IoT and GSM Integrated Automated Water Pump Controlling System for Prevention of Water Wastage

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Abstract

Despite water covering 71% of the Earth's surface, only 1% is suitable for drinking, and this limited precious resource is dwindling each year. It is a collective responsibility to conserve water and guarantee a steady supply of clean drinking water. Household overhead tanks are typically filled by centralized pump units, a situation that often leads to overflow if left unattended. This is a widespread problem encountered by numerous homeowners. When a water tank runs empty, someone needs to manually regulate the motor. In this paper, a prototype Internet of Things (IOT) & GSM-integrated automated system has been developed for monitoring and controlling water pumps. A water level sensor is employed to monitor water levels. Users can turn ON the motor pump and check the water level using an Android application via IoT whenever water surpasses or falls below a specific level. This way, users, specifically farmers from remote areas, can oversee and control all operations conveniently through their mobile devices. The system under consideration operates without requiring user intervention unless the water tank is empty. The system facilitated by an Arduino Nano enables notifications about the tank's water level and active status to be sent to a designated mobile number. This system allows users to decide whether water is required in the tank by responding accordingly. The developed system not only conserves electrical power but also prevents artificial flooding, promoting a cleaner environment.

Keywords
Internet of Things, Arduino Nano, Water Pump, Controlling, Monitoring, GSM

Introduction

A pressing challenge in recent times is the efficient use and management of water resources in the face of global concerns. The global scarcity of water has become a major concern, with the water crisis reaching alarming levels every day. Given that thirty percent of the world's freshwater is being wasted as groundwater, this issue deserves significant attention. In both urban and rural areas, water tank systems are commonly used. However, a noteworthy drawback of these systems is the overflow from overhead tanks and water pump overuse which is faced by many house owners with overhead tanks. Usually, overhead tanks get filled by centralized pump units, which may overflow if unnoticed. A person needs to observe the tank water level manually and operate pumps, i.e., turn ON and off valves when the overhead tank has an overflow of water. When a tank is empty, he has to switch ON the motor, and when it is full, he has to switch the motor OFF. One has to keep on observing his tank water level to switch off the motor once it is switched on. Moreover, sometimes the motor coil burns due to the absence of water in the reserve tank, if unnoticed by anyone. To resolve the issue of water shortages in household areas of metro cities, the wastage of water during pumping and dispensing into overhead tanks needs to be reduced. As deep underground water accounts for 30% of the world's freshwater, its wastage is unacceptable, even after it has successfully been extracted from the ground. Such wastage is not just of the water but also of the power used. Water overflowing from overhead (top tank) and underground tanks (reserve tank) has become a common scene, even when it leads to the accumulation of water in a particular spot, which can be seen as artificial flooding, which is a breeding ground for mosquitoes. Therefore, monitoring water levels and preventing water wastage are crucial tasks from both government and residential standpoints. This paper presents an automatic water pump controlling system which can be a great solution to avoid water overflow and wastage.

Literature Review

Over the past few decades, researchers have developed various water pump control systems. Irubor and Igimoh (2017) introduced a research paper focusing on efficient water resource utilization for agriculture and crop growth monitoring through GSM technology. They created a prototype that sends notifications about the water level to a dedicated mobile line. Gangadhar et al. (2017) proposed a remote water pump controller designed for agricultural use which employs GSM technology to remotely activate and deactivate the motor, enhancing efficiency in agricultural practices. Grace et al. (2015) presented a research paper focusing on efficient water resource utilization for agriculture and crop growth monitoring through GSM technology. Their automated system optimizes water usage and monitors crop growth effectively. Mulmane et al. (2015) developed a user-friendly 3-phase water pump control system for farmers, utilizing GSM technology. The system monitors electric supply, reservoir water level, and pump flow rate, and safeguards against short-circuits, enhancing irrigation efficiency.

