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Real-Time Based Drinking Water Quality Monitoring and Contamination Detection System Using Low cost Sensor Network

[1]B.Keerthi & [2]P.Suresh Babu
[1]Embedded systems (M.Tech), SVCE, Karakambadi Road, Email Id: bkondakeerthi@gmail.com
[2]Associate Professor, Dept of ECE, SVCE, Karakambadi Road, Email Id: sureshbabu476@gmail.com

ABSTRACT:
This project presents a low cost and holistic approach to the water quality monitoring problem for drinking water distribution systems as well as for consumer sites. Our approach is based on the development of low cost sensor nodes for real time and in-pipe monitoring and assessment of water quality on the fly. The main sensor node consists of several in-pipe electrochemical and optical sensors and emphasis is given on low cost, lightweight implementation, and reliable long time operation. Such implementation is suitable for large scale deployments enabling a sensor network approach for providing spatiotemporally rich data to water consumers, water companies, and authorities. Extensive literature and market research are performed to identify low cost sensors that can reliably monitor several parameters, which can be used to infer the water quality. Based on selected parameters, a sensor array is developed along with several micro systems for analog signal conditioning, processing, logging, and remote presentation of data. Finally, algorithms for fusing online multi sensor measurements at local level are developed to assess the water contamination risk. Experiments are performed to evaluate and validate these algorithms on intentional contamination events of various concentrations of escherichia coli bacteria and heavy metals (arsenic). Experimental results indicate that this inexpensive system is capable of detecting these high impact contaminants at fairly low concentrations. The results demonstrate that this system satisfies the online, in-pipe, low deployment-operation cost, and good detection accuracy criteria of an ideal early warning system.

Index Terns: Water quality Monitoring; Flat surface sensors; Multi-sensors system; Sensor networks; Arsenic and bacterial contamination detection

1. INTRODUCTION

Water distribution systems are inherently sensitive to both intentional and accidental contamination. There are many points at which a contaminant may enter the dispersion system. This grade of major components such as treatment plants, pumps and tanks, to individual hydrants and consumer sites. Since it is highlight to fully protect all potential points of entry, in accession trying to depress the likely of contamination events, a major stress has been on dealing the dispersion system in case of contamination and trying to minimize the impacts of such events. Conventional methods of water tone control requires the manual collection

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of water samples at various locations and at different times, followed by research lab analytical techniques in order to qualify the water tone. Such attacks are no longer considered efficient. Although, the actual methodology allows a thorough analysis including chemical and biological agents, it has several drawbacks.

Contaminated water sources may contain traces of metals such as copper (Cu), zinc (Zn), lead (Pb), mercury (Hg), nickel (Ni), cobalt (Co) etc. and other major ions such as nitrate (NO−3), phosphate (PO3− 4), ammonium (NH4+) etc. IN this paper, the magnetic field and electric field of the sensor are reactive to the metals and other major ions. Formal methods for detecting bacterial micro-organisms are culture-based, requiring conventional laboratory settings utilizing bacterial surrogates or indicators, such as total coli form bacterium, fecal coli form bacterium or Escherichia coli. Hence there is a clear need for continuous on-line water tone supervising with efficient comprehensive resolution. US Environmental Protection Agency (USEPA) has carried out a wide experimental evaluation of water tone sensors to assess their operation on several contaminations.

The independent decision was that lots of the chemical and biological contaminants used bear an impression on many water parameters monitored including Turbidity (TU), Oxidation Reduction Potential (ORP), Electrical Conductivity (EC) and pH. Therefore, it is executable to monitor and infer the water tone by observing changes in such parameters. The main part of this paper is to formulate a low cost system that can be used at the prefaces of consumers to continuously monitor qualitative water parameters and fuse multi-parametric sensor response in order to evaluate the water consumption hazard. The contributions regarding the low cost system is the design and development of low cost networked embedded systems as well as optical sensors(turbidity) for water tone monitoring, the development of event detection algorithms using fusion techniques, database evaluation and proof of system performance in various concentrations of microbiologically (E.coli) and chemically (Arsenic) contaminated drinking water.

2 . SYSTEM DESIGN:

Contamination warning schemes and other methods for detecting and mitigating contamination events require active treatment in order to minimize affects. An alternative or supplemental “passive” mechanism for reducing impacts involves the re-design of distribution systems aimed specifically at improving security. In the United States and many other countries, distribution systems are designed as looped systems composed of transmission lines and interconnected local delivery pipes used to deliver water to customers. Looped systems generally result in multiple paths that water can follow from the treatment plant to customers and provide redundancy in case of outages. However, the loops also result in multiple pathways for contaminants and greater difficulties in isolating contaminants.

