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A WIRELESS SENSOR NETWORK FOR POLYHOUSE CULTIVATION USING ZIGBEE TECHNOLOGY

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ABSTRACT

The required climatic conditions for the polyhouse cultivation can be provided by using this proposed technique. The Zigbee technology has used for implementing the proposed wireless network. Few of the surrounding parameters of ambient temperature, humidity percentage, light intensity range and soil moisture content inside polyhouse are controlled and optimum conditions for crop growth inside polyhouse can be provided with the proposed model using abrupt actuators used. This model has developed with the mesh topology consists various nodes which are deployed inside polyhouse and are controlled by one central monitoring unit (CMU). Based on the crop the threshold values for the sensors and control values for the actuators during day time and night time are programmed in the CMU and it continuously receives the sensors data from all the nodes, and with respect to the programmed values of crop the CMU sends the controlling data to the actuator node for maintaining constant and required environmental conditions. By using this proposed model the necessity of human effort can be reduced and also the suitable weather conditions for the crop production irrespective of the season can be provided for the maximum beneficiary to the farmer.

Keywords: polyhouse cultivation, zigbee module, AT89S52 microcontroller, DHT11, LM35, light intensity sensor, soil moisture sensor.

1. INTRODUCTION

India is a country where majority of its population are dependent on agriculture. Agriculture is the broadest economic sector which has major contribution in the development of India. India is also concentrating on the technological aspects. When technology and agriculture are integrated together that may yield good results.

Conventional method of cultivation requires tremendous amount of time, human effort and requires continuous monitoring. There are several problems such as unpredictable weather conditions and the plants may be easily affected by pest and diseases in conventional method of cultivation. A polyhouse is a closed environment where the plants are grown on a controlled platform irrespective of climate and location. Generally polyhouse is a structure built using bamboos or iron pipes which are covered with ultra violet sheet of certain thickness. The thickness of ultra violet sheets depends on the crop variety. Always the direction of the polyhouse is directed from east toward west as it can utilize the maximum amount of sunlight for the photosynthesis process to happen. A polyhouse is a closed structure where the plant can be protected from abnormal climatic condition, pests and diseases. Mainly the plant growth depends up on few parameters like temperature, humidity, co2 levels, soil moisture content and light intensity. If we are able to control all the above said parameters to which a plant certainly require it, results in proper growth of the plant which in turn results in high yield of the crop by improving the growth potential of the plant and by providing ideal condition for the plant growth. But it is highly impossible to monitor and control all the above said parameters in an open environment. The main idea is to perform cultivation in a closed environment which is nothing but a polyhouse environment and monitor and control all the required parameters. Any change in one parameter may affect the other climatic parameters, so it requires continuous monitoring and control action for the requirements to meet.

Inadequate and uncertain environmental conditions may affect the proper growth of the plant. Monitoring and controlling of the environmental parameters should be given utmost attention in order to attain high yield. The controlling of these parameters by performing some control action may result in proper plant growth and increased yield. Various papers [1]-[6] have been published claiming the need and advantages about polyhouse cultivation using various technologies. The required data about the existing parameters inside the polyhouse is acquired with the help of respective sensors and is sent to the control unit. The information is transferred to the control unit using wireless technology Zigbee. This data is processed with the help of a microcontroller which decides the control action to be performed in order to maintain optimal environment for the plant growth [3].

This paper mainly concentrates on various climatic parameters that can be monitored and controlled to improve the crop productivity. To monitor these parameters various sensors like temperature sensor to monitor the temperature, Humidity sensor to monitor the air moisture content, Soil moisture sensor to monitor the soil moisture content, light intensity sensor to monitor the amount of light inside the polyhouse are used. The required climatic parameters information can be acquired from the polyhouse environment using these sensors. In order to monitor all the above said parameters require

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large number of sensors and wires. The system uses long wires it becomes complex and the installation cost also will go high. The best solution to reduce the complexity and the cost is to use wireless sensor netwoks. WSN has its own advantages like less cost, size, low power consumption and above all flexibility. Zigbee has carved a niche for itself among the galaxy of wireless technologies. As Zigbee protocol is available with its unique features like low cost and other advantages, it is used widely for agricultural applications. This Zigbee protocol allows the communication between the control unit and the actuator unit in order to monitor and control the environment inside the polyhouse. Zigbee has many advantages over other wireless networking protocols, but it has got its own disadvantages such as batteries need to be replaced on periodic basis [1] and one cannot completely rely on Zigbee for long distance communication. The battery problem can be reduced to some extent by using alkaline batteries.

