

Low Cost Sensor Network for Real Time Water Quality Measurement System

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ABSTRACT: Human body contains about 80% of water hence, every man need water as important factor to sustain life on earth. So, quality of such highly consumed water became an important issue. As improved water quality is favorable for health so every possible effort should be made in that direction. For identifying the quality of consumed water in house a sensor based system is explained in this paper. This system detects the water quality by measuring various physical and chemical parameters of water such as turbidity, pH, temperature, conductivity and TDS (total dissolved solid) on real time basis. This system also displays the measured values on LCD for proper understanding as well as on wireless GUI for remote monitoring purpose. This will help to know the water quality at consumer level. This system consists of electrochemical and optical sensors arranged in an array so that all the parameters are detected at the same time. The sensors are interfaced with PIC controller and Zigbee CC2500 module is used for wireless data transferring. The system is very reliable & can work for a long time. It also helps to reduce the manpower which in turn reduces the expenditure on workers salary.

KEYWORDS: PIC controller, Zigbee, Water quality analysis, Turbidity, pH, TDS, LCD, wireless GUI etc....

I.INTRODUCTION

Water is essential for life. Drinking water, also known as potable water or improved drinking water is water that is safe to drink or to use for food preparation, without risk of health problems. Globally, in 2012, 89% of people had access to water suitable for drinking [11]. Nearly 4 billion had access to tap water while another 2.3 billion had access to wells or public taps [11] 1.8 billion people still use an unsafe drinking water source which may be contaminated. This can result in various water related diseases such as diarrhoea, cholera and typhoid among others.

Water quality refers to the chemical, physical, biological, and radiological characteristics of water [12]. Usually measured parameters of water are temperature, turbidity, pH, conductivity, dissolved oxygen (DO) and total dissolved solid (TDS). Water related diseases increases day by day which cause 3.4 million deaths a year, mostly among children. Since there are many efforts made by government but still many people do not have access to improved water sources. This is due to unawareness in public and administration and the lack of water quality monitoring system which creates serious health issues. As water is the most important factor for all living organisms it is necessary to protect it and water quality analysis is first step taken towards it [4].

Water quality analysis is process in which various parameters are tested generally using lab instruments which are the traditional method. In traditional method, water parameters are detected by collecting samples manually and then send them to the well-equipped laboratories for further analysis where the testing equipments are stationary and samples are provided to the testing equipments. But this is a manual method with a tedious process and it has many disadvantages. It requires too much manpower and material resource. It is a time consuming process which has various limitations like sample collecting, aging of experiment equipment. Hence it is less reliable and has disadvantages like lack of real time water quality information and it does not have any on field monitoring mechanism. In order to overcome above mentioned disadvantages there is need to have autonomous, low cost, reliable and flexible water quality measurement

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 12, December 2016

system. Hence such a low cost real time water quality measurement system which is more reliable than traditional method is proposed in this paper. This system overcomes all the drawbacks of traditional system.

II. LITERATURE SURVEY

There are different techniques available for water quality measurement which involves mainly two approaches traditional and modern. Modern approach include sensor network which were designed and deployed either on the ground for operations or mounted in pipe for continuous monitoring.

Various advanced technologies for measuring water quality have been proposed in the recent years. A sensor based wireless water quality monitoring system is proposed in which the data from monitoring nodes is send to the base station consisting of ARM controller and then sent to the remote monitoring station and then displayed on a server PC [4]. Now a days a wireless sensor network system is also becoming more popular which consist of high power Zigbee based technology together with the IEEE 802.15.4 compatible transceiver [5]. Most of the systems uses sensor circuitry for acquiring water quality parameters and send this data to the controller unit. The controller unit performs necessary actions and then delivers this data to the GSM module so that the data will be sent to the monitoring center in the form of SMS [1][4][6][9][10].

To find out the practical working of water quality analysis, field survey is done by visiting some labs of water quality testing which include 'Soil & water quality testing Lab' where pH, electrical conductivity, temperature & TDS (total dissolved solids) of water sample are tested using pH meter and EC-TDS analyser respectively and also visited water plant where different sensor based lab instrument which are high in cost were used to measure water quality by traditional method.

Summary

From the survey of available literature regarding water quality measurement, it is concluded that for quality measurement of water, sensor based system is efficient, economical, convenient and fast than the traditional method. It also has good flexibility as only by replacing sensors and small change in software programming the system can be used for measuring other water quality parameters as per their applications in industry or agriculture. But the choice of sensor should be made appropriate depending on the application and cost of the project. From the field survey it is noted that there is no real time monitoring system is available for water quality detection. Hence, there is need of development of the system which gives real time information about the water quality.

