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Design and Construction of Transistor Based Water Level Indicator Tank with Overflow Alarm

Olawale J. OLALUYI[1], Johnson O. ADEOGO[2], Aduragbemi F. OJO[3*], Olarewaju T. OGINNI[4]

[1,2,3*]Department of Electrical and Electronic Engineering, Bamidele Olumilua University of Education, Science and Technology, Ikere Ekiti, Ekiti State, Nigeria
[4]Department of Mechanical Engineering, Bamidele Olumilua University of Education, Science and Technology, Ikere Ekiti, Ekiti State, Nigeria

[1]olaluyi.olawale@bouesti.edu.ng, [2]johnson.adeogo@bouesti.edu.ng, [3*]ojoadura129@gmail.com, [4]olarewaju.oginni@bouesti.edu.ng

Abstract

The use of a sensor controlling water overflow in a tank offers several significant benefits, primarily focusing on water conservation, cost savings, convenience, and safety. This paper discusses the design and implementation of a low-cost, transistor-based water tank overflow alarm (TBWTOA) and a multi-level indicator system (MLIS) that prevent losses by providing real-time monitoring and timely alerts. The system provides a reliable, automated solution to problems associated with manually monitoring water levels. The system employs four conductive probes positioned at low, medium, full, and overflow levels inside the tank. Probes were connected to the base of a BC547 NPN transistor through current-limiting resistors. When water bridges a probe to the common supply, it delivers sufficient base current to saturate the transistor, allowing collector current to flow and illuminate corresponding LEDs: red for low, yellow for medium, blue for full, and green for overflow. At the overflow threshold, the same circuit simultaneously activates a 5V buzzer, producing a loud, continuous audible warning. The circuit operates on a simple 9V DC supply and is assembled in a water-resistant enclosure. Experimental results demonstrated high accuracy and reliability, with LEDs lighting sequentially as the tank filled and the buzzer triggering instantly upon overflow, remaining active until the water level dropped. Response time remained consistently under 1.4 seconds across all levels and multiple tests. The system offers an affordable, very low-maintenance solution for water conservation. The sensor alarm system transforms a manual, error-prone task into a smart, efficient, and reliable process for managing water storage.

Keywords: *Water level indicator, overflow alarm, transistor switching, LED display, buzzer alert.*

1.0 Introduction

Water is an essential element for human existence, industry, and agriculture. Due to urbanization and population growth, water conservation is a significant concern in the contemporary world. One identified problem in water management across homes, industries, and commercial buildings is the inefficient operation of water tanks that leads to water overflow and waste. This problem arises from the lack of effective monitoring systems to inform users about tank water levels [1]-[2].

In addressing this challenge, technological innovations have been explored, including the development of an electronic water level monitor that measures tank levels and alerts users before overflow. The design and construction of a water tank overflow alarm and water level indicator thus become necessary for resource management and environmental sustainability. [3]-[4]. This type of system reduces water waste, minimizes human effort, and prevents damage from overflows, such as structural deterioration and the proliferation of disease-causing organisms due to water stagnation [5]-[6].

Water wastage owing to tank overflow is a widespread issue in many homes, commercial buildings, and industries. Most conventional water storage systems lack an automated mechanism to monitor water levels, making it difficult for users to determine when to stop or start the water supply. As a result, excessive water overflows resulted in increased water bills and unnecessary consumption of a vital resource. Many households and facilities in both urban and rural areas rely on overhead water storage tanks to meet their daily water needs. Large volumes of water are wasted daily due to unmonitored replenishing, repetitive operations, and tank overflows, which is particularly problematic in areas with limited water resources or where water must be purchased at a high cost [7]-[8].

