

Design and Implementation of Wireless Computer Based Water Level Monitoring and Control System

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ABSTRACT: This research presents the design and implementation of a wireless, computer-based water level monitoring and control system. The system is developed to provide an efficient and reliable solution for real-time monitoring and management of water levels. At its core, the system utilizes an ESP32 microcontroller, a calibrated resistive water level sensor, and a 20x4 LCD display for visual feedback. A 12V DC relay is integrated to enable automatic or manual control of an external water pump, with manual override facilitated by a push button. The system is powered through a stepped-down, rectified mains supply. A mobile application, developed, offers a user-friendly interface for configuration and remote monitoring. Wireless communication between the ESP32 and the application enables real-time data transmission and control, using a suitable protocol to ensure reliability. The system is tested extensively to validate its performance, accuracy, and responsiveness, demonstrating its potential for use in residential, agricultural, and industrial water management applications.

KEYWORDS; Water Level Monitoring, Wireless Control System, C# Mobile Application, Real-Time Monitoring, and Embedded Systems.

1.0 INTRODUCTION

Water is a fundamental natural resource that supports both ecological systems and human development. Its effective management is critical for sustaining life and promoting economic growth. In various sectors—such as agriculture, industry, and municipal services—precise monitoring and regulation of water levels is crucial to prevent flooding, minimize water shortages, and mitigate environmental harm [1], [2].

Technological advancements have greatly enhanced the capabilities of water level monitoring systems. Modern systems now provide real-time data collection, automated control, and intelligent analysis, thereby improving the efficiency and responsiveness of water management practices [3]. These systems are particularly important in infrastructure involving water storage and distribution, such as tanks, wells, reservoirs, and treatment facilities.

By delivering continuous and accurate information on water levels, such systems enable users to optimize resource usage, reduce manual intervention, and ensure sustainable operations. Automated monitoring not only improves decision-making but also helps in conserving water and preventing wastage [3][5].

Modern water level monitoring and control systems typically consist of several interrelated components designed to ensure accurate measurement, reliable control, and user accessibility. The primary component is the water level sensor, which detects the level of water in a reservoir or tank

and converts it into electrical signals interpretable by digital systems [4][12]. These signals are processed by a microcontroller or embedded processor, which acts as the system's central unit, executing control algorithms and managing input/output operations.

To provide users with visual feedback, systems commonly include display modules, such as LCDs or LED panels that show current water levels and operational status. Wireless communication modules such as Wi-Fi, Bluetooth, or GSM enable remote data transmission, allowing information to be sent to centralized monitoring stations or user interfaces in real time [5][7]. Control components, including relays or electrically actuated valves, are used to automate the operation of water pumps or valves based on predefined thresholds. Additionally, user interfaces, such as desktop or mobile applications, are integrated to allow remote access, system configuration, real-time monitoring, and manual control [6].

Wireless, computer-based monitoring systems provide substantial improvements over traditional manual systems. Remote access enables users to monitor water levels and control systems without the need for physical presence, which is especially beneficial for managing dispersed or hard-to-reach locations. These systems are also scalable, supporting the addition of more sensors to accommodate multiple tanks or distributed systems. The flexibility in sensor placement leads to better measurement precision and efficient resource management [7]

Real-time data transmission is another key advantage, enabling quick and informed responses to fluctuations in water levels. Moreover, wireless systems are often more cost-effective, as they minimize the need for complex wiring and reduce the likelihood of mechanical failure due to damaged cables. This results in lower maintenance requirements and greater operational reliability [8].

2 METHODS AND MATERIALS

In the design and development of the wireless based water monitoring system, it is essential to clearly define both the hardware and software requirements. This chapter outlines the system architecture, hardware components, software environment, and the process of integrating the fingerprint sensor with the ESP32.

2.1.1 Hardware Requirements

The primary hardware components required for the system include:

- **ESP32 Microcontroller:** This is the central processing unit that manages all system operations, including communication with the database servers. The ESP32 is chosen due to

its built-in Wi-Fi and Bluetooth capabilities, allowing for seamless integration with cloud services.

