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Zigbee Based Soil Moisture Monitoring System

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ABSTRACT: Accurate and appropriate moisture of soil is required for the proper growth of crop. The maximum amount of water is used in agriculture in form of irrigation. The plants should be irrigated only when they need water, unwanted application of water increases the chances of weed production and incidence of disease. This paper presents a system that can help the farmers to get proper information about the amount of water required for irrigation as well as the temperature and humidity of atmosphere. The data is send to remote location using Zigbee based Wireless sensor network.

KEYWORDS: WSN; Soil moisture; Temperature; Humidity; Arduino; Zigbee

I. INTRODUCTION

Soil moisture and climatic conditions are the two most important factors, which decide the agriculture productivity and its production. As India consumes 80% of total available water resources for irrigation purpose, there is an urgent need to reduce water consumption using advanced scientific techniques [1]. The water is the biggest resource for the development of life on earth. Now days, it is scarce. So, we need to use it with utter care. During irrigation water wastage should be avoided. The plants or crop should be irrigated only when they need to be. When plants transpire more amount of water, the relative humidity of atmosphere increases [2]. The presence of large amount of relative humidity increases the chances of disease attack [2]. So, the status of soil moisture in the field requires periodic inspection, from where one can come to know, when the next irrigation should be done and how much amount of water should be applied.

Now a day's micro and nano electromechanical systems are getting advanced, as a result wireless sensor networks have come up with an interesting and innovative approach for industrial and civilian applications. A network made up of small low cost sensors, which consume less power, is known as wireless sensor network [3]. Zigbee based wireless sensor networks have a lot of applications in agriculture, such as monitoring atmospheric temperature and humidity, soil moisture content etc. As shown in fig 1, the main units of sensor network are data acquisition or sensor unit, processing unit, communication protocol and power supply unit.

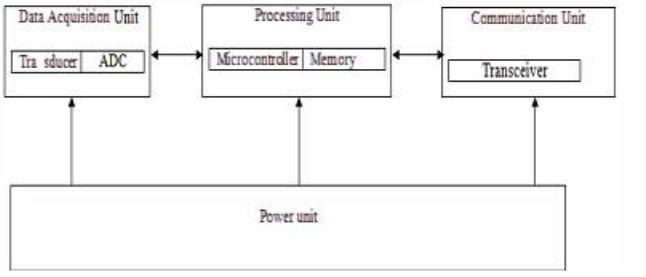

Fig1 Block Diagram of Wireless Sensor Network [3]

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The following sections include problem related to agriculture regarding soil moisture and unpredictable weather conditions, background of use of WSN in agriculture, proposed model of soil moisture monitoring system and hardware description of the proposed model. The steps for experimental setup are elaborated and results are discussed.

II. PROBLEM STATEMENT

In India, farmers are under big financial losses. Their suicide rate is increasing day by day. The general weather prediction is not helping them to take proper decisions. The non availability of good meters makes them dependent on traditional methods to measure agriculture parameters. Suppose if they want to know the type of soil of their farm, they have to send the soil samples to the laboratory in the city. And, moreover soil type may vary few kilometres, it is very difficult to send so much samples. The wireless sensor networks can provide automatic agriculture monitoring.
Generally farmers visit their farms often to check soil moisture level. This process wastes their precious time. The objective of this paper is to give a easy to install methodology to monitor and indicate the level of soil moisture, temperature and humidity of air. With WSN the data about their field will be easily available with them, at their farmhouse. This will not only save water as well as time and labour of farmers.

