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Design of Group Control System of Manipulator Based on PLC

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Abstract

The development of a control system with excellent technical performance for industrial manipulators is of great significance for improving the overall technical performance of industrial manipulators. Aiming at this problem, this paper chooses PLC as the control system of industrial manipulator, which plays a good role in improving the overall technical performance of industrial manipulator. Based on the PLC manipulator group control system design, the control object of this paper is a manipulator group composed of three handling manipulators, each manipulator completes eight basic actions, three manipulators cooperate with each other. The manipulator is driven by the cylinder, and the cylinder is controlled by the solenoid valve. The limit switch detects whether the manipulator reaches the fixed position. It focuses on the design and introduction of each hardware part of PLC and the compilation of PLC ladder diagram. In the whole design process, according to the leading idea of "putting forward problems, analyzing problems and solving problems", the design work of the whole system is elaborated in detail.

Keywords

PLC; Pneumatic manipulator; Ladder diagram; CPU224.

1. Introduction

At present, with the development of microelectronic technologies such as large-scale and ultra-large-scale integrated circuits, PLC has evolved from the first single computer to the current microcomputer PC composed of 16-bit and 32-bit microprocessor, and has realized the multi-channel processing of multiprocessors. Nowadays, PLC technology is very mature. Not only is the control function enhanced, the power consumption and volume are reduced, the cost is reduced, the reliability is improved, the programming and fault detection are more flexible and convenient, but also with the development of remote I / O and communication network, data processing and image display, PLC is used in the direction of continuous production process control, becoming a major pillar of industrial production automation[1].

In the late 1940s, in the atomic energy experiment in the United States, firstly, a manipulator was used to carry radioactive materials, and people operated the manipulator in a safe room for various operations and experiments[2]. After the 1950s, the manipulator was gradually extended to the industrial production department, used to pick and place workpieces and loading and unloading materials in high temperature and seriously polluted places. It was also used as an auxiliary device of machine tools in automatic machine tools, automatic production lines and machining centers to complete the operation of loading and unloading or taking and placing tools from the magazine and replacing tools according to the fixed procedures. Manipulator is mainly composed of hand and moving mechanism[3]. The hand is used to hold the workpiece (or tool). According to the shape, size, weight, material and operation requirements of the object, there are many kinds of structural forms, such as clamping type, holding type and adsorption type[4]. The movement mechanism enables the hand to complete various rotations (swings), movements or compound movements to achieve the specified actions, and changes the position and posture of the object to be grasped. The lifting,

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stretching, rotating and other independent motion modes of the moving mechanism are called the degrees of freedom of the manipulator[5]. In order to grasp objects in any position and orientation in space, it needs 6 degrees of freedom. The degree of freedom is the key parameter of manipulator design. The more degrees of freedom, the greater the flexibility of the manipulator, the wider the versatility, and the more complex its structure. General purpose manipulator has 2-3 degrees of freedom. The types of manipulator can be divided into hydraulic, pneumatic, electric and mechanical manipulator according to the driving mode; special manipulator and general manipulator according to the scope of application; point position control and continuous trajectory control manipulator according to the motion trajectory control mode.

2. System scheme demonstration

2.1 Manipulator design

There are many kinds of manipulator, but according to the type of arm coordinate, there are mainly rectangular coordinate, cylindrical coordinate, spherical coordinate, joint coordinate and SCARA type [6].

The manipulator in this paper belongs to cylindrical coordinate type, as shown in Fig.1. The manipulator is mainly composed of base and arm. The main task of the base is to support and complete the arm rotation. The arm is installed on the base and moves up and down in a straight line. The hand can be clamped / relaxed. All actions of the manipulator are driven by the cylinder. The cylinder is controlled by a solenoid valve. The driving part includes lifting cylinder, swinging cylinder and hand driving cylinder.

