Implementation of Sensor Nodes for Drinking Water Quality Assessment

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Abstract— Clean drinking water is important for health and well-being of all humans. In large water distribution system, the technique used for determination of contamination present in water involves taking random water samples in different areas and testing them through laboratories. Since this process takes much time, quick measures cannot be taken regarding serious threat issue. Hence, this paper presents an approach to determine the quality of water automatically using low cost in-pipe sensors. Here an array of sensor node is developed for water quality determination. Algorithms are developed for fusing the data collected by the sensors. ZigBee and GSM transmitters are used to transmit the collected data to the server.

Key words: water quality assessment, in-pipe sensors, sensor network, ZigBee transmitter, GSM transmitter

I. INTRODUCTION

As most of the diseases are spreading through water, clean drinking water is the most important resource for the well being of human being. Nowadays, due to limited water resources, ageing infrastructure, increased population and decreased attention towards safeguarding, there is a need for on-line in-pipe water quality monitoring systems.

The methods used for water quality assessment at present involve collection of random samples of water at various locations and analyzing them in the laboratories. This approach is not much efficient because they have various drawbacks such as a) long time consumption b) only water samples from few areas can be determined simultaneously c) involves manual work. The laboratory based methods are too slow and hence we cannot enable critical decisions for public health protection. This method also involves manual work to monitor the quality of water regularly. In order to overcome those above mentioned drawbacks and to automate the process we are in need of on line in-pipe sensors for real time monitoring of water quality.

This paper proposes the idea of monitoring the quality if water using low cost multiple sensors. Here an array of sensors is used to monitor the quality of water. The information collected by the sensors is transmitted to the main server through ZigBee transmitter and also the GSM is used for transmitting the message to mobile phones.

ZigBee has been developed to meet the growing demand for capable wireless networking between numerous devices. In industries, ZigBee is used for next generation automated manufacturing. This increased level of communication permits finely-tuned remote monitoring and manipulation systems. In the consumer market, ZigBee is being used for everything from linking low-power household devices such as smoke alarms to a central housing control unit, to centralized light controls. The maximum range of operation for ZigBee devices is 250 feet (76m). This paper also proposes the techniques to resolve the contaminants present in water.

The remaining parts of this paper is organized as section II survey of related works, section III proposed method, section IV result analysis and section V conclusion.

II. SURVEY OF RELATED WORKS

The initial version of this article has appeared in [2]. In that article, they presented an improved hardware platform and developed a new advanced contamination event detection algorithm and provided experimental results of this algorithm in the presence of real biological contamination. Only limited number of on-line, reagent-free water monitoring Systems are commercially available, but these Systems are bulky and costly to use in large environments.

A number of multi-parametric sensor arrays have been developed and presented in the literature based on various sensor technologies. A recent review on multi-parametric sensors for water quality is given in [3]. An array of chemical Sensors for water quality monitoring based on thick-film technology is discussed in [4], [5] and [6], [7], these sensors are very low cost, they have limited lifetime and require a conventional glass reference electrode to operate accurately.

Several water monitoring Microsystems have been developed for large scale water monitoring based on wireless sensor networks (WSNs) technology. In [8] a sensor node is developed for monitoring salinity in ground waters as well as the water temperature in surface waters. [11], [12], deals with development of WSN and an energy harvesting system to monitor nitrate, ammonium and chloride levels in rivers and lakes.

A survey on energy harvesting for WSNs is provided in [13] and [15]. In [16] a WSN is proposed to monitor hydraulic parameters in order to detect events such as leaks, pipe bursts. A cost effective multi sensor probe for monitoring chlorine, conductivity and pressure without any event detection algorithms has been proposed by Endetec [17] in 2012. Finally, [1] low cost sensor network is formed to detect the quality of water using event detection algorithm. Other data validation methodologies are given in [9] and references therein.

III. PROPOSED WORK

The organizations like world health organization (WHO), EU, USEPA has set the standards for drinking water quality parameters and indicate which microbiological, chemical and indicator parameters must be monitored and tested regularly in order to protect the health of the consumers and to make sure the water is clean.

The developed system monitors both the biological contaminations and chemical contaminants that are present in water and also it provides methods to resolve those contaminants.

A. Block Diagram:

The Block diagram of proposed work based on GSM and ZigBee is shown in the figure1 and figure 2.