The absence of a reliable, automated water monitoring system leads to inefficient use and escalates water supply costs. This paper focuses on designing and constructing a simple, cost-effective transistor-based water tank overflow alarm and water level indicator system. The objectives of the present study were to develop a reliable monitoring mechanism that directly detects water levels inside the tank using conductive probes and BC547 transistors. It provides a clear visual indication of the current water status through multi-colored LED lights (red for low, yellow for medium, blue for full, and green for overflow) and implements an audible alarm system using a piezo buzzer that promptly alerts users with a loud, continuous sound when the water reaches maximum capacity, thereby preventing overflow and promoting efficient water management.

1.1 Related Works

In recent times, several researchers and engineers have explored different methods for water level monitoring and overflow prevention. [9]-[10] presented a comparative study of sensing techniques for water level monitoring, including capacitive, ultrasonic, and transistor-based methods. The study concluded that while ultrasonic sensors offer higher precision, transistor-based systems remain unbeatable in terms of affordability and ease of implementation.

In another work, [11]-[12] utilized capacitive sensors to measure water levels in a tank and interfaced the sensor output with an Arduino system to produce an alarm when the tank was full. Although effective, the cost of capacitive sensors and the calibration requirements make them less suitable for low-income regions.

In microcontroller-based designs, [13]-[15] introduced systems utilizing analog-to-digital converters (ADCs) to handle water level signals. The results were displayed on an LCD. A significant drawback of such designs is their dependency on software, which presents the risk of bugs. It required firmware updates, or chip failure, while transistor-based systems are purely hardware-driven, requiring no programming, providing instant operation without boot time, greater inherent robustness, and simpler troubleshooting for users with basic electronics skills. [16]-[17] proposed an ultrasonic-based water level detection that measures the distance between the sensor and the water surface to determine the system's level of high accuracy but was prone to errors due to splashes and irregular tank geometries. However, ultrasonic sensors are relatively expensive and complex to maintain.

One of the most foundational approaches involves the use of conductive probes in combination with transistor switches, a method that has proven effective for low-cost water level detection. [18]-[19] presented a system that employs NPN transistors to detect varying water levels based on the conductivity of water. The design incorporated multiple transistor stages, each corresponding to a specific water level. When water comes into contact with the respective probe, it activates the base of the transistor, allowing current to flow and triggering an LED or buzzer output. The results demonstrated high reliability with minimal power consumption, making it ideal for residential use.

[20] developed a system implementation that utilizes an Arduino Uno to monitor and display the water level in a tank. It employs an ultrasonic sensor to accurately gauge the water level. The data collected by the sensor is transmitted to the Arduino, which in turn shows the water level on an attached LCD screen. The setup also includes a mechanism to prevent overflow, ensuring efficient management of the water tank's capacity. The Arduino turns ON or OFF the servo motor, thereby closing the source of water. The system servo and DC motor require a high-power supply. If the water level is not constant, then it might not show the exact water level in the tank. However, the work is more complex in design and also expensive using BC547 NPN.

[21] developed a transistor-driven water level alarm with a seven-segment display and multiple alert modes. Its configuration used BC547 transistors and logic gates to reduce power loss while maintaining consistent detection performance. The design was validated using both simulation and physical prototyping, showing a strong correlation between water levels and circuit activation. A notable shortcoming in transistor-driven water level alarms is their reliance on a seven-segment display and additional logic gates, which increases circuit complexity, component count, and overall cost compared to simpler LED-based indicator systems. A comparative analysis of water level detection, including float switches, capacitive sensors, and ultrasonic sensors, was carried out. The results indicated that float switches are the most reliable and cost-effective solution for domestic applications. This reinforces the study's decision to use float-based detection, especially in low-resource environments. Float switches were adjudged the most reliable and cost-effective option for domestic use. The comparative analysis overlooks the mechanical wear, sticking issues in dirty water, and limited precision of float switches compared to modern capacitive or ultrasonic alternatives, making them a rather outdated choice for anything beyond the most basic, low-resource setups.

