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The Design of Wireless Data Acquisition and Remote Transmission Interface in Micro-seismic Signals

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Abstract: The micro-seismic signal acquisition and transmission is an important key part in geological prospecting. This paper describes a bran-new solution of micro-seismic signal acquisition and remote transmission using Zigbee technique and wireless data transmission technique. The hardware such as front-end data acquisition interface made up by Zigbee wireless networking technique, remote data transmission solution composed of general packet radio service (or GPRS for short) technique and interface between Zigbee and GPRS is designed in detail. Meanwhile the corresponding software of the system is given out. The solution solves the numerous practical problems nagged by complex and terrible environment faced using micro-seismic prospecting. The experimental results demonstrate that the method using Zigbee wireless network communication technique GPRS wireless packet switching technique is efficient, reliable and flexible. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Micro-seismic signals, Wireless data acquisition, Remote transmission, MG323, CC2530.

1. Introduction

Micro-earthquake (mine tremor or micro-seismic), as a small earthquake, is usually defined as those seismic events which are caused by rock failure or rock mass changes in the stress field near the mining tunnel. The micro-earthquake monitoring technique based on ballistics and seismology is subject to the geophysical exploration technique. The technique core focuses on monitoring the effects and results of production and the underground states through observing and analyzing the micro-seismic events. The following is the basic method. Firstly, according to certain rules, sensors are placed in the well or on the ground to receive production activities arising out of or induced micro-seismic events, then through the inversion of these events the micro-seismic source is located and other parameters are calculated, finally, through these activities the production is controlled or guided by these parameters.

Similar to Bluetooth, the Zigbee technique is emerging short-range, low-rate wireless network technique. This technique has widely been used in sensing control applications and local area network at short range. Its outstanding advantages are simple in application, flexible on working frequency, lower power, low cost, high reliability, self-networking and self-recovery capability. With the development of science and technology in recent years, Zigbee has deeply been integrated into sensor technique, data acquisition, information processing and wireless sensor network techniques.

The general packet radio service network based on a packet switching technique is an efficient data transmission network. The basic function of GPRS is

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to transmit the packet data between the mobile terminal and the internet network router. Colloquially, GPRS is a high-speed data processing service based on the existing GSM. The method is to transfers data to the user equipments in the form of the "grouping". It has high-speed characteristics theoretically up to 171.2 kbit/s. In addition to the advantages of speed, GPRS has advantages of always-on and charging according to flow rate.

If the traditional field bus communication mode is adopted in the harsh environments such as the remote mountain mines, producing wells, etc., wiring costs will be highly increased due to the limited condition, of course including pre and post wiring ease of maintenance. GPRS wireless communication technique is a good remote data transmission solution because with the aid of this technique the remote communication system can be established without frame lines, and the wiring problems caused by the adverse environmental factors (such as in remote mountainous areas, climate variability, etc.) can easily be solved and the investment issues can greatly be decreased. At the same time, a lot of manpower and physical resources can be saved in this method.

2. The Overall Design and Realization for the Interface Unit of the Zigbee and GPRS Part

According to the practical requirement, the whole system is generally composed of several front-end nodes. As an example here gives such a solution that only single one data acquisition module-terminal node is considered. The whole design includes both the data being transmitted to the Zigbee center node with the wireless sensor network from the terminal node and micro-seismic signal being sent to the computer monitoring and management center through the GPRS network [1].

2.1. The Communication between Zigbee and GPRS Part

The front-end data acquisition works as follows: firstly, the Zigbee network is created by the center node successfully, after that the network waits for the terminal node to join. When the terminal node powered on, it will search the Zigbee network which exists in the local area automatically, and the terminal node gets access to the network as soon as possible when the network is found, and the terminal node sends its physical address to the center node, the communication between center node and terminal node is whereupon established. CC2530 serve as the core of center node in this solution which is an integrated circuit yielded recently. With serial port, CC2530 of center node sends data to the GPRS module which is responsible for TCP/IP protocol conversion and sending data to the GPRS base station with the form of GPRS data packet, and then the data is sent to the serving GPRS support node (or named as SGSN). SGSN communicates with gateway support node (GGSN) of GPRS. The data will be dealt with accordingly in GGSN unit, and then sent to the internet. Data collection server connected to internet receives the data returned finally. The schematic block diagram of remote data acquisition is shown in Fig. 1 [2].

