VOL. 15, NO. 4, FEBRUARY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EFFICIENT AUTOMATED MONITORING SYSTEM FOR WATER TANKS

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ABSTRACT

Continual water supply is one of the most vital daily requirements of communities for industrial, agricultural, commercial, and household uses, e.g., drinking, cooking, and cleaning. It is common for people to get water by using pumps to draw water from an underground water tank and fill an upper tank. However, use of a non-automated switch to turn a pumping machine on and off may sometimes cause water spills or non-due, increased electricity consumption. This paper presents simple, low-cost water tank monitoring system using an Arduino board. The proposed system is constructed from automatic switch module, ultrasonic sensor, pumping machine, turbidity sensor, and Arduino microcontroller so as to automatically switch the water pump on and off according to the level of water in the storage tank. In this system, the tank monitoring results are displayed on LCD screen that, in addition to the water level, shows the water turbidity to monitor suitability of water for household use. This system controls water pumping, eliminates water wastages and leaks, saves electricity, and helps the water users ensure appropriateness of the water for household uses, especially drinking and cooking.

Keywords: water level, ultrasonic sensor, water turbidity, arduino microcontroller.

1. INTRODUCTION

There is a growing interest in making human life easier and safer than before, which is one of the major objectives of technology. The control system can be defined as device, or a set of devices, that commands, manages, directs, and regulates behavior(s) of other system(s) and/or device(s). Hence, automatic control entails designing and operating a control system that functions automatically with low, or no, human interference.

Nowadays, there is ongoing search for new smart technologies to use in the different industrial, commercial, and domestic sectors. New designs and applications of smart monitoring systems are developed day by day. In general, the smart monitoring and control system can be defined as an electro-mechanical system with computer programming that employs power and a control device to perform tasks automatically using relevant sensors. Arduino is an open-source electronics prototyping platform [1] and hardware development board that is frequently employed for constructing and programing electronic circuits [2]-[9].

Apart from water quality, one of the main water-related problems faced by almost every house is underground and upper water tanks suddenly running out of water. Another problem is overflow when people refill the upper tank from the underground tank and the time wasted in tracking the level of water in the tank during the refilling process. The difficulties of checking the level and purity of the water in the tanks at any time makes people feel stressed and upset. Thereupon, this paper proposes an easy and very helpful way of solving all these problems.

Reza *et al.* [10] suggested water level monitoring and management in terms of electrical conductivity of the water. They proposed wired and wireless microcontroller-based water level sensing and controlling system that has the ability to indicate the volume of water in the tank. This system can support cellular data loggers and satellite data transmission systems for remote water monitoring. Owing to that cellular phones with relatively high computation power and high-quality graphical user interface (GUI) became available recently, the users of this system look forward to having this valuable resource at hand as a mobile application [10].

Santra *et al.* [11] developed a system for measuring the water level in tanks by using ultrasonic sensors. Ultrasonic distance measurement is based on echo. When the sound waves are transmitted in environment, they return to their source as echo after striking an obstacle. Accordingly, one has just to compute the travel time of both sounds, that is, the travel time of the outgoing sound and the returning travel time after striking obstacle [11]. This concept is employed in the control system proposed in the present study, where the motor water pump is automatically turned on when water level in the tank becomes low, and vice versa.

Marzuki [12] designed a system for measuring the water level in an aquarium tank such that the outcome is displayed on user-friendly graphical interfaces. This system was intended for residential use, especially in the house water tanks. It is designed to inform the household on the level of water consumption. The proposed system is composed of an ultrasonic sensor, an Arduino UNO, valve, and a pump. Operation of this system begins when the transmitted signal is returned to the receiver, which then coverts the signal travel time into distance. Afterwards, a pump and valve are employed to control inlet and outlet of water and the water flow into the aquarium tank. The level of water in the aquarium is calculated using an appropriate formula before being displayed on the LCD screen and GUI [12].

Eltaieb and Min [13] developed a system that uses arranged aluminum wires connected to the analog input pins of Arduino board to automate the process of water pumping into a tank. This system also has the ability to detect the level of water in the tank, switch the pump on or off accordingly, and display the water level on LCD screen. In addition, this system monitors the level of water in the sump, i.e., source, tank. If the level of water inside the sump tank is low, then the pump will not be switched on, thus protecting the motor from dry running. A beep sound is made when the level of water in the pump tank is low or when there is fault in the sensors [13].

A summary of the advantages and disadvantages of a number of the automated systems designed for monitoring water tanks that have been published in the literature is given in Table-1.

Table-1. Summary of advantages and disadvantages of previous automated systems for monitoring water tanks.

Ref.	Advantages	Disadvantages
[10]	Monitoring and management of the level of water in tanks based on the electrical conductivity of water.	Very complicated and expensive because it uses satellite and cellphones.
[11]	Measuring the water level via ultrasonic sensors.	Using expensive wireless tools. Complexity of wireless connection and associated problems.
[12]	Measuring the water level via ultrasonic sensors.	The system does not involve, and establish connection with, the main tank (underground water tank).
[13]	Controlling water pumping in tanks. Ability to determine the level of water in the tank.	The system uses aluminum wires to detect the water level.