Arduino Nano ATMEGA 16 controls the high-voltage 3-phase irrigation water pump, providing motor status through LED indicators. Maqbool and Chandra (2013) devised a remote monitoring system for water levels in various sources such as tanks, rivers, groundwater tables, and bore wells. Their system, incorporating water level sensors, Zigbee 802.15.4, 74HC14 inverter, and GSM technology, facilitates wireless flood area monitoring and reduces water overflow and power consumption. Jena (2013) introduced an automated water level control system that activates and deactivates the motor based on water reaching critical levels, ensuring optimal water usage. Hebbar (2017) proposed an automatic water supply system for plants, conserving time and water resources. Their system, controlled by microcontroller 16F877A, uses moisture sensors to regulate the pump. Additionally, GSM technology enables remote control via mobile phones, allowing users to send commands to the system through the GSM modem. In related studies, Hartman (2002) suggested a remote-control system for water pumping stations using GSM cellular communications. Another research paper by Wu-Quan et al. (2011) outlined an automatic water supply control system with fixed pressure and variable frequency speed. This system combines frequency conversion and automation technologies, conserving water and energy, and safeguarding pumps and pipelines. Grace et al. (2015) presented a research paper focusing on efficient water resource utilization for agriculture and crop growth monitoring through GSM technology.

The proposed system optimizes water usage and monitors crop growth effectively. Mulmane et al. (2015) developed a user-friendly 3-phase water pump control system for farmers, utilizing GSM technology. The system monitors electric supply, reservoir water level, and pump flow rate, and safeguards against short-circuits, enhancing irrigation efficiency. Arduino Nano ATMEGA 16 controls the high-voltage 3-phase irrigation water pump, providing motor status through LED indicators. Maqbool and Chandra (2013) developed a remote monitoring system for water levels in various sources such as tanks, rivers, groundwater tables, and bore wells. Their system incorporates water level sensors, Zigbee 802.15.4, 74HC14 inverter, and integrates GSM technology and facilitates a wireless flood area monitoring system. The proposed system reduces water overflow and power consumption. Jena (2013) introduced an automated water level control system that activates and deactivates the motor based on water reaching critical levels, ensuring optimal water usage. Hebbar (2017) proposed a microcontroller-based automatic water supply system integrating GSM technology for plants, conserving time and water resources. In related studies, Hartman (2002) suggested a remote-control system for water pumping using GSM technology. Another research paper by Wu-Quan et al. (2011) outlined an automatic water supply control system with fixed pressure and variable frequency speed. This system combines frequency conversion and automation technologies while conserving water and energy.

Godwin Premi and Malakar (2019) attempted to design an automatic water tank level and pump control system that has various advantages. This system's sensor devices detect and control the water level in the overhead tank and even the pump. The sensor detects the amount of water in the overhead tank and provides varied signals to the Arduino, which are utilized to turn on and off the motor pump according to needs. Furthermore, Prima et al. (2017) proposed an automated water tank filling system that uses an ultrasonic sensor, an automatic switch module, a water-flow sensor, an Arduino microcontroller, and a pumping machine to switch the water filling automatically. In this method, an ultrasonic sensor is used, and an ultrasonic transmitter is installed on the top of the tank, transmitting an ultrasonic pulse down into the tank. Moreover, some researchers developed an IoT SMS-enabled gadget that analyzes water levels and alters motors automatically when water levels rise or fall. This instrument also offers information on the pH level of the water. All of the above information is delivered to the user via SMS [Choubey et al., 2022]. Besides, Getu and Hussain (2016) designed a water level sensor that is able to detect and control the level of water in a certain water tank or a similar water storage system. The electronic design uses sequential logic implemented through a flip-flop. A seven-segment display and a relay-based motor pump driving circuit are part of this integrated design.

