Design and Development of Microcontroller Based Liquid Level Detector with Graphical Output.

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ABSTRACT

This paper presents and discusses the design and construction of a microcontroller-based liquid level detector with graphical output. This was achieved using a programmable microcontroller and some additional components, including a pumping machine.

This project was done with the use of a 220V AC power supply which was stepped down to 12V AC via a transformer. A switch was added as a protective device to break the power supply in case of a bridge or short circuit. A voltage regulator was incorporated to convert the incoming AC voltage to DC voltage, as 5V DC is needed by the microcontroller to execute its work. The microcontroller responds to the program written through the MAX 232. A crystal oscillator serves as the intermediary between the microcontroller and the personal computer (PC). The PC at the last stage of the design shows the status of the indicator probes at various levels of water. The PC also shows the levels of water in percentage (10%, 15%, 25%, 50%, 75% and 100%) when the pumping machine began to transport water from the first probe to the last probe. The system is applicable in industry and for residential use to avoid spillage of liquid (hazardous or otherwise) to the environment.

(Keywords: sensors, microcontroller, MAX 232, personal computer, PC)

INTRODUCTION

Due to high risk of floods in a compound, along a street, or low lying areas and the danger posed to pedestrians, commuter traffic, and infrastructure (including road damage and foundation damage), there is a present need for sensors which can detect and control liquid levels and pumping systems. The cost of replacing damaged properties, reconstructing a collapsed building, or dealing with human causalities could be very high.

In Nigeria today, as the pace of technology advances, the need for citizens and industries to make use of and purchase electronically controlled pump machines with indicators and automatic actuation control has grown.

Putting together a pump machine with bore hole is expensive. Possession of it alone requires both maintenance and protections against it causing flooding damage to the buildings and streets around it, not to mention the secondary costs and inconvenience of infrastructure damage to motorist, cyclist, and pedestrians.

In the construction of the electronic liquid level detector with indicator and automatic pump actuator described in this paper, the authors have attempted to construct a system that can not only control against spillage of liquids but also engineers safety for any surrounding building, street, and individuals at large.

Liquid level sensors are used to detect the presence, height, or volume of liquid in a system and the display unit gives numerical values in percentages on the level of liquid within a tank or container. Liquid level detection is critical to a wide variety of processes. There exists a wide variety of applications in which it is desirable to monitor to some degree the level of a liquid within a tank or a vessel. Liquid level detectors have widely been used in various storage tanks, for example, in an automobile for detecting the changing level of fuel in a tank. A liquid's level is generally sensed by obtaining a discrete indication if a predetermined level has been reached or obtaining an analog representation of the level as it changes.

LITERATURE REVIEW

In October 2010, Reza, Ahsanuzzaman, Tariq, and Reza, all worked on design and implementation issues on microcontroller based automated water level sensing and controlling systems [9]. They introduced the notation of water level monitoring and management within the context of electrical conductivity of the water. More specifically, they investigated microcontroller-based water level sensing and controlling in a wired and wireless environment, proposed a web and cellular-based monitoring service protocol which determine and senses water level globally.

In June 2010, Olabimpe worked on the design and construction of an automatic water pump control with level indicator [8]. The project was designed principally on the knowledge of digital circuitry. The design has automatic control for switching the pumping machine on and off, and an indicator to notify the user about the level of water in the overhead tank, while using an alarming circuit was to alert the user whenever there is an absence of water in the underground tank.

In November, 2010, Omolola worked on the design and construction of a water level detector with pump control [12]. 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 indicating the following levels; 0%, 25%, 50%, 75%, and 100%. It makes use of a seven-segment display to display the ranges. It has an alarm indicates when water is at the 0% level and a continuous sound which indicates for 10 seconds at the 100% level of the tank. The project is microcontroller-based, that is, aside from the power supply unit; all other units are controlled by the microcontroller.

In August 2013, Abang worked on the construction of an automatic water level controller for both overhead and underground tanks [10]. 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 was activated automatically to refill the tank. When the tank was filled to its maximum capacity, the pump was automatically de-energized. In this project several circuits were put together to ensure the proper function of this design and the block diagram includes the supply unit, the micro-processor unit, the sensor unit, the display unit, and the pump drives unit.