- **Power Supply:** A regulated power supply (3.3V or 5V) is required to power the ESP32 and fingerprint sensor.
- **LCD Display:** A small display is used to show real-time feedback, such as "Fingerprint Matched" or "Fingerprint Not Recognized."
- **Breadboard and Jumper Wires:** These components are needed to connect the ESP32 and the fingerprint sensor during prototyping.
- **Real time clock (RTC) module :** component provides accurate time and date information for the system. The time and date are updated every second based on a one pulse per second interrupt from a 32.768-kHz crystal
- **Resistor:** to limit the flow of electric current.
- **Capacitor:** capacitors is energy storage, power conditioning, electronic noise filtering

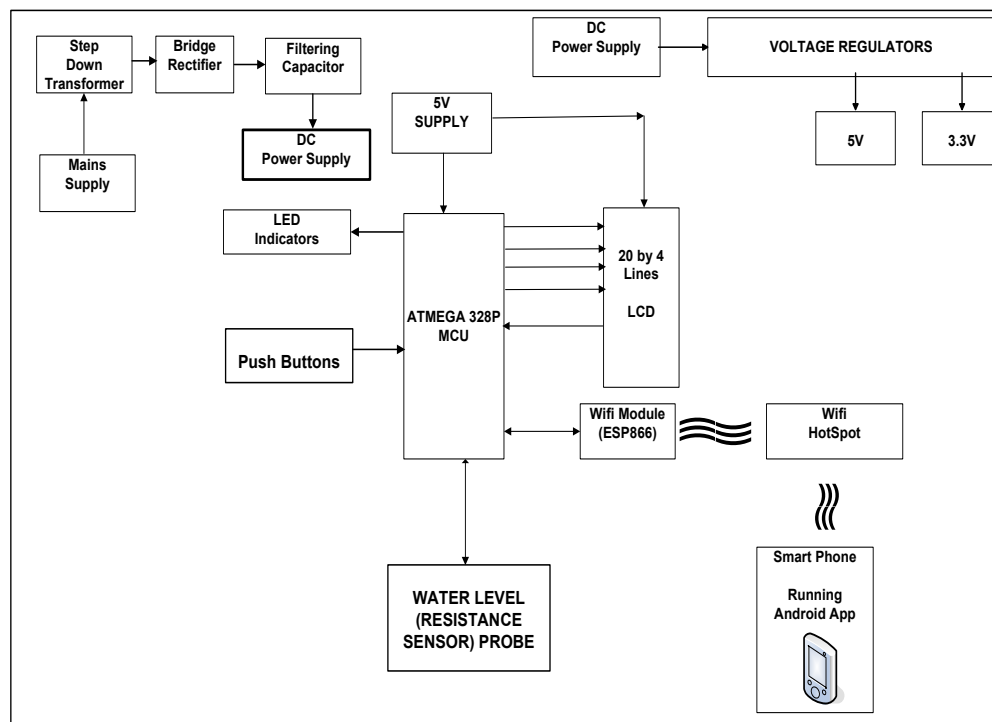


Figure 1: System Block Diagram

The figure 1 shown above is the simple block diagram of the research. It is a simple illustration of how we the system will be implemented and the various parts involved in it.

2.2 HARDWARE OVERVIEW

The microprocessor (ATMEGA 328P) forms the heart of the system. The System Hardware can be sub-divided into two inter-dependent units, namely: (i) Liquid Level Measurement Unit and (ii) Display Unit

2.2.1 DISPLAY UNIT

Due to the use of a microcontroller to display liquid level accurately, it was decided that a liquid crystal display (LCD) module would be the most flexible way of displaying this numerical output. It is considered worthwhile to integrate the display unit together and limit the number of components required. In addition, the information which the LCD could

