DEVELOPMENT OF AN AUTOMATIC WATER PUMP CONTROL UNIT

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***Abstract*—In this study, an automatic water pump control unit has been designed, constructed and tested. The aim of this study is to ensure there is enough water and its continuous flow without the stress turning ON and OFF the pump thereby saving time, energy, water, and prevent the pump from overworking provided that there is constant power supply. The Automatic water pump control unit was connected to the regulated power supply which regulated the power and supplied power to the ultrasonic sensor, the Arduino Uno and to the electric pump. The ultrasonic sensor sensed the water level and sent signal to the Arduino, it also received signal from the Arduino, and then the Arduino switched the pump based on the signal received from the sensor. After the complete design of the system, the deviation between the expected result and the actual result was very close. Performance evaluation of work from test results showed that the system was highly efficient since it eliminated human responsibility, and also improved the workable lifespan of the water pump by controlling when to switch ON and Switch OFF the pump.**

Keywords— ***water level, Arduino uno microcontroller, ultrasonic sensor, water pump.***

I. INTRODUCTION

Water is a common chemical substance that is most essential to man for survival as it forms an average of 60% of the human body. Although water forms a larger mass of the earth, it is not readily available to man for use as result of its composition and distance from place of necessity. This has led to efforts to store and retrieve it when needed by the development of various water storage schemes or systems such as dams, reservoirs, wells, artificial lakes etc., which engage the use of an electric pump to aid its transportation during storage and retrieval. Water is pumped from its source (e.g. well) to where it is stored (e.g. reservoir) which is then distributed to where it is needed.

Borehole is a narrowly drilled hole into the ground using a rotary drilling technology. Boreholes are usually constructed for different purposes like extraction of water, oil etc. boreholes are usually dug deeper than water well. Thus, its water is cleaner, more colourless and odourless i.e. borehole is more efficient and resourceful than water well. And because of its narrow path, water cannot be raised mechanically or by hand, it can only be extracted using a narrow submersible water pump. The water extracted goes through pipes (plastic, steel, etc.) to a reservoir.

II. LITERATURE REVIEW

Several works have been done on the control of water pumping machine and level indication but these systems have their own disadvantages as a result of the method of sensing employed.

Ishwar and Yadav (2013), constructed experimental setup which consists of a motor pump which is switched ON when the overhead tank is about to go dry and switched OFF when the overhead tank is about to overflow. Metallic contacts sensors are used. When water comes in contact with these sensors, the circuit gets completed and signal is generated. This signal is fed to logic circuit to get correct actuator signal. The logic gate used is NAND gate. They have concluded by saying that this system is very beneficial in rural as well as urban areas. It helps in the efficient utilization of available water sources. If used on a large scale, it can provide a major contribution in the conservation of water for us and the future generations.

Ejiofor and Francisca (2007), used a microcontroller to automate the process of water pumping in an over-head tank storage system and has the ability to detect the level of water in a tank. The pump will switch on/off accordingly and display the status on an LCD screen. The automatic water level monitor used in the study consists of the following major units: sensors, microcontroller, display unit, and the pump and the core work of detecting the level of water is done by the comparator. Taking advantage of the electrical conductivity property of water, the copper conductors are used as the water level sensor. When water touches the copper, sensor positioned at a particular level in the tank, voltage is transferred to the copper which in turn is transferred to the comparator circuit for further processing. The LM324 comparator is used to compare the inputs from the electrodes in the tank and with a pre-set resistance and output a HIGH or a LOW with respect to the result from the comparison. The author concludes by saying that this research has successfully provided an improvement on existing water level controllers by its use of calibrated circuit to indicate the water level and use of DC instead of AC power thereby eliminating risk of electrocution.