In July 2011, Han and Myaing worked on the design and construction of a microcontroller-based water flow control system [15]. The system is a technology resource for the fluid handling industry's critical disciplines of control, containment, and measurement. It covers products, processes, and services for efficient, reliable, and cost-effective control and delivery of fluids in a variety of industries. There are many flow control mechanisms. 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. This system is implemented by MPASM assembly language.

DESIGNS AND CONSTRUCTION

This section deals with design and analysis of the work whose block diagram and circuit diagram of various part is shown below, as it contributes to the overall design of the work. The design incorporates both hardware and software. The block diagram for the system is shown in Figure 1.

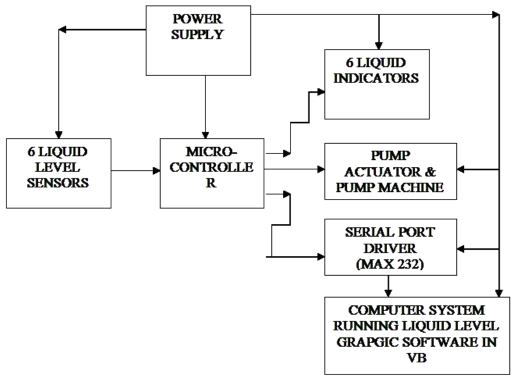

Figure 1: Block Diagram of the System.

Power Supply Stage

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 220V AC step-down mains transformer was used, whose job was to deliver 12V AC. The stepped down voltage was then passed through a bridge rectifier after a switch was added as a protective device to break the power supply in case of a bridge or a short circuit. The bridge rectifiers' responsibility is to convert the incoming AC voltage to DC.

The next step is that the just rectified DC signal is filtered for smoothness. This smooth 12V DC voltage is available for use, while still being stepped down by a voltage regulator. A 5 volt voltage regulator was used and its output voltage filtered too for a smooth and proper supply.

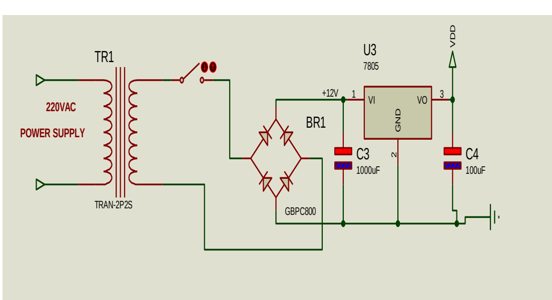

Figure 2: Power Supply Stage.

Sensor Stage

Level sensors detect the level of substances that flow in the system, including liquids, slurries, granular materials, and powders. Fluids and fluidized solids flow to become essentially level in their containers (or other physical boundaries) because of gravity, whereas most bulk solids pile at an angle of repose to a peak.

The substance to be measured can be inside of a container or can be in its natural form (e.g., a river or a lake). The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally the latter detect levels that are excessively high or low.

The simple water level indicator circuit presented in this system is automatic (i.e., it switches on the pump when the water level in the overhead tank goes low and switches it off as soon as the water level reaches a pre-determined level). It also prevents "dry run" of the pump in case the level in the underground tank goes below the suction level. To achieve a low power dissipated at the resistor, 1/80Watt resistor is chosen.

$$P = IV \quad (1)$$

$$V = IR \quad (2)$$

$$I = V/R \quad (3)$$

$$P = V^2/R \quad (4)$$

$$P = 1/80W, V = 12V$$

Microcontroller Stage

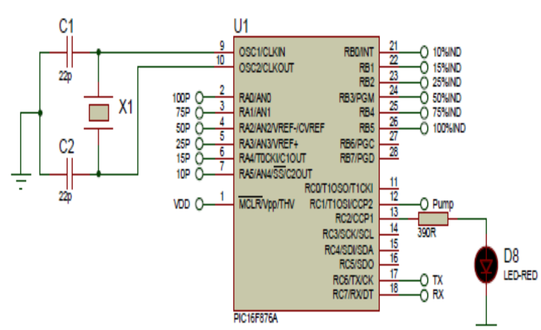

Figure 3: The Microcontroller Structure.

