ISSN: 2664-9640

Research on Optimization of Self-locking Function of End Door Control System of EMU

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Abstract

Since the reform and opening up, my country has continuously accelerated the construction of railway transportation, and strived to promote the high-quality and efficient development of railway transportation. The formation of EMUs has become one of the necessary tools for passenger travel. At the connection between the inner car and the car of the EMU, double-leaf electric end doors are installed. This electric end door is a necessary passage for passengers to pass between different cars. The safety issue is whether the entire high-speed EMU A key consideration for stability. Due to the frequent shaking of the train during the traveling, the door panels of the end doors were opened for no reason. In response to this phenomenon, a self-locking function is designed to further improve the stability of the control system.

Keywords

End door control system; Self-locking function; EMU.

1. Introduction

When the electric end door of the EMU is in the closed state, it must be kept tightly closed, and no gap should be left between the double doors to ensure the airtightness between the different compartments[1]. When there are accidents such as artificial external force (hands forcing the door with both hands), the car body shakes during the operation of the EMU, and there is no door opening signal, the double-leaf end door will open to a certain extent. In order to avoid the above-mentioned accidents, the electric end door control system of the EMU should have a self-locking function[2].

2. Self-locking function optimization

2.1. Existing self-locking function

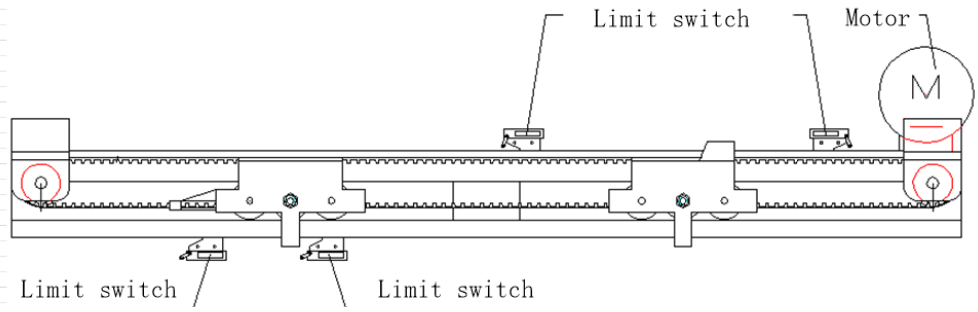

Fig. 1 Control system with limit switch

As shown in Fig. 1, ordinary self-locking control requires limit switches to be installed on both sides of the double-leaf end door. When the end door control system does not receive the door opening signal, the appearance of external force will cause the double-leaf door to move. If it

ISSN: 2664-9640

moves to a certain distance, it will trigger the limit switch action, and the control system will receive the action from the limit switch Signal, it will execute the closing process and return to the closed position again.

This control method is relatively easy to implement due to its simple idea. However, in actual control, the position of the limit switch and its own different mechanical structure will have varying degrees of influence on the actual effect, resulting in many shortcomings such as large gaps between the end doors on both sides and slow response.

2.2. Optimized self-locking function

To optimize the above-mentioned self-locking control function, the Hall counting down method is adopted. According to the perimeter formula:

$$l = \pi d = 2\pi r \tag{1}$$

It is calculated that the circumference of the reduction gear is approximately 245 mm, that is, the gear rotates once, and the converted horizontal distance is 245 mm, and the Hall jump signal that the motor must experience for one revolution is:

$$PPR = 2\times3\times4 = 24 \tag{2}$$

One revolution of the reduction gear will accumulate the Hall count as:

$$N_{hall} = PPR\times15 = 2\times3\times4\times15 = 360 \tag{3}$$

When the system is in standby, the motor is in a stopped running state, and no Hall feedback signal is sent back to the microprocessor STM32[3]. In this state, the system has recorded the running distance of the lower end door (stored in the form of the accumulated value of the Hall count). If the double-leaf end door moves due to external force, the count value will continue to decrease (in the door opening movement, the accumulated Hall value will decrease continuously). The self-locking threshold can be set to be effective when 10 Hall count values are reduced, that is, if the displacement of the double-leaf end door exceeds 7 mm, the locking procedure will be executed, as shown in Fig. 2.

