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

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There are so many factors that contribute to water stress, including poor management of water distribution. These fluctuations are important to be known, as the properties of lake and river shores are significantly affected by the changes in water levels. An automatic water level recorder in this condition is essential for proper distribution of water to the fields, and for researchers to get the data via mobile. A system comprising of an Arduino Nano (open source), water-level sensor (float/magnetic sensor and ultrasonic sensor), and GSM module was proposed in this study to monitor the water level of a water body. The device performed very well in both good network areas, and bad network areas with an R^2 value of 1.0 for the float sensor, and 0.9996 for the ultrasonic sensor. All the sensors were reliable and accurate, whereas in case of bad network areas the SMS received was delayed at an average of 5.7 minutes. This delay can only cause some issues when the data is needed on an immediate basis. The study concluded that the device built is reliable and can be used for the real-time monitoring of water levels.

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

Introduction:

Water is a crucial factor for agricultural production, and plays a vital role in the growth and development of human life [1]. Pakistan is one of the 36 countries classified as experiencing water stress. Monitoring the water level in sources such as dams, reservoirs, groundwater wells, etc., plays a major role in agricultural management and development [2]. Monitoring channel flow is crucial for water resource studies, where various measurement techniques are adopted to ensure accurate assessment and management [3]. A series of flow-related factors, including depth, flow velocity, and turbulence, must be assessed beforehand, as they help determine the most suitable measurement technique for a given problem [4]. An automatic water level recorder is essential for the proper distribution of water to the fields and for researchers to obtain the data via mobile device [5]. The voice recorder circuits are physically placed on the dam, and centralize the village's position using an Arduino, a water level sensor, and a GSM module. When the water level rises over the specified safety threshold, the system sends an SMS to the operator. A warning SMS is sent to the engine control system, triggering the engine to start and causing water to spill out of the dam [6].

During the rainy season, most dams in Pakistan become inaccessible to the irrigation service. Heavy overnight rainfall can even sometimes cause drastic changes in water levels. Therefore, it is very important to get an updated water level for the safety of the dam and the neighboring villages that could be flooded [7]. A water level indicator is a device that informs users about the water level in a reservoir [8]. This system helps minimize water wastage during the filling process. Water supplies are declining in many regions worldwide, making this an increasingly urgent issue. This is caused by inefficient water usage, poor water allocation, and a lack of comprehensive water management [9]. Aquaculture, industry, and households all need large amounts of water. As a result, effective water usage, water monitoring, and management becomes critical. Several new methods have been adopted to guarantee efficient use while resulting in as little waste as possible [10].

Novelty Statement:

The use of Global System for Mobile (GSM) has been adopted by researchers to observe real-time monitoring for different uses, whereas, for automatic water level recorders, little has been reported for fabrication, installation, and determination of real-time data for the study area conducted, this research was therefore conducted to fill the research gap.

Objectives:

To address the challenges, the study aimed to design and fabricate the automatic water level recorder, and to determine the actual/real-time water level of the water body.

Materials and Methods:

The study 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 area, as shown in Figure 1, is located at a latitude of 25.4264° N and a longitude of 68. 5434° E [11]. In the current study, two types of sensors i.e. float sensor and ultrasonic sensor were used to monitor water levels. In the float sensor type, multiple sensors were integrated into the system, recording data when water reached each sensor. In the ultrasonic sensor type, the sensor measures the water level (cm) at specified time intervals. The flowchart of the methodology is presented in Figure 2.

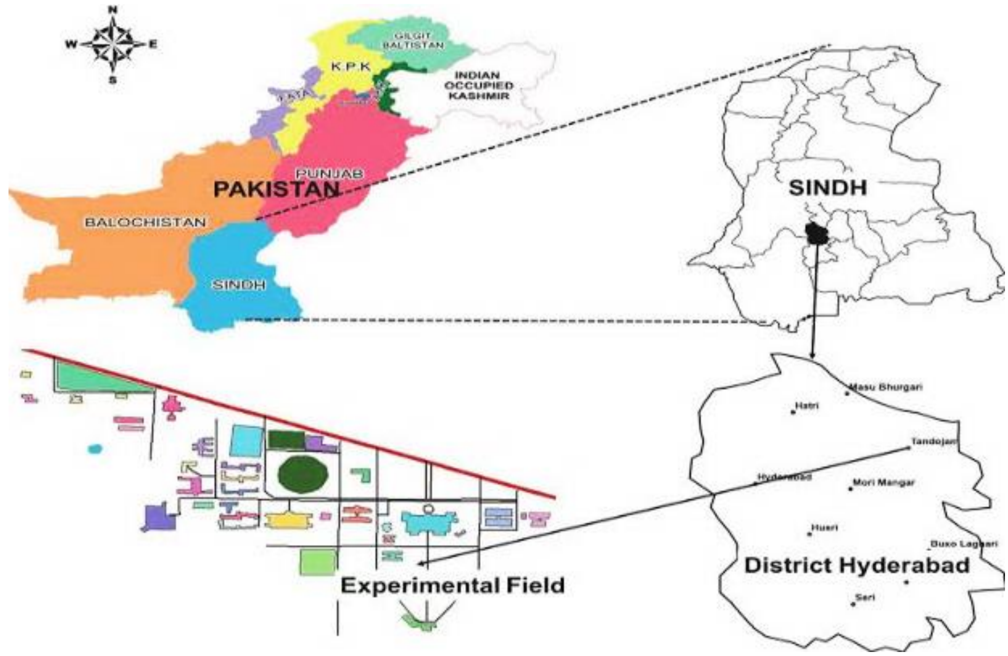

Figure 1: Geographical location of study area

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 was 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].

