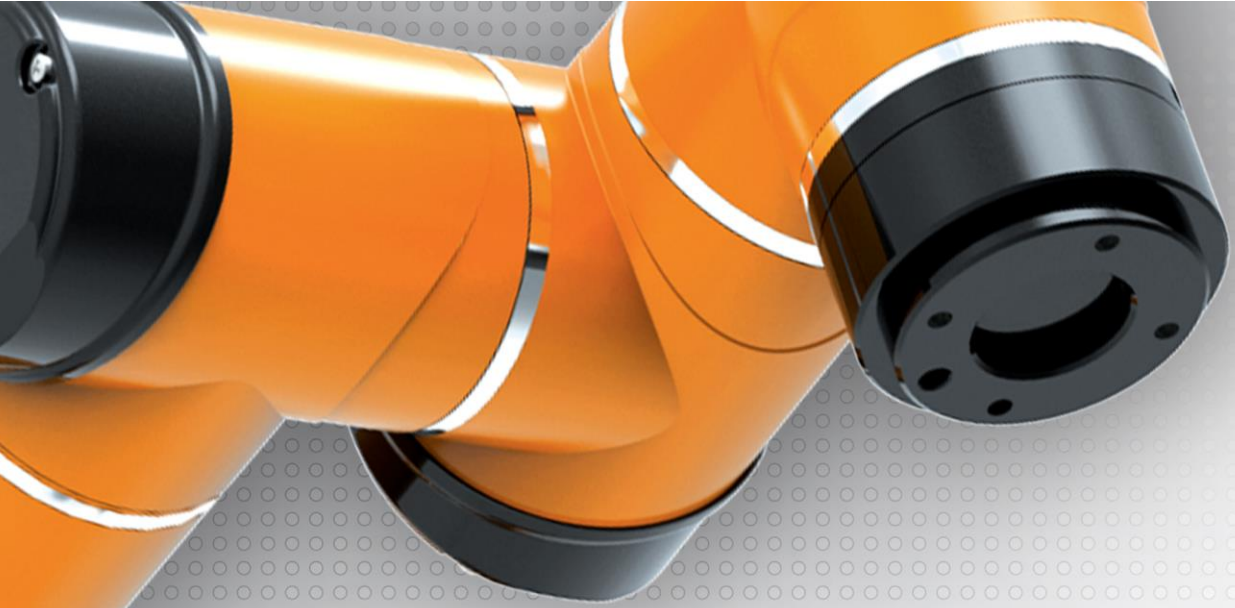

AUBO-i5
USER MANUAL

遨博智能
AUBO

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User Manual

AUBO-i5 & CB4

Translate Version 4.3

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

For the information of this version of the user manual, please refer to the version information section of this manual. Before using the manual, please check the actual product version information carefully.

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Please read this manual before install or use.

Please keep this manual to read and as reference any time.
The pictures in this manual are for reference only, please refer to the actual product received.

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Preface

Thank you for purchasing 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 application interface provide by the AUBO platform. Meanwhile, AUBO robot is equipped with a dedicated programmable operation interface, which allows the user to observe robot's operating status in real time, carry out many robot control settings, and perform offline simulation. This can improve the efficiency of practical application greatly.

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

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Components of AUBO-i5 Robot

The components of the AUBO-i5 robot are listed 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

Product outline structure is shown in picture above.

More Information

If you need more information, please visit our official website at: www.aubo-robotics.com

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1. Safety

1.1 Introduction

This chapter introduces the principles and norms that should be followed when operating a robot or robot systems. Integrators and users must read the relevant description in this manual carefully and fully understand and strictly adhere to the warning symbols in the contents. Because of the complexity and highly risks of the 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.

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

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	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 symbol, 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 symbol, depending on the circumstances, sometimes may have significant consequences.

1.3 Safety Precautions

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 try to describe all the various situation 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

The following basic information needs to be understood and followed when using the robot or robot system for the first time. Also, other safety-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.

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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 have inspection for robots and its protection systems before using the robot or putting it into production for the first time.
3. Make sure to check the system and equipment for completion, operational safety, and any damage that can be detected before starting the system and equipment for the first time. The test needs to confirm whether it accords with valid safety production rules and regulations in country or region. All safety functions must be tested.
4. Make sure that all safety parameters and user programs are correct, and all safety functions are working normally. A qualified robotics operator is needed to check each safety function. Only pass the thorough, careful safety test and reach the safe level, we can power on the robot.

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 people from setting and modifying safety parameters. After a safety parameter is modified, the related safety functions need to be analyzed.
4. When the robot is in 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 damage or injury. This function is a particularly for the safety of cooperative work, but robot system must be in the normal operating range and use the AUBO series control box. If the user develops the controller personally, the robot will not have the functions above, and all the dangerous consequences are undertaken by its owner.

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1. Make sure that the robot's joints and tools are installed properly and safely.
2. Make sure that there is enough space for the manipulator to move freely.
3. Don’t use robot 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 barriers should 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’s 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 the 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. Changes to the robot 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. Transporting robots must follow the transport requirements. Handing carefully and avoid t bumps.

1. The robot and control box generate heat during operation. Do not handle or touch the robot while the robot is working or just stop working.
2. To cool the robot down, power off the robot and wait for one hour.
3. Never stick fingers behind the internal cover of the control box.

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1. When the robot is combined with or working with machines capable of damaging the robot, then it is highly recommended to test all the functions of the robot 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 field. Very strong magnetic fields can damage the robot.

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1.3.3 Operator safety

In the operation of the robot system, we must ensure the safety of the operators first. The 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 through a training course 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 service@aubo-robotics.com
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 drewed to mark the range of motion of the robot to let the operator knows the robot's, 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) near the robot operating area to protect the operator and surrounding crowd. The lock should be set as needed so that those who are not operators cannot access the robot power supply.
6. When using the operation panel or the teach pendant, make sure to take off the gloves in case of operational errors.
7. Pushing or pulling the robot arm (at least 700N), force the joint to move in the 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.

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1.4 Responsibility and standard

AUBO-i5 can be combined with other equipment to form a complete machine, and itself is not complete. The information in this manual does not cover how to design, install and operate a complete robot, 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.

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 level in the final installation;
- Convey the residual risk to the users;
- Mark the logo and contact information of the integrators 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 safety 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, we 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.

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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 safety devices, the robot needs to perform a risk assessment first 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;
- Fingers being caught by robot base or joint;
- The risk of being hit by manipulator;
- The danger due to incompletely fix of manipulator or connected tool;
- Danger due to impact between a heavy payload and a solid surface.

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

Combine the inherent safety design which applied by AUBO robot with the safety specifications or risk assessment performed by integrators and users, risks that are associated with 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 integrator's risk assessment shows that there may have unacceptable risks in specific applications, integrators must take appropriate risk reduction measures 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 no cooperative installation (for example, when using dangerous tools), risk assessment may infer that integrators need to connect additional security devices (such as a boot device) when it is programming to ensure the safety of personnel and equipment.

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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 a special level of safety for cooperative operation. It can perform collaborative operation, which means it can be used without setting peripheral safety device. However, it can only be used under non-hazardous circumstance which has passed the risk assessment. 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 controllers and robots 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;
- For devices such as medical devices that involve human life
- Use to have a major impact on social and public;
- Use under vibration environment like vehicle or ship;
- Use as a climbing tool;

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1.7 Emergency situations

1.7.1 Emergency stop device

Pressing the emergency stop button to immediately stop all robot's motion. Emergency stop shall not be used as a risk reduction measure, but as a secondary protective device. If multiple 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 the teach pendant and the control box of AUBO-i5. The button must be pressed when a dangerous situation or emergency occurs. As shown in Figure1.1, control box is equipped with an external port for emergency stop button. Integrators and users can use according to the actual situation.

Figure 1.1Emergency stop button

If the equipment or tools which connect to the end cause potential danger, it must 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

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1.7.2 Recovering from the emergency condition

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

Rotating 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, 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 and required to perform risk assessment if other use is needed.

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2. TRANSPORTATION AND PRECAUTIONS

When hoisting robot, the moving parts should be located properly to avoid unexpected movement which can cause damage during hoisting and transportation. When packaging and transporting, it should follow packaging standards and mark with the required signs outside the package.

When transporting, the robot must remain in its transport position stably.

The control box should be lifted using handle.

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

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

Save the original packaging after transportation. Store the packaging material in a dry place for future repackaging and moving the robot.

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

1. Make sure not to overload the robot's 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 the instruction when installing a robot.

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3. MAINTENANCE, REPAIR AND DISPOSAL

3.1 Maintenance and repair

Maintenance and repair work must strictly follow all safety instructions in this manual.

Maintenance, calibration and repair work must be performed in accordance with 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. should have the access to this website.

Maintenance must be performed by authorized integrators or AUBO (Beijing) Robotics Technology Co., Ltd. All parts returned to AUBO (Beijing) Robotics Technology Co., Ltd. will 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.

The purpose of maintenance and repair is to r to make sure that system runs normally or help it return to normal condition 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 main input cable from the bottom of the control box to ensure that it is completely power off. Take necessary precautions to prevent other people from recharging the system during the repair period. After the power is turned off, the system must be re-examined to ensure that is powered off.
2. Please check the ground connection before turning the system back on.
3. Observe ESD (Electro-Static discharge) regulations when parts of the manipulator 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 entering the manipulator or control box.

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1. Replace the defective components by new components with the same article number 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 maintaining or repairing service is required, please contact your dealer or AUBO (Beijing) Robotics Technology Co., Ltd.

3.2 Disposal

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

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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 related components.

AUBO (Beijing) Robotics Technology Co., Ltd. has the ownership of the devices or components which have been replaced or returned to AUBO (Beijing) Robotics Technology Co., Ltd.

If the products are no longer under warranty, 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 outside the warranty period, AUBO (Beijing) Robotics Technology Co., Ltd. is not responsible for any damage or loss caused by the equipment, such as loss of production or damage to other production equipment.

4.2 Disclaimer

This Warranty will be invalid if the equipment defect is caused by improper handling or failure to follow the relevant information described in the user manual.

Failures caused by the following conditions are not covered by this warranty:

1. Does not meet the requirements of 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. Storage method and working environment are beyond the appointed range (e.g. pollution, salt injury and moisture condensation).
5. Products' damages caused by improper transportation.
6. Damage caused by accident or crash.
7. Not installing the original assembled components and accessories.
8. The damage caused by the third-party which is not AUBO (Beijing) Robotics Technology Co., Ltd. or the designated 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. Changing the software or the internal data.

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3. The malfunction cannot reappear or be identified by AUBO (Beijing) Robotics Technology Co., Ltd.
4. Using the products as 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 damage and consequences caused by the relevant products.

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5. ROBOT HARDWARE COMPOSITION

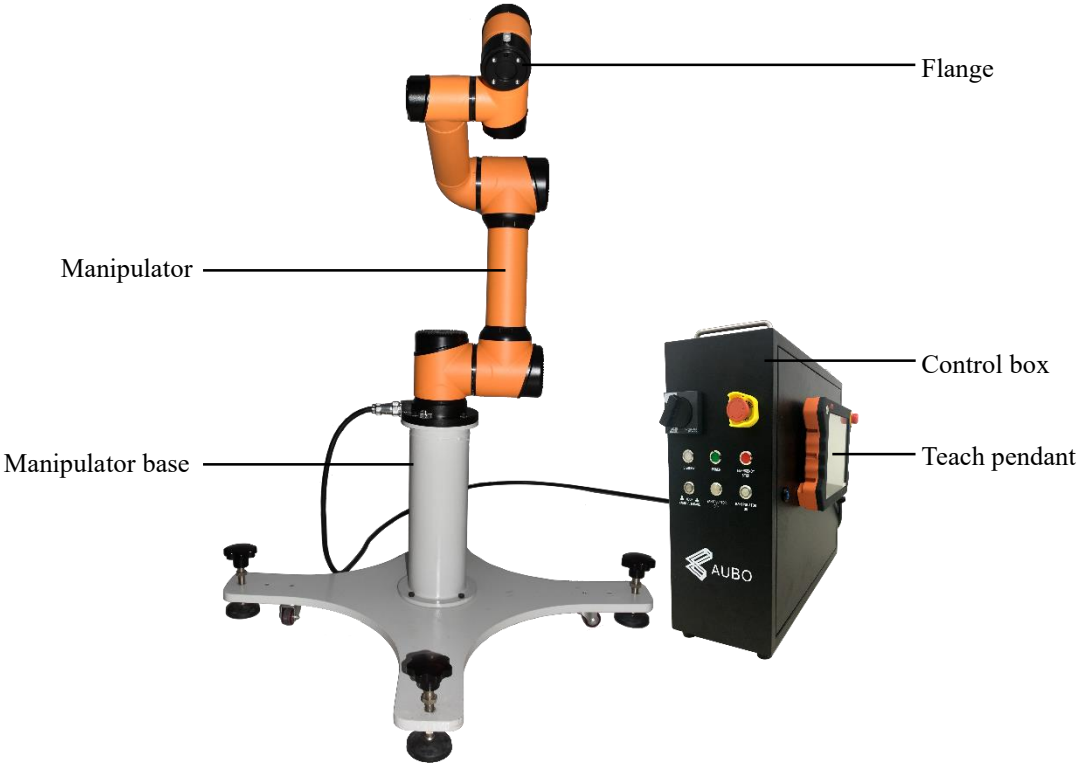

Figure 5.1 AUBO-i5 robot

As shown in figure 5.1, The AUBO-i5 robot system consist of a manipulator, a control box(which can choose a variety of models), a manipulator base and a teach pendant. The manipulator imitates human which has six joints and each joint represents a degree of freedom. As shown in figure5.2, manipulator's joint includes a robot base (A), a shoulder (B), an elbow (C), a wrist1(D) ,a wrist2(E) and a wrist3(F). The manipulator base is used for the robot body and the base connection. 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 control the rotation of every joint and move end-effector to any poses.

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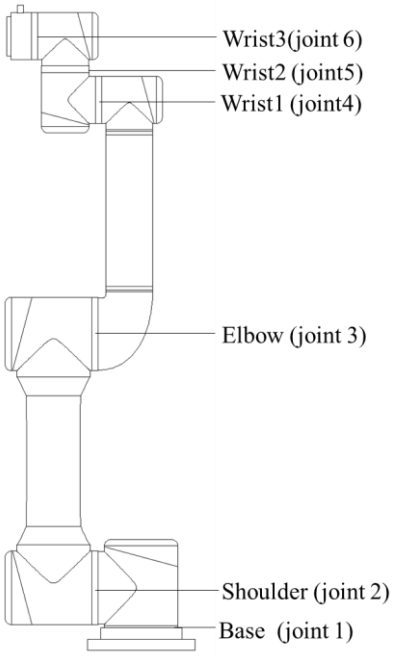

Figure 5.1 Manipulator Joints

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 I/O 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.

The teach pendant provides a visual interface. Users can test, program, and simulate the manipulator through the teach pendant with a small amount of programming skills.

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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

<table>
<tr><td> 
</td><td>Installation Conditions：
•No corrosive gases or liquids
•No oil mist
•No salt
•No dust or metal powders
•No mechanical shock, vibration
•No electromagnetic noise
•No radioactive materials
•Low humidity
•No flammable materials
•Ambient temperature:0 ℃ ~ 45 ℃
•Avoid direct sunlight (avoid using outdoor)</td></tr>
<tr><td> 
</td><td>Floor carrying capacity：
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 cannot be shaken... Please read appendix for more precise data of carrying capacity.</td></tr>
<tr><td> 
</td><td>Safety assessment is needed after every installation. Please strictly follow the instructions in chapter 1(Safety).</td></tr>
</table>

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Install additional equipment:

If any additional modules, like cable, which are not provided by AUBO (Beijing) Robotics Technology Co., Ltd., are integrated in industrial robot, users have the responsibility to ensure these modules won't affect safety function.

6.3 Workspace of the Robot

6.3.1 Mechanical dimensions of manipulator

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

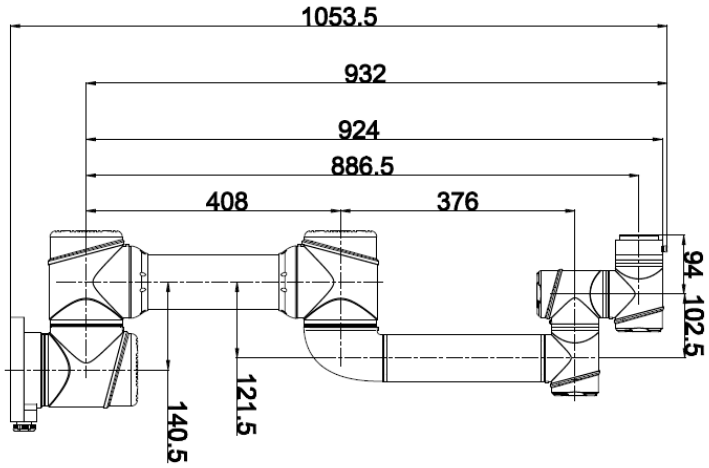

Figure 6.1 AUBO-i5 mechanical dimensions, unit: mm

6.3.2 Effective working range

The workspace of the manipulator, as shown in Figure 6.2, is a sphere of radius 924mm except the cylindrical space directly above and directly below the robot base. When choosing the installation position, be sure to consider the cylindrical space directly above and directly below the robot base must to avoid moving the tool into this cylindrical space as much as possible. In practical application, the range of rotation of joint 1 to joint 6 is -175°~ +175°.