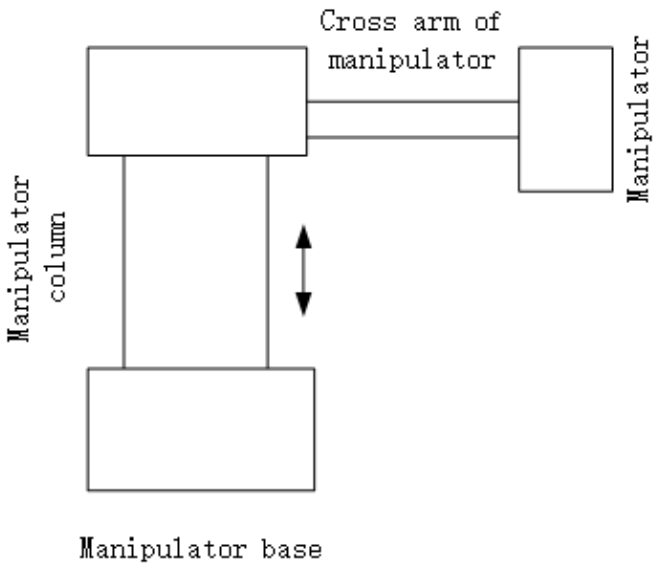

Fig. 1 Schematic diagram of manipulator

The manipulator is driven by air pressure, with a pressure of 0.6MPa and a maximum of 1MPa. This manipulator has two linear motion and one rotational motion freedom, which is used to move the objects on the original workbench to its left workbench. All the actions of the manipulator are driven by the cylinder, and the cylinder is controlled by the solenoid valve[7]. The whole manipulator can realize the functions of rising / falling, left / right rotation, clamping / loosening in the work. It is a relatively simple and widely used manipulator at present. The lifting movement is completed through the cooperation of lifting cylinder, vertical guide post, sliding guide post, vertical guide rail and lifting position microswitch, and the lifting working stroke is 0 ~ 1500mm. The rotation is coordinated by the swinging cylinder, the axial thrust bearing, the swinging arm and the swinging position microswitch, and the rotation stroke is 0 ~ 180 °. The hand holds the object by the action of air cylinder and spring, and the holding force is adjusted by adjusting the pre compression of spring. The working process of the manipulator is shown in Fig.2.

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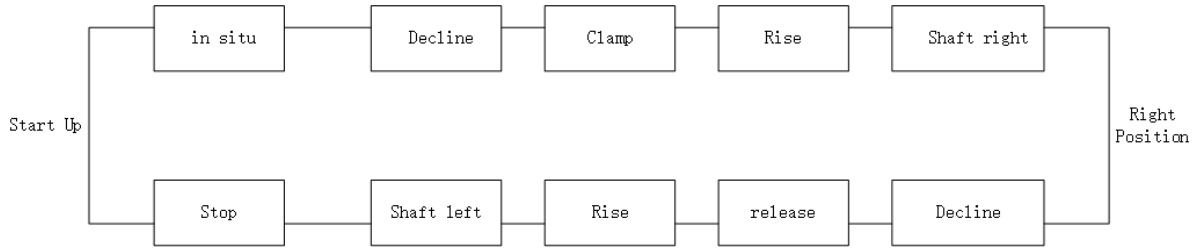

Fig. 2 Work flow chart of manipulator

2.2 Pneumatic handling manipulator group

The control object of this paper is a group of three manipulators. Its structure is shown in Fig.3. Three manipulators, three worktables and three infrared detectors are fixed on a large base. Each manipulator has a working table directly under the hand to place objects. There is an infrared detector between the base of each manipulator and the workbench, which is used to detect whether there is any object on the workbench. The manipulator moves the object from the right side table to the left side table.

