Design and Development of Wireless Sensor Network System to Monitor Parameters Influencing Freshwater Fishes

Santoshkumar[1]
Assistant Professor, Electrical Engineering Department,
SDM College of Engineering and Technology,
Dharwad, India.
santoshkumar777@yahoo.com

Vishal Hiremath[2]
Electrical Engineering Department,
SDM College of Engineering and Technology,
Dharwad, India.
vishalhiremath.8@gmail.com

***Abstract*— In this paper we have designed, developed and proposed a prototype Wireless Sensor Network (WSN) System to monitor the Fish Farm. Salinity of the fresh water is a prominent parameter and is responsible for the difference in environment from marine conditions. Salt is an effective ingredient for fishes in fighting disease, parasites and chemical poisoning. The pH is equally a key parameter which influences the environment where fishes live. Generally, the fishes can live in pH ranges from 6.0 to 9.0, but their quality of life is best between pH 7.0 to 8.0. The change in the value of pH even by a small amount will be more stressful for fish. The temperature is other parameter which decides the value of pH and in turn affects the fishes. The developed prototype WSN system monitors these three parameters affecting the fresh water fishes. The open source technology-ARDUINO (open electronics prototype and open source) is used to develop the system.**

Keywords- pH, Salinity, Temperature, Wireless Sensor Network (WSN), Fishfarm, ZIGBEE, XBEE, ARDUINO

I. INTRODUCTION

Freshwater fish are the fish which spend their lives in freshwater such as rivers and lakes with a salinity of less than 0.05%. These environments differ from marine conditions in many ways and the most common being Salinity. In order to survive in fresh water, the fish needs a range of physiological adaptations in order to keep the ion concentrations of their bodies balanced. Salt is a natural ingredient for purifying water and for energizing stressed and wounded fishes. However, salt is effective only in small quantities and excessive use can be harmful. Tap water usually has very low salt content and the addition of Salts make the fishes feel home and defeats toxic chemical and avoiding fish poisoning. Also, the Salts help fishes in gaining energy due to illness and stress thereby increasing the oxygen intake and flow of blood. The pH is equally a key parameter which influences the environment where fishes live. Usually fishes can live in pH ranges from 6.0 to 8.0, but their quality of life is best between pH 7.0 to 8.0. The change in the value of pH even by a small amount will be more stressful for fish. Freshwater has a natural pH in the range 6 to 8. As the pH value drops below 6, the non-desirable species may begin to invade fish population and aluminium ions from nearby soil may be released into the water which can kill fishes. The most chronic effect of increased acidity may disturb the reproduction cycle making fishes sterile. The increase in the value of pH above 8 can kill the adult fishes, harm the juvenile fishes and increase the toxicity of other substances like ammonia.

Temperature is other key parameter which influences the value of pH. Many substances exhibits increased toxicity levels at elevated temperatures which affect the fishes. The Figure1. depicts the changes in pH with the change in temperature [10].The temperature also contribute to the growth and reproduction of the fish.

One approach to solve this problem would be to employ a Sensor Network that would enable users to monitor the required factors such as pH, temperature and level of salinity. Sensor Networks offer many attractive low cost solutions to monitor these conditions. Few applications of Sensor Networks are volcano monitoring, machine monitoring, animal tracking, vehicle traffic monitoring etc. All these sensor network applications are deployed with the help of the sensor nodes developed by various commercial manufacturers, those are costly, comes with fixed design and shipping them to India is very time consuming and complex process. All these factors make it difficult to use sensor nodes and force us to develop a WSN system for our application.

The main aim of Sensor Networks is to sense any data from the desired location, transmit the same. The sensed parameters can be viewed at the receiver side in a personal computer. Sensor network is a combination of

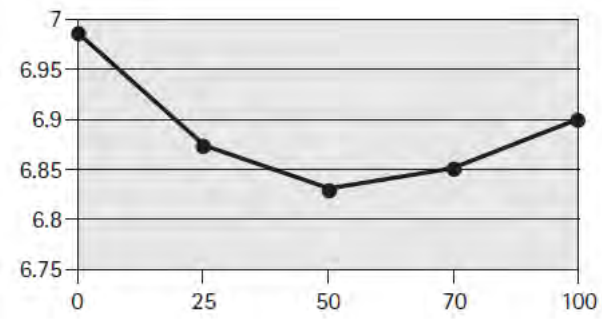

Figure 1. Plot of Temperature v/s pH

various sensors that are positioned to monitor. A sensor provides extra functions beyond those necessary for generating a correct representation of the sensed quality such as signal conditioning, signal processing and decision-making and alarm functions.

