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Real Time Remote Temperature & Humidity Monitoring Using Arduino and Xbee S2

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Abstract: Today monitoring environmental parameters have gained more importance due to the increasing security and regulatory compliance needs. So the measurement of such parameters becomes critically important. To do the parameter measurement of remote places, the traditional wired systems fail. Hence there is a need of next generation technology such as wireless technology. Due to the advancement in the Micro-Electromechanical systems (MEMS) technology tiny, low cost, low power, cost effective wireless modules are available and they work in such locations efficiently. This paper represents the use of wireless sensor network (WSN) technology for monitoring temperature and humidity using Arduino microcontroller, Xbee S2, DHT11 sensor and PC. Real time temperature and humidity parameters data were recorded at location Nashik (19.9975° N, 73.7898° E), Maharashtra (India). A result shows more variation of humidity parameter in night time as compared to day time. Such wireless system will prove to be boon for agriculture, health care, storage areas etc.

Keywords: Wireless technology, Wireless sensor node, Arduino, Xbee S2, Personal computer.

I. INTRODUCTION

A monitoring system generally refers to an automated system that simultaneously and continuously records one or more physical parameters such as temperature, relative humidity, wind flow, light intensity, soil moisture etc. at one or more predefined places. Continuous monitoring of any sensitive environment helps to meet security and regulatory compliance needs. Monitoring temperature and/or humidity conditions is an essential ingredient of a wide range of quality assurance applications. Monitoring deterioration would provide an early warning of incipient problems enabling the planning and scheduling of maintenance programs, hence minimizing relevant costs. Furthermore, the use of data from monitoring systems together with improved service-life prediction models leads to additional savings in life cycle costs [1, 2]. Temperature and humidity are key issues to be taken care of in manufacturing plants and particularly that of electronic assemblies. Lack of control over any of them will not only affect the component and equipment but also the process and the operators' comfort, all ultimately leading to loss in production [3].

Temperature and relative humidity affects the airborne survival of viruses, bacteria and fungi. Thus environmental control in hospitals is important because of infectious disease transmission from the aerosol or airborne infection [4].

Temperature and relative humidity plays an important role in the lifecycle of the plants. When plants have the right humidity they thrive, because they open their pores completely and so breathe deeply without threat of excessive water loss. [5]

Wireless sensor network (WSN) has revolutionized the field of monitoring and remote sensing. Wireless sensor network or wireless sensor & actuator network (WSAN) are spatially distributed sensors to monitor physical or environmental conditions such as temperature, humidity, fire etc. and to cooperatively pass their data through the network to the main location [6].

The aim of this paper is to design and develop a system which fulfils all above requirements. In this paper digital humidity temperature composite (DHT11) sensor is used to sense the environmental temperature and relative Humidity. Arduino microcontroller is used to make complex computation of the parameters and then to transmit the data wirelessly by using Xbee S2 module to the receiver. At receiver section Xbee S2 module is used to capture the serial data, which is transmitted, by transmitter and using Digi's XCTU software the data is logged onto PC. Transmitter and receiver block diagram is shown in Fig. 1(a) and 1(b) respectively.

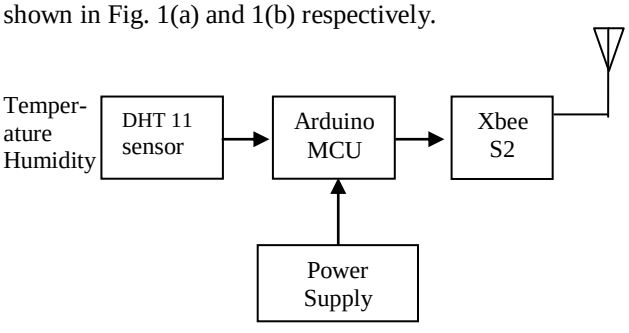

Fig. 1(a). Transmitter Section

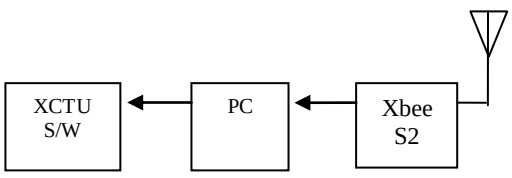

Fig. 1(b). Reciever Section

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II. SYSTEM HARDWARE DESCRIPTION

