

# Control Circuit Analysis and Conversion Calculation of Electric Switch Machine of High Speed Railway Turnout

**Abstract.** For the existing security monitoring system runs in the security alarm level and short of positioning and real-time monitoring underground personnel and mobile devices, a mine personnel and equipment positioning system, based on the ZigBee technology of wireless sensor networks, is proposed to make real-time detection and security management to the dynamic distribution of personnel and equipment. The system analyses the position and attendance management to monitor the location information with mobile monitoring equipment, and quickly implement the mine emergency rescue work. This new type of downhole positioning system has the characteristic of low power consumption, high positioning accuracy and strong anti-interference ability.

**Streszczenie.** Zaproponowano sieć czujników bezprzewodowych typu ZigBee do monitorowania w czasie rzeczywistym ruchu komunikacji podziemnej. Układ może służyć w systemach bezpieczeństwa ludzi i pojazdów na terenie kopalni. (Analiza obwodów sterowania i zabezpieczenia ruchu w komunikacji podziemnej)

**Keywords:** wireless sensor network, ZigBee technology, localization system, mobilizable.

**Słowa kluczowe:** sieć bezprzewodowa czujników, system lokalizacji

## Introduction

In recent years, the situation of the mine safety production has been continuously improved because the government pays much more attention to it. But the coal mine safety accidents still occur frequently. The special major accidents, the death toll of which surpasses 30, are more than 30 times every year. At present, our country's coal mining accident casualty is four times as the casualty of the world mainly coal-producing countries. The 1,000,000 tons mortality rates are 30-50 times as the America and other advanced coal mining countries. Therefore, the mine safety situation is still stern.

At present, most of the large coal mines are equipped with safety monitoring system in our country, which reduce the safety accident in some extent, but there are still a lot of problems. The current safety monitoring system mostly runs in safety alarm level, and lack of positioning and real-time monitoring to personnel and mobile equipment. Once the mine disaster occurs, the casualties will increase efficiently due to lack of reliable information to rescue the mine personnel. Based on the technology of Radio Frequency Identification (RFID), the mine real-time positioning and early-warning system is small size, light weight, and easy to carry [1]. But the system has some obvious shortcoming. For example the communication area covers only for short distance; wireless stations may also have leakage phenomenon, and incomplete coverage of the wireless signals of down hole and precise localization of personnel. A mine personnel and equipment positioning system, based on the ZigBee technology, is proposed in this paper. It used the method of carrying on the terminal operators for personnel to make real-time detection and safety management, and achieve positioning, attendance management and implementation of sudden accident rescue work.

## Zigbee technology introduction

ZigBee technology, based on IEEE802.15.4 agreement, is a two-way radio communications technology. It has the characteristics of close range, low complexity, low power consumption and low cost. Through the network information transmission technology, two # 5 batteries can support a node to work more than half a year in low power mode. Compared with Bluetooth, WIFI have prominent advantages [2]. The most important thing is, ZigBee supports geolocation function, which has been widely used in recent years [3,4].

The ZigBee network is consisting of coordinator, routers and terminal. The coordinator is essential and responsible for management and maintenance of networks including routing, security and the nodes to join or leave. It can connect 65535 subordinate equipments at most. Routers and terminal work as FFD and RFD, respectively. When the network's state is changed, FFD node also can act as the coordinator. ZigBee network support star structure and net structure, also allow to use a combination of the two (cluster tree network). Taking the concrete application environment into account, the mine area is suitable for cluster tree network structure.

## The design and principle of positioning system

Due to the scattered distribution, the far distance, the large area coverage of network as well as minor traffic, the mesh network topology can be used to transmit data. Through the wireless network connections, it can provide more data communication channels. Once the data communication equipment malfunctions, it can provide a path to transmit data communication to greatly improve the network stability and reliability.

### Positioning system design

Personnel localization system is a distributed processing system which can be integrated to coal mine monitoring system as a subsystem. Every miner wears a sensor node with ZigBee function, which reports position information to coordinator, acting as terminal equipment. Transfer stations deliver data via Internet or the CAN bus. Positioning system includes: terminals, mobile monitoring devices, transfer stations, ground control center and various cable, which are showed in figure 1.