The smart sensor network system is designed using open source technology-ARDUINO. ARDUINO is an open electronics prototype and open source.

II. Related Work

After reviewing many articles, there are very few papers that discuss about monitoring fish farm. In the available papers only two parameters like pH and temperature are considered [1]. There is no mention of Salinity which is a prominent parameter and is responsible for the difference in environment from marine conditions. Also, the information about the effects of temperature on pH is not clear.

III. Wireless Sensor Networks

Wireless sensor network is used in special situation for signal collection, processing and transmitting. A wireless sensor network (WSN) is a system consisting of a collection of nodes and a base station. A node is composed by a processor, local memory, sensors, radio and battery and a base station is responsible for receiving and processing data collected by the nodes. They perform collaborative activities due to limited resources, such as battery, processor and memory [2]. Nowadays, the applications of WSN's are many and varied, and the applications in monitoring fishfarm are still incipient. One interesting WSN application is in fishfarm, where the conditions such as pH, temperature and salinity are to be monitored. In such application, the sensors are fixed in the farm and WSN should guarantee real time monitoring. A WSN consists of generally two main parts: Data Acquisition Network and Data Distribution Network. The Figure 2. shows a simplified block diagram WSN System.

A Sensor network is an infrastructure comprised of sensing, computing and communications element that allows the administrator to instrument, observe and react to events and phenomena in a specified environment. The main aim of the Wireless Sensor Networks is to sense any data from the desired location, transmit the same through wireless network. The block diagram of wireless sensor network consists of two main parts, transmitting side and receiving side respectively. At the transmitting side, various sensors and controllers are connected with the FREEDUINO and XBEE. At the receiving side the transceiver and the microcontroller are present along with the display device.

The sensed parameters with their exact precision values are transmitted to the observing station through Wireless Communication and details are monitored by the administrator. Apart from monitoring the details of a distantly located fishfarm, control signals can also be sent back from the observing station to the base station. When any of the parameter measured is found to be above a threshold value either an Alarm is generated. Thus any disaster can be controlled.

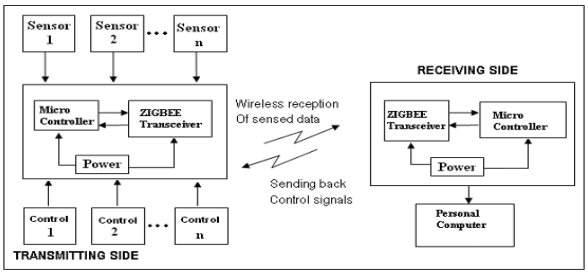

Figure 2. Simplified block diagram of WSN

IV. ZIGBEE PROTOCOL OVERVIEW

ZigBee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital radio connections between computers and related devices. WPAN Low Rate or ZigBee provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life.The relationship between IEEE 802.15.4 and ZigBee is similar to that between IEEE 802.11 and the Wi-Fi Alliance. For non-commercial purposes, the ZigBee specification is available free to the general public. XBee is a brand of radio that supports a variety of communication protocols, including ZigBee,802.15.4, and WiFi among others. Every ZigBee network will have a single coordinator device and every ZigBee network will also have at least one other player, either a router device or an end device.

A. Coordinator

ZigBee networks always have a single coordinator device. This radio is responsible for forming the network, handing out addresses, and managing the other functions that define the network, secure it, and keep it healthy. Remember that each network must be formed by a coordinator and that you'll never have more than one coordinator in your network.

B. Router

A router is a full-featured ZigBee node. It can join existing networks, send information, receive information, and route information. Routing means acting as a messenger for communications between other devices that are too far apart to convey information on their own. Routers are typically plugged into an electrical outlet because they must be turned on all the time. A network may have multiple router radios.

