



AUBO

AUBO

User Manual

AUBO Robotics



Translate Version 4.0.0

PLEASE READ CAREFULLY BEFORE USE

User Manual

AUBO-i5

Translate Version 4.0.0

Published by AUBO (Beijing) Robotics Technology Co.

Published by AUBO (Beijing) Robotics Technology Co., Ltd.

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The picture is only for reference, please make the object as the standard.

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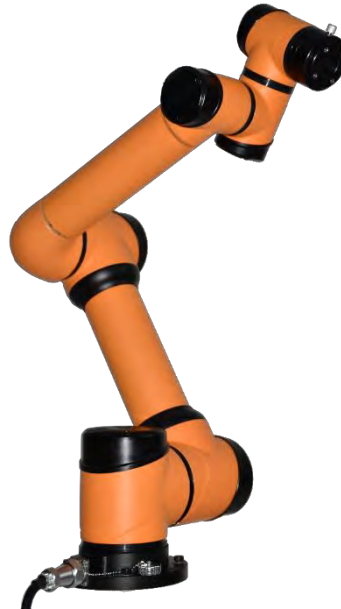
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Preface

Thanks for the purchase of this lightweight modular industrial robot with 6 degrees of freedom, AUBO-i5, which is researched and developed by AUBO (Beijing) Robotics Technology Co., Ltd.



AUBO-i5

AUBO series robot adopts the fully modular design and uses system towards developers. Users can develop their own robot control system based on the API of AUBO robot. Meanwhile, AUBO robot is equipped with its own programmable interface, which allows the user to observe robot's operating status in real time, carry out lots of robot control settings and perform offline simulation. This can improve the efficiency of practical application greatly.

AUBO-i5, the second generation of smart lightweight 6 DOF modular collaborative robot, whose payload is 5kg, is one of AUBO series modular robots.

Components of AUBO-i5 Robot

The components of the AUBO-i5 robot are illustrated as below.

Name	Quantity
Manipulator AUBO-i5	1
Teach Pendant	1
Control Box	1
Teach Pendant cable	1
Manipulator cable	1
Power cable	1
Manipulator base(optional)	1
<AUBO-i5 User Manual>	1
Terminal Tool	1

Product shape structure is shown in picture above.

More Information

If you need more information, the support website is available at: www.aubo-robotics.com




1. Safety

1.1 Introduction

This chapter introduces the principles and norms of operating robot or robot systems. Integrators and users must read the relevant description in this manual, fully understand and strictly adhere to contents with warning symbols. Because of complexity and highly risks of robot system, operators need to be fully aware of the operation risks and follow the requirements and specifications in this manual. Both the integrators and users should have adequate safety awareness and follow the Industrial robots' safety regulations, ISO 10218.

1.2 Warning Symbols in this Manual

The table below defines the captions specifying the danger levels used throughout this manual. These warnings, which are relevant to safety, must be observed.

 DANGER ! ELECTRICITY !	This indicates an imminently hazardous electrical situation which, if not avoided, could result in death or serious injury.
 Hot surface Do not touch!	This indicates a potentially hazardous hot surface which, if touched, could result in injury.
 DANGER!	This indicates an imminently hazardous situation which, if not avoided, could result in injury or major damage to the equipment.



This indicates a potentially hazardous electrical situation which, if not avoided, could result in injury or major damage to the equipment.



This indicates a potentially situation which, if not avoided, could result in injury or major damage to the equipment. Marked with this symbols, depending on the circumstances, sometimes may have significant consequences.



This indicates a situation which, if not avoided, could result in injury or major damage to the equipment. Marked with this symbols, depending on the circumstances, sometimes may have significant consequences.

1.3 Safety Caution

1.3.1 General

This manual includes safety precautions for protecting the user and preventing damage to the machine. Users need to learn all the relevant descriptions and fully understand the safety precautions. In this manual, we have tried to describe all the various matters as much as possible. However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.

1.3.2 Terms and Conditions

Before the first time use of the robot or robot system, users should understand and follow the basic information as follows firstly. Also, other security-related information will be introduced in other parts of this manual. However it may not cover everything. In practical applications, it is necessary to analyze specific issues.



DANGER!

1. Make sure to install the robot and all electrical equipment according to the manual requirements and specifications.
2. Make sure to conduct a preliminary test and inspection of robots and its protection systems before the first time to use the robot or its protect system.
3. Make sure to check the system and equipment for completeness, operational safety and any damage that can be detected before the first time to start it. The test needs to confirm whether it accords with valid safety production rules and regulations in country or region. All security functions must be tested.
4. Make sure that all safety parameters and user programs are correct and all security functions are working normally. A qualified robotics operator is needed to check each security function. Only pass the thorough, careful test and reach the safe level can we power on the robot.



DANGER!

1. Installation and commissioning needs to be performed by professionals in accordance with the installation standards.
2. When the robot is installed, a comprehensive risk assessment is necessary and the test results need to be recorded in a report.
3. Set and modify the safety parameters by a qualified person. Use password or isolation measures to prevent unauthorized persons from setting and modifying safety parameters. After a safety parameter is modified, the related security functions need to be analyzed.
4. When the robot is in the event of an accident or abnormal operation, the emergency stop switch needs to be pressed down to stop the movement.
5. AUBO-i5 joint module has brakes inside, it will remain manipulator's pose when power outage occurred. Don't power on and power off frequently. It is recommended that the time interval of each switch should be more than 10s.
6. AUBO-i5 has collision detecting function. When the external force of the manipulator is beyond the users' safety range, the manipulator will automatically stop to prevent the robot or operator from injury. This function is a particularly for the safety of cooperative work, but robot system has to within the normal operating range and use the AUBO series control box. If the user develops the controller personally, the robot will not have the function above. Otherwise all the dangerous consequences caused are undertaken by its own user.



1. Make sure that the robot's joints and tools are installed properly and securely.
2. Make sure that there is enough space for the manipulator to move freely.
3. Don't use if the robot is damaged.
4. Do not connect any safety equipment to normal I/O. Use safety-related interfaces only.
5. Make sure to use the correct installation settings (e.g. the robot's mounting angle, TCP weight, TCP offset, security configuration). Save and load the installations file along with the program.
6. Tools and obstacles shall not have sharp edges or pinch points. Make sure that all people keep their heads and faces outside the reach of the robot.
7. Be aware of robot movement when using the teach pendant.
8. Any strike would release a large amount of kinetic energy, which is much higher than the case of high speed and high payload.
9. The different mechanical linking may increase risk or lead to new dangers. Make sure to perform a comprehensive risk assessment for entire installation. Always choose the highest level performance when different safety and emergency shutdown performance level is needed. Make sure to read and understand all the devices' manual used for installation.
10. Do not modify the robot. Robot changes may cause unpredictable danger to the integrator. The robots authorize restructuring need in accordance with the latest version of all relevant service manuals. If the robot is changed or altered in any way, AUBO (Beijing) Robotics Technology Co., Ltd disclaims all liability.
11. User needs to check the insulation and protection measures before transportation.
12. Handling robot must follow the transport requirements. Handling carefully and avoid the bump.



1. The robot and controller box generate heat during operation. Do not handle or touch the robot while in operation or immediately after operation. To cool the robot down, power off the robot and wait one hour.
2. Never stick fingers behind the internal cover of the controller box.



1. When the robot is combined with or working with machines capable of damaging the robot, then it is highly recommended to test all functions and the robot program separately. It is recommended to test the robot program using temporary waypoints outside the workspace of other machines.
2. AUBO (Beijing) Robotics Technology Co., Ltd cannot be held responsible for any damages caused to the robot or to other equipment due to programming errors or malfunctioning of the robot.
3. Don't expose the robot to a permanent magnetic fields. Very strong magnetic fields can damage the robot.

1.3.3 Operator safety

In the operation of the robot system, we must ensure the safety of the operators first. General precautions are listed in the table below. Please take appropriate measures to ensure the safety of operators.



1. Each operator who uses the robotic system should be trained in training courses hosted by AUBO (Beijing) Robotics Technology Co., Ltd. Users need to make sure to fully grasp the safe and standardized operating procedures with the robot operating qualifications. Please inquire for training details, mail to support@aubo-robotics.cn.
2. Do not wear loose clothing or jewelry when working with the robot. Make sure long hair is tied back when working with the robot.
3. When the device is running, even if the robot seems to stop, it is possible that robot is waiting for the signal and in the upcoming action status. Even in such state, it should be considered as the robot is in action.
4. A line should be draw to mark the range of motion of the robot to let the operator know the robot including the holding tools (like mechanical hand or tools) operating range.
5. Make sure to set security-building measures (for example, rails, ropes, or protective screen) in the vicinity of the robot operating area to protect the operator and surrounding crowd. According to needs to set locks prevent those who are not operating personnel from contacting the robot power.
6. When using the operation panel or teach pendant, make sure to take off gloves in case of operational errors.
7. Pushing or pulling the robot arm (at least 700N), force the joint to move in case of emergency or abnormal condition (like a person is caught in or surrounded by a robot). Manually move the robot arm without electric drive only for emergency and it may damage the joints.

1.4 Responsibility and standard

AUBO-i5 can form a complete machine with other equipment and itself is not complete. The information in this manual does not cover how to design, install and operate a complete robot application, nor does it cover all peripheral equipment that can influence the safety of the complete system. The safety of installing a complete robot is determined by how it integrated.

Therefore Integrators must follow the standards and regulations and laws of the country where the robot is installed to perform a risk assessment for its system design and installation. Risk assessment is one of the most important things that integrators must done. Guidance on the risk assessment process may be found in the following standards.

- ISO 12100:2010 Safety of machinery - General principles for design - Risk assessment and risk reduction.
- ISO 10218-2:2011 Robots and robotic devices - Safety requirements - Part 2: Industrial robot systems and integration.
- RIA TR R15.306-2014 Technical Report for Industrial Robots and Robot Systems - Safety Requirements, Task-based Risk Assessment Methodology.
- ANSI B11.0-2010 Safety of Machinery; General Requirements & Risk Assessment.

AUBO robot integrators need to fulfill but not limited to the following responsibilities:

- Comprehensive risk assessment of complete robot system;
- Make sure the whole system design and installation is correct;
- Provide training to users and personnel;
- Create operational specifications for a complete system, specify instructions for process;
- Establish appropriate safety measures;
- Use appropriate methods to eliminate or minimize all hazards to acceptable levels in the final installation;
- Convey the residual risk to the end user;
- Mark the logo and contact information of the integrator on the robot;
- Archive technical file

Guidance on how to find and read applicable standards and laws is provided on: www.aubo-robotics.com

All security information contained in this manual are not considered as a guarantee for AUBO (Beijing) Robotics Technology Co., Ltd. Even if all the safety instructions are observed, the personnel injury or equipment damage caused by the operator is still likely to occur.

AUBO (Beijing) Robotics Technology Co., Ltd is committed to continuously improve the reliability and performance of the product. Therefore, reserve the right to upgrade products without notice. AUBO (Beijing) Robotics Technology Co., Ltd seeks to ensure the accuracy and reliability of the contents in this manual, but is not responsible for any errors or omissions.

1.5 Hazard Identification

Risk assessment should consider all potential contacts and foreseeable misuse between robot and operator. Operator's neck, face and head should not be exposed in case of collision. Without using peripheral security devices, the robot needs to perform a risk assessment first in order to determine whether the risk is unacceptable, such as:

- The risk of using a sharp end-effector or tool connector;
- The risk of processing toxic or other hazardous substances;
- Entrapment of fingers between robot base or joints;
- The risk of collision by manipulator;
- The danger due to incompletely fix of manipulator or connected tool;
- Sprain or bone fracture due to strokes between a heavy payload and a hard surface.

Integrators must measure these dangers and its repellent risk level through risk assessment. Identify and implement appropriate measures to lower the risk to acceptable level. However it should be aware that specific robotic equipment may have other dangers.

Combine with inherent safety design which applied by AUBO robot and safety specifications or risk assessment performed by integrators and users, risks reverent to AUBO-i5 collaborative operation should be lower to reasonable and practicable level. Any residual risks before installing will be conveyed to integrators and users through this manual. If integrators' risk assessment shows that there may have unacceptable risks in specific applications, integrators must take appropriate measure to eliminate or minimize these risks to acceptable level. It is not safe to use before taking appropriate risk reduction measures (If necessary).

If perform uncooperative installation (for example, when using dangerous tools), risk assessment may infer integrators need to connect additional security devices (such as a boot device) when programming to ensure the safety of personnel and equipment.

1.6 Intended use

AUBO robot is industrial only and intended for operating or fixing tools or device or for processing or transferring components or products. AUBO robot can only be used under specified conditions. For details about the operating environment and conditions, see appendix.

AUBO robot has the feature of special safety class. It can perform collaborative operation, which means it can be used without setting peripheral security device. But it can only be used under non-hazardous circumstance which has passed the risk assessment. That is to say, on the premise that not using any security device and sensing device, there will be no unacceptable risk when personnel or other objects in workplace (like tool, equipment, surfaces etc.) has expected or unexpected contact with AUBO robot or its end-effector.

Robot controller and robot can only be used in general industrial equipment. Any use or application deviating from the intended use is deemed to be impermissible misuse. This includes, but is not limited to:

- Use in potentially flammable and explosive environments;
- Use to move or carry people or other animals;
- Use in medical and life critical applications
- Use to have a major impact on social and public;
- Use under vibration environment like vehicle or ship;
- Use as a climbing aid;

1.7 Emergency situations

1.7.1 Emergency stop device

Activate the emergency stop button to immediately stop all robot motion. Emergency stop shall not be used as a risk reduction measure, but as a secondary protective device. If more emergency stop buttons are connected, it should be recorded in the risk assessment of the robot application. Emergency stop buttons should comply with IEC 60947-5-5.

Emergency stop button can be found on both teach pendant and control box of AUBO-i5. The button must be pressed when a dangerous situation or emergency situation occurs. As shown in Figure 1.1, control box is equipped with external ports for emergency stop button. Integrators and users can use according to the actual situation.



Figure 1.1 Emergency stop button



If the equipment or tools which connect to the end can cause potential dangers, it has to integrate to the emergency stop circuit in system. It may result in death, serious injury or substantial property damage if failure to observe this warning notices

1.7.2 Recovering from the emergency condition

All the emergency stop device in button form has a "lock" function. This "lock" must be opened to end the emergency stop state.

Rotary emergency stop button can open the "lock".



Recovery from an emergency stop state is a simple but very important step. This step can only operate after making sure that the robot system is completely excluded from danger.

1.7.3 Emergency move for joint

In rare cases, it may be required to move one or more robot joints when the robot's power failure or in an emergency situation, which can force the robot to move by follow method:

Forced back-driving: Force a joint to move by pulling hard (at least 700 N) on the robot arm.



Forced to move the robot arm manually is limited to emergency situations and it may damage the joints.

1.7.4 Excessive force protection

Manipulator has excessive force protection. When manipulator is power-on and in stationary state, if impact force hit by operators or other objects mistakenly exceeds the safety threshold, manipulator will follow the direction of impact force to move passively. This function can reduce the damage when operators or other objects collide with manipulator.



This function can reduce the collision damage. For other uses needs to perform a risk assessment.

2. TRANSPORTATION

When hoisting robot, moving parts should be located by appropriate measures to avoid unexpected movement which can cause damage during hoisting and transportation. Package should follow packaging standards and mark the needed sign outside the box.

The robot must remain in its transport position stably.

The controller box shall be lifted by the handle.

When moving robot from packaging to installation position, hold the robot in place until all mounting bolts are securely tightened at the base of the robot.

Power up the robot after fixing it. Using hand-guiding to adjust robot orientation to suitable location.

Save the original packaging after transportation. Store the packaging material in a dry place for future need to repack and move the robot.

Users can move the manipulator to the installation position by using the packagePos project in the **【Online Programming】** -> **【Project】** -> **【Open Project】** on the AUBOPE Programming Environment. For details, please refer to **【Open Project】** .



1. Make sure not to overload your back or other body parts when the equipment is lifted.
2. All regional and national guidelines should be followed. AUBO (Beijing) Robotics Technology Co., Ltd is not responsible for any damage caused during the transportation of equipment.
3. Make sure to follow instructions when installing.

3. MAINTENANCE, REPAIR AND DISPOSAL

3.1 Maintenance and repair

It is essential for both maintenance and repair work that it be performed in compliance with all safety instructions in this manual.

Maintenance, calibration and repair work must be performed according to the latest versions of Service Manuals, which can be found on the support website www.aubo-robotics.com

All dealers in AUBO (Beijing) Robotics Technology Co., Ltd. have access to this support site.

Maintenance must be performed by authorized integrators or AUBO (Beijing) Robotics Technology Co., Ltd. All parts returned to AUBO (Beijing) Robotics Technology Co., Ltd. shall be returned according to the service manual.

Make sure to reach the safety level of maintenance and repair, follow all regional and national guidelines and test whether all safety functions work normally.

Maintenance and repair in order to make sure that system runs normally or return to normality when system error occurs, including faults diagnosis and actual maintenance.

Operating manipulator or control box must follow safety procedures and warnings as below:



1. Remove the mains input cable from the bottom of the control box to ensure that it is completely un-powered. Take necessary precautions to prevent other persons from energizing the system during the repair period. Recheck the system again to make sure after power-down.
2. Please check the earth connection before re-powering the system.
3. Observe ESD (Electro-Static discharge) regulations when parts of the robot arm or control box are disassembled.
4. Avoid disassembling the power supplies inside the control box. High voltages can be present inside these power supplies for several hours after the control box has been switched off.
5. Prevent water and dust from entering the robot arm or control box.



1. Replace faulty components using new components with the same article numbers or equivalent components approved by AUBO (Beijing) Robotics Technology Co., Ltd.
2. Reactivate any deactivated safety measures immediately after the work is completed.
3. Record all maintenance operations and save in technical documentation.
4. There is no self-serviceable part in control box. If maintain or repair service is required, please contact your dealer or AUBO (Beijing) Robotics Technology Co., Ltd.

3.2 Disposal

AUBO robot must be disposed of in accordance with the applicable national laws, regulations and standards.

4. WARRANTIES

4.1 Product Warranty

AUBO robots have the finite warranty period for 12 months.

In the case of new devices and their components exhibiting defects resulting from manufacturing and/or material faults within 12 months of entry into service (maximum of 15 months from shipment), AUBO (Beijing) Robotics Technology Co., Ltd. should provide the necessary reserve components to replace or repair the relative components.

AUBO (Beijing) Robotics Technology Co., Ltd. has the right of the devices or components which are replaced or turned back.

If the products are not in the warranty period, AUBO (Beijing) Robotics Technology Co., Ltd. reserves the right to charge customers for replacing or repairing the products.

If there are any defects appear in the device beyond the warranty period, AUBO (Beijing) Robotics Technology Co., Ltd. is not responsible for any damage or loss, such as loss of production or damage to other production equipment.

4.2 Disclaimer

This Warranty shall be invalid if the device defect is attributable to improper treatment and/or failure to comply with information contained in the user guides and does not warrant uninterrupted or error-free operation.

Warranty will not be provided in case of malfunction caused by the following conditions:

1. Not meeting the requirements industrial standards or not following the user manual to install, connect wires and connect to other control devices.
2. Using products beyond the specifications or standards of the manual.
3. Using products beyond the appointed purposes
4. Store method and work environment are beyond the appointed range (e.g. pollution, salt injury and moisture condensation).
5. Products' damages caused by improper transportation.
6. Damages caused by accident or crash.
7. Not installing the original assembled components and accessories.
8. The damages caused by the third-party which is not AUBO (Beijing) Robotics Technology Co., Ltd. or the appointed integrator while reconstructing, adjusting or repairing the original components.
9. Any nature disasters including fires, earthquakes, tsunamis, lightning, high winds and flooding.
10. Any malfunction not relates to AUBO (Beijing) Robotics Technology Co., Ltd.'s responsibility apart from the circumstances mentioned above.

Warranty will not be provided in following circumstances:

1. Unable to identify the production date or the warranty start date.
2. Changes for the software or the internal data.

3. The malfunction cannot reappear or be identified by AUBO (Beijing) Robotics Technology Co., Ltd.
4. Using the products in radioactive equipment, biological test equipment or any other dangerous environment ascertained by AUBO (Beijing) Robotics Technology Co., Ltd.

According to the product warranty, AUBO (Beijing) Robotics Technology Co., Ltd. only provides warranty to the flaws and defects in the products and components which are sold to dealers.

AUBO (Beijing) Robotics Technology Co., Ltd. is not responsible for the relevant warranty responsibility to any other express or implied warranty or responsibility, including but not limited to the implied warranty to the merchantability or the specific use. In addition, AUBO (Beijing) Robotics Technology Co., Ltd. is not responsible for any indirect damages and consequences caused by the relevant products.

5. ROBOT HARDWARE COMPOSITION



Figure Figure 5.1 AUBO-i5 robot

As shown in figure 5.1, The AUBO-i5 robot system consist of manipulator, control box(which can choose a variety of models), manipulator base and teach pendant. The manipulator imitates human which has six joints and each joint shows a degree of freedom. As can be seen in figure5.2, manipulator's joint includes The robot base (A), shoulder (B), elbow (C), wrist1(D) ,wrist2(E) and wrist3(F). The manipulator base is used to fix the manipulator. End-effector is used to connect manipulator and tool. Aluminium pipe is used to connect shoulder and elbow or elbow and wrist. Through the AUBOPE user interface or hand-guiding, users can cotrol every joint to turn and move end-effector to any poses.

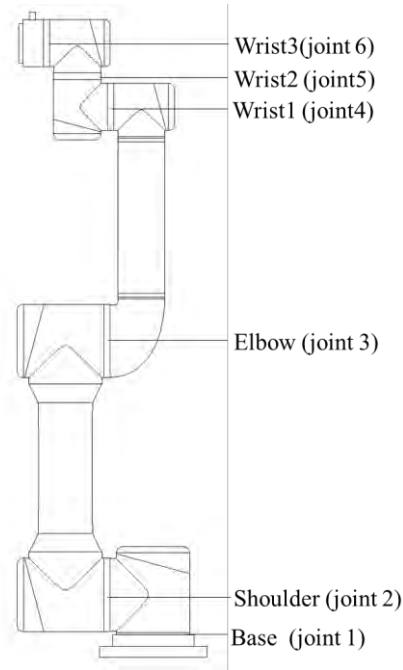


Figure 5.1 Manipulator Joints

Control box is the main control part of AUBO-i5 robot. Please read chapter 8 for any modules inside control box.

AUBO-i5 provides multiple interfaces, there are 4-channel digital I/O and 2-channel analog inputs on end-effector flange. Control box communicates with manipulator by CAN-Bus.

Teach pendant provides a visual interface. Users can test, program and simulate the robot manipulator through the teach pendant with little programming skills.





6. ROBOT INSTALLATION

6.1 Brief installation steps

The installation of AUBO robots includes:

1. Define a robot workspace;
2. Install the robot manipulator on base;
3. Install end-effector

6.2 Important safety instructions

 CAUTION	<p>Installation Conditions :</p> <ul style="list-style-type: none"> •No corrosive gases or liquids •No salt •No mechanical shock, vibration •No radioactive materials •No flammable •Avoid direct sunlight (avoid using outdoor) •No oil mist •No dust or metal powders •No electromagnetic noise •Low humidity •Ambient temperature:0°C ~ 45°C
 CAUTION	<p>Floor carrying capacity :</p> <p>Install manipulator on a hard surface which can undertake at least 10 times heavier than overturning moment of robot base and at least 5 times the weight of the manipulator. Moreover, the surface can't have any tremors. Please read appendix for more precise data of carrying capacity.</p>
 CAUTION	<p>Safety assessment is needed after every installation. Please strict adherence to instructions in chapter 1(Safety).</p>
 CAUTION	<p>Install additional equipment:</p> <p>If any additional modules, like cable, which are not provided by AUBO (Beijing) Robotics Technology Co., Ltd. are integrated in industrial robot, users have responsibility to ensure these modules won't affect safety function.</p>

6.3 Workspace of the Robot

6.3.1 Mechanical dimensions of manipulator

The mechanical dimensions of the manipulator is illustrated in figure 6.1. The robot working range should be firstly considered during installation in case of bumping into people or equipment around.

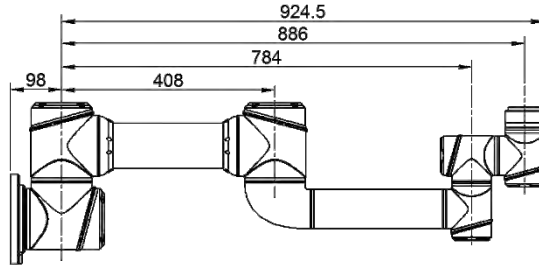


Figure 6.1 AUBO-i5 mechanical dimensions, unit: mm

6.3.2 Effective working range

The workspace of the manipulator, as illustrated in Figure 6.2, is a sphere of radius 886mm except the cylindrical space directly above and directly below the robot base. When choosing installation position, the cylindrical space directly above and directly below the robot base has to be considered. Try to avoid moving tools into this cylindrical space. In practical application, the rotational angle range of joint 1 to joint 6 are $-175^{\circ} \sim +175^{\circ}$.



The robot has to work within the effective workspace.

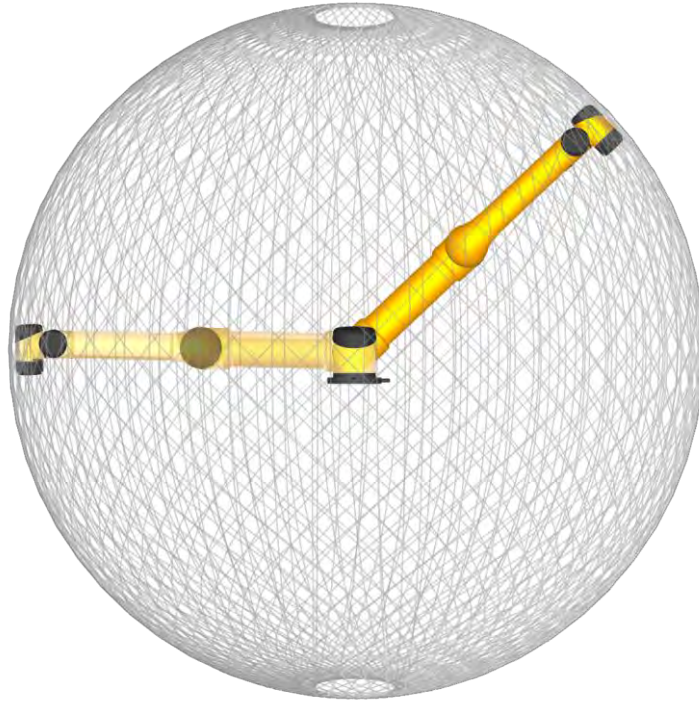


Figure 6.2: AUBO-i5 workspace illustration

6.4 Hardware Installation

6.4.1 The Manipulator Base

AUBO robot manipulator base is shown in figure 6.3.

There are 4 foundation bolts and 4 universal wheels for fixing and moving the robot easily. When fixing the robot, rotate the top of foundation bolt and lower it. When moving the robot, use tool (wrench) to rotate the lower part of foundation bolt and raised the foundation bolt to make the universal wheels touch the ground.



Figure 6.3 Diagram of manipulator base structure

The mechanical dimensions of the manipulator base structure is illustrated in Figure 6.4

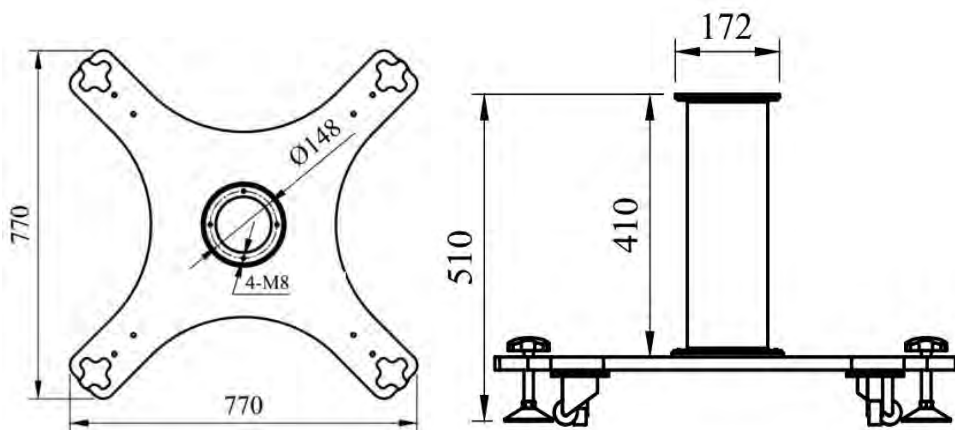


Figure 6.4 Mechanical dimensions of the manipulator base structure (left: plan view; right: front view)

6.4.2 Manipulator Installation

The robot has a function of self-adaption for Installation pose. It can be installed in base, hoisting, mount on wall or any specific installation method, as shown below:

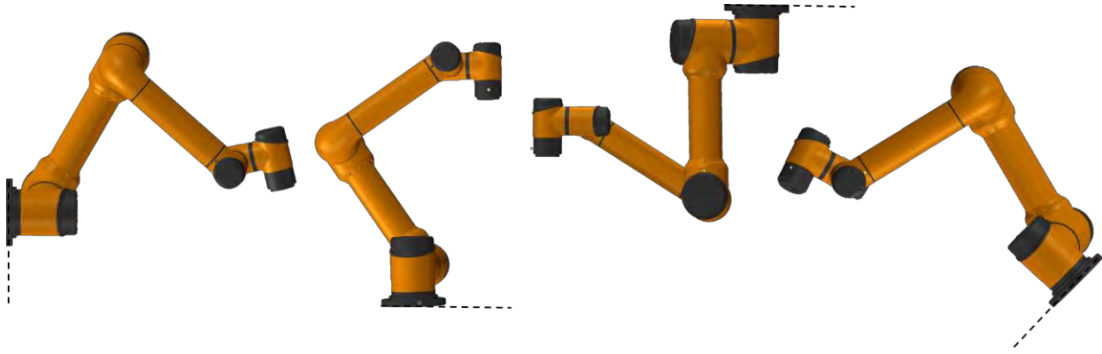


Figure 6.5 Diagram of different installation poses

Use four M8 bolts to fix manipulator on the base. It's recommend to use two -6mm holes to install pins to improve the installation accuracy. Mechanical Dimensions is shown in Figure 6.6.

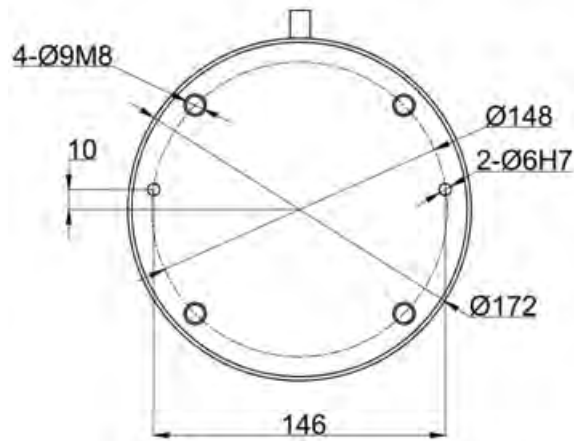


Figure 6.6: Mounting whole size of the manipulator base.

If installation method is changed (such as choosing hoisting, wall-mounted etc.), after running the AUBOPE and click the “ON” ->”OFF”, then teach pendant will pop up this window:

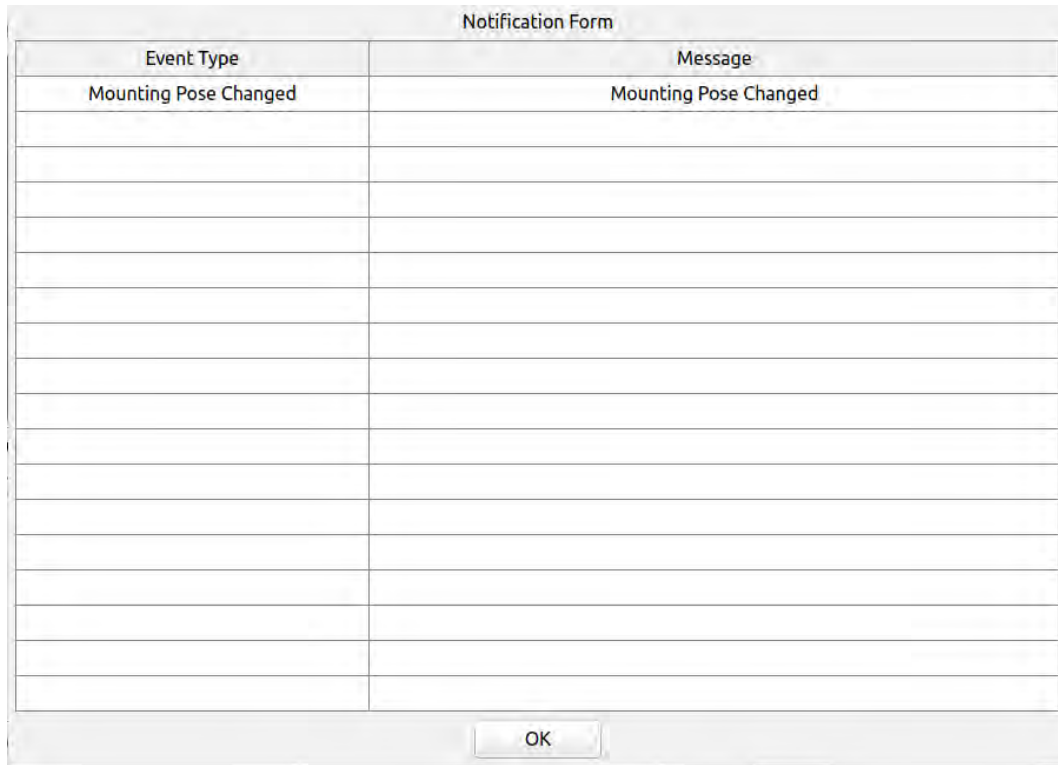





Figure 6.7 Pop window of changing installation position

Under this circumstance, please choose the correct option on the AUBOPE, Otherwise, it may have unpredictable movements in hand-guiding mode.

 DANGER!	Make sure manipulator is installed correctly and safely
 DANGER!	If the robot is bathed in water over an extended time period it might be damaged. The robot should not be mounted in water or in a wet environment unless it has IP67 protection class.
 DANGER!	Tipping hazard. If the robot is not securely placed on a sturdy surface, the robot can fall over and cause an injury.

6.5 End-effector Installation

6.5.1 Mechanical structure size of end-effector flange

End-effector flange has four M6 threaded holes and a $\Phi 6$ positioning hole to fix the fixture on the end conveniently, as illustrated in figure 6.8.

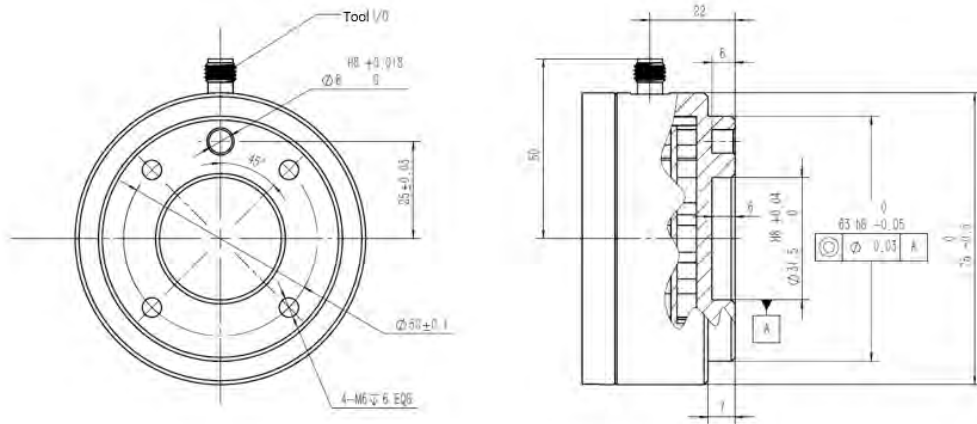


Figure 6.8 Mechanical dimensions of end-effector flange, unit: mm.





