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Design of a Wireless Monitoring Network for Granary Temperature and Humidity Based on Zigbee

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Abstract

The granary monitoring systems in used in China are mostly based on wired networks such as RS-485 serial bus, CAN fieldbus, etc. Inevitably these monitoring systems have drawbacks of high installation cost, high failure rate and high maintenance cost. Aiming at these problems, this paper designed a granary temperature and humidity monitoring system based on Zigbee wireless network. The monitoring system consists of sensor modules as Zigbee end devices, a host PC connected to a Zigbee coordinator and some Zigbee routers if necessary. The sensor module is a temperature and humidity testing device using a CC2430 as the controller and a SHT11 as the sensor. All testing results are displayed as figures and curves in real-time on the host PC, and history data are saved in a database file for further analysis.

Keywords: *Granary monitoring, temperature and humidity, Zigbee, CC2430, SHT11*

1. Introduction

With the increasing of grain reserves, the grain storage loss rate increases simultaneously in China. One of the most important reasons is that large amount of traditional granaries have not equipped with automatic temperature and humidity monitoring devices for economic reason. So decreasing the installation and maintenance cost is an urgent requirement of granary monitoring device. Replacing the wired network of monitoring device such as RS-485, CAN fieldbus with a wireless one is an effective method of decreasing the cost [1-3]. Considering the granary range of thousands square meters, Zigbee network is employed to design a wireless monitoring system in this paper.

2. General Design of Wireless Monitoring System

The monitoring system designed in this paper has functions of temperature and humidity automatic testing, sample data wireless transmitting and results real-time displaying. Functional requirements of the monitoring system are shown in Table 1.

Table 1. Functional Requirements of the Monitoring System

Parameters	Measuring rang	Resolution	Error range
temperature	40~+123.8 centigrade	0.1 centigrade	≤±0.4 centigrade
humidity	0~100%RH	0.1%RH	≤±3.0%RH

The system consists of a host PC with a Zigbee coordinator and sensor modules as Zigbee end devices as shown in Fig.1. Considering the granary range and the EMI environments, some Zigbee routers can be included in the system for better reliability. The coordinator

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connects to the host PC via its RS-232C serial port in a distance of 1 through 2 meters. The parameters of Zigbee network are shown in Table 2.

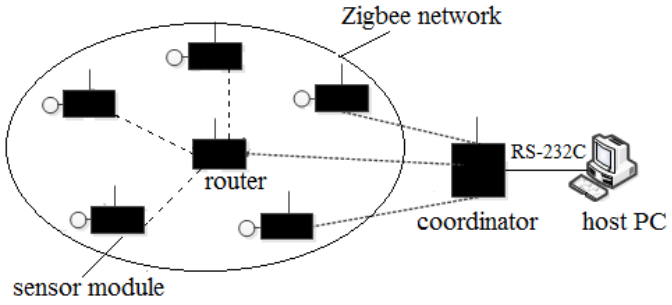

Figure 1. System General Schematic Diagram

Table 2. Zigbee Network Parameters

parameter	value
working frequency	2.4GHz
voltage	2.0~3.6V
data transfer rate	250kbps
maximum power consumption	less than 1mW
number of connected devices	216~264
transmission distance	more than 100 meters

3. Sensor Module

As a Zigbee end device in the wireless network, sensor module has two functions, temperature and humidity testing and wireless transmission. The diagram of sensor module is shown in Figure 2.

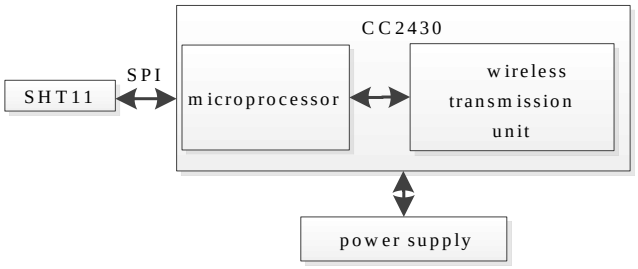

Figure 2. Diagram of Sensor Module

SHT11, a sensor chip produced by Scnsirion Cooperation (Swiss), is used to test the temperature and humidity. SHT11 outputs the results data via SPI interface [4, 5].

