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Design and Implementation of a GSM Based Tank Water Level Control System

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Abstract: *This research work is all about describing and building a system capable of controlling the water level in an overhead or underground tank using a GSM phone by ensuring water does not start overflowing from the tank before the pump machine is deactivated. Water wastage as a result of overflow from the tank during extraction from the ground using a water pump has become a common scene in major cities of the world especially in developing nations. Considering that this ground water being wasted accounts for thirty percent of the world's fresh water makes this problem attention deserving. In this research, a prototype system has been designed and built that involves notification on the state of the water level in the tank being sent to a dedicated mobile line. The system through a microcontroller turns on the pump machine when the water level is low by receiving a command from the user handset. In a condition when the water level got full, the microcontroller first turned off the pump machine and then sent a notification to the user that the tank was full and turned off. The idea of making this system operate in such a way is to ensure that the user have the power to decide if water is required in the tank at any point in time by choosing either to respond or ignore the SMS notification when water level is low and also being less attentive to monitoring when the water level is full as the system will automatically turn of the pump machine in this case. This research piece will not only save energy (electrical power) but also guarantee our environment is free from artificial flooding and erosion thereby ensuring a sanitized environment.*

***Keywords*:** GSM phone, microcontroller, pump machine, water level, water wastage

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I. INTRODUCTION

Water wastage has become a major challenge in many countries in the world especially developing nations of the world. The United Nations water-statistics shows that developing nations waste about seventy percent of useful water [14], [16]. The fact that this water being wasted often comes from deep down underground which accounts for about thirty percent of the world's fresh water [16] makes this wastage more troubling. This problem of water overflowing from storage tanks during transmission from the ground has garnered a lot of attentions so much so that engineers and scientist have proposed, designed and built several systems with the goal of tackling it. In curbing this negative trend, systems have been designed where a simple buzzer was used as a notification to the user whenever the water level is low or full so the pump machine can manually be turn ON or OFF [1], [11], [12]. Also, systems that involve the microcontroller doing the entire task of interpreting the water level as well as controlling the water pump [6], [9] also exist. It had gotten to a point where even governments of nations has implemented policies ranging from fines to detention for offenders who fail to turn of water pumps thereby leading to overflow.

The GSM one of the major devices used in this system which stands for Global System for Mobile Communication is a digital mobile telephony system that is widely used in the world today and hence has become a global standard for mobile communication. In this research, a GSM handset was used as the communicating tool with the microcontroller which is the hub of the entire system. This established communication pattern was made possible with the help a quad band GSM/GPRS module. With a SIM (Subscriber Identification Module) card slot present in the GSM module and then the user's mobile phone, two SIM cards – one of which is the dedicated mobile line ensured that the microcontroller and the user communicated effectively. A form of language called the Attention Commands or AT commands for short ensures this communication of the microcontroller (via the GSM module) with the mobile phone. In this research, a prototype system was developed that sends notification to a mobile line when the water level in the tank is low and full. The system was built in such a way that user can give a command for the microcontroller to turn on the water pump when low. When the water tank is full, the microcontroller turned off the pump machine and notified the user.

II. LITERATURE SURVEY

Controlling the water level in the storage tank during transmission from the ground using a pumping machine can either be done manually whereby the user turns ON/OFF the machine by hand or by using an automatic or programmed approach whereby a controller does that. Several designs exist whereby the manual approach which involves a sensor placed at various levels in the tank and an alarm is used to notify users upon water reaching these levels [1], [12]. Even though a microcontroller was being used, it only interpreted result of the sensor to decide the water level and when the buzzer should be sounded and not for controlling the pump machine. There also are systems where water sensor(which most times are just pair of wires which conducts current upon contact with water) were used with a microcontroller such that the microcontrollers turns on and off the pump machine when the water level is below or above threshold[6], [9]. Such systems ensure there must always be water in the tank as long as there is power supply. This mean there is no room for the user to decide on not having water in the tank at a particular point in time if for example an urgent maintenance requires the tank empty. There also exist system designs that uses complete software like xigbee [10] and NI labview [13] in attempting to solve this problem Other systems exist which uses a GSM phone [2], [4], [5], [7] an RF system [11], or even a wireless/Wifi system as a medium to instruct the microcontroller to turn on or off the pumping machine[10]. This creates an avenue for the user to be the major deciding factor in whether or not water should be in the tank.