2.0 Materials and Methods

The primary components of the water tank overflow alarm system include a 5V piezo buzzer, LED indicators, resistors, and a BC547 NPN transistor. The buzzer alarm is an audible alert device that produces a distinct beep or tone when activated, commonly employed in security systems, timers, and household appliances for warnings or notifications. It generates a loud audible warning when the water reaches the overflow level, effectively alerting users to prevent spillage. LED indicators utilize Light Emitting Diodes (LED) to provide visual status feedback through different colors, such as green for full, blue for almost full, yellow for medium, and red for low water levels. Resistors ranging from 1kΩ to 10kΩ regulate current flow, protect sensitive components from excessive current, control voltage levels, and perform voltage division within the circuit. The BC547 NPN transistor serves as a semiconductor switch with three terminals: Base (B), Collector (C), and Emitter (E) to amplify or control electronic signals. Power is supplied via a 9V AC adapter that converts mains electricity to the required voltage

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for stable circuit operation, while a power connector with positive and negative terminals securely links the adapter or battery to the system. These components form a cost-effective, efficient water tank overflow alarm system that provides both visual and audible indications to prevent water wastage and potential damage. The methodology encompasses circuit design, assembly, and functional variation stages.

2.1 Circuit Design

The design principle was based on creating a tiered level detection system where individual sensors respond at specific water heights. The levels were defined as low water level, medium water level, full water level, and high (overflow) level. The circuit diagram was designed to ensure accurate placement of BC547 transistors, current-limiting resistors, LEDs, and the buzzer. Conductive probes were securely mounted at low, medium, full, and overflow heights inside the prototype tank. A copper wire was connected to the positive supply and submerged as the reference point (Figures 1 and 2). As the water level rose and touched each probe, it completed the base circuit of the corresponding transistor. This instantly activated the respective LED indicators and triggered the buzzer at the overflow level.

