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Agricultural Collection System Based on Zigbee

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Information technology has received a wide range of applications in agriculture industry to improve production environment and reduce resource costs. This article introduces the agricultural collection system of ARM Company, which uses S3C2440 as its control core and takes zigbee as its wireless transmission. This system achieves the collection and processing of information like illumination intensity, CO2 concentration, soil temperature and humidity and geographic position. This article also gives the introduction to the main hardware and software design. It has been proved by experiments that the data collected is accurate and the working condition is stable and thus this system receives a wide range of applications in agriculture industry.

1. Introduction

With the rapid development of economy and the improvement of living standards has, higher and higher requirements on agricultural labor productivity are asked by people. To collect the accurate information about the farmland soil and its geographical distribution can help us in achieving the goal of throwing in agricultural means of production targeted and accurately (S.W. Lin (2012)), improving the management level of farmland and agricultural productive efficiency in our country, promoting the modernized precision management of agriculture, advancing the efficient and rational utilization of cultivated land resources, enhancing the quality of agricultural products and increasing productive efficiency (S.H. Li and C.H. Xiao (2011)), lowering production cost, utilizing agricultural resources rationally and improving the ecological environment. Consequently, we can push forward the economic development in rural areas and promote the rapid economic development in China. For that purpose, this article designs the agricultural information collection system based on zigbee.

2. Overall design of hardware

2.1 Overall structure of the system

The structure of agricultural information collection system is shown in Figure 1. The function of wireless sensor data collection network is to achieve the establishment of network and the collection of perception data. Based on Zigbee wireless communication protocol, the Mesh network is built upon the sensor node on the hardware.

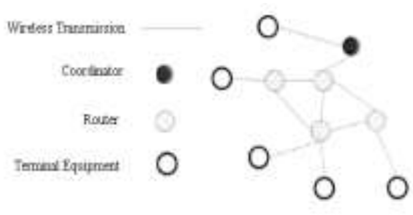

Figure 1: Structure of the Agricultural Information Collection System

The sensor node can be subdivided into terminal node, router node and coordinator node. The terminal node can achieve the collection of real-time environmental parameters like temperature, humidity, illumination intensity, CO2-concentration and so on. The data collected is transmitted to coordinator node through router

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node and byway of multi-hop relay. And then, the data is transmitted to computer servers by RS-232 serial port from the coordinator node (G.F. Li and D.M. Chen (2013)).

2.2 Hardware design of Zigbee node

Data collection is the first step of the work of this system. Therefore, we have to make sure the data we collect is accurate and reliable so that the whole system can perform normally. The wireless collection nodes are widely distributed among fields and there exists some distance between them. The data collected is transmitted wirelessly. An issue that should be given the highest priority is how to achieve the lowest packet loss probability of sensor node data in the transmission (J. Guo and X.M. Ma (2013)). At the same time, how to extend the battery life of the sensors is another issue that needs to be settled considering the sensor nodes are widely distributed in large amount. Having considered all the factors above, this system chooses the CC2530 as the sensor node of wireless data collection as CC2530 has low power dissipation, high radio frequency, low cost and good expansibility. The concrete zigbee node circuit design is shown in Figure 2.

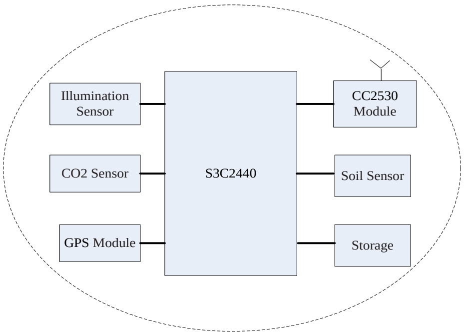

Figure 2: Zigbee Node Circuit Design

2.3 Sensor module

The sensor nodes in the wireless sensor data collection network collect the environmental information like temperature, humidity, illumination intensity, CO2-concentration that may influence crop growth. Having considered factors like range, precision, supply voltage, power dissipation and so on, we choose SHT10 temperature and humidity sensor to collect the information of environmental temperature and humidity, TSL2561 illumination intensity sensor to collect the information of environmental illumination intensity and GSSCZO-SK infrared CO2 sensor to collect the information of environmental CO2-concentration. The introduction of every kind of sensor will be given respectively in the next part.

