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Research on AGV Transportation Vehicle Based on PLC

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Abstract. To improve the workshop production efficiency and degree of automation, a PLC based magnetic guided AGV (automated guided vehicle) transport trolley was designed. Taking PLC as the control core and the inductance as the path detection sensor, hardware and software are developed. The inductance signal is amplified by the operational amplifier LM358, and the design of the AGV transport vehicle is completed according to the control and process requirements of the AGV system. Use Solidworks modeling the AGV, and simulate the actual path of motion simulation. Use CodeSys of the PLC programming and Realization of motion control, and on the scene of the input and output panel monitoring and simulation test. The test results show that the system has characteristics of simple operation, stable operation, reliable operation, etc., and can meet the design requirements.

1. Introduction

The automatic guided trolley is a transfer transport trolley equipped with an automatic guiding device. The controller is the core, the battery is powered, and the driver can safely and autonomously travel according to the pre-planned route, and complete the unmanned driving of the designated transportation action [1]. Auto-guided car has the functions of environment awareness, real-time decision-making and behavior control and execution. It is one of the key equipments of modern flexible production line, assembly line and warehouse logistics automation system, which Provides important and effective guarantee for system flexibility, integration and efficient operation [2,3]. In recent years, the application range and technical level of AGV have been rapidly developed [4].

At present, there are many researches on AGV scheduling at home and abroad, mainly focusing on AGV path and production efficiency optimization [5]. At present, the technical level of China's AGV is still only in the 1980s and 1990s, and there is still much room for improvement in China's AGV technology [6]. The core of the AGV system, the AGV ground control system (Stationary System), is also called the AGV upper control system. It mainly implements the division of labor among multiple AGVs in the AGV system (AGVS) to maintain communication and vehicle order.

This design uses Solidworks to carry out three-dimensional modeling of the mechanical structure of the transporting vehicle and carries out motion simulation, and dynamically simulates the running track of the transporting vehicle; using CodeSys to program the PLC, the monitoring interface is prepared, and the logic function of the transporting vehicle was simulated, which laid the foundation for subsequent research and development.

2. Hardware design and software design

2.1 Mechanical structure of AGV transportation vehicle

As shown in Figure 1, the mechanical structure of the AGV transport vehicle mainly includes: chassis frame, detection module bracket, two power wheels and their drive motors, two universal support wheels [7], a battery and a box. The steering of the trolley mainly relies on the differential rotation of the two front wheels driven by the two motors, forcing the front universal wheel to change direction and realize the steering function of the trolley. The structure of the steering system of the trolley adopts a differential steering type four-wheeled vehicle.

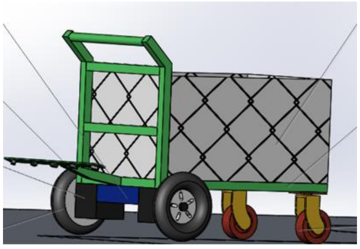

Figure 1. Diagram of the overall appearance.of the transport truck.

2.2AGV magnetic trace tracing principle

The two commonly used tracing methods are divided into magnetic conduction and light guide. Since the magnetic conduction mode is relatively stable, it is not affected by light, and the anti-interference ability is strong, so the magnetic permeability method is finally selected.

As shown in Figure 2, an electromagnetic guiding line is laid on the road surface, and there is an extension rod in front of the transportation vehicle. Five inductances are evenly distributed on the rod for detecting electromagnetic signals, and electromagnetic signals are detected on both sides of the guiding line. When the signal is symmetrical, it is judged that it is running on the straight track, and the rotational speeds of the two motors are controlled to be equal, thereby achieving straight line.

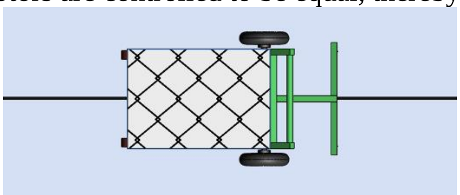

Figure 2. Running chart of the straight channel.