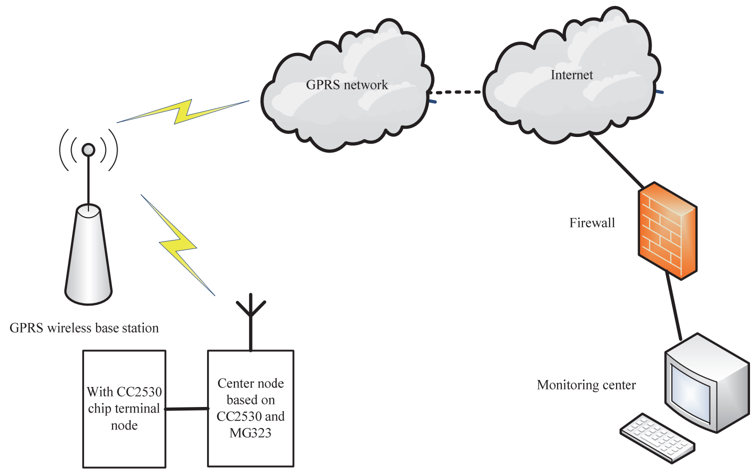

Fig. 1. The principle of remote data acquisition.

There are such networking modes as public static IP, dynamic DNS, SMS communication, dedicate line of APN etc between GPRS and Internet. Among these networking modes the dynamic domain name resolution scheme is the most common networking mode in practice. Here adopts the dynamic domain name resolution scheme. In this mode, the IP got access to server every time may be different, but DNS could establish the association between them. In this mode, a domain name for the data collection server want firstly to be applied from the DNS service provider, and then the domain name is written into GPRS module. When accessing Internet successfully, the data acquisition server is connected to the DNS server, and reports dynamic IP obtained currently to the DNS server. After powered on, GPRS module is connected to DNS with the domain name address mode, and the DNS could find the server public network dynamic IP automatically. In this way, the both sides could communicate with each other [3].

2.2. The Overall Design of the Zigbee and GPRS Communication Part

The schematic diagram of the architecture of micro-seismic signal wireless acquisition and remote data transmission interface circuit is shown in Fig. 2. Terminal node is made up of micro-seismic signal sensor, power source, CCS2530 RF chip and PCB antenna. The micro-seismic signal sensor is used to collect sound signal produced by the micro seismic, power supply provides energy for the operation of terminal node. Because of power consumption of terminal node being very low, the power supply is provided by the button battery. CC2530 radio frequency chip is responsible for storing and processing the micro-seismic signal data collected via its A/D converter, transmitting and receiving it through the PCB antenna in accordance with the Zigbee protocol.

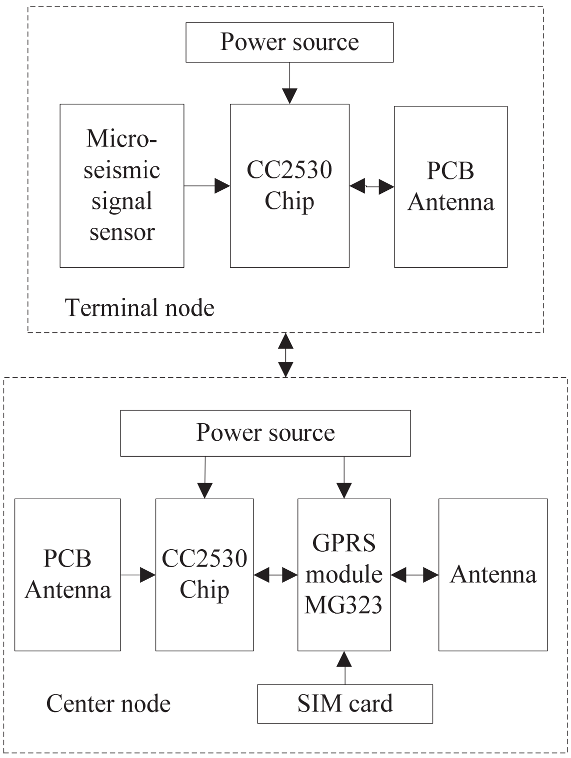

Fig. 2. System structure diagram.

