Low-Power Consumption Wireless Monitoring System Based on MSP430/LabVIEW

Yang Sun, Yawen Dai

School of Science, Wuhan University of Technology, Wuhan 430070, Hubei, China

Abstract

Concerning the scientific management of dustbins caused by the increasing urban rubbish, this paper puts forward a low-power consumption and wireless monitoring rubbish system and fault self-test design method based on MSP430 single-chip microcomputer. MSP430 features the conversion of two low-power consumption models, namely LPM0 and LPM3, which can effectively reduce the power consumption of the system. The wireless monitoring system can realize the collection of the geological position, weight and height of the box carrier, which can be sent to the monitoring terminal in the format of data packages through the GSM/GPRS module. LabVIEW can unpack and verify data. The Baidu Map API technique can be employed to display the node information on the visualized screen. Besides, when cleaning or fault signals are tested, the terminal will immediately send messages to corresponding personnel in charge for treatment. The test results show that the system is characterized by high precision, low-power consumption, small volume and easy installation, so it can contribute to scientific management of urban dustbins.

Key words: LOW-POWER CONSUMPTION, FAULT SELF-TEST, GPS, WIRELESS MONITO-RING, BAIDU MAP API, LABVIEW

1. Introduction

As people's living standards keep on improving, domestic garbage is also on the increase, thus worsening the issue of living environment, especially the treatment of surrounding dustbins.

With the rapid development of science and technology, people become more expected about the intelligent experience brought by science and technology development[1]. For example, the utility model provides an intelligent ash bin with rational structure, safe and convenient use, economic and practical, having functions of sterilization, disinfection and deodorization no medicament is needed the sterilization disinfection has no dead angle and no any remnant so as to prevent secondary[2]. To make the intelligent machine more acceptable to human life, and to develop an intelligent dustbin which controlled by gestures will realize interactions between human and intelligent dustbin[3].

Concerning the issue, this paper studies the intelligent dustbin system. In response to the current demands, a wireless intelligent dustbin monitoring system design plan is put forward in this paper. According to the geological position suggested by the collected data, the system can judge whether it is necessary to change the dustbin. Due to the adoption of battery power supply, low-power consumption design becomes a necessity. Not only does the main control chip MSP430 adopt the low-power consumption method, but also the power management chip is adopted to realize the low-power consumption of the GSM/GPRS module and GPS module. Among them, the wireless transmission through the GSM/GPS module can ensure the reliability of data transmission[4]. LabVIEW is characterized by short development period, diversified function performances and display controls, data collection, instrument control, Active X and other integration banks, DLL bank interface, implementation of external scripts, etc.

2. Wireless monitoring node design

Wireless monitoring node adopts MSP430F5342 as the controller, acquires the value of various indexes by reading the ultrasonic module, GPS module and ADS1248 module, and sends the value to the monitoring terminal in the specific frame format through the GSM/GPRS module.

The system is mainly made up of two parts, the wireless monitoring nodes and the monitoring terminal. The former is made up of the main control chip, the MSP430F5342[5], the GSM/GPRS communication module (MC52IR3), the NEO-6 of the GPS module, the ultrasonic transducer, the spoke-type sensor and the power supply module. See Figure 1 for the node design framework.

