Research on dynamic management technology of mining products safety approval and certification based on UHF

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Abstract: With the development of mine automation technology, more and more electronic products are installed in coal mine. In order to strengthen the safety management of the mine products, research on dynamic management technology of mining products safety approval and certification based on UHF is proposed in this study. This paper analyzes the existing problems in the current security management of products information. The overall structure of the dynamic management system of security mark information is designed. The system coupling communication mode is decided. The electronic tag and reader which can be used in the complex conditions of coal mine are designed in detail. And the laboratory experiments are carried out. The results show that: the system can effectively monitor the mine product safety certificate number, production date, manufacturer, safety parameters and other information. The experiment effect is better. The use of unsafe products in coal mine is prevented from the source. It has important significance for the protection of coal mine safety.

Introduction

The characteristics of energy reserves are rich coal, lean oil, less gas in China. Coal will be an important basic energy for a long time in the future in China. Party and government attach great importance to coal mine safety production work. At present, the number of coal mine accidents and the death toll is greatly reduced. But heavy accidents still occur. Coal mine safety situation is still grim.

At present, the six systems such as gas monitoring, personnel positioning, communication, emergency hedge, and so on, have been installed in most of the coal mines in China [1]. According to the relevant provisions, the coal mine products need to have the safety standard certificate. The safety certification information of mining products can be queried through the network. It is important for the safety management of mining products. But current safety approval and certification management is a static management. There is still insufficient. The safety parameters of the products cannot be known in real time. If the users do not connect the equipments according to the rules, it is difficult to be found. Whether the production of products accordance with the safety standards in strict cannot be determined.

The office of China State Administration of Work Safety had ever informed[2], some enterprises pursuit the economic interests, safety responsibility consciousness and product quality awareness are lax. After obtaining the product safety mark certificate, the enterprises do not make mining products strictly according to the requirements of the safety mark management, and some of them even change the performance index and parameters of the products. The quality of product safety is seriously affected.

Based on this context, the paper presents research on dynamic management technology of mining products safety approval and certification based on UHF. This study is very important to improve the safety management technology of mining products and prevent the occurrence of safety accidents.

Structure of the RFID system

As shown in Figure1, the RFID system includes two parts of mine and ground. The card reader, antenna and electronic tag work in the mine. The electronic tag and the reader complete the energy transfer and data communication through the way of the coupling. And the coupling communication distance is not less than 1m.

The monitoring host is installed in the ground. The monitoring host can interact with the database of the safety mark certificate data center. The system can monitor the equipments safety parameters, operating status maintenance times, and other relevant information in real-time. It also timely warns the aging obsolete equipments, and alert the users connect the device according to the provisions.

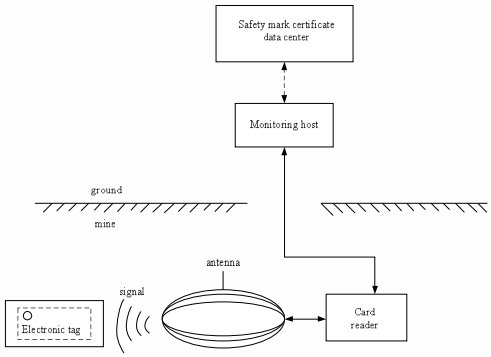

Fig. 1 the structure of the UHF RFID system

Selection of the RFID system coupling mode

There are two kinds of common coupling modes between the electronic tags and the reader[3]. They are inductive coupling and electromagnetic coupling methods. Where, the inductive coupling method is also known as transformer coupling. In this coupling method, the coupling is realized through the space magnetic field. The antenna of the reader can be considered as the primary coil of the transformer. The antenna of the electronic tag can be considered as the secondary coil of the transformer. A coupling field between the coils of the reader and the tag form a closed loop. So this kind of coupling method is suitable for short distance communication. The environment of coal mine is dark and wet, and mine products are mainly metal equipments. The signal transmission is subject to certain shielding, when the electronic tag is fixed on the surface of the mine products. So this method has some limitations in coal mine.

The electromagnetic coupling method is another signal sending coupling method. As shown in Figure 2 , in this method, the electromagnetic waves are transmitted by the antenna of the reader according to a certain direction in space. The tags in the active region of the radiation field receive energy from the electromagnetic waves. Then the information stored in the tag is transmitted to the reader through the internal circuits and antenna of the tag. Because of the directional transmission of electromagnetic wave, the transmission distance of this method is far away. Even if there is some signal decay in coal mine, the communication distance of signal can meet the requirements. So this study uses this method as the transmission mode of the signal. And in order to improve the rate of information reading, the information stored in the tag is as little as possible.

