Scientific Research Publishing

Journal of Sensor Technology, 2022, 12, 19-31
https://www.scirp.org/journal/jst
ISSN Online: 2161-1238
ISSN Print: 2161-122X

The Design of a Mobile Phone-Based Remote-Control Application to Submersible Motor for Effective Water Supply

Winfred Adjardjah, David Bright Kofi Arthur, Alex Ewuam, Kingsley Nunoo

Department of Electrical and Electronic Engineering, Takoradi Technical University, Takoradi, Ghana
Email: winfred.adjardjah@ttu.edu.gh

How to cite this paper: Adjardjah, W., Arthur, D.B.K., Ewuam, A. and Nunoo, K. (2022) The Design of a Mobile Phone-Based Remote-Control Application to Submersible Motor for Effective Water Supply. *Journal of Sensor Technology*, **12**, 19-31.
https://doi.org/10.4236/jst.2022.122002

Received: February 17, 2022
Accepted: June 27, 2022
Published: June 30, 2022

Abstract

In the last few decades, several monitoring systems integrated with water level detection have been the major research focus. Production boost and its sustainability depend mainly on sustainable water supply, measuring water level, and avoiding waste of water is an essential task for all stakeholders. Therefore, the aim of this paper is to design and implement a mobile phone-based remote control. This will be applied to control the operation of a submersible motor in a water tank. The water level in the tank is detected and the device remotely turns the motor pump on/off. The design process is accomplished by developing an android application that works on GSM technology to manage the filling of water tank. An AT89C51 microcontroller is used for the desired programming. At the transmitting end, sensor is used for level detection and GSM module is used to send the information to user. According to this information, user controls the on/off operation of the pump. A SIM card is required for its operation and it works on attention (AT) commands. After the design and implementation of the device, the test results showed that all features of the device worked properly, and the device functions exactly as expected. More significantly, the paper has shown that ultrasonic sensors can be used to determine the level of water in a water tank and a GSM module can be used to control a submersible pump. The design and implementation of this device can help to reduce waste of time and power. Ultimately, it avoids water wastage thereby ensuring availability, conservation, and sustainability of water supply.

Keywords

Water Supply, Submersible Motor Pump, Mobile Phone, GSM, Android

1. Introduction

Water is basic need of all lives and it is commonly used in agriculture, in many industries, as well as for domestic purposes. Sustainability of available water resource in many regions of the world is now a pressing issue. This problem is quietly related to poor water allocation, inefficient use, and lack of adequate and integrated water management [1]. Therefore, efficient use and water monitoring potential are of premium concerns for home or office water management system. Many existing systems use computers, database technologies for monitoring and controlling irrigation activity, for example, [2]. In the last few decades, several monitoring systems integrated with water level detection have been accepted [3]. Measuring water level and avoiding waste of water is an essential task for government and residence perspective. To say the least, Galgalikar [4] proposed real-time atomization of agricultural environment for social modernization of Indian Agricultural System which focuses on using an ARM7TDMI Core 32-bit microprocessor, GSM services which operate through SMS as a link between ARM processor and centralized unit. In another study, a remote irrigation monitoring and control system was designed for continuous move systems and was recommended for application in agriculture [5]. In addition, automated drip irrigation systems [6] [7] [8] [9] using linear programming [6] were proposed. The concept of linear programming properly makes use of available water resource to irrigate the field affected in such a way to get maximum profit at lower cost. Moreover, a smart irrigation technique of remote-controlled irrigation system with the help of voice commands was designed [10].

Nowadays, Global System for Mobile Communication (GSM) based Control System implements the applications of the GSM technology by using GSM networks as the control system. This technology has been proposed and will act as an embedded system, which can monitor and control appliances and other devices. The data studied here show the results that may be useful for any business that plans to implement a remote monitoring system using Cellular Network (GSM/GPRS). Although submersible pumps variables are used in the experiment, other remote monitoring applications are possible using air communication channels, such as monitoring pollutant emissions, river and reservoir level alerts, landslide warnings, wind turbine.