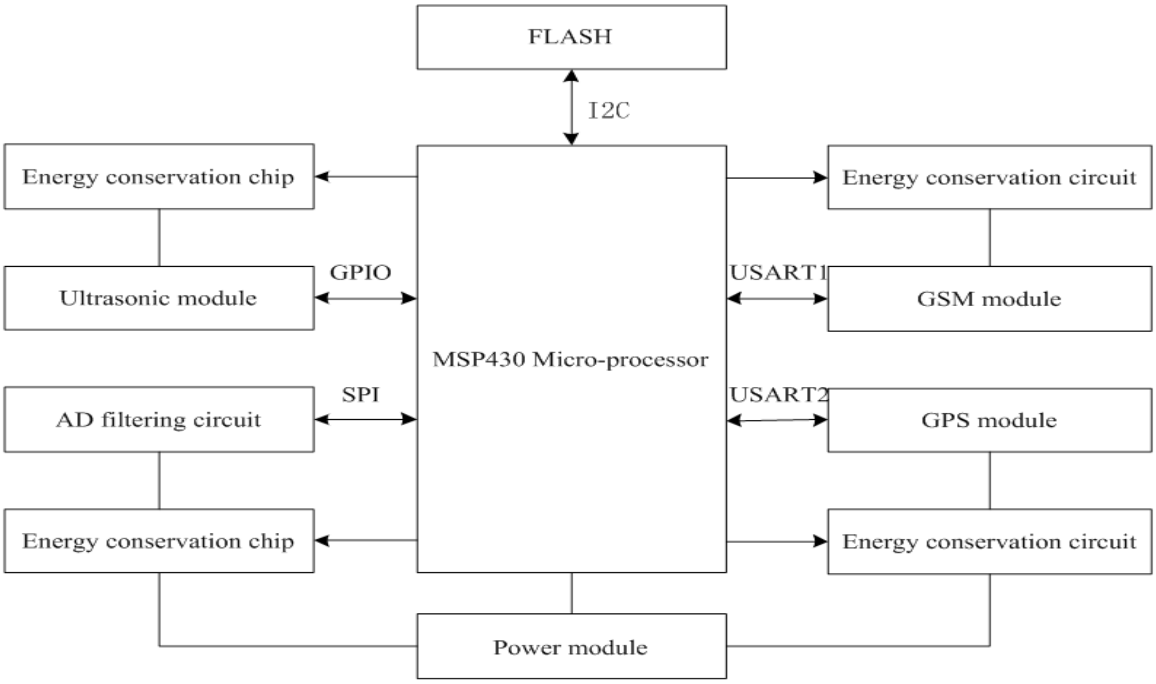

Figure 1. Node design framework

The circuit undergoes low-power design. The micro-processor controls every part of the circuit through the energy conservation chip or the energy conservation circuit. The standard interface, either RS232 or four-wire interface (power supply, signals+, signals- and ground connection) is designed between the sensor and the micro-processor.

2.1. GPS precision and fault test design

Due to the huge influence of environmental factors on the GPS, software needs algorithm analysis and starts proper GPS module time so as to better achieve low-power consumption and positioning precision of the system. Cyclic Redundancy Check (CRC) verification algorithm [6] is employed to improve the accuracy of GPS data. GPS positioning precision experiment is conducted on the system on rainy days. The GPS antennas are placed outside the window. The GPS module is started every 15 minutes. After being started for one minute, the GPS module will be closed. The data are read for 120 times. The tested positioning precision of GPS is shown in Figure 2.

In order to better achieve low-power consumption and the valid positioning data, the experiment of the GPS module starting time and the valid positioning time relationship is conducted on rainy days. There are eight nodes in total. Apart from the starting time, the other configurations of every node are totally the same. The starting time of the GPS module of every node is 30s, 35s, 40s, 45s, 50s, 55s, 60s and 65s, respectively. Through the comparison of 120 times of data reading of every node, it is found out that the optimal starting time of the GPS module is 60s. The optimal starting time can not only achieve valid positioning data, but also moderately reduce the system's power consumption. The relationship between the starting time and the valid positioning time is shown in Table 1.

Through the above two experiments, it can be found out that, if the GPS module is not broken or the antenna is not covered, the GPS module will not conduct positioning continuously for three times. Therefore, if the GPS module among nodes fails to receive the valid positioning data continuously for three times, the GPS fault signals re sent to the monitoring terminal.

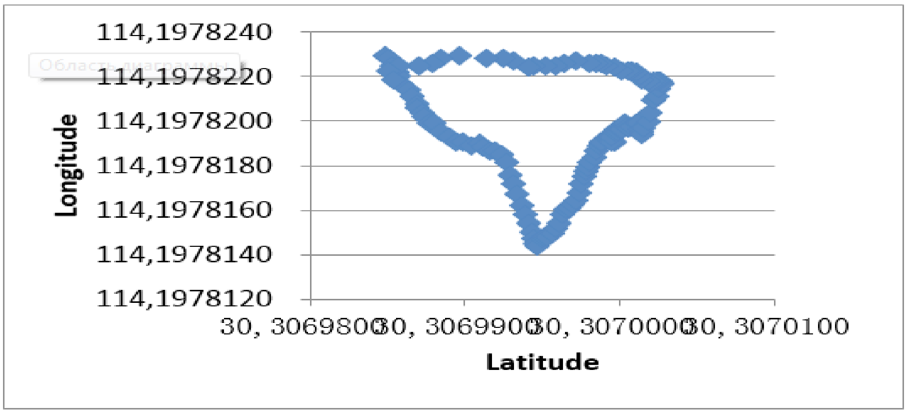

Figure 2. GPS positioning precision

Table 1. The relationship between the GPS starting time and the valid positioning time

