Zigbee Wireless Soil Moisture Sensor Design

Ms. Akshata Shilkar[1], Ms. Nikita Sonawane[2], Ms. Swapnali Yewale[3], Prof. Sonali Sahu[4]
[1, 2, 3, 4] Department of Electronics & Telecommunication
[1, 2, 3, 4] Bharati Vidyapeeth College Of Engineering,Navi Mumbai.

Abstract- *The main objective of the present paper is to develop a smart wireless sensor network (WSN) for an agricultural environment. Monitoring agricultural environment for various factors such as soil moisture, temperature and humidity along with other factors can be of significance. A traditional approach to measure these factors in an agricultural environment meant individuals manually taking measurements and checking them at various times. This paper investigates a remote monitoring system using Zigbee. These nodes send data wirelessly to a central server, which collects the data, stores it and will allow it to be analyzed then displayed as needed and can also be sent to the client computer.*

Keywords- WSN; Soil moisture; Temperature; Humidity; Arduino; Zigbee

I. INTRODUCTION

Wireless Sensor Networks (WSN) have been the subject of research in various domains over the past few years and deployed in numerous application areas. WSN is seen as one of the most promising contemporary technologies for bridging the physical and virtual world thus, enabling them to interact. A WSN is composed of a number of sensor nodes, which are usually deployed in a region to observe particular phenomena in a geospatial domain. Sensor nodes are small stand alone embedded devices that are designed to perform specified simple computation and to send and receive data. They have attached to them a number of sensors, gathering data from the local environment that is being monitored. WSNs have been employed in both military and civilian applications such as target tracking, habitant monitoring, environmental contaminant detection and precision agriculture. It is a system for gathering (sensing) and analysing climate, atmosphere, plant and soil data. It is specifically designed for microclimate analysis in agricultural/horticultural environments. This research has produced a prototype in order to demonstrate how state-of-the-art devices could be used in precision viticulture as a management tool to improve crop yield quantity and crop quality in a agricultural land.

A. Wireless Sensor Networks

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. Sensor networks are used for a variety of applications, including wireless data acquisition, machine monitoring and maintenance, smart buildings and highways, environmental monitoring, site security, automated on-site tracking of expensive materials, safety management, and in many other areas. A general WSN protocol consists of the application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management plane and the task management plane. Currently two there 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. In general, as frequency increases, bandwidth increases allowing for higher data rates but power requirements are also higher and transmission distance is considerably shorter. Multihop communication over the ISM band might well be possible in WSN since it consumes less power than traditional single hop communication. It is also possible to create a WSN using Wi-Fi (IEEE 802.11), but this protocol is usually utilized in PC-based systems because it was developed to extend or substitute for a wired LAN . Its power consumption is rather high, and the short autonomy of a battery power supply still remains an important disadvantage.

B. ZigBee

The ZigBee standard is built on top of the IEEE 802.15.4 standard. The IEEE 802.15.4 standard defines the physical and MAC (Medium Access Control) layers for low-rate wireless personal area networks. The physical layer supports three frequency bands with different gross data rates: 2,450 MHz (250 kbs-1), 915 MHz (40 kbs-1) and 868 MHz (20 kbs-1) It also supports functionalities for channel selection, link quality estimation, energy measurement and clear channel assessment. ZigBee standardizes both the network and the application layer. The network layer is in charge of organizing and providing routing over a multi-hop network, specifying different network topologies: star, tree, peer-to-peer mesh. The application layer provides a framework for distributed application development and communication. Aside from the agriculture and food industry, it is widely used in home building control, automation, security, consumer electronics, personal computer peripherals, medical monitoring and toys. These applications require a technology that offers long battery life, reliability, automatic or semi-automatic installation, the ability to easily add or remove network nodes, signals that can pass through walls and ceilings and a low system cost.

II. SYSTEM ARCHITECTURE

The proposed WSN system consists of sensor nodes located in critical locations within the farm for collecting the necessary data such moisture, temperature and humidity. The system architecture consists of three layers namely, sensor layer, server layer and application layer.