CC2430, a SoC (system on chip) produced by TI Cooperation (USA), is used as the main controller in the sensor module. In CC2430, an enhanced 8051 microprocessor and a 2.4GHz DSSS wireless RF transmission unit (IEEE802.15.4) are integrated on chip along with 8K bytes SRAM and a bulk FLASH on which the Zigbee protocol stack is stored [6].

A 9V battery is used to supply the power in the module. The schematic of the sensor module is shown in Figure 3.

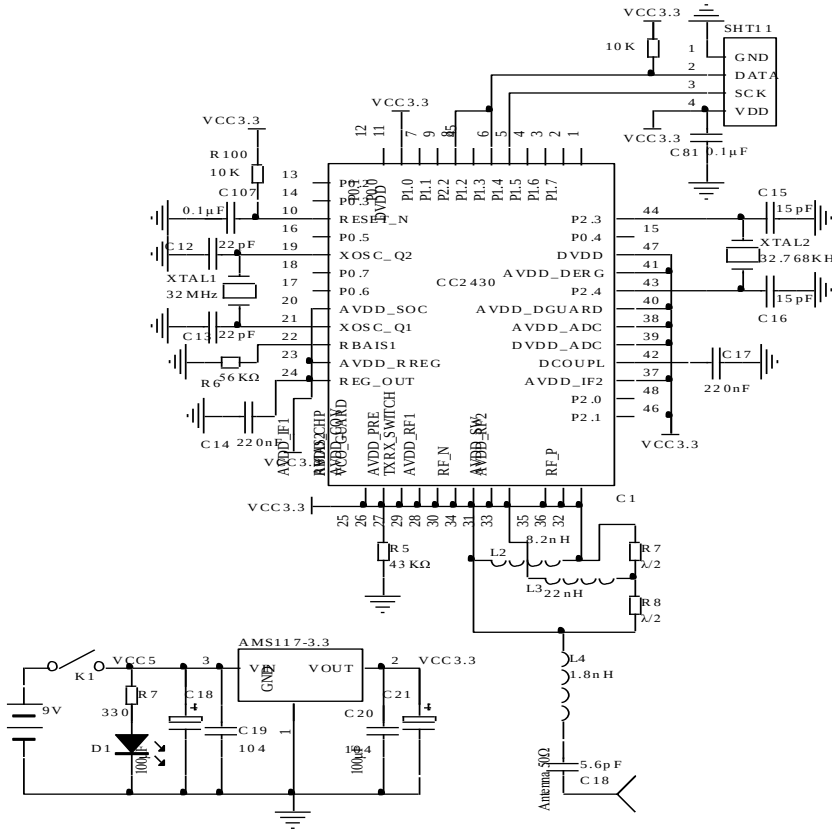

Figure 3. Schematic of the Sensor Module

4. Host PC and Coordinator

Temperature and humidity data are transmitted to the host PC via the RS-232C serial port through a Zigbee coordinator and displayed on the monitor. The diagram of the host and coordinator is shown in Figure 4.

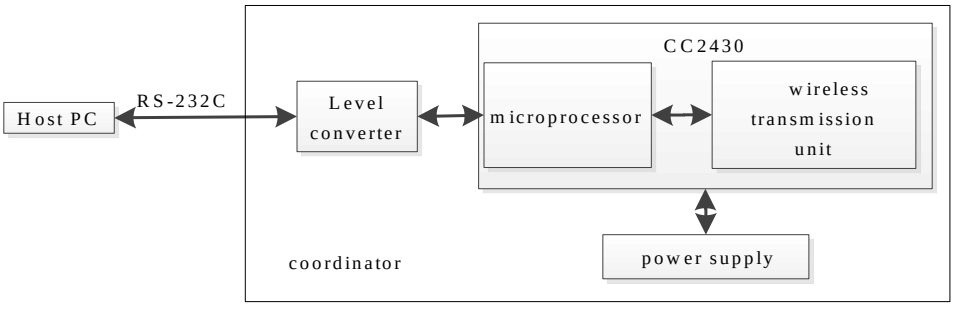

Figure 4. Diagram of the Host and Coordinator

As in the sensor module, a CC2430 is used as the main controller in the coordinator. And a level converter is designed to convert the TTL level of CC2430 serial port to the RS-232C level of the host PC serial port. Converter chip MAX232 is used in the level converter as shown in Figure 5.

