

# The Application of CC2431-based Wireless Sensor Network in Greenhouse Environment Monitoring

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**Abstract:** With the rapid development of protected agriculture technology, the research of greenhouse information collection and related equipment has become one of the research directions of technological innovation. This paper probes into the application of the wireless sensor network technology in the field of greenhouse monitoring confronted with the problems of the traditional greenhouse monitoring system. It analyzes the structure of the greenhouse control system, the design of the wireless sensor node and the design of the gateway management platform in order to realize the wireless monitoring of greenhouse environment.

## 1. Introduction

Modern greenhouse is the workshop of protected agriculture, while the monitoring and control system of greenhouse environmental information is the most important part to achieve its production automation and high efficiency. The traditional greenhouse monitoring system is mainly based on wired communication. Wired communication system has the disadvantages of complex wiring, difficult maintenance, and the inflexibility of the deployment of sensor nodes with the change of crops in the greenhouse production practice. Wireless sensor network (WSN), as a new information acquisition technology and processing technology, has the characteristics of large scale, small size, low cost and self-organizing network, which has wide application prospect in greenhouse environmental monitoring.

## 2. Structure of greenhouse control system

In the greenhouse monitoring and control system, the sensor node is responsible for collecting the environmental parameters inside the greenhouse, which is the core part of the greenhouse control system. The sink nodes are the managers of the greenhouse monitoring nodes and the collectors of the monitoring data and responsible for the communication between the sensing area and the server side. The server is the control center of the whole greenhouse control system, in charge of the management and control of the Sink node. It determines the strategy to be taken based on the monitoring data provided by the Sink node and provides the access control interface to the end user. In the client-side, PC or mobile devices can view the current greenhouse environment status and historical data at any time via the Web service, and can send further instructions to the greenhouse environment monitoring system for further processing by the server.

## 3. Design of wireless sensor node

### 3.1 Hardware design of wireless sensor node

The sensor node is the basic unit of the greenhouse monitoring system, and has the functions of environmental factor collection, data processing and wireless communication. In the context of greenhouse environmental monitoring applications, the sensor node design focuses on factors such as low cost, low power consumption, stability and reliability.

#### 1) CC2431

As sensor network nodes consume a lot of energy in communication, a low-power wireless communication chip will effectively reduce the energy consumption of communication modules.

The CC2431 is a low-power communication chip compliant with the ZigBee standard from Chipcon. It has the feature of quick wake up and search for external devices, which enables the nodes to stay long in sleep mode and thus save power. Besides, its channel frequency and power consumption parameters can be set flexibly. In the sleep mode, the current consumption is only  $0.9\mu\text{A}$ , and in standby mode, the current consumption is less than  $0.6\mu\text{A}$ . In view of network communication quality requirements of the wireless sensor, CC2431 communication module antenna uses unipolar antenna. The unipolar antenna is required to use the “balance - unbalanced transformer” between the differential output and the antenna. The CC2431-based design of node can achieve data collection and transmission through only a small number of peripheral circuits, greatly improving the reliability of the system and reducing system power consumption.

2) Sensor selection. It is necessary to for sensor nodes to collect environmental factors which are closely related with the growth of plants. This kind of information collection requires sensors with high accuracy and low power consumption. The sensors used in this design and technical parameters: 1. SHT71 digital atmospheric temperature and humidity sensor with the operating current of  $550\mu\text{A}$  and of  $0.3\mu\text{A}$  when standby, the measuring temperature of  $\pm 0.3\text{ }^\circ\text{C}$  and humidity accuracy less than or equal to 1.8%, and the interface of 12C bus. ISL29010 digital light intensity sensor with the operating current of  $0.25\mu\text{A}$  and standby current of  $0.1\mu\text{A}$ , the measurement accuracy of  $\pm 50$  lux and the interface of 12C. SLST1-5 digital soil temperature sensor with the measuring current of 1.5 mA and standby current of  $1\mu\text{A}$ , the measurement accuracy of  $\pm 0.5\text{ }^\circ\text{C}$ , the interface of a single bus. H550 digital CO<sub>2</sub> sensor with the operating current of  $15\mu\text{A}$ , the accuracy of  $\pm 30$  ppm and the interface of 12C. FDS100 analog soil moisture sensor with the operating current of  $15\mu\text{A}$ , the accuracy of less than or equal to 3% and the analog signal for the output.

From the above technical parameters indicate that the digital sensor has low power consumption, and the CPU is connected by a single bus or dual bus. In addition to FDS100 analog soil moisture sensor, the rest can be attached to the 12C data bus. In this design, two I / O ports of the CC2431 simulate 12C bus clock line and digital lines, simplifying the circuit design and saving the CPU I / O port. FDS100 outputs analog signal which can be directly connected with the P0 port of CC2431 and use internal ADC of CC2431 to achieve data conversion.

### **3.2 The implementation of ZigBee communication protocol**

The ZigBee protocol is a wireless communication technology standard developed by the ZigBee Alliance, which is characterized by close proximity, low complexity, self-organization, low power consumption, low rate and low cost. In addition, ZigBee equipment has energy detection and link quality indication function. According to the test results, the device can automatically adjust the transmit power to minimize the consumption of equipment energy under the premise of ensuring the quality of the communication link.

