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Original Research Paper

Development of an Arduino-Based Water Level Indicator with Audio-Visual Alert Mechanisms

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Abstract: Monitoring water levels in tanks and reservoirs is essential to prevent overflow, dry running of pumps, and inefficient water usage. This study presents the design and implementation of a low-cost water level indicator and alert system based on Arduino, integrating a water level sensor, RGB LED indicators, and an audible buzzer. The proposed system detects discrete water levels using conductive probes or a resistive water level sensor placed at different heights inside a container. The Arduino microcontroller processes the sensor signals and provides real-time visual feedback through an RGB LED, where different colors represent low, medium, and high water levels. In addition, a buzzer is activated when the water reaches a critical threshold, serving as an audible warning to prevent overflow or system damage. The system architecture is simple, modular, and easy to implement, making it suitable for domestic water tanks, laboratories, and small-scale industrial applications. Experimental testing demonstrates that the system responds reliably to changes in water level, with minimal latency and stable operation under repeated trials. Compared to conventional mechanical float-based indicators, the proposed design offers improved flexibility, ease of maintenance, and expandability, such as integration with wireless modules or IoT platforms. The results show that combining visual (RGB LED) and audio (buzzer) indicators enhances user awareness and system usability. Overall, this Arduino-based water level indicator provides an effective, economical, and scalable solution for real-time water level monitoring and alerting, supporting efficient water management and resource conservation.

Keywords: Arduino, Buzzer, Embedded System, RGB LED, Water Level Indicator.

1. Introduction

Efficient water management is a critical requirement in residential, commercial, and industrial environments due to increasing water demand and limited freshwater resources. One common problem encountered in water storage systems is the lack of real-time information about water levels, which can lead to tank overflow, water wastage, pump dry running, and increased maintenance costs [1]. Conventional water level monitoring methods, such as manual inspection or mechanical float switches, are often unreliable, require frequent maintenance, and provide limited feedback to users.

Advancements in embedded systems and microcontroller technology have enabled the development of low-cost, intelligent, and automated water monitoring solutions. Among various microcontroller platforms, Arduino has gained significant popularity due to its open-source nature, ease of programming, and wide availability of sensors and peripheral modules [2] [3]. Arduino-based systems allow flexible integration of sensing, processing, and output components, making them suitable for real-time monitoring applications.

This study focuses on the development of a water level indicator system using an Arduino microcontroller integrated with a water level sensor, an RGB LED, and a buzzer. The water level sensor detects the presence and height of water within a tank, while the Arduino processes the sensor signals and determines the current water level. Visual feedback is provided through an RGB LED, where different colors correspond to specific water levels such as low, medium, and high. In addition, an audible alert in the form of a buzzer is triggered when the water reaches a predefined critical level, warning users of potential overflow.

The combination of visual and audible indicators enhances system usability by allowing users to quickly interpret water level conditions without the need for additional display devices. The proposed system is simple in design, cost-effective, and easy to deploy, making it suitable for domestic water tanks, laboratories, and small-scale industrial setups. Furthermore, the system can be expanded by incorporating wireless communication, data logging, or Internet of Things (IoT) capabilities for remote monitoring.

The objective of this work is to design, implement, and evaluate an Arduino-based water level indicator and alert system that provides accurate, real-time water level information while improving efficiency, safety, and water conservation.

2. Literature Review

2.1. Water Level Sensing Principles

Water level sensing in low-cost embedded systems is commonly achieved using conductive or resistive sensing techniques. These sensors operate on the principle that water conducts electricity, allowing a change in resistance or voltage when water contacts exposed probes or sensor tracks. Arduino microcontrollers read this variation through analog or digital inputs and map it to discrete water levels [3]. Such sensors are widely used in domestic and educational projects due to their simplicity, low power consumption, and ease of calibration [4] [5].

2.2. Arduino Microcontroller Platform

Arduino is an open-source microcontroller platform designed for rapid prototyping and embedded system development. The Arduino Uno, based on the ATmega328P microcontroller, provides multiple analog and digital input/output pins suitable for sensor interfacing and actuator control [6]. Its compatibility with water level sensors, LEDs, and buzzers has been demonstrated extensively in previous studies and tutorials [7] [8]. The Arduino Integrated Development Environment (IDE) allows programming using a simplified C/C++ syntax, making it accessible for beginners while remaining powerful enough for scalable applications [9].

2.3. RGB LED as Visual Indicator

An RGB LED integrates red, green, and blue light-emitting diodes into a single package. By controlling each color channel via pulse-width modulation (PWM), multiple colors can be generated to represent different water levels [10]. Several implementations use green to indicate normal levels, blue or yellow for intermediate levels, and red for critical or overflow conditions [11] [12]. Compared to single-color LEDs, RGB LEDs reduce hardware complexity and improve visual clarity, as reported in prior Arduino-based monitoring systems [13] [14].