A. ZigBee Standard

There are many types of wireless communication technologies such as ZigBee, Wi-Fi and Bluetooth. All these types work at similar RF frequencies and their application sometimes overlap. ZigBee works on 802.15.4 standard which uses unlicensed frequency spectrum such as ISM band. In this project, ZigBee technology has been used because of advantages over the others technologies and the aspects are most suitable to our proposed application. The features are reliable and self-configuration, Supports large number of nodes, easy to deploy, very long battery life, secure and low cost. [7]

B. Arduino Microcontroller

Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices. This Project uses Arduino UNO board which is based on ATmega328. It has 14 digital Input / output pins (of which 6 can be used as PWM outputs), a 16 MHz ceramic Resonator, a USB connection, a power jack, an ICSP header and a reset button as shown in figure 2. Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232.

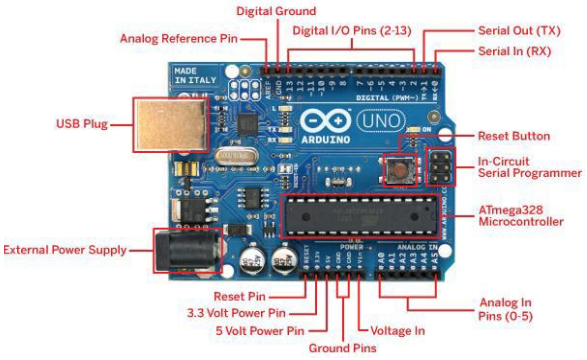

Fig.2. Arduino ATmega328 board

The Uno has 6 analog inputs, labelled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). A Software Serial library allows for serial communication on any of the Uno's digital pins. The features of ATmega328 are 5V operating Voltage, 6-20V input Voltage, 32 bit Flash Memory, 2KB SRAM, 1KB EEPROM, Clock Speed: 16 MHz [8].

C. XBEE S2 MODULE

XBee Series 2 is based on ZigBee protocol from Digi international. It features ZigBee firmware for creating ad-hoc mesh networks. The XBee Series 2 performs automatic route discoveries to create a self-healing network of full-function routers and low-power end devices. The Xbee modules are ready to operate out of the box and offer simple AT commands or an API for advanced, user-settable configurations. XBee modules are recognized worldwide for reliable wireless data communication in the license-free 2.4 GHz ISM band. It is capable of connecting 255 devices per network. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters. This technology allows users to set up a network quickly, and allows them to set up networks where it is impossible or inconvenient to wire cables. [9]. Pin out of Xbee S2 module is shown in Fig.3.

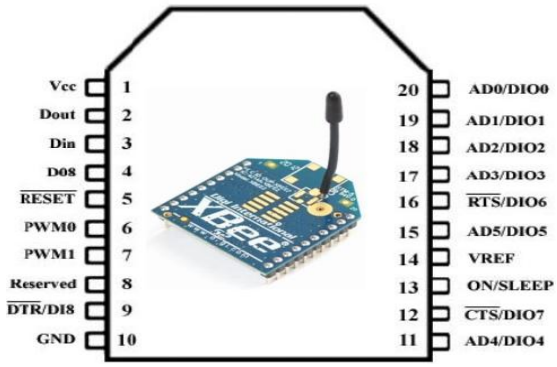

Fig. 3. Pin diagram of X-Bee Transceiver

D.USB Explorer

This is a simple to use, USB to serial base unit for the XBee line. This unit works with all XBee modules including the Series 1 and Series 2, standard and Pro version. The board is powered by the USB cable. Features: USB connectivity, USB powered, small footprint, reset button, on-board 3.3V regulated supply which is shown in Fig. 4.