It consists, power supply section, GSM, ZigBee, microcontroller, MAX232driver, LCD, Flow Sensor, Conductivity Sensor, Temperature Sensor, pH Sensor, ORP sensor and Turbidity Sensor. The GSM board has a valid SIM card with a sufficient recharge amount to make outgoing calls. The circuits powered by +5v Dc.

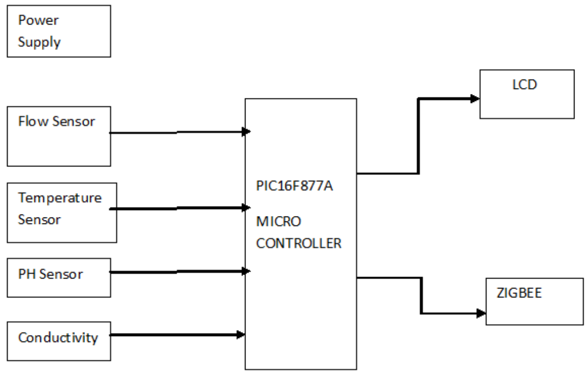

Fig. 1: Transmitter Section

The Receiver Section consists of Power supply section, Microcontroller, LCD, MAX RS 232, ZigBee, Server Computer and GSM Module.

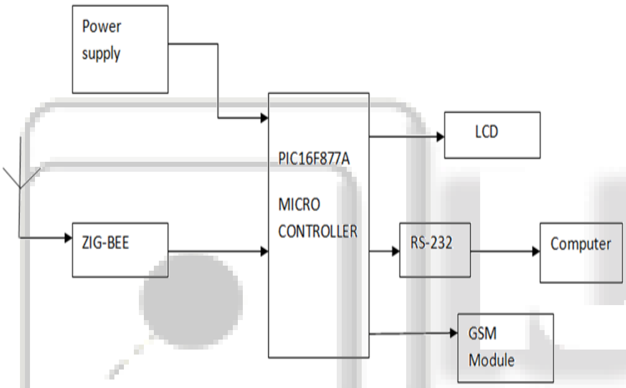

Fig. 2: Receiver Section

B. *Hardware Description:*

1) *Power Supply:*

Power supply unit consists of following units: Step down transformer, Rectifier unit, Input filter, Regulator unit and Output filter.

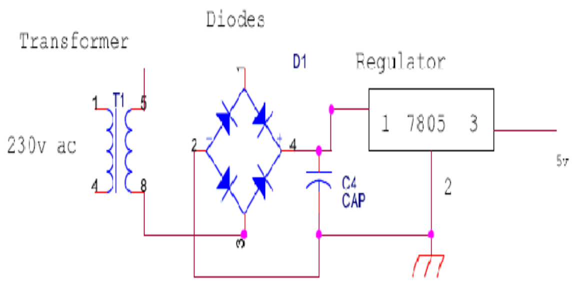

Fig. 3: Power Supply

The Step down Transformer is used to step down the main supply voltage from 230V AC to lower value. The Rectifier circuit is used to convert the AC voltage into its corresponding DC voltage. The most important and simple device used in Rectifier circuit is the diode. Capacitors are used as filter. The ripples from the DC voltage are removed and pure DC voltage is obtained. And also these capacitors are used to reduce the harmonics of the input voltage. Regulator regulates the output voltage to be always constant. The output voltage is maintained irrespective of the fluctuations in the input AC voltage. The Filter circuit is often fixed after the Regulator circuit. Capacitor is most often used as filter. The principle of the capacitor is to charge and discharge. It charges during the positive half cycle of the AC voltage and discharges during the negative half cycle. So it allows only AC voltage and does not allow the DC voltage. This filter is fixed after the Regulator circuit to filter any of the possibly found ripples in the output received finally.

2) *Microcontroller:*

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller". PIC's are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming capability.