III.RELATED WORK

The idea of use of Wireless sensor Network in agriculture has been proposed in [4]. This paper gave information that how the data collected from various sensors can communicate and can be send it to destination wirelessly. In [5] distributed wireless sensor network system is proposed, that can be used for the efficient water management controlled sprinklers from various GPS systems. In [6] authors presented that there are two types of wireless sensor Networks (WSN) in agriculture, one is terrestrial WSN and another is underground WSN. The underground WSN is not affected by the human intervention, as it lies below the soil. The combination of both types gives more promising results. The framework to operate and deploy hybrid WSN was developed. In [7] Advanced technique to measure soil moisture content based upon automatic pumping is proposed. These papers presented a system based on microcontroller that senses the soil, calculates the moisture content and according to the moisture value, irrigate the fields. A water flow sensor is used to measure the flow water. In [8] authors investigated a remote monitoring system using Zigbee. The nodes send data wirelessly to a central server, which collets the data, stores it and analyse it and sent to the client mobile. The authors in [9] Proposed an agriculture solution combination of WSN and GSM technology. The PIC microcontroller is used as a heart of the system and Zigbee based low power devices are employed to enable cost saving. Arduino based automatic plant watering system is presented in [10] which uses Arduino board, having ATmega 328 microcontroller. It senses the soil moisture level and supply the water when required. In this paper soil moisture is taken into consideration. In [11] agriculture monitoring system proposes the use of microcontroller AT89C52 as a heart of the system. The humidity and temperature values are displayed on the LCD and are transmitted to remote station using Zigbee transceiver. Wireless sensor based crop monitoring system is developed and implemented that is connected to a central station using Global System for Mobile (GSM) technology. The PH value of the soil is send via SMS to mobile phone using GSM [12]. Development of low cost soil moisture sensor for drip irrigation system is proposed in [13]. This automatic system increases the yield of the crop, save water, energy, and labour cost. Soil moisture sensor was calibrated to switch on the motor when soil moisture reaches field capacity. In [14] authors have presented work on the remote automatic irrigation system which was based on the embedded systems. The test for fertilizer requirement, chemical constituents and water content of the field is detected. The proposed system in [15] is automatic irrigation controller is open loop, automatic and adaptive system. A relay controlled microcontroller is used to control all the process management. The system determines soil moisture and according to that applies the amount of water. The proposed model in [16] uses the sensor node consisting JN5121 module, an 802.15.4/Zigbee wireless controller. The sink node for data collection was ARM9 based. The literature review presents that Moisture deficit stress and high temperature are two of the major environmental factors that affect crop production. The amount of water used by a crop always depends on moisture availability in the soil, air temperature, and soil temperature. Microcontrollers and solid-state sensors can be found in many commercial, industrial, and consumer applications. There are many advantages in developing microcontroller based circuits and incorporating new sensor technologies into agricultural applications.

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IV. PROPOSED METHODOLOGY

This paper would take the opportunity to design a device that monitors soil moisture, temperature and humidity of field atmosphere, and transmit the information to the remote receiver at the farmhouse or outside the field. The remote receiver is laptop connected to the Zigbee transceiver. The proposed system as shown in fig 2 consists of Arduino as processing unit and WSN base station. A soil moisture and temperature humidity sensor is connected to the WSN data collection node. The sensor node also consists of a LCD module, where the sensor output is displayed in real time. The sensor node is building block of the WSN. The task of sensor node is to achieve the perception, collection, processing and wireless transmission. The sensor node converts the physical quantity to the voltage signal and Arduino UNO board controls the processing, and manages the communication protocol. The sensor node communicates with the base station using transceiver. The base station collects all the data send by sensor node and evaluate important information.

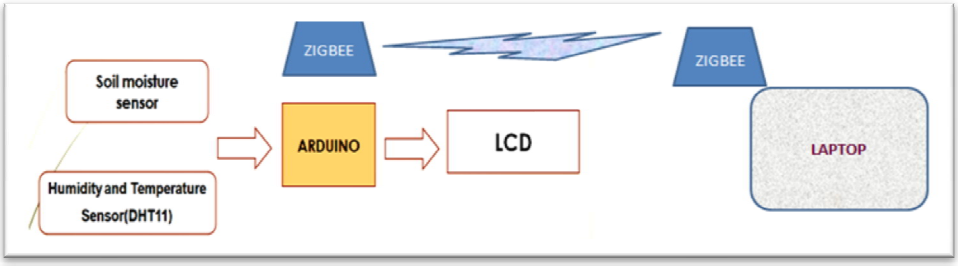

Fig 2 Soil Moisture Monitoring System

V. SYSTEM COMPONENTS

The whole system is made with the collaboration of hardware and software components. The hardware components include Arduino UNO board, soil moisture sensor, DHT11 temperature humidity sensor, LCD module and Zigbee transceivers. The software includes Arduino IDE and X-CTU.

A. *Arduino:*

The Arduino UNO is a microcontroller board based on the ATmega 328. It has 6 MHz ceramic resonator, a USB connector, reset button and a power jack. It is the most robust board. It has 14 digital I/O pins and ICSP header. UNO represents one in Italian and was chosen to indicate Arduino Software (IDE) version1. Arduino doesn't require any extra hardware for boot loading. It is pre planned with boot loader that makes it simpler to upload programs to on board flash memory. The advantages of Arduino are that it provides inexpensive and simpler method for novices and professionals to create their own devices using sensors. It provides platform that easily runs on windows and Linux operating system.

B. *Soil moisture sensor:*

Soil moisture sensor measures the content of water present in the soil. It works on the principle of frequency domain reflectometry technique of soil moisture measurement. Frequency domain reflectometry uses capacitance probes to measure the moisture. The moisture is calculated by considering the dielectric constant of the soil. The dielectric constant of any material is defined as capacity to transmit the electromagnetic pulses or waves. The dielectric constant of water is much bigger in value than soil. Two electrodes are embedded into the soil and soil acts as dielectric medium. The electrodes are given voltage supply, due to presence of water the dielectric of soil changes. Because of which the frequency oscillations occur, at a certain point resonance occurs and the resonance frequency value is used to calculate the water content in the soil. More the water, smaller will be the resonant frequency. FDR is more accurate method as compared to TDR. It is not affected by the salinity levels, gives better resolution. The design of probe is flexible and robust. It is an inexpensive method compared to other methods.

