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Water Quality Monitoring System Using Wireless Sensor Network

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Abstract— **The parameters involved in the water quality monitoring such as the pH level, turbidity and temperature is measured in real time by the sensors that send the data to the base station or control/monitoring room. As the monitoring is intended to be carried out in a remote area with limited access, signal or data from the sensor unit will then be transmitted wirelessly to the base monitoring station. The application of wireless sensor network (WSN) for a water quality monitoring is composed of a number of sensor nodes with networking capability. Such monitoring system can be setup emphasizing on the aspects of low cost, easy ad hoc installation, easy handling and maintenance. The use of wireless system for monitoring purpose will not only reduce the overall monitoring system cost in terms of facilities setup and labor cost, but will also provide flexibility in terms of distance or location. In this paper, the fundamental design and implementation of WSN featuring a high power transmission Zigbee based technology together with the IEEE 802.15.4 compatible transceiver is proposed. It is chosen due to its features that fulfill the requirement for a low cost, easy to use, minimal power consumption and reliable data communication between sensor nodes. The development of graphical user interface (GUI) for the monitoring purposes at the base monitoring station is another main component discussed in this paper. The GUI should be able to display the parameters being monitored continuously in real time. The developed GUI platform using MATLAB is cost-effective and allows easy customization.**

Keywords— **graphical user interface, water quality monitoring, wireless sensor network, Zigbee technology.**

I. INTRODUCTION

Water is a limited resource and is essential for agriculture, industry and for creatures' existence on earth including human beings. Water quality monitoring is essential to control the physical, chemical and biological characteristics of water. It provides information about the current health of the water body, whether the water body meets the designated use and how it has changed over time.

Information gathered can be used to suggest that the water body requires improvement to meet its designated use and lead to actions to protect and restore the health of the water body. For example, drinking water should not contain any chemical materials that could be harmful to health; water for agricultural irrigation should have low sodium content; water for industrial uses should be low in certain inorganic chemicals. In addition, water quality monitoring can help with water pollution detection, discharge of toxic chemicals and contamination in water. Temperature, pH and turbidity are the typical parameters collected in river/lake water quality monitoring systems.

The goal of this project is to design and manage a Wireless Sensor Network (WSN) that helps to monitor the quality of water with the help of information sensed by the sensors immersed in water, so as to keep the water resource within a standard described for domestic usage and to be able to take necessary actions to restore the health of the degraded water body. A WSN featuring a high power transmission Zigbee based technology together with the IEEE 802.15.4 compatible transceiver is chosen because of the simplicity of its deployment, low cost, minimal power consumption, reliability and high scalability.

The development of graphical user interface (GUI) for the monitoring purpose at the base monitoring station is another main component in the project. The GUI should be able to display the parameters being monitored continuously in real time.

II. RELATED WORKS

There are many works on the application of WSN for monitoring system. One classic example of using ZigBee is in security systems. A security system might have several sensors, including motion detectors, security cameras and glass-break sensors. These devices are required to communicate with the central security centre by either wires or a wireless network. ZigBee-based security systems are simple to install, requiring no wired connection, and easy to upgrade. Although ZigBee has a low data rate, it has still the capability to transfer images wirelessly with reasonable quality. ZigBee has been used in a wireless camera system which records the videos of visitor at a front door and then transmits these recordings to monitor, inside the house. Zigbee is also used for Light control in a house or commercial building. In a typical light installation system, it is necessary to install a wire from the light to a switch in order to turn on or off the light. No wired connection between the light and the switch is necessary if the light and switch are equipped with the ZigBee devices. In this way, any switch in the house can be assigned to turn on and off a specific light.

One other application of ZigBee is in the healthcare industry, where it is used to monitor a patient's vital health information remotely. For example, a patient is staying at his home but for him it is important that his physician monitors his blood pressure and heart rate regularly, continuously.

