Fabrication and Installation of Automatic Water Level Recorder through Global System for Mobile (GSM)

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Citation | Z. A Chachar, M. A. Talpur, I. A. Shaikh, Z. A. Khan, S. A. Soomro, A. R. Noonari, A. Tunio, V. K. Rajani, G. H. Awan, I. K. Phullan and K. F. Zaman, "Fabrication and Installation of Automatic Water Level Recorder through Global System for Mobile (GSM)", IJIST, Vol. 7, Issue. 2, pp. 733-740, 2025

DOI | https://doi.org/10.33411/ijist/202572733740

Received | March 13, 2025 **Revised |** April 15, 2025 **Accepted |** April 18, 2025 **Published |** April 20, 2025.

The water stress is influenced by numerous factors including inefficient water distribution management. Monitoring water level fluctuations is critical, as these variations significantly impact the ecological and physical properties of lake and river shorelines. To address this, an automated water-level monitoring system is essential for ensuring equitable water distribution to agricultural fields and enabling researchers to access real-time data remotely. A proposed system integrates an Arduino Nano (open-source microcontroller), water-level sensors (float/magnetic and ultrasonic) and a GSM module for wireless data transmission. The device demonstrated high reliability and accuracy, achieving an R^2 value of 1.0 for the float sensor and 0.9996 for the ultrasonic sensor. Performance remained robust even in low-network areas, though SMS alerts experienced an average delay of 5.7 minutes—a negligible margin for most applications but potentially limiting in time-sensitive scenarios. The study confirmed the system's effectiveness for real-time water-level monitoring, offering a practical solution for sustainable water management.

Keywords: Water level; GSM; Arduino Nano; Microcontroller; Float sensor; Ultrasonic sensor.

Introduction:

Water is an essential resource for agricultural productivity and plays a pivotal role in sustaining human life [1]. Pakistan is among the countries currently experiencing severe water stress. Monitoring water levels in various reservoirs—such as dams and groundwater wells—is critical for efficient agricultural planning and management [2]. Accurate monitoring of channel flow is equally important in water resource studies, where appropriate measurement techniques must be employed to ensure proper assessment and management [3].

Several flow-related parameters, including water depth, flow velocity, and turbulence, must be evaluated to select the most suitable monitoring technique for a specific application [4]. Automatic Water Level Recorders (AWLRs) are increasingly vital in ensuring timely and accurate distribution of water to agricultural fields. These systems also enable researchers to access real-time data remotely via mobile devices [5].

The system developed in this study includes voice recorder circuits installed at dam sites and centrally located within the village. It incorporates an Arduino microcontroller, water level sensors, and a GSM module. When the water level surpasses a predefined safety threshold, the system automatically sends an SMS alert to the operator. Simultaneously, a warning is issued to the engine control unit, activating the engine and allowing excess water to be released from the dam [6].

During the rainy season, many dams in Pakistan become inaccessible to irrigation authorities. Sudden and intense rainfall, especially overnight, can cause rapid and dangerous fluctuations in water levels. Therefore, obtaining real-time water level data is crucial for ensuring the safety of dams and surrounding communities that may be vulnerable to flooding [7].

A water level indicator is a device designed to inform users of the current water level in a reservoir [8]. Such systems help reduce water wastage during filling operations. With global freshwater resources under increasing pressure due to inefficient usage, poor allocation, and lack of integrated water management, the need for real-time monitoring systems has become more pressing [9]. Agricultural, industrial, and domestic sectors all require significant water resources. Thus, the development of efficient monitoring and management techniques is essential. Recent innovations aim to maximize water use efficiency while minimizing waste [10].

Novelty Statement

While GSM-based real-time monitoring systems have been explored in various domains, limited research exists on the fabrication, installation, and application of Automatic Water Level Recorders (AWLRs) for real-time water level monitoring in the context of the present study area. This research aims to address that gap by developing a tailored solution for local water resource management.

Objectives

The objectives of this study are:

- To design and fabricate an Automatic Water Level Recorder (AWLR).
- To determine and monitor the real-time water level of a selected water body using sensor-based technology.

