

# Railway signal simulation system based on microcomputer interlocking

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**Abstract.** With the rapid development of railway transportation industry, the higher demand for railway signal control is put forward. In recent years, the rapid development of computer technology and the continuous enhancement of reliability have laid the foundation for the development and application of microcomputer interlocking system. The microcomputer interlocking system is gradually replacing the electric interlocking system used by many stations. Based on this, the railway signal simulation system based on microcomputer interlocking was studied in this paper. The microcomputer interlocking system was introduced in this paper. Then, the control system design of microcomputer interlocking was studied. Then, the simulation system of railway signal based on microcomputer interlocking was studied and debugged. The actual test results show that the signal serial port is working properly, and the signal is consistent with the relay action and interlock table information, which shows that the system is stable and will be applied in a large number of railway stations in the future.

**Key words.** Railway signal, simulation system, microcomputer interlocking, control system.

## 1. Introduction

China is the most populous country in the world, and the annual railway ride rate is the highest in the world. With the gradual development of social economy, people's demand for railway transportation safety is improving. In this case, the railway sector has begun to implement the reform and revision of railway signal control system. Nowadays, the computer interlocking simulation system has gradually replaced the traditional relay centralized control system, and has been applied in a large number of railway stations. Therefore, the research on the railway signal simulation system based on microcomputer interlocking has important practical significance for the development of green ecological building and environment-friendly society. In view of this situation, the railway signal simulation system based on microcomputer interlocking is studied deeply in this paper. The microcomputer interlocking system is the important foundation of the research, and so the microcomputer interlocking system is firstly interpreted. Then, the design of the computer

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interlocking control system is analyzed, and some results are obtained. Finally, the railway signal simulation system based on microcomputer interlocking is studied in detail. The test results show that, compared with the interlock table, it is found that the signal of the system is consistent with the relay action and interlocking table information, indicating that the whole system function is good, and the module is working properly.

## 2. State of the art

In 1978, the world's first microcomputer interlocking devices appeared in Sweden (Dong et al. 2010) [1]. National computer interlocking technology is developing rapidly. Sweden is one of the first countries in the world to develop and apply microcomputer interlocking. Its development is divided into three stages (Wang et al. 2004) [2]. In the first generation of products, the relay control signals, steering, and tracking relay were used. In the second generation of products and signal, the fault safety non-contact circuit was adopted. The tracking relay was still the main contact. At present, the third generation products were all electronic control circuits. Contactless functional block was adopted track relay. In 1985, Halsburg station first used this product (Akita et al. 1985) [3]. In 1979, West Germany decided to develop computer interlocking. In 1983, West Germany commissioned SIEMENS and AGE to develop. In December 1985, Munich developed the first set of computer interlocking devices, and used it at Walter's station (Wang et al. 2006) [4]. The computer interlocking device developed by SIEMENS, Lorenz and AGE three companies was basically of three levels. The difference was that the connection between computer systems was determined by the number of outdoor signal devices and the use of hardware and its fail safe solutions (Ning et al. 2011) [5]. The three levels were: the first level was to preprocess the input and output of the computer, the order of the keyboard input and the individual operating commands. The instruction level was promoted to the next level and displayed in the working state of the interlock logic, so as to display the location and status of the outdoor signal equipment. The second level was the interlocking logic level, and the interlock logic program ran according to the operating conditions. The third level task was to connect and control signals, and carry out polling and track inspection equipment. British SS solid state interlocking system was a distributed structure. The whole system can be divided into several parts: the control and supervision subsystem, the interlocking subsystem, the data path module and the terminal processing device. There were following features in the design: In order to avoid confusion when using the new system, the traditional control panel was still used. Centralized interlocking control mode was used. The interlocking function of each station was concentrated in the control center, and each station was equipped with a terminal processing device, such as a driving signal machine and a switch machine. In the control center, the interlocking function was dispersed. The monitoring object was divided into several regions along the line, and each region was assigned a microcomputer for interlocking. The interlocking device adopted three-fold structure, and the majority voting function was realized by software. In addition to the track circuit, the signal

and switch control relays were fully electronic.