A GSM-SMS remote measurement and control system for greenhouse based on PC-based database system connected with base station was introduced [2]. Base station was developed by using a microcontroller, GSM module, sensors and actuators. In practical operation, the central station receives and sends messages through GSM module. Criterion value of parameters to be measured in every base station is set by central station, and then in base stations parameters including the air temperature, and air humidity. Embedded System based submersible motor control to prevent it from overload, dry run and single phasing using GSM for water supply was proposed [3]. Mobile phones have been used in the control of irrigation [11] [12]. In [11], an embedded-based remote-control

using mobile phones was proposed for application in irrigation. Similarly, in [12], a GSM-based automatic irrigation control system for effective and efficient resource management via application of android mobile phones was designed. This application makes use of the General Packet Radio Service (GPRS) feature of mobile phone as a solution for water supply. Control system (GSM) is used to inform the user about the exact field condition. The information is passed onto the user request in the form of SMS. These projects are similar to the device we seek to design and implement in this paper, which can be used to control and monitor the submersible motor used for water supply via a GSM network. This project provides the development of the mobile phone as remote-control application for submersible motor pump, which could be used in water supply. This system was built using GSM with voice recognition technique and moisture sensor unit to control water supply [11]. Remote sensing and control of water supply systems using a distributed wireless sensor network were introduced [11] [13]. Distributed infield sensor-based water supply systems offer a potential solution to support site-specific water supply management that allows producers to maximize their productivity while saving water. A design and implementation of GSM-based fertigation system were implemented [14]. By using GSM system, Start and Stop action of the motor that feeds the field with water can be controlled only by sending the GSM command. Through GSM mobile is used as a control of the whole process and backbone of a whole system. This system can be used to control water from any distance. To add to the record, automatic power meter reading system using GSM network was developed [15]. It utilizes the GSM network to send power usage reading to authorize office to generate the billing cost and send back the cost to the respective consumer through SMS.

The intention of this project is to reduce time, power and avoid the wastage of water. Therefore, this problem can be stopped by developing an android application that works on GSM technology. Thus, the detection of water level is done and accordingly, this pump is turned on/off as the situation applies. An AT89C51 microcontroller is used for the desired operation. At the transmitting end, a sensor is used for level detection and GSM module is used to send the information to user. According to this information, user controls the on/off operation of the pump. A SIM card is required for its operation and it works on attention (AT) commands.

The strategic objectives of this paper are in threefold: design a remote control for submersible pump, construct a remote control for submersible pump, and turn OFF and ON of a submersible pump through SMS Notifications.

This device will help minimize the volume of water wasted or loss during production when the pump is unable to stop pumping. It will also reduce the frequent use of the pump since it sends signal to the operator. In addition, it will reduce production cost and signal the operator about the volume of water in storage tank. Additionally, it can inform the operator about the volume of water used in a day.

The scope of this project is limited to Community Water and Sanitation Agency Water Supply System in the Upper Denkyira West District Assembly in the Central Region. The device can send SMS to any android phone at any distance. The Remote-Control System for Submersible pump has the following limitations; the device can only be used by android-based phones, it is only supported on Global System for Mobile communication, and finally, it cannot operate when there is no telecommunication network.

2. Method

This chapter presents the design concept which is the block diagram and circuit diagram of the design. It also presents the construction steps, both the hardware components employed and summary.

2.1. Block Diagram of the Design

Figure 1 represents the block diagram of this project. The block diagram is made up of the power supply block, the ultrasonic sensor block, the microcontroller block, the GSM module block, the LCD block, the amplifier block, the relay block and the block that represents the submersible pump. The function of the power supply block is to supply the system with enough current and at the required voltage level because the GSM module is much sensitive to the current and voltage supplied to it. The output from the power supply is feed to the microcontroller. The function of the ultrasonic block is to sense the level of water in the water tank. The microcontroller picks the data from the ultrasonic sensor and activates output signals. The amplifier block increases the magnitude of the signal from the microcontroller. The GSM module communicates with the microcontroller to send and receive instruction to and from the user to and from the microcontroller. The LCD block is responsible for the display of the level of water in the water tank and the state of the submersible pump, either ON or OFF. The purpose of the relay block is to close and open the circuit to the submersible pump. The function of buzzer is to provide audio notification when required.

