User Manual
Robot System
V1.1

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Warnings

★ Before operating the robot, press the emergency stop key on the teach pendant, and confirm that the main servo power supply is cut off, and the motor is in the state of power loss and holding brake.

In case of emergency, if the robot cannot be braked in time, personal injury or equipment damage may be caused.

★ When the servo power supply is switched on after the emergency stop is removed, the servo power supply shall be switched on after the accident causing the emergency stop is removed.

The robot action caused by misoperation may cause personal injury accidents.

★ When teaching within the action range of the robot, please observe the following:

Keep looking at the robot from the front.

The strain scheme when the robot suddenly moves to its own orientation is considered.
Be sure to set up a shelter in case.

The robot action caused by wrong **operation may cause personal injury accidents.**

★ When carrying out the following operations, please confirm that there is no one within the action range of the robot and the operator is in a safe position:

When the robot control cabinet is powered on

When operating the robot with the teach pendant

During commissioning

During automatic reproduction

Inadvertently entering the action range of the robot or contacting with the robot may cause personal injury accidents.

Notes

★ To operate the robot, you must confirm:

Whether operators have received relevant training on robot operation Have enough understanding of the motion characteristics of the robot Have enough knowledge of the dangers of robots

Work without drinking

Did not take drugs that affect the nervous system and slow response

★ Before robot teaching, the following items shall be checked, and any abnormality shall be repaired in time or other necessary measures shall be taken.

Whether the robot moves abnormally

Whether the external auxiliary equipment associated with the robot is normal

★ After use, the teach pendant must be put back to its original place and ensure that it is firmly placed.

★ Prevent the accidental drop of the teach pendant from causing the misoperation of the robot, resulting in personal injury or equipment damage.

-Catalog-

1 Welcome to use SZGH Robot control system

This chapter introduces the characteristics and application scenarios of SZGH Robot control system, explains composition of system hardware and software, and the way of using the system to control robot motion.

1.1 System introduction

SZGH Robot control system is developed by Shenzhen Guanhong Automation Co., Ltd. and has completely independent intellectual property rights. It can customize intelligent factory solutions according to customer needs.

Figure 1.1 Appearance of SZGH Robot control system

The appearance of the system is shown in Figure 1.1, which mainly includes two parts: main controller and teach pendant. The main controller is installed in the robot control cabinet, and the teach pendant is placed on the robot control cabinet. The basic technical parameters are shown in Tables 1.1 and 1.2.

The system currently supports:

Robot: 4-axis / 6-axis robot

Maximum number of supported axes: 11

Driver: pulse, EtherCAT bus, mixed

System features:

Hardware: the embedded system design scheme is adopted, which has the advantages of small volume, low power consumption and fast response to system maintenance and upgrading.

Motion performance: the control cycle is 2ms, the deviation between the actual motion trajectory and the ideal motion trajectory of the manipulator is small, and the motion process is stable and flexible.

Operation: it adopts graphical man-machine operation interface and

programming mode, which is simple to use and easier for customers to accept.

Table 1.1 technical parameters of SZGH Robot controller

Number	Item	Specification description
1	Control hardware	Multiprocessor system 8-way pulse drive interface, MODBUS bus, dual network port, USB Expansion board Flash memory for mass storage 22 optocoupler isolated inputs, 10 collector open circuit outputs and 8 brake outputs
2	Control software	Object oriented design SZGH Robot software products Pre-install software
3	Input voltage	220V~50Hz , 24V

Table 1.2 technical parameters of teach pendant

Number	Item	Specification description
1	Material	Reinforced plastic shell +
2	Quality	1kg
3	Operation	8-inch touch screen + Physical keys Scroll wheel + Touch pen
4	Operate hobbit	The left hand passes through the hand rope and gently presses the enable button.
5	Language	At present, in addition to Chinese, it also supports English, Russian, Korean and Vietnamese.

1.2 Main controller

The main controller is composed of CPU, action control circuit, storage circuit, bus circuit, input / output (I / O) circuit, power supply circuit, etc., which is loaded with core function software package to complete the functions of robot motion control, auxiliary equipment control, input /output response, external communication and so on.

Figure 1.2 Appearance of the main controller

1——The printing is "ECAT", which is the EtherCAT bus interface used to connect the robot servo driver

2——The printing is "ENET", which is the network port used for Modbus Communication in TCP / IP mode.

3——The screen printing is "TP", which relates to the teach pendant.

4——8-way relay output port

5——10 open collector output ports

6——24V DC input

7——Port of "COMM", which is RS485 and RS232 communication interfaces.

8——Reserved interface

9——USB 2.0 interface used to update and back up the system program

10——Port of "AVO", analog output interface. (Additional options are required.)

11——22 Optocoupler isolation input ports,of which the last two are used as phase A and phase B ports of external encoder (used in pipeline tracking function)

1.3 Teach pendant

Teach pendant is a device to facilitate operators to complete the control of robot system online. The subsequent contents of this manual are based on the teach pendant.

SZGH Robot teach pendant has the following specific features:

It adopts 8-inch touch screen and is equipped with a touch pen. When wearing gloves, it can operate the interface through the touch pen;

More abundant keys are provided for convenient operation;

Equipped with a scroll wheel, which greatly improves the efficiency of manual teaching programming.

1.3.1 Scroll wheel functions

The scroll wheel functions are different in two working modes: focus mode and scroll mode.

The Default mode is focus mode. In focus mode, you can open a basic program with the scroll wheel.

You can quickly switch the highlight of the control on the software interface by rolling the scroll wheel;

Pressing the scroll wheel is equivalent to the Enter key;

When a control with a list is highlighted, press the scroll wheel to enter the control list and quickly switch by rolling the scroll wheel. When you press the scroll wheel again, you will return to the control switch.

Press and hold the scroll wheel for 2 seconds to switch to the scroll mode. For all units with scroll bars, you can scroll through the content.

In the main interface of teach pendant,you can use the scroll wheel to find the function icon;

In the programming interface, you can use the scroll wheel to browse the program line.

Press and hold the scroll wheel for 2 seconds again to switch to the focus mode.

1.3.2 Key functions

Teach pendant is a hand-held programmer for robot online operation. It can realize various operation and display functions required by robot programming and control without mouse and keyboard.

The main key functions on the front and back of the teaching pendant are described as follows.

Figure 1.3 Front appearance of the teach pendant

The physical keys on the front of the teach pendant are divided into three types, and the function definitions are shown in Table 1.3.

Table 1.3 Functions of physical keys on the front of the teach pendant

Type	Function	Explanation
Program execution keys	1	Mode switch It is used to switch between manual mode and automatic mode.
	2	"Program stop" key in automatic mode It can stop the running program and the robot stop at the current position. Then press the "program run" key, and the program will return to the first instruction line and start running.
	3	"Program pause" key in automatic mode It can make the running program pause in the current position line and the robot stop at the current position. Then press the "program run" key, and the program will continue to run from the current instruction line.
	4	"Program run" key in automatic mode
	5	"Step forward" key in automatic mode Under "single motion" mode: select a curve below the current position as the target line, and then click "step forward", it will go and pause on the target line. Click the "Program stop" key to exit. Under "single step motion" mode: click "step forward" to execute one line of instructions downward. The motion mode cannot be switched under the s paused state. "Step back" key in automatic mode
	6	Under "single motion" mode: select a curve above the current position as the target line, and then click "step back", it will go reversely and pause on the target line. Click the "Program stop" key to exit. Under "single step motion" mode: click "step back" to execute one line of instructions upward.Non-curves are not executed during a step back. The motion mode cannot be switched under the s paused state. Be careful: (1) It has a high security level. After logging in the system each time, you need to manually turn on the function according to the configuration interface. (2) It is unavailable in the following scenarios: no reverse collaborative process; …… movement in subprogram; no reverse movement during offset; no reverse movement during stacking; no reverse movement during
	22	"Emergency stop" key It can be used to stop all operations of the system and servo in case of "emergency".
Software editing keys	7	"HOME" key It is mainly used to return to the home page from the sub page, including the exit of the modal dialog box.
	8	"Shift" combination key You can customize the function through system - user defined key.
	9	F1: the default is "move focus forward" in the roller focus mode. F2: The default is "move focus backward" in the wheel focus mode. You can customize the function through system - user defined key.
	10	I / O key: basic port debugging. Press once to pop up and again to hide.
	11	"Menu" key You can pop up a box on the touch screen for corresponding query and setting operations.
	12	"Tab" key You can switch the operation history box/ configuration and monitoring box. "Tab" combination key You can customize the function through system - user defined key.

Manual teaching Keys	13	"-V, +V" keys in manual mode They are used to increase or decrease the teaching speed according to a certain step. The step is divided into four gears according to the current speed: 0.01, 0.1, 1 and 10.
	14	"J6 -" and "J6 +" keys in manual mode After pressing "enable", J6 joint motion can be controlled in the joint coordinate system (C attitude adjustment in the base coordinate system).
	15	"J5 -" and "J5 +" keys in manual mode After pressing "enable", J5 joint motion can be controlled in the joint coordinate system (B attitude adjustment in the base coordinate system).
	16	"J4 -" and "J4 +" keys in manual mode After pressing "enable", J4 joint motion can be controlled in the joint coordinate system (A attitude adjustment in the base coordinate system).
	17	"J3 -" and "J3 +" keys in manual mode After pressing "enable", J3 joint motion can be controlled in the joint coordinate system (z-axis direction movement in the base coordinate system).
	18	"J2 -" and "J2 +" keys in manual mode After pressing "enable", J2 joint motion can be controlled in the joint coordinate system (y-axis direction movement in the base coordinate system).
	19	"J1 -" and "J1 +" keys in manual mode After pressing "enable", J1 joint motion can be controlled in the joint coordinate system (x-axis direction movement in the base coordinate system).
	20	"EXT" key in manual mode Switch to additional axis teaching mode.
	21	Coordinate system switching key in manual mode It is used to switch the currently used teaching coordinate system (Joint Coordinate System → Base Coordinate System → User Coordinate System →Joint Coordinate System). Tool Coordinate System needs to be selected at the same time sometimes.

Figure 1.4 Rear appearance of teach pendant

An enable button is used on the back of the teach pendant. During manual teaching, the left hand passes through the hand rope and gently presses the button.

This enable button has three states:

State 1: when fully released, the driving device of the robot is cut off;

State 2: when gently pressed, the driving device of the robot is connected;

State 3: when pressed hard, the driving device of the robot is cut off.

1.3.3 System login permission

Turn on the power switch of the robot control cabinet and the human-computer interaction interface of the teach pendant starts.

The login interface will appear on the teach pendant screen, which is divided into three login permissions: administrator, operator and viewer, as shown in Figure 1.5. Different types of operators have different permissions. The specific permissions are shown in Table 1.4.

Three different types of users need to check the corresponding type and log in through user name and password.

Figure 1.5 Login interface

Table 1.4 User permissions

Number	Type	User permissions
1	Administrator	Robot control system programming teaching Debugging of peripheral equipment Manage the permissions of different operators in the system Maintenance of robot control system Robot system power on / off operation Start and stop of robot program Recovery of system alarm state (part of the work needs to be carried out in the robot work area and must receive professional training for robots.)

2	Operator	After logging in the "Administrator" mode, set the "user name" and "password" of the operator mode in [user] - [user management]. Robot system power on / off operation Recovery of system alarm state Start and stop of robot program (only work outside the robot working area.)
3	Viewer	You do not need to set "user name" and "password" when logging in. You can "log in" directly. You can only "Browse" the system and can't do anything else.

1.3.4 Operation modes

There are two operation modes of using the teach pendant: manual mode and automatic mode. The switching between the two modes is realized by the "mode switch" button on the teach pendant.

Manual mode

Carry out "manual teaching" for the robot, and carry out parameter setting, program design, configuration of various functions and process packages, system management, etc., which are realized interactively in the manual mode interface.

In manual mode, the teach pendant can be used to control the movement of the robot by using 6 groups of manual control physical keys on the right side of the front while pressing the "enable" button on the back, to realize the manual operation of single joint movement and linear movement of the robot at different movement speeds.

Automatic mode

It is mainly used for program execution. The robot performs single step, single or cyclic motion according to the program setting and the set motion speed.

1.4 Control modes of robot

Based on SZGH Robot control system, the robot has several different control modes, as shown in Table 1.5.

Table 1.5 Robot control modes

Control mode	Method	Speed
Manual operation of teach pendant	In the manual mode of the teach pendant, 6 groups of control physical keys are used to control the single axis or linear motion of the robot	The maximum speed ofjoint movement is 600r/min The maximum speed of linear motion is 200 mm/s The maximum rotation speed in the tool coordinate system is 50 degrees/second When manually controlling the physical key operation, the default is 10% slow operation on this basis
Manual fast operation	In the manual mode of the teach pendant, use the interface software keys to test the program	Run at the speed set by the program 6 groups of physical keys cannot be controlled manually

Run in automatic mode	In the automatic mode of the teach pendant, use the interface software keys to run the program	Run at the speed set by the program 6 groups of physical keys cannot be controlled manually
External control	When there is no teach pendant, the external key / upper computer communication mode controls the program to run	Run at the programmed / set speed

1.5 Setting of safety zone and interference zone

1.5.1 Safety zone

In the process of industrial robot running,it is often necessary for the robot to return to the starting point of program curve or zero point from a certain position. This motion process does not consider the surrounding environment of the robot, but the control system calculates the motion trajectory by point motion control. In some cases, if the operator does not consider the position of the workpiece, the machine collision accident will occur due to misoperation.

In order to ensure that the robot does not touch other objects and is in a safe state when starting the robot from the current position and posture to the program starting position and posture, it is necessary to set the safe starting area of the robot through the teaching pendant after the installation of the robot is completed. When the robot is not in the safe area of a job, the job program cannot be started and run, and the corresponding prompt box will pop up. The program cannot be started until the robot is manually taught to the safe area. Similarly, when the robot exits the operation, it also needs to be zeroed in the safety zone, and the zeroing safety zone needs to be set in advance.

Click [tools] - [regional setting] - [safety zone] in the manual interface of the teach pendant, as shown in Figure 1.6, and the setting interfaces of "Starting-safety zone" and "Home-safety zone" appear. Multiple safety zones can be set, which can be completed by creating the starting point and ending point of the opposite corner of the safety zone (as shown in Figure 1.7).

Figure 1.6 Safety zone setting interface

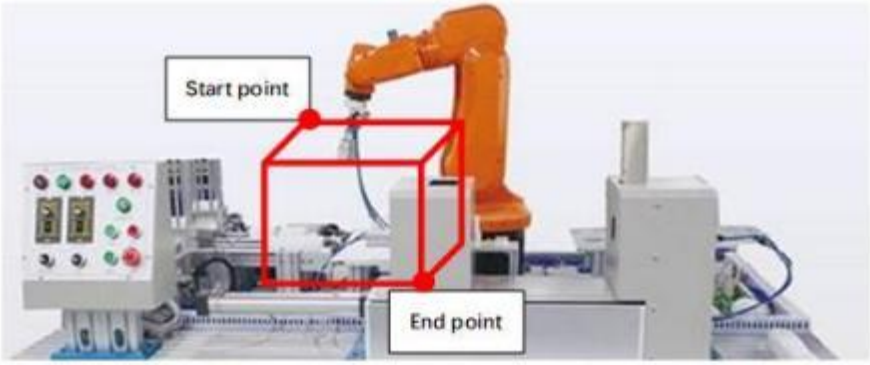


Figure 1.7 Start point and end point of safety zone

1.5.2 Interference zone

Setting the "interference area" has no effect on the running track of the system curve, but it can interact with the program through PLC programming or with other robots through the output port to work together. For example, in the stamping process, the robot must set the picking and discharging interference area in order to ensure the safety when working with the front and rear robots. The interference function of the system is divided into three types: point interference, space interference and axis interference. After setting the "interference section", whether it is manual teaching or program operation, the system will detect if it enters the "interference section".

Click [tools] - [area setting] - [interference area] in the manual interface of the teach pendant, as shown in Figure 1.8, and three types of interference area setting interfaces of "Space interference", "Point interference" and "Axis interference" appear.

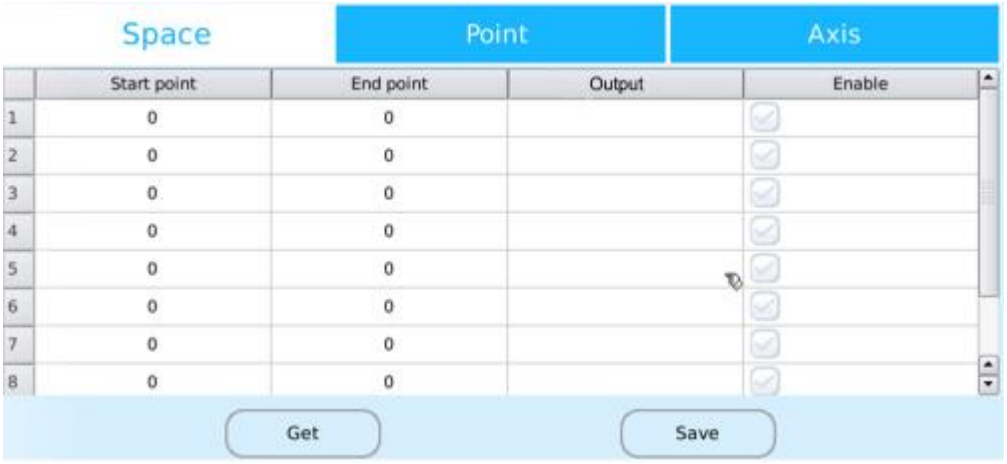


Figure 1.8 Interference area setting interface

The interference function is represented by "I" type in PLC editing, and different numbers represent different interference intervals:

Point interference - when setting "point" interference, when running to this point, enter the interference interval, which is represented by i0-i19 in PLC editing.

Space interference - when setting "spatial" interference, the interference interval refers to a "spatial body" generated diagonally with "starting point" and "end point" (excluding the "face" generated by "starting point", "end point" and "base coordinate system", so the "interference interval" can be set larger as needed). It is represented by i20-i39 in PLC editing.

Axis interference - it is divided into 8 groups, which are respectively used to set the interference interval of 8 axes (j1-j8). It is represented by i40-i47 in PLC editing.

2 Coordinate systems

This chapter introduces five coordinate systems commonly used by industrial robots, and how to use teach pendant to establish tool coordinate system and user coordinate system.

2.1 Five common coordinate systems of robot

Coordinate system is a position index system defined on the robot or space in order to determine the position and attitude of the robot, including: base coordinate system, joint coordinate system, tool coordinate system, flange coordinate system and user coordinate system. In the process of "manual teaching", the motion of the robot is carried out in several different coordinate systems.

2.1.1 Base coordinate system

The base coordinate system is composed of the origin and coordinate orientation of the robot base, which is the basis of other coordinate systems of the robot. The direction of the base coordinate system is specified: the x-axis is forward, the z-axis is upward, and the y-axis is determined according to the right-hand rule (as shown in Figure 2.1).

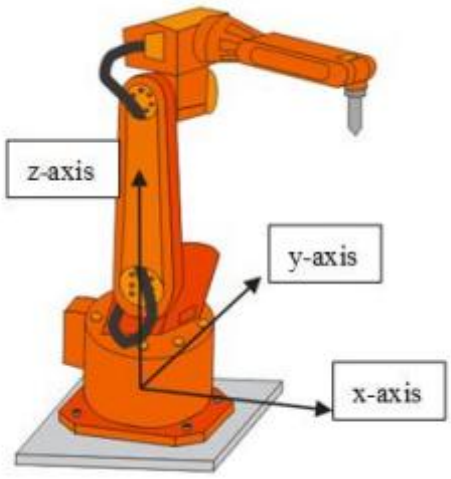


Figure 2.1 Robot base coordinate system

2.1.2 Joint coordinate system

Joint coordinate system the joint coordinate system of robot is used to describe the motion of each independent joint of robot. For six axis robots, the joint type is rotating joint. In the joint coordinate system, each joint can be driven in turn, so that the end of the robot can reach the specified position. First, specify the "zero position" of the robot in the joint coordinate system, as shown in Figure 2.2. Then, the coding direction is set by the controller to specify the

rotation direction of each joint. In the joint coordinate system, the rotation direction of each joint of the robot must be consistent with Figure 2.2, that is, standing directly behind the robot body and using the "right-hand screw rule".

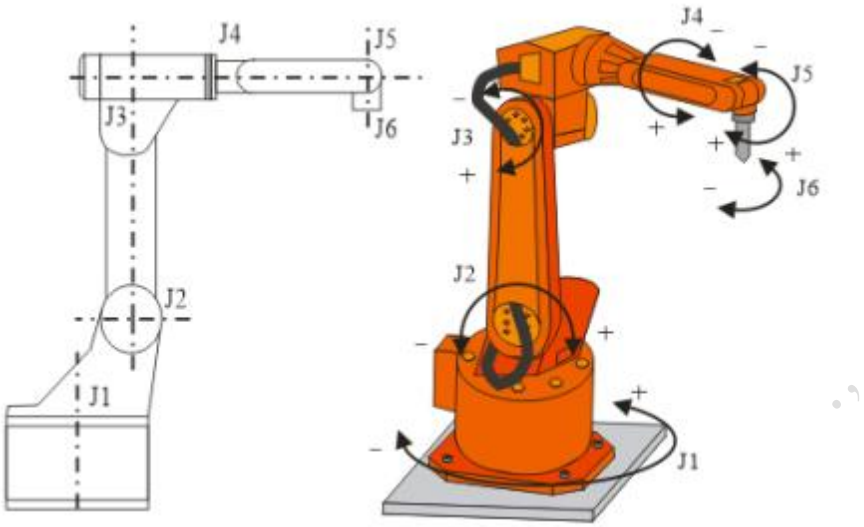


Figure 2.2 Robot joint coordinate system

2.1.3 Tool coordinate system and flange coordinate system

Tool coordinate system and flange coordinate system tool coordinate system is used to determine the position and attitude of the tool. It is composed of tool center position (TCP) and coordinate orientation. The tool coordinate system must be set in advance. The default coordinate axis direction is to rotate around the axis under the base coordinate system, or you can customize the coordinate axis direction. When there is no definition, the origin of the robot's default tool coordinate system is in the center of the robot's wrist flange. At this time, the coordinate system established with the center of the flange as the origin is called the flange coordinate system. When the robot is in the zero position, the flange coordinate system is parallel to the base coordinate system, as shown in Figure 2.3.

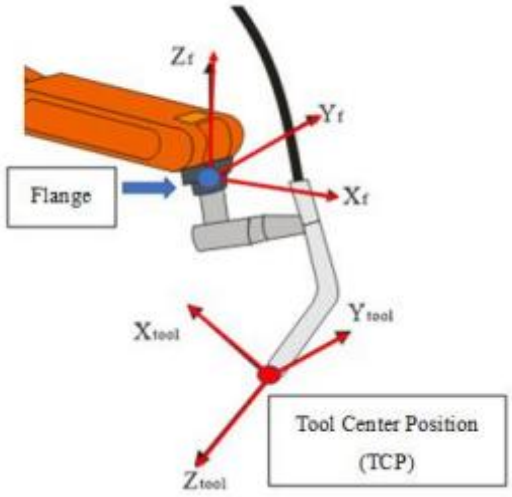


Figure 2.3 Robot tool coordinate system

2.1.4 User coordinate system

User coordinate system is a rectangular coordinate system defined by the user within the allowable range of robot action, which can be defined by the user according to their own needs and habits. As shown in Figure 2.4, the user coordinate system can be defined on the workbench.

