The Design of Intelligent Home Furnishing System Based on ZigBee Technology

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Abstract—**In this paper, the design of intelligent control system in home furnishing application that uses CC2530 TI Company's chip, this chip integrates the RF transceiver with 2.4 GHz communication protocol (IEEE802.15.4), meet the system requirements with less cost by using ZigBee technology. The system is designed by using temperature and humidity sensor, light intensity sensor, ambient gas information monitoring for home furnishing environment, and the GSM technology for information exchange. More specifically, it combines the mobile communication technology with ZigBee wireless network technology as well as micro controller technology to realize the data communication between human and machine, machine and machine, in order to achieve the intelligent control of home furnishing life.**

Keywords-component; intelligent home furnishing; ZigBee; CC2530; GSM; sensor

I. INTRODUCTION

With the development of the information age, intelligent equipment has become an indispensable part of people's life. The intelligent home furnishing as a product of the information age, the various information sensing devices that are integrated with the subsystems organically, and connected with the Internet and communication network to realize the information exchanging between every equipment directly or indirectly. Consequently, the environmental monitoring and controlling of home furnishing will be well implemented. In this paper, the design of wireless intelligent home furnishing system based on ZigBee technology, monitoring of the home furnishing ambient parameters through all kinds of sensors in the system, and the users can use the terminal equipment to realize the long distance control of household appliances, which has greatly improved the safety and comfort in home furnishing life.

II. OVERALL FRAMEWORK DESIGN OF THE SYSTEM

The ZigBee wireless network technology is adopted, and the intelligent monitoring of the whole home environment is combined with the microcontroller, the data acquisition module and the data output module. At the same time, users can use the terminal devices (such as computers, mobile phones, etc.) for local control or remote control of the system. The overall architecture of the system is shown in figure 1.
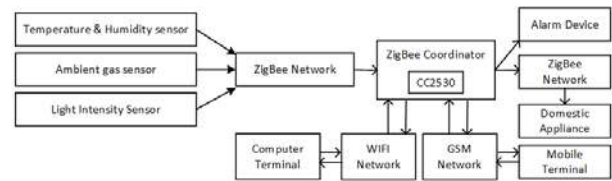

FIGURE I. OVERALL ARCHITECTURE DIAGRAM OF THE SYSTEM

In the home environment need to monitor the location of the collection node, these acquisition nodes under the ZigBee protocol to build an internal self-organizing network. Each household appliances contains acquisition node (sensors), and the information is collected by the CC2530 unified processing chip ZigBee module, and the user can be observed and controlled by computer, mobile phone and other intelligent terminal.

In terms of CC2530 serial communication interface chip [1], the system can realize the data transmission between the acquisition node and CC2530 chip within the users' terminal equipment that is equipped with Wi-Fi, GSM network as well as UART serial communication interface for information exchange in ZigBee communication protocol. Additionally, the user can use the terminal equipment sends corresponding control command to control household appliances, such as water heater, refrigerator, air conditioning and so on. To achieve data upload and command between the system controller and terminal equipment. The user can configure the sampling frequency and output module to set the acquisition module according to the needs of their own values, improve the control accuracy of the controller, improve the home furnishing environment safety and comfort, and create a better home furnishing life.

III. SYSTEM HARDWARE STRUCTURE DESIGN

Hardware is the foundation of the whole system, only the establishment of a perfect hardware structure, the whole system can be established with stable and accurate management. The modular design of hardware structure, one can simplify the configuration and reduce design risk, improve the quality and reliability of hardware; on the other hand, the combination of different modules to meet the diversified demands of the user.

The modules of the home furnishing system are stated as follows.

A. ZigBee Control Module

The core of the ZigBee control module is the CC2530 chip, which integrates an enhanced 8051 microcontroller core. At the same time, it also has four different versions of flash, CC2530F256 respectively with 256KB flash, this device provides a nonvolatile memory circuit within the program that is programmable and mapped to the CODE and XDATA of storage space, we can use network data stored at any time. CC2530 has the active mode, idle mode and sleep mode of three kinds of power management mode, making it especially suitable for ultra-low power requirements of the CC2530 system has a wide set of peripherals, including 8 channel 12 bit A/D converter and 21 universal I/O interface, 2 USART interface, 128 bit AES encryption and decryption protocol processor. The watchdog timer 32 kHz oscillator sleep mode timer, so only few peripheral circuits can be built into a simple ZigBee node [2]. At the same time, each connected to the CC2530 universal I/O interface. The peripherals can select two different I/O pin locations to ensure their flexibility in different applications.