III. SYSTEM MODELLING

The proposed system is an embedded system which will measure the different physical and chemical quality parameters of water and display the result on LCD as well as on wireless GUI for monitoring purpose. The system design basically consists of two units, the hardware and software units. The sensors constitute the data acquisition system that is mainly used for the measurement of temperature, pH, conductivity, TDS and turbidity content of water. LCD display is used to display the measured values and RF transceiver is mainly used to display the values on PC with GUI so that parameters can be monitored at remote location.

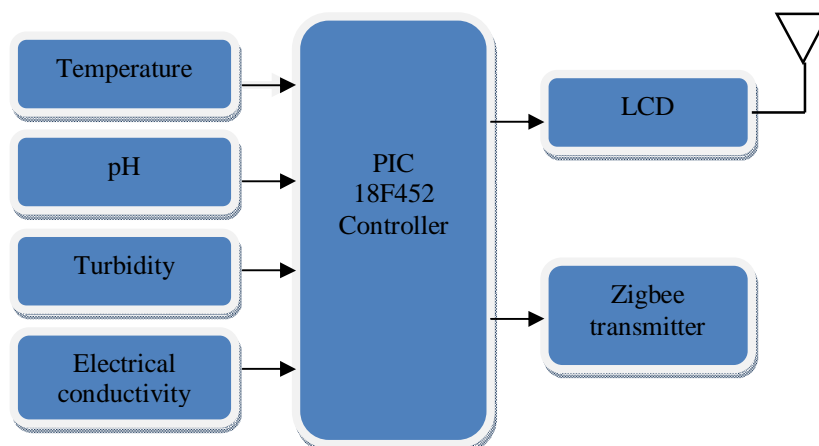


Fig.1 Block diagram of transmitter section

The hardware unit of the prototype is divided in two sections; the transmitter section of the system is represented by the block diagram shown in fig.1. It contains PIC 18F452 microcontroller as the main processing unit and it gets inputs from the temperature sensor (LM35), pH sensor (pH probe with sensor), conductivity sensor (Two copper wires mounted on pen) and turbidity sensor (TDS 10). From the data obtained from the sensors the program calculates the measured values in an appropriate range to achieve the system requirements and then display the output on LCD and at the same time the data is transmitted with the help of Zigbee CC2500 transmitter. The block diagram of receiver section is shown in fig.2 which consist of Zigbee CC2500 receiver which receives upcoming signal from transmitter and display the result on a PC with GUI.If the value is not in standard quality range then it is indicated on GUI by red light indication.

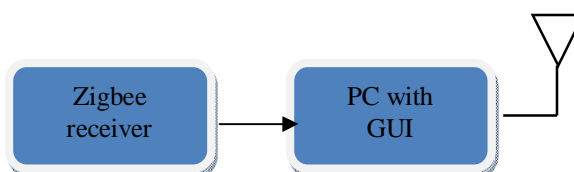


Fig.2 Block diagram of receiver section

Temperature sensor: Water temperature is one of the five important factors for water quality testing. It controls the rate of metabolic and reproductive activities and hence aquatic life cycle. In the proposed system temperature of water is measured with the help of LM 35 temperature sensor. It is commonly used temperature sensor whose output voltage is linearly proportional to Celsius temperature. It is more accurate than thermistor. It does not require any external calibration or trimming to provide typical accuracies at room temperature over range -55°C to 150°C . It possesses low self-heating and does not cause more than 0.1°C temperature rise or fall. It has three pins one for input voltage (VCC), one for ground (GND) and one for output voltage (Output). It gives output in analog form in specific voltage range. This voltage can be mapped into actual values of temperature using PIC Controller. The output varies by 10mV with respect to every $^{\circ}\text{C}$ rise or fall in ambient temperature which means its scale factor is $0.01\text{V}/^{\circ}\text{C}$ [8][10].

pH sensor: pH is an important chemical factor of water. It is measure of acidity or basicity of a solution. It is based on concentration of H^+ or OH^- ions present in water. The system uses pH sensor with pH probe fitted with coaxial cable and BNC type of connector. A pH glass probe is made up of special glass that can conduct electricity and allow only hydrogen ion. When glass probe touches the hydrogen ion the potential is produced. Likewise different pH in water generates corresponding potential [1]. The combined Electrode consists of glass and reference electrodes in a single entity. Therefore a separate, reference electrode need not be used along with this electrode. Below the cap a hole is provided for filling the solution in internal reference electrode. The reference electrolyte solution or filling solution is a 2 M Potassium Chloride (KCl) Solution. It operates on 5V DC supply and current of 5 to 10mA. Its response time is 5 sec. and stability time is 60 sec. It has service life of 3 years and has analog voltage signal output.