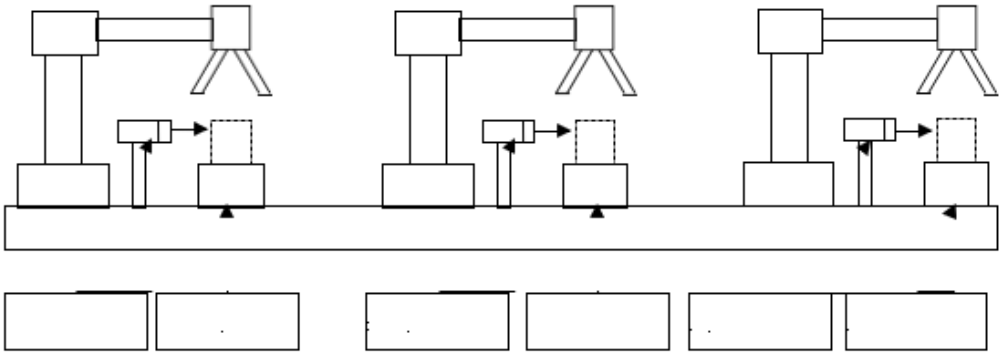

Fig. 3 structure of manipulator group

When the system starts to work and there are articles on workbench a, manipulator 1 works first. After eight basic operations (i.e. one cycle) are completed, put the articles on workbench B, manipulator 2 starts to work. After the same cycle is completed, put the articles on workbench C, manipulator 3 starts to work, so the three manipulators work in a continuous cycle. When the system ends, the machine The manipulator 1 first completes a cycle and then stops, and then the manipulator 2 and manipulator 3 stop working in sequence.

2.3 Main research content of this project

The main content of this paper is to take pneumatic conveying manipulator as the control object, use PLC as the controller, and finally realize the automatic operation control of pneumatic conveying manipulator group. The main program of group control system designed this time

The goal of this paper is that when the system starts to work, manipulator 1 works first. After eight basic operations (i.e. one cycle) are completed, manipulator 2 starts to work. After the same cycle is completed, manipulator 2 starts to work 3. Start the work, so that the three manipulators work in a continuous cycle; when the system is finished, the manipulator 1 first completes a cycle and then stops, and then the manipulator 2 and manipulator 3 stop working in sequence.

Each manipulator completes 8 basic operations. Step 1: when there is something on the workbench, the manipulator descends. The second step is for the robot to hold the object at the lowest position. The third step is to clamp the object up. The fourth step is to clamp the object with a manipulator and turn it 180 degrees to the right. The fifth step is to clamp the object down. Step 6 is to release the item

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at the lowest level. Step 7: the manipulator rises. Step 8 is to rotate the manipulator 180 degrees to the left and return to its original position.

2.4 Control scheme of the system

In order to realize the automatic control of the pneumatic conveying manipulator group, the system uses PLC as the controller. The input switch value of the system is digital signal, which is directly connected to PLC. PLC controls the solenoid valve through the intermediate relay. The system block diagram is shown in Fig.4.