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A ZigBee network has the ability to collect the data from various sensors that are connected to the patient. The 802.15.4 standard uses a 128-bit Advanced Encryption Standard (AES) technology in order secure the data flow between ZigBee devices and other networks. A patient wears a ZigBee device that is interfaced with different sensors, such as a blood pressure sensor, which gathers the information from these sensors on a periodic basis. The received information is transmitted to a ZigBee gateway. A ZigBee gateway provides the interface between ZigBee and other types of networks, such as an Internet Protocol (IP) network. The patient's gathered information is then transmitted via Internet to a personal computer of a physician or nurse that they use to monitor the patient's health status. This system could help hospitals to improve patient care and relieve hospital overcrowding by giving them the authority to monitor patients at home.

ZigBee is expected to provide low cost and low power connectivity for equipment that needs battery life as long as several months to several years but does not require data transfer rates as high as those enabled by Bluetooth. This kind of network eliminates use of physical Ethernet cables. The devices could include telephones, hand-held digital assistants, sensors and controls located within a few meters of each other. Thus, ZigBee technology is a low data rate, low power consumption, low cost, wireless networking protocol targeted towards automation and remote control applications.

From all the previous related works described, it can be concluded that there are limitless possibilities of Zigbee in wireless sensor network application. Solution providers of Zigbee offer various kinds of platform in the market based on user requirement. For this paper, we exploit the low power consumption and long battery life Zigbee platform.

III. HARDWARE DESIGN

A. Sensor Unit

A sensor unit basically consists of several sensors used to detect the predetermined parameters that indicate the quality of water. In this work, three types of sensor; ***pH sensor*** that senses the acidity or basicity of the water, ***temperature sensor*** that senses the temperature of the water, and ***turbidity sensor*** that senses the turbidity/purity level of water based on phototransistor are used. All the sensors use battery for their operation. The information being sensed by the sensors is then converted into electrical signal and then it is passed to a microcontroller or microprocessor that processes it to the value understandable by humans.

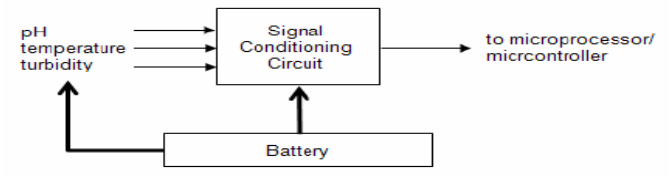


Fig.1 Block diagram of sensor unit

B. Wireless Sensor Node

The wireless sensor node in this work consists of sensor unit as mentioned above; a microcontroller with the task of signal digitizing, data transmission, networking management etc; and radio frequency transceiver for communications at the physical layer. The main microcontroller of the sensor node is P89V51RD2 by Philips. The high power transmission type Zigbee module is using transceiver IC that complies to the IEEE 802.15.4 standard. The transceiver IC is integrated with the microcontroller with a low power but high performance of 64kB programmable flash features. The module alone requires a 5VDC power supply, multiple sensor inputs/outputs with ADC, operating at a frequency of 2.4 GHz .

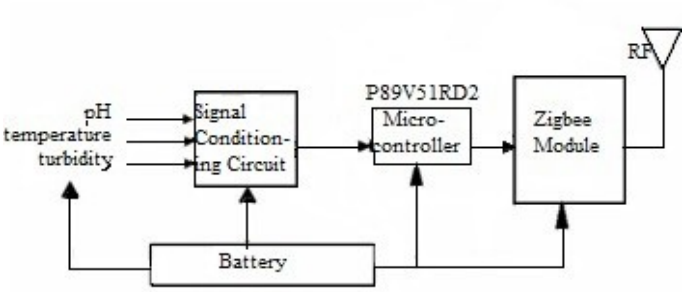


Fig.2 Block diagram of zigbee based wireless sensor node

The main microcontroller in the module is reprogram-mable whether to function as an end device, router or coordinator nodes. As an end device sensor node, it can only communicate with the router or coordinator to pass the data from the sensor. The sensor node defined as a router is responsible for routing data from other routers or end device to the coordinator or to other routers closer to the coordinator.