Starting time	30s	35s	40s	45s	50s	55s	60s	65s
Data reading time	62	74	80	96	104	110	118	119

2.2. Spoke-type sensor software design

The median average filtering algorithm adopted by the software is equal to the combination of the median filtering method and the arithmetic average filtering method. AD continuously collects data 16 times and removes the maximum and minimum value. Then, the arithmetic average filtering of 14 times of data is calculated. The algorithm can remove the deviation of the sampling value caused by the impulse interference[7].

In order to increase the precision of the sampling data, INSTRON 5882 is employed for the standardization. Since the value collected by the sensor and the weight value are linearly related, the sampling data conducts the linear fitting through the least square method to obtain the fitting linear equation. The data fitting images are shown in Figure 3.

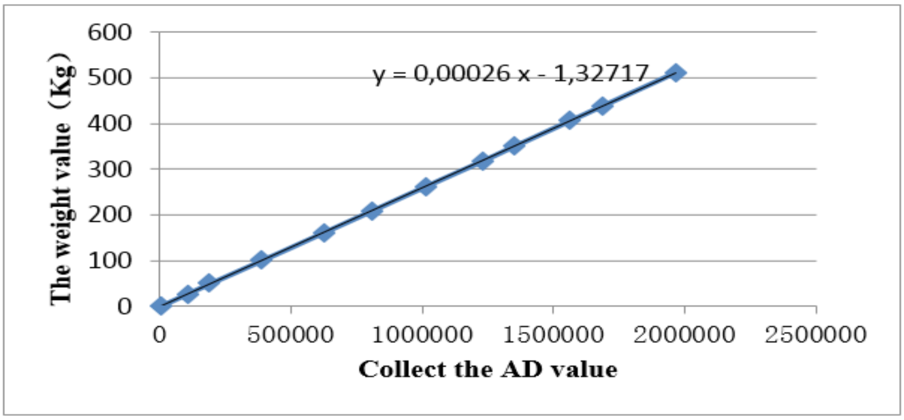

Figure 3. Data fitting images

2.3. Low-power consumption design of the software

Through the setting of the control bit, MSP430F5342, it can transfer from the activity model to the corresponding low-power consumption model. On the contrary, various low-power consumption models can return to the activity model through the interrupt mode[8]. Under the voltage of 3V and the period of 1us, the power consumption situation under various working modes can be tested. (See Figure 4)

The above chart shows the power consumption situations under various working modes. The software design makes full use of the low-power consumption model. When the system is power on, various peripherals are initialized. During the process of data collection, the system is converted from the activity mode to the LPM0 working mode. The CPU is under the dominant state to allow the peripherals to work independently. When there is no data collection, the system turns from the LPM0 working mode to the LPM3 working mode. When CPU should be powered on, the system is interrupted to awake the CPU. After tasks get handled, it will enter the LPM3 mode[9]. While the LPM3 model is maintained to operate under the MSP430F5342 real-time clock status, it is found out that LPM3 is the lowest-power consumption working mode. The flexible conversion between various modes in the system design achieves the purpose of reducing power consumption.

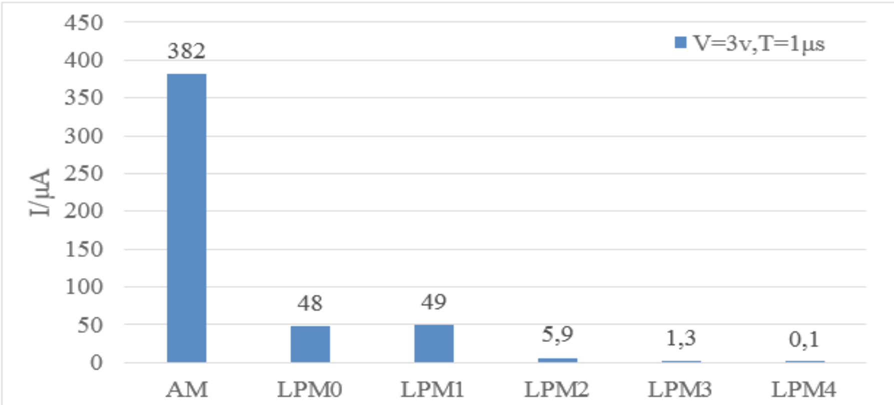

Figure 4. Power consumption situation under various working modes

Nodes can be divided into three threads, namely data collection, data sending and dormancy. The current, power and starting time of every thread are shown in Table 2.