2.4. Buzzer as Audible Alert System
Buzzers are commonly used as alert devices in embedded systems to provide immediate audible feedback. In water level monitoring applications, buzzers are activated when the water reaches a predefined threshold, such as a full tank or abnormal condition [15] [16]. Arduino controls the buzzer through digital output signals or tone generation, enabling flexible alarm patterns. Studies show that combining audible alerts with visual indicators significantly enhances system responsiveness and user awareness [17] [18].

2.5. Integrated Water Level Indicator Systems
The integration of water level sensors, Arduino microcontrollers, RGB LEDs, and buzzers forms a complete real-time monitoring and alert system. Compared to traditional float-based methods, Arduino-based systems offer improved accuracy [19] [20], lower maintenance requirements [21] [22], and greater expandability [23]. Prior works also indicate that such systems can be extended with wireless communication [24] - [26], data logging [27], or IoT connectivity for smart water management applications [28] - [30].

3. Methodology
The methodology used to design, implement, and evaluate the Arduino-based water level indicator system employing an RGB LED and a buzzer. The methodology is structured into system design, hardware implementation, software development, and testing procedures.

3.1. System Overview
The proposed system is designed to monitor water levels in a container and provide real-time feedback through visual and audible indicators. A water level sensor detects the presence of water at different heights and sends corresponding signals to the Arduino microcontroller. Based on predefined threshold values, the Arduino controls an RGB LED to indicate the current water level and activates a buzzer when a critical level is reached.

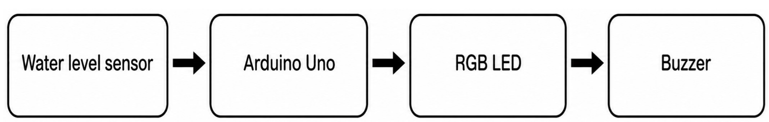

Figure 1. Block diagram of the Arduino-Based Water Level Indicator System

3.2. Hardware Design
The hardware components used in this study include an Arduino Uno microcontroller, a resistive water level sensor, an RGB LED, a piezo buzzer, current-limiting resistors, and a breadboard with jumper wires. The water level sensor is placed vertically inside the water container to detect varying water heights. The RGB LED is connected to PWM-enabled digital pins of the Arduino to allow color mixing, while the buzzer is connected to a digital output pin for alarm signaling.

Table 1. Hardware Components and Functions

Component	Function
Arduino Uno	Processes sensor data and controls outputs
Water level sensor	Detects water height
RGB LED	Visual indication of water level
Buzzer	Audible alert at critical level
Resistors	Limit current for LED protection
Breadboard & wires	Circuit prototyping

3.3. Software Development
The system software is developed using the Arduino IDE and programmed in C/C++. The program continuously reads analog values from the water level sensor and compares them with predefined

threshold values representing low, medium, and high water levels. Depending on the detected level, the Arduino sets the RGB LED color accordingly. When the water level exceeds the maximum threshold, the buzzer is activated to alert the user.

Threshold values are determined experimentally by observing sensor readings at different water heights. This approach ensures stable and reliable detection under normal operating conditions.

3.4. System Flowchart

The operational logic of the system is illustrated in Figure 2. The process begins with system initialization, followed by continuous sensor data acquisition. The Arduino evaluates the water level and determines the corresponding output actions.

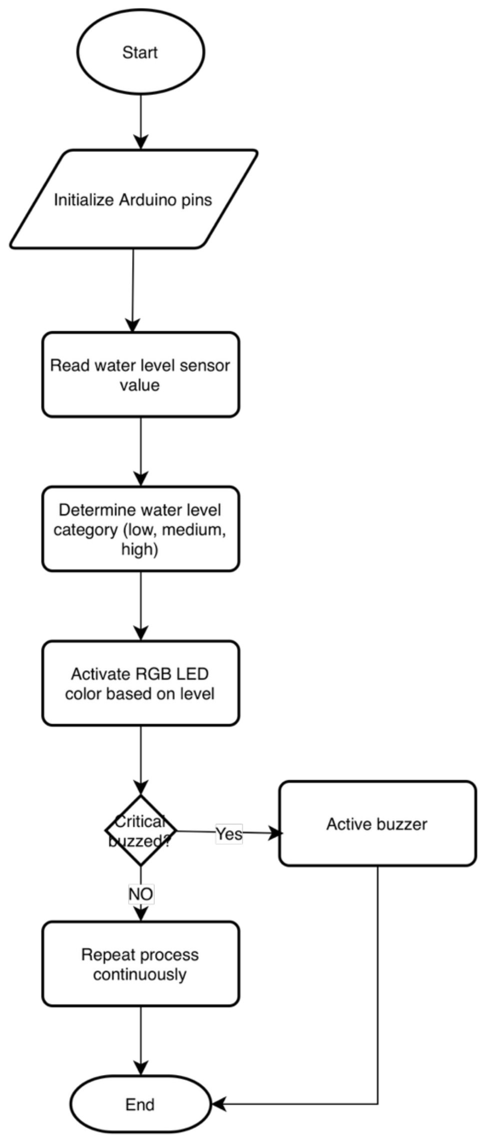

Figure 2. Flowchart of the Water Level Indicator System

3.5. Testing and Evaluation

The system is tested by gradually filling and emptying the water container while observing LED color changes and buzzer activation. Multiple trials are conducted to ensure consistency and reliability. The performance is evaluated based on response time, accuracy of level detection, and stability of visual and audible outputs.