As shown in Figure 3, when entering the curve, the electromagnetic signals on both sides of the guide line are no longer symmetrical. As far as this figure is concerned, it is obvious that the electromagnetic signal detected on the left side (upper side in the figure) is stronger than the right side. (The lower side in the figure) The detected electromagnetic signals are transmitted to the PLC and converted into digital quantities. Through a series of calculations, the rotational speed difference between the left and right motors is controlled to achieve cornering.

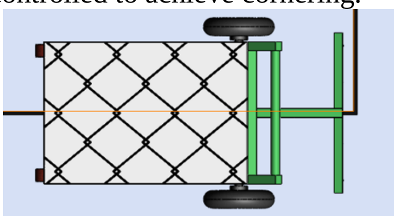

Figure 3. Operating diagram of the curve.

2.3 Hardware selection

2.3.1 Signal source and detection component selection

The so-called signal source, that is, the electromagnetic signal generating device. Considering the problems of loud noise, electromagnetic field and vibration in the factory environment, a common 20khz signal generating power source was selected, as shown in Figure 4. The current can be set by

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adjusting the knob. After testing, we found that the best when the current is adjusted to 100mA. To ensure the signal quality and consider the cost, the selected wire is a 0.8mm enameled wire.

The detection component uses a 10mH I-shaped inductor, as shown in Figure 5. This inductor is low cost, stable, safe and reliable.

Figure 4. signal source.

Figure 5. I-inductor.

2.3.2 Power source and drive selection

The power source can choose stepping motor or DC motor. Considering that precise speed is not needed, in order to save cost, the DC motor is finally selected, and a high-power DC brushless motor is selected in the DC motor, as shown in Figure 6. The driver has chosen one that is compatible with the brushless motor, as shown in Figure 7.

Figure 6. DC brushless motor.

Figure 7. DC motor drive.

The driver shown in Figure 7 has two modes of operation, one is to adjust the speed by inputting 0-5V analog quantity, and the other is to adjust the speed by inputting the PWM duty ratio of 0-100, as shown in Table 1. Because PLC is the core controller, it is convenient to adjust the PWM speed regulation, and the control is more accurate. Finally, the second method is selected.

Table 1. List of drive parameters.

Input voltage	DC18V-50V
Working current	<=10A
Motor hall type	60 degrees, 300 degrees, 120 degrees, 240 degrees
Operating mode	Hall speed closed loop
Speed mode	0-5V analog input, 0-100% PWM input
Speed range	0-30000RPM

2.3.3 Power supply selection

In this design, three different voltage supplies are required, namely 48V, 24V and 5V, of which 48V is used to supply power to the motor, 24V is used to supply power to the PLC, and 5V is used to supply power to the detection module. Therefore, it is designed to supply power to the battery. The total voltage is 48V, which is made up of four 12V batteries connected in series, as shown in Figure 8. The 48V voltage is directly supplied by the total voltage. The 24V voltage is provided by two batteries in series. The 5V voltage is converted by a 12V battery through the step-down conversion module. The conversion module is shown in Figure 9.

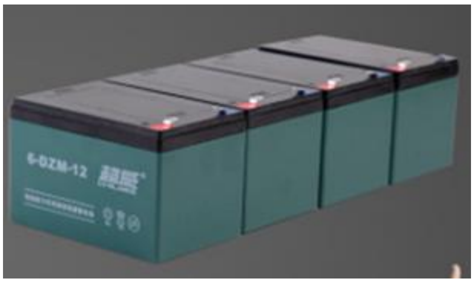

Figure 8. Power supply module.

Figure 9. buck module.