This research work was driven by the necessity to address the water shortage and unnecessary wastage by tackling the issue of water wastage during the pumping and filling of overhead tanks. Creating a barrier to waste will not only provide more financial gains and energy-efficiency but also will ensure that water can be saved for the future. This work aims to develop a user-friendly, reliable, and automated water pump control system for house owners integrating a water level indicator, Arduino Nano, and GSM. The issue of water scaling is also addressed in this work. Scale deposits are typical indicators of hard water. Furthermore, this system can monitor the level of water inside the water tank, system line voltage, motor switching status, and percentage of water scaling as well. All this information are displayed on LCD as well as transmitted to the user via text message and visible on the IOT platform.

System Set Up

The block diagram of the IOT and GSM-based automatic water pump control system is illustrated in Figure 1. In this block diagram, the water pump controlling system is controlled by Arduino Nano. A water level sensor is used to detect the level of water in the main water tank. Arduino Nano is connected to a level sensor that will detect the level of water in the main tank automatically. Whether the pump will supply or not supply water is based on the level of the water, which is detected by the level sensor. This data is crucial for decision-making regarding pump activation and deactivation. A water scaling detector, on the other hand, will detect the degree of scaling. The water scaling detector pin and level pin in this system is responsible for transforming the analog to digital signal. Furthermore, a GSM module is incorporated with the Arduino Nano as it is pivotal for the remote messaging aspect, allowing users to interact with the water pump system through SMS commands. This module facilitates communication via mobile networks, enabling remote control and monitoring as well. Thus, users can remotely manage the motor's activation and deactivation using these SMS commands. Also, an IoT connection is established through a Wi-Fi module which enables the Arduino Nano to communicate with an IoT platform or cloud service, where data on water levels and pump status can be stored and accessed remotely. IoT enables users to monitor the water pump system through a dedicated IoT platform or mobile application.

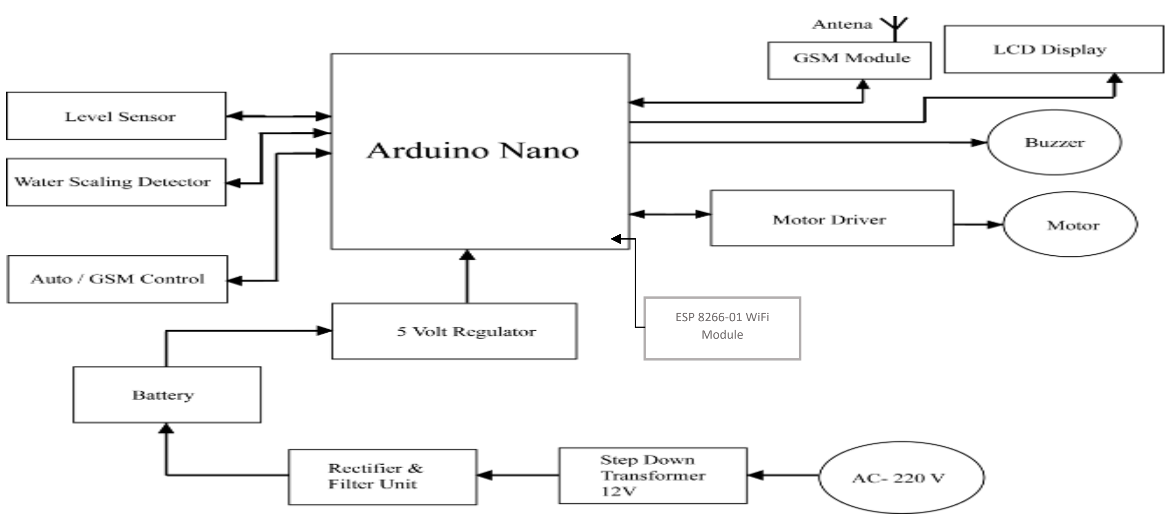

Figure 1. System Block Diagram

Two water tanks are used to reserve and supply water which is shown in the following Figure 2 & 3.

Figure 2. Top Tank

Figure 3. N Reserve Tank

A DC motor is used to transfer and lift water from reserve tank to main tank. Figure 4 shows the circuit diagram of the automatic water pump controlling system.

