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Design of Elevator Control System Based on S7-200PLC

Xin Chen, Xuemin Bai, Li Yang*, Qi Wang

Department of Physics and Electronic Engineering, Jinzhong University, Jinzhong 030619, Shanxi, China

**Author to whom correspondence should be addressed.*

Abstract: With the acceleration of urbanization and the increasing number of high-rise buildings, elevators, as key equipment for vertical transportation, have attracted significant attention regarding the safety, reliability, and efficiency of their operation. This design develops a four-floor elevator control system based on S7-200PLC. It realizes the following functions: the second and third floors support both upward and downward request functions (with corresponding indicator lights turning on), the first floor only supports the upward request function, and the fourth floor only supports the downward request function. Meanwhile, the elevator automatically opens its door after arriving at each floor and closes the door automatically 6 seconds later. The design aims to achieve precise control and efficient operation of the elevator.

Keywords: PLC; Elevator; Control system

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1. Introduction

In the field of modern industrial control, the Programmable Logic Controller (PLC) has become a key device for realizing automated control due to its high reliability, strong anti-interference capability, and flexible programming features. It is widely used in various fields such as manufacturing, energy, construction, and transportation. In the construction industry, elevators are indispensable vertical transportation tools, and the performance of their control systems directly affects people's daily life, work efficiency, as well as ride safety and comfort.

Traditional elevator control systems mostly adopt the relay control mode, which has defects such as weak functions, frequent failures, poor reliability, and short service life. As a general-purpose automatic control device manufactured using microcomputer technology, the PLC can control both discrete quantities and analog quantities, and possesses functions such as logical judgment, timing, counting, memory, and arithmetic operations. It plays an important role in elevator control systems [1]. At present, relevant research on elevator control systems has been quite extensive. For example, the article "Design of a 30-Floor Elevator Control System Based on S7-200" presents the high-voltage circuit and protection circuit of the 30-floor elevator control system based on the S7-200

PLC [2]. The article "Design of an Elevator Control System Based on Siemens S7-200 PLC" provides a complete control scheme for a three-floor elevator [3].

This paper designs a four-floor elevator control system based on the S7-200 PLC, aiming to give full play to its advantages and improve the performance of the elevator. Through this system, precise control of elevator operation can be achieved, including the accurate indication of indicator lights when arriving at each floor, the realization of the up and down request functions for the 2nd and 3rd floors as well as the normal operation of the corresponding indicator lights, the realization of the specific direction request functions for the 1st and 4th floors, and the function of opening the door for 6 seconds and then automatically closing it (accompanied by the illumination of indicator lights) after the elevator arrives at each floor. Thus, it provides users with a more convenient, efficient, safe, and comfortable elevator riding experience, and meets the actual needs for elevator control systems in modern buildings.

2. Composition of the system

The elevator is mainly composed of a drive system, a guidance system, a mechanical safety protection system, a door opening and closing system, etc. [4]. The PLC main unit is the core of the control system. External signals can be sent to the interior of the PLC through interfaces for logical operation and processing. The results after operation and processing send display signals to peripheral devices through output interfaces, and issue control signals to the main circuit and door motor circuit, so as to realize the control of the elevator's operating status [5].

3. Hardware equipment selection

Currently, elevator control methods include relay and instrument control, single-chip microcomputer control, and PLC control. Among them, relay and instrument control is composed of combined electric unit instruments and relays. Initially, traditional relay control was the primary method for automated control, which involved combining various relays, meters, and measuring instruments for control purposes. This control method can only achieve single parameter control and cannot form a complete system [6,7]. The advantages of this design lie in its low cost and relatively mature technology; however, it has significant drawbacks: it wastes space and energy, has a short service life, lacks safety, and features a long response time. Its biggest disadvantage is the difficulty in remote data transmission when the system malfunctions, making maintenance cumbersome.

With the development of technology, single-chip microcomputer controllers were introduced [8,9]. Using a single-chip microcomputer integrated circuit as the CPU for an elevator control system offers numerous advantages over relay control. Nevertheless, its main issue in elevator control is the presence of excessive interference factors. When building the hardware for this chip, extremely complex anti-interference measures are required, and the chip itself has poor stability. This makes the system vulnerable to interference from the external environment, so it is usually only used in scenarios with relatively few interference factors [10]. Compared with the previous two designs, PLC control systems are more suitable for elevator control systems. The design concept of PLC is mainly based on the logic and principles of computers.

