Journal of Engineering Technology Vol. 10: 43-48, 2022
ISSN 2231-8798© 2013 UniKL BMI

Development of Dual Sensors for Fluid Level and pH Measurement

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Abstract: Fluid Level and pH measurements are applied in the oil & gas and food industries. This system is desirable for supervised by humans to control the fluid level and monitor the pH level for storage purposes. The advancement of dual sensors for liquid level and pH measurement focuses on the measurement of the liquid level and pH value. The employment of the Internet of things (IoT) for this system is to ease people to monitor both readings. The ultrasonic sensor is used to replace the conventional method which is floating switch liquid to measure the pH and fluid level in the storage tank. The range for this ultrasonic sensor is set to 5 points from 0 cm to 30 cm and the range for pH value is 0~7(acid), 7(neutral), and 8~14(alkaline) Therefore, this development ease human control and monitoring of the water level and pH value.

Keywords: Level, Water, pH, IoT, Monitoring, Arduino.

1.0 INTRODUCTION

Fluid Level and pH measurements are vital and widelyused in many industries, especially in the oil and gas industry and food industry [1]. The system requirements are to be accurate and can be easily monitored by humans, such as in the oil and gas industry. It is crucial to control the water level and monitor the pH level to produce quality water for storage purposes [2]. Furthermore, the designed system is to replace the conventional way to measure the level by using a floating system which is outdated and difficult to do maintenance [3]. The system first detects the amount of water available in the tank by the level detector and then adjusts the state of the valve following the water level information. The DC motor pump will be controlled and water will start filling the tank when the water level is empty or low, and the pump will stop when the water level reaches maximum level [4]. In addition to the system, the water and pH levels can be monitored through LCDs and smartphones by using the Blynk Application. Therefore, the designed system could ease humans in controlling and monitoring the water and pH levels for accurate readings [5][6].

2.0 MATERIALS AND METHODS

The hardware required to design this system are being discussed in this section. The software that is being used for this system is Proteus ISIS 7 and Blynk Application.

Figure 1: Arduino UNO

A. Arduino UNO

Arduino UNO is the main part to read the voltage output from the transducer as shown in Figure 1 and displays the reading on the LCD. This Arduino Uno contains a single-board microcontroller based on 8-bit ATmega328p. It consists of other components such as a crystal oscillator, serial communication, and voltage regulator to support the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header, and a reset button [7].

B. Ultrasonic Sensor

The ultrasonic sensor as shown in Figure 2 has an operating voltage of 3-5 volts. This ultrasonic sensor offers very short to long-range detection with low power consumption which is 75mW. The sensor detects objects from 2cm up to 400- meters.

Figure 2: Ultrasonic HC-SR04

C. pH Electrode

A potential hydrogen (pH) electrode as shown in Figure 3 is a scientific instrument that measures the hydrogen-ion activity in the water-based solution indicating its acidity or alkalinity [8].

Figure 3: pH electrode

D. 2x16 I2C LCD Display

Liquid Crystal Display (LCD) as shown in Figure 4 is an electronic display module and has been used in many applications. LCDs are commonly used in most embedded systems. The 16×2 LCD contains 16 Columns and 2 Rows. There are a lot of combinations available such as 8×1, 8×2, 10×2, and 16×1 and the most used one is the 16×2 LCD [9].

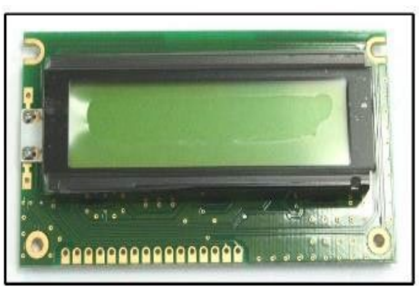

Figure 4: LCD 16x2

E. DC Water Pump

The DC water pump as shown in Figure 5 is suitable for any system that requires moving water from one storage tank to another [10]. The required operating input voltage is between 6-12V DC and between 0.5-0.7A. It delivers 6W , maximum operating values when power is at the upper end of these ranges [11].

Figure 5: DC water pump 12v

F. The Wi-Fi Serial Transceiver Module (ESP8266)

The Wi-Fi Serial Transceiver ESP8266 as shown in Figure 6 is a highly integrated chip designed for the requirements of a new connected world. The ESP8266 is Wi-Fi enabled system-on-chip (SoC) module and is mostly used for the development of IoT (Internet of Things) embedded applications [12][13]. ESP8266 has many capabilities such as 2.4 GHz WI-fi, Inter-Integrated Circuit (I2C) serial communication protocol, analog-digital conversion (10-bit ADC), pulse-width modulation, and many more [14].