The robot must work within an effective workspace.

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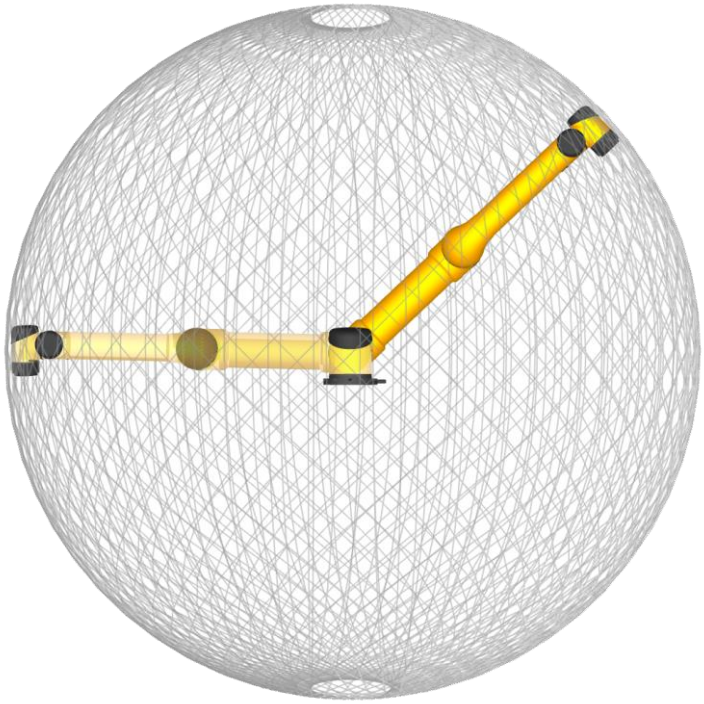

Figure 6.2: AUBO-i5 workspace illustration

6.4 Hardware Installation

6.4.1 The Manipulator Base

AUBO robot manipulator base is shown in figure 6.3.

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

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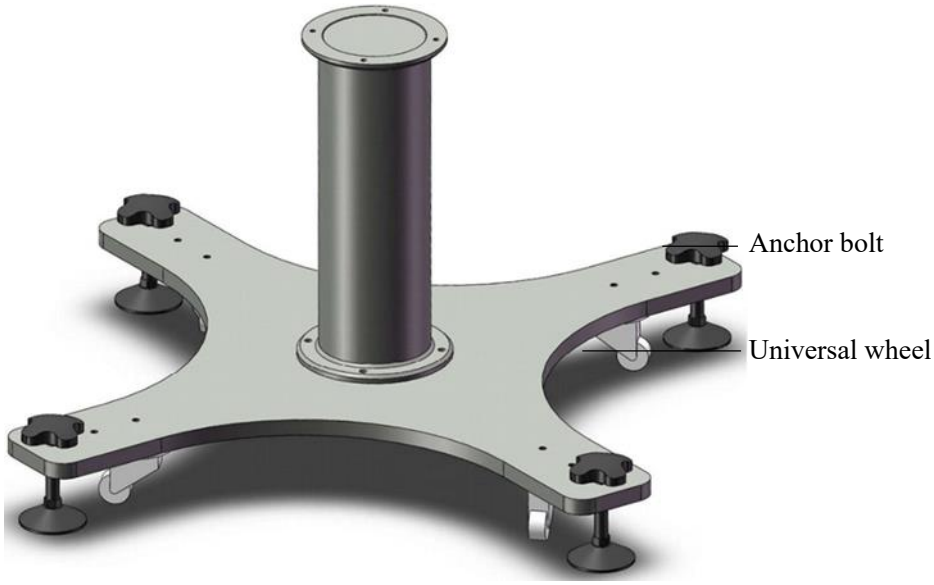

Figure 6.3 Diagram of manipulator base structure

The mechanical dimensions of the manipulator base structure are shown in Figure 6.4

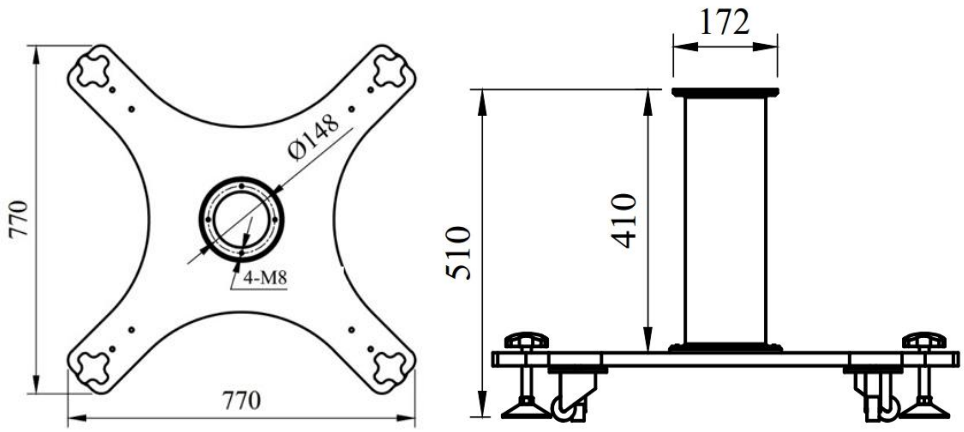

Figure 6.4 Mechanical dimensions of the manipulator base structure (left: plan view; right: front view)

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:

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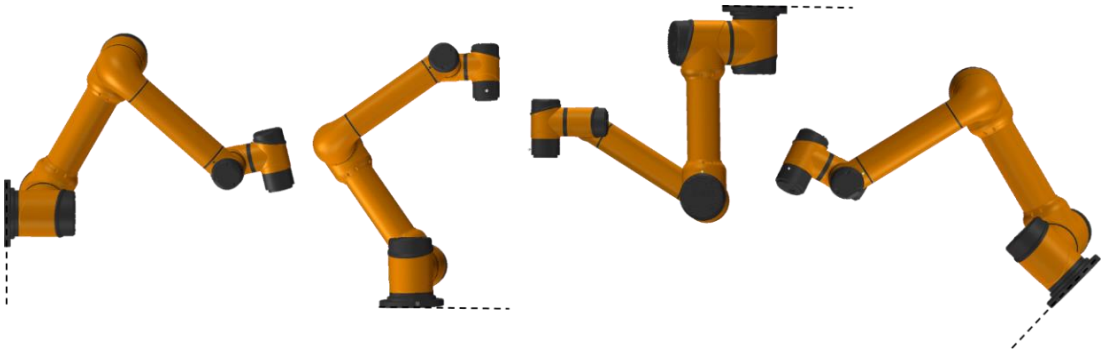

Figure 6.5 Diagram of different installation poses

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

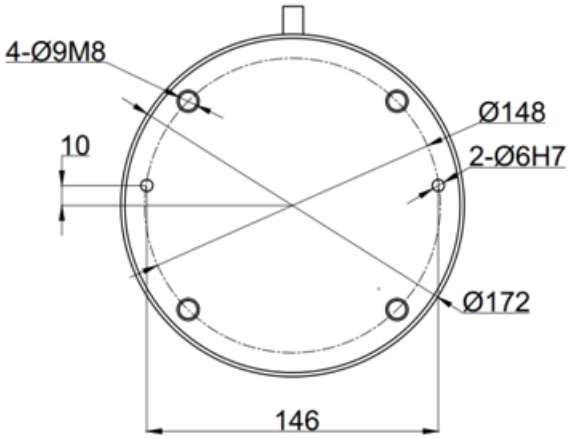

Figure 6.6: Mounting whole size of the manipulator base.

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

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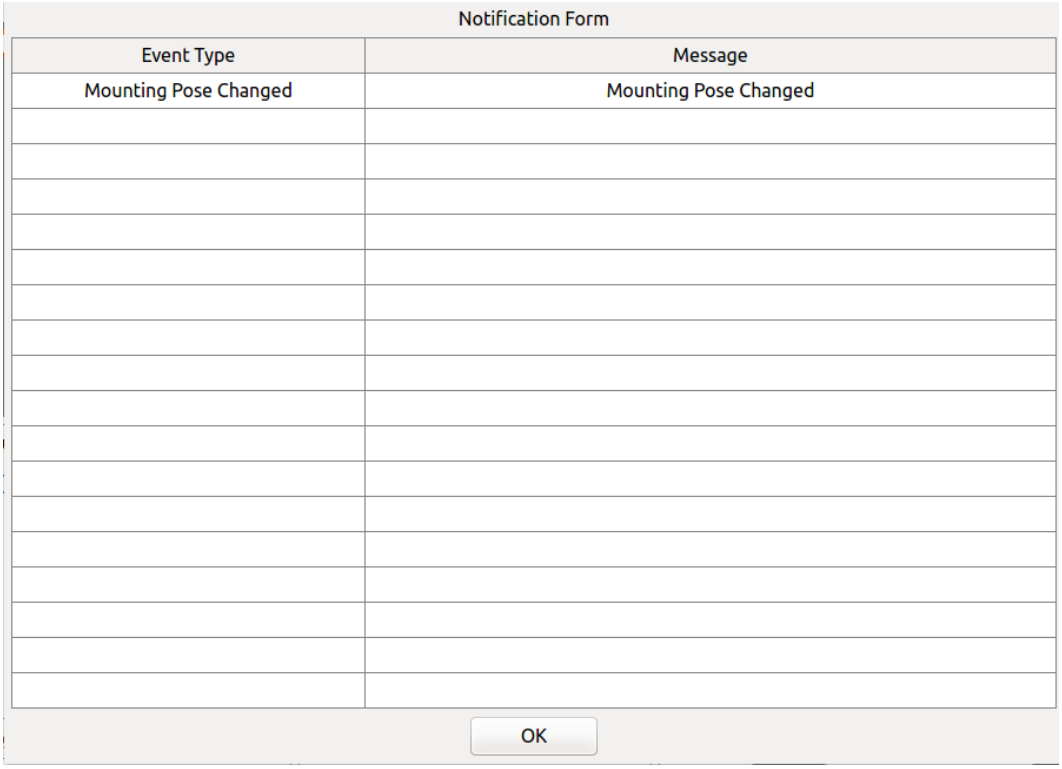

Figure 6.7 Pop window of changing installation position

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

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

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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 Φ6 positioning hole to fix the fixture on the end easily, as shown in figure 6.8.

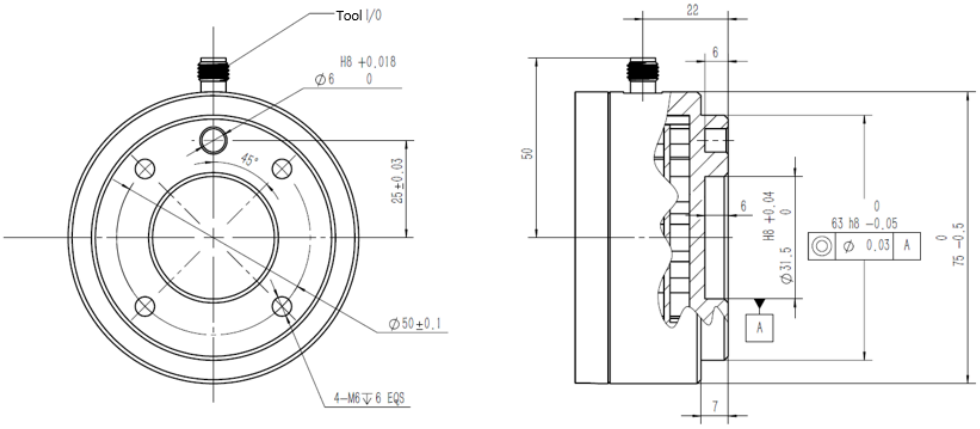

Figure 6.8 Mechanical dimensions of end-effector flange, unit: mm.

1. Make sure the tool is properly and safely bolted in place.

2. Make sure that the tool is constructed such that it cannot create a hazardous situation by dropping a part unexpectedly.

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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 the specific installation instructions in chapter 6: Installation.

	1. Control box should be placed horizontally on the ground. A gap of 50mm on each side is needed for sufficient air circulation 2. The teach pendant can be hung on the control box. Make sure that no one can step on the cable.
	1. Make sure that the control box, teach pendant, and cables are not in contact with liquids. A wet control box can cause casualties. 2. The control box and the teach pendant should not be exposed to dusty or wet environments that exceed IP20 rating. Pay close attention to the environment that contains conductive dust.

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7.1.2 Cable connection

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

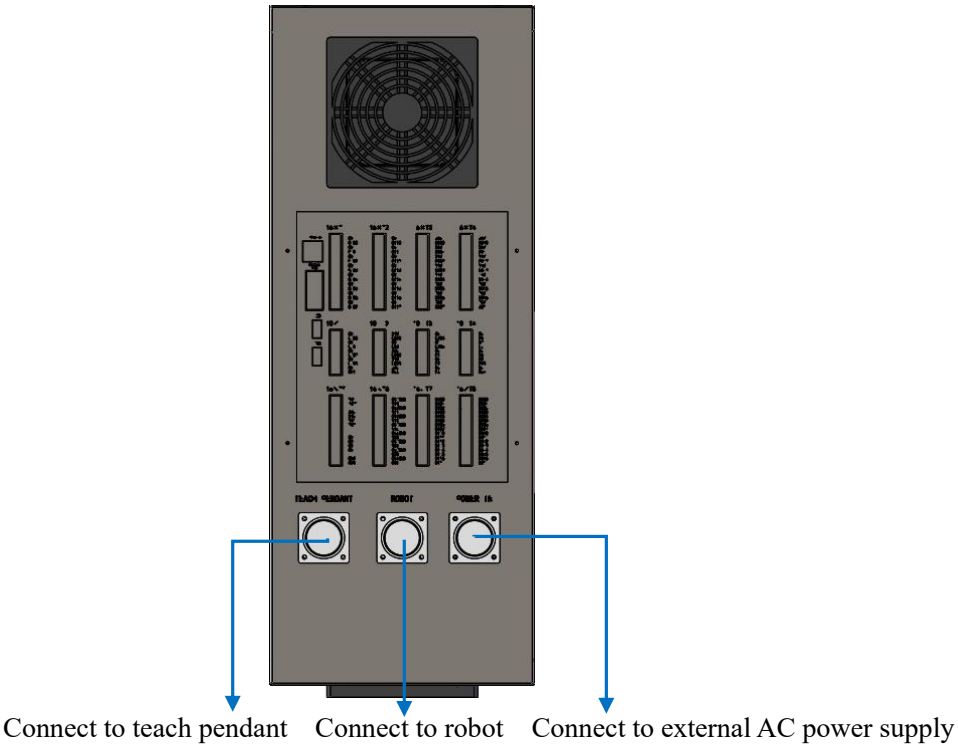

Figure 7.1 Figure 7.1 the bottom plugs of control box

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. Plugging the connector into the control box's connector, and pay attention to the insert direction. After plugging in, lock the connector as shown below in figure 7.2.

Figure 7.2 Robot cable connects to control box

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b) **Robot cable connects to Manipulator**

Figure 7.3 Manipulator Interface

Before connecting the robot cable to the manipulator, remove the dust cap on the manipulator interface from the socket first. 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 7.4Manipulator Cable

c) **Teach pendant connection**

The cable of teach pendant has plugs on both sides, as shown in figure 7.5.

Figure 7.5 Teach pendant cable

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Connect the elbow plug to the control box, as shown in figure 7.6. Elbow plug has positioning groove, please pay attention to the direction.

Figure 7.6 Connect aviation elbow plug cable to control box

Connect the straight plug to the teach pendant, as shown 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 to avoid drop damage, as shown in figure 7.8.

Figure 7.8 Suspension of teach pendant

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d) Power cable of Control box.

The control box cable has plugs on 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 the control box is off when connecting the power supply.

Figure 7.9 Power cable of control box

1. Make sure that the robot is grounded correctly (connecting to the earth). The grounding conductor should have at least the rated current 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.

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

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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 the power indicator.

Figure 7.10 Power switch

b) Power on the teach pendant and the manipulator

- Turn the key switch to the manual mode (manipulator has two working modes: manual mode and 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 the teach pendant for about 1s when the blue light appears. Robot and the teach pendant power-on at same time and the screen of teach pendant lights up.
- The startup button and the state of LED indicator are shown in figure 7.11

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Figure 7.11 the start button and LED indicator

7.3 Power off the manipulator

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

a) Power off the manipulator and the teach pendant.

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

b) Power off the control box.

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

1. Unplugging the power cord directly from the wall outlet to show down the system may result in damage to the robotic file system, which may result in robot malfunction.2. Ensure to unplug the power cord after power off the whole robot system!

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8. THE I SERIES STANDARD CONTROL BOX

8.1 Introduction

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

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

Figure 8.1 I Series Standard control box

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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.

The software in this robot system only supports the upgrade and use of the default software. It is forbidden to install other software such as ROS system. If there is software installation requirement, it is recommended that users install it on other platforms.

Never connect safety signals to a PLC which does not fulfill the requirements of a correct safety level. Failure to follow this warning could result in serious injury or death due to the failure of the safety stop function.