2.2. Circuit Representation

Figure 2 illustrates the circuit diagram which depicts the internal circuit representation of the project. The circuit was designed to operate under a 5 VDC supply and a 12 VDC supply. The circuit consists of a 5 VDC power supply module and a 12 VDC power supply module. The 5 VDC power supply module is connected to the main circuit consisting of the GSM module, the microcontroller, the relay, the buzzer and the LCD screen whereas the 12 VDC power supply module is connected to the submersible pump. When the circuit is activated, the ultrasonic sensor begins to read the state of the water tank, the ultrasonic sensor is connected to the microcontroller for the purpose of communication. The ultrasonic sensor is made up of a sound transmitter and a sound receiver.

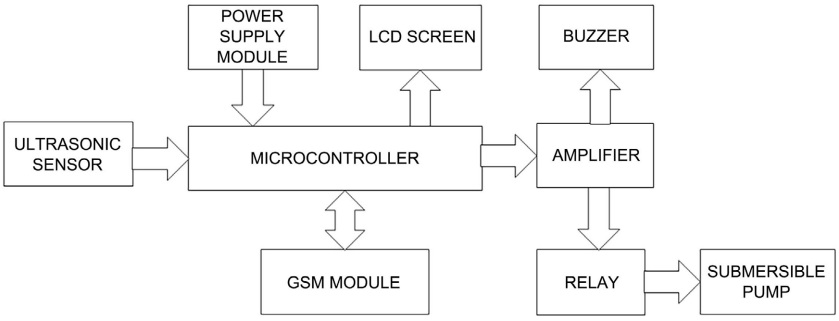

Figure 1. Block diagram of the project.

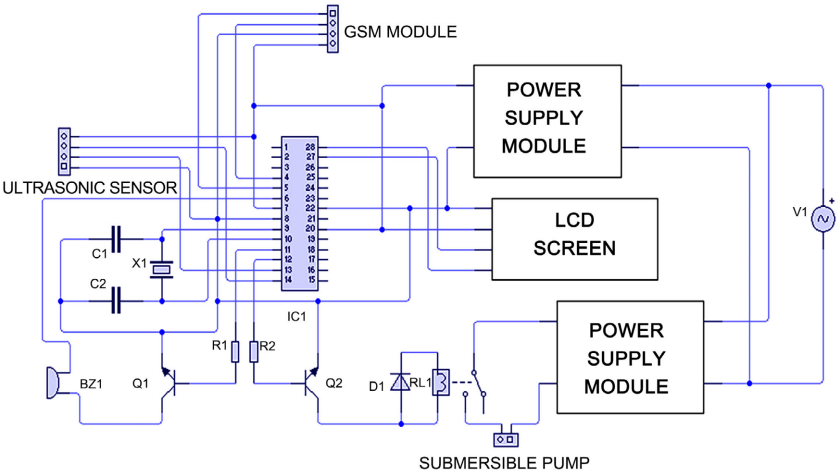

Figure 2. Circuit diagram of the project.

Therefore, the microcontroller will cause the ultrasonic sensor to send an ultrasonic sound wave through the echo pin of the sensor. This transmitted sound wave is reflected or bounced back to the receiver of the sensor by any obstacle (water in the tank) in the path of the sound wave. The microcontroller is going to calculate the time the sound wave was reflected back with respect to when it was transmitted. This will make the microcontroller know the distance or level of water in the tank. The microcontroller has been calibrated to the tank during programing. Therefore, when the tank is empty, the microcontroller will sound an alarm through the buzzer and activate the submersible pump through the relay. The microcontroller will display the level of water in the tank and the state of the pump through the LCD screen. When the tank gets full, the microcontroller cut power to the submersible pump through the relay. The submersible pump can be controlled through the GSM module by a text message as well. The text message received by the GSM module shall be interpreted by the microcontroller and either turn ON the submersible pump or turn OFF the submersible pump as may be warranted by the situation. The microcontroller then sends a feedback to the sender of the text message through the GSM module.