C. End Device

There are many situations where the hardware and full-time power of a router are excessive for what a particular radio node needs to do. End devices are essentially stripped-down versions of a router. They can join networks and send and receive information, but that's about it. They don't act as messengers between any other devices, so they can use less expensive hardware and can power themselves down intermittently, saving energy by going temporarily into a nonresponsive sleep mode. End devices always need a router or the coordinator to be their parent device. The parent helps end devices join the network, and stores messages for them when they are asleep. ZigBee networks may have any number of end devices. In fact, a network can be composed of one coordinator, multiple end devices, and no routers at all.

V. METHODOLOGY

A very systematic approach was considered for the overall design of the project, in which three parameters were monitored. The pH, temperature and salinity sensors were used to monitor the fishfarm. The node is designed for the increased battery life and the ZigBee technology supports the same and is shown in Figure 3 below.

A. Fishfarm details and parameters to be sense:

The freshwater fishes live in fishfarm and the care should be taken to facilitate them. The parameters influencing the growth of the fishes should be monitored. The parameters to be monitored are pH, temperature and salinity. The pH sensor and Salinity sensors are designed to monitor the value of pH and Salinity respectively. LM35 is used to sense the temperature.

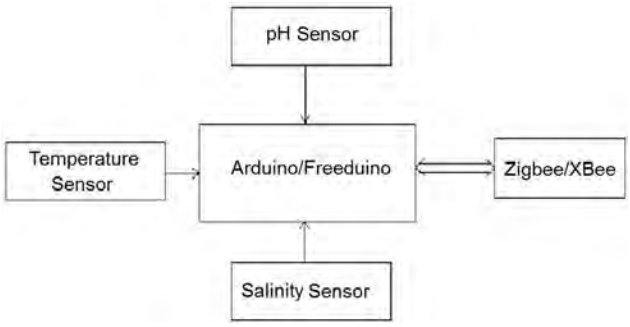

Figure 3. Sensor Node

B. Hardware Description

a) Microcontroller

The Freeduino board uses the ATMega328, was selected as the microcontroller for this project. This was an ideal selection, as the processor is extremely strong and cost efficient. An input voltage ranging from 0 – 5V is required, which corresponds with the humidity sensor. An on-board 10-bit analog to digital converter (ADC), aids in the digitization of the analog signal acquired from the sensor. The Arduino has a serial port to allow communication with the computer. The USB connection from the computer goes directly onto the Arduino board, where a USB to serial converter then allows communication to occur. PIC's also contained 10-bit ADCs, however they had operating voltages ranging from 1.8 – 5.5V.Additionally, to upload a code from the computer, a bootloader program along with its corresponding hardware was required, another factor that made the PIC series unfavourable.

b) Description about Arduino

Arduino is an open-source physical computing platform based on a simple I/O board, and a development environment for writing Arduino software. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other outputs. Arduino projects can be stand-alone, or they can communicate with software running on your computer (e.g.Flash, Processing, MaxMSP). Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP). The boards can be built by hand or purchased preassembled; the software can be downloaded for free. The hardware reference designs (CAD files) are available under an open-source license, you are free to adapt them to your needs.

c) Salinity Sensor

Salinity of the fresh water is a prominent parameter and is responsible for the difference in environmenfrom marine conditions. We have considered 5 grams of Salt per gallon of water. The lower threshold is set to 3 grams of Salt per gallon. The designed Salinity sensor is shown in the Figure 4. below.

d) pH Sensor

The glass type combination pH electrode is used to sense the pH and is shown in the Figure 5. The lower and upper threshold value of pH are set is 7 and 8 respectively. The pH sensor is designed and is shown in Figure 6. below.

e)TEMPERATURE SENSOR:

The LM35 temperature sensor produces an analog voltage directly proportional to temperature with an output of 1 mill volt per 0.1°C (10 mV per degree). The sketch (program) converts the analogRead values into milli volts and divides this by 10 to get degrees. The temperature sensor is shown in Figure 7. below. The lower and upper threshold are set to 20 and 30 respectively.

VI. DESIGN ISSUES

The prototype wireless sensor network system is designed and the sensors are fixed in the farm and the node is designed keeping in mind battery life. We have considered the Salinity range between 3-5, pH range between

7-8 and temperature range between 20 to 30 degrees centigrade. The upper and lower threshold values are considered. If the threshold values (lower and upper) of any of the three parameters change, the alarm is sent to observing station.