The proposed hardware architecture, design methodology of mesh topology and the description about temperature, humidity sensor, soil moisture sensor and light intensity sensor has discussed in chapter II of proposed hardware and methodology of polyhouse automation system implementation. The overall process of the proposed system has classified and the classified blocks has explained has presented as a flow chart and explained in the later chapter III. The snapshots of the final outputs and the designed prototype of proposed system is discussed and shown in chapter IV of results. The chapter V discus conclusion and its usefulness.

2. PROPOSED HARDWARE AND METHODOLOGY OF POLYHOUSE AUTOMATION SYSTEM

A. Hardware architecture

The entire prototype is divided into two hardware blocks. Those are sensor node and central monitoring system. The hardware designed and placed inside the polyhouse is sensor module which helps in providing optimum environmental conditions inside the polyhouse. Central monitoring system is the monitoring block from which the entire operation can be monitored and controlled using microcontroller through Zigbee network. Attached LCD display connected will provide the information of the environmental parameters existed in the polyhouse.

The hardware block of module 1 as shown in Figure-1 performs three tasks. Firstly, it acquires the data from sensors, secondly processes the data as per instructions and controls the cooling fans and motors, and finally transmits the data to the receivers.

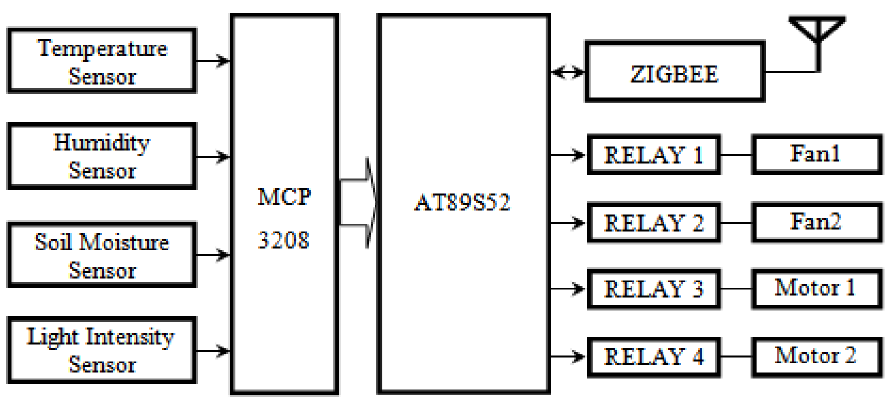

Figure-1. Sensor node.

The four sensors LM35, DHT11, soil moisture sensor and light intensity sensor are connected to MCP3208. The analog output from these sensors is converted into digital using eight channels ADC of MCP3208 and the output is directed to the AT89S52 microcontroller. The Microcontroller compares the received values from ADC with the pre-loaded values of temperature, humidity, moisture content of the soil, light intensity levels and the received values from Zigbee, and if the result exceeds stored threshold value, it sends the signals to corresponding relay switches in order to maintain the optimum weather conditions inside polyhouse. The readings of temperature, humidity, moisture content of the soil, light intensity levels and the status of Fan 1, Fan 2, Motor 1 and Motor 2 is transmitted to the Central monitoring system (CMU). Can use Xbee itself as ADC but has the drawback limited ADC channels, thereby can't provide more number of sensors. To overcome this hurdle, AT89S52 and MCP3208 has used. In similar, by using Xbee can control digital outputs but if need to control more actuators it won't support. The ADC resolution is less in Xbee (8 bit) but needed more resolution for better controllability.