In the course of this research, it was observed that though numerous water level control systems had been dome using GSM phone/ GSM /GPRS modules. Yet in some of the prototype systems, the phones acts majorly for notification purpose only [7] without full implementation of the AT commands to allow the phones give commands to the microcontroller to turn on the water pump hence these systems are simply monitoring without controlling. In this research, a full implementation of the necessary AT commands ensures that the built prototype system could receive a command from the dedicated mobile line to turn on the water pump when the water level in the tank was low. and also turned off the pump when water level was full before sending notification to the user.

III. PROBLEM STATEMENT

1. Developing nations waste about seventy percent of useful water and this has been identified as one of the major causes of water scarcity in major cities in the world [14].
2. With deep underground water accounting for thirty percent of the world's fresh water, its wastage is totally unacceptable and even more so after it has successfully been extracted from the ground where wastage now becomes associated with not just the water but also the power used [14].
3. Water overflowing from overhead and underground tanks during transmission for storage has become a common scene even when it messes up our surrounding by wearing out the top soil and brings about accumulation of water in a particular spot which can be seen as artificial flooding which is a breeding ground for mosquitoes and then malaria in Africa [6], [16].

3.1 System overview

This motivation for this research work was to develop a system prototype that uses a very popular device such as the GSM handset. With basically an average of one member in a family having a GSM phone, this system does perform its task. Unlike a RF Remote controller where the frequency bandwidth is limited, with the GSM module (SIM 800 quad band) used, the mobile phone of the user could always be reached as long as it is on. The idea of having the user send a command from wherever he may be for the microcontroller to turn on the pump machine rather than having the microcontroller just do that without prior command to is to ensure that the user become the decider. This will be helpful if the user wants to carry out an unscheduled maintenance on the tank and also if the user was to be away for a period of time and wouldn't want water in the tank during this period. The microcontroller turning off the water pump when the tank is full without waiting for a command to do so from the user is to ensure that should the user not respond in time, the main goal of the research will not be defeated. With the prototype system capable of detecting the various levels of water in the tank and also controlling the state of the water pump, the system could be said to be performing tasks of monitoring and controlling. The sensing was achieved using pair of wires by simply capitalizing on the conductive capability when water comes in contact with it when once a voltage is applied to a single one first.

IV. SYSTEM ARCHITECTURE AND OPERATIONAL FRAMEWORK

The various sections and major components required in this research work to achieve building the prototype system is represented below in a block diagram.

