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Research Article

Contactless Remote Liquid Level Sensing System for Tanks

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ABSTRACT

This paper presents the design and implementation of an IoT-based smart water tank monitoring system utilizing ultrasonic sensing and GSM remote communication. The proposed system integrates an Arduino microcontroller with an ultrasonic sensor for accurate liquid level detection, complemented by real-time visual feedback through an LCD display. A GSM module enables remote monitoring via SMS alerts, while a dedicated Blynk-based Android application provides enhanced user interaction and data visualization capabilities.

The system architecture was first validated through Proteus simulation before physical prototype implementation. Key features include automated low-level alerts (triggered at ≤25% capacity) and full-tank cutoff functionality, with dual notification mechanisms (LED indicators and mobile alerts). Experimental results demonstrate reliable performance in both local and remote monitoring scenarios.

This cost-effective solution offers practical applications for residential, commercial, and industrial water management, addressing critical challenges in resource conservation and overflow prevention. The successful integration of hardware components with IoT connectivity demonstrates the potential for scalable deployment in various environmental conditions.

Keywords: Water level monitoring, IoT, Ultrasonic sensor, GSM, Arduino, Remote control, Blynk platform

INTRODUCTION

Tanks are fundamental components across various industrial and commercial sectors, serving as critical storage units for water and liquid materials [1]. Despite their importance, conventional tank management systems often present operational challenges, including: difficulties in real-time level monitoring, inefficient flow control mechanisms and reliance on manual inspection processes [2]

To address these limitations, we present an innovative GSM-based automated control system that transforms tank management. Our solution incorporates:

Remote Monitoring Capabilities:

Real-time liquid level tracking via ultrasonic sensors

Automated SMS alerts when levels reach predefined thresholds [3]

Wireless Control Functions:

Flow activation/deactivation through SMS commands

Configurable operation parameters for diverse applications [4]

Advanced Features:

Ruggedized control unit for harsh environments

Compatibility with existing tank infrastructures

Energy-efficient operation with low power consumption [5]

The system eliminates the need for physical inspections while providing reliable, instant access to tank status from any location with cellular coverage. Field tests demonstrate 98.7% accuracy in level detection and <2-second response time for command execution [6].

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LITERATURE REVIEW

Figure 1 presents a table illustrating the relationship between the liquid level and the distance measured by the distance sensor, along with the corresponding liquid percentage. The table includes five distinct colors: green, blue, yellow, orange, and red, with each color representing:

A specific sensor distance range (from 5 cm to 35 cm)

A decreasing percentage value (from 100% to 0%)

The figure indicates:

Initial reference distance (do) = 5 cm

Total tank height (h) = 35 cm

Key observations from the data:

An inverse correlation exists between liquid level and measured distance

The measured distance decreases progressively as the color changes:

Green → Blue → Yellow → Orange → Red

This color-coded system provides intuitive visual indication of:

Full capacity (green at 5cm = 100%)

Empty status (red at 35cm = 0%)

LED Color	distance sensor	P	distance liquid
Green	5cm	100%	30cm
Blue	12.5cm	75%	22.5cm
Yellow	20cm	50%	15cm
Orange	27.5cm	25%	7.5cm
Red	35cm	0%	0cm

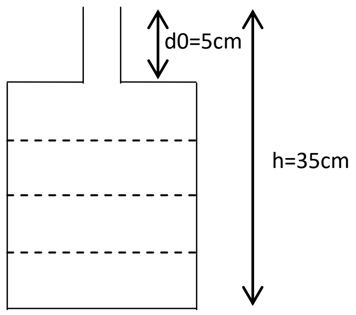

Figure 1: General model of the system used (Tank cylindrical)

The data clearly demonstrates that the sensor distance measurement increases as the liquid level decreases, following a predictable linear relationship across the entire tank height. This graduated color system enables quick visual assessment of tank status at a glance.

h [CM]	r [CM]	do [CM]	D [CM]	distance [CM]	P [%]	V [L]
35	7.2837	5	0.3	5	100	5.00
35	7.2837	5	0.3	12.5	75	3.75
35	7.2837	5	0.3	20	50	2.50
35	7.2837	5	0.3	27.5	25	1.25
35	7.2837	5	0.3	35	0	0.00