Sensor layer: This layer consists of all the wireless sensor nodes and a Base Station (BS). Each node has one or more sensors plugged into the hardware device with a transmitter, power supply (usually a small battery) and microcontroller. The nodes are distributed over an area of interest uniquely arranged as required provided the distance between the sensor devices does not exceed the maximum communication range. Therefore, energy optimized routing becomes essential. Data transmission from sensor nodes to the BS depends on the application: continuous, event driven, query-driven or hybrid. In the continuous approach, data is transmitted to the BS periodically according to predetermined intervals. In the query and event driven models, data is transmitted when an event takes place or a query is generated from the BS. The hybrid model uses combinations of these approaches to transmit data from sensor nodes to the BS. Various types of routing protocols such as data centric, hierarchical and location based protocols are available.

Server layer: Data are sent to the data server from the BS through the internet.

Two main tasks performed by the data server are to:

1. Obtain and process data from the BS.
2. Populate the database with WSN data and enable the application layer to access WSN data.

The server layer also deals with on-time data delivery from the BS and generates alarms when undesirable events take place.

Application layer: This layer allows users of the system to have remote access to WSN data using web browsers. This provides a powerful tool to visualize real time WSN data and compare data from various nodes. In addition, the BS can be accessed remotely to modify sensor node configurations.

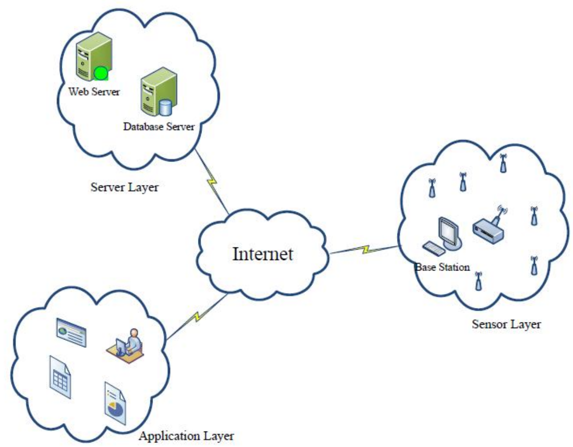

Figure 1. WSN Architecture

III. WORKING

The working consists of two parts:

1) Transmitter
2) Receiver

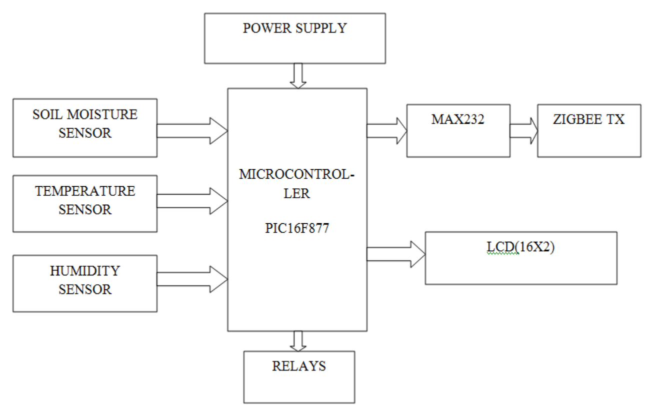

Figure 2. Block diagram of transmitter

A. Transmitter

Initially power is on. After this system is reset. Signals are read by different sensors and its output is given to microcontroller. Output to microcontroller from sensor is taken through 8 channel ADC pins.

The output from microcontroller is given to Zigbee through Rx and Tx pins.

On exceeding the limits of soil moisture, temperature n humidity the alarm will be on and the corresponding relays will be activated.

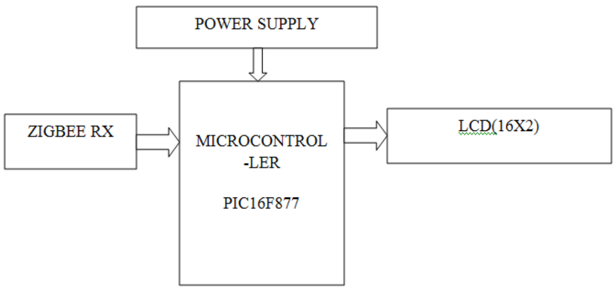

Figure 3. Block diagram of receiver

B. Receiver

At receiver side ZigBee come into picture. There is only one Tx and Rx pins Signal is send to microcontroller and parameters like temperature, soil moisture and humidity are monitored. These parameters are monitored on computer using serial interface. This data can be used for precision farming The actuators can be controlled using microcontroller data. This is how total working takes place of automation irrigation system. Different sensors like moisture and temperature sensor senses the moisture content and temperature required. Thus it helps to provide a proper environment to grow crops easily. A different technique of irrigation has been used to irrigate the field. First water is stored in tanks trough pipes then different sources like sprinklers and drip irrigation can been used as both are suitable to irrigate crops.