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C. *Humidity and temperature sensor DHT11*

Humidity is the vapour amount present in the air. Humidity sensors detect the relative humidity of the surrounding environment. DHT11 measure both the humidity and temperature of the air and express relative humidity as a percentage of the ratio of moisture in the air to the maximum amount that can be held in the air at the current temperature. Humidity sensors use capacitive method to find out the amount of moisture present in the air. The temperature measurement is done using the principle of thermistor.

D. *LCD(*liquid crystal display*)*

LCD is liquid crystal display, generally used in devices and circuits to display the data. The main advantage is LCD is, it is very economical and easy to program. The most common LCD module is 16×2. It contains two rows and 16 columns. LCD has two registers, one is command register and another one is data register. Command register is used to store the data related to different commands, such as clear screen, initialization etc. Data register stores data to be displayed on LCD.

E. *ZIGBEE*

Zigbee is developed by Zigbee alliance. It is based on IEEE 802.15.4 standards. Zigbee is well known wireless communication protocol. It consumes very less power and is reliable for wireless personal area network. There are three types of device in Zigbee network. These are a Coordinator, router and end device. A network may consist of a coordinator node and multiple router and end devices. The configuration of Zigbee modules is done through X-CTU software. Zigbee operates in the industrial, scientific and medical (ISM) radio bands: 915 MHz in the USA and Australia, 868 MHz in Europe, and 2.4 GHz in worldwide.

F. *Arduino IDE tool*

Arduino IDE is Arduino integrated development environment or we can say it is Arduino software. It consists of a text editor, where the code is written. A message area is given, which shows message or any error message. The tool bar contains buttons for common features. The programs are uploaded to Arduino board by USB connection. The coding for soil moisture monitoring system is done using Arduino IDE.

G. *X-CTU Software*

It is a simple graphical user interface designed for the multi platform applications to interact with digi RF modules. It contains tools that are used to setup, configure and test Zigbee modules. It can be used to configure multiple modules. It receives the data using Zigbee transceiver and displays the results of sensors on the console.

VI. EXPERIMENTAL SETUP AND TESTING

This system measures the three most important parameters of agriculture soil moisture, temperature and humidity.
The different steps for hardware implementation of soil moisture monitoring system are described as below.
Step1: Connect soil moisture and DHT 11 sensor to Arduino using jumper wires.
Step2: Interface the liquid crystal display (LCD) to Arduino.
Step3: Write code for soil moisture sensor, DHT11sensor and LCD in text editor of Arduino IDE.
Step4: Save the code and compile it. After compilation if any error occurs, debug it.
Step5: Connect the Arduino board to Arduino IDE using USB connection.
Step6: Select the port and Arduino UNO using TOOLS icon.
Step7: Upload the code to Arduino board.
Step8: Make connection of Zigbee transmitter to Arduino and Zigbee receiver to laptop.
Step 9: Configure transmitter Zigbee as router and receiver as coordinator using X-CTU software.

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Testing of soil moisture sensor is done by using Gravimetric method. Different soil samples are taken from any depth from any farm or garden. The collected samples are put into an air tight container. The samples are weighed and then heated in oven at temperature 100-110ºC, more specifically at 105ºC. the heated samples are left for 24hours , so that no more content of water is present. Then dried soil samples are weighed and at the end the moisture content is calculated using formula

$$Moisture\ content = \frac{(weight\ of original\ sample - weight\ of\ dried\ soil)}{weight\ of original\ sample} \times 100$$

Fig 3 Sensor Node

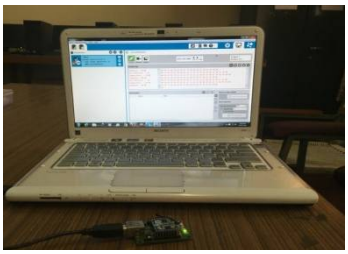

Fig 4 Base Station

VII. RESULTS AND DISCUSSION

The soil moisture monitoring system involving soil moisture, temperature and humidity sensors for monitoring various agriculture parameters of agriculture has been successfully implemented. As shown in Fig 3, When soil sensor is embedded into soil, it gives percentage of water present in the soil on LCD and laptop. The data received from the sensors is displayed on IDE serial monitor, which gives the value of soil moisture in percentage, atmospheric temperature in degree Celsius and relative humidity in percentage. When soil sensor is present in dry soil it gives 0% reading, as the water is added to soil, the reading starts increasing. The DHT11 sensor gives the value of atmospheric temperature and humidity, the value is same as predicted by the internet. The coding is performed in the simulation environment of Arduino IDE as shown in fig 5.At control station a Zigbee transceiver is connected to the laptop to receive data remotely as shown in Fig 4.

