Research and Implementation of the Micro-robot Control System

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Abstract: This article is around the fischertechnik robot control system as the core, research the appropriate control system. Based on the LLWin control principle of the fischertechnik robot, design hardware circuits and resolve motor running problems. Use PLC (Programmable Logic Controller) ladder diagram language to program. Achieve the control of the double of table lines and three degree of freedom manipulator separately. They all have reached an ideal control effect. It provides enforceability of the operation scheme for the simulation and simulation experiment of robot control system.

Keywords: Fischertechnik, PLC, Relay, Double worktable line, Three degree of freedom manipulator.

1. Introduction

Fischertechnik teaching aids and creative models are known as Fischertechnik which combines teaching aids and simulation model together. It is the best vehicle of the knowledge of science and technology enlightenment, the training creative thinking, creativity development. Now the international cutting-edge engineering technology such as bionic technology, pneumatics, sensing technologies, computer technology and robotics, achieve a micro-simulation of alternative in Fischertechnik and do 1:1 reappearance in the technology. Simulation of the part almost can realize any complicated technical process and the large design model of the real reproduction. Its main components include mechanical components (ordinary gear, bevel gear, bevel gear, internal gear, external meshing gear, turbine, vortex bar etc.), electrical components (9 V two-way DC motor, infrared emission sensors, luminous device, electromagnetic valve) etc. It is not only related to the traditional mechanical content but also includes the energy, pneumatic, sensor technology, automatic control (PLC control, single-chip microcomputer control), software programming (editing software LLWin3.01). The most important thing is that it can combine the knowledge well, and reflect to a certain model [1].

This system does the research as to the Fischertechnik models more deeply. Set up double table lines and three degrees of freedom manipulator according to their mechanical character. Refer to the corresponding LLWin control process, on the basis of the actual design needs, using PLC from the hardware and software of control respectively, put
forward new control method which is more practical and applied to industrial production. It is verified reliable performance and ideal control effect through the experiment.

2. Hardware Connection Characteristics

This system is based on PLC belongs to the computer control mode. PLC and its related peripheral equipment should design in accordance with the principle which is easy to form a whole with industrial control system and expand its function. And scan events in a circular. Execute orderly along the ladder diagram. The design uses the Panasonic FP0 series. In this system the positive and negative rotation of the two-way motor is controlled by two signals from PLC. At the same time the two signals provide a positive and a negative level respectively, the motor realizes a direction of rotation, conversely for reversal. But because PLC output is 24 V, and the motor rated voltage is only 6-9V, it is not appropriate that PLC output signal is directly to the motor. In order to match the motor driving voltage, the system adopts the electromagnetic relay to connect PLC and motor. Use Huike DC – 24 V relay specifically.

2.1. The Features of Relay

Relay is an electronic control device, usually has induction mechanism (input part) which can reflect a certain input variables (such as current, voltage, power, impedance, frequency, temperature, pressure, velocity, light, etc.). It has an actuator (output part) which is used to control the circuit that can realize pass or break. There are Intermediate agencies that can couple isolation lose, process input quantity, and drive output part between the input and output sections of the relay. In fact it is a kind of automatic switch with less current to control large current. So in a circuit it plays the function of automatic adjustment, safety protection, conversion circuit. In the design electromagnetic relay is selected to connect the robot and PLC [2].

Electromagnetic relay is composed of iron core, coil, armature, contact reed. As long as in the coil ends with a certain voltage, the coil is through certain current, which causes the electromagnetic effect. Armature attracts to the core overcoming the return spring tension in the electromagnetic force under the action of attract, thus drive armature suction together of the dynamic contact and static contact (normally open contact). When the coil is without electricity, electromagnetic suction disappears with it. Armature returns to its original position in the spring of the reaction, which makes suction close of the dynamic contact and the original static contact (normally closed contact). After the close and suction release, realize the purpose of the conduction and cut of the circuit. The static contact that the relay coil lies off state without electricity is called normally open contact. On the contrary, it is called normally close contact [3].

