Microcontroller-Based Automatic Water Pump Controller with Real-Time Pumping Schedule and Time Display

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Abstract- ***The need for a better water management system, as well as the need for the application of the modern technological trend, is what lead to the development of microcontroller-based automatic water pump controller. The use of microcontrollers, electrical machines, solar systems, wireless sensors and other associated components in the design of this system, forms the basis of the methods adopted to accomplish this task. The developed system comprises of two units namely; water monitoring unit and the pump controller unit. In this work, the water level monitoring unit consisting of ultrasonic sensor, RF transmitter, Arduino and solar system is mounted on the cover of the overhead tank. The RF module transmitter enables wireless communication between the water level control unit and the water pump control unit. To ensure real-time monitoring, this system is charged by a solar system. The ultrasonic sensor, which works on the principle of sonar (sound navigation and ranging), monitors the water level in the upper tank so that, at a preset minimum threshold that is 0% or 25%, the signal is transmitted to the pump control unit which activates the pumping machine. When the tank is filled to the maximum threshold (100%), the system automatically shuts down the pumping machine. Between these two established limits whatever level the water reaches, the LCD will display the output. On a second note, this system also has a peripheral keypad that is used to schedule pumping according to the real time of the day. This system also displays real time of the day on the LCD at all time. The design was simulated using software (proteus 8) and implemented using hardware components. This design reduces energy consumption in the office or home, eliminates overflow and water dissipation, which are the main shortcomings of the manually operated water pump system.***

Indexed Terms- ***Arduino, Microcontroller, Monitoring, RF-Transmitter, Ultrasonic sensor, Water Level Sensor, Water Pumping, Wireless.***

I. INTRODUCTION

Water is essential in life. It is inevitably important for human existence. Water is commonly used for agriculture, industry and for domestic purposes. The problem with the availability and use of water varies from poor source of good water to inefficient utilization [1]. However, the efficient use of water and its monitoring during pumping are potential constraints for industries and the home. Before the modern use of the elevated tank in the buildings, the buckets and gallons were the only means used to store water after being extracted from the stream or well. The evolution in water management has led to the production of elevated tanks as a medium of water reservoir. Today, in all homes, elevated tanks are used to store water, so it is readily available. As the need for a continuous supply of food becomes a major concern, farmers began to adopt an irrigation farming system that ensures that plants are constantly receiving water even in the dry season. Initially, they use the water-can to manually water the plants every morning and afternoon, as the case may be. Originally, stream and river were their only source of water, but as the tendency in the use of the overhead tank arose, they gradually adopted it, reducing the hectic routine of visiting the stream every time they want to water the plants. The increase in the use of elevated tanks resulted to the invention of a water pumping machine that would pump the water from the well to the upper tank, making it readily available to the user.

Today, we have a system of automated toilets that automatically flush and fill the closets with water. This automation has been adopted in the water pumping machine. Conventional water pump machines are only manually operated with a huge monitoring effort to

determine the water level before it can be refilled. Most of the time, due to negligence, we may not know until all the water in the tank has dissipated, leading to downtime in the case of an industrial environment [2]. The evolution in the water management system and the need for a more convenient and reliable system has continued to pose a great challenge for innovative engineers. However, far from the conventional water pumping machine, there has been a slight change in the system. Today, in most industries, there are systems that indicates the water level in the overhead tank for onsite evaluation. In order to eliminate downtime in industries, this automatic water pump controller would have some measure of artificial intelligence built into the system, thus solving those big challenges. If implemented in buildings, it will lead to good water management due to its automation. It has keypad that enables the user schedule a daily routine pumping say every 7:30am weekdays. It is designed to overcome the shortcomings of the conventional water pumping machine through its automated function. Not only are manual pumping machines strenuous to operate, there is always an overflow of the overhead tank during pumping, which leads to waste of water. Water dissipation especially in offices and industrial environments, often cause downtime of normal work activities, as water is required for routine daily office cleaning. This work addresses the dissipation of water in the overhead tank and its rippled effects.

II. REVIEW OF RELATED WORK

Throughout history, people have devised systems to make water supply to their communities and homes more convenient. As the need for water availability increased, a water storage tank was invented that is used to provide water storage for use in many applications [3].

Today, the use of overhead tanks has been adopted by almost all homes and factories. These tanks are refilled by the use of an electric pumping machine, but they present another challenge of overflow and water dissipation Many electronic designs have been built to solve the problem of water overflow in the overhead tank. A water level alarm circuit design consisting of 555 timer Integrated Circuit was designed to indicate the water level in the overhead tanks. The circuit produced a clear sound when the water level reaches its level point. According to the design, if the water does not reach the level of the probe, the astable multivibrator of the circuit will not produce any oscillation. Therefore, no sound will be produced by the circuit. If the water level reaches the probe, then current flows in the water, therefore, the sound is produced by the circuit. Therefore, an astable multivibrator produces an oscillation and the buzzer will produce a beep to indicate that the water level has reached a particular level [4].

