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Monitor and Control Physical Parameters in Polyhouse

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***Abstract*- Polyhouse needs the monitoring of the parameters like temperature, humidity and light. These parameters should be kept within the specified range. All these real time parameters are measured and sent to coordinator through zigbee. As an open and global standard for wireless sensor network zigbee protocol IEEE 802.15.4 shows advantages on low cost, low power consumption and low data rate. Zigbee's network layer supports three networking topologies star, mesh, and cluster tree. Star networks are common and provide for very long batter y life operation. Zigbee based wireless monitoring and control system in polyhouse is composed of a coordinator and end devices including sensor nodes and electrical devices organized as a star network.**

Keywords- Polyhouse, Zigbee, WSN, FFD, RFD

I. INTRODUCTION

We live in a world where everything can be controlled and operated automatically, but there are still a few important sectors in our country where automation has not been adopted or not been put to a full-fledged use, perhaps because of several reasons one such reason is cost. One such field is that of agriculture. Agriculture has been one of the primary occupations of man since early civilizations and even today manual interventions in farming are inevitable. Polyhouses form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. Automating a polyhouse envisages monitoring and controlling of the climatic parameters which directly or indirectly over on the plant growth and hence their produce. Automation is process control of industrial machinery and processes, thereby replacing human operators.

A. *Necessity*

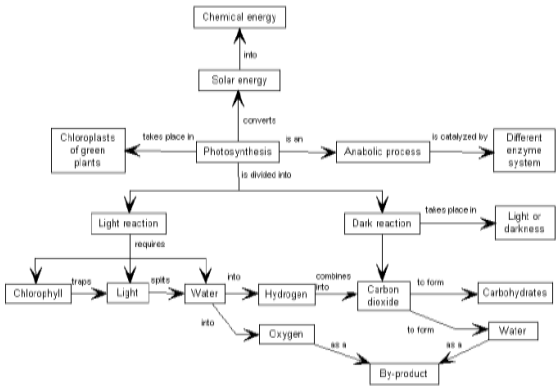

Fig. 1 Block Diagram of Photosynthesis

The two major life-processes occurring in plants are photosynthesis and transpiration. Photosynthesis is the conversion of light energy into chemical energy by living organisms. The raw materials are carbon dioxide and water; the energy source is sunlight and the end- products are oxygen and (energy rich) carbohydrates, for example sucrose, glucose and starch. This process is arguably the most important biochemical pathway, since nearly all life on Earth either directly or indirectly depends on it.

B. *Photosynthesis*

Light energy obtained from the sun is very essential for photosynthesis. The photons present in light are responsible for triggering the light-reaction in plants. Plants need an optimum amount of exposure to light in a day. This optimum period is called its photo- period. The plant sensitivity curve for photosynthesis has its peak at the red side of the spectrum. This indicates that providing plants with the wavelengths best suited to photosynthesis is most efficient with the use of artificial light. Tests how a mean deviation from the average sensitivity curve of less than 5% for a wide variety of plants. The curve shows that the maximum sensitivity for photosynthesis lies in the far red at approximately 675 nm. The plant sensitivity curve disputes two common misconceptions. The first is that an "ideal" plant growing lamp duplicates the spectral energy distribution of the sun. sunlight has a continual spectrum, radiating energy in wavelengths that contribute less to photosynthesis, and are therefore wasted" on the plant. For this reason, many lamps are more efficient than sunlight for plants.

C. *Transpiration*

Transpiration is the evaporation of water from the aerial parts of plants, especially leaves but also stems, flowers and roots Transpiration also cools plants and enables mass flow of mineral nutrients and water from roots to shoots. Mass flow is caused by the decrease in hydrostatic (water) pressure in the upper parts of the plants due to the diffusion of water out of stomata into the atmosphere. Water is absorbed at the roots by osmosis, and any dissolved mineral nutrients travel with it through the xylem.The rate of transpiration is directly related to the degree of stomatal opening, and to the evaporative demand of the atmosphere surrounding the leaf. The amount of water lost by a plant depends on its size, along

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with the surrounding light intensity, temperature, humidity, and wind speed (all of which influence evaporative demand). Soil water supply and soil temperature can influence stomatal opening, and thus the transpiration rate.