Fig.4. XBee USB Explorer

E. Xbee Breakout Board

XBee adaptor and explorer is advanced breakout board operates on 5V and it have internal 3.3V convertor. It also has reverse polarity protection. It comes with 3 LED indications DI05, RSSI and Power indicator, and is very easy to connect with PC using FTDI Board. It is shown in Fig. 5.

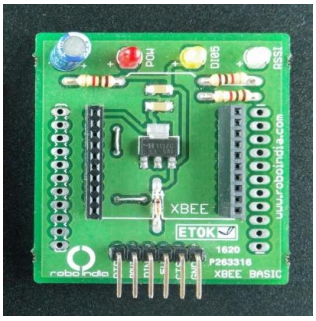

Fig.5. X-Bee Break-out board

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F. DHT 11 Sensors

DHT11 digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity. It ensures high reliability and excellent long-term stability. This sensor is resistive-type humidity and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

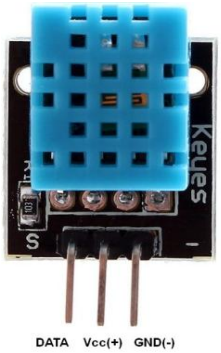

Fig.6. DHT11 Sensor

It has a small size, low power consumption and signal transmission up-to-20. DHT11 is a 3-pin single row pin package as shown in Fig. 6. Its features are as follows [10].

It works on 5V.
Temperature range: 0 - +50 ºC.
Temperature accuracy: ± 2.0 ° C.
Humidity range: 20-95% RH.
Humidity accuracy: ± 5.0% RH
Response time: <5 sec

III. TRANSMITTER SECTION

Transmitter section includes Arduino, DHT11 and the Xbee S2 module. Power supply from Arduino microcontroller is used for DHT11 sensor and XBee S2 module. The output of the DHT11 sensor pin 1 is connected to digital pin 2 of the Arduino. The Xbee S2 module is mounted on the Xbee breakout board. The Tx pin of Arduino is connected to Rx pin of the Xbee breakout board and Rx pin of Arduino is connected to Tx pin of the Xbee breakout board. It is shown in Fig. 7.

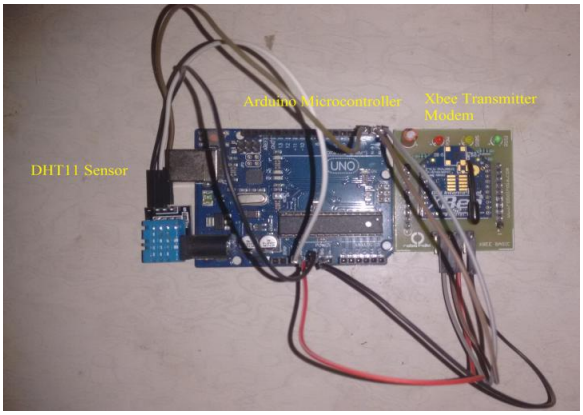

Fig.7. Circuit Diagram of Transmitter

IV. RECEIVER SECTION

The receiver section consists of Xbee S2 module acting as a coordinator is going to receive the serial data wirelessly from the transmitter. It is mounted on the Xbee USB explorer so that it can be interface with the Personal Computer (PC). Fig. 8 shows the implementation.

Fig.8. Implementation of Receiver

V. PROTEUS SIMULATION

Before actually implementing the hardware modules, it was simulated in Proteus software. The Proteus Design Suite is an Electronic Design automation (EDA) tool including schematic capture, simulation and PCB Layout modules. It is developed in Yorkshire, England by Labcenter Electronics Ltd. The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in temperature control and user interface design. It also finds use in the general hobbyist community and, since no hardware is required, is convenient to use as training or teaching tool [11]. Fig.9 shows the simulation of the transmitter section of the circuit using Proteus.