2.3.1 SHT10 digital temperature and humidity sensor

This design chooses the SHT10 digital temperature and humidity sensor produced by Swiss company Sensirion. This sensor applies intelligent chip and can detect temperature and humidity at the same time. This sensor is also equipped with temperature sensor, humidity sensor, signal amplifying and adjusting, A/D conversion, and I2C bus interface and has the advantages of short response time, strong anti-interference capacity and high cost performance.

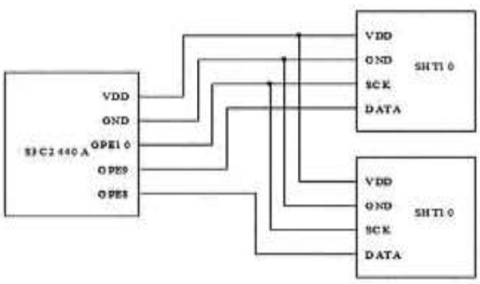

Figure 3: Connection Diagram of SHT10 and S3C2440A

The working voltage of SHT10 is between the ranges of 2.4 to 5.5 V, the temperature measurement is between the range of -40.0 to 123.8℃ and the precision is ±5℃; the humidity measurement is between the range of 0 to 100%RH and the precision is ±4.5%RH, which all conform to requirements of the system. To achieve the collection of real-time temperature and humidity in the drying oven, the system has to collect the data on each sensor at the same time (X.G. Sun and W.H. Lin (2014)). We can choose to connect the SCK on each temperature and humidity sensor to one input/output port of S3C2440A at the same time and connect DA-TA on each sensor to different input/output ports of S3C2440A respectively. In this way, we can better use the I/O port and shorten the collection time. The connection of SHT10 and S3C2440A is shown in Figure 3.

2.3.2 GPS design

This design adopts the EB818 launched by ALL Ture Company as its GPS module. This module applies the high-performance and low-power dissipation Star III chip produced by as its core chip SiRF Company. The received frequency of that chip is 1575.42 MHz and has internal integration of two high-speed serial UART ports, 4MB FLASH ROM and 20-channel receiver. This module has relatively high sensitivity to satellite signals under low-power dissipation. We connect the serial ports of EB818 to those of S3C2440A. The GPS circuit diagram is shown in Figure 4.

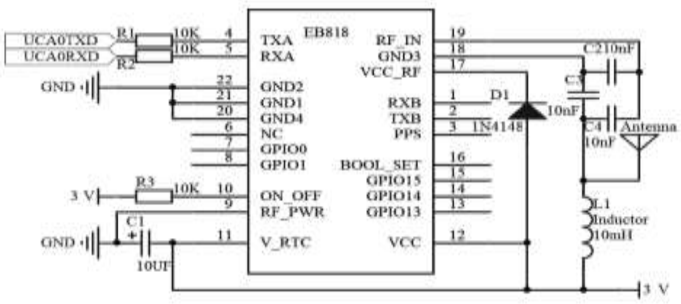

Figure 4: GPS Circuit Diagram

2.3.3 GSSCZO-SK infrared CO2 sensor

GSSCZO-SK is a sort of solid-state photoelectric sensor that applies the NDIR infrared technology. It can collect the concentration of CO2 and carry on temperature compensation at the same time. Therefore, it is especially suitable for the environment that need to measure temperature and CO2 at the same time. GSSCZO-SK bears the features of small volume, long hours of use and strong stability. The parameter characteristics of GSSCZO-SK infrared CO2 Sensor is shown in Table 1.