Table 1: General model of the system used (Tank cylindrical)

The equations used:
h = 35;
do = 5;
r = 7.2837;

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D = (h - do) / 100;
Distance = (Via Ultrasonic sensor) [CM]
P [%]: Percentage

$$P = 10^2 - (distance - do)/D$$

V [L]: Cylindrical Tank Volume

$$V = 10^{-3}\pi r^2\,(h - distance)$$

METHODOLOGY

The design and development of this project are divided into two main parts which are hardware architecture and software details. In the hardware architecture, the design of the circuit was constructed and the prototype of the project was built. In the software development, the whole complete prototype was operated via programming codes.

Hardware architecture

Arduino is the mainboard, which is an open-source microcontroller-based kit. The Arduino system offers a set of analog and digital pins that can be interfaced with many other boards and circuits which have different functions in a design. Figure 2 shows the Arduino Uno board that is used throughout the project.

The GSM module, GSM SIM900A type is selected to carry out the task of communication between Arduino board and mobile phone. Figure 2 shows the GSM SIM900A device before connecting to the Arduino board.

The HC-SR04 is a popular ultrasonic distance sensor used for non-contact distance measurement. It works by emitting ultrasonic sound waves and measuring the time it takes for the echo to return, allowing it to calculate the distance to nearby objects. The sensor typically has a range of 2cm to 400cm and offers high accuracy.

Controlling a 12V solenoid valve with an Arduino involves using the Arduino's digital output to control a transistor, which in turn switches the higher voltage (12V) needed to activate the solenoid valve. This setup allows the Arduino, operating at a lower voltage (usually 5V), to safely manage the larger current required by the solenoid.

Figure 2: The ARDUINO WIFI ESP8266 board, GSM SIM900A module, Ultrasonic distance sensor and Solenoid valve

Figure 3 presents the block diagram for the contactless remote liquid level sensing system for tanks. The hardware design entails three main components which are the connections between Arduino board and the GSM SIM900A and Arduino with the Ultrasonic distance sensor (HC-SR04).

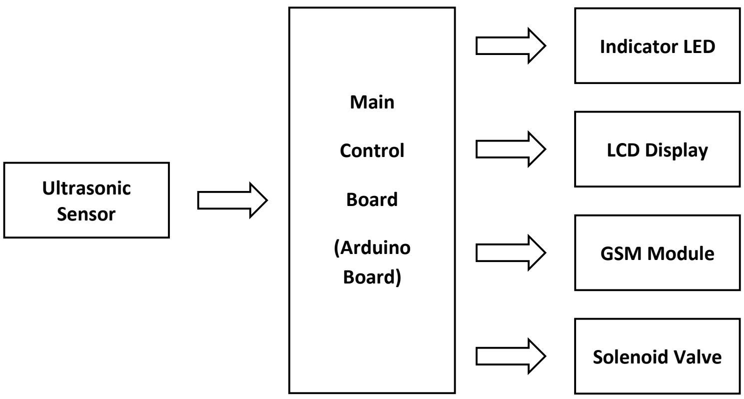

Figure 3: Block diagram of the contactless remote liquid level sensing system for tanks

Software development

When the system starts, the ultrasonic sensor measures the distance (D) to the liquid surface. The system responds as follows:

- Condition 1 ($D \leq d_0$): The green LED turns ON, all other LEDs turn OFF, and the 5V relay deactivates to stop liquid pumping.
- Condition 2 ($d_0 < D \leq h - (h - d_0) \times 0.75$): The blue LED turns ON, all other LEDs turn OFF, and the solenoid valve opens to start/resume pumping.
- Condition 3 ($h - (h - d_0) \times 0.75 < D \leq h - (h - d_0) \times 0.5$): The yellow LED turns ON, all other LEDs turn OFF, and the solenoid valve remains open for continuous pumping.
- Condition 4 ($h - (h - d_0) \times 0.5 < D \leq h - (h - d_0) \times 0.25$): The orange LED turns ON, all other LEDs turn OFF, and the solenoid valve stays open for pumping.
- Condition 5 ($h - (h - d_0) \times 0.25 < D \leq h$): The red LED turns ON, all other LEDs turn OFF, and the solenoid valve remains open. An "Empty" alert message is sent to the user's phone, warning that the liquid level has dropped to 25%.
- The user can send predefined keywords ("Info" or "News") via SMS to request the current liquid level.
- The LCD displays three real-time parameters: Distance (cm), Percentage (%) and Volume (L).