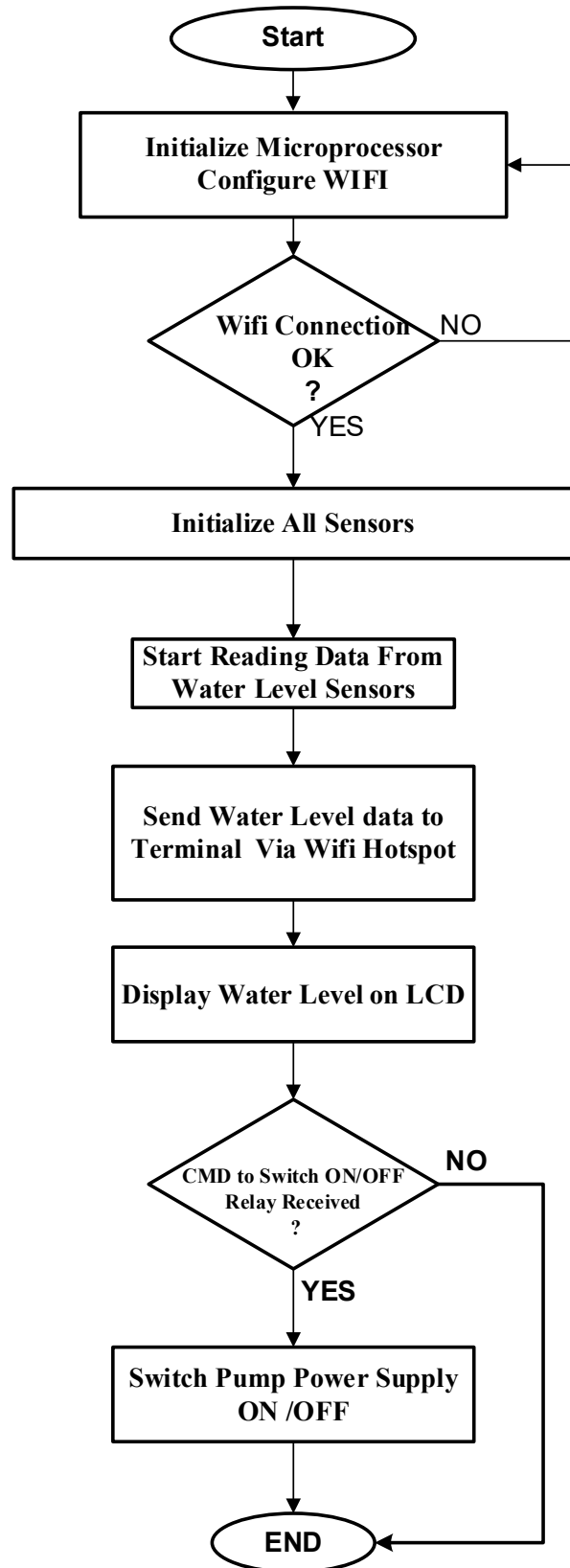


Figure 3: Water Level Monitoring and Control unit flowchart.

2.3 Software Development Using Integrated Development Environments (IDEs)

To develop the firmware that runs on the ESP32, and the application for the desktop clients, two different Integrated

Development Environments will be used: 1. Arduino IDE and 2. Microsoft Visual Studio.

2.3.1 Arduino IDE

Arduino IDE is a software development environment or software application for Arduino where users can write

different kind of computer programs and test. The user can write codes in IDE in a language which an Arduino understands, i.e. C, C++. The program (codes) written in IDE, when uploaded into the Arduino microcontroller determines what and how the system works. The Arduino IDE comes with a ‘built-in code parser’ that studies the validity of the written codes before sending it to the Arduino. The compilation and translation work is done in IDE after checking the validity of codes. After translating the code, the IDE uploads the program to the Arduino microcontroller. IDE software includes the set of different programs that are ready for being tested on the device. Just like in other programming platform, Arduino IDE can also be extended with the use of libraries; the IDE installation includes the installation of number of libraries. The software page where Arduino codes are written looks has two main functions ‘setup ()’ function and ‘loop()’ functions. The setup part is where the codes should be written so that the program runs and the loop part is where the codes should be written so that the program runs with repetition until the power off or reset button is pushed. It allows users to program and edit Arduino to do anything they like to do with it. Depending upon the feature of different boards, the IDE enables communication with Arduino board through USB.

2.3.2 Microsoft Visual Studio

Microsoft Visual Studio is a comprehensive IDE that can be used to develop and deploy numerous computer software solutions ranging from Desktop application, Web and Mobile Applications, Cloud computing, Office Automation to Game development. It features numerous programming languages such as Visual Basic, Visual C#, Visual C++ and Visual F#. The developed Client Software for the soil moisture monitoring system was developed using C# due to its versatility and robustness.