II. SYSTEM DESIGN

A number of problems associated with the above mentioned systems are enumerated as below:

1. Complexity involved in monitoring climatic parameters like humidity, soil moisture, illumination, soil pH, temperature, etc which directly or indirectly govern the plant growth.
2. Investment in the automation process are high, as today's polyhouse control systems are designed for only one parameter monitoring (as per GKVK research center); to control more than one parameter simultaneously there will be a need to buy more than one system.
3. High maintenance and need for skilled technical labor. The modern proposed systems use the mobile technology as the communication schemes and wireless data acquisition systems, providing global access to the information about one's farms. But it suffers from various limitations like design complexity, inconvenient repairing and high price. Also the reliability of the system is relatively low, and when there are malfunctions in local devices, all local and data will be lost and hence the whole system collapses. More over farmers in India do not work under such sophisticated.

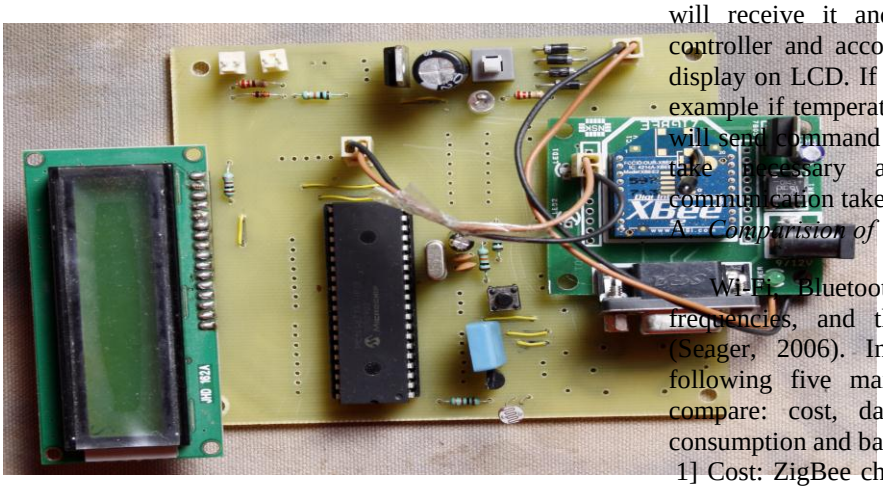

Fig. 2-Photograph of the Transmitter

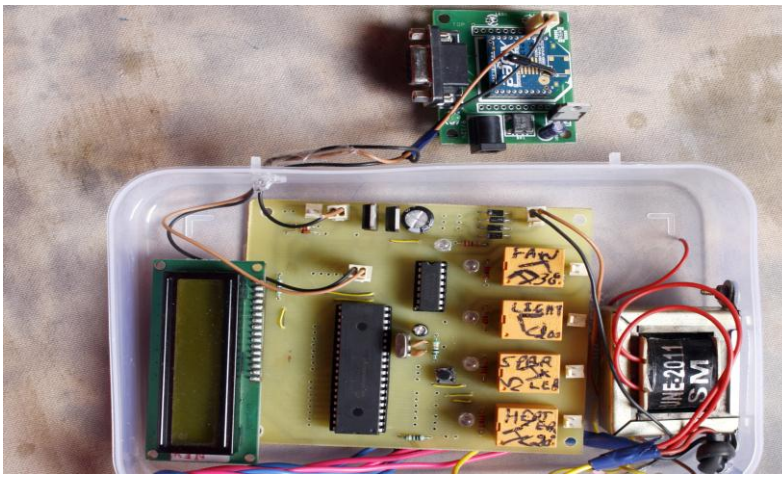

Fig. 3-Photograph of the Receiver

The parameters which we want to measure are physical parameters (i.e in non –electrical form).So as to convert it into electrical form we are using sensors. The output of sensor is in analog in nature, to convert it into digital form we apply it to DC which is inbuilt in PIC controller. The converted digital output of sensor is analyzed by controller for taking proper action. After that controller ask Zigbee module it is ready or not. Then controller sends these data through SPI to Zigbee transceiver .The information is send to master module. It will receive it and decodes it. Then give it to PIC controller and according to information is received, will display on LCD. If we want to switch off any process for example if temperature is more than set point then master will send command to slave to witch off the fan that is to take necessary action. In this way bidirectional communication takes place.

A. Comparision of Wireless Technologies:

Wi-Fi, Bluetooth and ZigBee work at similar RF frequencies, and their applications sometimes overlap (Seager, 2006). In the current study, we chose the following five main factors of polyhouse etworks to compare: cost, data rate, number of nodes, current consumption and battery life.

1] Cost: ZigBee chip is US$ 1 or less, the lowest; Wi-Fi and Bluetooth chips are $ 4 and $ 3, respectively. The overall system cost can be significantly reduced by the employment of ZigBee chip.