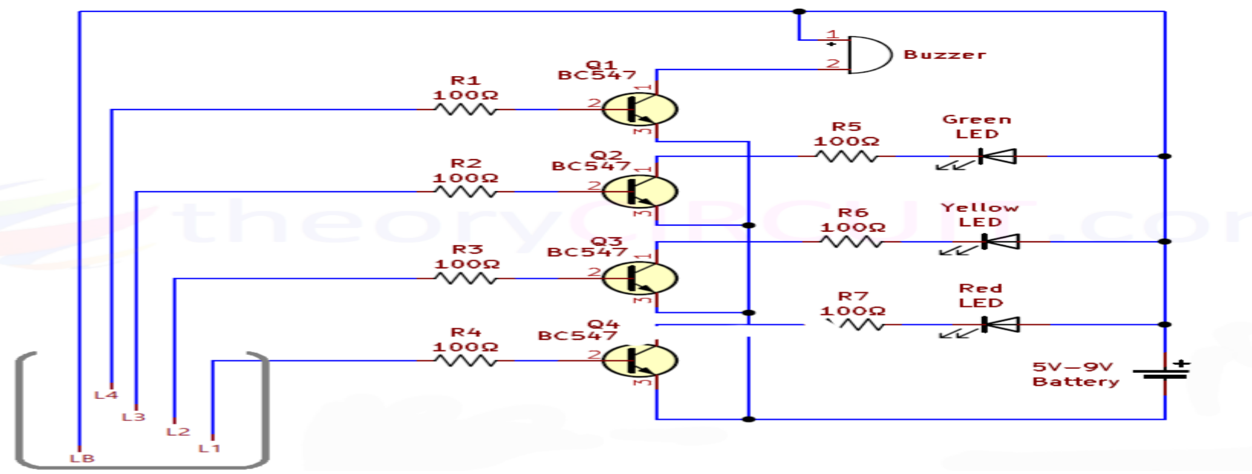

Figure. 1: Circuit design

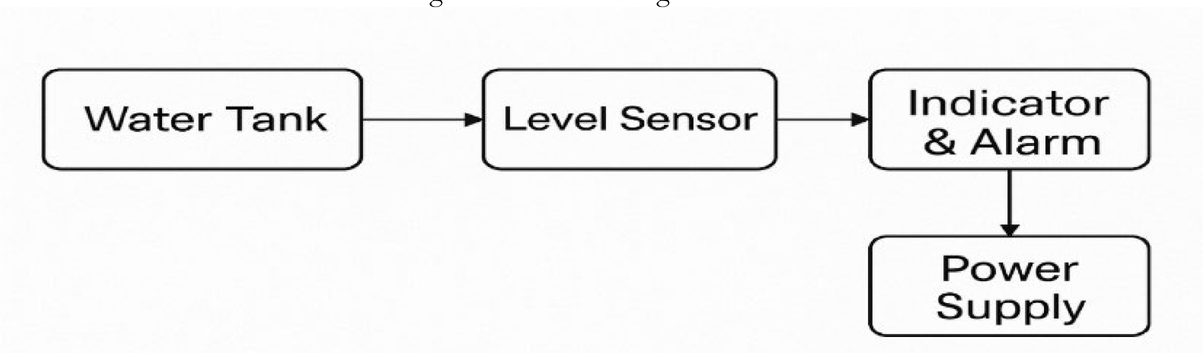

Figure 2: Design plan

2.2 Circuit Assembly and Activating LED Indicators

The circuit was constructed on a flat surface board to facilitate prototyping and testing. The assembly process involved critical steps to ensure proper functionality. Electrodes (or float switches) were connected to the designated bases of transistors to serve as input triggers. Collector-emitter pairs of the transistors were assigned to the output devices, which included LEDs or a buzzer, depending on the design requirements. To protect these output devices, resistors were incorporated in series to limit the current flowing through each one. Conducting wires used for water level detection typically generate a weak signal that cannot directly power an LED. To overcome this limitation, an NPN transistor, specifically the BC547, was utilized in a switching configuration. This setup effectively amplifies the signal, enabling consistent activation of the LED. Each copper wire was linked to the base of an NPN transistor, facilitating a small current to pass through when the switch completed the circuit. This small current triggered the transistor, enabling a larger current to flow from the collector to the emitter, which in turn powered the LED. The circuit utilized four LEDs—green, yellow, blue, and red—each connected to a conducting wire positioned at different water levels. As the water level rose and a float switch closed, the corresponding LED illuminated, providing a clear visual indication of the water level.

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2.3 Triggering the Overflow Alarm

A conducting wire positioned at the tank's maximum capacity level was configured to activate a buzzer alarm when triggered, signaling that the tank had reached its full capacity. Due to the buzzer requiring higher current and voltage than a conducting wire can directly provide, an NPN transistor, specifically a BC547, was utilized as a switch to manage the power demands of the alarm. When the float switch at the maximum level was triggered, it allowed a small current to flow into the transistor's base, enabling the transistor to permit a larger current to pass from the collector to the emitter, thus activating the buzzer.

2.4 System Testing

Phase testing involved filling the water tank while closely observing the system's responses to verify its functionality. As the water level increased, the activation of corresponding LEDs and the buzzer was monitored to ensure they triggered at the appropriate levels. All components were enclosed in a water-resistant casing, using a Plexiglas plastic casing, ensuring safe operation in humid environments. The probe assembly was immersed in a standard domestic water tank to test real-world performance.

3.0 Results and Discussion

The conducting wires exhibited high accuracy and reliability during testing, effectively responding to water levels in the prototype tank. As water levels reached specific thresholds—low, medium, almost full, and overflow—the wires tilted and closed their internal contacts, successfully completing the circuit for level detection. This process occurred without false readings or delays.

3.1 Results

3.1.1 Overflow Alarm

When the water in the tank reached its maximum capacity, the uppermost conducting wire instantly closed the circuit, successfully triggering the 5V piezo buzzer and illuminating the green overflow LED indicator. The buzzer produced a continuous high-pitched tone that remained active for as long as the water level stayed at or above the overflow threshold, effectively warning users of potential spillage. Once the water level was manually lowered below the critical point, the conducting wire reopened, immediately silencing the alarm and turning off the green LED, demonstrating reliable latching and release behavior. Table 1 showed the experimental result of the system performance.

