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Wireless Acquisition System For Water Quality Monitoring

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***Abstract*— Water is an important natural resource and is required in our day to day life. The proposed system aims to design a wireless acquisition system which is the basic building block of the water quality monitoring system. This paper explains the work carried out to design the embedded wireless monitoring system that can measure the turbidity and pH of the water remotely. The system is built using the Peripheral Interface Controller (PIC) microcontroller, which gives a low cost and low power water quality monitoring system with the intrinsic use of RISC type controller. The system consists of two sections, namely, Transmitter section, that collects the pH and turbidity readings from remote place, and, Receiver section, that collects transmitted readings using the ZigBee wireless communication protocol. The results are classified into three classes using the different pH and Turbidity levels to get a water quality index. The results are displayed on the LCD as well as on PC over different time periods.**

Keywords—pH level, Turbidity level, Temperature, PIC microcontroller, ZigBee.

I. INTRODUCTION

In the current era, we are moving towards making our cities as the smart cities, due to the lot of technological research and inventions over the decades. So the current era is said to be era of inventions, era of development, era of globalization and the era of smartness etc. But the counter side of the same is that the current era is era of the pollution, global warming, insecurity and miserable health factors. One of the intrinsic and prime barrier is world's population does not have pure and safe water for drinking. This is more dangerous situation in some developing countries like in India, where dirty water is being used for drinking without any proper water treatment before drinking. The main causes for this are the ignorance of people & government sector and the deficient water quality monitoring system, which results in serious health issues.

The motivation behind the proposed system was to design a wireless system to monitor water quality in a simplest and cost effective manner. This system can analyze some important and harmful factors of water to take preventive actions for water quality maintenance. The pH sensor SEN0161 and turbidity sensor SEN0189 are used to collect the pH and turbidity level of the water [1]. With the use of ZigBee technology, we can get the data from the remote areas. The sensors have the analog output, hence they are interfaced to analog input of the PIC microcontroller and the data are transferred through the ZigBee [2-3]. The real time data, at the receiver section, is displayed on the LCD as well as on PC [4].

II. SYSTEM ARCHITECTURE

As we know, water is one of the prime requirements for life of each living organism on the earth. The pH level and turbidity level of water plays intrinsic role in assessing the quality of water. Water quality plays intrinsic role in the health issues of human beings, plants and living organisms on the earth. Particularly, the main sources of water are rain, rivers and ponds. Rain water running over the lands contains many purities and impurities that may be soluble or insoluble. The main aim is to measure the pH level and turbidity level in the drinking water as well as in the sewage water from industries that are driven into the rivers and also the water used for agriculture.

The parameters that are used to determine the quality of the water are the pH level and turbidity level.

The objectives of the system are given below:

- To design the wireless water quality monitoring system.
- To measure the pH level and turbidity level using the sensors at remote place.
- To transmit and collect data from remote place to the receiver section using the ZigBee communication protocol.
- To display the real time data on LCD as well as on PC.

III. HARDWARE SPECIFICATIONS

As the aim is to design the wireless system, Xbee-S2 series module is used as the wireless communication protocol as shown in Fig. 1 and Fig. 2. The water quality parameters are collected using the pH sensor, Turbidity sensor and Temperature sensor, which are interfaced to PIC18F4550 in the transmitter side, and transmitted over Xbee-S2 module, as shown in Fig. 1. These parameters are received by Xbee-S2

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module, interfaced to another PIC18F4550 at receiver side and displayed on LCD as well as on PC, as shown in Fig. 2.

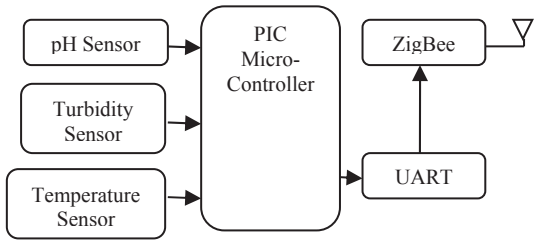

Fig. 1: Block Diagram of Transmitter Section.

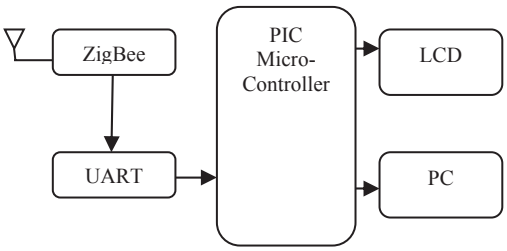

Fig. 2: Block Diagram of Receiver Section.

