Weld

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CONTENTS

INTRODUCTION

In welding applications, direct communication between robots and welders is usually required to reduce communication delay and achieve better welding quality. The welding process package is divided into two parts, the setup of the welding machine and the application of welding instructions.

1.1 Adaptation Description

Before the installation of the welding process package, it is necessary to ensure that the software version of the robot matches, specifically:

Robot control software version	V2.2.1 or later
Robot slave firmware version	V1.0.2 and above
Robot safety controller version	V2.1.0 and above

You can query the version information of the robot on the About interface after the robot is powered on. For how to open the "About" interface, see Section 7 of the DUCO CORE- User Manual.

For the welding process package V1.3 and above, the software version of the robot must be V2.7.0 and above

The current version supports the following welding machine models:

Welder manufacturer	Welder model	Communication protocol
Megmet	ArtSet Plus/Pro series	CAN

The current version supports laser sensors: Beijing Idea, Tangshan Yinglai, Suzhou Quanvision

1.2 Welding Machine Connection

When using CAN communication, it is necessary to refer to the "Collaborative Robot User Manual (Hardware part)" and the welding machine manual to connect the CAN communication interface of the two. In order to ensure the communication quality, it is usually necessary to parallel a 120Ω terminal resistor at the interface to eliminate signal reflection. Take Magmet ArtSet Plus/Pro series welder as an example:

1、Query "User Manual of Collaborative Robot (Hardware part)" and find the CAN communication interface, as shown in the following figure:

编号	信号定义	复合应用
1	AI_C1	电流模拟量输入 1
2	AGND	模拟地
3	AI_C2	电流模拟量输入 2
4	AGND	模拟地
5	AI_C3	电流模拟量输入 3
6	AGND	模拟地
7	AI_C4	电流模拟量输入 4
8	AGND	模拟地
9	AI_V1	电压模拟量输入 1
10	AGND	模拟地
11	AI_V2	电压模拟量输入 2
12	AGND	模拟地
13	AI_V3	电压模拟量输入 3
14	AGND	模拟地
15	AI_V4	电压模拟量输入 4
16	AGND	模拟地
17	空	空
18	CAN_H	CAN 通讯
19	CAN_L	
20	CAN_GND	
21	RS485_A	RS485 通讯
22	RS485_B	
23	RS485_GND	

As the table, CAN communication uses pins 18,19,20

2、query the welding machine manual, find the welding machine side CAN communication interface, as shown in the following figure:

表 5-4 航空插引脚定义

| 引脚编号	颜色	信号名称	功能
1	红(18AWG)	24V 电源	机器人电源信号
2	白(22AWG)	CAN_H 信号线	通讯线 CAN_H
3	黑(18AWG)	地	机器人电源地
4	蓝(22AWG)	CAN_L 信号线	通讯线 CAN _L
5	屏蔽线(18AWG)	屏蔽线	外壳 PE

📖　　　　注意

1. 焊接电源提供 24V 供电，若机器人有 24V，此电源不接；
2. 数字口高低电平间要求并上 120 欧电阻，若机器人已有此电阻，不需再匹配电阻。

3、According to the instructions of the robot and welding machine, connect the white wire of the welding machine to the 18th pin of the robot expansion interface, connect the blue wire to the 19th pin of the robot expansion interface, and connect the black wire to the 20th pin of the robot expansion interface.

1.3 Process Package Installation and Uninstallation

The welding process package file is the plug-in of weld.plugin. The installation procedure is as follows:

1. the welding process package into the U disk, U disk requires FAT32 format

2. After the robot system is started, insert a U disk into the USB interface on the robot control cabinet.
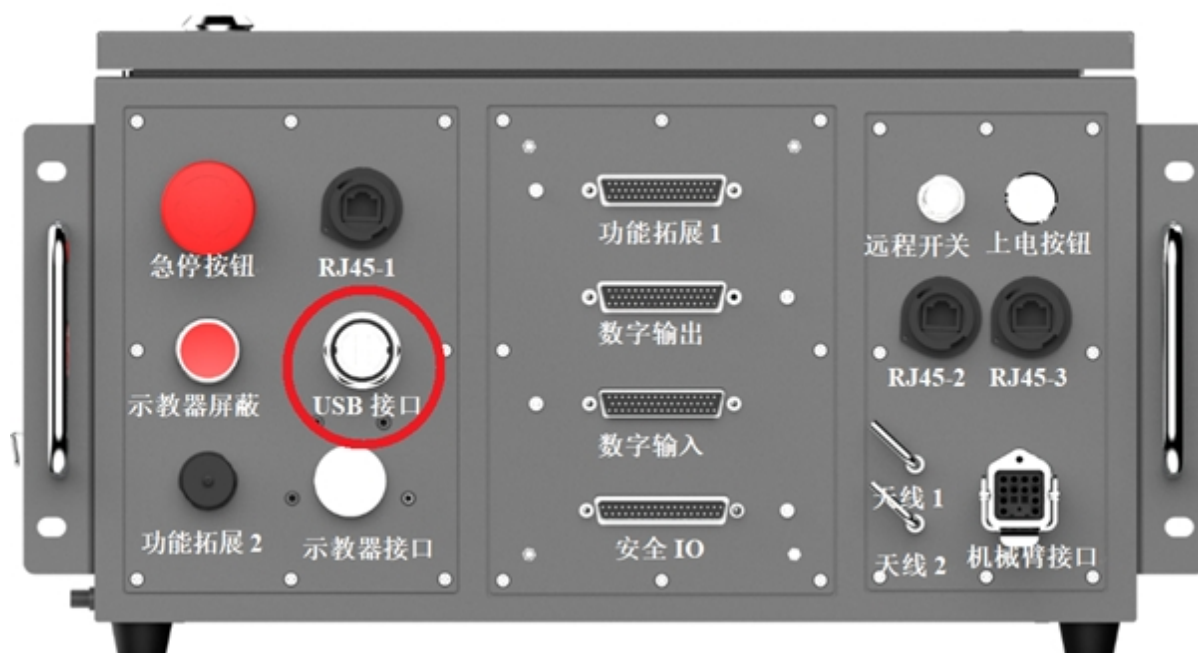
3. Log in to the robot system as user admin.
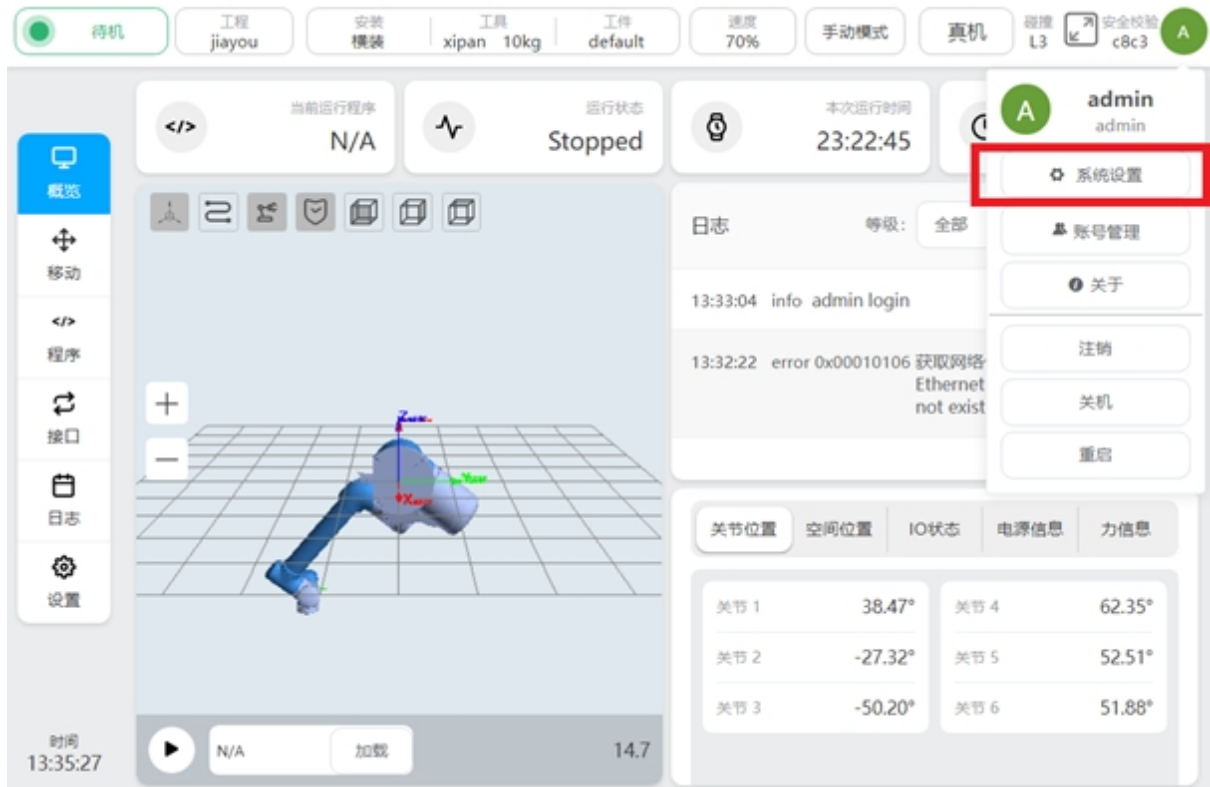
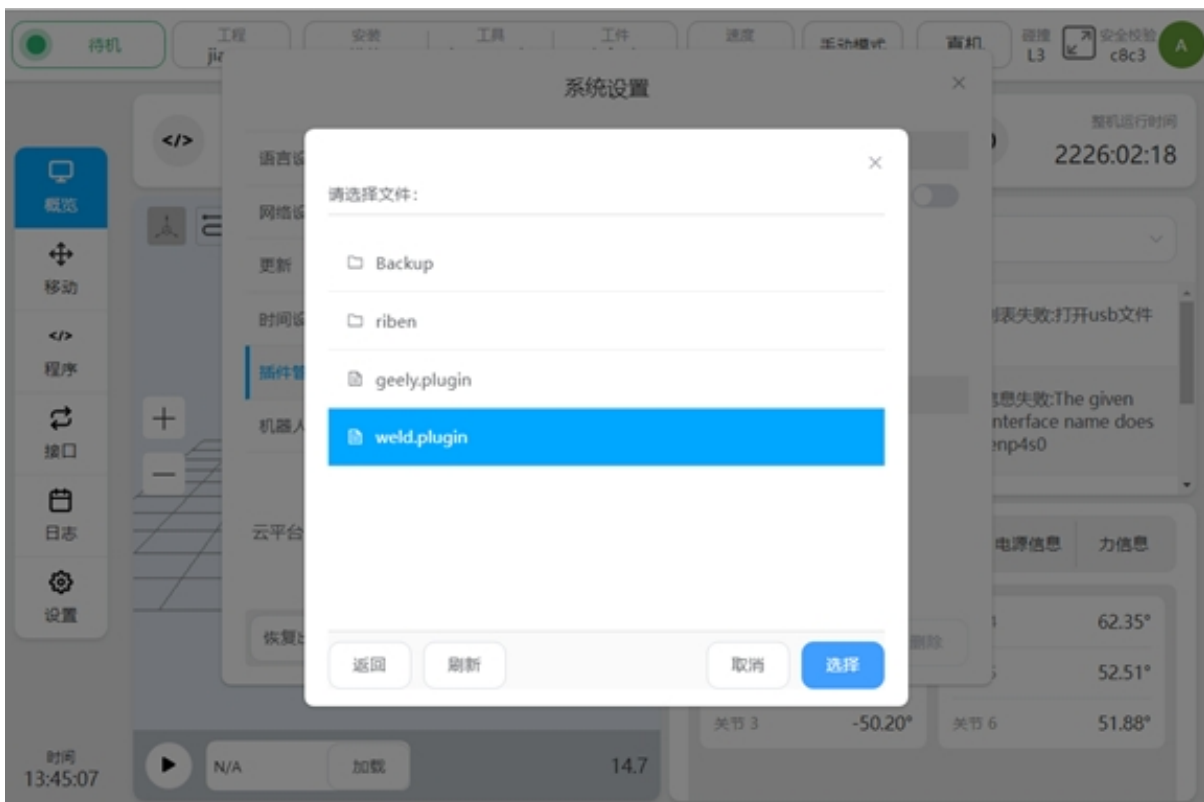4. Click the user profile picture

, select System Settings.
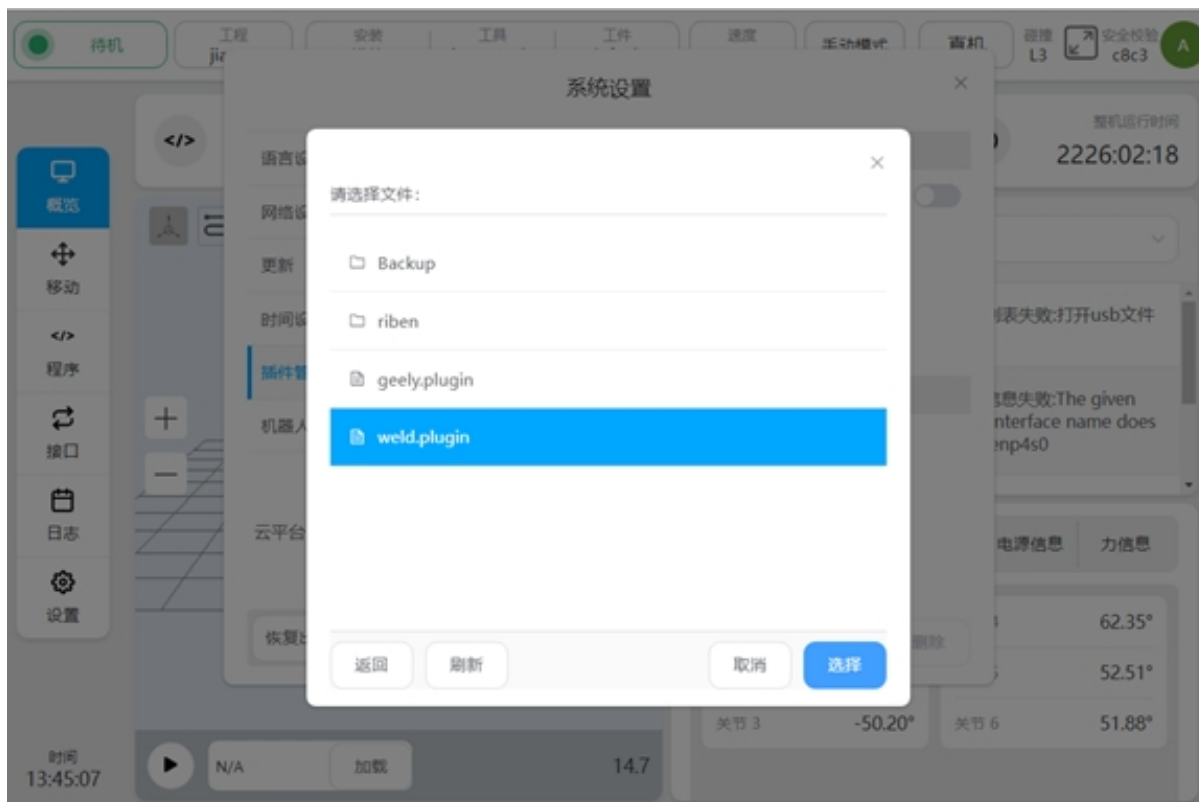
5. Select the plug-in management function.

6. Click the Add button.

7, select the USB flash drive and from the file list, find and select the weld.plugin package.

