Research on temperature acquisition system of printing machine oven based on wireless Sensor network

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Abstract: Aiming at the problems such as limited transmission distance of traditional temperature data, complex wiring and aging line, ZigBee wireless network is introduced into the temperature acquisition system of the intaglio printing machine oven, which makes the whole system easy to operate and simple, and greatly improves the transmission distance of temperature signal. The composition of the temperature monitoring system and the hardware circuit of the ZigBee master node are described, including DC 5 V power supply circuit and USB interface power supply circuit, the connection circuit between the RADIO frequency board and the backboard, to realize the construction of the network and the wireless reception of temperature data. To realize the construction of the network and wireless reception of temperature data. It combines ZigBee wireless communication technology to complete real-time transmission of multi-point temperature data, realize real-time LCD display of multi-point temperature data collected by DS18B20, and realize ZigBee networking function based on ZigBee protocol stack.

1. Introduction

In recent years, under the wave of industrial 4.0, as the "made in China 2025" plan is put forward, more and more manufacturing enterprises in our country started the practice of intelligent factory, including packaging and printing enterprise has to intelligent manufacturing and intelligent of the construction of the factory. At present, there is still a gap between Chinese printing equipment and developed countries' in data acquisition technology and methods. This is an important factor restricting the development of high-end printing equipment in China. Therefore, it is particularly important to improve the collection means and enhance the intelligent data collection of printing equipment process. It is an essential step to build intelligent factories of packaging and printing enterprises and realize the intelligent data collection of printing equipment.

ZigBee translates to "purple bee" and is similar to Bluetooth. It is an emerging short range wireless communication technology for Sensor and Control applications. Compared with traditional network communication technology, ZigBee wireless communication technology is more efficient and convenient. As a close-range, low-cost, low-power wireless network technology, its networking, security and application software technology is based on the IEEE approved wireless standard 802 15.4. ZigBee adopts wireless transmission mode to build the corresponding wireless network, which can better solve the problems existing in manual and wired mode. The application of it in intelligent factory printing equipment can greatly increase the distance of data signal transmission.

Wireless sensor networks have been widely used in the military field. At the same time, with the development of applications, WSN has gradually expanded from the military field to civil fields such
as environmental monitoring and building automation \[1\]. In the United States, Berkeley, Massachusetts Institute of Technology and other research on low power wireless sensor networks. In addition, Britain Invensys, Japan Mitsubishi Electric, the United States MOTOROLA and the Netherlands Philips semiconductor, four internationally renowned companies joined the "ZigBee alliance", committed to the research of low power consumption, low complexity, support a large number of network nodes, support a variety of network topologies, safe and reliable ZigBee technology \[2,3\]. ZigBee has become one of the best technologies in the field of wireless sensor networks. The technical parameters of short distance communication are shown in Table 1.

| The technical standards | bluetooth | Wi-Fi | Infrared l/dA | Excess bandwidth communication | ZigBee |
|-------------------------|-----------|-------|---------------|-------------------------------|--------|
| Working frequency band  | 2.4G      | 2.4G  | 820nm         | 3.1-10.6G                     | 868-915M, 2.4G |
| Transmission medium     | RF        | RF    | infrared      | RF                            | RF     |
| Transmission distance   | 10-100m   | 25-100m | 200cm-1.2m    | 10m                           | >75m   |
| Transport               | Point to multipoint | Point to multipoint | Point to point | Point to multipoint | Point to multipoint |
| Maximum rate            | 1Mbps     | 11Mbps | 16Mbps        | 500Mbps                       | 0.020/0.040/0.25Mbps |
| Directional             | omnidirectional | omnidirectional | <30 degrees | omnidirectional | omnidirectional |
| Security                | medium    | low   | no            | strong                        | Multiple security levels |
| Power consumption       | low       | ultra-low, <1mW | low | low | low, 1-3mW |
| The cost of             | lower     | highest | low | lower | Very low |

The Chinese Academy of Sciences as well as major research institutions and commercial companies are involved in applied theoretical research related to wireless sensor networks. GAINZ, a wireless sensor network node developed by the Institute of Computer Science under the Chinese Academy of Sciences, has been compatible with mainstream 2.4g wireless sensor network nodes in the market, and has certain advantages in transmission distance and power consumption \[3\]. The Chinese Academy of Sciences has also done a lot of work in the research of security protocols for wireless sensor networks and achieved a lot of achievements.