### 3. Methodology

#### 3.1. Overview of microcomputer interlocking systems

Railway signal is an important technical means for railway transportation department to ensure traffic safety, improve transport efficiency, and realize automation of transportation management and automatic control of train operation (Chandra et al. 1991) [6]. According to its application, railway signal system can be divided into station signal control system, marshalling station shunting control system, interval signal control system, railway driving control system and automatic train control system. The station signal control system is one of the important control systems in the field of railway transportation (Wang et al. 2006) [7]. It is based on the station signal, voting, segmentation control. The main function of the station signal system is to eliminate or weaken the safety hidden trouble of the station, ensure the traffic safety, provide the transportation efficiency, and manage the modern information scientifically through the identification of the technical means (Roanes et al. 2011) [8]. The system is a security system, and the output fault of any part of the system will be safely guided. On the other hand, the station signal control system consists of indoor control equipment (outdoor station equipment personnel signal lights, polling stations, parts), as well as communication lines and other hardware devices and circuits (Yang et al. 2006) [9]. These specific rules, the relationship between lights, switches, cross sections, as well as the relationship between constraints, are called interlocking, and the realization of such interlocking devices called interlocking devices, and a device that implements this interlocking is called an interlocking device (Turner et al. 1987) [10]. It can be seen that the core of the station signal control system is interlocked. Therefore, the station signal control system is the realization of interlocking system, also known as the station interlocking system. Figure 1 depicts the actual situation of railway signals.



Fig. 1. Railway signal

From the technical point of view, the station interlocking system has been carried out in the process of mechanical interlock and electrical interlock phase, and now it has been turned on the electronic lock. In the application of the railway station interlocking system in China, according to the difference of the concentration of the scheduling signal and the interlocking control, it can be divided into non-centralized interlocking system and centralized interlocking system. The non-centralized interlocking system is not perfect in identifying, eliminating and mitigating the technical measures that endanger traffic safety, which is only for busy and unreliable stations. A centralized interlocking system is an interlocking system that focuses on the signal floor, which is used to control signals and voting systems. The interlocking mechanisms are also concentrated in the signal architecture (Verma et al. 1985) [11]. At present, the widely used centralized interlocking system is realized by the relay interlocking logic, which is also known as the power centralized interlocking system (Geng et al. 2008) [12]. Electrical control is used to centrally control and monitor station rutting, traffic lights, sections and sections, and to achieve linkage control among them, as shown in Fig. 2.

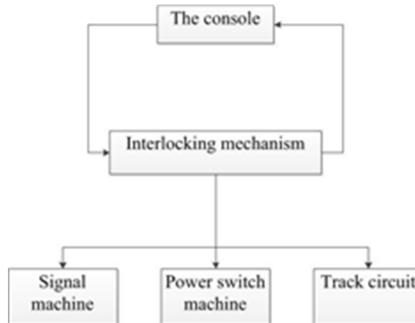


Fig. 2. Microcomputer interlocking system control

### ***3.2. Design of microcomputer interlocking control system***

In a computer interlocking system, a computer control system is used to monitor and control the transportation and production processes of a railway station. It works in the field of railway transport production, and is directly connected with the station signal equipment (Tian et al. 2005) [13]. Therefore, unlike the traditional information processing computer system, the computer itself has a series of features to suit its use. Real time refers to the characteristics of an industrial control computer that must respond to external events within a limited period of time. Industrial control computer can be driven simultaneously. The industrial control computer can respond to an interrupt request within a certain period of all detected scan events (Cribbens et al. 1978) [14]. These changes are usually not very fast, and even if they do not respond immediately, events will not be affected or damaged. The retention time is very short in the inspection process, needing a computer to respond immediately. As the source of the interrupt request, the computer can respond immediately when the event occurs.

The standardization and serialization of an industrial control computer is the use of the recommended standard bus and the preferred industrial control machine, which not only increases the probability of success, but also enhances the benefits of mass production by low price and high performance. At the same time, the low-level repeated development should be avoided, and the system design, manufacturing and debugging, and open cycle should be shortened. In order to ensure the industrial control computer system can lay a good foundation for the long time work in the field of railway transportation production, a series of technical measures must be adopted to improve its reliability (Jianrui et al. 1998) [15]. Modularization means that: in accordance with the implementation of the function, the industrial control computer system' each part is divided into a number of modules, which are produced by computer manufacturers. In the design and manufacture of industrial control computer system, these modules can be used directly. These modules can be used as building blocks in the form of building blocks. With the increase of the size of the system or the increase of the required system function, the industrial control computer system may need to be transformed into the distributed control system, which requires that the industrial control of the computer system should have reliable and simple communication capabilities, and can constitute a LAN capacity. Specific advantages are shown in Table 1.