3) *Sensors:*

A Sensor is a device, which responds to an input quantity by generating a functionally related output usually in the form of an electrical or optical signal. The Sensors used are Flow Sensor, Conductivity Sensor, and Temperature Sensor, pH Sensor, ORP sensor and Turbidity Sensor.

a) Temperature Sensor:

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°Cat room temperature and ±3/4°C over a full -55 to +150°Ctemperature range. Low cost is assured by trimming and calibration at the wafer level.

b) pH Sensor:

A pH-sensor is an electronic device which is used for measuring the pH (acidity or alkalinity) of a liquid (though special probes are sometimes used to measure the pH of semi-solid substances). A typical pH sensor consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading. The probe is a key part of a pH sensor, it is a rod like structure usually made up of glass. At the bottom of the probe there is a bulb, the bulb is a sensitive part of a probe that contains the sensor. Never touch the bulb by hand and clean it with the help of an absorbent tissue paper with very soft hands, being careful not to rub the tissue against the glass bulb in order to avoid creating static. To measure the pH of a solution, the probe is dipped into the solution. The probe is fitted in an arm known as the probe arm.

c) Flow Sensor:

Flow sensor tube shall be constructed of 304 stainless steel with carbon steel or 304 stainless steel flanges, which shall conform to standards such as ansi or awwa. The sensor walls shall be lined with a non-conductive material such as hard rubber (vhe/h3b for sewage, sludge, waste water, and raw water), soft rubber or novalak (for sludge, abrasive chemicals and slurries) the flow sensor shall be equipped with a smart plug feature for sensor calibration data.

d) Conductivity Sensor:

Conductivity (or specific conductance) of an electrolyte solution is a measure of its ability to conduct electricity. The SI unit of conductivity is siemens per meter (S/m). Conductivity is linked directly to the total dissolved solids (TDS.). High quality deionized water has a conductivity of about 5.5 μS/m, typical drinking water in the range of 5-50 mS/m, while sea water about 5 S/m (i.e., sea water's conductivity is one million times higher than that of deionized water).

Conductivity is traditionally determined by measuring the AC resistance of the solution between two electrodes. Dilute solutions follow Kohlrausch's Laws of concentration dependence and additivity of ionic contributions. The electrical conductivity of a solution of an electrolyte is measured by determining the resistance of the solution between two flat or cylindrical electrodes separated by a fixed distance. An alternating voltage is used in order to avoid electrolysis. The resistance is measured by a conductivity meter. Typical frequencies used are in the range 1–3 kHz.

4) Liquid Crystal Display:

More microcontroller devices are using 'smart LCD' displays to output visual information. The following discussion covers the connection of a Hitachi LCD display to a PIC microcontroller. LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8 x 80 pixels of the display. Hitachi LCD displays have a standard ASCII set of characters plus Japanese, Greek and mathematical symbols.

5) GSM:

The GSM modem is a specialized type of modem which accepts a SIM card operates on a subscriber's mobile number over a network, just like a cellular phone. It is a cell phone without display. Modem sim300 is a tri band GSM/GPRS engine that works on EGSM900MHz, DCS1800MHz and PCS1900MHz frequencies. GSM Modem is RS232-logic level compatible, i.e., it takes-3v to -15v as logic high and +3v to +15 as logic low.MAX232 is used to convert TTL into RS232 logic level converter used between the microcontroller and the GSM board. The signal at pin 11 of the microcontroller is sent to the GSM modem through pin 11 of max232.this signal is received at pin2 (RX) of the GSM modem. The GSM modem transmits the signal from pin3 (TX) to the microcontroller through MAX232, which is received at pin 10 of IC1.

6) ZIGBEE:

ZigBee is the set of specs built around the IEEE 802.15.4 wireless protocol. The IEEE is the *Institute of Electrical and Electronics Engineers*. The name "ZigBee" is derived from the erratic zigging patterns many bees make between flowers when collecting pollen. This is evocative of the invisible webs of connections existing in a fully wireless environment. The standard itself is regulated by a group known as the ZigBee Alliance, with over 150 members worldwide. While Bluetooth focuses on connectivity between large packet user devices, such as laptops, phones, and major peripherals, ZigBee is designed to provide highly efficient connectivity between small packet devices. As a result of its simplified operations, which are one to two full orders of magnitude less complex than a comparable Bluetooth device, pricing for ZigBee devices is extremely competitive, with full nodes available for a fraction of the cost of a Bluetooth node.

IV. SIMULATION

A. Proteus:

Many CAD users dismiss schematic capture as a necessary evil in the process of creating PCB layout but we have always disputed this point of view. With PCB layout now offering automation of both component placement and track routing, getting the design into the computer can often be the most time consuming element of the exercise. And if you use circuit simulation to develop your ideas, you are going to spend even more time working on the schematic. ISIS has been created with this in mind.

