DESIGN ON INTELLIGENT HOME TEMPERATURE 
AND HUMIDITY MONITORING SYSTEM 
BASED ON IOT TECHNOLOGY

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ABSTRACT. Aiming at the disadvantages of temperature and humidity control system, 
such as hysteresis of manual adjustment, poor flexibility, and false alarm, intelligent home temperature and humidity monitoring system based on IOT (Internet of Things) technology is designed. All the nodes in the system take CC2530 as the core. Wireless acquisition terminal nodes collect the indoor temperature and humidity data by SHT10 temperature and humidity sensor. Then, data is sent to coordinator node in a wireless way. Coordinator node sends data to a PC for real-time dynamic display through the serial port. Coordinator node processes and judges data, then sends instructions to the wireless control terminal nodes which control the running status of temperature and humidity conditioning equipment. Thus, the purpose of automatic control indoor temperature and humidity will be achieved. The experimental results show that the system in this paper has high precision, stable performance, high reliability, and low power consumption. The problems which temperature and humidity control system has at present have been solved.

Keywords: IOT, Intelligent home, CC2530, Temperature and humidity

1. Introduction. At present, the application fields of temperature and humidity control system is very extensive, such as, agricultural greenhouse temperature and humidity control, granary temperature and humidity control, the mine temperature and humidity control. The traditional temperature and humidity control system usually used wired mode, laid a large number of cable, used singlechip to detect signal [1]. The obvious disadvantages are that the wiring is difficult, the networking is not flexible, and the mobility is poor. If you add a node, hardware and software must be reconfigured [2]. In recent years, researchers have introduced embedded microprocessor, GPRS, wireless communications, Ethernet and other new computer technology, communication technology or computer software technology [3]. However, the existing temperature and humidity control system basically adopts open-loop control. That is, when the temperature and humidity is abnormal, the system only provides the alarm function. So you need to take measures manually, but the system cannot take appropriate measures to achieve the automatic control function of temperature and humidity.

In view of the above disadvantages and deficiencies, this paper designs a high reliability, low power consumption, closed-loop intelligent home temperature and humidity monitoring system with automatic measurement and control function.
2. System General Design. ZigBee, based on IEEE802.15.4 standard, is a new kind of wireless communication technology. Its characteristic is near distance, low complexity, self-organization, low power consumption, and low data rate. When it is combined with sensor, a ZigBee wireless sensor network can be formed. It can achieve a one-to-multipoint communication and communication between two points. The ZigBee network supports star, tree, mesh topology. ZigBee network nodes are divided into three categories according to the functions: the coordinator node and router nodes, terminal nodes. Because this system is relatively simple networking, data transmission is not large. To this end we use a star topology with only coordinator and terminal nodes [2].

The overall structure diagram of the intelligent home temperature and humidity monitoring system is shown in Figure 1. ZigBee wireless acquisition terminal nodes first collect the indoor temperature and humidity data, and carry on preliminary treatment. Then, the data which received from the sensor nodes is sent to coordinator node through ZigBee protocol. According to the result of comparing acquisition results with system setting values, the coordinator node decides whether to start the ZigBee wireless control terminal nodes to control the running status of temperature and humidity conditioning equipment to achieve the purpose of automatic control indoor temperature and humidity. In addition, the coordinator node is also responsible for the establishment of a ZigBee network, send and receive instructions, data communication via RS-232 serial port and a PC. PC machine is responsible for the centralized display of the indoor temperature and humidity information which is collected by each sensor node.

![System overall structure diagram](image)

**Figure 1.** System overall structure diagram

3. System Hardware Design. Terminal nodes of the system design can be divided into the wireless acquisition terminal nodes and wireless control terminal nodes. The main task of the wireless acquisition terminal nodes is to drive SHT10 temperature and humidity sensor, which is to collect indoor temperature and humidity data. The data will be sent out by 2.4 GHz antenna after it is processed by CC2530. The main task of the wireless control terminal nodes is to receive instructions which are sent by the coordinator node via the 2.4 GHz antenna. They drive the temperature and humidity conditioning equipment through the relay circuit to start or stop to automatically control the indoor temperature and humidity according to the instructions. Its structure is shown in Figure 2.