2.3. Construction Procedure

The circuit was designed on a personal computer using the software named li-

vewire. The circuit was first constructed on a breadboard; the programming was written using the Arduino IDE programing software and then uploaded unto the microcontroller. The components were then removed from the breadboard and then placed on a Vero board for soldering. The components were carefully connected and soldered together on a Vero board. The output from one of the power supplies was connected to the main circuit by connecting the positive output terminal of the power supply to the V_{cc} terminal of the GSM module together with the main circuit and the negative output terminal of the power supply was also connected to the ground terminal of the GSM module together with the main circuit as ground. The current circuit is connected based on the circuit diagram. The positive terminal of the other power supply connects to the common of the relay and the negative connected directly to the negative terminal of the submersible pump. The output from the power supply module is connected as the V_{cc} and ground of the microcontroller circuit. The LCD screen is soldered to the pins of the microcontroller. The output from the microcontroller was connected to the bases of the amplifier transistors (Q1 and Q2) through the series resistors (R1 and R2). The emitter of the transistors is connected to ground and the collector of Q1 connected to the buzzer, the collector of Q2 connected to the relay (RL1). The transmitter and receiver pins of the GSM module were connected to the corresponding pins of the microcontroller. The trigger pin and echo pin of the ultrasonic sensor were connected to the microcontroller pins. The construction was based on the circuit diagram provided. The circuit was packaged in a plastic box. The ultrasonic sensor was installed under the plastic box and holes were made on top of the water tank. The box was fitted onto the cover or top of the water tank. The circuit was attached to the box by the help of a glue gun and its sticks.

2.4. Hardware Components Employed

2.4.1. 5 VDC Power Supply Module

Switching regulated 5 VDC power supplies, sometimes referred to as SMPS power supplies, switchers, or switched mode power supplies, regulate the 5 VDC output voltage using a complex high frequency switching technique that employed pulse width modulation and feedback. Switching regulated power supplies also employed extensive Electromagnetic Interface Filter (EMI) filtering and shielding to attenuate both common and differential mode noise conducted to the line and load. Galvanic isolation was standard in 5 VDC switchers, affording the user input to output and output to ground isolation for maximum versatility. Switching regulated power supplies are highly efficient, small and lightweight, and are available in both AC-DC single and wide-adjust output and DC-DC configurations. Low Profile wide adjusts output switchers can be voltage or current regulated and are externally programmable.

This design uses to separate power supply module, a 5 VDC supplies power to the circuit including the GSM module and a 5 VDC supplies power to the submersible pump.

2.4.2. GSM Module

SIMCOM SIM800L V2.0 GSM/GPRS Module is a QUAD BAND GSM/GPRS module which compatible with Arduino. The module works to add both of GSM features (voice call or SMS) and GPRS features. The advantages of these modules are the VCC and TTL serial levels that have 5 V voltage, so you can directly connect it to Arduino or other minimum system with 5 V of voltage level. There were so many GPRS/GSM modules on the market which need to add 5 V regulator and level converter circuit, while SIM800L V.2 GSM/GPRS module already has a built-in regulator circuit and TTL level converter on the board.

SIM800L V2.0 GSM/GPRS Module have many specifications, you can check it below:

- TTL serial interface compatible with 3.3 V and 5 V Microcontrollers, compatible with Arduino.
- This SIM800L module has a set of TTL level serial interface, a set of power supply interface.
- Besides, there are a set of antenna interface on this module.
- Network support: Quad-Band 850/900/1800/1900 MHz, it can transmit Voice, SMS and data information with low power.
- VDD TTL UART interface The TTL UART serial interface, you can connect the MCU like 51 MCU or ARM or MSP430 directly. The pin of VDD is used to match voltage of the TTL.