With a user coordinate system, we can:

(1) Quantify the position of the point on the workbench.

(2) When teaching, the robot can move strictly according to the edge path of the workpiece in the user coordinate system.

(3) When the workpiece position or the workbench changes, transformation instructions of user coordinate system can be used without teaching the robot again.

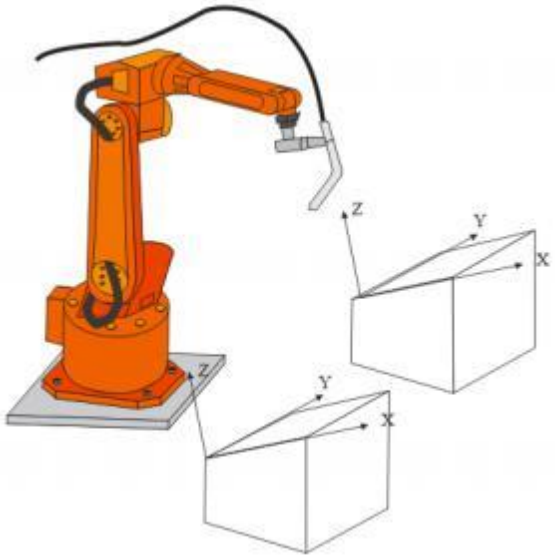


Figure 2.4 Robot user coordinate system

2.2 Establishment of tool coordinate system

The establishment of a tool coordinate system is also called tool coordinate system calibration. There are two main approaches:

Multi-point calibration method

We usually use four-point method. Let the tool TCP arrive at the same point with four different attitudes, and obtain the data of these four points, then the system can calculate the position of TCP relative to the center of flange.

When we need change the Axis direction, we use six-point method. Based on the four-point method, the data of points are obtained in x-axis and z-axis respectively, and the y-axis is determined by the right-hand rule.

Click [tool coordinate system] in the "manual interface" of the teach pendant, and the new

tool coordinate system interface as shown in Figure 2.5 will appear.

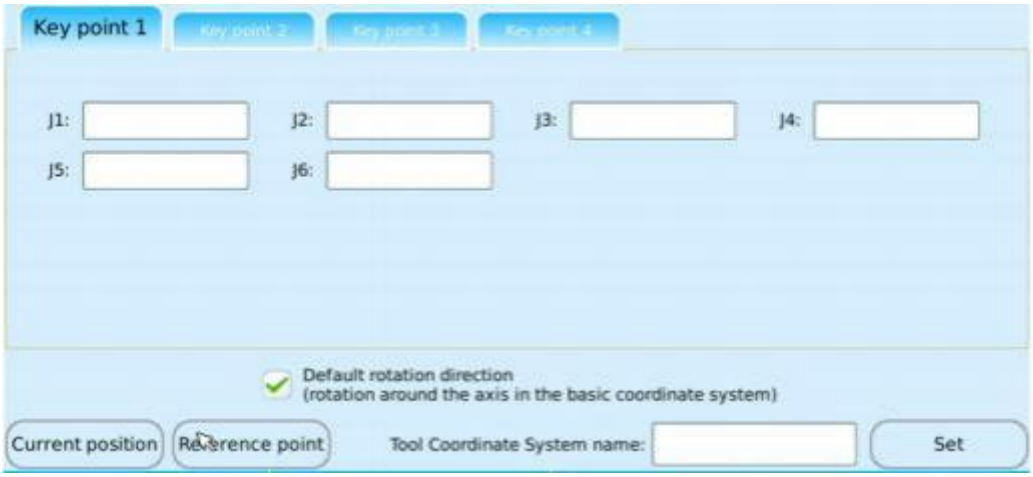


Figure 2.5 Tool coordinate system interface 1

When checked, the attitude of the default tool coordinate system is to rotate around the axis under the base coordinate system. The tool coordinate system can be established only by using four-point. Principle of four-point method:

(1) Find a very accurate fixed point (the sharp cone end of the workpiece) within the working range of the robot as the reference point.

(2) Manually teach the robot, and use different tool postures to just touch the TCP of the robot tool with the reference point as far as possible, as shown in Figure 2.6.

(3) Through the 6-joint data of the robot flange position in four different postures of key point 1-key point 4, the system can automatically calculate the TCP data.

(4)System records TCP data and constructs the conversion relationship between tool coordinate system, flange coordinate system and base coordinate system.

Note: If the TCP setting is accurate, when the tool is checked in the manual teaching, the TCP position will not change when the tool attitude is changed.

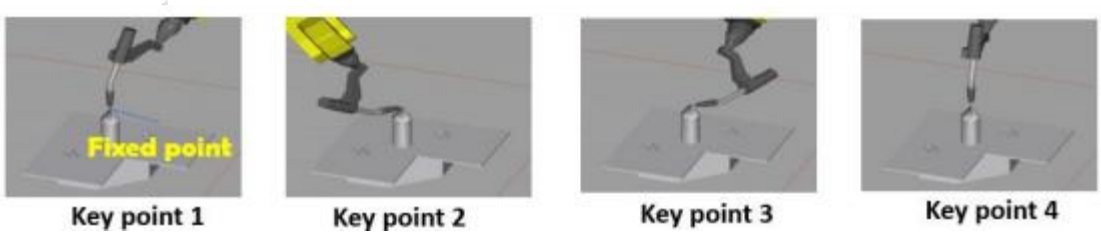


Figure 2.6 Sharp cone end of workpiece is used as reference point to establish TCS

When the tool coordinate system attitude to be established is not the default rotation direction, it is necessary to additionally determine the direction point x and the direction point z, as shown in Fig. 2.7 and Fig. 2.8. Determine key point 1- key point 4 points according to the previous method, and then direction point z point shall move vertically upward on the basis of key point 4, and direction point x point shall move forward on the basis of key point 4 to determine the direction points of Z axis and X axis.

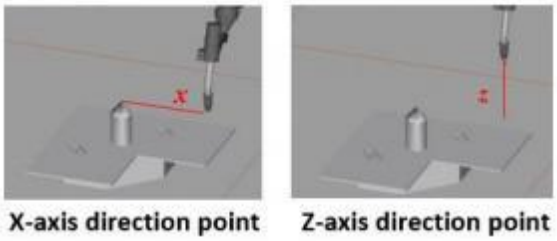


Figure 2.7 Additionally determine the direction point x and the direction point z

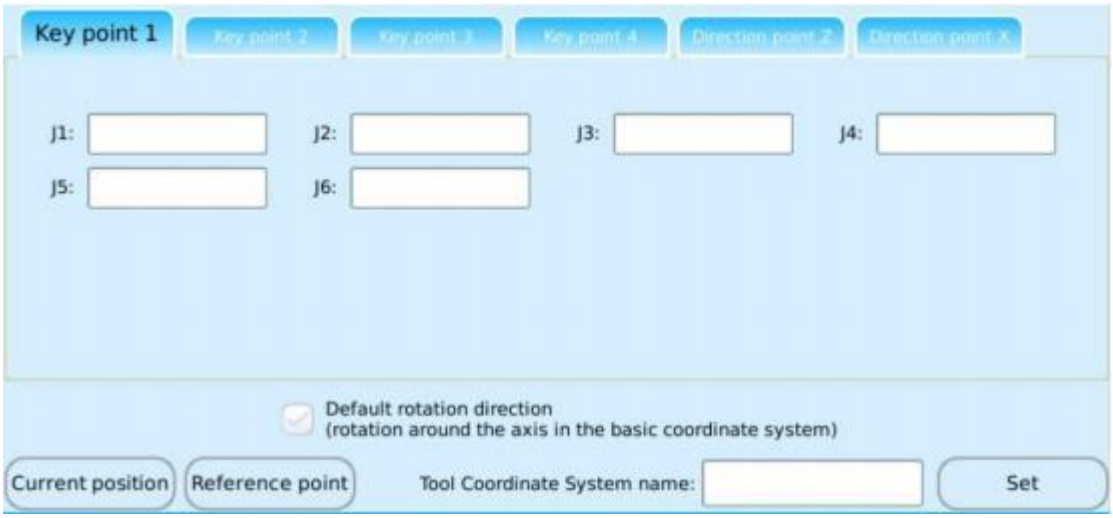
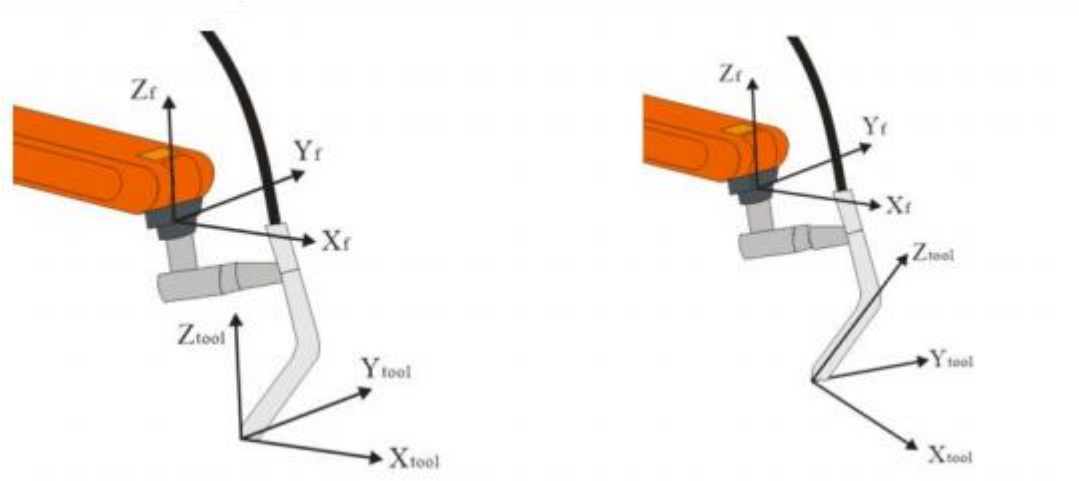


Figure 2.8 Tool coordinate system interface 2

Comparison:

Four-point calibration method: The tool coordinate system is parallel to the flange coordinate system.

Six-point calibration method: Define the X and Z directions by yourself.



(a) Four-point calibration method (b) Six-point calibration method

Figure 2.9 Comparison of two calibration methods

External reference calibration method

let the tool TCP reach a measured external reference point (mark point), as shown in Fig. 2. 10. If the tool needs to be changed frequently, this method can be used for rapid calibration.

All the program points associated with the original tool coordinate system will be associated with the revised new tool coordinate system, and the six joint data will be automatically corrected to keep the pose of TCP unchanged.

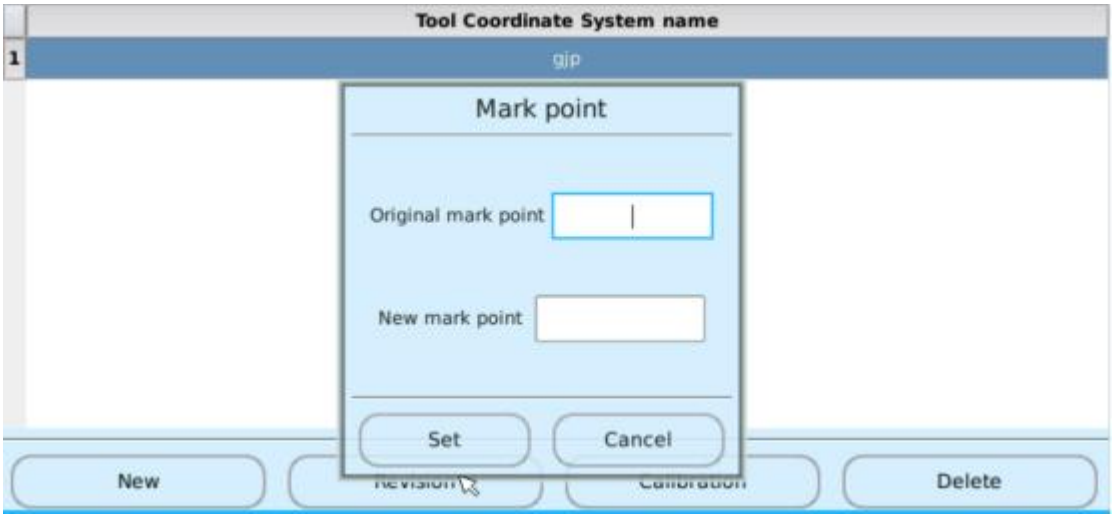


Figure 2.10 Using mark point for rapid calibration

2.3 Establishment of user coordinate system

The establishment of user coordinate system generally uses the three-point method:

(1) We let the tool TCP reaches the origin of the coordinate system, a point on the x axis and a point on the y axis.

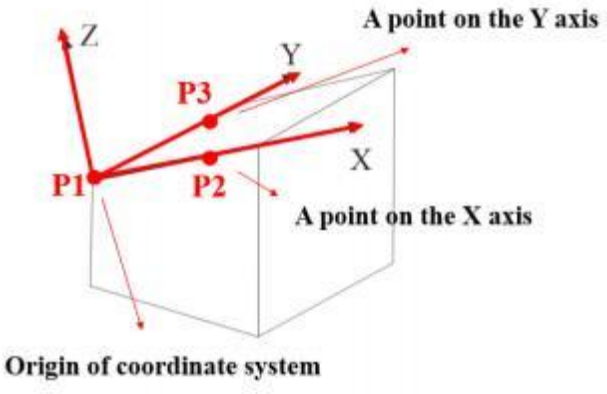


Figure 2.11 Three-point method to establish user coordinate system

As shown in t Figure 2.12, we obtain the data and create three points. Please pay attention here, the created "point" needs to check the tool coordinate system.

(2) Click [user coordinate system] in the "manual interface" of the teach pendant, and the user coordinate system interface as shown in Figure 2.13 will appear. Then the user coordinate system can be established by referencing the three points in turn.

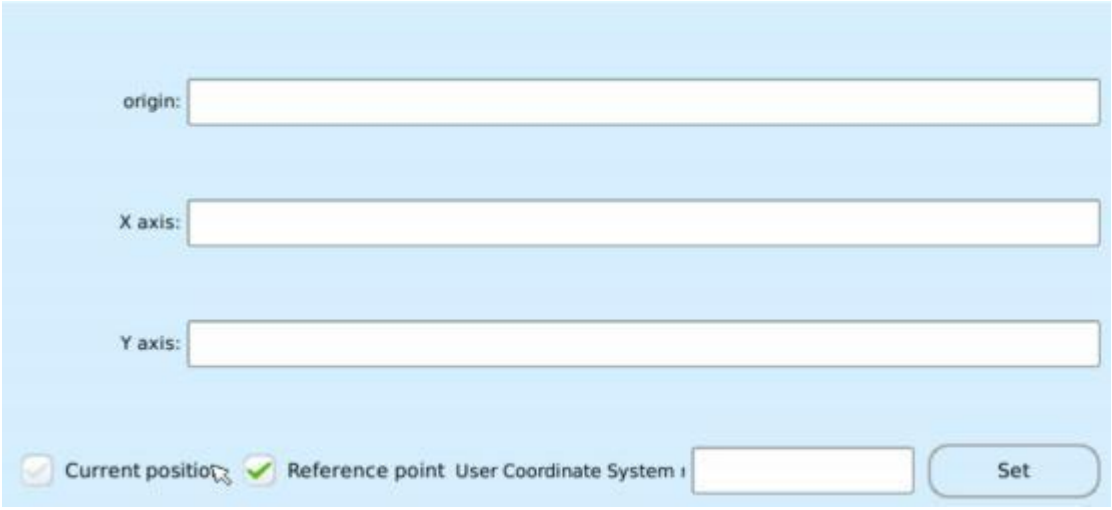


Figure 2 12 Create three points for user coordinate system

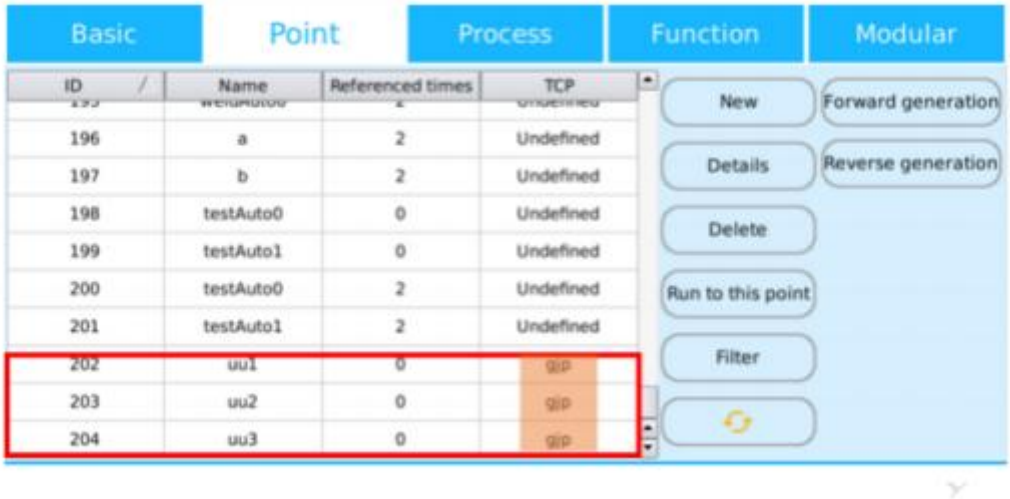


Figure 2.13 User coordinate system interface

3 Robot manual teaching

Using teach pendant to operate robot manually is the basis of industrial robot programming.

You can switch the teach pendant to "manual mode";Press the "enable" button on the back of the teach pendant, select the coordinate system and set the teaching speed; then operate the button on the right side of the teach pendant to control the movement of the robot, as shown in Figure 3.1.

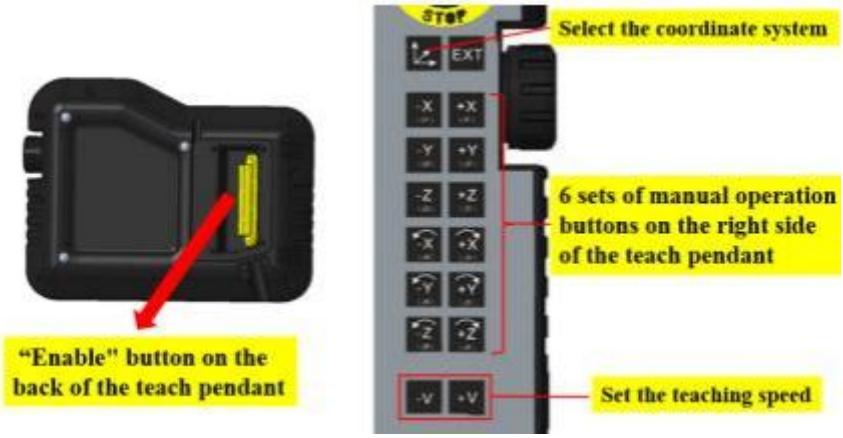


Figure 3.1 Buttons for manual teaching

3.1 Enable button

Carry out "manual teaching" in the "manual mode" of the teach pendant. The way to start is to press the "enable" button on the back of the teaching pendant. Release the "enable" button, and the teach pendant cannot control the motion of the robot.

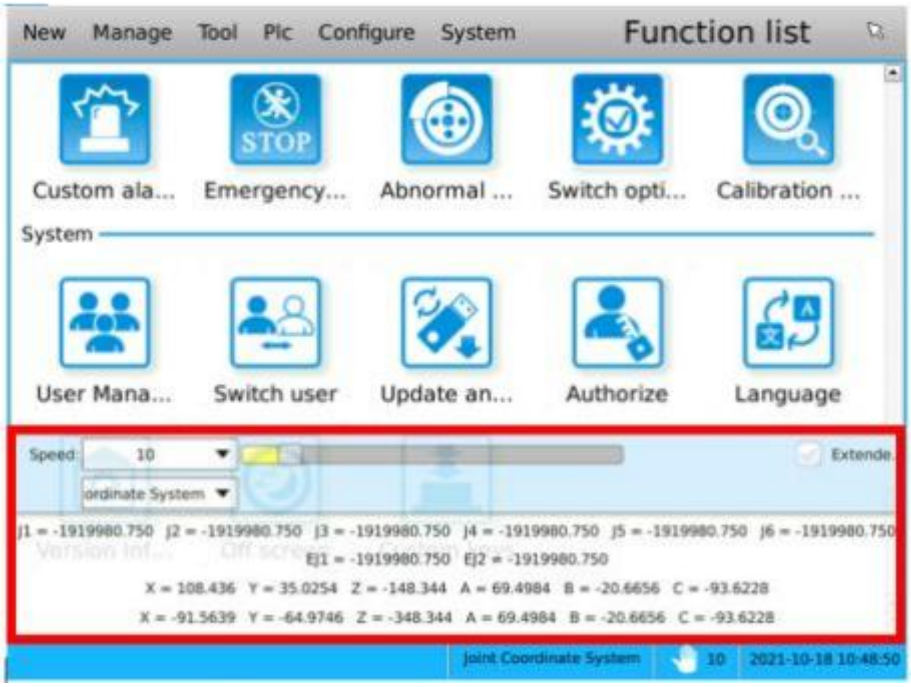


Figure 3.2 Manual teaching configuration and motion monitoring page

After pressing "enable" button, manual teaching configuration and motion monitoring page will be displayed at the same time, as shown in Figure 3.2. The upper part is the teaching configuration: including teaching speed, additional axis radio box, teaching coordinate configuration, precise position function button and so on. The lower part is the display of current joint angles and coordinate values under corresponding coordinate system.

This page will pop up automatically when the "enable" button is pressed. It will be hidden after the focus is lost. In manual mode, when the "enable" button is pressed, slide from left to right or from right to left anywhere on the interface to call up the interface again.

3.2 Manual Teaching in Different Coordinate Systems

When selecting different coordinate systems and manually controlling the physical keys according to the six groups on the right side of the teach pendant, the motion mode of the robot is different.

Operation type: joint coordinate system

The robot has six movable joints, which are defined as j1-j6. In the joint coordinate system, six groups of buttons enable each joint of the robot to rotate independently, as shown in Figure 3.3.

The joint coordinate system can be selected for large range motion without TCP attitude.

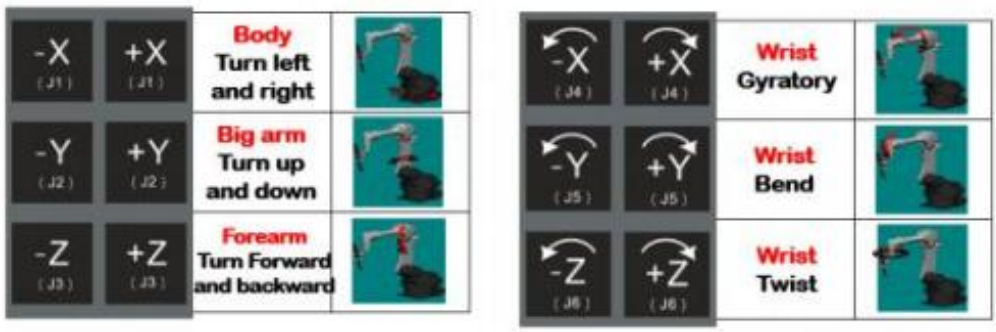


Figure 3.3 Keys function when the operation type is " joint coordinate system"

Operation type: base coordinate system + TCP

The base coordinate system is a common coordinate system in teaching. In this operation type, the robot is multi-joint linkage.

