



Intelligent Controller to Monitor and Control Physical Parameters in Greenhouse

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Abstract— Green house 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 battery life operation. Zigbee based wireless monitoring and control system in greenhouse is composed of a coordinator and end devices including sensor nodes and electrical devices organized as a star network. By running software, the coordinator periodically receives the data from the wireless sensor nodes and displays them on its LCD. Meanwhile, it sends orders to electrical devices in the network to control them automatically.

Keywords— Greenhouse, 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. Greenhouses 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 greenhouse 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

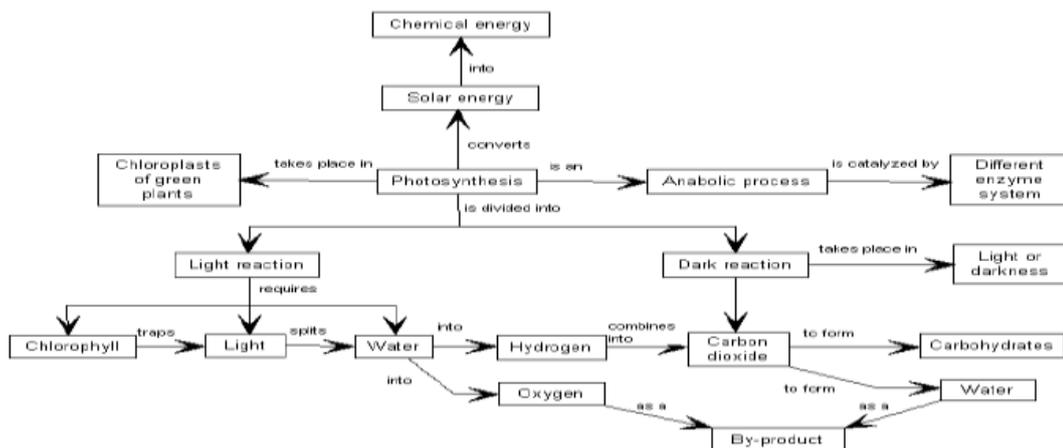


Fig. 1 Block Diagram of Photosynthesis

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 show 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 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 greenhouse 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 environment and find no afford the same.

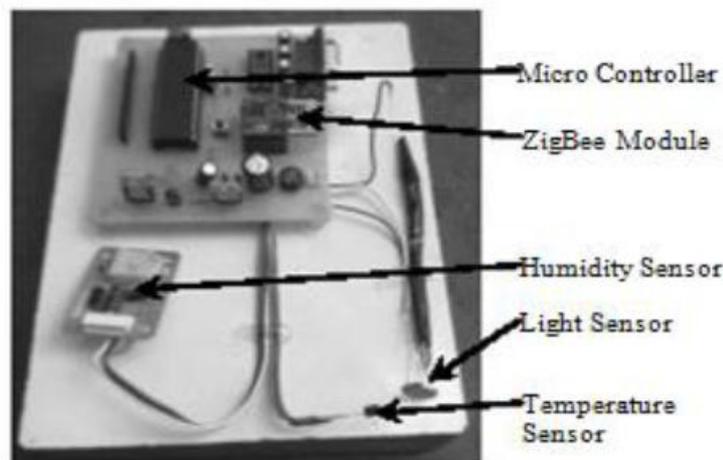


Fig. 2 Hardware Implementation of Transmitter

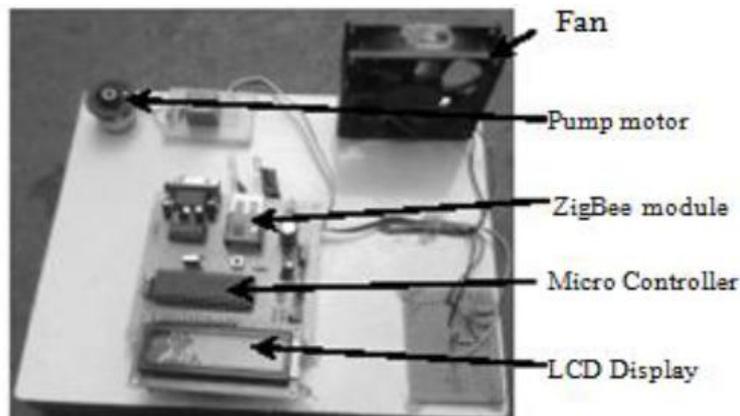


Fig. 3 Hardware Implementation of receiver

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 measure, 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. The sensing element's multilayer construction provides excellent resistance to most application hazards such as wetting, dust, dirt, oils and common environmental chemicals.