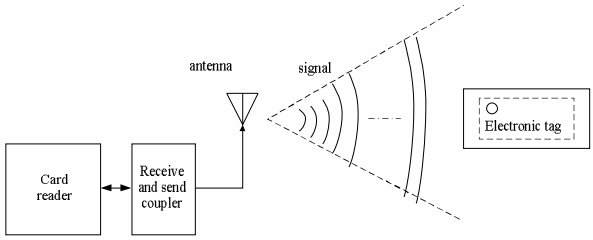

Fig. 2 the electromagnetic coupling method

Design of the coal mine electronic tag

The tags include two kinds of the active and passive tags. The active tags require battery power supply. The passive tags do not carry a battery, and the energy required for the electric wave transmission and the work of the internal processor is derived from the electromagnetic wave generated by the reader. The specific performance of active tags and passive tags is shown in Table 1.

Table 1 The performance of active tags and passive tags

Index	Active tags	Passive tags
Power supply	active	passive
Communication distance	Not less than 50m	Not less than 1m
Life time	Not less than 6 months	permanent
Storage capacity	Not less than 2K	Not less than 128B

The electronic tag installed on the surface of the mine equipment is not easy to change frequently. And the amount of information needed to store in the electronic tags is just a encoding with no more than 128 bytes. More information can be associated with the database in the ground computer servers. So the design method of using the passive tags principle is adopted in this study.

Emission frequency selection is a key problem in RFID tag design. The emission frequency of RFID tag includes LF band, HF band, UHF band and microwave band. The low frequency band can pass most of the objects. The directional requirement of antenna is not high. But the data transmission rate is small, and the wireless coverage is small. The ultra high frequency band is easily blocked by obstacles, not easy to achieve omnidirectional transmission. But the data transmission rate of ultra high frequency band is high, and the transmission distance is far. The communication quality is better. The microwave band is used in the active tag. So the UHF band is adopted in this study. The frequency of tag is 915M.

The RFID tag antenna is a transponder antenna of RFID tag, which is very important for communication response, and the antenna and the chips composed the RFID tag transponder in common. The type of antenna includes the micro-strip, flat plate, a rod antenna, etc. According to the application conditions of coal mine, the structure of the micro-strip type is chosen.

The basic formula of micro-strip design is[4]:

$$f_r = \frac{c}{2L\sqrt{\varepsilon_r}} \tag{1}$$

Where, f_r is the working frequency of antenna, c is the speed of light, L is the length of the antenna, ε_r is the relative permittivity of the dielectric plate.

After determining the basic parameters based on formula (1), the simulation software HFSS of the Ansoft company can be used to design the antenna. After the antenna size is calculated, finally the physical processing is carried out. According to the difference of the material and manufacturing process, the RFID tag antenna is divided into several kinds, such as metal etching antenna, printed antenna, copper plating antenna and so on. As shown in Figure 3, the tag antenna designed in this study is mainly composed of the following parts: pads, antenna, antenna capacitance, the point of bridge, the bridge.

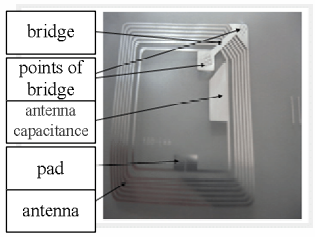

Fig. 3 the tag antenna

Design of safety mark information card reader

The structure of the safety mark information card reader for coal mine is shown in Figure 4. According to Figure 4, the safety mark information card reader includes two parts: the main control circuit and RF transceiver circuit. The main control circuit is composed of micro controller unit, power supply, touch screen, communication circuit, input and output, alarm and other circuits.

The main controller unit is the core of the whole control system. The cooperative communication between the reader and the tag is accomplished by the master controller. And the communication with the ground computer server is also carried out by the main controller unit. The communication modes include Wi-Fi, RS-485, USB. The security information of the mine products can be viewed through the touch screen. The memory stores the related information of the products of encoding and the product safety mark information.

The radio frequency signal unit is composed of a radio frequency signal receiving circuit and a modulated transmitter circuit. The function of the radio frequency signal processing unit is to provide the electronic tag with the excitation energy, modulate the transmit signal, receive and demodulate the information of the electronic tag. The data information is converted into electromagnetic wave and sent. A loop is fixed on the front of the RF circuit, to achieve the send and receive function by one antenna.

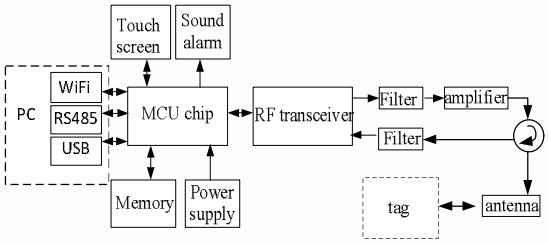

Fig. 4 the structure of the card reader

Key technology of coal mine card reader

Hardware circuit design of the main control circuit

LPC2194 of NXP is used as the micro controller unit. LPC2194 is based on a 16/32-bit ARM core of the microprocessor. The CPU operating frequency can be up to 60MHz. LPC2194 supports real-time simulation and tracking of the CPU, and with 256 (kB) embedded in high-speed Flash memory. The 128 bit wide memory interface and unique acceleration structure enable 32 bit code to run at maximum clock rate. The code size has a strict control of the application can be used in 16 bit Thumb mode to reduce the code size of more than 30%, while the performance of the loss is very small[5].