2] Data rate: ZigBee is 250 kbps, while Wi-Fi and Bluetooth are 54 Mbps and 1~2 Mbps, respectively. ZigBee is sufficient for a polyhouse. Generally, data traffic in a polyhouse is low usually small message such as the change of temperature or a command from the controller or an actuator. And also, low data rate helps to prolong the battery life.

3] Number of nodes: The capacity of network is determined by the number of nodes, and ZigBee has up to 254 nodes, the largest on the three. It meets the application demand of more and more sensors and

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actuators in a polyhouse.

4] Current consumption: ZigBee has the lowest current consumption, 30 mA, while Wi-Fi, 350 A, and Bluetooth, 65~170 mA. It also greatly helps to prolong the battery life.

5] Battery life: ZigBee chip has the longest battery life, few months or even years. As a whole, ZigBee technology offers along battery life, small size, high reliability, automatic or semiautomatic installation, and, particularly, a low system cost. Therefore, it is a better choice for polyhouse monitoring and control than other wireless protocols.

B. Temperature Sensor:

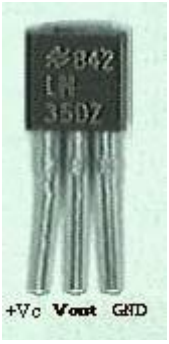

Fig. 4 Temperature Sensor

Most commonly-used electrical temperature sensors are difficult to apply. For example, thermocouples have low output levels and require cold junction compensation. Thermistors are nonlinear. In addition, the outputs of these sensors are not linearly proportional to any temperature scale. Early monolithic sensors, such as the LM3911, LM134 and LM135, overcame many of these difficulties, but their outputs are related to the Kelvin temperature scale rather than the more popular Celsius and Fahrenheit cables. Fortunately, in 1983 two- I.C.'s, the LM34 Precision Fahrenheit Temperature Sensor and the LM35 Precision Celsius temperature Sensor, were introduced. This application note will discuss the LM34, but with the proper scaling factors can easily be adapted to the LM35.The LM35/LM34 has an output of 10 mV/°F with a typical nonlinearity of only ±0.35°F over a −50 to +300°F temperature range, and is accurate to within ±0.4°F typically at room temperature (77°F). The LM34's low output impedance and linear output characteristic make interfacing with readout or control circuitry easy. An inherent strength of the LM34 sensor over other currently available temperature sensors is that it is not as susceptible to large errors in its output from low level leakage currents. For instance, many monolithic temperature sensors have an output of only 1 µ A/°K. This leads to a 1°K error for only 1 µ-Ampere of leakage current. On the other hand, the LM34 sensor may be operated current mode device providing 20 µA/°F of output current. The same 1 µA of leakage current will cause an error in the LM34's output of only 0.05°F (or 0.03°K after scaling).

