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DEVELOPMENT OF AN ELECTRIC WATER PUMP CONTROLLER AND LEVEL INDICATOR

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ABSTRACT

An Electric Water Pump Controller and Level Indicator (EWPCLI) has been designed, constructed and tested. The EWPCLI exploits the electrical conductivity of water to give indication of water level in a storage tank and ultimately, the automatic control of the water pump. The EWPCLI employs a number of metallic conductors or probes, each positioned at separate levels along the tank height to act as sensors. Comparators monitor the presence of water at the probes (utilizing the conductivity of ionized water due to its impurities) and give out corresponding digital outputs which are used by the microcontroller to drive digital outputs which turn on visual display LEDs that indicate various water levels in the tank. The microcontroller also controls a switch to turn the water pump on (when water goes below the preset minimum level) or off (when water goes above the chosen maximum level). EWPCLI when tested turned the water pump on or off depending on the water level in the tank as designed. The required visual LEDs were also turned on at the corresponding water level. The system will help to eliminate 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.

KEYWORDS: Water pump, controller, Level indicator, water storage schemes

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 [1, 2, 3]. Although water forms a larger mass of the earth, it is not readily available to man for use as a 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 [4,5,6]. Water is pumped from its source (lower surface) to where it is stored and treated (higher surface) after which it is distributed by gravity or pumped to where it is needed (places of utility) usually at different surface levels.

The use of electric pumps to pump water from a source to where it is needed and during retrieval was successful but did have a number of shortcomings [7, 8]. The short comings reflected in the challenges of achieving high energy efficiency and extended lifespan of the pump by controlling when to pump, when to stop pumping and how to monitor the level of water in a storage tank. Human intelligence (which in this particular case is highly unreliable, costly, inefficient and prone to errors) was employed to address these issues. However, this led to wastage of human resources as well as the inefficient maximization of the performance and life span of the electric pump. Putting a check to these issues will require an improved operation of the electric water pump which has led to the design and development of several electric water pump controllers [9, 10].

The use of electrical water pump controllers (EWPCs) are not limited to just storage and utility. They find application industrially in the cooling of heavy duty machines. Using temperature sensors, the electric pump can either be switched on by an EWPC to pump cool water to machines that are hot or turned off as soon as the temperature of the machines reduces to desired levels thus improving the energy usage efficiency and lifespan of the pump.

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EWPCs also find application in ships to pump water and liquid waste that is collected in the bilge when the bilge is full and in agriculture for irrigation purposes where the electric water pump controller is used to control an electric pump which pumps water into a farmland depending on the pressure on the underground valves which communicate with the sensors via pressure pulses. This principle is also being used today in green fields like football pitches to maintain lawns.

The EWPCLI presented in this paper was designed with focus to reduce complexity hence reducing cost and energy requirements so that it will be readily affordable by users.

MATERIALS AND METHOD

In order to achieve the aim set out, some water supply schemes were studied. The various electric water pump controllers developed for these water schemes were studied and various design options and their cost implications were considered [9, 4, 7]. The system was designed using proven electrical and electronic principles with focus on reducing complexity, hence reduced high cost and energy requirement. It was broken down into three sections: the power supply unit, the sensing and control unit and the output unit.

The device employs five metallic conductors which span through the height of the storage tank, each positioned at separate levels along the height, to act as sensors. The lowest probe in the tank was 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 (ADCs). The ADCs, by utilizing the conductivity of water when ionized because of impurities present in it, were 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 were 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. A program was developed and written in C programming language into the microcontroller for control and coordination of the system functions. The outputs from the ADCs are used by the microprocessor to give out digital signals which turn on visual display LEDs (that indicate various water levels in the tank) as well as automatically control the water pump. The pump was designed to turn on when water goes below the preset minimum level or turn off when water goes above the chosen maximum level. The system was first tested in modules and then in whole by monitoring the LEDs which turns on and the action of the pump at any water level. Different minimum preset levels were chosen and the output was monitored to determine the system performance.

Principle of Operation of the EWPCLI

Fig1 shows a detailed circuit diagram of the EWPLI. All components were powered by a regulated and rectified 5V supply except the electric pump which was powered by a 12V rectified supply. The sensors are metallic probes mounted at different tank levels. The reference voltage of the sensor unit is 5 volt mounted at the bottom of the tank. Since water conducts electricity when ionized, electric current flows to each probe only when the water level is above it. The signal level at each sensor is fed to a comparator whose positive reference voltage is fixed using a 100k resistor. The comparator output is normally high and goes low only when the water level is above it. The microprocessor uses this high and low outputs of the comparator to determine when and when not to trigger the pump through a relay and to determine which LED is turned on to indicate the water level.

AT89C52 which is a 40 pin I/O CMOS 8 bit microcontroller was connected to the oscillator circuit and the set and reset circuitry. When the EWPCLI is put ON, the Set and Reset circuitry ensures that the processor starts working immediately while the oscillator provides the timing needed for the processor operation by generating clock pulses. Microcontroller Pins 1, 2, 3, 4 are dedicated to the sensor circuit, that helps detect the level of water in the tank. These pins are assigned to the 4 individual metallic probes inferring different levels in the tank. Probe 4 or level1 (which can also be selected as the maximum level) sets the minimum level and at this point the microcontroller triggers the switching unit whenever water goes below this level. Probe1 (level4), Probe2 (level3) and Probe3 (level2) can be varied as maximum levels by using pin5 and pin6 to select and enter the desired level respectively.