A. pH Sensor

The pH probe SEN0161 is used as the pH sensor with the BNC connector. When dipped into the solution, it provides the output voltage in millivolts with respect to the hydrogen ion concentrations in the solution. The output voltage range is from -414mV to +414mV with the operating temperature range of 0-60 degree Celsius. It has the accuracy of 0.01ph. The output voltage is positive for the acidic solution and negative for the alkaline solution. For neutral solution it gives zero output. The output pH range for SEN0161 is from 0 to 14. The pH sensor v1.1 is used as the signal amplification circuit to boost the output from mV to volts.

B. Turbidity Sensor

The SEN0189 module is used as the turbidity sensor. The SEN0189 module measures the turbidity (amount of suspended particles) of the water in river, lakes etc. It has operating voltage of 5V and operating current of 40mA. It has analog output from 0 to 4.5V with the response time less than 500mS. Also it has operating temperature range from 5 to 90 degree Celsius.

C. Temperature Sensor

The DS18S20 is used to measure the water temperature. It is a single wire digital output sensor. It has output temperature range from -55 to +100 degree Celsius. It has +/-5 degree Celsius accuracy from -10 to +85 degree Celsius. It converts temperature in 750mS. The purpose of using this sensor is to measure the water temperature with respect to surrounding temperature.

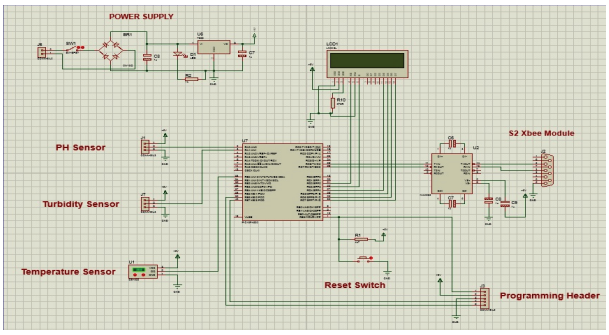

Fig. 3: Circuit Schematic of Transmitter Section.

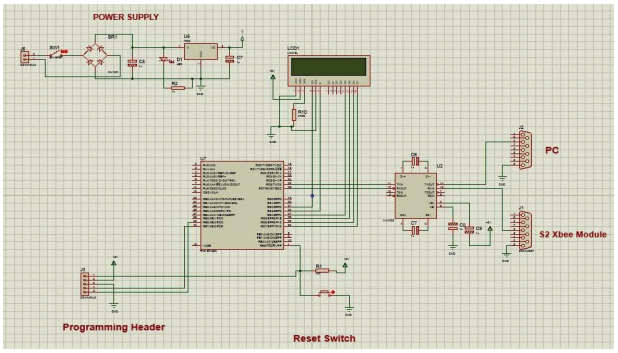

Fig. 4: Circuit Schematic of Receiver Section.

D. ZigBee Module

A wireless technology like ZigBee works on standard IEEE 802.15.4 protocol & operates on unlicensed bands worldwide at the frequencies 2.400-2.484GHz, 902-928MHz and 868.0-868.6MHz. The XBee Series 2 OEM RF Module is used in the system for the wireless transmission of the remote data. It is a high performance, Low cost, low power and easy to use RF module. It has the communicating range of 40m for indoor and 120m for the outdoor line-of-sight. It has the transmitting power of 2mW and receiver sensitivity of -95 dBm with the serial interface data rate of 250,000 bps. It requires a supply voltage of 2.8-3.4V with operating temperature range from -40 to 85º C.

E. PIC Control

The system is designed on the embedded platform of Peripheral Interface Controller (PIC) microcontroller. Both the sensors and the Xbee module are interfaced to the PIC microcontroller. The sensor inputs are given to the analog input of PIC and the Xbee is interfaced using the UART serial communication protocol. The Microchips PIC18F4550 PIC microcontroller is used, as it provides operating voltage of 5V and supports SPI, I2C and enhanced USART communication protocol.

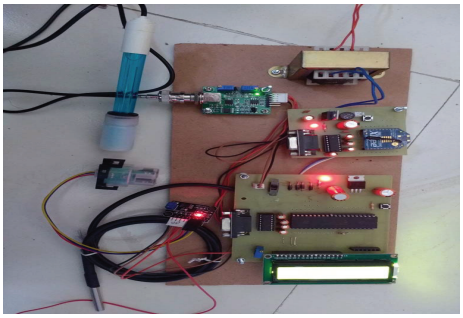

Fig. 5: Hardware of Transmitter Section.