1. Make sure the tool is properly and securely bolted in place.
2. Make sure that the tool is constructed such that it cannot create a hazardous situation by dropping a part unexpectedly.

7. GETTING STARTED

7.1 Installation

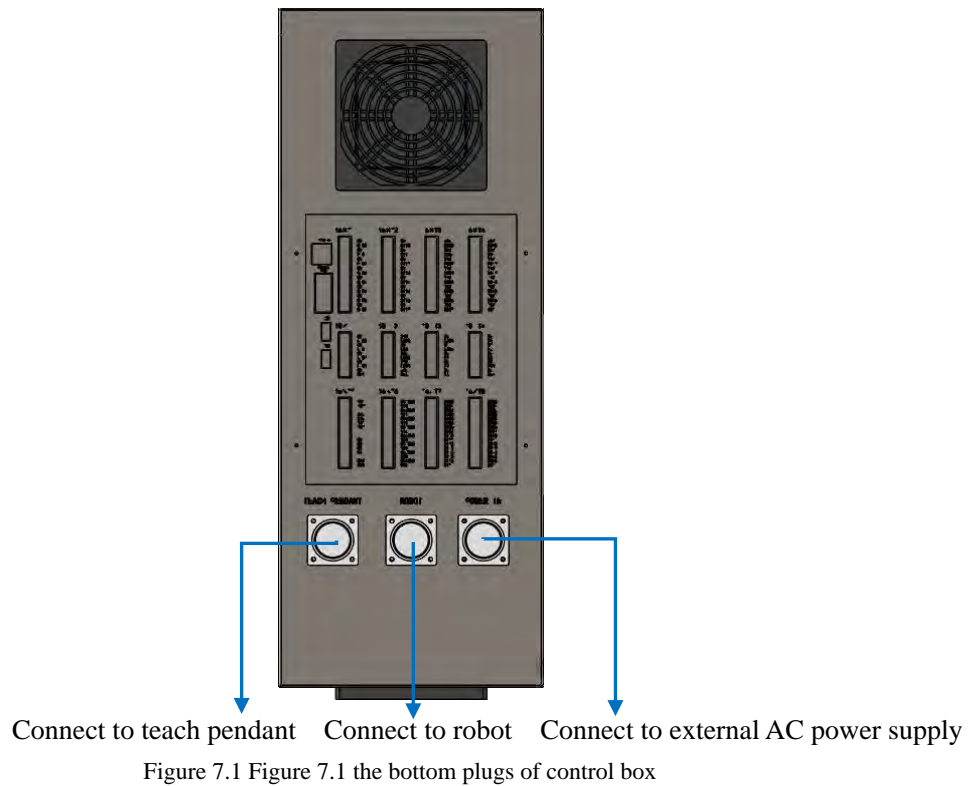
7.1.1 Installing robots

Take out the AUBO robot from the packing box and install it on the base. Please read specific installation instructions in chapter 6: Installation.

 CAUTION	<ol style="list-style-type: none">1. Control box should be placed horizontally on the ground. A clearance of 50mm on each side is needed for sufficient airflow2. The teach pendant can hung on the control box. Make sure that no one can trip over the cable.
 DANGER!	<ol style="list-style-type: none">1. Make sure that the control box, teach pendant, and cables do not come into contact with liquids. A wet control box could cause death.2. The control box and teach pendant must not be exposed to dusty or wet environments that exceed IP20 rating. Pay special attention to environments with conductive dust.

7.1.2 Cable connection

There are three sockets at the bottom of the control box. Put the corresponding cable into socket before use the robot.



a) Robot cable connects to control box

Take out the manipulator from packing box, there is a cable from robot base with an overloaded rectangular connector on the other side. Plug the connector into the control box's connector. Note the insertion direction and locked it properly as illustrated in figure 7.2.



Figure 7.2 Robot cable connects to control box

b) **Robot cable connects to Manipulator**



Figure 7.3 Manipaltor Interface

Before connecting the robot cable to the manipulator, remove the dust cap on the manipulator interface from the socket firstly. Align the pin of the plug and socket with the jack individually, ensure the gap on the socket and the protrusion on the plug is aligned. Then, insert the plug into the socket. Rotate the fastening nut on the plug clockwise until you hear a click, which means that the connection is successful.



Figure 7.4 Manipulator Cable

c) **Teach pendant connection**

The cable of teach pendant is aviation plug on both sides, as shown in figure 7.5.



Figure 7.5 Teach pendant cable

Connect the aviation elbow plug to the control box, as illustrated in figure 7.6. Aviation elbow plug has positioning groove, please note the direction.



Figure 7.6 Connect aviation elbow plug cable to control box

Connect the straight aviation plug to the teach pendant, as illustrated in figure 7.7.



Figure 7.7 Connect straight aviation plug to teach pendant

Fixed the teach pendant on the side of the control box when you are not using it, in order to avoid drop damage, as illustrated in figure 7.8.





Figure 7.8 Suspension of teach pendant

d) Power cable of Control box.

The control box cable with aviation plug and on the two sides, as shown in figure.7.9 below. The method to connect rectangular plug is similar as robot cable. Make sure the power switch in control box is off when connecting power supply.



Figure 7.9 Power cable of control box

	<ol style="list-style-type: none"> 1. Make sure that the robot is grounded correctly (Electrical connection to earth). The grounding conductor shall have at least the current rating of the highest current in the system. 2. Make sure that all cables are connected correctly before the controller box is powered. Always use an original and correct power cord.
	<ol style="list-style-type: none"> 1. Do not disconnect the cable when manipulator is turned on. 2. Do not extend or modify the original power cable.

7.2 Power on the manipulator

7.2.1 Preparation

- Check the connection of manipulator and control box.
- Check the connection of teach pendant and control box.
- Check the connection of power cable and control box.
- Check whether the power switch of the control box is shutdown when robot is unpowered.
- Check whether the emergency stop button of the control box and teach pendant are pop-up.
- Check whether the mode switch key is in right position.
- Ensure the robot never hit any personnel or equipment.

7.2.2 Power on System

a) Power on I series control box

Connect the cable connector to the AC power outlet, then switch the power from OFF to ON to light power indicator.



Figure 7.10 Power switch

b) Power on the teach pendant and manipulator

- Turn the key switch to the manual mode (manipulator has two working modes: manual mode, linkage mode. Please read chapter 8.4.4 for more instructions).
- Wait for STANDBY lights steady and enters the standby state.
- Press start up button on the upper left of teach pendant for about 1s to light the blue light. Robot and teach pendant power-on at same time and the screen of teach pendant lights up.
- The startup button and the state of LED indicator is illustrated in figure 7.11




Figure 7.11 the start button and LED indicator

7.3 Power off the manipulator

Power off order: First, power off the robot and teach pendant, then power off the control box.

a) Power off the manipulator and teach pendant.

- 1 Normal exit: click the shutdown button on the upper right of the screen .
- 1 Mandatory shutdown: Press and hold the startup button on the upper left of the teach pendant for about 5s to turn off blue light, then the teach pendant and manipulator will power off.

b) Power off the control box.

Turn the power switch of the control box to OFF position.



- 1. Shutting down by pulling the power cord from the wall socket may cause corruption of the robot's file system, which may result in robot malfunction.
- 2. Ensure to unplug the power cord after power off the whole robot system!

8. THE I SERIES STANDARD CONTROL BOX

8.1 Introduction

Control box is the control center of AUBO robot, which contains the control board, safety control board, switching power supply and safety protection device. It powered by 100V-240V AC. It has 2 internal switching power supplies which turn 100V-240V AC into 12V, 24V and 48V DC power for the load inside control box and the robot. Therefore, the connection between the robot and teach pendant or the control box has to be checked firmly and reliably before use.




Control box is designed with hardware protection and software protection to ensure the security in the greatest degree when use. Using a plurality of circuit breaker inside the control box plays a reliable role in short-circuit and overload protection on the hardware. With emergency stop switch in both control box and teach pendant, users can cut off robot's power in shortest time to protect personnel and equipment.



Figure 8.1 I Series Standard control box

8.2 Electrical warnings and cautions

The following warnings and cautions must be observed when a robot and control box application is designed and installed. The warnings and cautions also apply for service work.

 WARNING	<p>Never connect safety signals to a PLC which does not fulfill with the requirements of a correct safety level. Failure to follow this warning could invalidate safe stop function which result in serious injury or death.</p>
 DANGER!	<ol style="list-style-type: none">1. Make sure that all non-waterproof equipment remains dry. If water comes inside the product, lockout and tag out all power and then contact your supplier.2. Use original cables supplied with the robot only. Do not use the robot for applications where the cables will be subjected to flexing. Contact your supplier if longer or flexible cables are needed.3. All mentioned GND connections are only for powering and signaling. For Protective Earth (PE) use the screw connections marked with earth symbols inside the control box. The grounding conductor shall have at least the current rating of the highest current in the system.4. Care must be taken when installing interface cables to the robot I/O.
 NOTICE	<ol style="list-style-type: none">1. Higher than the level specified in the standard IEC interfering signal will cause the abnormal behavior of the robot. Very high signal levels or excessive exposure can damage the robot permanently. EMC problems are found to happen usually in welding processes and are normally prompted by error messages in the log. AUBO (Beijing) Robotics Technology Co., Ltd is not responsible for the loss caused by the EMC problem.2. I/O cables going from the control box to other machinery and factory equipment may not be longer than 30m, unless extended tests are performed.

8.3 I series control box's Internal Electrical Interface

8.3.1 Introduction

AUBO robot I series standard control box provides a variety of electrical interfaces to connect the external equipment and tools. Users can easily use these interfaces.

The electrical interface of the control cabinet is divided into: safety I/O and general I/O. The AUBO interface board has 16 general digital input interfaces, 16 general digital output interfaces, 4 pairs of analog voltage input interfaces, 2 pairs of analog voltage output interfaces and 2 pairs of analog current output interface. The electrical errors is about $\pm 1\%$.

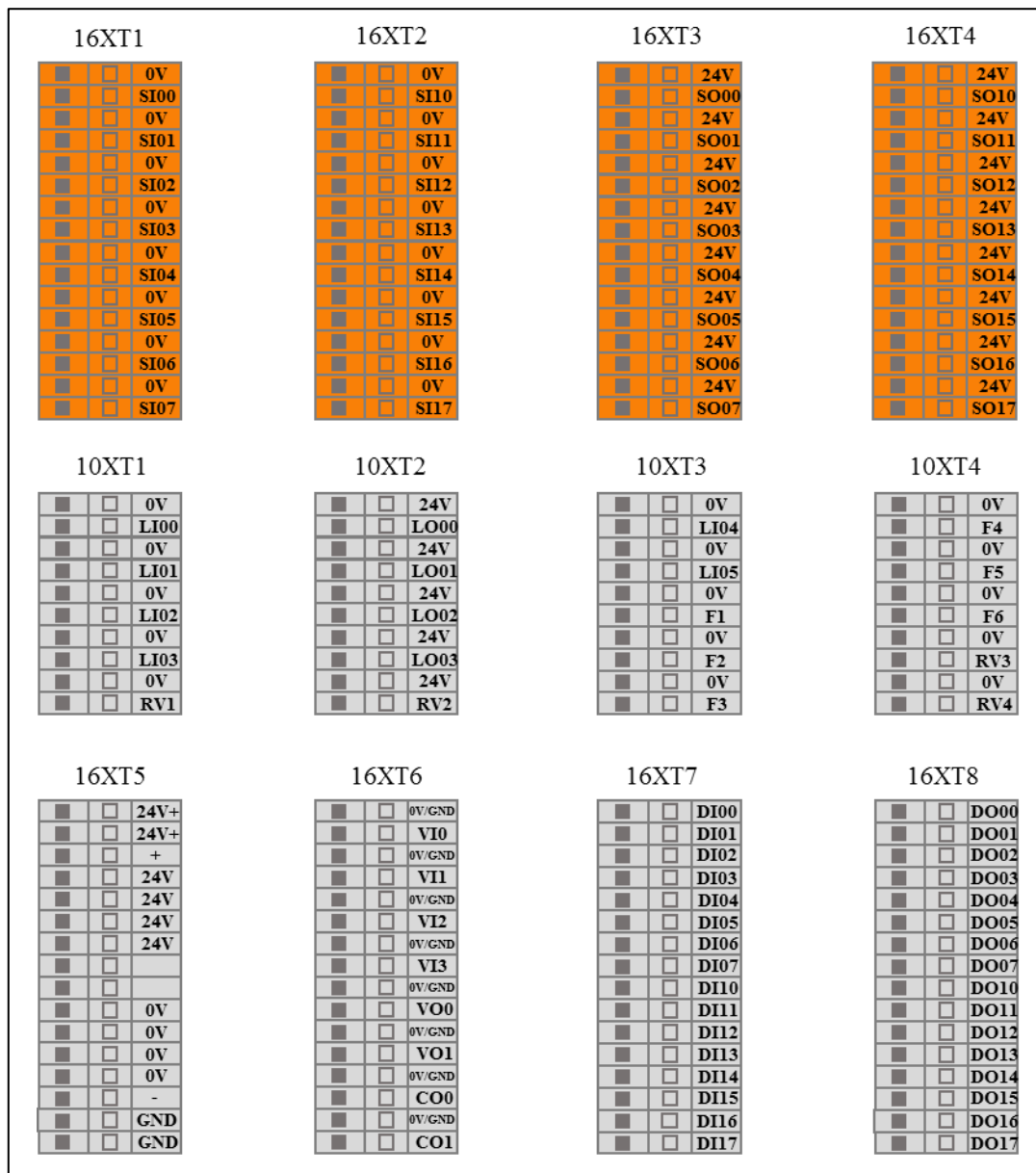


Figure 8.2 IO Layout of Control Box

Control Box IO chose internal power supply by default, as shown below:

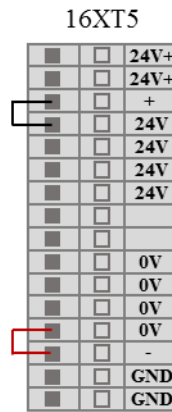


Figure 8.3 Internal Power Supply

If user want to use an external power supply, please use the following wiring way:

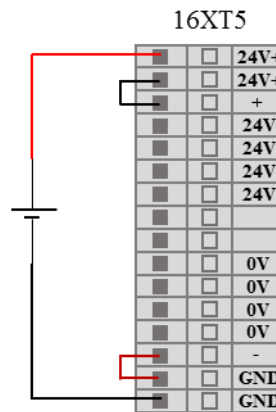


Figure 8.4 External Power Supply



The control box must be powered down when wiring with the control box IO.

8.3.2 Safety I/O

The safety I/O designed as dual channel (redundant design) to ensure the safety function shall not lost in any case of single failure. In use, the safety devices and equipment must be implemented in accordance with the safety instructions, and finished the comprehensive risk assessment before use.



1. Never connect safety signals to unsafety PLC which is not in correct safety level
2. Keep separating the safety I/O signal with normal I/O signal
3. All safety-related I/O are dual-channel which can ensure a signal fault cannot cause the losing of safety function.
4. Ensure to check the safety function before using the robot, and the safety function must be tested regularly.

The safety I/O are orange color in the external panel of the control box. The safety functions are defined as follows:

Input	SI00	SI10	External Emergency Stop	SI04	SI14	Enabling Device
	SI01	SI11	Safeguard Stop	SI05	SI15	Operational Mode
	SI02	SI12	Reduced Mode Input	SI06	SI16	Hand Guiding Enable
	SI03	SI13	Safeguard Stop Reset	SI07	SI17	System Stop Input
Output	SO00	SO10	Robot Emergency Stop	SO04	SO14	Not Reduced Mode
	SO01	SO11	Robot Moving	SO05	SO15	System Error
	SO02	SO12	Robot Not Stopping	SO06	SO16	BACKUP(Unavailable For User)
	SO03	SO13	Reduced Mode	SO07	SO17	BACKUP(Unavailable For User)

Safety related electrical input

Safety Input Functions	Worst Case		
	Detection time	Power off time	Response time
External Emergency Stop	100ms	1200ms	1300ms
Safeguard Stop	100ms	—	1200ms
Reduced Mode Input	100ms	—	1200ms
Safeguard Stop Reset	100ms	—	1200ms
Enabling Device	100ms	—	1200ms
Operational Mode	100ms	—	1200ms
Teach Pendant Emergency Stop	100ms	1200ms	1300ms
System Stop Input	100ms	—	1200ms

Safety-related electrical outputs

Safety Output	Worst case responding time	Safety Output	Worst case responding time
Robot Emergency Stop	1000ms	REDUCED MODE	1000ms
Robot Moving	1000ms	NOT REDUCED MODE	1000ms
Robot Not Stopping	1000ms	SYSTEM ERROR	1000ms

8.3.2.1 Default Safety Configuration

The robot is shipped with a default configuration as below. In this case, the robot can be operated without any additional safety equipment

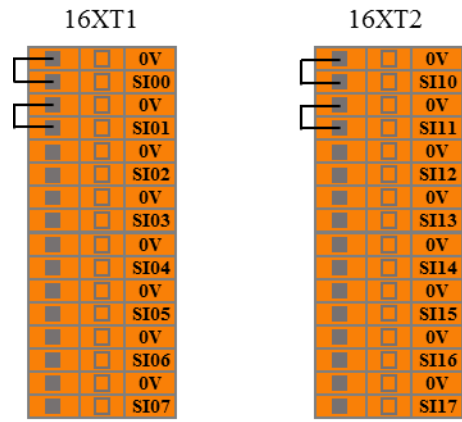


Figure 8.5 Default safety configuration

8.3.2.2 External Emergency Stop Input

In the case there is required to use one or more external emergency stop buttons, users can connect those devices as below.

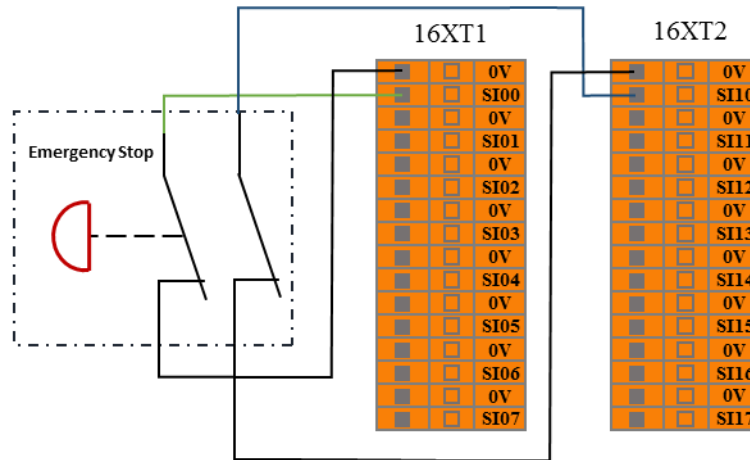


Figure 8.6 External emergency stop input

8.3.2.3 Safeguard stop Input

Users can connect external safety devices (such as safety light curtains, safety laser scanners, etc.) through this interface, then control the manipulator enter into the safeguard stop state, and stop the movement of the manipulator.

When configuring the auto-reset safeguard stop, the user can refer to the following example, using the safety light curtain to connect to the safeguard stop input interface. See below.

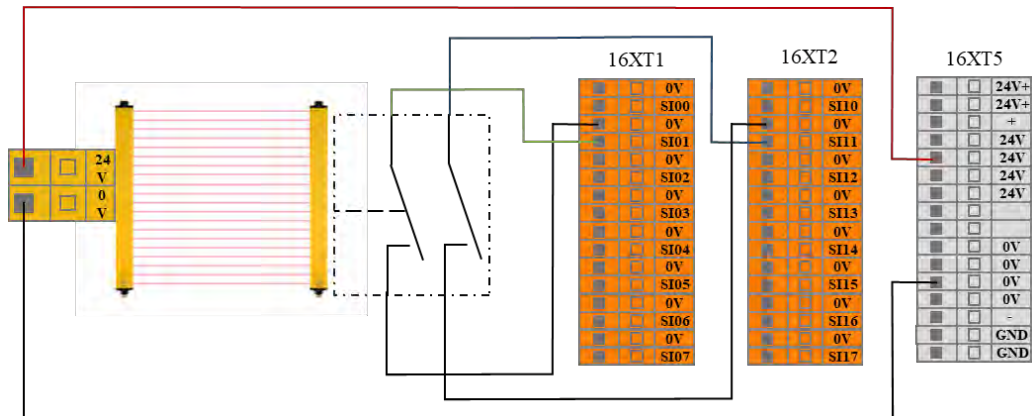


Figure 8.7 Safeguard stop input (Internal Power Supply)

After the operator enters into the safety zone, the robot stops moving and maintains category 2 stop. After the operator leaves the safety zone, the robot starts automatically from the waypoint which it stopped.

During this process, there is no need to use protective reset input.



In this configuration, user should select the protective reset as auto-reset via AUBOPE.

When configuring the safeguard stop with reset button, the user can refer to the following example, using the safety light curtain to connect to the safeguard stop input interface. See below.

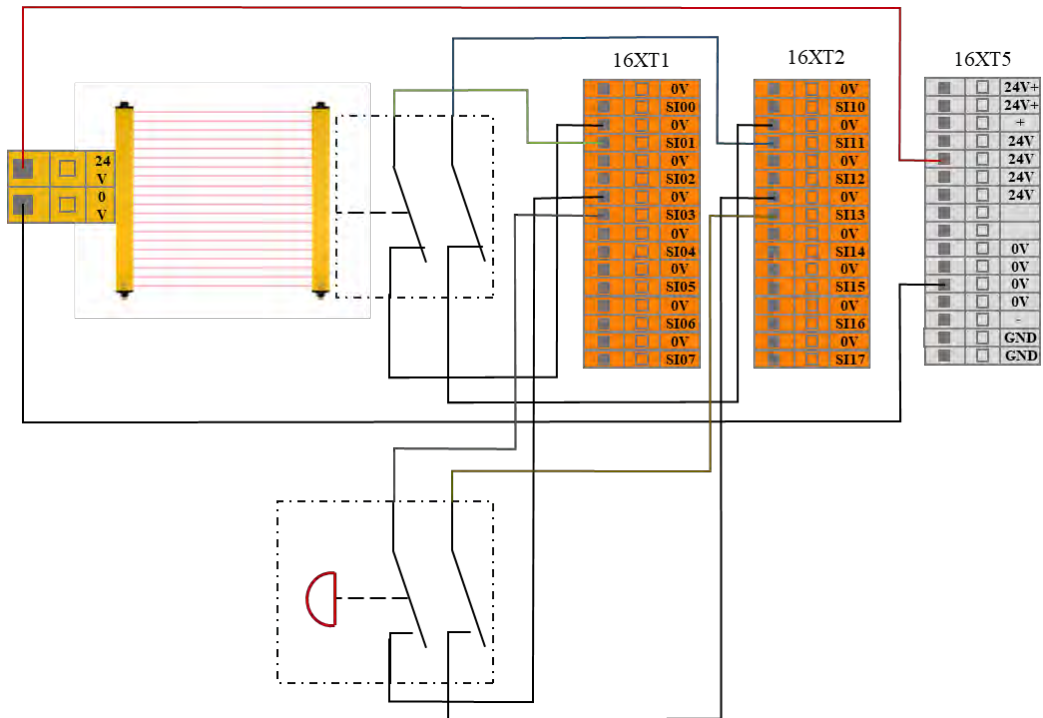



Figure 8.8 Safeguard stop input (Internal Power Supply)

After the operator enters into the safety zone, the robot stops moving and maintains category 2 stop. The operator leaves the safety zone, needs to be removed from the outside of the safety zone, reset the robot arm by resetting the button, and then click on the AUBOPE to run. The robot continues to run from the stop point. In this process, you need to use the protection reset input. After the operator leaves the safety zone, a reset outside the safety perimeter is required. Then click run on the AUBOPE, the robot starts from the waypoint which it stopped. During this process, a protective reset input is required.



In this configuration, user should select the protective reset as manual reset via AUBOPE.

8.3.2.4 Reduce Mode Input

The user can use this interface to control the manipulator enter into the reduced mode. In the mode, the motion parameters (joint speed, TCP speed) of the manipulator are limited to the user-defined reduced mode range.

The user can refer to the following example, using a safety mat to connect to the reduced mode input interface. See the next figure.

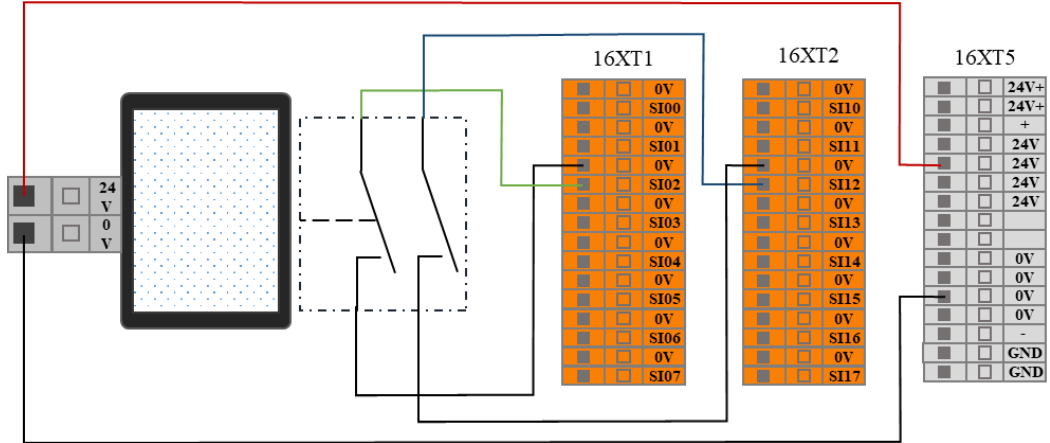



Figure 8.9 Reduced mode input connection

When the operator enters into the safety zone, the robot enters into the reduction mode, and the motion parameters (joint speed, TCP speed) of the manipulator are limited to the user-defined reduced mode range. After the operator leaves the safety zone, the manipulator exits the reduced mode, enters into the normal mode, and the robot moves normally.



When using this type of configuration, the user needs to configure the reduced mode motion parameters through the AUBOPE.

8.3.2.5 Safeguard stop Reset Input

When configure the safeguard stop with reset device, Users can use this interface to connect external reset devices (reset buttons, etc.). Refer to the following example, connect the safety light curtain to the safeguard stop input terminal and use the safety reset button to connect to the safeguard stop reset input terminal. See the next figure.

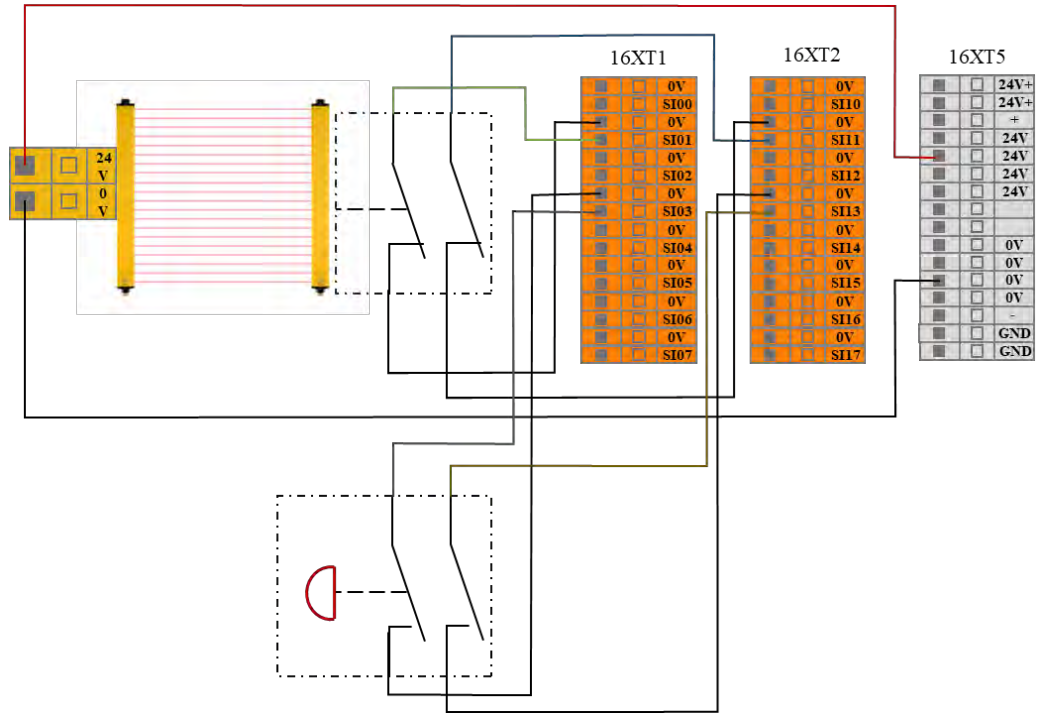


Figure 8.10 Safeguard stop Reset Input connection (Internal power supply)

After the operator enters the safety zone, the robot stops moving and maintains at category 2 stop. When the operator leaves the safety zone, it is necessary to reset the manipulator from the outside of the safety zone and reset the button. The robot continues to run from the stop point. In this process, user need to use the safeguard stop reset input.



When using this type of configuration, the user needs to configure the protective reset as manual reset through the AUBOPE.

8.3.2.6 Enabling Device Input

Users can use this interface, connect external safety devices (such as three-position enabling switch, etc.), used to verify the project. The user can refer to the following example, using the three-position enabling switch to connect the enabling device input interface. See the next figure.

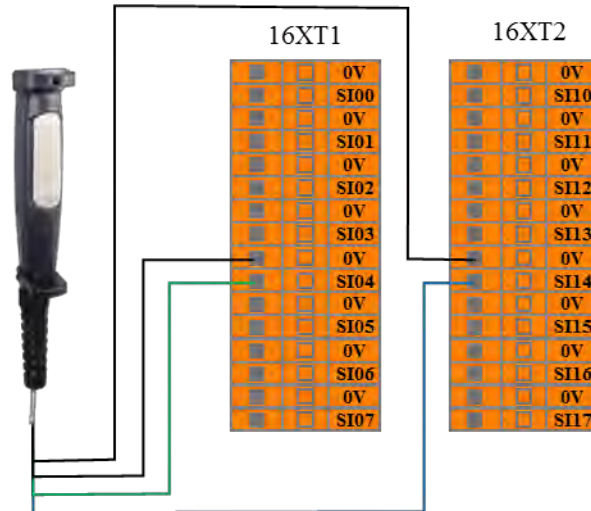


Figure 8.11 Enabling device input connection

In the verify mode, the robot starts to move when the three-position enable switch is in the enable position (intermediate position); when the user releases or presses the three-position enable switch, the three-position enable switch is in the non-enabled position, The manipulator stops moving.



When using such a configuration, the user is required to ensure that the robot is in verification mode. Users can configure the operating mode through AUBOPE to verification mode, or also through the operation mode input configure the robot to verification mode

8.3.2.7 Operational Mode Input

Users can use this interface, connect an external safety device (mode selector switch, etc.), select the robot working mode. The user can refer to the following example, using the safety selector switch connect to the operation mode input interface. See the next figure.

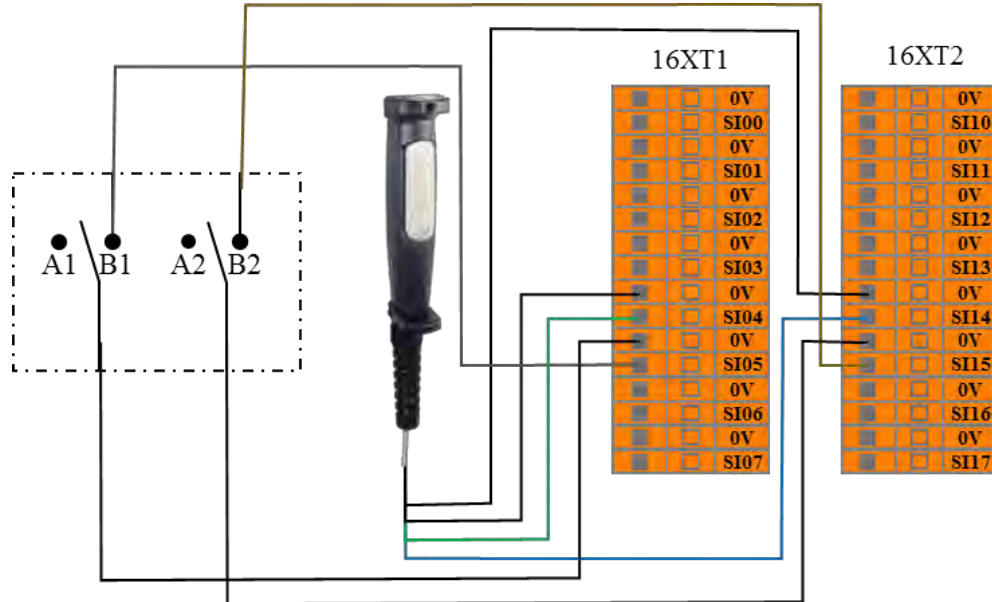


Figure 8.12 operation mode input connection

When the user switches the selector switch to the A position, the robot enters the normal mode, and the user can use the robot normally. When the user switches the selector switch to the B position, the robot enters the verification mode. In this mode, only when the enabling device input is valid, the manipulator executes the verification project and operates normally. When the enabling device input is invalid, the robot stops immediately.

8.3.2.8 System Stop Input

Users can use this interface to receive external stop signal input, control the robot enters into a category 1 stop. This input can be used in multi-machines collaboration mode, by setting a common emergency stop line, and sharing emergency stop with other machines. The operator can use the emergency stop button of one machine to control the entire line of the machine into an emergency stop state. The user can refer to the following example, the two robot share the emergency stop function, in this system, the emergency stop output connected to the system stop input terminal. See the next figure.

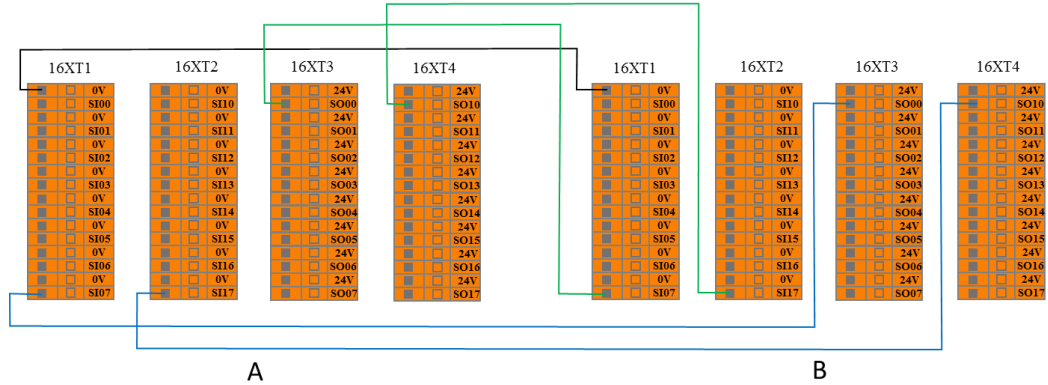


Figure 8.13 system stop input connection

When one of them enters into the emergency stop state, the other will immediately enter into the emergency stop state, to achieve the function of two machines share emergency stop

8.3.2.9 Robot Emergency Stop Output

The user can use this interface, when the robot into the emergency stop state, it will output a emergency stop signal. The user can refer to the following example, connect the external alarm light to the system emergency stop output interface. See the next figure.