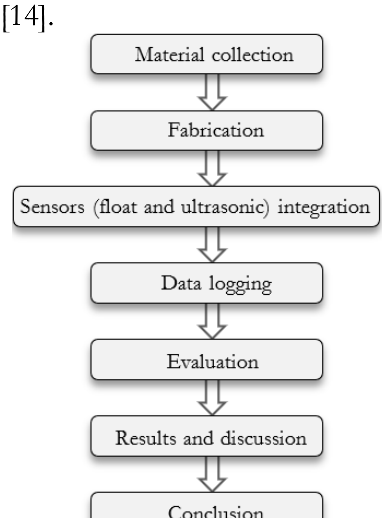

Figure 2: Flowchart of Methodology

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.

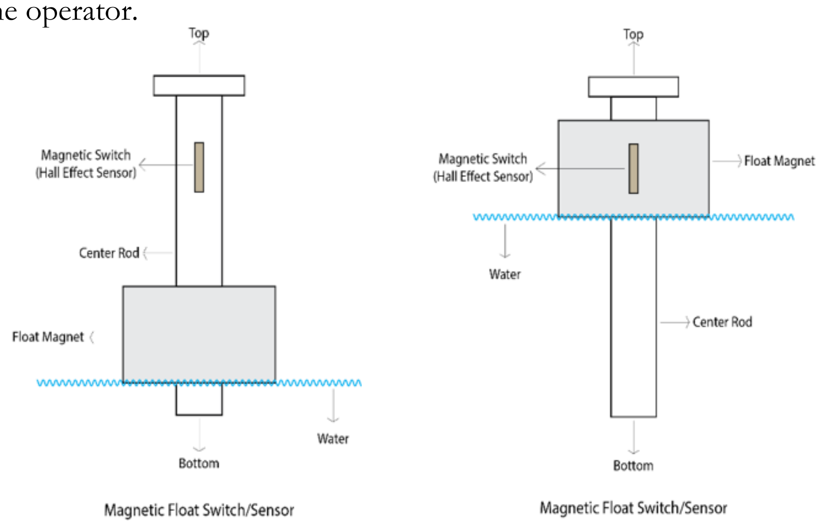

Figure 3: Magnetic float switch

An ultrasonic sensor consisting of a transmitter and receiver, measures 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].

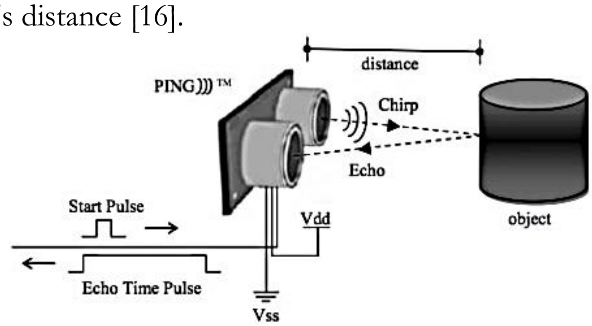

Figure 4: Ultrasonic sensor theory

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 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.

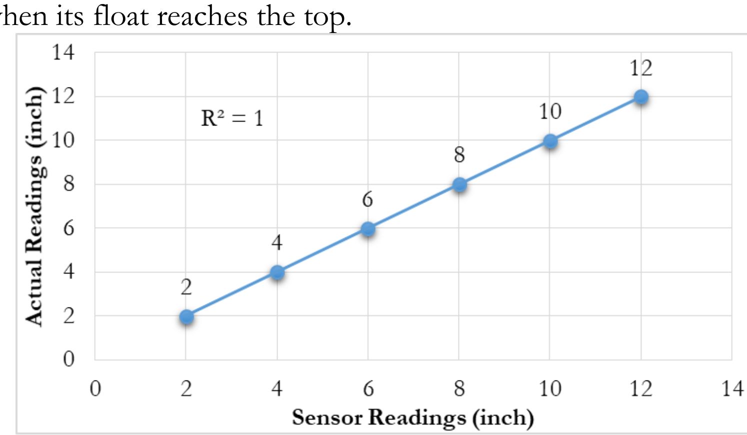

Figure 5: Float sensor readings

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.

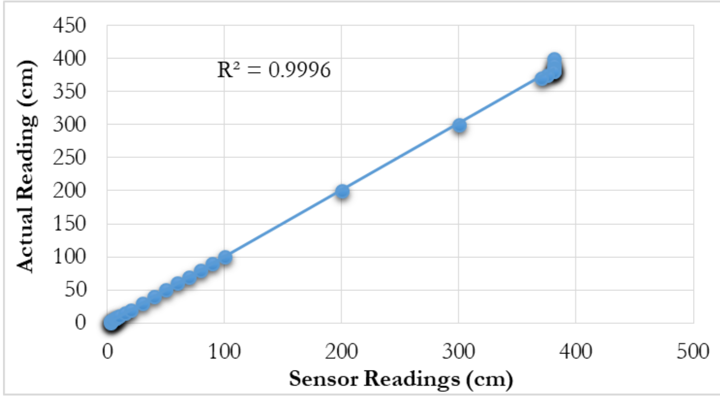

Figure 6: Ultrasonic sensor readings

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 sensor 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 an exact point (of the water body) it may lead to some errors if the float sensor is not installed in 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, and 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 the 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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