Tank Monitoring and Operational Control System

Report by

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1 Introduction

Water management is a critical requirement in residential buildings, hostels, apartments, and institutions. In many places, water tanks are still monitored manually, which often leads to problems such as water overflow, dry running of motors, unnecessary power consumption, and lack of real-time information. Manual supervision is inefficient and unreliable, especially when continuous monitoring is required.

With the advancement of the Internet of Things (IoT), it is possible to automate water tank monitoring and motor control using sensors, microcontrollers, and real-time dashboards. IoT enables remote monitoring, automatic decision-making, and instant alerts, thereby improving efficiency and reducing human effort.

This project presents an IoT-based Tank Monitoring and Operational Control System using an ESP32 microcontroller, HC-SR04 ultrasonic sensor, DHT11 temperature and humidity sensor, and a Node-RED dashboard. The system continuously monitors the water level, controls the motor automatically based on threshold values, and allows manual override through a dashboard. Email alerts are also generated for critical water levels.

2 Problem Statement

In traditional water tank systems, the motor is switched ON and OFF manually without knowing the exact water level inside the tank. This results in frequent issues such as water overflow when the motor is not turned off on time and motor damage due to dry running when the tank is empty. Additionally, users do not have real-time information about tank status when they are away from the location.

There is no centralized monitoring system to display water level, motor status, or environmental conditions. This lack of automation leads to water wastage, increased electricity consumption, and reduced motor lifespan. Hence, an automated and IoT-based solution is required to monitor tank levels, control the motor intelligently, and provide real-time alerts.

3 Proposed Solution

To overcome these issues, an IoT-based Tank Monitoring and Operational Control System is developed using ESP32, HC-SR04 ultrasonic sensor, DHT11 temperature and humidity sensor, and a Node-RED dashboard. The system automatically controls the motor based on predefined water-level thresholds and also allows manual control through the dashboard. Real-time monitoring and email alerts improve reliability and user convenience.

4 Objectives of the Project

- The main objectives of this project are:
- To continuously monitor the water level inside the tank
- To automatically control the motor based on predefined threshold levels
- To provide manual motor control through a remote dashboard
- To monitor temperature and humidity conditions
- To display real-time data on a Node-RED dashboard
- To generate alerts for low and high water levels
- To reduce water wastage and prevent motor damage.

5 Scope of the Project

This project is designed for small to medium-scale water tank systems such as residential houses, hostels, apartments, and institutional buildings. The system focuses on automating a single tank and motor setup using low-cost and easily available components.

The scope includes real-time monitoring, automatic motor control, manual override, dashboard visualization, and alert notifications. Advanced features such as multiple tank integration, mobile applications, or AI-based water prediction are not included in the current implementation but can be added in future enhancements.

6 Hardware Components

The hardware components used in this project are:

- ESP-32 Microcontroller – acts as the central control unit with built-in Wi-Fi
- HC-SR04 Ultrasonic Sensor – measures water level by distance calculation
- DHT11 Sensor – measures temperature and humidity
- LED – represents motor ON/OFF status
- Breadboard and Jumper Wires – for circuit connections
- Water Tank (Prototype Setup)