A microcontroller is a type of microprocessor furnished in a single integrated circuit and needing a minimum of support chips. Its principal nature is self-sufficiency and low cost. It is not intended to be used as a computing device in the conventional sense; that is, a microcontroller is not designed to be a data processing machine, but rather an intelligent core for a specialized dedicated system. The rest of the code is used to monitor the sensor input of the microcontroller and depending on the state specific data are serially transmitted through the MAX232 to the personal computer female D shape pin.

<u>Indicators Stage</u>

The device works on the principle that the water is capable of passing current through it. One wire which is connected to VCC is left in the bottom-most part of the tank and the rest of the wires are set at different levels in the tank.

Except for the bottom-most wire, which provides VCC to the water medium, we have five wires set at different levels. The other terminal of these six wires is connected to the base of transistors (BC547) and hence in turn to the microcontroller which is the heart of the device. When water starts rising, different levels touch the water and get some positive voltage. This positive voltage is given to the base of transistors to activate them and hence passing signal to the controller as shown in the figures below. The indicating component is the LED and the PC. This component shows the current status of the water in the tank. The PC shows different message strings starting from the vacant stage to the full stage. The six indicating stage of the project is as below:

- When the water is at first level of the sensor, the message displayed on the PC is 10%.

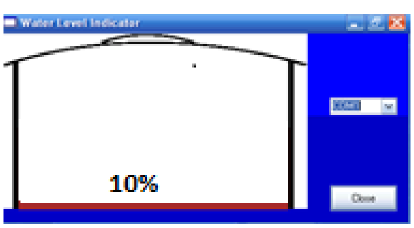

Figure 4: The First Level of Water level at 10%.

- When water touches the second level of the sensor, the message displayed is 15%.

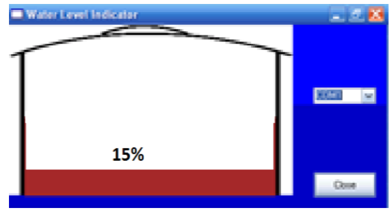

Figure 5: The Second Level of Water at 15%.

- When water touches the third level of the sensor ,the message displayed on the PC is 25%.

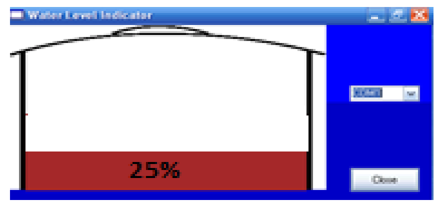

Figure 6: The Third Level of Water at 25%.

- When water touches the fourth level of the sensor, the message displayed on the PC is 50%.

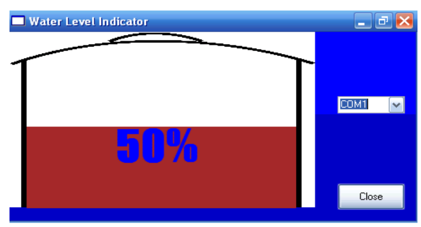

Figure 7: The Fourth Level of Water at 50%.

- When the water touches the fifth level of the sensor, the message displayed on the PC is 75%.

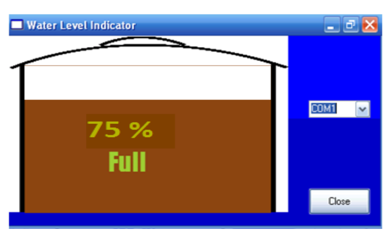

Figure 8: The Fifth Level of Water at 75%.

- When the water touches the sixth level of the sensor the message displayed on the PC is 100% which signified that the water has gotten to the highest level (fullest).Therefore, the pump will automatically shut off.

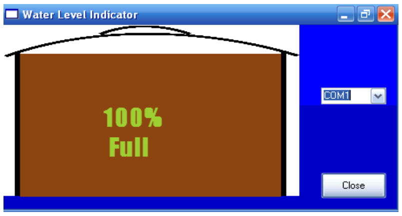

Figure 9: The Sixth Level of Water at 100% Light Emitting Diode Value Calculation (Indicator Stage).

