

Design of ZigBee-WiFi Gateway for Vacuum Oven

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Abstract: In the process of power battery production, it is necessary to put battery into vacuum oven for drying, the temperature, the vacuum degree and other factors directly influence the quality of the power battery. In order to remotely control the temperature and vacuum degree of vacuum oven in the process of power battery manufacturing, the wireless communication system based on the ZigBee-WiFi gateway for the power battery production is presented. The system uses wireless module CC2530 as the core chip, to complete the machine networking in workshop, and use of WiFi wireless module ESP8266 to complete data interconnection ZigBee and WiFi network, implement the data information exchange and sharing between the vacuum oven and the Internet. This wireless communication system has the characteristics with easy networking, low power consumption and low cost. So, this communication system can meet the requirement of data transmission and sharing in power battery manufacturing and other production activities.

Keywords: battery drying; vacuum oven; ZigBee; wireless communication; monitoring system

1 Introduction

In the power battery manufacturing, the internal moisture content of battery directly affects the battery voltage, internal resistance, self-discharge and other indicators^[1]. If the battery with much high moisture content will lead to battery quality decline, scrapped, and even the risk of explosion. Therefore, in the production process of the lithium battery, the positive and negative pole pieces, the core and so on should be baked several times to remove the moisture as much as possible to enhance the battery quality. At present, the most factories use the vacuum oven to create the environment of high vacuum, high temperature uniformity and low dew point to reduce the moisture content of the battery^[2]. Battery production process is show in Figure 1.

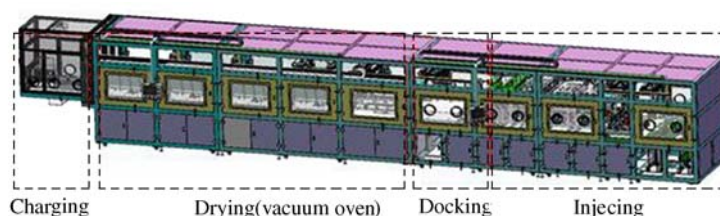


Figure 1 Battery production process

A series of environmental factors such as vacuum degree and temperature determine moisture content of lithium battery. Through the real-time online monitoring of the vacuum drying oven environmental factors, it helps to control power battery drying technology, so as to guarantee the quality of the power battery. However, in the actual power battery production, there are a large number of vacuum ovens, and each oven needs to monitor a number of environmental factors, therefore, a data transmission system with a large number of nodes, easy networking and low power consumption is needed.

ZigBee technology is a short-range, low-power wireless communication technology, operating at a frequency of 2.4 GHz^[3], it is characterized by large network capacity, self-organization, low complexity, low power consumption, low data rate. ZigBee can be embedded in a variety of equipment, mainly suitable for automatic control and remote control, now which has been widely used in military, agricultural, industrial, environmental, medical and other fields^[4].

This paper aims to design a wireless communication system for power battery production, through ZigBee module and WiFi module and the corresponding software to complete the data transmission and interconnection to share, and then realize the power battery production equipment monitoring and seamless link between production data and Internet to ensure the quality of products and improve the level of power battery production.

2 Hardware

ZigBee-WiFi gateway on the hardware is divided into ZigBee module and WiFi module. The ZigBee node is responsible for collecting the data of temperature, air pressure and equipment status of each vacuum oven, and then the data is collected into the ZigBee coordinator. The ZigBee coordinator to transmit data to the WiFi module. The WiFi module is connected to the router to transmit the data to the internet. The system is shown in Figure 2.

