

## Design and implementation of PLC escalator control system

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**Keywords:** PLC; Escalator control system; Safety; Reliability

**Abstract:** The escalator provides great convenience for people's life. It is an indispensable means of transportation in major shopping malls and other public places. Therefore, we also put forward higher requirements for the safety and reliability of escalator control system. Firstly, this paper introduces the principle and characteristics of PLC control system, and compares the advantages of PLC escalator control system. Finally, this paper analyses the design requirements of elevator control system, and puts forward a kind of escalator control system based on PLC. At the same time, it describes the design scheme of hardware circuit, the specific main control system circuit and program control flow.

### 1. Basic Composition of PLC

PLC (Programmable Logic Controller) is an electronic device for digital operation. It is designed for industrial production and is the core of industrial control. It USES a kind of programmable memory for its internal storage program, and performs some user-oriented instruction logic operations. These logical operations include timing, counting, sequential control, and arithmetic operations. PLC through digital or analog input, output control of various types of machinery and production process.

PLC control system consists of four parts, including the basic single-chip microcomputer system, photoelectric isolation switch quantity input, photoelectric isolation switch quantity output and external expansion memory. Its composition block diagram is shown in figure 1.

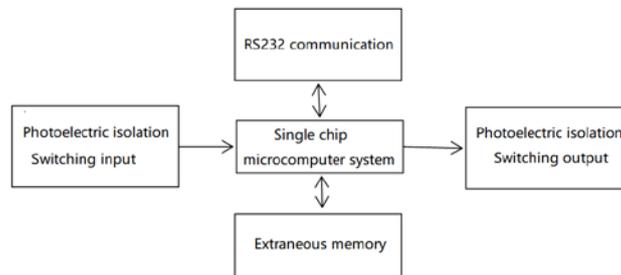


Fig. 1 Basic block diagram of PLC system

### 2. Characteristics of PLC escalator control system

The traditional escalator adopts relay control, so compared with the relay control of the traditional escalator, the PLC control escalator has obvious advantages.

(1) Higher reliability and stability. The reliability and stability of escalator operation depends on the reliability and stability of control system. Because of the maturity of technology, PLC control system uses better components and higher technology, which is more stable, safe and reliable than relay control system. The PLC system has the function of automatic detection. It can check the system before operation. If there is a problem, it is forbidden to start. In the process of operation, the PLC system can also automatically check and monitor its own operation. If it detects a problem, it will automatically cut off power and avoid burning other parts of the circuit. In addition, the PLC system also has the function of current limiting protection. It can distribute the current and voltage reasonably according to the circuit conditions, so as to avoid the excessive current and protect the components.

(2) The programming operation is simple. PLC programming is flexible and easy to understand. At present, ladder diagram programming is widely used, which is simple and easy to understand. Formally similar to relay control, people with electrical control foundation are easier to master.

(3) Flexible control. PLC has the characteristics of system standardization and modularization, flexible combination and flexible control. It can control either one escalator or multiple escalators at the same time, and its operation is flexible.

(4) The communication function is powerful. It is convenient for PLC to communicate with computers, sensors and other equipment. It can be perfectly combined with computer to communicate and control different electrical equipment.

### **3. Design requirements of escalators**

In addition to meeting the requirements of energy saving, escalators should also meet the compulsory standards of relevant national equipment in order to ensure passenger safety. Only when the escalator design is full of relevant requirements, the control system is stable and the design is reasonable, can the escalator have higher safety and reliability, and can accidents be avoided as far as possible. Therefore, the requirements of escalator control system design are more stringent.

#### **3.1 Requirements for Automatic Operation**

First of all, escalators should be able to achieve automatic operation, which should meet the following requirements:

(1) When the specified direction of escalator operation is set, the escalator is automatically started and the machine is in standby state.

(2) When a passenger is approaching the elevator, the signal is detected by the photoelectric sensor. The escalator accelerates slowly from standby state to the rated speed and enters the normal operation state.