Figure 3.4 Keys function when the operation type is " base coordinate system"

Among the six groups of keys: the first three groups of keys respectively control TCP to move horizontally along the X, Y and Z axes of the base coordinate system, and the last three groups of keys make the tool rotate around the X, Y and Z axes of the base coordinate system on the premise that TCP position remains unchanged.

Note: if the corresponding tool coordinate system is not selected before manual operation, the point at the same position during rotation is the center of the connecting flange.

Operation type: user coordinate system + TCP

The robot is multi-joint linkage.

Among the six groups of keys: the first three groups of keys respectively control TCP to move horizontally along the X, Y and Z axes of the user coordinate system. The last three groups of keys make the tool rotate around the X, Y and Z axes of the user coordinate system on the premise that TCP position remains unchanged.

Note: if the corresponding tool coordinate system is not selected before manual operation, the point at the same position during rotation is the center of the connecting flange.

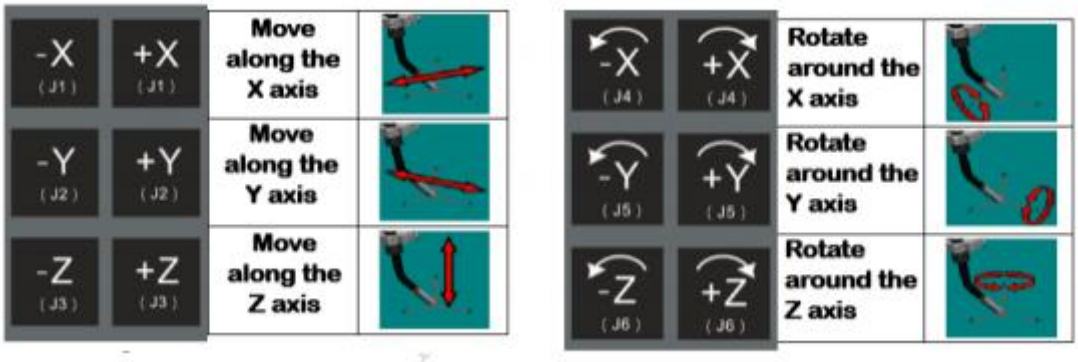


Figure 3.5 Keys function when the operation type is " user coordinate system"

Operation type: tool coordinate system

The robot is multi-joint linkage.

Among the six groups of keys: the first three groups of keys respectively control TCP to move horizontally along the X, Y and Z axes of the tool coordinate system. The last three groups of keys make the tool rotate around the X, Y and Z axes of the tool coordinate system on the premise that TCP position remains unchanged.

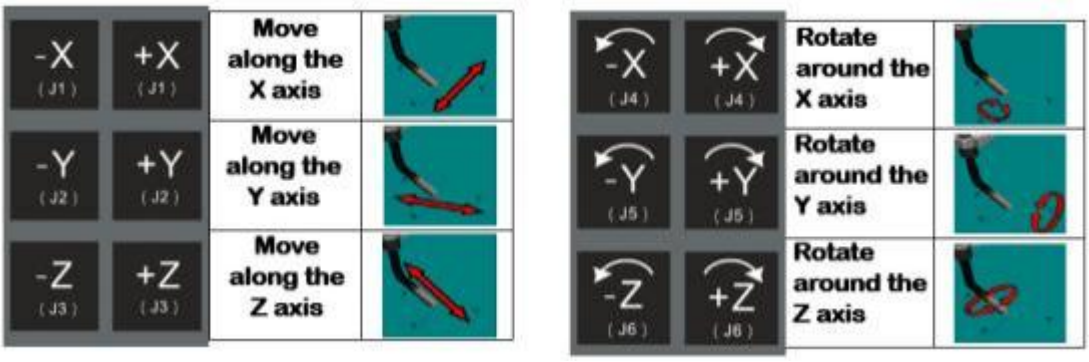


Figure 3.6 Keys function when the operation type is " tool coordinate system"

In the "tool coordinate system" operation mode, it is relatively easier to control the motion track of the tool TCP, and the posture of the tool can be adjusted when the TCP position is not moved. If the six point method is used to establish the tool coordinate system and the effective direction of the tool is set as the Z axis,as shown in Figure 3.7, in some cases, the tool coordinate system is the most suitable for the translation operation without changing the tool attitude relative to the workpiece.

Figure 3.7 Manual teaching in tool coordinate system

3.3 Manual teaching speed

During manual teaching, it is better for the robot to move slowly in the working area. At present,the system settings during manual teaching:

The maximum speed of joint movement is 600 r/min;

In the base coordinate system, tool coordinate system and user coordinate system, the maximum speed of linear movement in X, Y and Z directions is 200 mm/s, and the maximum speed of rotation around X, Y and Z axes is 50 degrees/s.

On this basis, the "motion configuration floating box" adopts the percentage method to control the motion speed of the robot. The system provides three speed regulation methods: Stepless speed regulation, specified input and gear selection.

Stepless speed regulation:realized by dragging the adjustment button.

Specify input:click the speed text box and a soft keyboard will appear for direct input.

Gear selection: click the drop-down triangle button on the right side of the speed text box to display the set gear value for selection.

3.4 Operational feedback

For each operation on the teaching pendant, the history can be seen in the operation feedback display box.

For each operation on the teach pendant, the history can be seen in the operation feedback display box. The operation history display box of the teach pendant is a pop-up page, which is

displayed at the bottom of the screen.

In manual mode: slide the interface from left to right or from right to left, you can call up the operation history pop-up box, and it will be hidden automatically when the focus is lost.

Manual mode + press the enable key: slide the interface from left to right or from right to left. By default, the motion configuration page will be called out first. At this time, switch with the "tab" key to switch to the operation history page and automatically hide when the focus is lost.

In automatic mode: slide the interface from left to right or from right to left. You can call up the operation history pop-up box and hide it automatically when the focus is lost.

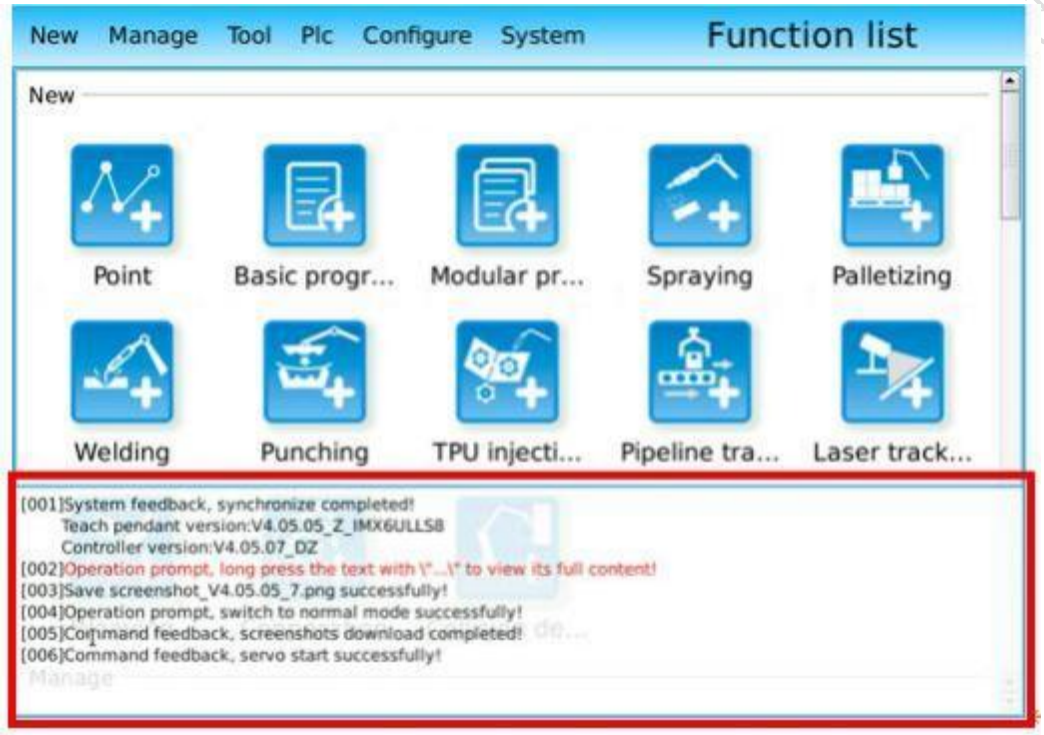


Figure 3.8 Operation feedback display box

4 Online teaching programming

This chapter explains how to quickly generate and execute a simple robot motion control program through teaching programming, to help operators master the basic programming method of teach pendant.

4.1 Contents of teaching programming

The information required for robot operation includes three parts: motion trajectory, operation conditions and operation sequence.

4.1.1 Motion trajectory

Motion trajectory is the key point for the robot to complete an operation. When teaching, it is impossible to teach all the points on the operation trajectory once, but segments the trajectory, manually teach the starting point, and end point of each segment of the trajectory, then confirm the attributes of each segment of the trajectory in the programmed curve motion command, and then the path planning module of the control system performs interpolation operation.

4.1.2 Operating conditions

In teaching programming, in addition to telling the robot motion trajectory, it is also necessary to reasonably configure the process conditions of robot operation in advance. For example, in order to obtain good welding quality, robot welding operation needs to set welding conditions, including welder model, welding sequence, welding control signal, welding current and voltage control and other parameters.

There are two types of input methods for operating conditions on SZGH Robot teach pendant:

(1) Create function package or process package

(2) Set by command in the program

4.1.3 Operation sequence

The movement and process implementation of robot need to be carried out according to a certain operation sequence. The setting of operation sequence mainly involves two aspects.

(1) Process sequence of operation object

When writing the robot trajectory program by manual teaching, it is necessary to integrate the operation sequence of the process.

(2) Action sequence of robot and peripheral equipment

In the complete industrial robot system, in addition to the robot itself, it also includes some peripheral equipment. The discovery device provides functions such as collaboration,

pipeline tracking and so on, which can be set up before programming and invoked in the program.

4.2 "Point" in teaching programming

"Point" is a description of the position and attitude of the robot. Specifically, it is the position and attitude of the center of the end flange in space when the tool TCP reaches the target position when the robot is taught manually. This information can be uniquely determined by the joint angle data of the robot.

4.2.1 "Point" management

Click [manage] - [point], as shown in Figure 4.1, to open the "point" management interface, it shows the relevant information of the points, including ID number, name, reference times and the name of the corresponding TCP (tool center point).

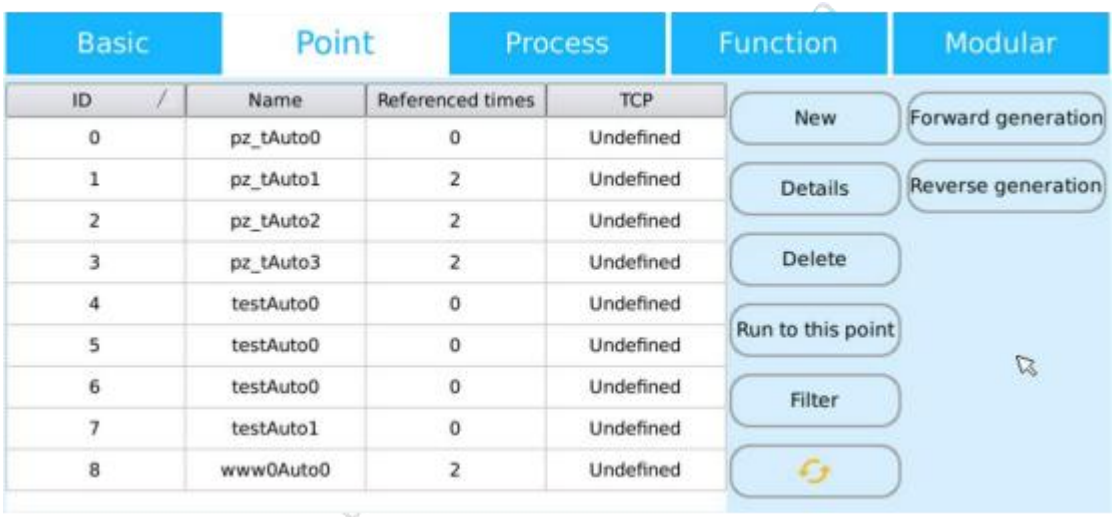


Figure 4.1 "Point" management interface

(1) ID: the ID number is the unique identification of the point, which is automatically generated when it is created. The points referenced in the curve motion instruction in the basic program are associated and uniquely confirmed by the ID number.

(2) Name: the point name can be automatically generated during teaching or input by operators, which is convenient for point reference and management in the program.

(3) Reference times: refers to the number of times the point is referenced in all basic programs in the controller.

Note: when the reference times is greater than 1, modifying the data of this point may affect some motion curves in a basic program or the motion curves in many basic programs.

(4) TCP: the corresponding tool coordinate system needs to be checked. When it is undefined, this point can only determine the position and attitude of the robot flange center, but cannot determine the position and attitude of the TCP.

4.2.2 Creation of "point"

When the robot reaches the specified position, click [new] - [point], as shown in Figure 4.2, to open the "point" information interface. It can be named according to the purpose of the point. Enter the "point" name and click [current position], then the system will read the six joint data of the current robot and display the X, Y and Z coordinate values at the same time.

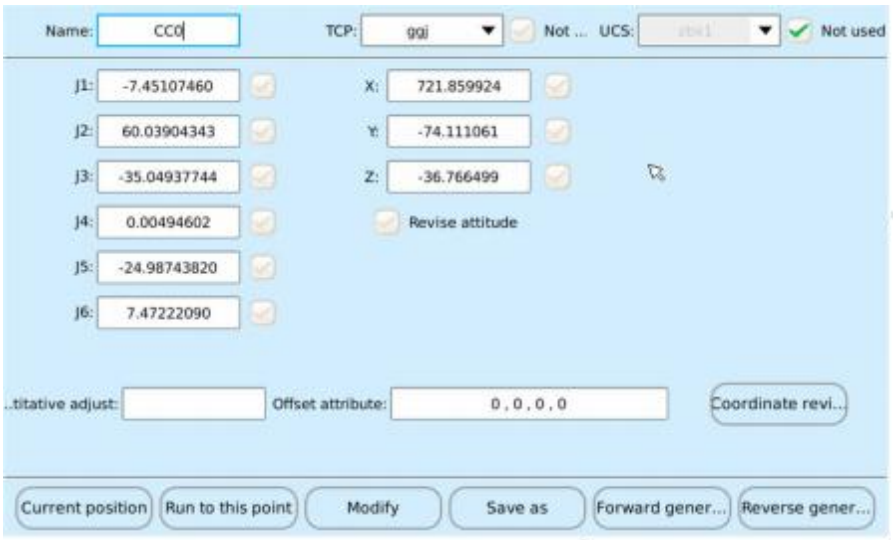


Figure 4.2 "Point" information interface

In the "Point" information interface, five basic functions are provided:

(1) . Click [run to this point] to control the robot to directly reach the position and attitude of this point.

(2) Select “user coordinate system”, we can view the position data of the point in the user coordinate system.

(3) Check “Revise attitude", then enter the revised value, and click [coordinate revision], then the 6 joint values will be revised. Click Modify or save as a new point.

(4) If checking the "check boxes", you can modify multiple coordinate value data at the same time by entering the value in the quantitative adjust text box.

(5) The "offset attribute" function is provided. You can enter the maximum absolute value of the point offset to limit the operator's modification of the point.

Note:(1) The six joint coordinate value can only determine the position of the center of the robot flange.

However, the operator pays attention to the posture of TCP when teaching, so the tool coordinate system must be selected when creating a new point, and the controller can carry out interpolation operation based on TCP to generate straight-line or arc continuous path trajectory.

(2) When saving point data, only six joint data and associated tool coordinate system ID are stored, and user coordinate system ID is not saved. Therefore, when you need to copy the

program written on one robot to other robots, you need to click the [forward generation] button to bind the user coordinate system.

(3) The displayed X, Y and Z coordinate values have the following meanings:

When "do not use" tool coordinate system is checked, it is the X, Y and Z coordinate values of the flange center under the base coordinate system;

When selecting the corresponding tool coordinate system, the X, Y and Z coordinate values of the tool TCP in the base coordinate system;

When the tool coordinate system and user coordinate system are selected at the same time, it is the X, Y and Z coordinate values of TCP in the user coordinate system.

4.2.3 Display of current "point"

When entering the manual or automatic mode main interface of the teaching pendant, you can see the real-time display of the current "point" information of the robot as shown in Figure 4.3 at the bottom of the interface.

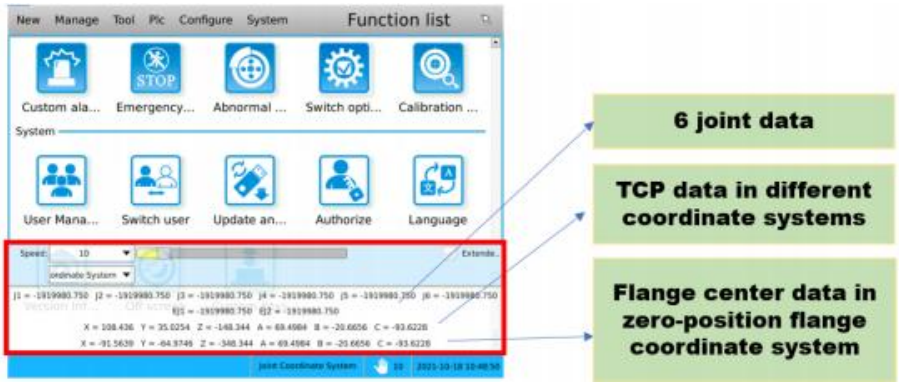


Figure 4.3 Real time display of current "point" information

4.2.4 Home position

As shown in Figure 4.4, after the installation of the robot system, each joint of the robot body will move to each position as shown in the figure before leaving the factory, and then set the home point in the "machine parameter setting" interface. When the robot manually teaches and reads the joint angle of the "point", it is positioned with the set "home position" as the reference point.

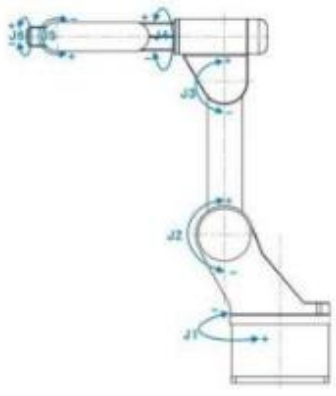


Figure 4.4 Robot home position attitude

When the teach pendant is in "automatic mode", click the "run to home position" button on the interface (as shown in Figure 4.5) to control the robot to run to the home position. At this time, read the angle value of each joint of the current "point", and the angle value is displayed as "0".

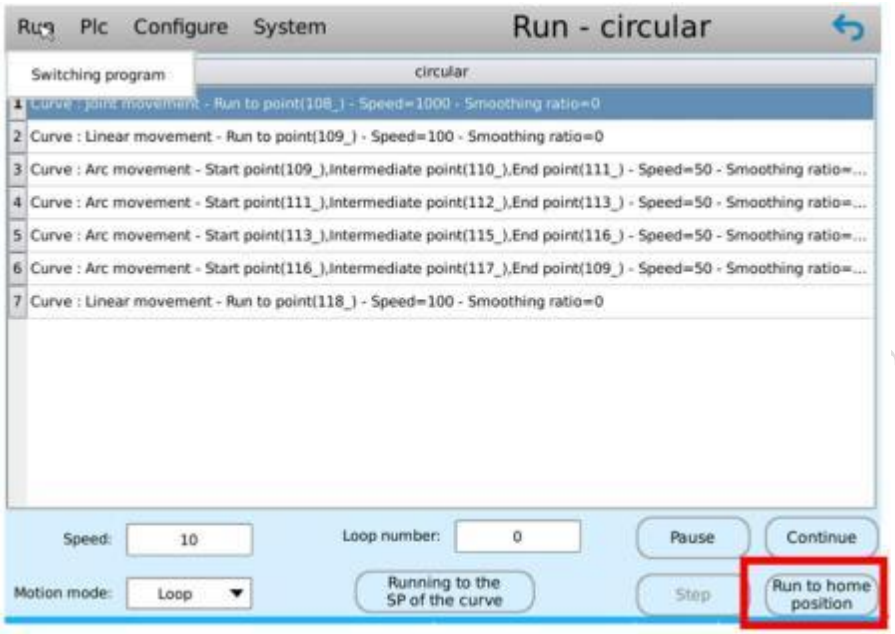


Figure 4.5 "run to home position" button in "automatic mode"

4.3 Online teaching a basic program

4.3.1 Task description

Write a "test1" motion curve control program for robot welding through manual teaching, let the robot move from T1 (operation start point) to T2 (operation adjacent point) at the speed of 1000mm/s,and then move in a straight line at the speed of 100mm/ from T2 to T3 (operation start point) to start welding at the speed of 10mm/s, After welding to T4 (operation end point), exit to T5 (operation avoidance point) in a straight line at the speed of 100mm/s. The trajectory of the robot is shown in Figure 4.6.

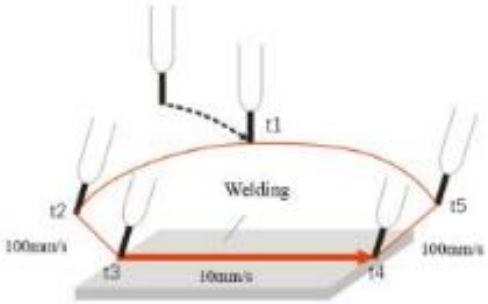


Figure 4.6 Robot motion trajectory for welding

Before creating the basic program, there are four things to do:

Set startup safety zone and home safety zone

Create the tool coordinate system and user coordinate system

Create the welding process package

Carry out trajectory path planning

After completing the above steps, you can start teaching and write a basic program.

4.3.2 Create a basic program

The programs in SZGH Robot software system are divided into four types: basic program, process package,function package and modular program. Among them,the other three types will eventually be converted into basic programs for interpretation and execution by the main controller.

This section describes how to create a new basic program.

Log in to the software with administrator privileges

Turn on the power supply of the robot control cabinet, wait for the human-computer interaction interface of the teaching pendant to start, and then log in to the system as an administrator. The other two types of operators (operators and viewers) do not have programming permission when logging in.

Enter the basic program programming interface

Switch the mode change-over switch of the teach pendant to the "manual" sign. On the manual main interface: click [new] - [basic program] to enter the basic program programming interface, as shown in Figure 4.7. Here you can create a "basic program".

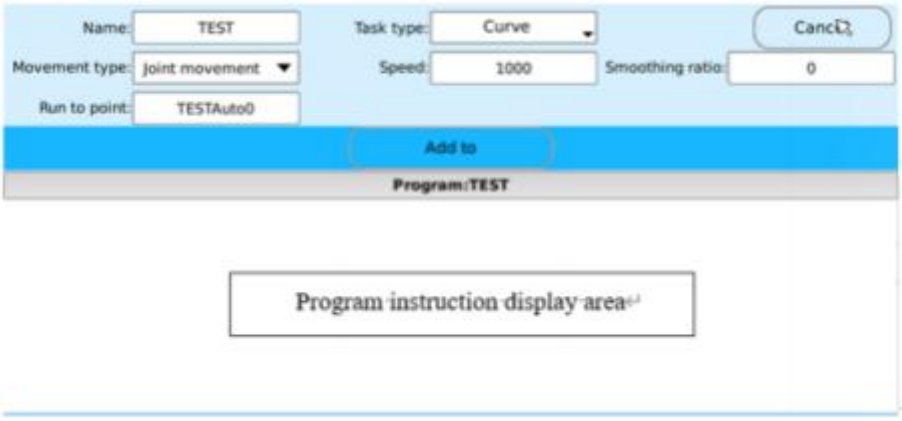


Figure 4.7 Basic program programming interface

Program naming and creation

After entering the "basic program" creation interface, the first step is to establish the program name. As shown in Figure 4.7, click the blank box after "program name" on the touch screen by hand, and a soft keyboard will appear. Enter the English letter "XXX", click [Enter] on the soft keyboard, and the blank box after "program name" will appear "XXX".

