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Design and Implementation of an AT89C52 Microcontroller Based Water Pump Controller

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Abstract

serious problem faced by several cities of the World, with wastage during pumping and distribution identified as a culprit. This paper developed a microcontroller based water pump controller aimed reducing water wastages and pump failures, due to not switching it off immediately when not needed. The control system from which water level of both tanks are observed with simultaneous water pump control is based on existing water level technology using the principle of ultrasound for level sensing. A prototype of the proposed microcontroller based water pump controller was fabricated and tested. This paper 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. The developed system is capable of powering a 1HP pump from the input voltage, which can deliver an output current up to 20A. The system will help to eliminate the cost and inefficiency of human interference associated with manual monitoring and controlling of pump, while maximizing the performance and life span of the electric water pump.

Keywords: Microcontroller, Sensor, Water, Water level and Water pump

1. Introduction

Water is an indispensable substance to all living things due to its usability and link to man's existence. Provision of large volume of waters is essential due to its significance, which therefore called for a means through which sufficient, and good quality water can be obtained. There are different types of water namely; well water, pipe-borne waters, rain water, stream water, river water, and so on (Hicks, Tyler, & Edwards, 1971). Sustainability of available water resource in many regions of the World is now a dominant issue. This problem is related to poor water allocation, inefficient use, and lack of adequate and integrated water management. Therefore, efficient use and water monitoring, have necessitated research into various water level sensing technologies, and collection methods (Khaled, Shah, & Mohsin, 2010; Venkata, 2013; Hodgson & Walters, 2002). In order to eliminate water wastage during pumping and to care for future need for large volumes of water, the concept of automatic pumping machine with microcontroller based water level controller is developed.

The rest of the paper is arranged as follows: Section 2 reviews existing water level monitoring technologies. Section 3 presents methodology for a microcontroller based water pump controller system. Whereas, section 4 presents the implementation, testing of the system. Finally, section 5 presents conclusion reached and gave appropriate recommendation.

2. Literature Review and Components Description

Hodgson and Walters (2002) discussed the potentials of modern optimization technology to the pumping industry and presented examples of cost-saving design experiences. However, Khaled, et al., (2010) introduced the notion of water level monitoring and management within the context of electrical conductivity of the water. The authors investigated the microcontroller based water level sensing and controlling in a wired and wireless environment. Finally, a proposal for a web and cellular based monitoring service protocol to determine and sense water level globally was given. Olabimpe, (2010) worked on the design and construction of an automatic water pump control with level indicator. The design consists automatic control, with digital circuitry, for switching ON and OFF the pump, and an indicator to notify the user about the level of water in the overhead tank. Another feature of the design was the use of an alarming circuit to alert the user whenever there is an absence of water in the underground tank. Meanwhile, Omolola, (2010) worked on the design

and construction of a water level detector with pump control based on a microcontroller. The project involved the use of a digital water level detector with pump control and an instrument that indicates the level of water in a tank, using seven-segment display to indicate the following levels; 0%, 25%, 50%, 75%, and 100%. Like Olabimpe, (2010), it has an alarm to indicate when water is at the 0% level. However, the alarm emits a continuous sound for 10s indicates the 100% level of the tank.

Moreover, Hani and Myaing (2011) developed a microcontroller-based water flow control system. In this system, automatic water flow control system is implemented, and can be used as process control system. A sensing unit, photo interrupter, and slotted disk are used to produce pulse train for frequency input of the microcontroller. The sensor signal is counted as frequency and converted to the flow rate by using the software program in PIC. This flow rate is compared to the set point value. The PIC16F628 can control the water valve by using DC motor to vary the water flow rate based on this comparison.

A controller based automatic plant irrigation system was designed by Venkata, (2013). The aim of the research was is to provide automatic irrigation to the plants with a system that operates with less manpower. Temperature sensor and humidity sensor were connected to internal ports of the microcontroller via a comparator, and whenever there is a change in temperature and humidity of the surroundings these sensors senses the change in temperature and humidity and gives an interrupt signal to the 8051 microcontroller and thus the sprinkler is activated.