2. THE PROPOSED SYSTEM DESIGN

This paper designs an automated system for monitoring the water level and purity in tanks and controlling operation of the water pump accordingly without human interference. An Arduino board is employed in this system to achieve the target operation. Moreover, an ultrasonic sensor is used for detection of the level of water and sending a command to the Arduino microcontroller accordingly. As such, this system provides households with the ability to know and control the water levels in their own water tanks and refill them automatically when needed. A block diagram of the proposed system is shown in Figure-1 whereas a flow chart of the steps defining operation of the proposed system is shown in Figure-2.

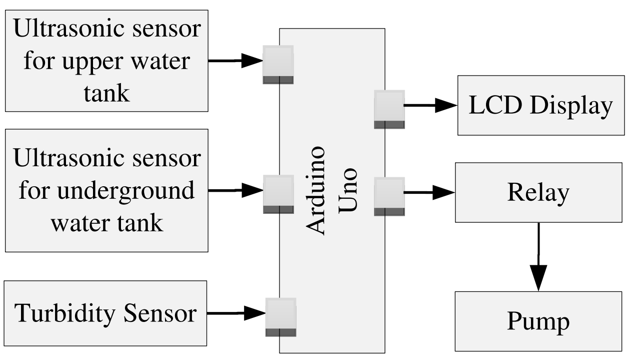

Figure-1. Block diagram of the proposed automated system for water tank monitoring.

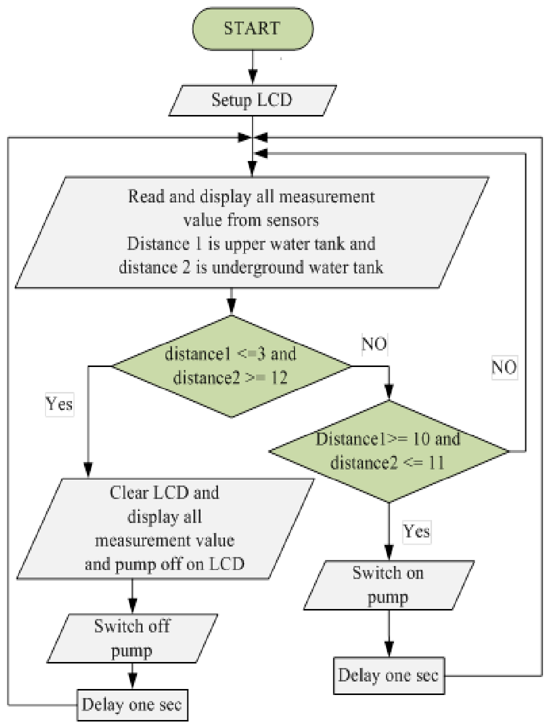

Figure-2. Flowchart of the steps defining operation of the proposed automated system for water tank monitoring.

The proposed system was designed,assembled, and tested to assess its performance. A schematic diagram of this system is shown in Figure-3.

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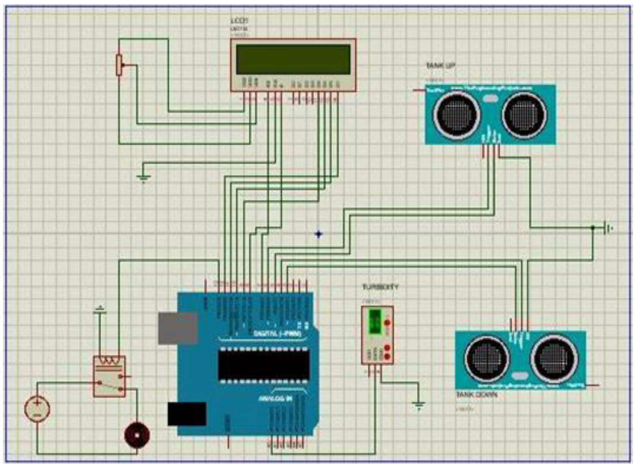

Figure-3. Schematic diagram of the proposed automated system for water tank monitoring.

It should be highlighted that each system component (Figure-3) has its own way of connection with the other components, depending on the manufacturing company and its model. Relevant, detailed information can be found in the manufacturers' datasheets for each component.

The proposed automated system for water tank monitoring consists of an input device, microcontroller, and an output device as follows:

a) Input unit

(1-a) Ultrasonic sensor

Four pins of the ultrasonic sensor 1 (VCC, Trig (sending), Echo (receiving), and GND pins) are connected with Arduino board (5v, pin 6, pin 5, and GND) consecutively and four pins of the ultrasonic sensor 2 (VCC, Trig (sending), Echo (receiving), and GND) are connected with Arduino board (5v, pin 4, pin 3, and GND pins) consecutively.

(2-a) Turbidity sensor

Three pins of a turbidity sensor (VCC, signal, and GND) are connected with Arduino board (5v, pin a0, and GND pins) consecutively.

b) Relay as controller of the pump

The proposed control system uses relay as a switcher (NC, Comment) positioned before the pump. This relay has three pins (VCC, GND, and signal pins) that are connected with the Arduino board (VCC, GND, and pin 13).

c) Output unit

The digital pin of the LCD is connected to the Arduino board as illustrated in Table-2.

