ARM Based Solar Powered Water Quality Measurement System Using ZigBee

Abstract
Water quality measurement system is the challenging task to find the parameter in the water by using wireless sensor network (ZigBee) and powered by solar panel. In rural-cities areas quality of water is different so we have to find the different parameters such as pH, turbidity, conductivity, salinity and temperature. The values of parameter is measured by sensor at sensor node station is transmitted to the base station by using ZigBee. The measured data is displayed in visual format as well as it can be analyzed using simulation tools for control strategy. ZigBee based technology with IEEE 802.15.4 compatible transceivers is proposed. Solar panel is used at the sensor node station for the purpose to save the electricity.

1. Introduction
Water quality measuring system has become a critical problem around the world. Traditionally, remote water sensing based on satellites is widely used to monitor the water quality for rivers, lakes, seas and oceans. However, satellites only offer a macro view of the water quality. When it comes to a particular region of interest, the accuracy of the satellite surveillance may not meet our
requirements. Water quality measurement using ZigBee and solar panel system is propose to control water pollution and human diagnosis due to the water pollution. Solar panel is used to save the electricity. The different sensors are used to measure the different parameter in the water. The standard values of the parameter stored in database are compared with the measured values. If measured values are not approximately equal to standard values then the quality of water is not good. This system is mainly used for Municipal Corporation to checking the quality of drinking water. For other application such as agricultural, domestic, industrial etc. The developed platform is cost effective and allows easy customization.

2. Aims of Project
The main aims of the project are:

- Measurement of Ph, Salinity, Conductivity, Temperature and Turbidity of water using available sensors at remote place.
- To avail local power supply to sensor nodes using solar energy.
- To collect data from various the sensor nodes and send it to base station by wireless communication.
- To control data communication between source and sink nodes. (Synchronization using time division)
- To simulate and analyze quality parameters for quality control.
- To publish the corresponding record over web for public information and further assessment of resource.

3. System Architecture
Water is essential resource of life for each living organism on the earth. Oxygen level in water plays important role in examining quality of water. Water quality plays important role in the health issues of human, plant and living organisms on the earth. Generally, main sources of water are rain, rivers and lakes. Rain water running over the lands contains many useful as well as harmful contents, may be soluble or insoluble. Acidity of water is decided by the salt and particles in soil. Traditional measure of water quality is transparency of water that means insoluble particles mixed in water degrades usefulness of water for particular application. The main aim is to measure the oxygen level, acidity and turbidity of drinking water as well as water that may be used for agriculture and industrial processes. The remote access of water quality measurement parameters using wireless communication facilitates quality control, record keeping and analysis using simulation software at base station. Oxygen level, pH and turbidity level are the parameters that are analyzed and control to improve water quality. Following are the objectives of idea implementation

4. Project Specifications

- All the components will work on the +5v power supply. (Expect LCD)
- ARM7 controller used is Low power, high speed CMOS FLASH/EEPROM technology. It is high performance RICS CPU.
- 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. Low cost, low power (3.3V), and up to 65000 nodes with an AES encryption standard for communication are the main advantages of ZigBee.
- pH sensor will give the output from 0-14.(0-6:Acidic,7-Neutral,8-14:Alkanity)
- Turbidity sensor uses an optical transistor and optical diodes; an optical washing machine sensor measures the amount of light coming from the source of the light to the light receiver, in order to calculate water turbidity.
- Redox sensors consist of a pair of wire-wound metal toroid’s over moulded with either corrosion resistant.
- Temperature sensor pt100 will sense the temperature from 2-100 degree Celsius.
- Salinity sensor range is 0-50 ppt. Resolution is 0.1ppt.
- Conductivity sensors consist of a pair of wire-wound metal toroid’s over moulded with either corrosion resistant. Minimum range is 5 uS/cm maximum range is 500ms/cm.

5. Hardware Implementation

![Diagram of the water quality automatic monitoring system](image)

Figure 5.1: The structure solar panel sensor based water quality automatic monitoring system

The structure of the water quality automatic monitoring system includes three parts, one is the waste water quality collection system, transmission using Zig-BEE module and the other is the monitoring centre system. The system components are showed in Figure.

Water parameters collection and transmission system- As shown in figure the five sensors are deployed under water to monitor five parameters of water they are

**Ph sensor** -
PH is the measurement of potential activity of hydrogen ions in the sample. pH was positively correlated with electrical conductance and total conductivity. For pH measurement pH meter with probe of Toshniwal Company is used.