Materials and Methods

The research was conducted at the Laboratory of the Department of Irrigation and Drainage, Faculty of Agricultural Engineering and Technology, Sindh Agriculture University, Tandojam, Pakistan. The study site is geographically located at latitude 25.4264° N and longitude 68.5434° E [11]. Two types of sensors were employed for water level monitoring: a float sensor and an ultrasonic sensor. The float sensor system consisted of multiple integrated sensors, each of which recorded data when contacted by water at different levels. The ultrasonic sensor system measured water level (in centimeters) at regular time intervals, providing continuous real-time monitoring. A flowchart illustrating the methodology is presented in Figure 2.

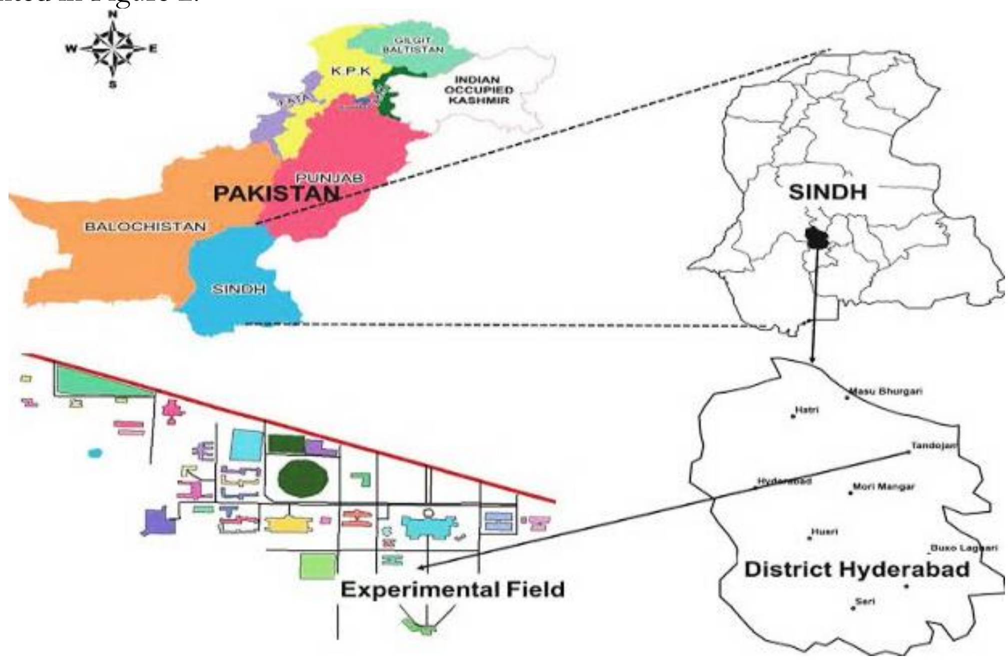

Figure 1: Geographical location of study area

EasyEDA was used to design and test the circuits in this study. It is a PC-based tool for designing and simulating schematics, as well as creating Printed Circuit Boards (PCBs). Other features included the creation of a Bill of Materials and documentary outputs in PDF, PNG and SVG formats [12]. The Arduino Integrated Development Environment (IDE) is a cross-platform program built in C and C++ functions. It is used to create and upload programs to Arduino-compatible boards, as well as other vendor development boards with the assistance of third-party cores [13]. In this study, Arduino IDE was used to write, test and upload code to the microcontroller board. A single integrated circuit is a microcontroller (Arduino Nano). In modern terminology, it is considered less advanced than a System on Chip (SoC), but also less complex. The Arduino board is intended to get started with microcontrollers extremely simple for novices. Nano board has a total of 14 digital pins and 8 analog pins. As input pins, the digital pins may be used to connect sensors and as output pins, they can be utilized to drive loads. To manage their functioning, basic functions were utilized i.e. pin Mode () and digital Write () for digital pins, the working voltage were 0V and 5V. Using any of the 8 analog pins and a simple function like analog Read (), the analog pins measured analog voltage from 0V to 5V [14].