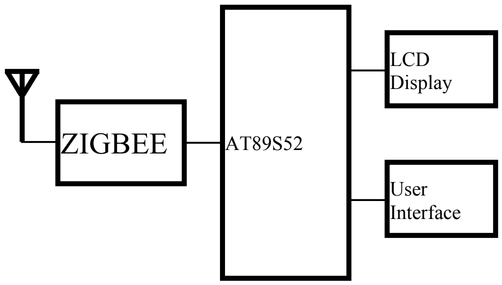

Figure-2. Central monitoring system.

Figure-2 shows the module 2 of hardware block, Central monitoring system. It collects the information from sensor node and displays the received data on the LCD screen connected to it. The whole transmission and reception takes place with the help of Zigbee Module. Using RS232 serial communication the Zigbee Module is connected to AT89S52 board from where the conditions can be monitored and controlled. The CMU is provided with the user interface. From user interface can configure the threshold values of sensors based on the requirement of the user choice for particular crop. To program the AT89S52 microcontroller µvision-3 C51 IDE software has used.

B. Topology

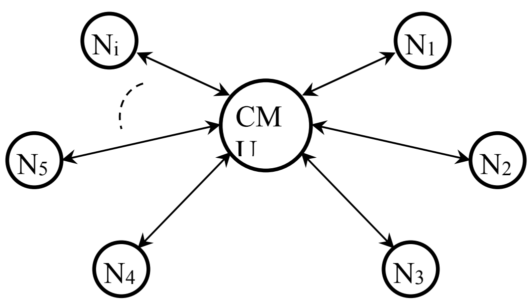

Figure-3. Connection of nodes to the CMU.

From the Figure-3 can observe that the nodes N_1 to N_i are connected to central monitoring unit. Each node consists of sensors and controlling microcontroller unit with the Zigbee Module attached to through RS232. All the nodes are always in communication with the CMU using Zigbee with the unique ID. No information can be accessed by intruders as these nodes have the unique ID, based on this ID only the node can communicate with the CMU. Among all the nodes of N_1 to N_i one node is considered as principle node which is connected by required actuators of cooling fans and motors. The CMU gives the controlling commands to the principle node based on the information received by the nodes N_1 to N_i through Zigbee. The entire process is in loop and can be reconfigured the CMU based on the end user necessity. The configuration of the nodes can be done through X-CTU software interface.

C. Temperature sensor

Figure-4. LM35 [7].

LM 35 has taken for measuring the temperature values inside polyhouse due to its high accuracy and no oxidation as the sensor is sealed in plastic package. It has high accuracy levels and doesn't require further requirement of any external calibration or trimming. Its accuracies are ±1⁄4 °C at room temperature and ±3⁄4 °C over a full −55 to +150 °C temperature range also it has very low self-heating, less than 0.1 °C in still air, due to drawing of less current about 60 µA. The wide range of temperature about -55° to +150 °C can be sensed using LM35.

D. Humidity sensor

Figure-5. DHT-11 [8].

DHT-11 provides the information about both temperature and humidity values. And it provides high quality, quick response, and good cascadability and also offers low price. DHT-11 is a mixed sensor with calibrated digital signal output. High reliability and good long-term stability can be achieved by using this sensor as it uses exclusive digital-signal-acquisition technique. It has resistive type humidity measurement for calibrating humidity and an NTC temperature measure component for calibrating temperature value.

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E. Soil moisture sensor

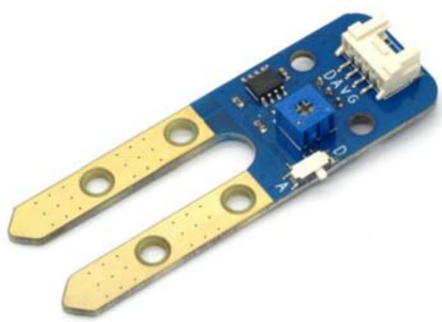

Figure-6. Soil moisture sensor [9].

