A ZigBee based Energy Efficient Environmental Monitoring Alerting and Controlling System

K.Lokesh Krishna
Associate Professor, Department of ECE,
S.V.C.E.T. (Autonomous),Chittoor, India
E-mail: kayamlokesh78@gmail.com

J.Madhuri
M.Tech Student, Department of ECE,
S.V.C.E.T. (Autonomous), Chittoor, India
E-mail: madhurictr15@gmail.com

Dr.K.Anuradha
Professor, Department of CSE,
L.B.C.E.W.,
Visakhapatnam, India

***Abstract*—The usage of Wireless Sensor Networks has become essentially important in recent years because of their ability to manage real-time data for various novel services. In this paper a novel ZigBee based energy efficient environmental monitoring, alerting and controlling system for agriculture is designed and implemented. This system utilizes an ARM7 processor, various sensors and ZigBee communication module. Sensors gather various physical data from the field in real time and transmit it to the processor and to the end user via ZigBee communication. Then necessary actions are initiated to perform action on behalf of people to reduce or eliminate the need of human labor. A wireless camera is connected to the processor to monitor the activities in real time. The proposed system has been tested for a month and satisfactory results have been observed, which indicate that this system is very useful for greenhouse environment monitoring, alerting and controlling various physical parameters in the field.**

Keywords—ARM, Base station, Network, Embedded System, Microcontroller, Green House, Sensors and Crop monitoring.

I INTRODUCTION

Wireless Sensor Networks are one of the crucial technologies in many applications for enhancing the quality of day to day life. They attracted the attention of many researchers due to their vast application scope. Wireless sensor networks have the capability to be used in many unthinkable applications. It includes military applications, habitat monitoring applications, industrial and business applications, environmental observation applications, health and home applications. A wireless sensor network includesmain functions such as sensing, measuring, computing and communication elements that give the user to monitor and take appropriate actions based on the physical parameters measured. It consists of hundred to thousand numbers of nodes. A sensor node is embedded with important parts such as a battery, a radio transceiver with an antenna, an actuator and a microcontroller. These sensor nodes have limited memory space and minimum bandwidth and are positioned in difficult to contact locations, so a wireless radio technology is implemented to transfer the data to a computer system, which is called a base station. Battery is the main source for powering the sensor node. Actuators can also be installed along with different sensors, depending on the type of application required. A WSN is classified into two types such as Structured and Unstructured. In an unstructured wireless sensor network several sensor nodes are organized in a dense manner and are installed randomly in the measuring environment. Once installed, the network is unmonitoredand doesn't look into the various measured physical variables. In a Structured wireless sensor network, all or some of the sensor nodes are arranged in a pre-planned manner. The main advantage of a structured wireless sensor network is that less number of nodes can be installed at desired locations with minimum network repairs and supervision cost [1].

Wireless sensor networks have become gradually important because of their ability to monitor and manage situational information for various intelligent services. A wireless sensor network consists of the physical layer, transport layer, application layer, data link layer and network layer.

Current advances in computer and information technology and in wireless sensor networks have made maintaining and functioning of agro-based industries like Greenhouse, Floriculture and Horticulture etc. easier than ever before. The need for intelligent farming has grown to a larger extent in the production of various crops. Nowadays the greenhouse agriculture is emerging very fast with the rising demand of various fresh vegetables and crops in the large and medium cities. A greenhouse is a kind of place in which it can change the plant growth environment, create optimum condition for plant growth, and keep out of the environment changes and the influence of terrible weather. The main purpose of using greenhouse concept is to increase crop yield, regulate growth cycle, improve its quality and improve economic benefit. By utilizing natural resources, various physical parameters such as temperature, humidity, intensity of illumination and carbon dioxide content can be improved in a greenhouse system.

However a wireless sensor network has some challenges in its design and applications. Firstly, the sensors operate from a very limited power source i.e. a battery. Secondly the sensors operate in short communication range and have limited processing and storage capabilities in each node. Also the size of the network varies with the monitoring environment. For indoor environments, fewer nodes are required to form a network in a limited space whereas outdoor environments may require more nodes to cover a larger area. In this paper, we designed and implemented a ZigBee based energy efficient environmental monitoring, alerting and controlling system for agriculture. We used the ZigBee (IEEE 802.15.4 standard) technology for networking and communication, because it has low-cost characteristics and operates at low-power.