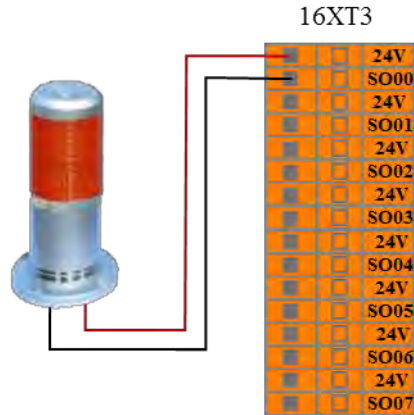


Figure 8.14 robot emergency stop output connection

In this configuration, when the robot enters the emergency stop state, it outputs a system emergency stop signal, the external alarm light.



This function is widely used and, in any case, requires a complete risk assessment by user or Integrator.

8.3.2.10 Robot Moving Output

The user can through this interface, when the robot moves normally, it outputs the robot moving signal to the outside. The user can refer to the following example, connect the external indicator to the robot moving output interface. See the next figure.

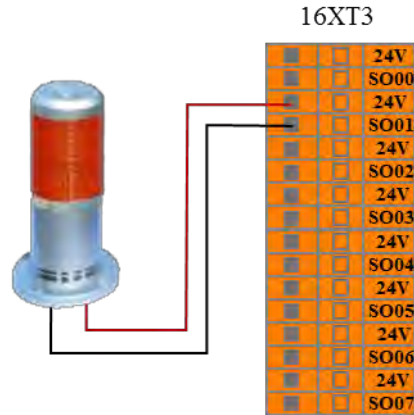


Figure 8.15 Figure robot moving output connection

In this configuration, when the robot moves normally, it outputs the robot moving signal to the outside, and the external robot moving status indicator lights.



This function is widely used and, in any case, requires a complete risk assessment by user or Integrator.

8.3.2.11 Robot Not Stopping Output

The user can through this interface, when the robot receives the stop signal and decelerates the moving, has not yet completely stopped, it outputs a robot not stopping signal. The user can refer to the following example, connect the external indicator to the robot not stopping output interface. See the next figure.

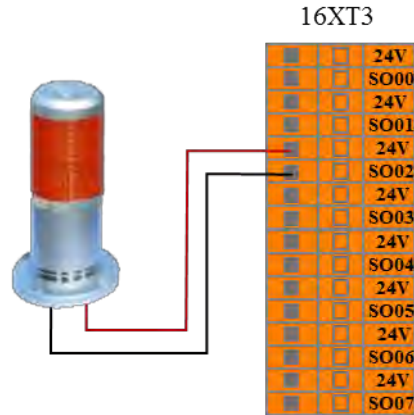


Figure 8.16 robot not stopping output connection

In this configuration, when the robot receives the stop signal and decelerates the moving, has not yet completely stopped, it outputs a robot not stopping signal, and the external robot not stopping status indicator lights.



This function is widely used and, in any case, requires a complete risk assessment by user or Integrator.

8.3.2.12 Reduced Mode Output

The user can use this interface to output a reduced mode signal to the external when the robot enters into the reduced mode. The user can refer to the following example, connect the external indicator to the reduced mode output interface. See the next figure.

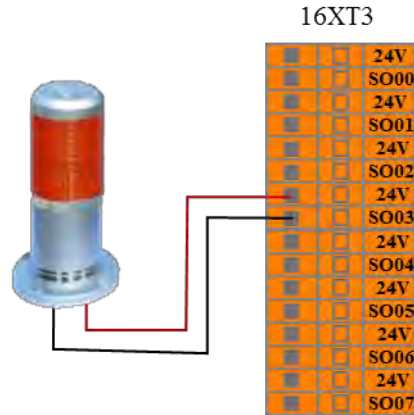



Figure 8.17 reduced mode output connection

In this configuration, when the robot enters into the reduced mode, it outputs a reduced mode signal and the external reduction mode indicator lights



This function is widely used and, in any case, requires a complete risk assessment by user or Integrator.

8.3.2.13 Not Reduced Mode Output

The user can use this interface to output a not reduced mode signal to the external when the robot enters into the not reduced mode. The user can refer to the following example, connect the external indicator to the not reduced mode output interface. See the next figure.

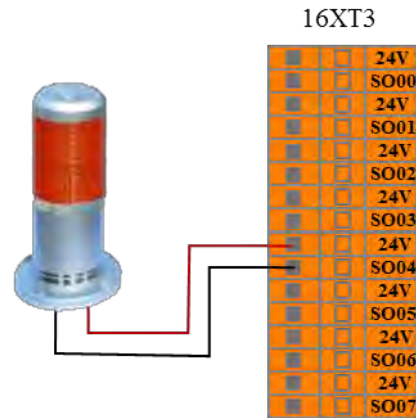


Figure 8.18 not reduced mode output connection

In this configuration, when the robot enters into the not reduced mode, it outputs a not reduced mode signal and the external not reduction mode indicator lights



This function is widely used and, in any case, requires a complete risk assessment by user or Integrator.

8.3.2.14 System Error Output

The user can use this interface, and when the robot system is error, it outputs a system error signal to the outside. The user can refer to the following example, connect the external indicator to the system error output interface. See the next figure.

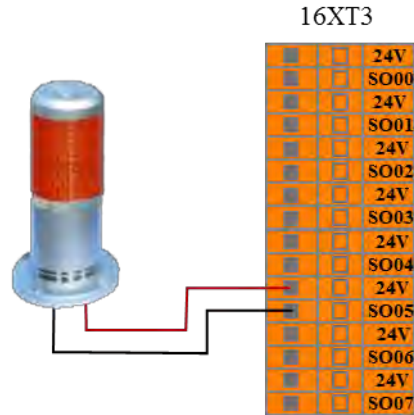


Figure 8.19 System error output connection

In this configuration, when the robot system error alarm, it outputs a system error signal, the external system error indicator light.



This function is widely used and, in any case, requires a complete risk assessment by user or Integrator.

8.3.3 Internal I/O

Control cabinet internal IO for the internal function interface, not open to the user. The IO function of the control cabinet is shown in the following table:

Input	Function
CI00	Linkage/Manual
CI01	Host/Slave
CI02	Power Contactor For Manipulator
CI03	Control Box Emergency Stop
CI10	Manipulator On
CI11	Manipulator Off
CI12	Power Contactor For Manipulator
CI13	Control Box Emergency Stop
Output	Function
CO00	Stand By
CO01	Emergency Stop
CO02	Linkage/Manual
CO03	AUBOPE Running
CO10	Back Up
CO11	Emergency Stop
CO12	Back Up
CO13	Back Up

8.3.4 General I/O electrical interface

The AUBO interface board has 16 digital input interfaces, 16 digital output interfaces, 4 pairs of analog differential input interfaces, 2 pairs of analog voltage output interfaces and 2 pairs of analog current output interfaces whose electrical errors is about $\pm 1\%$.

The following table lists the function definitions of the various I/O. Users must be in accordance with the requirements in the table. In addition, users should note that buttons and switches on control panel occupy part of the I/O.

Linkage mode I/O

Input	LI00	LINKAGE-START	LI03	LINKAGE-INITIAL POSITION
	LI01	LINGKAGE-STOP	LI04	LINKAGE-REMOTE POWER ON
	LI02	LINKAGE-PAUSE	LI05	LINKAGE-REMOTE POWER OFF
Output	LO00	LINKAGE-OPERATING	LO02	LINKAGE-PAUSE
	LO01	LINKAGE-STOP	LO03	LINKAGE-INITIAL POSITION

The default project selection IO: F1-F6, the user can by setting F1-F6 different input signal, configure up to 64 IO combination signal.

Digital input and output available for user:

Input	DI00	DI01	DI02	DI03	DI04	DI05	DI06	DI07
	DI10	DI11	DI12	DI13	DI14	DI15	DI16	DI17
Output	DO00	DO01	DO02	DO03	DO04	DO05	DO06	DO07
	DO10	DO11	DO12	DO13	DO14	DO15	DO16	DO17

Users can control the above IOs through the AUBOPE online programming, the general digital input and output interface electrical parameters are as follows:

DI	Input form	P-lesend No-voltage contact input NPN open collector transistor
	Input method	Input signal current
	Electrical specifications	5mA/DC24V
DO	Output form	Transistor (P-lesend type)
	Electrical specifications	300mA/DC24V

Analog input and output available for user:

Input	VI0	Analog voltage input	VI2	Analog voltage input
	VI1	Analog voltage input	VI3	Analog voltage input
Output	VO0	Analog voltage output	CO0	Analog current output
	VO1	Analog voltage output	CO1	Analog current output

Among them, the voltage input and output range of 0 ~ +10 V, accuracy of $\pm 1\%$; current output range of 0 ~ 20mA, accuracy of $\pm 1\%$.

Internal power supply:

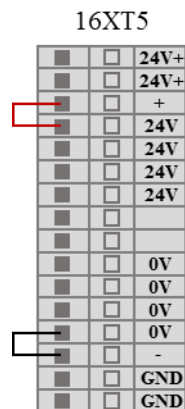


Figure 8.20 Internal power supply

External power supply:

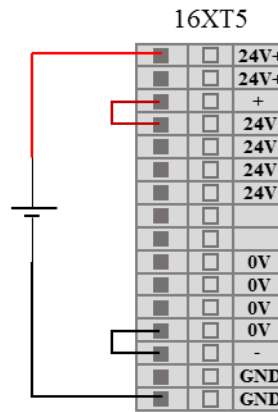


Figure 8.21 External power supply

1、 Digital input

Interface board has 16 digital inputs (Hereinafter use "DI" to represent digital input). They work as NPN, which means input low voltage to DI trigger action, input high voltage to DI does not trigger action.

DI terminal can read the switch button, sensors, PLC or other AUBO robot operation signals. Some common wiring will be listed in following examples.

Some common wiring will be listed in following examples.

1) DI connect to button switch

As shown in figure 8.11, DI through a normally open button connected to ground (G). When the button is pressed, DI and GND is connected, which is equivalent to inputting low voltage to DI and triggering action. When the button is not pressed, DI and GND is disconnected and won't trigger action. This is the easiest wiring example.

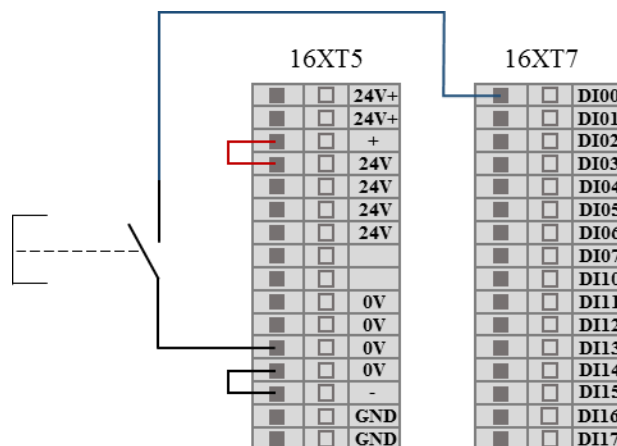


Figure 8.22 DI DI connect to button switch

2) DI connect to two-terminal sensor

As shown in figure 8.12, the DI and GND are connected to a sensor. If the voltage difference between

OUT and GND is very small when sensor working, it can trigger action too. When the sensor does not work and the circuit is disconnected, it does not trigger action.

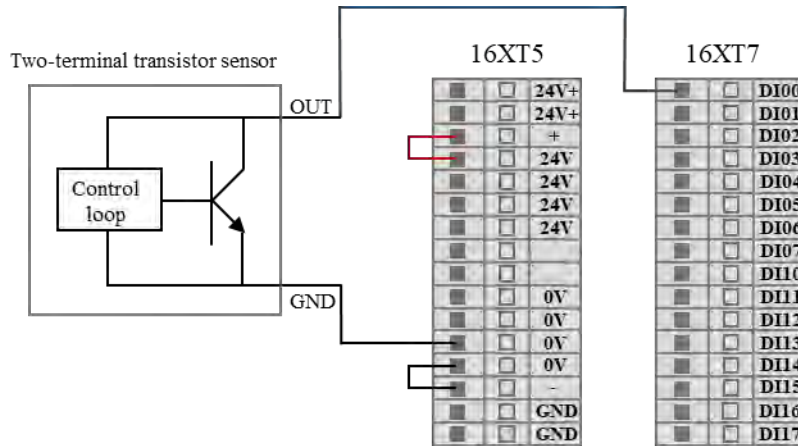


Figure 8.23 DI connect to two-terminal sensor

Electrical parameters of DI are as follows :

Parameter term	minimum value	Maximum value
Single DI input voltage	0 V	24 V

a) Digital output

Interface board has 16 digital outputs (Hereinafter use "DO" to represent digital output). They work as NPN as shown in figure 8.13. When given a logical "1", DO is connect to GND, outputting low. When given a logic "0", DO is connect to GND, outputting high.

DO terminals can be connected directly to the load, communicate with other PLC or robot.

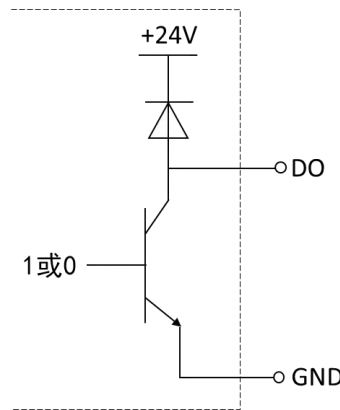


Figure 8.24 DO NPN Operating Mode

DO terminal connect to load as shown in figure below:

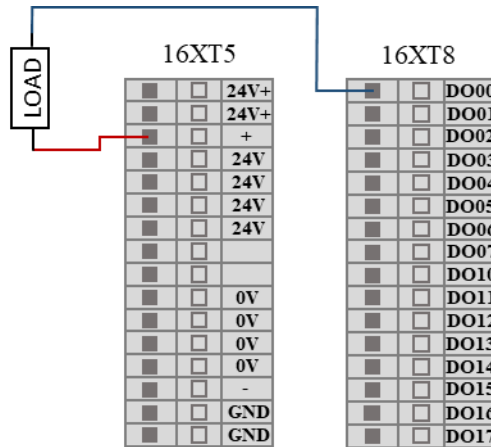


Figure 8.25 DO connect to load

b) Analog input

The control box has four pairs of differential analog input interfaces (Hereinafter use "VI" to represent analog voltage input), input voltage range:0V~+10V, as is shown in figure below

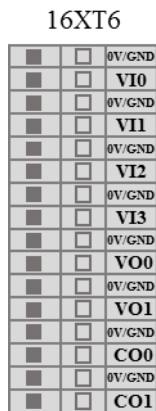


Figure 8.26 4Analog input

External sensor wiring:

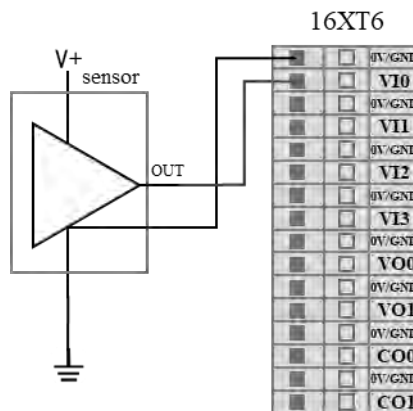


Figure 8.27 connect to sensor

VI electrical specification

Parameter term	Minimum value	Maximum value	Unit
Input voltage	0	+10	V
Input resistance	100K		Ω
VI sampling resolution	12		BITS
VI sampling accuracy	10		BITS

c) Analog Output

Interface board has two analog voltage outputs and two analog current outputs, denoted as VO and CO respectively.

The common analog voltage output connection methods are listed below.

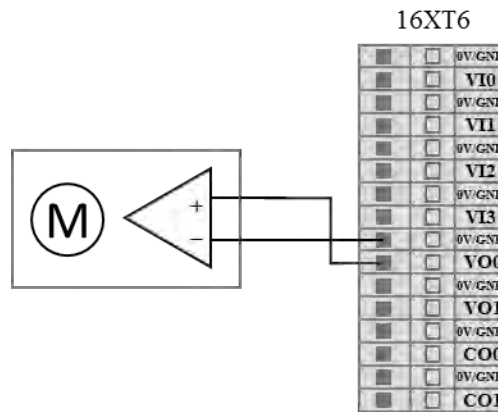


Figure 8.28 Analog output drive differential device

The common analog current output connection methods are listed below.

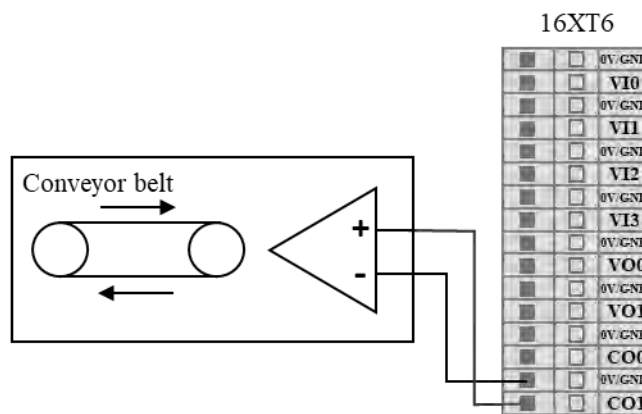


Figure 8.29 Analog current output connect to current source

Analog output electrical specification

Parameter term	minimum value	Maximum value
Single VO terminal input voltage	0V	+10 V
Single CO terminal input current	0mA	20 mA

**WARNING**

When connecting external devices, all external devices should be common ground with the control cabinet.

8.3.5 End-effector I/O interface

There is a 8-pins mini connector on end-effector, which electrical error is about $\pm 10\%$, to provide power and control signals to specific tools (Holder for example) used in end. Wiring as shown below.

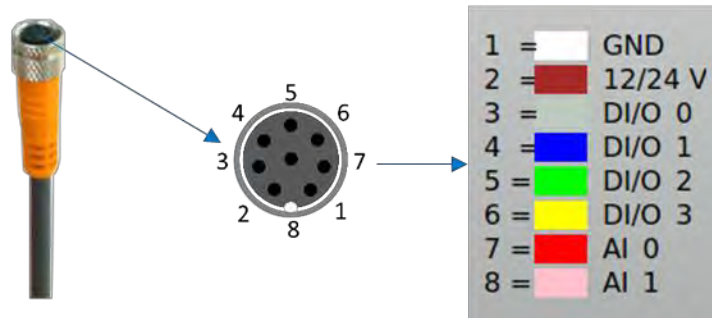


Figure 8.21 connecting cables

The eight wires inside the Lumberg RKMV 8-354 industrial cable have different colors. The different colors designate different functions, see table below:

Pin	Color	Signal
1	White	GND
2	Brown	12/24V
3	Gray	DI/O 0
4	Blue	DI/O 1
5	Green	DI/O 2
6	Yellow	DI/O 3
7	Red	AI 0
8	Pink	AI 1



Construct tools and gripper so that an interruption of power does not create any hazards.
E.g. a work-piece falling out of the tool.

8.3.6 Communication Interface

The back of control box provides Ethernet interface, Modbus-RTU, USB interface, I/O and, as shown below.

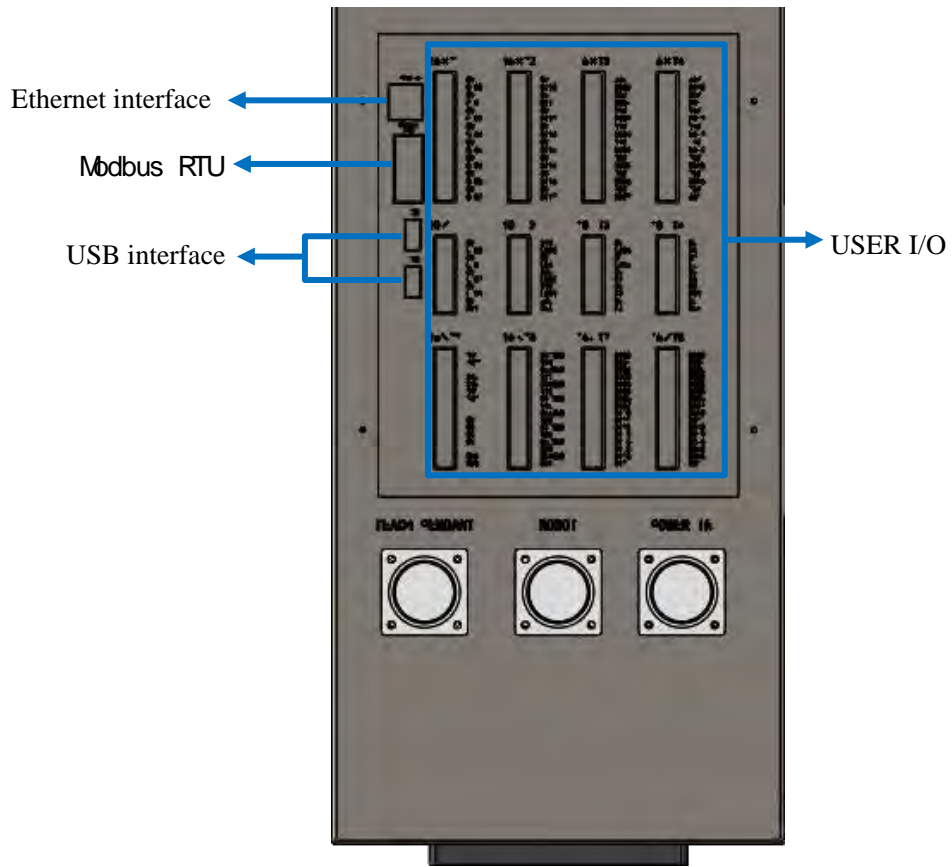


Figure 8.22 Back panel of control box

Application:

- 1 Ethernet interface can be used for remote access and control.
- 1 USB interface can be used to update, import and export project.
- 1 Modbus-RTU for external communication
- 1 External I/O



Never insert or remove the USB device when the manipulator is running

8.4 Getting Started

8.4.1 Safety

As shown in figure 8.2, the red frames are danger zone with 100-240V AC and 48V DC. Never fix screws

or touch any mental components by hands directly and never remove live wiring. Non-professionals do not open the control box.

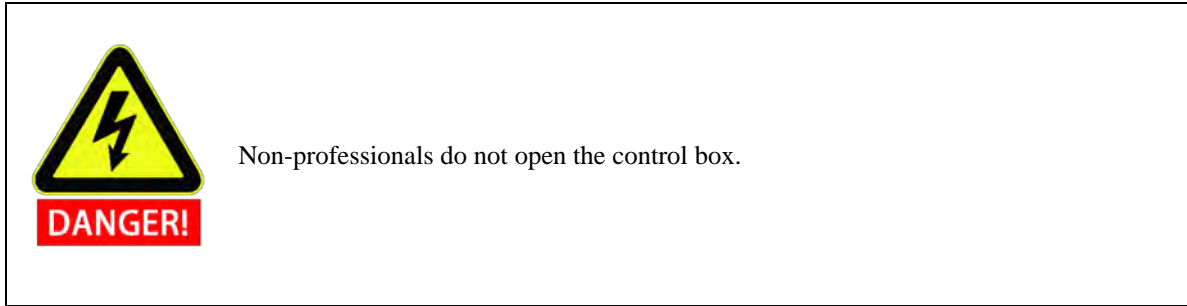


Figure 8.23 High voltage region inside I series control box.

8.4.2 Notes before use

- 1 Check whether the control box power connectors are connected correctly.
- 1 Check whether the control box and the robot is connected correctly.
- 1 Check whether the control box and teach pendant is connected correctly.
- 1 Check whether the control box connectors are connected correctly.
- 1 Check foundation bolt on control box support firmly and horizontally.
- 1 There are 100V-240V AC and 48V DC hazardous voltage inside, non-professionals do not open the box.

8.4.3 Control box panel

The layout of the control box front panel is shown in figure below



Figure 8.24 Schematic diagram of the control box front panel button

Functions of panel switches, buttons and indicator are shown in the following table:

Name	Function
POWER SWITCH	The main power switch. ON is energized state, OFF is power-off state.
EMERGENCY	Emergency stop button. Press to power off the manipulator in emergency situations.
STANDBY	The indicator lights indicates that the program of control box interface board initialized completely, presses the teach pendant power button to power on the robot.
POWER	The indicator lights indicates that the control box has been powered on.
EMERGENCY STOP	The indicator lights indicates that the robot is in a state of emergency stop.
MODE MANUAL/LINKAGE	Selection of manual and linkage mode. Pressed as linkage mode
MANIPULATOR ON	The indicator lights indicates when the manipulator has been powered on
TEACH PENDANT ENABLE	Indicator of Teach pendant enable status. Indicator lights in Manual mode. In linkage mode, teach pendant disable when indicator off.

8.4.4 Manual mode and linkage mode

The manipulator has two working modes, manual mode and linkage mode, which can be selected through the button. When changing manipulator operating mode, users have to press the button to appointed operating mode after cutting off the power, then restart the manipulator.

8.4.4.1 Manual mode

In manual mode, the external signal from linkage mode IO cannot control manipulator. It's usually applied to operation that only one manipulator works.

- 1 Startup: Power on the control box firstly, after the standby indicator lights, press the startup button on teach pendant for 1s to power up robot.
- 1 Force control button: in teaching mode, hold on the force control button to the center position and drag the end of the robot to target position, then release the button.
- 1 Emergency stop: Press the emergency stop button on control box or teach pendant to power off robot. Rotate emergency stop button to re-power robot according to teach pendant programming interface.
- 1 Shutdown: Normal exit: Click the close button on the upper right of the teach pendant interface.
Mandatory shutdown: Press and hold start up button on the upper left of the teach pendant for about 3s. The blue light off indicates teach pendant and manipulator are unpowered.

8.4.4.2 Linkage mode

In linkage mode, manipulator can communicate with one or more external devices (manipulator etc.) through linkage mode I/Os. Linkage mode is applied to cooperative operation between multiple manipulators generally.

The instruction of linkage mode I/O function and state for users under linkage mode:

Input	LI00	LINKAGE-START	LI03	LINKAGE-INITIAL POSITION
	LI01	LINGKAGE-STOP	LI04	LINKAGE-REMOTE POWER ON
	LI02	LINKAGE-PAUSE	LI05	LINKAGE-REMOTE POWER OFF
Output	LO00	LINKAGE-OPERATING	LO02	LINKAGE-PAUSE
	LO01	LINKAGE-STOP	LO03	LINKAGE-INITIAL POSITION

8.4.4.3 Teach Pendant Enable Switch

This works only in Linkage mode. Push the switch on to enter into teach pendant enable mode (default setting). If user wants to remove the teach pendant, user can push the switch down to enter into teach pendant disable mode, in this mode, user can remove and teach pendant and user external IO to control the robot.

The teach pendant enable switch is inside of the control box, as illustrated below.



Teach pendant enable switchch

Figure 8.25 Teach pendant enable switch



User can Only push the switch in whole system power off state.

9. TEACH PENDANT

The teach pendant is an important component of AUBO-i5 robot. Users can acquire robot log information, control the manipulator to move and perform simple programming through the teach pendant.

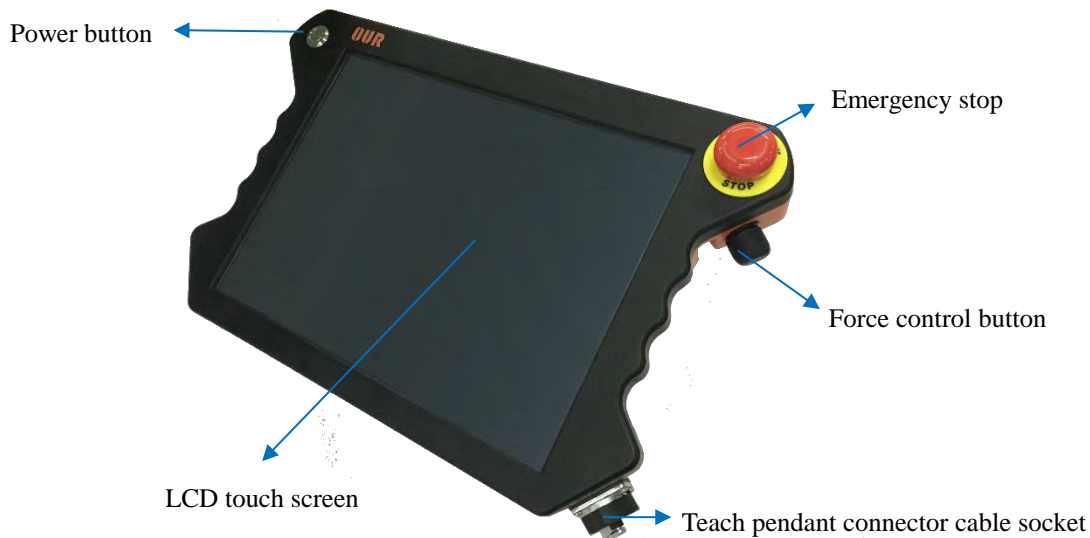


Figure 9.1 Overview of the teach pendant

The teach pendant mainly includes a 12.1 inches LCD touchscreen, a power switch, an emergency stop button, a force control button and a teach pendant connector cable socket. LCD touch screen can show the detail of robot motion and pose parameters clearly. All the operations can be completed by clicking on the screen directly for users' convenience. Moreover, the design of outer casing combines aesthetics and ergonomics. A nylon rope at the back of teach pendant is used to hold it in one hand.

Force control button is a three-position enabling device which have OFF \Rightarrow ON \Rightarrow OFF three state, when the button is in center position, user can use the hand-guiding function for teach mode.

This chapter mainly focuses on brief introduction of teach pendant.

9.1 Turn on Teach pendant

Press the power button on the upper left for about 1s until a blue light on, which indicates the teach pendant is power up.

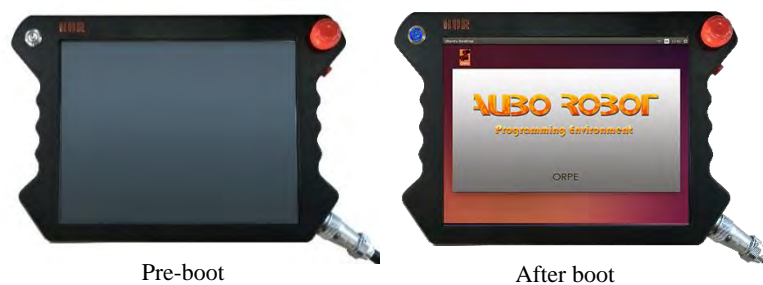



Figure 9.2 power button on teach pendant

9.2 Shut down Teach Pendant

There are two ways to shut down the teach pendant: software and power button.

- Software: click the shutdown button on the upper right corner of the screen .
- Power button: press and hold the power button for a while until the teach pendant is unpowered.

10. TEACH PENDANT USER INTERFACE

The screen shows the user interface after opening AUBO robot control software. The teach pendant interface consists of 5 panels: **Robot Teaching**, **Programming**, **Setting**, **System Info**, and **About**, each panel includes different operation buttons and information displays. **Robot Teaching** is used for demonstrating the robot manipulation. **Programming** is used for robot programming. **Setting** is used for setting the robot and system information. **System Info** displays status information of the robot. **About** displays the information of the Software.

10.1 Coordinate System

User can use base coordinate system, end coordinate system and user-defined coordinate system to control robot movement.

10.1.1 Base coordinate system

Choose base coordinate system in teach pendant interface, robot will operating as follow figure.

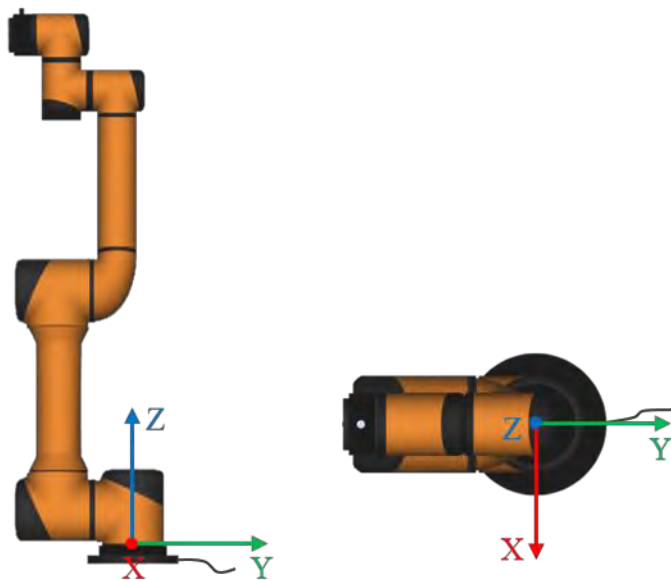


Figure 10.1 (a) Base coordinate system

10.1.2 End coordinate system

Choose end coordinate system in teach pendant interface, robot will operating as follow figure.

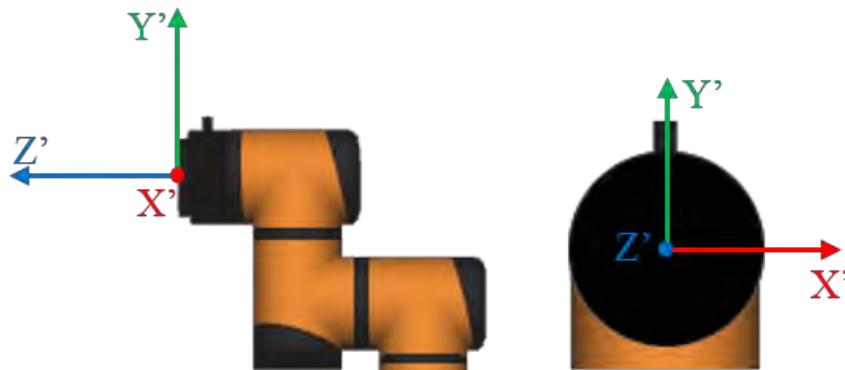


Figure 10.1 (b) End coordinate system

10.2 Initial Interface

After start the AUBOPE, there will pop up the following window:

Collision Class:	6		
Tool Name:	flange_center		
Kinematics Name: flange_center			
End Pos X(m):	0.000000	End Pos Y(m):	0.000000
End Ori RX(deg):	0.000000	End Ori RY(deg):	0.000000
		End Ori RZ(deg):	0.000000
Dynamics Name : flange_center			
Payload(kg):	0.00		
Gravity Center X(m):	0.000000	Gravity Center Y(m):	0.000000
		Gravity Center Z(m):	0.000000
Save		Start Up	

Figure 10.2 Initial Interface

Collision class means Safety collision detection level, a total of 1-10 safety level. The higher the level, the lower the force to stop the manipulator with collision detection function. The sixth level is the default level.

User can select the specified tool flange center as the tool name.

Click save-> start up button, then enter the teaching interface

10.3 "Robot Teaching" User Interface

Robot teaching panel is used for the robot teaching operation. User can move robot by clicking icon on the panel and get feedback information of movement from panel. This section mainly focuses on the Robot Teaching panel.