After naming the new program, click the [new] button in the upper right corner of the interface, and the program name "program: XXX" will appear on the blank programming area in the middle, as shown in Figure 4.8. At this time, the [new] button will change to the [Cancel]

button, indicating that the new program is created; Click the [Cancel] button to cancel the whole current program operation.

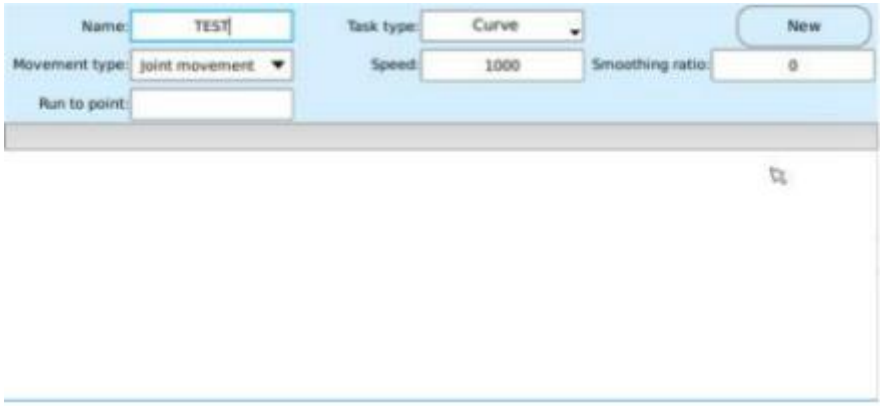


Figure 4.8 Creating the basic program named "TEST"

4.3.3 Manual teaching for the program design

After the basic program is created, it is necessary to conduct manual teaching and add corresponding instructions one by one in the program instruction display area.

4.3.3.1 Select task type

In the "task type" drop-down menu, we can see various instructions provided by the software, as shown in Figure 4.9. Among them, the command to control the precise motion of the robot is the default "curve" of "task type", or select "movement statement" - "curve motion" in the drop-down menu (both are the same command).

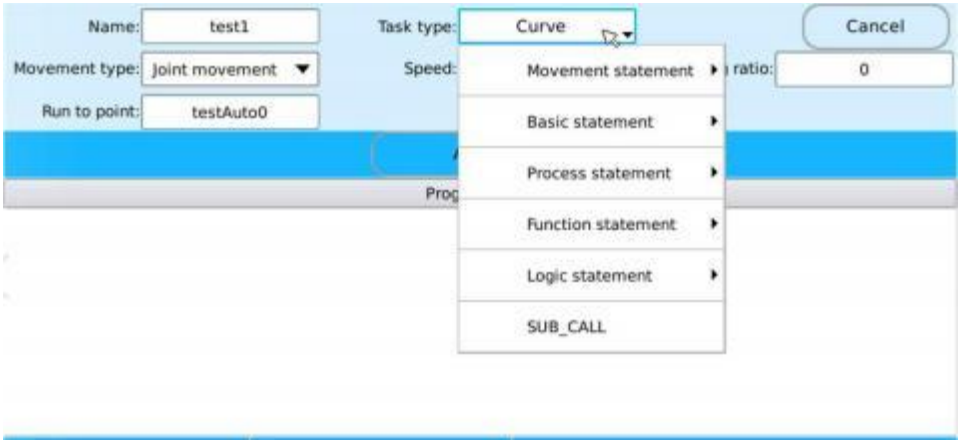


Figure 4.9 Various instructions included in the task type

4.3.3.2 Curve instruction description

A curve instruction runs in the robot system,which is expressed as a moving track that accurately controls the robot from "start point" to "end point". In this instruction, the following contents need to be specified:

Movement type: Specifies the motion control method of the moving track.

Run to point:teach the pose of end point that the curve segment robot TCP will move.

Speed:Specifies the movement speed of the robot.

Smoothing ratio:the smoothness of robot motion.

The format of curve instruction is as follows:

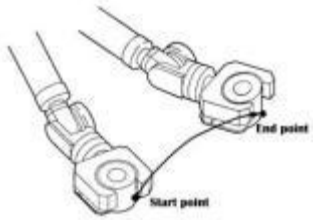
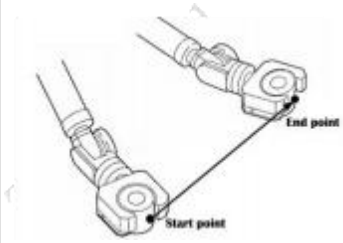
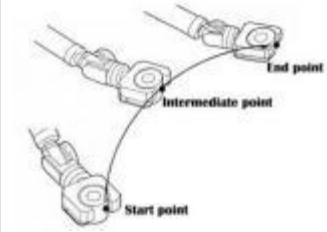
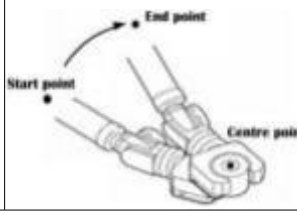
Curve - Movement type: Run to point (ID_point name);

Speed=XXXX; Smoothing ratio =XXX

Movement Type

The movement type specifies how the motion of the movement track is controlled. The movement types and functions currently provided are shown in Table 4.1.

Table 4.1 Description of curve instruction movement type

Type	Figure	Description
Joint movement		The basic movement method of moving the robot TCP to the specified position. All axes of the robot accelerate at the same time. After moving at the teaching speed, it decelerates at the same time and stops.
Linear movement		A moving method for controlling the robot TCP moving trajectory in a linear motion mode from the start point to the end point.
Arc movement		A moving method to control the TCP moving track of robot in the form of arc from the start point through the intermediate point to the end point.
Circular movement		A movement method for controlling the TCP movement trajectory of the robot in a circular motion from the start point to the end point. The Centre point needs to be taught.

Run to point

The running track of the program is connected by the "start point" and "end point" of each curve in the program. The "end point" of each curve is the "start point" of the next curve. Therefore, when using the curve instruction, you only need to set the "end point" of the curve through manual teaching, that is, the "motion to point".

After the program is named and created successfully, the system will automatically set a "point" name for the "run to point" for the first curve instruction. As shown in Figure 4.9, the name "testauto0" is set for the new "TEST" program. You can click the "run to point" text

box to change the name of the point, or select an existing "point" for reference.

Speed

In the process of robot movement, the speed of movement needs to be set. The speed unit in the "joint movement" type is r/min, and the maximum should not exceed the setting parameters in "machine parameters"; The speed units of "linear movement", "arc movement" and "circular movement" types are mm/s, and the maximum speed should not exceed 2000 mm/s.

Smoothing ratio

By setting the "smoothing ratio",the robot can run more smoothly. The range of "smoothing ratio" parameter is "0- 100", "0" means no "smoothing", and "100" means the maximum "smoothing".

4.3.3.3 Teaching programming

The trajectory of the robot is composed of several curve instructions. According to the task, there are two methods to teach manually and add curve instructions: one is to teach t1-t5 points manually and add curve instructions synchronously in the basic program programming interface; The other is to manually teach new t1-t5 points in the "point" management interface, and then add curve instructions by referencing points in the basic program programming interface.

After adding curve instruction by manual teaching method for many times, the program instructions display area is shown in Figure 4.10. Click one of the instructions, you can modify, replace and delete the instruction.

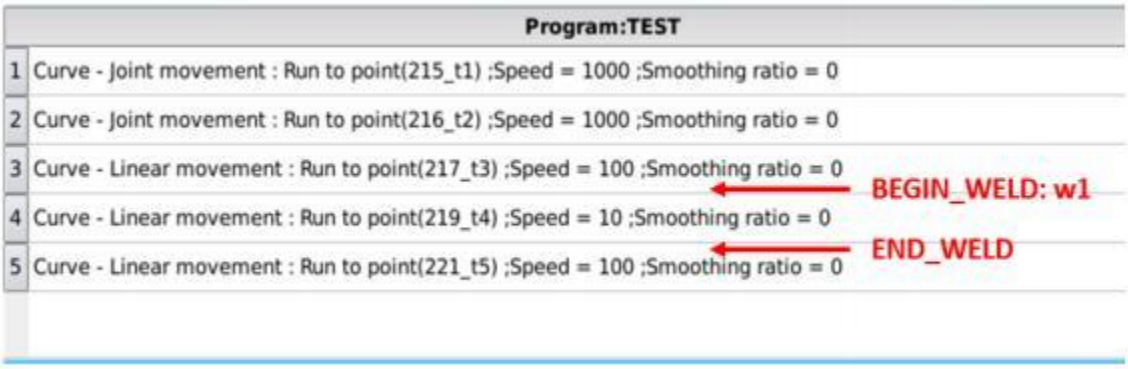


Figure 4.10 TEST program

In the "TEST" program, if the program is run for a single time, the robot will eventually stop at T5. If the motion program is cycled, after the last curve trajectory is completed, the robot takes T5 as the start point and continues to run the first curve to the "run to point" T1 to form a closed loop of motion trajectory.

4.3.3.4 Save program

After the program design is completed, click the [save] button to save the program. When the program is saved in "program management", the creation of "basic program"

is completed.

4.3.4 Program running

After the program is created, switch the mode change-over switch of the teach pendant to the "automatic" sign, and the system will switch to enter the "automatic interface". In automatic mode, the program can be run without pressing the "Enable" button.

5 SZGH Robot programming

This chapter describes the type of instructions constituting the application program in SZGH Robot control system, the steps of writing, debugging, modifying, and executing the application program, the composition of modular program, and how the system starts up and automatically runs the program.

5.1 Program instruction

Program instruction is the basic unit of robot program and the execution method to control the specified actions of robot and peripheral equipment. In the SZGH Robot control system,writing the program only needs to select the corresponding instructions, input parameters, and click the "add"button. There is no need to manually input the command line code, which is very convenient and easy to use.

The instructions provided in SZGH Robot control system are divided into the following types, as shown in Figure 5.1.

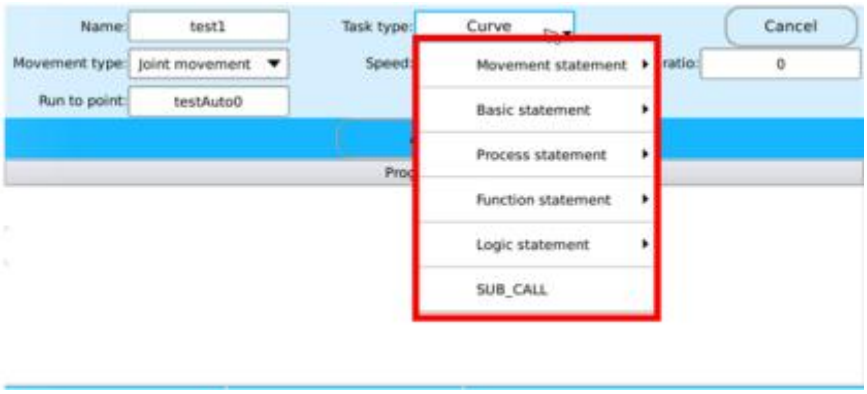


Figure 5.1 Instructions provided in SZGH Robot control system

See Appendix 1 for specific instructions.

5.2 Global variable definition

In order to cooperate with program instruction function, logic judgment and external communication interaction, the system defines global variables with specific meaning in the storage space.

See Appendix 2 for details.

5.3 Programming and testing

5.3.1 New program

Switch the mode change-over switch of the teach pendant to the "manual" sign, and

enter the new basic program interface in the main interface of manual mode.

See Section 4.3, Chapter 4, part I of the manual for specific operation.

5.3.2 Manual teaching programming

In the task type, select the corresponding instruction through the drop-down menu (as shown in Figure 5.2), and the interface of the instruction parameter setting area will switch to the parameter setting interface corresponding to the instruction. Set the parameters of the instruction and click the "add" button to complete the programming.

Among them, see Chapter 3 for the procedure manual teaching steps of the robot motion part.

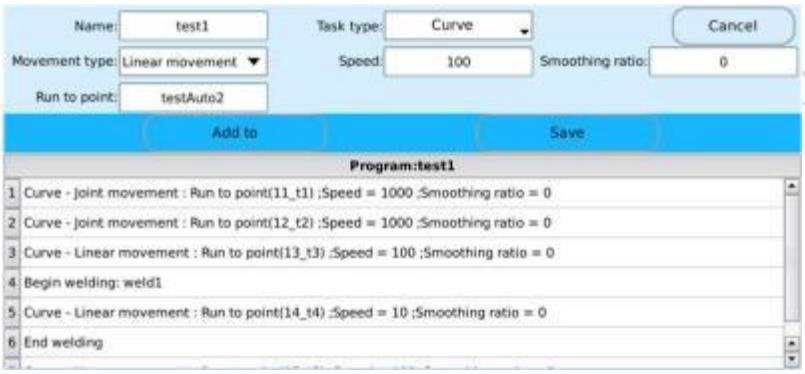


Figure 5.2 Basic program editing interface

5.3.3 Program notes

The program instruction display is divided into left and right parts, as shown in Figure 5.3. The program content is displayed on the left. Click the blank area on the right of the instruction to pop up the soft keyboard, and you can enter the program notes in Chinese or English.

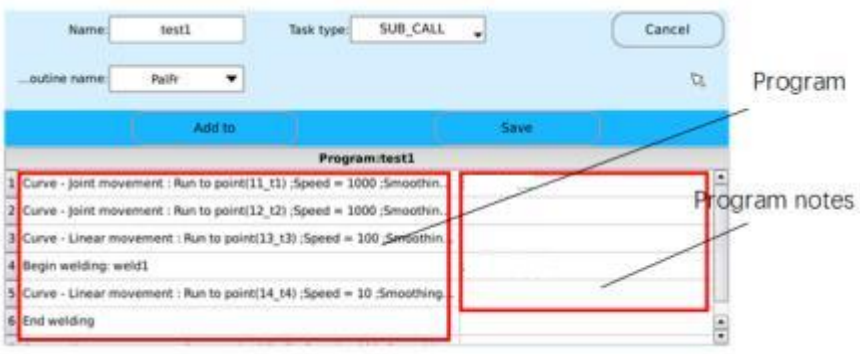


Figure 5.3 Program content and annotation display

5.3.4 Program editing

After the program is created, modify the program as needed. You can change, insert, delete, copy, cut and other operations of instructions through the toolbar and clicking the program name.

Deletion, modification and insertion of instructions

Select an instruction in the program instruction display area on the touch screen, the instruction will turn gray, and the task type and parameter setting area above the interface will be changed to be consistent with the instruction. The toolbar in the programming area will be switched to figure 5.4.

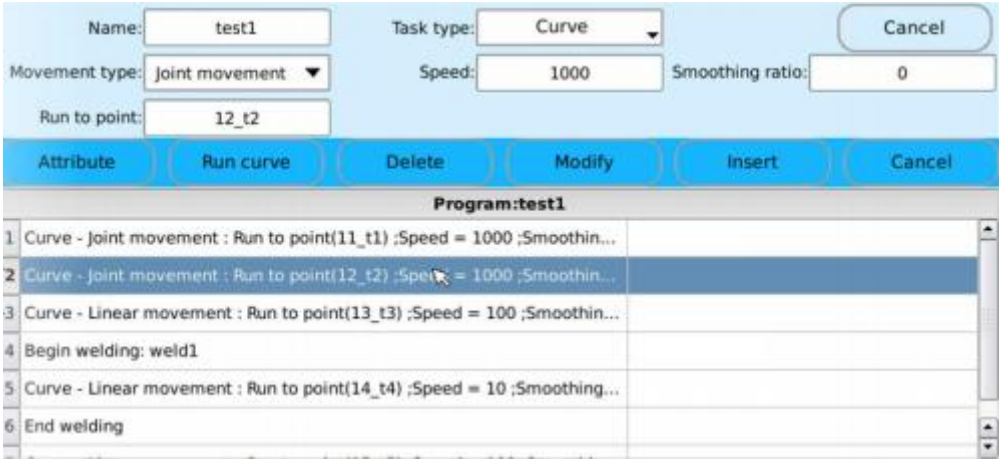


Figure 5.4 Toolbar in the programming area

Clip and copy of program segments

Click the program name bar, and it will switch to the full screen interface of the program. Click the command on the touch screen, the command will change color, the "selected task" appears on the right, and the [Delete], [Copy] and [Cut] buttons appear on the lower bar at the same time, as shown in Figure 5.5. Multiple instructions can be selected at one time for copying and cutting.

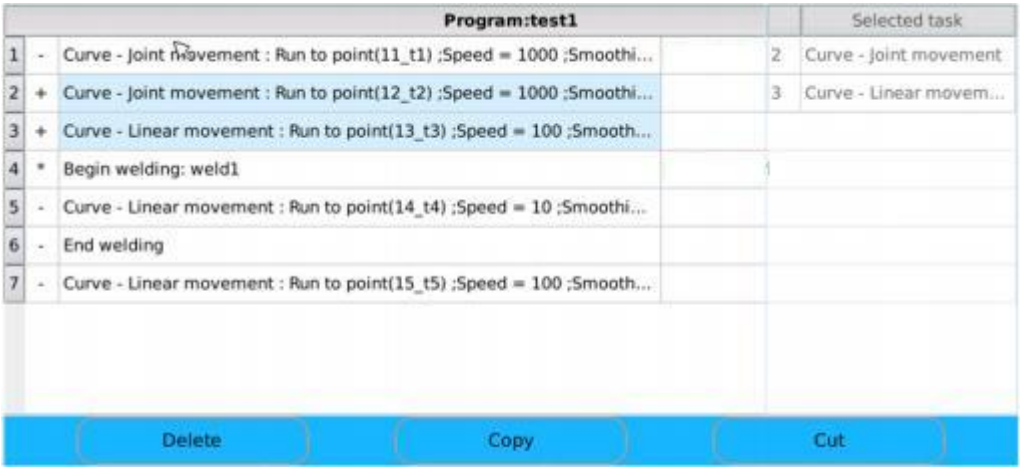


Figure 5.5 Copy and cut program instructions

After clicking [copy] or [cut], the lower bar will switch to another toolbar, as shown in Figure5.6. At this time, select the position to be inserted, and the corresponding instruction will turn gray. You can realize the "selected task" instruction in front of the "front" or "rear" of the gray instruction [forward paste] or [reverse paste].

Figure 5.6 Forward or reverse pasting instructions at the specified position

5.3.5 Trajectory debugging

In the manual mode, there are two methods to debug whether the robot motion trajectory instructions in the program is correct: line by line debugging in the program command display area and entering the special motion trajectory debugging interface through the menu.

Line by line debugging of program instruction display area

elect a curve command in the program command display area on the touch screen, the curve command will become gray, and the task type and parameter setting area above the interface will be changed to be consistent with the command. The toolbar will be switched to Figure 5.7.

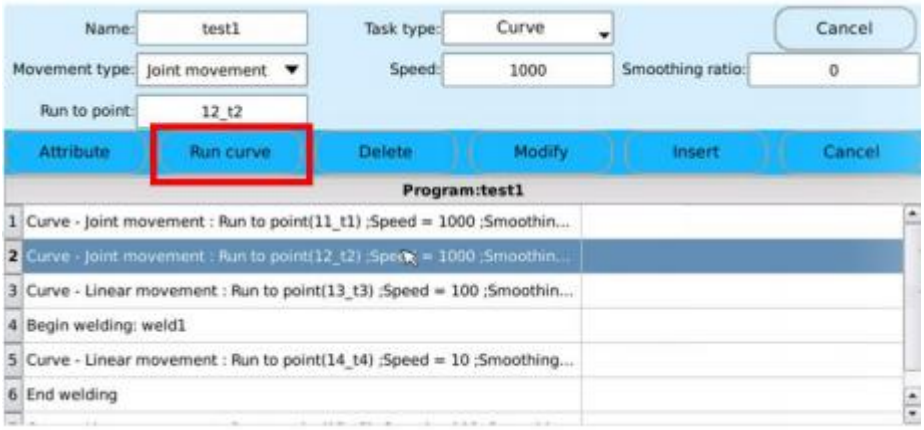


Figure 5.7 [Run curve] button will appear when selecting curve command

The [operation curve] button on the toolbar is a one-step debugging button only available for curve instructions. Under the condition of ensuring safety, press the "enable" button on the back of the teach pendant and click the [Run curve], and the robot will execute the curve instruction and run to the "run to point" set by the curve.

Select the next curve instruction, continue to press any "enable" button on the back of the teach pendant, and click [run curve] for manual teaching to check whether the motion trajectory of the robot meets the design requirements.

Motion track debugging interface

The program includes not only a series of robot trajectory instructions executed in sequence, but also many basic instructions, process instructions, function instructions and logic instructions. In the program instruction display area, look for the motion instruction line by line for debugging, which is inefficient and easy to miss. Therefore, the system provides a special motion trajectory debugging interface.

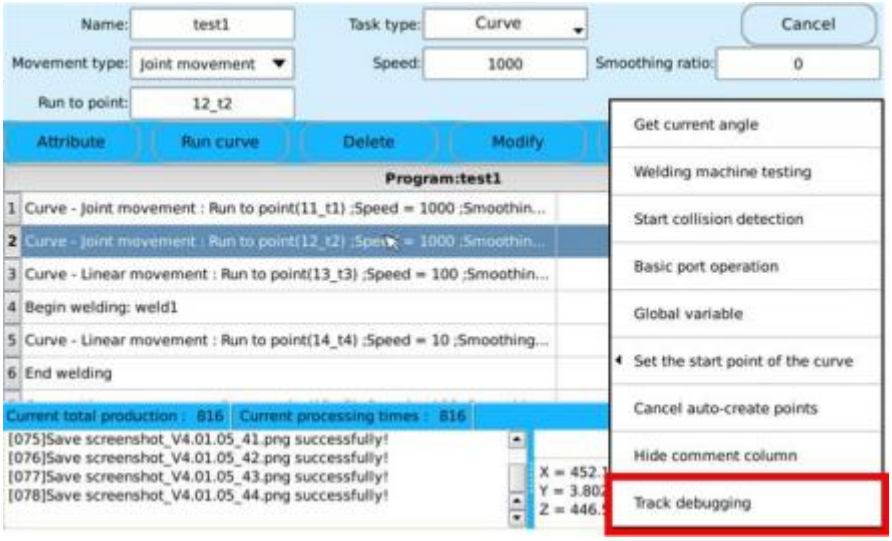


Figure 5.8 Menu [track debugging]

Click the [menu] key on the teach pendant, and click the [track debugging] key in the pop-up menu (as shown in Figure 5.8), and the motion track debugging interface will appear.

As shown in Figure 5.9, on the motion track debugging interface, other instructions in the program are shielded, and all curve instructions are presented visually in turn, so as to enable the user to verify the consistency between the running track of the program and the teaching track.

Figure 5.9 Motion trajectory debugging interface

In this interface, you can check "single step" or "continuous" operation by "sequence" or "reverse order". You can select the corresponding instruction to stop the program when it runs to the instruction. Note that click the [run] button here to debug the motion track. It is a manual teaching process, and you need to press the "enable" button on the back of the teaching

pendant at the same time.