Table 1: Parameter Characteristics

Name of Parameter	Index Value	Name of Parameter	Index Value
Measuring Range	0 to 5000 ppm	Working Voltage	2 to 5 V
Resolution Ratio	10ppm	Working Current	≤200 mA
Response Time	＜4s	Output Signal	digital
Range of Temperature Compensation	-25℃ to +55℃	Size of the Device	4 mm×2 mm

2.3.4 TSL illumination intensity sensor

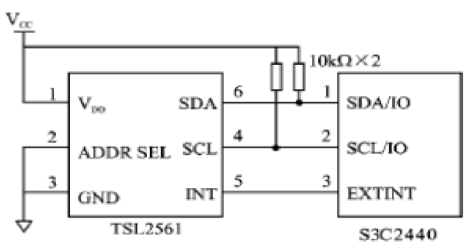

Figure 5: Circuit Design of TSL2561

TSL2561 is accessible through the I2C bus, so it has simple hardware interface circuit. If the microcontroller we choose is equipped with I2C bus controller, then we can connect the clock line and the data line directly to the SCL and SDA of TSL2561 I2C bus respectively; if there is no pull-up resistor inside the microcontroller, then we need two more pull-up resistors connected to the bus. If the microcontroller is not equipped with I2C bus controller, then we only need to connect the SCL and SDA of TSL2561 I2C bus to the plain I/O port; however, we need to simulate the timing sequence of TSL2561 I2C bus when we do the programming and the INT pin should be connected to the external terminal of the microcontroller. The hardware connection is shown in Figure 5.

2.3.5 Zigbee wireless communication

The performance of the whole system is determined by whether the data can be transmitted accurately. And the performance of the wireless communication module is closely bound up with the communication quality of wireless sensor network. We choose the radio frequency chip CC2530 and radio-frequency amplification front end CC2591 as major components of the whole wireless communication module. CC2530 is a sort of radio frequency transceiver that has been widely used in the industry and is a famous product of T1 Company. CC2530 can provide the most advanced industrial applications and has proper functioning within the range of -40℃to +125℃. CC2530 has very excellent receiving sensitivity and compossibility and has superb connection performance and link design. The working voltage ranges between 1.8V to 3.8V, which means it can work under low voltage. The circuit diagram of CC2530 is shown in Figure 6.