Figure-6 shows the snapshot of the soil moisture sensor and is used to detect the moisture content in the soil of the proposed model. This sensor provides either analog or digital outputs which can be selected by choosing the corresponding button on the board. By varying the potentiometer the suitable threshold value for the moisture content can be made. Analog data provides over wide range and where as digital provides the information about whether the soil is wet or dry.

F. Light INtensity sensor

Light detection for the proposed model can be achieved by using the sensor shown in Figure-7. This sensor also provides both the analog and digital outputs. The attached control board receives the analog information about light through the attached light dependent resistor (LDR) and gives the proportionate output, specifically the resistance of photo resistor decreases with the increase of the light intensity in the surroundings.

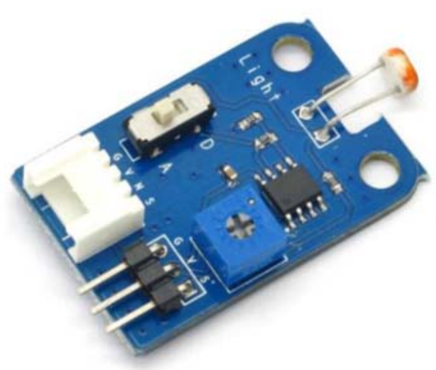

Figure-7. Light intensity sensor.

3. FLOW CHART

The operation of the proposed system can be described using flow charts as shown in Figure-8 and Figure-9. From the Figure-8. Main CMU unit can be explained as the operation starts from the selection of crop. Based on the crop the threshold values of sensors are fixed. And based on these values the actuators are controlled. Once the crop selection is chosen next step is to wait for the data from nodes. The sensor values from corresponding nodes are processed by the microcontroller unit based on the selection of crop. And with respect to the programmed control parameters of actuators the abrupt information is transmitted to the actuator node.

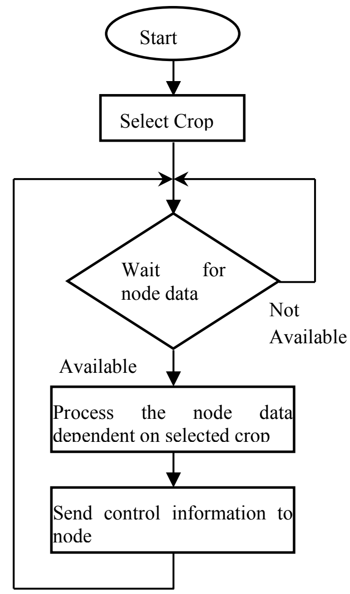

Figure-8. CMU.

The sensor node operation starts from the data reception from the sensors. And this sensors data is transmitted to the CMU using Zigbee Module. Then CMU process the transmitted data from sensor node and sends the controlling information about the operation of actuators Fan1, Fan 2, Motor 1 and Motor 2. Each Node is assigned with the unique ID for each Zigbee module and based on this Zigbee ID only all the nodes are communicated with the CMU.

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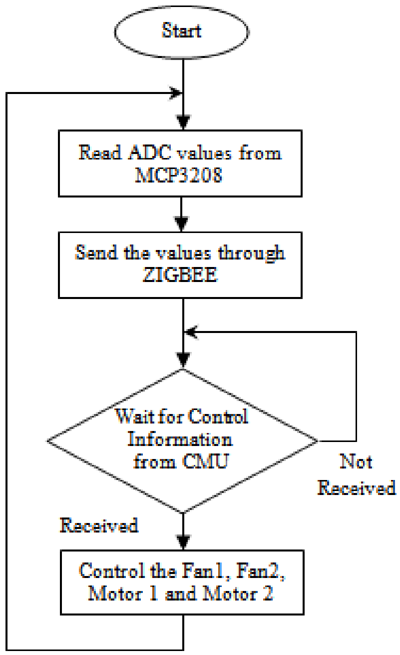

Figure-9. Sensor node.