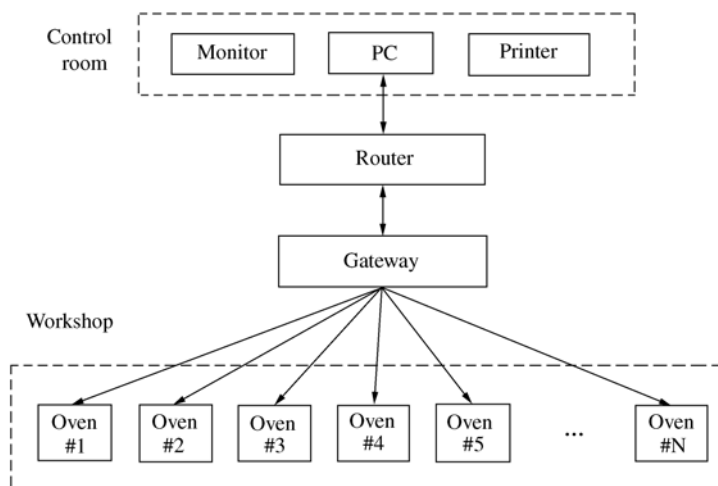


Figure 2 Structure of the system

There are many vacuum ovens in the production of power battery, so it is necessary to set up a ZigBee node

in each oven, and collect the data of the corresponding oven respectively. The working mode of the node is set as the terminal (end device). As Figure 3 show, the gateway is composed of ZigBee Coordinator and WiFi chip, the ZigBee Coordinator is responsible for constructing the ZigBee network and the data collection of the terminal equipment, and the WiFi chip completes the connection between the gateway and the router^[5]. Router to achieve the connection with Internet and data forwarding. In this way, the data of the vacuum oven can be transferred from the production workshop to the control room, and the physical parameters of the vacuum oven can be observed in real time by controlling the monitor in the room.

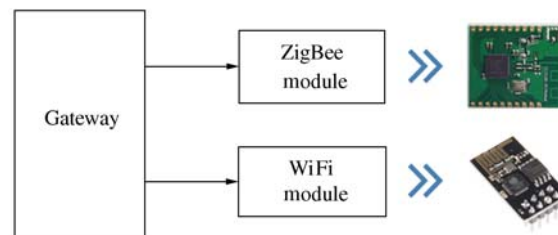


Figure 3 Structure of the Gateway

ZigBee modules currently on the market include JN513x series, cc25xx series, MC1321X and MC1319X series chips, and both have introduced ZigBee protocol stacks based on their respective chips. CC2530 has the following advantages^[6]:

1) The internal integration is the standard enhanced 8 051 controllers and widely used, the it reference material is sufficient. Other manufacturers are using their own unique processor, needs to re-understand the internal structure of the processor.

2) The Z-Stack protocol stack is completely free and is semi-open source.

3) The integrated development environment is IAR, which is more efficient.

As for WiFi module, ESP8266 is a low-cost, high-performance, highly integrated wireless SOC. The chip integrates TCP/IP protocol, supports 802.11b/g/n/e, supports AP, STATION, AP & STATION three kinds of work pattern^[7]. When ESP8266 is responsible for wireless internet access to assume the task of WiFi adapter, you can add it to any micro control based design, the connection is simple, just through the SPISDIO or I2C/UART port.

Taking the advantage of ZigBee and WiFi, the gateway has the characteristics with large capacity, low power consumption and easy networking^[8].

3 Software

CC2530 all data sent and received via the Z-Stack protocol, Z-Stack is a semi open commercial protocol stack based on ZigBee alliance member of the TI company. Launched the protocol stack programming environment is IAR compiler^[9], IAR embedded workbench is an efficient embedded integrated development environment (IED).

Each specific project needs to be properly configured before development. The working mode of the ZigBee module in vacuum oven should be set to the terminal mode (end device), ZigBee module inside the gateway is set to the coordinator (Coordinator), establishment, receiving information, collection and transmission coordination is responsible for the ZigBee network. The coordinator flowchart is shown in Figure 4.