Low cost and high accuracy are maintained by performing trimming and calibration procedures at the wafer level. The device may be operated with either single or dual supplies. With less than 70 µA of current drain, the LM34 sensor has very little self-heating (less than 0.2°F in still air), and comes in a TO-46 metal can package, a SO-8 small outline package and a TO-92 plastic package.

The LM35/LM34 is a versatile device which may be used for a wide variety of applications, including oven controllers and emote temperature sensing. The device is easy to use (there are only three terminals) and will be within 0.02°F of a surface to which it is either glued or cemented. The TO-46 package allows the user to solder the sensor to a metal surface, but in doing so; the GND pin will be at the same potential as that metal. For applications where a steady reading is desired despite small changes temperature, the user can solder the TO-46 package to a thermal mass. Conversely, the thermal time constant may be decreased speed up response time by soldering the sensor to a small heat fin.

C. Humidity Sensor

The humidity sensor HIH4000, manufactured by Honeywell is used for sensing the humidity. It delivers instrumentation quality H (Relative Humidity) sensing performance in a low cost, solder able SIP (Single In-line Package). Relative humidity is a erasure, in percentage, of the vapour in the air compared to the total amount of vapour that could be held in the air at a given temperature.

Fig. 5 Humidity Sensor

The RH sensor is a laser trimmed, thermoset polymer capacitive sensing element with on-chip integrated signal conditioning. he sensing element's multilayer construction provides excellent resistance to most application hazards such as wetting, dust, dirt, ills and common environmental chemicals.

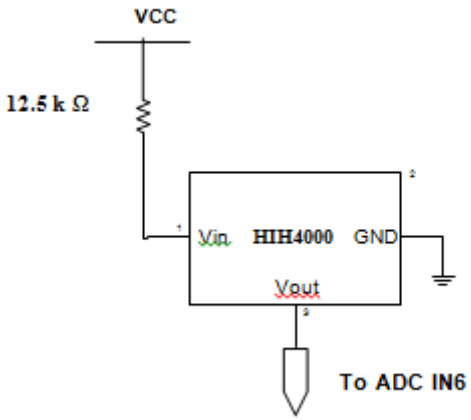

Fig. 6 Humidity Sensor Circuit

C. I .Functional Description:

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1] The sensor develops a linear voltage vs. RH output that is ratiometric to the supply voltage. That is when the supply voltage varies; the sensor output voltage follows in the same proportion. It can operate over a 4-5.8 supply voltage range. At 5V supply voltage, and room temperature, the output voltage ranges from 0.8 to 3.9V as the humidity varies from 0% to 100% noncondensing).

2] The humidity sensor functions with a resolution of up to 0.5% of relative humidity (RH).

3] With a typical current draw of only 200 µA, the HIH-4000 Series is ideally suited for low drain, battery operated systems.

4] The change in the RH of the surroundings causes an equivalent change in the voltage output. The output is analog voltage proportional to the supply voltage. Consequently, converting it to relative humidity (RH) requires that both the supply and sensor output voltages be taken into account according to the formula:

RH = ((Vout / Vsupply) – 0.16) /0.0062, typical at 25°C

D. Light Sensor

Light Dependent Resistor (LDR) also known as photoconductor or photocell, is a device which has a resistance which varies according to the amount of light falling on its surface. Since LDR is extremely sensitive in visible light range, it is well suited for the proposed application. An LDR and a normal resistor are wired in series across a voltage, as shown in the circuit below. Depending on which is tied to the 5V and which to 0V, the voltage at the point between them, call it the sensor node, will either rise or fall with increasing light. If the LDR is the component tied directly to the 5V, the sensor node will increase in voltage with increasing light.