8. After the plug-in package is installed, ▯ will be marked as shown in the following figure. Newly installed plug-in packages will be enabled by default at ▯. ▯ displays the name and version of the current plug-in package.
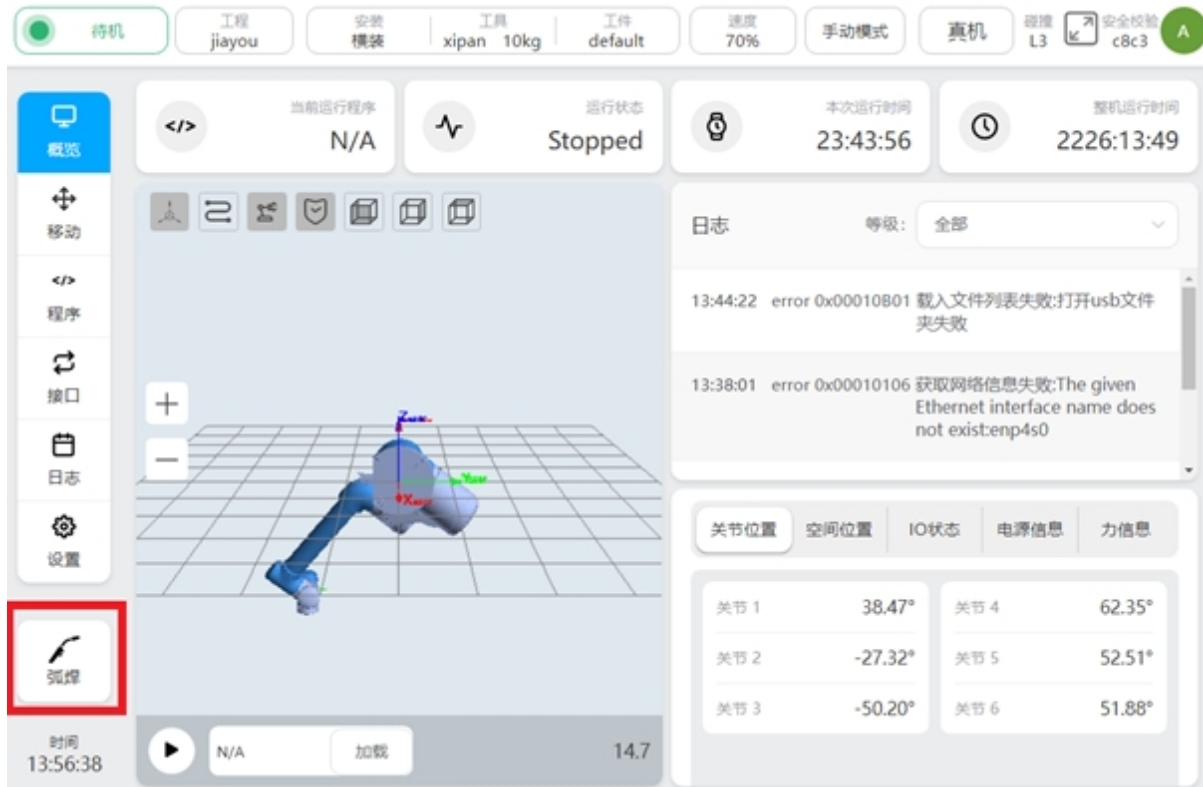
9. After the welding process package is installed, the process package setting portal will appear at the lower left of the main interface.

10, click the process package setting entry button, you can enter the welding process package setting interface.

11. The welding process package that has been installed can be temporarily disabled by turning off the enable signal. Or click the Delete button to delete the package completely.

WELDING PACKAGE SETTINGS

Welding process package Settings, including welding machine Settings, welding Settings, process files, welding protection, welding machine signals.

2.1 Welder Settings

Welder Settings Used to display communication status, configure the welder model and corresponding communication Settings.

Welding machine connection status: When the communication between the robot and the welding machine is established, the status indicator will turn from gray to green. As shown in the picture below:

Welder brand and model: Used to configure the current welding machine. After selecting the welder correctly, the robot will invoke the corresponding communication protocol.

On the welding machine side, it is necessary to refer to the welding machine manual, adjust the control mode of the welding machine to the robot control mode, and select the corresponding communication protocol. Take Magmet ArtSet Plus/Pro series welder as an example:

1. 按下左循环键，选择网络 N00；
2. 旋转左旋钮，选择相应的协议。

NOO 的协议详见表 4-7。

表 4-7 协议对应表

协议号	合作方	应用层协议
FAN	发那科	DeviceNet
ABB	ABB	DeviceNet
CCA	库卡	DeviceNet
CRP	卡洛普	DeviceNet
CHF	柴福	CanOpen
TUR	图灵	CanOpen
ANC	安川	DeviceNet
GSD	广数	DeviceNet
FNE	发那科	Ethernet/IP
CHQ	川崎	Ethernet/IP
HYD	现代	DeviceNet
GOG	固高	CanOpen
SIA	新松	DeviceNet
KBA	KEBA	CanOpen
ANG	/	模拟口

The communication protocol of the welding machine needs to be modulated to GOG mode, and the N00 parameter is set to GOG. At the same time, the function of the robot communication module is activated, and the P05 parameter is set to On.
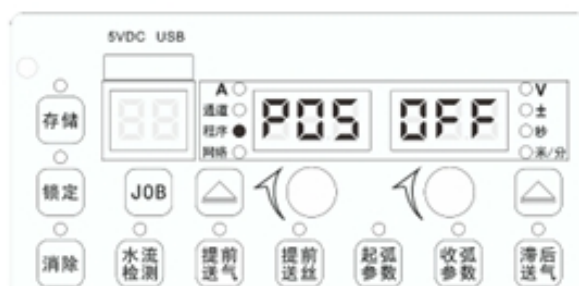
4.1.3 机器人通讯模块激活（P05）

图 4-3 P05 显示界面

步 骤

1. 按下左循环键选择程序，旋转左旋钮，选择 P05；
2. 旋转右旋钮，选择激活，ON 为激活，默认为 OFF。

📖 **注意**

1. 通讯模块激活后，必须连接通讯盒，否则会告警。
2. 通讯模块激活后，且通讯盒已与焊接电源正确连接，如果焊接电源与机器人未正确通讯，"网络"指示 LED 灯会闪烁；如果焊接电源与机器人正确通讯，"网络"指示灯 LED 灯停止闪烁；此功能不适用模拟通讯盒。

Communication baud rate: Used to set the baud rate of CAN communication, supporting 125kbps,

250kbps, 500kbps three baud rates. It should be noted that the baud rate of the robot and the welding machine needs to be set consistent in order to achieve communication. Take Magmet ArtSet Plus/Pro series welder as an example:
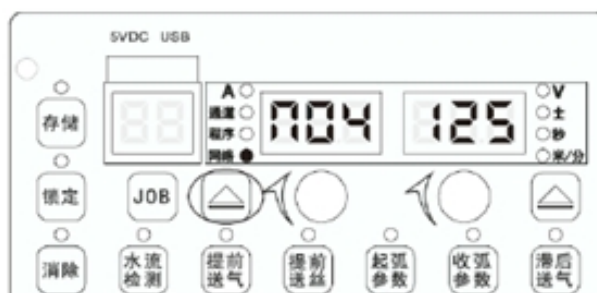
4.2.4 机器人通讯波特率（N04）

图 4-46 N04 显示界面

步 骤

1. 按下左循环键选择网络，旋转左旋钮，选择 N04；
2. 旋转右旋钮，选择相应的波特率，范围为 125kbps、250kbps、500kbps，默认值 125kbps。

The baud rate of the welder N04 parameter should be consistent with that of the robot.

Automatic connection: It is used to automatically connect the welding machine when the robot starts up next time. When it is set to ON, the robot will save the current setting information, and the next time the robot starts up, it will automatically connect the welding machine after the robot completes the power-on operation of the robot.

Connection: The "Connect" button is usually used when the robot communicates with the welding machine for the first time. Click the "Connect" button to send a connection request to the welder according to the message format of the welder. After receiving the correct feedback from the welder, the welder connection status light turns green.

2.2 Welding Settings

Welding Settings used to set welding mode, arc parameters, manual debugging function of the welder trigger and current and voltage display of the welder.

Welding mode: used to set the working mode of the welding machine. When setting, the corresponding communication data will be sent to the welding machine to switch the operating mode. It should be noted that whether the setting can be successful also depends on whether the communication protocol of the welder supports modification. If the communication protocol of the welder does not support it, the same setting needs to be performed manually on the side of the welder. The welder mode that can be set is shown in the following figure:

焊机设置

焊接模式   直流一元化 ∧

分别模式   直流一元化

起弧参数设置   脉冲一元化

             JOB模式

起弧检测时间   断续焊

起弧重复次数   3

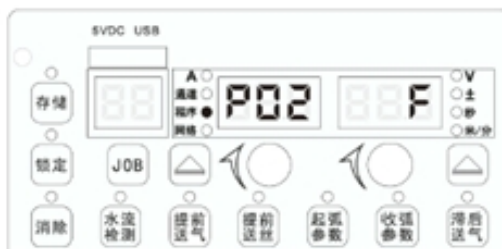Take Magmet ArtSet Plus/Pro series welder as an example:

4.1.1 焊接电源控制模式选择（P02）

图 4-1 P02 显示界面

> **步 骤**

1. 按下左循环键选择"程序"，旋转左旋钮，选择 P02,默认为 F；
2. 旋转右旋钮，选择相应控制方法。焊接电源控制模式说明见表 4-1。

表 4-1 控制模式说明

显示	F	N	DF	DN
控制模式	送丝机控制	电源显示板控制	机器人一元化控制	机器人 JOB 调用控制

> **注意**

1. F: 送丝机板控制模式，指的是在 JOB 号为"10"时，送丝机控制的信号有焊枪开关、点动送丝、气体检测、主送丝速度和主弧长系数，其余参数由电源面板设定。
2. N: 焊接电源显示板控制模式，送丝机控制的信号有焊枪开关、点动送丝、气体检测，其余参数由面板设定。
3. DF: 机器人一元化控制，指的是在 JOB 为"10"时，机器人控制的信号有焊枪开关、点动送丝、反向抽丝、气体检测、故障消除、主送丝速度和主送丝速度弧长系数，其余参数由电源面板设定。
4. DN:机器人 JOB 调用控制指的是机器人的调用通道控制焊接过程，机器人控制的信号有焊枪开关、点动送丝、反向抽丝、气体检测、故障消除及 JOB 号，其余参数由电源面板设定。

If the DC unified mode is used, in addition to selecting the DC unified mode on the robot side, the P02 parameter needs to be set to DF on the welder side. If the JOB mode is used, set this parameter to DN. At present, the communication protocol does not support pulse unified and intermittent welding, so it is necessary to save the pulse unified parameters or intermittent welding parameters in JOB mode at the welder side, and then invoke the robot in JOB mode to realize the corresponding welding mode.

Separate mode: This parameter is used to set the current and voltage parameter setting mode of the welding machine. It supports separate mode and unified mode. As shown in the picture below:

When using separate modes, the unit of current is A and the unit of voltage is V. When using the unified mode, the unit of current is A and the unit of voltage is %. The setting of this parameter will affect the welding voltage unit of the current welding parameters, process files, welding machine signal interface and arc starting/closing parameters in the program script.

Taking the adaptation of Magmet ArtSet Plus/Pro series welder as an example, it is also necessary to set the N11 parameters on the side of the welder, as shown in the following figure:
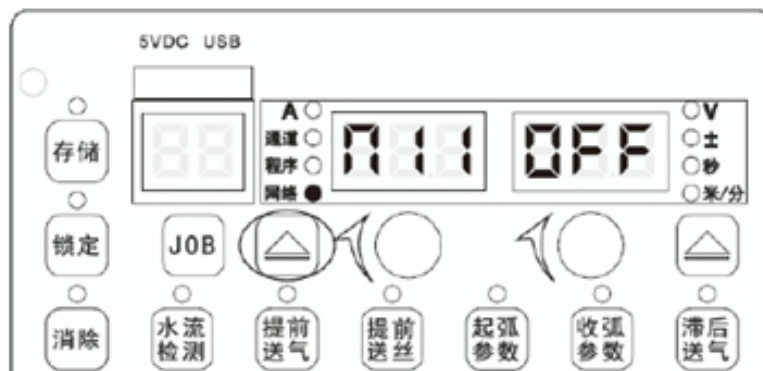
4.2.11 网络参数选择（N11）

图 4-53 网络参数 N11 显示界面

步 骤

1. 按下左循环键选择网络，旋转左旋钮，选择 N11；
2. 旋转右旋钮，ON 为分别模式，OFF 为一元化模式，默认 OFF。

Arcing Settings: You can set the arcing detection time and the number of arcing repeats. The unit of arcing detection time is ms. After sending the arcing command, the robot will monitor the successful arcing signal returned by the welder. If the successful arcing signal is not received within the detection time, the arcing command will be re-sent. The number of repetitions is set by the number of arc-starting repetitions.

Currently set welding parameters: change the current and voltage value of the welder in real time. It is usually used in the test welding stage to adjust the current and voltage to find the combination of parameters in line with the process. The set of parameters are the current and voltage parameters actually sent to the welder at present, and have nothing to do with the set values in the program script and process file. For example, after ArcStart is run, this value becomes the parameter set by the ArcStart function block.

Welding idle rate: Enable button for welding idle function. After the function is enabled, when the welder is not enabled, the robot is allowed to run at double speed to quickly observe the correctness of the welding trajectory. The magnification is set in the welding program script.

Welder enable: The enable signal of the arc starting function of the welder. If off, the arcing command will no longer be executed when the robot program is run.

Point wire feeding: button long press trigger, control wire feeding machine, button release will stop wire feeding.

Welding wire reverse pumping: the button is triggered by long press to control the wire feed machine, and the button is released to stop the wire.

Protection gas detection: control the welding machine air valve open, used to test whether the normal gas supply. Taking Magmet ArtSet Plus/Pro series welder as an example, the air valve will be automatically closed by the welder after opening 30 seconds. If you click again midway, turn off the air valve.

Welder status: real-time display of welder feedback welding current and welding voltage. The unit of welding current is A, and the unit of welding voltage is V.

2.3 Process Document

Process files for setting and saving welding currents and voltages for starting and closing arcing. Click "arcing process file" and "arcing process file" to switch process file types. Click "New" to create a process file of the corresponding type. Enter the process file name and click "OK" button to complete the new process file.

Click File, the input box of welding current and welding voltage will be displayed on the right side. The unit of welding current is A, and the unit of welding voltage will be determined by the setting of the respective mode. See the respective mode Settings. Click "Save" to record the welding current value, welding voltage value and the mode type set during the setting.

If the current welding separate mode Settings are inconsistent with the separate mode Settings selected during process file generation, a pop-up will remind you. As shown in the picture below:

2.4 Welding Protection

Welding protection is the protection function in the welding process, the principle is:

Real-time monitoring of the tool end of the robot whether there is more than the monitoring displacement. If the end of the tool of the robot does not produce enough displacement within the set monitoring time, it is judged that the robot is in the same position, and the arc closing command of the welder will be triggered. The purpose of this function is not to allow the robot to have a long welding operation in the same position, in case the weldment burns through.