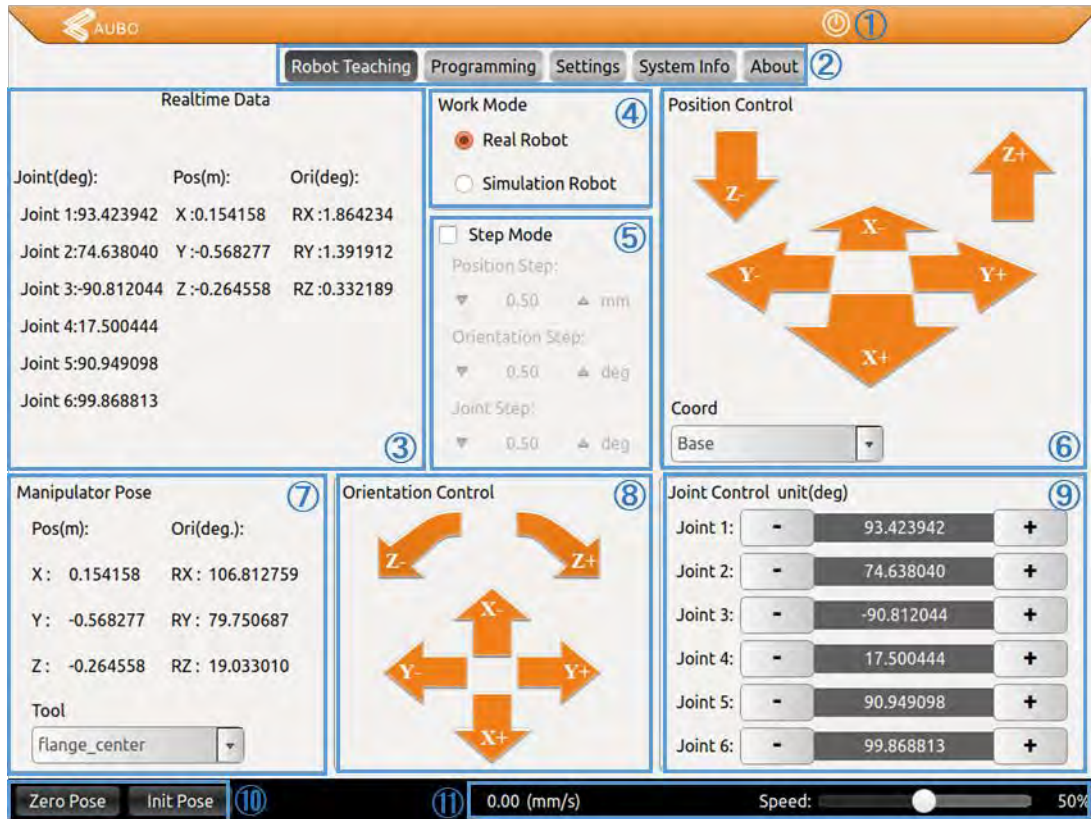



Figure 10.2 Robot Teaching interface

The Robot Teaching user interface consists of 11 components:

- 1 Software shut down button
- 1 Menu
- 1 Robot 3D display window
- 1 Simulation/real control switch button
- 1 Step mode control
- 1 Position control
- 1 Tool end position and pose information display
- 1 Orientation control
- 1 Joint control
- 1 Robot status control, includes zero position, initial position
- 1 Motion speed control

10.3.1 Software shut down button

- 1 Click  to shut down the software.

10.3.2 Menu

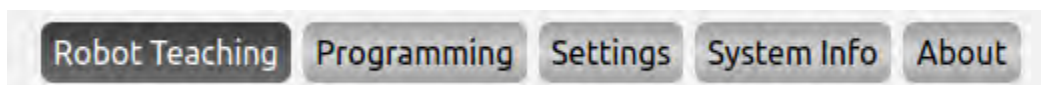


Figure 10.3 User interface menu

- 1 The interface functions can be activated by clicking the name on menu for users' convenience. Chosen tab shown as light text on a dark background.

10.3.3 Robot 3D display window

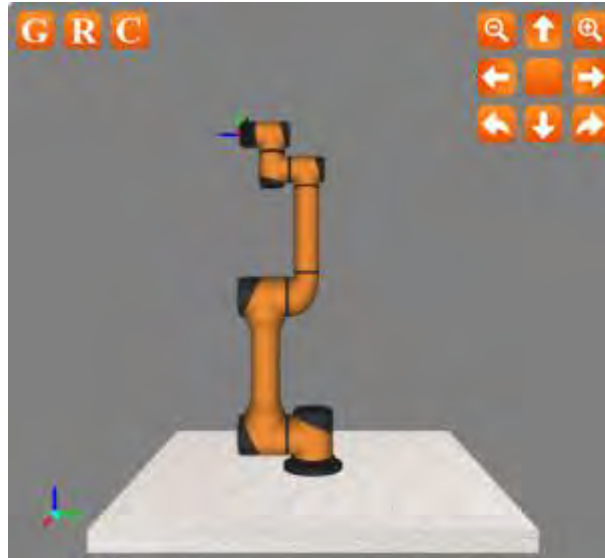











Figure 10.4 Robot 3D display window

- 1 Robot 3D display window is to verify the user-written project without the real robot.
- 1 The buttons on the upper left corner are used to observe 3D model. From left to right: rotating counterclockwise along Z axis, rotating clockwise along Z axis zoom in, and zoom out.
- 1 The function of the icons as follow:
 - G** : Base plane, Click to hide the base reference plane in the simulation interface
 - R** : Actual waypoint model, click to hide
 - C** : User coordinate, click to hide
 - T** : Target waypoint model, click to hide
 -  : Zoom out button
 -  : Zoom in button
 -  : Pan up button
 -  : Pan down button
 -  : Pan left button
 -  : Pan right button
 -  : Turn clockwise
 -  : Turn counterclockwise
 -  : Reset button
- 1 The simulation environment can also be used to validate control programs before applying on the real robot.

10.3.4 Simulation/real control switch button

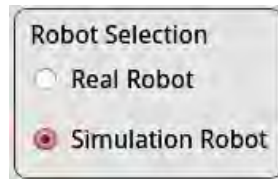


Figure 10.5 Robot mode selection.

- 1 When "Real Robot" is selected, the teach pendant will control the robot manipulator in real time.
- 1 When "Simulation Robot" is selected, 3D manipulator model operate but the real robot won't move. To finish a program, users can test whether the procedure is right firstly by simulation to improve the safety of the robot's procedure.

10.3.5 Step Mode Control

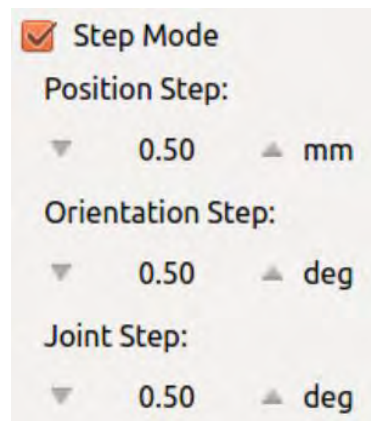


Figure 10.6 Step mode control.

To improve the control accuracy and flexibility, step mode control is needed to make controlled variable change precisely in a stepwise manner.

- 1 Use step control mode by activating step mode.
- 1 Click the button on both sides of input box to adjust robot's step length.
- 1 Position step indicates the step length of end position movement, unit: mm, range:0.1-10.00mm
- 1 Orientation step indicates the step length of the end pose movement, unit: deg, range:0.1-10.00deg
- 1 Joint Step indicates the step length of joint movement angle, unit: deg, range:0.1-10.00deg
- 1 Step mode control is valid to control end position/orientation and joints only.

10.3.6 Position control

The end of manipulator is based on base coordinate system, end coordinate system or user-defined coordinate system to control robot movement. The end of manipulator can be teaches under different coordinate systems.

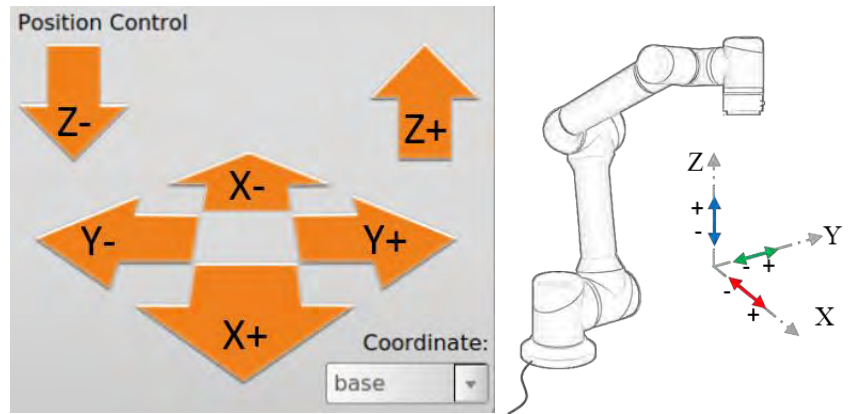


Figure 10.7 (a) Position control (base)

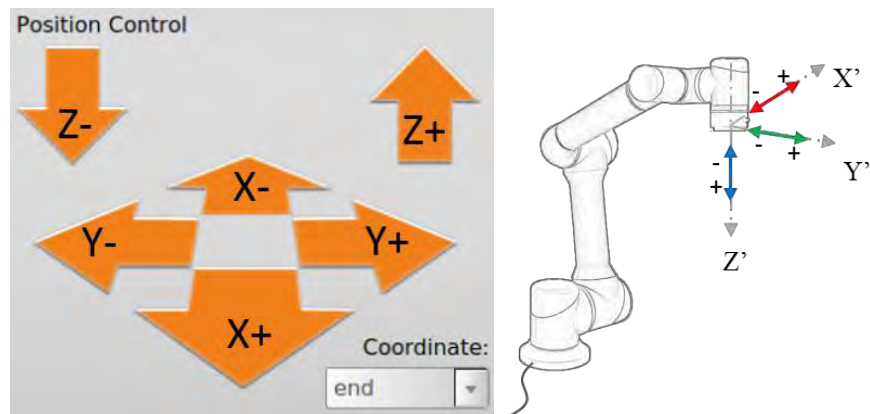


Figure 10.7 (b) Position control (end)

10.3.7 Robot real-time status parameter display

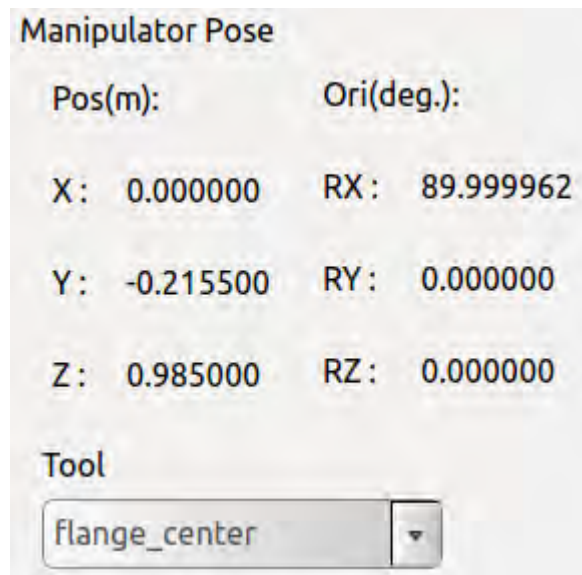


Figure 10.8 Pose and position information.

- 1 The X, Y, Z coordinates under Position indicates that the coordinate of tool flange center (Selected tool coordinate system) under selected coordinate system (base coordinate system, end coordinate system and user-defined coordinate system). The W, X, Y, Z under Pose are represented to end pose quaternions.
- 1 End pose is represented by quaternions, which can also be transformed as other representations (for

example, Euler angles).

- 1 The drop-down menu provides whether the target is flange focus (default) or end-effector.
- 1 Users can add new option to drop-down menu by TCP Setting- Tool coordinate system settings

10.3.8 Orientation Control

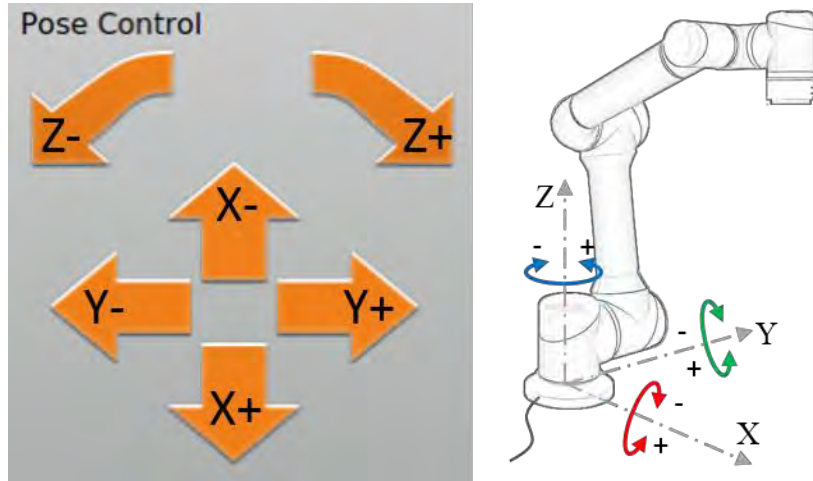


Figure 10.9(a) Orientation Control (base)

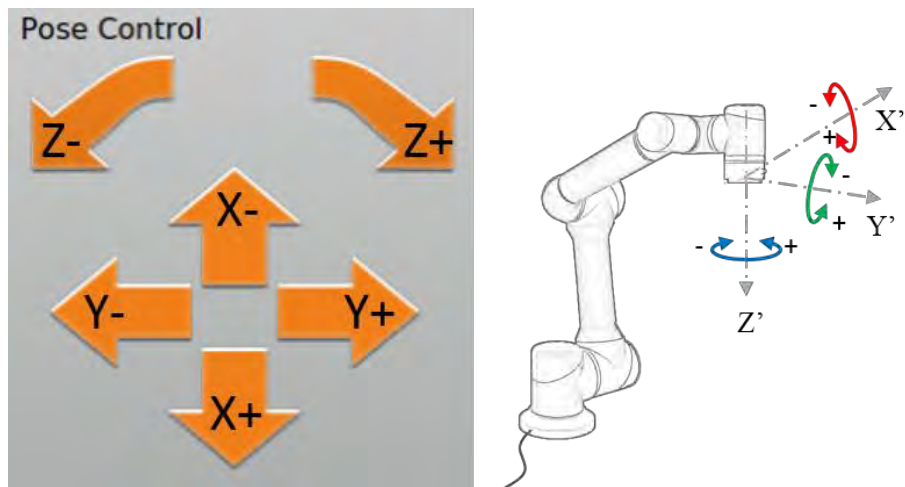


Figure 10.9(b) Orientation Control (end)

10.3.9 Joint axis control

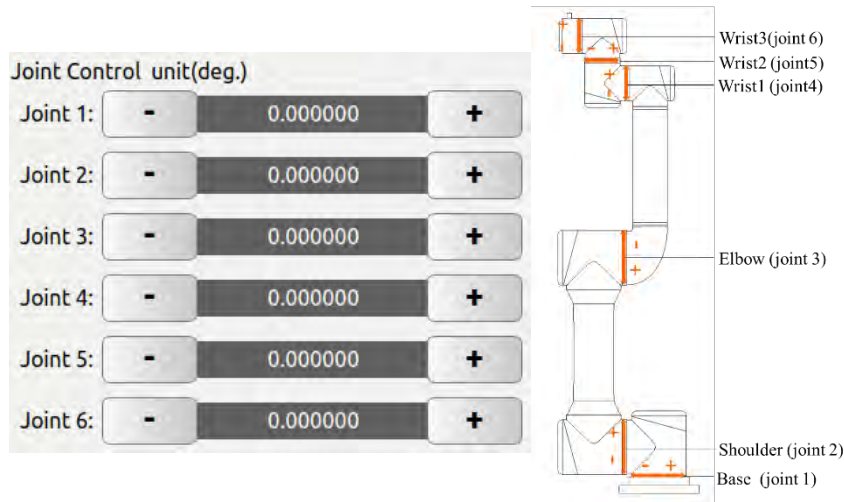


Figure 10.10 Illustration of Joint control.

- 1 The robot has six degrees of freedom, namely Joint 1 to Joint 6 from bottom to top. Users can control the movement of each joint by using the buttons on teach pendant interface.
- 1 "+" represents that a joint motor rotates counterclockwise; and "-" represents that a joint motor rotates clockwise, as shown above.
- 1 Units: degree.

10.3.10 Zero Pose, Init Pose



Figure 10.11(a) Buttons for Zero Pose and Init Pose

- 1 **Zero Pose:** Press and hold the button to back to zero
- 1 **Init Pose:** Press and hold the button to back to initial pose. Users can set arbitrary initial pose by **【Robot Settings】** -> **【InitPose】** on teach pendant interface.

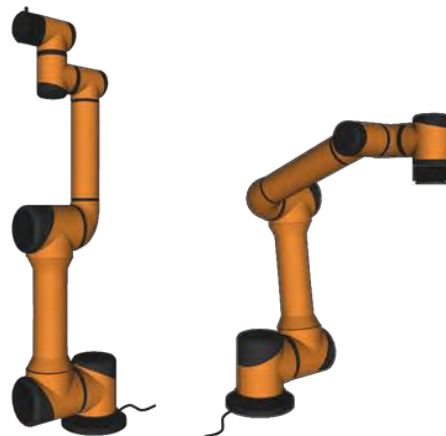


Figure 10.11(b) Zero Pose and Init Pose(default)

10.3.11 Motion speed control

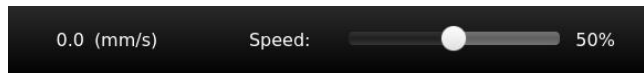


Figure 10.12 Motion speed control.

- 1 Users can adjust the motion speed of the robot by sliding the slide bar (the percentage of the maximum speed).
- 1 Slide the slide bar can only be used in teaching mode. Users can not adjust the motion speed of the robot by sliding the slide bar in auto mode.

10.4 I/O Control Interface

10.4.1 Controller I/O Tab

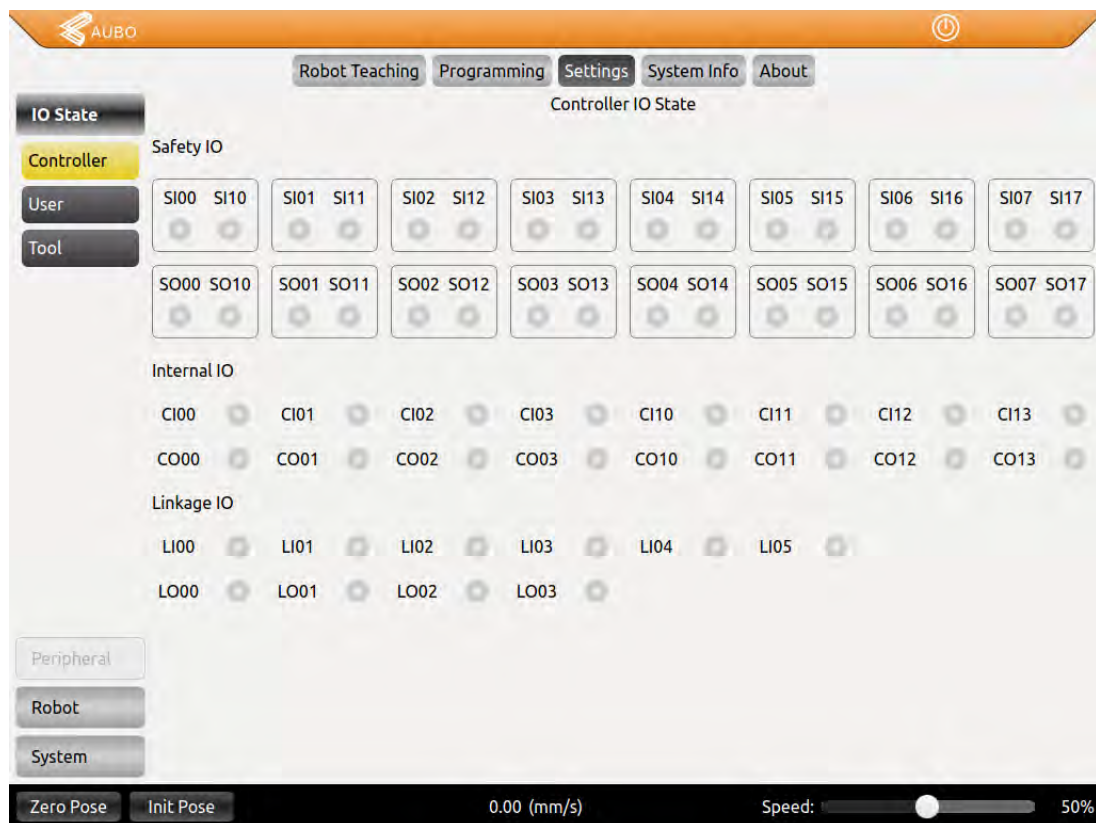


Figure 10.16 Controller I/O

- 1 Safety I/O: The safety I/O designed as dual channel (redundant design) to ensure the safety function shall not lost in any case of single failure.
- 1 Internal I/O: only for internal function interface, to provide status display of internal I/O which are not available for user.
- 1 Linkage I/O: for linkage mode I/O status display.

10.4.2 User I/O



Figure 10.18 User I/O

- 1 DI and DO for the general digital I/O, a total of 16 input and 16 output, can be used for direct drive relays and other electrical equipment.
- 1 Analog input is used to display the voltage of the external sensor. There are 4 analog input signals: VI0, VI1, VI2 and VI3, the range is 0V ~ +10V, the accuracy is $\pm 1\%$.
- 1 Analog output is used to display the voltage / current value of the output of the interface board. There are four analog output signals: VO0, VO1, CO0 and CO1, respectively VO0, VO1 output voltage, CO0, CO1 output current.
- 1 output IO control: select the IO, and then enter the corresponding value in the text box, where DO have 0 and 1 two states, AO: the voltage output range of 0V ~ +10 V, the current output range of 0mA ~ 20mA (recommended input 4mA ~ 20mA current value), click **【Send】** button, the corresponding IO is set to the set value.

10.4.3 Tool I/O Tab

This section introduces the setting of I/O interface provided by teach pendant. For the detailed description of the interface, please refer to electrical interface Manual. I/O settings panel includes tool I/O tab, controller I/O tab and PLC I/O tab.

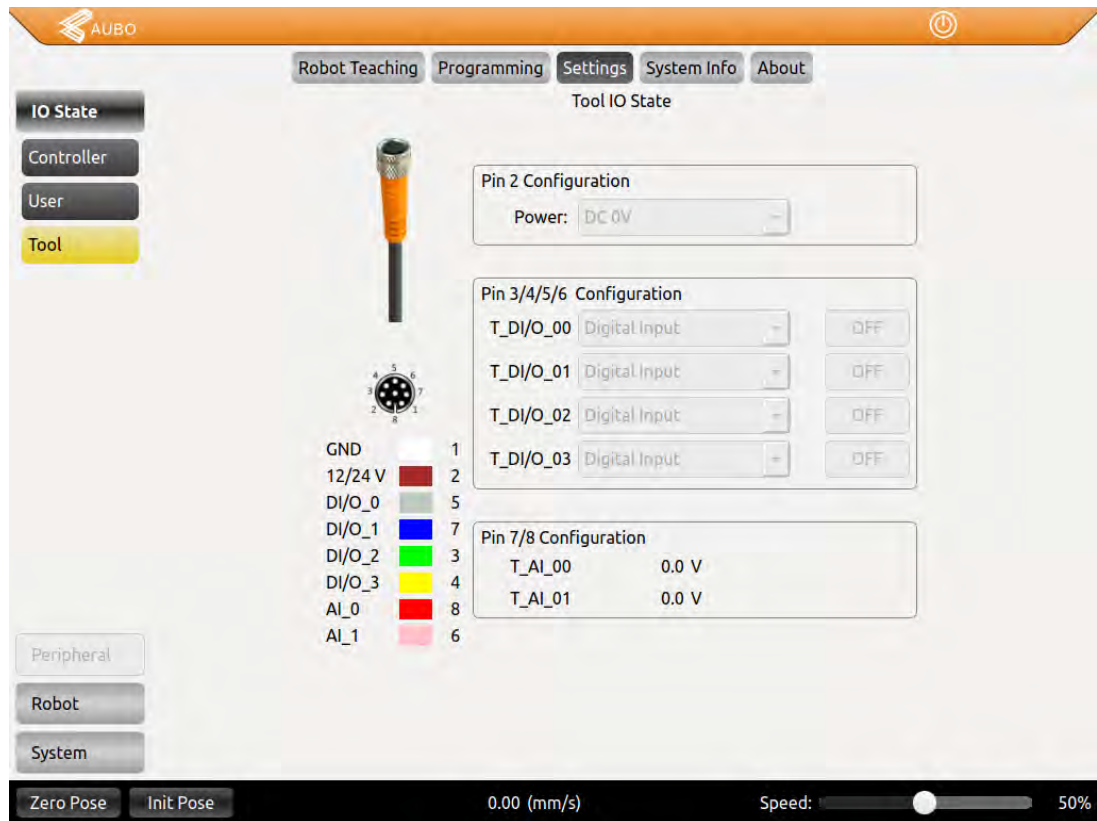


Figure 10.13 Tool I/O Setting interface.

- 1 Tool I/O Tab: the display of end-effect's setting status. Users can configure 4 digital I / O by pin 3/4/5/6, pin 7/8 can be configured as an analog input, Pin 2 can be configured to three kinds output voltage: 0v, 12V and 24V.
- 1 Users need to configure the voltage of pin 2 and states of pin 3/4/5/6 based on actual usage before using this function.

10.5 Robot Setting Tab

10.5.1 InitPose

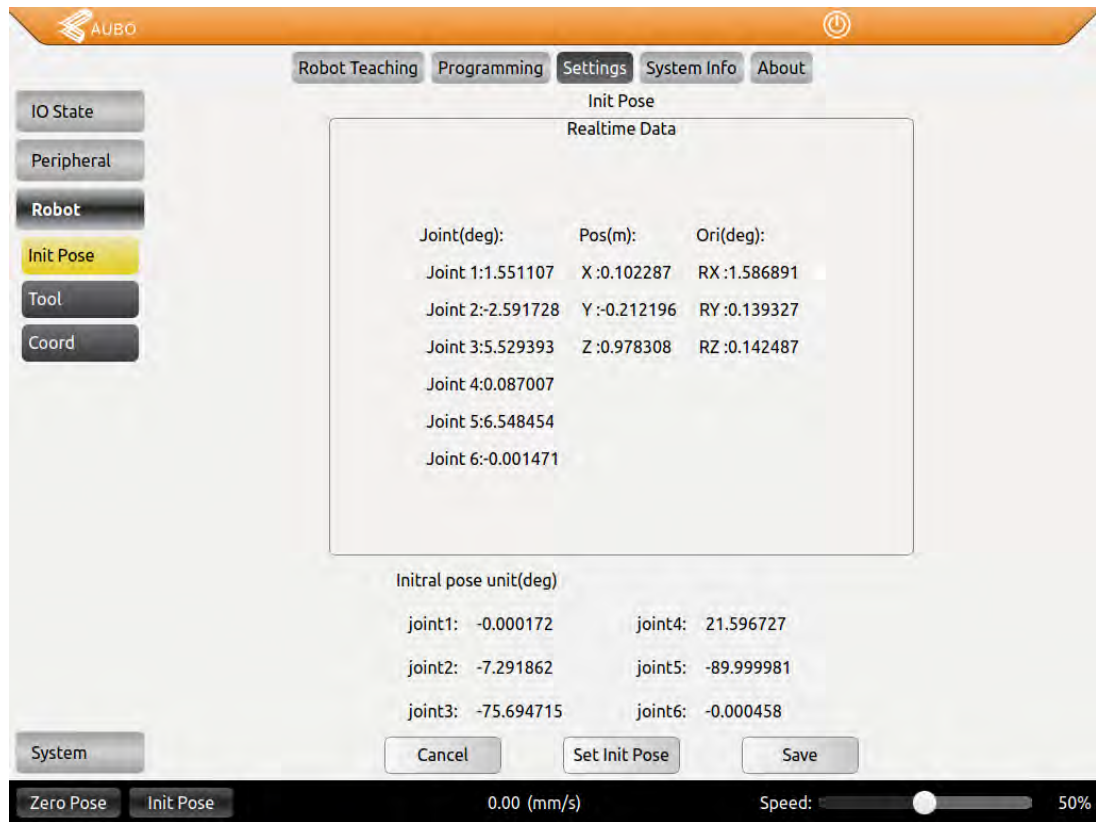


Figure 10.23 InitPose

- 1 Click **【Set InitPose】** to set the initial position by moving robot via teach pendant or hand guiding, which correspond to **【Init Pose】** on the interface. and synchronize to the **【Init Pose】** below the teaching interface after setting.

10.5.2 Tool Calibration

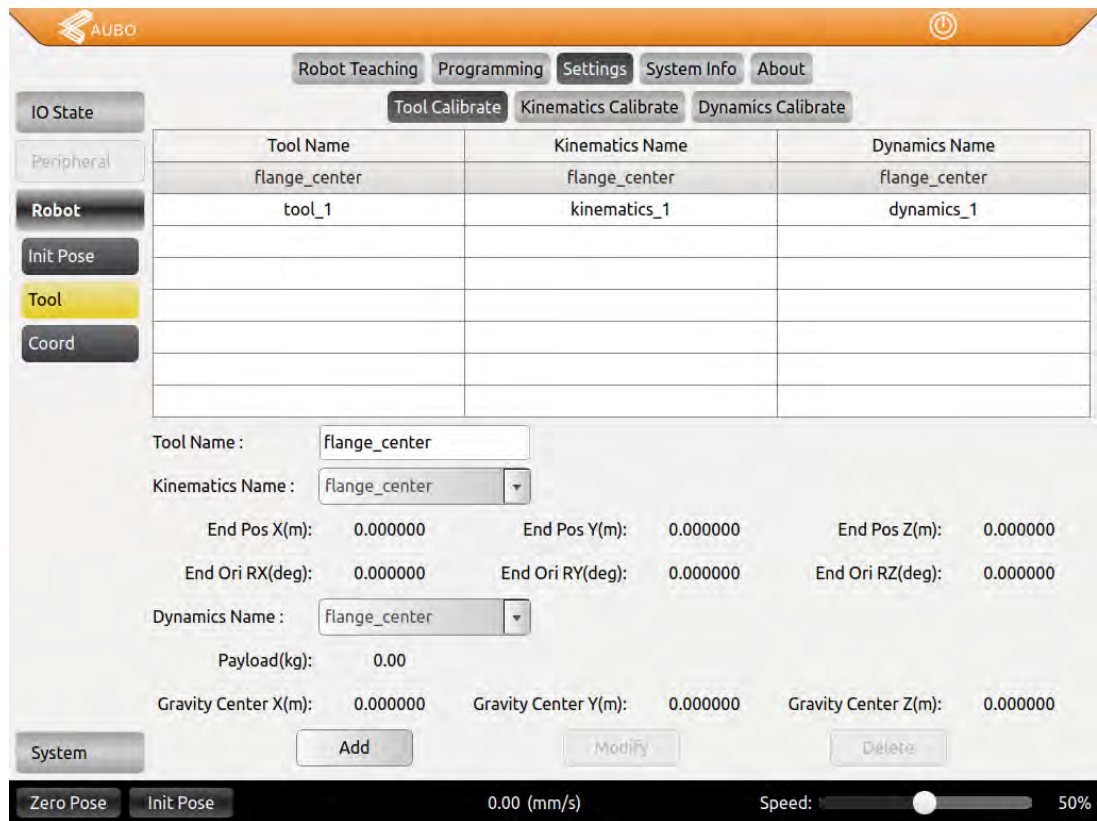


Figure 10.16 1.1.1 Tool Calibration

Tool calibration consists of two parts: kinematics calibration and dynamics calibration. A tool consists of kinematic properties (kinematic parameters that constrain tool end trajectory) and dynamics properties (Constraints on the dynamics, such as speed and acceleration, of a manipulator with a load).

The tool calibration in the above figure is divided into three calibration interfaces, namely Tool Calibrate, Kinematics Calibrate and Dynamics Calibrate.

After calibrating the kinematic and kinematic parameters of the tool, enter the tool calibration interface, select a kinematic and Dynamics attribute for the tool, enter the name of the tool, and then add the tool.

10.5.2.1 Tool Kinematics Calibraton

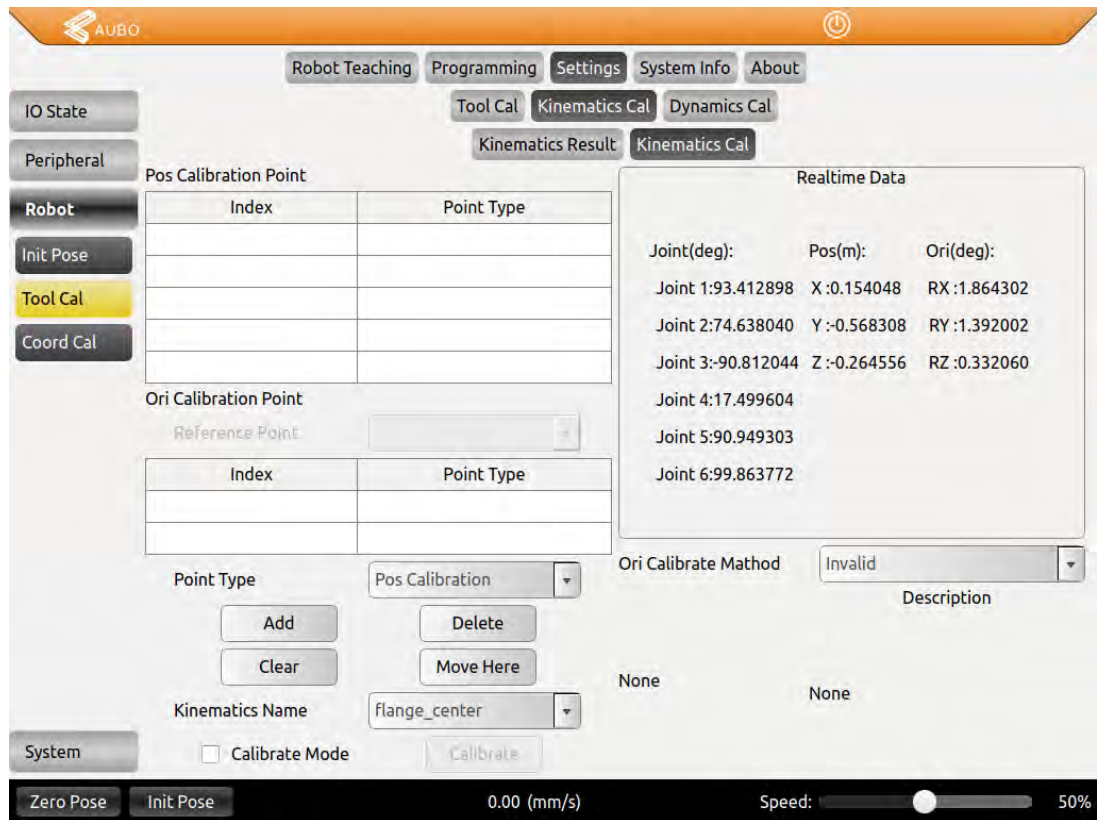


Figure 10-1 Tool Kinematics Calibraton

Tool kinematics calibration consists of two interfaces, the figure above is the tool kinematics point selection interface. Tool kinematics parameters consist of end-effector position parameters and orientation parameters. Calibration position parameters need to be greater than or equal to 4 waypoints, and calibration orientation parameters need to have only two waypoints.

The position calibration needs to add a position reference point (used as the origin of the end tool when calibrating the orientation). Before calibrating the kinematic parameters of the tool, make sure that the arm has been installed with the tool. First calibrate the reference position, select the Point Type as Pos Calibration, click the Add button to enter the teaching interface, and calibrate the reference position by hand guiding or teaching interface. Position calibration requires at least 4 waypoints to determine the parameters. After that, you only need to change the orientation and then add three waypoints while keeping the reference point (the end tool relative to the coordinate system of the base) unchanged. At the final calibration of the 4 waypoints, ideally the center point of the 4 waypoints is on the sphere centered on the true end of the tool.