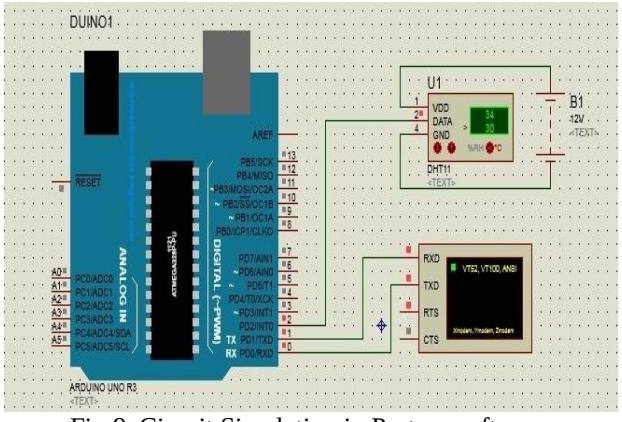

Fig.9. Circuit Simulation in Proteus software

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Fig.10 shows the output in the Virtual Terminal of the Proteus software, which was transmitted by the transmitter section.

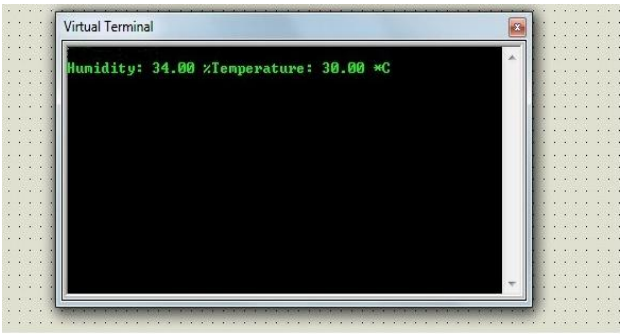

Fig.10. Output in Virtual terminal

VI. SOURCE CODE

The source code is required for the Arduino microcontroller for giving appropriate commands to the DHT11 sensor [12] for sensing the parameter of interest, and to send the measured data to the Xbee transmitter modem for wireless transmission. The source code is given below.

```
#include "DHT.h"
#define DHTPIN 2
#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);
void setup() {
  Serial.begin(9600);
  dht.begin();
}
void loop() {
  // Wait for 10 minutes between measurements.
  delay(6000000);
  float h = dht.readHumidity();
  // Read temperature as Celsius
  float t = dht.readTemperature();
  // Check if any reads failed and exit early (to try again).
  if (isnan(h) || isnan(t) ) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }
  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  delay(500);
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.print(" *C ");
}
```

VII. XCTU SOFTWARE

XCTU is a free, multi-platform application compatible with Windows, MacOS and Linux to enable developers to interact with Digi RF modules through a simple-to-use graphical interface. It includes new tools that make it easy to set-up, configure and test XBee® RF modules [13]. Fig.11 shows the receiver and transmitter ports and MAC address. It also shows the humidity and temperature parameters values such as 31% and 30^0C respectively.

Fig. 11. Output in XCTU window

VIII. RESULT

The measurement of humidity and temperature were carried out during summer in the state of Maharashtra (India) at Nashik place (19.9975° N, 73.7898° E).Two sets of readings one for the night on dated 06-05-2016 and the other for the day on dated 07-05-2016 were taken. The Night time recordings of the two parameters are compared and displayed in the form of plot,where the parameter value is on Y-axis and time on X-axis in shown in Fig. 12.

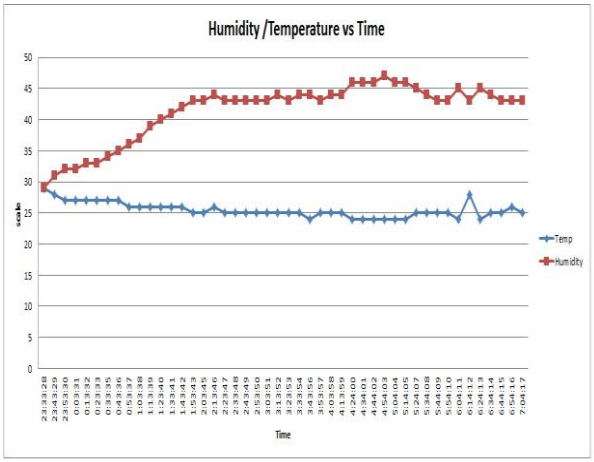

Fig.12. Plot of temperature/humidity vs. time (Night Recordings)

Likewise the comparison of the day time recordings plot is shown in the fig. 13.