2.4 Connection Overview

The integration of the sensor with the ESP32 is one of the key tasks in system design. Most, sensors communicate via UART, making them easy to connect to the ESP32 using the TX and RX pins. The wiring diagram for connecting the water sensor to the ESP32 includes the following steps: Connect the TX pin of the sensor to the RX pin of the ESP32. Connect the RX pin of the sensor to the TX pin of the ESP32. Provide power to the sensor by connecting the VCC and GND pins to the corresponding power and ground pins on the ESP32.

2.4.1 Step-by-Step Guide to Connect and Monitor Water Level:

- Install the Application:
- Download and install the water level monitoring app from your Android phone's app store.
- Power On the Device:

- Ensure the device is powered on and ready for connection.
- Configure WiFi Settings:
- Turn off mobile data on your phone to avoid interference.
- Enable WiFi and search for a network named "Water Level Monitor."
- Connect to the Device:
- Select the "Water Level Monitor" network.
- Enter the password: oscotech2024.
- Press "Connect" to establish the connection.
- Launch the App:
- Once connected, open the installed app on your phone.
- The app will display the current water level in the container, providing real-time monitoring.

2.4.2 User Interface Design

The user interface of the system consists of two primary components:

LCD Display: This component is used to provide real-time feedback to users, such as “to show the level of water in a container.” This display ensures that users knows the quality of water. **Web/Mobile Interface for Admins:** A web or mobile-based interface allows administrators to monitor water in real time, generate reports. This interface communicates with the cloud database and displays data in a user-friendly format.

2.4.3 Component Connections

Component Connections for this system includes the following key connections:

- ESP32 to water Sensor: The water sensor is connected via UART pins (TX and RX), with appropriate power (VCC and GND) connections.
- ESP32 to LCD Display: The display is connected via I2C communication, with the SCL and SDA pins connected to the ESP32.
- Power Supply: The ESP32 and sensor are powered using a regulated power source, typically from a USB cable or an external battery

2.4.4 Software Development Environment

The software for the water levels monitoring system using the Arduino IDE, a widely used platform for microcontroller programming. Key steps in software development include:

- Sensor Enrollment Code: This code captures and stores the level of water in a data base
- Cloud Integration Code: Firebase libraries are used to send attendance data from the ESP32 to the cloud. The system uploads each successful record to Firebase, allowing remote access to the data.

3 RESULTS AND DISCUSSION.

The method used in this project can be divided into two parts which are hardware and software development part. The hardware development involves the circuit construction and prototyping. Meanwhile, the software part involves the firmware coding, circuit simulation and data acquisition.

3.1 Data Collection and Parameter Analysis

The water monitoring system developed for this project collected data on essential water quality parameters such as pH level, turbidity, temperature, dissolved oxygen (DO), and conductivity. These parameters were chosen as indicators of water health, providing insights into contamination levels, chemical balance, and overall water quality.

Data Collection Process: The sensors were placed in various water bodies (e.g., rivers, lakes, or reservoirs) and connected to the mobile app via a wireless communication module. Data was collected at predefined intervals and transmitted to the app in real-time, enabling continuous monitoring.

3.2 Hardware components and Diagram

The hardware setup is the foundation of the system implementation. The following components are assembled to form a functional wireless water level monitoring system using mobile application.



Figure 3: The ESP 32

ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor.

3.2.1 LCD Display

The LCD display is connected via the I2C used to show real-time system feedback to users, to know the level of water in a container. The LCD communicates with the ESP32 via I2C,

which is relatively easy to configure and use. The display is crucial for user interaction and helps ensure users are informed about the status of their water Steps:

- Connect the LCD display to the ESP32 using the I2C protocol (SDA and SCL pins).
- Write a simple program to display a message, ensuring the display is functioning correctly.



Figure 4: LCD Screen Display

3.2.2 12v adapt Power Supply

12v adapt Power Supply is connected to 7805 5v regulator. ESP32 are powered by 5v power source ensuring stable and continuous operation.