The GSM module was used in this circuit to send and receive SMS as and when instructed.

2.4.3. Microcontroller (Atmega328)

The atmega328 is a single-chip microcontroller created by Atmel in the megaAVR family (later Microchip Technology acquired Atmel in 2016). It has a modified Harvard architecture 8-bit RISC processor core. The high-performance Microchip 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8 - 5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

The microcontroller was used as the brain of the circuit by comparing the current before the energy meter and the current after the energy meter.

2.4.4. Resistor

A resistor is an electronic component which offers opposition to the flow of electric current in a circuit. The resistors used in this circuit were used to limit the flow of current to the base of the amplifier transistor.

2.4.5. Transistor

A transistor is an electronic component that operates as a switch or as an amplifier. The transistors used in this circuit were used for the purpose of amplification.

Transistor (Q1) was used to amplify the signal from the microcontroller to sound the buzzer. Transistor (Q2) is used to amplify the signal to the relay.

2.4.6. Diode

A diode is an electronic component that allows current to flow in only one direction (D1). A diode has two terminals, namely, the anode and cathode. The diode was connected in a circuit in two ways. Either in the forward biased or reversed biased.

2.4.7. Buzzer

A buzzer is an electronic device or a transducer that converts electrical signal into sound. The buzzer is used in the circuit provides sound notification.

4.4.8. Liquid Crystal Display

The Liquid Crystal Display (LCD) is a type of flat panel display which uses liquid crystals in its primary form of operation. The LCD technology has been able to replay other display technologies. The function of the LCD screen is to convert the electrical signal from the microcontroller into numeric and alphabetical display. The LCD screen used in this design is to display the level of water in the water tank and display the state of the pump.

2.4.9. Relay

The relay is an electromagnetic device used to open or close a circuit. The relay has the coil component and the contact component. When the coil component of the relay is energized, it closes the open contact of the relay and opens the closed contact of the relay. The relay was used in this circuit to open and close the circuit of the submersible pump.

2.4.10. Ultrasonic Sensor

The ultrasonic sensor is a device that measures distance using ultrasound waves. The ultrasonic sensor consists of an ultrasound transmitter and an ultrasound receiver. The ultrasound transmitter generates and transmits ultrasound waves. The ultrasound receiver also receives ultrasound waves. The ultrasonic sensor is employed in the circuit to determine the level of water in the water tank.

3. Result

This chapter presents the testing and results of the project.

Before the system was completely connected to the power source, series of test were carried out from the power supply through the ultrasonic sensor to the GSM module. Again, from the power supply through the microcontroller to the buzzer, LCD screen and then to the submersible pump. Connections between the various sections are also checked. Tests like the continuity test and the polar-

ity test were performed to ensure that there is no short circuit in the system; also, there are no breaks or no joint in the connections. The polarity test was done to ensure that all positives are connected to the positive source and all negatives are connected to the negative source. After the series of checking were carried out, we then powered the system and the results were positive. The LCD screen display was good, the ultrasonic sensor could read the level of water in the water tank. The microcontroller was able to compare codes and control the relay. The submersible pump was able to pump water and the GSM module was successful in sending and receiving SMS.

The design of submersible pump control using GSM system consisting of an ATmega328 microcontroller, an ultrasonic sensor, GSM module, power supply module, diodes, relay, transistors, buzzer, etc. The power supplied 5 VDC energy and the 12 VDC energy. The 5 VDC was able to supply the microcontroller circuit and the GSM module and the 12 VDC was able to supply the submersible pump.

The main function of the ultrasonic sensor which is to read the level of water in the water tank was successful. The microcontroller was able to communicate with the ultrasonic sensor. The microcontroller was able to process the information from the ultrasonic sensor and take action. The LCD screen was able to display the instructed information. Figures 3-5 present the pictorial view of the test results of the project.