4. RESULTS

Figure-10 shows the main sensor node. And from the Figure-10 can observe the four different sensors, different actuator units, Zigbee module and microcontroller startup kit considered for the implementation of the proposed model. For testing the prototype different environmental parameters have applied to sensor node manually.

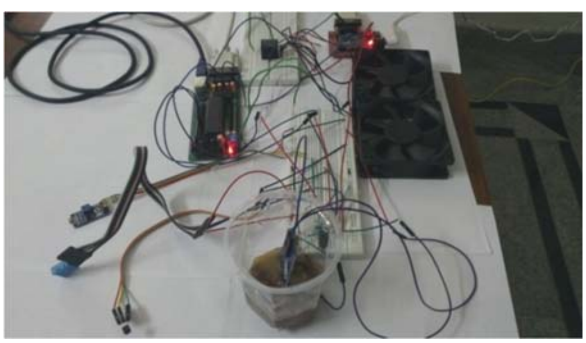

Figure-10. Sensor node of the poly house.

Figure-11 shows CMU and its received values of sensors from Zigbee module on its LCD screen. The LCD screen has the 16x2 characters provision and the sensors values are displayed on the first row and its actuators status of ON or OFF are shown in the second row. The received values of ambient temperature, humidity level, light intensity range and soil moisture sensor values are shown as in degree centigrade and percentage levels. And the actuators of Fan 1, Fan 2, Motor 1and Motor 2 status are shown as ON and OFF levels. From the Figure-11 the user interface buttons can be observed and using these buttons the values for the actuators can be fixed based on the requirement of the environmental parameters needed for the polyhouse.

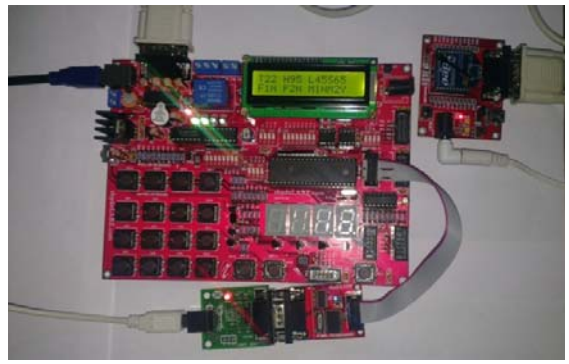

Figure-11. PC node with values 1.

Figure-12 shows the different values received by the CMU. The polyhouse needs different climatic conditions for day time and night time for the same crop. In order to test the status of actuators for the different values of climatic parameters of sensors have applied different climatic conditions.

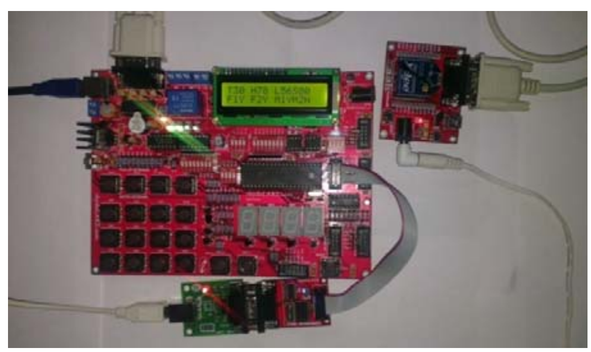

Figure-12. PC node with values 2.

The snapshots of Figure-11 have taken at 22ºC and Figure-12 is taken at 30ºC, followed by different values of humidity, light intensity and soil moisture content. The status of actuators are given as Y for ON and N for OFF which can be observed from the second row of the LCD screen from the Figure-11 as well as in Figure-12.

5. CONCLUSIONS

The wireless sensor network has developed using Zigbee technology for the crop production inside polyhouse. And using this proposed model the requirement of human surveillance can be reduced and increased crop yield by making suitable environment for the crop growth throughout the year irrespective of season can be achieved. The embedded systems have its own cost and the research has to be done for the economical devices.

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