Note: (1)"Track debugging" is to extract curve tasks in the program and run them one by one to preview the running track of the program. Therefore, only curve instructions are executed and non-curve instructions are skipped. When the program contains logical statements "if", "while" and "Jmp", special attention should be paid: if there is an "if", "while" or "Jmp" that is not completely paired between the two points to be run, the result of judgment and jump is uncertain because the non-curve does not run. At this time, the track between these two points cannot complete automatic operation, which needs to be judged by the user, manually reset the starting point to skip such statements.

(2) During track operation, the interface will be set to read-only to prevent users from modifying configuration parameters during operation.

5.3.6 Modification of track points

There are two ways to modify the position and attitude of the track point in the program during the motion track debugging or due to subsequent changes in the environment: at the instruction of the program editing interface and at the point management interface.

Modify at the instruction of program editing interface

Enter the basic program editing interface, select the motion instruction line to be modified, and the instruction will turn gray. Click this instruction again, and the program editing toolbar will switch to Figure 5.10. The border of the text box after "run to point" will be highlighted.

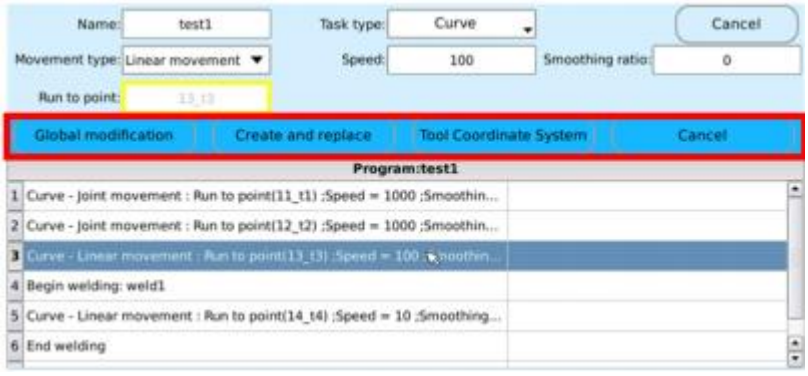


Figure 5.10 "point" modification in curve instruction

At this time, press the "enable" button to manually teach to a new position and attitude, and click:

[global modification] - a prompt box appears, "are you sure to modify the joint angle of curve point * * to the joint angle of the current posture?", Click "yes" and the point data will be modified and saved. If other motion instructions in the program use the point data, it will also be modified synchronously.

[Create and replace] - a prompt box appears, "do you want to create and replace curve points * * with the current joint angle?", Click "yes", a new "point" will be created and saved, and the "motion to point" of the instruction will be replaced with the new point. At this time, the original * * point data will not be modified.

Modify in the point management interface

In the system, some key track points will be referenced by multiple programs for many times. At this time, if you need to modify the point data, you can implement it in the point management interface.

Click [manage] - [point] to enter the "point" management interface, as shown in Figure 5.11. Select the point to be modified, click the [details] button, the "edit box" of the selected "point" will appear, press the "enable" switch, manually teach to the new position and attitude, click "read the current point", and click "save" to complete the modification of "point".

Note: if the modified "point" is referenced, be sure to switch to the "program" management interface and [check] the program that "references" the modified "point" (as shown in Figure 5.12), otherwise the motion track in the program will make mistakes and cause accidents

Figure 5.11 Click the [details] button to modify the data of the point

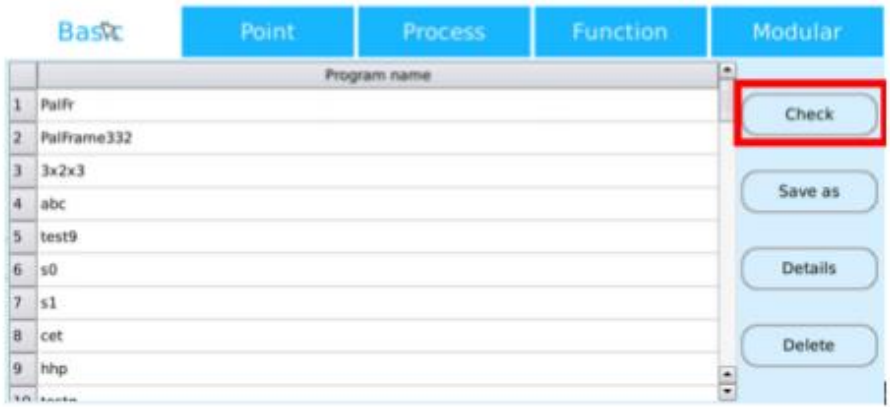


Figure 5.12 Program check

5.3.7 Program saving

After program editing and debugging, you must click the [Temporary save] or [Formal save] button to complete the establishment of "basic program", as shown in Figure 5.13.

[Temporary save]: Continue to stay in the program editing interface.

[Formal save]: Automatically jump to the basic program management interface.

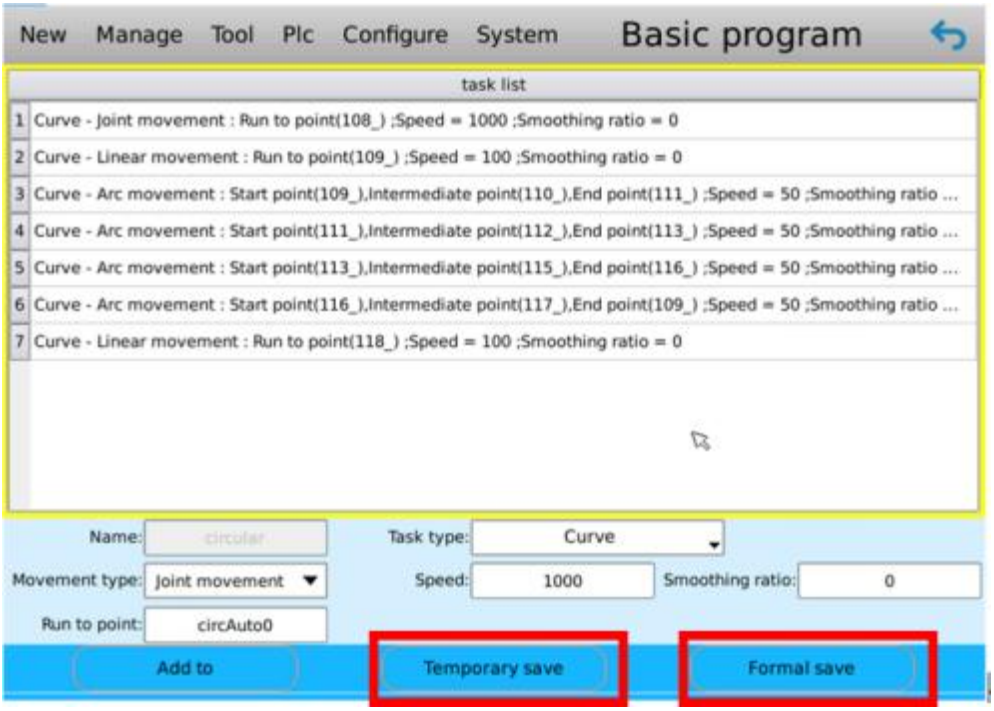


Figure 5.13 Program saving

5.4 Programming interface menu function

Click the [menu]key in the lower right corner of the teaching pendant, and a menu will appear in the lower right corner of the interface, as shown in Figure 5.14.

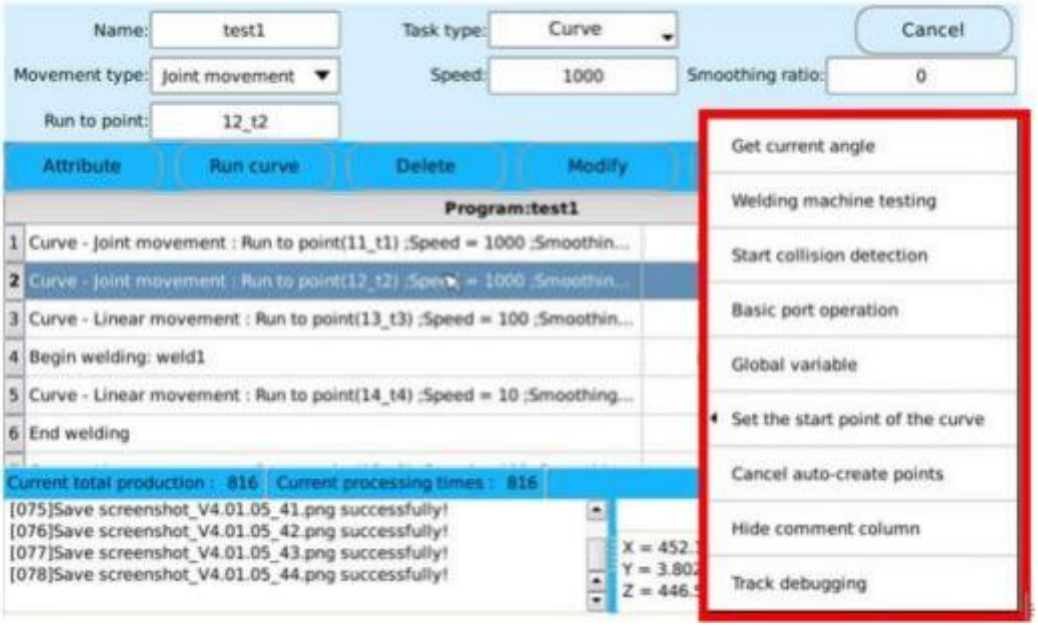


Figure 5.14 Menu of programming interface

The function description of the menu is shown in Table 5.1.

Table 5.1 Menu function description

Number	Item	Function description
1	Basic port operation	Monitor the status of input port and relay port, and check the output effect by setting output port and analog quantity.
2	Get current angle	The operation record display area displays the joint angle data of the current point.
3	Global variable	Open the global variable interface to view the global variable data.
4	Welding machine resting	Adjust the welding machine according to the welding process.
5	Set the start point of the curve	Set the starting point of the program running curve.
6	Auto-create point	Auto name the "run to point" in curve instruction.
7	Hide comment column	Hide / show the comment column in the program instruction display area.
8	Track debugging	Enter the program track debugging interface.
9	Start collision detection	Select the created collision detection function package and alarm output port to make the robot in collision detection state and stop moving immediately in case of collision.

5.5 Modular program

Modular programming refers to dividing a large program according to its functions, writing subroutines to complete the determined functions, and then calling it in the main program. To this end, SZGH Robot system provides two modular programming methods:

(1) Using SUB_CALL instruction in basic program

(2) Enter [modular program] to create "modular program"

5.5.1 Use SUB_ CALL instruction

As shown in Figure 5.15, you can use sub_ The CALL instruction calls another basic program in a basic program. Click "save" and the subroutine will be saved into the program as an instruction.

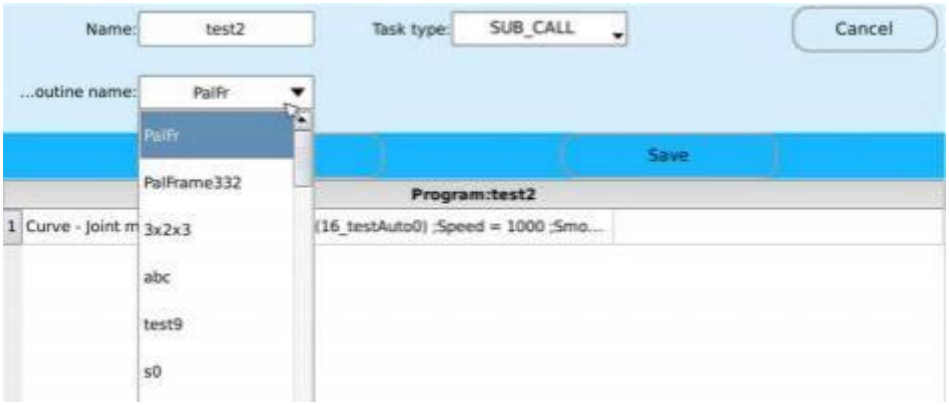


Figure 5.15 Using SUB_CALL in basic program

Switch the teaching pendant to the "automatic mode" interface, and a plus sign will appear in front of the Subroutine instruction. As shown in Figure 5.16, click the plus sign and

the instruction line of the called subroutine will appear.

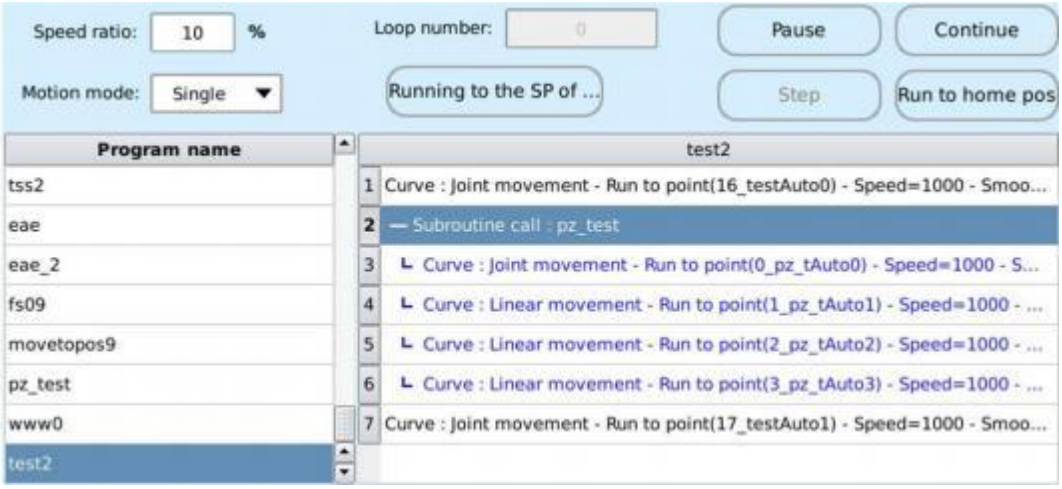


Figure 5.16 Presentation of subprogram in automatic mode

In this way, the program design is simpler and more intuitive,and the readability and maintainability of the program are improved. The disadvantage is that when running the main program,the preprocessing of the subroutine is running to SUB_CALL instruction. If there are many curve instructions in the subroutine and they need to be smoothed, the subroutine preprocessing during operation will affect the operation efficiency.

5.5.2 Create a "modular program"

Enter the modular program programming interface. The programming process of the modular program is the same as that of the basic program, but there are multiple "pcall" task types in the "modular program". In "modular program", you can call "subroutine" through "pcall" task type to generate "modular program". The "subroutines" called by the "pcall" task type are all completed "basic programs".

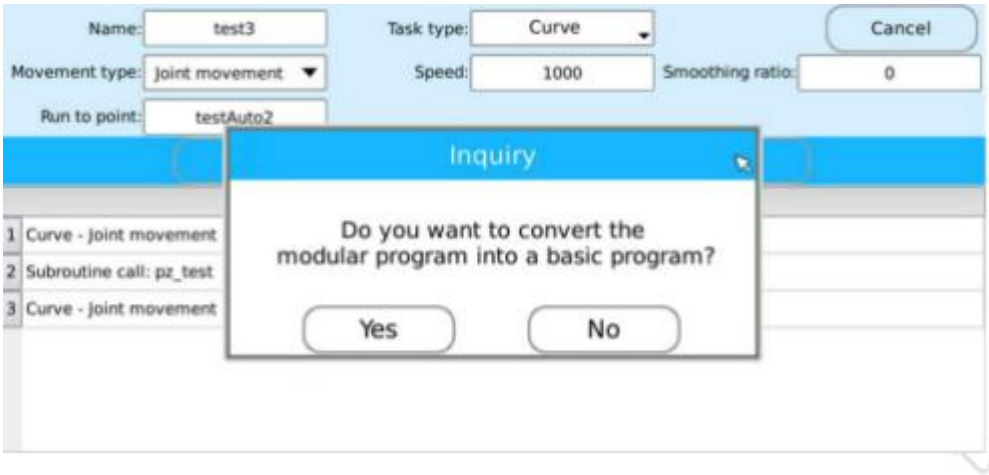


Figure 5.17 "PCALL" task type and usage

After the modular program is created, click [Save] to save it into a "modular program" in [management] - [modular program], and then you will be prompted: "Do you want to convert the modular program into a basic program?", as shown in Figure 5.17. After selecting [Yes], the

system will convert the "modular program" into a "basic program" and save it in the "basic program".

In this way, when the teach pendant is switched to "automatic mode", only the generated basic program will appear in the list, and the program instruction will not be preprocessed in the process when the program is running, so as to ensure the operation efficiency. The disadvantage is that when the program is long, its readability is poor, which is not convenient for program testing.

5.6 Program execution in automatic mode

After the program is created, switch the teach pendant to "automatic mode" to run the program.

5.6.1 Program automatic positioning

For the last newly created program or the last modified and saved program, switch to "automatic mode", and the system will automatically locate the name of the program and automatically query its details, and locate the task line of the last operation of the program in the program (operations include creating, modifying, inserting, and deleting the task line).

5.6.2 Parameter setting

As shown in Figure 5.18 below, various parameters need to be set on the configuration page before "operation", including movement speed, movement times and movement mode.

The description of parameters is shown in Table 5.2.

For safety, it's best to slow down the " speed" before running the program, select the "single" motion mode to test the running track, and then set the "speed" and "motion mode" according to the operation requirements after there is no problem

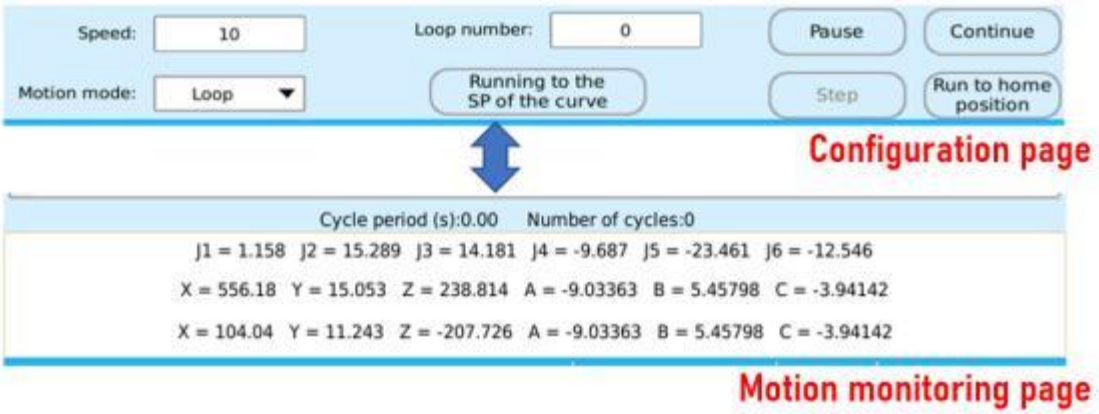


Figure 5.18 pages in automatic mode interface

Table 5.2 Description of program operation parameters

Number	Parameters	Description
1	Speed	Set the overall speed of "program", with a range of 1- 100 (percentage).
2	Loop number	Used in "Loop" motion mode to determine the number of cycles. Number of movements = 0: the program will cycle indefinitely.
3	Motion mode	Three motion modes are available: a. "Single" motion: let the program perform a complete operation, that is, the motion track runs from the "start point" along the track set by the "program" to the "end point". b. "Step" motion: let the program start from the "start point" and execute "step by step" along the track set by the "program". Specific format: select the "program name" to be executed, press the physical key [program start] on the teach pendant, wait until the first step of the robot body is completed, then click the [step] key to proceed to the next step, and then click the [single] key repeatedly to complete the single step operation. c. "Loop" motion: let the program "cycle" run, which should be used in conjunction with the setting of "motion times". When the parameter in "motion times" is set to "0", the circular motion will become the "infinite cycle" motion mode.

In automatic mode: the program is displayed as the configuration page by default before startup. After the program starts running, the interface will automatically switch to the motion monitoring page.

Click the program task list to switch the motion monitoring page back to the configuration page. When the interface is idle for 5 seconds, it will automatically switch back to the motion monitoring page.

5.6.3 Use of keys

In the "automatic mode" mode of the teach pendant, see Table 1.3 in Chapter 1 for the description of key functions.

5.7 Run the program by using external keys

After programming and testing with the teach pendant, by setting the port configuration, you can run a job program using the external keys instead of entering the teach pendant interface.

Step 1: install physical keys on the control box and connect the input port of the main controller.

Step 2: in [user management], select the check box of [automatic login] and complete the "automatic login" function setting according to the prompt, as shown in Figure 5.19.

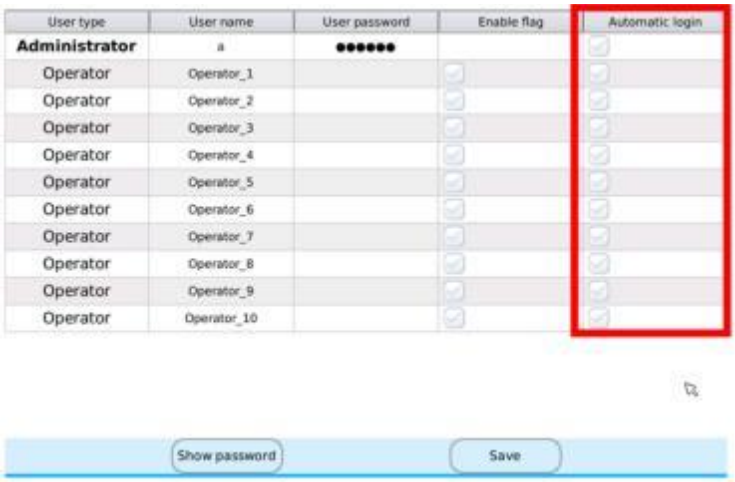


Figure 5.19 Select the check box of [automatic login]

Step 3: Select [configuration] - [environment configuration], as shown in Figure 5.20. Check "Load running parameters automatically". The parameters set in "automatic mode" (such as "speed ratio", "motion mode" and "loop number") will be saved, and the parameters will be loaded automatically after the system is restarted.

Figure 5.20 Check "Load running parameters automatically"

Step 4: select [port configuration], the system provides 8 special functions. Enter the port according to the physical keys installed in the control box, and configure the special function, as shown in Figure 5.21.

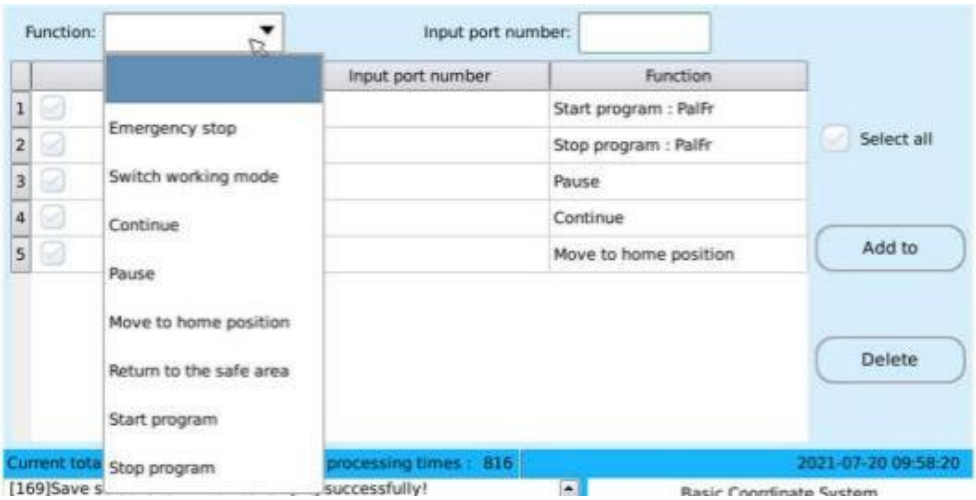


Figure 5.21 Port configuration

Note:

The same special function can be configured many times with different I/O input ports. If the I/O input port is configured as a special function, it can no longer be used as a common I/O input port.