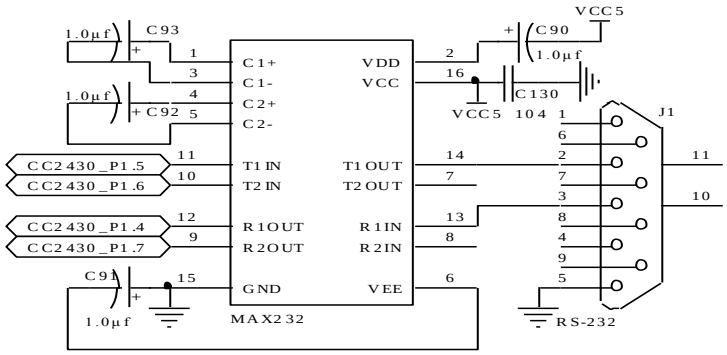

Figure 5. Schematic of Level Converter

5. Software Design

The sensor module samples temperature and humidity and sends a data frame to host through coordinator once two minutes under the control of Timer0, one of the two timers embedded in the microprocessor on CC2430. And the host sends a reply frame to ensure the sample data are truly received. After the reply frame is received by the sensor module, it enters a sleep (low power) mode to lower power consumption. The flow chart of sensor module main program is shown in Figure 6.

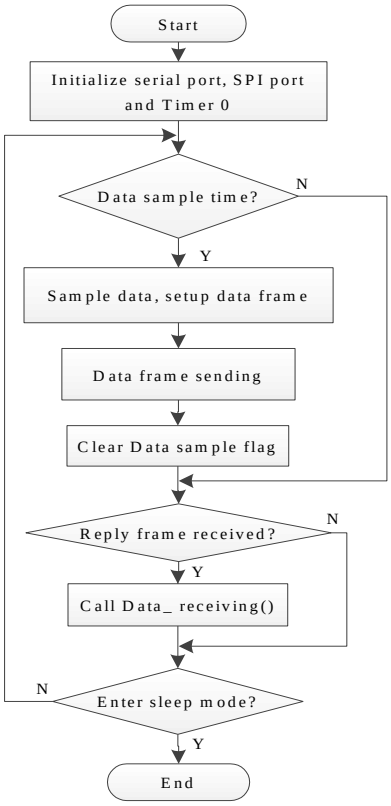

Figure 6. Flow Chart of Sensor Module Main Program

Coordinator has two functions in the monitoring system, one function is receiving and sending data between the host and the Zigbee network, the other function is setting up and maintaining the Zigbee network. Two serial ports are embedded in CC2430. Serial port0 is used to communicate with wireless RF transmission unit. Serial port1 is used to communicate with the host. The flow chart of interrupt service subroutines of serial port0 and serial port1 on coordinator are shown in Figure 7.