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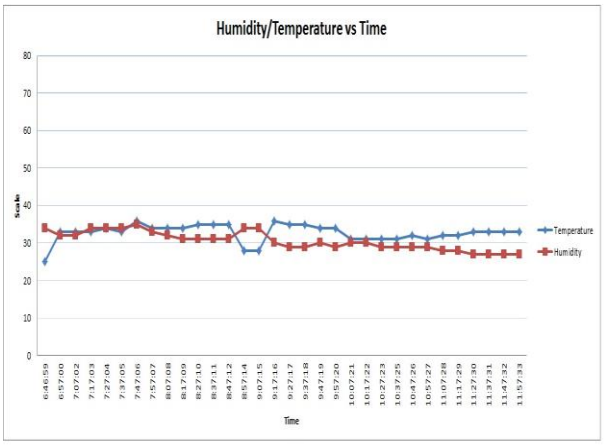

Fig.13. Plot of temperature/humidity vs. time (Day recording)

IX. CONCLUSION

Using wireless sensor node the data is collected and transmitted using Xbee S2 module. Real-time data is received using Xbee S2 and it was saved and displayed to achieve temperature and humidity monitoring. The monitoring results for temperature and humidity have shown that in summer at night the two parameters varied as the time progresses. The present plot shows that, temperature variations in day (6.45am to 12 noon) and night (23.33 pm to 7.05 am) are less as compared to humidity. In day time the humidity variations are less, but at night time the humidity variations are of the order of 17%. The day readings of summer season show that the temperature and humidity curve goes side by side with not much variation. So we can conclude that at night the humidity variations are high compared to the day.

A simplified temperature and humidity monitoring system with least number of components, and less complexity has been developed. The system is compact and cost effective when compared to prices of instruments used to measure parameters.
The proposed system was tested and found stable, highly reliable in data transmission and easy to use, and can be widely use in various areas of automatic monitoring of environmental parameters. The main advantage of this system is that it is less expensive and one time investment. It can be used effectively in healthcare, agriculture, storage areas etc.

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[13] http://www.digi.com/products/xbee-rf-solutions/xctu-software/xctu

BIOGRAPHIES

Vijay Kale (M.Sc, M.Phil, Ph.D, PGDIM, ADCSSA) is working as Associate Professor (Department of Electronic science, KTHM College, Nashik, Maharashtra, India). He has been in the teaching profession (UG and PG) since last 28 years. He has been presented research paper in international conferences (USA, Bangkok). He published research papers in national and international journals. He received R. Chandrasekhar award from Indian Physics Association (IPA), Savitribai Phule Pune University. He has written five books. He worked as a board of studies (BOS) member of SPPU, Pune. Presently he is working as a Vocational Ad-Hoc BOS member of SPPU, Pune. He worked as project guide for M.Sc. (Electronic Science) and research guide to M. Phil. students. He has worked on several academic committees of SPPU, Pune. He has worked as a resource person in refresher course, workshop etc. He is presently working on ARM microcontroller based sensor application, Wireless sensor application, e-CALLISTO etc.

Rohit D. Kulkarni (M.Sc, NET) is an M.Phil student in the Department of Electronic science, KTHM College, Nashik, Maharashtra, India. He has two years Industry experience and over six years of teaching experience. His active interest areas are wireless sensor networks, simulation software's, and embedded systems applications using sensors, Digital Signal Processing. He is currently working on Wireless Sensor Networks project.