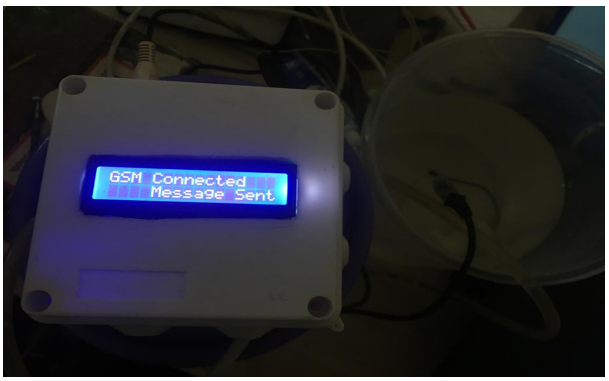

Figure 3. Indication of a GSM module being connected.

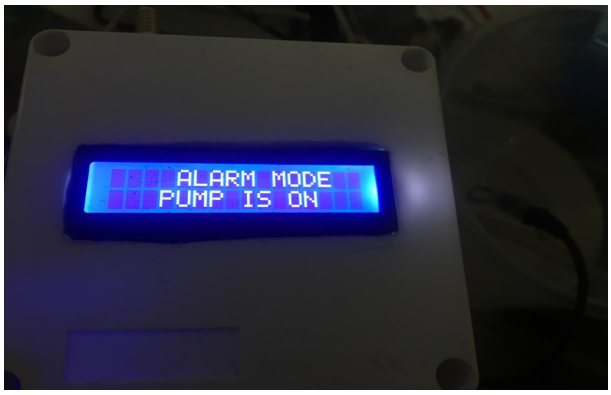

Figure 4. Indication of water tank being empty.

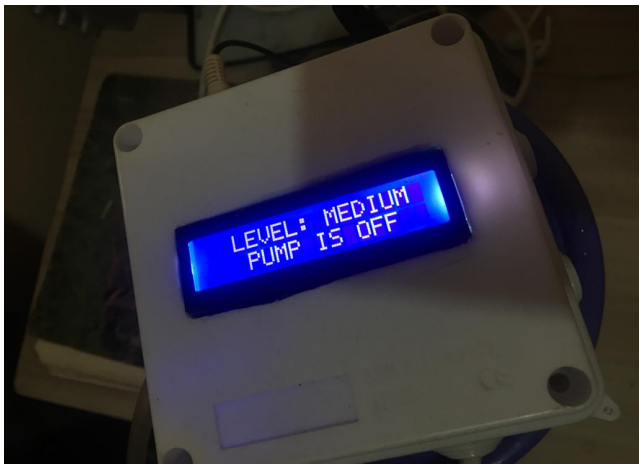

Figure 5. Indication of the submersible pump being OFF.

4. Discussion

The design of the water pumping system in this project considered the manual and automatic operation of a submersible pump. The system uses an ultrasonic sensor to automatically control the submersible pump by measuring the distance of water from the top direction of the water tank to the bottom of the water tank. The system again uses a GSM module to manually operate the submersible pump. The discussion of the project result is in two parts. The first part talks about the automatic control and the second part talks about the manual control mode.

In the automatic control, when the circuit was initially connected to the power supply, the ultrasonic sensor reads the level of water in the water tank. When the tank is empty, the submersible pump is activated to start pumping water into the water tank. When the water in the water tank was full, the submersible pump was deactivated. The LCD screen displayed the level of water in the water tank.

In the manual control, when the circuit was initially connected to power supply, the GSM module went into the initializing mode. The "remote start" SMS is received by the GSM module, the GSM module communicates with the microcontroller to start the submersible pump. After the activation of the submersible pump, the GSM module sends SMS to notify the user that the pump is activated. When "remote stop" SMS was received by the GSM module, the GSM module communicated with the microcontroller to stop the submersible pump. After the deactivation of the submersible pump, the GSM module sends SMS to notify the user that the pump is deactivated.