2. Overall system design

CC2530 main control chip can be roughly divided into CPU, memory module, peripheral, clock, power management module and radio frequency module. The CPU core used by CC2530 is a single cycle 8051 compatible kernel. The digital core and peripherals are powered by a 1.8V low-differential voltage regulator. The CC2530 also includes a power management module that can be used to power low-power applications for long periods of time using different power modules. The CC253x device family provides an IEEE 802.15.4 standard radio transceiver. RF core control analog wireless module. In addition, an interface is provided between the MCU and the wireless module. This allows it to issue commands and read status, automatically obtaining the sequence of events on the wireless device. The wireless device also includes a packet filtering and address recognition module. ZigBee is a synonym of IEEE 802.15.4 protocol. It is a short-range, low-power wireless communication technology according to this protocol. Using CC2530 as the main control chip, this paper designs a ZigBee-based temperature acquisition system for intaglio printing machine oven. Three power supply circuits including DC 5 V power supply, USB interface power supply and battery power supply, liquid crystal display circuit, serial port communication circuit, touch button, five-way button control circuit and temperature sensor circuit are designed respectively. The intelligent temperature sensor is used to collect, transmit and display the temperature signal in real time. Through software programming, the main development board is defined as the coordinator node, router node and terminal sensor node, and the networking function is completed through the ZigBee protocol stack, so as to centrally control and manage the temperature monitoring points, realize the temperature alarm function, and complete the real-time monitoring of the thermal energy usage of users. The hardware of the system is
mainly composed of radio frequency module for wireless communication, panel module for power supply and other peripheral circuits, and DS18B20 temperature measurement module, which together constitute the coordinator, router or terminal sensor node. The composition of oven temperature acquisition system is shown in Figure 1.

![Figure 1. Composition of temperature acquisition system](image)

The liquid crystal display module adopts 128×64 dot matrix graphic liquid crystal. The LCD adopts serial mode. The collected temperature value can be displayed on the terminal node in real time through the LCD module. Figure 2 shows the physical hardware and LCD temperature values of sensor node of terminal 1.

![Figure 2. LCD module](image)

The core chip of the system is CC2530 with a powerful wireless front end, which integrates IEEE802.15.4 standard RF transceiver in the 2.4ghz band, RF modulation mode DSSS (direct Sequence Spread spectrum mode), and provides a wide set of peripherals. Including 8-channel 12-bit A/D converter, 21 general GPIO, 2 USART interfaces, 128-bit AES encryption and decrypt security coprocessor, watchdog timer, 32 kHz crystal oscillator sleep mode timer, only a few peripheral circuits can build a ZigBee node [4, 5]. The schematic diagram is shown in Figure 3.
The CC2530 supports a power supply voltage of 2.0 ~ 3.6 V and has three power management modes: wake mode 0.2 μA, sleep mode 1μA and interrupt mode 0.4μA. When the CC2530 is in idle mode, any interruption can restore the CC2530 to active mode. Some interruptions can also wake up CC2530 from sleep mode, which can meet the ultra-short time and fast conversion, and ensure low energy consumption. The operating temperature range is -40 ~ 125℃, which is especially suitable for outdoor working mode that requires long battery life and large environmental changes [6]. CC2530 has its own RF function, and it can be achieved by adding a simple circuit.

The coordinators and routers are similar in composition, including CC2530, antenna, power module, LED and so on. CC2530 is the control center and the central axis of the entire circuit. The antenna is mainly used to transmit and receive data information [7]. Figure 4 shows the composition of the coordinator and router. In the figure, the serial port module is mainly used to establish a connection between the host computer and the router, and the temperature data acquisition module is mainly used to send the temperature data to the coordinator. The LED light on and off indicates the connection of the network.

3. Extended design of temperature sensor module and CC2530 interface

The temperature sensor module consists of a temperature sensor DS18B20 and a 4.7K ω pull-up resistor. DS18B20 chip is a typical single bus acquisition mode, only one data line can complete the communication, with parasitic power supply and external power supply two power supply modes, the design uses external power supply mode. Because DS18B20 internal ROM has a 64-bit serial number, provides the possibility for single-bus multipoint temperature measurement, using DS18B20 internal TH, TL two high and low temperature alarm triggers can realize the temperature alarm function.

The main development board expanded the serial port transceiver module, flash memory module, touch button control and five-way button control module, infrared transmitting and receiving module, liquid crystal display module and temperature sensor module, and THE I/O port resources in CC2530.
is very limited, so the use of jumper cap to extend THE I/O port of CC2530, I/O port multiplexing. All peripherals are connected to the RF module through high-speed full-duplex synchronous communication bus SPI, universal asynchronous receiving/sending device UART, DEBUG and other interfaces. The DEBUG interface is connected to the emulator, and the related signal SPI bus and DEBUG signal are connected to the RF control module through the socket.

4. Rf module and serial port
The rf module interface design circuit uses PORTS P0, P1, and P2.0 to P2.2 in PORTS P2 of CC2530. The RF module leads out all THE I/O ports of CC2530, facilitating function evaluation and secondary development.