This methodology ensures that the proposed water level indicator system is simple, effective, and suitable for practical water monitoring applications.

4. Finding and Discussion

Theexperimental results obtained from implementing and testing the Arduino-based water level indicator system using an RGB LED and a buzzer. The system was evaluated under controlled conditions by gradually increasing and decreasing the water level in a container to observe sensor response, visual indication, and alarm activation.

‘

```
if((sensorValue>=100)&&(sensorValue<=600)){
  digitalWrite(2,HIGH);
  delay(100);
}

else if((sensorValue>=601)&&(sensorValue<=625)){
  digitalWrite(3,HIGH);
  delay(100);
}

else if((sensorValue>=626)&&(sensorValue<=700)){
  digitalWrite(4,HIGH);
  digitalWrite(5,HIGH);
}

else{
  digitalWrite(2,LOW);
  digitalWrite(3,LOW);
  digitalWrite(4,LOW);
  digitalWrite(5,LOW);
  delay(100);
}
```

Figure 3. Decision Logic for Water Level Monitoring System

4.1. System Functionality

The system operated as intended throughout the testing phase. When the water level sensor detected low water levels, the RGB LED illuminated in red, indicating insufficient water. As the water level increased to a medium range, the LED color changed to blue, signaling a normal operating condition. When the water reached a high or near-full level, the LED turned green, providing a clear visual indication of sufficient water availability. Upon reaching the predefined critical threshold, the buzzer was activated, generating an audible alert to warn users of a potential overflow condition.

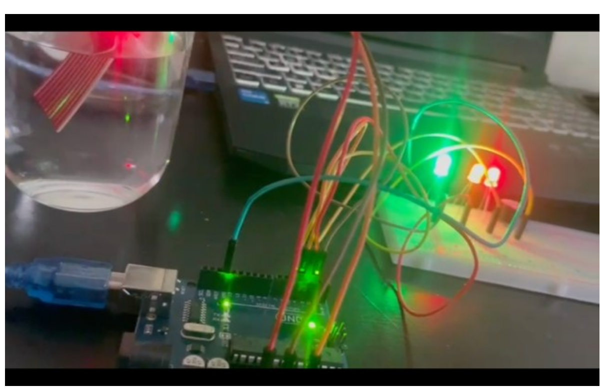

Figure 4. Water Level Response and Indicator Output

4.2. Sensor Response and Accuracy

The water level sensor exhibited a consistent and repeatable response to changes in water height. Analog readings increased proportionally with the water level, allowing the Arduino to reliably categorize the water level into low, medium, and high states. Minor fluctuations in sensor readings were observed due to water movement and surface disturbances; however, these variations did not significantly affect system performance, as threshold margins were defined to prevent false triggering.

Table 2. Water Level Detection Results

Water Level Condition	Sensor Reading Range	RGB LED Color	Buzzer Status
Low	0 - 300	Red	OFF
Medium	301 - 600	Blue	OFF
High	601 - 800	Green	OFF
Critical / Full	> 800	Green	ON

The results indicate that the system can accurately differentiate between water levels and respond accordingly.

4.3. Response Time and Stability

The response time of the system was observed to be nearly instantaneous, with LED color changes and buzzer activation occurring within milliseconds after sensor value changes. This fast response ensures timely alerts and effective monitoring. Long-duration testing showed stable operation without noticeable drift in sensor readings or malfunction of output components.

4.4. Practical Observations

From a practical standpoint, the use of an RGB LED simplified the hardware design by reducing the number of individual LEDs required. The buzzer provided an effective audible warning, particularly useful in environments where users may not continuously observe the visual indicator. The system's simplicity and low cost make it suitable for household water tanks, laboratories, and educational demonstrations.

5. Conclusion

This study successfully designed and implemented a low-cost water level indicator and alert system using an Arduino microcontroller, a water level sensor, an RGB LED, and a buzzer. The experimental results demonstrate that the system is capable of providing accurate, real-time monitoring of water levels with clear visual and audible feedback. The RGB LED effectively represents different water level conditions, while the buzzer serves as a reliable warning mechanism when critical levels are reached.

Compared to traditional mechanical water level indicators, the proposed system offers several advantages, including improved reliability, ease of maintenance, and flexibility for future enhancements. The modular design allows the system to be easily expanded with additional features such as LCD displays, wireless communication modules, or Internet of Things (IoT) integration for remote monitoring and data logging.

In conclusion, the Arduino-based water level indicator system presented in this work provides an effective and economical solution for water monitoring applications. Its simplicity, responsiveness, and scalability make it a practical choice for promoting efficient water management and preventing water wastage in various environments.

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