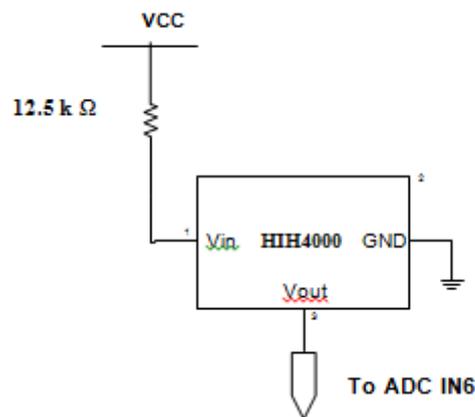


Fig. 6 Humidity Sensor Circuit

C. I. Functional Description:

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 4-5.8V supply voltage range. At 5V supply voltage, and room temperature, the output voltage ranges from 0.8V 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:

$$RH = ((V_{out} / V_{supply}) - 0.16) / 0.0062, \text{ typical at } 25^{\circ}\text{C}$$

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:

$$RL = 500 / \text{Lux k}\Omega$$

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

$$V_o = 5 * RL / (RL + 10)$$

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 be done by putting other resistors in parallel with it.

E. ZigBee Technology

In 21st century, wireless sensor networks are becoming necessary and seen as indispensable 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. Ability to connect in mesh network allows Zigbee to provide more range compared to other wireless technologies such as —INFRARED|, —BLUETOOTH| etc. In addition, it also provides high reliability of the data reproduced at receiver. It also consumes less power in communicating data between its transmitter and receiver, which means longer life with smaller batteries. The primary reason for low power consumption in Zigbee devices is that they work on very small duty cycle that helps them to have a longer life span. Variation in duty cycle depends upon the application usage, for example, some applications need data more frequently like in health centers compared to others such as home automation systems.

E. I. Zigbee Network

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 table 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 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 their transceiver comes to ON position to get the data packet which was sent to them when they were in sleeping mode.

I. 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.

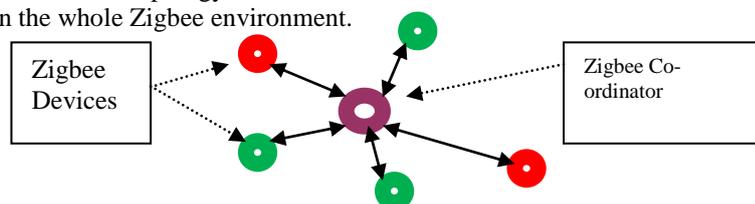


Fig. 7 Zigbee Co-coordinator

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.

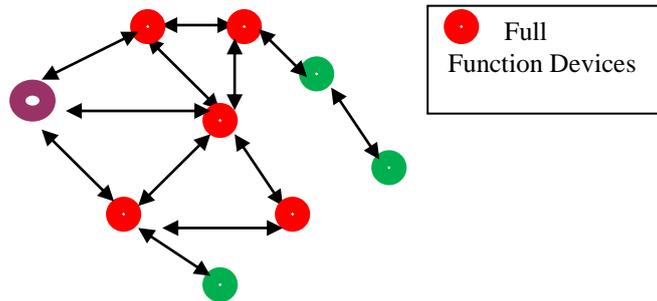


Fig. 8 Full Function Devices

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.

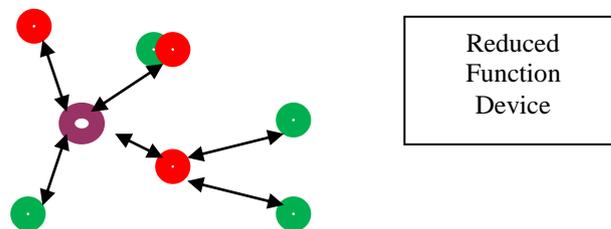


Fig.9 Reduced Function Devices

III. RESULTS

An experiment has done to record the Temperature, Humidity and Light intensity readings in greenhouse. 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	46
11.00 AM	35
12.00 PM	18
13.00 PM	19
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	258
10.00 AM	265
11.00 AM	268
12.00 PM	272
13.00 PM	270
14.00 PM	275
15.00 PM	260
16.00 PM	265
17.00 PM	263
18.00 PM	265

IV. CONCLUSION

Greenhouse 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 greenhouse environment monitoring and control are crucial. Applying ZigBee-based WSN technologies to greenhouses 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 greenhouse 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 greenhouse monitoring and control.

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