There are some differences between "emergency stop" function and other "special functions": when configuring "emergency stop" function, it is "valid" when I/O input port level is low; When configuring other "special functions", it is "valid" when I/O input port level is high.

Step 5: set the operation parameters in the “automatic mode” interface of the teaching pendant, execute the selected program, and the parameters during program operation will be “saved”. Restart the system, you can control the program by using the external keys.

5.8 Execution of the reservation programs

When a robot needs to cooperate with many operators to complete multiple operations, the operators can click the [reservation] button to make a reservation after preparing the workpiece. The robot will complete the corresponding program work in turn according to the reservation order of different operators.

5.8.1 Reservation Settings

In the manual interface of the teach pendant, click [reservation] to enter the "program reservation" setting interface, as shown in Figure 5.22. The description of each parameter is shown in the Table 5.3.

After setting the parameters, click the [add to] button to complete the reservation setting of one program, repeat the operation, select “enable” to take effect. The number of “enable” reservation procedures cannot exceed 10.

Figure 5.22 Program reservation execution settings

Table 5.3 Parameter description of program reservation setting interface

Number	Parameter	Description
1	Program name	Select a basic program for program reservation.
2	Trigger port	Set the "IO input" port number that triggers the "reservation program",and the "IO input" port number cannot coincide with the "function configuration" port number.
3	Speed ratio	Set the running speed ratio of "reservation program", the unit is "%", and the value is an integer of "1- 100".
4	Pausing port (indication)	Set the "IO output" indication port number when the "reservation program" pauses or stops. When the "reservation program" runs, the output is "low level". Otherwise, the output is "high level".
5	Reservation port (indication)	Set the "IO output" port number after the program reservation is been "executed"; When the program starts "running", the "LED light" will change from "flashing" to "on".
6	Enable	Select "enable" to take effect.

5.8.2 Execution of The Reservation Programs

When the system uses the "reservation program", it must be "triggered" in the "automatic mode"state to run. The "sequence" of the running program runs according to the time sequence of successful triggering. When the "reservation program" runs successfully and the program is "triggered" again, it will not be counted.

When multiple programs are reserved successful, and the "program stop" or "emergency stop" button is pressed through the teach pendant, all "reservation programs" will be stopped and the "count" will be cleared, including "reservation programs" of "being executed" and "not executed". When executing the reservation program, if it is in the "pause" state, press the "trigger" button corresponding to the program again, and the reservation program will "continue" from the current command line; If you need to start from the first task, you need to select [configuration] - [other configuration] - [environment configuration], as shown in Figure 5.23, and check "Appointment to start the program from the first task".

Note: the [stop] external key can only stop the program of the current operator and will not affect the program execution of other operators.

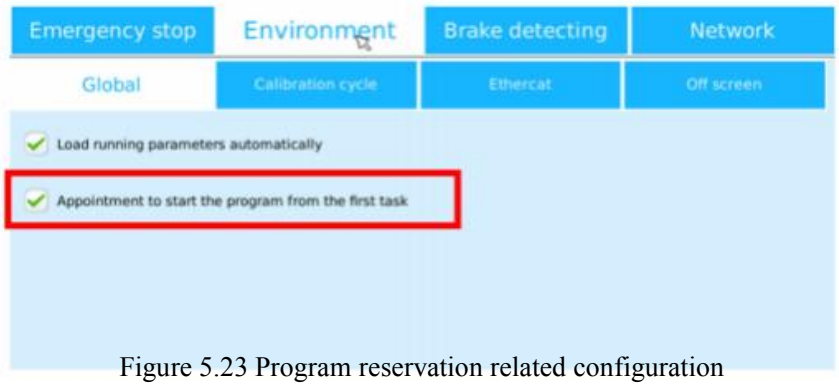


Figure 5.23 Program reservation related configuration

5.9 Program management

After the program is established, sometimes the set "point" position changes, or the program needs to be modified according to the robot operation requirements. At this time, it should be realized through "program management".

Click [management] - [basic program], as shown in Figure 5.24, and the program name will be displayed in the list.

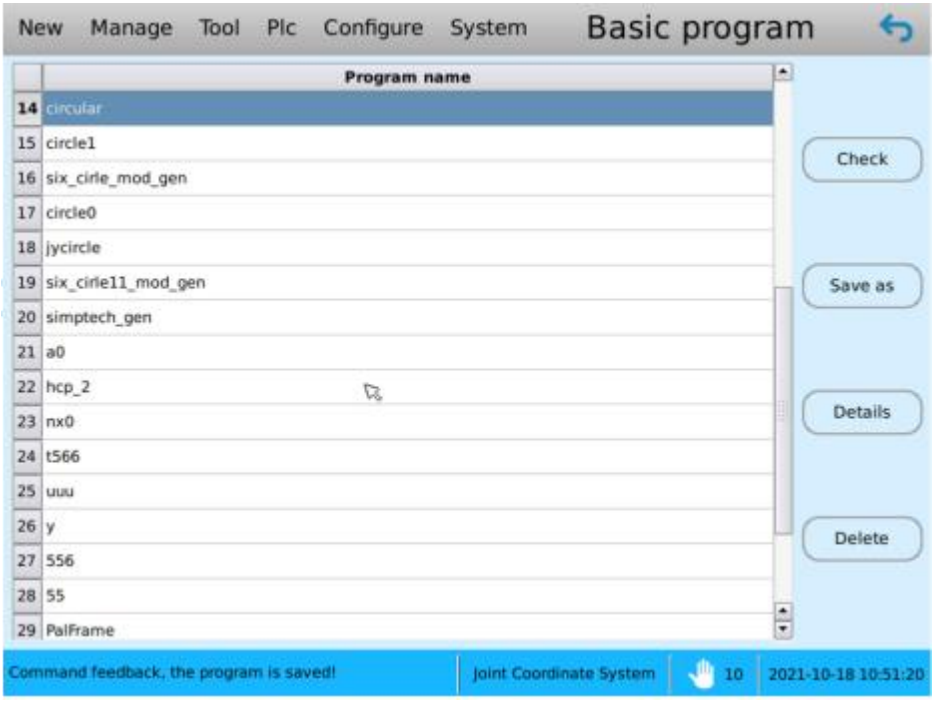


Figure 5.24 Basic program management interface

The management of "basic program" is divided into "check", "save as", "details" and "delete" of the program. The functions of each key are shown in Table 5.4.

Table 5.6 Function description of "basic program" management keys

Number	Key	Description
1	Check	When it is used in conjunction with the management of "points", when a "reference point" in the program changes, it must "check" the program (all other programs that have referenced this "change point" need to "check"), otherwise the motion trajectory in the program will make mistakes and cause accidents.
2	Save as	Select the "program name", click the "save as" button to enter the basic program creation interface of the selected "program", modify and save the "program name", and then save the "program" as a program with a new name under the condition that the original program remains unchanged.
3	Details	You can return to the basic program creation interface to "delete", "modify" and "insert" the selected program.
4	Delete	Delete the completed program.

6 PLC programming

In order to facilitate the programming habits of operators, the system provides PLC programming mode, so that users can use the standard PLC programming language to write specific control applications.

6.1 PLC programming environment

The system provides two PLC programming environments: ladder diagram and instruction table. Click [PLC edit] to enter the PLC ladder diagram programming interface shown in Figure 6.1. Click [instruction list] on the interface to switch to PLC instruction list programming interface, as shown in Figure 6.2.

Figure 6.1 PLC programming ladder diagram

Figure 6.2 PLC instruction list programming interface

The capacity of PLC program is 800 component symbols, and the basic instructions can realize the logic control of internal relay, timer, counter, input relay X and output relay y. The ladder column range is 0 ~ 100, and the command line range is 0 ~ 1000.

6.1.1 Ladder component symbols

The basic symbols of components provided by PLC ladder diagram programming interface are shown in Table 6.1.

Table 6.1 Component symbol description

Number	Symbol name	Symbolic graphics	Description
1	Normally open contact		Normally open contact of each element (relay)
2	Normally closed contact		Normally closed contact of each element (relay)
3	Direct output coil		Coil of each element (relay)
4	Set output coil		Coil of each element (relay) (set hold)
5	Reset output coil		Coil of each element (relay) (reset hold)
6	Horizontal connection		Used to connect the contacts and coils of each relay horizontally
7	Vertical connection		Used to vertically connect the contacts and coils of each relay (usually for branch)

6.1.2 Basic logic instruction in instruction table

There are 15 basic logic instructions in the PLC instruction table, which are used to realize the basic logic control, as shown in Table 6.2.

Table 6.2 Basic logic instruction in instruction table

Number	Instruction name	Description
1	LD, LDI instructions	LD: normally open contact and bus connection command. LDI: normally closed contact and bus connection command. LD and LDI instructions can be used for X, Y, S, A, M, C and t (including TGT, TGH, AGT and AGH). They can also be used for the start point of branch circuit in combination with AND and ORB instructions. Out: relay coil output command. The out command can be used for Y, M, C and T (including TGT, TGH, AGT and AGH), but cannot be used for input relay X, status relay S and alarm relay A.
2	AND, ANI instructions	AND: normally open contact series connection command. ANI: normally closed contact series connection command. AND and ANI instructions can be used for X, Y, M, C and T (including TGT, TGH, AGT and AGH).
3	OR, ORI instructions	OR: normally open contact parallel connection command. ORI: normally closed contact parallel connection command. OR and ORI instructions can be used for X, Y, M, C and T (including TGT, TGH, AGT and AGH).

4	ORB instruction	ORB: parallel connection command of series circuit block. The circuit formed by connecting more than two contacts in series is called "series circuit block". When the series circuit blocks are connected in parallel, ORB command is used.
5	ANB instruction	ANB: serial connection command of parallel circuit block. The ANB command connects the parallel circuit block in series with the previous circuit. Before using the ANB command, the internal connection of the parallel circuit block should be completed.
6	MPS, MRD, MPP Stack memory and multiple output instructions	MPS, MRD and MPP instructions are stack in, stack read and stack out instructions respectively, which are used in multiple output circuits.
7	SET, RST instructions	SET: set instruction, the instruction to hold the operation. RET: reset command, the command to keep the operation reset. SET instruction can be used for Y and M, RST instruction can be used for Y, M, C and T (including TGT, TGH, AGT and AGH).
8	NOP, END instructions	NOP: empty operation instruction. END: end instruction, indicating the end of the program.

6.1.3 Run PLC program

Click [PLC] - [Run PLC] to enter the PLC program execution interface shown in Figure 6.3. In this interface, you can run, stop and monitor the PLC program, and view the program details.

In the interface shown in Figure 6.3, the automatic operation of PLC program can also be realized through setting. Click the [PLC program] button in the lower right corner, then select the program to be run automatically, click the [menu] key in the lower right corner, and select "Setup program self-starting" in the pop-up menu item, as shown in Figure 6.4. Then power off and restart, and the PLC program will run automatically.

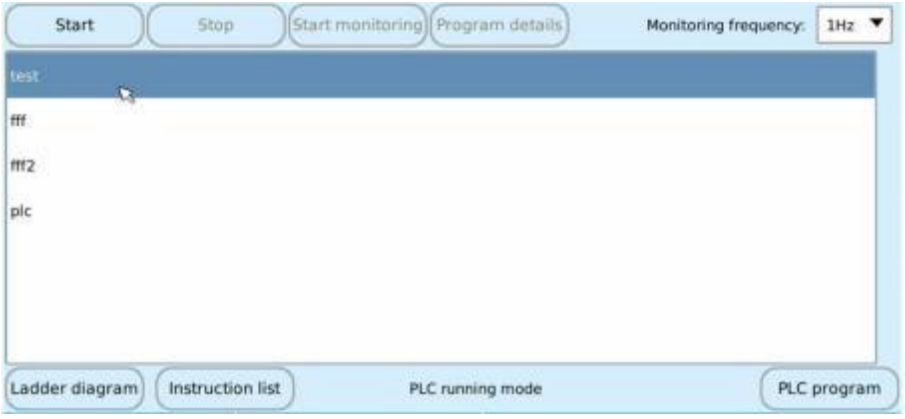


Figure 6.3 PLC program execution interface

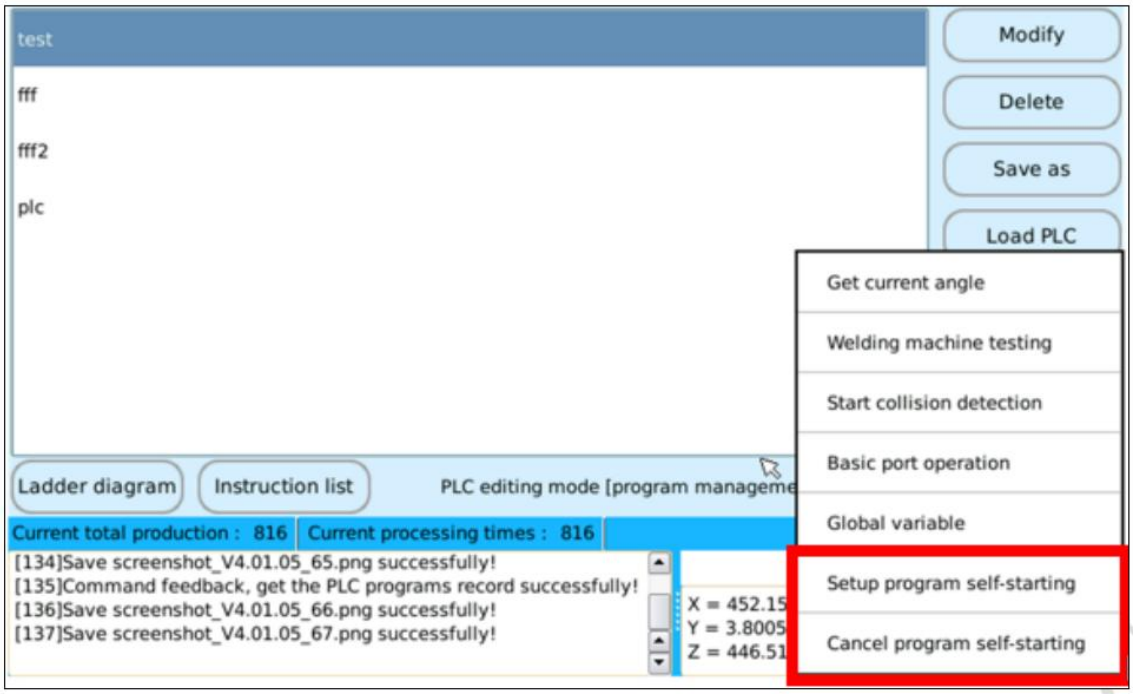


Figure 6.4 Setting the automatic operation of PLC program

6.1.4 Load PLC program

The "PLC Editor" software can be used on the PC to complete PLC programming, and finally generate the PLC program required by the control system.

Copy the PLC program file to the folder named PLC under the root directory of USB flash disk (create a new folder named PLC under the root directory). The teach pendant enters the [PLC-edit] interface, click [PLC program] - [load], and select the PLC program to be loaded in the pop-up list (the loaded PLC program name cannot be the same as the program name already in the control system).

6.1.5 PLC program encryption

The system provides PLC program encryption function. As shown in Figure 6.5, the password can be set in this interface. If you need to check the PLC program details later, you need to enter the password, as shown in Figure 6.6.

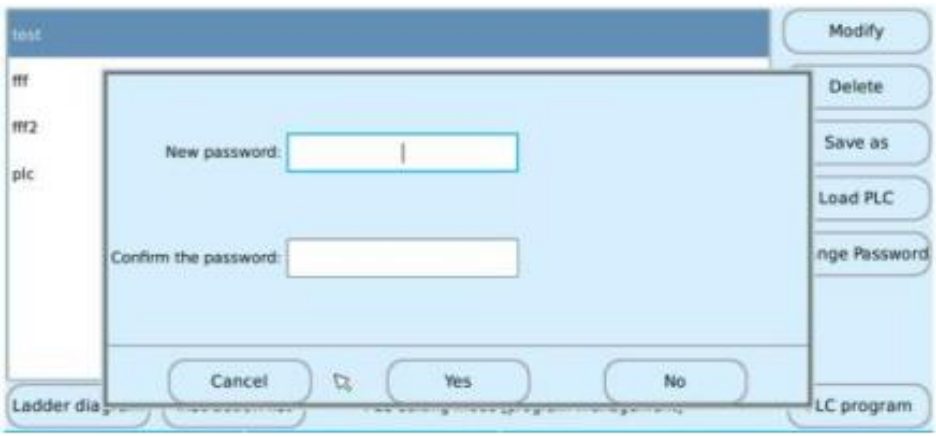


Figure 6.5 Setting password for PLC program

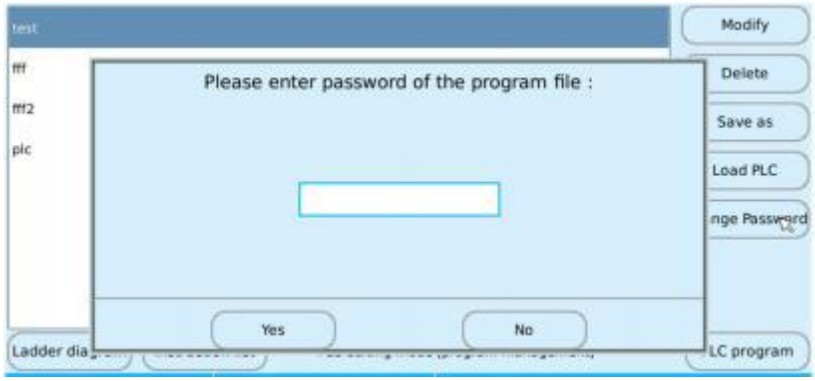


Figure 6.6 Enter password to view PLC program details

6.2 PLC component library

Components are address symbols used to identify signals processed in PLC. The component number is the serial number assigned to the component. Components in the PLC system are represented by X, Y, M, etc.

See Appendix 3 of the manual for the definition of PLC elements.

7 I/O communication of SZGH Robot system

SZGH Robot system provides rich I / O communication interfaces, including standard I/O circuit, serial port, network port, USB interface, etc., which can easily realize the communication with peripheral devices.

7.1 Interface signal definition

The definitions of comm and AVO interfaces of the main controller are shown in Table 7.1 and table 7.2. By default, there is no analog output module in the controller and additional configuration is required.

Table 7.1 Definition of RS485 and RS232

Pin	Signal	Definition	Pin	Signal	Definition
1	CAN1H	CAN1_H	6	/	
2	CAN1L	CAN1_L	7	U5TX	232_TX
3	U4B	485_B	8	U5RX	232_RX
4	U4A	485_A	9	GND	232_GND/
5	/				

Table 7.2 Definition of analog output interface

Pin	Signal	Definition	Pin	Signal	Definition
1	AOUT1	Analog output 1	6	/	Empty, no signal
2	AOUT2	Analog output 2	7	/	Empty, no signal
3	AOUT3	Analog output 3 (not open)	8		
4	AOUT4	Analog output 4 (not open)	9		
5	GND	Analog output ground			

7.2 Standard I/O circuit

The standard I/O port circuit of the system is divided into three types:

(1) 20 Optocoupler isolation inputs

The circuit diagram of Optocoupler isolation input is shown in Figure 7.1.

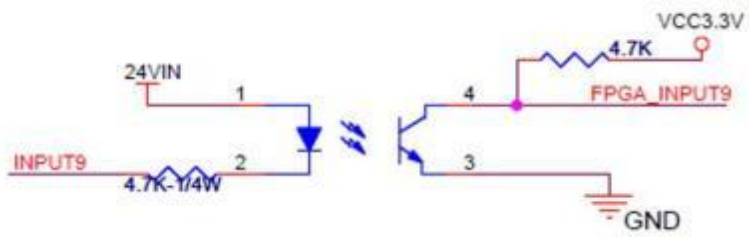


Figure 7.1 Optocoupler isolation input circuit

(2) 10 open collector outputs

The open collector output circuit is shown in Figure 7.2. The default system output is low

level and the triode is off; The system output is at high level, and the triode is on. When the collector is open and the output port is connected externally, pay attention to current limiting, and do not exceed the maximum collector current of the triode.

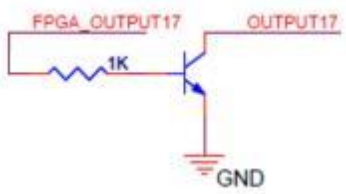


Figure 7.2 Open collector output circuit

(3) 8 relay outputs

The relay output circuit is shown in Figure 7.3, and the ports are normally closed NC, common terminal COM and normally open NO. By default, the system outputs low level, the two contacts of common terminal COM and normally closed NC are closed, and they are disconnected from normally open NO. When the system output is high level, the common terminal COM is disconnected from the normally closed NC and switched to the normally open NO contact.

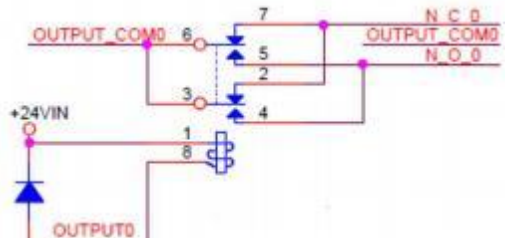


Figure 7.3 Relay output circuit

7.3 Basic port operation

The system provides input and output related program instructions for programming. In addition, click the [menu] key in the lower right corner of the teach pendant, and a menu will appear in the lower right corner of the interface.

Figure 7.4 Basic port operation interface

Click [Basic port operation] to enter the basic port operation interface, as shown in

Figure7.4, including "monitoring relay port", "setting output port", "setting analog quantity" and "monitoring input port".

7.3.1 Monitor relay port

As shown in Figure 7.5, after selecting "Relay", click the [add to] key to pop up a prompt box of "add single or multiple relays", enter the "relay port" number to be monitored, and click the [set] key to complete the "add" of "relays". When multiple relays are "added" at the same time,the serial numbers are connected by "underline".

After completing the "add" of "relays", you can carry out "status monitoring", "status setting" and "delete" operations on these "relays".

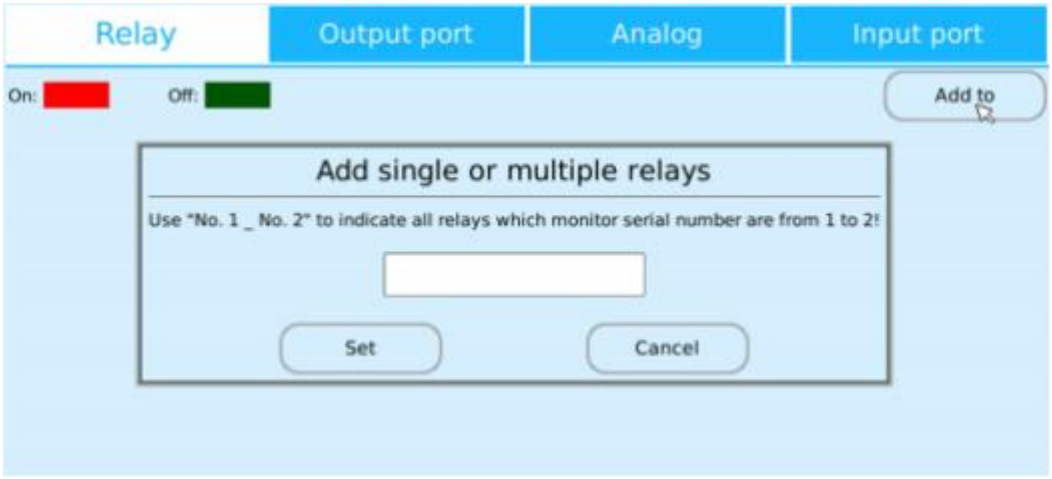


Figure 7.5 Monitor relay port

7.3.2 Set output port

As shown in Figure 7.6, after selecting "Output port", you can perform "status monitoring" and "set status" operations on the "output port". The "set status" operation means that the "output port" can be manually "send high level" and "send low level".