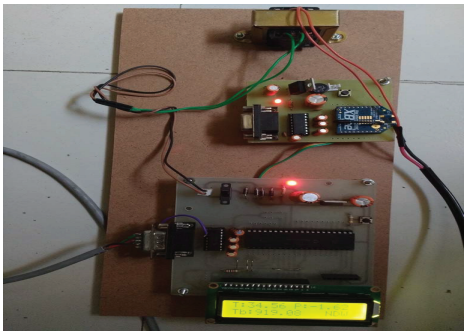

Fig. 6: Hardware of Receiver Section.

IV. System Flow Diagram

The software flow for the given system is given in three approaches as data collection, data transmission and display of data. The decision of the water quality is decided based on the different pH level and Turbidity levels taken from the remote areas. The decision is made whether the water is clean and drinkable or not. Fig. 7 shows the software flow for the Transmitter section and Fig. 8 shows software flow for the Receiver section.

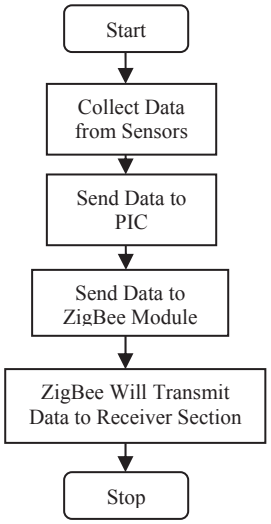

Fig. 7: Transmitter Software Flow Diagram.

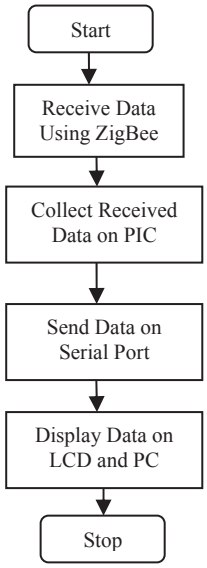

Fig. 8: Receiver Software Flow Diagram.

V. Results

The water quality is decided by taking the pH value and Turbidity value collectively, as shown in Table I. The collected data from the sensors are classified into three categories as: 'Safe & Pure Water for Drinking', 'Drinkable Water', and 'Impure and Non-Drinkable Water'. As per the norms given by the World Health Organization (WHO), the water with pH level 06, 07 and 08 is drinkable water [5]. We know that, water with pH level from 01 to 06 is Acidic and from 08 to 14 is Alkaline. Also the water with Turbidity level 0.1 NTU is safe and pure water for drinking, and water with Turbidity level below 1.0 NTU is drinkable water. Water with Turbidity level above 1.0 NTU is Turbid and Non-Drinkable water [6]. Hence the result is obtained as water with pH level 07 and Turbidity level 0.1 NTU is 'Safe and Pure Water for Drinking'. Water with pH level 06, 07 & 08 and Turbidity level from 0.2 NTU to 1.0 NTU is 'Drinkable Water'. Also water with pH level from 01 to 05 & from 09 to 14 and Turbidity level from 1.1 NTU to 1500 NTU is 'Impure and Non-Drinkable Water', as shown in Table I.

TABLE I. RESULTS

Turbidity Level (NTU)	pH Level (pH)	Water Quality Index
0.1	07	Safe and Pure Water for Drinking
0.2 to 1.0	06 to 08	Drinkable Water
1.1 to 1500	01 to 05	Impure and Non-Drinkable Water
	09 to 14	

CONCLUSION

The system provides the wireless water quality measuring tool with remote data collection. The data is collected at the receiver section and depending on the pH level and turbidity level, the data are classified and water quality is decided. The pH level of water, from 0 to 6 is called as acidic, while that from 8 to 14 is called as alkaline. The water with the pH value 7 is called as Neutral solution. The water with pH 6 to 8 is preferably drinkable water as per the WHO report [5]. If turbidity level is above 1.0NTU, then it is dirty water and if it is less than 1.0 NTU, then it is clean water [6]. The water quality index with Turbidity level 0.1NTU and pH level 07pH gives the safe and pure water for drinking. The system can be implemented at the on-site areas like Rivers and lakes to determine the pH and Turbidity level, which is used for the drinking and agriculture purpose. In Smart Cities, the big housing societies provide the direct drinking water, which is stored in the tank at the top of building. The system can predict the drinkable water quality and displays the readings on the LCD, which can be mounted inside the individual home. Also it can be implemented in the chemical plants, where the sewage water is driven into the Rivers and lakes. We can predetermine the water quality, before driving it into Rivers and lakes, to avoid the water pollution.

Acknowledgment

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