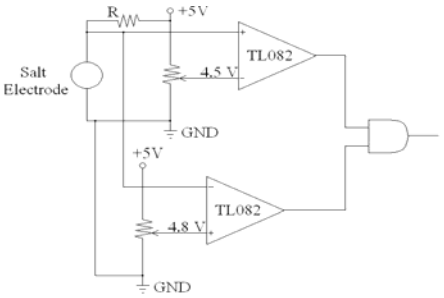

Figure 4. Salinity Sensor

Figure 5. Combination Electrode

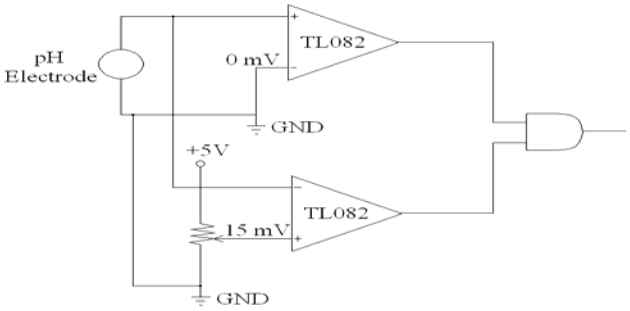

Figure 5.pH Sensor

The software design consists of two main sections: Transmitting side and Receiving side. At the transmitting side, various sensors are connected to the FREEDUINO. Continuously the values are monitored and the details of distantly located sensors are stored in the base station as data base. The parameters read are salinity, pH, and temperature.

At the Base Station (receiving side) the transceiver and the FREEDUINO are present along with the display device. The sensed parameters with their precision values are transmitted to the Base station through Wireless. The flow charts of the developed algorithm for the WSN system for Fishfarm and the base station are shown below in figures Figure 8. and Figure 9. Communication and details are monitored by the administrator and stored in data base.

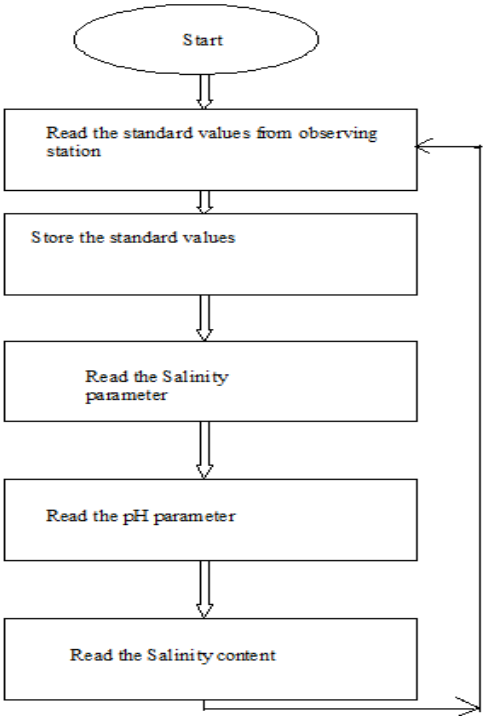

Figure 8. Flowchart for Fishfarm Program

VII. RESULTS

We have performed various lab based experiments to validate the proposed hardware design. The wireless sensor network is fixed in the fishfarm and the care is taken with regard to battery life as the node is suppose to work for long duration.The prototype developed shows promising results. The measured salinity, pH, and temperature are shown in figures Figure10,11 and 12 respectively.

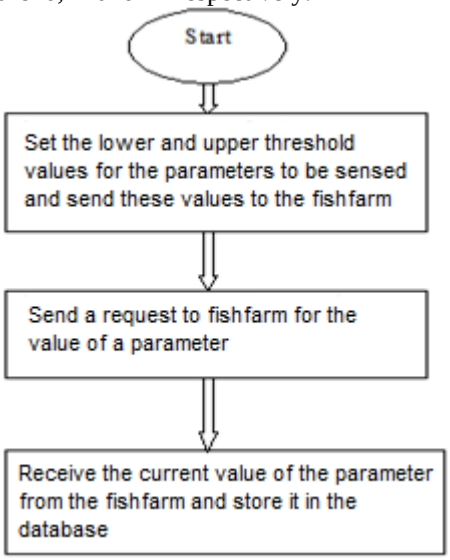

Figure 9. Flowchart for Base Station

VIII. CONCLUSION

The developed prototype wireless sensor network system using open source technology-ARDUINO has proven to successfully acquire accurate measurements for the above mentioned parameters like Salinity, pH, Temperature. The alarm is sent to the observing station if the value received at the observing station is more or less than the upper and lower threshold values respectively. So, this helps us to monitor fishfarm and facilitate the stay of fishes freshwater comfortable.

