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Design of Low Power Wake up And Monitoring System for Wireless Sensor Networks

Mujeeb S. Khan[1], Monica S. Joshi[2]

[1] Electronics and Tele-Communication Engineering Department, MIT (E), Aurangabad, Maharashtra, India

[2] Electronics and Tele-Communication Engineering Department, MIT (E), Aurangabad, Maharashtra, India

Abstract

This paper shows a wake up and monitoring system for wireless sensor networks based on microcontroller which also makes use of ZigBee as well as GSM module for wake up operation. The system makes use of sensors for collecting data. The micro controller processes this data and compares the values with a set of pre-defined threshold values above which system goes into wake up state. Different parameters include water turbidity sensing, water level sensing, Temperature sensing and Fire sensing as well. The system can be connected to a GUI using ZigBee for real-time monitoring of system parameters and can also be used for transmitting message using SIM300 GSM module for transmitting alarming values to remote operator.

Keywords: *Wake-up and monitoring, Wireless sensor networks, ZigBee, GSM, Micro controller, Turbidity sensing, level sensing, Fire and Temperature sensing.*

1. Introduction

Wireless sensor networks (WSN) are those which comprises of sensors which are small, low cost and low power communication devices. Basically, a WSN consists of a number of sensor nodes and a single sensor node itself consists of sensing part, power source, transceiver and Controller or Processor [1]. In general, a wireless sensor network is a set of sensor nodes at a point where there is need of gathering information for some specific application and again transmitting the information to a centrally controlled unit called as Sink [2].

This project attempts to overcome the problem of limited power storage in a WSN.Here are some of the applications of Wireless sensor Networks which are covered in this Project.

- **Sensing of Wild fires:** Sensors nodes can be randomly and densely placed across swaths of forest to detect drastic changes in temperature or heat. The information is controlled by a control center.This mechanism will buy time for early action and controlling the fire [5].
- **Lake Water Quality monitoring:** This project aims to measure the vertical temperature profile in a large water storage mostly near the city meant for the purpose of supplying drinking water to the entire city. The data from a string of temperature transducers also gathers information about water mixing with the lake [6].

Challenges in WSNs:

The characteristics of WSN described mentioned above itself describes challenges which may arise. Some of them are mentioned below [1].

- **Power:** Power consumption determines the size of battery or any other power source that may be installed at the node. Low power consumption design is the priority.
- **Cost:** Feasibility of a WSN application depends upon the cost of system. Factors such as cost of single sensor and also type of power source used also affects the cost of a WSN.
- **Communication Protocol:** Use of large number of devices in a limited spectrum poses communication challenges. Use of wake up receiver can be a solution for the same.
- **Node Size:** Sensor nodes of generally small size are preferred to avoid interference problem.

2. Related Work

This Project aims to develop a low power consumption model of the wake up receiver developed in 2.4 GHz Zigbee module with application specific features including lake water monitoring, atmospheric temperature sensing and Fire sensing packed as one single model. Many works on WSN based monitoring system have been proposed in the past few years. One such example is the application to security systems. It is worth noting that a security system

will have number of sensor nodes, detectors etc. but the need of communication with base station which may be wired or wireless still arises. In such case, Zigbee can prove very much useful in spite of its low data rate can still be able to transmit images with significant quality[7].

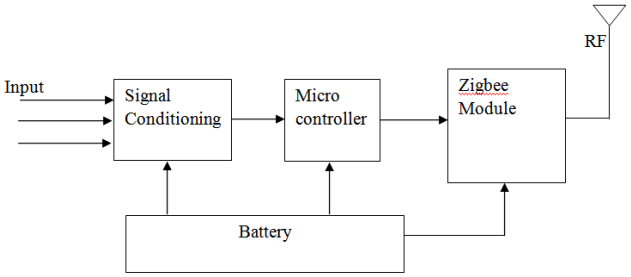

Figure 1. Wireless Sensor Networks using Zigbee

One of the methods of achieving Water Quality Monitoring is the design of Wireless Sensor Network (WSN) that helps to monitor the quality of water by collecting information from the sensors which are immersed in the water whose quality is to be monitored [2]. The main aim of water quality monitoring system [2] is to monitor water at remote places with a WSN designed for low power consumption, low cost and high detection accuracy etc. Parameters such as pH level, turbidity, algal formation etc must be measured by the system. Following are the objectives of system design implementation [3]:

- To measure water parameters such as pH, dissolved oxygen, turbidity, conductivity, etc using available sensors at remote place.
- To collect data from various sensor nodes and send it to base station by wireless channel.
- To simulate and analyze quality parameters for quality control. (Graphical and numerical record using MATLAB)

To send SMS to an authorized person automatically when water quality detected does not match the preset standards, so that, necessary actions can be taken.

Another important factor to which most researchers have shown interest is the Atmospheric Temperature sensing. Energy Harvesting [7] which may be in the form of windmills, watermills and solar powered system has been around for centuries and though small, but has been a contributor to the world`s growing energy demands.

WSNs have succeeded in revolutionizing sensors in a vast field of application because of its promising features including reliability, detection accuracy, cost effectiveness and ease of installation [1].

Another important application of WSNs is the Fire detection or Remote fire sensing [4]. Forest fires cost millions of rupees in damages and claims hundreds of human lives. Apart from preventive measures early detection and suppression of wild fires is the only way of minimizing the casualties and damages[5]. One of the most recent research work includes habitat monitoring [3] and forest fire detection.

There were some literatures that focused on fire behavior rather than studying Fire detection [5]. They presented FireWxNet, a portable fire sensor network to measure the weather conditions surrounding active fires. The system comprised of sensor nodes, webcams and base station for long distance communication.

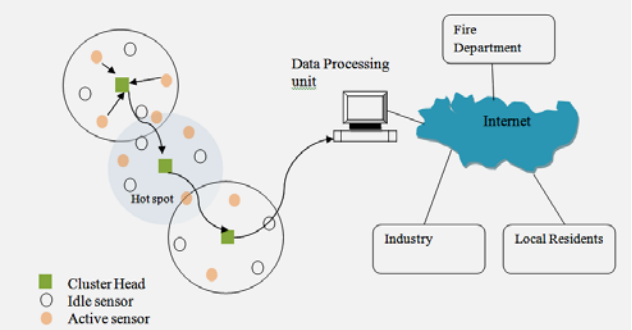

Figure 2 Architecture of Forest Fire Detection System

Fig. 2 represents the architecture of a typical forest fire detection system [5]. Nodes self-organize into clusters, where cluster heads aggregate collected data using the FWI System. The shaded area represents a forest zone with higher fire potential and thus needs higher monitoring accuracy. A sensor network deployed in a forest reports its data to a processing center for possible actions, such as alerting local residents and dispatching firefighting crews.

3. System Modeling.

3.1 System Block Diagram

The main aim of this project is to design a Wireless Sensor Networks (WSN) with application of Lake water quality monitoring, atmospheric temperature sensing and Fire sensing system using sensors, LCD and Zigbee module to transmit and receive data using the system sleep and wake up techniques with an aim to provide a system that consumes extremely low power with high accuracy and low cost.