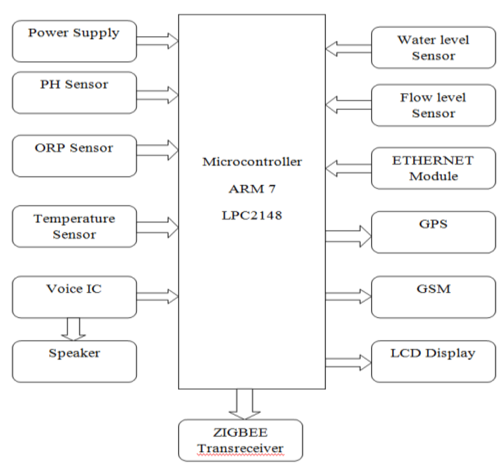

Figure: Block diagram of Transmitting section

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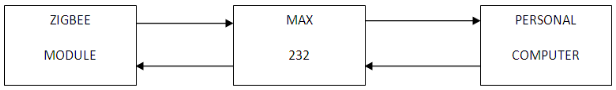

Figure: Block diagram of Monitoring section

3. HARDWARE DESIGN

The hard ware design of the contamination water detection system consists of the following hardware modules LPC 2148 microcontroller, Zigbee wireless communication module, LCD display ,temperature sensor, PH sensor, Turbidity sensor

A. Microcontroller (LPC 2148):

ARM is one of the most licensed and thus widespread processor cores in the world Used especially in portable devices due to low power consumption and reasonable performance (MIPS / watt) Several interesting extensions available or in development like Thumb instruction set and Java machine. Advanced RISC Machine, First RISC microprocessor for commercial use, Market-leader for low-power and cost-sensitive embedded applications.

B. Temperature sensor:

The LM35 series are precision integrated circuit temperature sensors. Output voltage is linearly proportional to centigrade temperature. Operates from 4 to 30 volts. Rated for full b55§ to a150§C range Linear a 10.0 mV/§C scale factor.

C. Water level sensor:

The water level indicator employs a simple mechanism to detect and indicate the water level in an overhead yank or any other water container. The sensing is done by using a set of seven probes which are placed at seven different levels on the tank walls .The level 3 represents the "tank full" condition while level 1 represent the "tank empty" condition.

D. PH Sensor:

The CSIM11, measures the full pH range of liquids. It can be sunken in water or put into tanks, pipelines, and open channels. The CSIM11 is for non-pressurized systems and was not designed for applications above 30 PSI.

Benefits and Features

- Internal amplifier boosts the signal decreasing signal interference.
- Compatible with most Campbell Scientific data loggers.
- Porous poly tetra fluoro ethylene (PTFE) liquid junction is less susceptible to clogging as compared to conventional reference junctions.
- Plunger-style pH glass electrode allowing the probe to be mounted at any angle.

E. Turbidity sensor:

Turbidity is the amount of cloudiness in the water. An instrument used for measuring the turbidity of water or other fluids is called turbidity meter. An instrument for measuring and comparing the turbidity of liquids by viewing light through them and determining how much light is cut off.

Advantages:

- Very accurate.
- Useful for measuring low turbidities(less than 5 TU).

F.GSM Module:

GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM supports voice calls and data transfer speeds of up to 9.6 kbps, together with the transmission of SMS (Short Message Service). GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US. GSM services are also transmitted via 850MHz spectrum in Australia, Canada and many Latin American countries.

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The use of harmonized spectrum across most of the globe, combined with GSM's international roaming capability, allows travelers to access the same mobile services at home and abroad. GSM enables individuals to be reached via the same mobile number in up to 219 countries. Terrestrial GSM networks now cover more than 90% of the world's population. GSM satellite roaming has also extended service access to areas where terrestrial coverage is not available.

Fig: GSM module

G. GPS System:

GPS is the Global positioning system is to determine your position on earth: east- west north-south and vertical (longitude, latitude and altitude). GPS is provided on mid 1990. Today many different standard was used which are WAAS LAAS DGPS NDGPS. DGPS is used to correct bias errors at one location with major bias error at one position. Local area augmentation system focus its service on the airport area. It work using very high frequency radio data link.