Turbidity sensor: Turbidity is a measure of suspended particles present in water also called as cloudiness of water. It is mainly caused by suspended solids like soil particles and plankton (microscopic plants). TSD 10 turbidity sensor is used in this system. This sensor uses light to convey information about turbidity of water. It has two horns like structure having top to bottom mono material body with a black colored cap at the bottom. The thick alloyed contact legs provide means for various connectors to hold the sensor. A white plastic slab protects the legs from damage and acts as fixture for good clamping. Outer part is covered with plastic so that it can survive high variations and mechanical abrasion. It works on 5 V DC supply and current up to 30mA. It operates on temperature ranging from -10°C to $+90^{\circ}\text{C}$.

Working: It is an optical sensor which is used as measuring product for turbid water density or an extraneous matter concentration using the refraction of wavelength between photo transistor and diode. By using an optical transistor and optical diode, this sensor measures the amount of light coming from source of light to the light receiver in order to calculate water turbidity.

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Conductivity sensor: Conductivity defines the ability of water to conduct electricity. This type of measurement accesses the concentration of ions in a solution. Conductivity sensor circuit is same as that of photo resistor circuit. A voltage divider circuit consists of the conductivity sensor and a 10kΩ resistor which is energized by setting high digital output. Some portion of 5V dropped across sensor while remaining portion dropped across the 10kΩ resistor. Voltage drop across 10kΩ resistor is measured by an analog input on ADC while voltage drop across conductivity sensor can be easily measured by making it the resistor closest to ground. The sensor is made by mounting two copper wires on a plastic pen such that both the open terminals should be dipped inside the water properly. The sensor is configured such that the voltage measured at the analog input increases as the water becomes more salty. TDS of the can be measured with the help of electrical conductivity of water.

Total dissolves solid (TDS): Total dissolved solids refer to the amount of minerals and salts present in the water. It combines the sum of all ion particles that are smaller than 2 microns. This includes all the disassociated electrolytes that increase the salinity concentration of water and other compounds such as dissolved organic matter. This term can be obtained by multiplying the conductivity term by a factor usually taken as 0.67. TDS of water is measured in unit mg/L. Freshwater can have maximum TDS as 2000 mg/L.

$$\text{TDS} = 0.67 \times \text{conductivity}$$

By using this sensor array five parameters of water can be measured at a time. Since all the sensors gives analog input, the analog pins of PIC controller are used. As such all these analog data is converted into digital with the help of inbuilt ADC converter of controller. These digital values are then mapped into specific range which can be then compared with the standard quality range. The pictorial view of developed system is shown in Fig. 3.

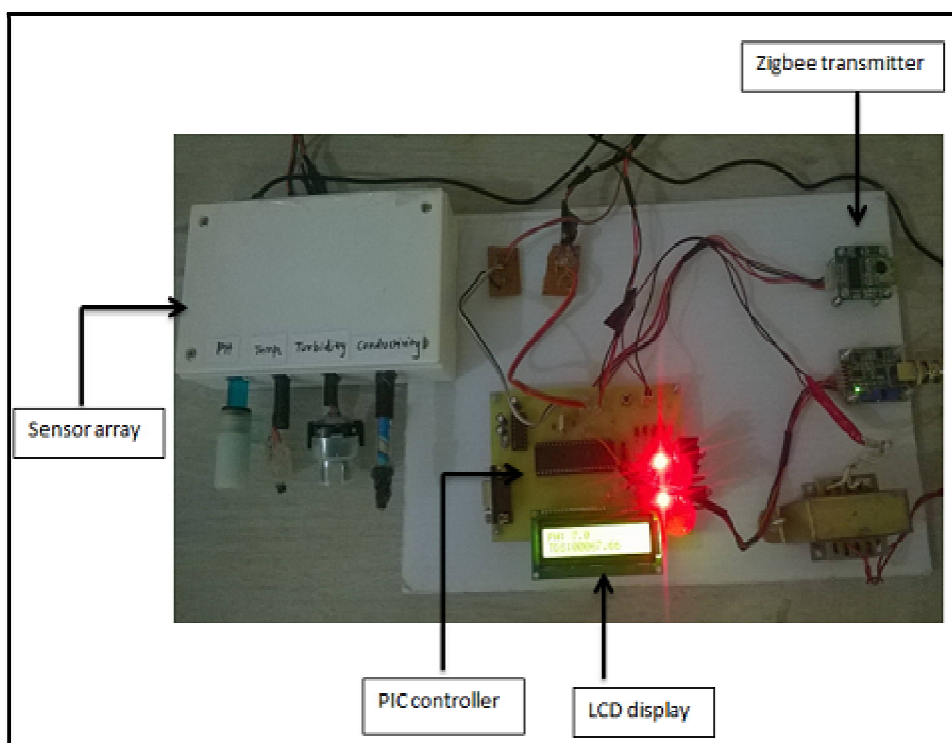


Fig.3 Developed system

When the sensor array is inserted into a water sample the actual values of temperature, pH, conductivity, TDS and turbidity of water sample are displayed on LCD. So that at a time all the parameters of a single water sample can be measured. These values are then transmitted by Zigbee transmitter to be displayed on GUI. If the temperature of water sample is in between 0 to 45°C, turbidity is in between 0 to 5 NTU, pH is in range of 6.5 to 8.5, conductivity is in range