1. Make sure that all non-waterproof equipment remains dry. If water comes inside the product, turn off all the power switches 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 bent. Contact your supplier if longer or flexible cables are needed.
3. All mentioned GND connections are only for powering and transmitting signals. For Protective Earth (PE) use the screw connections marked with the earth symbols inside the control box. The grounding conductor shall have at least the current rating of the highest current in the system.
4. Be careful when installing the interface cables to the robot's I/O.

1. Interference signals higher than the level specified in the IEC standard will cause the abnormal behavior of the robot. Extremely high signal levels or excessive exposure can damage the robot permanently. EMC problems usually occur in welding processes and are normally prompted by an 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.

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8.3 I series control box's Internal Electrical Interface

8.3.1 Introduction

The 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 box 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 error is about ±1%.

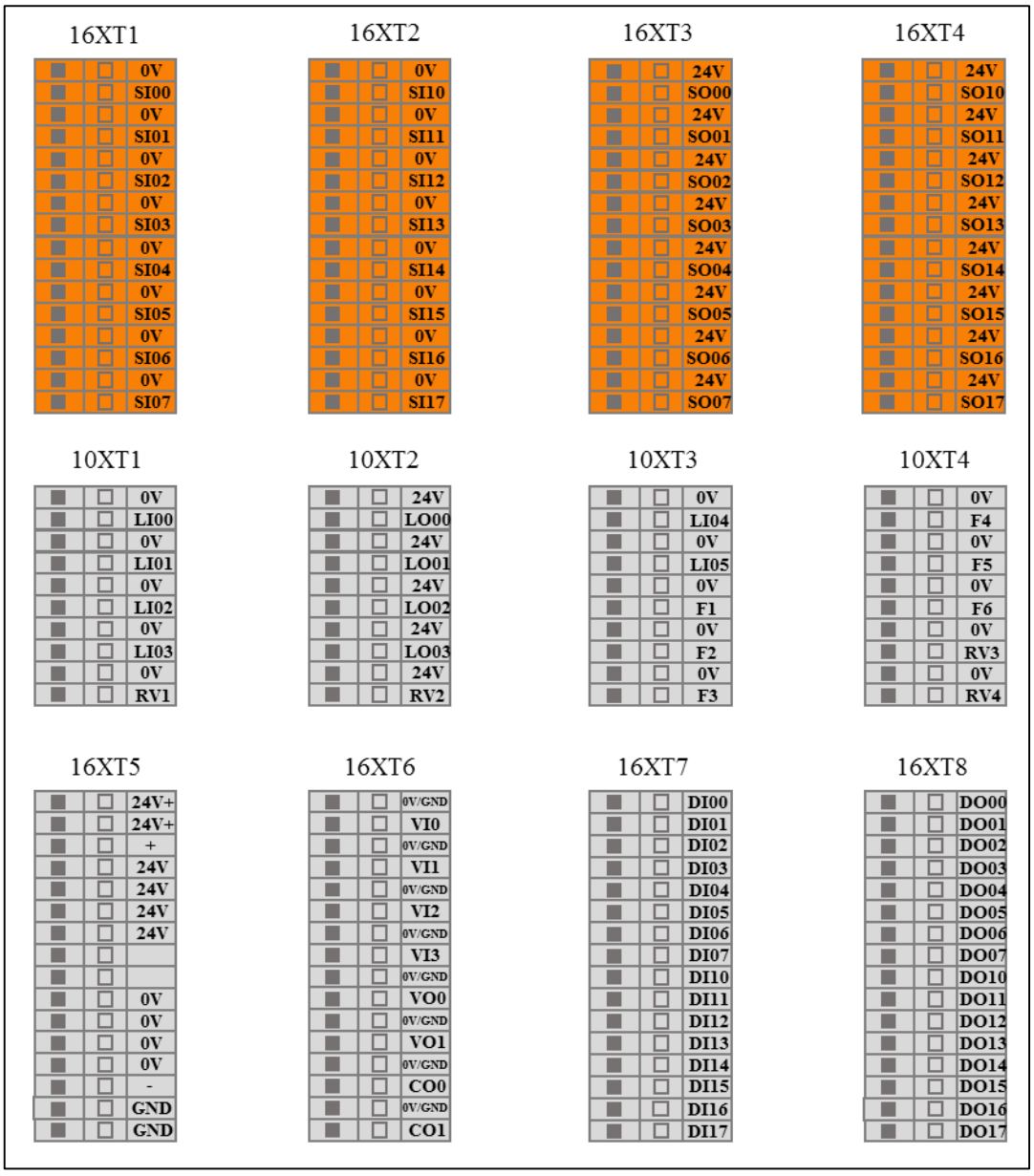

Figure 8.2 IO Layout of Control Box

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

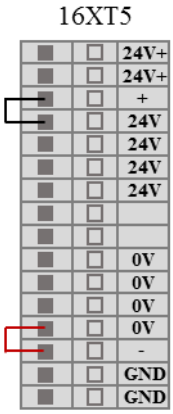

Figure 8.3 Internal Power Supply

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

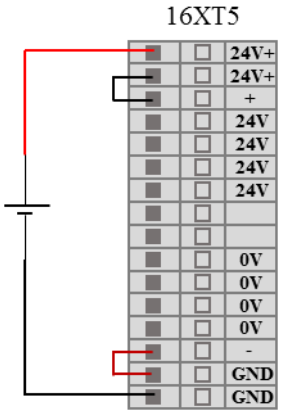

Figure 8.4 External Power Supply

The control box must be powered off 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. The safety devices and equipment must be implemented in accordance with the safety instruction and finished the comprehensive risk assessment before use.

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1. Never connect safety signals to unsafety PLC which is not in correct safety level
2. Be sure to separate 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 following:

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 inputs

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

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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

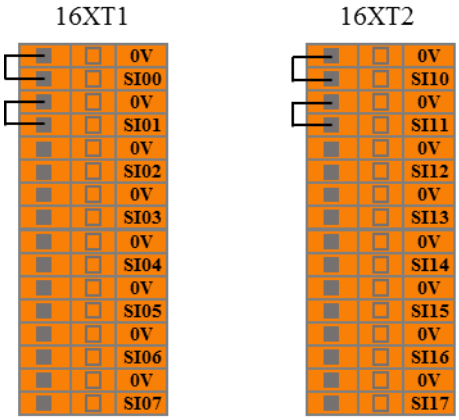

Figure 8.5 Default safety configuration

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8.3.2.2 External Emergency Stop Input

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

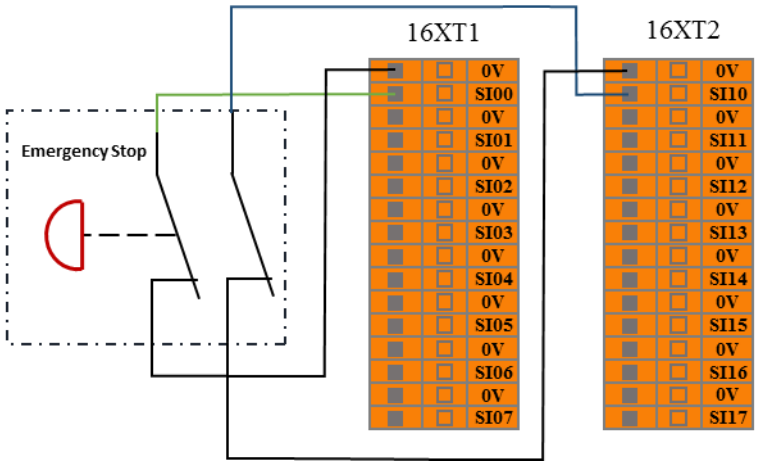

Figure 8.6 External emergency stop input

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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 to enter 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.

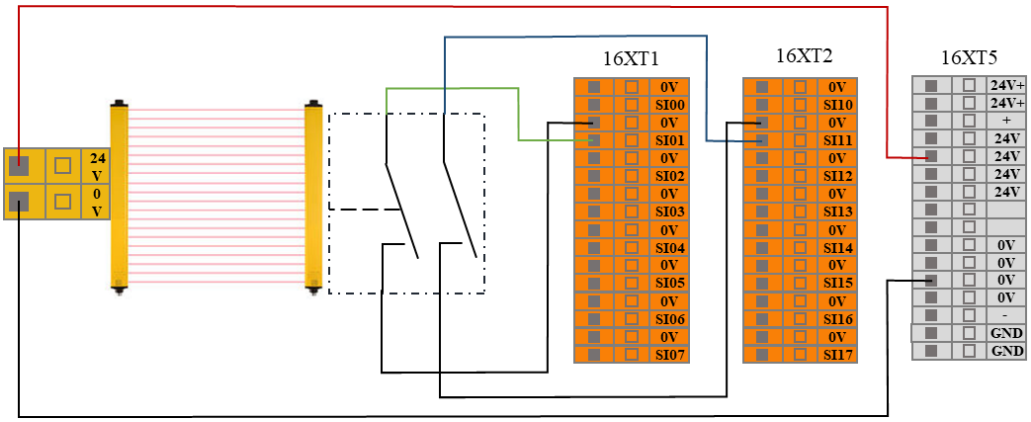

Figure 8.7 Safeguard stop input (Internal Power Supply)

After the operator enters 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 where it stopped. During this process, there is no need to use protective reset input.

- In this mode, the response time of the system is 1200ms. If the user operates too frequently, the system may report an error.
- In this configuration, user should select the protective reset as auto-reset via AUBOPE.

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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.

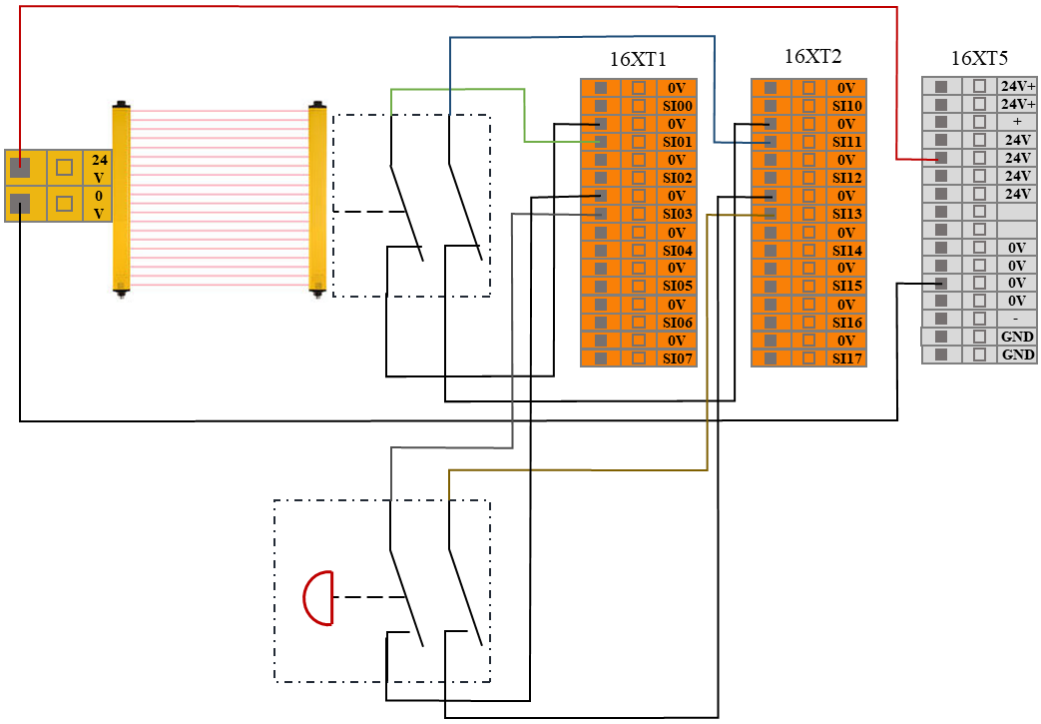

Figure 8.8 Safeguard stop input (Internal Power Supply)

After the operator enters the safety zone, the robot stops moving and maintains category 2 stop. When the operator leaves the safety zone, it needs to be reset from the outside of the safety zone by pressing reset button, and then click on the AUBOPE to run. The robot continues to run from the stop point. During this process, a protective reset input is required.

.

- In this mode, the response time of the system is 1200ms. If the user operates too frequently, the system may report an error.
- 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 enters the reduced mode. In this 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.

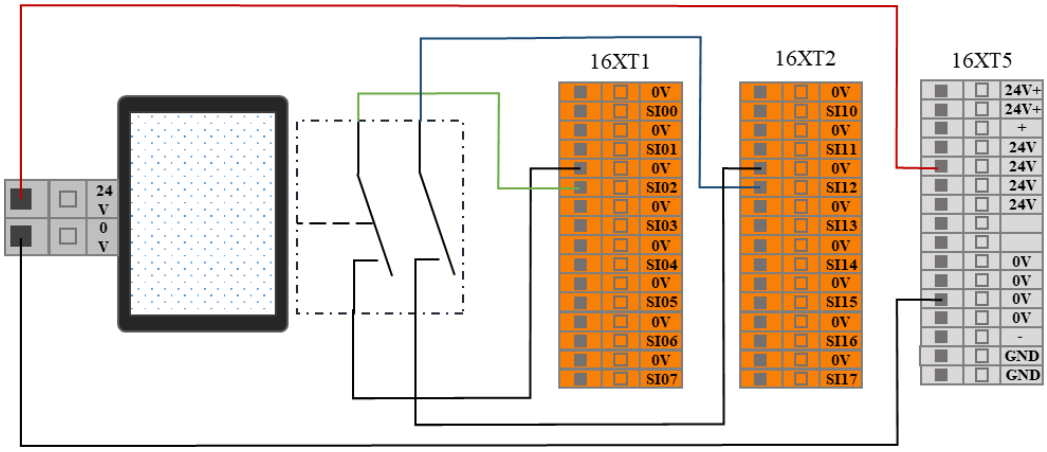

Figure 8.9 Reduced mode input connection

When the operator enters the safety zone, the robot enters 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 and enters the normal mode, and the robot moves normally.

- In this mode, the response time of the system is 1200ms. If the user operates too frequently, the system may report an error.
- When using this type of configuration, the user needs to configure the reduced mode motion parameters through the AUBOPE.

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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.

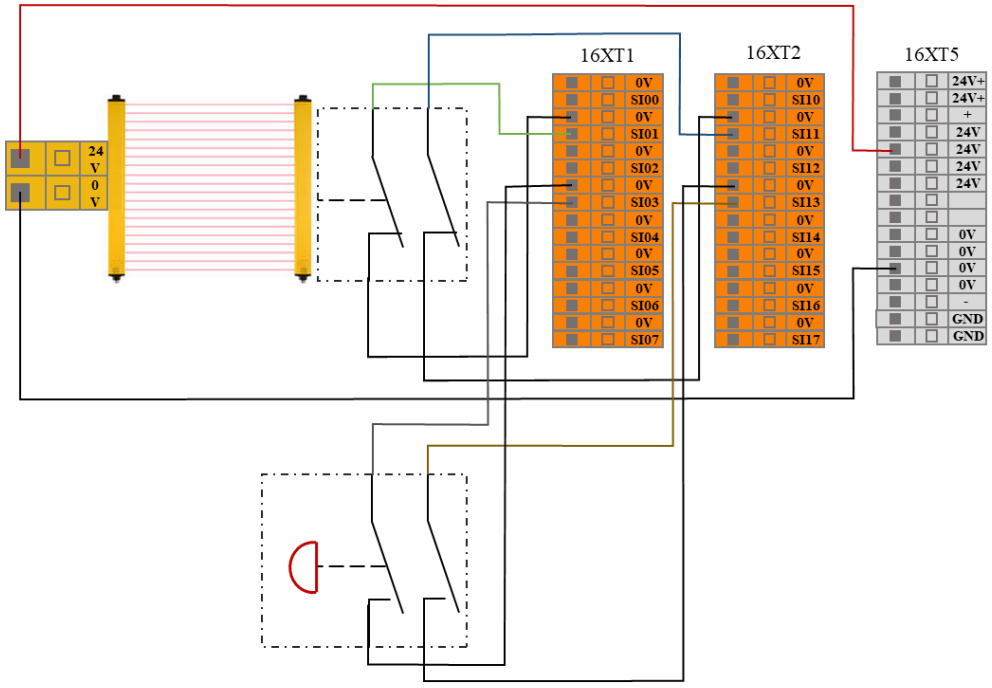

Figure 8.10 Safeguard stop Reset Input connection (Internal power supply)

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 needs 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.

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8.3.2.6 Enabling Device Input

Users can use this interface to connect external safety devices (such as three-position enabling switch, etc.), in order 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.