It is generally used to extend the coverage distance of the monitoring system. There can be only one coordinator for the monitoring system. It is responsible for setting the channel for the network to use, assigning network address to routers and end devices and keeping the routing tables for the network that are necessary to route data from one end device to another in the same Zigbee network.

For actual implementation, a 12V battery supply is used and directly connected to a 5V voltage regulator before goes to the Zigbee module.

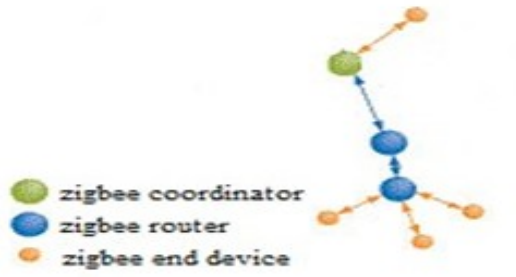


Fig.3 Block diagram of Zigbee based wireless sensor network for the monitoring system

C. Base Monitoring Station

The base station consists of the same Zigbee module programmed as a coordinator that receives the data sent from the sensor nodes i.e. end devices and routers, wirelessly.
The coordinator is normally mains powered. Data received from the end device nodes is sent to the computer using the RS 232 protocol and data received is displayed using the built GUI on the base monitoring station.

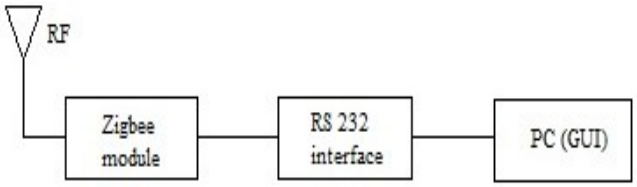


Fig.4 Block diagram of components in base station

IV. SOFTWARE DESIGN

The GUI platform was successfully developed using the MATLAB software that was able to interact with the hardware (coordinator) at the base station.

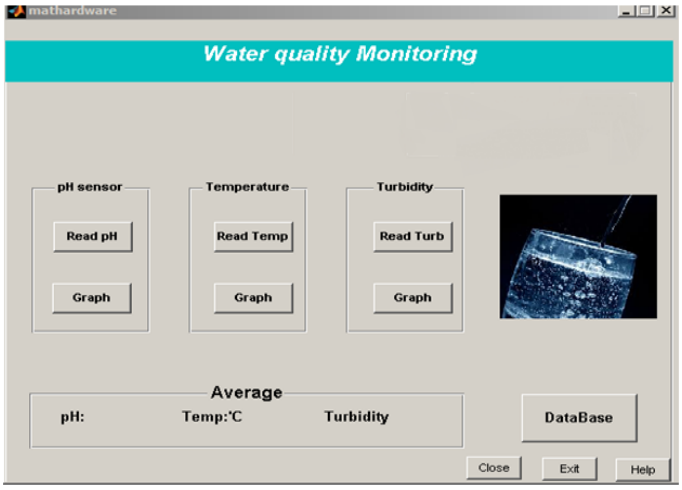


Fig.5 Layout Design of the front end of the GUI

Once the battery powered sensor node is turned on, the temperature, pH and turbidity sensors immersed in water start sensing the respective data. Different push buttons are provided for reading the temperature ,pH and turbidity values which are 'Read pH' ,'Read Temp' and 'Read Turb'. Once the user clicks on any of the push buttons of the panel the zigbee transceiver on the receiver side sends a signal to the zigbee transmitter on the transmitter side demanding the corresponding data values to be sent. The 'Graph' push button plots the different values that are obtained at the receiver side. Once the values are plotted , it is inherently saved and stored in MS Excel Database, which can be accessed by clicking on the 'Database' tab. The average of these values is also calculated and displayed in the textbox 'Average', shown in Fig.5.