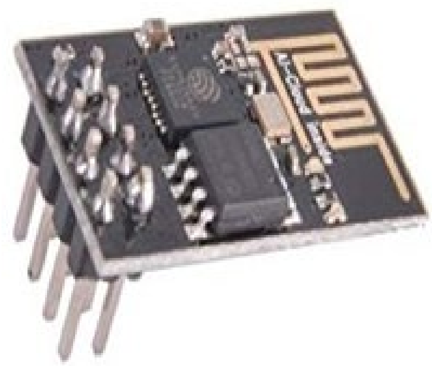

Figure 6: ESP8266 module

2.1 Methodology

The detailed methodology for developing the dual sensors device for level and pH measurement is discussed in this section. This methodology includes the block diagram of the hardware, the flow chart of the system, and the circuit diagram of the designed system.

A. Block Diagram

The block diagram of the dual sensor device for level and pH measurement is shown in Figure 7. The ultrasonic sensor and pH electrode will be the input of the device by converting the analog to a digital signal and sending the signal to the Arduino [15]-[18]. Then Arduino will give the command to the output to operate which are LCD Display, DC water pump, and buzzer. LCD Display will show the water level of the tank and the pH value of the water. When the tank is full, Arduino will stop the DC water pump from running and the buzzer will trigger to give a signal for a high-level alarm. LCD Display will digitally show the current level of the water and the value of the pH for easier monitoring [16].

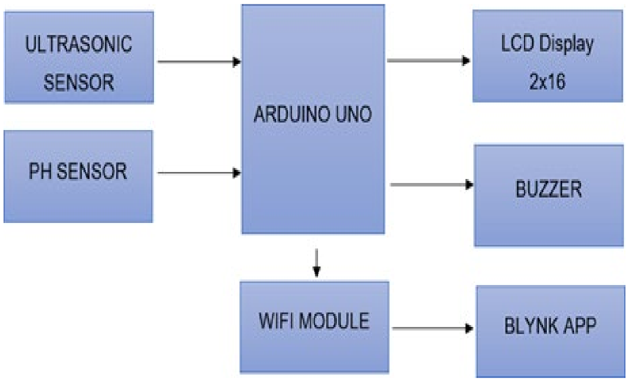

Figure 7: Block Diagram

B. Flowchart

The flow chart of the designed system is shown in Figure 8. When the input power is turned ON, the Ultrasonic will detect the level of water. LCD will take a few seconds to display the level of water and pH value.

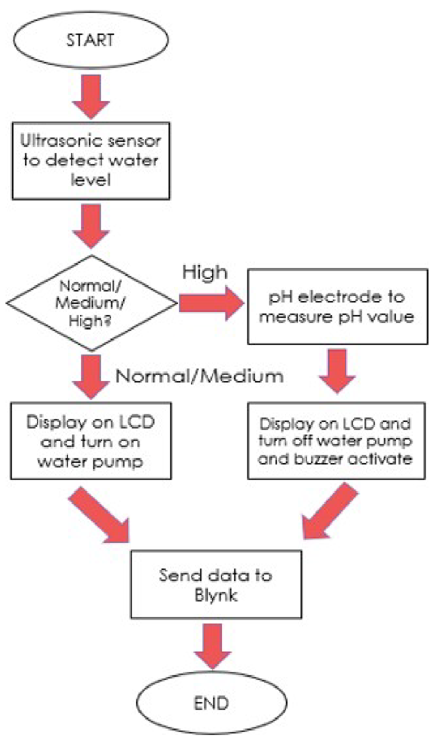

Figure 8: Flow chart of the designed system

The DC water pump will continue running when the level is below 90%. When the water level reaches 90%, the DC water pump will stop running and the buzzer will be triggered to give alarms to the user. Simultaneously, the users can monitor the results by using smartphones through the Blynk application. This Blynk application only can monitor the level of water and pH value [17].