Table 2. Current, power and time of various threads

	Data collection	Data sending	Dormancy
Current	0.125A	0.062A	0.0002A
Power	0.925w	0.46w	0.0015w
Starting tIME	60s	20s	Others

According to the above measured data, the data are collected on every one hour, and the hourly power consumption is:

0.125A*60/3600+0.062A*20/3600+0.0002*3520 /3600=0.00215Ah

In order to save expenses and achieve low-power consumption, no data are collected during nodes from 8:00 p.m. to 4:00 a.m. (The time is provided by the GPS module.) During the period, it is under the low-power consumption status. Therefore, the daily power consumption is:

0.00215Ah*16+0.0002*8Ah=0.036Ah

The node battery features the 5Ah chargeable lithium battery. Every power charge enables the battery to be continuously used for about 140 days.

2.4. Software flow design

The major software flow of the wireless monitoring nodes is shown below.

After it is time for MSP430F5342 to collect, it will collect various sensors and AD to acquire corresponding data. Later, the data is packed in specific format. When the up-loading interval is up, all data in the data pack are converted into the PDU format. Different AT instructions are written into the MC521IR3 communication model to finish the system's sending task. The monitoring terminal system can distribute the wireless monitoring nodes through instructions of the specific format ten minutes before the power-on of the system. The configuration parameters include the collection interval, the up-loading interval and the numbers of the short-message center. The system process chart is shown in Figure 5.

Figure 5. Software flow diagram of the monitoring nodes

3. Monitoring terminal system design

3.1. Data structural design

The design focus of the monitoring terminal system should be on the analysis and report of the monitoring data. The PC software of the monitoring terminal system is based On the LabVIEW software development platform. The software is mainly responsible for data communication and interpretation, receives and analyzes the data from the wireless monitoring nodes. When the wireless monitoring nodes are fully loaded or might encounter faults, the node information can be sent to the personnel in charge.

The data communication is realized through the port communication between the PC and the GSM module[10]. The message sending module of the GSM communication module includes the PDU and TEXT module. The system adopts the PDU model, which is convenient for the encryption of the message format and the removal of the disturbance of the spam messages[11]. The system designs the specific data frame format, which is defined in Figure 6.

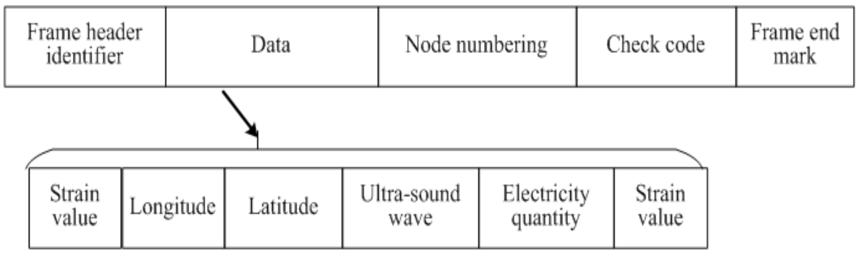

Figure 6. Data frame format

3.2. Realization of the electronic map

The system's electronic map technique realizes the display of the position of the intelligent dustbin through Baidu Map API. Baidu Map API is a webpage API which is compiled through the JavaScript language with Baidu Map embedded into it. Through API, Baidu Map can be embedded into the LabVIEW development plan and provide the positioning services for users through its positioning data[12]. Before the use of Baidu Map API, users need to get registered on the Baidu website and apply for an API secret key. After the application for the secret key succeeds, Baidu Map API can be invoked.

Before the invoking of Baidu Map API, the most important thing is the abbreviation of LabVIEW program of Baidu Map.vi. The flow sheet for the invoking of Baidu Map's API.vi is shown in Figure 7.