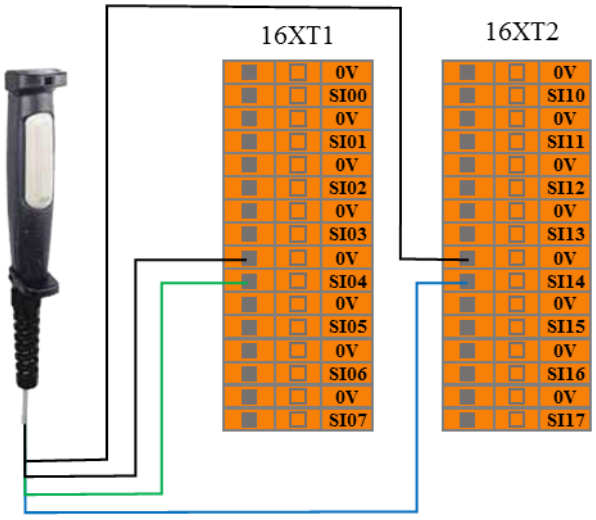

Figure 8.11 Enabling device input connection

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 switch is in the non-enabled position, and 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

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8.3.2.7 Operational Mode Input

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

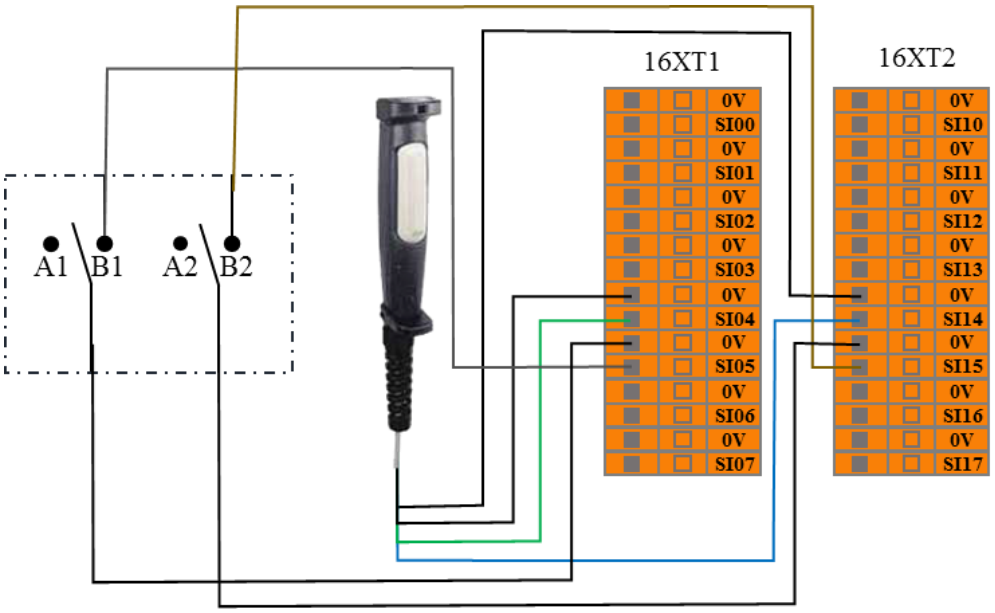

Figure 8.12 operation mode input connection

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 Hand Guiding Enable Input

User can use this interface to receive external hand guiding enable signal input, then the robot enters hand guiding mode. The user can refer to the following example, using the hand guiding function without the force control button in the teach pendant.

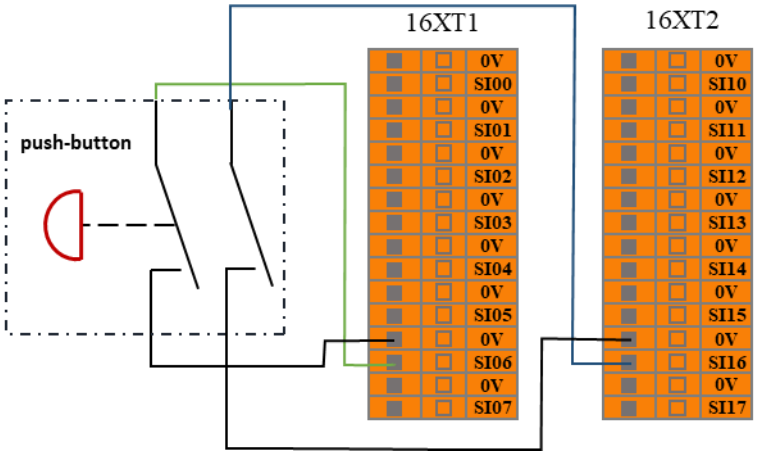

Figure 8.13 hand guiding enable input

8.3.2.9 System Stop Input

Users can use this interface to receive external stop signal input and control the robot to enter 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 machines into an emergency stop state. The user can refer to the following example, the two robots share the emergency stop function. In this system, the emergency stop output connected to the system stop input terminal. See the next figure.

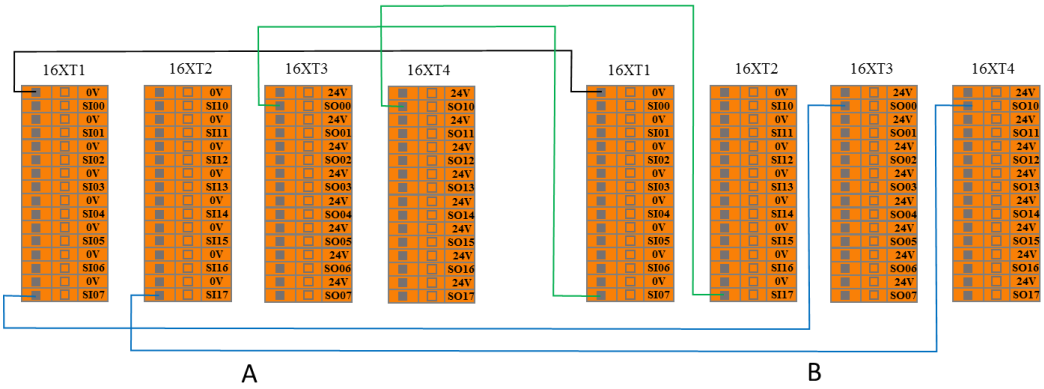

Figure 8.14 system stop input connection

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

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8.3.2.10 Robot Emergency Stop Output

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

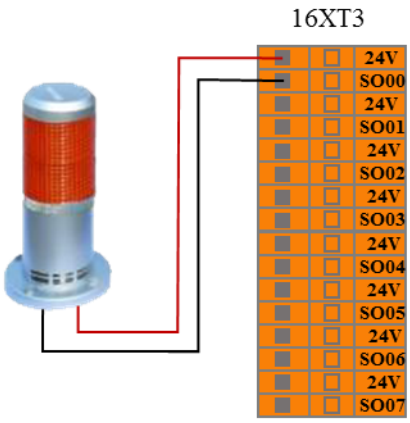

Figure 8.15 robot emergency stop output connection

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

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

8.3.2.11 Robot Moving Output

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

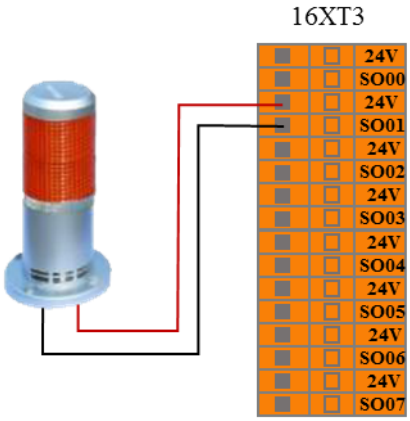

Figure 8.16 Figure robot moving output connection

In this configuration, when the robot moves normally, device 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 users or Integrators.

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8.3.2.12 Robot Not Stopping Output

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

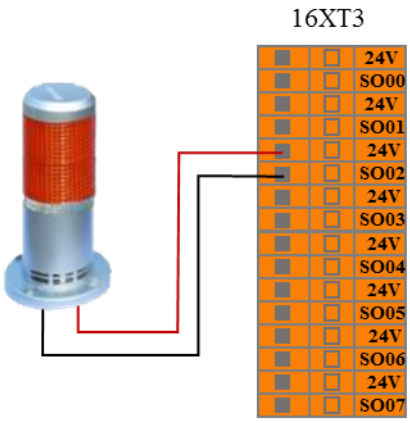

Figure 8.17 robot not stopping output connection

In this configuration, when the robot receives the stop signal and decelerates the moving, robot 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 users or Integrators.

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8.3.2.13 Reduced Mode Output

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

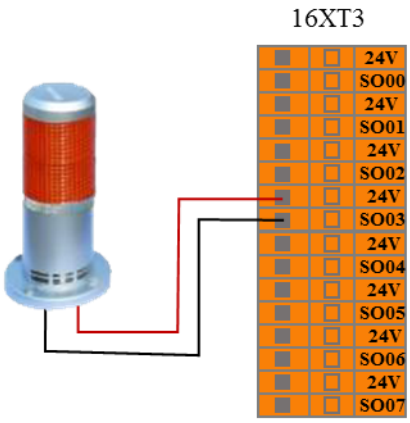

Figure 8.18 reduced mode output connection

In this configuration, when the robot enters 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 users or Integrators.

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8.3.2.14 Not Reduced Mode Output

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

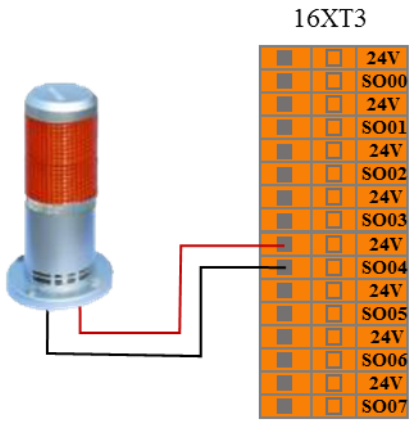

Figure 8.19 not reduced mode output connection

In this configuration, when the robot enters 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 users or Integrators.

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8.3.2.15 System Error Output

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

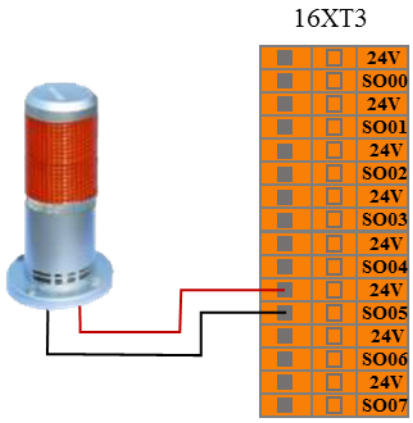

Figure 8.20 System error output connection

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

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

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8.3.3 Internal I/O

Control box internal IO for the internal function interface is not open for the user. The IO function of the control box 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 which electrical errors are about ±1%.

The following table lists the function's definitions of the various I/O. Users must followed 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	LINKAGE-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

F1 – F5: Users can use F1 – F5 to send signals.

F6 can clear alarm signal and active low enables.

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Digital inputs and outputs 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 inputs and outputs interface electrical parameters are as follows:

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

IO Specification

All AUBO robot IOs are set to NPN mode, which means low voltage level effective. When a User IO is set to “Effective” or “High” on the teach pendant, the actual voltage level at the IO output is low.

Note：Open circuit protection is set in each IO. Therefore, whenever an IO is not connected in a closed circuit, its output voltage is going to remain at high even if the IO is set to “Effective” by script or by teach pendant.

For digital IO outputs, the method to check the IO status is to measure the resistance between DO and 0V. When the DO is set to “Effective” or “High”, the resistance goes to approximately 0Ω, otherwise the resistance is about 12KΩ.

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 inputs and outputs range are 0 ~ +10 V, accuracy of ± 1% and current output range is 0 ~ 20mA, accuracy of ± 1%.

Internal power supply:

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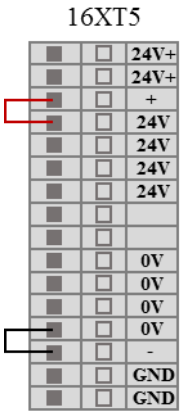

Figure 8.21 Internal power supply

External power supply:

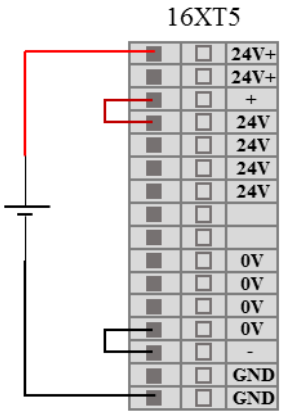

Figure 8.22 External power supply

1、 Digital input

Interface board has 16 digital inputs (Hereinafter use "DI" to represent digital input). They work as NPN, which means inputting low voltage to DI trigger action. Inputting 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 wirings will be listed in following examples.

Some common wirings 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 the ground (G). When the button is pressed, DI and GND are connected, which is equivalent to inputting low voltage to DI and triggering action. When the button is not pressed, DI and GND are disconnected and won’t cause any action. This is the easiest wiring example.

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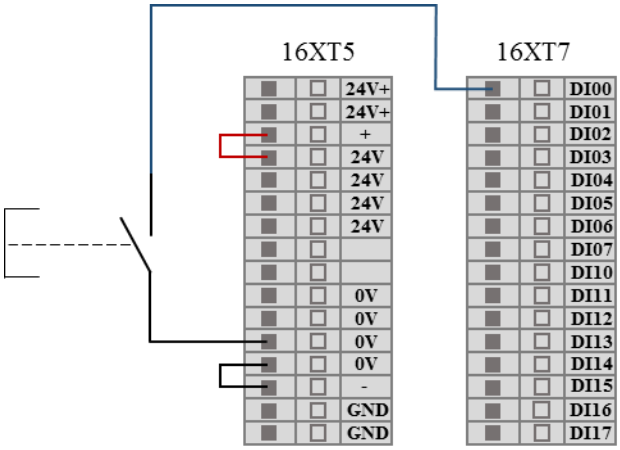

Figure 8.23 DI connect to button switch

2） DI connects 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 are very small when sensor is working, it can trigger action too. When the sensor does not work, and the circuit is disconnected, it does not cause any action.

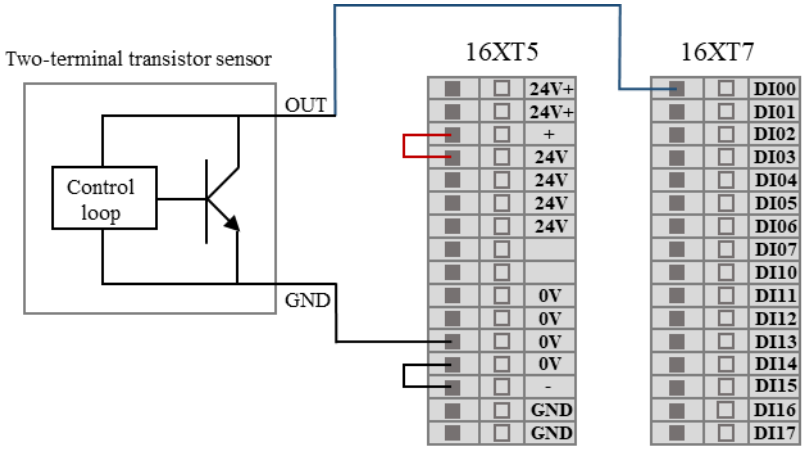

Figure 8.24 DI connect to two-terminal sensor

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 connected to GND and output is low. When given a logic "0", DO is connected to GND, and output is high.

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

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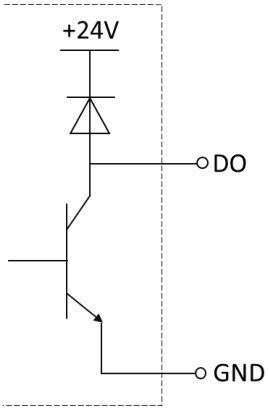

Figure 8.25 DO NPN Operating Mode

DO terminal connects to load as shown in figure below:

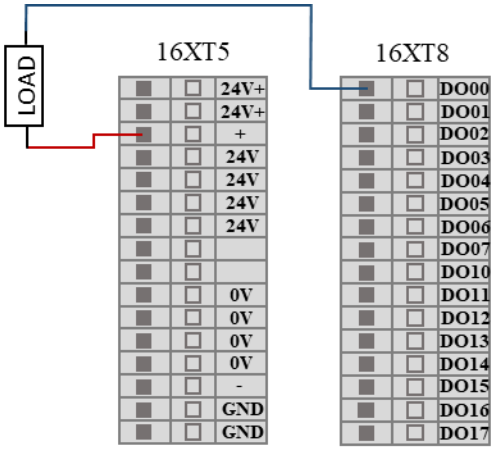

Figure 8.26 DO connect to load

b) Analog input

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

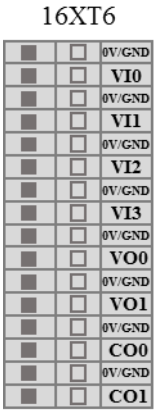

Figure 8.27 4Analog input

External sensor wiring:

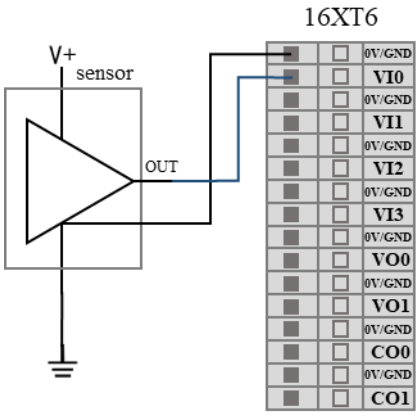

Figure 8.28 connect to sensor

VI electrical specification

Parameter term	Minimum value	Maximum value	Units
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 method is listed below.