2.5 Welder Signal
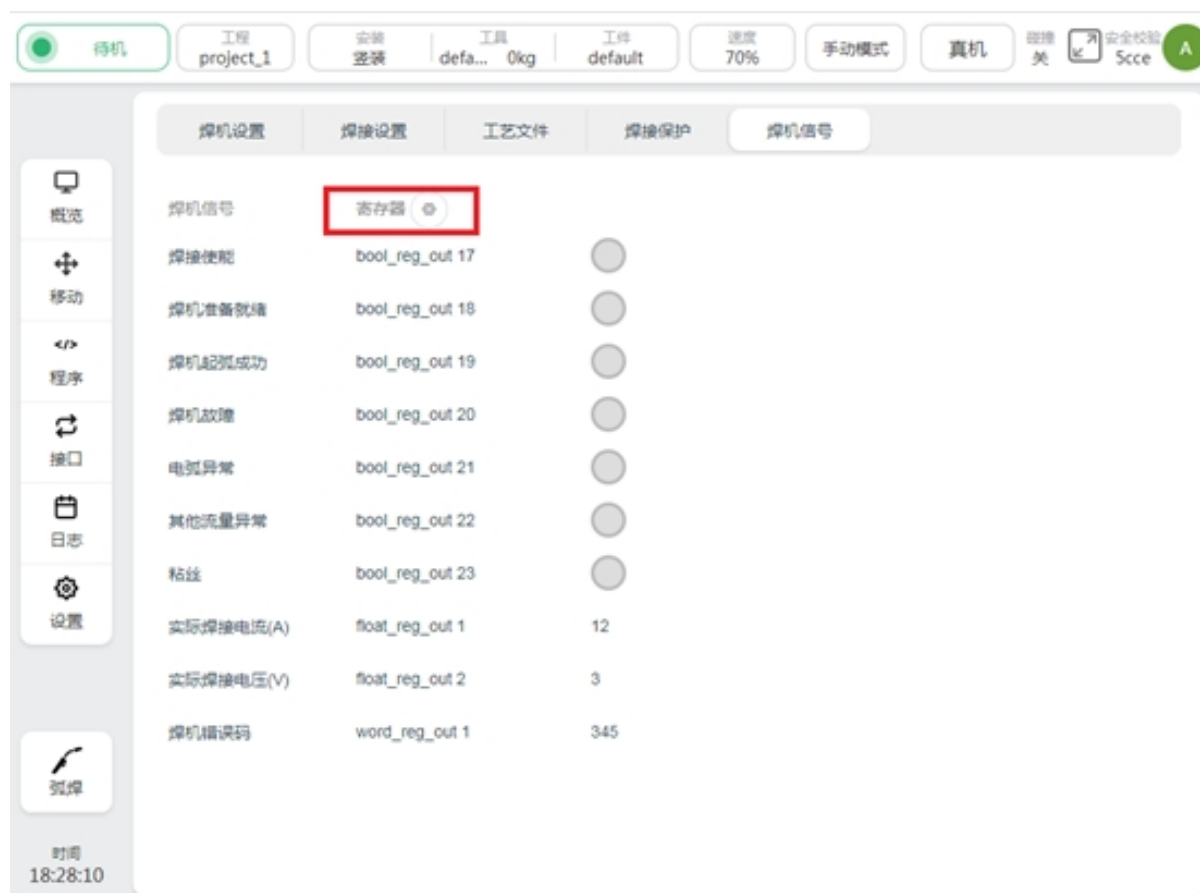
The welding machine signal page is used to display the welding machine signal, and configure the signal to the register, so that the upper controller of the robot can obtain the welding machine information

through profinet, modbus, TCP/IP and other ways. tap   to perform register configuration, and a list of configurable registers will be displayed on the right side of the signal, as shown below:
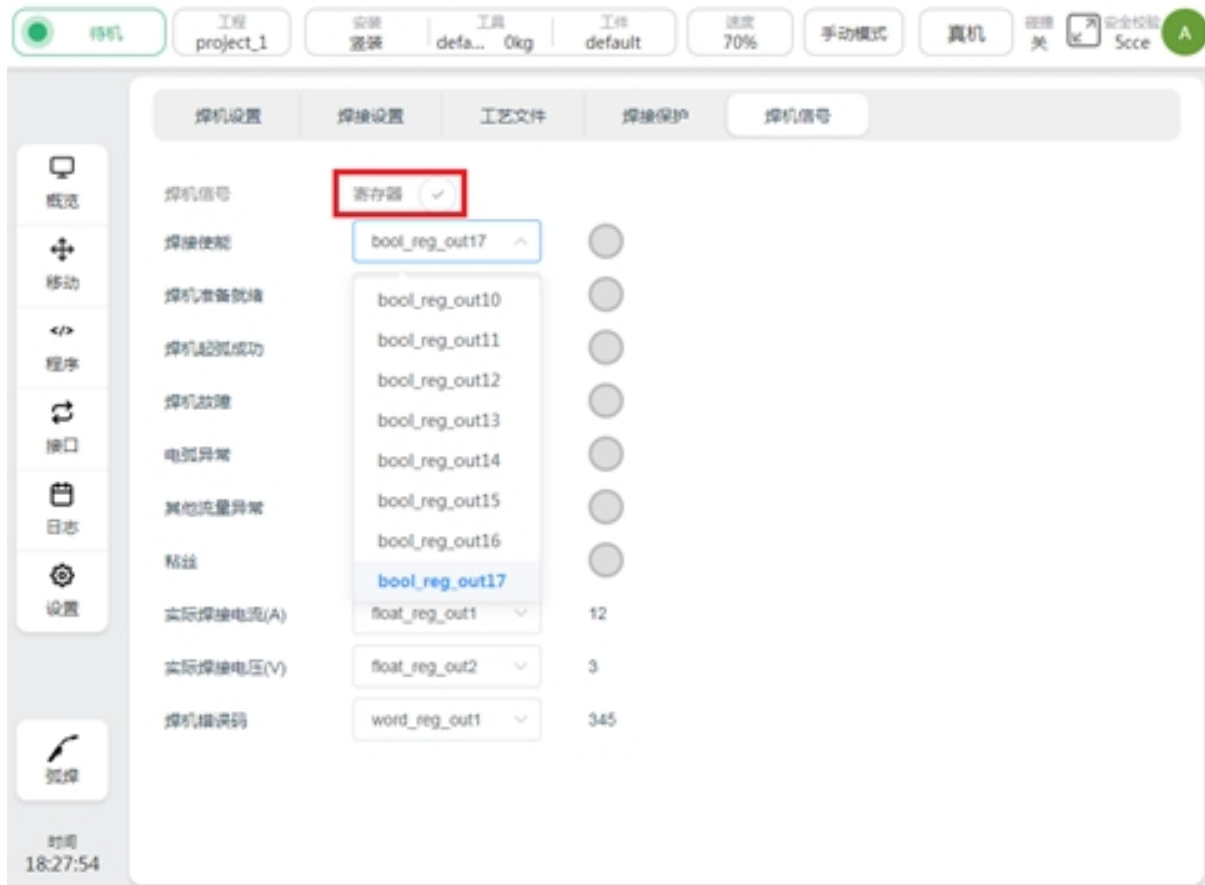
Once the register configuration is complete, click to save the configuration.

2.6 Sensor Settings

The Sensor Settings page is used to set the laser sensor manufacturer, connection sensor, control sensor, and calibration sensor. In the figure, the left area is used for sensor connection and operation, and the right area is used for viewing calibration parameters and calibration of the laser sensor. See Section 7 Laser Tracker for specific use
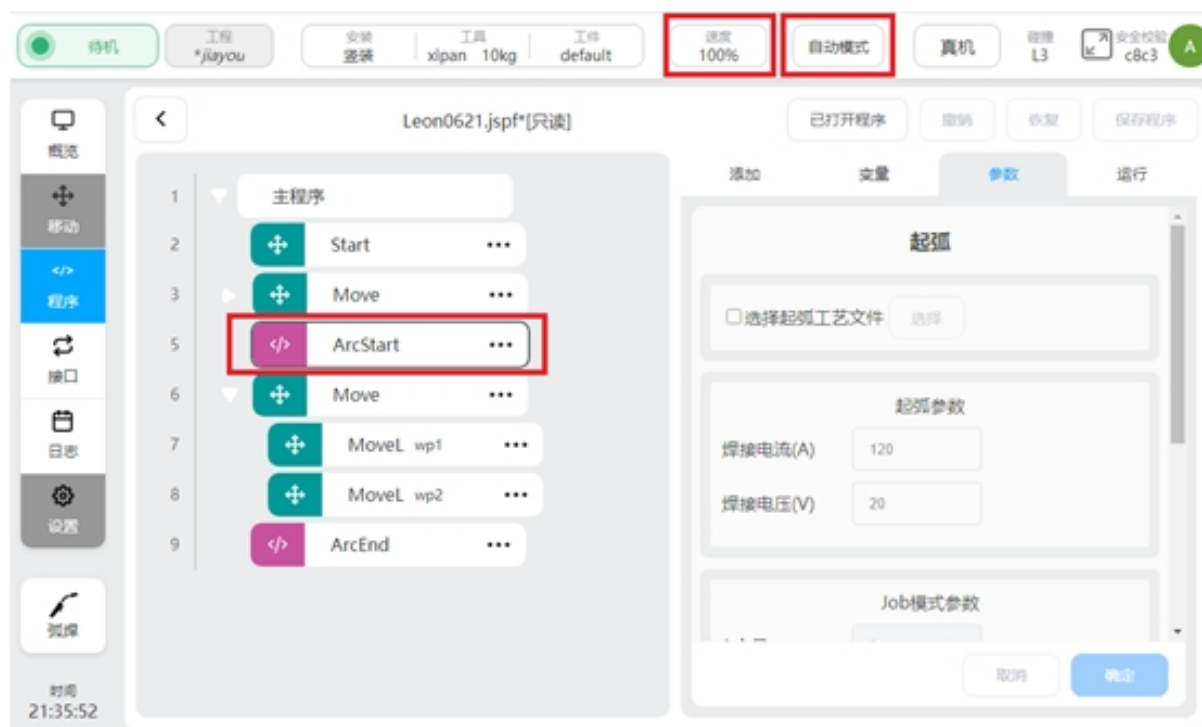
Weld

WELDING APPLICATIONS

3.1 Arc Starting Conditions

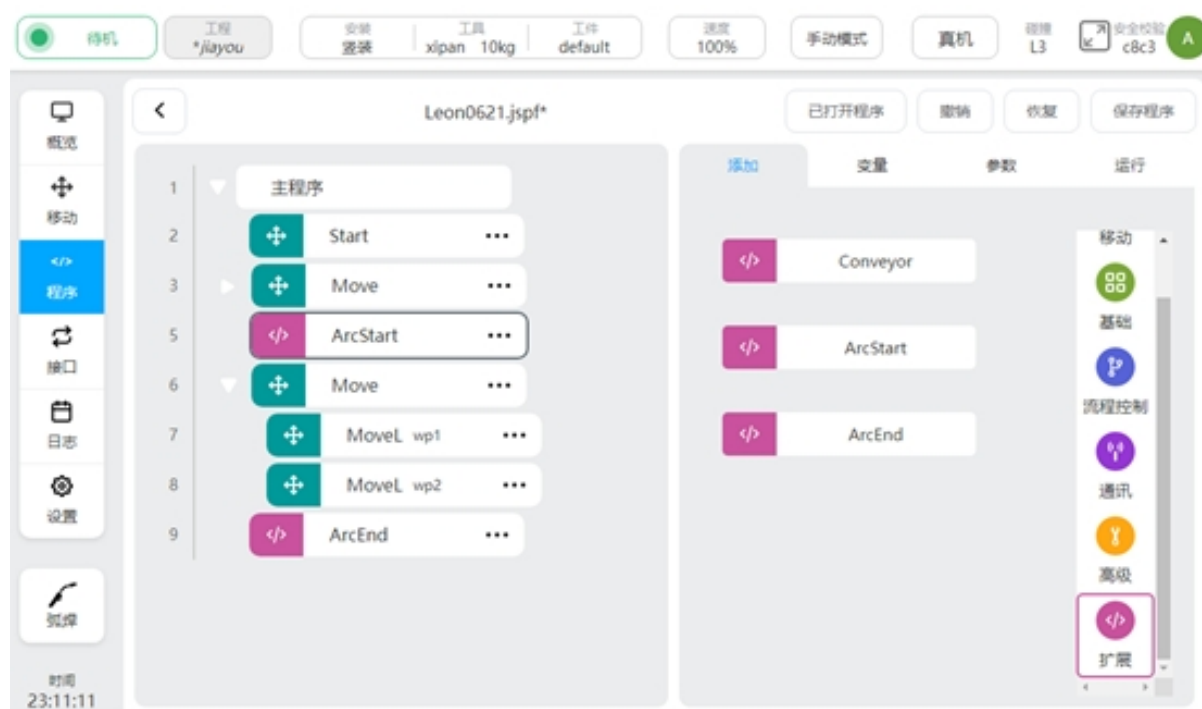The robot sends the arc signal to the welding machine, which needs to meet four necessary conditions:

1、welding enable signal open

2、the robot movement mode is automatic mode

3、The robot's global speed is set to 100%

4、in the robot script, there is an arc script

3.2 Arc Starting and Ending Function Blocks

After the welding process package is installed and the plug-in package is enabled, two new program function blocks ArcStart and ArcEnd will be added in the extension function script bar of the robot program interface.

The arc starting/closing block allows the arc starting/closing instructions to be sent to the welder in three different modes. They are the methods of calling the process file, setting the arc starting parameter, and setting the JOB number. In the arc starting function block, the magnification can also be set during idle running, so that the robot can run at high speed when the welding function is not enabled, so as to quickly observe the correctness of the welding trajectory during debugging. In the welding process, it is necessary to change the welding parameters during the operation of the robot, which can be achieved by setting two arcstarts.

Select arcing/closing process file:

When selecting process files, ensure that the welder control mode is DC unified, see the welding Settings section for details. Check the check box first when using, as shown below:

When the check box is displayed, the parameters in arc starting parameters and Job mode parameters become gray and cannot be edited. Click "Select" to select the process file, as shown in the picture below:
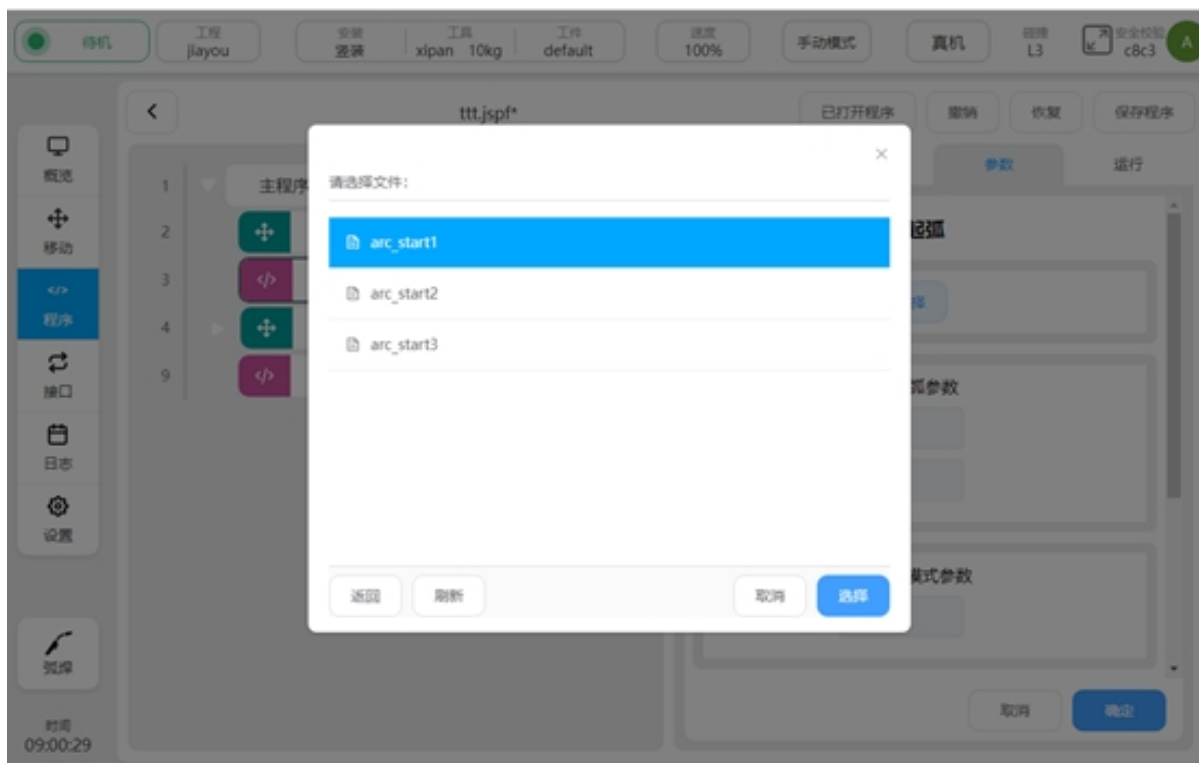
After the process file is selected, the welding parameters in the process file will be displayed in the gray arcing parameters, and the parameter units are related to the respective modes set. As shown in the picture below:

If the selected process file has a different mode from the currently set mode, a pop-up will remind you.
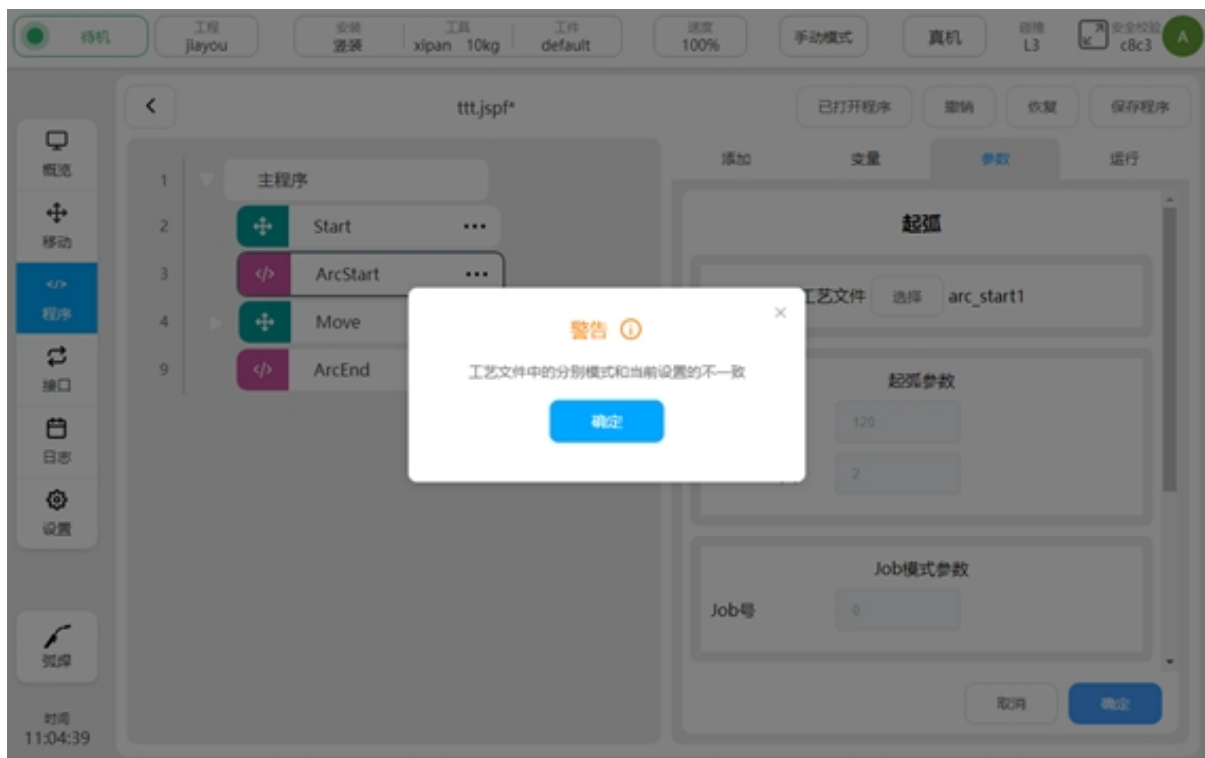
Arcing/closing parameters:

When choosing arcing/arcing, ensure that the control mode of the welder is DC unified. For details, see the Welding Settings section. The process file check box cannot be selected, and the Job mode parameters are gray and cannot be edited. Parameter units are related to the respective modes set.

3.2. Arc Starting and Ending Function Blocks 27

Job mode parameters:

When selecting the Job mode parameter, ensure that the welder control mode is Job mode. For details, see Welding Settings. When the parameter is set to Job mode, the process file and arc starting parameters are gray and cannot be edited.

Set the empty run ratio:

After the empty run ratio is set, when the empty run function is turned on and the welder enable is turned off in the welding setting, all robot motion scripts between ArcStart and ArcEnd will be run at a rate of magnification. The actual speed of the robot will be multiplied by the set multiplier. The calculation formula is:

Actual operating speed = set welding speed * Manual/automatic reduction ratio * Global speed * magnification

For example, set the welding speed to 20mm/s, set the global speed to 70% in manual mode, and set the idle speed to 3:

Among them, the manual reduction ratio is 25%, and the automatic reduction ratio is 100%.
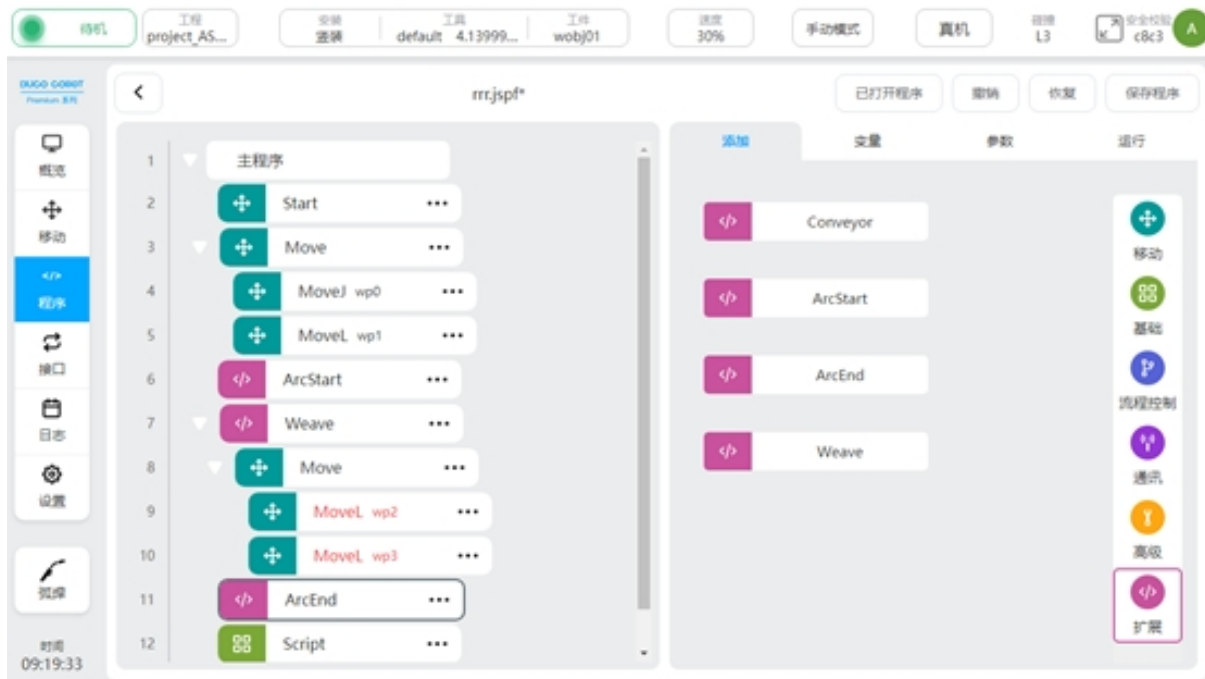
Actual operating speed =10.5mm/s.

For example, the welding speed is set to 20mm/s, the global speed is set to 80% in automatic mode, and the idle speed is set to 3:

Among them, the manual reduction ratio is 25%, and the automatic reduction ratio is 100%.

Actual running speed =42mm/s.

3.3 Swing Welding

Welding process package V1.2.0 and above, adding pendulum welding function. In the "Extension" instruction set in the programming interface, call the "weave" function block to enable the swing welding function. As shown in the picture above.

Usually, when the swing welding function is used, it is programmed to add a swing welding function block (Weave) behind the original ArcStart function block. Then in weave, add trajectories that need to be wobbled. All motion instructions added in weave will have a wiggling motion effect until the motion instructions are complete.
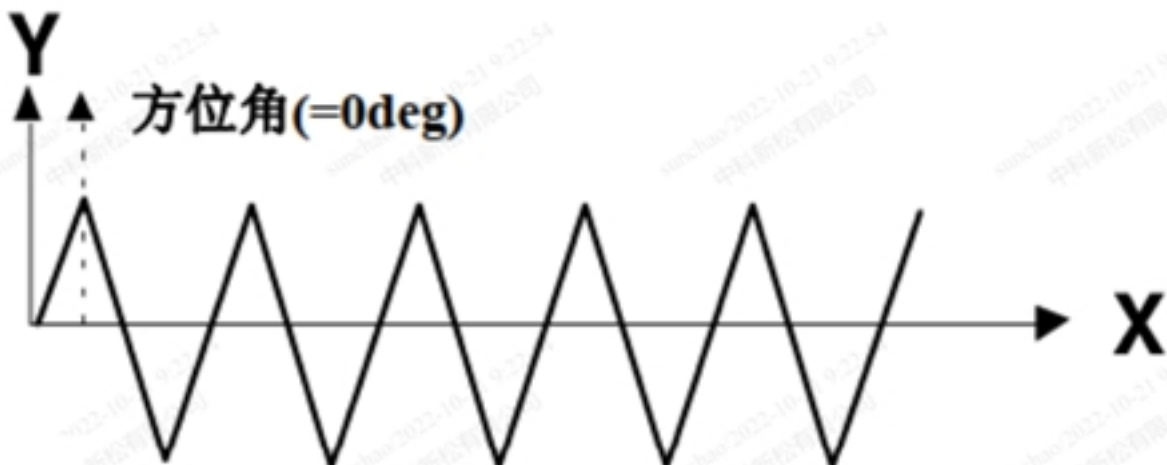
The business logic of pendulum welding is to superimpose a layer of periodic and regular swing trajectory on the basis of the original motion trajectory. In the current version, the azimuth is 0° by default and cannot be set. As shown in the picture above.

Click the weave feature block to set the weave trajectory. The parameters that can be set are: track type, reference plane, frequency amplitude. When selecting a trapezoidal trajectory, the left and right residence time parameters need to be added.
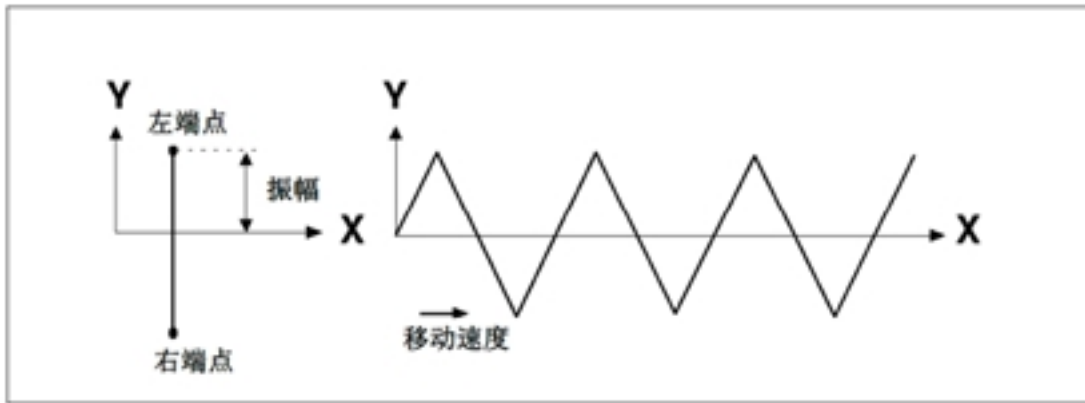
Weave

轨迹类型	三角 ⌄
参考平面	工具XOY ⌄
频率(Hz)	1
幅值(mm)	1

取消　确定

Track type:

Support the following types, triangle, sine, arc, trapezoid, 8-word

Weave

轨迹类型	三角 ⌄
	三角
参考平面	正弦
	圆弧
频率(Hz)	梯形
	'8'字
幅值(mm)	1

Triangular trajectory: Standard swing welding mode. It is usually used in scenarios with large welds and multi-layer welding.
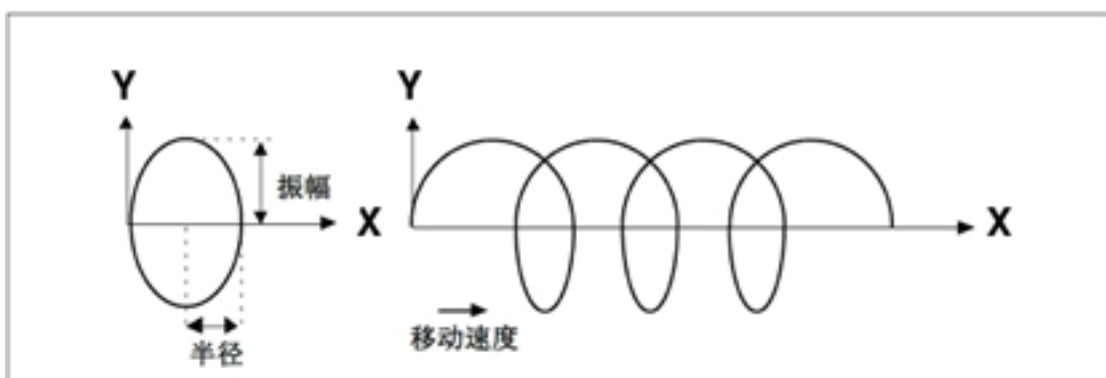
Sinusoidal trajectory: Standard swing welding mode. It is usually used in scenarios with large welds and multi-layer welding.
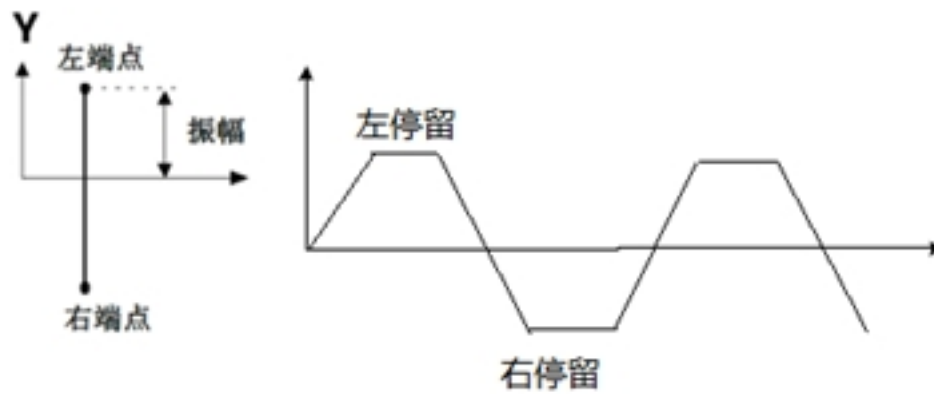

For a sinusoidal trajectory, the residence time of the left and right endpoints can be set

Arc track: mainly used in lap joints and welding with large caps. The radius of the circle is the same as the amplitude.

Trapezoidal trajectory: Standard swing welding mode. It is usually used in scenarios with large welds and multi-layer welding.

"8" word track: mainly in thick plate welding and surface/exterior grinding, improving strength and other applications.
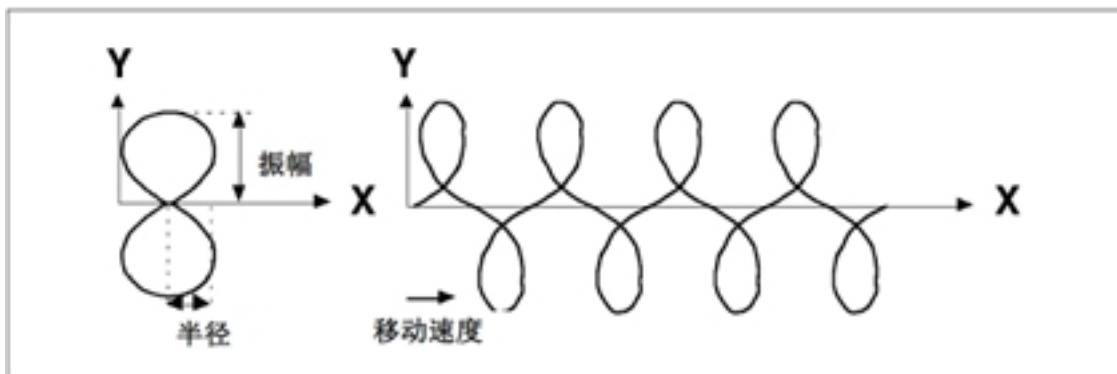
Reference plane:

With the current tool coordinate system as reference, set the plane where the swing trajectory takes effect. Supports XOY, XOZ, and YOZ planes.

Frequency: The number of cycles performed per second by the swing trajectory.

Amplitude: The boundary of the swing trajectory deviates from the maximum value of the reference trajectory.

Left and right residence time: Used to define the length of the upper and lower sides of a trapezoidal or sinusoidal trajectory.