This paper is organized as follows. Various works related to the existing system are presented in Section II. Design and Implementation of greenhouse wireless sensor network node is discussed in Section III. The hardware results and discussions are presented in Section IV. Finally, conclusions are drawn in Section V.

II RELATED WORK

Use of technology in the field of agriculture plays important role in increasing the production as well as in reducing the man power efforts. Research for improving agricultural production by utilizing wireless sensor network technologies is still in progress. Shen et al. developed a remote real-time data analyzing and processing system based on GSM-SMS[2].Stipanicev describes a networked embedded greenhouse monitoring and control based on simple embedded web servers and connecting sensors and actuators using 1-wire protocol. [3]. Gill et al. proposed Zigbee based home automation system that can control and monitor various home appliances. The proposed system consists of four devices, a safety sensor; light switch, radiator valve and Zigbee remote control have been integrated and evaluated with the home automation system. [4]. M. Haefke et al. designed and developed a Zigbee based smart sensing platform for monitoring environmental parameters such as relative humidity, pressure, temperature and sunlight. These units collectively send the sensor data wirelessly to a central station, which collects the data, stores and displays them into a database. Also the facility of adding few more sensors and a few more stations has been provided in the proposed system. [5]. Ahonen et al. monitored the environment of a greenhouse using a wireless sensor network and evaluated the network using collected data [6]. Li et al. designed a remote monitoring system for the greenhouse environment. In this system the gathered real time data is transmitted to the remote server by using wireless module GPRS and CDMA IX [7]. Sun et al. designed an embedded database system for temperature and humidity control in the greenhouse environment [8]. Kang et al. designed and developed an automatic greenhouse environment monitoring and control system and studied the development of environmental monitoring sensor nodes and a monitoring system in greenhouse environment [9]. Compared to the existing related research works, in this paper, we propose an energy efficient environmental monitoring, alerting and controlling system using ZigBee communication.

III DESIGN AND IMPLEMENTATION OF GREENHOUSE WIRELESS SENSOR NETWORK NODE

Sensor network nodes are objects which are installed in the monitoring areas of wireless sensor network, in order to measure various physical data and finish the specified task. Improvement in growth of various crops depends on various environmental parameters such as soil moisture, soil temperature, relative humidity, pH of soil, light intensity, etc. Little changes in any of these parameters can cause problems like formation of diseases, improper growth of crops, etc. which results in lesser yield.

The proposed greenhouse wireless sensor network consists of transmitter section and the monitoring section. The block diagram of the proposed transmitter section is shown in fig.1. The transmitter section consists of microcontroller (LPC2148), various sensors such as humidity sensor, temperature sensor, soil moisture sensor, CO_2 sensor and light dependent resistor sensor, power supply section, Zigbee transmitter, Water sprinkler, DC motor and Camera. The monitoring section consists of a Zigbee receiver and a Laptop with application language. The block diagram of monitoring section is shown in fig. 2.

The main hardware components used in the system are

A. MICROCONTROLLER:

The ARM7is a general purpose 32-bit microcontroller, which offers high performance and consumes very low power.The LPC 2148 microcontrollers are of 32-bit. It is extremely tiny in size and consumes low power and is ideal for applications where low power is a key requirement. ARM7 is a versatile processor specially designed for various mobile devices. It supports both 32-bit and 16-bit instructions using Thumb and ARM instruction sets. The ARM7 processor is capable of executing upto 130MIPS on 0.13µm digital CMOS process.

Pipelined techniques are employed so that all parts of the processing and memory systems can operate simultaneously. Typically, while one instruction is being executed and completed, its successor is being decoded, and a third instruction is being fetched from memory. The ARM7processor also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume