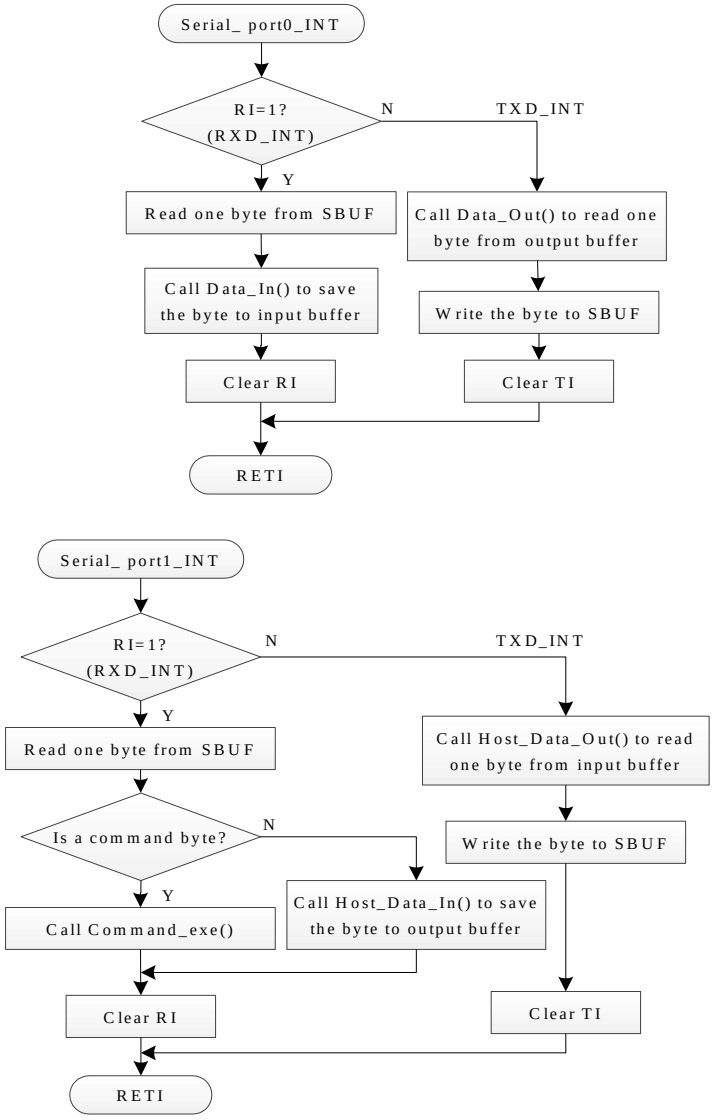

Figure 7. Flow Chart of Interrupt Service Subroutines of Coordinator

Host PC runs a monitoring program (developed in Microsoft Visual Studio 6.0) to display real-time sample data and store history data. The main display window is shown in Figure 8. The three columns are sensor module ID, temperature and humidity respectively. On the right bottom corner, a newly accessed sensor module (ID=28537) is displayed as an instant information box.

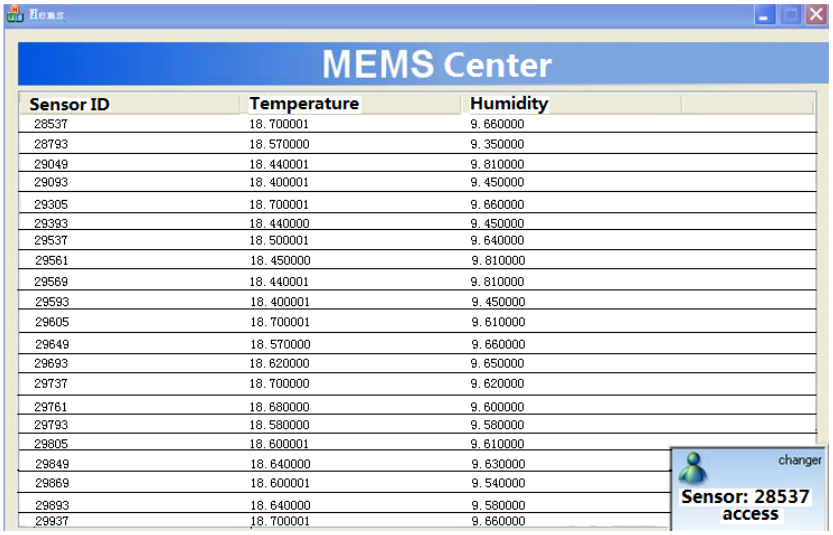

Figure 8. Main Display Window on the Host PC

6. Conclusion

Aiming at cutting down the cost of granary management and maintenance, Zigbee wireless network is used to transmit temperature and humidity data in this monitoring system. The measuring range of temperature is from -40 through 120 centigrade; the maximum absolute error of temperature is 0.4 centigrade; the maximum absolute error of humidity is 0.03%. The monitoring system designed in this paper is widely praised by granary managers who provide the experimental fields.

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