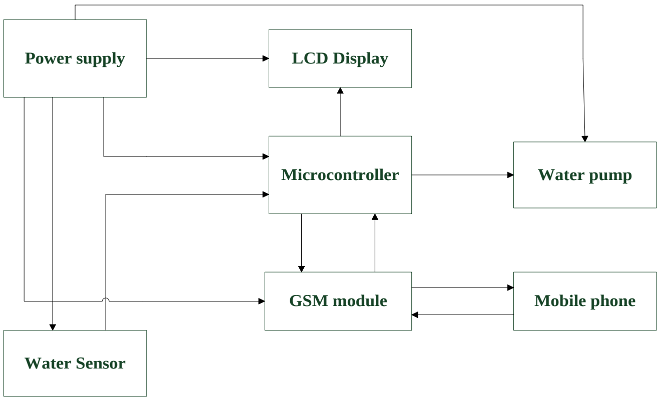

Figure 1: Block Diagram of the System Architecture

4.1 Components Selection

In selecting the components for the various sections/unit in building the prototype system, a lot of factors were considered. These decisions were made based on the availability of materials to work with, the size of the components as well as how it fits in accomplishing the task at hand. For instance, a PIC microcontroller was used because of the readily availability of its electronic programmer. For the GSM module, efficiency in terms of the frequency range as well as availability and ease of implementing was the major considerations. With a 12v submersible dc motor pump used in building the prototype system, factors, like ascertaining the voltage ratings as well as current ratings of all the components were necessary. Finally, the cost as well as size of the components was considered. The size especially was necessary as the prototype was built on a Printed Circuit Board. The several component unit sections are as follows:

1. Power Supply Unit
2. DC pump machine unit
3. Sensing unit
4. General system unit

4.1.1 Power Supply Unit

This section deals with all the power required by every device and component used in realizing the prototype design except for the submersible dc pump machine. A battery of 12v acted as the power source. This 12v passed into the circuit consisting of two zener rectifier diode (D1and D9) connected in parallel whose main aim is to ensure current flows only in the forward direction hence protecting the system [15]. The output of this is still a 12volt. However, the microcontroller, GSM module and the LCD all requires 5v hence the need for a 5v voltage regulator. The choice of two 5v voltage regulator connected in parallel was to ensure better output current as the GSM module required that. A 1µF polyester capacitor was used to filter out pulsating voltages. The GSM module requires a voltage of range 3.4v to 4.6v yet we had an output of 5v. To achieve this, four diodes with two each(D3, D4 and D5, D8) connected in series before being joined in parallel was used [15]. This was possible as the diodes had a voltage drop of 0.4v each. This yielded a final voltage of 4.2v which was required by the GSM module. The power supply for the various components excluding the dc motor pump is shown in fig 2 below

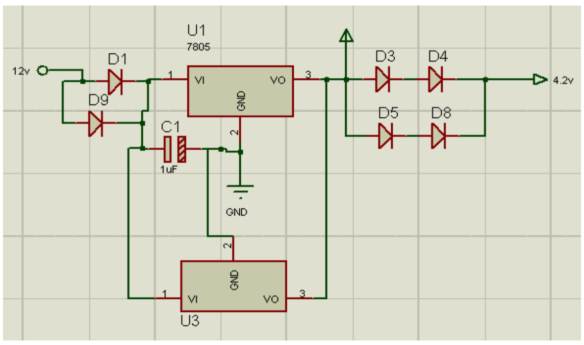

Fig 2: Circuit diagram of system's power supply unit

4.1.1 DC pump machine unit

The 12v submersible dc motor pump used is no doubt an electromechanical device. And to turn it on/ off will require an electromechanical switch. To be able to turn a 12v motor from a 5v PIC16F877 microcontroller, both an electronic switch (in this case an NPN BC547 transistor) and an electromechanical switch had to be used together. From fig 3, a relay which is an electromechanical device acted as a switch. It is by standard usually open. Since the intention of this work was to use a microcontroller to turn on and off the dc pump, it was necessary to incorporate a transistor which normally does act as an electronic switch. With the emitter grounded, whenever the base which was connected to pin 15 (labeled PCTRL) of the microcontroller which enable it to control the power became +5v instead of 0v its switches on the microcontroller and then the voltage from the emitter goes all the way up to the coil of the relay. Since one end of the relay was already connected to a 12v battery (positive flow), the relay circuit was closed and then the dc motor powered up. When a 0v got into the base of the transistor from the microcontroller, the relay switches off the motor pump.