Wireless communication interface circuit consists of PCB antenna, power source, CC2530 radio frequency chip, GPRS module (MG323), SIM card. Because of TCP/IP protocol embedded, the GPRS module can easily be to realize to communicate with the computer connected to internet network. Power supply provides the energy for CC2530 radio frequency chip and GPRS module (MG323). SIM card needs to open wireless communication service of the GPRS, and thus it can log on to the GPRS network.

The antenna is responsible for transmitting the data by radio frequency carrier signal. The data of sensor is sent to the base station via antenna, and then the base station transmits the data to the network, and the whole information is finally put to the monitoring system of computer.

3. The Hardware Design of the Wireless Communication Interface Unit

3.1. The Design of the Terminal Nodes

The terminal node is the station of information collected. In the terminal node, the data acquisition and transmission of current sensor is completed, and through micro-seismic events in the mine to monitor the production activities.

CC2530 is a true system-on-chip (SoC for short) solution for 2.4GHz, IEEE 802.15.4, Zigbee and RF4CE applications. CC2530 combines the excellent performance of a leading 2.4 GHz Direct sequence spread spectrum (DSSS for short) radio frequency transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory, 8 KB RAM, and many other powerful features. CC2530 has various operating modes, making it highly suited for systems where ultralow power consumption is required.

The schematic diagram of the terminal node is shown in Fig. 3.

3.2. The Design of the Center Node

The center node is the command center for information collection system, which is responsible for data reception, uploading data to upper computer and issuing control commands sent by upper computer to the center node.

GPRS module of the center node is wireless communication module MG323.

In this module TCP/IP protocol is embedded to support four operating band: GSM850/900/1800/1900 MHz and support four coding schemes: CS-1, CS-2, CS-3, CS-4 and multi-link.

The schematic of the center node is shown in Fig. 4 [4].