The basic block diagram of the project is given below in Fig. 3

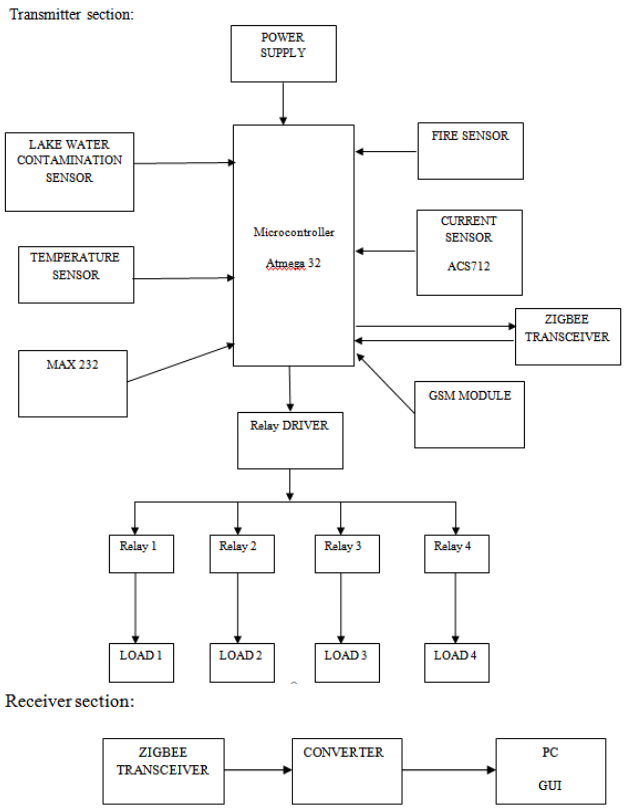

Fig 3. Proposed Architecture

The above architecture can be divided into two broad sections namely transmitter section and receiver section.

Transmitter section:

The transmitter section is basically designed to serve the purpose of gathering the required environmental data using different transducers where this data when available will perform the wake up action when the system will be in sleep mode. The required data will then be processed by micro controller. Micro controllers are available to implement various tasks, among them the 8051 and PIC are the mostly used. The 8051 is probably the most popular 8-bit microcontrollers ever. Many different I/O features are integrated around the 8051 core to create a microcontroller which needs only very little extra hardware to do most of the jobs. The PIC controller controls the devices and sends the sensor values to the PC via ZigBee module. Although Bluetooth is better than ZigBee for transmission rate, ZigBee has lower power consumption. Hence, ZigBee is generally used for 24 hours monitoring of communication transmission systems. The ZigBee protocol as the communication medium between the transmitter and receiver modules.

Receiver section:

As discussed earlier, the Zigbee protocol is used for communication between transmitter and receiver; likewise the ZigBee protocol receives wireless data and thereby converts it into digital form so that it can be available for the user.

Some of the important sensors used are mentioned below:

LM35:

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature [4]. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range.

Turbidity Sensor (CONN-SIL3)

The turbidity sensor development was based on the ratio turbidimeter design where both transmitted and scattered light intensities are measured to eliminate errors (interferences) due to IR emitter intensity drift and sample absorption characteristics. An infrared (860nm) narrow beam LED emits light through an optical gap to the water sample and two IR photodiodes separated around 1cm from the emitter receive simultaneously the 90° scattered and 0° transmitted light. The photodiodes spectral sensitivity is selected to fit with that of the IR light source [3].

Current Sensors

With the advancement in technology, current sensing has emerged as a method to monitor and enhance performance. Knowing the amount of current being delivered to the load can be useful for wide variety of applications. Current sensing is used in wide range of electronic systems, viz., Battery life indicators and chargers, 4-20 mA systems, over-current protection and supervising circuits, current and voltage regulators, DC/DC converters, ground fault detectors, programmable current sources, linear and switch-mode power supplies, communications devices , automotive power electronics, motor speed controls and overload protection, etc [6].

ZigBee:

The ZigBee OEM RF Module was engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other. This module interfaces to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device.

The proposed low power wake up system design based on WSN can be divided into three parts [2]:

a) Data sensing nodes
b) Data base station
c) Remote monitoring centre

(a) Data Sensing Nodes

The data monitoring nodes which consist of sensors (Temperature, turbidity, light and conductivity), signal conditioning circuit, a controller and RF module. The data sensed by the sensor will be passed through a signal conditioning circuit in order to manipulate the analog signal in such a way that it meets the requirements of the next stage for further processing. Then the manipulated data will be given to the controller (Atmega 32). The inbuilt ADC will convert the analog signal to digital signal for further processing. With the help of the RF module the manipulated sensed data will be sending to the data base station.