B. Data Acquisition Module

In the system, temperature and humidity sensors, light intensity sensors, gas sensors belong to the data acquisition module, its role is to collect temperature, humidity, light intensity, combustible gas concentration and other information. Ambient acquiring by using SHT10 digital temperature and humidity sensor on the indoor temperature and humidity, the humidity measurement precision is $\pm 4.5\%$, the temperature measurement accuracy of $\pm 0.5℃$ and the IIC interface with the micro controller connected with CC2530 to realize the data transfer, and the application circuit is shown in figure 2. At the same time, the sensor has the advantages of strong anti-interference ability, ultra-fast response, ultra small volume, very low power consumption, high cost performance, and so it is very suitable for monitoring the home environment [3].
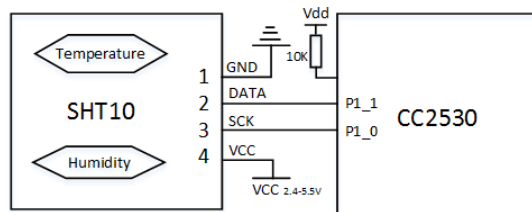

FIGURE II.   SHT10 APPLICATION CIRCUIT DIAGRAM

Using GY-30 digital optical module of the light intensity information is collected, the optical properties and the spectral range is very similar with sensory of the human eye, and the sensor built-in 16 bit A/D converter, the digital output can be directly connected with the microcontroller through the serial port, omit complex calculation and calibration. According to the gas environment parameters, using MQ-2 gas sensor has good sensitivity and stability of the monitoring of indoor combustible gas, the gas sensor detection range, induction speed, long service life and simple driving circuit. It can monitor methane, propane, butane, ethanol, carbon monoxide and other common combustible gases sensitively by [4]. This design uses MQ-2 gas monitoring module to provide the TTL signal output mode and CC2530 general I/O interface to achieve monitoring data upload.

C. Data Output Module

The data output module consists of relays and optical coupler, used in the design of two terminals as the input, the other two terminals as output, the intermediate optical coupler to realize input high performance solid state relay output electrical isolation, the relay has the characteristics of high power, high sensitivity and reliability. During the operation of the system, the controller can control the household appliances (such as refrigerators, air conditioners, water heaters, etc.) or drive the alarm device through the output module after receiving the user's control instructions.

IV.   SOFTWARE DESIGN

Through the modular design scheme, the whole structure mainly includes host module and terminal module. Through the implementation of information exchange system between the ZigBee network, Wi-Fi network and GSM network, the host module can be analyzed, the data collected by each sensor with feedback to the user, but the user can directly control the system through the terminal equipment.

A. Host Module Software Design

The main function of the host module is based on the received user instructions to make the corresponding control, and the collected data is sent to the user terminal, the specific program flow chart as shown in figure 3.
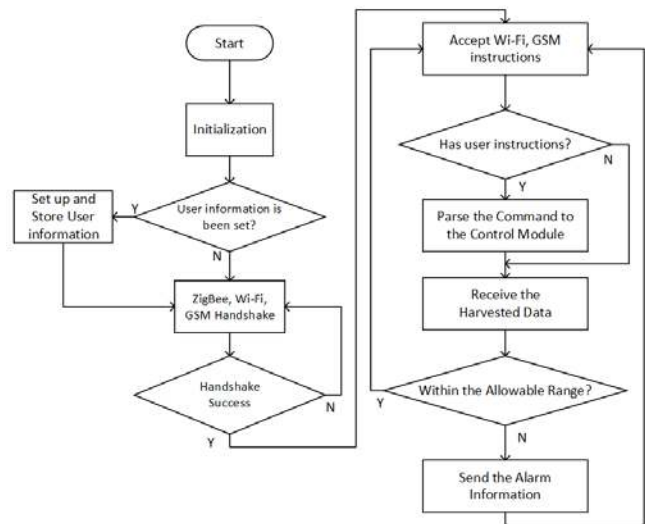

FIGURE III.   FLOW CHART OF HOST MODULE PROGRAM.

After initialization, the system will prompt the user to set the phone number, control parameter value and so on, and store the information into the CC2530 chip. After the user configuration is completed, the host module will connect to the Wi-Fi network, and send handshake signals to the GSM module to achieve GSM networking. Each module after the

successful handshake, the host module to receive user instructions from the Wi-Fi and GSM network, when the user receives instructions, the master chip will be forwarded to the corresponding control module, while the acquisition module receives the data (such as temperature and humidity, gas concentration etc.) sent to the user terminal.