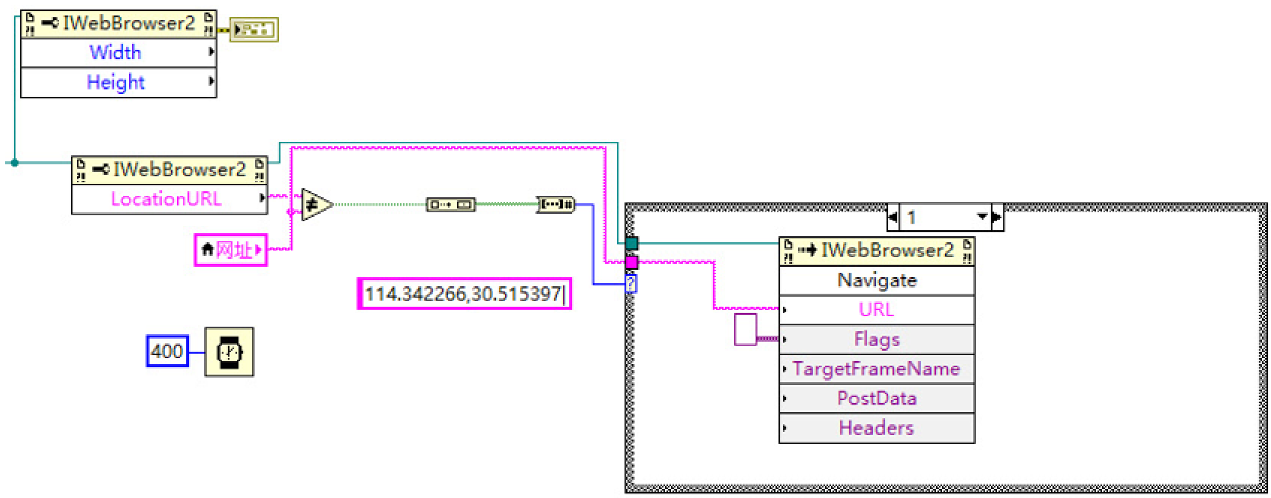

Figure 7. Program called BAIDU map

3.3. Software flow design

In this design, data reading, unpacking, storage and visualization are necessary. This system adopts the LabVIEW development software for data reading, unpacking and visualization. The database is employed to finish data storage and checking. LabSQL is employed to realize LabVIEW's access to the database. The software flow chart of the monitoring terminal system is shown in Figure 8.

When the program starts operation, the software scans all serial interfaces of the computer through VISA resource search function, and can correctly and intelligently identify the wireless network gateway according to the device name and the handshaking program. Based on the principle of the wireless gateway's automatic sending of CMTI instructions to the serial port after receiving messages, the system's serial port program keeps on checking CMTI instructions. When correct CMTI instructions are received, the system will send AT+CMGR instructions for the current data reading, unpacking, verification, storage and display on the visualized screen. When the data pack is verified to be wrong, it should be abandoned immediately. When the read strain data or ultrasonic data exceed the set threshold value and show fault signals, the system will automatically send the information of corresponding nodes to the corresponding personnel in charge. (For example, the dustbin about 30m away from the south of the Physics Building of Wuhan University of Technology Nanhu New Campus is full, which calls for immediate handling.) The corresponding functions of the system can check any nodes, print data tables, scale down maps and check all data of nodes in the database one month ago.