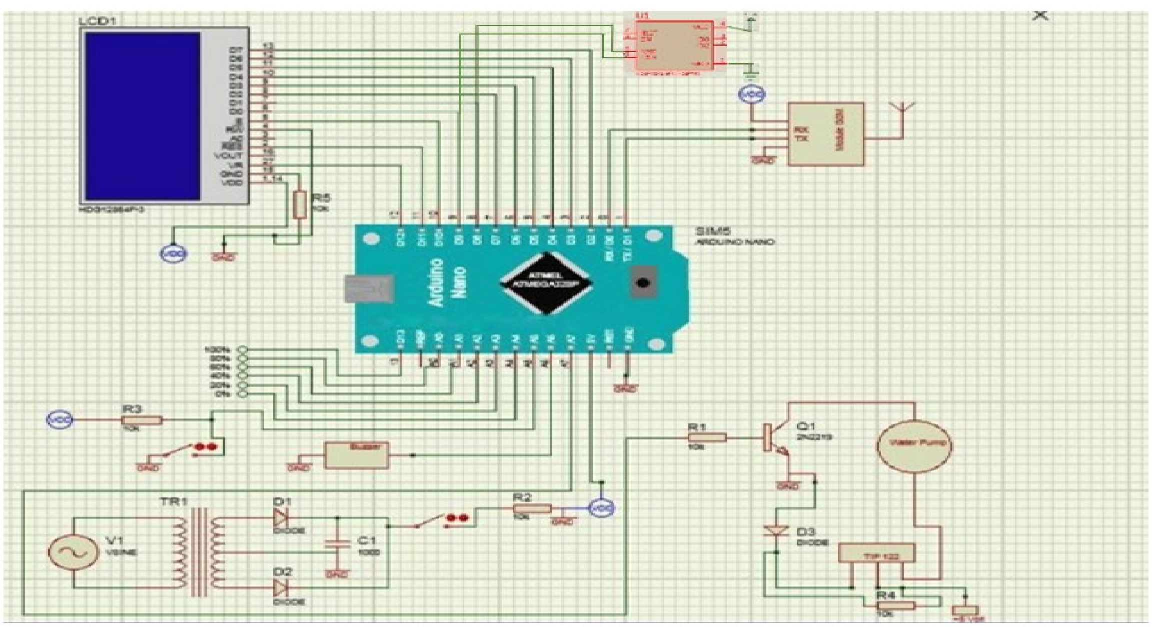

Figure 4. Circuit Diagram

In this Figure, Arduino Nano, ESP 8266-01 wifi module, GSM module, level switch, relays, pump, and water scaling detector, LCD and transformer connection are shown. Transformer was supplied by 220V in the input section whereas output is achieved by relay.

Figure 5 illustrates the flow chart of a GSM-based automatic water pump control system.