Orientation calibration need to calibrate the reference position (ie, the first point of position calibration). The principle of orientation calibration is that the reference position is the origin of the end tool coordinate system, the ray formed by the origin and the first orientation calibration point is the positive half-shaft of X-axis, the ray formed by the origin and the second orientation calibration point is the positive haft-shaft of Y-axis, ensure that the angle formed by the three waypoints at right angles. When calibration, move to the reference position first, select Point Type as Ori Calibration, click Add to enter the teaching interface, calibrate the first orientation point. Using the same method to calibrate the second pose point, be sure to make sure that the angle

formed by the three points is a right angle. Here you can use the position movement in the teach interface to help calibrate the orientation point.

The Delete button function is to delete the selected waypoint in the list on the left.

After calibrating the required waypoints, you can calibrate the position parameters and orientation parameters of the end tool through these waypoints. Select Tcp Calibrate Mode option, then, Kinematics Calibrate button is enabled, the table on the left change into multi-select mode, select a calibrated waypoint, and click the Kinematics Calibrate button to switch to the interface below.

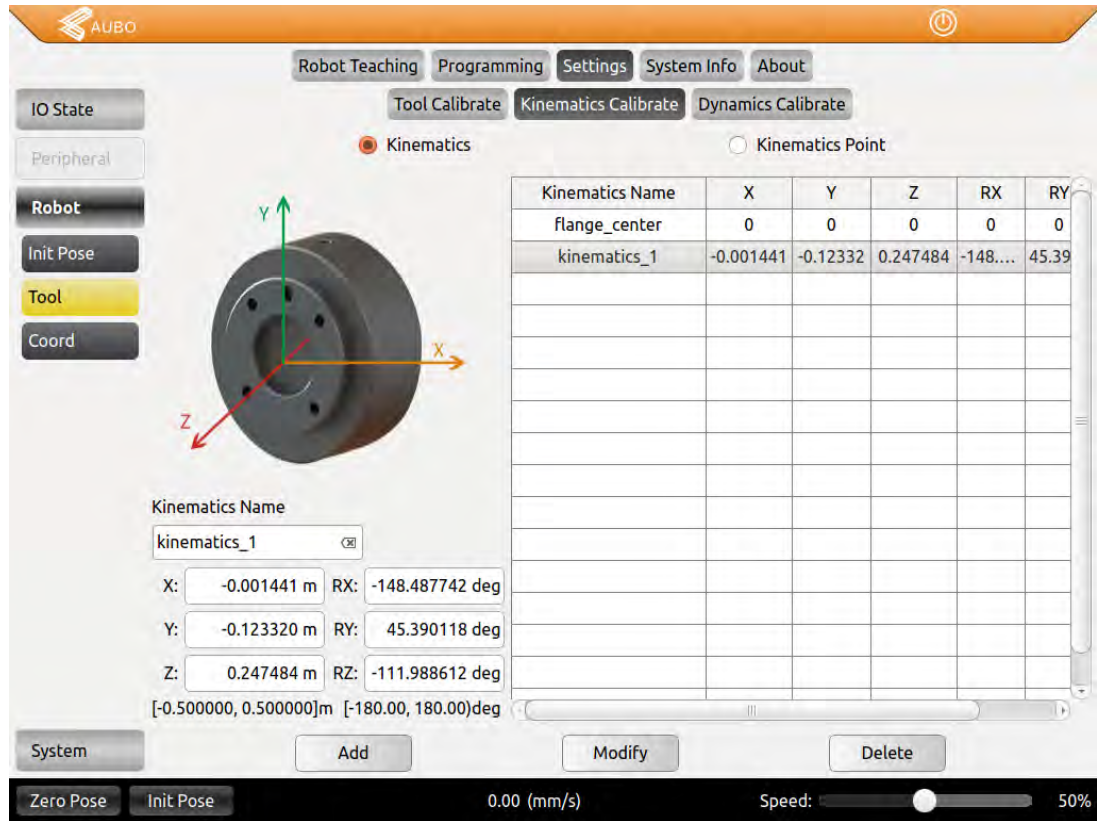


Figure 10-2 Tool Kinematics Calibrator

The end tool position parameters and orientation parameters marked by waypoints are added to the data display area in the lower left corner. Enter a tool kinematics name and click the Add button to add a tool kinematic calibration. The above figure also supports the manual write input of tool kinematics parameters. After manually entering the parameters, also click Add to save the parameters.

When modifying the kinematic parameters of the tool, just like adding the tool kinematics parameters, you can either calibrate the parameters by the calibration points or you can write the calibration parameters manually. After setting the parameters, select the kinematic parameters to be modified on the right side of the figure, and click the Modify button to complete the modification.

When deleting the kinematic parameters of the tool, first select the kinematic parameters to be deleted, and then click the Delete button to finish the deletion.

Need to pay attention to, kinematics parameter flange_center option is the system default parameters, which can not be modified and deleted.

10.5.2.2 Tool Dynamics Calibration

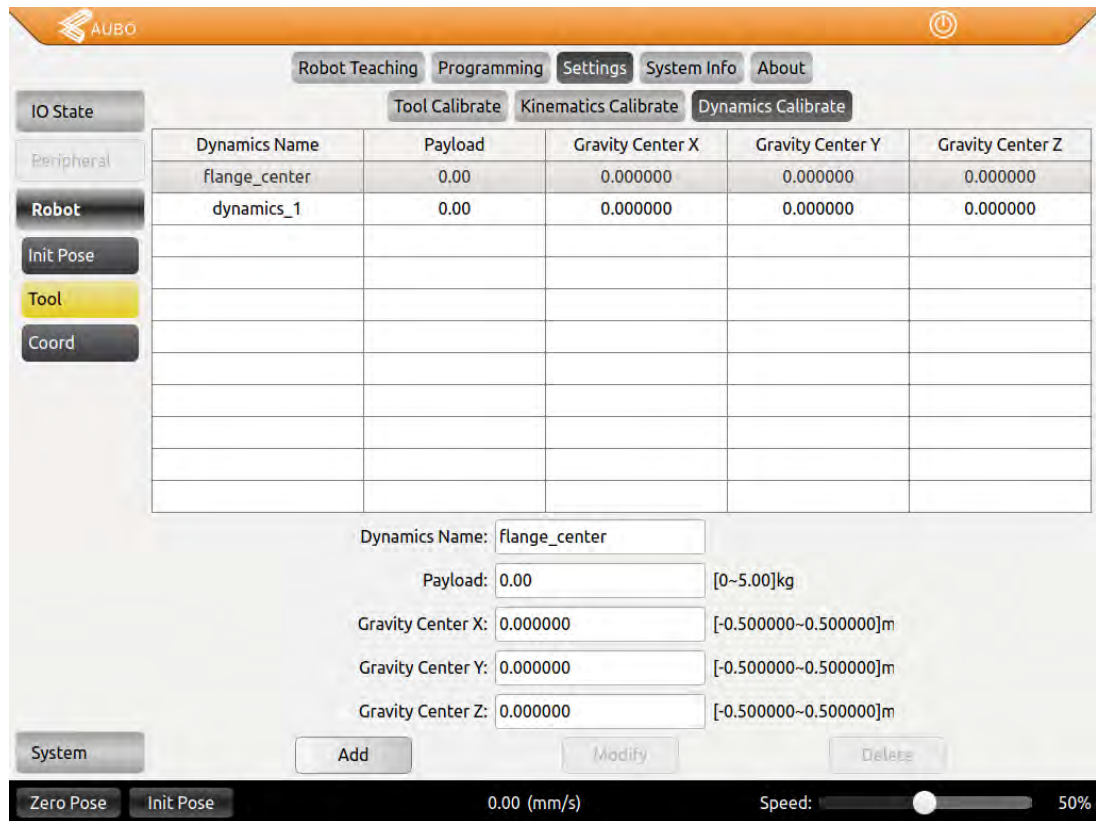


Figure 10-3 Tool Dynamics Calibration

- 1 The picture above shows the tool dynamic calibration interface, enter the load, the tool center of gravity parameters and tool name, click Add to save the parameters
- 1 When modifying the tool dynamics parameters, first select the item to be modified, enter the value to be modified, and click the Modify button to complete the modification.
- 1 When deleting the tool dynamic parameters, first select the item to be modified, and then click the Delete button to finish the deletion.
- 1 It should be noted that, flange_center option is the system default parameter, which can not be modified and deleted.

10.5.2.3 Tool Calibrate

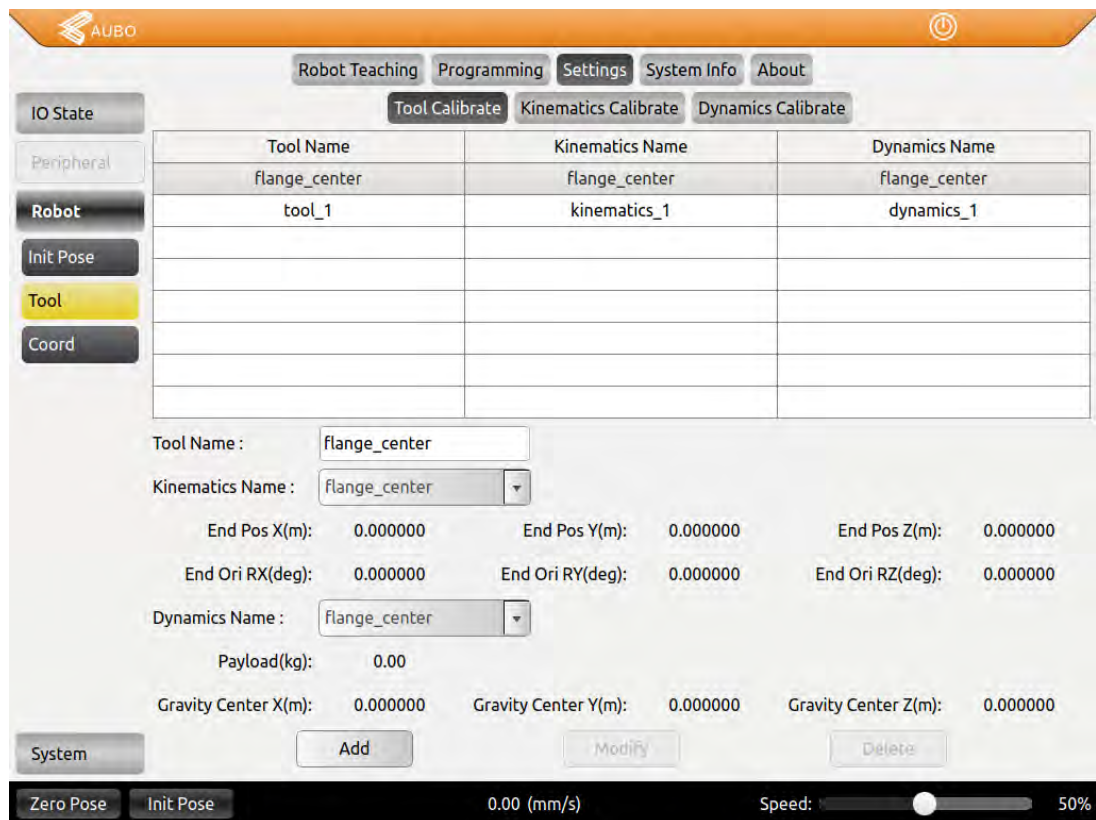



Figure 10-4 Tool Calibrate

The picture above is the tool calibration interface. After completing the tool kinematics and dynamic parameters calibration, enter the interface, select the tool kinematics and dynamics parameters from the drop-down list, enter the tool name, and click the Add button to save the tool parameters.

When modify the tool calibration, select the item to be modified, you can modify the name, kinematic parameters and dynamic parameters. Click the Modify button to complete the modification.

When delete tool calibration, select the item to be modified, click the Delete button to complete the deletion.

It should be noted that, flange_center option is the system default option, which can not be modified and deleted.



It may cause wrong stop and other malfunction if setting data is inaccurate in actual operation. If setting is wrong, manipulator and control box can't work normally and cause danger to personnel or equipment around.

10.5.3 Coordinate Calibration

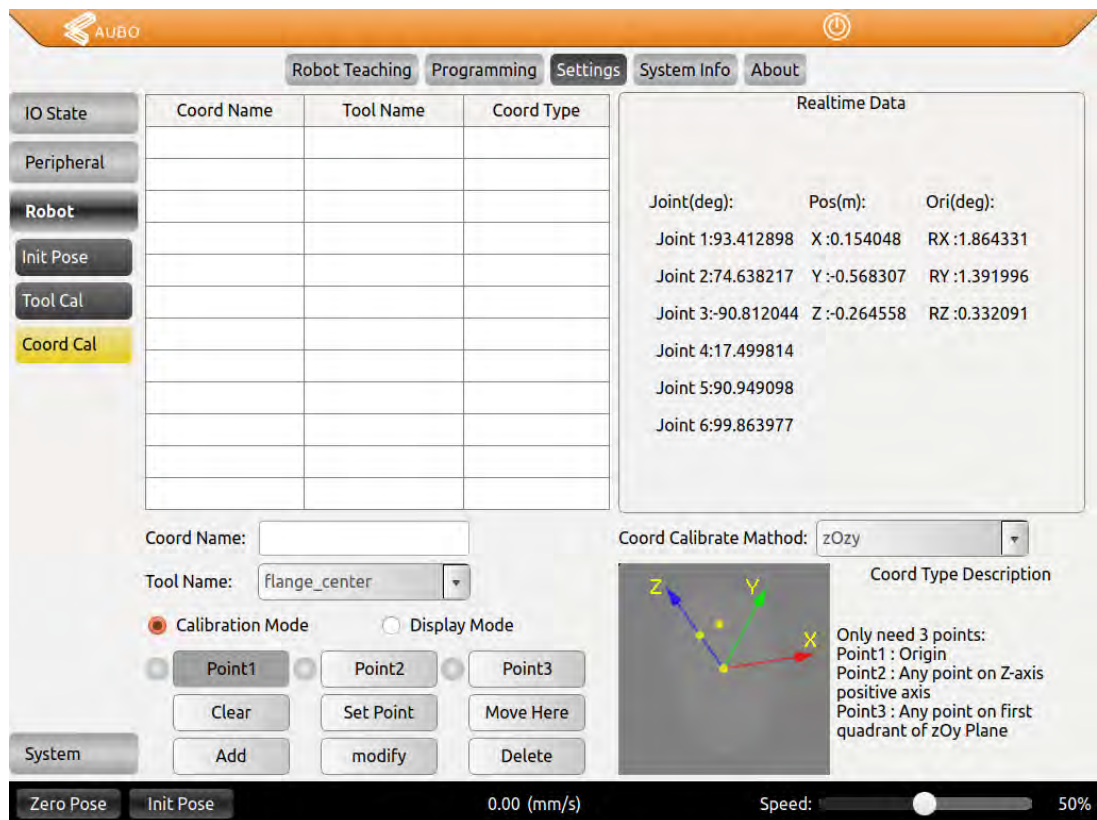


Figure 10-5 Coordinate Calibration

The picture shows the coordinate system calibration interface, the coordinate system is divided into nine types, namely: xOy, yOz, zOx, xOxy, xOxz, yOyz, yOyx, zOzx, zOzy. Coordinate system type naming rules and calibration points for each coordinate system requirements are as follows:

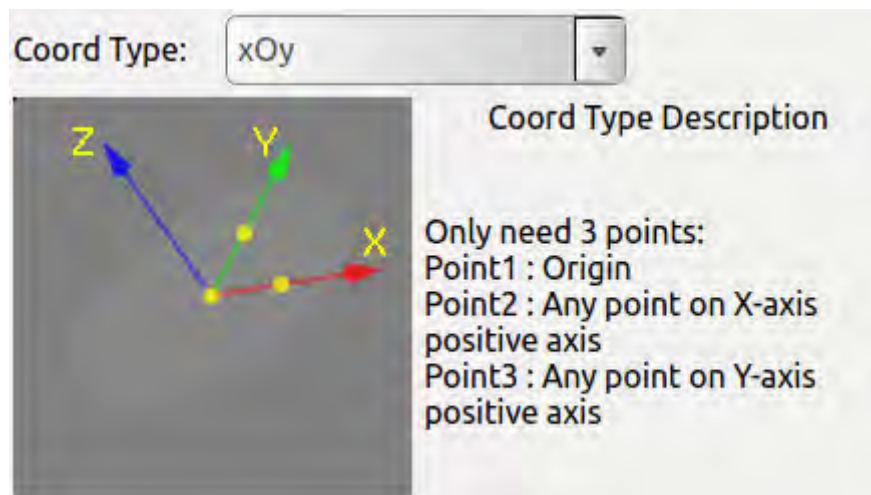


Figure 10-6 XOY

The figure above is xOy type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the X-axis, and the third point is any point on the positive semi-axis of the Y-axis. The angle formed by the three points

is a right angle.

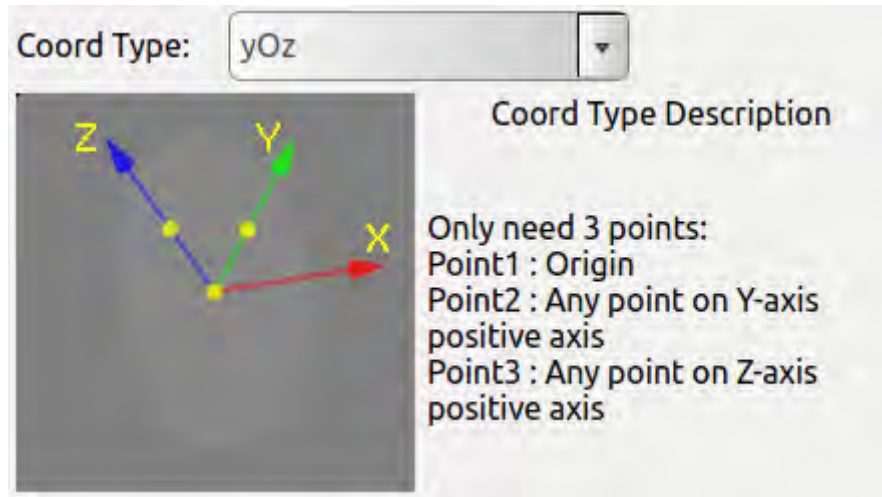


Figure 10-7 YOZ

The figure above is yOz type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the Y-axis, and the third point is any point on the positive semi-axis of the Z-axis. The angle formed by the three points is a right angle.

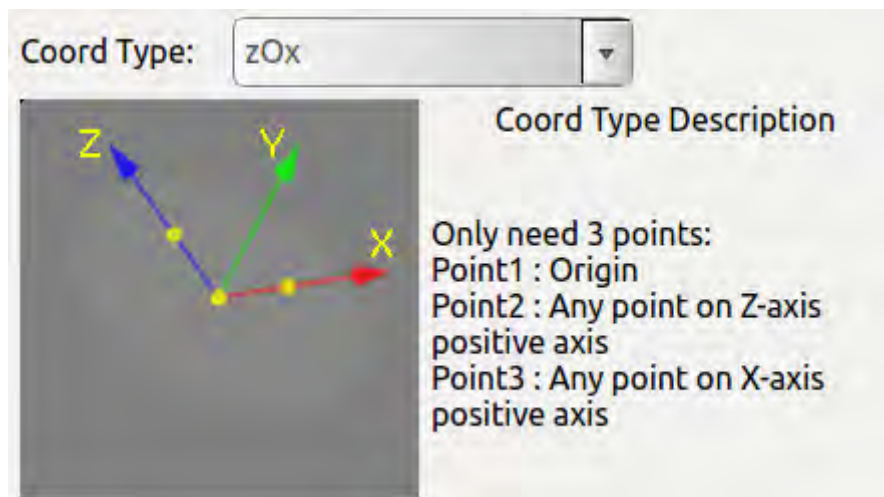


Figure 10-8 ZOx

The figure above is zOx type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the Z-axis, and the third point is any point on the positive semi-axis of the X-axis. The angle formed by the three points is a right angle.

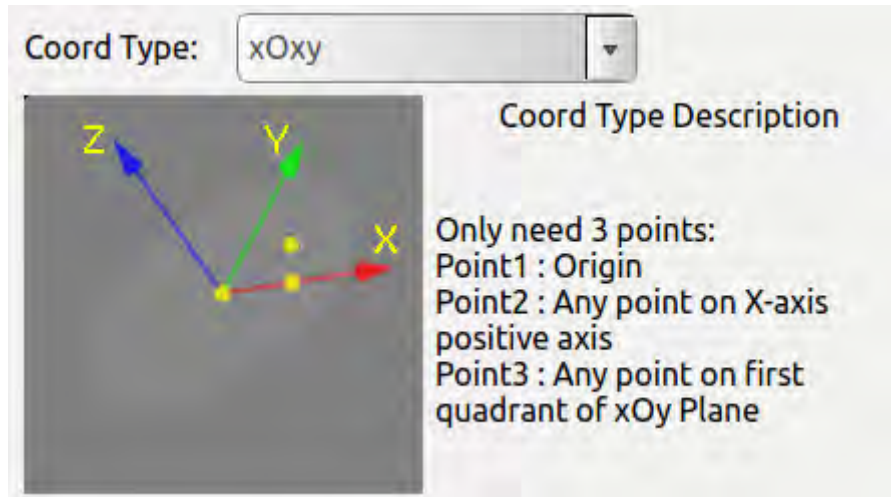


Figure 10-9 XOXY

The figure is xOxy type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the X-axis, and the third point is formed at any point within the first quadrant of the xOy plane. The angle formed by the three points is an acute angle.

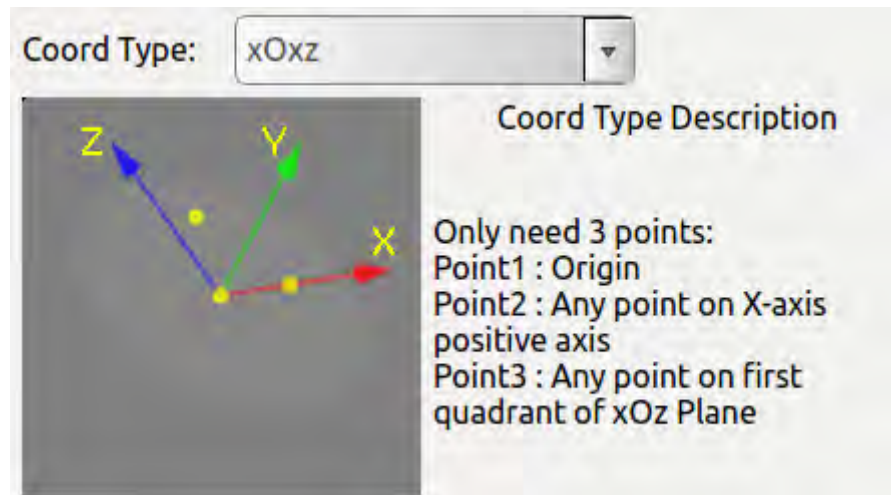


Figure 10-10 XOxz

The figure is xOxz type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the X-axis, and the third point is formed at any point within the first quadrant of the xOz plane. The angle formed by the three points is an acute angle.

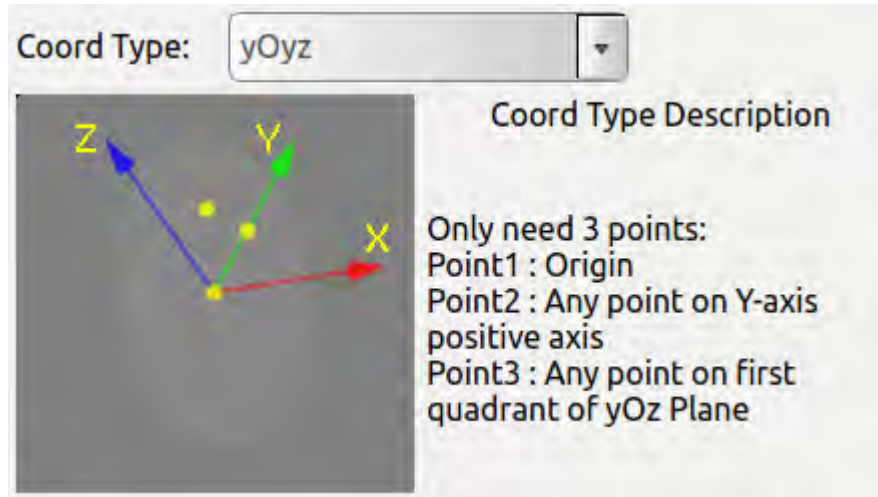


Figure 10-11 YOYZ

The figure is yOyz type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the Y-axis, and the third point is formed at any point within the first quadrant of the yOz plane. The angle formed by the three points is an acute angle.

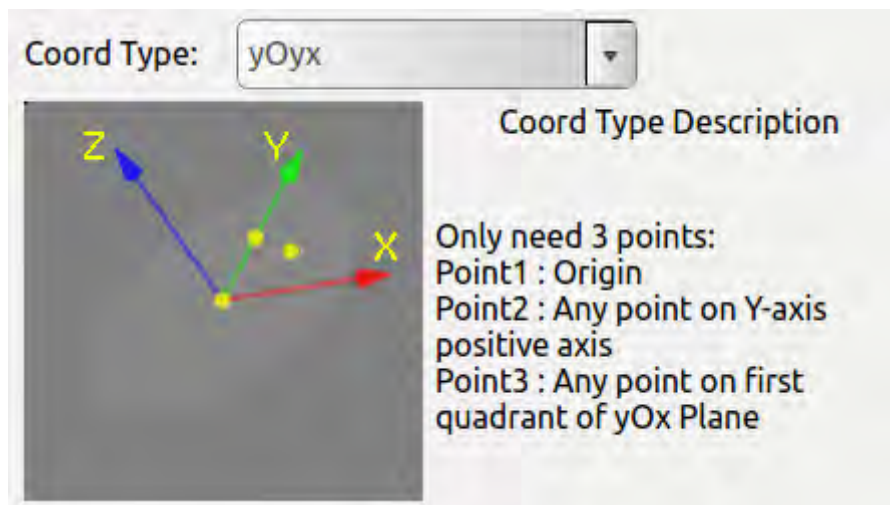


Figure 10-12 YOYX

The figure is yOyx type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the Y-axis, and the third point is formed at any point within the first quadrant of the yOx plane. The angle formed by the three points is an acute angle.

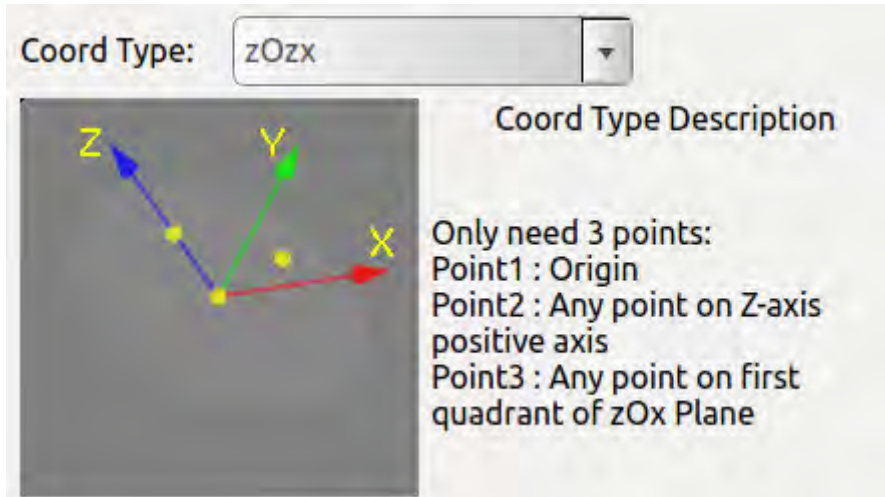


Figure 10-13 ZOZX

The figure is zOzx type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the Z-axis, and the third point is formed at any point within the first quadrant of the zOx plane. The angle formed by the three points is an acute angle.

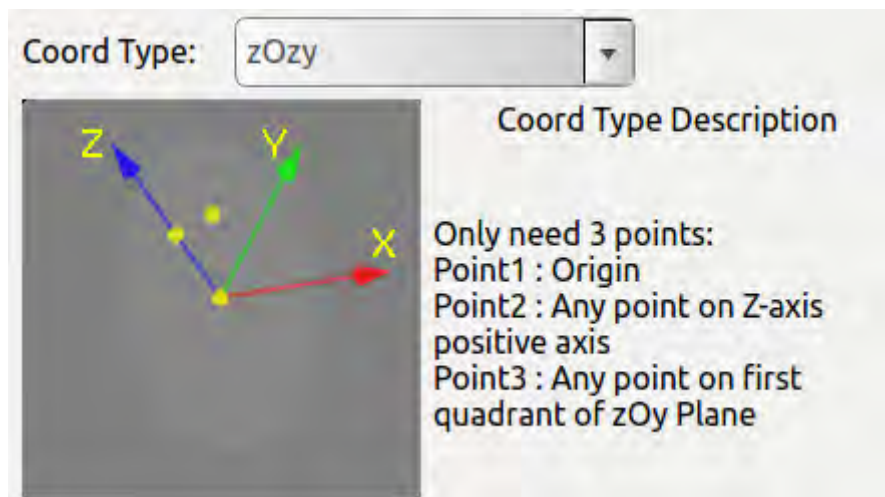


Figure 10-14 ZOZY

The figure is zOzy type, requiring the first point for calibration is the origin of the coordinate system, the second point is any point on the positive semi-axis of the Z-axis, and the third point is formed at any point within the first quadrant of the zOy plane. The angle formed by the three points is an acute angle.

When calibration, select the type of the coordinate system to be calibrated via Coord Type firstly. Then select the Calibration Mode mode, select Point1, click Set Point, enter teaching interface, calibration coordinate system origin. Use the same method to calibrate Point2 and Point3. Enter the name of the coordinate system and click the Add button to save the coordinate system parameters.

- 1 When modifying the coordinate system, first select the coordinate system in the list, click Calibration Mode, you can modify Point1 to Point3,

- 1 Coordinate system name can also be modified, after set up, click the Modify button, save the modified parameters.
- 1 When you delete a coordinate system, select the coordinate system in the list and click the Delete button. The coordinate system is removed.
- 1 The Clear button function clears the calibration results from Point1 to Point3 in Calibration Mode.
- 1 Display Mode function is to display the value of the three waypoints of the calibrated coordinate system. After a coordinate system is selected in the list, it automatically enters the Display Mode, clicks Point1 to Point3, the three waypoints used to calibrate the coordinate system are displayed in the simulation interface.
- 1 Move Here function is to move to a waypoint, the specific operation is in Calibration Mode mode, select any one of Point1 to Point3 button, click Move Here will move to the corresponding calibration point; in the Display Mode mode, select the selected Point1 To any of the Point3 buttons, click Move Here to move to the waypoint used to calibrate the coordinate system.

10.5.4 Safety

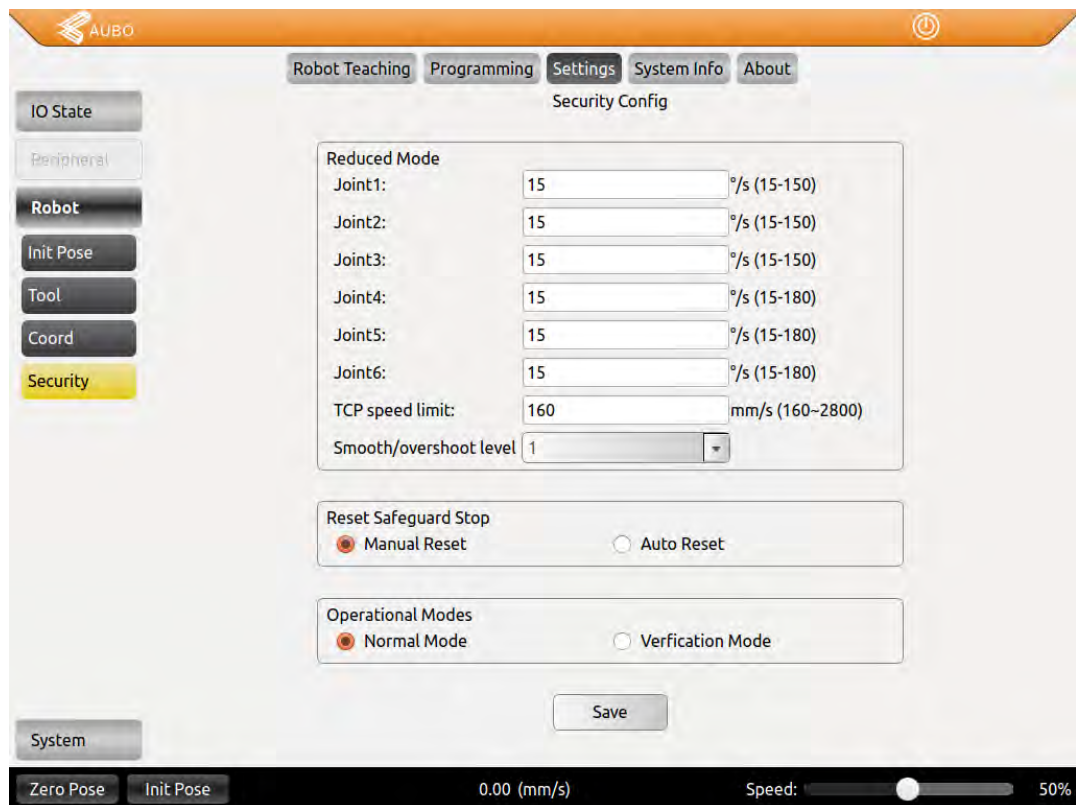


Figure 10.24 Safety Setting

- 1 Reduced mode: in this mode, the joint space speed of the manipulator shall be limited to the value of the corresponding text box.
- 1 Reset Safeguard Stop: select manual reset, only external safeguard reset signal can invalid the safeguard stop; select auto reset, ignore the external safeguard reset signal, only when

safeguard stop signal invalid can invalid the safeguard stop.

- 1 Operational mode: When "Normal mode" is selected, the external enabling device input signal is ignored. When "verification mode" is selected, the external enabling device input signal is valid.

10.6 System Setting tab

The Robot Setting tab has nine units, including Languages, Date& Time, Password, Lock Screen and Update.

10.6.1 Language Tab

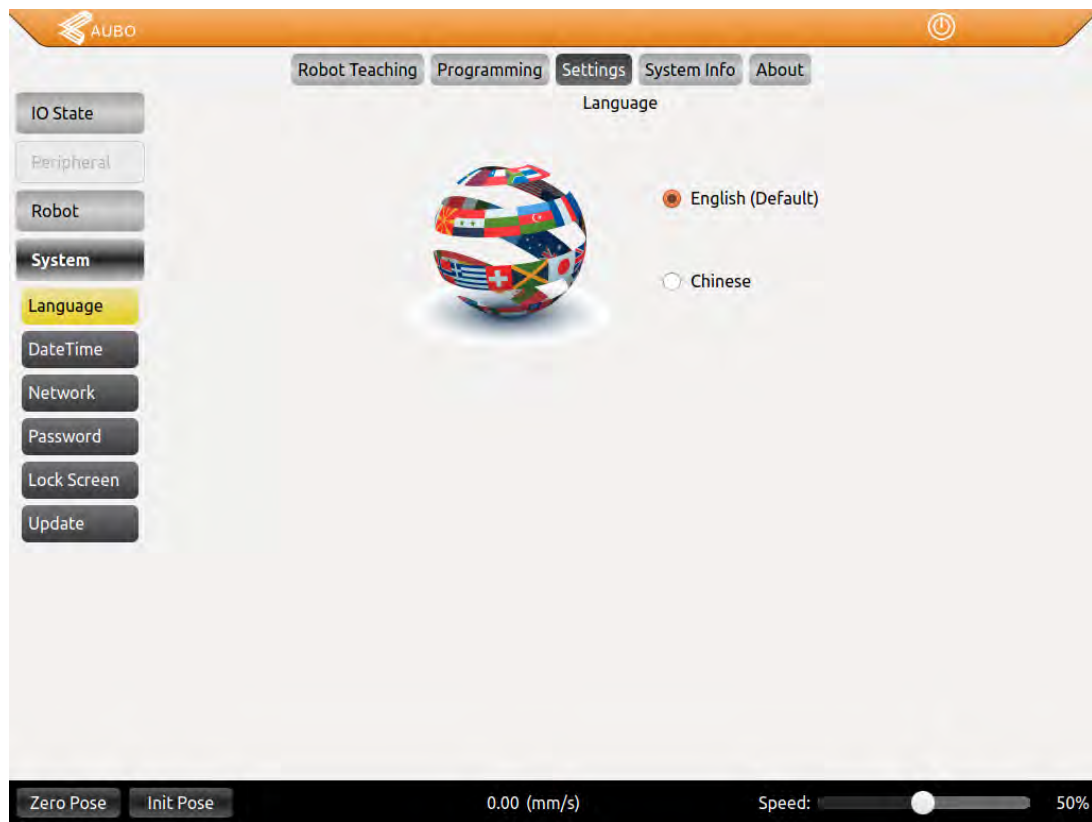


Figure 10.25 Language Tab

- 1 Language Tab provides English (default) and Simplified Chinese.