Table 1. Advantages of computer interlocking system

Advantage	Summary
Strong real-time	An industrial control computer has the ability to respond to external events in a given time.
Full process input and output capability	In addition to CPU, RAM and ROM, a wealth of input devices and output devices, as well as perfect external equipment should also be equipped.
Full process input and output capability	The industrial control computer has the basic part of an ordinary computer.
Standardization and serialization	The standardization and seriation of the industrial control computer is to use the national recommended standard bus and the industrial control machine.
High reliability	Industrial control computer system must be able to work in the environment of railway transportation production for a long time.
Strong communication and networking capabilities	The industrial control computer system must have the reliable and simple communication ability and the ability of the local area network.

### *3.3. 3 Research on railway signal simulation system based on microcomputer interlocking*

Interlocking railway signal system is an important part of interlocking software, and usually with the following characteristics: one is the multi functionality. Because

the interlocking process is in accordance with the design of the road control process, different structures have different station modules. As long as the base station data is modified into an interlocking program, and different data tables are provided, different modes of control can be realized. Therefore, the interlocking procedure is general. In the use of this generic standard structure, it is not necessary to design each specific route program. Because of the program's information sharing, if the program has some defects, then the defects can be easily exposed in the process of debugging and in the simulation of road control process, which can be corrected in time to improve the reliability and security of the program. The second feature is the convenience of the design, production, and maintenance of interlocking systems. For different sites, interlocks are common. The third one is that the station is easily to be easy rebuilt and expanded. The general computer control system is the same, and the modular structure is also adopted in the computer interlocking software design. Interlocking program is based on the process of completing the function, which can be divided into different modules to prepare. These modules are a whole, are relatively independent. The modular software architecture makes the system easy to expand and update.

The software of railway signal simulation system based on microcomputer interlocking can realize the following functions: man-machine interface information processing function. Business information processing: the transaction can be run properly to form an effective order operation, and the corresponding representation should be shown on the screen to let the waiter to confirm their operations. Information processing: the status of the field signal equipment can be displayed on the screen in real time, so that the staff can monitor the use of the equipment at any time. The basic interlocking control functions can complete the interlock function. By clicking the mouse in the track section, the trajectory occupation can be simulated to achieve the normal way to unlock, manual unlock, and abnormal unlock, as well as the manual voting, 64D relay semi-automatic block function, and so on. The control function: the control circuit of the field equipment is driven according to the control commands generated by the interlocking software. Input control: the scene, signal, and voting status information of the track circuit are collected in real time to provide data for the interlock operation.

#### 4. Result analysis and discussion

In this paper, the railway signal simulation system based on microcomputer interlocking is tested. Firstly, the control panel of the switch is connected with the microprocessor interface board and the signal control panel through the cable. Secondly, in order to facilitate the software debugging, the network interface and PC are used. Finally through the RS-422/RS-232 converter, the interlocking center of the RS-422 serial port is connected to the PC serial port. The purpose of using the NFS root file system is to connect the microprocessor interface board and PC through the network cable, which is easy to debug the system software. The RS-422/RS-232 converter is connected through the microprocessor interface board and PC to verify that the serial port is working normally. For the test condition of the signal control

board and the board, the action can be directly determined by the control panel. So after the connection is complete, the debug circuit can be tested on the whole system.



Fig. 3. Debugging process of railway signal simulation system based on microcomputer interlocking

Finally, the signal control board, the switch control panel and the serial port module are debugged. Simulation system can be called in the simulation of the whole process of the PC system, as shown in Fig. 3. The host program is running, the start and end buttons are clicked to observe the signal and relay action. Compared with the interlock table, it is found that the signal is consistent with the relay action and interlock table information, indicating that the whole system function is good, and the module is working properly.

## 5. Conclusion

The microcomputer interlocking analog signal control system is the future development direction of railway station signal control. Its application has obvious advantages. Through the design and development of the corresponding PLC software, the signal control operation can be realized, and the system design can make appropriate changes according to the different railway station conditions. It is found that its performance is good after evaluation. The microcomputer interlocking system was firstly introduced in this paper. Then, the design of microcomputer interlocking control system was studied. And the simulation system of railway signal based on microcomputer interlocking was studied and debugged. However, at present, the research of computer interlocking signal control system is still at the primary stage, and a lot of professional knowledge is not known to the public. Therefore, the combination of hardware and software can be used to achieve the control of the station

signal. With the continuous deepening of scientific research, it is believed that in the near future, all of the domestic railway station signal control system can achieve computer interlocking simulation control. Due to the limited time and ability, there are some deficiencies in this paper. For example, due to the uneven development of railway in various regions, the results of this study may not be suitable for other areas, thus needing further study.

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