(3) In the normal speed operation, if no one rides in the prescribed time, the escalator slowly slows down to low speed operation and enters the waiting state;

(4) In the pre-set low-speed operation process, if someone is detected approaching the escalator, the escalator slowly accelerates to the rated speed and enters the normal operation state; if no one takes the elevator at the prescribed time, it slows down slowly from the original low-speed to stop and enters the standby state; thus, the cycle is completed.

#### **3.2 Control Requirements**

In terms of electrical control, the corresponding requirements should be met.

(1) When the escalator starts, it runs smoothly without shaking.

(2) When nobody rides the escalator, the escalator can enter the energy-saving (low speed or stop) state from the original motion state.

(3) When an accident occurs, the escalator can be operated manually and forced to stop running.

(4) When the escalator is in a low-speed standby state or normal operation state, when someone is approaching in the opposite direction, it can give an automatic alarm or prompt.

(5) When the escalator is being repaired, the escalator should be in a low-speed operation or stop operation state, other switch control should not work, but the protection circuit should play a role.

### **4. Overall design of escalator control system**

#### **4.1 Hardware Circuit**

##### **4.1.1 Hardware Circuit Principle and Composition**

The escalator control system is mainly composed of some other peripheral circuits on the basis of the original power frequency control. It includes photoelectric signal detection, safety signal detection, state operation detection circuit, frequency converter and fault indicator lamp, etc. The

specific hardware circuit composition is shown in Figure 2.

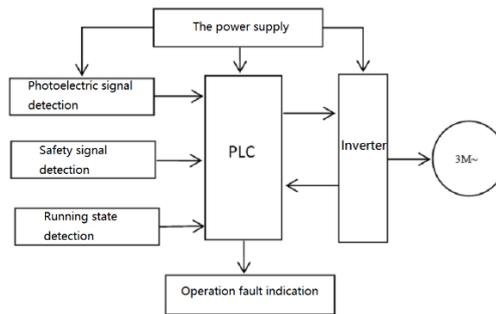


Fig.2 Circuit block diagram

As the core of the control system, PLC receives all kinds of signals detected by infrared sensors, processes the monitoring signals accordingly, and realizes the regulation of motor speed and the control of various operation states through frequency converter circuit, including normal operation, standby, stop operation, inspection and maintenance, condition display, fault judgment and record.

#### 4.1.2 Main Circuit Design of Control System

The PLC elevator control system is based on the principle of automatic control. Its main control circuit is shown in Figure 3.

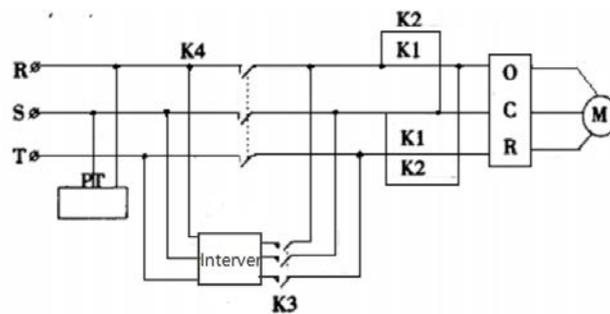


Fig. 3 Main circuit diagram of control system

Among them, R, S and T are three-phase power supply inverter power line, three-phase power supply servo driver power line and three-phase power supply servo spindle driver power line. K1, K2, K3 and K4 are four contactors, of which K1 and K2 are escalator forward and reverse contactors respectively, K3 and K4 are power connected contactors through frequency converter and without frequency converter respectively. OCR (Over Current Relay), also known as overcurrent relay, protects the overheated condition of the motor caused by excessive current. M is a three-phase asynchronous motor, which drives the elevator to rotate and realizes various movements of the elevator. PT is a power detection and protection driver. It mainly supplies power to relay protection devices. It protects valuable equipment and motors in the system when the circuit breaks down.