### Systemic function and positioning principle

The personnel carry a terminal node with sole address. It will regularly send RF signal to the adjacent sensor nodes with its logo. Data can be transferred to monitoring equipment and ground control center (PC), which can analyze and process the data. At the same time management personnel can make real-time observation of miners' position and working information. Mobile monitoring device can track of the personnel and equipment in underground environment. As the system runs in normal operation with no PC's participation, it can greatly reduce the amount of data transmission and improve the performance and reliability.

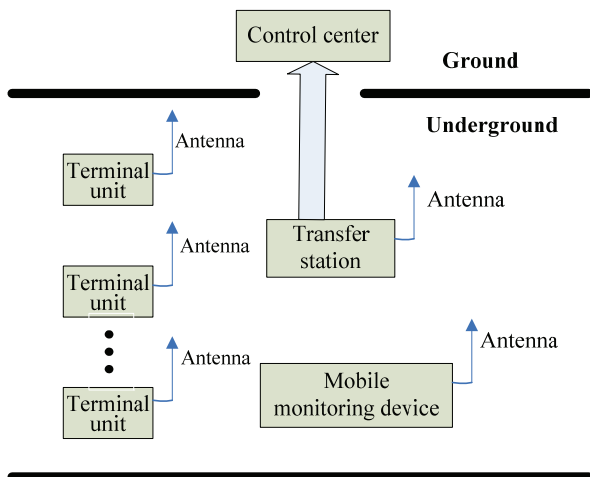


Fig.1. Sketch map of personnel and device positioning system

In order to calculate the location of terminal equipment, we can place a certain number of reference node in mine area and calculate relative coordinates by means of the signal strength(Received Signal Strength Indicator, RSSI), then the data information will be gradually transferred by the router nodes. RSSI is mainly affected by the antenna design, environment and several other factors. Due to the random fluctuation of RSSI, an appropriate data processing algorithm can be used to reduce the fluctuation of position estimation. Through actual measurements and proper calibration, these can improve the positioning accuracy.

### The hardware design

Hardware system environment comprise a computer, which is used for personnel monitor information and management. The CPU of the computer is no less than 2.6 GHz, the memory no less than 512 M, the hard disk no less than 120 G, the monitor no less than 19-inch, and the graphics no less than 256 M which supports dual-screen display, CD-RW and tape drive. This system employed Samsung S3C2440, the 400MHz CPU handheld devices, and TI2.4GHz RF transceiver CC2430/2431. The ZigBee network nodes are generally composed of sensor module, processor module, wireless communication module and power module. These modules are shown in Figure 2.

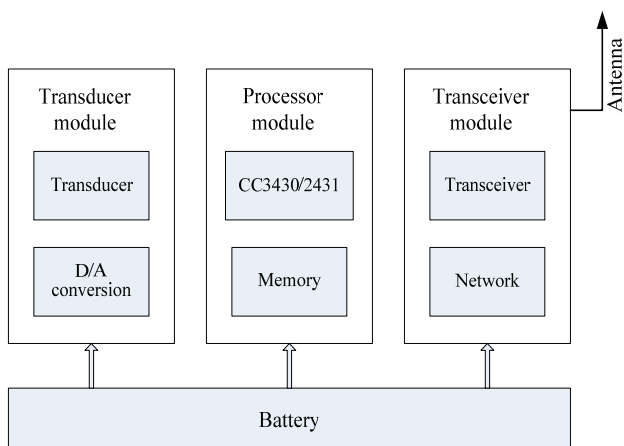


Fig.2. Sketch map of personnel and device positioning system

Sensor module is mainly responsible for information collection and analogue-to-digital conversion, processor module is the core of nodes and controls all the nodes' operation. Wireless communication module is responsible for wireless communication between the sensor nodes, exchanging control message and receiving data. The

energy supply module provides energy for sensor nodes and usually employs micro cells.

The controller chooses the CC2430 of TI. This chip is the first in view of low power loss RF application of SoC solution. The function module of its chip system integrates CC2420RF transceiver, and ZigBee RF, 128KB flash, SKBRAM and eight SO5IMCU nuclear. It can be applied to various ZigBee wireless network nodes, including tuner, routers and terminal equipment etc. The employed terminal uses the CC2431, which established above CC2430. Besides 128KB flash memory, 8kB RAM and many additional functions, this chip can also calculates the location of terminal according to the received signal intensity and the known CC2430 reference node position, then send information to route equipment or synchronizer. Compared with the centralized positioning system, the RSSI has greatly reduced network flows and communication delay. The CC2430/2431 module can download procedure via the serial port, JTAG or the USB downloading simulator.