The GSM module and magnetic float switch/sensor were used. The GSM Module (SIM900) connected with Arduino Nano was used to send and receive messages to the receiver (operator). The circuit design had a magnetic/hall effect switch controlled by Arduino Nano (microcontroller) mounted on the Lemnimeter. As the water level increases, the magnetic switch activates (Figure 3), completing the circuit and sending an SMS (Short Messaging Service) to the operator.

An ultrasonic sensor consisting of a transmitter and receiver, measure distance by emitting an ultrasonic pulse for 200 milliseconds and detecting the reflected wave. As illustrated in Figure 4 an ultrasonic wave spreads through the air at approximately 340 m/s (sound wave velocity), touches the item and is reflected to the sensor [15]. The time taken for a wave to travel from transmission to reflection and then reception by the receiver is key for determining an object's distance [16].

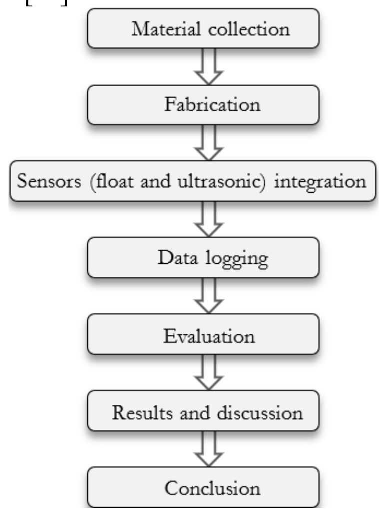

Figure 2: Flowchart of Methodology

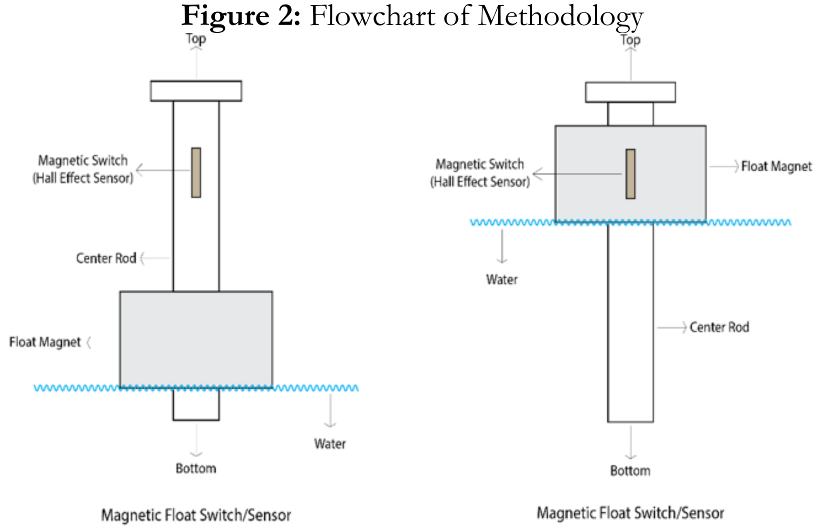

Figure 3: Magnetic float switch

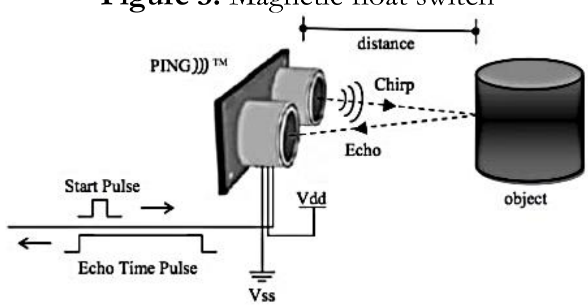

Figure 4: Ultrasonic sensor theory

Results:

Designed and Fabricated Device:

After wiring, writing and uploading the code, the program ran successfully. To evaluate the performance and real-time water level indication, the tests were conducted to assess SMS transmission delay, the accuracy of both sensors and the performance under varying cellular network conditions (good and poor signal strength). The device demonstrated with reliable and effective performance.

