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Wireless Sensor Network System to Monitor The Fish Farm

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Abstract-
In recent years, the interest in Wireless Sensor Network (WSN) has been growing dramatically. To meet this trend, we have designed Wireless Sensor Network system to monitor the fish farm. We present a practical application of wireless network. The application requires two different kinds of modules; the sensor itself and the wireless module. The sensor collects and transmits the information to a wireless module using wired connection. Once the information reaches the wireless node, it is forwarded to the central unit through a wireless protocol. The sensor module includes a temperature sensor and pH sensor. The wireless node collects the sensed data by means of an asynchronic wired serial polling communication. The use of this kind of protocol allows connecting a single master with multiple slaves. In our particular case, we have connected one master with two slaves using a transmission rate of 9600 bits per second. The wireless transmission follows the standard IEEE 802.15.4 and implements the routing protocol based on the ZigBee standard.
Keywords- pH, Temperature, Wireless Sensor Network, ZigBee.

I. INTRODUCTION

Water quality determines not only how well fish grow in an aquaculture operation, but whether or not the survive. Fish influence water quality through processes like nitrogen metabolism and respiration. Knowledge of testing procedures and interpretation of results are important to the fish farmer. Each water quality factor interacts with influences over parameters, sometimes in complex ways [2].

Regardless the kind of water available or the species chosen, all fish depend entirely on water to live, eat, grow and perform other bodily functions. Therefore is no surprise that the success of a fish farming establishment lies greatly on its water quality. The temperature and Ph are some parameters that are considered to be the most important in aquaculture [3].

This paper shows a practical application; the monitoring of a fish farm using temperature and pH sensors. Usually those kinds of tests require a very specialized and qualified staff, who should measure periodically the living conditions of the farm with high accuracy. However, it is not feasible to perform these measurements manually with enough periodicity to detect immediate changes or predict possible events. The implementation of an ambient intelligence Wireless Sensor Network makes it possible. The wireless sensor network consists of two main parts, transmitting side and receiving side. At the transmitting side, various sensors, microcontroller and transceiver will be used and at the receiving side the transceiver and Personal Computer will be used to monitor the sensed parameters [1].

II. WIRELESS SENSOR NETWORK

Recent technological advances led to the development of very small sensor devices with computational, data storage and communicational capabilities. These devices, which called wireless sensor nodes, when are deployed in an area form a Wireless Sensor Network (WSN). WSN can operate in a wide range of environments and provide advantages in cost, size, power, flexibility and distributed intelligence, compared to wired ones.

A WSN is a system comprised of radio frequency (RF) transceivers, sensors, microcontrollers and power sources.

Recent advances in wireless sensor networking technology have led to the development of low cost, low power, multifunctional sensor nodes. Sensor nodes enable environment sensing together with data processing. Instrumented with a variety of sensors, such as temperature, humidity and volatile compound detection, allow monitoring of different environments. They are able to network with other sensor systems and exchange data with external users [4].

Currently two standard technologies are available for WSN: ZigBee and Bluetooth. Both operate within the Industrial Scientific and Medical (ISM) band of 2.4 GHz, which provides license free operations, huge spectrum allocation and worldwide compatibility [9].

Table 1 provides a comparison between ZigBee and Bluetooth. For applications where higher data rates are important, Bluetooth clearly has the advantage since it can support a wider range of traffic types than ZigBee. However, the power consumption in a sensor network is of primary importance and it should be extremely low. Bluetooth is probably the closest peer to WSNs, but its power consumption has been of secondary importance in its design. Bluetooth is therefore not suitable for applications that require ultra-low power consumption; turning on and off consumes a great deal of energy. In contrast, the ZigBee protocol places primary importance on power management; it was developed for low power consumption and years of battery life. Bluetooth devices have lower battery life compared to ZigBee, as a result of the processing and protocol management overhead which is required for ad hoc networking. Also, ZigBee provides higher network flexibility than Bluetooth, allowing different topologies. ZigBee allows a larger number of nodes – more than 65,000 Sensors – according to specification [10].

Table 1: Comparison between Bluetooth and ZigBee.