Rojiha, (2013) analyzed existing oil-pumping systems and noted that they have a high power-consuming process and needs more manual power. He then proposed a sensor network based intelligent control system for better power economy and efficient oil well health monitoring. Several basic sensors were used for oil well data sensing, and the sensed data was fed to the controller which processed the oil wells data and used to control the oil pump accordingly. If any abnormality is detected then the maintenance manager is notified through a short messages services (SMS).

Water scarcity is a

Furthermore, Abang (2013) worked on the construction of an automatic water level controller for both overhead and underground tanks. The automatic controller was designed to monitor the level of water in a tank. It displays the level of water, and when it is at the lowest level; a pump is automatically switched ON to refill the tank. When the tank is filled to its maximum capacity, the pump is automatically de-energized. The block diagram of the system includes; the supply unit, the microprocessor unit, the sensor unit, the display unit, and the pump drives unit.

2.1 **Microcontroller**

Microcontroller is a computer on a chip that is programmed to perform almost any control, sequencing, monitoring and display the function. Because of its relatively low cost, it becomes the natural choice to the designer. Microcontroller is designed to be all of that in one. Its great advantage is no other external components are needed for its application because all necessary peripherals are already built into it. Thus, we can save the time, space and cost which is needed to construct low cost devices (Atmel Corporation, 2000).

3. Methodology

3.1 Water Level Indicator

In the water level indication unit, light emitting diode (LED) light which will work for water level indication is used. By touching different water levels through water level sensor, LED should be indicated as ON/OFF. When the sensor touches water, nozzles and connecting rod get electric connection using water conductivity (Khaled, et al., 2010). The pump is controlled by connecting it with an output pin of the microcontroller via a motor driver circuit. When microcontroller sends a positive signal (+5v) or a ground signal (0v) to the motor driver circuit, then the water pump become ON or OFF respectively. In order, to makes the system more flexible an electromagnetic switch is integrated into it.

3.2 System Block Diagram

In this work, the automatic water level monitor here presented consists of the following major units: copper conductor sensors, comparator circuit, microcontroller, display unit, and the pump and the core work of detecting the level of water is done by the comparator. Fig. 1 describes the flow of operations in the system as well as their inter-operability.

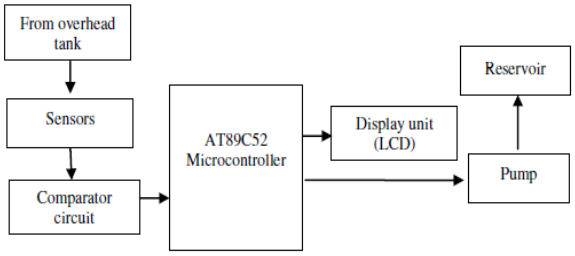


Fig. 1: Block Diagram of the system

Taking advantage of the electrical conductivity property of water, we used the copper conductors 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 was 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. This HIGH or LOW feeds the microcontroller, which in turn uses this to control the water pump and display the appropriate status on a Liquid Crystal Display (LCD) screen. The programmable Atmel 89C52 microcontroller was programmed in C Language to control the functionalities of the entire system. Relays were used in building a switching unit that simply triggers the pump ON or OFF, depending on the signal received from the microcontroller.

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3.3 Design of the Power Supply

Before commencing this design, power requirements had been carried out in relation to the various components that would be used, for instance, the microcontroller needs +5V DC, the relay needs +12V DC, and the pump machine would need 220VAC. In order to get all of these different voltage levels and types, a means to achieve them all in one would be needed; therefore a linear power supply comes in play. A regulated power shown in fig. 2 was used to obtain the 5V DC and 12V DC from 220V ac.