Time Delay: The good and bad network coverage reading (receiving time) was noted. Table 1 and 2 shows a difference in reading receiving time. In areas with good signal coverage, readings were received within seconds, whereas in areas with poor coverage, readings were delayed by several minutes.

Table 1: Performance of device in an area with good coverage of signals

Readings sent	Sent or Not	Reading received time (seconds)
1	Sent	5.86
2	Sent	5.88
3	Sent	5.86
4	Sent	5.82
5	Sent	5.76
6	Sent	5.86
7	Sent	5.78
8	Sent	5.82
9	Sent	5.76
10	Sent	5.82
Total Average Time		5.82 seconds

Table 2: Performance of device in an area with bad coverage of signals

Readings sent	Sent or Not	Reading received time (minutes)
1	Sent	5.53
2	Sent	5.62
3	Sent	6.76
4	Sent	3.76
5	Sent	6.66
6	Sent	5.66
7	Sent	5.64
8	Sent	6.67
9	Sent	5.43
10	Sent	5.38
Total Average Time		5.71 minutes

Actual/Real-Time Water Level Sensor Readings:

Figure 5 shows that the float sensor readings are similar to actual readings. The real-time float sensor provided equal readings of water level, which were accurate. The device's readings showed a strong correlation with actual measurements, achieving an R^2 value of 1. This was due to the sensor's placement on the limiter, as the float sensor functions as a switch that activates when its float reaches the top.

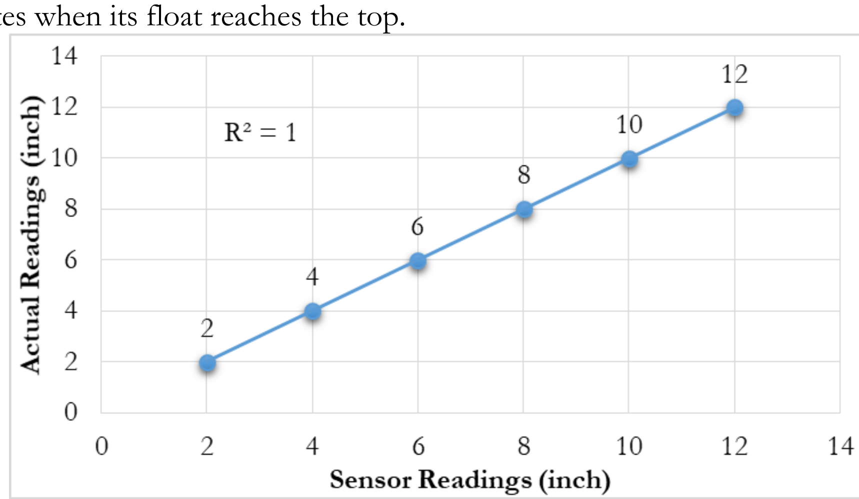

Figure 5: Float sensor readings

For the ultrasonic sensor, the readings were highly accurate and reliable, except for slight variations at the start and end measurements (Figure 6). In the beginning, the actual readings of 1, 2 and 3 cm differed from the ultrasonic sensor, which was recorded to be 3 cm. Similarly, in the end, instead of the actual 400 cm, the sensor displayed 381 cm. As represented in Figure 5, the actual readings and the device built have a strong relationship with the R^2 value of 0.9996.

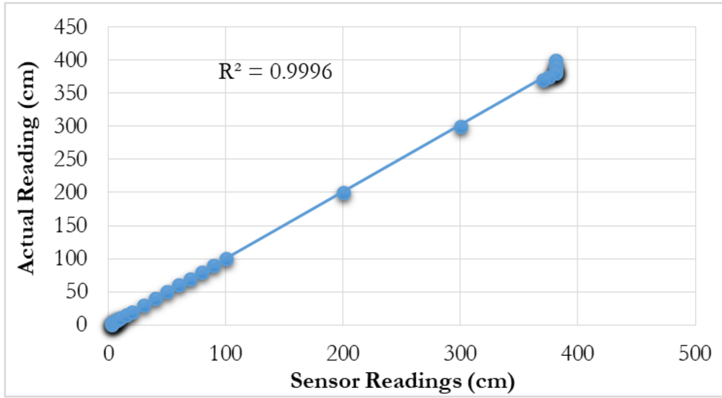

Figure 6: Ultrasonic sensor readings

Discussion:

The findings demonstrated that integrating GSM (Global System for Mobile) with an MCU (Microcontroller) provided an effective method for transmitting real-time water level data of a water body. The study also demonstrated that both sensors approaches were successful in their respective functions. The float switch sensor used with Arduino Nano (Microcontroller) equipped with the GSM module was successful in sending water level data in real-time on the selected points of the water body [17]. As the float sensor can only detect on exact point (of water body) it may lead to some error if the float sensor is not installed on the desired location, that is why it is necessary to install separate float sensors on every step of the water level [18]. Johari et al. [19] developed a water level monitoring system with an integration of a GSM module to alert the person in charge through SMS. They monitored the water level, sending the data through SMS to the intended technician mobile's phone upon reaching the critical level. Orike et al. [20] conducted a study on GSM and deployed to implement a wireless mobile robotic system that can be controlled from anywhere. They reported that both the microcontroller and the motor driver circuit worked perfectly well and the motor was able to move the robotic system in different directions accordingly. Similarly, Dogbe et al. [21] prepaid GSM-based monitoring system, that had been designed to help prepaid energy users remotely monitor their energy usage.

The second sensor used was the Ultrasonic sensor, which was connected to the Arduino Nano (Microcontroller) equipped with the GSM (Global System for Mobile). It successfully provided centimeter-level data ranging from 1 cm to 381 cm. It was observed that the ultrasonic sensor had a 2 cm error, as it recorded 3 cm instead of the actual 1 cm. This discrepancy was only present in the first and last 2 cm of the readings. Ultrasonic sensors can provide readings on all steps of the water level despite using a single sensor [22]. It was observed that the float sensor was successful in the discontinuous readings (as they were mounted on various points) and the ultrasonic sensor was successful in taking continuous data, as it can provide the data without eliminating any steps. Chamorro-Atalaya et al. [23] designed a level transducer circuit implemented using an ultrasonic sensor, controlled by Arduino Nano and applied to a water tank of a fire-fighting system. They reported that the proposed integration between the ultrasonic sensor, the Arduino Nano controller and the Siemens 1212C programmable logic controller was viable. Gabriel and Kuria [24] aimed at designing a sensor that can easily measure the distance and movement and display results in LCD. The circuit was developed using Arduino IDE and a microcontroller. Their study revealed that the designed sensor could be used to accurately determine the position of an approaching object and display the distance readings.

It is also worth mentioning that the built device was capable of sensing the readings (data of water level) even in bad network areas, whereas the SMS (short messaging service) in bad networks was delayed for minutes when compared to seconds in good network areas [25]. It was also noted that on average the SMS can take up to 5.71 minutes in bad networks, which made it almost impossible to determine which data was of which time, as the time on the SMS was of when the SMS (data) was received to the operator. This problem can be overcome by just adding a few more lines of code into the program, mentioning the time the data was sent from the device. Further studies may be carried out to evaluate the financial implications of using this device, using a microprocessor instead of a microcontroller and addressing the power and maintenance issues.

Conclusion:

It is concluded that a reliable circuit can be prepared and simulated using EDA open-source software, a circuit can be fabricated locally using relevant sensors, modules and accessories available at local electronic markets for prototyping and after testing and a printed circuit board can be designed using Easy EDA software and printed using third party services. It was observed that the float sensor was 100% accurate and could be mounted (limiter) on the desired level. The results further revealed that the ultrasonic sensor had an error of 3 cm on the minimum side. The data in good networks was received immediately, whereas, for bad network areas, SMS was received but can be delayed at an average of 5.71 minutes. Based on results, it is inferred that the developed device can reliably sense real-time water levels using either one or both sensors (float and ultrasonic).

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