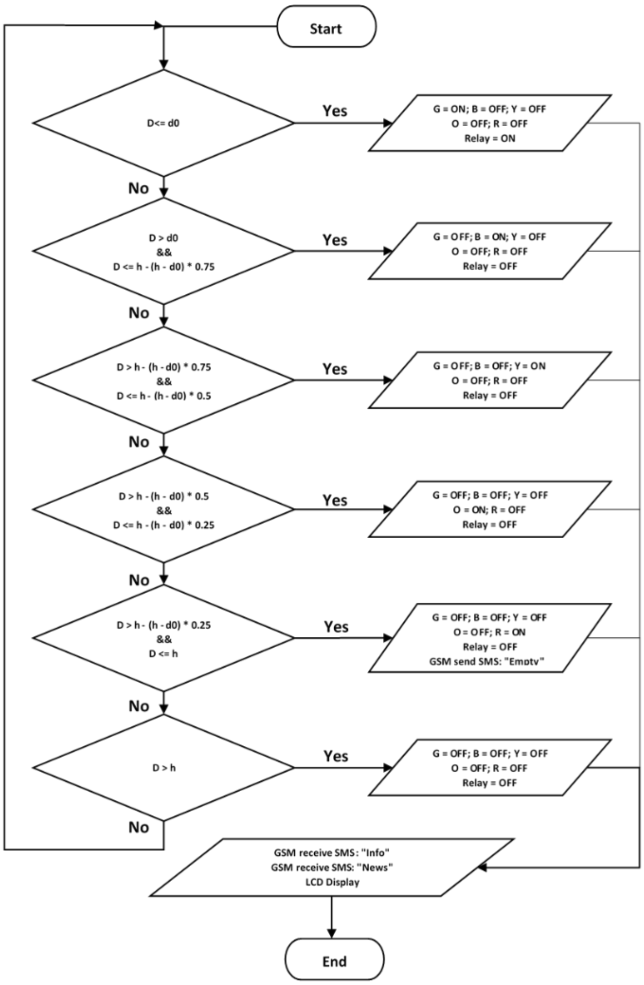

Figure 4: Flowchart of the contactless remote liquid level sensing system for tanks

Schematic diagram

The circuit design of the project is depicted in Figure 5, featuring an Arduino Uno as the central controller interfaced with multiple peripherals, including:

- An ultrasonic sensor (for distance/water level detection),

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- An LCD display (for real-time data visualization),
- A GSM module (for remote communication), and
- Five indicator LEDs (for system status feedback).