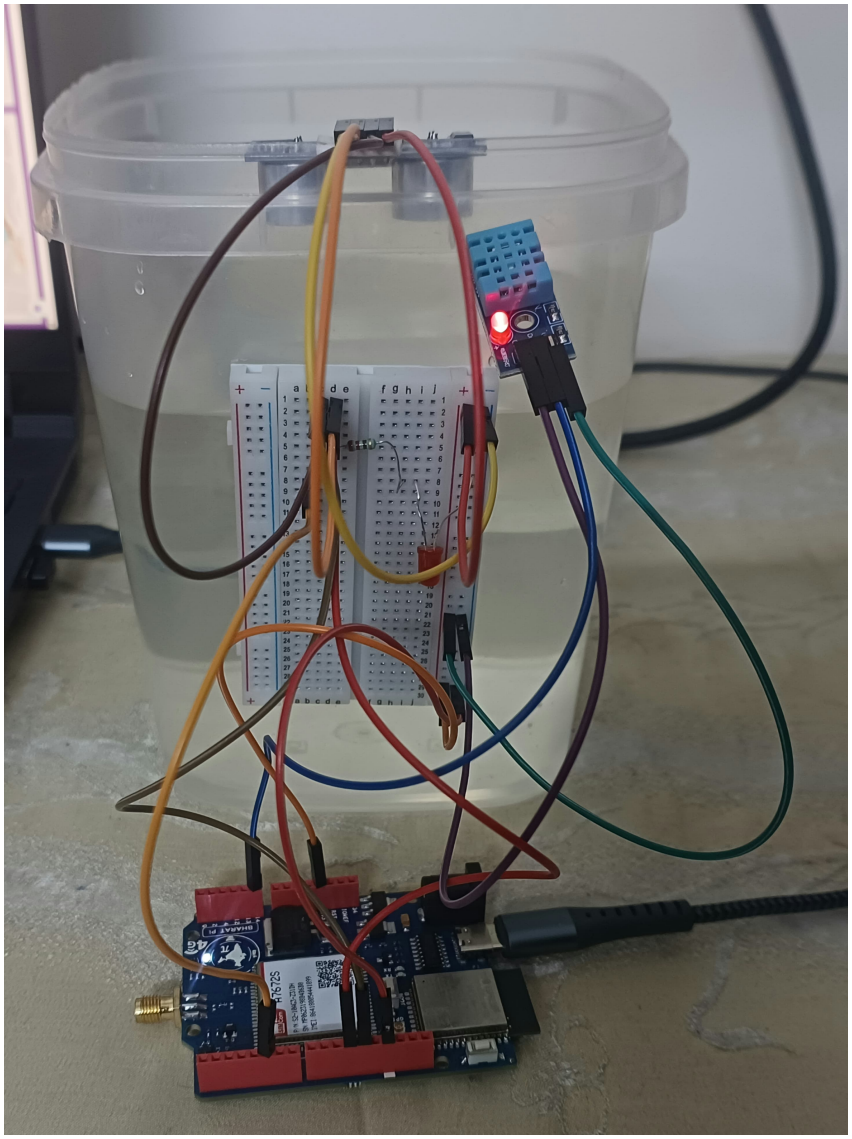

Figure 1: Hardware Setup of Tank Monitoring System

7 Software Requirements

- **Arduino IDE** – used to write and upload code to ESP32
- **MQTT Protocol** – used for lightweight publish–subscribe communication
- **Node-RED** – used to create the IoT dashboard and alerts
- **Email Service** – used for sending threshold-based notifications.

8 System Architecture

The system follows an IoT-based layered architecture that ensures efficient data flow and modular design.

- Sensors collect real-time water level and environmental data
- The ESP-32 processes sensor values and applies control logic
- Data is transmitted to an MQTT broker using Wi-Fi
- Node-RED subscribes to MQTT topics and visualizes data
- Control commands from the dashboard are sent back to ESP32

9 Working Principle

The ultrasonic sensor is mounted at the top of the tank to measure the distance to the water surface. This distance is converted into a percentage water level based on the tank height (50 cm). The ESP32 continuously publishes the water level, temperature, and humidity data to the MQTT broker.

The system operates based on the following logic:

- If water **level falls below 10 percent**, the motor turns ON automatically.
- If water **level reaches above 75 percent**, the motor turns OFF automatically.
- Motor status (ON/OFF) is published to the dashboard.
- Users can manually control the motor using dashboard buttons.
- **Email alerts** are sent for low-level and high-level conditions.

This ensures both automation and user control.

10 MQTT Communication Model

The project uses the MQTT publish–subscribe communication model, which is suitable for IoT applications due to its low overhead and reliability.

- ESP-32 publishes sensor data and motor status to MQTT topics.
- Node-RED subscribes to these topics for visualization and control.
- Separate topics are used for water level, temperature, humidity, and motor status.
- This modular topic structure improves scalability and fault isolation.

11 Email Alert System

The system includes an automated email alert mechanism. When the water level crosses predefined thresholds (low or high), Node-RED sends an email notification to the user. This ensures timely action without continuous manual monitoring.

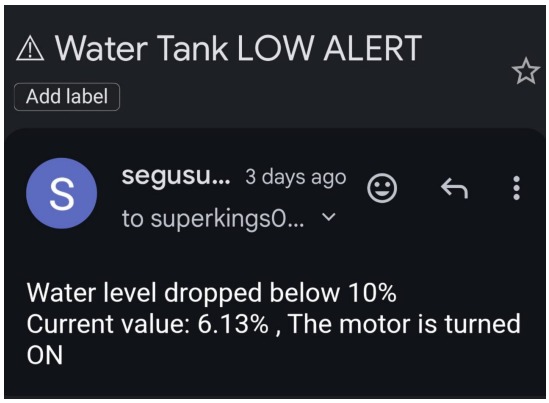

Figure 2: (a) Low Level Alert Email

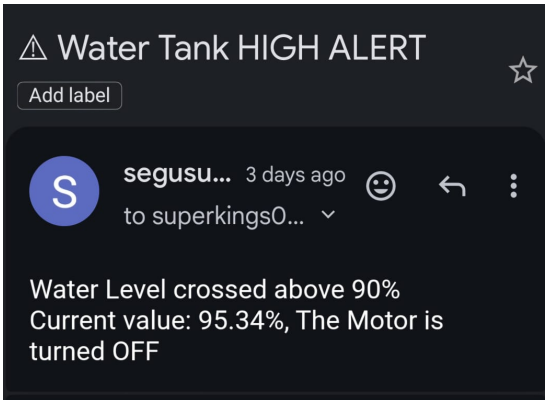

Figure 3: (b) High Level Alert Email

12 Advantages of the System

- Real-time water level monitoring
- Automatic motor control
- Manual override facility
- Reduced water wastage
- Prevention of motor dry running
- Remote access and monitoring
- Low-cost and scalable design

13 Node-RED Dashboard

The Node-RED dashboard provides a real-time and user-friendly interface to monitor and control the system. It displays:

- Water level percentage.
- Temperature and humidity gauges.