2.4 Design of detection module for AGV transport truck

The detection module has five inductors, each of which corresponds to an amplifying circuit. Figure 10 is a schematic diagram of one of the detecting and amplifying circuits, D1 is an inductor, D2 is a capacitor, and the detected electromagnetic signal is converted into several hundred millivolts by an inductor. The voltage signal, through the sliding varistor, is amplified by the operational amplifier LM358, amplified to a voltage signal varying within 0-5V, and then transmitted to the PLC as an analog quantity. Figure 11 is a PCB of one of the detection modules. Because the circuit is relatively simple, it is designed as a two-layer board.

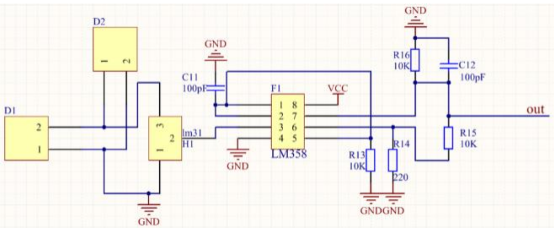

Figure 10. Schematic diagram of detection module.

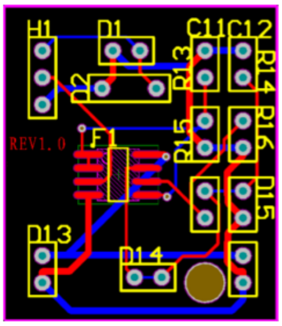

Figure 11. Detection module PCB diagram.

2.5 PLC programming

As shown in Figure 12, after the AGV transport vehicle is powered on, it is initialized first, and the initial value is assigned to the corner. For the convenience of calculation and control, a number of revolutions in the range of 0-100 is defined, and the intermediate value is 50. The corner value when going straight is 50, when the corner value is less than 50, it is left turn, and when the corner value is greater than 50, it is right turn. The initial value of the motor speed is set to 80, that is, the duty ratio of the PWM is given an initial value of 80, and then the truck starts to go straight. Real-time scanning of the corresponding digital quantity of 5 inductors in the PLC, the real-time corner is obtained by formula (1), and then the duty ratio of the left and right motors is determined according to the change of the corner value to realize the motor differential speed and complete the steering.