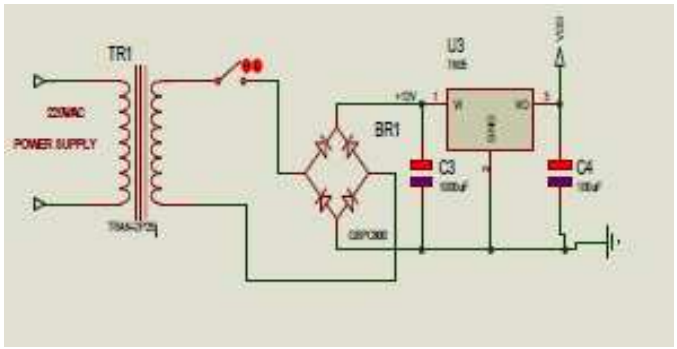


Fig. 2: Power Supply Stage

3.4 Design of the Microcontroller Stage

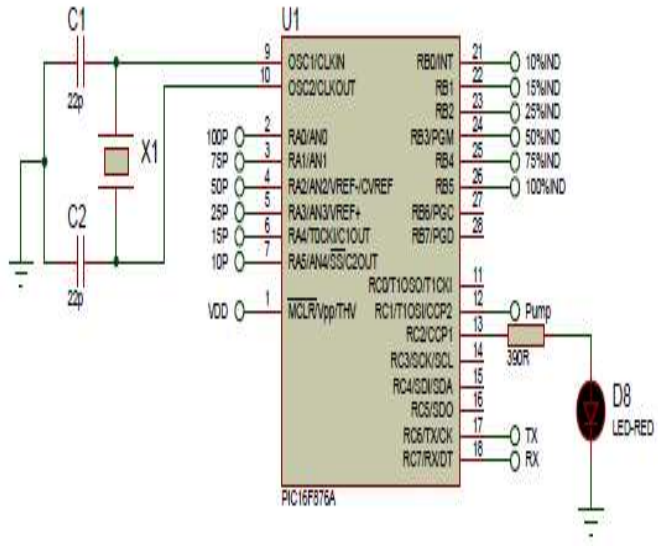


Fig .3: The Microcontroller Structure

The specific software tool deployed for the virtual design and the implementation of the device is the Proteus simulation software. The software has two environments; the ISIS and the ARES environments. We used the ISIS environment for the circuit design and instead of implementing the printing of the circuit board (PCB) in the ARES, we used a Vero board for our hardware implementation. The microcontroller, shown in fig. 3 is connected to an LCD interface.

3.5 Design of the Tank Unit

Fig. 4 shows the schematic diagram of proposed system.

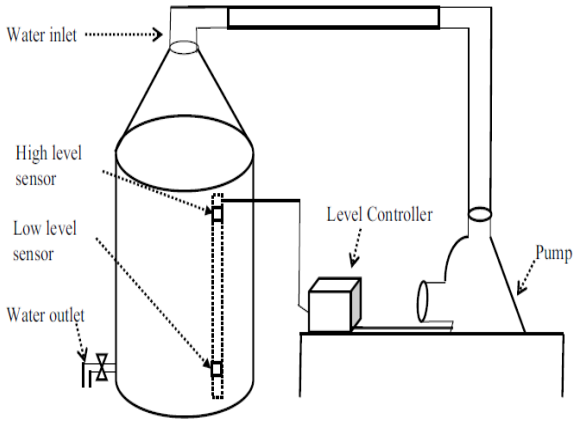


Fig. 4: Schematic of the tank and regulator

4.0 Implementation and Result

4.1 Design Algorithm

Step 1: Start.
Step 2: Sense Water in the Overhead tank.
Step 3: Is tank is empty?
Step 4: If tank is empty, go to step 8.
Step 5: Sense water tank at the six sensors.
Step 6: Else if tank is empty, go to step 7.
Step 7: Microcontroller (decision making based on water level).
Step 8: Display Unit.
Step 9: Is tank full?
Step 10: Pump off.
Step 11: Stop.