Table 1 presents the cost analysis of the construction of the design. Based on the item description, specification and quantity, a total amount of GH¢ 1000.00 is needed to implement the design. 10% (GH¢ 100.00) and 5% (GH¢ 50.00) of the total amount are allocated for preliminaries and contingency, respectively. Therefore, for the successful implementation of the research, a sum total of GH¢ 1150.00 is required (Table 1).

Table 1. Cost analysis of components used.

Sn	Items Description	Specification	Quantity	Unit Price GH¢	Total Cost GH¢
1	Power Supply Module	12 VDC/2amps 5 VDC/1amps	1 1	50.00 50.00	100.00
2	3 Pin Plug	13 Amps	1	10.00	10.00
3	Diodes	1n4001	2	1.00	2.00
4	Capacitors	22 pf	2	2.00	4.00
5	Transistors	C 1815	2	5.00	10.00
6	Resistors	330 Ω	2	1.00	2.00
7	Microcontroller	Atmega328	1	250.00	250.00
8	Relay	Single Pole Single Throw	1	10.00	10.00
9	LCD Display	16 × 2	1	30.00	30.00
10	GSM Module	Sim800lv2	1	100.00	100.00
11	Buzzer	Passive 5VDC	1	7.00	7.00
12	Sensor	Ultrasonic	1	50.00	50.00
13	Crystal Oscillator	16 MHz	1	15.00	15.00
14	Submersible Pump	12 VDC	1	100.00	100.00
15	Connecting Wires	0. 5 mm^2 1 mm^2	1 Coil 2 Coil	15.00 20.00	15.00 40.00
16	Vero Board	Small Size	1	5.00	5.00
17	Soldering Wire	1.2 Mm Rosin Core	1	50.00	50.00
18	Packaging	-	-	200.00	200.00
Total Amount (GH¢)		**1000.00**			
Preliminaries, 10% (GH¢)		100.00			
Contingency, 5% (GH¢)		50.00			
Sum Total Amount % (GH¢)		**1150.00**			

5. Conclusion

The aim of this research is to design and construct a system that uses a GSM module to start and stop a submersible pump. The constructed work employs an Atmega328 microcontroller, power supplies, an ultrasonic sensor, a relay module, a GSM module and a submersible water pump. The system employs SMS to manually control the submersible pump and employs an ultrasonic sensor to automatically control the submersible pump. The ultrasonic sensor senses the level of water in the water tank. The GSM module also receives SMS and sends the signal to the microcontroller. The microcontroller will activate or deactivate the relay controlling the pump based on the signal from the ultrasonic sensor. The microcontroller again provides the information or characters displayed by

the LCD screen and the GSM module. The LCD screen displays the level of water in the water tank and displays the state of the pump. The GSM sends a notification message. The system also employs a buzzer that provides a sound output when the water tank is empty. The constructed work will help reduce power and water wastage in most institutions. More significantly, the research has shown that ultrasonic sensors can be used to determine the level of water in a water tank and a GSM module can be used to control a submersible pump. If used on a large scale, the device can provide major contribution to the conservation of water for both present and future generations.

6. Recommendation

It is recommended that the system be interfaced with a radio frequency module to reduce the operation cost of the project.

Authors' Contributions

The work was carried out by the collaborative efforts of all authors. Specifically, authors WA and DBKA conceived the idea and developed the study design. Authors AE and KN conducted the literature search, organized and developed the methodological framework. WA and AE engaged in the programming and developed the GSM technology-based android application, while WBKA and KN developed the remote control for implementation. All authors engaged in the device testing and analysis, and wrote the first and final drafts of the manuscript. All authors read through the final manuscript before submitting it to the journal.