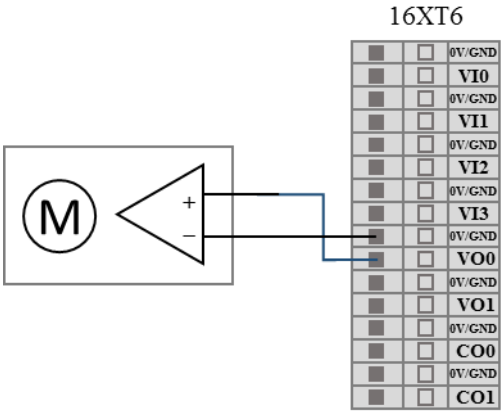

Figure 8.29 Analog output drive differential device

The common analog current output connection method is listed below.

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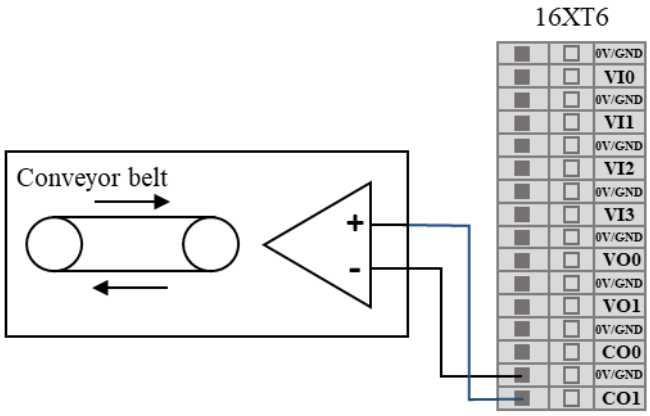

Figure 8.30 Analog current output connect to current source

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

When connecting external devices, all external devices should be connected to the 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±10%, to provide power and control signals to specific tools (Holder for example) used in the end. Wiring as shown below.

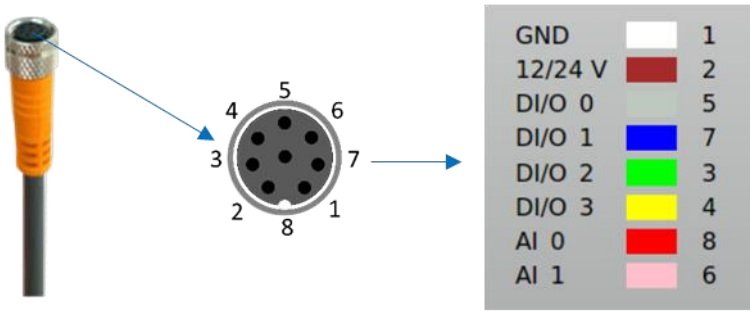

Figure 8.31 connecting cables

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
5	Gray	DI/O 0
7	Blue	DI/O 1
3	Green	DI/O 2
4	Yellow	DI/O 3
8	Red	AI 0
6	Pink	AI 1

When connecting the tool and the holder, ensure that there is no danger when interrupting the power supply, such as dropping the workpiece from the tool.

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8.3.6 Communication Interface

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

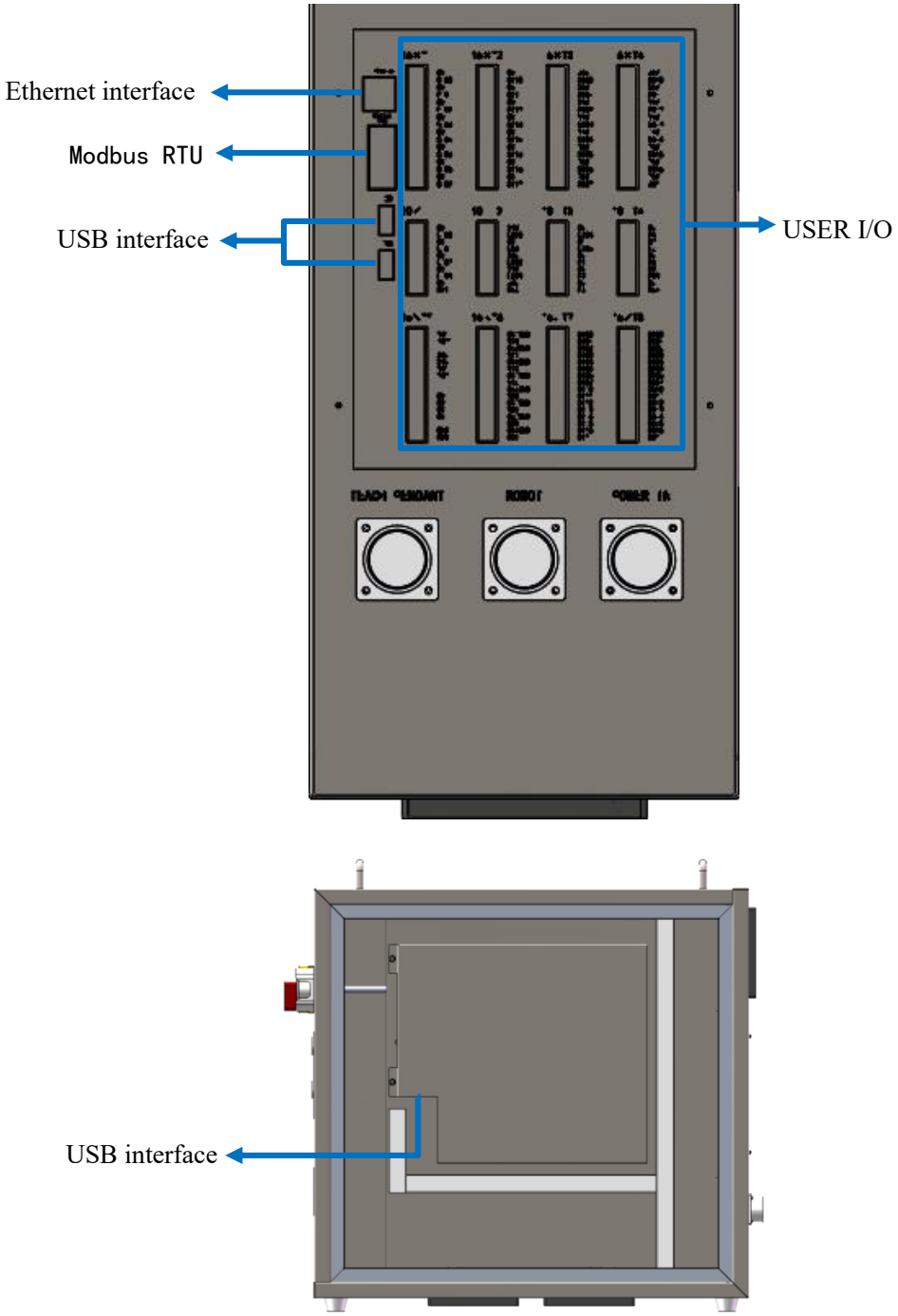

Figure 8.32 communication interface

Applications:

- Ethernet interface can be used for remoting access and control.
- USB interface can be used to update, import and export project.
- Modbus-RTU is used for external communication

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- 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 living wires. Non-professionals do not open the control box.

Non-professionals do not open the control box.

Figure 8.33 High voltage region inside I series control box.

8.4.2 Notes before use

- Check whether the control box power connectors are connected correctly.
- Check whether the control box and the robot are connected correctly.
- Check whether the control box and the teach pendant are connected correctly.
- Check whether the control box connectors are connected correctly.
- Check anchor bolts on control box support firmly and horizontally.

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- 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 8.34 Schematic diagram of the control box front panel button

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

Name	Function
POWER SWITCH	The main power switches. 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 indicate that the program of control box interface board initialized completely, press the teach pendant power button to power on the robot.
POWER	The indicator lights indicate that the control box has been powered on.
EMERGENCY STOP	The indicator lights indicate 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 indicate when the manipulator has been powered on
TEACH PENDANT ENABLE	Indicator of Teach pendant enable statue. Indicator lights in Manual mode. In linkage mode, teach pendant disable when indicator off.

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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 must press the button to select 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.

- Startup: Power on the control box first, after the standby indicator lights up, press the startup button on the teach pendant for 1s to power up the robot.
- Force control button: in teaching mode, hold on the force control button to the center position and drag the end of the robot to the target position, then release the button.
- Emergency stop: Press the emergency stop button on the control box or the teach pendant to power off the robot. Rotate emergency stop button to re-power the robot according to the teach pendant programming interface.

8.4.4.2 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 the teach pendant and the manipulator are powered off. Linkage mode

In linkage mode, manipulator can communicate with one or more external devices (manipulator etc.) through linkage mode I/Os. Linkage mode applies 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 (NOT LINKAGE MODE APPLICABLE)
	LI02	LINKAGE-PAUSE	LI05	LINKAGE-REMOTE POWER OFF
Output	LO00	LINKAGE-OPERATING	LO02	LINKAGE-PAUSE
	LO01	LINKAGE-STOP	LO03	LINKAGE-INITIAL POSITION

The case below demonstrates how to use external device to manipulate the robot under linkage mode. Users can refer the process described below:

For the first-time use, the user needs to configure the default boot program in the teach pedant manually. Instructions are below:

After the teach pendant is started, select the project file in the online programming -> project -> default project and select the automatic loading of the default project and click OK to set the default project.

Make sure the power to the control box is disconnected.

Follow the demonstration below, connect the external devices with IO interface on the back of the control box. Users can use the external signals to manipulate the robot.

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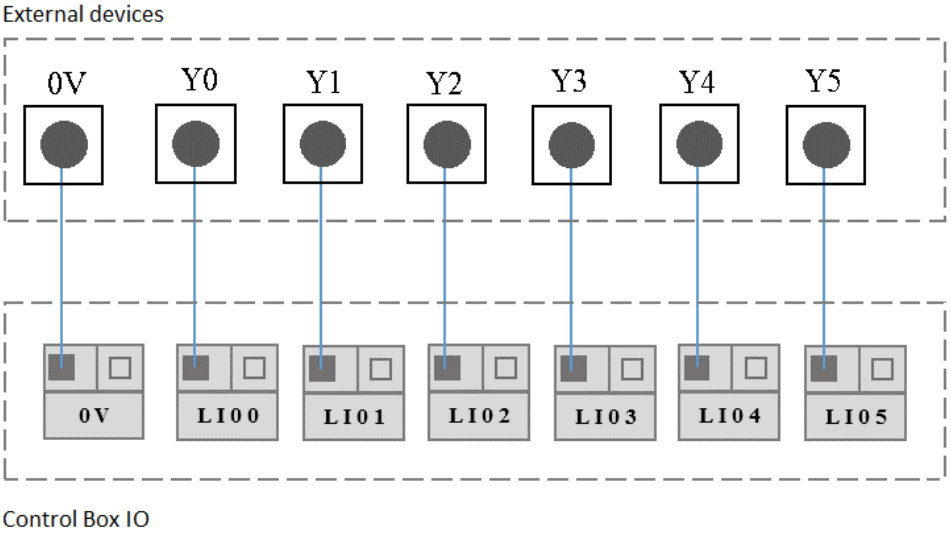

Figure 8.35 linkage mode wire connection showcase

Press the button “MODE MANUAL/LINKAGE” on the front panel of the control box.

Power the control box.

Configure the external devices signals.

Then the user can follow the process below to use linkage mode.

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Figure 8.36 linkage mode use showcase

Under linkage mode, if the teach pendant is not needed, after setup the default program successfully, the user can switch off the teach pendant enable in the control box. After “TEACH PENDANT ENABLE” is out, it is ok to remove the wire from the teach pendant.

8.4.4.3 Teach Pendant Enable Switch

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

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mode, in this mode, user can remove the teach pendant and the user external IO to control the robot. The teach pendant enable switch is inside of the control box, as illustrated below.

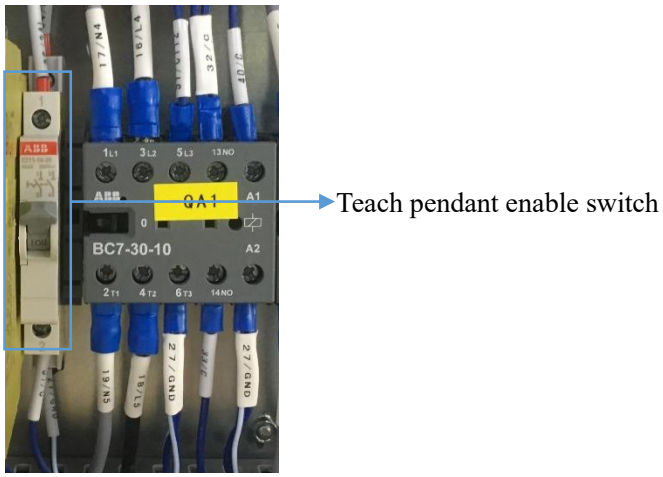

Figure 8.36 Teach pendant enable switch

User can only push the switch when the teach pendant power off.

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9. TEACH PENDANT

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

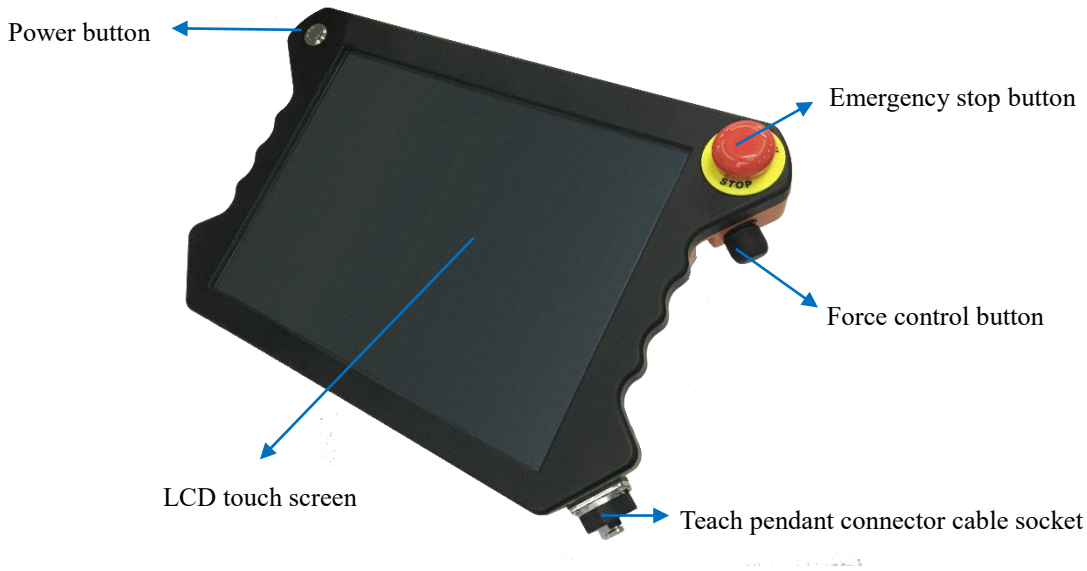

Figure 9.1 Overview of the teach pendant

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. The 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 the teach pendant is aesthetic and ergonomic. A nylon rope at the back of the teach pendant is used to hold it in one hand.

Force control button is a three-position enabling device which have OFF⇒ ON ⇒ OFF three states, when the button is at the 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 the Teach Pendant

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

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Pre-boot After boot

Figure 9.2 power button on teach pendant

9.2 Shut Down the 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 powered off.

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10.TEACH PENDANT USER INTERFACE

The screen shows the user interface after opening the 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's movements.

10.1.1 Base coordinate system

Choose base coordinate system in teach pendant interface, robot will operate as following figure.

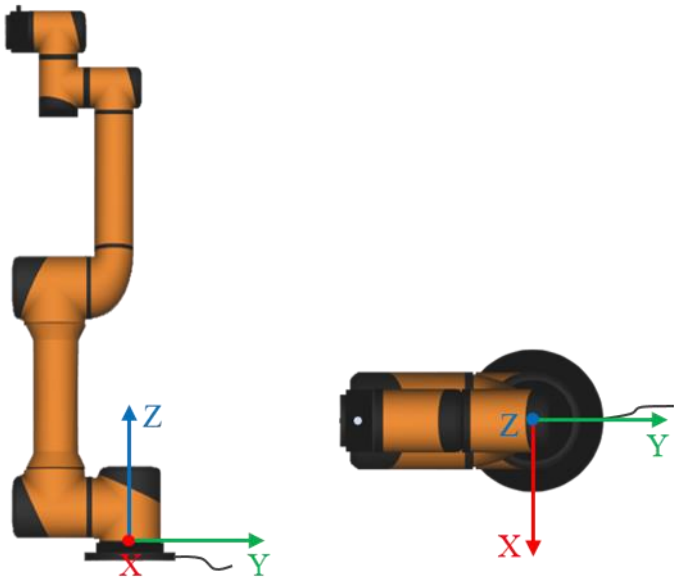

Figure 10.1 Base coordinate system

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10.1.2 End coordinate system

Choose the end coordinate system in teach pendant interface, robot will operate as following figure.