The Wireless Sensor Networks using ZIGBEE can be implemented in almost all fields where there is a necessity of continuous monitoring. The complexity of networking the numerous details from the real world, in

a two way non-wired communication is eased by the use of Zigbee wireless protocols. A sensor/control network must have good reliability, and that's where ZIGBEE's highly featured protocol stack adds to the equation.

In future, the Wireless Sensor Networks can be extended to applications of very long distances by using suitable antennas and amplifications.

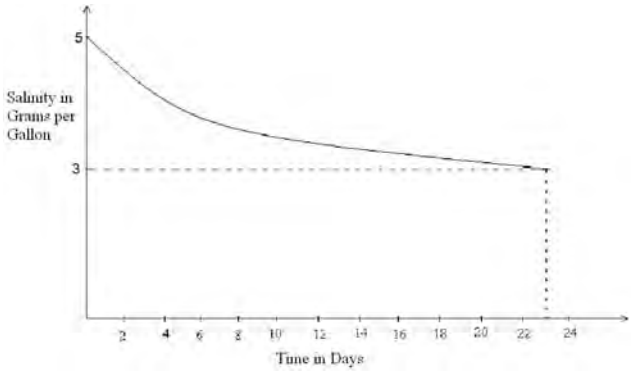

Figure10. Salinity

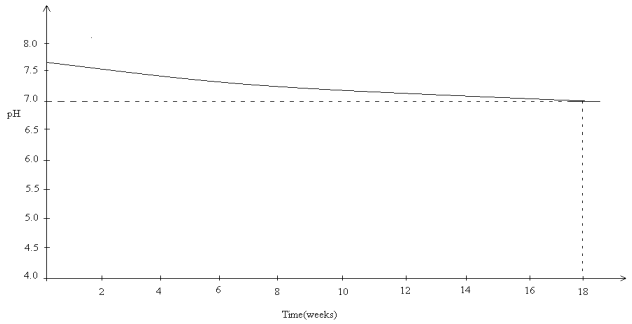

Figure11. pH

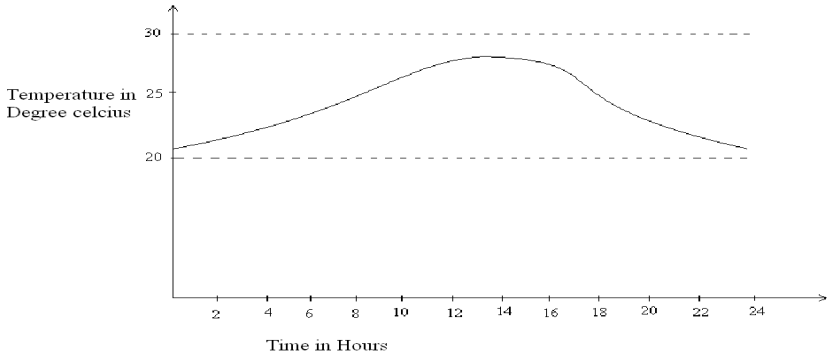

Figure12. Temperature

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Authors Profile

Prof. Santoshkumar is working as Assistant Professor in the Department of Electrical Engineering, SDM College of Engineering and Technology, Dharwad, Karnataka, India. He holds Masters degree in Digital Electronics Engineering and actively involved in teaching and research. His areas of interest include Signal Processing and Wireless Sensor Networks .He has addressed societal concerned issues using wireless sensor networks and published papers in International Conferences/ Journals.

Mr. Vishal Hiremath has completed Bachelors degree in Electrical Engineering from SDM College of Engineering and Technology. His areas of interest include Embedded Systems and Automation.