2.2. The Hardware Circuit Connection of the Motor and PLC

The forward and reverse control of a motor need two PLC output signal. Just need two relays to realize voltage conversion. Connection diagram is as shown in Fig. 1. The normally open pin of relay A and B is to 9 V, the normally closed pin is to ground. At the same time the ground pins are connected together to the ground. 24 V power supply pins are respectively connected to the PLC panel corresponding signal output. So the two signal pins are connected to the ends of the motor separately. When the output of PLC corresponding relay A is for high level 24 V, the normally open contact of the corresponding relay is closed. Then output of the signal pin is 9 V, thus can drive the motor forward turn. When the output of PLC corresponding relay B is for high level 24 V, the motor turns conversely. In the double table robot, there are eight motors, in which there are two motors need two-way rotation, the others are one-way rotation. The external connection of one-way rotation is as shown as Fig. 2. The one pin of the motor is to the power negative, the other ports are the same as above. When the corresponding control port of PLC has output, the normally open contact is closed, the motor turns forward [4, 5].
2.3. The Connection of Limit Switch and Counting Switch

Compared with the connection of motor and PLC, the connection of limit switch, counting switch with PLC is easier. Connect the PLC input with the public end of the corresponding switch. Connect the normally closed end of the switch with the PLC power negative. One point of the sensitive device is to the PLC input, the other end is to the PLC power negative. When receiving enough strong light, will be produced, which makes PLC input is in on state. Otherwise, the input is at the off state.

3. The Realization of the Double Work Table Line

3.1. Working principle

The double work table line is made up of four belts, eight DC motors, four terminal switches, five photoelectric sensors (the photo transistor and lens bulb). It was U arrangement and has two tables. The work is through each table for processing in turn and the processing order is the same. Two tables can work together at the same time, that is, after the first table finished processing a work and this work is manufactured by the second table, the first table can do the next work. The schematic diagram is as shown in Fig. 3 [6, 7].

![Fig. 3. The schematic diagram of the double work table line.](image)

The basic work principle is as follows:

The first, the photoelectric sensor E1 detects the loading of the work. When the work is loaded, it will block the light. Photoelectric sensor that cannot receive the opposite light will produce the falling edge pulse. The trigger motor M1 turns forward and drives the track 1 to ship the work to the table. The second, the photoelectric sensor E2 produces the falling edge pulse when the work is through E2. At this time the timer begins to work in order to make sure that the work can be transmitted from the caterpillar 1 to the platform 1. The third, when the time ends, M1 stalls and M2 turns forward, which puts the work from platform to caterpillar 2. When E3 closes, it will produce high electric level. Motor M2 stalls, motor M3 turns forward, which drives the work from caterpillar 2 to the work processing place. The forth, when the photoelectric sensor E5 produces falling edge pulse, the work has been transported to the processing place. The motor M3 stalls, M4 turns forward, process the work. According to the processing requirements, set the processing time.

The fifth, the time ends, the process ends, the motor M4 stalls. At the same time the motor M3 turns forward, ship the work to the track 3, the motor M5 turns forward, ship to the second processing place. To the track 3, M3 stalls and M2 reverses, until the switch E4 closes, M2 stalls, waiting for the load of the next work. The sixth, when the work is to the second processing place, photoelectric sensor E6 produces falling edge pulse. M5 stalls and M6 turns forward, begin to process the work. Set the processing time of the second table. The seventh, the time is over, M6 stalls and M5 turns forward, ship the work from the track 3 to the platform 4, M5 stalls. M7 turns forward to send the work to the track 4. When switch E7 closes, M7 reverses and M8 turns forward, send the work to the next work place. The eighth, when E8 closes, M7 stalls. The photoelectric sensor E9 produces falling edge pulse when the work is through E9, M8 stalls. The work process and software diagram is as shown in Fig. 4 [8, 9].