	Bluetooth	ZigBee
Standards	IEEE 802.15.1	IEEE 802.15.4
Data rate	1 Mb s^{-1}	20-250 kb s^{-1}
Latency (time to establish a new link)	< 10 s	30 ms
Frequencies	2.4 GHz	2.4 GHz
No. of nodes	8	65,000
Range	8 m (Class II, III) to 100 m (Class I)	1-100 m
Modulation	FHSS [2]	DSSS [1]
Network topology	*Ad hoc* piconets	*Ad hoc*, star, mesh
Data type	Audio, graphics, pictures, files	Small data packet
Battery life	1 week	> 1 year
Extendibility	No	Yes

III. SYSTEM ARCHITECTURE

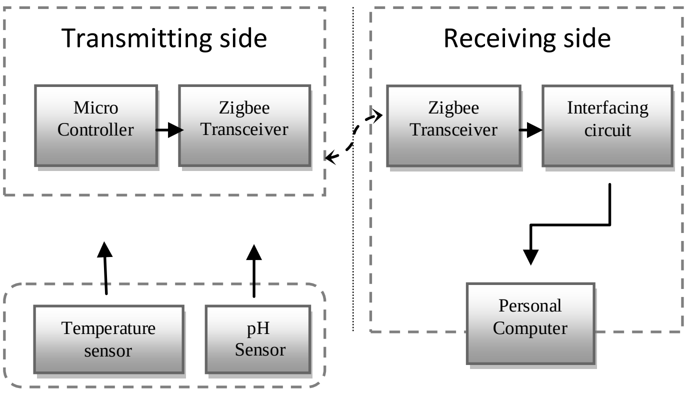

Figure 1: System Block Diagram

The modules included in the system architecture are as follows-

1. Microcontroller
2. ZigBee Network
3. Sensors

1. Microcontroller

The LPC2148 are based on a 16/32 bit ARM7TDMI-S CPU with real time emulation and embedded trace support, together with 128/512 kilobytes (KB) of embedded high speed flash memory. A 128 bit wide memory interface and unique accelerator architecture enable 32 bit code execution at maximum clock rate. For critical code size applications, the alternative 16 bit thumb mode reduces code by more than 305 with minimal performance penalty with their compact 64 pin package, low power consumption, various 32 bit timers,4 channel 10 bit ADC,USB port, PWM channels and 46 GPIO lines with up to 9 external interrupt pins [6].

With a wide range of serial communications, interfaces they are also very well suited for communication gateways, protocol converters and embedded soft modems as well as many other general-purpose applications [7, 8].

2. ZigBee Network

ZigBee is a specification for a suite of high level communication protocols using small, low power digital radios based on an IEEE 802 standard for personal area network. The technology defined by the ZigBee specifications is intended to be simpler and less expensive than other WPANs such as Bluetooth [5]. ZigBee is targeted at radio frequency applications that require a low data rate, long battery life and secure networking [9].

3. Sensors

A sensor is a device that measures a physical quantity and converts it into a signal which can read by an observer or by an instrument.

A. Temperature Sensor

Temperature sensor used is IC LM35 which is linear temperature sensor and linear temperature-to-voltage convertor. The convertor provides accurately linear and directly proportional output signal in millivolts over the temperature range of 0^0C to 1Volt at 100^0C and any voltage measurement circuit connected across the output pins can read the temperature directly. The LM35 does not require any external calibration. The LM35's low output impedance, linear output and precision inherent calibration makes interfacing to readout or control circuitry especially easy [10].

B .pH Sensor

pH is a measure of how acidic or basic (alkaline) a solution is. In any given solution some atoms of water dissociate to form hydrogen ions (H^+) and hydroxyl ions (OH^-). The Ph scale is a means of showing which ion has greater concentration. At a pH of 7.0, the concentrations of hydrogen ions and hydroxyl ions are equal, and the water is said to be neutral. Pure water has a Ph of 7.0. When the pH is less than 7.0, there are more hydrogen ions than hydroxyl ions, and the water is said to be acidic. When the pH is greater than 7.0, there are more hydroxyl ions than hydrogen ions and the water is said to be basic or alkaline.

pH sensor measure hydrogen ion activity and produce a voltage. The sensor operates based on the principle that an electric potential develops when two liquids of different pH levels come into contact on opposite sides of a thin glass membrane. The pH sensors today are composed of two main parts; a glass electrode known as the measurement electrode and the reference electrode. The tip of the measurement electrode is a thin glass membrane. The thin glass membrane is able to facilitate ion exchange. As the ions exchange they create a voltage that is measured by the measurement electrode. This voltage is converted into a corresponding pH level. The reference electrode's potential is kept constant. This is possible because the reference electrode's fill solution is kept at a pH of 7.

The pH sensor is a passive sensor, which means there is not a need for a voltage or current source. The sensor is classified as a bipolar sensor because the electrode's output can swing above and below the reference point. The sensor produces a voltage output that is linearly dependent on the pH of the solution it is placed in.