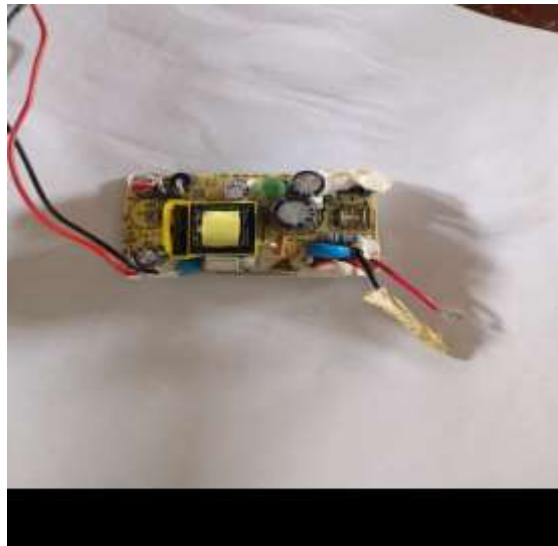


Figure 5: Power supply.

3.3 Parameter Analysis:

pH Level: pH is critical as it indicates the acidity or alkalinity of water. Ideal pH levels for safe drinking water are between 6.5 and 8.5. Deviations could indicate pollution from acid rain, industrial runoff, or wastewater.

Turbidity: This measures water clarity and reflects the presence of suspended particles like soil, algae, or organic matter. Higher turbidity often signals pollution or high sediment levels.

Temperature: Changes in temperature can affect aquatic ecosystems and indicate the presence of thermal pollution.

Dissolved Oxygen (DO): DO is vital for aquatic life; lower levels can indicate pollution or eutrophication (excessive nutrient accumulation).

Conductivity: Conductivity measures water's ion concentration, reflecting salinity levels and potential contamination by agricultural runoff or sewage.

3.4 Performance Evaluation of the Mobile App

The mobile app's performance was evaluated based on accuracy, user experience, and reliability.

Data Accuracy: The app's accuracy was verified by comparing sensor data with samples tested in a laboratory setting. While the app showed slight variations, the readings generally fell within acceptable margins of error for field-based monitoring.

Responsiveness and Real-Time Updates: The app's low-latency data transmission enabled quick updates, which is critical for detecting sudden changes in water quality allowing immediate intervention.

User Feedback on Usability: Feedback from users revealed that the app's intuitive design and clear data visualizations made it user-friendly. The ability to view both real-time and historical data on a single interface was especially appreciated.

4 CONCLUSION AND RECOMMENDATION

The research was a successful development of a mobile application-based water quality monitoring system, capable of delivering real-time insights into essential water quality parameters. Key outcomes of the project demonstrate the system's practicality, usability, and cost-effectiveness. However, the system facilitated real-time monitoring, enabling continuous data acquisition and immediate responsiveness to variations in water quality. This feature significantly enhances the ability to prevent and mitigate potential environmental and public health risks. Thus, the mobile application delivered effective data visualization through clear and interactive graphical representations of water quality trends. Also, the solution demonstrated enhanced accessibility, allowing users to remotely observe and manage water quality conditions from virtually any location. Therefore, the system offers a cost-effective alternative to conventional water monitoring approaches. By leveraging wireless communication and low-cost sensors, the solution is well-suited for long-term and large-scale deployment, particularly in regions with limited resources.

4.2 Future Implications for Water Management

The successful deployment of a mobile app-based water monitoring system has significant implications for water management which has proactive Water Quality Management in terms of Real-time monitoring enables authorities to take proactive measures to address water quality issues, reducing the risk of contamination and its associated health impacts. Also it enhances community Involvement prescribing the accessibility of the mobile app empowers local communities to participate in water quality monitoring, fostering a sense of responsibility and awareness about water resources. However, it can provide policy development

4.3 Recommendation.

Based on the successful development and evaluation of the mobile app-based water quality monitoring system, it is recommended that future implementations incorporate predictive analytics and AI-driven alert mechanisms to enhance proactive decision-making. Additionally, integration with cloud-based platforms could facilitate long-term data storage, broader accessibility, and collaborative water management across multiple stakeholders.

To increase system robustness and scalability, the deployment of additional sensor nodes in geographically diverse locations should be considered. Furthermore, future research should explore energy-efficient hardware configurations and solar-powered options to support continuous operation in remote or off-grid environments.

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