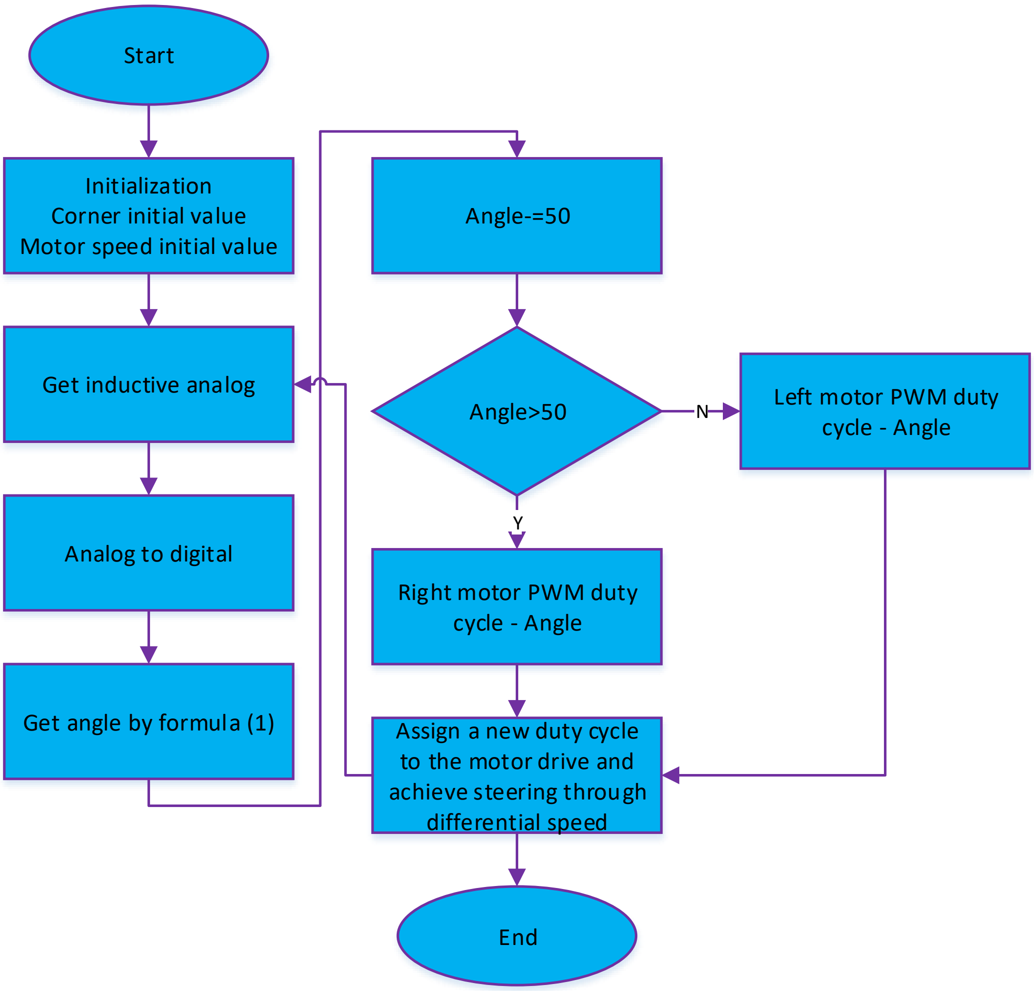

Figure 12. PLC program flow chart.

Formula (1): $$angle = \frac{a0x20 + a1x40 + a2x50 + a3x60 + a4x80}{a0 + a1 + a2 + a3 + a4}$$

For formula (1), a0 represents the digital quantity corresponding to the leftmost inductance, and a1_a4 are sequentially turned to the right. Using this formula, the range of variation of the corner can be effectively controlled within 0-100. When a0 or a1 increases, the value of angle will decrease, that is, the angle of rotation decreases, and the larger the amplitude of a0 and a1 changes, the larger the value of angle changes, the larger the change of the angle of rotation, and the amplitude of the left motor deceleration. The corresponding increase will be made, the differential speed of the two motors will increase, and the steering will be completed. When a3 or a4 increases, the value of angle will increase, that is, the angle of rotation increases, and the larger the amplitude of a3 and a4 changes, the larger the value of angle changes, the larger the change of the angle of rotation, and the extent of the deceleration of the right motor. The corresponding increase will be made, the differential speed of the two motors will increase, and the steering will be completed.

For this type of processing, it is possible to make a quick turn when the bending of the electromagnetic wire is large, and to turn slowly when the bending of the electromagnetic wire is small, thereby achieving the effect of flexible operation.

3. Simulation of AGV truck

3.1 Motion simulation of AGV truck

In the design of the mechanism, the most difficult and cumbersome work is the design and trajectory check of the motion mechanism. At present, the trajectory map method is used or the equations are solved according to geometric constraints, but for more than three moving parts. It is much more troublesome to design, and the design work is not intuitive, and the design results are not satisfactory. Solidworks software is an application software that integrates design and motion track checking. The modeling speed is fast and intuitive, and it can fully display the coordination relationship between components. Therefore, Solidworks was selected to simulate the running trajectory of the transport vehicle, as shown in Figure 13.

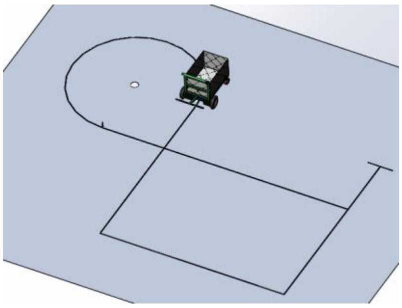

Figure 13. Solidworks motion simulation.