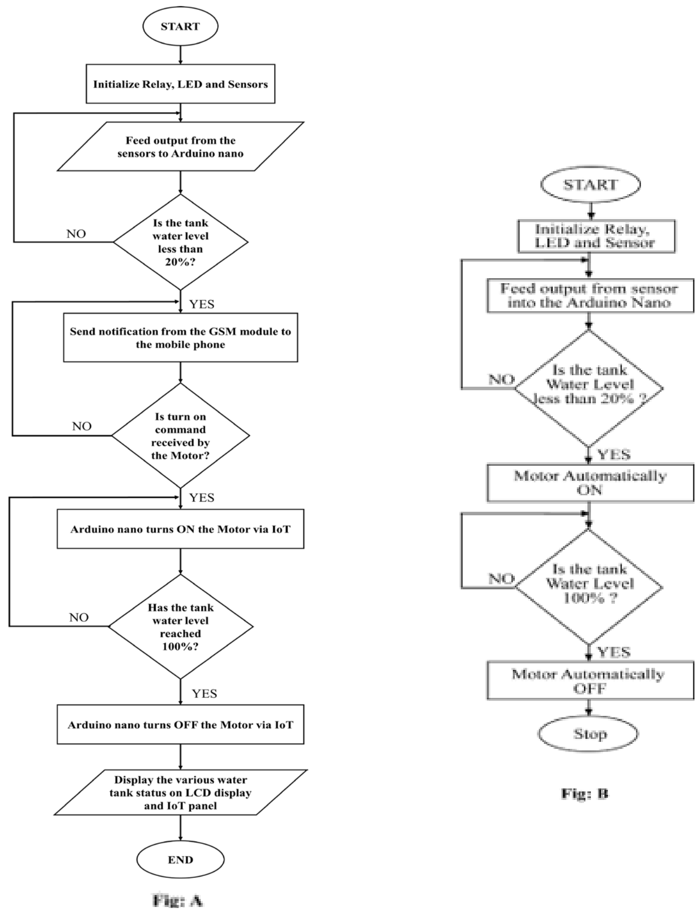

Figure 5. Flow Chart

Initially, the system detects the water level in the tank using a level sensor and subsequently adjusts the water pump's status based on the water level. The integrated design includes an LCD display and a relay-based motor pump driving circuit. The water pump is activated automatically to fill the tank when the water level is either empty or below 20%. On the contrary, it deactivates and stops filling the tank when the water level reaches its maximum capacity. Additionally, the water pump remains inactive (at level SEVEN to TWO) when the water level decreases due to water consumption. By pressing the start button, the system initiates. If the water level is below the required threshold, the motor switches ON to fill the main tank. Once the water level reaches the desired level, the motor is turned off.

Results & Discussion

A pair of tanks has been employed, with one positioned at the bottom (Reserve Tank) and the other at the top (Top Tank). The Reserve Tank functions as a storage unit and transfers water to the Top Tank through a motorized mechanism. All the essential components, including the Arduino section, LCD section, GSM section, supply section, control section, and probe water indicator section, have been integrated onto a single board. The overall setup is depicted in Figure 6.