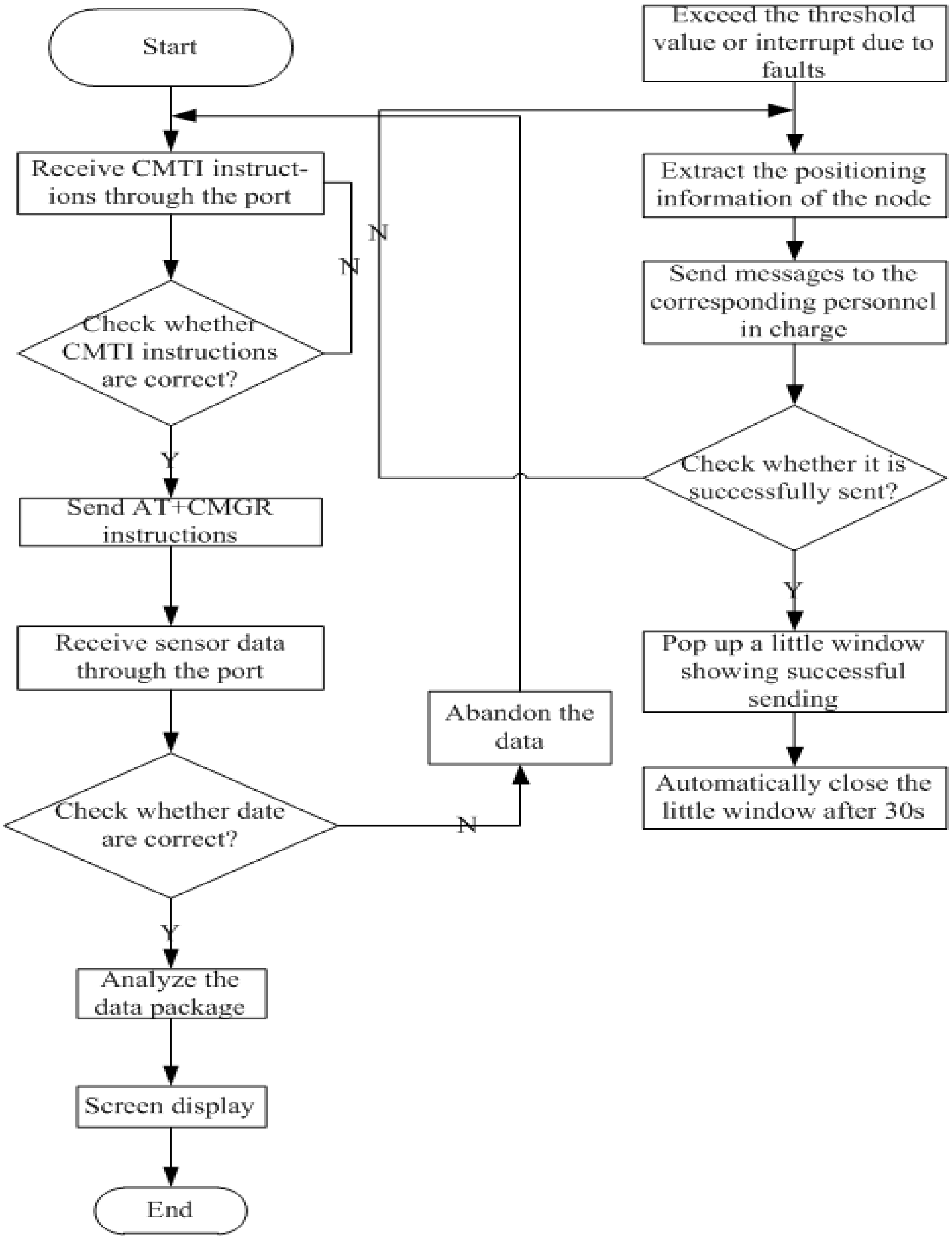

Figure 8. PC software flow diagram of the monitoring terminal system

4. Practical application effects of the system

The wireless monitoring node data collection system adopts the 5Ah chargeable lithium battery and finds out that the wireless monitoring nodes can work continuously for 140 days without electricity charge. Under the normal power supply situation of the battery, various sensors show that the data are normal and that the data received and sent by GSM and the information displayed by the monitoring terminal is also normal. All in all, the whole system shows good analysis and notification functions when the collected data exceed the set threshold value and the faults. The visualized interface of the monitoring terminal is shown in Figure 9.