The written program was loaded into a virtual microcontroller and then simulated. The output of the simulation was followed in the hardware implementation of the design. After construction, tests were carried out to ensure that the device is functioning according to design specifications. After a successful testing, the prototype design of the automatic water level monitor with feedback was implemented, as shown in fig. 5. The implementation of this work came with quite a number of challenges. Sockets were used to protect the legs of the ICs, so as to minimize damage to the components. Apart from components damage, open circuits constituted a problem because some of the wires to be soldered did not make proper contact with the Vero board.

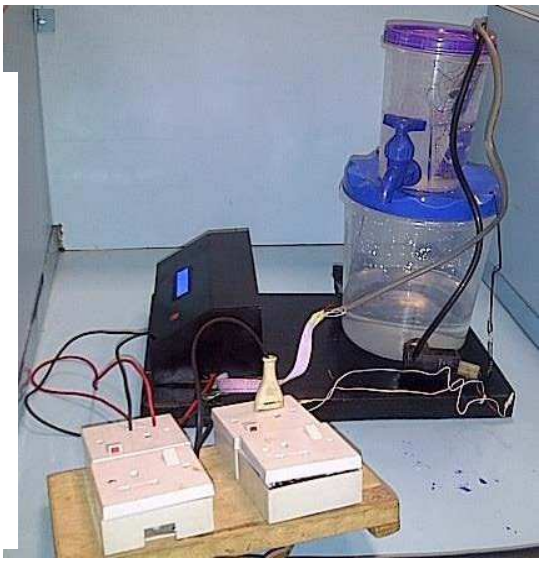


Fig. 5: Hardware prototype of the automatic water level controller

All the results are simulated using Proteus and AVR studio. Also all the states of circuits are checked using LED indicators. Table 1 shows percentage water levels versus level of Indicators Probes in litres. And the plot of the results is shown in fig. 6.

Table 1: Table of Water Levels (%) versus Level of Indicators Probes (litre).

Water Level (%)	**Level of Sensor Indicator Probe(Liter)**
10	1
15	2
25	3
50	4
75	5
100	6

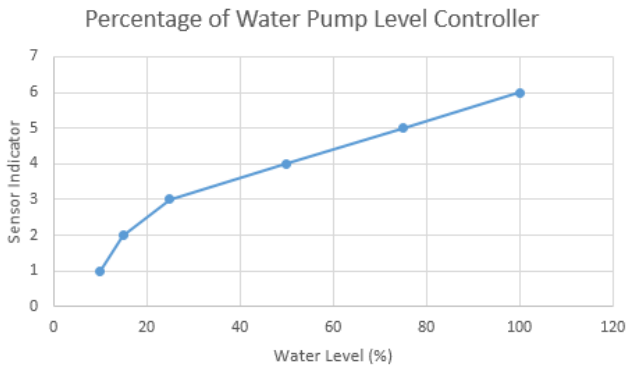


Fig 7: Percentage water pump controller

5.0 Conclusion and Recommendation

5.1 Conclusion

The system uses 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, switch ON/OFF the pump accordingly and display the status on an LCD screen. 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. The developed system is capable of powering a 1HP pump from the input voltage, which can deliver a maximum output current of 20A. This device can be used to operate different water pumping machines used at households and industries. With the use of this equipment, the available water supply can be effectively maximized. The system was designed as an attempt to eliminate the unreliability of humans, indicate the level of water in the tank and to improve the workable life of the pump by increasing its mean time to fail due to reduction of the stress on it, thus enhancing the electric pump's overall performance. Priority was given to making the circuit simple and efficient so as to reduce both running and maintenance costs and the energy requirements of the system. The system performed as designed but with slight modifications, the levels of water can be indicated digitally using a seven segment display or an LCD.

5.2 Recommendation

The system can also be interfaced with a personal computer (PC) so that it can be used to control the electric pump while monitoring the level of water on the PC screen on a real-time basis. A sound alert circuit and control to turn the pump OFF when it's pumping dry (i.e. when it's not pumping water due to lack of water flowing in from the source) can also be included in the design. These additions will however, increase the system's complexity, hence, cost and energy requirements which this work seeks to minimize.

Acknowledgments

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