The RS 232 serial transceiver module consists of a 3 V to 5.5 V multi-channel RS 232 linear transceiver MAX3232, a 9-pin RS 232 interface, a bypass capacitor required by a typical MAX3232 circuit, and an indicator light. The 0.1μF capacitor at the power and ground ends is used to remove the coupling interference from the digital circuit. Can perform RS 232 level conversion for communication with other peripherals [3, 4, 5]. A power jumper P9 is installed in the module to enable or disable the serial port chip. The serial port has two transceiving indicators, D5 and D6, which respectively indicate whether data is being received or transmitted over the serial port. D7 is the power indicator of the serial port.

The front panel of each program in LabVIEW corresponds to a block diagram program. Block diagram program written in G language, can be understood as the source code of the traditional program. The front panel of the temperature monitoring system consists of tabs, parameter setting panel, and monitoring interface panel.

You can switch between the parameter setting and monitoring screen by selecting the button on the Monitoring screen and Parameter Setting TAB. In the monitoring interface, data waveform display and receive buffer data display can be carried out. With LabVIEW, the temperature measurement received from the serial port can be dynamically displayed in real time. After the program starts to run, click the "Start" button to collect data, and click the "Stop" button to save and playback data. The setting parameters front panel displays as shown in Figure 5.

The program uses a conditional structure, and the True Case on the right belongs to the same Case structure as the False Case in the figure. Decide which Case program to use based on the value on the input. If the generated random temperature value is greater than the high limit value, the True Case program is executed, and if not, the False Case program is executed, and the write spreadsheet file function is used. This module converts a two-dimensional or one-dimensional single-precision array into a string, writing the string to a new folder or following an existing file. In this system, it appends a two-dimensional array composed of temperature collection data and upper limit value to a data file whose default path is D:\testdata.xls.
5. LABVIEW design serial communication

There are three types of nodes in a ZigBee network: ZigBee coordinator node, ZigBee router node, and ZigBee terminal node. Users can choose the right nodes according to their own needs to facilitate the realization of wireless sensor network and networking. The coordinator node sends or receives data from the router node or terminal sensor node and sends the received data to the computer. When the coordinator node cannot communicate with all terminal sensor nodes, the router node serves as a kind of intermediary to enable the coordinator node to communicate with the terminal sensor nodes, realizing the routing communication function. At the same time, the router also has the function of collecting sensor data. The terminal sensor node controls the device and collects data. A ZigBee network has only one ZigBee coordinator, which is often more powerful than other nodes in the network and is the main control node of the whole network. The coordinator initiates the establishment of a new network, sets network parameters, manages nodes in the network and information about nodes in the storage network, etc. After the network is formed, the coordinator can also perform router functions. ZigBee router nodes can participate in route discovery, message forwarding, and extend the coverage of the network by connecting other nodes. In a ZigBee network, each node has specified configuration parameters that determine its device type. Different types of devices have different network tasks. In a ZigBee network, two nodes need to complete data transmission, possibly with the assistance of other intermediate nodes, so it is necessary to configure the type parameters of the nodes. Each node has two tasks: performing specified network function functions and configuring determined parameters to specified values. The terminal sensor node is added to the network as shown in Figure 7.

The setting of the network function determines the type of the node. The temperature monitoring network consists of three nodes: coordinator node, router node and terminal sensor node. First, the three nodes are set through the program configuration. Power off all nodes on the network, connect the serial port of the coordinator to the host computer, start the network temperature monitoring software Z-Sensor Monitor, and select the correct COM port. If no node is connected, the router node and terminal node are empty and the coordinator node is gray, indicating that the network is not working properly. Power on the coordinator node and click the "run" button on the toolbar to enable the

Figure 6. Terminal sensor node joining the network

Figure 7. Router node and terminal sensor node joining the network
function of receiving reports. GATEWAY MODE is displayed on the LCD. That is, the coordinator works in GATEWAY MODE and can receive binding requests from router nodes and terminal sensor nodes to form a new network. If the power supply of the router node is enabled, the router starts to send a node report to the coordinator. The z-sensor Monitor screen displays the router node joining the network established by the coordinator node and the current address of the router node. If the power supply of the terminal Sensor node is enabled, the terminal Sensor node starts to send a report to the coordinator node. When the router node and sensor node join the network, the coordinator node also makes a binding response. The Z-sensor Monitor interface shows that the Sensor node is added to the network established by the coordinator node and that the current oven is 45 ° C. At this time, the address of the Sensor node is shown in Figure 7.

6. Conclusion
The traditional temperature measurement method has a long cycle, high cost, and must connect many transmission lines from each sensor node to the host according to the wired transmission scheme. The wiring in a large scope and large space inevitably produces extremely complex lines, so the work efficiency is low, and it is not easy to manage. ZigBee is a relatively cheap wireless communication technology, the use of it in the field of temperature measurement can greatly expand the function of the temperature detection system. CC2530 as the main control chip, through the design and development of the board circuit and supporting peripheral circuit and temperature sensor circuit, single bus to receive multi-point temperature data, it better realize the ZigBee protocol based on the heating system multi-point temperature transmission and ZigBee networking function.

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