In the early stage of its development, PLC had simple logic, with only one main program executed sequentially. The control tasks it completed were similar to those of relays, involving only switching values. However, with the development of microcomputer technology, communication technology, and industrial automation, PLC has made significant progress: its operating speed has been greatly improved, and in particular, the improvement of communication modules and functions enables PLC to realize the calculation of analog quantities while processing and calculating digital data. PLC has the characteristics of being not susceptible to interference, not easily damaged, convenient and easy to learn in terms of communication and configuration, short development cycle, easy maintenance, and facilitating equipment expansion and modification. It is applied in various fields, such as the automated control of mechanical equipment production and manufacturing processes, and is expected to be widely adopted in large-scale equipment and automatic control fields. Currently, most elevator design systems use PLC as the CPU. PLC has the advantages of high applicability, strong anti-interference ability, easier control, and convenient maintenance, so it is widely used in industrial on-site and other occasions. Therefore, it has become a key technology in elevator operation.

Among the numerous S7-200 PLC models, the CPU224 model was selected after comprehensively considering the functional requirements and I/O point requirements of the elevator control system in this design [11–13]. The CPU224 integrates 14 digital input points and 10 digital output points, which can meet the basic input and output requirements of the elevator control system in this design. Its program memory capacity is 16 KB and data memory capacity is 10 KB, which is sufficient to store the programs and data required for elevator control. This model also has strong computing capability and fast scanning speed, enabling it to quickly process various input signals and execute user programs, thus ensuring the real-time performance and stability of the elevator control system. In addition, the CPU224 supports multiple communication protocols, such as PPI, MPI, and PROFIBUS, which facilitates communication and networking with other devices and provides possibilities for the expansion and remote monitoring of the elevator control system [14,15].

4. System software design

4.1. Ladder diagram program design

The program control flow chart of this design is shown in **Figure 1**.

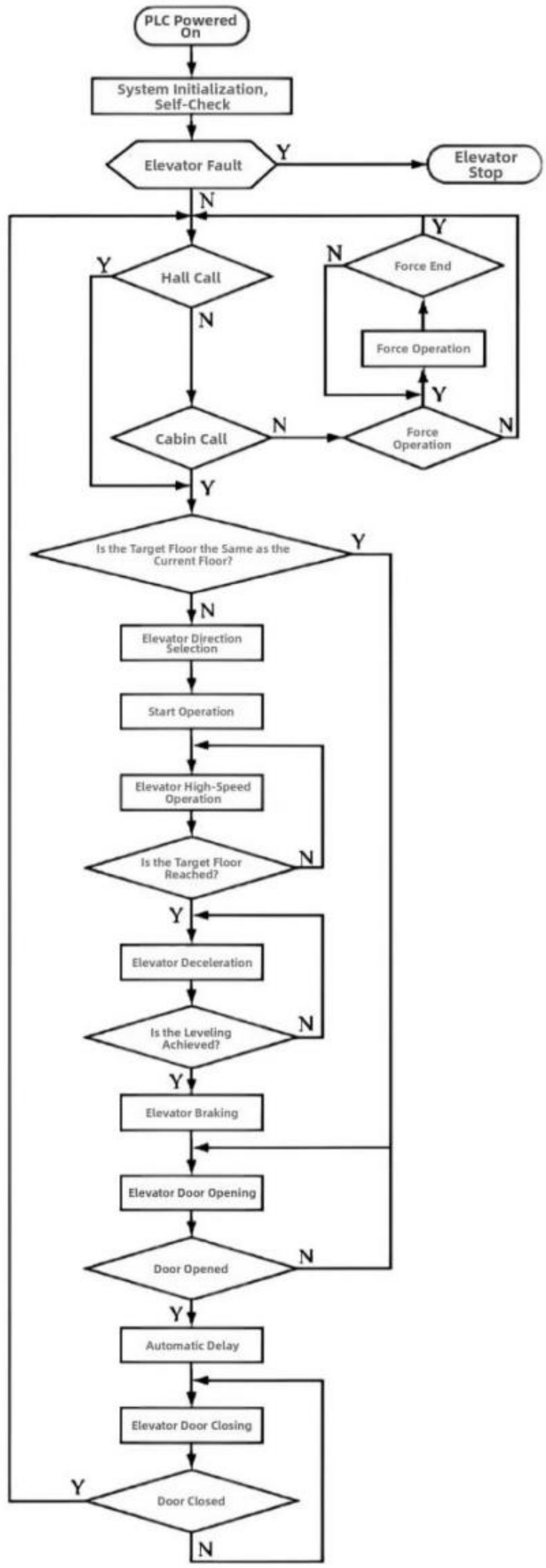

Figure 1. Program control flow chart.