B. Terminal Module Software Design

The program flow chart of the terminal module is shown in figure 4. After the terminal module is initialized, it shakes hands with the host module. After the handshake is successful, the program will prompt the user to directly control the system. If direct control, the user can send instructions directly to the main control module to achieve the control of the system; if not directly controlled, the program will enter the receiving host module instruction state. When the host module commands are received, the program will parse it back to the user, and then the user can send the corresponding control instructions according to the information obtained.
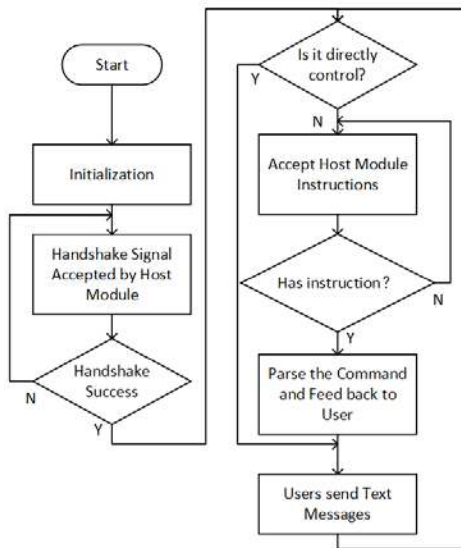

FIGURE IV.   FLOW CHART OF TERMINAL MODULE

V.   SYSTEM COMMUNICATION NETWORK DESIGN

In the system, the ZigBee wireless sensor network is used to communicate with each other between the acquisition nodes and the microcontroller, while the microcontroller and the user terminal equipment use Wi-Fi and GSM network to communicate.

A. ZigBee Technology

- ZigBee network overview

ZigBee is a two-way wireless network communication technology based on IEEE 802.15.4 standard. It has the characteristics of low power consumption, low cost, low complexity, high reliability, strong compatibility and so on. At the same time, ZigBee supports star, cluster, mesh and other network topology [5]. In this design, the star network topology with low complexity and simple control is used. In ZigBee protocol, the ZigBee terminal node information acquisition and

data transmission, and finally the data collected through the ZigBee network to the micro controller for unified treatment, in order to achieve the home furnishing environment intelligent monitoring.

- ZigBee protocol stack.

The Z-Stack protocol stack developed by TI Company is used in the ZigBee network, and the stack is an operation system based on rotation query. Overall, the Z-Stack stack has two aspects: one is system initialization, and the other is the start of operating system entities. System initialization refers to the system boot code need to complete the initialization of hardware platform and software architecture for each module, for the operation of the operating system to do the preparatory work. Initialization is divided into system clock, chip working voltage, initialization stack, initialization module, the hardware initialization of Flash storage, forming MAC chip address, initializing nonvolatile variable, initialization of MAC layer protocol, application layer protocol, and frame initialization operation system more than a portion. Boot operating system refers to the initialization of the operating system for the operation of the system to do the preparatory work, the beginning of the implementation of the operating system entry program, and thus completely control the right handed to the operating system. Its function is to constantly query whether each task has an event, if there is, then perform the corresponding operation; if not, then query the next task [6].

B. Wi-Fi/GSM Network Technology

Wi-Fi and GSM networks are used to provide network services for the information transfer between the host and the mobile terminal and the ZigBee module. Wi-Fi is a wireless network technology based on IEEE 802.11 standard. It has low price, strong anti-interference ability and fast transmission speed. It is very suitable for smart home system. In this design, the Wi-Fi module can be connected with the ZigBee network through the ZigBee coordinator, and the data transmission between the Wi-Fi network and the ZigBee network can be realized. GSM is a kind of mobile communication network technology with large network capacity, strong stability and low power consumption. Is used in the design of a dual band 900 / 1800 MHz highly integrated GSM module (TC35i), the module can be connected through the USART serial communication interface RS 232 communication interface with CC2530, and to achieve the user's mobile terminal and home furnishing system controller [7] data transfer using AT instructions. So as to achieve the user remote control home equipment, monitoring the effect of the home environment

VI.   CONCLUSION

The intelligent home system designed in this paper mainly uses ZigBee wireless network technology to realize the home environment of the network, and combined with micro controller and a variety of sensing equipment to achieve the intelligent control effect of the home environment. The use of modular design makes the stability, flexibility and compatibility of the system is relatively strong, the user can monitor and control the environment home furnishing far short of electrical equipment at the same time, to further improve the

user's living conditions, make life more comfortable, safe. The whole system has the advantages of simple structure, easy operation, low cost, low power consumption, high reliability and so on. It is very suitable for use in modern smart home.

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