D. I. Features of LDR

1] The LDR's resistance can reach 10 k ohms in dark conditions and about 100 ohms in full brightness.

2] The circuit used for sensing light in our system uses a 10 kΩ fixed resistor which is tied to +5V. Hence the voltage value in this case decreases with increase in light intensity.

3] The sensor node voltage is compared with the threshold voltages for different levels of light intensity corresponding to the four conditions- Optimum, dim, dark and night.

4] The relationship between the resistance RL and light intensity Lux for a typical LDR is:

RL = 500 / Lux kΩ

With the LDR connected to 5V through a 10K resistor, the output voltage of the LDR is :

Vo = 5*RL / (RL+10)

In order to increase the sensitivity of the sensor we must reduce the value of the fixed resistor in series with the sensor. This may done by putting other resistors in parallel with it.

E. *ZigBee Technology*

In 21st century, wireless sensor networks are becoming necessary and seen as indispensible in various medical and telecommunication equipment's, smart energy resources, home automation products etc., which require monitoring and control. zigbee is a wireless technology, which communicates on the principle of IEEE 802.15.4 standard. IEEE 802.15.4 is a standard that states the details for the lower layers of the communication. This standard focuses on the low-cost and low power communication. because of Zigbee's low cost, low power consumption and ability to connect in a mesh network, it is becoming more optimum solution for monitoring and control applications

E. I. Zigbee Network

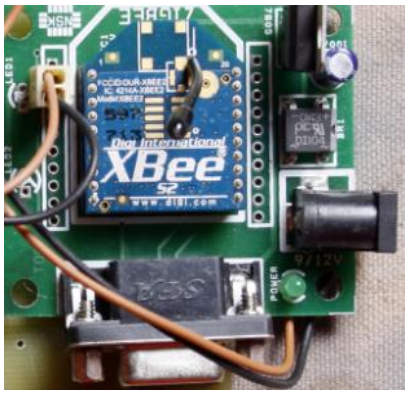

Fig 7 - ZigBee Module

1 Network Setup

The Zigbee coordinator does Zigbee network initialization. As soon as the network is powered up, the coordinator starts the network initialization sequence. After that, the coordinator starts a search for the full function devices and reduced function devices to establish a network.

2. Joining Network as a New Device

Whenever a new device either Full Function Device (FFD) or Reduced Function Device (RFD) wants to join a network, it sends a request to all other parent capability devices such as FFDs that it wants to join the network. Then all the parent devices send a packet, which gives the information about their address and number of devices already connected to it. The child device that can be either FFD or RFD collects all the data and then selects one of the devices as a parent device, which is best suited for it. Then that parent device is responsible to provide the child device a unique ID

3. *Joining Previous Network*

Zigbee devices save the information in a table whenever they are connected to a network. This table stores the information, which helps the device to reconnect to the same network again. So next time whenever they are switched on, they first look into that able about the previous information and try to connect to the old network. If the table is blank then they try to connect into a network as a new device.

E.II. Mechanism for Data Transfer:

Whenever a device wants to send a data packet, it has to check for channel. If the channel is idle, device can send a packet else it has to wait. If the receiver is FFD then transmitters can send the packet any time because its

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transceiver always remains ON. however if the receiver is RFD then there are chances that its transceiver is OFF to save power. So to avoid data loss all RFDs send a packet to their corresponding parent device as soon as there transceiver comes to ON position to get the data packet which was send to them when they were in sleeping mode.

1. Zigbee Coordinator

This acts as the building block of the Zigbee communication. Zigbee coordinator forms the root of the various topologies like mesh, star, tree topology network etc. and communicates from one device to other. There is only one Zigbee coordinator in the whole Zigbee environment.