Table-2. Connections between the LCD and the Arduino board.

Pin7	**RS**
Pin8	E
Pin9	D4
Pin10	D5
Pin11	D6
Pin12	D7

An ultrasonic transmitter is mounted on the tank. It transmits ultrasonic pulse down into the tank that travels at the speed of sound. This pulse is reflected back from the surface of water to the transmitter. Calculation of the time delay between the transmitted and the received signals enables the ultrasonic sensor to compute distance to the water surface. The transmitter is programmed in such a way as to automatically determine the level of water in the tank and switch the pump on or off accordingly.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The Arduino board was connected to Laptop in order to upload the program to it. Moreover, it was fed by power from the Laptop. Then, a 220-volt power supply was connected with a step-down transformer connected to a relay and pump so as to reduce the voltage from 220 V to 12 V. The relay device works as a switch for the pump. It receives signals from the Arduino board. Three sensors were connected to the Arduino as input sensors; two sensors for tracing ultrasonic sound and one for turbidity assessment. The first ultrasonic sensor and the turbidity sensor are used to read the data derived from the upper water tank and the data sent to the Arduino board. Thereafter, the Arduino board analyzes the received data and, then, gives order to the relay device based on the received information, either to switch the pump on or off. The second ultrasonic sensor reads the level of water in the underground water tank. If the underground water tank is full and the upper water tank is empty or under level, then the Arduino microcontroller sends order to the relay device to switch the pump on. Otherwise, the Arduino microcontroller delays its order to the relay device until the level of water in the underground water tank is high. This process prevents dry running of the pump. Information on the level and turbidity of water in the upper water tank and the level of water in the underground water tank is shown on the LCD screen all the time.

A prototype of the herein proposed automated system for water tank monitoring is presented in Figures 4 and 5.

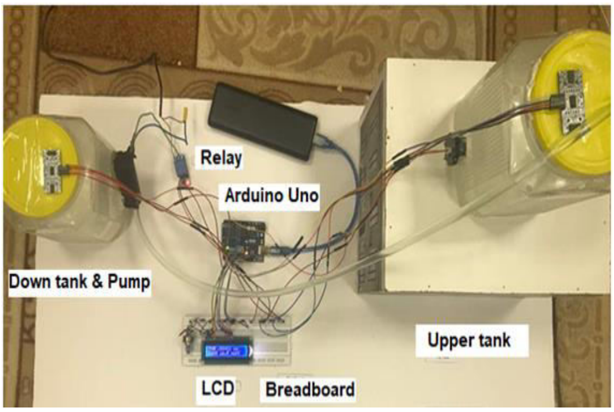

Figure-Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**.** Top view of prototypeof the proposed automated system for water tank monitoring.

Figure-5. Side view of prototype of the proposed automated system for water tank monitoring.

The ultrasonic sensors located in both the upper and underground water tanks are used to measure the water level. If distance 1 in the upper water tank is less than 3 m, then it is assumed that this tank is full and, thus, there is no need to fill it more. Likewise, if distance 2 in the underground water tank is higher than 12 m, then it is presumed that this tank is empty and that it needs to be refilled with water. In this case, if the pump works, then this will cause dry running and the pump will be damaged. Hence, there is a need for making sure that the underground water tank is always full (i.e., having a distance that is less than 11 m). By design, the proposed system will allow for a delay of one second before measuring the distances again.

If distance 1 is higher than 10 m, then the upper water tank needs to be refilled. As well, if distance 2 is lower than 11 m, then the underground water tank is not empty. When the upper tank is empty, the Arduino microcontroller will give a signal to the relay (switcher) in order for it to switch on the pump until the upper water tank becomes full or the underground water tank becomes empty. This process will be repeated again every one second to confirm that the upper water tank is always full. All these actions are automatic and the measurement outcomes will show on the LCD screen all the time.

Briefly, the herein proposed automated system for water tank monitoring was assembled and tested. This system has the following main features:

- It allows the house owner to get enough information continuously about the levels of water in the upper tank and the underground tank and displays the results on LCD screen.
- It provides steady measurements of the turbidity of water in the upper tank and displays the results on LCD screen.
- It is automatic and safe.

4. CONCLUSIONS

In this paper, an efficient automated system for water tank monitoring was proposed. This system can be used in any house. It can supply the upper household tanks with water automatically when needed. It also provides information all the time about level of water in the upper and underground water tanks and about level of water turbidity in the upper tank that is displayed on LCD screen.

The results of this study indicate that the automatic water tank monitoring system proposed in this paper has numerous advantages over the existing systems that include (i) providing accurate data on the water level and purity, (ii) saving money, and (iii) simultaneously preventing overflow of water and running out of water. Successful upgrading of this proposed system to the industry scale will be useful for industries, farms, homes, and other applications as it is economical in that it saves electric power, labor, time, and the water stored in the upper and underground tanks.

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