The output of the gate is 12 volts at maximum:

$$V = IR \qquad \textbf{(5)}$$

$$R = V / I \qquad \textbf{(6)}$$

$$R_{LED} = \frac{V - V_{LED}}{I_{LED}} \qquad \textbf{(7)}$$

$$R_{LED} = \frac{12 - 1.25}{10mA}$$

$$R_{LED} = \frac{10.75}{0.01}$$

$$R_{LED} = 1075\Omega$$

$$R_{LED} = 1K\Omega$$

Serial Port Driver

The MAX232 is an integrated circuit (IC), first created by Maxim Integrated Products that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The MAX232

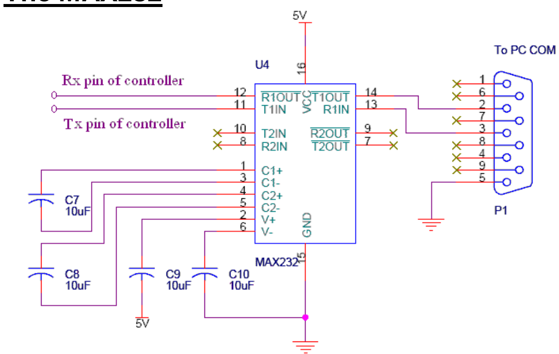

Figure 10: Circuit Diagram of the MAX 232,

The Pump Stage

Pumps are machine used for lifting and transporting liquids under pressure from one location to another or one level to another. They fundamentally consist of two parts:

- Rotating part
- Stationary part.

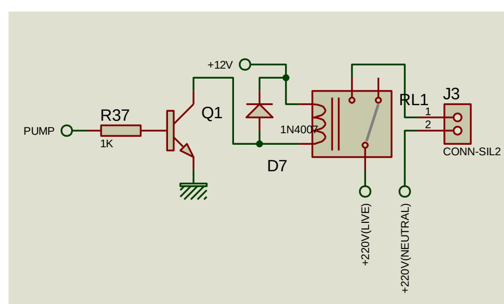

Figure 11: Circuit Diagram Showing Part of the Pump.

Computer System Stage

At this stage, the output of the water is easily be determined by displaying the water level from the computer system in percentage. This is achieved by pumping action of the pumping machine which helps to transport the water from the underground tank to the overhead tank. By so doing, the operator can easily ascertain the level of water without monitoring it from the pumping machine itself. The operator will see the level of the water from the PC without the stress of continuous first-hand observation.

Circuit Diagram of the Design

Circuit of the liquid level detector device interface with a PC is as shown in Figure 12.

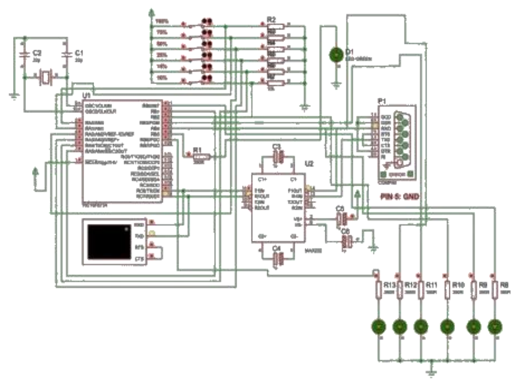

Figure 12: Circuit Diagram of a Liquid Level Detector and Graphical Output.

Mode of Operation

As the liquid (water) level in the liquid vessel changes and there is change in resistance across the probes, the liquid level detector senses it and converts the signal into digital signal that the micro-controller understands.

So the micro-controller receives this digital signal as inputs, compares each inputs to a set of instruction written into it, executes the instruction(s), and gives an output corresponding to each input. It also lights the LED indicator corresponding to each liquid level.

Since the micro-controller gives out a CMOS output of 5V and the serial port of the computer system receives a maximum input of 30V, an interface is planted in between the two devices in order for them to communicate effectively. The interface used in this case is MAX232 Buffer.

The serial port is interface to an object oriented environment where the signal received, in this case a string data is sent to the output indicating the liquid level in the vessel or tank.

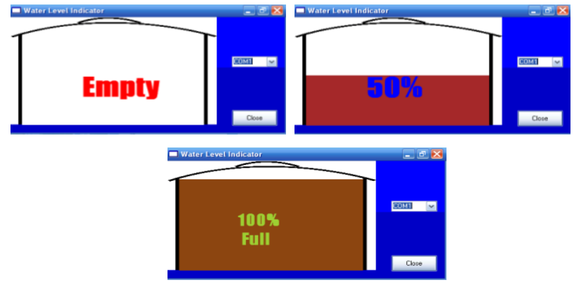

Figure 13: GUI when Tank is Empty, 50%, and 100% Full.