Power circuit is the basis of all the activities of the chip. The main control chip LPC2194 is supplied by three power, so that the power supply of the external to the main board is balance, which can reduce the pressure drop, reduce heat, and increase the stability of power supply.

The system clock can be divided into the external clock and internal clock circuit. The internal clock frequency is not high, which can not meet the requirements of the system. Taking into account the needs of the system, external clock circuit is used.

Reset refers to the system of all the hardware logic back to the initial state, such as the default value of register recovery, etc. So the reset system is indispensable. The reset circuit is shown in Figure 5.

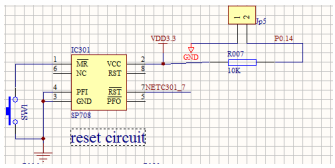

Fig. 5 reset circuit

Design of radio frequency unit

In the radio frequency signal receiving circuit, the AS3991 UHF RFID Gen2 reader chip is adopted.

The AS3991 UHF reader chip is the 1st Generation integrated analog front-end and data framing system for a 900MHz RFID reader system. Built-in programming options make it suitable for a wide range of applications in UHF RFID systems. Designed to simplify the design and implementation of an EPC Class1 Gen2 reader, this IC requires only a standard 8-Bit microcontroller with minimal other components [6]. The structure of AS3991 and connect method are shown in Figure 6. The inner of AS3991 integrated the phase locked loop circuit. Phase tracking of the phase locked loop can improve the spectrum of the signal.

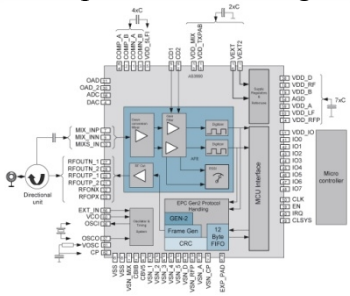

Fig. 6 AS3991 and connect method

In coal mine, card reader is often required to carry out multiple objectives at the same time. This will appear to read and write conflict issues. At present, there are many ways to avoid conflict, such as air separation method, frequency division multiplexing, time division multiplex method. According to the apply condition of coal mine, time slot ALOHA algorithm is used in this study[7].In this algorithm, the tag only transmit data at the beginning of the time slot. Time slots for transmitting data are controlled by the reader. When the reader allocates all the time slots, the tag use the time slots to send data. So the collision frequency is only half of the pure Aloha algorithm. And the performance of the system is doubled.

Experiment of monitoring coal mine products safety mark information

For the mining equipment needed to be on-line managed, this study designs a new intelligent control method of safety mark information, and the laboratory test is carried out. The principle of the experimental test is shown in Figure 7. The card reader is connected to the computer server through the Wi-Fi network. The structure of B/S is adopted. The tags use the radio frequency signal to transmit data to the reader wirelessly. The wireless communication distance between the tags and reader is not less than 1m.

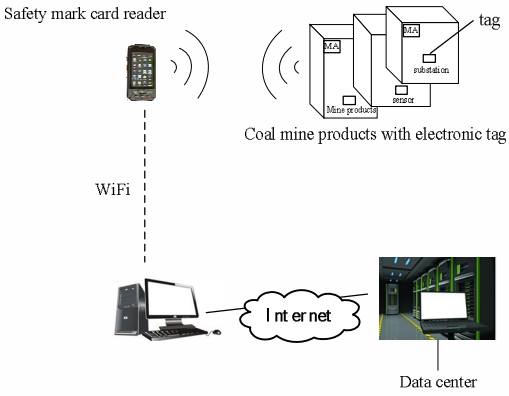

Fig. 7 the principle of the experimental test

As shown in Table 2, it is the result of the software test of security mark information. It can be seen from the table, the production date , security number and other information of mining products can be clearly seen through the card reader based on the security information query system, which can prevent the use of expired, counterfeit products in the coal mine.

Table 2 The security mark information of coal mine products

name	EPC code	safety certification	Company of product	Production date	Expired date
Gas substation	00146F740072	MFB130011	ZGKD	2011/1/1	2013/2/6
CH_4 sensor	00146F740075	MFB090016	BJZK	2012/5/8	2014/5/8
CO sensor	00146F740076	MFB090019	CUMTB	2010/5/9	2012/5/9
Pressure sensor	00146F740077	MFB090018	XZBL	2014/3/9	2016/3/9

Conclusion

(1) A new security mark information detection method is proposed. The safety mark information of mine product is monitored on-line, which can effectively detect intrinsically safe parameters, expired date, connect method, which greatly improve the use security.

(2) A kind of remote communication tag for complex environment in coal mine is designed.

(3) A portable multi object recognition card reader for coal mine is designed.

(4) The laboratory test of coal mine products safety mark information system is finished, and the effect is better.

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