic frequencies, typically 40 KHz. The ultrasonic sound sensor sends out pulses and then listens to see whether any of them are reflected. The amount of time that passes between transmission and reception is measured if they do. The distance to the item that reflected the sound may be calculated using this time delay1. The sensor is appropriate for outdoorapplication since it is dust- and waterproof-resistant1. It might be utilized to create outdoor robots, identify intruders, or function as your car's backup alarm1.Utilizing SPI/IIC protocols, the sensor is user-friendly and can be interfaced with any microcontroller1. Numerous applications, such as industrial monitoring and control, home automation, and other projects requiring distance measurement in challenging conditions, are perfect for this sensor.

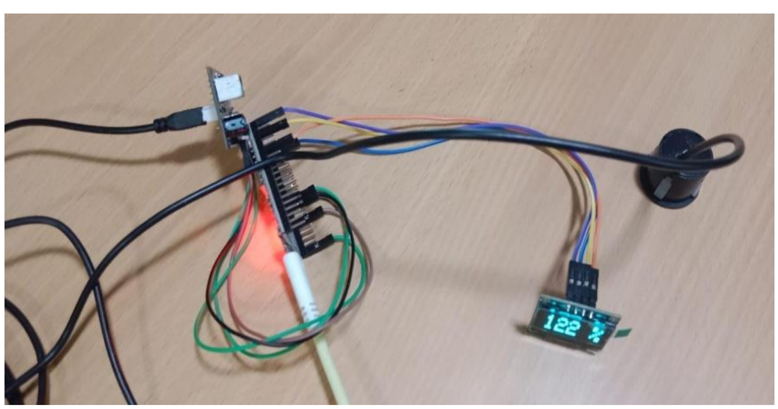

Fig 5 Prototype of proposed System

IV. Results And Discussion

The final objective has been establishedfor monitoring liquid levels in tanks, reservoirs, and other containers, the Wireless Liquid Level Monitoring System provides an adaptable and affordable option. The SX1278 LoRa Long Range RF Wireless Module, which operates at 433 MHz and consumes little power, is the foundation of the system1. The prototype is designed and shown in the figure 5. Any microcontroller that supports SPI1 can utilize the module, which communicates over the SPI protocol. For optimal operation, the module needs an antenna and should only be powered by 3.3V1.Wireless communication and control over the wireless module are provided via the ESP32S 38Pin Development Board. It is furnished with an ESP32-WROOM-32 microcontroller, supporting Bluetooth and Wi-Fi communication protocols, and features a 32-bit dual-core CPU12. With 38 pins total—analog and power pins included—the board offers a multitude of possibilities for input and output3. The board may be programmed using the Lua programming language and supports three modes of operation: AP, STA, and AP+STA1. Additionally, the Arduino IDE and the C++ programming language are compatible with the board1.To show the liquid level measurements, an OLED show 0.96 Inch I2C Interface / 6 Pin Blue SSD130 is utilized. SPI/IIC protocols may be used to interface the module with any microcontroller1. OLED display technology is perfect for low-power applications since it doesn't need a backlight and emits light on its own1. With its SSD1306 driver IC, the module only needs two I/O ports to control1.To gauge the amount of liquid in the container, utilize the Waterproof Ultra Sonic Sensor. Ultrasonic frequency transducers, typically operating at 40 KHz1, are utilized by the sensor. The ultrasonic sound pulses are sent out by the sensor, which then listens to see if any of them are returned. It is then measured how long it takes for them to receive and transmit data. To calculate the distance to the liquid level1, one might utilize this time delay. It may be used outside because the sensor is dust- and waterproof-proof1. Build outdoor robots with it, use it to identify intruders, or use it as your car's backup alarm1. Simple SPI/IIC protocols may be used to link the sensor with any microcontroller1.The system's numerous components are connected via jumping wires. They are perfect for testing and prototyping since they are simple to use and versatile.It is an adaptable and affordable way to keep an eye on the liquid levels in reservoirs, tanks, and other types of containers. The OLED Display 0.96 Inch I2C Interface / 6 Pin Blue SSD130 for displaying the liquid level readings, the Waterproof Ultra Sonic Sensor for measuring the liquid level, the ESP32S 38Pin Development Board for wireless connectivity, the 433MHz SX1278 LoRa Long Range RF Wireless Module for long-range wireless communication, and the Jumping wires for connecting the various system components are all used in this setup. Numerous uses for the system are excellent, such as industrial monitoring and control, home automation.

V. Conclusion

The Wireless Liquid Level Indicator with LoRa and ESP32 technology is more than just a convenience.It is a critical necessity in our modern society. As we navigate the complexities of urbanization and industrialization, efficient resource management becomes paramount. This innovative device addresses the pressing need for real-time monitoring and control of liquid levels across various sectors, from agriculture and water management to industrial processes and smart homes. The wireless nature of this solution eliminates the cumbersome wiring and accessibility limitations of traditional systems, making it an ideal choice for remote and hard-to-reach locations. Furthermore, LoRa technology ensures long-range communication, facilitating the seamless integration of devices across vast areas. The ESP32's robust processing power and versatility enhance its capabilities, enabling not only precise liquid level monitoring but also data analysis and predictive maintenance. In a world grappling with climate change and resource scarcity, the Wireless Liquid Level Indicator with LoRa and ESP32 emerges as a sustainable solution that minimizes waste, reduces costs, and promotes environmental responsibility. Its potential to enhance water conservation efforts, improve operational efficiency, that make smart city projects conceivable are obvious. The implementation of such innovative technologies becomes critical as we work toward a more sustainable and linked future, guaranteeing a civilization that flourishes in balance with the world and its resources.

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