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 12, December 2016

of 160-250 mg/L and if TDS of water is in range of 70 to 150 mg/L then it is indicated by green light in front of parameter value.

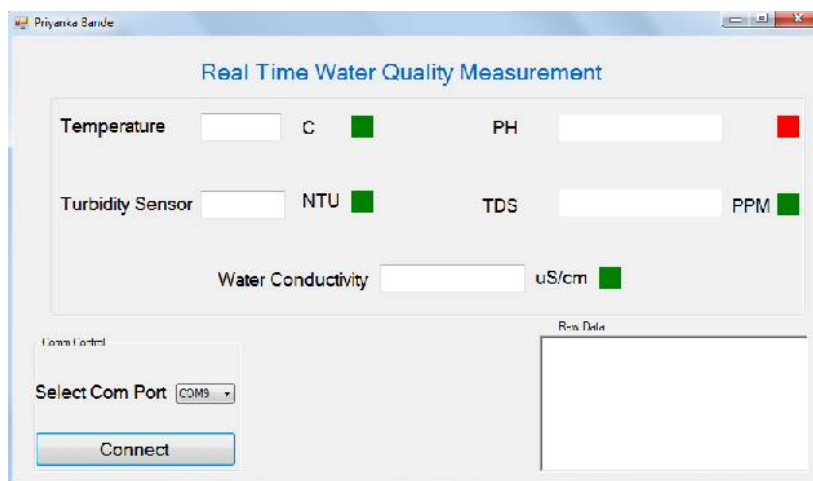


Fig.4 Wireless GUI created by VB.net

Wireless Graphical user interface (GUI) is created using VB.net which shows real time monitoring and continuously records the value of all parameters in the system as shown in Fig.4. The database is created which saves the continuous data for the future analysis and prediction purpose.

IV. PERFORMANCE EVALUATION

The system performance is observed by taking multiple readings of three different samples .One sample is tap water of Municipal Corporation which is used in home for daily need, another sample is rain water and third sample is highly impure water which involves all the impurities. These samples are tested on proposed system as well as in Lab. The test results are compared as shown in table II. The standard valued of water quality parameters as per IS 10500-2012 standards are shown in table I:

Table I: Treated water standards

Sr. no.	Parameter	Acceptable	Cause of rejection
1	pH	6.5 to 8.5	<6.5 or >9.2
2	Odour & Taste	Unobjectionable	Objectionable
3	Turbidity (NTU)	5	>5
4	Conductivity (µS/cm)	160-250	>250
5	Temperature (°C)	5-40	>40
6	Total Dissolved Solid (mg/l)	0-2000	>2000

Calibration: It is the key aspect of this proposed method. PIC controller gives output in 10 bit resolution. So output comes in the range of 0 to 1024 . By analyzing the response of each sensor to different samples, a scale was developed & then the system is calibrated accordingly.

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Table II : System performance

Sr. no.	Temperature		pH		Turbidity		EC		TDS	
	System result	Lab test result	System result	Lab test result	System result	Lab test result	System result	Lab test result	System result	Lab test result
1	26	26.9	7	7.48	3	2	165	164.2	110.55	113.36
2	25	26.8	8	8.40	42	44	298	301.2	199.66	202.85
3	27	27.4	9	8.92	98	99	392	394.2	262.64	265.23

As shown in above table the system performance is tested by comparing the system result with the lab result and if the all the measured values are in specified standard range then the water quality is safe for drinking and it is indicated by green light on GUI otherwise red light is indicated in front of the parameter value. For the tap water all the values are in standard range hence, this water is safe for drinking on the other hand the parameters of rain water and impure water samples are not in standard range hence the water is unsafe for drinking.

V. CONCLUSIONS

In this paper a system is described which detects the quality of water by measuring different quality parameters with the help of chemical and optical sensors. The system response is tested by comparing measured valued with the standard value provided by WHO (IS standard-10500 2012). This system is made wireless with the help of Zigbee module, so that it is possible to determine the instantaneous values of water samplesremotely. Performance of the system is crosschecked in lab and output is found same as that of the standard value.

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