IV. PROPOSED METHODOLOGY

The main aim of this research is to investigate and develop a wireless network for irrigation management. This network is also used to collect other environmental and plant data such as humidity, temperature, soil moisture and soil temperature. The research is specifically focused on the development of an accurate, stable and fast reacting soil moisture sensor for irrigation management. It finally investigates the design of a micro climate weather station for agricultural land management.

V. SYSTEM COMPONENTS

A. Temperature sensor

Analog Devices's AD2210 is voltage output temperature sensor with in built signal conditioning. It has a temperature span of 200 ◌C. The accuracy of the sensor is better than ±2% of full scale. The linearity of the sensor is better than ±1% of full scale. The sensor can operate over a temperature range of -50◌ C to +150 ◌C. The built in signal conditioning eliminates the need for any trimming, buffering or linearization circuitry. The output temperature coefficient is 22.5mV/◌ C.

B. Humidity Sensor :

This is a voltage output humidity sensor with in built signal conditioning. It has near linear voltage output vs %RH (Relative Humidity). The sensor is manufactured with laser trimmed, thermoset polymer capacitive sensing elements. The sensor has a sensing accuracy of ±3.5%RH. This capacitive sensor has a response time of 5 seconds in slow moving air.

C. 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.

VI. EQUATIONS

The dew point temperature can be calculated at a particular temperature and pressure. By using Magnus formula [21] the saturation vapour pressure and dew point can be calculated, at a temperature T (in °C). The saturation vapour pressure EW (in hPa) over liquid water can be expressed as:

$$EW = \alpha . e^{\left(\frac{\beta . T}{\gamma + 1}\right)}$$

For the temperature range – 45°C to 60°C, the Magnus parameters are α = 6.112 hPa, β = 17.62 and γ= 243.12 °C. By restating above equation the dew point temperature Dp (in °C) can be calculated from vapour pressure E.

$$Dp = \frac{\gamma . \ln\left(\frac{E}{\alpha}\right)}{\beta - \ln\left(\frac{E}{\alpha}\right)}$$

$$E = RH * \left(\frac{EW}{100}\right)$$

Introducing the relative humidity RH (in %), it can be calculated as:

$$Dp(T, RH) = \frac{\gamma\left(\ln\left(\frac{RH}{100}\right) + \frac{\beta . T}{\gamma + T}\right)}{\beta - \left(\ln\left(\frac{RH}{100}\right) + \frac{\beta . T}{\gamma + T}\right)}$$

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. 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 monitor, which gives the value of soil moisture in percentage, atmospheric temperature in degree Celsius and relative humidity in percentage. At control station a Zigbee transceiver is connected to the laptop to
receive data remotely.

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 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.

REFERENCES

[1] Wheeler, A. ZigBee Wireless Networks for Industrial Systems - White Paper; Available from: http://www.microcontroller.com/Embedded.asp?did=149.

[2] Egan, D., The emergence of ZigBee in building automation and industrialcontrol. Computing & Control Engineering Journal, April-May 2005 16(2): p.14-19.

[3] Soil Science Instrumentation. 2003-2009 [cited 10/01/2010]; Available from: http://www.ictinternational.com.au/soils.htm.

[4] Maxwell, J.C., A Treatise on Electricity and Magnetism. Agronomy journal,, March-April 2001.

[5] Jose', D. and A. Gutierrez, IEE Std. 820.15.4 Enabling Prevasive Wireless Sensor Networks. Innovation Centre, 2005.

[6] Young Hun, S., et al. Performance evaluation of wireless networked control system using time-triggered IEEE 802.15.4. in ICCAS-SICE, 2009.