Table 1: Experimental results of the systems

Water Level %	LED indicator status	Buzzer Status	System Response
0%	OFF	OFF	Idle
25%	Red LED ON	OFF	Indicate low fill
50%	Yellow LED ON	OFF	Indicate quarter fill
75%	Blue LED ON	OFF	Indicate mid fill
100%	Green LED ON	ON	Overflow alarm

The complete water tank overflow alarm system was rigorously tested by gradually filling the prototype tank with water while closely observing the real-time responses of all components. As the water level rose, various subsystems triggered at specific thresholds: the red LED indicated a low level, followed by the yellow LED for medium level, and the blue LED for full level. At maximum capacity, both the green overflow LED and the piezo buzzer activated. The BC547 transistors operated to switch the appropriate circuits, while the 1kΩ–10kΩ resistors were in place to limit current, ensuring the protection of the LEDs and buzzer. Figure 3 presents the response time of system components across test cycles. While Figure 4 revealed the average response time of system components

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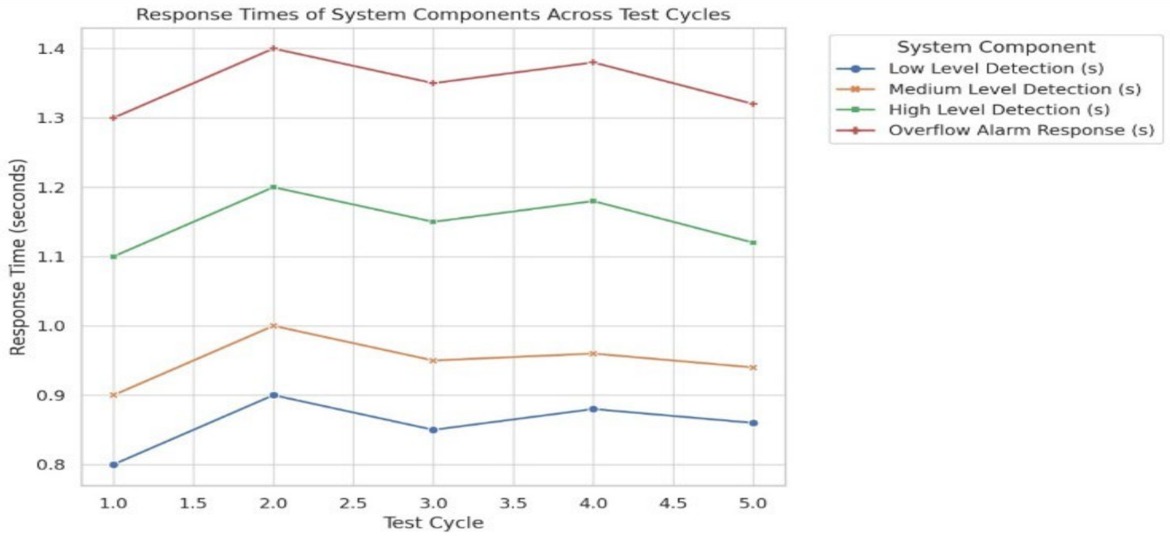