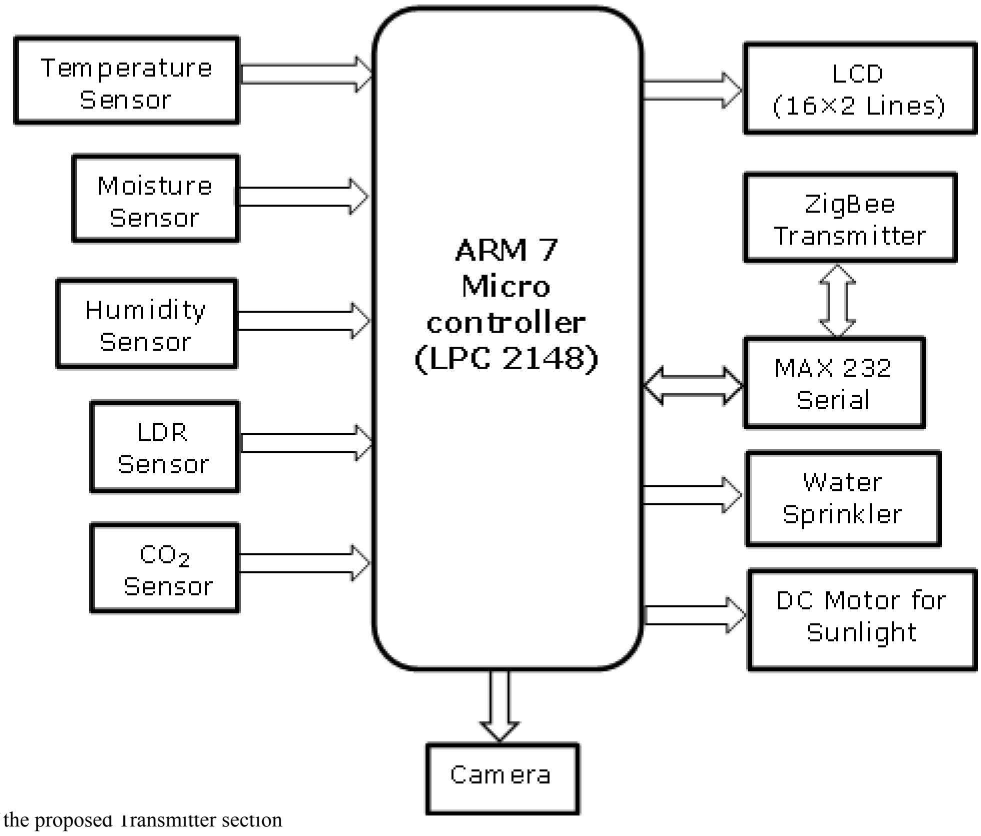

Fig. 1 Implementation of the proposed Transmitter section

applications with memory restrictions, or applications where code density is an issue.

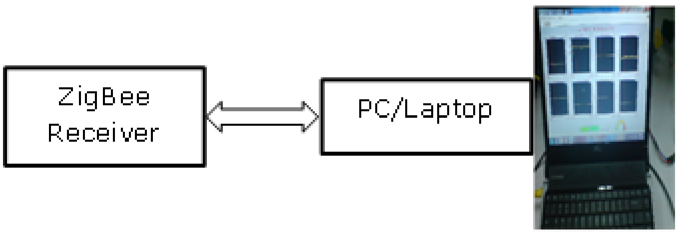

Fig. 2 Block diagram of the Monitoring section

B. CO_2 SENSOR:

The CO_2 Gas Sensor measures the gaseous carbon dioxide levels by monitoring the amount of infrared radiation absorbed by carbon dioxide molecules. It has two settings: low range (0–10,000) ppm and high range (0–100,000) ppm. Fig. 3 shows a typical CO_2 sensor used in the proposed system.

Fig. 3CO_2 Gas Sensor

C. TEMPERATURE SENSOR:

The LM35 sensors are used for the measurement of temperature. They are precise, whose output voltage is changes proportionally to the Centigrade temperature. These LM35 series sensors does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full temperature range of -55 to +150°C. It can be powered from a single power supply, or with ± power supplies. As it draws only 60µA from a given power supply voltage, it has very low self-heating, less than 0.1°C in still air. Fig. 4, shows a typical temperature sensor used in the proposed system.

Fig. 4LM35 Temperature Sensor

D. HUMIDITY SENSOR:

Humidity is the amount of water vapour present in the air. It indicates the exact amount of water vapour present in the air and these values are displayed on LCD. It converts directly relative humidity to voltage. Fig.5 shows a typical humidity sensor used in the proposed system.

Fig. 5 Humidity Sensor

E. MOISTURE SENSOR:

The Moisture Sensor detects the moisture of the soil around the sensor, which is ideal for monitoring the plants or the soil moisture. This sensor uses the two probes to pass current through the soil, and then it reads that resistance to get the moisture level. Excess water makes the soil conduct electricity better; while dry soil conducts electricity poor. Fig. 6, shows a typical moisture sensor used in the proposed system.