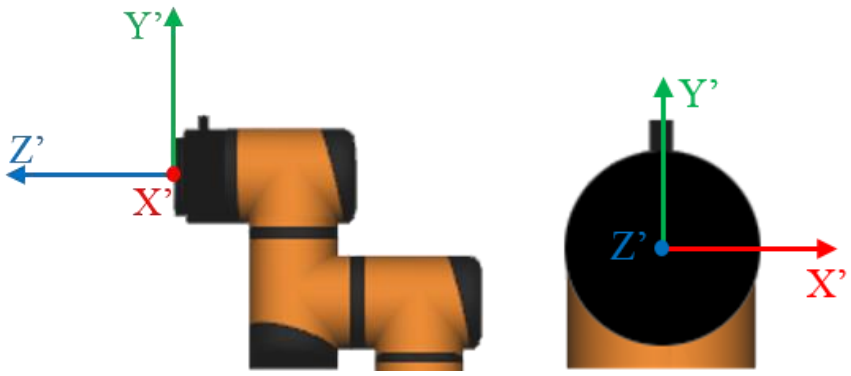

Figure 10.2 End coordinate system

10.2 Initial Interface

After starting the AUBOPE, The following window will pop up:

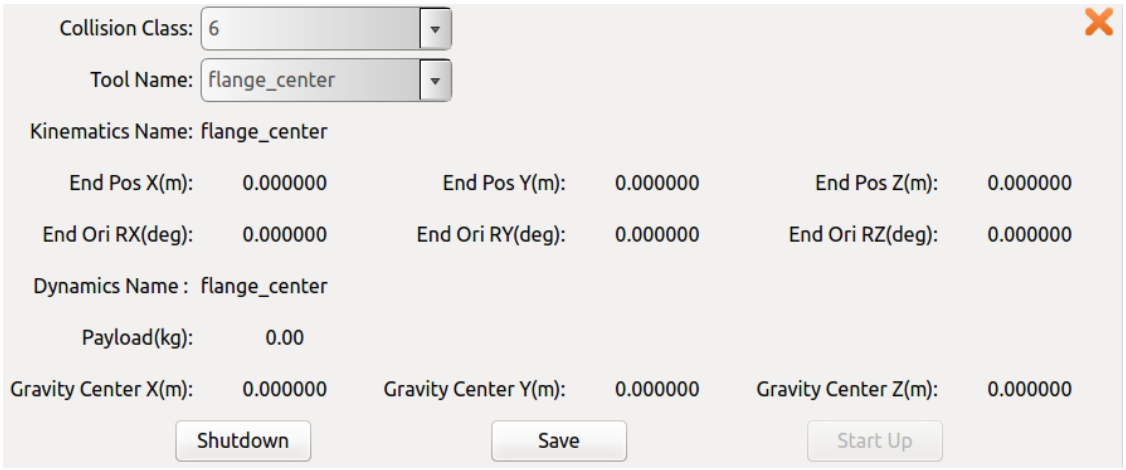

Figure 10.3 Initial Interface

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

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

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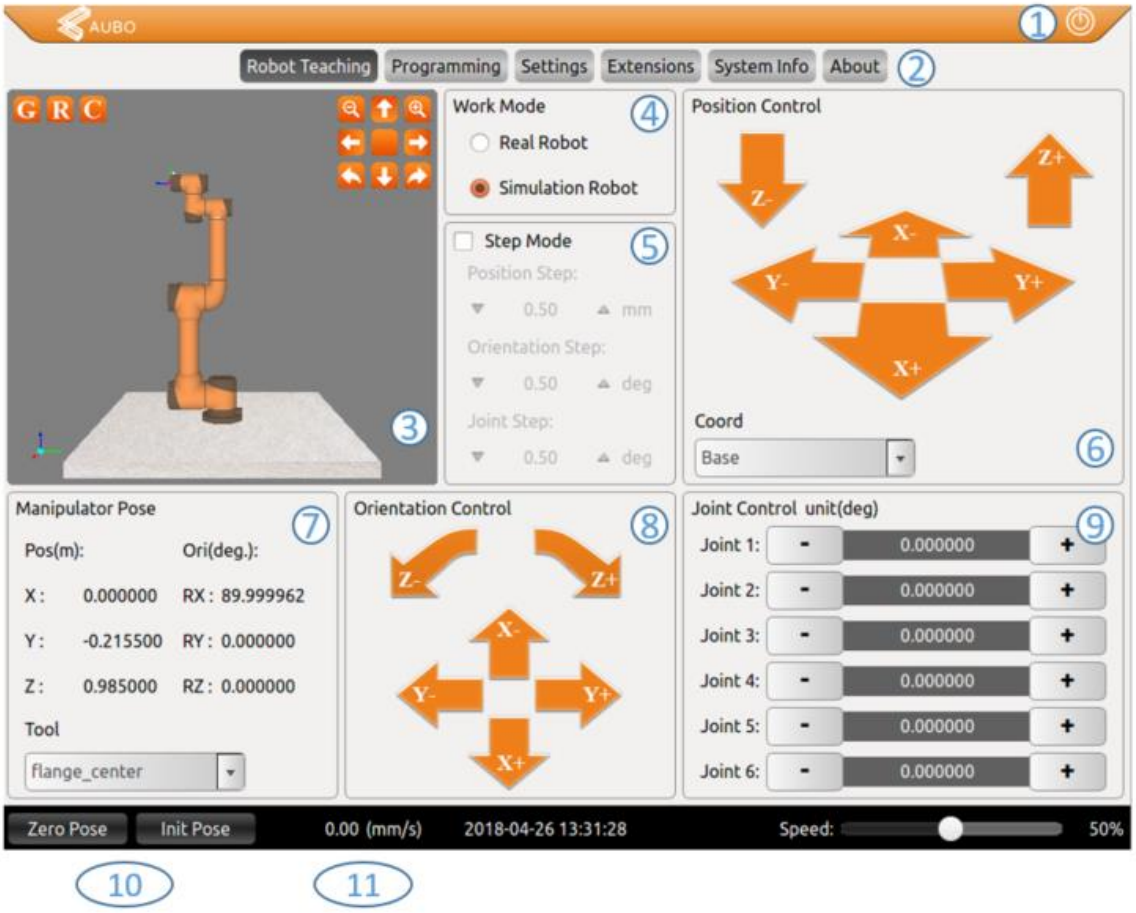

Figure 10.4 Robot Teaching interface

The Robot Teaching user interface consists of 11 components:

1. Software shut down button
2. Menu
3. Robot 3D display window
4. Simulation/real control switch button
5. Step mode control
6. Position control
7. Tool end position and pose information display
8. Orientation control
9. Joint control
10. Robot status control includes zero position, initial position
11. Motion speed control and display, robot time display

10.3.1 Software shut down button

- Click to shut down the software.

10.3.2 Menu

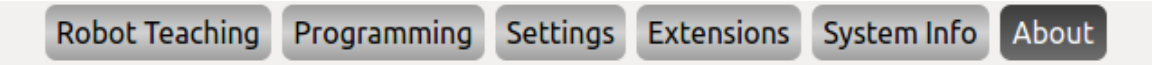

Figure 10.5 User interface menu

- Press on the menu would select the menu item. The selected menu renders a light text on a dark background.

10.3.3 Robot 3D display window

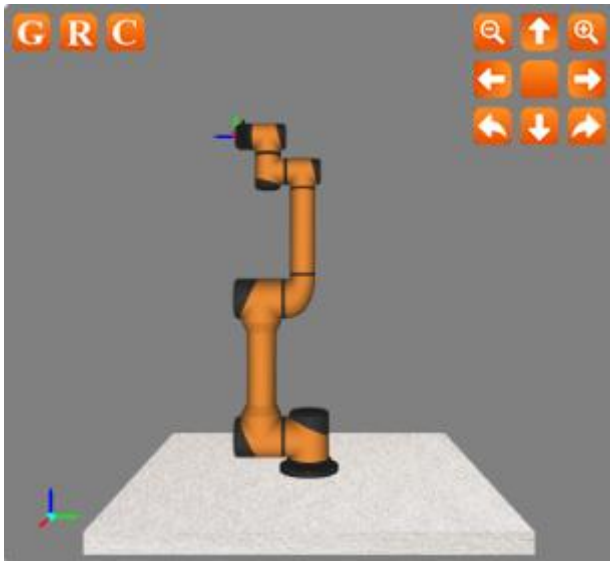

Figure 10.6 Robot 3D display window

- Robot 3D display window verifies the user-written project without the real robot.
- 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.
- 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
- The simulation model can also be used to validate control programs before applying on the real robot.

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10.3.4 Simulation/real control switch button

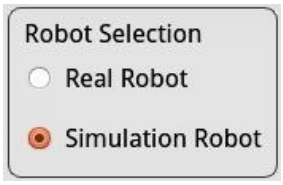

Figure 10.7 Robot mode selection.

- When "Real Robot" is selected, the teach pendant will control the robot manipulator in real time.
- When "Simulation Robot" is selected, the 3D manipulator model operates 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 10.8 Step mode control.

To improve the control accuracy and flexibility, it is necessary to increase the step mode control to allow the controlled variable change precisely in a stepwise manner.

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

10.3.6 Position control

The end of manipulator is based on the base coordinate system, the end coordinate system or the user-defined coordinate system to control robot movements. The end of manipulator can teach under different coordinate systems.

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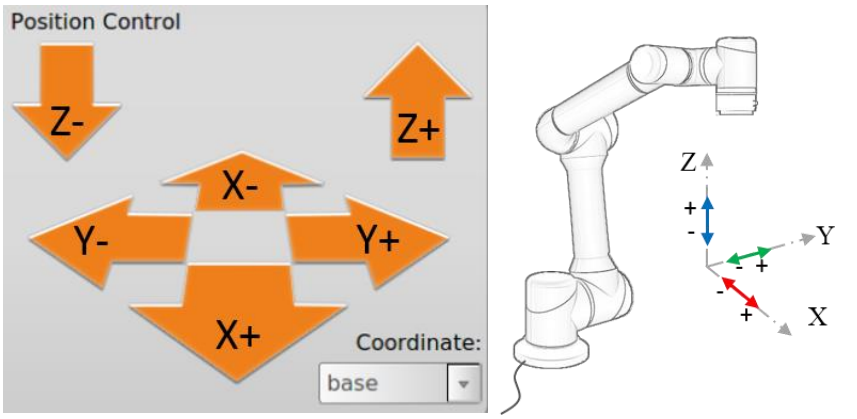

Figure 10.9 Position control（base）

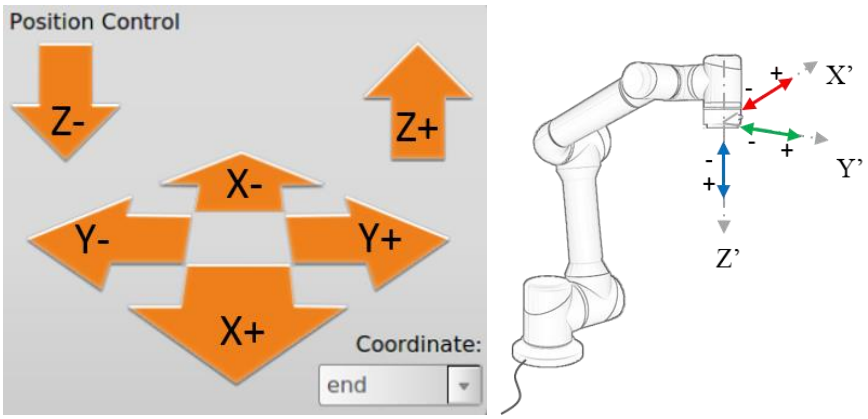

Figure 10.10 Position control（end）

10.3.7 Robot real-time status parameter display

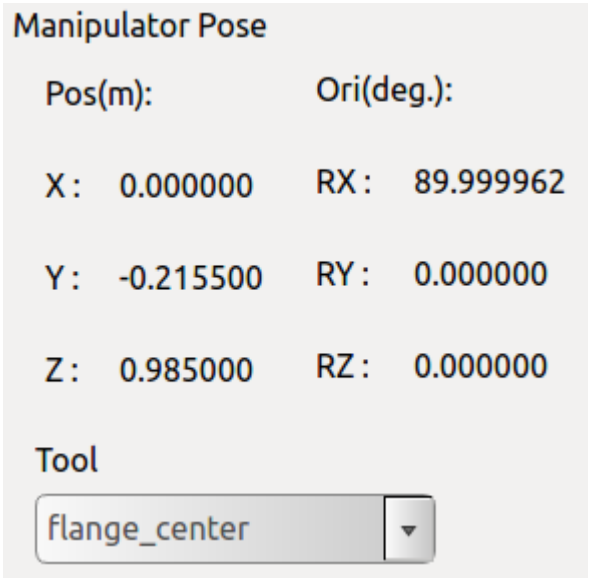

Figure 10.11 Pose and position information.

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

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example, Euler angles).

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

10.3.8 Orientation Control

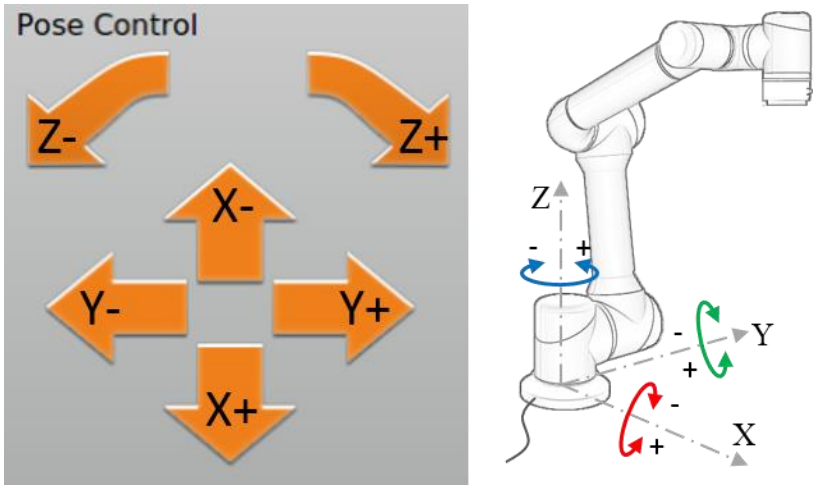

Figure 10.12 Orientation Control (base)

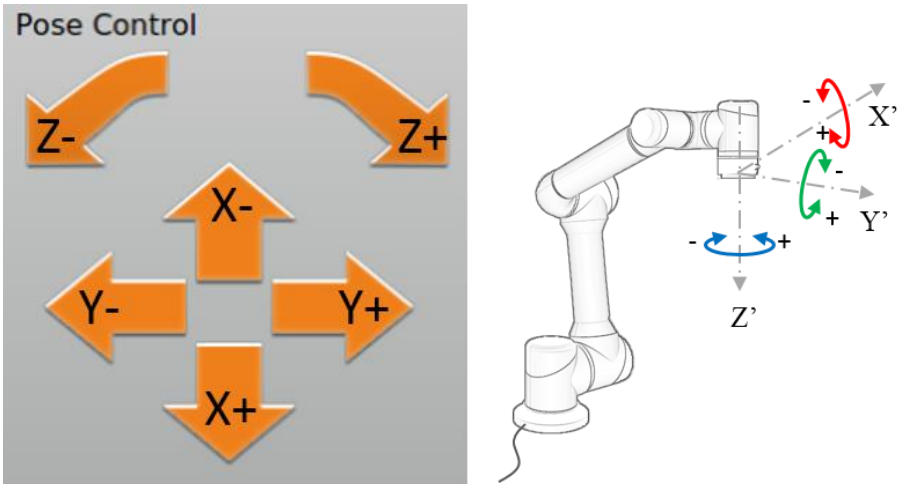

Figure 10.13 Orientation Control (end)

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10.3.9 Joint axis control

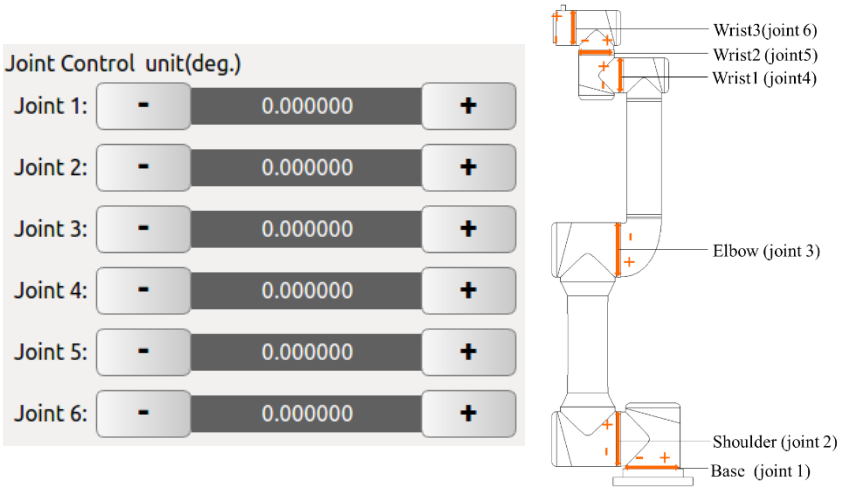

Figure 10.14 Illustration of Joint control.

- 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 the teach pendant interface.
- "+" represents that a joint motor rotates counterclockwise; and "-" represents that a joint motor rotates clockwise, as shown above.
- Unit: degree.

