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Multi-Point Temperature Detection System Design

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Abstract: In the context of the rapid development of the beekeeping industry, accurately measuring the temperature inside the hive is crucial for beekeeping. Traditional methods of measuring the temperature inside hives consume a significant amount of manpower and resources. This paper designs a wireless temperature measurement system for remote temperature measurement inside hives based on the NRF905 wireless RF chip. The system designed in this paper includes both a host computer system and a slave computer system, which can be divided into six modules: power supply module, temperature measurement module, minimum system, NRF905 wireless RF module, display module, and over-temperature alarm module. This design allows for the remote display of temperature data inside the hive, enabling real-time monitoring of the bee growth environment. By combining wireless communication technology with agricultural production, this design provides a relatively good solution for hive temperature detection, which is of great significance for promoting the modernization of beekeeping.
Keywords: Wireless communication; DS18B20; NRF905;

1. INTRODUCTION

Temperature, as one of the most common physical quantities in life, not only affects people's daily lives but is also closely related to industrial and agricultural production. In agricultural production, temperature influences the yield of crops and the growth conditions of livestock. Beekeeping, as one of the components of agriculture, also has high requirements for temperature, thus necessitating the design of a temperature detection system to monitor the temperature inside hives in a timely manner. With the rapid development of temperature measurement technology, temperature sensors have been widely used in various temperature measurement and detection systems. This has led to a significant increase in signal cables, which not only complicates wiring and increases the workload of installation but also poses the risk of electromagnetic interference, affecting the accuracy of the measured temperature data, and making maintenance difficult. To overcome these drawbacks, there is an urgent need to develop wireless sensing technology that meets data communication requirements, in order to address the issues caused by connecting cables and reduce production costs.

Using wireless technology for temperature data collection and measurement offers several advantages, such as flexibility, ease of maintenance, and low cost. This is particularly beneficial in harsh environmental conditions where it is difficult to lay cables. By utilizing wireless technology to transmit sensor data, the costs of equipment and labor are reduced, transmission reliability is improved, and the system can meet most usage requirements. It can be widely promoted in the context of beekeeping applications.

This paper focuses on the measurement of temperature inside bee hives, designing a temperature monitoring system capable of remote real-time monitoring. The design integrates wireless communication technology with agricultural production. Specifically, for the task of measuring temperature inside bee hives, a small-volume, high-stability, easy-to-maintain, and reliable data transmission wireless temperature data transmission system is designed, consisting of temperature sensors, microcontrollers, RF chips, and other components. This system enables the measurement, wireless transmission, and display of temperature at multiple points inside the hive, allowing for real-time remote monitoring of the hive's temperature. It provides technical support for the production and life of bees and for increasing honey yield[1].

2. OVERALL SYSTEM DESIGN

The design, differentiated by functionality, is divided into six modules: power supply module, temperature measurement module, minimum system, NRF905 RF module, display module, and over-temperature alarm module.

The overall layout of the design is split into two parts: the upper computer (host) and the lower computer (slave).The lower computer mainly consists of four parts: the minimum system, temperature measurement module, power supply module, and NRF905 RF module. It is responsible for accurately measuring temperature data from multiple points and sending this temperature data to the upper computer via the NRF905 RF module.The upper computer receives the temperature data sent by the lower computer through the NRF905 RF module and displays it using the display module. If the temperature exceeds a threshold, it triggers an over-temperature alarm. Communication between the upper and lower computers is facilitated by wireless transceiver chips, together forming a wireless temperature monitoring system[2].

This design utilizes the digital temperature sensor DS18B20, which can directly output a 9 to 12-bit digital temperature value. Eight DS18B20 sensors are used to measure temperature at eight different points inside the beehive. The system design employs the NRF905 as the wireless communication chip, based on two STC51 microcontroller units. The temperature data collected by the temperature sensors is sent through the SPI interface to the NRF905 transmitter and then to the NRF905 receiver. After the receiver gets the temperature data, it is displayed on the display module, enabling remote monitoring of multiple points within the beehive.

3. SYSTEM HARDWARE CIRCUIT DESIG

3.1 Minimum system

The AT89C51 is a microcontroller produced by ATMEL Corporation. It includes an 8-bit CPU and is an 8-bit CMOS microcontroller. The chip contains 8KB of programmable FLASH memory, which offers strong compatibility and makes debugging and development very convenient. Additionally, it has excellent expandability, allowing it to work with other external chips to achieve functions such as button control, analog-to-digital conversion, and display control. The minimum system of a microcontroller refers to the simplest working environment in which the microcontroller can execute programs normally. An AT89C51 connected externally to a clock circuit, a reset circuit, and basic input modules constitutes a minimum system.