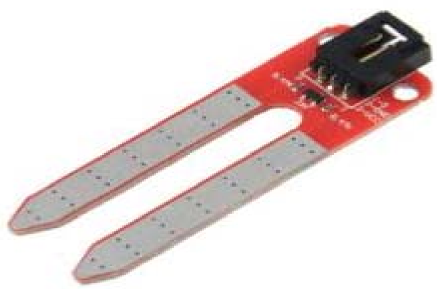

Fig. 6 Moisture Sensor

IVHARDWARE IMPLEMENTATION AND RESULTS

Measurements have been carried out using various sensors and the following monitoring results were obtained, recorded and plotted. Fig.7 shows a prototype view of the hardware implementation of the proposed system. Fig. 8 shows the various monitored values on the system from the field.

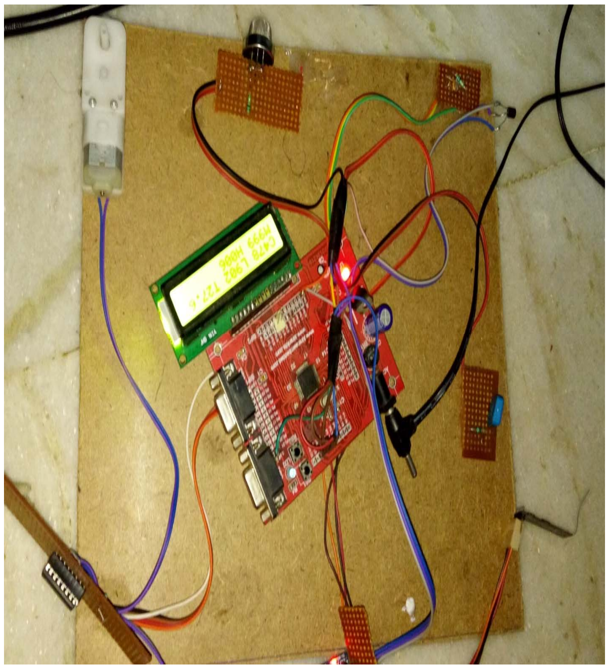

Fig.7 Prototype of the Transmitter section

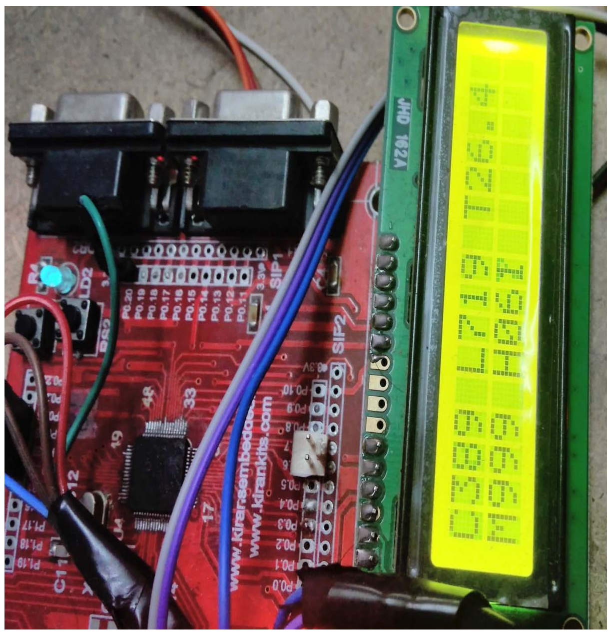

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Table 1 shows various sensor readings monitored from fields with exact time and date.

Tab.1 various sensor readings monitored on a given day

S.No:	Date and Time	Temperature in °C	Relative Humidity in %	Moisture in mV
1	08-01-2016 09:00:00AM	28.2	39	186
2	08-01-2016 09:30:00AM	31.1	39	185
3	08-01-2016 10:00:00AM	33.4	39	183
4	08-01-2016 10:30:00AM	34.6	38	182
5	08-01-2016 11:00:00AM	35.4	38	180
6	08-01-2016 11:30:00AM	36.2	35	172
7	08-01-2016 12:00:00PM	38.5	35	164
8	08-01-2016 12:30:00PM	39.9	35	155
9	08-01-2016 01:00:00PM	40.3	33	143
10	08-01-2016 01:30:00PM	40.6	32	138
11	08-01-2016 02:00:00PM	40.8	32	132
12	08-01-2016 02:30:00PM	41.3	32	126
13	08-01-2016 03:00:00PM	41.5	32	121

Fig. 9, Fig. 10 and Fig. 11 shows the monitoring of temperature, relative humidity and moisture for the first ten days in the month of January 2016.