### Localization algorithm and software design localization algorithm based on RSSI

The localization algorithm calculates the loss through signal intensity of launch node and receiving node, transform the transmission loss to distance using the theory and the empirical model, and then calculate the node position by the existing algorithm[5]. For the localization node has the wireless communication ability, this technology mainly uses the RF signal and is a low power and inexpensive technology. Ideally a commonly used localization algorithm is the weight center of mass localization algorithm[6], but the location information is random and easy to be disturbed. On the basis of localization algorithm, accurate RSSI can be obtained through the averaging value

$$\overline{RSSI} = \frac{1}{n} \sum_{i=0}^{i=n} RSSI_i \quad (1)$$

Using the filtration approximation, we can use the formula (2) to obtain the scope of parameter a, which is  $(0.75 \leq a < 1)$

$$RSSI_n = a \cdot RSSI_n + (1-a) \cdot RSSI_{n-1} \quad (2)$$

The trilateration is a typical sensor node localization algorithm; it obtains the distance between terminal node and 3 reference nodes via RSSI, and then uses the distance value to calculate the position of terminal node. When the reference nodes R1, R2, and R3 receive positioning signal from R, d1, d2, d3 can be obtained according to RSSI, where R1, R2, R3 are the center of circle and d1, d2, d3 are the radius. The relative coordinate position of mobile node can be calculated via these 3 circles, which is shown in Figure 3.

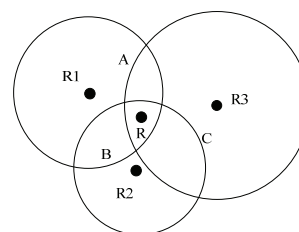


Fig.3. Node-localization algorithm based on trilateration

### The process of Node positioning

The source code of each type nodes in positioning system correspond to the latest ZigBee PRO protocol standards. The configuration of RF chip CC2430/2431 was

written using C language in IAR EW8051 development environment. The positioning operation process of CC2431 is shown in figure 4.

Locating node (i.e. mobile node) will first read all reference nodes coordinates value (X, Y), and then read the other standard parameters (A, N, RSSI). Of which:

A — the absolute value of RSSI from transmitter (CC2430 / CC2431) 1m away.

N — the absolute value of RSSI attenuation quantity while the distance from transmitter increase 1m.

RSSI — the signal strength of CC2430 / CC2431, the unit is dBm.

When CC2431 read all the necessary parameters, then the locating node localization coordinates is calculated and outputted. In figure4, LOCENG, REFCOORD, MEASPARM, LOCX, LOCY and LOCMIN are the related registers of CC2431 wireless location.

The management system software of PC is developed in Windows XP environment. The system, which has the ability of data collection and information processing, uses MapInfo and Visual Basic to develop database management system. The software platform of hand-held monitor equipment uses the embedded operating system Windows CE 5.0. Using Platform Builder to customize Windows CE.net kernel and EVC to develop application, Windows CE provides a robust and real-time operating system in rapid build smart mobile and small memory equipment. It has complete operating system feature and is very suitable for this system software platform. According to monitoring software, the personnel condition can be directly checked such as the personnel names, positions, up time, down time, underground accumulative total time and etc. It provides powerful support for the safety of personnel, attendance and management.

configurations have three states: normal, dormancy and lost. Terminal node sends request command to reference node periodically. When the response time exceed the maximum time, it will resent request command. The positioning system sets the reference node coordinates according to the actual position. Terminal equipment will calculate coordinates based on the collected RSSI mean and display it in monitoring interface. The monitoring interface of hand-held devices is shown in Figure 5.



Fig.5. Interface of the handheld device

Figure 5 shows the monitoring interface of hand-held devices which based on ARM9. Through system commissioning, several miners' position, type, and unit information can be collected, and these information can be used by the administrator of orefield to make scientific and effective management. The ID is the staff's only logo. Positioning system is tested in underground comparative empty regions. The positioning accuracy is about 3 meters and geographic coordinate resolution is about 0.25 meters. When there are interference sources in the tested environment, the position of terminal node will float around. If two reference nodes are added, the measured coordinate position will be more accurate.