3.2 Display module

The LCD1602 display is a character-type display device, consisting of 32 blocks of 5×8 dot matrices. Each character requires only one complete dot matrix block, allowing the device to display up to 32 characters simultaneously. The display operates on a supply voltage of +5V. The LCD1602 can interface with a microcontroller using either an 8-bit data bus or a 4-bit data bus.

3.3 Temperature measurement module

The DS18B20 is a common digital temperature sensor, known for its small size, strong interference resistance, and high precision. It uses a one-wire interface, requiring only a single data line for communication with the controller. Each DS18B20 has a unique serial number, which allows for multi-point networking and effectively reduces the occupation of microcontroller input/output interfaces[3]. Additionally, the device can be powered using a parasitic power supply, drawing energy from the communication line. This offers advantages such as good economy, strong interference resistance, flexible power supply, and high measurement accuracy.

3.4 NRF905 wireless RF module

This design selects the NRF905 wireless transceiver chip as the core of wireless communication. This device is an independent transceiver introduced by the Norwegian company NORDIC, operating normally within a voltage range of 1.9~3.6V. It can perform wireless communication on three ISM bands: 433MHz, 868MHz, and 915MHz[4]. When using the 433MHz communication frequency, which offers the longest transmission distance and the least signal attenuation, the communication range can reach up to 500 meters, with a packet loss rate of less than 1%. Additionally, it is not limited by communication networks, overcoming the risks of GPRS disconnection and the short communication range and high packet loss rate associated with Wi-Fi and Bluetooth technologies [5]. The channel switching speed is fast, capable of making a switch operation within 650μs. It supports the low-power ShockBurst™ transmission mode, which automatically handles the preamble and CRC checksum, thereby simplifying the tasks of the microcontroller and improving the efficiency of data transmission.

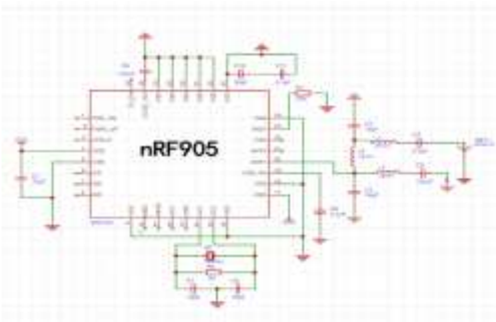

Figure. 1 NRF905 Pinout Diagram

4. SOFTWARE PROGRAM DESIGN

The software part mainly involves the writing of the host and slave programs, requiring modular programming. The slave system collects temperature values from each temperature sensor at various measurement points and sends them to the NRF905 wireless RF module, which then wirelessly transmits the data to the host's NRF905 wireless RF module, completing the transmission process. The slave program includes the main program, temperature collection program, and wireless transmission program.

The host system receives data transmitted from the nodes through the NRF905 wireless RF module, sends it to the microcontroller, and displays it on the LCD1602 screen, while also using an LED for over-temperature alarm. The host program includes the main program, wireless reception program, data display program, and over-temperature alarm program.

4.1 Temperature acquisition program

In the temperature acquisition module of this design, the host is an AT89C51 microcontroller, and the slaves are eight DS18B20 sensors connected in parallel on the bus. When the AT89C51 needs to receive temperature data measured by the DS18B20, it first actively initiates an initialization sequence to initialize the device, then enters the write sequence to send temperature conversion commands, ROM match commands, and read memory commands. Finally, the AT89C51 initiates a read sequence to retrieve the temperature data.

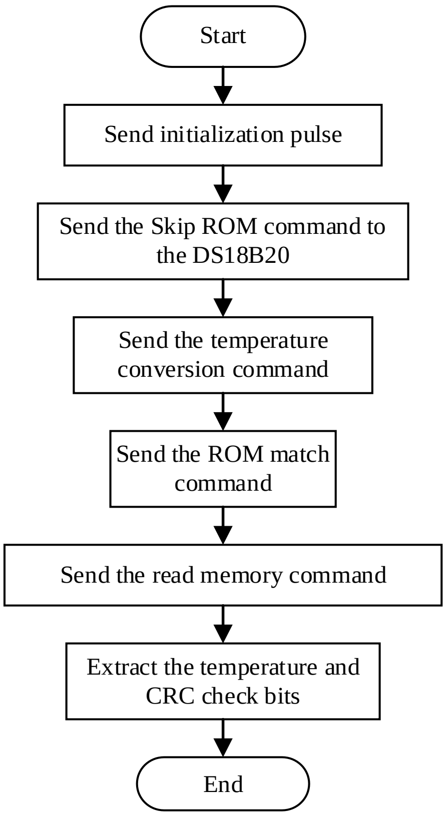

Figure. 2 Temperature Measurement Program Flowchart

4.2 Wireless transmission program

The NRF905 temperature data transmission process is divided into the following steps:

A. When the AT89C51 in the temperature measurement and transmission module receives temperature data, the AT89C51 first sets the SPI interface rate and simultaneously transmits the address of the NRF905 in the temperature reception and display module and the temperature data to the NRF905 through the SPI interface.

B. The AT89C51 controls TRX_CE and TX_EN to go high, setting the NRF905 to ShockBurst™ transmission mode.

C. The NRF905 enters the ShockBurst™ transmission state:

1. The RF configuration register is automatically enabled.
2. The NRF905 automatically combines the preamble and CRC checksum with the temperature data and packs them together.
3. The data packet is transmitted.
4. After the data packet is sent to the NRF905 receiver in the temperature reception and display module, the data ready pin DR automatically goes high.

D. If the automatic retransmission parameter AUTO_RETRAN is set high during device initialization, the NRF905 continuously repeats the data packet transmission.

E. When TRX_CE is set low, the transmission process is completed, the ShockBurst™ transmission mode ends, and it automatically enters the standby power-saving mode.

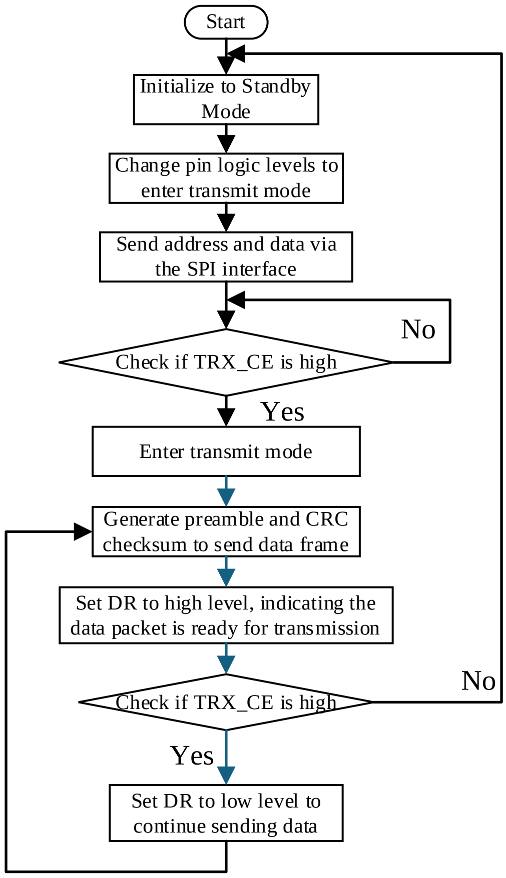

Figure.3 Wireless Transmission Program Flowchart

4.3 Wireless reception program

The NRF905 temperature data reception process is divided into the following steps:

A. The AT89C51 sets TRX_CE to a high level and TX_EN to a low level, configuring the NRF905 to ShockBurst™ reception mode.

B. After a brief 650μs preparation time, the NRF905 continuously monitors the external carrier signal.

C. When the NRF905 detects a carrier signal at 433MHz, the carrier detect pin CD is set to a high level.

D. The address in the data packet is checked to see if it matches the address set in the internal register of the NRF905 in the temperature reception and display module during initialization. If they match, the address match pin AM is set to a high level.

E. The preamble synchronization sequence and CRC check are used to verify the accuracy of the temperature data. Once the data is confirmed to be correct, the NRF905 automatically removes the preamble, address, and CRC check bits from the data packet and sets the data ready pin DR to a high level.

F. The AT89C51 sets TRX_CE to a low level, completing the reception process. The ShockBurst™ reception mode ends, and it automatically enters the standby power-saving mode.

G. The AT89C51 in the temperature reception and display module transfers the data to the AT89C51 via the SPI interface at the user-defined SPI interface rate.

H. After the complete transfer of data to the AT89C51, the NRF905 in the temperature reception and display module sets the data ready pin DR and the address match pin AM to low.