This review contains the brief discussion of some recent works of water automation of water automation for water pump controller system through android application. A model is presented in which water can expense from a customer and detect the leakage in the water distribution system. The advantage of this model is that it can reduce the periodic tours of providers to each physical location to read each meter. Another advantage is that the hill of water usage can give based on the near real-time expense from the previous expense. Detecting leak support to save water resources and energy and also reduce the cost. The paper proposes a water monitoring system by using automatic overflow control circuit unit. The proposal is designed from the perspective of monitoring the flow of water into the tanks automatically and from the perspective of setting as per the user demands using a mobile application. The advantages of the system are the conservation of water resource, reduction of the manual attempt and time to time changes over the situation of water storage with the help of sensors. A basic model is proposed which states that water pumps can be switched ON and OFF with the assistance of radio transmitters and Wi-Fi router (Jain, 2015).

Oghogho and Azubuike (2014), performed a fabricated experimental setup using five metallic contact probes. The lowest probe in the tank is connected to a 5V source to provide a fixed reference voltage which is conveyed upward along the tank as the water level rises while the other four probes were used as inverting inputs to the various comparators. The ADCs (Analog to Digital Converter), by utilizing the conductivity of water when ionized because of impurities present in it, are used to monitor the presence of water at the probes and give out corresponding digital outputs. The ADC's are comparators whose outputs at any time depend on the voltage difference between their inverting and non-inverting inputs. The non-inverting (positive inputs) of the ADCs are fixed at a voltage higher than that of the inverting (negative inputs) using a potentiometer. This will set the output logic states of all the comparators in the 1 state.

When water level rises and touches the conductor connected to any of the comparator inverting input, it raises the voltage at that inputs such that it becomes greater than the voltage at the non-inverting input thus leading to a change in the output logic state of the Comparator from the 1 state to 0 state. The outputs from the ADCs are used by the microprocessor to give out digital signals which turn on visual display LEDs. The author concludes that the system eliminates the cost and inefficiency of human interference associated with monitoring and controlling the pump while maximizing the performance and life span of the electric water pump.

III. Methodology

In order to achieve the aim, set out, some water supply scheme was studied. The system was designed using proven electrical and electronic principles with focus on reducing complexity, hence reduced high cost and energy requirement.

IV. Design Concept

An automatic water level control for overhead or any form of reservoir with switching device is designed using electrical control to refill the water without human intervention. The system design was carefully arranged to refill the water tank any time the water level low to a certain level. Finally the system automatically shut down the water pump by putting the electric pump by putting the electric pump off when the tank is full. The automatic control system block diagram is shown in the Figure below.

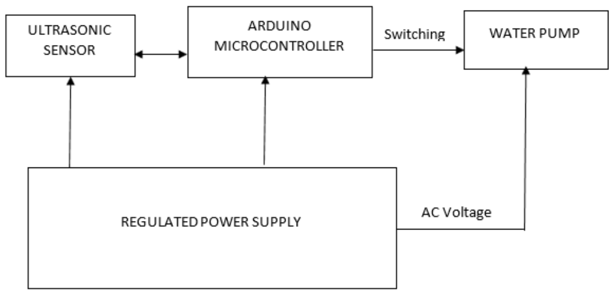

Fig. Block diagram of the Microcontroller Based Automatic Control for Water Pumping Machine.

V. Working Principle of the System

The device uses an ultrasonic sensor installed at the top of the storage tank which is triggered by the microcontroller to send and receive sound waves, and the time it takes to send and receive the signal is converted to distance to give out corresponding digital outputs which will be used by the microcontroller to drive digital outputs.

The microcontroller is programmed to send a pulse to the trigger pin of the sensor, after which the sensor is enabled to send and receive sound wave. When the water level rises, the time it takes to send and receive the sound waves is converted to distance by the microcontroller using a specific equation. The value of the distance is compared with the pre-set distance in the program and when it gets to a pre-set distance, the microcontroller gives a digital output to turn ON the pump. The height of tank used for this design is 0.30 metres (30 cm).