### Conclusions

This system can make real-time detection and safety management to achieve the goal of positioning, attendance management and quickly processing of sudden accident by using the method of ZigBee wireless communication technology, and personnel carry terminal equipment. And avoid the disadvantages of high cost and performance instability. Due to the special environment of mines, we can add more reference nodes or improve the sensor transmission power to increase localization accuracy.

### Acknowledgment

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### REFERENCES

- [1] Sun E J, Li Zh X, Li C P. The real-time 3D localization and hazard warning platform based on the RFID and WSN in underground mine [J]. Journal of Safety Science and Technology. 2009, 3(5):36-40.
- [2] Paolo Baronti, Prashant Pillai, Vince W. C. Chook, Stefano Chessa, Alberto Gotta, Y Fun Hu, Wireless sensor net works: A survey on the state of the art and the 802.15.4 and ZigBee standards [J]. Computer Communications, 2007, 30(2007): 1655-1695.
- [3] Sun J SH, Wang N, Liu L P. A novel water-sludge interface data transfer system applying zigbee wireless network[J]. International Journal of Information Acquisition, 2006, 3(4): 301-309.

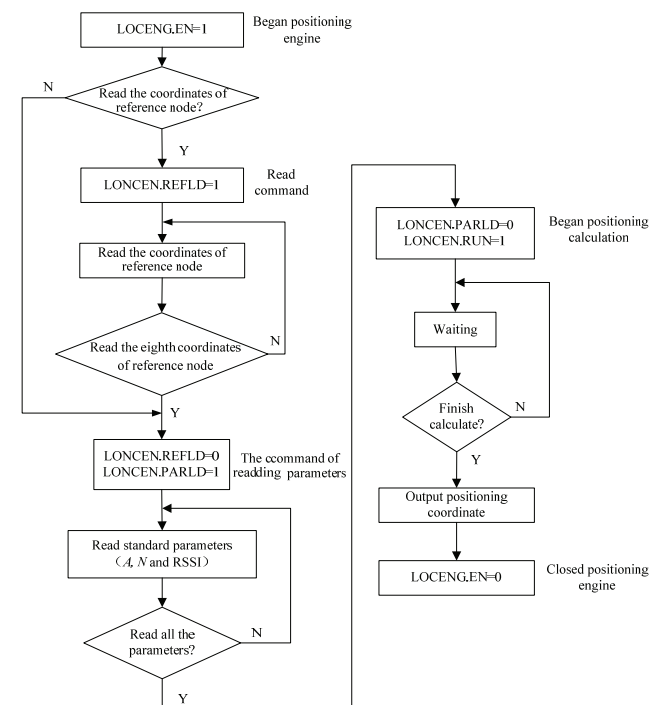


Fig.4. Work flow chart of node positioning

Theoretically, the more reference nodes are, the more accurate RSSI value is, the more accurate the obtained coordinates is. Moreover, the positioning accuracy greatly affects the actual environment.. This positioning system uses four reference nodes for personnel positioning. Node

- [4] Pora Kim, Sekchin Chang, Intelligent positioning and optimal diversity schemes for mobile agents in ubiquitous networks[J]. International Journal of Software Engineering and Knowledge Engineering, 2008, 18(5): 637-650.
- [5] Rajshekhar Vajjinath, Ashuedb Dutta, T.K. Bhattacharyya. IEEE 802.15.4/ZigBeeTM Compliant IF Limiter and Received Signal Strength Indicator for RF Transceivers[C]. IWWAN workshop[A], London UK, 2005: 653-665.
- [6] Mare Srbinovska, Cvetan Gavrovski, Vladimir Dimcev. Localization estimation system using measurement of RSSI based on ZigBee standard[C]. Conference proceedings of the 17th International Scientific and Applied Science Conference Electronics [A]. Sozopol, Bulgaria, 2008: 45-50.
- [7] Feng D F, He J M. System Design of Digital Wireless Locating Tracer Based on Zigbee[J]. Journal of Hangzhou Dianzi University, 2008,28(5): 66-68.
- [8] Xu L. Research on WSN Location Technology Based on Zigbee [D]. Harbin Engineering University, 2009.
- [9] Wang G F. B, Shi L, Ren F. Y. Self-localization systems and algorithms for wireless sensor networks[J]. Journal of software, 2005, 16 (5): 1148 - 1157

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