(b) Data Base Station

The data from all the nodes is collected at the data base station where the data from each node is collected one after another i.e. using time multiplexing. This obtained data is displayed on a LCD display. Also, this data is forwarded to the remote monitoring station via zigbee module.

(c) Remote Monitoring Station

The remote monitoring station consists of a zigbee module which will receive the data sent by the data base station. This data will be fed to a server PC consisting of Graphic User Interface (GUI) via serial communication as shown in figure above. The obtained data will be represented graphically with the help of MATLAB and will be saved for further reference. Also the obtained data is compared with the standard values of the water, temperature parameters.

4. Performance Analysis of the project

Our wireless turbidity, temperature and fire monitoring System is an automated version of manually measuring temperature and sending the information to a distant database wirelessly via ZigBee. Our system has got almost all things automated so that we get an advantage of this concept ie the real time direct measurement of the parameters (here temperature, Forest Fire and Lake water Monitoring) through ZigBee. Maintaining backup of sent data is easy and can be done within a few seconds. This project uses an LM35, SIL CONN3, ACS712, ZigBee module, LCDJHD 162A and ATMEGA-32 microcontroller (AVR trainer Board). The ZigBee transceiver is connected to PC/Notebook through RS232 cable .Windows has built in serial monitoring software called HyperTerminal to read the messages sent by modem. The system model is shown in Figure 4.1 which says about the connectivity of all mentioned devices. The LCD used in this project can be detached when we use the design for commercial purpose. LCD is attached to ATMEGA32 to simultaneously display the measured temperature, water turbidity and current sensitivity through which we can experimentally check whether the data that is being sent is correct [].

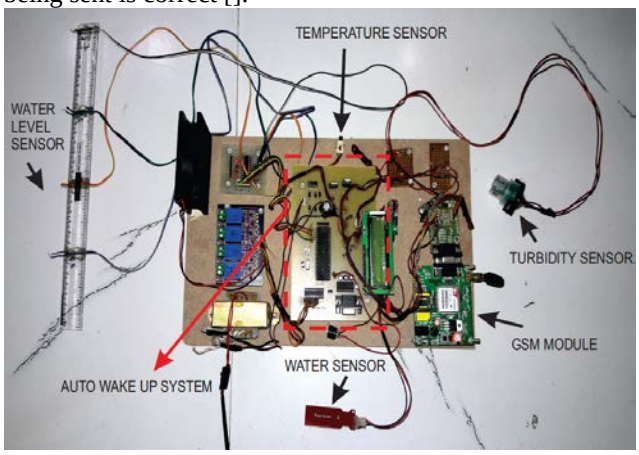

Fig 4. Top view of proposed project

5. Conclusions

We presented a wake-up system, which combines a passive circuit and sensors to detect carrier pulses with a simple digital circuit for node identification. Our wake-up system consumes very little power when both receiving data end is idle. The radio-triggered hardware could provide a wake-up signal to the MCU without using power supply, and it takes no more than 30us for the circuit to produce the wake-up signal.

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Mujeeb S. Khan was born on 18th July, 1987 in Aurangabad, Maharashtra and completed graduation in Bachelor of Engineering in Electronics and Tele Communication in 2009 from Dr. Babasaheb Ambedkar Marathwada University and currently pursuing Masters of Engineering in Communication Engineering from MIT, Aurangabad.

Monica S. Joshi was born in Aurangabad, Maharashtra and completed graduation in Bachelor of Engineering in Electronics and Tele Communication from Dr. Babasaheb Ambedkar Marathwada University in the year1999 and completed Masters of Engineering in Electronics in the year 2008. Currently she is working as Assistant professor in MIT, Aurangabad.