V. SIMULATION AND RESULTS

A. pH Measurements And Results

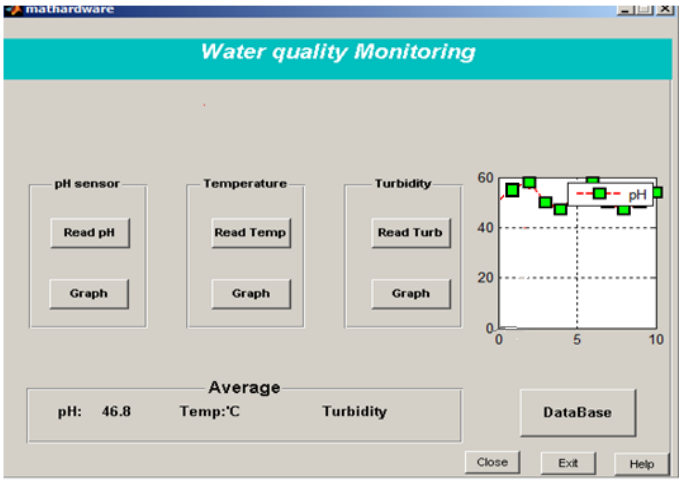


Fig.6(a) The graph for the received pH values is plotted and average is calculated

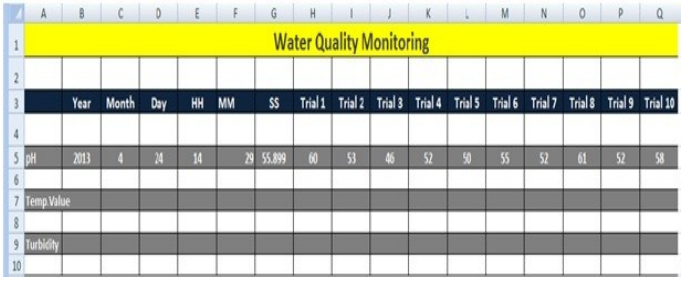


Fig.6(b) Excel database of the received pH values over 10 trials

From prior testing, we define a threshold value(range of values) for the monitoring of pH of water. Depending on whether the average of the values obtained is less than or greater than the defined threshold , we get to know whether the water is acidic or basic and hence if it is suitable or not for the specific purpose.

B. Temperature Measurements And Results

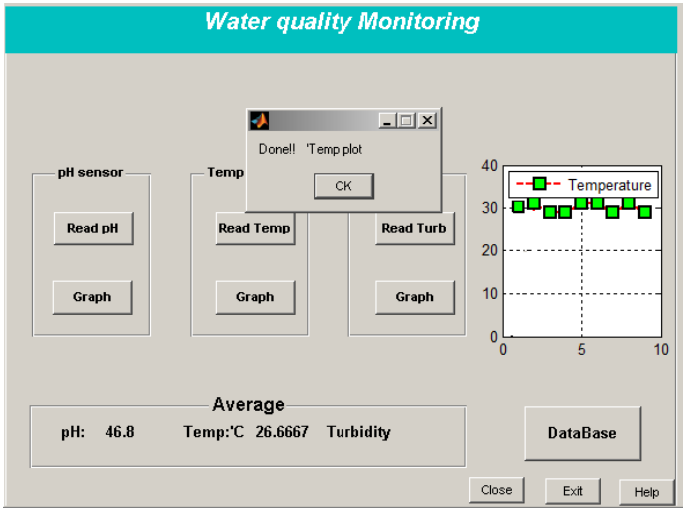
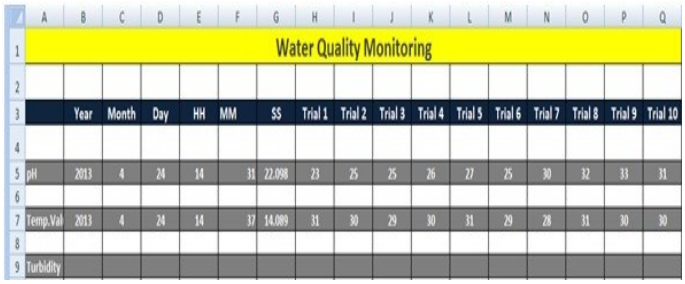


Fig.7(a) The graph for the received temperature values is plotted and average is calculated