3.2 Panel Monitoring and Simulation of AGV Transportation Vehicle

Before the on-site debugging, it is necessary to simulate the debugging of the program. The interface of the operation panel is written by CoDeSys software, and the input and output signals of the scene are simulated to analyze the availability of the program.

As shown in Figure 14, on the operation panel, the upper left corner shows the rotation speed of the two left and right motors through two tachometers. The upper right corner is the start button, stop button and running indicator. Below the tachometer are three indicators, the left turn signal, the right turn signal and the straight line light. The buttons below the indicator light are used to simulate the control of the truck between the three stations. The right side is used to simulate the voltage signal obtained by amplifying the five inductor values through the amplifier.

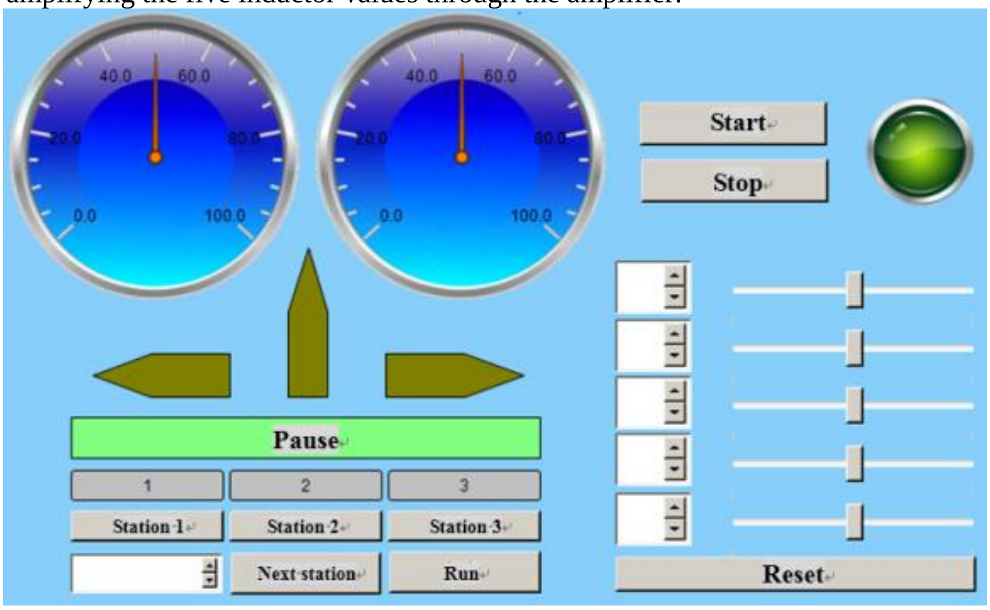

Figure 14. Panel monitor.

Press the start button, the start indicator lights, because the initialization will give the initial value of the motor speed, the left and right two motor tachometer will display a certain value, and the straight line indicator will light up. By adjusting the size of the five voltage signals, the steering of the truck can be simulated.

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During the operation, it is assumed that there are three stations, and any one station can send instructions to the truck at any time. The truck will not immediately execute the command. When the truck runs to the station, it will execute the corresponding command. Through panel monitoring, a simulation test of this function can be implemented.

4. Conclusion

This paper studies the factory automatic handling robot AGV system, and mainly completed the following work:

(1) Designed an AGV transport vehicle based on PLC control, which can realize automatic tracking motion.

(2) Based on PLC control structure, the control system of factory automatic handling robot AGV is studied. The circuit schematic of the detection system is designed by Altium Designer. Based on the knowledge of ladder diagram, the program of control system is designed under the Codesys compilation platform. And use PWM pulse width modulation program to reasonably control the speed of the motor, so that the car runs at a stable speed.

(3) Through the Solidworks 3D software, the motion simulation of the transport vehicle is realized.

(4) The test shows that the developed AGV transport vehicle can achieve performance requirements, and the anti-jamming capability of the trolley model is the key to maintaining the normal operation of the trolley.

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