Figure 7.6 Set output port

7.3.3 Set analog quantity

As shown in Figure 7.7, after selecting "Analog", the "analog value" output can be set

for the "analog quantity output channel" of the system. Among them, the number of analog channels depends on the actual situation of the system, and 02/4 channels are possible.

Figure 7.7 Set analog quantity

After inserting AVO module, the main controller provides 2 channels of "analog" output channels, which are "0" and "1" respectively, and the output range of "analog value" is [0, 10V]. The specific setting steps are as follows: first select the "analog" output channel, set the "analog value", and click the [send] button to complete the "analog output" setting.

7.3.4 Monitor input port

As shown in Figure 7.8, after selecting "input port", the system "input port" can be "status monitored".

Figure 7.8 Monitor input port

In the interface, after "checking" the "details" function, you can add "remarks" information to each "input port".

When the system is externally connected with "IO expansion module", you can press the "menu" key and select "Show expansion port", and then you can perform "status monitoring" and "setting status" operations on the "input port", "output port" and "analog channel" in the "IO expansion module".

8 Software configuration and use

SZGH Robot system provides port configuration, automatic positioning of programs and tasks, custom alarm and other functions, which is convenient for operators to quickly complete program programming and debugging.

8.1 Port configuration

In the manual interface, click [tool]-[port], including function port, indication port and program reservation. The procedure reservation method is detailed in Section 5.8 of Chapter 5 of the manual.

8.1.1 Function port

Function port can map the input port to a function related to the control system, such as start program, stop program, etc., as shown in Figure 8.1.

At present, the special function keys that can be set directly include: emergency stop, switching working mode, continue, pause, return to zero, return to safety zone, start program, and stop program. The operator does not need programming, just set the function corresponding to the corresponding input key, and then directly control the program operation through the external key.

I/O input port number "0- 19" can configure these functions arbitrarily. Different I/O input ports can be configured for the same special function, but only one special function can be configured for the same I/O input port, and the configuration will take effect only after the "add" button is clicked; If the I/O input port is configured with special functions, it can no longer be used as an ordinary I/O input port. Only after the special function of "I/O input port" configuration is "deleted", the "I/O input port" can be used as a normal I/O input port again. See Chapter 5, section 5.7 of the manual for more instructions.

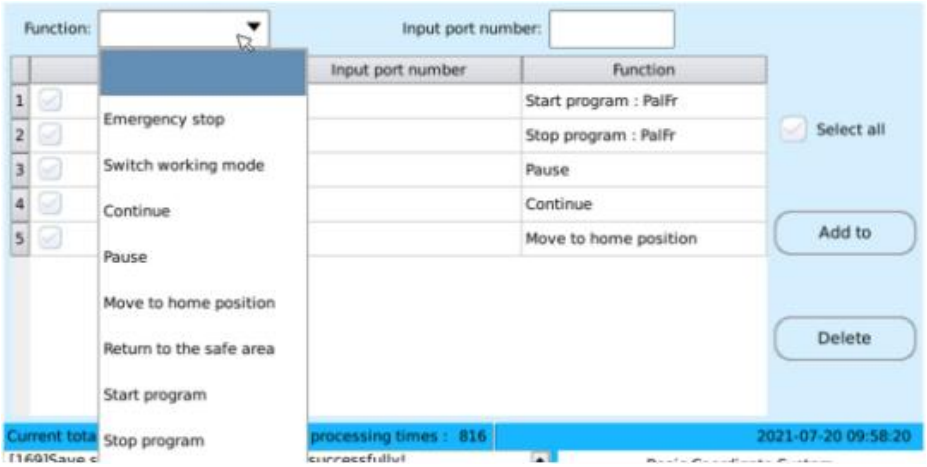


Figure 8.1 Function port setting

8.1.2 Indication port

The indicating port can map the output port to a certain state of the system, such as running state, servo state, alarm state, etc., so that the user can judge the state of the current program through output, as shown in Figure 8.2.

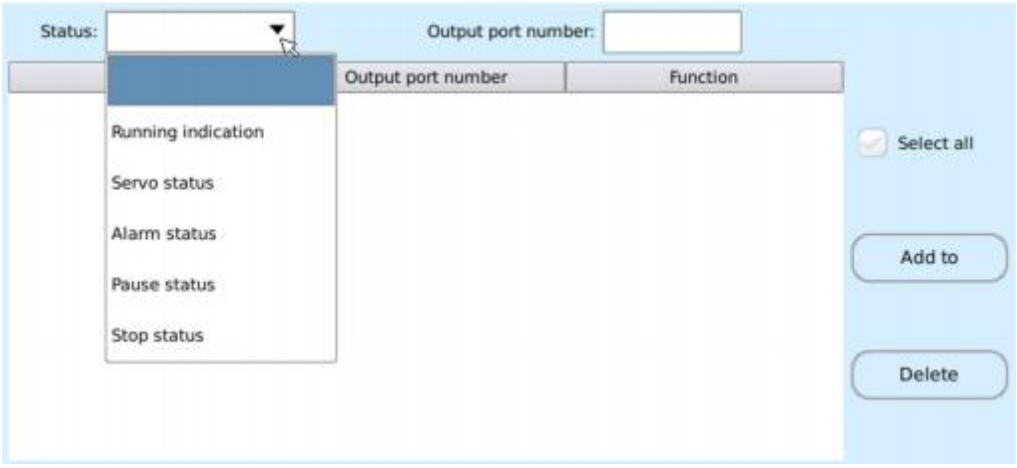


Figure 8.2 Indication port setting

8.2 Custom alarm prompt

The operator can define the alarm prompt information and map it to the output element w of PLC in turn, as shown in Figure 8.3.

Figure 8.3 Custom alarm setting

8.3 Other configurations

Click [configure] in the manual interface to configure emergency stop, operation environment, abnormal braking and network.

8.3.1 Emergency stop trigger output configuration

When pressing the [emergency stop] button of the teach pendant or the external [emergency stop] button, in order to stop the work of other cooperative systems outside the robot at the same time, it is necessary to configure the corresponding output for the "emergency stop"

trigger. As shown in Figure 8.4, the emergency stop output configuration can be customized to output high level or low level.

Figure 8.4 Emergency stop output configuration

The system provides three setting modes for the output port, which are distinguished by different colors: "high level effective" red, "low level effective" green and "PLC control" yellow. Different states can be switched by clicking the port button.

Operation steps of "emergency stop configuration" of the system: first select the serial number of "IO output port" according to the actual situation and click the port button to switch the state, and finally click the [set] button to complete "emergency stop configuration". The initial state of the system for "emergency stop configuration" is "active at low level" by default, that is, when the controller receives the "emergency stop" command, the IO output port outputs "low level".

8.3.2 Calibration cycle configuration

When performing programmed work, robots often deviate from their predetermined path over time. Therefore, in order to ensure the accuracy and reliability of the robot on the production line, recalibration is necessary. As shown in Figure 8.5,you can configure how many times the robot runs the program and then calibrate it once.

Figure 8.5 Robot calibration cycle configuration

8.3.3 Off screen time configuration

The teach pendant can enter the sleep state during the working process of the robot. As shown in Figure 8.6, you can set how long it takes to turn off screen display. Click the teach pendant screen to wake up.

Figure 8.6 Off screen time configuration

8.3.4 Abnormal braking detection

The robot body needs six degrees of freedom, and the power provided comes from six three-phase AC servo motors. When the robot is not working, the brake circuit of the motor is not powered on, and the motor is fixed by friction of the brake pad. After passing through the reducer, the whole mechanical mechanism is deadlocked. When working, the motor is powered on, the brake circuit is powered on, the brake pads are released, and the motor is fixed by the magnetic field. Therefore, it is necessary to detect abnormal braking conditions, as shown in Figure 8.7. The braking detection attribute of each pulse driver port can be set.

Figure 8.7 Brake abnormality detection attribute setting

8.3.5 Network configuration

As shown in Figure 8.8, before using the network, it is necessary to configure and

detect the network IP address, port number, etc.

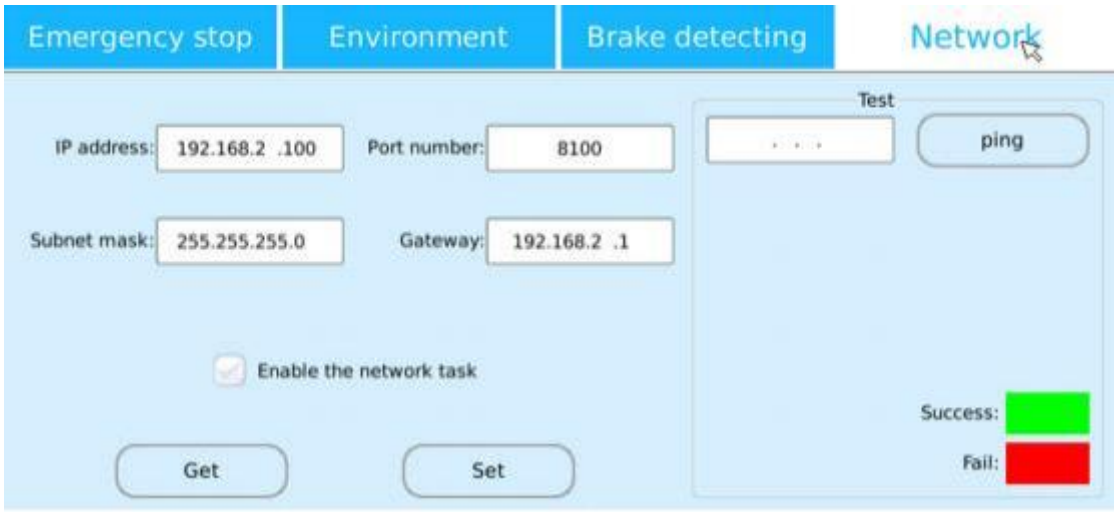


Figure 8.8 Network configuration

8.4 Language configuration

Click [system] - [language] in the manual interface to switch the language of the teaching pendant system. At present, in addition to Chinese, English, Russian, Korean and Vietnamese are also supported.

Figure 8.9 Language configuration

9 System backup and update

9.1 System backup

SZGH Robot system software provides direct configuration and USB flash disk configuration backup functions. The backup programs and file types are shown in Table 9.1.

Table 9.1 Backup programs and file types

Number	Storage location	Program type
1	Controller	Exe system program "robcon", FPGA program and user program
2	Teach pendant	Exe system program "robteach", resource document, manual

9.1.1 Backup configuration

Enter the system [update and backup], as shown in Figure 9. 1. There are two backup configuration methods: direct configuration and USB flash disk configuration.

Select "direct configuration" to check the backup of "user program", "PLC program" and"exe system program".

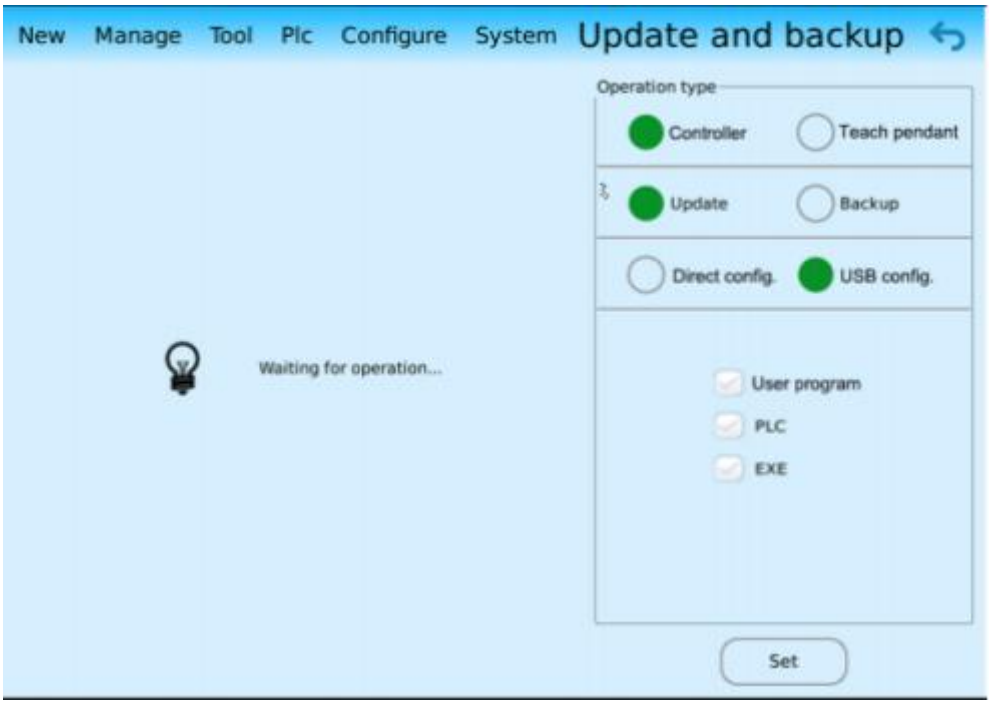


Figure 9.1 update and backup interface

Select "USB flash disk configuration" and prepare a FAT32 format USB2 0 and create a new folder and configuration file in it. This method can backup more file types. The steps are as follows:

1) Create a new folder under root directory of the USB flash disk. The name must be "robcon".

2) Create a new text document in the "robcon" folder and rename it "config.ini".

3) Open "config.ini" with notepad and edit the text content as shown in Figure 9.2. The text

contents related to backup are described in table 9.2.

If you want to back up, set the corresponding parameters. If you don't want to back up, set the parameters to "0".

Table 9.2 Description of configuration file content

Text content	Description	Text content	Description
[control_backup]	Controller backup	[teach_backup]	Teach pendant backup
app	1: Exe system program backup	pic	2: Screenshot backup
fpga	1: FPGA program backup	doc	1: Document backup
record	1: User program backup 2: PLC program backup 3: The user program and PLC program are backed up at the same time 64: User program reuse	app	1:Exe system program backup

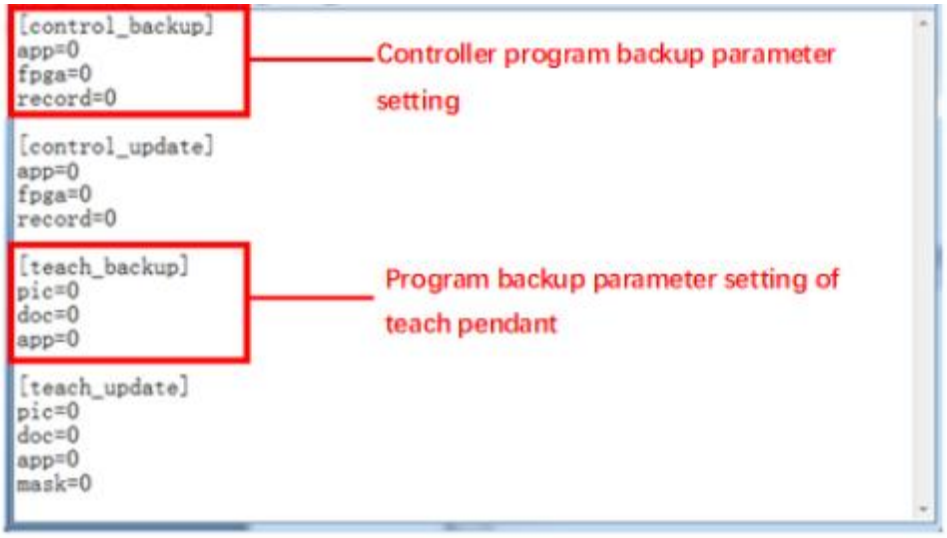


Figure 9.2 Related contents of "config.ini" configuration file backup

9.1.2 System program backup

Before backup, you need to select "direct configuration", check "exe" (controller and teach pendant system files can only be backed up separately), or select "USB flash disk configuration", and then set parameters in the "config.ini" configuration file in the "robcon" folder of USB flash disk (controller and teaching pendant system files can be backed up at the same time).

As shown in Figure 9.3, when the USB flash disk is configured to back up the EXE system program of the main controller,modify the parameter app = 1 in [control_backup] in the "config.ini" configuration file to save the configuration file. When backing up the teaching pendant exe system Program, modify the parameter app = 1 in [teach_backup] in the "config.ini" configuration file and save the configuration file.

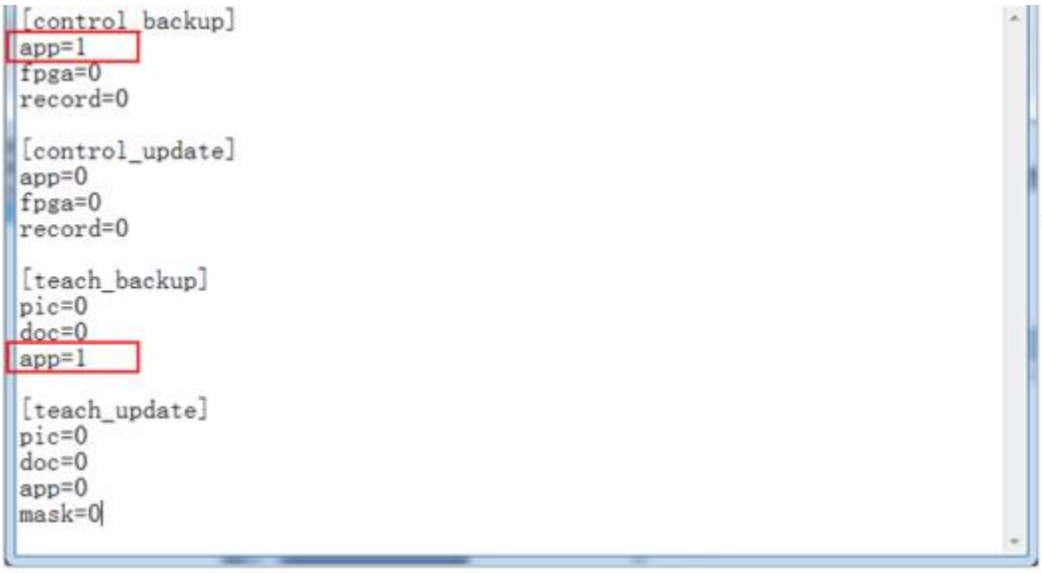


Figure 9.3 Configuration file setting parameter backup system program

After setting the backup configuration, insert the USB flash disk into the controller, click [system] - [update and backup] in the manual interface of the teach pendant, select "backup" and click [OK]. After the backup is successful, the "robcon" folder of USB flash disk will contain three files, as shown in Figure 9.4.

Figure 9.4 Files of USB flash disk backup controller and teach pendant program

9.1.3 User program backup

Before backup, you need to select "controller" - "direct configuration", check "user program", or select "USB flash disk configuration", then set the "[control_backup]" parameter record = 1 in the USB flash disk configuration file "config.ini", and save the configuration file, as shown in Figure 9.5. After setting the configuration file, insert the USB flash disk into the controller, and click [system] - [update and backup] in the manual interface of the teach pendant to backup.

After the user program is backed up successfully, the folder "robcon" will contain "program" folder, "teachRecord.dat" file and "Point.dat" file, in which the "program" folder contains the program files established in the system and is stored in "*.raw" format.

Figure 9.5 Configuration file backup controller user program

9.1.4 PLC program backup

Before backup, you need to select "controller" -"direct configuration", check "PLC", or select "USB flash disk configuration", and then save the configuration file in the parameter "record = 2" of "[control_backup]" in the USB flash disk configuration file "config.ini". After setting the configuration file, insert the USB flash disk into the controller and click [system] - [update and backup] in the manual interface of the teach pendant to backup.

Figure 9.6 Configuration file backup PLC program

After the PLC program is backed up successfully, the "robcon" folder will contain two files: the configuration file "config.ini" and the "PLC" folder. Among them, the PLC program in the system is backed up and saved in the "PLC" folder and stored in the format of "*.PLC", as shown in Figure 9.7.

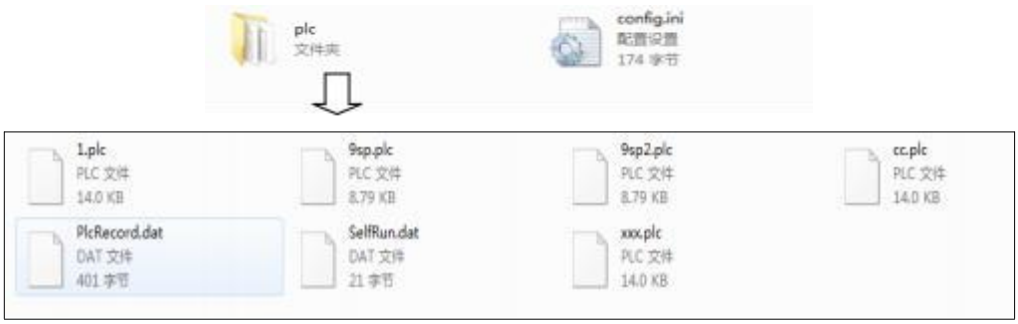


Figure 9.7 PLC program backup files

9.2 System update

SZGH Robot system software provides the functions of direct configuration update and USB flash disk configuration update. The update programs and file types are shown in table 9.3.

Table 9.3 Update programs and file types

Number	Storage location	Program type
1	Controller	Exe system program "robcon", FPGA program and user program
2	Teach pendant	Exe system program "robteach", resource document, manual, mask file

9.2.1 View system version

Select [system] - [version] information to view the system version information. As shown in Figure 9.8 below, you can view the specific information of "machine code", "controller system version number", "teach pendant system version number", "authorization status" and "copyright" of the control system.

Figure 9.8 View system program version information

9.2.2 Update configuration

Before system update, prepare a FAT32 format USB2 0, copy the "robcon" folder with

updated files into the root directory. Then you need to "configure directly" in [update and backup], or configure in "config.ini" on USB flash disk.

1) In the root directory of the USB flash disk, the name of the update folder must be "robcon". The "robcon" folder contains the update application files robcon and robteach, "config.ini" configuration file and "check.dat" verification file.

2) Open "config.Ini" with Notepad, as shown in Figure 9.9, and the text content description related to update is shown in Table 9.4.

For updates, the corresponding parameters will be set in the configuration file. If not updated, the parameters will be set to "0".