Figure 3: Response time of system components across test cycles

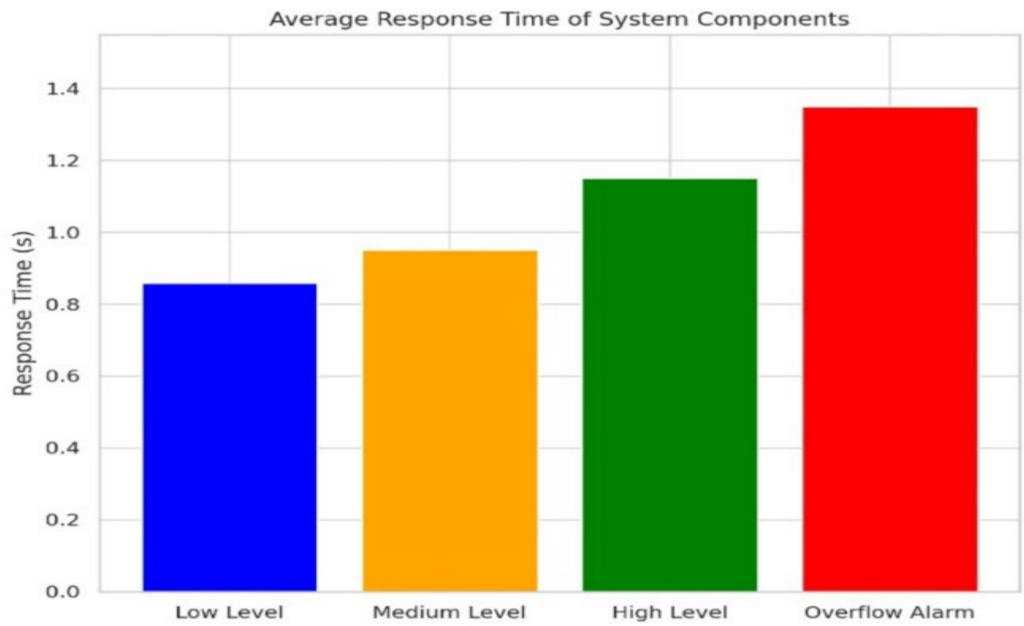

Figure 4: Average response time of system components

Figure 4 presents the average response time of each detection stage in the water tank overflow alarm system across all test cycles. Low-level detection achieved the fastest average response at approximately 0.85 seconds (blue bar), followed by medium-level detection at around 1.0 second (yellow bar) and high-level detection at about 1.15 seconds (green bar). The overflow alarm, which simultaneously triggers both the buzzer and the final green LED via the transistor circuit, recorded the longest yet highly acceptable average response time of roughly 1.35 seconds (red bar). Table 2 presented the system responses to water level variation.

Figures 5 and 6 present the pictorial view of the tanks without water and when filled with water, respectively.

Table 2: System performance response time (s)

Test Cycle	Low Level Detection (S)	Medium level detection (s)	High Level detection (s)	Overflow Alarm response (s)
1	0.80	0.90	1.10	1.30
2	0.90	1.00	1.20	1.40
3	0.85	0.95	1.15	1.35
4	0.88	0.96	1.18	1.38
5	0.86	0.94	1.12	1.32

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Figure 5: Tank without water


Figure 6: Tank filled with water

3.2 Discussion

The experimental results demonstrate that the water tank overflow alarm (WTOA) and water level indicator system (WLIS) are reliable (Figures 5 and 6). Throughout multiple tests, the system demonstrated precise detection of water at four specific levels: low, medium, high, and overflow. It utilized float switches to activate corresponding-colored LEDs via red, yellow, blue, and green (Figure 6) for effective real-time visual monitoring. Upon reaching maximum capacity, the overflow alarm activated immediately and consistently, producing a loud, continuous buzzer sound alongside the green LED until the water level dropped below the threshold, effectively preventing spillage. The system functions as designed under typical circumstances, according to repeated testing. There was no discernible drop in performance, suggesting long-term dependability.

4.0 Conclusion

A water tank overflow alarm and water level indicator system that detects water levels, activates visual indicators, sets off an overflow alarm, maintains electrical safety, and evaluates overall system performance was successfully developed and evaluated in this study. The results provide a practical and cost-effective solution for monitoring water levels and preventing overflow. Users could easily track water levels thanks to the precise real-time monitoring made possible by the installation of float switches, LED indicators, and a buzzer alarm. Integrating a small solar panel with a charge controller and rechargeable battery backup would ensure uninterrupted operation during power outages, making the system highly suitable for rural and off-grid locations where electricity supply is unreliable.

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