Another system was developed based on the fact that water conducts electricity. As the water level rises or falls, the detection probes and the control circuit detect the same and the signals were used to turn the pump motor ON or OFF, as the case may be. The probe placed in the upper tank sends signal to the NE555 IC controller to act accordingly [5].

Another designer developed a system that could monitor and initiate pumping using Ultrasonic sensor [6]. Assuming the tank is empty when the system is switched ON, the microcontroller sends a pulse of 10 μs to the trigger pin of the sensor. The sensor then transmit an 8 x 40 KHz sound wave to enable the echo pin, the reflected sound wave is receive to disable the echo pin. The time it takes to transmit and receive the sound wave is used by the microcontroller to calculate the distance. If the distance calculated is less than or equal to the preset minimum distance, the pumping machine is automatically switched ON and the process continues.

However, the related works done in the past for a better water management system have some shortcomings which this work will address. The MC14066 IC that was used in one of the designs lacks the programmable characteristics of a microcontroller and is difficult to use in designs. Another design that was made with a metal probe has a long-standing defect due to oxidation and contamination of the water, posing further health concerns in trying to solve an existing problem. These shortfalls highlighted in previous research work would be solved in this work by developing a system that would have no contact with the water using ultrasonic sensor.

III. METHODOLOGY

The design and construction of the microcontroller-based automatic water pump controller takes several planned steps that were necessary to achieve a good and reliable monitoring system. This work is achieved using prototype method, the microcontroller is programmed using the basic C programming language and this would help control the actions of the integrated circuits. Once the microcontroller receives the signal from the sensors, it processes them and sends the processed signal to the LCD screen and the pump machine controller. The pump controller receives an RF signal from the water control unit and acts accordingly. This system has a default pump time of 7:30 am that can be reconfigured using the matrix keyboard. Without time setting, when the water is at 25%, it is displayed on the LCD screen and the pump machine is activated to fill the tank to 100%. Real time of the day is also constantly displayed on the LCD of the controller.

The water level monitoring section is charged by the solar system; of course, this allows constant monitoring. The power capacity is 2x4.2v dc, which means that the system lasts for days without severe sun rays. The transmitter is radio frequency, RF transmitter to avoid any form of interference. The best way to summarize this process is a block diagram. The following diagram is classified into the basic blocks of the system to give a clearer explanation of the working principle of the system.

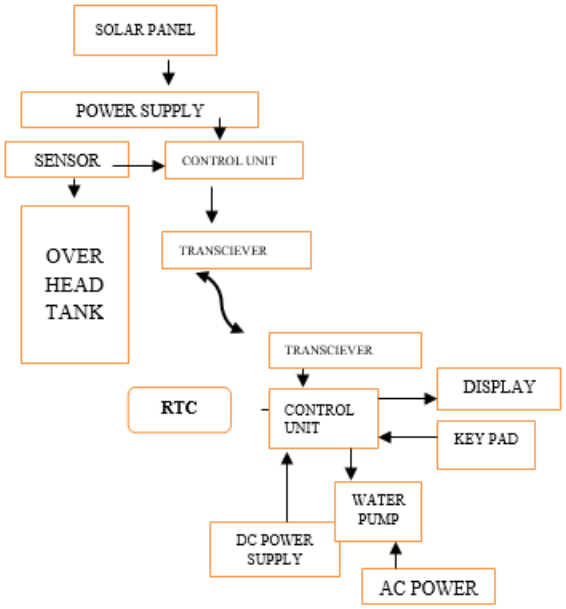

Fig.1 Block Diagram of the system.

IV. UNIT DESCRIPTION

a. Solar Panel

The solar panel is used to convert the sun's rays into electrical energy. Electric power is supplied to the power bank and this power bank is the power source for the water level monitoring system. The reason for the solar panel is to maintain a constant power supply to the monitoring system installed in the upper tank for monitoring the water level.

b. The Control Unit

The control unit is the board that contains the microcontroller, the Crystal oscillator, and the pull-up and pull-down resistors. The microcontroller unit serves as the brain box of the system. The microcontroller used here is ATMEGA328. ATMEGA328 is used in this design considering its wide application, flexibility, and programmability. The crystal oscillator helps Arduino deal with timing issues. The pull-up and pull-down resistors in this system is to ensure a known state for the signal. The microcontroller momentarily receives signals from the sonar sensor and transmits them to the pump control circuit through a transceiver.

c. The Transceiver

It is a device that can send or receive radio waves. The transceiver used is in this design is nRF24L01. With

the help of the transceiver both the Arduino in the water control unit and the one embedded in the monitoring circuit can communicate with each other wirelessly over a distance. The NRF24L transceiver module is designed to operate in the worldwide 2.4 GHz ISM frequency band and uses GFSK modulation for data transmission. The data transfer rate can be 250 kbps, 1 Mbps and 2 Mbps. In this work, the data transfer rate is 2Mbps. The function of this module in this system is to allow communication between the water level monitoring system and the water pump control system.