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Water Quality Monitoring																
2																	
3		Year	Month	Day	HH	MM	SS	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
4																	
5	pH	2013	4	24	14	31	22.098	23	25	25	26	27	25	30	32	33	31
6																	
7	Temp.Val	2013	4	24	14	37	14.089	31	30	29	30	31	29	28	31	30	30
8																	
9	Turbidity																

Fig.7(b) Excel database of the received temperature values over 10 trials

From prior testing, we define a threshold value (range of values) for the monitoring of temperature of water. Depending on whether the average of the values obtained is less than or greater than the defined threshold , we get to know whether the temperature of the water is high or low and hence if it is suitable or not for the specific purpose.

C. Turbidity Measurements And Results

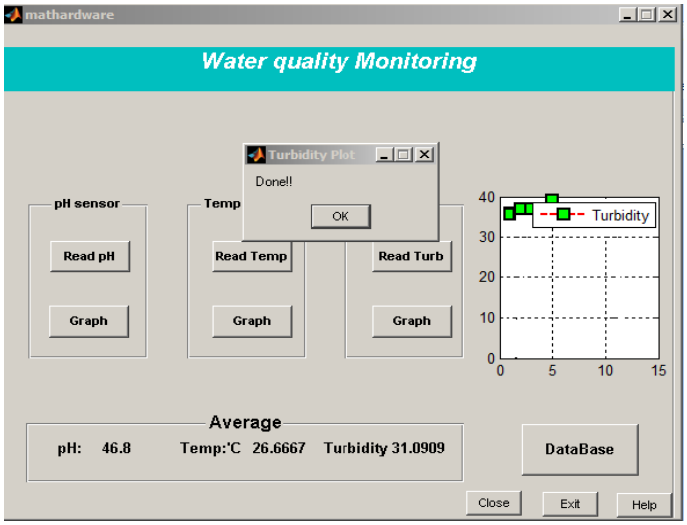
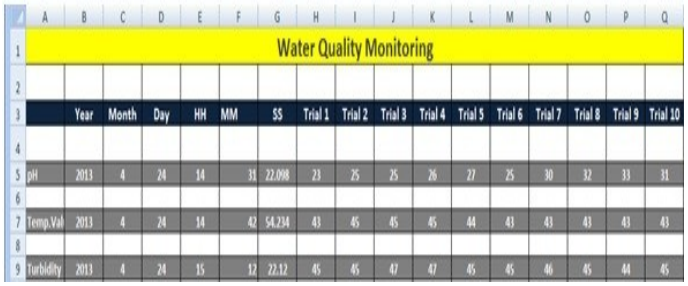


Fig.8(a) The graph for the received turbidity values is plotted and average is calculated



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Water Quality Monitoring																
2																	
3		Year	Month	Day	HH	MM	SS	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
4																	
5	pH	2013	4	24	14	31	22.098	23	25	25	26	27	25	30	32	33	31
6																	
7	Temp.Val	2013	4	24	14	42	54.234	43	45	45	45	44	43	43	43	43	43
8																	
9	Turbidity	2013	4	24	15	12	22.12	45	45	47	47	45	45	46	45	44	45

Fig.8(b) Excel database of the received turbidity values over 10 trials

From prior testing, we define a threshold value(range of values) for the monitoring of turbidity level of water. Depending on whether the average of the values obtained is less than or greater than the defined threshold , we get to know whether the water is pure or impure and hence if it is suitable or not for the specific purpose.

VI. CONCLUSION

The main issue that is being addressed in this project is about developing an efficient wireless sensor network (WSN) based water quality monitoring system, that examines 'water quality', an important factor as far as, irrigation, domestic purposes, industries, etc are concerned.

Overall, the proposed implementation of high power Zigbee based WSN for water quality monitoring system offering low power consumption, and long battery life is presented. The use of high power WSN is suitable for activities in industries involving large area monitoring such as manufacturing, constructing, mining etc. Another important fact of this system is the easy installation of the system where the base station can be placed at the local residence close to the target area and the monitoring task can be done by any person with minimal training at the beginning of the system installation.

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