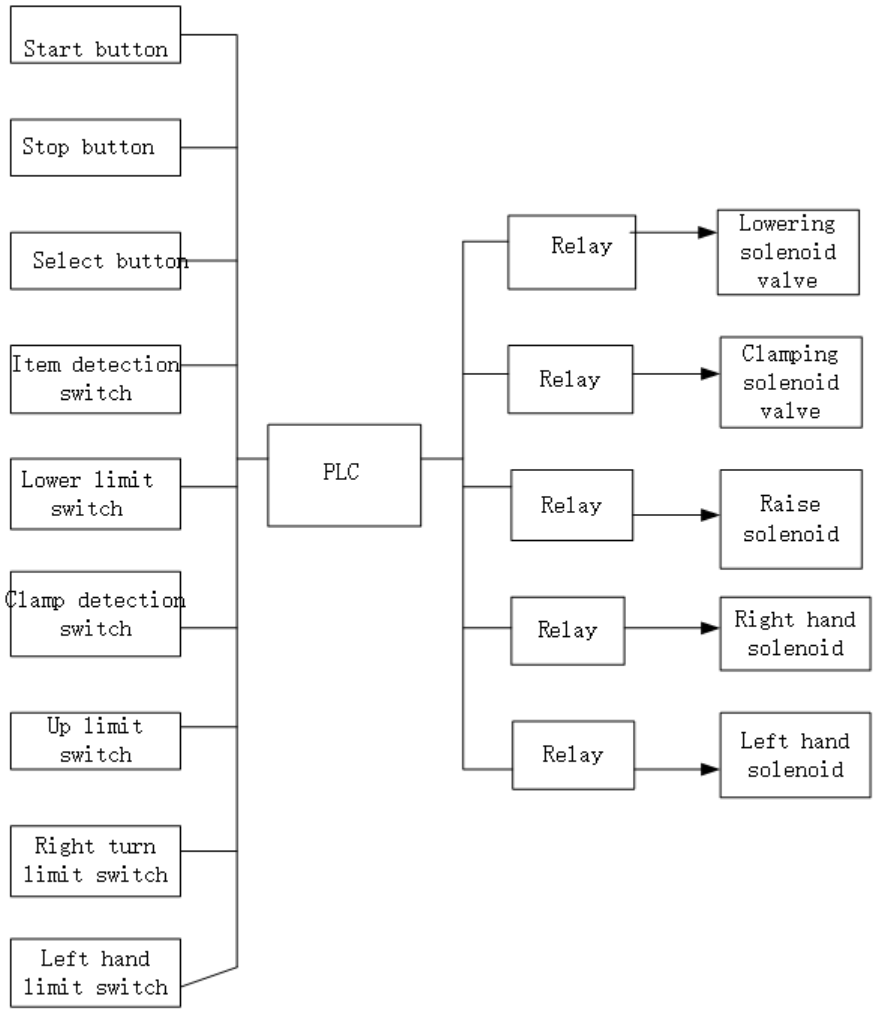

Fig. 4 system block diagram

3. Software design

3.1 Omron CX programmer programming software

OMRON PLC programming software CX programmer [18-20] is the best programmable controller software in the current work, which provides a CPS (component and network profile Sheet) integrated development environment, which can support CS / CJ, CV, C, fqm, CP1H / cp1l, cp1e and other series of instructions, support Omron full series of PLC, support offline simulation, and can be used by staff with knowledge of electrical system.

It has the following characteristics:

1. CPU bus unit and special unit can be set in io table without manual setting and distinguishing address;

2. The setting of CPU bus unit and special unit of Cx one software can be compared with the setting of CPU bus unit and special unit of actual PLC on line, and the inconsistent and are marked out;

3. The network structure can be displayed graphically;

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4. Multi language support, Chinese version can be installed;

5. The CPUs of CP, CJ and CS series can support offline simulation, and the touch screen of NS series can also support online offline simulation, that is, the touch screen and PLC can be put together for offline simulation.

3.2 Manipulator group master program

When I0.0=1 (The main start button is closed); and I0.2=1 (Manual / Auto button closed); and M0.5=0 (System stop auxiliary relay), M0.0=1 (Manipulator group automatic mode auxiliary relay). Ladder diagram is as shown in Fig.5.

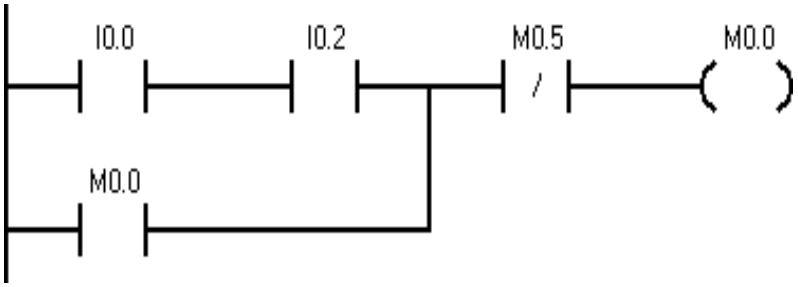

Fig. 5 Ladder

When I0.1 = 1 (The total stop button is closed); and M0.2 = 0; and M0.3 = 0; and M0.4 = 0; and I1.2 = 0 (Workbench A item detection switch closed); and I1.3 = 0 (Workbench B item detection switch closed). Then M0.5 = 1 (System stop auxiliary relay). The ladder diagram is shown in Fig.6.

