Design and Simulation of an IoT-Based Smart Water Tank Monitoring and Automatic Pump Control System Using ESP32

Abstract

Water storage management is an essential requirement in residential, industrial, and agricultural environments. Manual monitoring of water tanks often leads to water wastage, pump damage due to dry running, and inefficient water usage. This project presents the design and simulation of an Internet of Things (IoT) based Smart Water Tank Monitoring and Automatic Pump Control System using the ESP32 microcontroller. The system monitors water levels using multiple level indicators representing low, medium, and high tank conditions. Light Emitting Diodes (LEDs) are used to provide visual feedback of the water level status. An ultrasonic sensor is integrated to measure water depth accurately, while a relay module is used to automatically control the water pump based on tank level conditions.

Additionally, the system incorporates wireless communication using Wi-Fi to send real-time alerts and status updates to a smartphone through the Blynk IoT platform. This enables remote monitoring and control, improving convenience and system reliability. The project was simulated using the Wokwi online simulation environment before hardware implementation. The developed system helps prevent water overflow, reduces pump damage risk, and improves water management efficiency. This solution demonstrates how embedded systems and IoT technology can be applied to solve real-world engineering problems effectively.

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Chapter 1

1.1 Introduction

Water storage management is an important challenge in homes, hostels, industries, and offices. Many people manually switch water pumps ON and OFF, which often leads to:

Water tank overflow

Dry running of pumps

Water wastage

Electricity wastage

Pump damage

This project introduces a Smart Automatic Water Tank Pump Control System using ESP32 microcontroller. The system automatically monitors water level and controls the pump accordingly while displaying status through LEDs and serial monitoring.

1.2 Project Objective

The main objectives of this project are:

To automatically monitor water level in a tank

To automatically control water pump using relay

To indicate water levels using LEDs

To prevent overflow and dry tank conditions

To provide real-time pump status monitoring

To create a low-cost and efficient automation system

1.3 Project Statement

Manual water pump operation causes several problems such as:

Forgetting to switch OFF pump → Tank overflow

Forgetting to switch ON pump → Tank becomes empty

Pump running without water → Motor damage

Lack of real-time monitoring

This project solves these problems by introducing automation using sensors and microcontroller technology.

1.4 System Overview

The system uses water level sensors connected to an ESP32 microcontroller. Based on the detected water level, the ESP32 automatically controls a relay that switches the water pump ON or OFF. LED indicators are used to display tank levels:

- Low Water Level (Red)
- Medium Water Level (White)
- Full Tank (Green)
- The system also sends pump status information to the Serial Monitor.

Chapter 2

2.1 Component Used

Component	Quantity	Function
ESP32 Microcontroller	1	Main controller
Water Level Sensors / Probes	3	Detect water levels
Relay Module	1	Controls pump
LEDs (Red, Yellow, Green)	3	Water level indicators
Resistors (220Ω)	3	LED protection
Jumper Wires	Several	Connections
Power Supply	1	System power
Water Pump	1	Pumps water

2.2 Working Principle

The system operates using three water level sensors placed at different tank heights:

1. **Low Level Sensor**

When activated:

- Pump turns ON
- Red LED turns ON

2. **Mid Level Sensor**

- Indicates medium water level
- Yellow LED turns ON

3. **High Level Sensor**

When activated:

- Pump turns OFF

- Green LED turns ON

The ESP32 continuously reads sensor signals and makes decisions automatically.

2.3 System Flow

1. ESP32 reads water level sensors
2. If water is LOW → Pump ON
3. If water reaches MID → Monitoring continues
4. If water is FULL → Pump OFF
5. LED indicators show tank status
6. Serial monitor displays pump condition

2.4 Software Design

The system was programmed using Arduino IDE and ESP32 libraries.

Main Software Features:

- Sensor input reading
- Automatic pump control
- LED level indication
- Serial monitor pump status display

2.5 Simulation and Testing

The system was tested using Wokwi Online Simulator before hardware implementation.

Testing confirmed:

- Accurate water level detection
- Proper pump ON/OFF automation
- Correct LED indication

- Reliable relay operation

Chapter 3

3.1 Advantages of the System

1. Prevents water overflow
2. Saves electricity
3. Protects water pump
4. Low cost implementation
5. Easy to maintain
6. Expandable for IoT integration

3.2 Limitations

1. Sensor accuracy depends on installation
2. Requires stable power supply
3. Limited remote monitoring (without IoT upgrade)

3.3 Future Improvement

The system can be upgraded to include:

1. Mobile app monitoring
2. WiFi / IoT integration
3. Water usage analytics
4. SMS alert system
5. Solar power support

3.4 Conclusion

The Smart Water Tank Automatic Pump System successfully automates water pump control using ESP32. The system improves water management efficiency, reduces human error, and protects pump equipment. It demonstrates how embedded systems can solve real-life automation problems effectively.

3.5 References

1. ESP32 Documentation
2. Arduino IDE Documentation
3. Wokwi Simulation Platform
4. Embedded System Design Resources