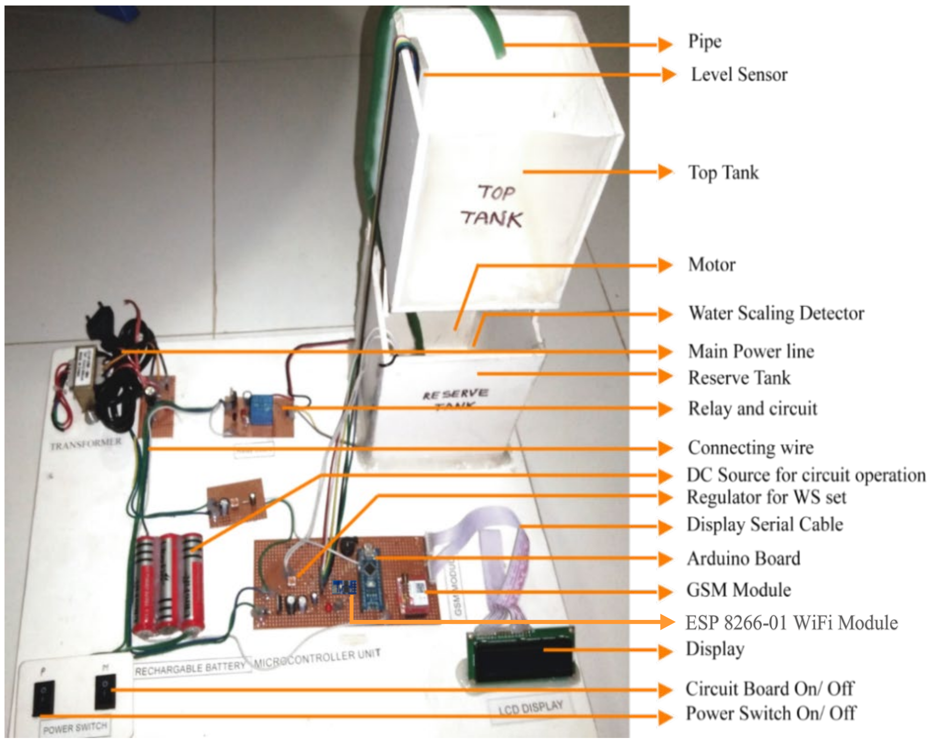

Figure 6. Experimental Setup

The motor activates automatically when the top tank reaches a 0% water level and turns OFF when it reaches 100%. The display provides information on water level, voltage, system status (Auto/GSM), and water scaling in percentage. The motor can operate either automatically or through GSM control. The GSM system is accessible through mobile application software, enabling users to transmit signals from the application to the circuit board for motor control, as illustrated in the following Figure.

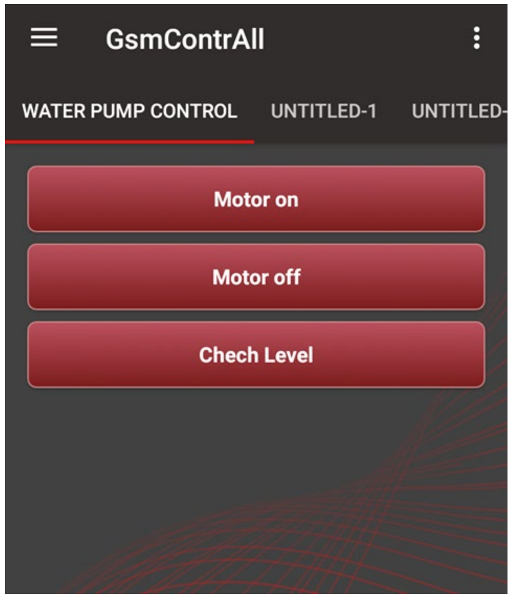

Figure 7. Mobile Application Screen

Mobile application software is used here to control the motor status. With this application software, the motor ON/ OFF can be controlled and the water level can also be checked. Figure 8 shows the motor ON status where water flows from reserve tank to top tank.

Figure 8. Motor ON and Water Flowing from Reserve Tank to Top Tank

Figure 9 shows water leveling system of reserve tank.The level of top tank water is detected by level sensor. The percentage is shown on the display. When tank is full the motor will be shut down.