10.6.2 Date& Time tab.

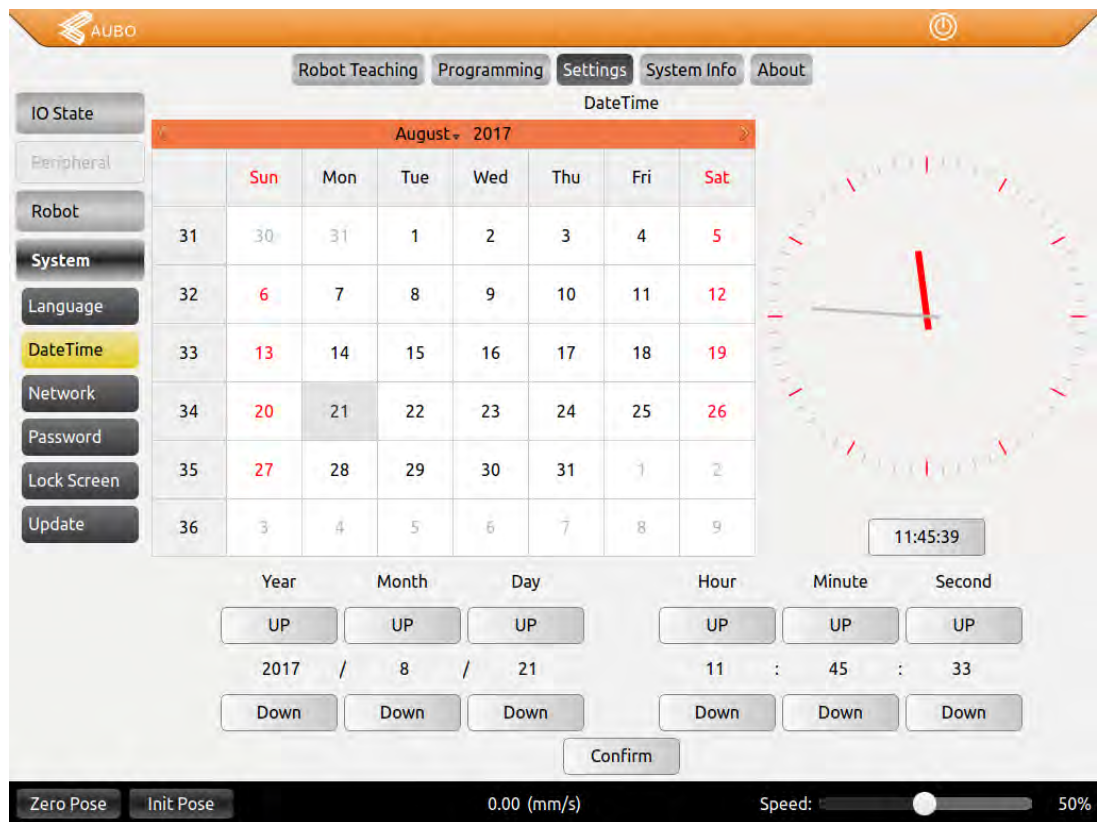


Figure 10.28 Date& Time tab.

- 1 Date& Time tab can set date and time.

10.6.3 Network Tab

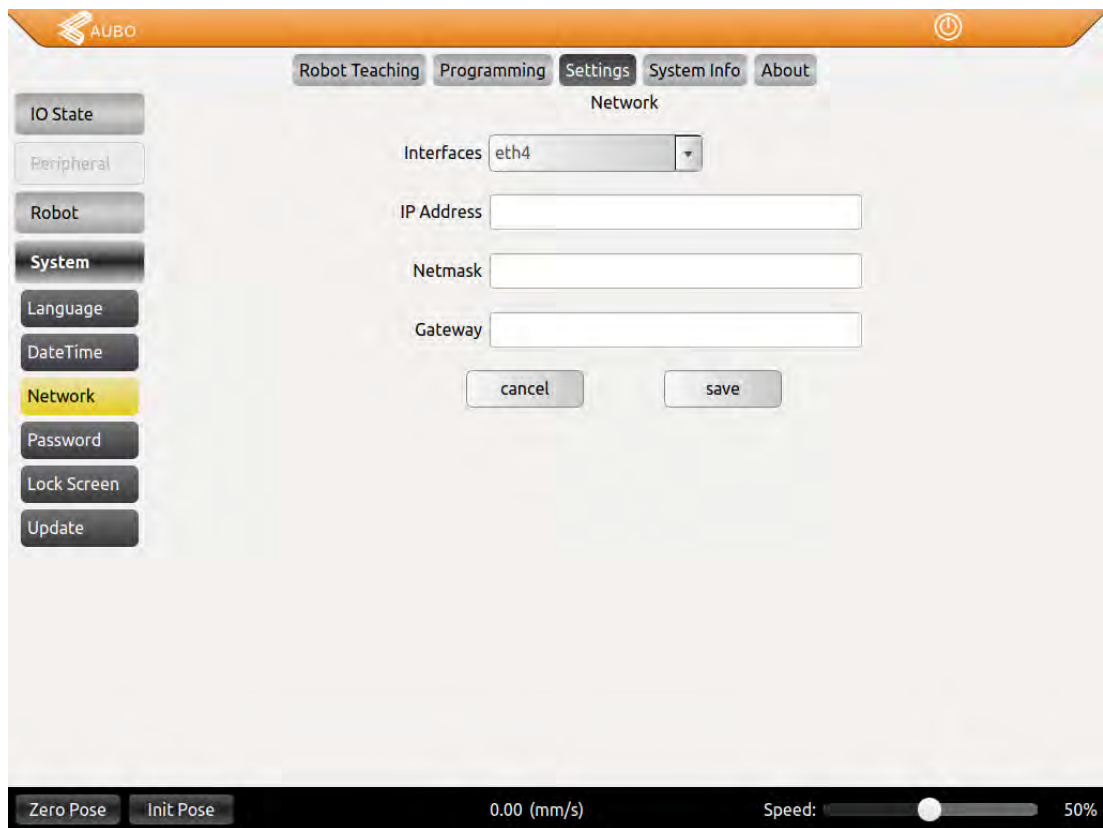


Figure 10.27 Network Tab

- 1 Network Tab is used for network settings controlled by third party interface.
- 1 Specified name of the NIC and its IP Address, Net mask and Gateway can be configured in this interface. The network IP address of the external device should in the same network segment with the IP address of robot.
- 1 Restart the AUBOPE system after saving the configuration

10.6.4 Password Tab

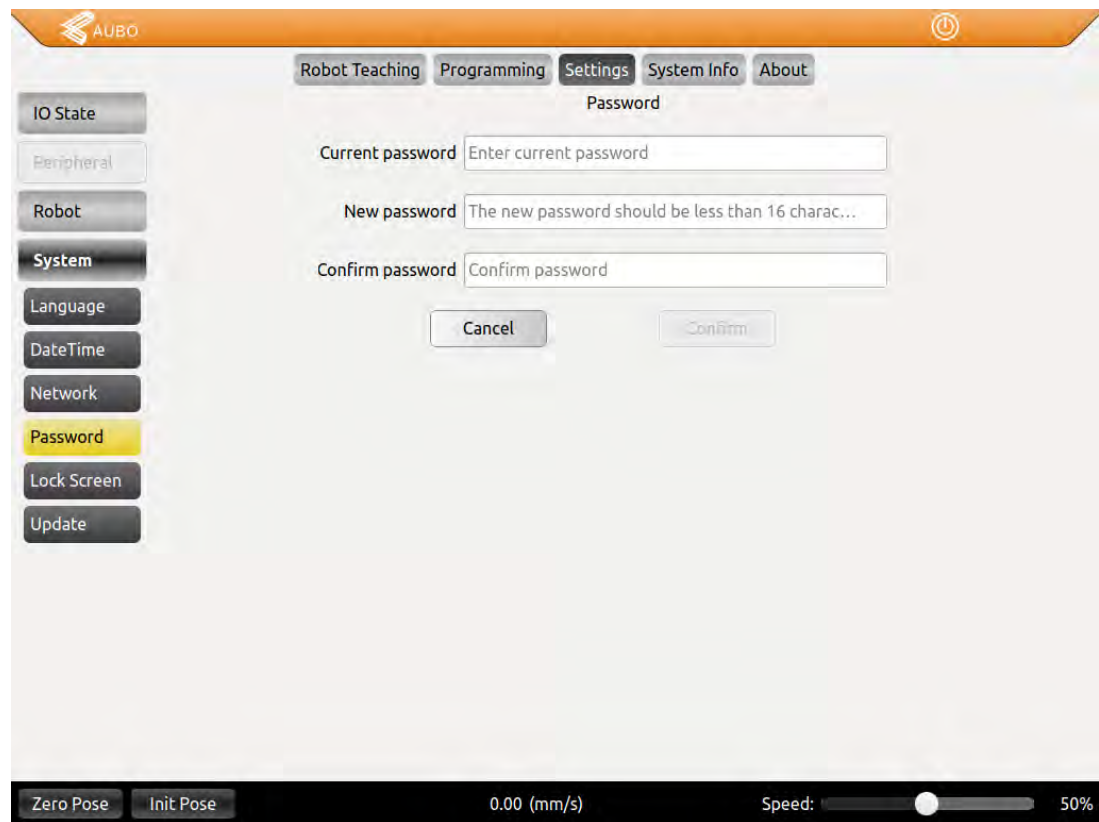


Figure 10.26 Password Tab

- 1 Users can set screen lock (default password is 1) and time of screen lock in Password Tab.
- 1 Click **【set password】** to update settings. The teach pendant can only be used under right password.

10.6.5 Lock Screen

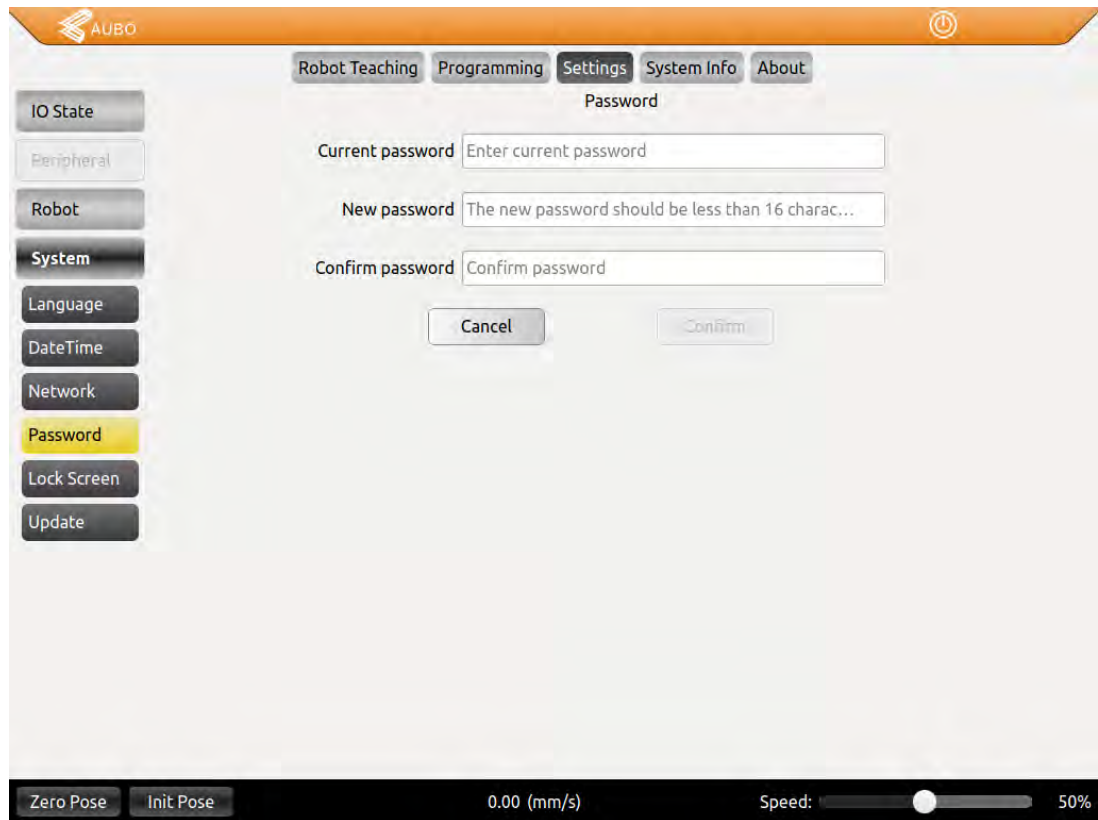


Figure 10.26 Lock Screen

- 1 Input time of screen lock and click **【set timeout】** to update screen lock.

10.6.6 Update Tab

Update Tab can install new update, import or export the project file and reset from USB memory stick.



Figure 10.29(a) Update tab

- 1 Steps of updating software: Insert an USB memory device and click **【Scan software】** as shown in Figure 10.25(a). Click the name of updated software and click **【Update】** . Then the system will reboot to finish update.
- 1 The name file directory can only be English
- 1 Updated Software can only be put in root directory.
- 1 Updated Software has to be a compressed file end with our.
- 1 After updating software, system will reboot automatically.
- 1 This tab can import or export the project file and reset too.



U disk format support FAT32, does not support NTFS format.

10.7 System Info Tab

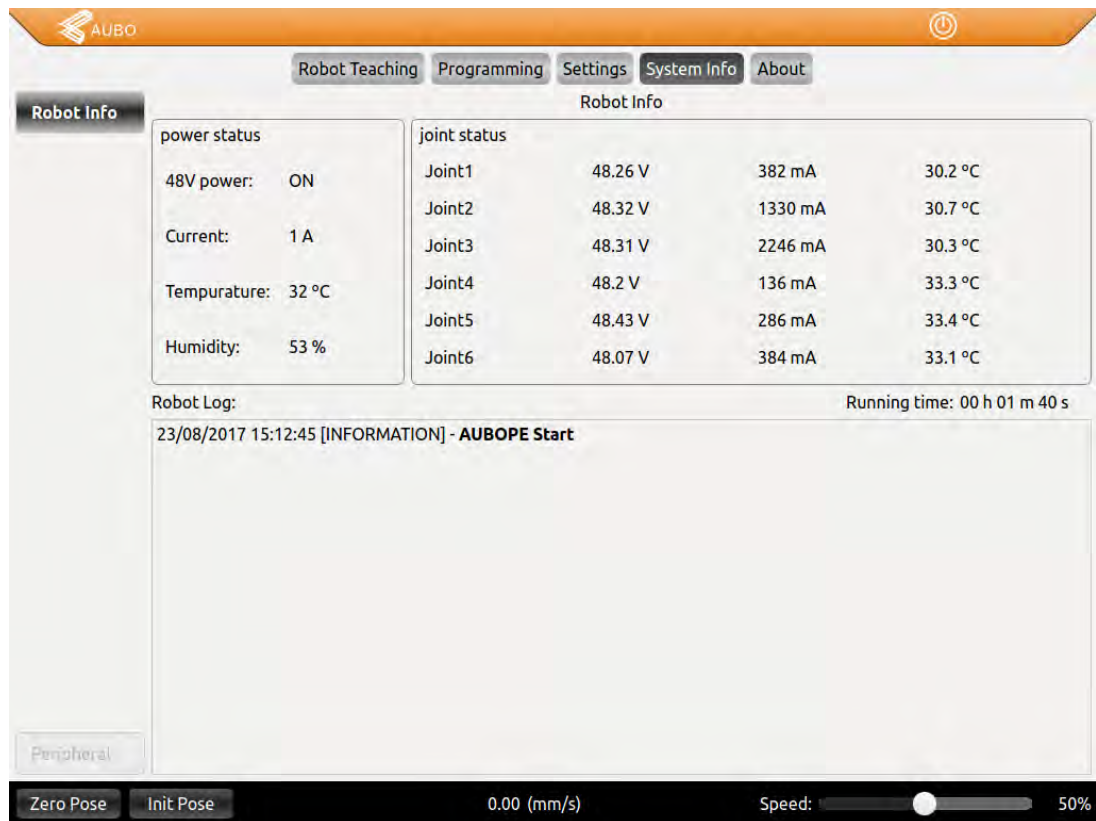


Figure 10.30 Version

- 1 Power status: the state of 48V power and detection of current, temperature and humidity.
- 1 Joint status: the operating state of the six joints (voltages, currents and temperatures).
- 1 Robot log: display the log information.
- 1 Running time: the robot operation time.
- 1 The format of Robot Log: date, time, information category and information description.
- 1 When the robot system is operating irregularly, users can check logs by slide the slide bar on the right to find out problems.

10.8 About



Figure 10.31 Version

- 1 Version unit is used for version information of software and other hardware.
- 1 Corresponding version in this manual as shown in table below:

version information	version number
AUBOPE version	V4.0.*
Interface board version	V4.0.*









11. ONLINE PROGRAMMING

11.1 Introduction

AUBO-i5 robot provides convenient programming method in Online Programming Interface. Users can program AUBO-i5 based on little programming skills, which can improve work efficiency greatly.

Users can program AUBO-i5 in ONLINE PROGRAMMING Tab, which includes 3 parts:

- a) Program logic list, which are arranged in a tree structure for users to read and modify programs.
- b) Option tabs, which includes 5 options: Project, Command, Condition, Variable settings and Simulator.
- c) Program control buttons, which includes start, stop, and single step execution.
 - 1 **Stop:** Click **【Stop】** during an execution to stop robot. In this case, only the **【Start】** button can activate the robot again by firstly placing the robot to zero pose.
 - 1 **Step:** Click **【Step】**, the robot will execute the first waypoint program according to the program logic order and click again to execute the next waypoint program.
- d) Program operation button.
 - 1  Undo command: Undo is a program edit control command, which can be restored to the last program edit state, up to 30 times. Click the Undo button to return to the previous program editing status.
 - 1  Undo recovery command: Undo recovery is program edit control command, you can restore the last undo command. Click the Resume Undo button to revert to the last Undo command.
 - 1  Cut  Copy  Paste command : they are the program edit control command, user can achieve the program segment cut, copy, paste operation.
 - 1  Delete command: delete is a program edit control command, user can delete the same level directory of the program segment.

This chapter will introduce the meaning of option tabs and provide complete programming examples to deepen the mastery of AUBO-i5 program skill.

11.2 Project Tab

- 1 The first step to write a new program is to setup a new project.
- 1 Programs are saved as projects.
- 1 There are 4 buttons in the Project tab: New Project, Load Project, Save Project and Default project.

11.2.1 New Project

- 1 Click **【New Project】** to create a new project. There will be a root node (Robot Control Project) on Program Logic. The following command will under this root node and the tab will change to Command automatically.
- 1 When a new project is created, it will cover the current project. So remember to save the current project.
- 1 Click **【Add before】** to insert a new command before selected command.
- 1 Click **【Add after】** to insert a new command after selected command.

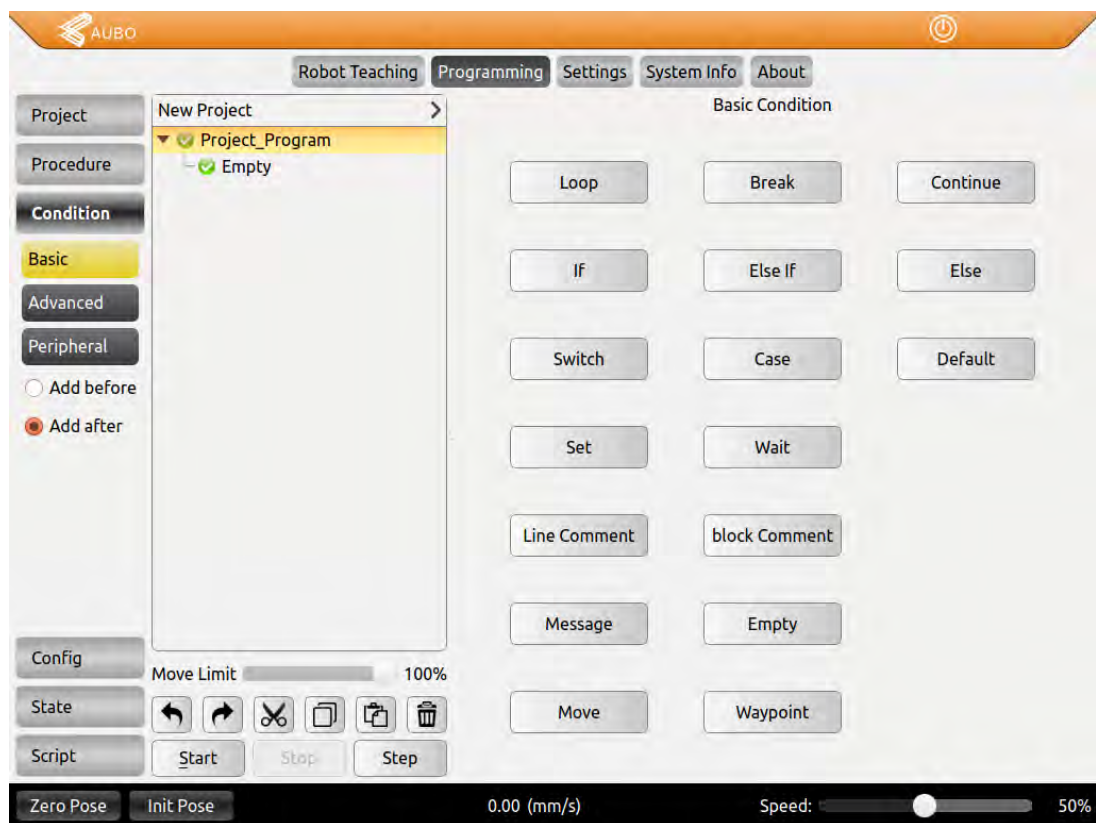


Figure 11.1 Project tab

11.2.2 Load Project

- 1 Click **【Load Project】** , find a target program and load.
- 1 The selected program will be loaded in program logic list.
- 1 Click **【Start】** button on the lower left corner to enter Auto move tab. Press and hold **【Auto】** button to move robot to initial pose. Click **【OK】** -> **【Start】** , the robot will start to move.

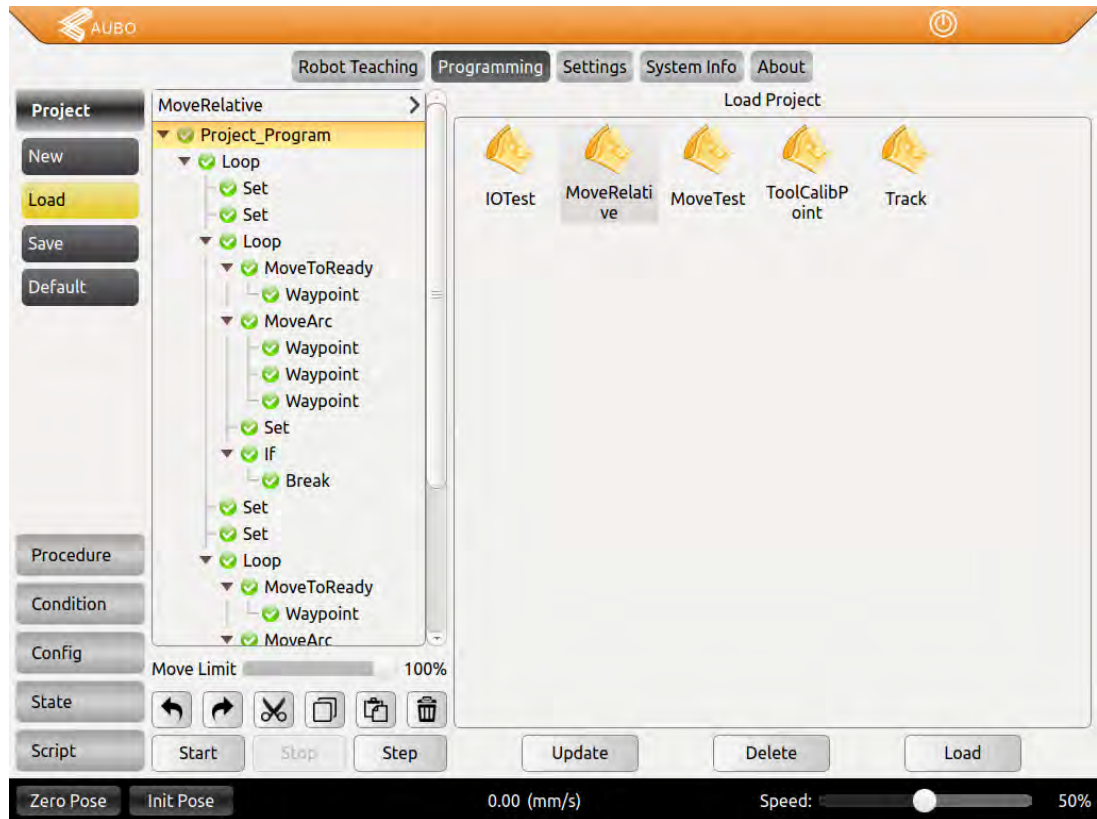


Figure 11.2: Project tab.

11.2.3 Save Project

- 1 Click **【Save Project】** , enter a name and click **【save】** .
- 1 The project files will be saved as xml format.
- 1 If saved project need to be edited, click **【Save Project】** again.
- 1 Saved project can be exported by clicking **【Robot Settings】** -> **【Update】** in teach pendant interface.
See 10.5.7 Update.

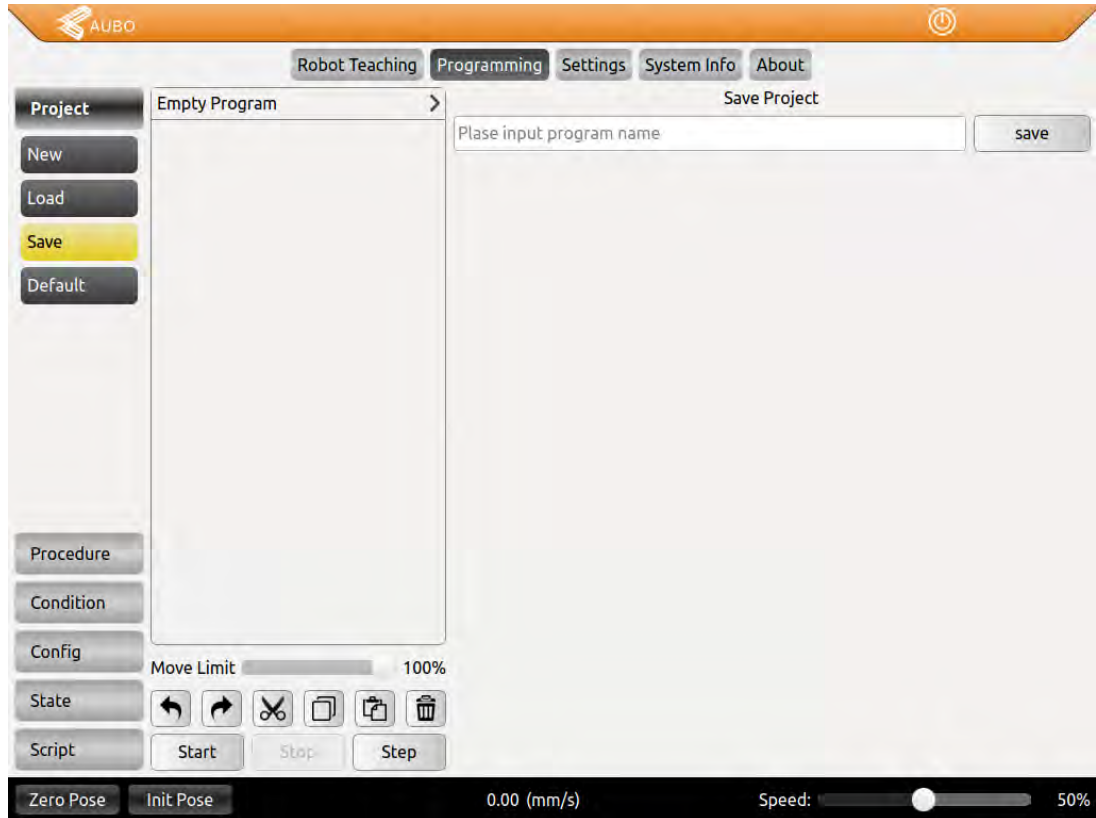


Figure 11.3 Save project

11.2.4 Default Project

- 1 Click **【 Confirm 】** button to select a default project file.
- 1 Click **【 auto load default project 】** to load the default project automatically after opening the programming environment.
- 1 Click **【 auto run default project & check ready position 】** to load and operate the default project automatically after opening the programming environment.
- 1 Click **【 auto run default project & don't check ready position 】** to operate program from current location. If don't click **【 auto run default project & don't check ready position 】** , robot needs to be operated to at first waypoint by teach pendant when load and operate the default project automatically.
- 1 Click **【 Default 】** to restore default configuration.

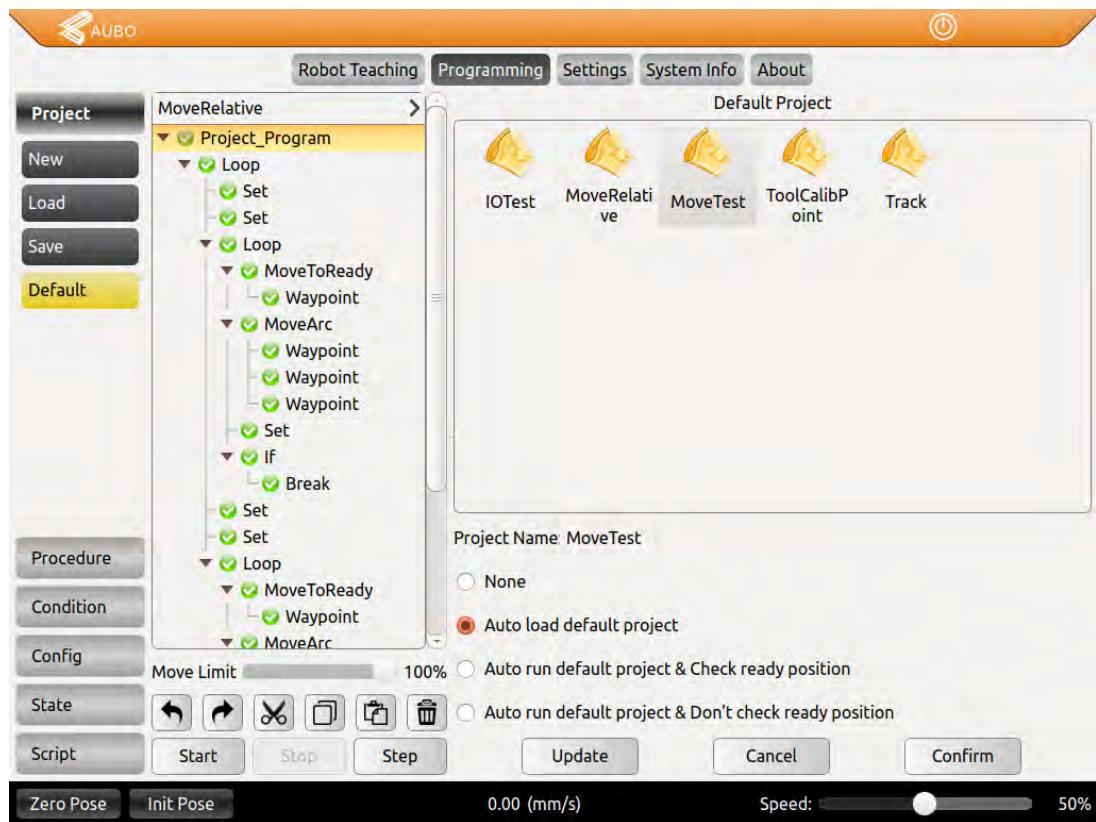


Figure 11.4 Default Project

11.2.5 Automove tab

- 1 Automove: Press and hold **【Auto】** button to operate robot to current position. Note: Release the button to stop the motion at any time.

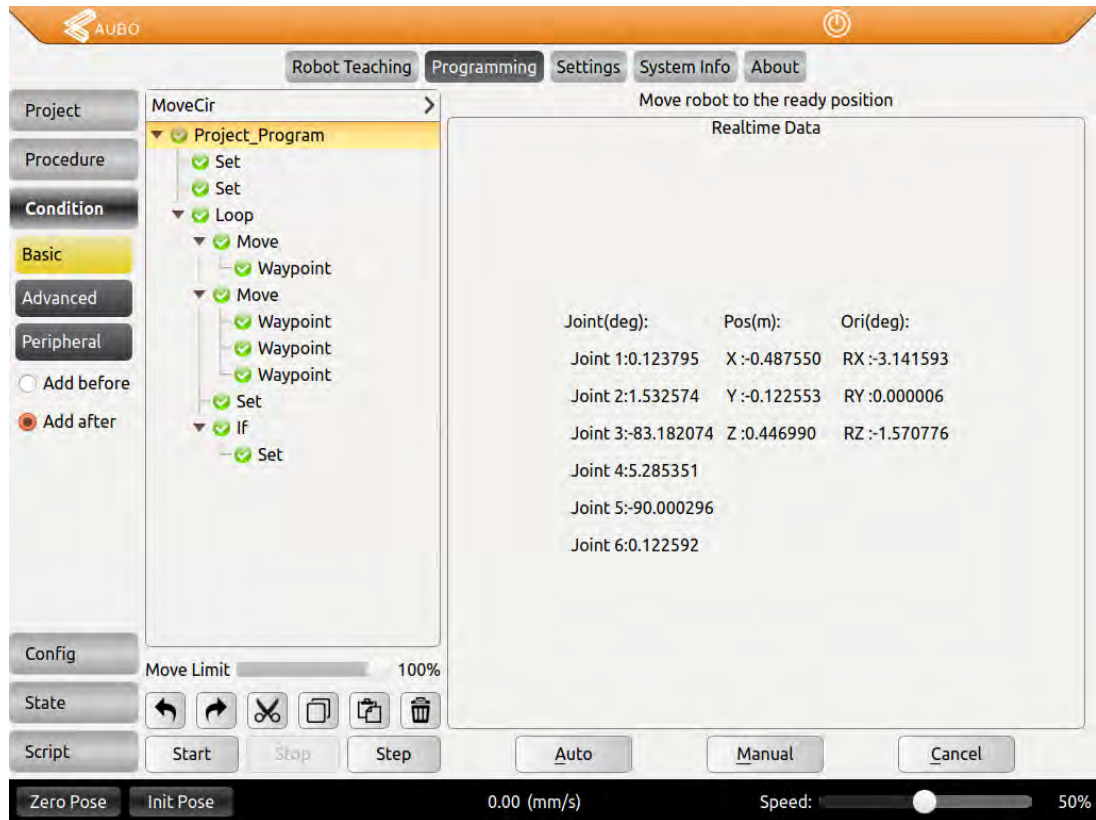


Figure 11.5 Automove

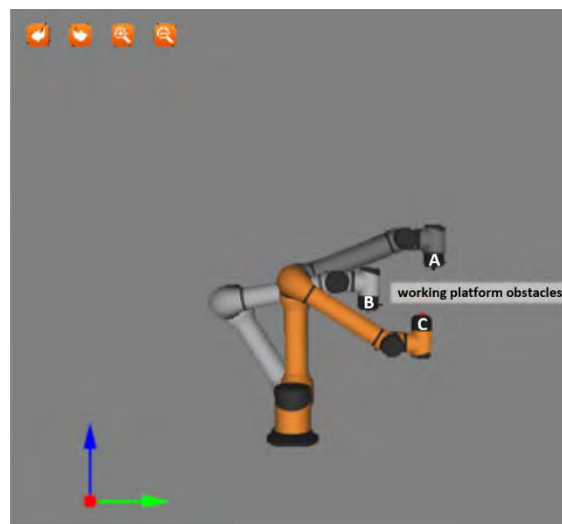


Figure 11.6 Manually move

- 1 Manually move: Press **【Manual】** button to jump into teaching interface, which can move robot manually.
- 1 Manually move mode can be taken when manipulator moves undesirably.
- 1 Manually move mode can be taken when auto move is not suitable. As shown in figure 11.7,

manipulator will hit working plane or obstacle when moving from C to A under auto move. In this case, manually move can be taken to move to safe point (like B) firstly, then move to initial position A in order to avoid damaging robot or other equipment.