10.3.10 Zero Pose, Init Pose

Figure 10.15 Buttons for Zero Pose and Init Pose

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

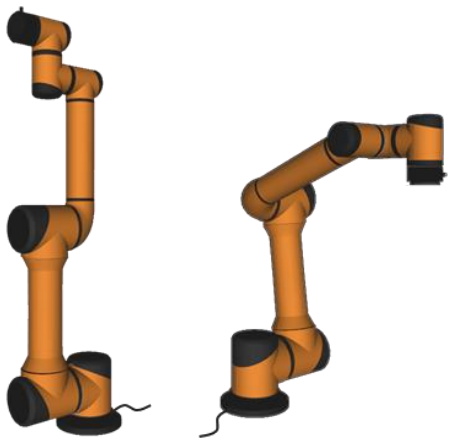

Figure 10.16 Zero Pose and Init Pose (default)

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10.3.11 Motion speed control

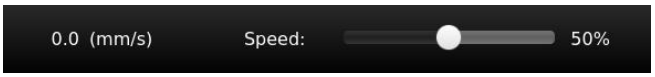

Figure 10.17 Motion speed control.

- Users can adjust the robot's motion speed by sliding the slide bar (the percentage of the maximum speed).

- Sliding 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 the auto mode.

10.4 I/O Control Interface

10.4.1 Controller I/O Tab

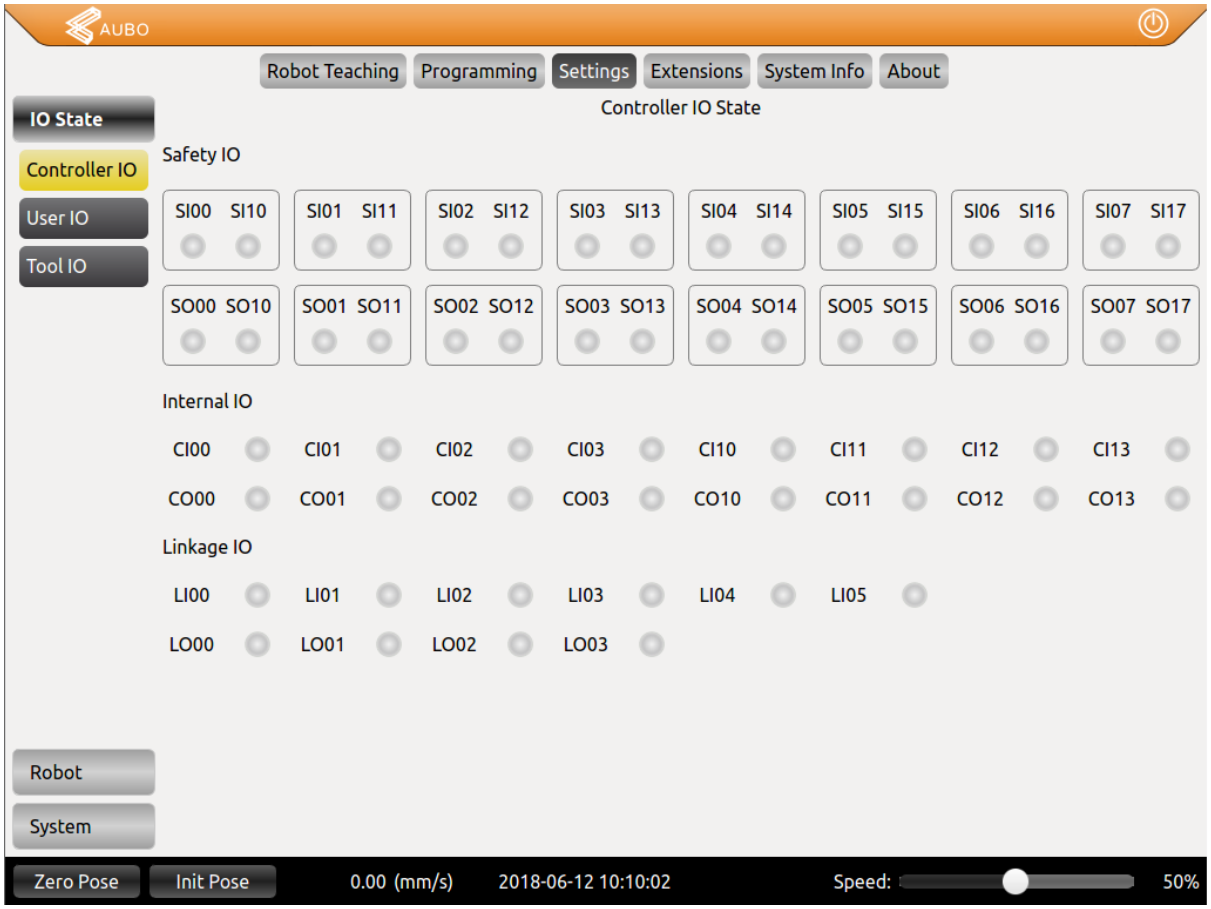

Figure 10.18 Controller I/O

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

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10.4.2 User I/O

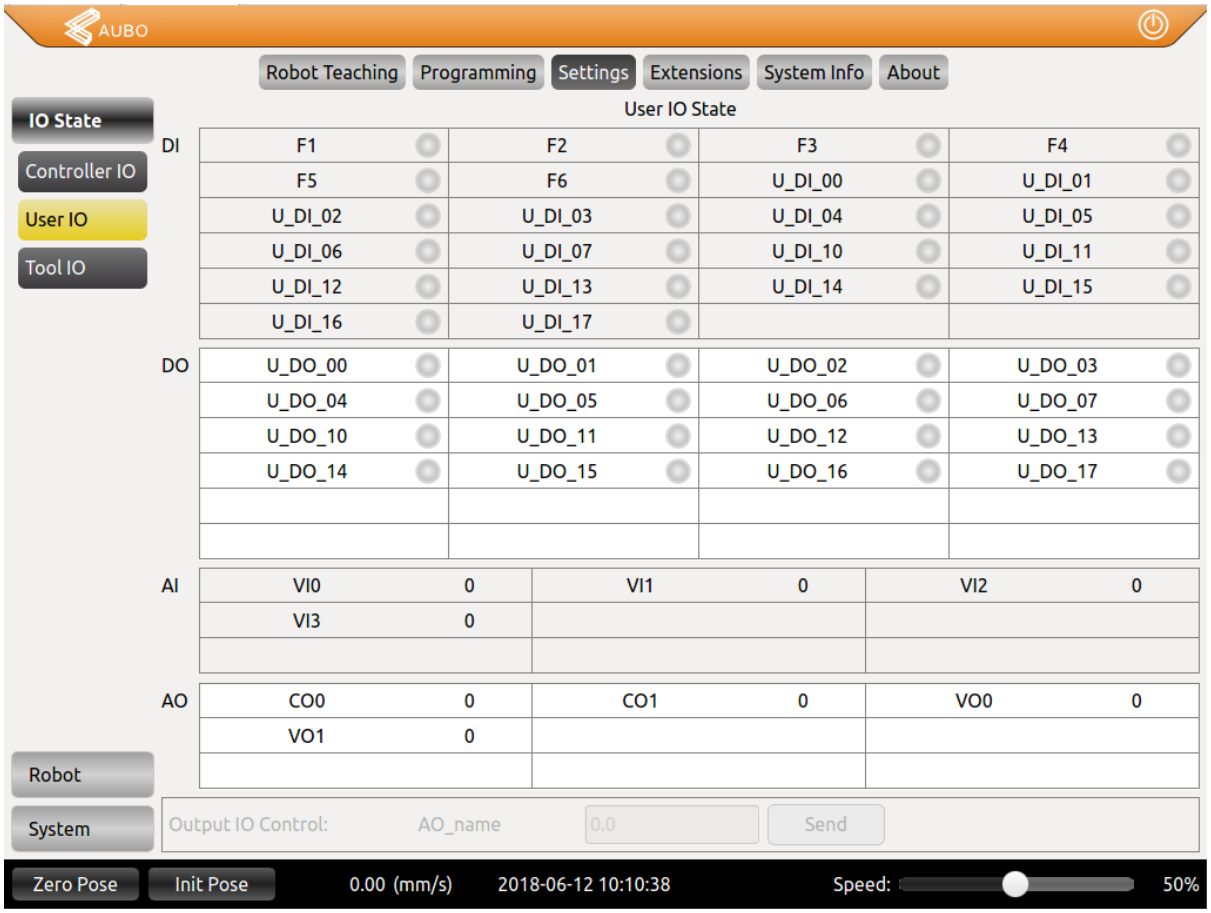

Figure 10.19 User I/O

- DI and DO are general digital I/O with a total of 16 inputs and 16 outputs that can be used for direct drive relays and other electrical equipment.
- 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, and the accuracy is ± 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.
- 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 default value.

10.4.3 Tool I/O Tab

This section introduces the setting of I/O interface provided by the 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.

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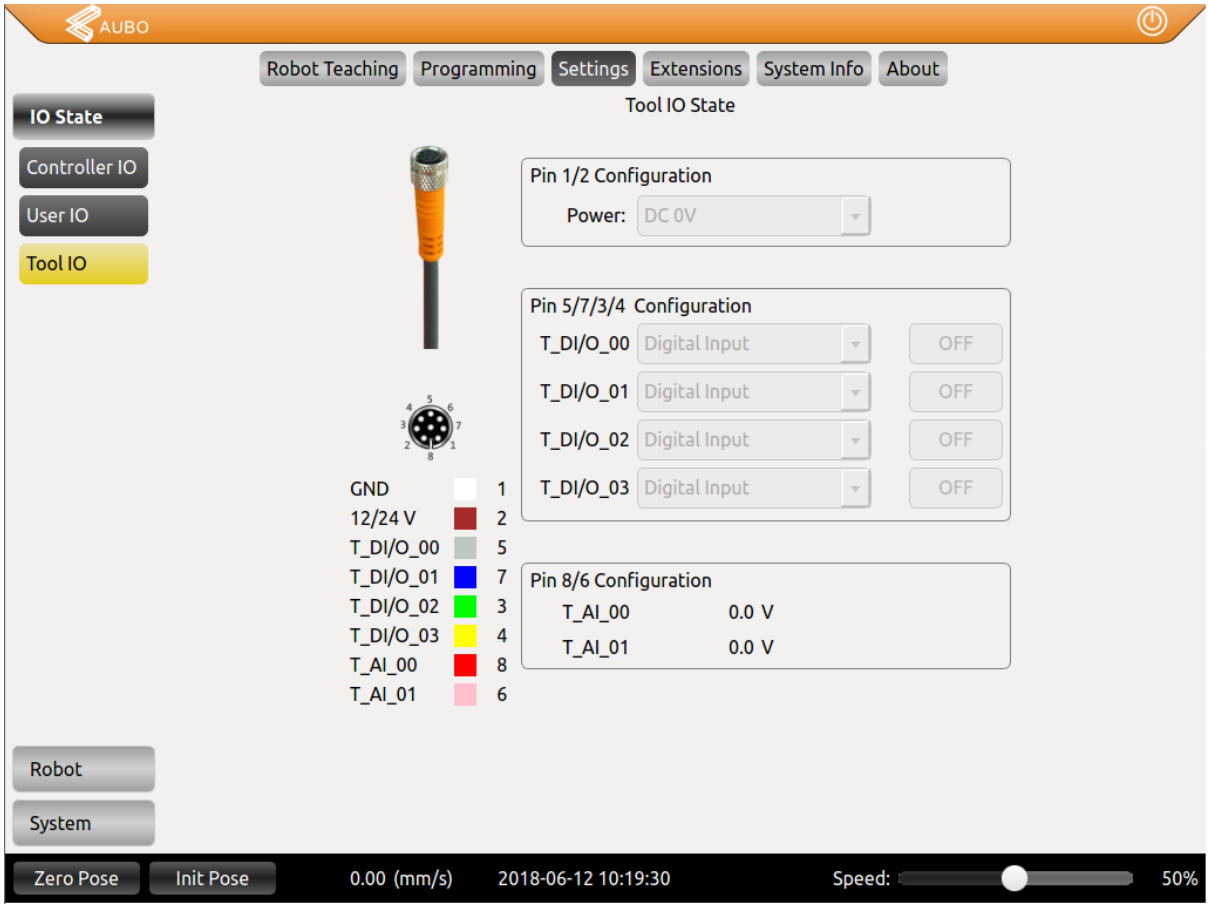

Figure 10.20 Tool I/O Setting interface.

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

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10.5 Robot Setting Tab

10.5.1 InitPose

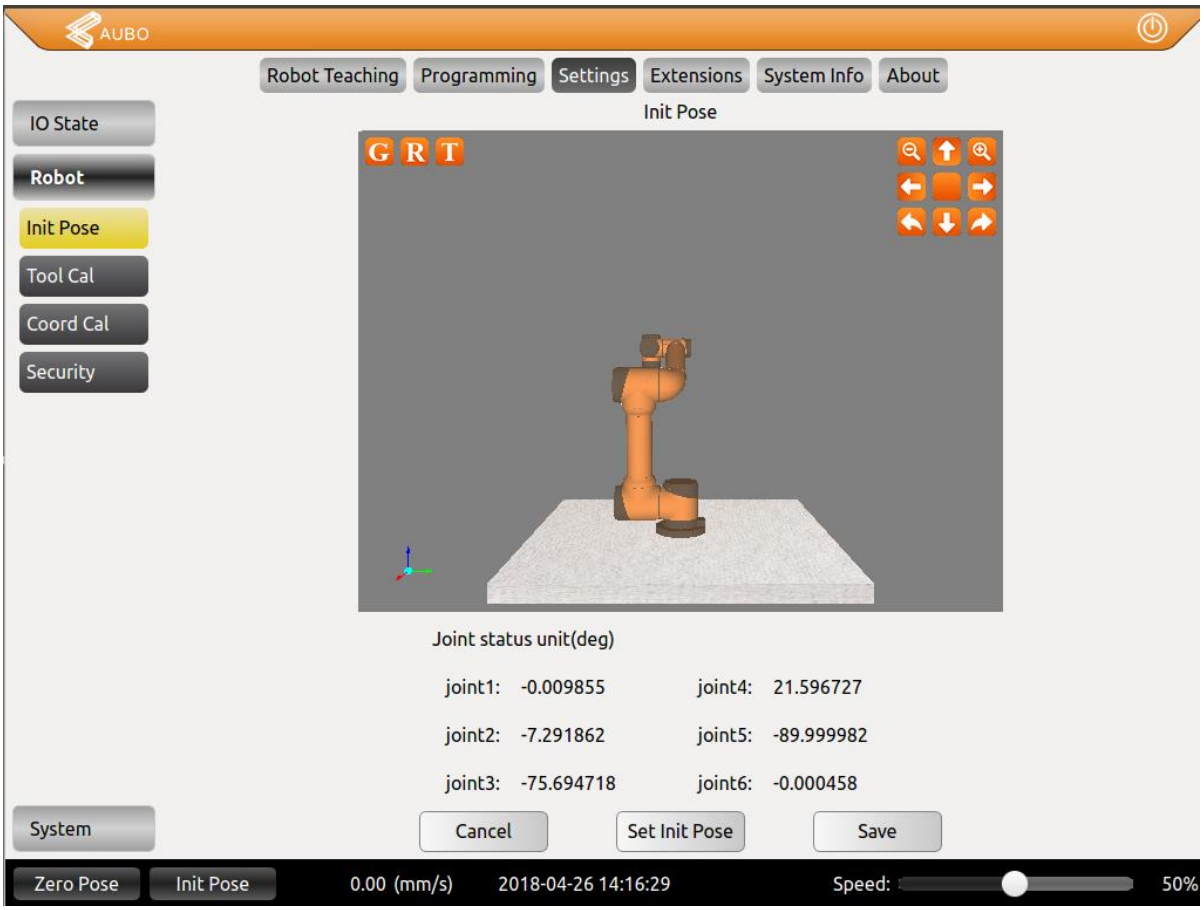

Figure 10.21 InitPose

- Click【Set **InitPose**】to set the initial position by moving robot via the 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.