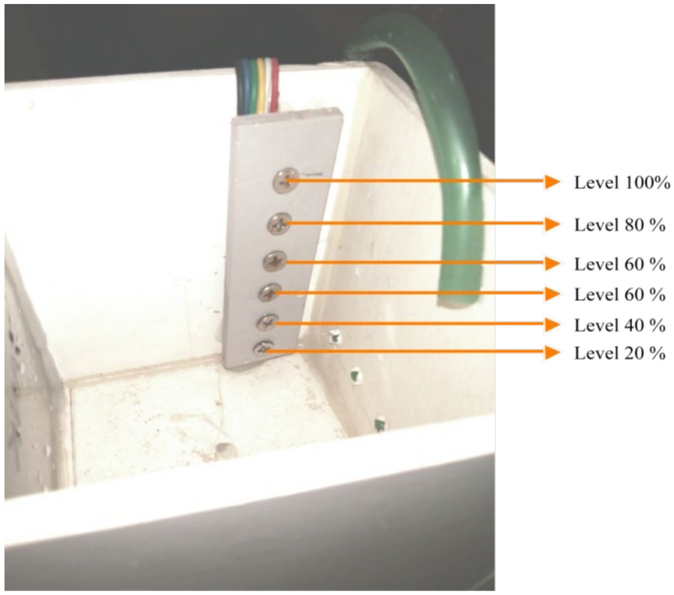

Figure 9. Water Level Detection in Reserve Tank

Besides detecting the water level, water scaling detection is also crucial. Water scaling level refers to the degree of mineral content, particularly calcium and magnesium ions, in water. Scaling occurs when the chemistry and temperature conditions are such that the dissolved mineral salts in water precipitate and form solid deposits. These ions do not pose any health threat, but they can engage in reactions that leave insoluble mineral deposits. When water with high concentrations of these minerals is heated or evaporates, it can lead to the formation of scale deposits. This scale, often seen as a white, chalky substance, can accumulate on surfaces such as pipes, faucets, and other appliances. The water scaling detecting sensor detects the water scaling level of reserve tank water. Scaling can reduce the efficiency of water pumps by restricting the flow of water through pipes and impellers. This can result in increased energy consumption as the pump has to work harder to move water through the system. Over time, this can reduce the lifespan of the pump and lead to the need for more frequent maintenance or replacement. Addressing scaling issues early on can help prevent more extensive damage that might necessitate costly repairs or replacements. The level of water hardness, or scaling potential, is commonly measured in terms of milligrams per liter (mg/L) or parts per million (ppm) of calcium carbonate ($CaCO3$). The water scaling level is indicated in percentage here in the LCD display.

Figure 10 and 11 shows different water level and scaling level in LCD displays. Information like voltage of line, level of water of top tank, percentage of water scaling, selection system can be viewed on LCD display as well .

Figure 10. LCD Display showing status

Figure 11. LCD Display showing status

Figure 12 & 13 shows the interface of Arduino IoT cloud mobile application tool for water level monitoring water pump controlling system.