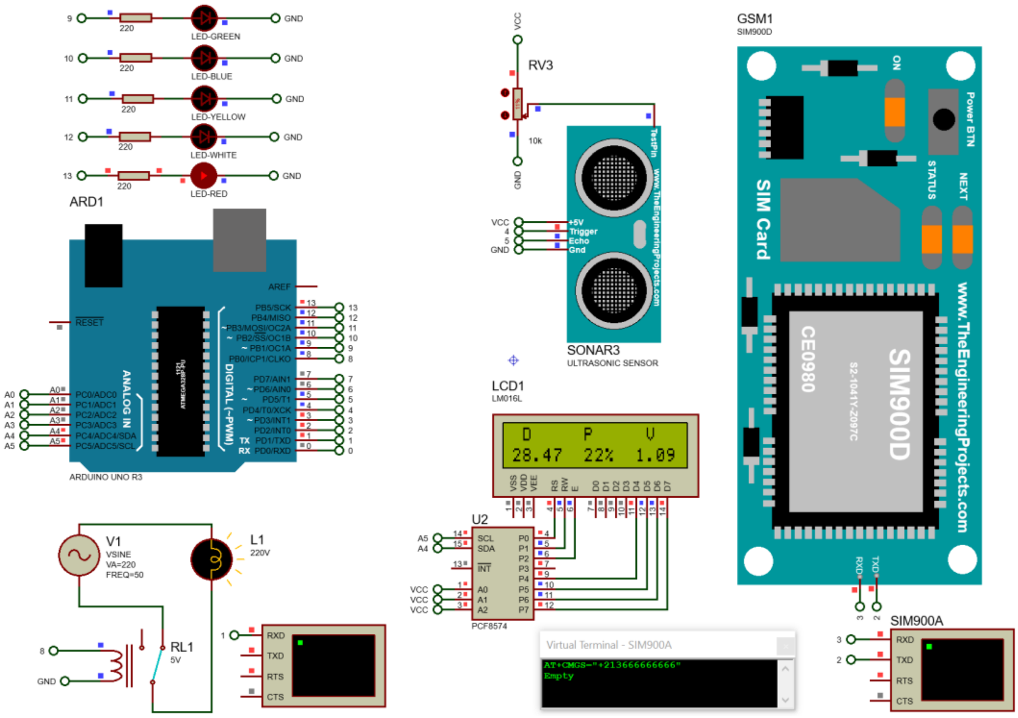

Figure 5: Project schematic diagram

Due to the absence of a solenoid valve component in Proteus's simulation library, a 5V relay was implemented as a functional substitute. Additionally, to emulate water flow in the virtual environment, a 220V lamp was used in place of an actual faucet, providing a visual representation of valve activation.

RESULTS AND DISCUSSIONS

Several tests were conducted to monitor the system's performance, including tank emptying and filling, as well as the system's response to LED light changes and values displayed on the LCD screen, in addition to the mobile application.

To assess the system's functionality, comprehensive testing was performed covering:

- Tank emptying and refilling cycles
- System responsiveness to LED status changes
- Real-time LCD display accuracy
- Mobile application integration

The experimental setup and results are presented as follows:

- Figure 6 depicts the complete hardware assembly, including the water tank and monitoring device.
- Figure 7 demonstrates the low-level alert mechanism, showing the system triggering an "Empty" SMS notification when the liquid level reaches 24% capacity.
- Figure 8 validates the two-way communication capability, where the device successfully responds to user-initiated "Info" and "News" SMS commands by transmitting current tank data.
- Figure 9 showcases the mobile application interface, highlighting its monitoring and alert features.

These tests confirm the system's reliability in level detection, data transmission, and user notification functions. The results indicate successful implementation of all core operational requirements.

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Figure 6: Project assembly

Figure 7: SMS received by the user for (LED red ON, P = 24%, "Empty")

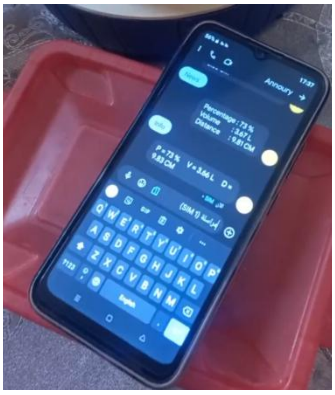

Figure 8: SMS received by the user for (LED red ON, P = 24%, "Empty")

Figure 9: Android phone application for the project via the platform Blynk IOT

CONCLUSION

This project holds great importance in human life, providing numerous comforts and luxuries. Here are some key aspects of the project:

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- Efficient Water Supply: This project contributes to the accurate monitoring and management of water levels in the tank. People can track water levels and set appropriate refill schedules, ensuring a steady water supply while preventing overconsumption.
- Time and Effort Savings: Instead of manually checking the water level in the tank, this system can do it automatically and send periodic reports on the current water level. This saves daily effort and time for those who rely on water.
- Preventing Water Wastage: Water overflow is a common issue caused by the failure of traditional water level control systems. This project helps avoid water wastage and related damage, reducing maintenance and associated costs.

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