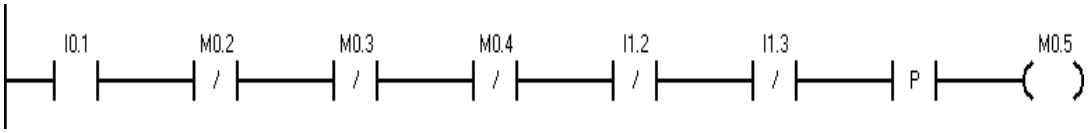

Fig.6 Ladder

When M0.0 = 1 (Auxiliary relay for robot group automatic mode); and M0.2 = 0; and M0.3 = 0; and M0.4 = 0; and I0.7 = 1 (Workbench A item detection switch closed); and I1.2 = 0 (Workbench B item detection switch is off); and I1.3 = 0 (Workbench C item detection switch is off). Start timer T60. When T60 = 1 (the timing time is up), call the manipulator 1 control program. The ladder diagram is shown in Fig.7

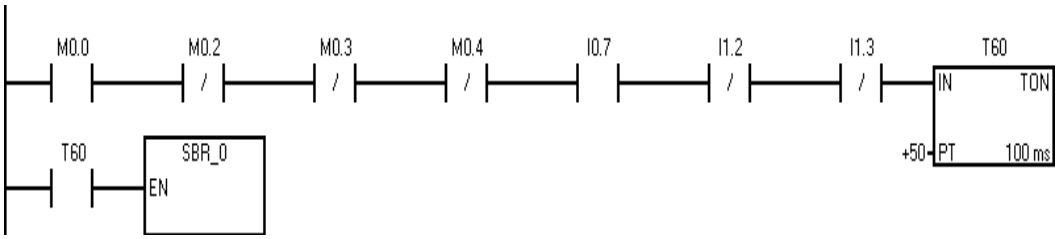

Fig.7 Ladder

When M0.0 = 1 (Auxiliary relay for robot group automatic mode); and M0.2 = 0; and M0.3 = 0; and M0.4 = 0; and I1.2 = 1 (Workbench B item detection switch closed). Start timer T61 timing. When T61 = 1 (the timing time is up), call the manipulator 2 control program. The ladder diagram is shown in Fig.8.

Fig. 8 Ladder

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When M0.0 = 1 (Auxiliary relay for robot group automatic mode); and M0.2 = 0; and M0.3 = 0; and M0.4 = 0; and I1.3 = 1 (Workbench C item detection switch closed). Start timer T62 timing.

When T62 = 1 (the timing time is up), call the manipulator 3 control program. The ladder diagram is shown in Fig.9.

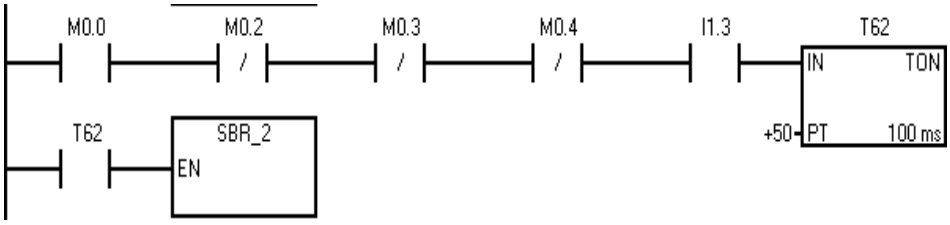

Fig. 9 Ladder

When I0.0 = 1 (The main start button is closed); I0.2 = 0 (Manual / Automatic button is disconnected); and M0.5 = 0 (System stop auxiliary relay), M0.1 = 1 (Manipulator group manual mode auxiliary relay). The ladder diagram is shown in Fig.10.

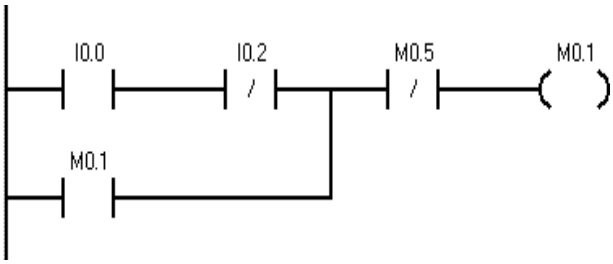

Fig.10 Ladder

When M0.1 = 1 (Manipulator group auxiliary relay); I0.3 = 1 (Start button of manipulator 1 is closed); and I0.4 = 0 (Manipulator 1 stops opening), the control program of manipulator 1 is called. The ladder diagram is shown in Fig.11.