Application of GPS Technology:

- Location - determining a basic position
- Navigation - getting from one location to another
- Tracking - monitoring the movement of people and things
- Mapping - creating maps of the world
- Timing - bringing precise timing to the world

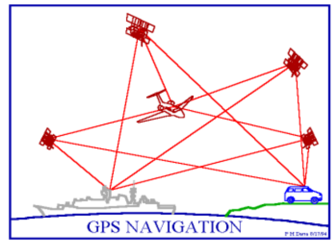

Fig : GPS Navigation system

4. RESULTS:

Figure1: Real time drinking water Quality monitoring and contamination detection system without power supply.

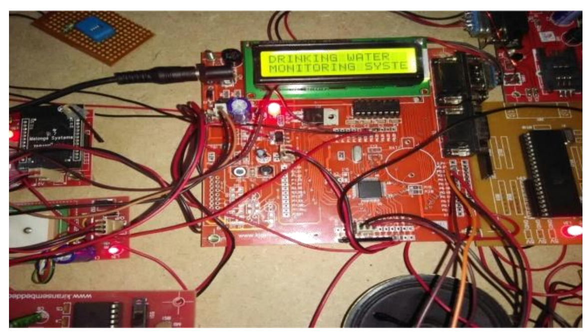

Figure2: Real time drinking water Quality monitoring and contamination detection system when power supply is connected

Figure 3: When there is flow through the pipe at certain force.

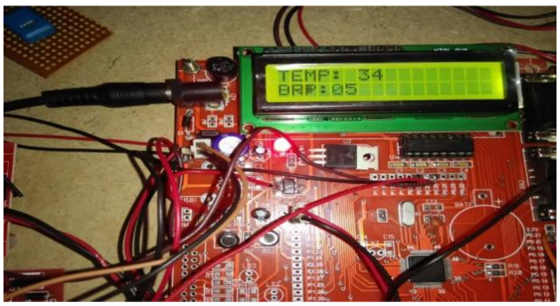

Figure 4: Temperature and ORP values of impure water

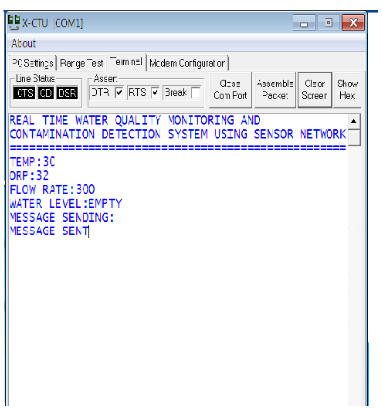

Figure 5: Results Displayed on PC through the ZIGBEE

	Parameter	Units	Quality Range	Meas. Cost
1	Turbidity	NTU	0 – 5	Medium
2	Free Residual Chlorine	mg/L	0.2 – 2	High
3	ORP	mV	650 – 800	Low
4	Nitrates	mg/L	<10	High
5	Temperature	^oC	–	Low
6	pH	pH	6.5 – 8.5	Low
7	Electrical Conductivity	μS/cm	500 – 1000	Low
8	Dissolved Oxygen	mg/L	–	Medium

Table I: Specifications and Accomplished Performance for Each Monitored Parameter

5. CONCLUSION:

In this article, the design and development of a low cost sensor node for real time monitoring of drinking water quality at consumer sites is presented. The proposed sensor node consist of several in-pipe water quality sensors with flat measuring probes. Unlike commercially available analyzers, the developed system is low cost, low power, lightweight and capable to process, log, and remotely present data. Moreover, contamination event detection algorithms have been developed and validated to enable these sensor nodes to make decisions and trigger alarms when anomalies are detected. Such implementation is suitable for large deployments enabling a sensor network approach for providing spatiotemporally rich

data to water consumers, water companies and authorities. In the future, we plan to investigate the performance of the event detection algorithms on other types of contaminants (e.g. nitrates) and install the system in several locations of the water distribution network to characterize system/sensors response and wireless communication performance in real field deployments. Finally, we plan to investigate network-wide fusion/correlation algorithms to assess water quality over the entire water distribution system.

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[1]B.Keerthi , pursuing M.tech., Embedded systems, Sri Venkateswara College of Engineering, Karakambadi
bkondakeerthi@gmail.com

[2]POTLADURTY SURESH BABU, completed B.Tech in S.V.University and M.Tech in S.V.University and PhD (Pursuing) on Signal Processing in S.V.University, Tirupati. He published 8-International journals. Presently he is working in SVCE, Tirupati with 8 years Teaching experience. His areas of Interest are Signal, Image and Video processing.
Email ID: Sureshbabu476@gmail.com