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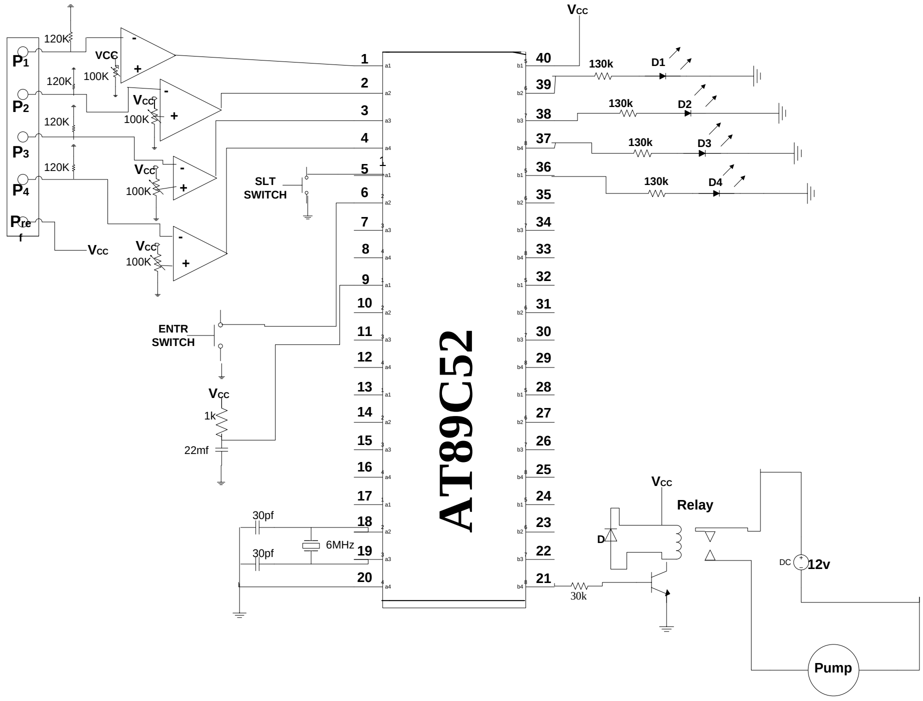

Fig.1 Complete Circuit Diagram of the Electronic Water Pump Controller and Level Indicator

The display unit whose operation is also dependent on the microcontroller is made up of 4 LEDs to indicate various levels of water in the tank at every point in time.

Tests and Results

Table1 shows a summary of test results by selecting level1 (probe4) as minimum. A water source was used to supply water to the Electric water pump which was connected to the water storage tank on the other end. The water storage tank was made of a transparent container containing the metallic probes so that the level of water in the tank can be seen. The EWPCLI was turned on after being connected to a 12V D.C source after which the maximum and minimum levels were selected using the select and enter buttons. The pump was turned on or off by the EWPCLI depending on the level of water in the tank.

Table1: Summary of test results by selecting level1 as minimum.

Min level selected	**Max level selected**	**Action of Electric water pump**	**Led type turned on**
1	1	1. Pumps water into the storage tank and turns off when water reaches level 1 2. Resumes pumping water into the storage tank when water falls below level 1 due to opening of the tap.	1. Red LED turns on when water reaches level1. 2. Red LED turns off when water falls below level 1
1	2	1. Pumps water into the storage tank and turns off when water reaches level 2. 2. Resumes pumping water into the storage tank when water falls below level2. 3. Maintains water level between levels 1 and 2.	1. Orange LED turns on when water reaches level2. 2. Orange LED turns off while LED LED turns on when water falls below level2 but above level1.
1	3	1. Pumps water into the storage tank and turns off when water reaches level 3. 2. Resumes pumping water into the storage tank when water falls below level3.	1. Blue LED turns on when water reaches level3. 2. Blue LED turns off while Orange LED turns on when water falls below level3 but above level2

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		3. Maintains water level between levels 1 and 3.	3. Orange LED turns off while Red LED turns on when water level was below level2 and above level1.
1	4	1. Pumps water into the storage tank and turns off when water reaches level 4. 2. Resumes pumping water into the storage tank when water falls below level4. 3. Maintains water level between levels 1 and 4.	1. Green LED turns on when water reaches level4. 2. Green LED turns off while blue LED turns on when water falls below level 4 but above level3. 2. Blue LED turns off while Orange LED turns on when water falls below level3 but above level2 3. Orange LED turns off while Red LED turns on when water was below level2 and above level1.

Any other level selected as minimum gave similar results except that the water in the tank was maintained between the minimum and maximum levels selected and it also determined the LED type turned on.

Conclusion and Recommendations

The EWPCLI 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.

The system can also be interfaced with a personal computer (PC) so that a PC can be used to ascertain control of the electric pump while monitoring the level of water on the PC screen. 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.

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