I. At this point, the NRF905 can enter any operating mode or power-down power-saving mode.

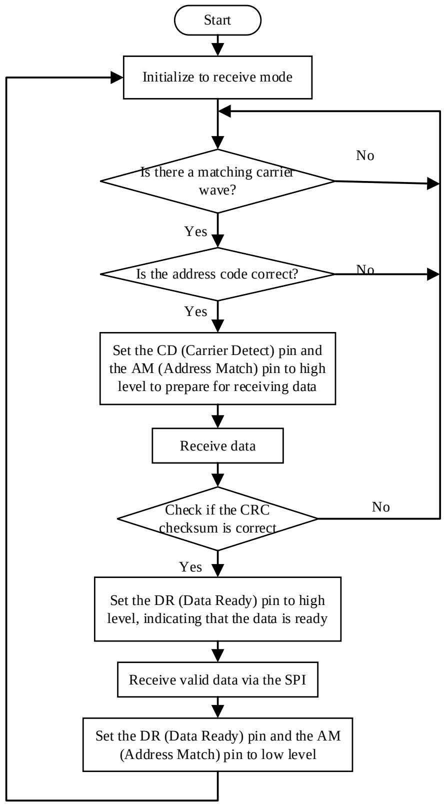

Figure.4 Wireless Reception Program Flowchart

5. CIRCUIT HARDW ARE ASSEMBLY AND SYSTEM DEBUGGING

This design uses Keil uVision5 for programming and Proteus8.6 for circuit diagram simulation. Keil is one of the most commonly used software development platforms for microcontroller learners. It integrates a variety of functions such as editing, compiling, and simulation. In terms of programming languages, it not only supports assembly language, which is often used by beginners, but also supports the more concise and clear C language, catering well to all kinds of users. This has made it one of the most popular software for the development of programs for 8051 architecture microcontrollers.Proteus is a widely used circuit simulation software that not only covers circuit simulation and PCB design capabilities but also allows for the simulation of microcontroller circuits. It assists users in learning about and designing a variety of circuits. After adding the target file with the .hex extension, which has been successfully compiled by Keil, to the microcontroller, the two software programs operate in conjunction to simulate the data acquisition and display module. The simulation results show that the eight DS18B20 temperature sensors measure temperature and the LCD1602 displays the temperature normally, and it is possible to switch and display temperature data from different sensors using buttons. When the temperature exceeds the user-defined threshold set in the program, the temperature alarm light turns on, and the over-temperature alarm module functions properly.

6. REFERENCES

Based on the study of various short-range wireless communication technologies, this paper designs a short-range wireless temperature acquisition, transmission, reception, and display system that is based on the nRF905 RF transceiver module, DS18B20 digital temperature sensor, and the AT89C51 microcontroller.This paper addresses the need for multi-point temperature detection inside beehives by carrying out both hardware circuit design and relevant software programming. The hardware circuit design includes the selection of a microcontroller, temperature sensors, wireless transceiver chips, and display modules, as well as the circuit design for the temperature measurement module, wireless transmission module, and LCD display module. This paper employs partial simulation to simulate two important modules identified in the requirements. In terms of software program design, programs for temperature measurement and wireless transmission of temperature data have been developed.The design takes full advantage of the low power consumption characteristics of the selected components, significantly reducing the system's energy consumption. This allows the system to operate normally for extended periods in the field where power supply conditions are lacking, making it more suitable for beekeeping environments. The temperature measurement system is cost-effective, reliable in temperature measurement, has a high rate of accurate data transmission, is convenient for maintenance, and offers considerable economic benefits.

7. REFERENCES

[1] Hugo Hadjur, Doreid Ammar, Laurent Lefèvre, Toward a n intelligent and efficient beehive: A survey of precision beekeeping systems and services. Computers and Electro nics in Agriculture, 2022, Volume 192: 0168-1699.

[2] Wang, Xue Mei, and Guo Ping Li. "Granary Wireless Te mperature Monitoring and Alarm System Based on DS18 B20." Applied Mechanics and Materials 220–223 (Nove mber 2012): 1625–27.

[3] Wu, Yan Xiang, Dan Liu, and Xing Hong Kuang. "A Te mperature Detecting System Based on DS18B20." Advan ced Materials Research 328–330 (September 2011): 1806 –9.

[4] Huang, J., Liu, D., & Yuan, Q. (2019). An Anthurium Gr owth Environment Monitoring System Based on Wireless Sensor Network. International Journal of Online and Bio medical Engineering (iJOE), 15(05), pp. 69–85.

[5] Huang Tao, Fang Qing, Sun Qingye. Design of Unmanne d Boat Wetland Environmental Monitoring System Based on Microcontroller Technology [J]. Science, Technology and Innovation Application, 2024, 14(9): 50-55, 60.