It has evolved over twelve years of research and development and has been proven by thousands of users worldwide. The strength of its architecture has allowed us to integrate first conventional graph based simulation and now - with PROTEUS VSM - interactive circuit simulation into the design environment. For the first time ever it is possible to draw a complete circuit for a micro-controller based system and then test it interactively, all from within the same piece of software. Meanwhile, ISIS retains a host of features aimed at the PCB designer, so that the same design can be exported for production with ARES or other PCB layout software.

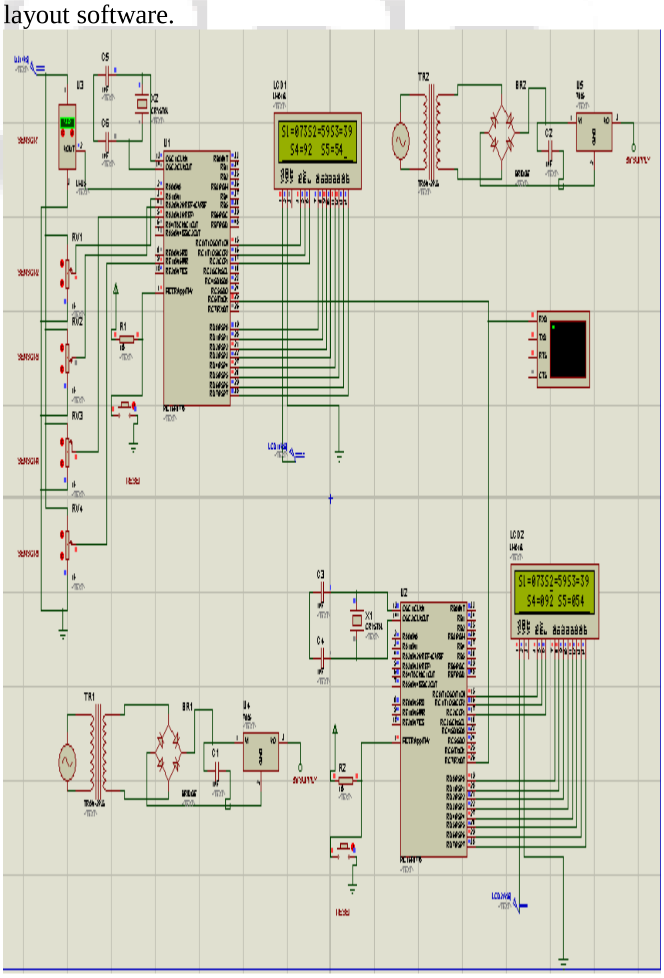

Fig. 4: Simulated output

V. RESULT

The below figure shows the transmitter and receiver modules.

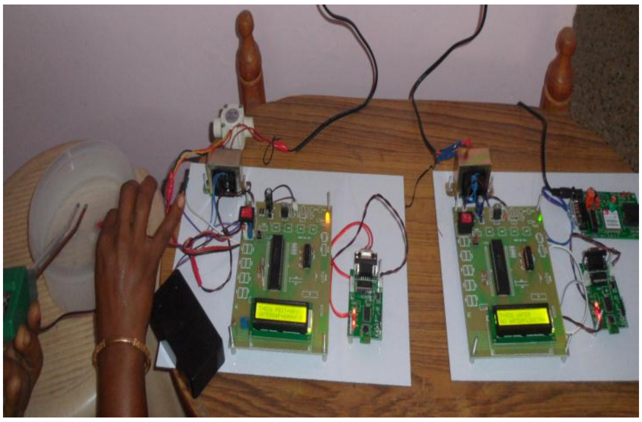

Fig. 5: Transmitter and receiver modules

VI. CONCLUSION

Hence in this paper, with the help of the values detected by various sensors, the contamination level present in water is determined. pH sensor is used here to determine the chemical contaminants, the conductivity sensor is to find the biological contaminants and the flow sensor is used to determine the dust and other particles present in water. This implementation of several on-line in pipe sensors that are used to determine the contamination of water has been discussed and the results were produced. Here, the sensors are used are of low cost and hence implementation cost is low. The information collected by the sensors are sent to the main server so that the in case of any contamination, the information will be passed to the authority as well as the common people can see how far the water being used by us is clean. The message will also be sent to the mobile phones through GSM incase of any emergency.

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