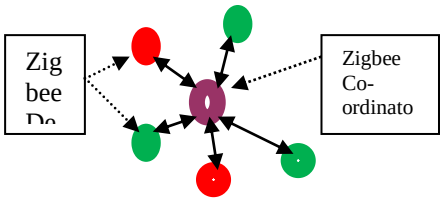

Fig. 8 Zigbee Co-coordinator

2.Full Function Device

Full function devices support all IEEE 802.15.4 functions and features that are defined by the standard. They can also function as a Zigbee coordinator. More memory and computing power availability helps them to work as router also, which helps in transmitting data to longer distances through different networks.

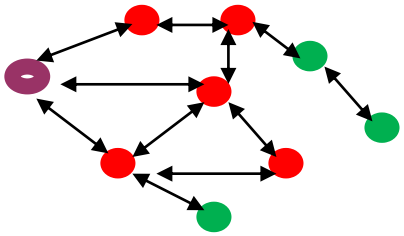

Fig. 9 Full Function Devices

3. Reduced Function Device

Reduced function devices just talk to the Zigbee coordinators or Full function devices. They cannot perform the functions of a router or coordinator.

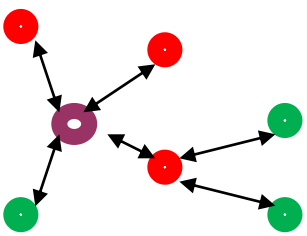

Fig.10 Reduced Function Devices

III. **RESULTS**

An experiment has done to record the Temperature, Humidity and Light intensity readings in polyhouse. The reason for this experiment is to make sure that the system that was design is functioning well and the data can record correctly.

1. *Readings of Temperature at different time*

Time	Temperature in °(Celsius)
6.00 AM	25
7.00 AM	26
8.00 AM	26
9.00 AM	27
10.00 AM	28
11.00 AM	30
12.00 PM	32
13.00 PM	31
14.00 PM	32
15.00 PM	33
16.00 PM	33
17.00 PM	32
18.00 PM	30

2. Readings *of Humidity at different Time*

Time	Humidity in % RH
6.00 AM	65
7.00 AM	58
8.00 AM	58
9.00 AM	52
10.00 AM	
11.00 AM	
12.00 PM	
13.00 PM	
14.00 PM	18
15.00 PM	16
16.00 PM	16
17.00 PM	18
18.00 PM	35

3. *Readings of Light Intensity at different time*

Time	Light Intensity in Lux
6.00 AM	253
7.00 AM	255
8.00 AM	258
9.00 AM	
10.00 AM	
11.00 AM	
12.00 PM	
13.00 PM	270
14.00 PM	275
15.00 PM	260
16.00 PM	265
17.00 PM	263
18.00 PM	265

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IV. **CONCLUSION**

A step-by-step approach in designing the microcontroller based system for measurement and control of the four essential parameters for plant growth, i.e. temperature, humidity, soil moisture, and light intensity, has been followed. The results obtained from the measurement have shown that the system performance is quite reliable and accurate. The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment.

The continuously decreasing costs of hardware and software, the wider acceptance of electronic systems in agriculture, and an emerging agricultural control system industry in several areas of agricultural production, will result in reliable control systems that will address several aspects of quality and quantity of production. Further improvements will be made as less expensive and more reliable Polyhouse prevents the plant from the effects of climate; inspect and so on, which makes great sense for agricultural production. The automation and high efficiency on polyhouse environment monitoring and control are crucial. Applying ZigBee-based WSN technologies to polyhouses is a revolution for protected agriculture which overcomes the limits of wire connection systems. Such a system can be easily installed and maintained.

In this we discussed the wireless solution of polyhouse monitoring and control system based on ZigBee technology, and designed the wireless nodes, network establishment and control system. With the capabilities of self-organizing, self-configuring, self-diagnosing the ZigBee based monitoring and control system provides nearly unlimited installation flexibility for transducers, increases network robustness, and considerably reduces costs. We therefore, conclude that the ZigBee based monitoring and control system can be a good solution for polyhouse monitoring and control.

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