Table 9.4 Description of configuration file content

Text content	Description	Text content	Description
[control_update]	Controller program update	[teach_ update]	Teach pendant program update
app	1 :Exe system program update	pic	1 :Resource document update
fpga	1 :FPGA program update	doc	1 :Manual update
record	1 :Local user program update 2 :Local PLC program update 3 :The user program and PLC program are updated at the same time 64:Reuse and update of other machine user programs	app	1 :Exe system program update
		mask	1 :Mask file update

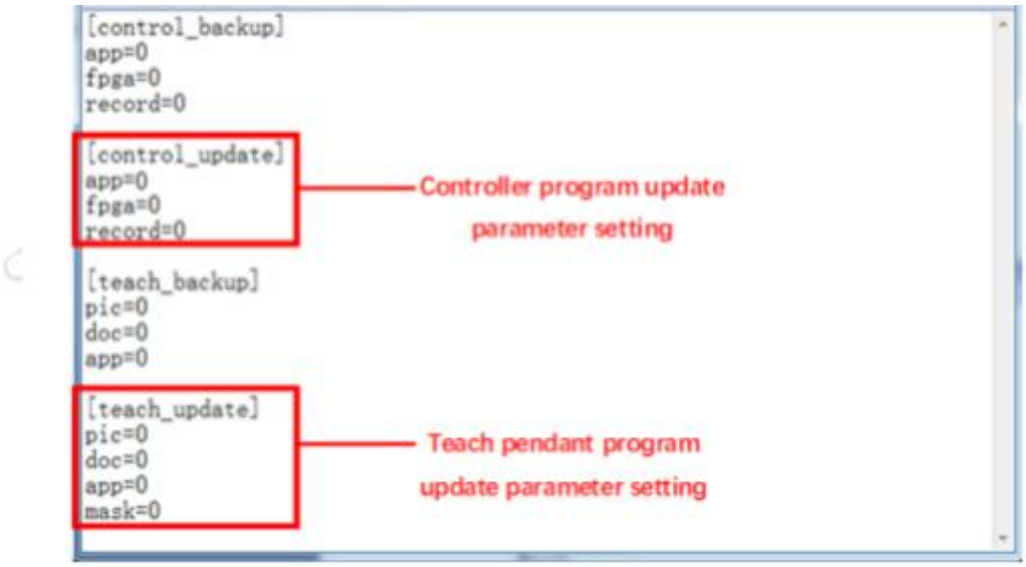


Figure 9.9 Update related contents of "config.ini" configuration file

9.2.3 System program upgrade

The system upgrade includes the upgrade and update of "controller program" and "teach pendant program":

1) If you use USB flash disk configuration, you need to set the parameters in the configuration file "config.ini", mainly in the two "types of" [control_update] "and" [teach_update] ": app = 1, as shown in Figure 9.10.

2) Log in as administrator and click [System] – [update and backup].

3) **First update the teach pendant. After the update is completed, the system will remind "whether to restart?". Please click "NO" and then update the controller. After the update is completed, click restart to confirm.**

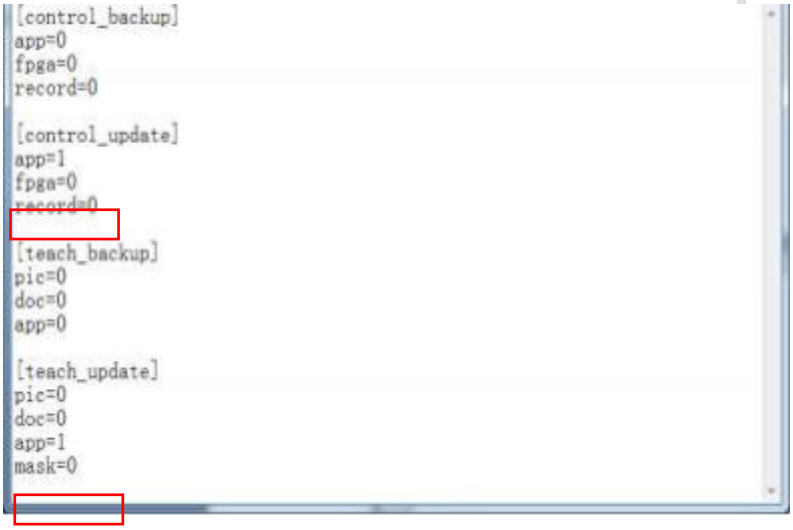


Figure 9.10 Configuration file setting parameter update exe program

Appendix 1 Instruction description

(1) Movement instructions

Please refer to the motion instructions provided in Table 1 when programming the robot. When the tool attitude needs to be changed greatly, it is suggested to divide the motion trajectory into several curves for teaching.

Table 1 motion instructions

Instruction	Description		
Curve movement	Function	Robot motion control.	
	Items	Movement Type	Joint motion / linear motion / arc motion / circular motion
		Run to point	The end point of the curve movement Arc movement: it is also necessary to set the intermediate point (the center of the arc is on the vertical line connecting the start point and the end point, and the intermediate point is any point on the arc) Circular motion: it is also necessary to set the centre point and circular surface point (a sphere can be determined by the start point and centre point, and a circle can be determined by adding any point on the circular surface.)
		Speed	Range(0, 2000], unit: mm/s
		Smoothing ratio	The range is "0- 100", "0" means there is no "smooth", and "smooth" is the largest when it is "100".
	Note	For arc movement, during debugging, if the current position is in the middle of the arc curve when pausing, you can't run directly from the current curve instruction when running again, but you need to return to the previous curve instruction to start running.	
Additional joint movement	Function	Additional axis motion control.	
	Items	Axis	EJ1/EJ2/……
		Control	Start/Stop
		Direction	Positive/Negative
		Speed	Unit: r/min
Forbidden additional joint	Function	Disable and enable additional axes.	
	Items	ENABLE EJ1/DISABLE EJ1; ENABLE EJ2/DISABLE EJ2	
Additional joint Zeroing parameters	Function	Return the additional axis to zero.	
	Items	Number	EJ1/EJ2/……

(2) Basic instructions

Basic instructions include: I / O instruction, register instruction, global variable instruction, speed control instruction, wait event instruction, other control instructions, etc. Please refer to Table 2.

Table 2 Basic instructions

Instruction name	Description		
Output	Function	Change the state of the output port by assignment.	
	Items	Output port number	Y0-Y17
		Output level value	0 indicates low level and 1 indicates high level.
Pulse output	Function	Make the output port output in pulse form by assignment.	
	Items	Output port number	Y0 -Y17
		Polarity	Positive/Negative
		Pulse width	Unit: ms
Analog quantity	Function	Sets the analog value of the channel.	
	Items	Channel number	0-3, 4 channels in total.
		Data source	Variable (take value from global variable) / constant (input analog value directly)
		Analog value	[0, 12), (required when "constant" is selected as the data source)
Start input monitoring Stop input monitoring (Used in pairs)	Function	Monitor the level value of the input port, and assign the output port if there is any change.	
	Items	Input port number	X0-X19
		Port value	0 indicates low level and 1 indicates high level.
		Event relationship	And/
		Output port number	Y0-Y17
Global variable assignment and operation	Function	Global variable assignment operation.	
	Items	Number	General global variable 0-99
		Operation symbol	=, +=, -=, /=
		Assignment	Constant/Variable
Global variable self-increment	Function	The value of the global variable increases by 1.	
	Items	Number	General global variable 0-99
Global variable self-subtraction	Function	The value of the global variable is reduced by 1.	
	Items	Number	General global variable 0-99
Global variable reset	Function	Th f an interval global variable is reset to 0.	
	Items	Starting number	General global variable 0-99
		End number	General global variable 0-99
Register variable	Function	Assignment of register variables.	
	Items	Number	Register 0-499
		Operation symbol	=, +=, -=, /=
		Assignment	Constant/Variable
Digital welding machine operation	Function	Digital welding machine operation.	
	Items	Brand	Jinrui
		Function	Wire feeding / wire withdrawing / gas inspection
		Enable or not	Enable / Non enable

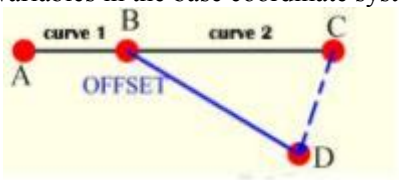
Wait for accurate position		Function	Wait for the robot to reach the specified target point within the distance deviation in the setting time.	
		Items	Target point ID	"Point" ID number
		Distance deviation	Unit: mm	
		Time	Unit: ms	
Pipeline	Function	While the robot moves, preheat the welding gun through the pipeline time.		
	Items	Pipeline duration	Unit: ms	
PLC operation	Function	Operate the PLC relay.		
	Items	M number	0-499	
		State	Valid/Invalid	
Wait (event)	Function	Wait for the event.		
	Items	Event type	Input port / PLC / register variable / global variable / signal edge / signal edge hold	
		logical relationship	And / Or	
		Related parameters	Enter relevant information according to the event type.	
Delay	Function	Delay.		
	Items	Parameter type	Variable / Constant	
		Time	Unit: ms, (required when "constant" is selected)	
		Variable number	0-99	

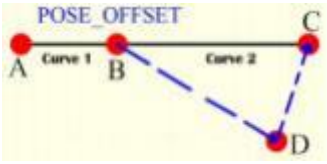
(3) Offset instructions

Aiming at the problem of low precision of teaching points in the process of manual teaching programming and the deviation of workpiece placement position in the actual operation process,the system provides a variety of offset instructions (Table 3) to realize the offset of robot motion trajectory during the operation of the program.

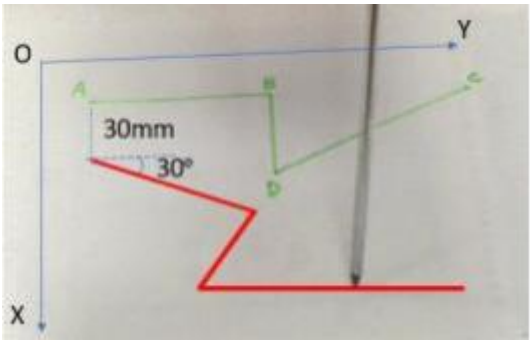
Table 3 Offset command

Instruction	Description		
	Function	In a coordinate system, set the offset to offset the "run to point" of the next curve instruction.	
Offset	Items	Coordinate system	Base coordinate system / User coordinate system / Tool coordinate system
		Data source	Global variables / teaching parameters (input) (Set the offset of X, Y and Z axes and the offset of A, B and C attitude angles)
	Example	Procedure: Curve-Linear movement:Run to point(1-B); Speed=1000; Smoothing ratio=0 OFFSET :Base coordinate system Curve- Linear movement: Run to point(2-C); Speed=1000; Smoothing ratio=0 Explain: Curve 1: A-B; Curve 2: B-C; When the OFFSET instruction is not used,the complete trajectory is A-B-C; When the OFFSET instruction is used after curve 1, the movement of original curve 2 to point "C" will shift to point "D". Therefore, after using the OFFSET instruction, the running track of the program will change to A-B-D. The offset "amplitude" and "offset direction" of point d relative to point C	

<table>
<tr><td></td><td></td><td colspan="2">are given by the global variables in the base coordinate system.
 

Global variable: "value" represents the offset amplitude, and "+" and "-" before "value" represent the offset direction.</td></tr>
<tr><td rowspan="5">Pose Offset
Begin</td><td>Function</td><td colspan="2">In a coordinate system, by setting the offset, add a new curve from the current position, and the "run to point" is the offset point after the offset of the current position, and then run from the offset point to the "run to point" of the next curve instruction .</td></tr>
<tr><td rowspan="4">Items</td><td>Coordinate system</td><td>Base coordinate system / User coordinate system / Tool coordinate system / Joint coordinate system</td></tr>
<tr><td>Data source</td><td>Global variables / teaching parameters (input)
(Set the offset of X, Y and Z axes and the offset of A, B and
C attitude angles)</td></tr>
<tr><td>Curve type</td><td>Joint movement /Linear movement</td></tr>
<tr><td>Speed</td><td>Range(0, 2000], unit: mm/s</td></tr>
<tr><td>Example</td><td colspan="2">Procedure:
Curve- Linear movement: Run to point(1-B); Speed=1000; Smoothing ratio=0
POSE_OFFSET : Base coordinate system; Linear movement; Speed=1000
Curve- Linear movement: Run to point(2-C); Speed=1000; Smoothing ratio=0
Explain:
Curve 1: A-B; Curve 2: B-C; When the POSE_OFFSET instruction is not used, the program running track is A-B-C; When the POSE_OFFSET instruction is used after curve 1 (i.e., the position of point B), the motion track of the point will first offset from the current point "B" to the position of point "D" and then run to the position of point "C". Therefore, after using the POSE_OFFSET instruction, the operation track of the program will become A-B-D-C. The offset "amplitude" and "offset direction" of point D relative to point B are given by the global variables in the base coordinate system.
 

Global variable: "value" represents the offset amplitude, and "+" and "-" before "value" represent the offset direction.</td></tr>
<tr><td rowspan="2">outline offset
End outline offset</td><td>Function</td><td colspan="2">Offset the outline formed by the curve between begin outline offset instruction and end outline offset instruction by setting the offset.</td></tr>
<tr><td>Item</td><td colspan="2">User coordinate system</td></tr>
</table>

<table>
<tr><td></td><td>Example</td><td colspan="2">Procedure:
BEGIN_OUTLINE_OFFSET :h0
Curve- Linear movement: Run to point(1-A); Speed=100; Smoothing ratio=0
Curve- Linear movement: Run to point(1-B); Speed=100; Smoothing ratio=0
Curve- Linear movement: Run to point(1-C); Speed=100; Smoothing ratio=0
Curve- Linear movement: Run to point(1-D); Speed=100; Smoothing ratio=0
Explain:
Before using this pair of instructions, you need to establish a corresponding "user coordinate system" for the "outline" and select it.
The "direction" and "amplitude" of the contour offset are set "assignment" to the corresponding "global variable".
 
</td></tr>
<tr><td rowspan="3">Begin range-offset
End range-offset</td><td>Function</td><td colspan="2">By setting the offset, all the run to points of the curve between " Begin range-offset" and " End range-offset" can be operated with the "offset" instruction in a certain coordinate system.</td></tr>
<tr><td rowspan="2">Items</td><td>Coordinate system</td><td>Base coordinate system / User coordinate system</td></tr>
<tr><td>Data source</td><td>Global variables / teaching parameters (input)</td></tr>
</table>

(4) Process instructions

In order to facilitate users to better use the SZGH Robot control system, the system fixes some operation processes, and manual teaching programming is particularly cumbersome. Through "collection" to form a "process package", users can easily complete the original complex and cumbersome work. To invoke the process package in the basic program, we need to use the process instruction, and use the method in detail in the part III of the instruction.

(5) Function instructions

For some complex operation processes, the SZGH Robot control system is packaged in advance, and the packaging is successful. Users only need to set parameters and can call them in the basic program. See Part II of the manual for the call of function instructions.

(6) Logic instructions

Many logic judgment, loop and jump operations are often involved in the application. The logic instructions provided by SZGH Robot control system are shown in Table 4.

Table 4 Logic instructions

Instruction name	Description
IF	Conditional judgment

ELSE_IF	Conditional branch judgment
END_IF	End of condition judgment
WHILE	Loop
CONTINUE	Exit this cycle and judge the conditions of the next cycle
BREAK	Exit loop
END_WHILE	End loop
JMP	Jump
LABEL	Label
COND_UNTIL_BEGIN	Interval interrupt start
CON_UNTIL_END	Interval interrupt end

Appendix 2 Definition of Global Variables

Address	Data meaning
GV0-GV99	General
GV100-GV109	Number of stacks already placed in 10 pallets in palletizing process
GV110-GV199	Exclusive reservation
GV200	X offset (for “offset”, “section offset”, “outline offset” instructions)
GV201	Y offset (for “offset”, “section offset”, “outline offset” instructions)
GV202	Z offset (for “offset”, “section offset” instructions)
GV203	Attitude angle A offset (for “offset”, “section offset” instructions)
GV204	Attitude angle B offset (for “offset”, “section offset” instructions)
GV205	Attitude angle C offset (for “offset”)/Rotation (for “outline offset”)
GV206-GV208	XYZ data in Base Coordinate System
GV209-GV211	ABC data in Base Coordinate System
GV212-GV217	6 joints offset/X-Y-Z-A-B-C offsets in base coordinate system (for “position offset” instruction)
GV218	Current number of layers in palletizing process
GV219	Serial number of the position to be stacked in the current layer in palletizing process
GV220-GV225	Special register for program control
GV226-GV229	Exclusive reservation
GV230	X offset (for “offset”, “section offset”, “- Intermediate point)
GV231	Y offset (for “offset”, “section offset”, “- Intermediate point)
GV232	Z offset (for “offset”, “section offset”, “- Intermediate point)
GV233-GV235	Rotation angle (for “offset”, “section offset”, “- Intermediate point)
GV236-GV240	Rotation angle of the additional joints 0-4 (Additional joint offset instruction)
GV241	User coordinate system ID
GV242-GV244	XYZ coordinate value in user coordinate system
GV245	The tool coordinate system ID used to display the robot end coordinates and attitude, and the pose offset function. The default value is 255, indicating no tools.
GV246-GV256	Current joint angle of each joint
GV257_L	Completion flag of arc swing process parameter setting
GV257_H	Completion flag of welding machine process parameter setting
GV258-GV263	Arc swing process parameters (mode < 0-z, 1-arc, > - frequency – amplitude - left stay time -right stay time - arc swing radius)
GV264-GV265	Welding process parameters (welding current / wire feeding speed - welding voltage)
GV266-GV279	Exclusive reservation

GV280_L	Mode (0-manual, 1-automatic)
GV280_H	Running status (0-stop, 1-running, 2-pause)
GV281	Alarm category (represented by bits, 0-no such alarm, 1-have such alarm) (B0 emergency stop alarm, B1 servo alarm, B2 brake abnormal alarm, B3 algorithm alarm, B4 encoder angle acquisition alarm)
GV282	Running times
GV283	External encoder task enable flag (read / write)
GV284	Zero crossing trigger port of external encoder (read / write)
GV285	External mechanism reduction ratio (read only)
GV286	Number of external encoder lines (read / write)
GV287	Current value of external encoder (read only)
GV288	System date: Year (2B) + Month (1B) + Day (1B)
GV289	System time: Hour (2B) + Minute (1B) + Second (1B)
GV290	System millisecond counter
GV291	Incremental motion command return status
GV292-GV299	Exclusive reservation
GV300-GV499	General, Data loss after power failure
GV500-GV699	General, No data loss after power failure
GV700-GV705	Special, palletizing frame curve skip flag （0-don't skip, 1-skip）
GV706	Special, palletizing prepare to release point modification mark (0 - do not modify, 1 -Modify)
GV707	Special, modified palletizing transition point (entry) ID
GV708	Special, palletizing prepare to release point modification mark (0 - do not modify, 1 -modify)
GV709	Special, modified palletizing prepare to release point ID
GV710	Special, palletizing release point modification mark （0 - do not modify, 1 - modify）
GV711	Special, modified palletizing release point ID
GV712	Special, palletizing leaving point modification mark （0 - do not modify, 1 - modify）
GV713	Dedicated, modified palletizing leaving point ID
GV714	Special, palletizing transition point (away) modification mark (0 - do not modify, 1 - modify)
GV715	Special, modified palletizing transition point (away) ID
GV716	Special, Hongtu packaging process, current quantity
GV717	Special, Hongtu packaging process, total production
GV718-GV799	Exclusive reservation

Note: gv700-gv799 is special global variables with no data loss after power failure.

Appendix 3 Definition of PLC components

Number	Component type	Component number	Component range
1	Input relay (X)	20+ 40 (expansion board)	X0-X19; X20-X59 (expansion board)
2	Output relay (Y)	18+36(expansion board)	Y0-Y17; Y18-Y53 (expansion board)
3	Status relay (S)	100	S0-S99
4	Alarm relay (A)	50	A0-A49
5	Universal relay (M)	500	M0-M499
6	Counter (C)	50	C0-C49
7	Hotkey relay (F)	30	F0-F16; F17-F29 (reserved)
8	Interference relay (I)	48	I0-I47
9	User defined alarm relay (W)	60	W0-W59
10	Universal 10ms timer (TGT)	10	TGT0-TGT9
11	Universal 100ms timer (TGH)	10	TGH0-TGH9
12	Universal 1s timer (TGS)	10	TGS0-TGS9
13	Cumulative 10ms timer (TAT)	10	TAT0-TAT9
14	Cumulative 100ms timer (TAH)	10	TAT0-TAT9
15	Cumulative 1s timer (TAS)	10	TAS0-TAS9

The specific description of PLC elements is as follows:

1. Input relay

Number	Meaning	Note
X0-X19	System onboard input INPUT0-INPUT19	
X20-X59	Expansion board input INPUT0-INPUT39	

2. Output relay

Number	Meaning	Note
Y0-Y7	System onboard output OUTPUT0-OUTPUT7	Relay output
Y8-Y17	System onboard output OUTPUT8-OUTPUT17	OC output
Y18-Y33	Expansion board output OUTPUT0-OUTPUT15	Relay output
Y34-Y53	Expansion board output OUTPUT16-OUTPUT35	OC output

3. Status relay

Program status and interaction for interaction with PLC.

Number	Meaning	Note
S0	Run	
S1	Stop	
S2	Pause	
S3	Manual mode	
S4	Automatic mode	
S5	Single step motion	
S6	Single motion	
S7	Loop motion	
S8	Servo on	
S9	Servo off	
S10	Additional axis 0 position control	
S11	Additional axis 0 speed control	
S12	Additional axis 0 tracking control	
S13	Additional axis 1 position control	
S14	Additional axis 1 speed control	
S15	Additional axis 1 tracking control	
S16-S69	Y0-53 output status during pause	
S70	There are continuing events	
S71	Program running completed	
S72-S99	Reserve	

4. Alarm relay

The state when the controller gives an alarm.

Number	Meaning	Note
A0	There's an alarm.	
A1	Emergency stop alarm	
A2	Servo alarm	
A3	Joint overrun alarm	
A4	Algorithm operation error alarm	
A5	Encoder angle update error alarm	
A6	Failed to get external encoder angle	
A7	Tracking failed	
A8	Failed to read stacking process file	
A9-A49	Reserve	

5. Universal relay

Input / output interaction area.

Number	Meaning	Note
M0-499	User defined	

6. Counter

Number	Meaning	Note
C0-C49	User Defined	

7. Hotkey relay

Start the function corresponding to the hotkey.

Number	Meaning	Note
F0	Emergency stop	
F1	Continue to run	
F2	Pause the program	
F3	Stop the program	
F4	Switch to manual mode	
F5	Switch to automatic mode	
F6	Run to zero – all the joints	
F7	Run to zero – joint 1	
F8	Run to zero – joint 2	
F9	Run to zero – joint 3	
F10	Run to zero – joint 4	
F11	Run to zero – joint 5	
F12	Run to zero – joint 16	
F13	Run to zero – joint 7	
F14	Run to zero – joint 8	
F15	Run to zero – joint 9	
F16	Run to zero – joint 10	
F17	Run to zero – joint 11	
F18	Run to safety zone	
F19	Run the program	The parameter is the program ID
F20-F29	Reserve	

8. Interference relay

Number	Meaning	Note
I0-I19	Point interference output	Interference point 0 - interference point 19
I20-I39	Spatial interference output	Space interference 0 - Space interference 19
I40-I47	Axis interference output	Axis interference 0 - axis interference 7

9. User defined alarm

Number	Meaning	NOTE
W0-W59	User defined alarm input	The corresponding alarm prompt box pops up on the teach pendant interface

10. Timer

Number	Meaning	Note
TGT0-TGT9	Universal 10ms timer	
TGH0-TGH9	Universal 100ms timer	
TGS0-TGS9	Universal 1s timer	
TAT0-TAT9	Cumulative 10ms timer	
TAH0-TAH9	Cumulative 100ms timer	
TAS0-TAS9	Cumulative 1s timer	