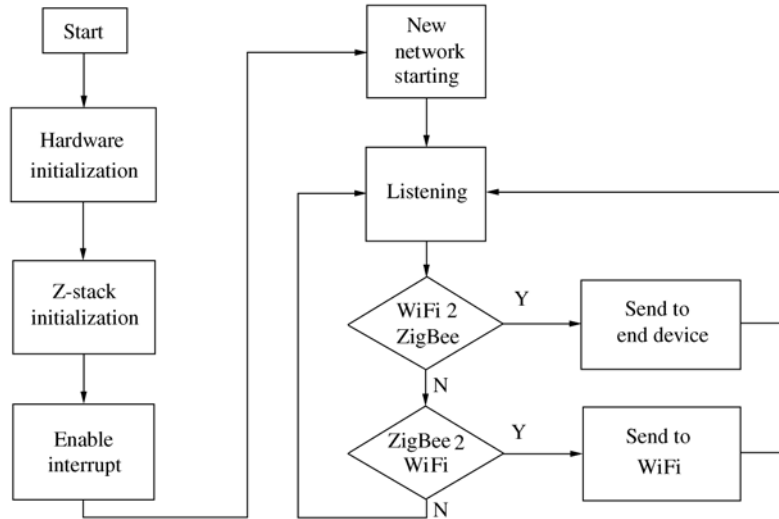


Figure 4 Coordinator flow chart

WiFi module to achieve ZigBee network data transmission and WiFi network data reception. Firstly, the ESP8266 is configured as a station mode, so as to connect to a wireless router, and then into the listening state, listening to the ZigBee network whether there is data transmission and router data sent to the ZigBee coordinator^[10]. The flowchart of ESP8266 is shown in Figure 5.

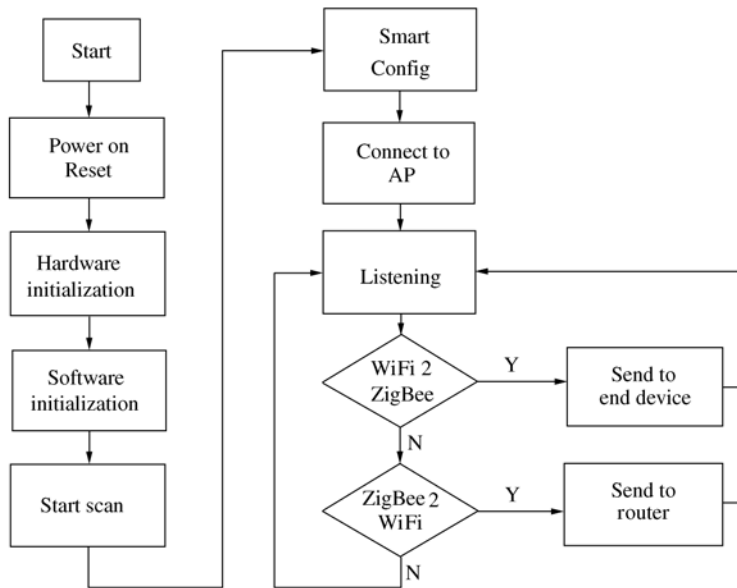


Figure 5 ESP8266 flow chart

4 Testing

Firstly, the gateway function testing is shown in Figure 6. The gateway by curing in WiFi module of the program to connect to the server on the Internet, the operation monitoring software on PC (monitoring software) (slave) as the client connects to the server, this software can monitor and ZigBee nodes for data transmission. In order to transmit data to the real reaction, six vacuum ovens are simulated, each vacuum oven temperature value as the data to be transmitted, by placing in different locations of the temperature sensor to collect temperature as the vacuum oven temperature value is transmitted to the server^[11]. As seen from Figure 6, the monitoring software can be real-time observation of these six different temperature data. After a few days of testing, the system does not appear abnormal, which shows that the present gateway is stable and reliable.

Workshop	Oven	Condition
#1	001	running
#1	002	running
#1	003	running
#1	004	running
#1	005	running
#1	006	running

Oven	Device ID	Temperature	Vacuum	Time
001	54824	11.2 °C	null	2016/03/10 10:47:26
002	72428	23.2 °C	null	2016/03/10 10:47:26
003	67223	17.5 °C	null	2016/03/10 10:47:26
004	31804	20.8 °C	null	2016/03/10 10:47:26
005	47692	38.2 °C	null	2016/03/10 10:47:26
006	69940	19.6 °C	null	2016/03/10 10:47:26

Figure 6 Monitoring software

5 Conclusions

In this paper, CC2530 and ESP8266 as the core chip, the design and implementation of a power battery for the production of ZigBee-WiFi gateway are completed. The wireless gateway implements the seamless connection between the ZigBee network and the WiFi network, satisfies the requirements of the remote monitoring and production data uploading of the production equipment, and extending the coverage of the ZigBee network. In addition, the gateway has low power consumption, simple structure, convenient networking and other characteristics, can be widely used in power battery production.

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