Algorithm of the Design

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.

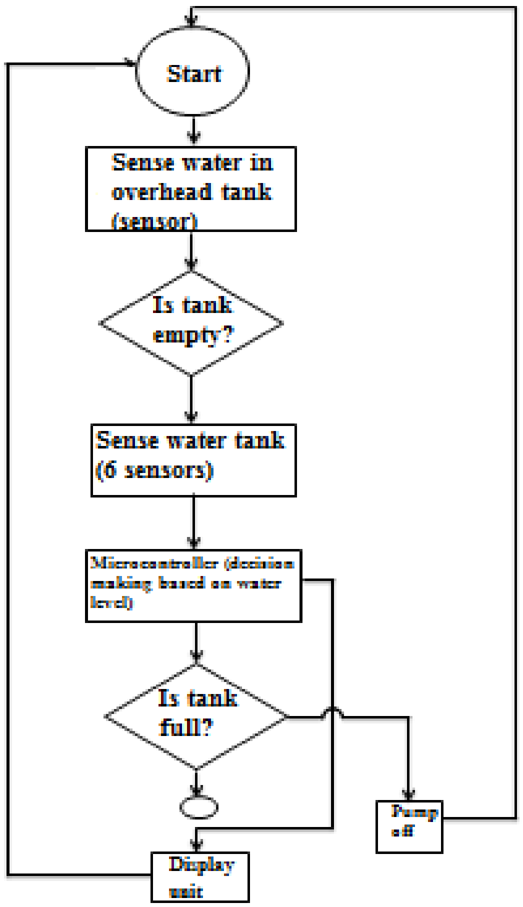

Figure 14: Flowchart of the Design.

TESTING AND EXPECTED RESULTS

Each component and material was tested before configuration to know the values of the components and to know their working conditions, so that there would not be any problems after the components had been soldered or configured on the Vero- board. The tank specification (volume) to be used was also considered**.**

From the set up below, the results were obtained. The entire circuit was tested and the circuit worked as planned and the following results were obtained.

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

Water Levels (%)	Levels of indicators probe (liter)
10	1
15	2
25	3
50	4
75	5
100	6

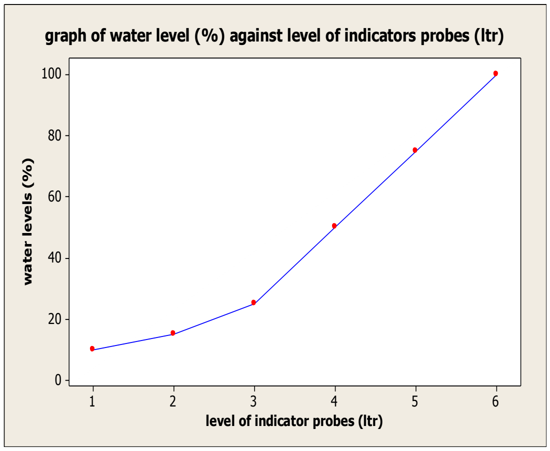

Figure 10: Graph of Water Levels (%) against Level of Indicators Probes (ltr).

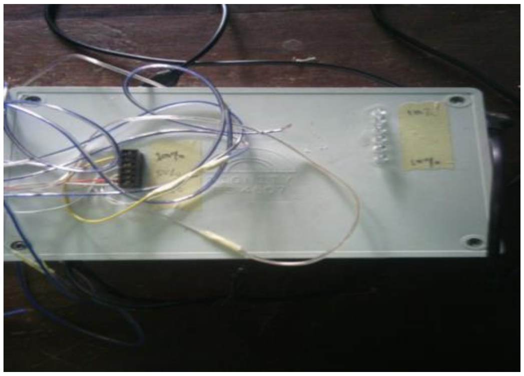

Figure 15: Picture of the Design (Diagram).

Figure 16: Internal Structure of the Design.

Figure 17: Side View of the Setup.

Figure 18: Layout of the Setup.

CONCLUSION

This work (automatic water pump control and indicator) 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.

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