CC2530, which is a true Soc (System on a Chip) of TI company, works in the 2.4 GHz band and it is consistent with IEEE802.15.4 specification [4]. It combines the excellent performance of the advanced RF transceiver and enhanced 8051 CPU. It has 8 KB of
RAM and a standard UART, SPI. And it can directly realize serial communication with the other terminal equipment. In combination with Z-Stack protocol stack, it provides a complete solution for ZigBee. In addition, CC2530 can transit from sleep mode to active mode in a very short time, with fast response. These features make the chip very suitable for applications in wireless sensor networks [2].

SHT10 is a humidity-temperature compound sensor with calibrated digital signal output. The product has excellent quality, super fast response, strong anti-interference ability, extremely high cost performance and other advantages. Its main performance parameters are: operating voltage 2.4~5.5 V, humidity measurement range 0~100% RH, measurement accuracy is ±4.5% RH, temperature measurement range is −40~+123.8 °C, the measuring accuracy is ±0.5 °C [5]. SHT10 and CC2530 interface circuit is shown in Figure 3.

The temperature and humidity conditioning equipment includes humidifier and fanner, so we need to add relay circuit to complete the action that small current to control large current. Relay is a kind of power switching device, and it can achieve the function of the weak signal control strong signal. Relay driver circuit is shown in Figure 4, optocoupler EL817 plays a role in isolation, and also can eliminate the influence of the load. D1 is the freewheeling diode, which is used to protect components, so that the components will not be broken down by the coil remanence voltage. LED is the indicator lamp for relay path. If the I/O port of CC2530 outputs high level, the circuit makes contact 2 and K key linkage through the optocoupler EL817, which is to achieve the open of a temperature and humidity conditioning device. On the other hand, if the I/O port outputs low level, temperature and humidity conditioning device is closed [6].
The main task of the coordinator node is to build the ZigBee network, receive and process data from the wireless acquisition terminal nodes. Through controlling the running status of temperature and humidity conditioning equipment by the wireless control terminal nodes and communicating with PC via RS-232 serial port, the data will be sent to the PC for display [7]. Its structure is shown in Figure 5.

Figure 5 shows that the coordinator node is mainly composed of CC2530 ZigBee wireless transceiver module, RS-232 serial interface circuit, PC machine and power module. The CC2530 module is the core part of the coordinator node. It undertakes the task of receiving and storing data which is from the wireless acquisition terminal nodes, and is able to analyze and process the data, then sends instructions to the wireless control terminal nodes. In order to make the coordinator node realize the communication between CC2530 and PC, using RS-232 communication interface, the data collected will be transmitted to the PC through the RS-232 serial interface circuit. Because the high and low level standards set by the RS232 are different from the CC2530 TTL level, we need MAX3232 chip to convert the level [8].

4. System Software Design. The wireless acquisition terminal nodes are responsible for collecting temperature and humidity data from the monitoring area, and sending the data to the coordinator. The requirement for sampling frequency is not high in this system. We use the way of timing sampling data, considering the battery life and power consumption [5]. After the nodes are powered up, they first initialize the hardware and protocol stacks, and search the neighboring network. Then they send the application to join the network. Once the network coordinator confirms the application information, the nodes will join the network successfully. Then the nodes enter into the sleep mode. When there is a data transfer request, the nodes immediately go into work mode by sleep mode. They collect, preprocess and transmit the temperature and humidity information. Each time data acquisition and data transmission then the nodes enter a period of low-power sleep mode, until the next interrupt request information awakens the sleep nodes. The software design process is shown in Figure 6.
Wireless control terminal nodes mainly communicate with the coordinator node. They receive and parse instructions from the coordinator, then execute the instructions which control the temperature and humidity conditioning equipment start-stop. After nodes are powered up, the same, they first initialize the hardware and protocol stacks. Then they query and join the coordinator network, and enter the sleep mode. When the nodes receive instructions information from the coordinator node, immediately go into work mode by sleep mode. Through controlling the relay circuit, the control terminal nodes drive a humidifier or a fan to run or stop. The software design process is shown in Figure 7.
The coordinator node is responsible for building and maintaining a ZigBee network. It also undertakes the task of gathering, analyzing and processing data, and sending the control instructions. The hardware design process is shown in Figure 8.