When the escalator is moving up or down, turn on K1 and K2. When the elevator starts, the speed increases slowly, and the frequency converter needs to be connected. At this time, the elevator is in the state of variable speed operation, and the contactor K1K3 or K2K3 is connected. The frequency converter increases the motor torque, which increases the motor speed and the elevator speed. When the elevator speed reaches the normal operation speed, the frequency converter disconnects and stops working. The contactor K4 is connected, while the system is connected to K1K4 or K2K4. The function of frequency converter is to increase the motor torque when starting, stopping or pointing. When the elevator reaches normal speed, it does not need a large torque. Therefore, the frequency converter is disconnected at this time to reduce energy loss and achieve the purpose of energy saving and environmental protection.

## 4.2 Program Control Flow Design

Various states of the motor, such as normal operation, standby, inspection and maintenance, fault alarm, etc., are judged by various signals collected by sensors. Then through the internal processing of PLC, the operation of external frequency converter and motor is controlled by instructions. The flow chart of PLC program control is shown in Figure 4.

Before the PLC control program runs, it initializes and reads the running state of the escalator into the system through signal acquisition. The system confirms the running mode of the elevator and carries out safety detection. If a fault occurs, the escalator stops running and shows the fault; if no fault is detected, the escalator runs normally and shows the running state.

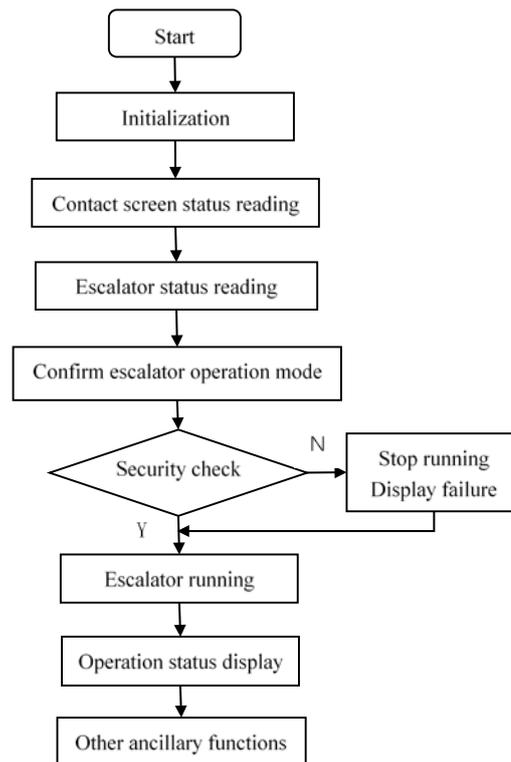


Figure 4 Program Control Flow Chart

## 5. Conclusion

The escalator plays an important role in people's life. With the development of the times, the elevator control system has become more sensitive and convenient. Compared with relay control, PLC control system has many advantages; we can realize the variable speed movement of elevator by adding frequency converter in the circuit, and achieve the goal of energy saving and environmental protection. In short, with the development and combination of PLC technology, computer technology and sensor technology, escalator operation will become more intelligent, and safer and more reliable.

## References

- [1] Shi Guosheng. Electrical Control and Programmable Controller Technology [M]. Beijing: Chemical Industry Press, 2003
- [2] Gu Deren, Lu Xiaochun. Design of multi-function frequency conversion and energy-saving control system for escalator based on PLC [J]. Inverter World, 2009 (04).
- [3] Chen Qingfeng. Design of escalator control system based on PLC [D]. Suzhou University, 2014.

- [4] Zheng Min, Liu Ming. Design of escalator frequency conversion speed regulation based on PLC control [J]. Silicon Valley, 2014 (09).
- [5] Shen Yumei. Design of frequency conversion system of escalator based on PLC [J]. Mechanical and electrical engineering technology, 2011 (12)
- [6] Zhang Wenwei, Xia Jiaoyong, Zhang Rui. Application of PLC in energy-saving operation of escalators [J]. Mechatronics, 2008 (09)
- [7] Chen Yubin. Design of escalator energy-saving operation control system [J]. Journal of Changjiang University: Natural Science Edition, 2010 (06)