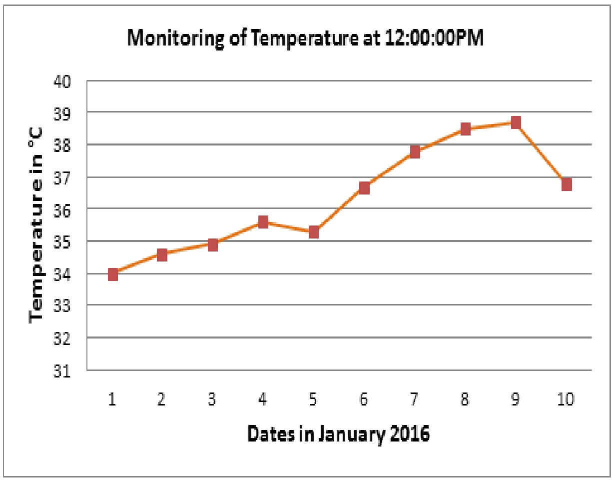

Fig.8 Monitored values

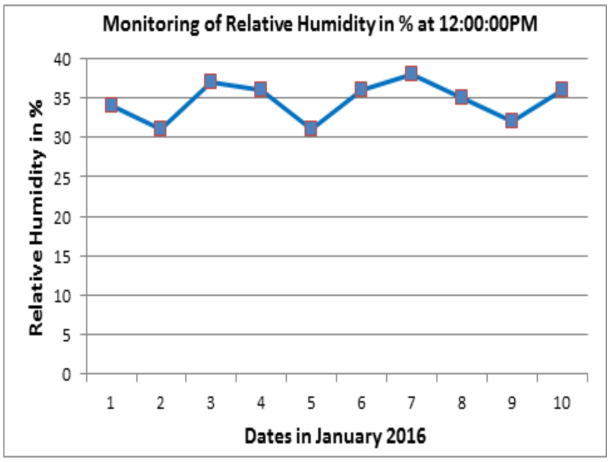

Fig. 10 Monitored Relative Humidity values

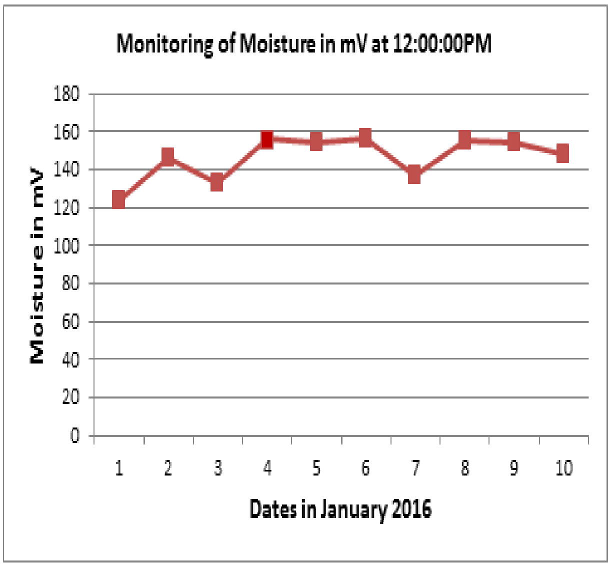

Fig. 11 Monitored Moisture content values

V CONCLUSIONS

In this paper, design and implementation of a ZigBee based energy efficient environmental monitoring, alerting and controlling system for agriculture is proposed. Wireless monitoring of field not only allows the farmer to lessen the human power, but it also allows helps to track the changes accurately happening instantly at the field. The proposed system is capable of controlling the essential parameters necessary for plant growth, viz. watering using sprinkler, temperature, humidity, soil moisture and light intensity etc. Also this proposed system of farming is user-friendly and highly robust.

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