- Motor ON/OFF status.
- Manual motor control buttons.
- Usage graph and location map.
- The dashboard can be accessed remotely through a web browser.

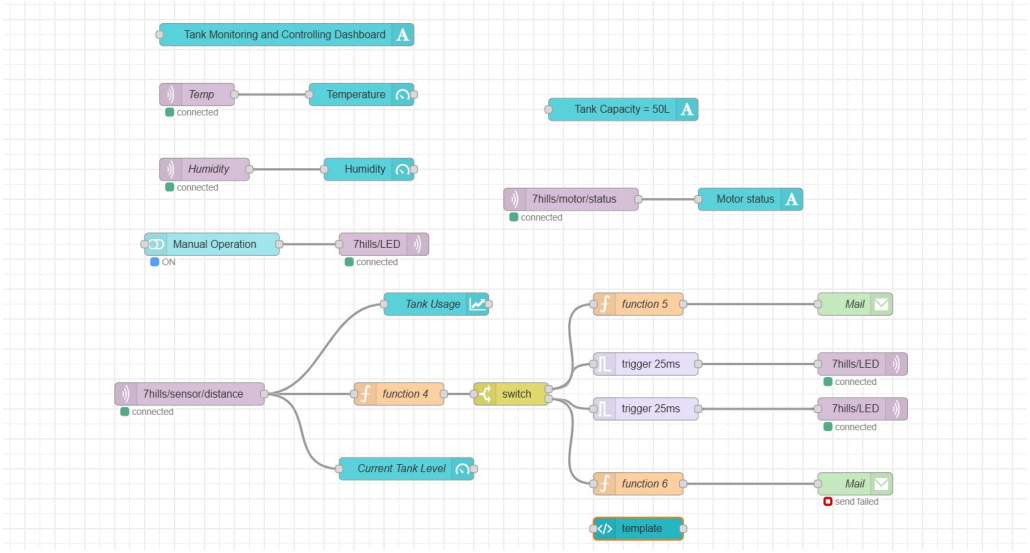

Figure 4: Node-RED JSON flow

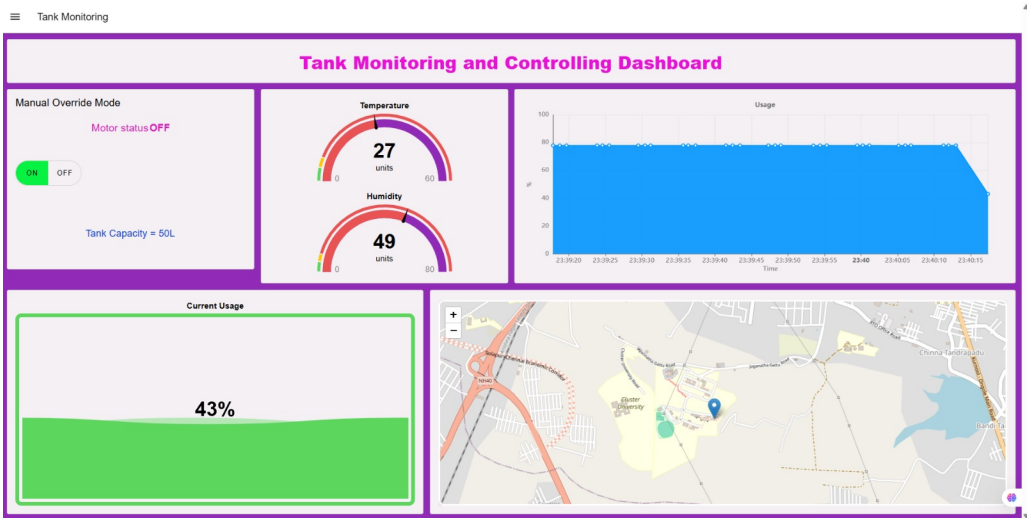

Figure 5: Node-RED Dashboard for Tank Monitoring

14 Limitations of the System

- Ultrasonic sensor accuracy depends on alignment.
- Requires stable internet connection.
- Suitable mainly for single-tank systems.

15 Future Enhancements

- Multiple tank monitoring.
- Water consumption analytics.
- Solar-powered operation.
- AI-based water level prediction.

16 Conclusion

The IoT-based Tank Monitoring and Operational Control System provides an efficient and reliable solution for automated water management. By integrating ESP32, sensors, MQTT communication, and Node-RED dashboards, the system enables real-time monitoring, remote control, and alert notifications. This project demonstrates the practical application of IoT in solving real-world water management problems and can be extended further for smart home and smart campus applications.