4.2. Ladder diagram design for partial functions

The request signals of the elevator are as follows:

(1) 2nd floor up request signal: When the up button on the 2nd floor is pressed, the normally open contact I1.1 closes, and M2.2 outputs 1, thereby causing the normally open contact M2.2 to close and Q1.1 to output 1, that is, the 2nd floor up signal light is on (**Figure 2**);

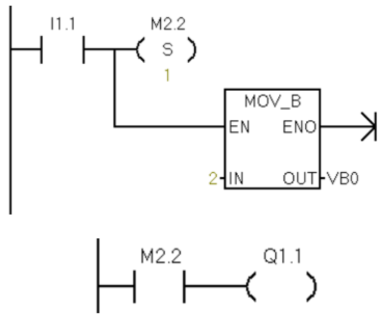

Figure 2. Ladder diagram for 2nd floor up request response.

(2) 2nd floor down request signal: When the down button on the 2nd floor is pressed, the normally open contact I1.0 closes, and M2.1 outputs 1, thereby causing the normally open contact M2.1 to close and Q1.2 to output 1, that is, the 2nd floor down signal light is on (**Figure 3**);

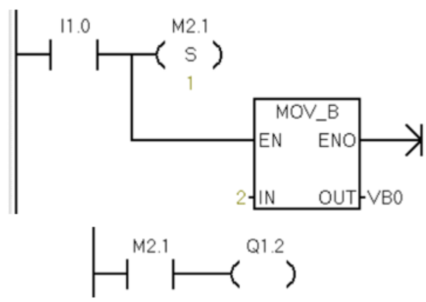

Figure 3. Ladder diagram for 2nd floor down request response.

(3) 2nd floor arrival signal: When the elevator arrives at the 2nd floor, the normally open contact I0.2 closes, and the request signal of the 2nd floor causes the normally open contact M2.1 or M2.2 to close. Then M5.0 outputs 1, which causes the normally open contact M5.0 to close. Timer T37 starts timing for 3 seconds. After the timing is completed, the normally open contact T37 closes, and Q0.4 outputs 1, indicating that the elevator door opens. At the same time, timer T38 starts timing for the door opening. After 6 seconds, the timing is completed, the normally open contact T38 closes, Q0.4 outputs 0 (indicating that the elevator door closes), and Q0.5 outputs 1 (indicating that the elevator leaves the 2nd floor) (**Figure 4**);

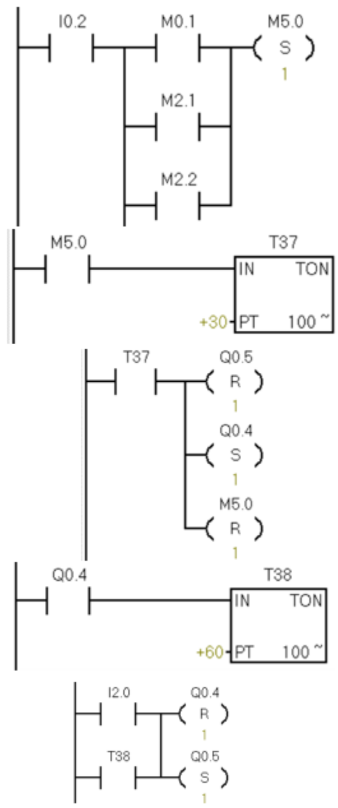

Figure 4. Ladder diagram for response to arrival at the 2^{nd} floor.

5. System function test

After completing the design of the system's hardware and software, tests will be conducted on the elevator's up/down request function and door opening function. The main function to be verified is whether the elevator can successfully arrive at the current floor and open/close its doors after an up/down request is issued from that floor. The test results are shown in **Table 1**.

Table 1. Test results

Request from (floor)	Successful attempts in arriving at the current floor/ opening/closing the elevator doors	Failed attempts in arriving at the current floor/ opening/closing the elevator doors
1^{st}	20/20	0/0
2^{nd}	20/20	0/0
3^{rd}	20/20	0/0
4^{th}	20/20	0/0

6. Conclusion

In this design, S7-200PLC is used as the core component of the entire system to determine the basic functions of the elevator. When a passenger sends an upward or downward request on a certain floor, the elevator can successfully arrive at that floor, automatically open the elevator door after 3 seconds, and automatically close the elevator door after 6 seconds. Through testing, the system has a simple and efficient implementation process, is safe and reliable, and provides a strong sense of comfort. Compared with other controllers, PLC control has better development prospects. Future elevators will develop in the directions of intelligent group control and Bluetooth-enabled elevators.

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Disclosure statement

The authors declare no conflict of interest.

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