Left endpoint OP: When swinging to the left end point, the action performed: controls the DO status and duration or triggers the event

Right endpoint OP: Action performed when the swing reaches the right endpoint: controls the DO status and duration or triggers an event

Left to right middle point OP: Action performed when the swing moves from the left endpoint to the right endpoint, passing the intermediate point: controls the DO status and duration or triggers an event

Right to left middle point OP: Action performed when the swing moves from the right endpoint to the left endpoint, passing the intermediate point: controls the DO status and duration or triggers an event

3.4 Custom Swing Welding

Welding process package V1.4 and above, DUCO Core v2.9.0 and above Custom swing welding, that is, the user can customize the trajectory of the swing welding In the process file, create a custom swing welding track file and set a custom track point


A maximum of 10 pendulum solder joint positions can be set. Point configuration parameters include X: The direction along the tangent line of the trajectory Y: The direction determined by Z and X cross Z: The direction in the reference plane perpendicular to the tangent line of the trajectory R: indicates whether the endpoint is a right endpoint L: indicates whether the endpoint is a left endpoint When setting, ensure that the sum of each point in the X, Y, and Z directions is 0

Reference plane: Select a plane of the tool coordinate system as the reference plane of the swing Left endpoint residence time: Residence time of the left endpoint

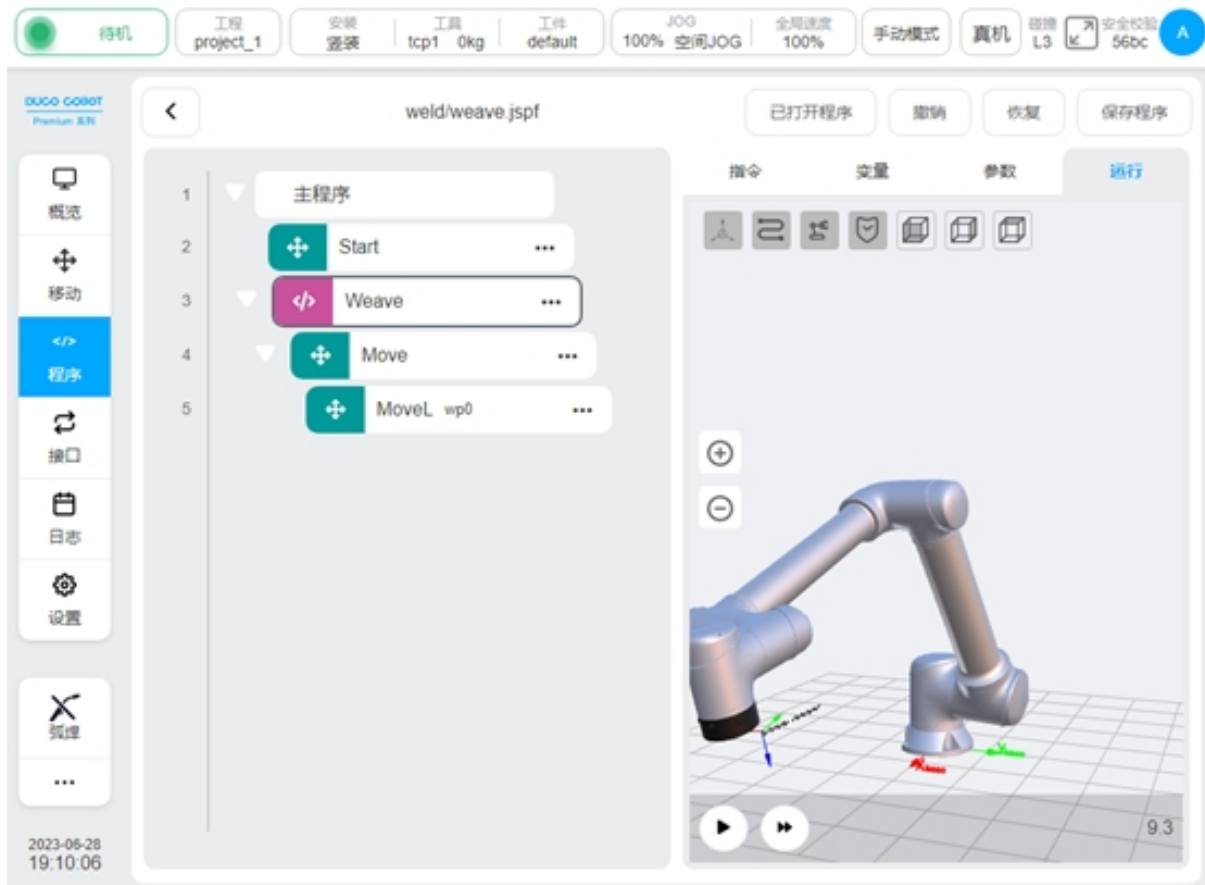Right endpoint residence time: Residence time of the right endpoint

In the Weave block, select the track type as Custom and select the track file.
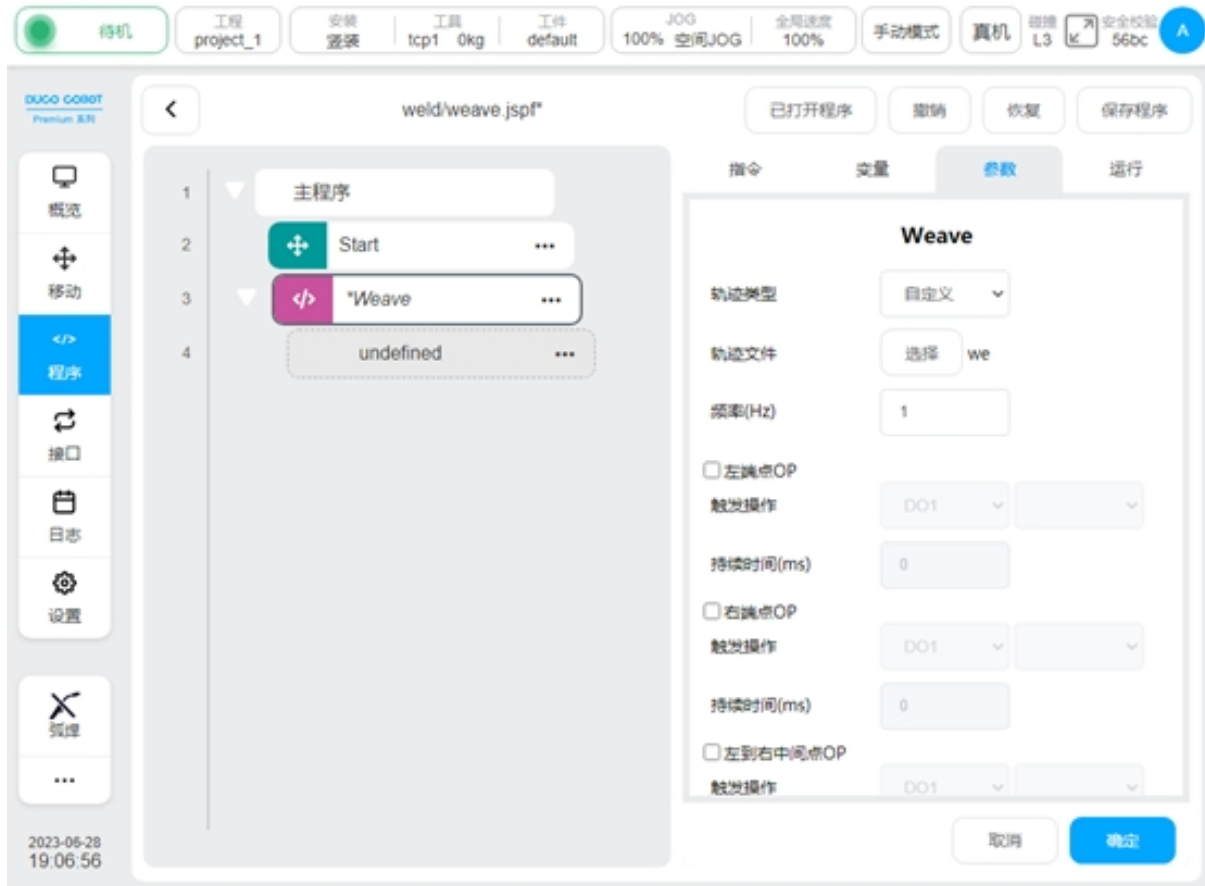
Weld

You can simulate running trajectories

3.5 Arc Tracking

Welding process package V1.4 and above, DUCO Core v2.9.0 and above Arc tracking is mainly used in the welding of thick plate. In the welding process, the current flow between the welding wire and the workpiece is detected to compensate the welding trajectory of the robot.

Only the up and down direction and the left and right direction can be compensated, and the left and right direction can be compensated only in the sine type swing welding.

Arc tracking command: ArcTrack

The configuration parameters are as follows:

Type: Used to set the arc tracking type, with the following options:

End Clear path information. The offset information is cleared when the tracing is complete

End The path information is retained, and the offset information is retained when the tracing ends

Use the recorded path information, use the offset information of the last tracking record to track (mainly used for multi-layer multi-pass welding)

Compensation direction: Select the direction where the compensation function is enabled, Y (left and right direction), Z (up and down direction). You can choose to enable Y and Z compensation for sine pendulum welding, other types can only enable Z compensation

Reference current: reference current value

Ratio coefficient of current height: Ratio coefficient of welding current to welding gun height, default value 4

Maximum compensation distance limit: The maximum allowable deviation distance of the left and right direction and the up and down direction relative to the teaching trajectory
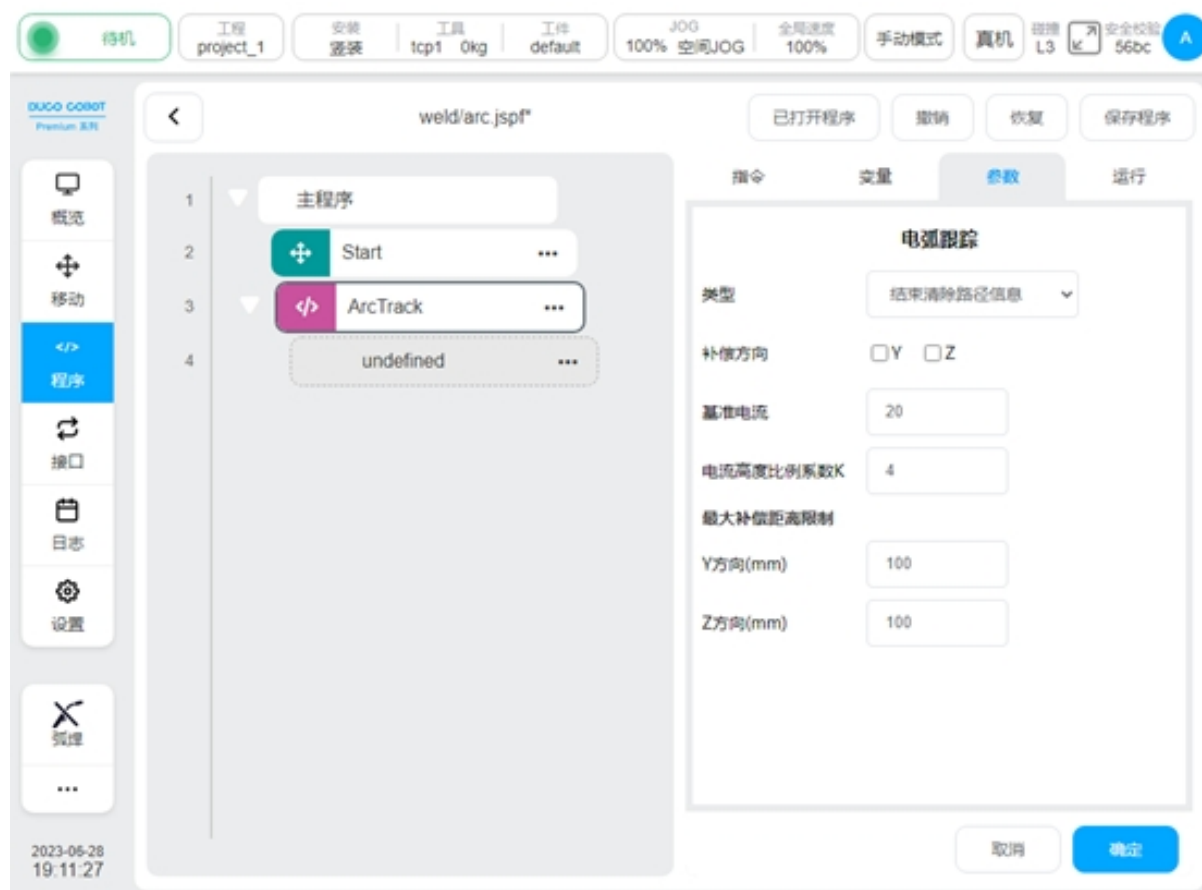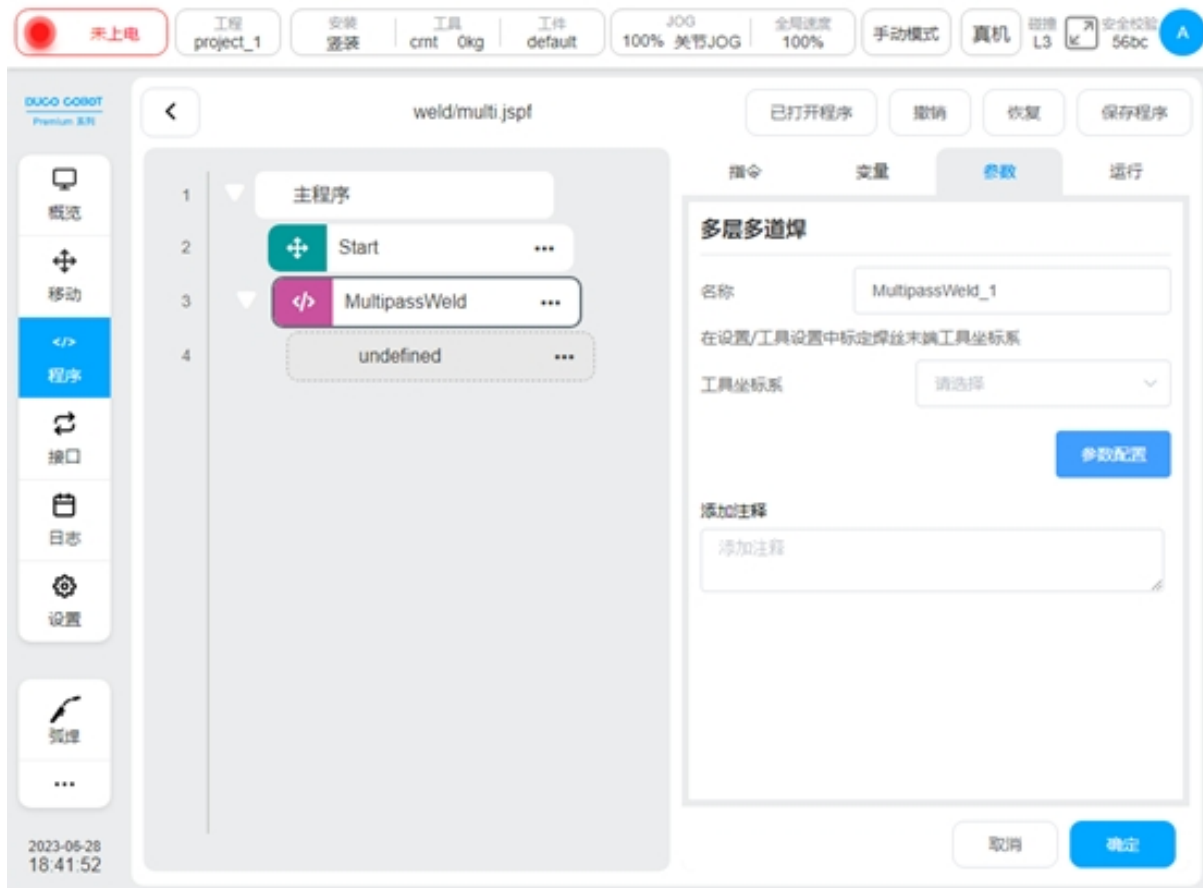

3.6 Multi-layer Multi-pass Welding

Welding process package V1.4 and above, DUCO Core v2.9.0 and above

The welding of medium and thick plates often requires multiple welding of the same part to increase the welding width. The main principle is: record the track of the first weld and the compensation amount; Based on the recorded amount of compensation, the overall offset is added to achieve subsequent pass operations.