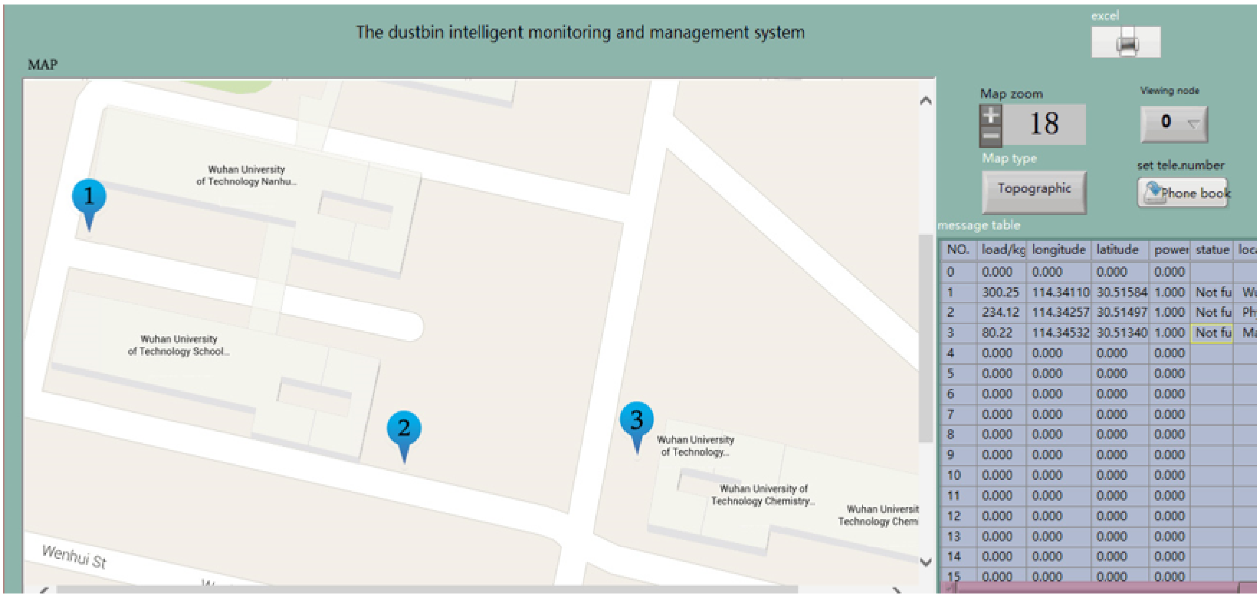

Figure 9. Test of the monitoring terminal on the visualized interface

5. Conclusions

This paper designs a small-scale and low-power consumption wireless monitoring system with a visual interface, and which can work for a long time. The short-message service based on GSM boasts the advantages of long transmission distance and more nodes. The visualized interface based on LabVIEW design features a short development period and can invoke Baidu Map API, so it can more clearly display the position and situation of dustbins. Data storage through the database can facilitate the check and analysis of the past data. Besides, the data has the self-test function, which can ensure the accuracy of the data. The interface, serial port and AD four-wire interface adopted by the system's sensor is highly universal and practical and can be applied to the collection of various wireless data and wireless monitoring systems, because the change of the sensor only calls for the modification of the LabVIEW data analysis form.

References

1. PALee, I. W. C., & Dash, P. K. (2003) S-transform-based intelligent system for classification of power quality disturbance signals. *IEEE Transactions on Industrial Electronics,* 50(4), p.p.800-805.
2. Zhou, H. (2014) Circuit design for an intelligent dustbin controlled by gestures. *Applied Mechanics & Materials*, 644-650, p.p.3647-3650.
3. Wang, H. P. (2011) Design of automatic infrared dustbin. *Journal of Chengde Petroleum College*, 13(3), p.p.40-43.
4. Zhai, W., Wen, Y. X., & Wang, Y. (2007) Design of remote monitor system of power supply based on GSM. *Journal of Southwest University of Science & Technology*, 22(1), p.p.71-75.
5. Zhu P, Hu C. (2012) Design of Wireless Electronic Scale Based On MSP430 Microprocessor. *Aasri Procedia*, 1(3), p.p.581-587.
6. Moreno Renata, Fonseca Pilar, & Rojo Ferno. (2011) Two small rnas, crcy and crcz, act in concert to sequester the crc global regulator in pseudomonas putida, modulating catabolite repression. *Molecular Microbiology*, 83(1), 24-40.
7. Wen, C., Gao, L., Fang, J., Yongfeng, J. U., & Yanming, L. I. (2014) The high-precision weighing system based on the improved amplitude-limiting and average filtering algorithm. *Chinese Journal of Sensors & Actuators*, 27(5), p.p.649-653.
8. Yan Cheng, Yongfeng Ren, Feng Wen (2015) Design of Low-Power Thermo Hygrometer Based on MSP430 Single Chip. *Chinese Journal*

of Electron Devices, 14(2), p.p. 382-385.

9. Jiao, B., Song, Y. E., & Wen, Y. T. (2011) Low-power consumption principle of msp430 and its application in sea temperature measurement. *Modern Electronics Technique*, 34(10), p.p.189-192.
10. Peng Ren-ming, He Chun-lin (2010) Design of Wireless Terminal Based on GSM. *Journal of Chongqing Normal University*, 27(3), p.p.77-79.
11. Yu Miao & Xianyong Meng (2008) Sending of Chinese Messages Based on GSM Module. *Computer and Information Techniques*, 41(7), p.p.44-48.
12. Cong XIAO. (2015) Multi-point Positioning System Design Based on Google Map/GPS/LabVIEW. *Science and Technology*, 28(2), p.p.85-89.