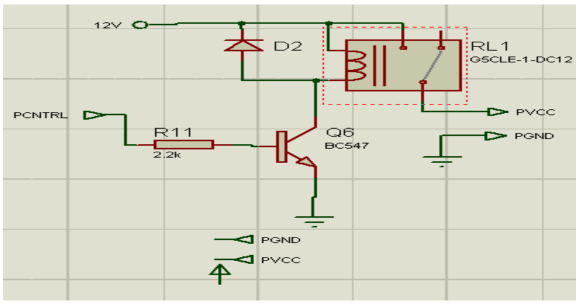

Fig 3: circuit diagram of the operation of the dc motor pump

4.1.3 General System Unit

In achieving this work, implementation of the 16 by2 HD44780 LCD, the SIM800 quad band GSM module and the PIC16F877 microcontroller was first done on a proteus simulator before the building on a PCB. In sensing the water level, the prototype system simply made use of a pairs of wires at four levels (low: 25 percent, mid1: 50 percent, mid2: 75 percent and full: 100 percent). These four pairs of wires placed at four levels in the tank were also attached to the bases of the four transistors in an obvious forward bias arrangement (that is the emitter N was connected to negative), with a fifth wire connected to a 5v. An NPN (BC547) transistor was used for this work. With the emitter grounded and the collector voltage forces to a positive state of 5v, the base which was dipped at specific levels in the tank switched on the transistors when it came in contact with water. When this happened, the negative from the emitter flows through to the collector and activates the LOW (pin2 RA0/AN0) which was labeled low. The same happened for the activation of HALF (which was labeled mid1), THREE-QUARTER (which was labeled mid2) as well as the HIGH as shown in fig 4 and 5. The 10kn resistors R4, R5, R6 and R7 where used to protect the transistor whenever it is switched on by reducing the current that will get to the forced 5v state.

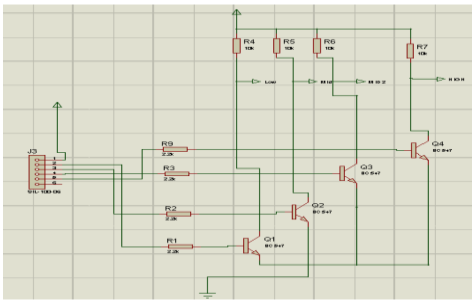

Fig 4: circuit of the sensing unit

Water must be in contact with the lowest wire probe else the tank water level will be deemed low. when the tank is low, the microcontroller upon receiving a command from the mobile user turns on the pump. The topmost wire probe in the tank signifies full whenever it comes in contact with water. When this happens, the microcontroller turns the water pump off before sending notification to the GSM phone. The sim800 GSM module which is a 14 Pin communication tool had is pin 4 and 5 (Rx and Tx) connected to Tx and Rx (pin 25 and 26 of the microcontroller) respectively. While the Vcc is connected to the 4.2v output of the power supply unit discussed earlier, the GND is grounded. For the LCD, the connection where made on its crucial pins starting from rs to D7 to its very equivalent in the microcontroller (pins 33 to 38). Below in Fig 5 is a general circuit representation of the system designed in proteus in net form

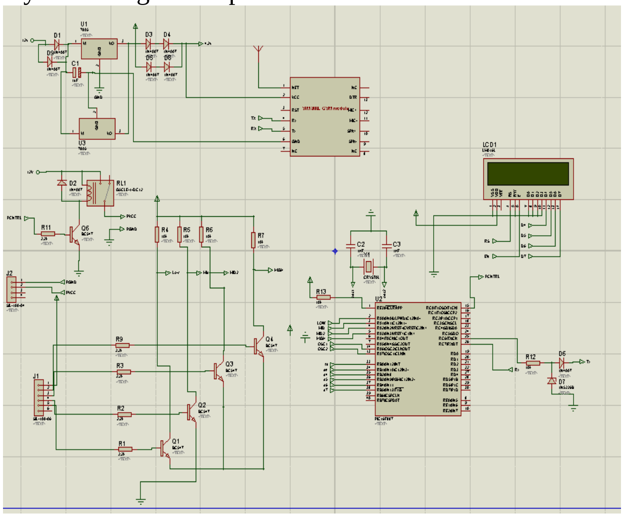

Fig 5: General circuit representation of the system

4.2 The System Software

In realizing this system, a particular aspect which is the programming of the microcontroller was central to achieving the goal of the project. The program was written in C language and simulated in a microC simulator as well as embedding into a microcontroller using a micromprog programmer. The actual goal was broken down and approached in a step by step algorithm to develop the program. Shown below in Fig 6 is a flowchart describing the flow of execution of the entire program.