This process package provides a MultipassWeld function block to guide the user through the programming of a multipass welding job.

In the programming page instruction "Extend", look for the "MultipassWeld" function block. Add it to the program, click, the configuration page is as follows

Configure the tool coordinate system: Use the end of the wire to show the tool coordinate system in the Settings page

Click Parameter configuration to enter the multi-layer and multi-pass welding boot configuration page. It is divided into the following steps, click next or click the navigation menu above to switch.

Weld configuration

Configure the point position of the initial weld, mainly configure the workpiece coordinate system, the beginning safety point, the starting point, the end point and the end safety point of the weld. It can teach the point coordinates and speed and acceleration of each point.

Tracking Settings

Configure whether the weld uses tracking, you can choose not to use tracking, use arc tracking, use laser tracking. When selecting arc tracking, see Section 5.4〝Arc Tracking〞for configuration parameters, and Section 7.7〝Laser Tracking〞for configuration parameters.

Swing welding Settings

Select whether to enable swing welding and set the type, reference plane, frequency, amplitude, OP, etc. For details about the configuration parameters, see Section 5.3 "Swing Welding".

Welding parameters

Set welding parameters, such as welding current, voltage, and JOB number. For details about the configuration parameters, see section 5.2 "Arc Starting/Closing Function Block".

Bead setting

Configure the offset, indent, tool posture, etc., for each subsequent pass, up to 9 passes can be added.

The parameters of the bead are:

Y offset: Y of the tool coordinate system

Z shift:

Tool-ry: indicates the rotation in the Y direction of the Tool reference coordinate system

Tool-rz: The rotation in the Z direction of the Tool reference coordinate system

Path-rx: The rotation of the Path tangent at the start of the tool's reference path coordinate system (for a straight line, the rotation in the direction of the reference path)

Start indent: The distance from the start of the weld to the path direction

End indent: The distance by which the end of the weld is indent along the path direction

The default swing welding parameters and welding parameters of each weld pass are the same as those of the initial weld. Individual pass parameters can be set individually by clicking the Edit button

Bead detailed configuration

After the configuration is complete, click OK to automatically generate the program block. Note: The generated block cannot edit the parameters separately, if you need to change the parameters, please set them in the parameter configuration of the MultipassWeld block.

WELDING TROUBLESHOOTING

In the welding process, according to the source of the fault, it can usually be divided into three fault modes, welding machine fault, communication fault, robot fault. This chapter describes three troubleshooting methods and how to restart the arc after the fault is rectified.

4.1 Welding Machine Failure

When an error occurs due to the welder, the welder will send the welder error id to the robot. The error id can be queried under the welder signal page. If the signal is configured with the corresponding register, the information can be obtained by reading the register through the external communication interface of the robot. After the failure:

On the side of the welder, the arc closure action will be performed automatically.

On the robot side, the program will be suspended after receiving an error message from the welder.

4.2 Communication Failure

During use, if the communication is affected, the CAN communication between the welding machine is interrupted:

At the welder side, communication interruption will be detected within 1 second, communication error will be reported, and automatic arc closure action will be performed.

On the robot side, a communication interruption is detected within 3 seconds, a communication error is reported, and the program is suspended.

4.3 Robot Malfunctions

When an error occurs due to the robot, the robot will send a robot fault signal to the welder.

On the side of the welder, after receiving the error signal from the robot, the welder will automatically perform the arc closure action.

On the robot side, when the robot reports an error, the program will be paused.

4.4 Re-arc

After a fault occurs, the robot program pauses and automatically records the current pause point information. At this time, the robot is allowed to move away from the current point in a manual jog, which is convenient for the user to troubleshoot.

When the fault is rectified, clicking the program to run again will ask the user to return to the pause point first. The way to return to the pause point is movej. As shown in the picture below:
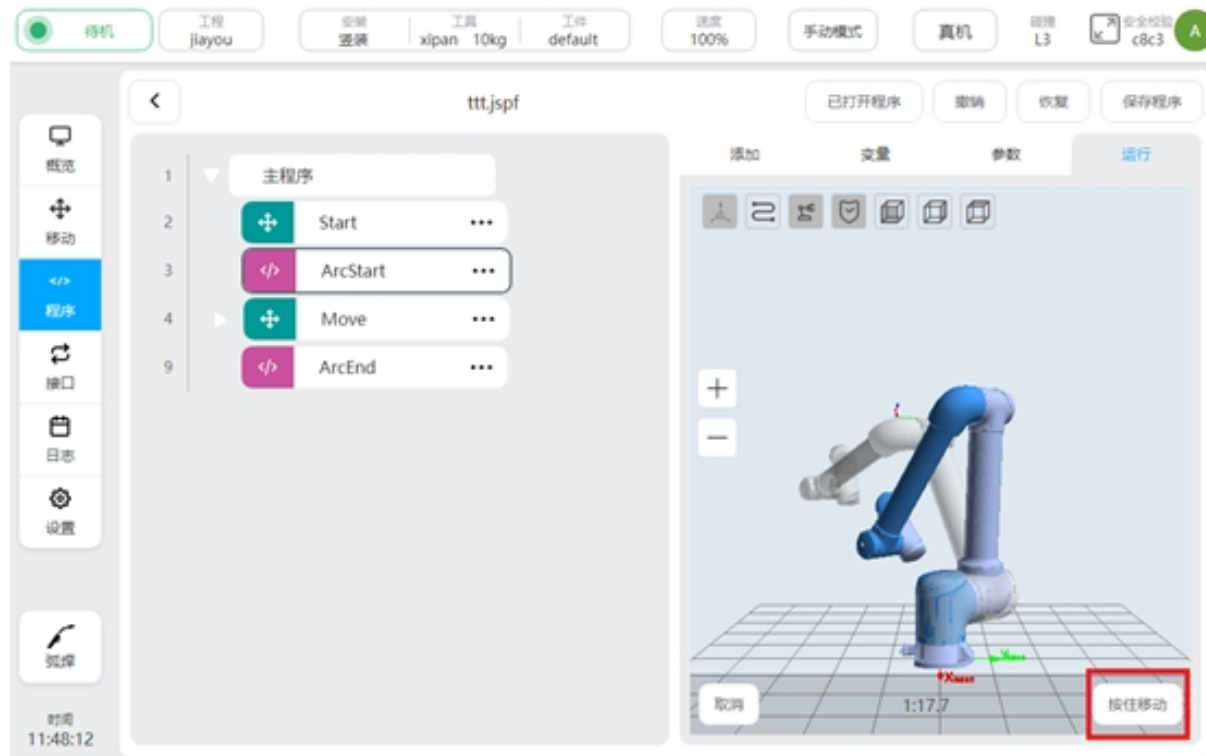
Press and hold the "Press and move" button, the robot moves in the way of movej, and the movement stops when you release it. To prevent the movej from bumping into other objects in its path, it is recommended that the user return to the pause point in advance in a manual jog.

After returning to the pause point, switch the robot to automatic mode, click continue to run the program, the robot will send the arc starting command to the welder, and continue to execute the subsequent program after the arc is successfully started.

LASER TRACKER

5.1 Introduce

The laser tracker acquires the characteristics of the weld and identifies the weld by collecting the laser image. The robot acquires the characteristic information it recognizes and realizes the automatic monitoring and correction of the weld. In practical application, it can solve the problems such as the placement error of the workpiece, the poor consistency of the workpiece, and the deformation of the weld caused by welding heat.

The welding process package supports laser locating and laser tracking.

5.2 Laser Communication Connection

Use a network cable to connect the network port on the robot control cabinet to the laser sensor, and configure the IP address of the robot and the laser sensor to the same network segment. Enter the IP and port number of the laser sensor and click Connect. After the connection is successful, the connection status is displayed. The connection Settings for each manufacturer are as follows

Beijing Creation:

It is necessary to set the laser protocol to Modbus by using the upper computer of the Idea first. Connect to port 502

Tangshan Yinglai:

Set the port number to 5020.

Suzhou Total Vision:

Set the port number to 502

Laser sensor control

You can manually operate the laser sensor, turn the laser on/off, and obtain the data detected by the laser.
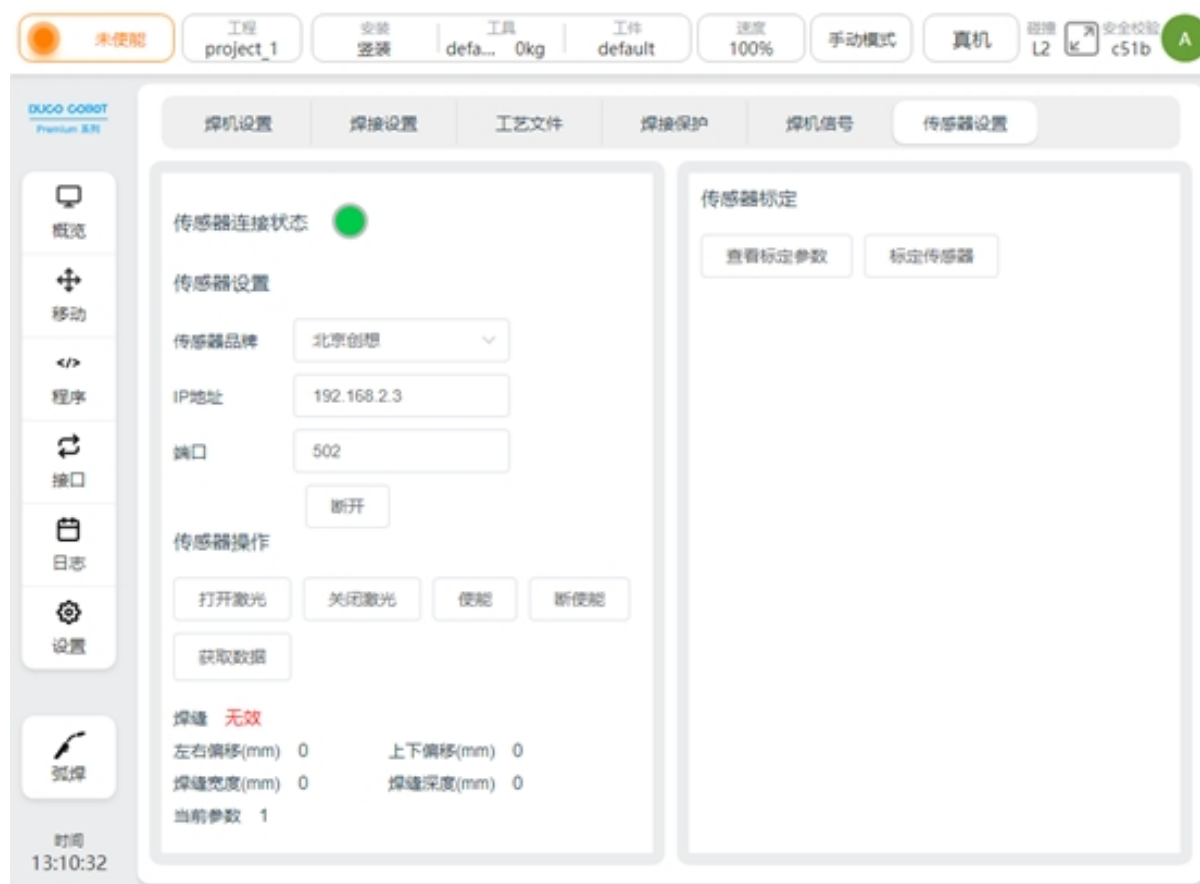
5.3 Laser Calibration

The calibration of the laser sensor is used to calculate the position relationship between the robot TCP and the sensor. That is, according to the results of calibration calculation, the feature points identified by the laser can be converted to their pose in the robot coordinate system.

Calibration preparation:

1、Install the welding gun and adjust the length of the welding wire to the length used in the welding process

2、Install the laser sensor according to the installation requirements of the laser sensor and the site situation

3、Prepare to calibrate the sharp points used by the robot TCP

4、prepare the switch and other network equipment to connect the laser sensor, the upper computer used by the laser sensor, the robot, and set them in the same network segment to ensure normal communication

5、make sure that the laser image can be seen on the upper computer of the laser sensor

6、Verify that the laser switch and data acquisition can work normally in the sensor setting page of the robot welding process package

Calibration process:

1、the tool (TCP) calibration, that is, the calibration of the end position of the wire, the length of the wire is the length of the actual welding wire. The calibration method is as follows:

In the robot's Settings page - Tool Settings, create a TCP, according to the 4 point calibration method or 6 point calibration method
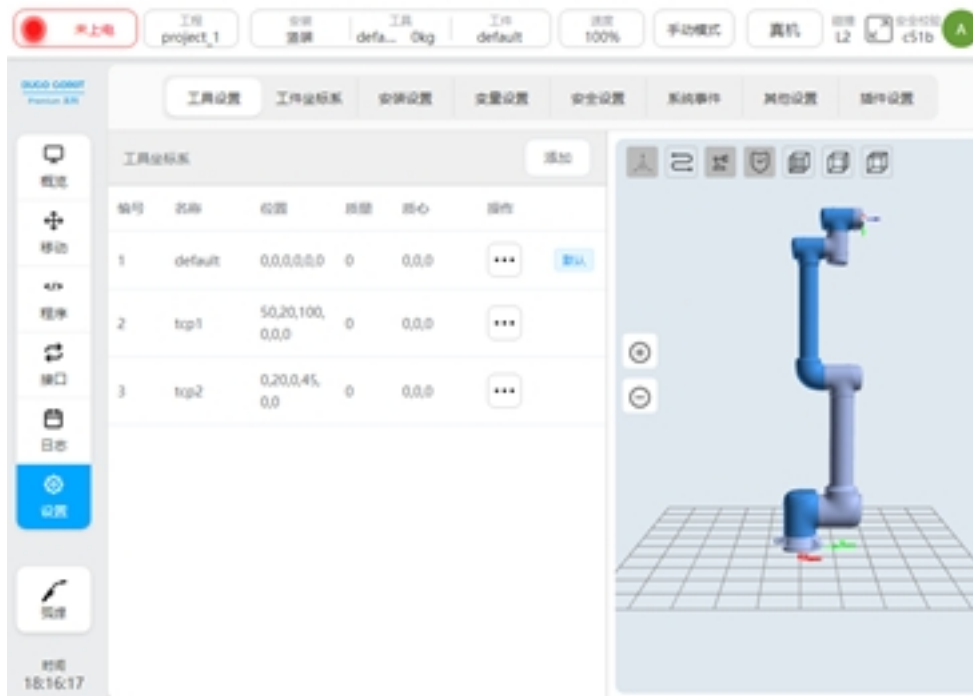
The mobile robot aligns the end of the wire to the cusp point and records the four points respectively

Click OK to calculate the calibrated TCP coordinates and errors. Control the average error and maximum error within 0.5mm.