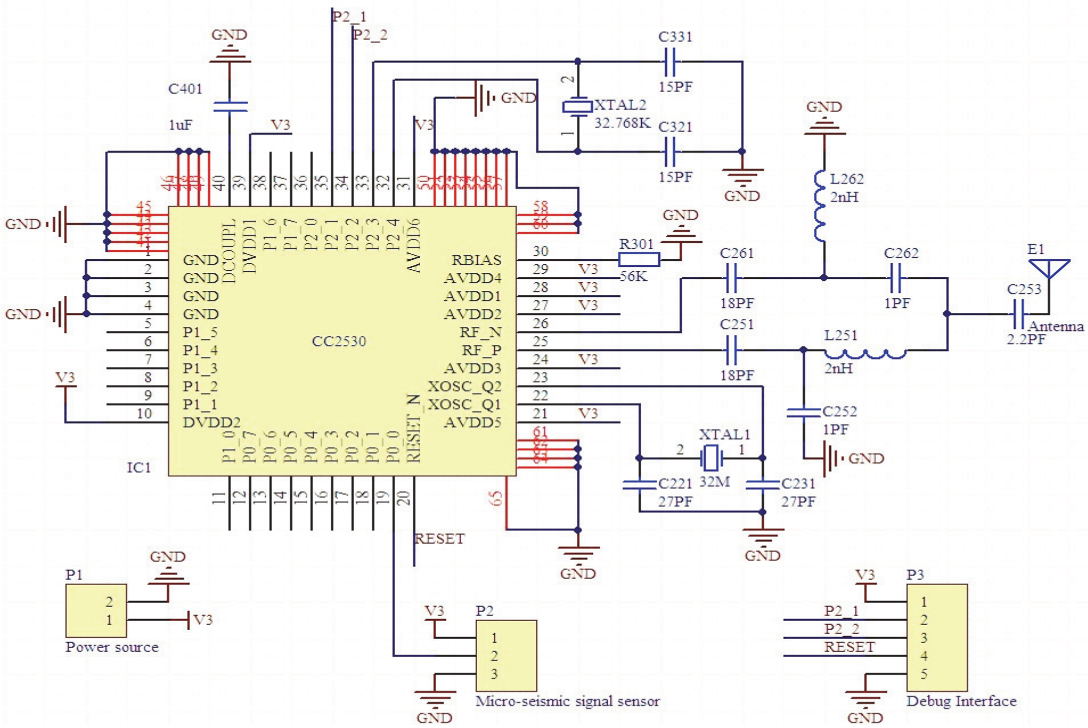

Fig. 3. Schematic diagram of the terminal node.

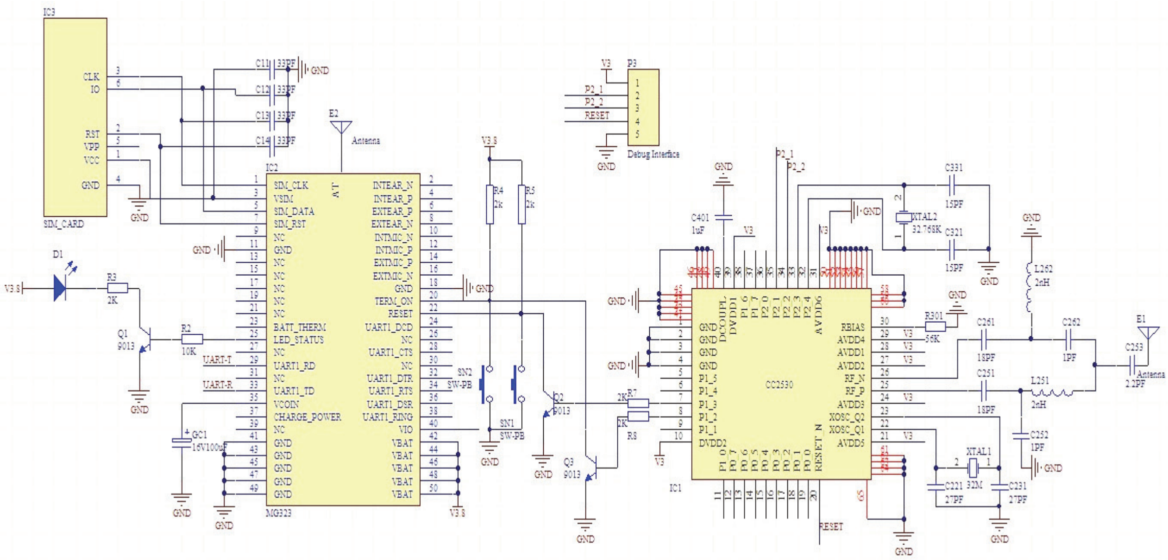

Fig. 4. Schematic of the center node.

4. The Wireless Communication Software Design for Interface

4.1. The Software Design of CC2530 Center Node Information Data Collection

In accordance with a certain frequency, the information coming from the terminal nodes is received by CC2530 chip of the center node and the data is resent through the antenna of MG323 in the center node. Program flow chart of route node is shown in Fig. 5 [5].

4.2. The Software Design of Transmitting and Receiving of GPRS Module

The AT command interface specification is supported by MG323 module. In this interface specification, the AT commands begin with "AT", and only one AT command can be seen in the each command line. A universal asynchronous receiver /transmitter (UART for short) external interface is provided by MG323, and through this UART MG323 is controlled by the routing node CC2530 by using AT commands.