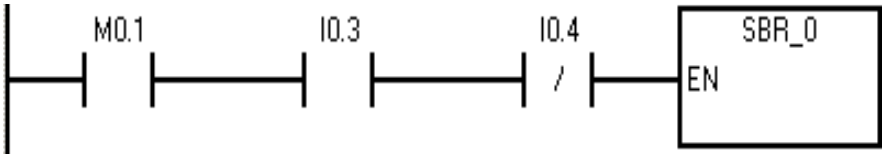

Fig. 11 Ladder

When M0.1 = 1 (Manipulator group auxiliary relay); I0.5 = 1 (Start button of manipulator 2 is closed); and I0.6 = 0 (Manipulator 2 stops opening), the manipulator 2 control program is called. The ladder diagram is shown in Fig.12.

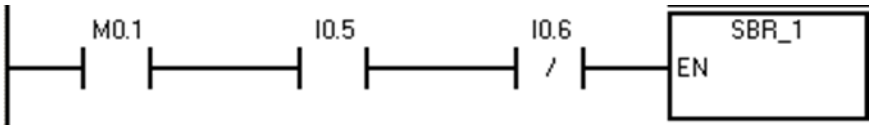

Fig. 12 Ladder

When M0.1 = 1 (Manipulator group auxiliary relay); I1.0 = 1 (Start button of manipulator 2 is closed); and I1.1 = 0 (Manipulator 2 stops opening), the manipulator 3 control program is called. The ladder diagram is shown in Fig. 12.

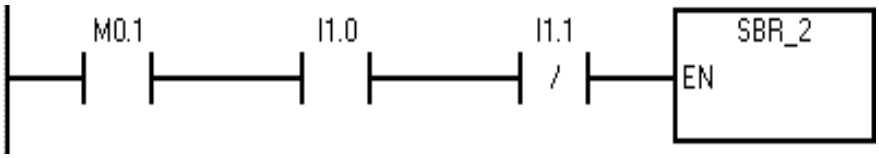

Fig.12 Ladder

When the general start button and the general stop button of the manipulator are pressed at the same time, the PLC will turn to the stop state. When the start button and stop button of manipulator 1 are

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pressed at the same time, PLC will turn to the stop state. When the start button and stop button of manipulator 2 are pressed at the same time, PLC will turn to the stop state. When the start button and stop button of manipulator 3 are pressed at the same time, PLC will turn to the stop state. The ladder diagram is shown in Fig.13.

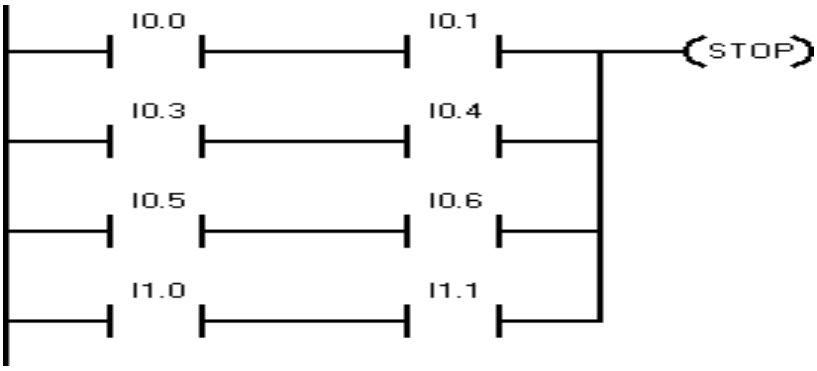

Fig. 13 Ladder

4. Conclusion

In this design, the manipulator model control system is controlled by PLC, which greatly improves the automation of the system, reduces a large number of intermediate relays, time relays and hardware wiring, and improves the reliability of the control system. The conclusion of this paper is as follows:

1. The manipulator in this paper is driven by air pressure. The pneumatic manipulator has the characteristics of energy saving, no pollution, high efficiency, low cost, safety and reliability, simple structure and so on.

2. PLC is used as the controller to optimize the control system of manipulator group.

3. The hardware of electrical control system and the external wiring of PLC are designed.

4. All the programs adopt the idea of modular design, which is not only clear in structure, but also easy to check and modify. The program is written with ladder diagram, which is simple and easy to understand.

5. Through the control of PLC, each manipulator can complete eight actions independently; the manipulator group can run automatically or manually.

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