Fig 5 Soil Moisture, Temperature and Humidity Reading On Arduino Serial Monitor

The control station is laptop installed with X-CTU. Fig 6 shows the values received by the control station during implementation. The console log of coordinated Zigbee is opened to see the result. The soil moisture is 2%, as few

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drops of water is added to soil tub as water level is increased the reading also increases, the humidity value is 33 and temperature is 30 degrees. The HEX code for the received data is also represented simultaneously.

The motive of designing hardware for soil moisture monitoring is achieved successfully. The designed sensor node is small size device, driven by battery. The node is tested for soil moisture using quantitative gravimetric method. The measured results match the actual value within a tolerance range of 1-2%. The testing of all the other sensors is also done manually. The range of Zigbee module is observed to be 40 meters for indoor communication and 115 meters for outdoor communication.

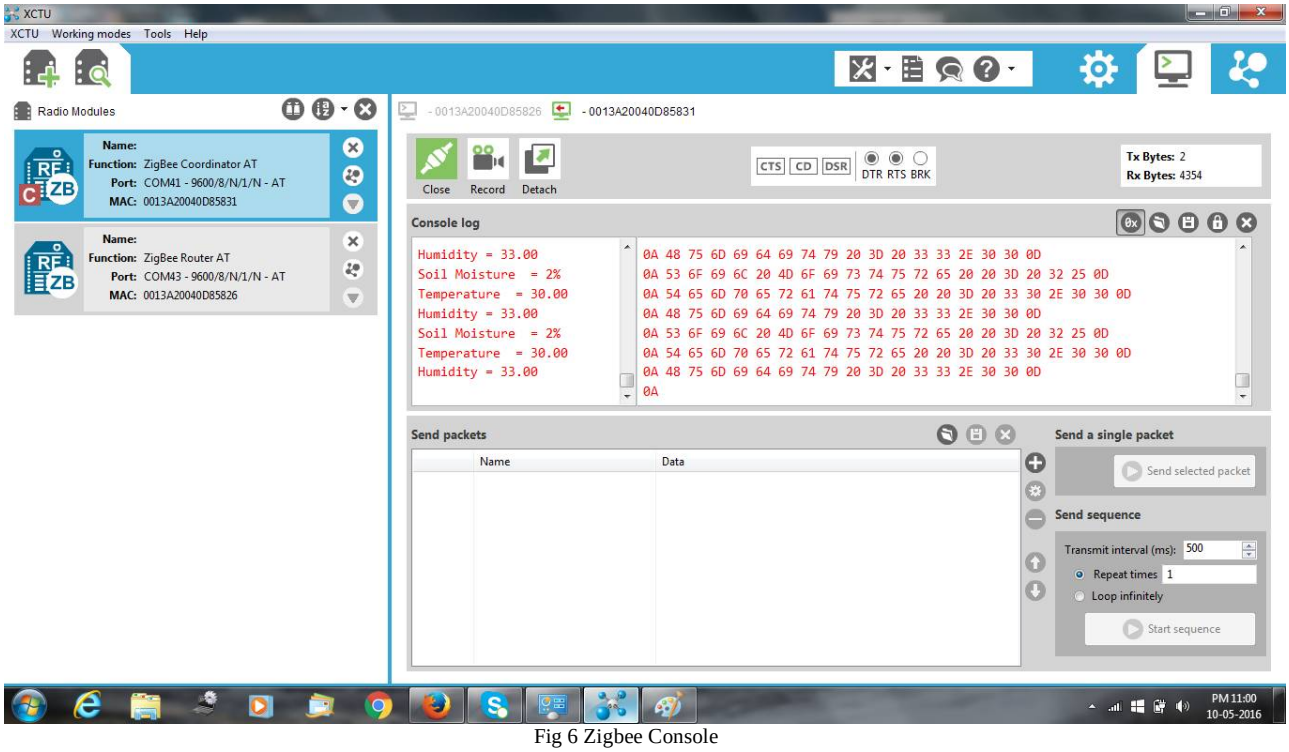

Fig 6 Zigbee Console

VIII. CONCLUSION

Indian farmers are facing a lot of problems, but the advancement of wireless sensor networks in agriculture would be promising in the present scenario of water scarcity and unpredictable weather conditions. This paper provides implementation of WSN based soil moisture monitoring system. As the implementation is done by using Arduino and Zigbee, so it is cost effective. The sensed parameters are displayed on LCD and Zigbee base station console. The developed system is successful in measuring soil moisture, temperature and humidity wirelessly. Thus the system provides information to farmer and reduces his load of visiting farm again and again.

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