d. Ultrasonic Sensor

The ultrasonic sensor uses the sound navigation and ranging principle (sonar) by sending an ultrasonic signal through its transmitter and receiving it again through the receiver. The time period between transmission and reception is used to calculate the distance between the overhead tank cover where the sensor is mounted and the water level in the tank. Unlike metallic probe that have direct contact with the water, ultrasonic sensor does not thus, no water contamination.

e. The Real Time Clock (RTC)

RTC, which stands for Real Time Clock, is used to keep time. The RTC maintains the time for the microcontroller which serves as a reference to allow the microcontroller determine the precise time and date. With this, the microcontroller would initiate pumping at a predetermined time.

f. The matrix keypad

The keyboard is an input device connected to the microcontroller used to send information to the microcontroller. This peripheral is used to modify the pumping period

g. The LCD Display

The LCD (Liquid Crystal Display) shows the water level and also the current time. It serves as a user interface that enables the user to modify the pump schedule.

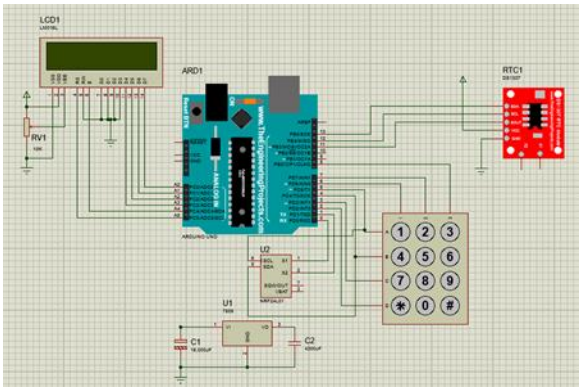

Fig.2 Proteus Simulation

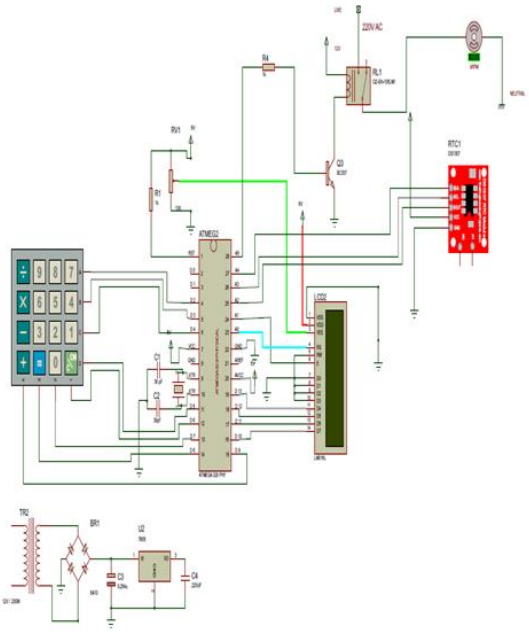

Fig.3 Complete circuit diagram

V. MAJOR COMPONENTS

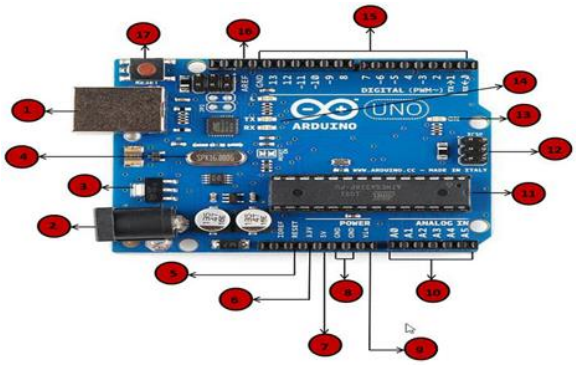

Fig.4 Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (data sheet). It has 14 digital input / output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power connector, an ICSP header, and a reset button [7].

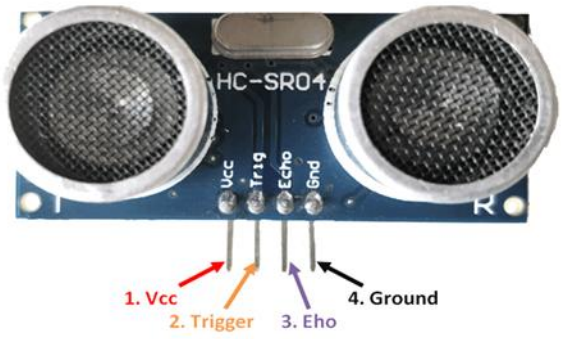

Fig.5 Ultrasonic sensor

An ultrasonic sensor is a device that can measure the distance to an object by using sound waves. Measure the distance by sending a sound wave at a specific frequency and listening to that sound wave to bounce back.

CONCLUSION

This design, microcontroller based automatic water pump controller is an improvement over other existing water pump controllers which has some shortcomings as highlighted earlier. These were overcome by using Arduino, which is newer technology. The water level was also monitored using Ultrasonic sensor instead of a metal probe to wirelessly monitor the water level and initiate pumping when necessary. In addition, this system has a special real-time synchronization feature that allows the user to schedule water pumping at any time of the day using the matrix keyboard. In conclusion, this work would obviously save water users in homes, offices and industries from water contamination, downtime, overflow and other problems associated with conventional pumping machine.

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