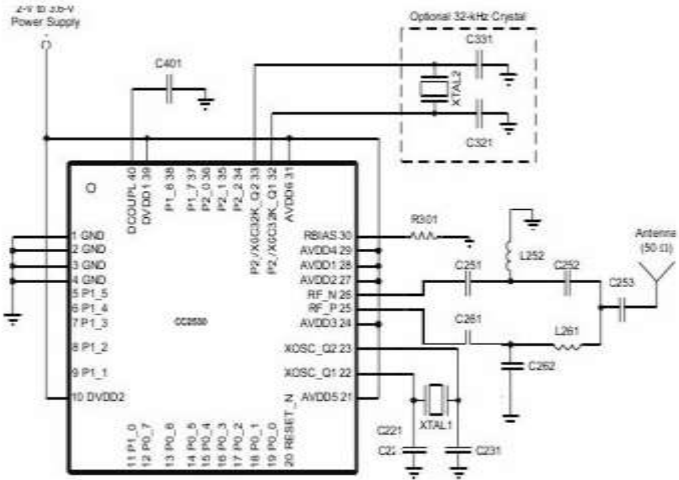

Figure 6: Circuit Diagram Design of CC2530

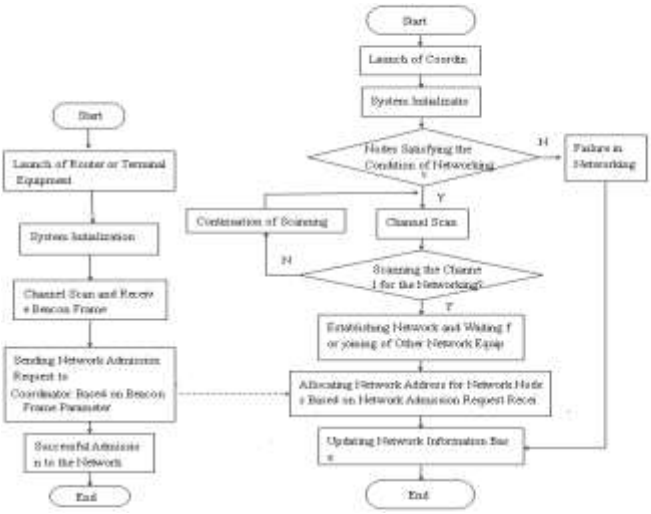

Figure 7: Zigbee network establishing flow chart

3. Main software design of the system

3.1 Zigbee node group flow chart

The implemented network of this system is based on the Zigbee Protocol of wireless Mesh network (ZigBee-WMNs). There are three types of equipment in this network, Zigbee coordinator, Zigbee router and Zigbee terminal equipment. Zigbee coordinator is the equipment for network start and configuration and at the mean time; the coordinator can communicate with equipment outside the network, which means it can serve as a gateway. There can be only one coordinator in one Zigbee network. Zigbee router is responsible for the path discovery and the maintenance router equipment. It can be used to collect data and completing the work of routing. Mesh network and tree network can be equipped with several routers while star network do not support routers. Zigbee terminal equipment is responsible for data collection and simple controlling work. The terminal nodes in this system can only complete the work of data collection and data returning. There can be more than one terminal equipment in one network. The network establishing flow chart is shown in Figure 7.

3.2 Overall software flow chart

When the Zigbee nodes meshwork is completed, each node starts to collect the data on each sensor, transfers it to the master routing node and finally the data is transmitted. The overall flow chart is shown in Figure 8.

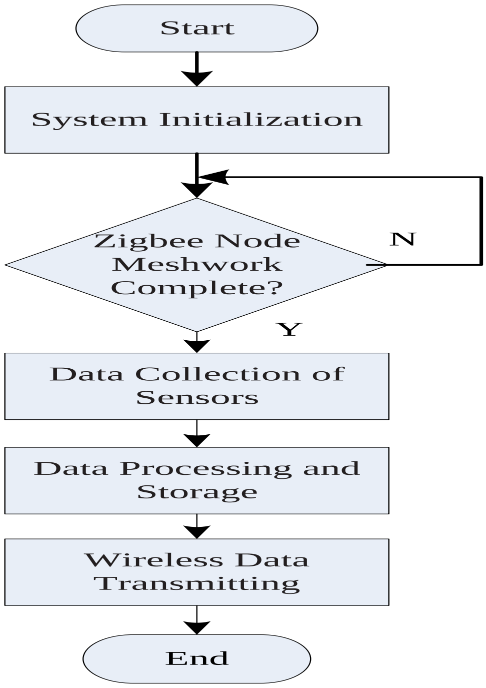

Figure 8: Overall Flow Chart

4. Experimental result

This experiment chooses 8 sensor nodes, among which one serves as coordinator and two serve as routers. This experiment also chooses 6 nodes as terminal equipment. The result of this experiment is shown in Table 2. According to the data collected by this system, we discover that the data collected has relatively high precision and the system can reflect the changing of environmental parameter accurately.

Table 2: Experimental Result

Serial Number	Longitude	Latitude	Time	Illumination Intensity	CO2 Concentration	Soil Temperature	SoilHumidity
1	114°26’22”	38°31’11”	10:55	89	356	4.5	70.33
2	114°26’18”	38°31’13”	11:15	85	410	4.5	77.95
3	114°26’21”	38°31’10”	11:22	90	409	4.0	62..87
4	114°26’20”	38°31’18”	11:43	97	346	3.9	58.43
5	114°26’24”	38°31’16”	11:56	96	389	3.8	55.67
6	114°26’24”	38°31’17”	12:02	98	372	3.7	51.26

5. Conclusions

This article introduces in detail the design of agricultural information collection system from both sides of hardware and software. It has combined the Zigbee wireless communication with sensor technology and realized the stable and accurate collection, processing, storage, communication and display of agricultural data. It has also adopted the low-power scheme for CC2530 and S3C2440 and reduced the power consumption greatly. After real testing, this system has realized the expected target and can be applied widely in the agricultural information collection industry.

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