Set the calibrated TCP to the current TCP

2、Take a mark point on the weld, move the robot, align its TCP with the mark point, and click Record

3、Keep the posture of the robot unchanged, turn on the laser, turn on the enable, move the robot, let the laser fall on the marking point, observe the laser image on the laser software during the marking process, and make the laser image into the six states in the following figure respectively, and record the points 1-6
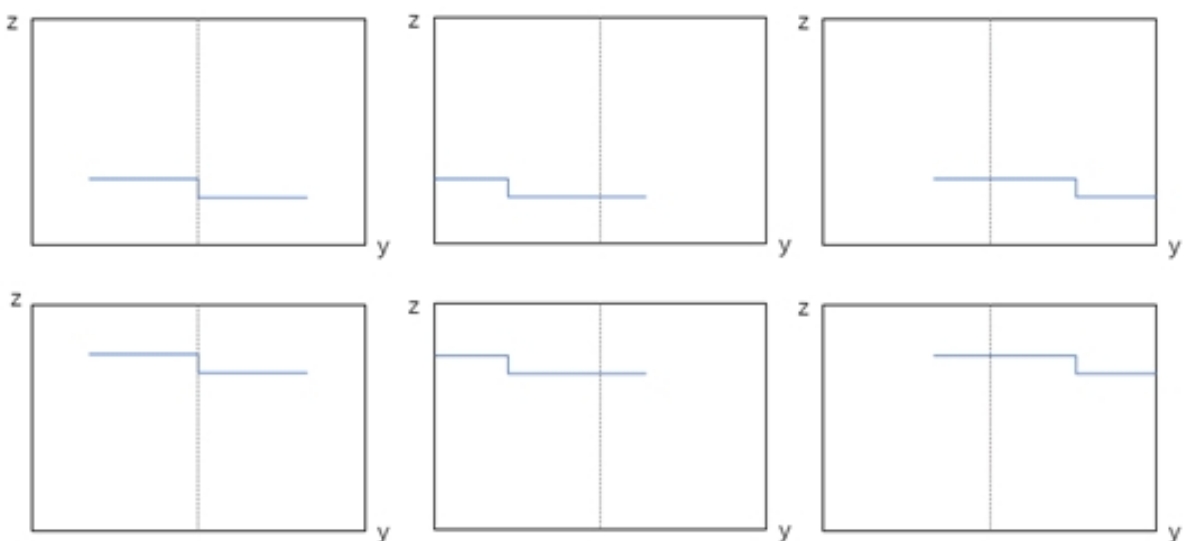
4、click calibration calculation, calibration error and calculation results will be displayed below. If each value is less than 1mm, calibration is valid, otherwise re-calibration.

5.3. Laser Calibration

5、 Click Save the calibration result, and the calculation result will be saved after confirmation. Note: The calculation result is stored in the current project of the robot. It is recommended to save the project at this time to prevent loss.

Attention:

1、 Robot TCP needs to be calibrated before calibration to ensure calibration accuracy

2、 Before calibration, set the calibrated tool coordinate system to the current

3、 When recording 7 points, the length of the welding wire is consistent with the calibration TCP, and the length of the welding wire should also be consistent with the welding process

4、 When recording 7 points, the posture of the robot cannot be changed

5、 When recording these 7 points, ensure the stability of laser image detection

Calibration accuracy verification

After the sensor and robot are calibrated, the accuracy of the calibration can be verified using a single point of search. Write the following program using the function blocks LaserSearchPose and MoveL. LaserSearchPose will turn on and enable the laser, obtain the feature point information recognized by the laser, convert it into its value under the robot base marker system, and assign the value to the variable. MoveL moves to this variable. Run the program to check whether the robot TCP has moved to the identified feature points.

Note: Please ensure that the TCP used at this time is the TCP used in the above calibration
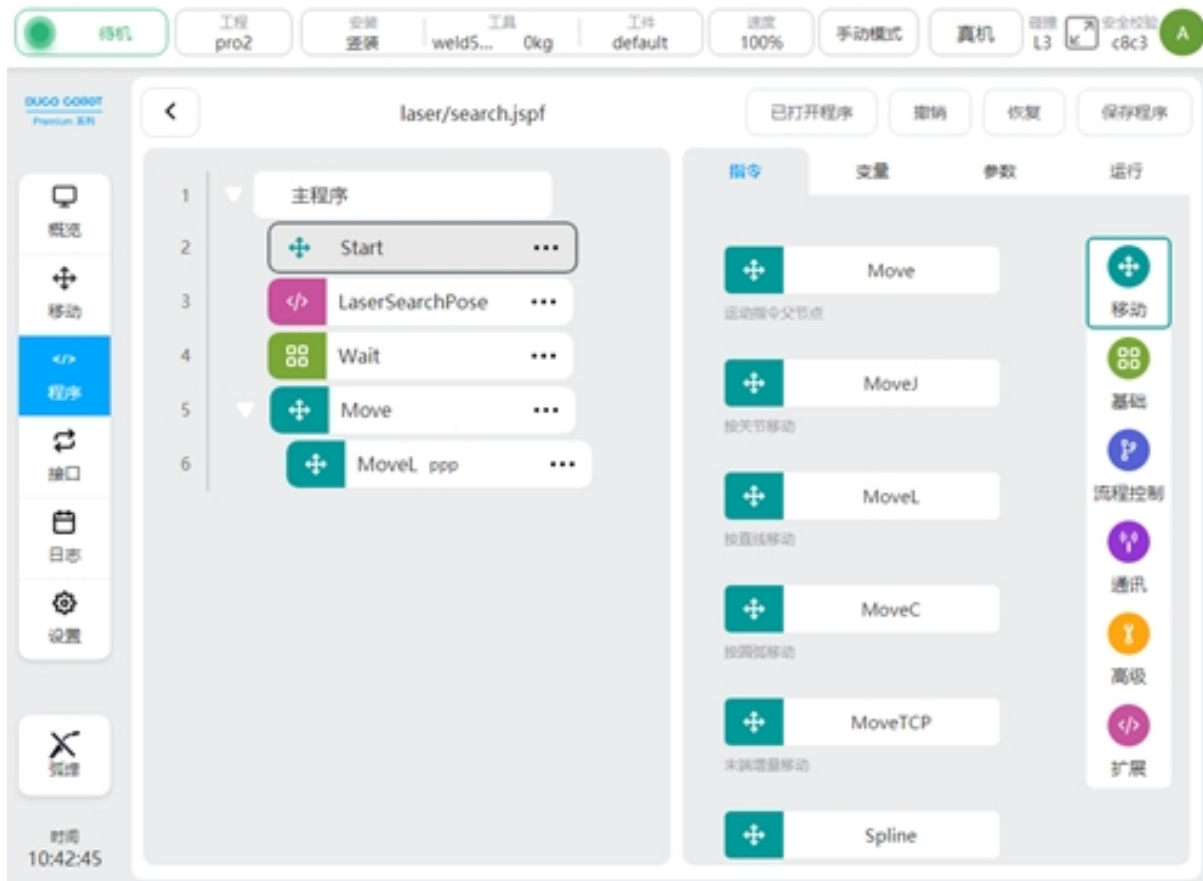
5.4 Programming Function Block

There are three functional blocks related to laser sensors: LaserSerachPose, LaserSearchOffset, Laser-Track.

LaserSearchPose

It is mainly used to obtain the pose of the feature points identified by laser in the robot base coordinate system. The function block encapsulates the following operations: select the Job number used, turn on and enable the laser, obtain the feature point position information recognized by the laser, obtain the current TCP value of the robot in the base coordinate system, calculate the pose information of the feature point in the base coordinate system of the robot according to the calibration relationship, and assign the pose type variable. If no weld is detected, return nil The configuration page is as follows

获取寻位点

打开激光，识别焊缝特征点，将识别到的特征点转换到机器人
基坐标系下，关闭激光。未识别到焊缝时，返回nil

| 焊缝模式参数(Job) | 1 |
| 寻位点 | ⌄ |

焊缝特征点偏移(传感器坐标系)

| Y方向(mm) | 0 |
| Z方向(mm) | 0 |

Weld mode parameter: that is, Job number, is a set of parameters set and saved at the end of the laser tracker: such as weld type, exposure, detection capability, etc.

Location-seeking: The result of a calculation that can be associated with a pose type variable

Weld feature point offset: Add the offset to the identified feature point and calculate the pose after the conversion of the offset point. It can be used to deal with problems such as robot error, detection point and welding process mismatch (if the laser tracker provides the function, it can also be set at the laser tracker end)

LaserSearchOffset

It is mainly used to calculate the pose of the coordinate system obtained by three or four point positioning

The configuration page is as follows

计算坐标系

计算方法　　三点导位

选择点位

P1	p1
P2	p2
P3	p3

结果　　teach_pos

The following Settings are available

Calculation method: Choose three-point or four-point search

Select point: Associates point information

Result: The calculated result, associated with the pose type variable

LaserTrack

Realize laser tracking function.

Main functions: turn on and enable the laser, set the Job number used by the laser, set the compensation direction and advance distance, obtain the weld feature points in real time, calculate the deviation and compensate to the actual trajectory.

The configuration page is as follows

激光跟踪

焊缝模式参数(Job)   2

补偿方向   ☑Y ☐Z

提前距离(mm)   0

最大补偿距离限制

Y方向(mm)   100

Z方向(mm)   100

结束关闭跟踪   ☑

焊缝特征点偏移(传感器坐标系)

Y方向(mm)   0

The following Settings are available

Weld mode parameter: Job number

Compensation direction: Select Y or Z direction to enable compensation

Advance distance: Set the distance between the laser wire and the welding torch, in mm.

Maximum compensation distance limit: The maximum allowable deviation between the taught trajectory and the trajectory measured by the laser

Weld feature point offset: The offset is added to the identified feature point (if the laser tracker provides the function, it can also be set at the laser tracker end)

5.5 Programming Scripts

The following script is added to the welding process package, which can be invoked when programming with the script

Turn on the laser

  _plugin_weld.open_laser()

Laser off

  _plugin_weld.close_laser()

Enable laser (Creative laser sensor needs to be called)

  _plugin_weld.enable_laser()

Lower enable laser (Creative laser sensor needs to be called)

  _plugin_weld.disable_laser()

Set weld type parameters (Job number)

_plugin_weld.set_laser_weld_type(type)

Position seeking, the function is the same as LaserSearchPose function block, turn on the laser, obtain the weld feature point, calculate its position and pose in the robot coordinate system, and turn off the laser.

_plugin_weld.search_pose(pose, offset)

pose: pose type, robot TCP pose, unit m, rad

offset: specifies the number_list offset of the weld feature points. The value is {y, z}. The default value is {0, 0}, in mm

Returned value

pose type: pose of the feature point in the robot coordinate system. When the unit m, rad, is nil, it means that no weld is detected

Similar to search_pose, the laser is not switched on and off, the weld feature points are obtained, and the pose in the robot coordinate system is calculated

_plugin_weld. get_laser_search_pose(pose, offset)

pose: pose type, robot TCP pose, unit m, rad

offset: specifies the number_list offset of the weld feature points. The value is {y, z}. The default value is {0, 0}, in mm

Returned value pose type: pose of the feature point in the robot coordinate system. When the unit m, rad, is nil, it means that no weld is detected

Obtain raw laser data

_plugin_weld.get_laser_raw_data()

Return the following array {status, y, z, width, depth}, respectively

status: boolean Indicates whether a weld is detected

y: number indicates the y-direction coordinate of the weld feature point (unit: mm)

z: number indicates the z-direction coordinate of the weld feature point, in mm

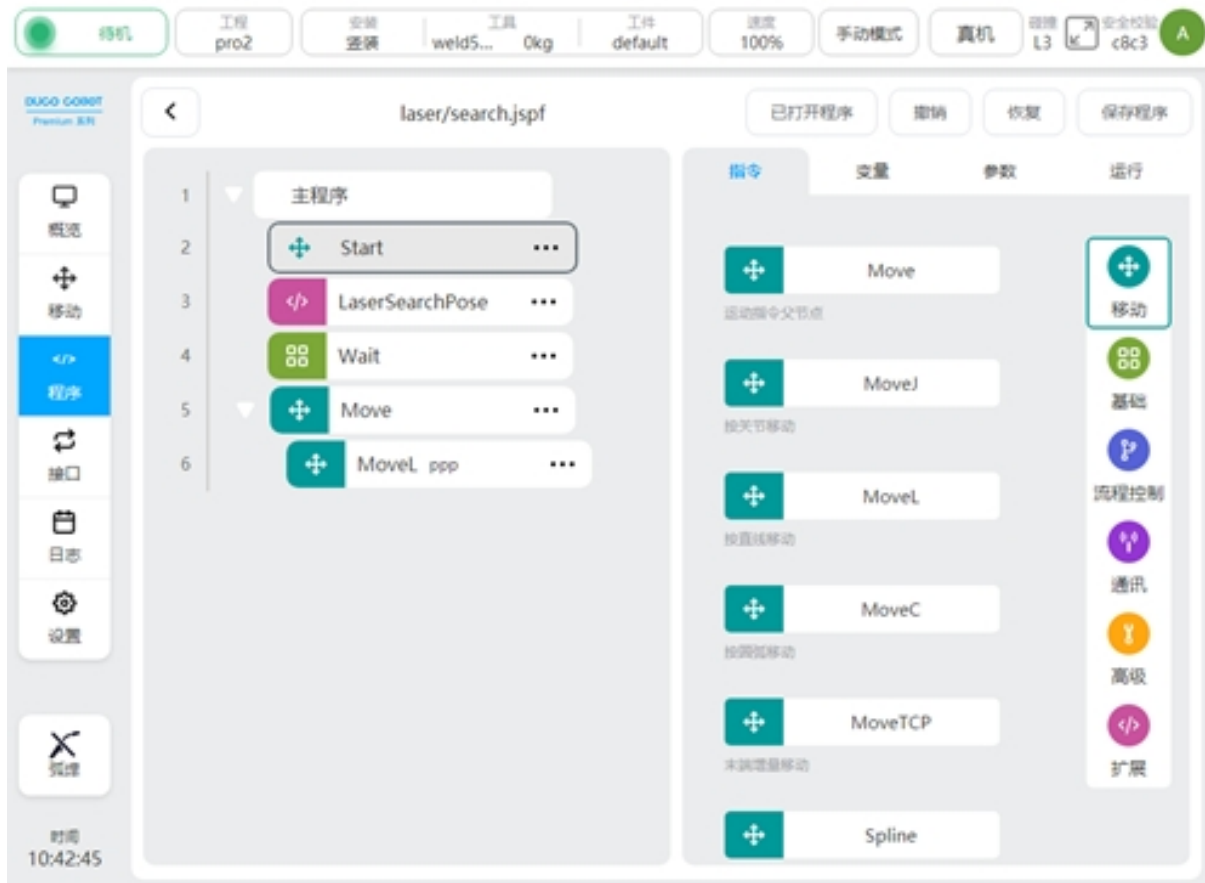width: number, the width of the detected weld, in mm

depth: number: depth of the detected weld (unit: mm)

5.6 Laser Locating

Single point search

Suitable for spot welding and other scenarios

A programming example is as follows:

Two-point search

Suitable for intermittent short welding and other scenarios
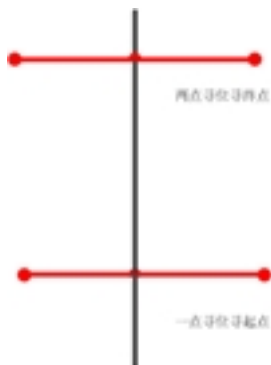
Programming example is as follows
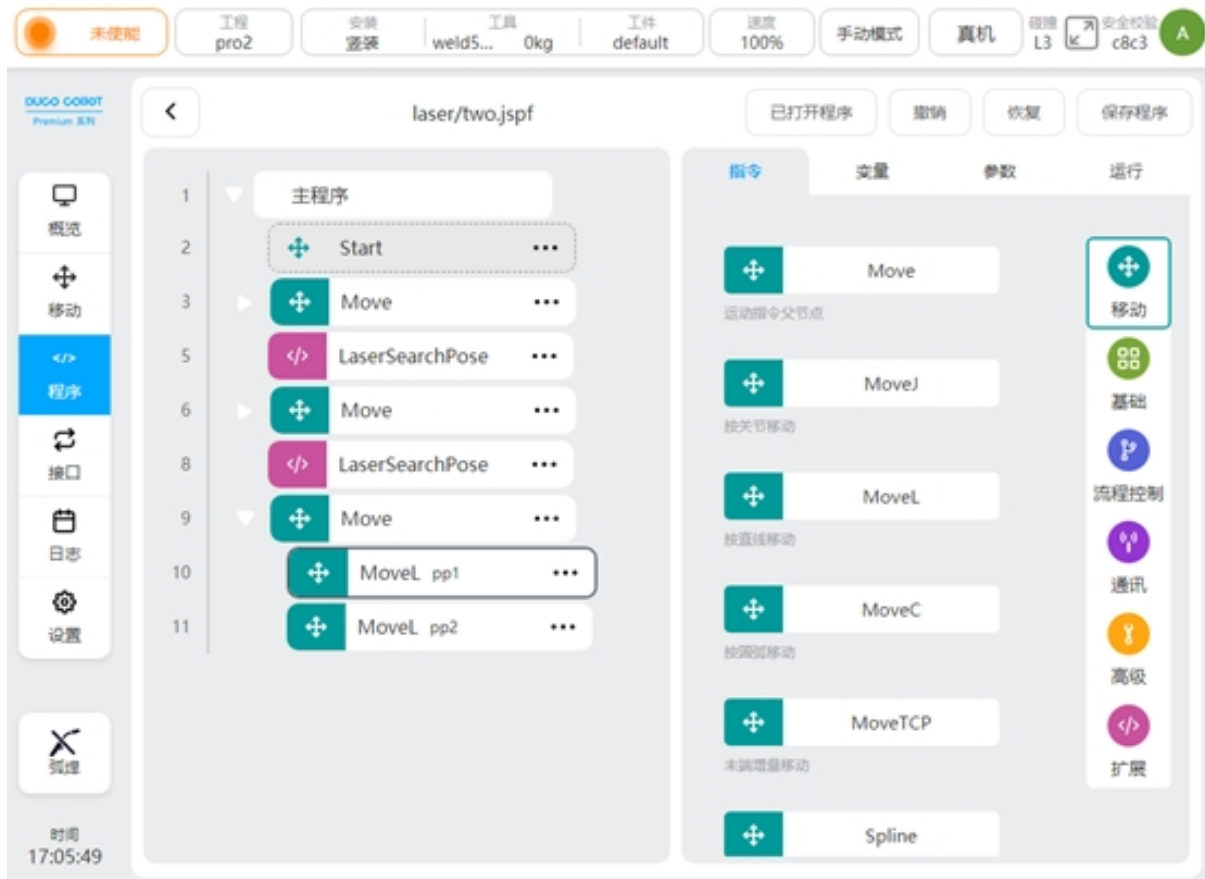
Three-point search/four-point search