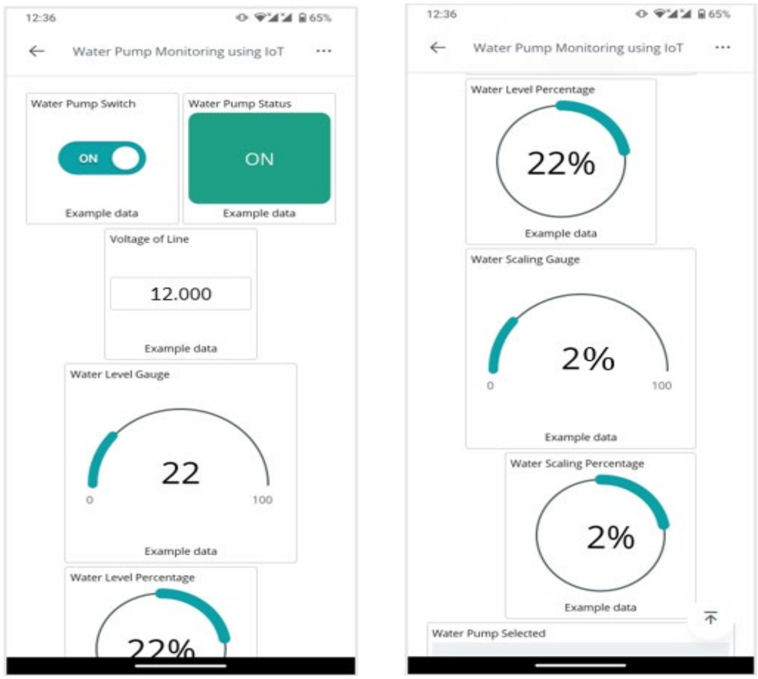

Figure 12. Water pump and water level status using IoT

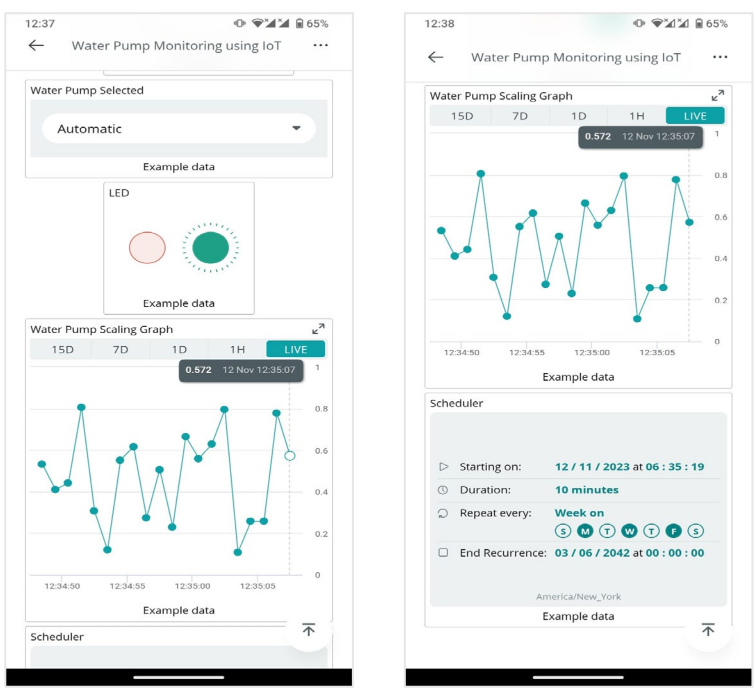

Figure 13. Water tank graphical status and scheduling using IoT

From this Arduino IoT application, users can visualize the tank's water level in gauge as well as in percentage, and the graph also shows the water scaling parameters. The voltage level of the line can also be shown in the water pump status. A system selector can be seen in that panel. Also, whether the water pump is automatically controlled or manually controlled, can be visualized as well. The app can also schedule the water pump to fill up the water tank from time to time. This can be illustrated from the table 1.

Table-1. Monitoring Water level of water tank using IoT application and LCD Display

Sl. No.	Controlling by Arduino IoT cloud	Water Pump Control	Water level in IoT Panel	Water Level Percentage in IoT Panel	Water level Status	Water Scaling Level in IoT Panel
1	ON	ON	Water level is increasing	80%	High	2.64%
2	ON	ON	Water level is increasing	90%	High	2.82%
3	OFF	OFF	Water level has stopped increasing	56%	Medium	2.43%
4	OFF	OFF	Water level has stopped increasing	15%	Low	2%
5	ON	ON	Water level is increasing	22%	Low (start increasing)	2%

Table 1 demonstrates that activating the ON button in the Arduino IoT cloud application results in the motor being switched ON and the water level increasing. The water level sensor not only detects the water level but also signals when the water level is low. Similarly, the sensor within the IoT program identifies and displays the medium water level, causing the LED on the IoT panel to turn yellow. Activating the button signifies the motor is in the ON state. Finally, when the user deactivates the motor through the IoT application and the level sensor identifies a high water level, the LCD indicates that the water level is full.

1. Conclusion

The developed automated water pump controlling system doesn't need any attention from the user unless the tank is empty. The system includes monitoring of availability of proper electric supply, water level inside the reservoir, water scaling, and motor switching status. The system provides a secure water pump controlling system in household sectors which is user-friendly, reliable, and easily configurable. This system efficiently controls the water pump by monitoring the water level which can work using a wireless network. As the system employs both GSM Module and IoT, users will receive water pump status notifications via messages even in the situation of internet connectivity issues. By employing this remote monitoring system, several users can simultaneously oversee the same water pump system. This functionality empowers the water pump control system to function autonomously, eliminating the need for continuous supervision. Users can stay updated on the operational status of the system at any time and from any location.

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Biographies

Rumana Tasnim is currently working as an assistant professor in the Department of Mechatronics Engineering at the World University of Bangladesh. She achieved her M.Sc. degree in Electronics Engineering (MSEE) from the International Islamic University of Malaysia (IIUM) and her B.Sc. degree in Electrical and Electronic Engineering (EEE) from the International University of Business, Agriculture, and Technology, Bangladesh. She has more than 50 publications in peer-reviewed international journals, conferences, and books. She has reviewed a number of international journals throughout her academic career. She is the advisor of the IEOM Society WUB Chapter. Her research interests include smart sensing, instrumentation and measurement, automation, robotics, IOT, Computer Vision and renewable energy.

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