After the coordinator node is powered up, it first performs a channel scan. Then it selects a free channel to create a network, and provides some appropriate network parameters. After the coordinator starts, it keeps monitoring the wireless signal. If it receives an application from a terminal node to join the network, it will determine whether to allow the terminal nodes to join the network according to the request information. If the terminal node is allowed to join, the coordinator will assign a network address to the terminal node as the only network identity [9]. If the temperature and humidity data which collected from the wireless acquisition terminal nodes is monitored by coordinator node, coordinator node will receive data and send the data to a PC for displaying through RS-232 serial interface circuit. Then it takes the method of data fusion to process the received data, and then the data will be compared with system setting value. If the temperature and humidity exceeds the upper and lower, the coordinator timely sends the appropriate instructions to the wireless control terminal nodes. The wireless control terminal nodes control temperature and humidity conditioning equipment to run or stop according to the instructions. Then the purpose of timely and automatically adjusting the temperature and humidity will be achieved.

5. Experiments and Results Analysis. In order to validate the measure-control precision of indoor temperature and humidity, we chose 5×6 m² laboratory instead of home environment. To avoid local error caused by the wireless acquisition terminal nodes which are placed centrally, the nodes above are uniformly distributed in different locations of the laboratory. After the system is installed and power initialized, the network will be established, and then the system will go into working mode. We set different temperature and humidity standards on the coordinator program design. Waiting for system control work is completed; we measure and record the actual temperature and humidity. Compared with the temperature and humidity standard; we use MATLAB in the form of line chart, as is shown in Figure 9.
Figure 9. Temperature and humidity comparison diagram

The temperature and humidity comparison chart shows that, after the system is stable, the temperature and humidity monitoring reliability is high, temperature error is less than ±0.9°C, humidity error does not exceed ±2.5% RH. After analysis, the main reason for the error is the uneven distribution of the temperature and humidity of the indoor air, which results in difference in data collected by wireless acquisition terminal nodes in different positions, and the error when the coordinator node analyzes the data.

In fact, the operating current of the terminal nodes is 60 mA, and it hourly works 50 s (other time is sleeping, negligible). The total charge of two 5th batteries is 3000 mA·h. The two 5th batteries can be used for terminal nodes working time is: 3600h = 150 days, that is about half a year. Considering the coordinator node has been in working condition, we can adopt large capacity lithium battery; for example, 2000 mA lithium battery provides 3.6 V power supply. It can be intelligent charging [10]. This power supply mode meets the low power consumption requirement of the system.

6. Conclusions. Through the design of the intelligent home temperature and humidity monitoring system based on IOT technology, this system well solves the hysteresis of manual adjustment which exists in the present temperature and humidity control system. The system takes CC2530 as the hardware core, and builds a ZigBee wireless sensor network. The paper has been elaborated in detail the hardware design method and the software design process of the coordinator node and terminal nodes. The experiment proved that the system has high reliability, low power consumption, and the error can satisfy the requirement for practical application. It can bring great security and convenience for the family life.

Using modern sensor technology, automatic control technology, digital communication technology, computer application technology, etc., the future of temperature and humidity monitoring system will be developed towards in intelligent, automated, systematic and network development.

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REFERENCES