Compare the position of the simulation with the real robot arm and make sure that the robot arm can perform safely without hitting any working platform obstacles.

11.2.6 Procedure

- 1 Procedure is a process project, you can edit the program section for multiplexing, it is easy to load into other project blocks.
- 1 New Project, Load Project, and Save Project Method are the same as **project** section.
- 1 The established sub-project file can be applied to Procedure command.

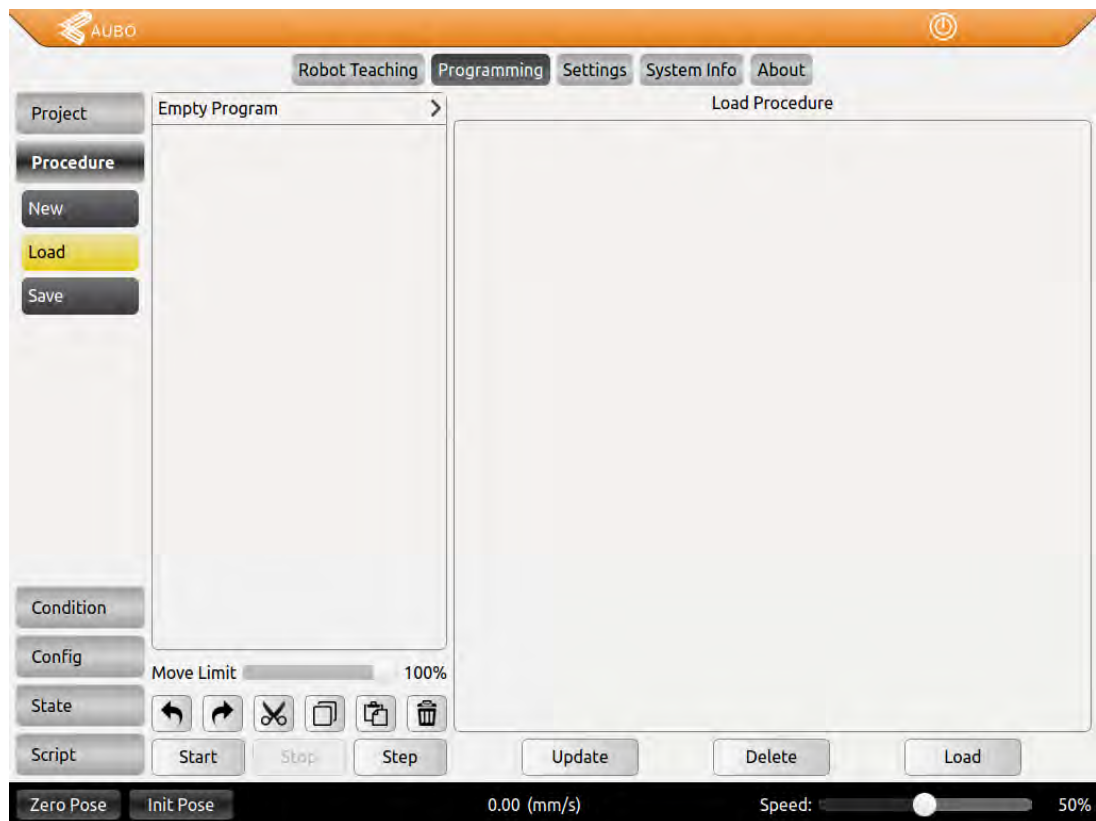


Figure 11.7 Procedure Project

11.3 Command & Condition Tabs

- 1 **【Command】** and **【Condition】** are two important parts in the programming environment. **【Command】** is used for writing and adding commands. **【Condition】** is used for configuring the selected command status. These two tabs usually are used in the same time, so this section will introduce them together.
- 1 This section mainly introduces the meaning and usage of commands. Only known the usage of commands, can we program successfully and completely.

11.3.1 Loop

- 1 Loop is loop command. The underlying program commands are either looped infinitely, a certain number of times or as long as the given condition is true.
- 1 Choose **【Loop always】** to loop infinitely.
- 1 Choose **【Loop_Times】** to set loop frequency and exit the loop when reach loop times.
- 1 Choose **【Loop condition】** to set loop expression. When expression is established, enter the loop, otherwise, exit loop. Click **【Clear】** to clear expression.
- 1 Click **【Confirm】** to confirm and save the configurations.

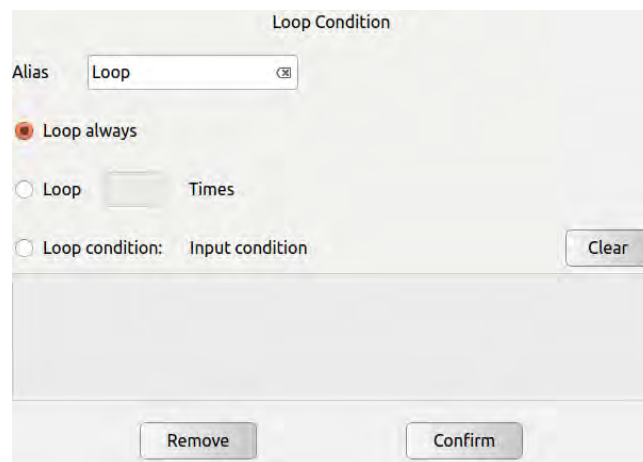


Figure 11.8 Loop

11.3.2 Break

- 1 Break command is used to jump out of a Loop when Break condition is satisfied.
- 1 The grammar of Break should be noted. Break can only be used inside Loop. And before Break command, there must be an If command. When If condition is true, Break will be executed and jump out of loop. Otherwise, an error message will pop up.
- 1 Click **【Remove】** to delete Break command.

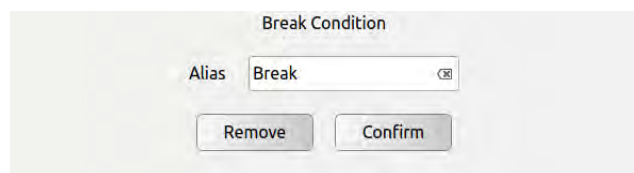


Figure 11.9 Break

11.3.3 Continue

- 1 Continue command is used to terminate a Loop for one time. Note the difference between Continue and Break, Break jump out of whole loop and don't enter again. Continue jump out of loop for one time and enter the loop in next time.
- 1 The grammar of Continue should be noted. Continue can only be used inside Loop. And there must have an If command before Continue. When condition in If is satisfied, then execute Continue to jump out of loop for one time. Otherwise, an error message will pop up.
- 1 Click **Remove** to delete Continue command.

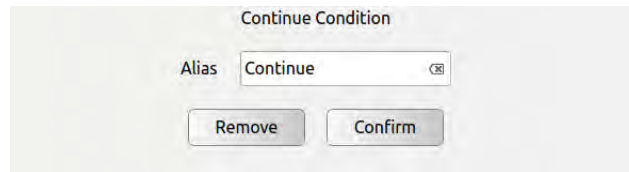


Figure 11.10 Continue

11.3.4 If...else

- 1 If...else command is used to operate different subprograms based on different conditions.
- 1 Click **Input condition** to input condition expression based on C language arithmetic rule, as shown in Figure 11.18(b). If the condition is evaluated to True, the lines inside this If are executed. If an expression evaluates to False while inside the body of the If part, the following Else If or Else statements will be executed.
- 1 Click **Clear** to delete an expression.
- 1 Click **Add Else** to add an Else node to make an If...Else. One **If** command can only add one Else.
- 1 Click **Add ElseIf** to add an Else If node. One **If** command can add multiple Else If nodes.
- 1 Click **Remove** to delete **If** command. All Else If nodes and Else nodes will be deleted together.
- 1 Click **Confirm** to confirm and save the configurations.

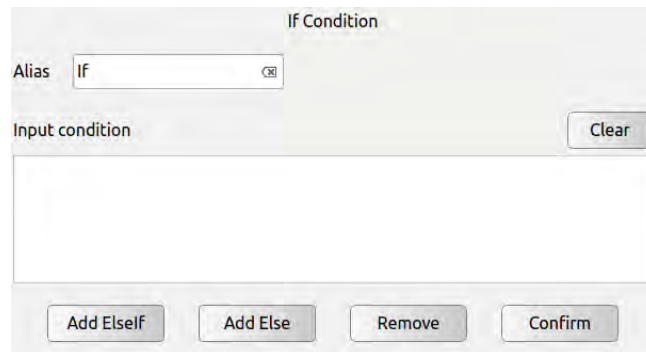


Figure 11.11 If...Else

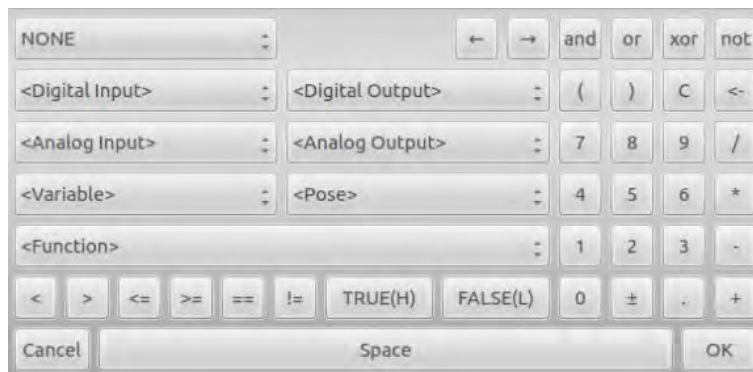


Figure 11.12 If...Else expression box

11.3.5 Switch...Case...Default

- 1 Switch...Case...Default is a condition selection command that runs different case program branches by judging conditions.
- 1 Click the blank space on the right of **【Alias】** , will pop up the input box, user can modify the command name.
- 1 Click the blank space on the right of **【Input condition】** , will pop up the input box for input the conditional expression. The expression operation follows the Lua language operation rules. When you run the **Switch** command, the program will calculate the value of the **Input condition** expression and compare with the condition value of the following **Case** statement. If they are equal, execute the following program segment in the **case**. If there is no **Case** value that satisfies the condition, then execute Default Corresponding program segment.
- 1 Note: To determine the authenticity can only be used true / false, can not use 1/0 instead.
- 1 Click **【Clear】** to clear the expression.
- 1 Click **【Add Case】** to add a Case node and form a Switch ... Case combination with the current Switch node. A Switch can add more than one Case.
- 1 Click **【Add Default】** to add a Default node. One Switch can only add one Default.
- 1 Click **【Remove】** to delete the selected switch, and the corresponding Case and Default of this switch will also be deleted.
- 1 Click **【Confirm】** to confirm configuration and save.

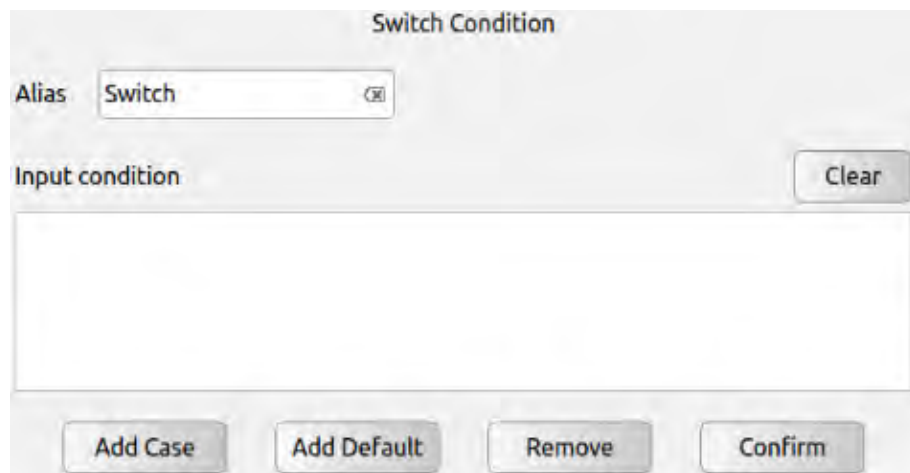


Figure 11.13 switch...case...default 命令

11.3.6 Set

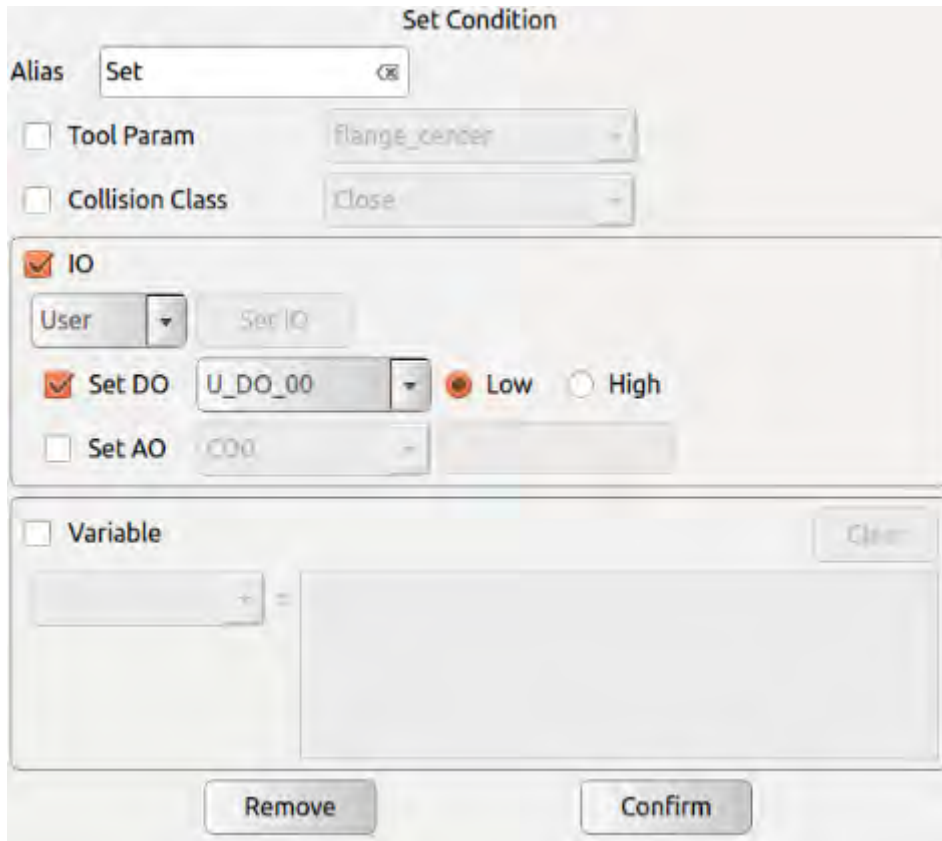


Figure 11.14 Set

- 1 Choose **【Tool Param-Set Tcp Center】** : Set the deviation of current tool payload (TCP) focus relative to end flange center in XYZ three direction.
- 1 Choose **【Collision Class】** :set the collision detection level.
- 1 Choose **【IO type】** : Choose IO type to set the DO/AO state.
- 1 Choose **【Variable】** : Choose a variable on the below drop-down list. Input an expression to assign value to choose variable, which should follow C language arithmetic rule. Click **【Clear】** to clear expression.
- 1 Click **【Remove】** to remove set command.
- 1 Click **【Confirm】** to confirm and save the configurations.



1. In actual operation, inaccuracy settings will cause wrong stop and other errors.
2. If these settings are wrong, the robot arm and control box will not function correctly and may become dangerous to people or equipment around them.

11.3.7 Wait

- 1 Wait command is used to set waiting time or digital input signal.

- 1 Choose **【Wait Time】** to set wait time by users.
- 1 Click **【Wait Condition】** to set wait mode by inputting expression.
- 1 Click **【Confirm】** to confirm and save the wait condition.
- 1 Click **【Remove】** to delete a wait command.

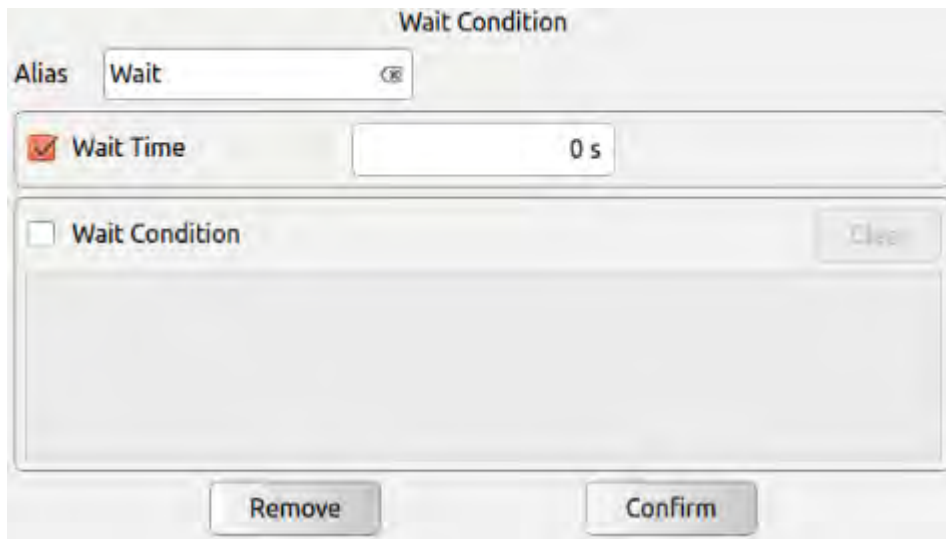


Figure 11.15 Wait

11.3.8 Line Comment

- 1 Line Comment is a line comment command that explains the following program by line comment.
- 1 Click **【Alias】** to the right of the blank interface will pop up the input box, you can modify the command name.
- 1 Click **【Comment】** to input text to explain the following block.
- 1 Click **【Remove】** to delete the selected Line_Comment.
- 1 Click **【Confirm】** to confirm configuration and save.

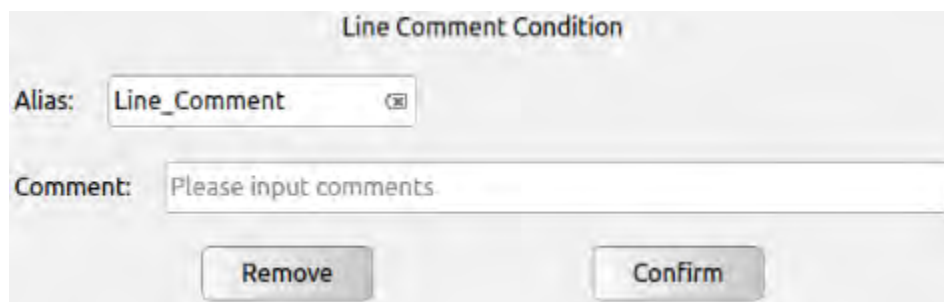


Figure 11.16 Line Comment

11.3.9 Block Comment

- 1 Block Comment is a block comment command that explains the following block by line comment.
- 1 Click **【Alias】** to the right of the blank interface will pop up the input box, you can modify the command name.
- 1 Click **【Comment】** to input text to explain the following block.
- 1 Click **【Remove】** to delete the selected Block_Comment.

- 1 Click **【Confirm】** to confirm configuration and save.



Figure 11.17 Block Comment

11.3.10 Message

- 1 Message is a message pop-up command that pops up the message window to convey status information to the user.
- 1 Click **【Alias】** input box on the right to modify the command name.
- 1 Click the **【Message Type】** drop-down menu to select the information type, corresponding to Information, Warning, Critical, and the corresponding window icons of the three types of information are different.
- 1 Click **【Message】** , the blank space on the right will pop up the input box), you can enter text to convey the status information.
- 1 Click **【Stop project when this message box pops up】** , the project will stop automatically when the information window pops up.
- 1 Click **【Remove】** to delete the selected message.
- 1 Click **【Confirm】** to confirm configuration and save.

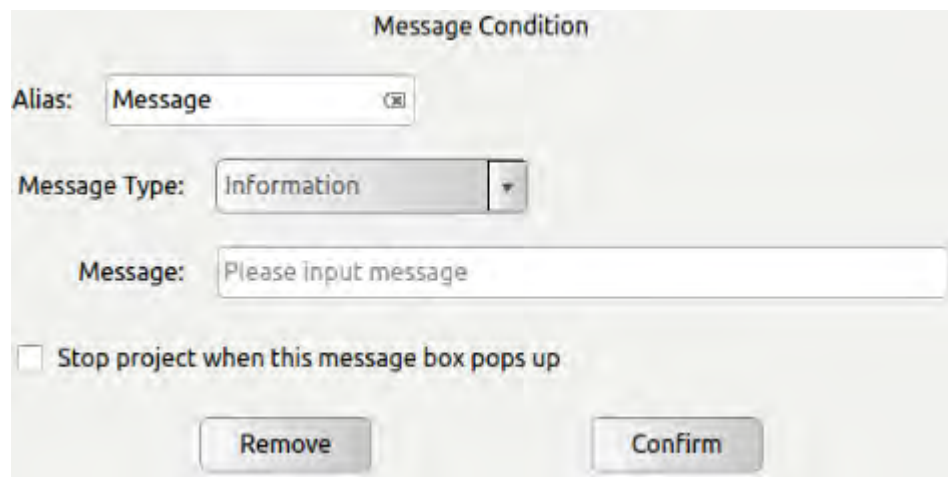



Figure 11.18 Message

11.3.11 Empty

- 1 Empty is an empty command, and an empty command is inserted to make it easier to space out program lines for operations such as pasting.
- 1 Click  to delete the selected Empty.

11.3.12 Move

- 1 The Move command is used to operate the movement of robot end-effector between waypoints.
- 1 Click **【Move】** to add a new Move node to the program list and a Waypoint sub-node will be added automatically.
- 1 Choose **【Move】** node, Condition Tabs will automatic pop-up, as shown in Figure 11.8. Users can configure the proceeding status of the Move command.

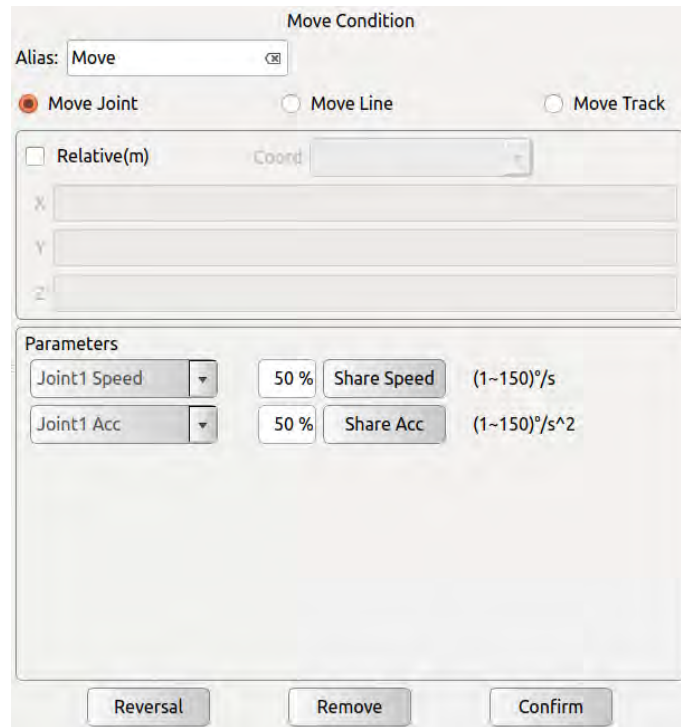


Figure 11.19 Move Joint

The Move Condition Setting has three choices: Move Joint, Move Line, and Move Track.

Blend radius can only be used in moveP mode (Arc smooth transition between the plurality of tracks), which range is 1~50mm. The feature of blend radius is continuous motion and it won't stop at waypoint. Blend radius operation mode is shown below.

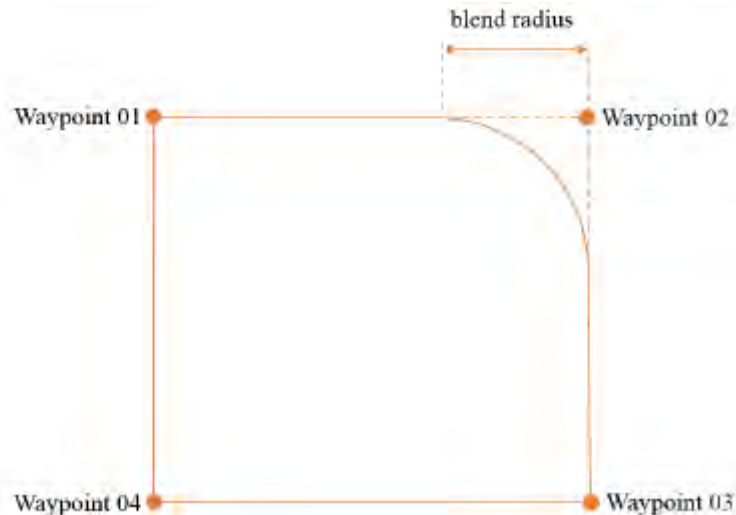


Figure 11.20 Blend radius moving track

- l Relative displacement: Users can adjust manipulator or TCP by changing the value of XYZ.
- l Coordinate system: Users can choose base coordinate system, end coordinate system or user-defined coordinate system (plane). User-defined coordinate system (plane) can set the reference coordinate system of relative displacement by **【IO control】** -> **【PLC I/O】** . See 10.3.3 PLC I/O Tab.
- l After checking the **【S Curve】** , robot waypoint transition will be smoother, but the speed will slow down a little. It can be used according to the circumstances.
- l Click **【Copy】** to copy all the waypoints under MOVE node.
- l Click **【Copy Reversal】** to copy all the waypoints in MOVE node in reverse.
- l Click **【Paste】** to paste all the waypoints in MOVE node into current waypoint.
- l Click **【Remove】** to delete the Move command.
- l Must click **【Confirm】** to finish the configuration and save it.

The Move command has three configuration: Move Joint, Move Line, and Move Track.

a) Move Joint

According to the joint angles between waypoints and configured motor's limitation of speed and acceleration (six manipulators' common parameters), all the joints move simultaneously to the target waypoint with fastest speed (Both initial velocity and final velocity are 0). The end moving path between these waypoints during the move can be observed on Track display. If you want manipulator to move quickly between waypoints and don't have to consider the TCP's moving path, this movement type is a good choice. Move Joint applies for the enough space and moves by the fastest way. As shown below.

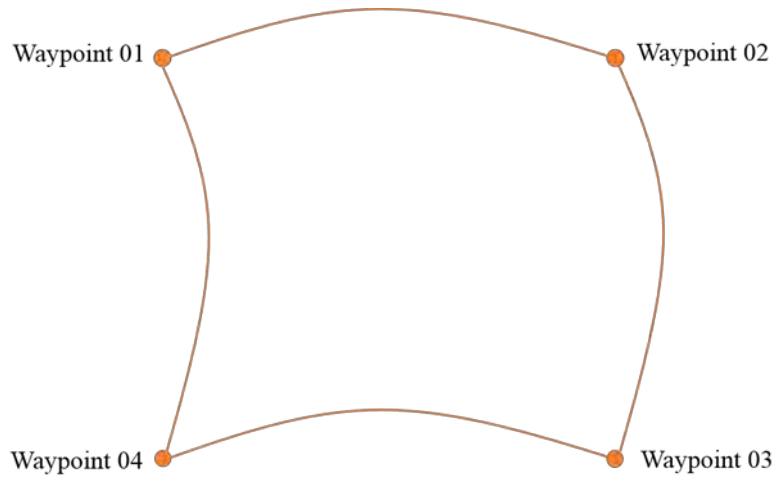


Figure 11.21 Move Joint track

Maximum speed and acceleration of joint:

- 1 Maximum speed of motor is 3000rpm. It is recommended that the speed is no more than 2800rpm in actual use. Maximum acceleration of motor (added speed per second) is 20000rpm/s.
- 1 The joint's speed is motor speed / speed ratio. The speed ratio of Joint 1~3, 4~6 in AUBO-i5 are 121 and 101.
- 1 Whether a joint can reach and keep maximum speed is determined by joint displacement and maximum acceleration parameters.
- 1 Motion mode includes S Curve and default Optimum time mode. It is recommended to choose S Curve to ensure start and end motion are smoother in a short time. Maximum joint speed and maximum joint acceleration can be set as Figure 11.8.

b) Move Line:

It makes the end-effector moves linearly between waypoints, which means each joint will operate more complex movements to keep end-effector's track in line. Common parameter applied for this movement type includes the maximum speed and maximum acceleration (represent as mm/s and mm/s²) of needed tool and motion mode. Similar with Move Joint, whether a joint can reach and keep maximum speed is determined by joint displacement and maximum acceleration parameters. As shown below.



Figure 11.22 Move Line

Users can set linear speed, linear acceleration and motion mode, which is S Curve or uniform motion mode. Similar with Move Joint, start and end motion smoother under S Curve mode. It is recommended to choose S Curve.

Moreover, **【arc】** and **【cartesian cubic】** motion mode of move line and move track belong to Cartesian space trajectory planning, which needed inverse kinematics result. There may have no solutions, multiple solutions or approximation solutions. Because of nonlinear relationship between joint space and Cartesian space, joint motion may beyond the limitation of maximum speed and acceleration.



It is strongly recommended that perform offline simulation firstly to verify the feasibility.

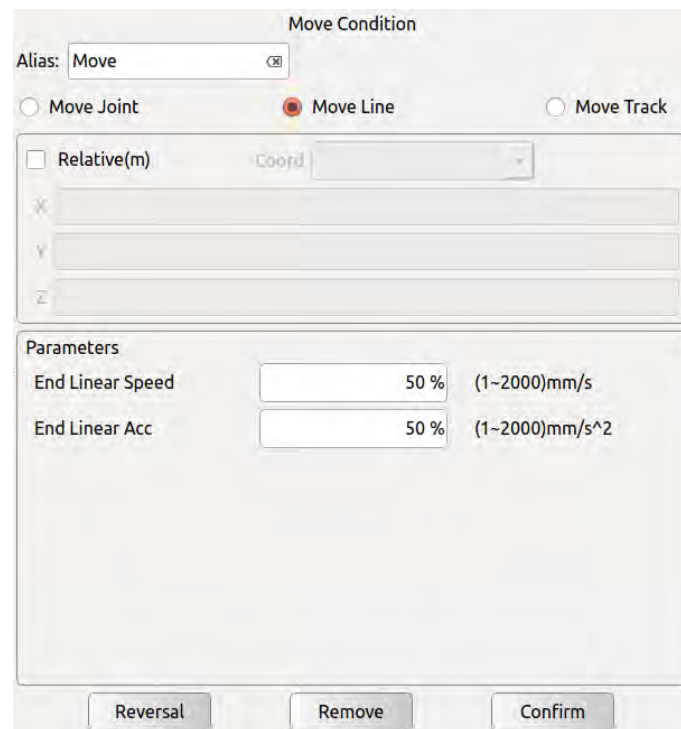


Figure 11.23 Move Line

c) Move Track

In multiple waypoints move track, the corresponding speed and acceleration of joint space and Cartesian space is continuous and the speed of start and end waypoint is zero during operation. It provides five modes: **【arc】**, **【joint cubic】**, **【Cartesian cubic】**, **【circular】** and **【moveP】**. Except **【arc】** and **【circular】**, other modes need at least three waypoints (No upper limit in theory).

Arc: Use three-point method to determine the arc and follow a sequence move from start waypoint to end waypoint. It belongs to Cartesian space trajectory planning. Pose changes only influenced by start and end point. The meaning of maximum speed and acceleration is same as Move Line.

Joint cubic: Joint cubic includes 【joint cubic】 and 【Cartesian cubic】 motion mode. It automatically optimizes uptime between waypoints according to maximum speed and acceleration. Operate velocity, acceleration continuous trajectory finally.

Circular: Similar with arc, use three-point method to determine the track of full circle and the direction of movement. Back to the start after completing the entire circumference of the movement. Keep the pose of start and end point unchanged during the movement. The meaning of maximum speed and acceleration is same as Move Line.

MoveP: The blend radius of two straight adjacent lines use arc smooth transition. Pose changes only influenced by start and end waypoint during the movement. The meaning of maximum speed and acceleration is same as Move Line.

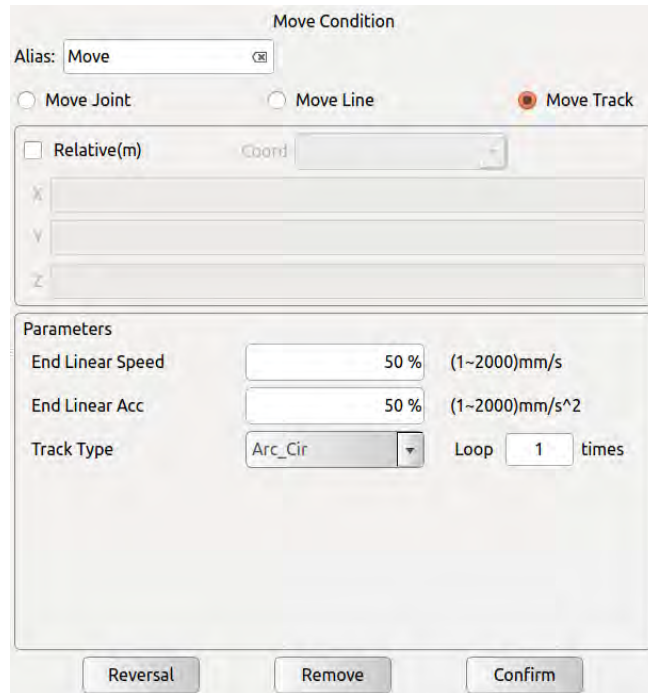


Figure 11.24 Move Track

11.3.13 Waypoint

- 1 Waypoint is an important part of AUBO-i5 program, which represents the position that the end-effector needs to arrive. Usually the trajectory of the end consists of two or more waypoints.
- 1 Waypoint can only be added after **【Move】** command.
- 1 Click **【Add before】** to add a new waypoint before the current waypoint.
- 1 Click **【Add after】** to add a new waypoint after the current waypoint.
- 1 Click on **【Move here】** to move the robot to the current waypoint. It's only effective for the real robot, not for the simulator.
- 1 Click waypoint which is needed to copy under Program Logic. Click **【Copy】** to copy current waypoint.
- 1 Click waypoint which is needed to paste under Program Logic. Click **【Paste】** to paste current waypoint.
- 1 Click **【Remove】** to delete a waypoint.
- 1 Click **【Set waypoint】** to configure a waypoint with robot pose. After clicking **【Set Waypoint】**, Robot Teaching is automatically activated. Users can move the robot end to a new waypoint, then click on the confirm button on the lower right corner.
- 1 Click **【Confirm】** to confirm status configuration of this waypoint and save.