Figure 2: pH Scale

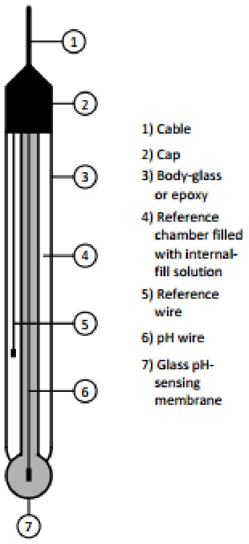

Figure 3: Measurement Electrode Diagram

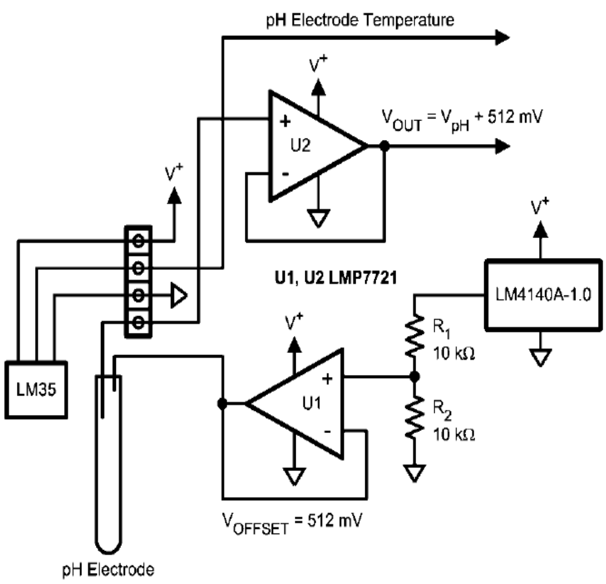

Figure 4: pH-Electrode Circuit

The circuit in Figure 4 solves all design challenges. Amplifier U1 offsets the pH electrode by 512 mV. This is achieved by using National's LM4140A-1.0 precision micro-power low-dropout voltage reference that produces an accurate 1.024V. That voltage is divided in half to equal 512 mV by the 10 kΩ resistor divider. The output of amplifier U1, which is set up in a unity-gain con-figuration, biases the reference electrode of the pH electrode with the same voltage, 512 mV, at low impedance. The pH-measuring electrode will produce a voltage which rides on top of this 512 mV bias voltage. In effect, the circuit shifts the bipolar pH-electrode signal to a unipolar signal for use in a single-supply system.

The second amplifier U2 is set up in a unity-gain configuration and buffers the output of the pH electrode. Again, a high-input impedance buffer between the pH electrode and the measurement instrument allows the circuit to interface with a greater variety of measurement instruments including those with lower input impedance. In most applications, the output voltage of the pH electrode is high enough to use without additional amplification. If amplification is required, this circuit can easily be modified by adding gain resistors to U2 [7].

IV. PROTOTYPE IMPLEMENTATION

The prototype wireless sensor network system is designed and the sensors are fixed in the fish farm. We have considered the pH range between 5 to 9 and temperature range between 30^0C to45^0C. The upper threshold value is considered. If the threshold value of any of the parameter changes, the indicator indicates it. The base station consists of a same Zigbee module programmed as a coordinator that receives the data sent from the sensor node wirelessly. Data received from the sensor node is sent to the computer using the RS 232 protocol and data received is displayed using the built GUI on the base monitoring station. The following figure 5 shows the built GUI using National Instruments LabVIEW.

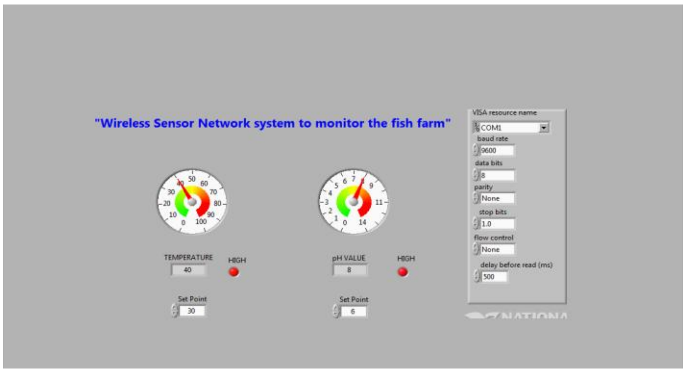

Figure 5: GUI using National Instruments LabVIEW.

V. CONCLUSION

In this paper, fish farm monitoring system based on wireless sensor network is presented. The system is constituted by a base station and sensor nodes. Data connection between the node and base station is realized using wireless sensor network technology. In the node side, water quality data such as pH and temperature is collected by sensors. The sensed parameters with their exact precision values are transmitted to the observing station through wireless communication and details are monitored by the administrator.

When any of the parameter is found to be above a threshold value an indicator will indicate it.

Finally, the prototype system with a sensor nodes and base station is designed and implemented. Real-time water quality data can be seen from a GUI window in Personal Computer. The system has advantages such as low power consumption, more flexible to deploy and so on.

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