C. Circuit Diagram

The software used for configuring the ICs is Arduino IDE and Proteus. The process began with the assembly of the hardware. The wiring diagram for Arduino UNO is shown in Figure 9, which also shows the construction of the designed system circuit. This whole circuit was powered by a 12V battery. For 5v components such as ultrasonic sensors, LCD, and Arduino, the voltage is taken from 12V to 5V regulator. For the DC water pump, 12V is connected directly to the motor driver circuit as shown in Figure 9. For the pH electrode will be connected to Analog Output pin A1. Proteus does not have any Wi-Fi module library and hence cannot be added to the simulation circuit. The Wi-Fi module (ESP8266) will be connected to TX and RX pins to get connected to the smartphones.

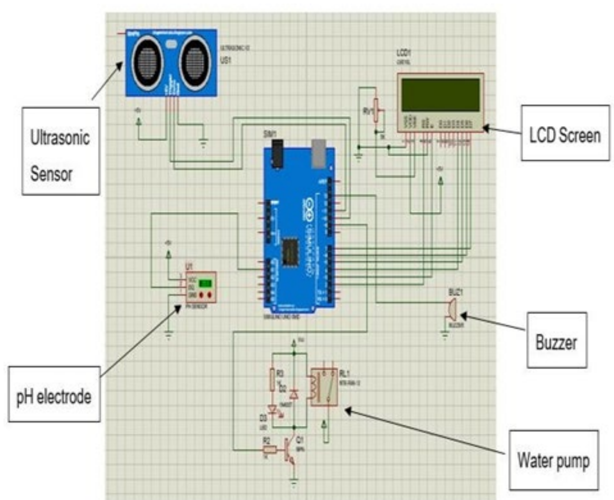

Figure 9: Circuit Diagram of the designed system

3.0 RESULTS

The development of dual sensors for level and pH measurement resulted in three different liquid solutions which are acid, neutral, and alkaline. The results were shown in Table 1 and Table 2. Figure 10 shows the water tank is filled with water by using some transparent tubes from the other tank. The ultrasonic sensor is located at top of the tank to sense the level of water. The pH electrode is submerged in the water. The LCD is mounted at the top of the black box. The black box is the storage for all circuits for the designed system. There is a valve on the bottom of the tank for sampling purposes and acts as a drain valve. Arduino will sense the output and the Wi-Fi module will send the data through Wi-Fi to the user by using the Blynk Application. The result that has been obtained were recorded in Table 1 and Table 2

Figure 10: Dual sensors device for pH and Level Measurement

Table 1 Condition for the water level

Condition	Range	Level Status	Output
1	0~6cm	Very Low	Pump ON
2	6~12cm	Low	Pump ON
3	12~18cm	Medium	Pump ON
4	18~24cm	High	Pump ON
5	24~30cm	Very High	Pump OFF

Table 2 Results of the pH measurement

	pH Electrode		Litmus Paper		Error
Condition	Range	Value	Color	Value	(%)
Acid	0~7	4.76	Red	2	58.67
Neutral	7	7.27	Yellow	7	3.86
Alkali	7~14	12.01	Black	14	14.21

Table 1 illustrates when the water pump and buzzer operate based on the different ranges and levels of water, and Table 2 shows the result that has been obtained from the pH electrode and Litmus paper experiment. This experiment uses three types of different solutions which are vinegar for acid, tap water for neutral, and milk for an alkaline solution. The results that have been obtained are compared in Table 2.

Table 2, shows that the pH electrode has more accuracy than pH litmus paper. To get better reading for the pH electrode, calibration needs to be done before using the pH electrode. Overall, the problem has been overcome and the system is working successfully but there is some part that can be improved in the future to produce improved results.

The values can be monitored by the smartphone Blynk App. Figure 11 shows the readings for the Acidic Solution. Similarly, Figure 12 and Figure 13 show the values for neutral and alkaline solutions respectively.

Figure 11: Reading from Blynk Apps for Acidic solution

4.0 DISCUSSION

There are many problems faced during this system development. For example, the power supply 9v cannot support the total output (1 dc water pump, 1 ultrasonic sensor,1 pH electrode, 1 buzzer, and LCD). This led to the dc water pump malfunction. This problem was solved by increasing the number of batteries. Based on the experiment, another problem is the pH electrode could not get a better reading below pH 7. The sensitivity of the electrode is high. The model of pH electrodes could be a part that can be upgraded in the future. The error measurement is recorded in Table 2.