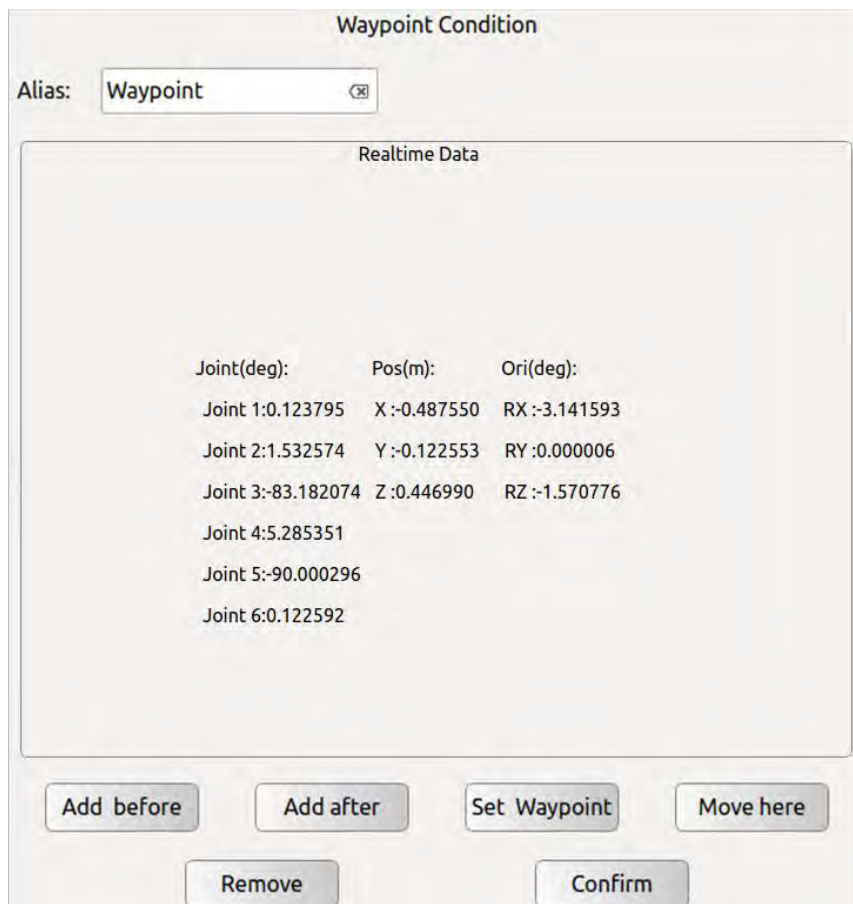


Figure 11.25 Waypoint

11.3.14 Thread

- 1 Thread is a multi-threaded control command. In the Thread block, there must be a Loop

loop command, in the Loop loop, user can achieve the parallel control with the main program.

- 1 Note: It is recommended to avoid the use of multi-threaded. If you have to use multiple threads, be aware of the parallel logic and timing of the main and auxiliary threads.
- 1 Click **【Alias】** input box on the right to modify the command name.
- 1 Click **【Remove】** to delete the selected Thread.
- 1 Click **【Confirm】** to confirm configuration and save.



Figure 11.26 Thread

11.3.15 Procedure

- 1 Procedure is a process edit command. In the Procedure block, you can edit the block for multiplexing and load it easily into other project blocks.
- 1 Note: Procedure can not be inserted into the process of the Thread program.
- 1 Click **【Alias】** input box on the right to modify the command name.
- 1 Click **【Update】** as the file update button to retrieve the current file save directory and update the display file changes.
- 1 Click **【Remove】** to delete the selected procedure.
- 1 Click **【Confirm】** to confirm configuration and save.

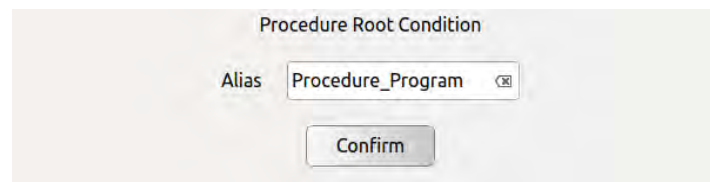


Figure 11.27 Procedure



Figure 11.28 Procedure 命令

11.3.16 Script

- 1 Script is a script editing command. In Script, you can choose to add Line Script and Script File.
- 1 Note: Procedure can not be inserted into the process of the Thread program.
- 1 Click **【Alias】** input box on the right to modify the command name.
- 1 Click **【Line Script】** to add a Line Script button, you can enter a line of script control commands in the input box below.
- 1 Click **【Script File】** to add Script File button, you can choose to load Script File.
- 1 Click **【Update】** as the file update button to retrieve the current file save directory and update the display file changes.
- 1 Click **【Remove】** to delete the selected Thread.
- 1 Click **【Confirm】** to confirm configuration and save.

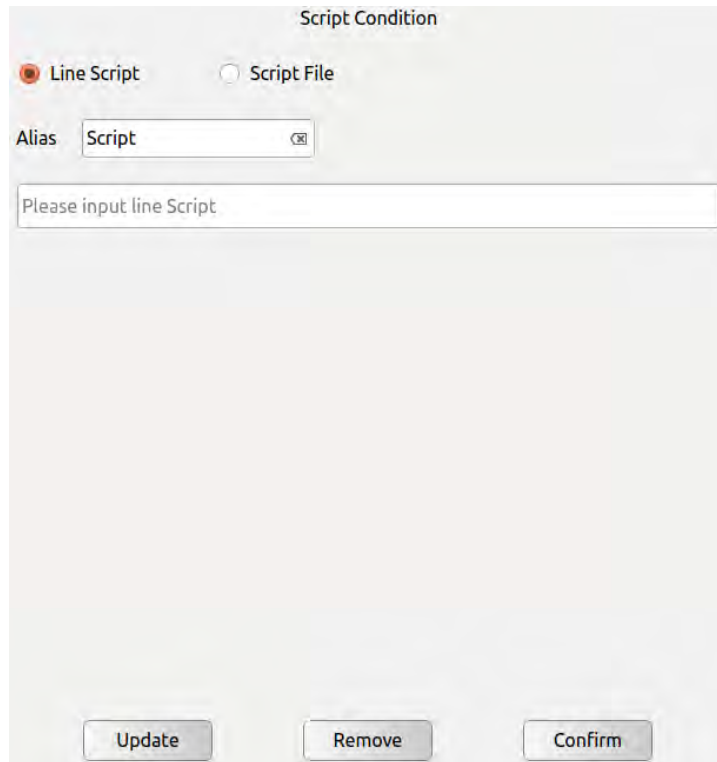


Figure 11.29 Script

11.3.17 Record Track

- 1 Record Track command is a track playback command, select the track icon, click **【confirm】** button, the track record can be loaded into the engineering logic.
- 1 The input box on the lower side of the interface can set the speed and acceleration of each joint when the robot moves to the preparation point. Please click **【confirm】** button after modification..
- 1 Click **【Update】** as the file update button to retrieve the current file save directory and update the display file changes.
- 1 Click **【Remove】** to delete the selected Track_Record.

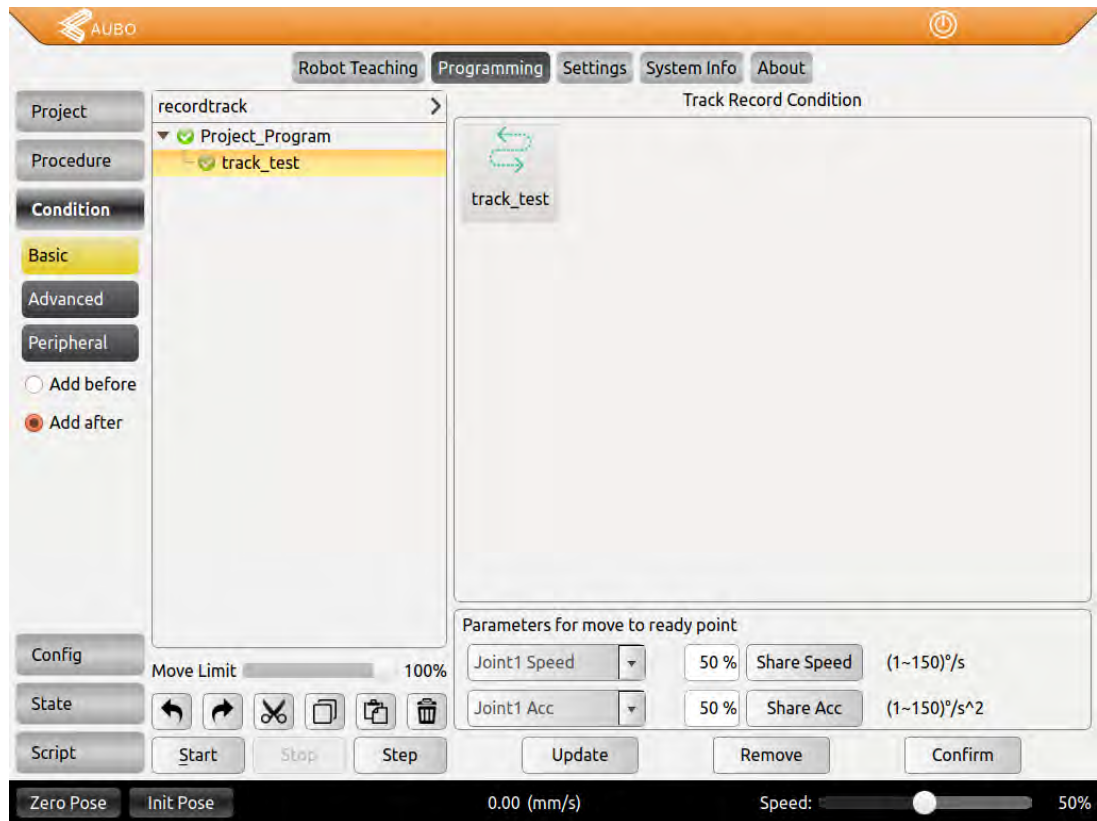


Figure 11.30 Record Track 命令

11.3.18 Offline Record

- 1 Offline Record command can importe the track file which was generated via offline programming software into the online programming.
- 1 Select the offline file and click 【confirm】 to save.
- 1 Offline Record command can embedd the track file which was generated via offline programming software in the online programming.
- 1 Select the offline file and click confirm to save.
- 1 The imported trace file format must include six joint angles in each line, and the unit is radian.
- 1 The imported trace file suffix should end with .offt.
- 1 The import file needs to be copied to the folder to be displayed in AUBORPE software interface, as shown in the following figure:

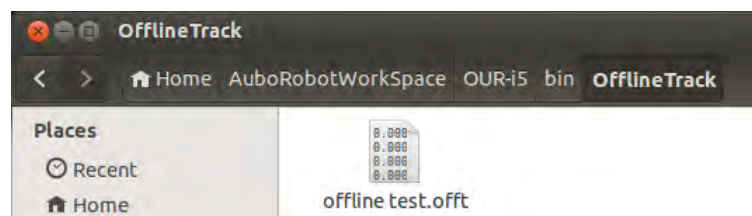


Figure 11.31 offline 文件导入目录

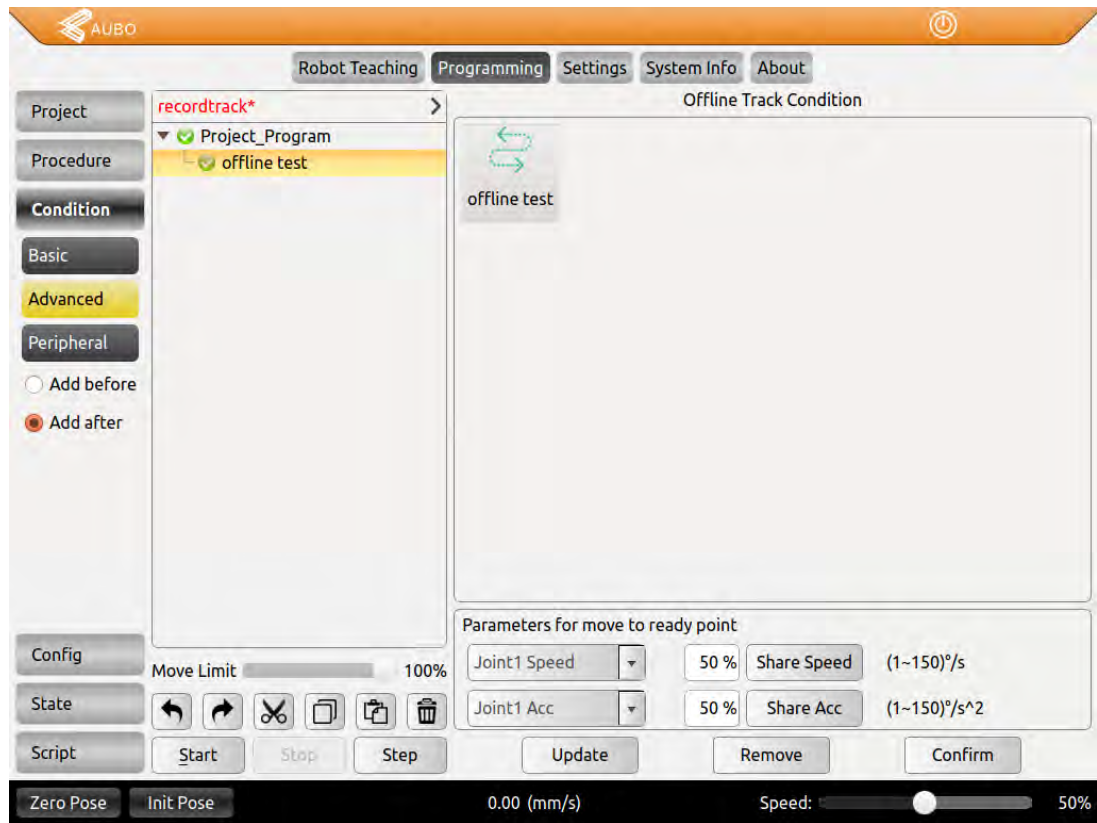


Figure 11.32 Offline Record

11.4 Peripheral



Figure 11.33 Peripheral

AUBOPE plug-in interface allows third-party developers to extend the programming software capabilities to their needs, making the software has unlimited expansion capabilities, for example.

Add Robotiq Gripper to Teach Pendant software;

Add Modbus device to Teach Pendant software;

Integrated the smart camera into the Teach Pendant software

Palletizing process package and so on

11.5 Variable Tab

Variable Tab only provides 3 variable types: Bool, Int and double. Configured list of variables is displayed in table, including name, type and value. Choose a variable, the information will display in the drop-down list of variable type, variable name input box and variable value selection / input options.

11.1 Rec Track

Rec Track can record the trajectory of the manipulator over a period of time and can be applied to the online programming environment.

New Track: Click the start button to start recording the trajectory of the manipulator. Click the finish button to end the recording. Input the name of the track in the input box, and click save to finish the track record.

Track playback: Select the track icon and click **【load】** in the interface. Press and hold the **【Ready】** button to move the robot to the initial position of the track record, and then click **【Play】**, and the track will be played back.

Pause track: Click **【stop】**, will stop the playback of the robot.

Resume after Pause: Long press **【Move Here】**, After the robot is synchronized to the current position and posture, click **【Play】** to resume track playback.

When playing track back, the progress of the track will be displayed through the slider and the progress bar. The user may also drag the progress bar manually to operate the track.

Click **【cut before】**, you can delete the track before the location of the slider, click **【cut after】**, you can delete the track after the location of the slider.

The time interval of track record is 2 " ~ 5".

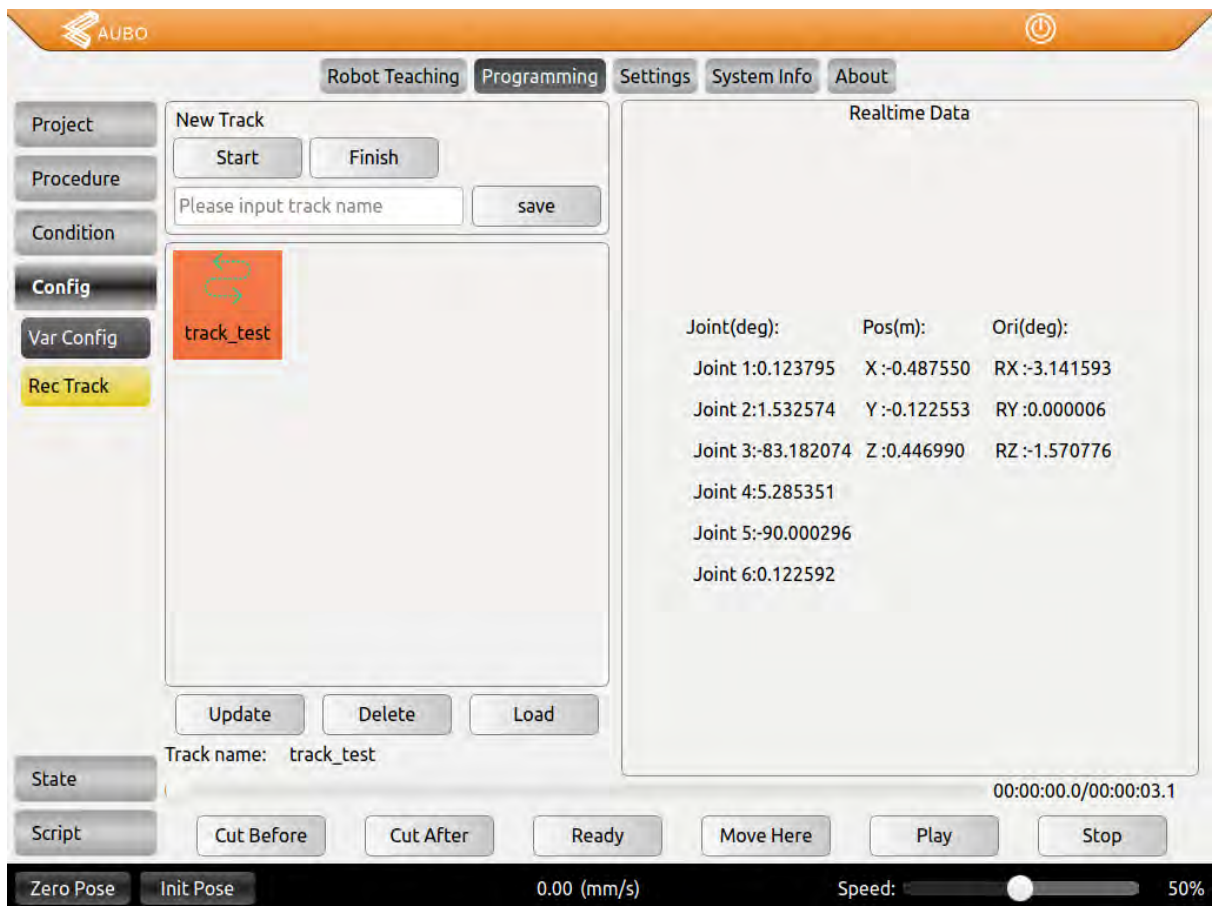


Figure 11.35 Track Record

APPENDIX

A GLOSSARY

Category 0 stop: Robot motion is stopped by immediate removal of power to the robot. It is an uncontrolled stop, where the robot can deviate from the programmed path as each joint brake as fast as possible. This protective stop is used if a safety-related limit is exceeded or in case of a fault in the safety related parts of the control system. For more information, see EN ISO13850:2008 or IEC60204-1:2006.

Category 1 stop: Robot motion is stopped with power available to the robot to achieve the stop and then removal of power when the stop is achieved. It is a controlled stop, where the robot will continue along the programmed path. Power is removed after one second or as soon as the robot stands still. For more information, see EN ISO13850:2008 or IEC60204-1:2006.

Category 2 stop: A controlled stop with power left available to the robot. The robot can use up to one second to stop all motion. The safety-related control system monitors that the robot stays at the stop position. For more information, see IEC 60204-1:2006.

Diagnostic coverage (DC): is a measure of the effectiveness of the diagnostics implemented to achieve the rated performance level. For more information, see EN ISO13849-1:2008.

Integrator: The integrator is the entity that designs the final robot installation. The integrator is responsible for making the final risk assessment and must ensure that the final installation complies with local laws and regulations.

MTTFd: The Mean time to dangerous failure (MTTFd) is a value based on calculations and tests used to achieve the rated performance level. For more information, see EN ISO13849-1:2008.

Risk assessment: A risk assessment is the overall process of identifying all risks and reducing them to an appropriate level. A risk assessment should be documented. Consult ISO 12100 for further information.

Performance Level: A Performance Level (PL) is a discrete level used to specify the ability of safety-related parts of control systems to perform a safety functions under foreseeable conditions. PLd is the second highest reliability classification, meaning that the safety function is extremely reliable. For more information, see EN ISO13849-1:2008.

B CERTIFICATION

AUBO-i5, is certified by a third-party certification body to pass the quality management system and sample type test. It has been confirmed that this product meets specific requirements and has the ability to consistently produce products that meet the standard requirements and has given written certification. Described as follows: AUBO-i5 has been tested and certified by many famous third-party international organizations and has obtained CE certification, North American certification and KCS certification. Its product safety has reached the international advanced level. AUBO-i5 passed the robotic performance test of China National Robot Testing and Assessment Center (headquarters).



AUBO-i5 robot is certified by SGS and passed CE certification. All products comply with all the relevant requirements of the EU CE directive:

- 1 LVD 2006/95/EC
- 1 MD 2006/42/EC
- 1 EMC 2004/108/EC
- 1 EN ISO 10218-1:2011
- 1 EN ISO 12100 : 2010
- 1 EN ISO 13849-1 : 2008
- 1 EN 60204-1 : 2006+A1 : 2009



AUBO-i5 robot is certified by TÜV SÜD and has been certified in North America to meet all relevant North American certification requirements:

- 1 UL 1740 : 2015
- 1 NFPA 79 : 2015
- 1 CAN/CSAZ434 : 2014
- 1 ANISI/RIAR15.06 : 2012



AUBO-i5 robot is certified by a Korean official agency and passed KCs certification. It meets all the relevant requirements of the Korean certification standard.



AUBO-i5 robot was test by the China National Robot Testing and Assessment Center (headquarters), robot performance testing, testing based on the following standard:

GB/T 12642-2013 Industrial robots - Performance specifications and test methods



C STOPPING TIME & STOPPING DISTANCE

Stopping time and stopping distance of CATEGORY 0.

The table below includes the stopping time and stopping distance measured when a CATEGORY 0 stop is triggered. These measurements correspond to the following configuration of the robot:

- Extension: 100% (the robot arm is fully extended horizontally)
- Speed: 100% (the general speed of the robot is set to 100% and the movement is performed at a joint speed of 183°/s)
- Payload: maximum payload when connecting to the TCP (5 kg)

The test on the joint 0 was carried out by moving horizontally, which means the axis of rotation is perpendicular to the ground. During the tests for Joint 1 and 2, the robot follow a vertical trajectory, which means the axes of rotation is parallel to the ground and stop when the robot moving downwards.

	Stopping Distance(rad)	Stopping Time(ms)
Joint 0 (BASE)	0.21	210
Joint 1 (SHOULDER)	0.60	500
Joint 2 (ELBOW)	0.12	135

D GUIDELINE

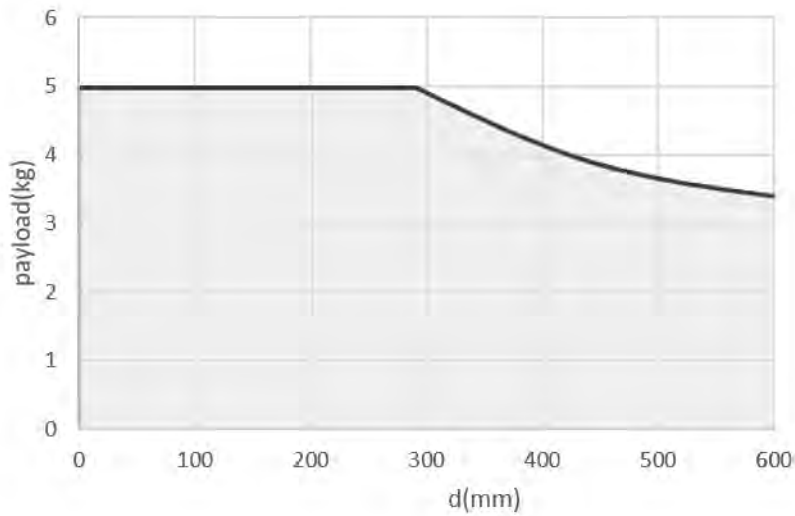
Robot design reference to the following standards.

<i>Standard</i>	<i>Definition</i>
<i>2006/42/EC:2006</i>	Machinery Directive: Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)
<i>2004/108/EC:2004</i>	EMC Directive: Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC
<i>EN ISO 13850:2008</i>	Safety of machinery: Emergency stop - Principles for design
<i>EN ISO 13849-1:2008</i>	Safety of machinery: Safety-related parts of control systems - Part 1: General principles of design
<i>EN ISO 13849-2:2012</i>	Safety of machinery: Safety-related parts of control systems - Part 2: Validation
<i>EN ISO 12100:2010</i>	Safety of machinery: General principles of design, risk assessment and risk reduction
<i>EN ISO 10218-1:2011</i>	Industrial robots: Safety Note: Content equivalent to ANSI/RIA R.15.06-2012, Part 1
<i>ISO/TS 15066: 2016</i>	Safety requirements for collaborative industrial robot Robots and robotic devices —Collaborative robots

E TECHNICAL SPECIFICATION

Robot Model	AUBO-i5		
Weight	24 kg		
Payload	5 kg		
Reach	924.5 mm		
Joint ranges	-175° ~ +175°		
Joint speed	150°/s(1-3 joint) 180°/s(4-6 joint)		
Tool linear speed	≤ 2.8m/s		
Repeatability	± 0.02 mm		
Footprint:	Ø172 mm		
Degrees of freedom	6 rotating joints		
Control box size (W * H * D)	727mm*623mm*235mm		
I / O ports		Standard control box	End-effector
	DI	16	4 (Configurable)
	DO	16	4 (Configurable)
	AI	4	2
	AO	4	-
I / O power supply	24V 3A in control box(parameters are subject to actual data.) 0V/12V/24V 0.8A in tool		
Communication	Ethernet, Modbus - RTU/TCP		
Interface	SDK(support C\C++\Lua\Python), support ROS, API		
Programming	AUBOPE graphical user interface on 12-inches touchscreen		
Noise	Small		
IP protection class	IP 54		
Power consumption	Approx. 200W using a typical program		
Collaboration operation	Collaborative operation according to ISO 10218-1:2011		
Temperature	Robot can work in a temperature range of 0-45°C		
Relative humidity	25%-85%		
Power supply	100-240 VAC, 50-60 Hz		
Calculated operating life	30,000 hours		
Cabling	Cable between robot and control box (2.9m) Cable between touchscreen and control box (2.9m)		

F PAYLOAD



Payload of wrist has shown above, in which d-axis represent the center of gravity offset which is the distance between end-effector flange focus and tool focus.

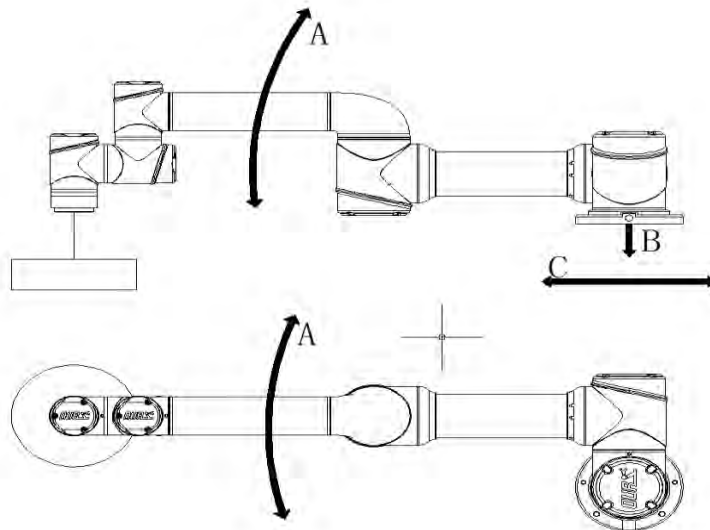


1. The load conditions should within the range shown in the figure.
2. The payload shown in figure represent maximum load capacity. Shall not overload in any case.
3. Overload may cause damage to the machine's internal parts

G MANIPULATOR INSTALLATION REQUIREMENTS

Manipulator's payload is 5KG. Then deviation of payload focus and the central axis of end-effector is 100mm when working normally and excludes external collision. There are three ways to install (Forward mounting, hoisting and Vertical mounting). It is recommended that every hole to fix robot bolt should provide the capacity of minimum anti overturning force.

<i>Mounting</i>	<i>Normal operation</i>	<i>Emergency stop</i>
<i>Forward mounting</i>	1554N±360N	1554N±2594N
<i>Reverse mounting</i>	1754N±360N	1754N±2594N
<i>Vertical mounting</i>	1554N±360N	1554N±2594N



Make sure to meet requirements when installation.

H ALARM INFORMATION & DESCRIPTION OF GENERAL PROBLEM

Alert Codes	Error information	Error Description	Possible error	Solution
10001	Encoder lines error!	Encoder lines are inconsistent.	Robot power up, press release brake button, robot power down automatically.	Check whether six modules photoelectric encoder lines are the same.
20001	Tool over voltage!	Tool is overvoltage.	1. End IO communication anomaly. 2. Power supply anomaly.	1. Check 48V power supply. 2. Check end control board power supply.
20002	Tool under voltage!	Tool is under voltage.	1. End IO communication abnormality. 2. Power supply anomaly.	1. Check 48V power supply. 2. Check end control board power supply.
20003	Tool over temperature!	Tool is over temperature.	Tool anomaly.	1. Check tool temperature sensor.
30001	Power current anomaly!	Power current is anomaly.	1. Robot power down.	1. Check current transducer wiring. 2. Check interface board analog acquisition section.
40001	Joint 1 can bus error! Please check can bus cable!	Joint 1 can bus error.	1. Interface board error. 2. Joint 1 circuit board error. 3. CAN bus error.	Check the connection of CAN bus before interface board and control box.
40002	Joint 2 can bus error! Please check can bus cable!	Joint 2 can bus error.	1. Joint 2 circuit board error. 2. CAN bus error.	Check CAN bus connection between module 1 and module 2.

Alert Codes	Error information	Error Description	Possible error	Solution
40003	Joint 3 can bus error! Please check can bus cable!	Joint 3 can bus error.	1. Joint 3 circuit board error. 2. CAN bus error	Check CAN bus connection between module 2 and module 3.
40004	Joint 4 can bus error! Please check can bus cable!	Joint 4 can bus error.	1. Joint 4 circuit board error. 2. CAN bus error.	Check CAN bus connection between module 3 and module 4.
40005	Joint 5 can bus error! Please check can bus cable!	Joint 5 can bus error.	1. Joint 5 circuit board error. 2. CAN bus error.	Check CAN bus connection between module 4 and module 5.
40006	Joint 6 can bus error! Please check can bus cable!	Joint 6 can bus error.	1. Joint 6 circuit board error. 2. CAN bus error 3. Whether matching resistor connected properly.	1. Check whether resistor of whole CAN bus is 60Ω. 2. Check CAN bus connection between module 5 and module 6.
40007	Tool can bus error!	Tool can bus error.	1. Robot power down.	1. Check whether tool exist. 2. Tool power up 3. CAN bus connection between joint 6 and toll. 4. Tool can bus.
60001	"Cartesian motion--- across irresolvable singularity!") ;	Across irresolvable singularity.	Irregular movement.	Re-planned trajectory.
60002	"Cartesian motion--- over speed protection for bad inverse	Over speed protection for bad inverse kinematic solution of singularity.	Irregular movement.	Re-planned trajectory.

Alert Codes	Error information	Error Description	Possible error	Solution
	kinematic solution of singularity!") ;			
60003	"Linear motion--- target point close to irresolvable singularity!") ;	Linear motion--- target point close to irresolvable singularity.	Irregular movement.	Re-planned trajectory.
60004	"Arc/circular motion--- waypoints too close!");	Waypoints too close.	Stop movement.	Re-planned trajectory.
60005	"Arc/circular motion--- waypoints in line!");	Collinear can't draw an arc.	Irregular movement.	Re-planned trajectory.
60006	"Arc/circular motion---last target point close to irresolvable singularity!") ;	Arc/circular --- last target point close to irresolvable singularity.	Irregular movement.	Re-planned trajectory.
60007	"Cartesian cubic splines motion---last target point close to irresolvable singularity!") ;	Splines motion-- -last target point close to irresolvable singularity.	Irregular movement.	Re-planned end waypoint.
60008	"MoveP--- zero blend radius	MoveP---zero blend radius is unsupported.	Stop movement.	Re-planned non-zero blend radius

Alert Codes	Error information	Error Description	Possible error	Solution
	unsupported! ");			
60009	"MoveP---blend radius bigger than half-length of line segment unsupported! ");	MoveP---blend radius bigger than half-length of line segment is unsupported.	Irregular movement.	Reduced blend radius or increase minimum distance between waypoints.
60010	"MoveP---two line segments in line!");	MoveP---two line segments in line.	Stop movement.	Re-planned trajectory or cancel intermediate point between two lines.
60012	"MoveTrack---waypoint number less than 3 unsupported! ");	Waypoint number less than 3 is unsupported.	Irregular movement.	Increase waypoint number.
60013	"Robot teach---over speed protection for cartesian motion!");	Over speed protection for teaching function.	Stop movement.	Stop moving
60014	"robot track--over speed protection for Cartesian motion");	Over speed protection for track.	Stop movement.	Re-planned trajectory.
60015	"Relative linear motion---target point close to irresolvable singularity!") ;	relative linear motion---target point close to irresolvable singularity	Irregular movement.	Re-planned trajectory.

Alert Codes	Error information	Error Description	Possible error	Solution
60016	"Relative track---target point is close to irresolvable singularity!") ;	relative track---target point is close to irresolvable singularity	Irregular movement.	Re-planned trajectory.
60017	"Robot teach---approaching to irresolvable singularity!") ;	Translational motion in teaching function is approaching to irresolvable singularity	Irregular movement.	Stop moving
60018	"robot teach--joint limitation to +/-175 degree!");	Spindle motion in teaching function beyond range.	Stop movement.	Stop moving
70001	Robot emergency stop!	Robot emergency stop.	Robot power down.	Disarm the alarm Directly.
70002	Robot collision! Value=X	Robot collision protect.	Robot power down.	Disarm the alarm Directly.
70003	Robot over speed!	Robot is over speed.	Robot power down.	Disarm the alarm Directly.
70004	Mounting_pose_changed	Mounting pose is changed	1. Robot release bake and power down automatically. 2. Hand-guiding anomaly	1. Mounting pose is changed : Yes 2. Mounting pose is unchanged : No
70005	singularity over speed	singularity is over speed	Speed mutate at some speed.	Check whether in singularity.
70006	robot power off	robot power off	Control box servo power down.	Control box servo power up.

Alert Codes	Error information	Error Description	Possible error	Solution
	Teach pendant can't power up	Teach pendant can't power up		1. Check emergency stop signal is Manual mode or linkage mode. 2. Check whether 48V power supply is Manual mode or linkage mode. 3. Check whether is linkage mode-linkage. 4. Check switch connection of control box. 5. Interface board hardware error.
Remark	Code example	First number		Following are error number
Explanation	XXXXXX	1-Joint problem 2-Tool IO problem 3-Interface board problem 4-Bus problem 5-Software problem 6-Programming problem 7- General alarm		Error number



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