The function of ultrasonic sensor in this project; the ultrasonic sensor has a trigger and an echo pin. The Arduino provides a high signal of 10microseconds to this pin. After the sensor is triggered, it sends out eight 40 KHz sound waves to the surface of the water. On getting to the surface of the water, the wave is echoed back to the sensor and the Arduino reads the echo pin to determine time spent between triggering and receiving of the echo. Since we know that the speed of sound is around 340m/s then we can calculate the distance from equation 3.1;

$$Distance = \left(\frac{time(t)}{2}\right) \times 343\, m/s\, (speed\ of\ sound)$$

To determine the level of the water in the tank we must know the corresponding height of the tank. This value will enable us to calibrate the tank. The total height of the tank to be used is 32cm. 2cm will be taken away (6.25% of the tank's height) because of clearance of water from the ultrasonic sensor, therefore our maximum level is 30cm (0.625 liters). Our minimum level will be 30% of the tank's capacity 9.6cm (3 liters), we used this because of redundancy. These are electronic components; they could fail at any time when the user is using it. By making our minimum level 9.6cm, the user should not be stranded or lack water till the component is replaced.

The Ultrasonic sensor module is placed at the top of bucket (water tank). This sensor module will read the distance between itself and the water surface and it will show the level of water and the status of the motor by turning on either LEDs. If the distance is greater than or equal to 15cm then Arduino turns ON the water pump. The green LED will turn ON to signify "MOTOR ON". When the distance reaches 30cm, Arduino turns OFF the relay and the red LED will turn on to signify "MOTOR: OFF".

The Volume (v) of the tank is calculated as follows:

$$v = \pi r^2 h$$

$$\pi \times 10^2 \times 32$$

$$= 10053.09649 cm^3 \approx 0.01 m^3 \approx 10\ litres$$

VI. RESULT AND DISCUSSION

Table 4.1 and table 4.2 shows the summary of the test result. A water source was used to supply water to the pumping machine which was connected to a water storage tank. The water storage tank was made of a transparent container in this experiment. When the system was connected to 240 VAC supply, water was below our pre-set minimum level so the pumping machine was automatically switched ON, and the water rose to the maximum level during a time duration of 18 seconds. When the water rose to the maximum level, the pumping machine was automatically switched OFF.

Table 4.1 shows a summary of the test results when the water level increases. When the minimum level of the tank is reached (3Litres), the pump switched ON and the indicator light shows GREEN. At maximum level (9.38litres), the pump automatically switched OFF and the indicator light turns RED.

Water level in tank (Litres)	Pumping machine state	INDICATOR(LED)
≤ Minimum(3L)	ON	GREEN
> Minimum but < Maximum	ON	GREEN
≥ Maximum (9.38L)	OFF	RED

Table 4.1 Increase in water level.

Table 4.2 shows a summary of the test results when the water level decreases. The water in the storage tank was drained and as the water level of the decreased to the minimum point (3L), the pumping machine was automatically switched ON.

Water level in tank (Metres)	Pumping machine state	INDICATOR(LED)
≤ Maximum	OFF	RED
< Maximum but > Minimum	OFF	RED
≤ Minimum	ON	GREEN

Table 4.2 Decrease in water level.

The pictorial view of the experimental setup both at the minimum and maximum levels are shown in Figures 4.1 & 4.2 respectively.

Fig. 4.1 Pictorial view of the system under test at minimum level.

Fig. 4.2 Pictorial view of the system under test at maximum level.

VII. CONCLUSION

This work unveiled the design and implementation of an Automatic water pump control unit using an Arduino based Ultrasonic sensor. The microcontroller gave a digital input which turned ON the water pump when the water in the tank was at a pre-set minimum level and turned OFF the pumping machine when the water was above the pre-set maximum level. After the complete design of the system, the deviation between the expected result and the actual result was very close. Performance evaluation of work from test results showed that the system was highly efficient since it eliminates human responsibility, and also improved the workable lifespan of the water pump by controlling when to switch ON and Switch OFF the pump.

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