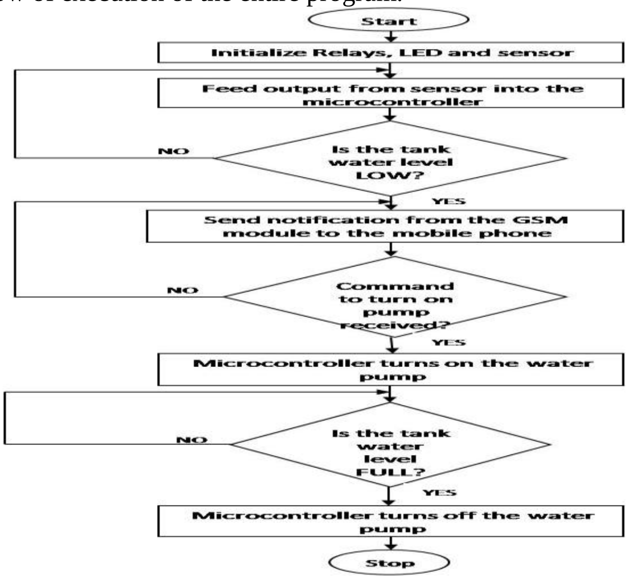

Fig 6: flow chart representation of the system.

4.3 Test and Results

Testing of the various components used to ensure the acclaimed voltage and current rating was ascertained was carried out. Other than the results from proteus simulation, the prototype system also did yield an expected result as the system was able to determine four levels of water in a 5 litres container, displayed it on an LCD, communicated to a dedicated mobile line when the container was low and full, received command from the mobile phone when water level was low and then through the microcontroller turned the water pump on and off when required. Below is a pictorial view of the prototype result.

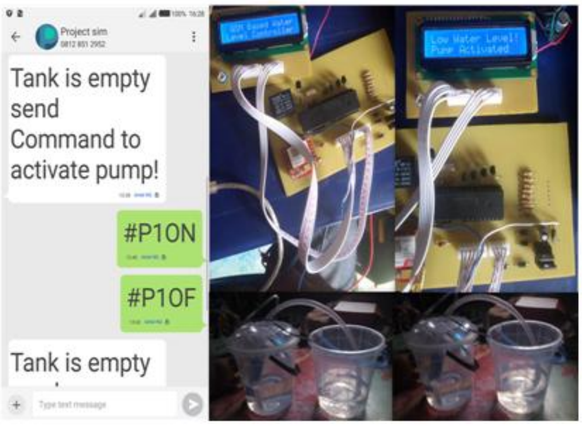

Fig 7: pictorial representation of results

V. CONCLUSION

Water overflowing from storage tanks which not only keep the environment untidy but also wastes useful water and energy can be drastically reduced by the implementation of the approached used in this research. This research not only attempts to provide a solution to the problem of water overflowing from tank during pumping from the ground, but does so using a very common but powerful device in the mobile phone while making the user the major decision maker. The efficiency of the system is also enhanced seeing that the microcontroller turns off the pump machine when tank is full as this is the conventional thing to do before notifying the user.

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Samuel Chinedu Irubor was born in Edo state, Nigeria. He obtained a Bachelor of Engineering (B.ENG) degree in Computer Engineering from the University of Benin, Nigeria in 2012. He also received a Masters degree in Computer Engineering from the same University. He has years of experience teaching Computer engineering courses in a Polytechnic in Nigeria. His research interest is in Embedded Systems and Signal Processing.

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