In the node software design, complete the equipment initialization, configuration network and start the network by calling the API function provided by the ZigBee protocol stack to achieve self-organized network of wireless sensor nodes distributed in a number of greenhouses. In order to further reduce the power consumption of the node, functions of flexible and dynamically configurable timing acquisition data, timed sleep and wake-up are designed.

## **4. Gateway management platform design**

### **4.1 Design of gateway node hardware**

In this design, the author built a gateway hardware platform of wireless sensor network with S3C2410A as the core, including:

1) ZigBee coordinator. In this design, the data collected by the entire sensor network is eventually aggregated to the coordinator node through ZigBee protocol. Therefore, in this paper, the ZigBee coordinator node is embedded in the gateway node and the coordinator conducts data communication through the serial port and gateway.

2) MC39i. Adopt GSM / GPRS dual-band module MC39i of Company Siemens to complete the wireless remote communication of gateway. MC39i supports the dual-band network of GSM900 and GSM1800 and the receiving rate is up to 86.20 kb / s, the sending rate is up to 21.5 kb / s, which could fully meet the requirements of smaller data transmission of wireless sensor network.

3) Memory interface. S3C2410A has the built-in external memory controller and the system expands 64MB SDRAM and 64MBNandFlash.

4) Universal peripheral interface. Gateway interface has a strong expansion capability. LCD with touch screen is an information exchange interface, USB interface can be used to connect the external standard mouse and keyboard, SD card can be used as expansion memory, and RJ45 interface can access the Ethernet Gateway.

5) Power supply. A stable power supply is critical to the operation of the gateway system. Through the transformer, the 220 V power is decreased to a stable 12 V DC as the main power supply. Meanwhile, the 12 V battery is used as the backup power of the system to form a power supply to ensure that the system could have normal operation in the case of power failure.

#### **4.2 Implementation of WinCE-based software platform**

WinCE5.0 is a 32-bit, multi-tasking, multi-threaded embedded operating system, with advantages of modularization, easy to cut and so on. This design uses Platform Builder to customize the WinCE5.0 operating system which is suitable for the gateway hardware platform, which provides the intuitive and graphical man-machine interface for the greenhouse management personnel and is convenient for the users' operation. At the same time, it provides a rich API interface for the application development. The system achieves the following communication procedures in the Embedded Visual C++ 4.0 development environment: serial communication and the management system conducts data communication through the serial port, ZigBee coordinator and MC39i. GSM communication achieves distant early warning of the gateway management system through the GSM short messages. Socket network communication, the remote monitoring center needs a server with a public IP address and the gateway achieves communication through the Ethernet / GPRS dual communication channel and remote management center. In this design, the use of reliable streaming socket is used to achieve network communications based on TCP / IP protocol Socket.

#### **4.3 Implementation of gateway management system**

As the local management platform of the greenhouse monitoring system, it is necessary for the gateway to complete a lot of data management. The design achieves environmental monitoring system management software based on SQLite3 to complete the management of sensor node and environmental data.

1) Node management. A large number of wireless sensor nodes are distributed in the monitoring area, so all nodes need to be managed uniformly. Nodes with the same ZigBee channel can be added to the wireless network. The management of the node includes the configuration of node power, node ID, node location, sensor type, sampling period, running status, update time and other attributes.

2) Data management and early warning. The gateway periodically receives a large amount of environmental information from all the nodes of the wireless sensor network, and uses the SQLite database to store and query the collected data. In addition, it is necessary to determine each environmental data written to the database. When it surpasses the security range set by the greenhouse management personnel, the alarm, flash, GSM short messages and other early warning methods will start.

Wireless sensor network node has small volume and one deploy could carry out long-term monitoring work at the same time. The sensor network node has certain data processing capabilities and communication capabilities, which can send a lot of wireless monitoring data to the base station for processing and get an edge of the traditional greenhouse Environmental monitoring system. It is very suitable for greenhouse environmental monitoring applications. Based on the wireless sensor network technology, this paper designs and implements a greenhouse monitoring system based on

wireless sensor network. The system can realize the fast-self-organizing of sensor nodes and real-time acquisition, transmission and display of various greenhouse environmental factors. It also has overcome the problems existing in the traditional greenhouse monitoring system, and has made useful explorations for the application of wireless sensor network technology in the field of greenhouse monitoring.

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### **References**

- [1] Wu Yanming. Wang Jizhang. Exploration of Greenhouse Management Information System [J]. Agricultural Mechanization Research, 2011,33 (3)
- [2] Zhou Suyin, Zhang Yun, Zeng Bin. Application of Wireless Communication Technology in Modern Greenhouse in China [J]. Journal of Sensors and Microsystems, 2011 (12)
- [3] Wu Hui. Yu Junqi. Study on Data Fusion Technology of Temperature Sensor in Greenhouse Based on ZigBee [J]. Journal of Agricultural Mechanization Research, 2009 (4)