**Turbidity sensor** -
Turbidity related to water clarity. For this TS-100 module is used.

**Conductivity sensor** - It measures conductance of water. For this conductivity sensor model is used.

**Salinity sensor** - It measures dissolved salts in water. For this simple formula is used on the conductivity sensor’s reading.

**Temperature sensor** - It measures temperature of water. For this PT100 is used. All sensors are powered by solar panel; solar panel is used in this system to supply power to the sensor node, together with an accumulator to recharge when solar power is not enough, such as night. An ARM processor LPC2138 is used to collect all the data from remote sensors, process it, and then send it to the base station wirelessly through Zig-Bee Module TARANG F20.

**Data Reception system** - Data which transmitted from data acquisition system using transmitter Zig-Bee Module (source Node) is received by Zig-Bee Module (Sink Node) at the base station. It provides the received data to ARM Board connected to it. And through the ARM board the received data is analyzed on PC. LCD on board used to verify correct and error free data transmission from earlier part of system. The base station contains a wireless receiver and a PC, where users can receive data from sensor nodes and analyze it. The base station can still connect to Ethernet so that users can login and get data faraway. The nodes and base station are connected via WSN technology.

![Circuit Diagram](image-url)
6. ARM- Base control

All sensors and Zigbee modules are connected to the ARM controller board designed for special compact space application using surface mount technique. RISC processor architecture of LPC2138 (ARM7) has many advantages in water quality monitoring system such as low power consumption, low cost, optimum baud rate and maximum operating frequency (12MHz). On chip ADC is fascinating feature of ARM processor that facilitates direct interfacing of sensors to ARM board and reduces space. 3.3V power consumption of ARM controller is much lesser than available power from solar module.[4] Following are the specifications of ARM7 LPC2138 controller.

6.1 Specifications of ARM7TDMI 2138:

- Embedded ICE and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high speed tracing of instruction execution.
- One (LPC2131/2) or two (LPC2134/6/8) 8 channel 10-bit A/D converters provide a total of up to 16 analog inputs, with conversion times as low as 2.44 ps per channel.
- Single 10-bit D/A converter provides variable analog output. (LPC2132/4/6/8 only).
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-time clock with independent power and dedicated 32 kHz clock input.
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.
- Vectored interrupt controller with configurable priorities and vector addresses.
- Up to 47 of 5 V tolerant general purpose I/O pins in a tiny LQFP64 package.
- Up to nine edge or level sensitive external interrupt pins available.
- 60 MHz maximum CPU clock available from programmable on-chip Phase-Locked Loop (PLL) with settling time of 100 ps.
- On-chip integrated oscillator operates with external crystal from 1 MHz to 25 MHz. Power saving modes include Idle and Power-down.
- Individual enable/disable of peripheral functions as well as peripheral clock scaling down for additional power optimization.
- Processor wake-up from Power-down mode via external interrupt or Real-time Clock.
- Single power supply chip with Power-On Reset (POR) and Brown-Out Detection (BOD) circuits:
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant.

6.2 Application

- This system checks quality of water at the places where generally it is inconvenient to take frequent tests manually.
- The higher turbidity and imbalance of pH in water supply used for drinking, agriculture...
and even for industry use is a serious issue. At such places the quality control can be done by monitoring the water and taking necessary action for quality improvement.

- The running water over particular land gets mixed with salt and other materials which changes the pH of water and is turbidity. The analysis of the material contents in the soil in that particular region can be monitored easily at the base station using the same system.

7. Conclusion & Future Scope

Monitoring the quality of water & collecting comprehensive data, achieves sequential follow up of water pollution status in remote region. This system not only provides comprehensive evaluation of water environment but also can quickly discover urgent water pollution accidents or natural disasters, transferring the abnormal water quality information to monitoring center by quicker communication network and provides graphical references for the decision-making department to comprehend the status of the disaster to establish the prevention and cure policy.

We can measure other parameters like Dissolved Oxygen, Nitrate, pesticides, Chlorides, Fluorides etc. We can use GPRS, GSM module in place of ZIG-BEE module. It can be implemented for different purification process to make industrial water fit for use. Our system can be used to monitor river water, dam water, and lake water, sea water etc. parameter continuously. In order to monitor water quality in different sites, future works can be focused on establishing a system with more sensor nodes and more base stations. Connections between nodes and base station are via WSN, while connections among different base stations are via Ethernet. The Ethernet can also be connected to Internet so that users can login to the system and get real time water quality data faraway. Another interesting field lies on the optimization of power consumption and data throughput of the WSN. The wireless data acquisition from remote places and database storage is the supporting structure of the system which can be used for further research studies like soil content analysis using different simulators. The simulation can be used for water pollution control in varying conditions.

References