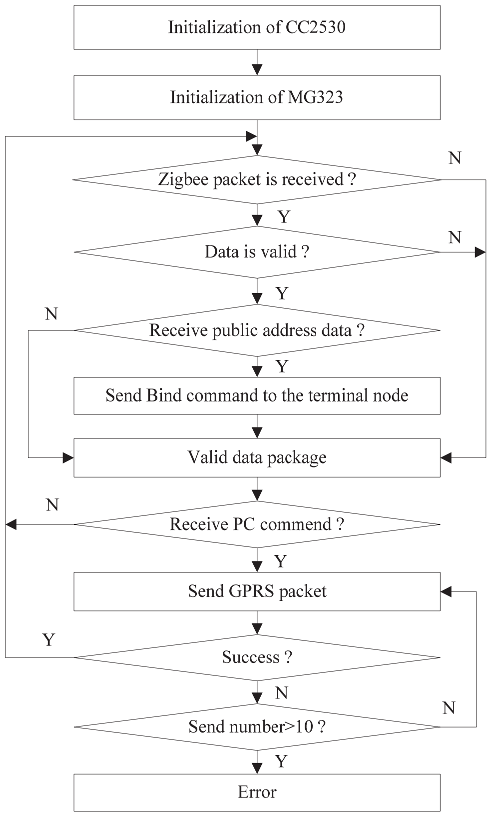

Fig. 5. Program flow chart of route node.

After powered on, wireless communication interface module wants to initialize the GPRS module first. In the process of initialization, the primary is to detect if the GPRS module works in normal: the AT command "AT" is sent to MG323 via a serial port, and it is checked if the MG323 could return "OK"; the second is to test if the SIM card works correctly: a AT command "AT+GSM " is sent to MG323 via a serial port; the final is to configure the parameters of APN: one set of AT commands such as "AT+ CGDCONT=1", "IP", "CMET" is sent to MG323 via a serial port. Thus the GPRS module initialization is completed.

After initialized the next step is to connect the GPRS module to the network. In this process, the primary is to query how the strength of the GPRS signal is: the AT command "AT+CSQ" is sent to the GPRS module via a serial port, and if the signal is better enough, registering mobile network can be done. The corresponding command of registering mobile network is "AT+CGREG?" command or "AT+CGEG?" command: "AT+CGREG?" command is used to register the local network and the command "AT+CGEG?" is to register the roaming network. The second step is to initialize the TCP/IP, and the corresponding AT command is as followed: "AT% ETCPIP = "USER", "GPRS"": USER and GPRS represent the user name and password respectively here, and both can be set by the user according to need of themselves. The followed is to choice and to resolve the domain name, connect the host computer, send AT command AT% DNSR = "domain", and the final is to connect to the internet. The corresponding commands are as below: "AT%IPOPEN="TCP", "DEST_IP", "DEST_PORT". In these commands, TCP represents the communication mode of TPC, DEST_IP and DEST_PORT represents the IP address and port number respectively.

So much for that the process of GPRS connecting to the network is completed. The configuration flow chart for the GPRS module is shown in Fig. 6.