The basic principle is: a workpiece coordinate system is established according to the point position of laser locating, and the deviation between it and the original workpiece coordinate system is calculated, so as to obtain the offset of the weld on the workpiece. It can be used for welding of complex structural parts. Compared with three-point locating, four-point locating can better deal with the incoming material error and assembly error of the workpiece.
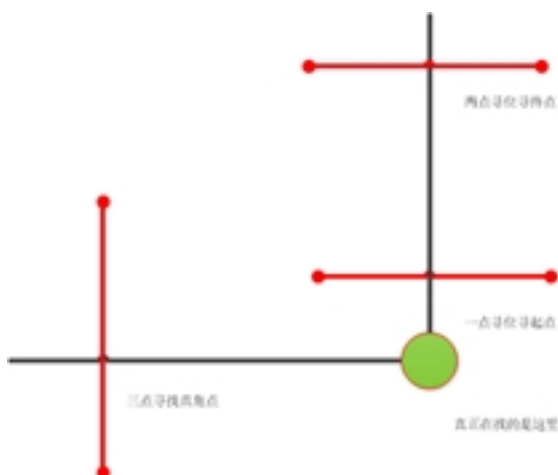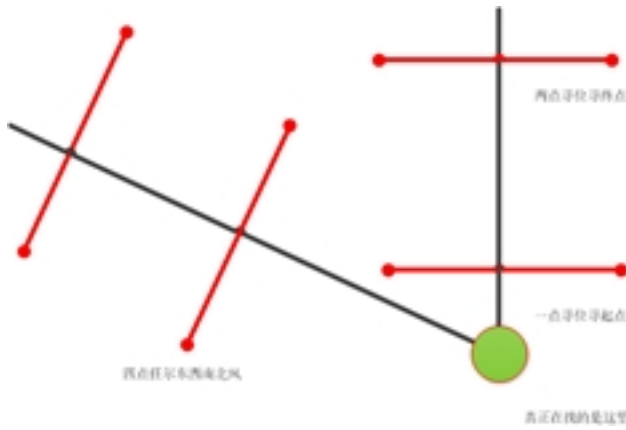
The following is a Demo of three-point search, four-point search is similar to three-point search.

Variable definition

Variable name	type	
P1	pose	The first search site obtained
P2	pose	The second seek site obtained
P3	pose	The third search site obtained
teach_po	pose	The result of three point search calculation
g_enable	boole	Control program operation. When false, it is used to calculate the initial workpiece coordinate system for the first search; If the value is true, the normal job process is performed
g_base_p	pose	Calculated initial workpiece coordinate system
g_pose	pose	The result of three search calculations
g_offset	pose	Deviation from the initial coordinate system

Program specification

The first search point in line 3

Line 5 search, get the search result, save in variable p1

Line 6 second search point

Search for 8 lines, obtain the search result, and save it in variable p2

Line 9 third search site

Search in line 11 to obtain the search result and save it in variable p3

12 lines of three-point search, calculate p1,p2,p3 determined coordinate system, save in variable teach_pose

If g_enable_offse is false, assign the teach_pose value to g_base_pose. Otherwise, the value is assigned to the variable g_pose

Line 17 Perform subsequent operations when g_enable_offset is set to true

The script in line 18 uses pose_offset() to calculate the coordinate deviation of g_base_pose and g_pose and assigns the result to the variable g_offset

Line 20 adds g_offset as a coordinate offset to the current coordinate system

21-24 lines of actual work points, using the workpiece coordinate system.

The actual use process is as follows: 1、teach the robot, determine the laser search point
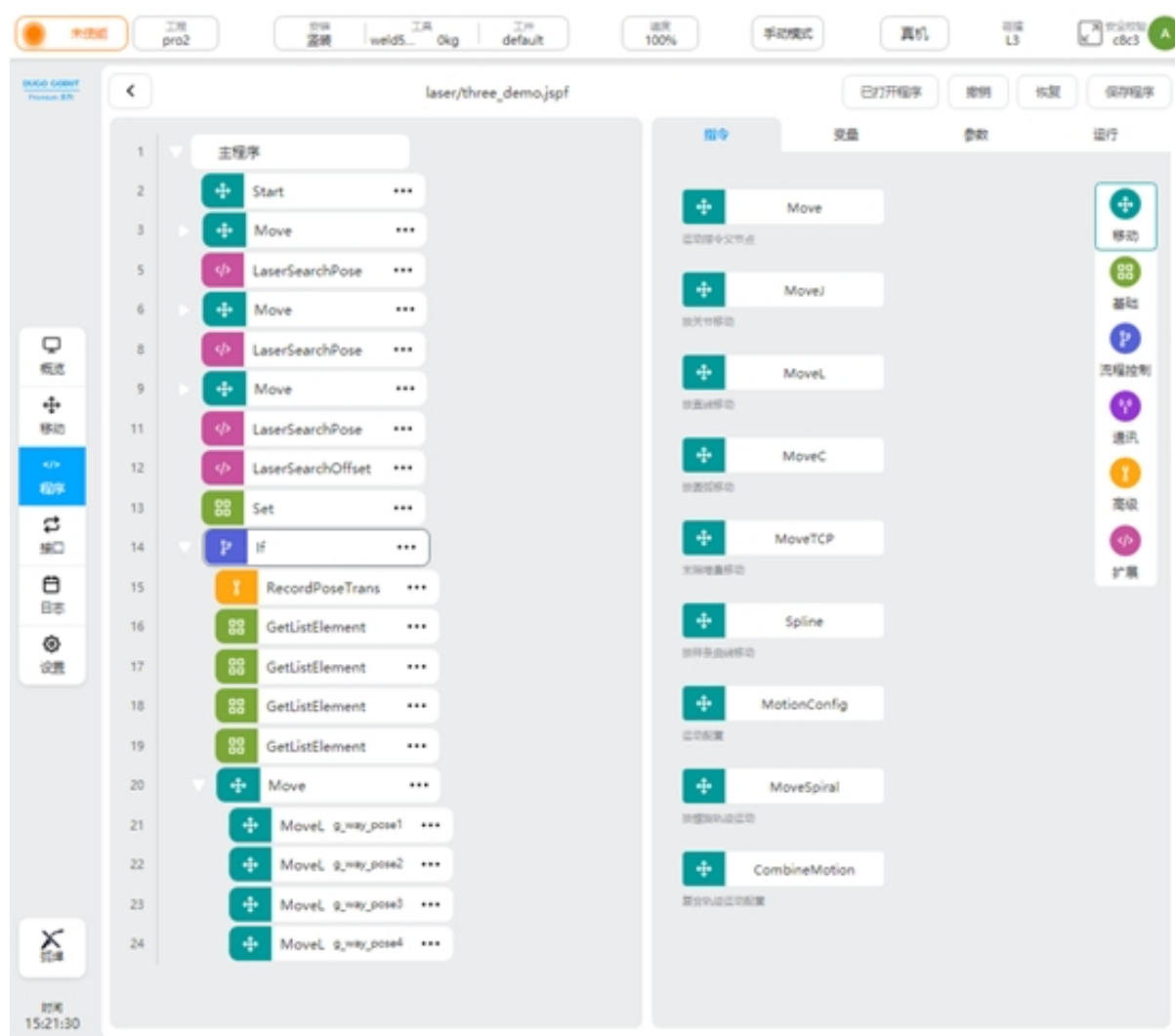
2、Set the workpiece, set g_enable_offset to false, and run the program

3、View the value of g_base_pose in the variables area and create a new workpiece coordinate system wobj1, which uses the value of g_base_pose

4、Set wobj1 as the current workpiece coordinate system, and use this coordinate system as the reference to show the work track of the teaching workpiece, that is, the point position of lines 22-24

5、Set g_enable_offset to true, run the program, and execute the normal job flow.

The above Demo uses the workpiece coordinate system, and obtains an initial workpiece coordinate system by performing the three-point search calculation for the first time, based on which the teaching operation point is shown. Ensure that if the workpiece has a certain deviation due to placement, you can calculate the deviation of the coordinate system obtained by three-point positioning and the initial coordinate system, and add the deviation to the workpiece coordinate system, so that the operation trajectory can adapt to the change.

Because the Demo needs to set the coordinate system of the workpiece, in some cases, the teaching needs to change the coordinate system frequently, which may be complicated. You can refer to the following Demo, using the RecordPoseTrans function block, you can be based on the base coordinate system programming.

Variable definition

Variable name	type	
P1	pose	The first search site obtained
P2	pose	The second seek site obtained
P3	pose	The third search site obtained
teach_po	pose	The result of three point search calculation
g_enable	boole	Control program operation. When false, it is used to calculate the initial workpiece coordinate system for the first search; If the value is true, the normal job process is performed
g_base_p	pose	Coordinate system for three-point homing calculation
g_result_	pose_	The pose of the actual operation point in the base coordinate system
g_way_p	pose	The first operation point
g_way_p	pose	Second operation point
g_way_p	pose	The third operation point
g_way_p	pose	The fourth operation point

Program specification

The first search point in line 3

Line 5 search, get the search result, save in variable p1

Line 6 second search point

Search for 8 lines, obtain the search result, and save it in variable p2

Line 9 third search site

Search in line 11 to obtain the search result and save it in variable p3

12 lines of three-point search, calculate p1,p2,p3 determined coordinate system, save in variable teach_pose

Line 13 assigns the teach_pose value to g_pose

Line 14 Perform subsequent operations when g_enable_offset is set to true

15 lines of action point to teach the transformation and save the results in the variable g_result_list

Lines 16-19 get the points from the g_result_list and assign them to the job point variables

Lines 20-24 perform the actual job, the point using the individual job point variables

The actual use process is as follows:

1、teach the robot, determine the laser search point

2、Set the workpiece, set g_enable_offset to false, and run the program

3、Check the value of g_base_pose in the variable area and open the RecordPoseTrans function block, as shown in the figure. Select variable g_base_pose from the input reference pose and click the "Set as baseline" button, the baseline pose value is displayed on the baseline pose.

4、In the operation point bias, teach to add job points, and select a pose_list variable in the output to store the calculated job points results

5、Set g_enable_offset to true, run the program, and execute the normal job flow.

Compared with the previous Demo, the variables are used as the actual job points, and the points are calculated through RecordPoseTrans. Use the coordinate system obtained for the first time as the benchmark to teach each job point and add it to the RecordPoseTrans block. Subsequently, if the workpiece is offset, the RecordPoseTrans function block is used to calculate the value of each operation point in the base coordinate system according to the coordinate system calculated by searching.

5.7 Laser Tracking

When it is necessary to detect changes in the weld in real time during the welding process, the laser tracking function is needed at this time.

The following example

Program specification

In line 4, the robot opens the tracking point wp1

5 line start point search, put the result in the variable start

Line 6 Enables tracing and does not disable tracing at the end of setting

7 rows move to the starting point

9 Line arcing

Line 10 Turn on tracing and turn off tracing at the end of setting

The 11 lines teach a primitive track wp0

The robot will perform the following operations: turn on and enable the laser to obtain the arc starting point, turn on the tracking and move to the arc starting point, turn on the arc starting, turn on the tracking, calculate the deviation from the teaching trajectory according to the real-time acquisition of the feature points obtained by the laser sensor, and compensate the deviation to the teaching trajectory, so that the robot TCP can operate according to the detected weld.

5.8 Exception Detection

Weld detection

LaserSearchPose can determine whether the return value is nil to determine whether the weld is detected. An example is as follows:


LaserSearchPose puts the search result in the variable target, and the If condition determines whether target is nil to perform the logic when the weld is detected and when the weld is not detected

Three/four point seeking deviation too large protection

In some cases, the weld may be detected incorrectly, resulting in excessive deviation of the calculated workpiece coordinate system, which can increase the deviation limit to prevent safety problems such as gun bump.

An example is as follows:
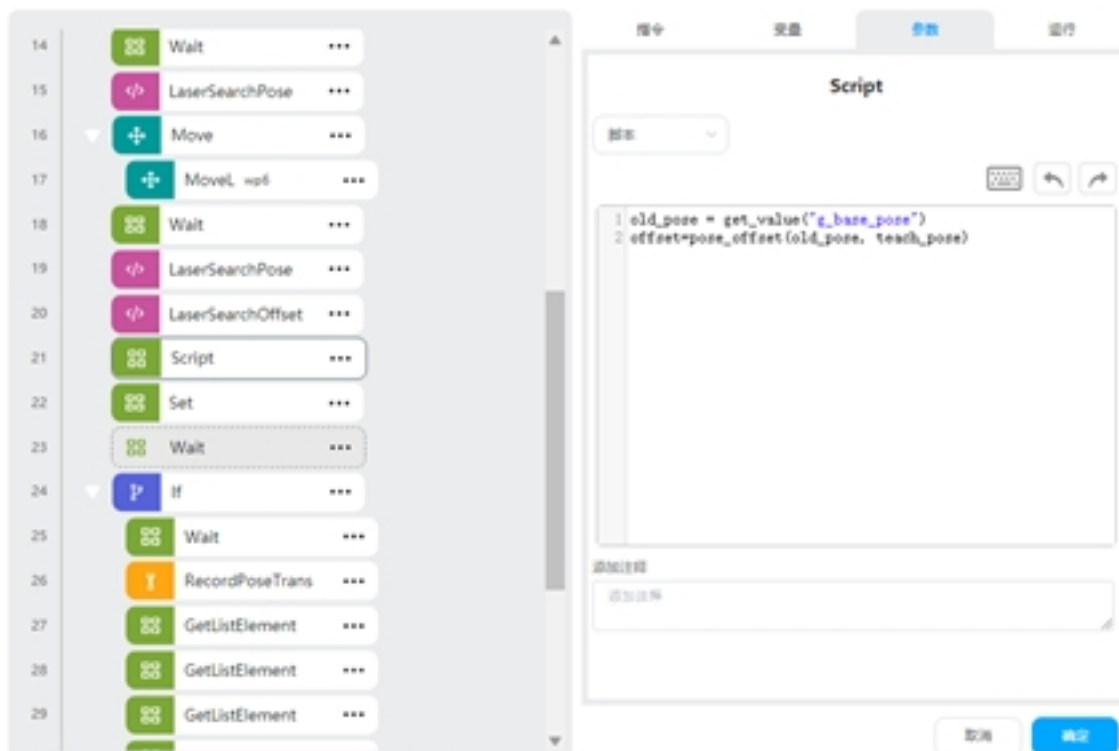
The Script function block uses the pose_offset script to calculate the deviation of the original and new calculated coordinate systems, adding execution logic that determines that the deviation is greater than a certain range.