Acknowledgements

As the authors of this manuscript, we express our gratitude to Mr. John Awuah Addor of the Department of Mathematics and Statistics of Takoradi Technical University for his editing assistance including all efforts in ensuring the success of this publication. Sir, your inputs are highly appreciated and acknowledged.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Wang, X.Z., *et al.* (2010) Efficient Registration of Optical and IR Images for Automatic Plant Water Stress Assessment. *Computers and Electronics in Agriculture*, **74**, 230-237. https://doi.org/10.1016/j.compag.2010.08.004

[2] Shen, J., *et al.* (2007) School of Electric and Electronic Engineering: A Remote Measurement and Control System for Greenhouse Based on GSM-SMS. *IEEE 8th International Conference on Electronic Measurement and Instrument*, Xi'an, 16-18 August 2007, 45-82. https://doi.org/10.1109/ICEMI.2007.4350806

[3] Ulaganathan, G., Periasamy, A. and Murugan, E. (2014) Embedded System Based Submersible Motor Control for Agricultural Irrigation Using GSM and to Prevent It

against over Loading, Dry Running and Single Phasing Automatically. *International Journal of Scientific Research and Development*, **2**, 454-456.

[4] Galgalikar, M.M. (2010) Real-Time Automization of Agricultural Environment for Social Modernization of Indian Agricultural System. 2010 *The 2nd International Conference on Computer and Automation Engineering*, Singapore, 26-28 February 2010, 286-288. https://doi.org/10.1109/ICCAE.2010.5451949

[5] Chavez, J.L., Francis, J., Pierce, T.E. and Robert, G.E. (2009) A Remote Irrigation Monitoring and Control System (RIMCS) for Continuous Move Systems Part A: Description and Development. *Precision Agriculture*, **11**, 1-10. https://doi.org/10.1007/s11119-009-9109-1

[6] Manish, G. and Dnyaneshwar, N.W. (2013) Automated Intelligent Wireless Drip Irrigation Using Linear Programming, Proceedings of the Special Interest Group on Management of Data Record. *International Journal of Advanced Research in Computer Engineering & Technology*, **2**, 1-5.

[7] Jyothipriya, A.N. and Saravanabava, T.P. (2013) Design of Embedded Systems for Drip Irrigation Automation. *International Journal of Engineering Science Invention*, **2**, 34-37.

[8] Sukhjit, S. and Neha, S. (2012) Research Paper on Drip Irrigation Management Using Wireless Sensors. *International Journal of Computer Networks and Wireless Communications*, **2**, 461-464.

[9] Mahir, D. and Semih, O. (2011) A Wireless Application of Drip Irrigation Automation Supported by Soil Moisture Sensors. *Scientific Research and Essays*, **6**, 1573-1582. https://www.arduino.cc/en/Guide/Introduction

[10] Divya, V. and Umamakeswari, A. (2013) Smart Irrigation Technique Using Vocal Commands. *International Journal of Engineering and Technology* (*IJET*), **5**, 391-397.

[11] Yoseop, J.K., Robert, G.E. and William, M.I. (2008) Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network. *IEEE Transaction on Instrumentation and Measurement*, **57**, 1379-1387. https://doi.org/10.1109/TIM.2008.917198

[12] Pavithra, D.S. and Srinath, M.S. (2014) GSM Based Automatic Irrigation Control System for Efficient Use of Resources and Crop Planning by Using an Android Mobile. *IOSR Journal of Mechanical and Civil Engineering* (*IOSR-JMCE*), **11**, 49-55.

[13] Christos, G., Berdan, O. and Achilles, K. (2014) Automated Zone-Specific Irrigation with Wireless Sensor/Actuator Network and Adaptable Decision Support. *IEEE Transaction on Computers and Electronic in Agriculture*, **105**, 20-33. https://doi.org/10.1016/j.compag.2014.03.012

[14] Singh, B., Rajeev, R. and Luthra, S.K. (2015) Design and Implementation of GSM Based Fertigation System. *International Journal of Research*, **2**, 472-477.

[15] Tan, H.G.R., Lee, C.H. and Mok, V.H. (2007) Automatic Power Meter Reading System Using GSM Network. 8*th International Power Engineering Conference* (*IPEC*), Singapore, 3-6 December 2007, 465-469.