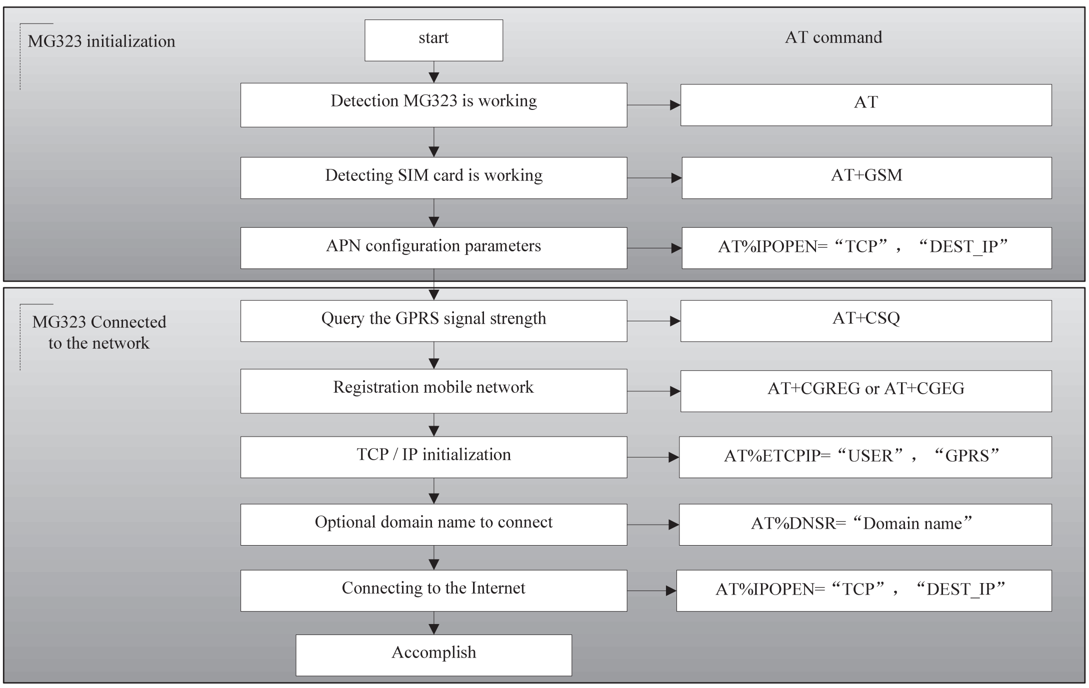

Fig. 6. GPRS module configuration flow chart.

After GPRS is connected to the wireless network, it could communicate to TCP/IP network. The data frame format transmitted by the GPRS module is "AT%IPSEND="DATA"": here "AT% IPSEND =" is string to start the TCP/IP sending command and DATA is the data to be sent. The data frame format received by the GPRS module is "%IP-ATA: <LEN>, "DATA"": here "% IP-DATA:" is received the data frame header, LEN is the number of bytes received and in two bytes, "DATA" is the received data.

4.3. The Software Design for PC System

The main function of the remote server is to send and receive commands and data from the data transfer center. The software architecture of PC monitoring system adopts C/S structure of TCP/IP protocol oriented based on Socket communication mechanism, and the program is programmed with C# under environment of the software platform of Visual Studio 2008 supplied by Microsoft.

The Socket interface is a kind of TCP/IP network application programming interface (API). There are four steps to realize the network communication using Socket interface: the first is to set up a Socket interface; the second is to configure the socket according to the requirements, that is, to connect the Socket to remote host or to specify a local protocol port for Socket; the third is to send or receive the data through Socket according to the requirements; the final is to shut down the Socket.

Some of program for the configuration and connection of Socket is as followed:

```
IPAddress ServerIP=IPAdress.Parse
   ("192.18.16.186");
   // Set the IP address of the server.
IPEndPoint Server=new IPEndPoint
   (ServerIP,8866);
   // Build server network endpoint.
Socket Sock=new Socket(AddressFamily.
   InterNetwork,SocketType.Stream,
   ProtocolType.Tcp)// Construct a socket.
Sock.Bind(Server);// Bind the socket and server.
Sock.Listen(8);//Start monitoring,
   and the connection queue length is 8.
Socket connectsock=sock.Accept();
    //Return Socket, use to communicate with the
     socket sending connection requests.
```

Following is the parameter description for two command.

The first one is “public int Send(byte[] buffer,int size,SocketFlag socketFlags)”. Its parameters is as below: “buffer” represents the data to be sent; “size” represents the size of data to be transmitted; “socketFlags”, which has the property of combines the members’ value according bit, provides constant values of Socket message. The return value of the command is the number of bytes sent to the Socket.

Another one is “public int Receive(byte[] buffer,int size,SocketFlage socketFlags)”. Below is the description of its parameters: “buffer” represents storage location of the received data; “size” represents the size of data to be received; “socketFlags”, which has the property of combines the members’ value according bit, provides constant values of Socket message. The return value of this command is the number of bytes of the Socket received [6].

5. Conclusions

In the mobile communications industry, GPRS technique is widely used, but it is also unusual for GPRS to be used in the industrial application of mine. Wireless data acquisition and network transmission system of micro-seismic signals based on the GPRS and Zigbee technique is available for staff to remotely realize real-time monitoring through the computer terminal node. Such system has a very important significance in micro-earthquake research and application in the mine. Besides, the solution can be used to collect the data and transmitting the data in wireless mode in every other region.

Acknowledgements

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