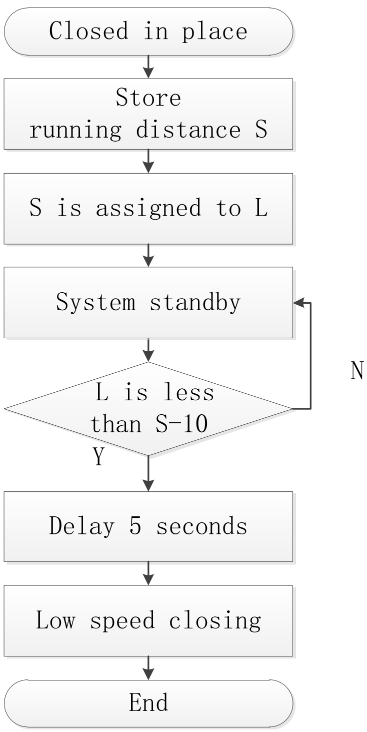

Fig. 2 Self-locking function

For safety reasons, after judging that the double-leaf end door does have a gap, in order to prevent small parts such as the passenger's fingers from being caught during the closing process, it is necessary to delay the execution of the closing procedure after 5 seconds, and run at a lower speed during the closing process, and add Anti-squeeze function.

When the Hall count value is reduced by more than 50, the gap between the two-leaf end doors is about 35mm. It can be considered that this is due to the increase of the gap caused by the artificially applied external force. Taking into account that passengers desperately want to get in and out of other cars and used improper methods, in the standby state of the system, once it is determined that the reduction of the Hall count exceeds 50, the double-leaf end door will open the door. The self-locking function flow after finishing is shown in Fig. 3.

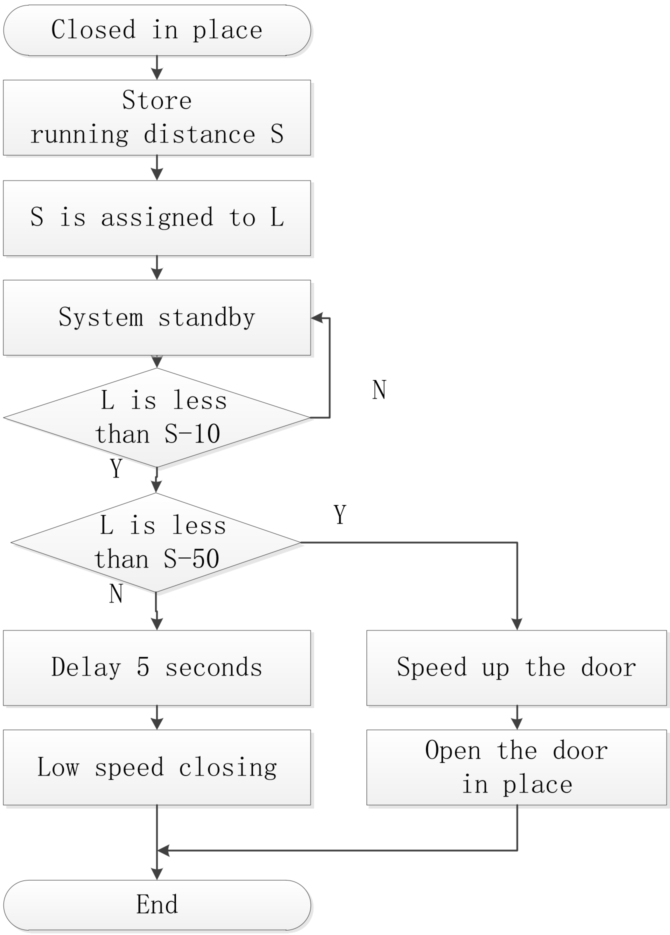

Fig. 3 Complete process of self-locking function

Through the method of decreasing the Hall count, the construction and installation of limit switches can be eliminated, cost is saved, and the self-locking function can be performed efficiently and practically.

2.3. Experiment

The experimental results are shown in Table 1. When the distance of the double-leaf end door is forcibly opened by external force is less than 7mm, the motor has no feedback action; when the opening distance is between 7mm and 35mm, the door is closed at a low uniform speed; When the opening distance exceeds 35mm, it is considered that the passengers are eager to pass through the car, and the double-leaf end door opens the door.

Table 1 Experimental test data of self-locking function

Double-leaf door clearance(mm)	self-locking function	waiting time	(Waiting time is over) End gate running status
0	Don't trigger	zero	Stop
5	Don't trigger	zero	Stop

10	Trigger	5 second	Low speed closing
15	Trigger	5 second	Low speed closing
30	Trigger	5 second	Low speed closing
35	Trigger	2.5 second	Open the door
40	Trigger	2.5 second	Open the door

3. Summary

The traditional self-locking function requires the use of limit switches. In this article, the existing method is optimized and improved, which reduces the cost, increases the value of use, and further improves the detection accuracy.

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