4. The Realization of the Three Degrees of Freedom Manipulator

4.1. Characteristics

The three degrees of freedom manipulator can realize grab or place items on the three degrees of freedom direction (horizontal, vertical and rotary). Therefore it has the wide operation scope and good flexibility. Fig. 5 shows the model structure diagram [10, 11].

Through the screw drive, manipulator (mainly by parts 3, 4, and 5) releases and grabs objects by its open and close. Manipulator is fixed in arm (part 6), through horizontal screw drive (parts of 15 and 16), arm can move in the horizontal direction. Through the vertical screw drive (parts of 8 and 17), arm can move in the vertical direction. By means of the drive of the worm gear, the whole system can rotate in the plane direction with the revolving stage (part 2). Therefore the manipulator realizes the movement of the three directions via the two screw drive and the one worm drive. The motion system is composed of horizontal motion, vertical motion, the rotary motion and paw movement. Every movement system control parts are made up of a DC motor, two stroke switches. Next introduce the working principle of three degrees of freedom manipulator using vertical motion as an example [12].
Vertical motion is mainly composed of motor, limit stroke switch and stroke counter switch. Motor provides power for the vertical motion. Choose DC motor which starts forward with 9 V and reverses the -9 V. The limit stroke switch limits the starting position of vertical movement. When the mechanical arm contacts the above limit travel switch, it will stop motion. The count travel switch that has the effect of location is used to measure the rotation cycles of the motor, so calculate accurately the distance of the vertical movement. Vertical motion of specific motion process includes the positioning stage and reset stage. In the positioning stage drive motor to make the arm decline from the initial position, the arm stops in the designated position through counts of the positioning travel switch. In the reset stage the motor reverses to make the arm up until comes to the limit travel switch. Micro computer sends instruction to the motor through PLC to start the motor sport. Signal of the travel switch inputs to the computer via PLC, implements according to the corresponding signal results. The limit stroke switch and the count stroke switch are the same kind of stroke switch. As a trigger type switch, the circuit is to ground when the contact is pressed. At this time the signal from PLC is low level and the digital signal is 0. When the contact suspends, the circuit disconnects, then the digital signal is 1. Computer gives orders according to the received signal such as rotation or cease [13, 14].

Fig. 4. The work process diagram of double table work line.
In Fig. 5: 1 – base; 2 – rotary table; 3 – small cylindrical; 4 – gripper travel switch; 5 – gripper motor; 6 – arm; 7 – vertical stroke switch; 8 – vertical screw; 9 – screw shaft gear; 10 – idler wheel; 11 – vertical motor gear; 12 – vertical motor; 13 – level motor; 14 – horizontal stroke switch; 15 – level screw; 16 – level mother; 17 – vertical nut; 18 – intelligent interface board; 19 – rotary travel switch.

The count principle of count travel switch is as shown in Fig. 6. Install a four gear wheel in the motor shaft. Trigger the travel switch four times when the motor rotates a whirl. That is the trigger number of the travel switch is the whirls of the motor, control the arm position in the vertical. The working principle of horizontal motion, the rotary motion and hand grasp movement is similar with the vertical motion which is made up of the motor and two stroke switches. The positioning travel switch count principle diagram is as shown in Fig. 7.

4.2. The Design Cycle and Application Program

Based on the above works, the application program and the design cycle are shown as Fig. 8 and Fig. 9 [15].
Fig. 9. The application program of the three degrees of freedom manipulator.

5. Conclusion

The system uses the fischertechnik to design and complete the control system of the double work table line and the three degrees of freedom robot manipulator. This design shortens the cycle, reduces the cost and meets the design requirements. The system realizes the transfer and processing for the machining, and the rotation, scaling pitching in space, and the robot can grab and place article in the horizontal, vertical and rotary directions. Adopt PLC as the controller. Solve the connection problem between PLC and the motor. Design the corresponding control process and realize. The whole system has strong practical value.

References