Figure 12: Reading from Blynk Apps for Neutral Solution

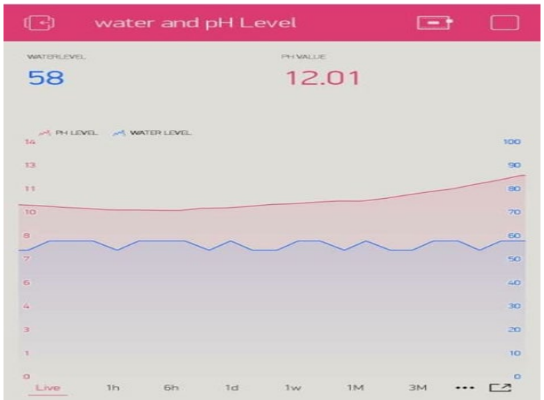

Figure 13: Reading from Blynk Apps for Alkaline Solution

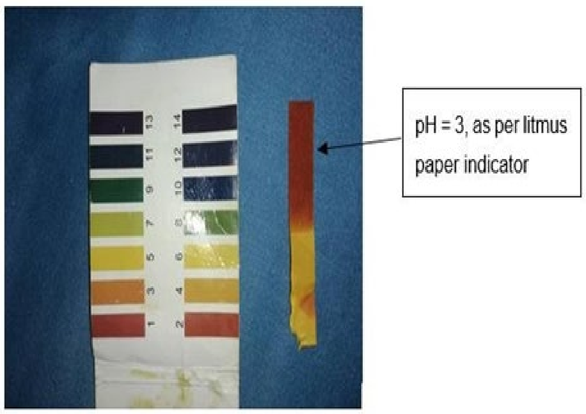

Figure 14: pH Litmus paper for the Acid Solution

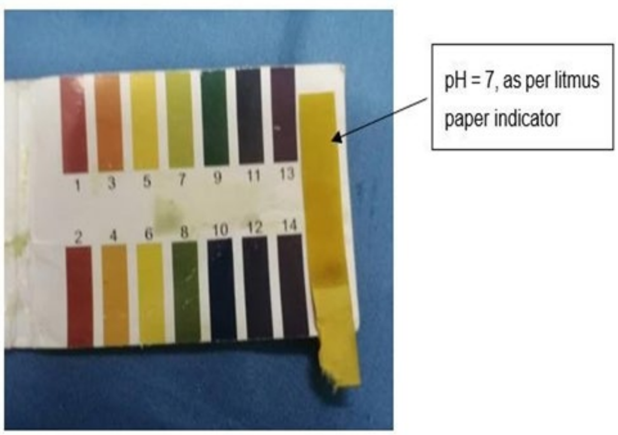

Figure 15: pH Litmus paper for Neutral Solution

The results from the Litmus paper are shown in Figure 14, Figure 15, and Figure 16. For the Acidic Solution, the Litmus paper turned its color to red which indicates the pH value as 3. The yellow color is for the Neutral pH value which is 7. The Alkaline Solution has a pH value of 14 which is represented by a black color on the litmus paper reading.

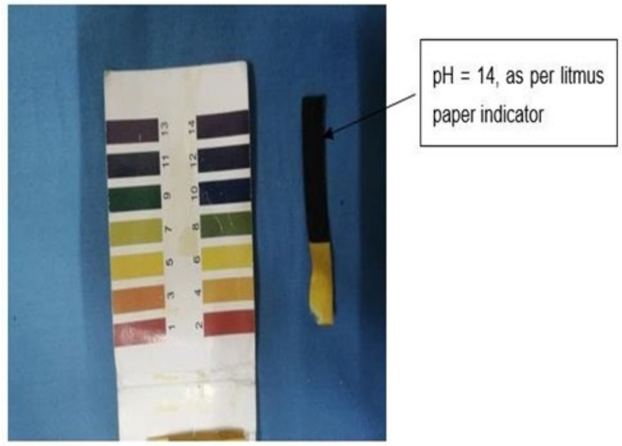

Figure 16: pH Litmus paper for Alkaline Solution

5.0 CONCLUSION

In the conclusion, the objectives of the designed system have been achieved and the system was fully functioning. A dual system that can measure and monitor liquid level and pH value. The two-way communication between the ESP8266 and smartphones by using the Blynk Application. All the recorded data was able to be viewed and exported into excel files by the application. The results that appear on an LCD screen can be monitored through smartphones by using the Blynk Application for the level and pH of the water from everywhere and at any time.

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