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10.5.2 Tool Calibration

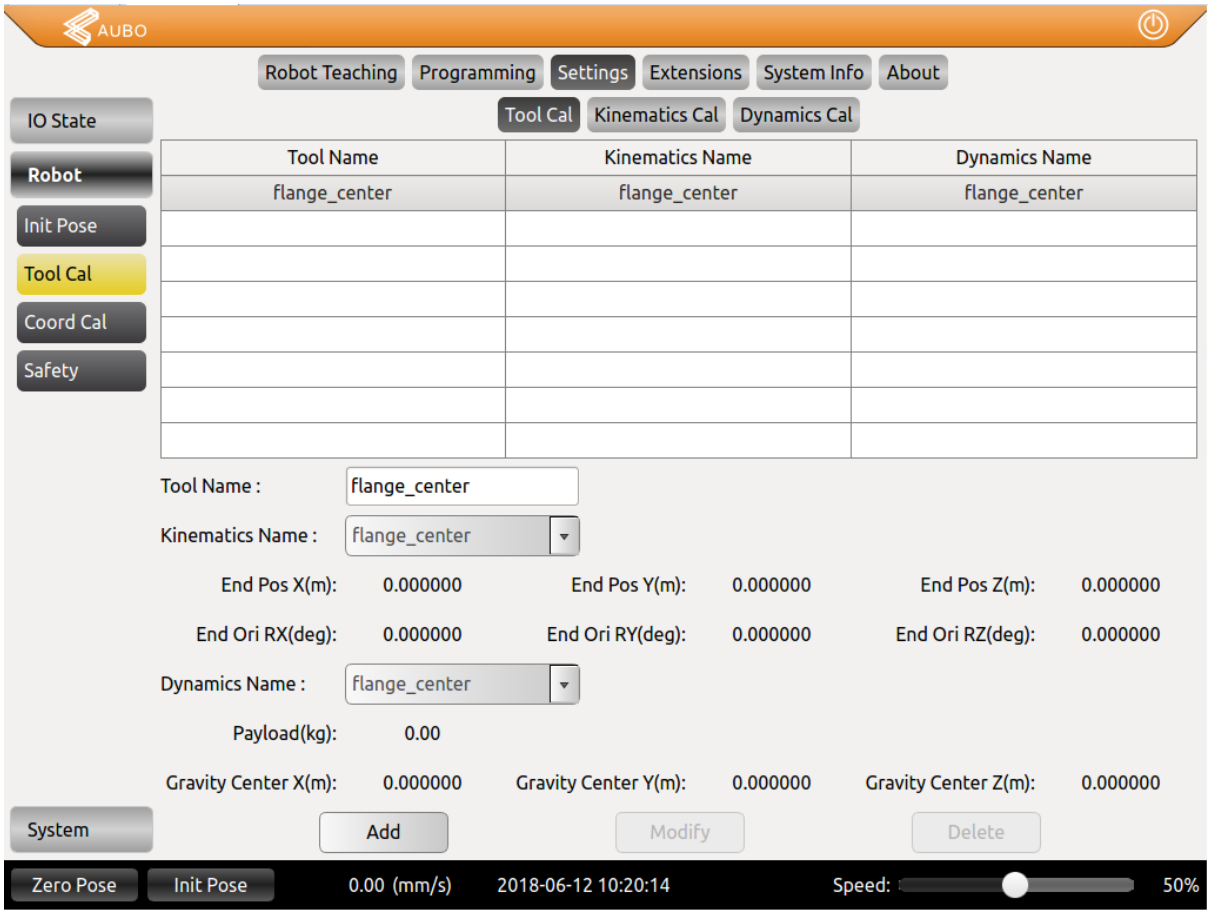

Figure 10.22 Tool Calibration

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: 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 attributes for the tool, enter the name of the tool, and then add the tool.

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10.5.2.1 Tool Kinematics Calibration

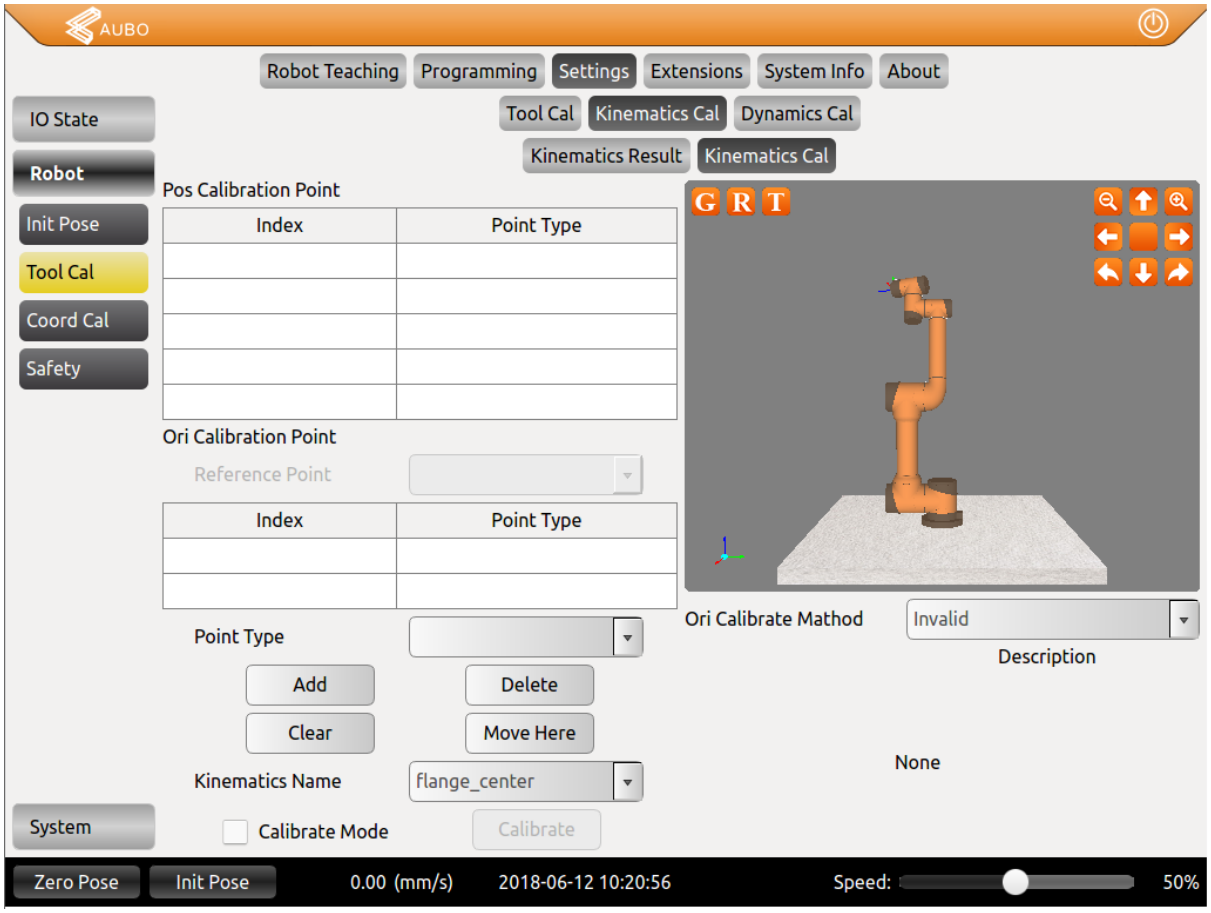

Figure 10.23 Tool Kinematics Calibration

The 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 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 center and in the middle of the true end of the tool.

The orientation calibration needs to calibrate the reference position (i.e., 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 is at right angles. During the calibration process, move to the reference position first, select Point Type as Ori Calibration, and click Add to enter the

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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 on the teach interface to help calibrating the orientation point.

The Delete button function is to delete the selected waypoints 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 Tool 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.

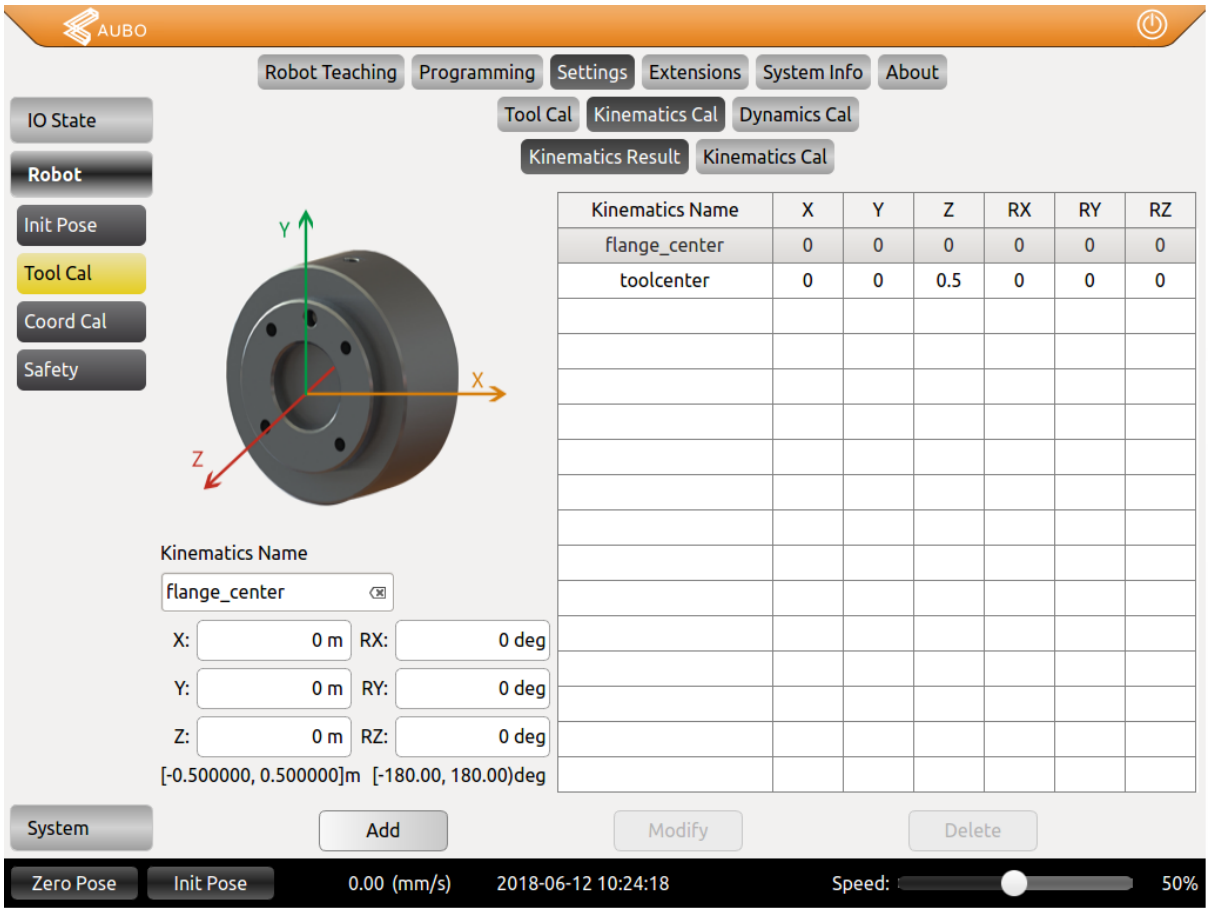

Figure 10.24 Tool Kinematics Calibration

The end tool position parameters and the 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 cannot be modified and deleted.

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10.5.2.2 Tool Dynamics Calibration

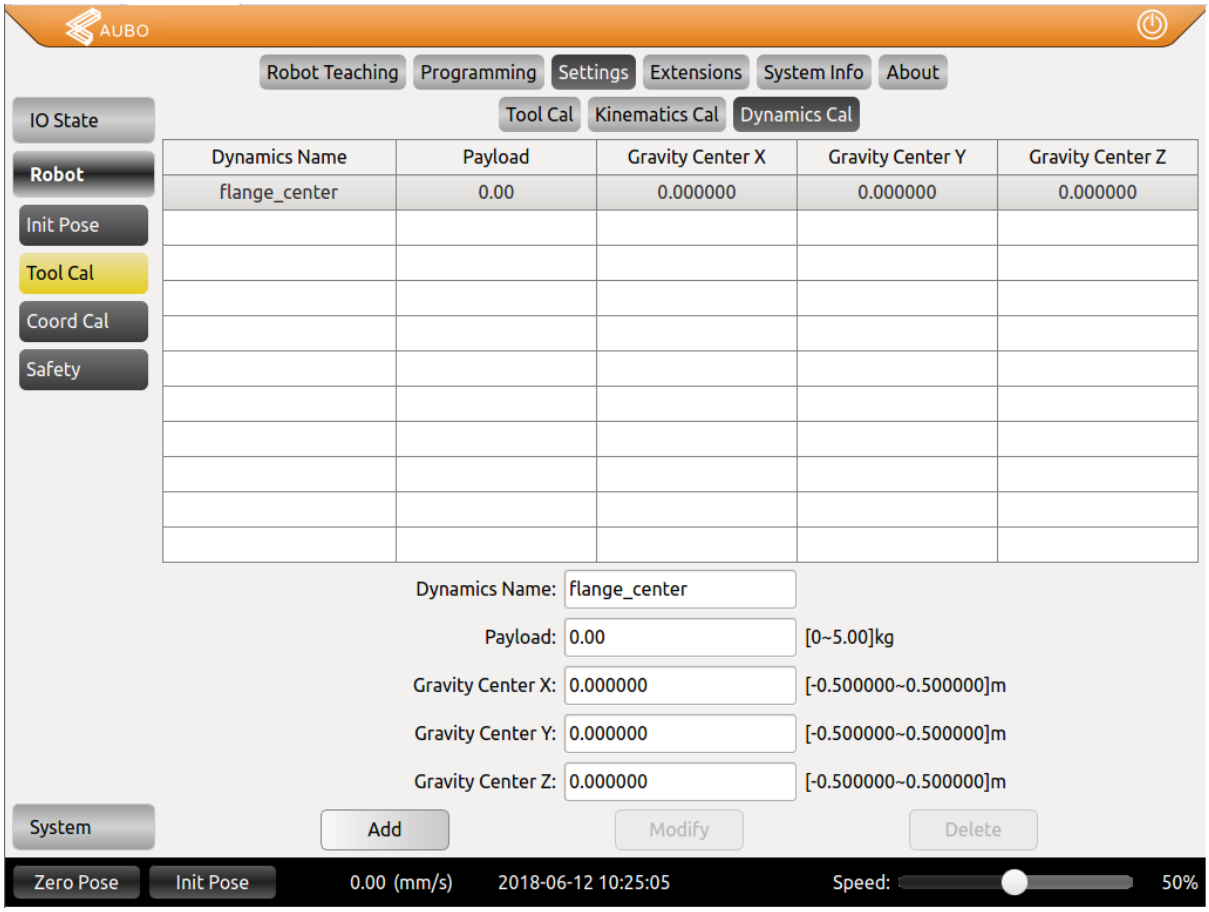

Figure 10.25 Tool Dynamics Calibration

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

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10.5.2.3 Tool Calibrate

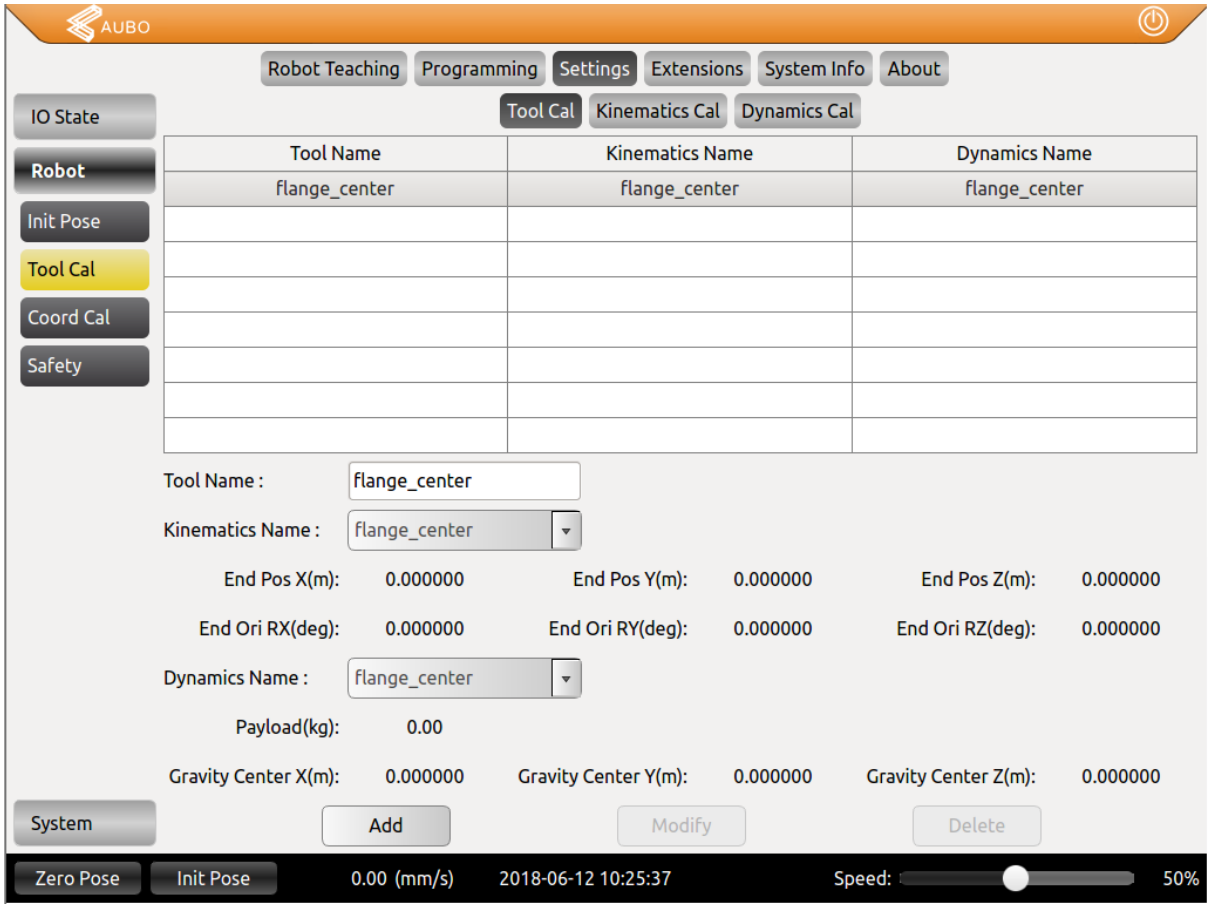

Figure 10.26 Tool Calibrate

The picture above is the tool calibration interface. After completing the tool kinematics and the dynamic parameters calibration, please follow the following steps: 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 and click the Delete button to delete.

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

It may cause different malfunctions if setting data is inaccurate in the actual operation. If the setting is wrong, the manipulator and the control box can’t work normally and can cause danger to personnel or equipment around.

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10.5.3 Coordinate Calibration

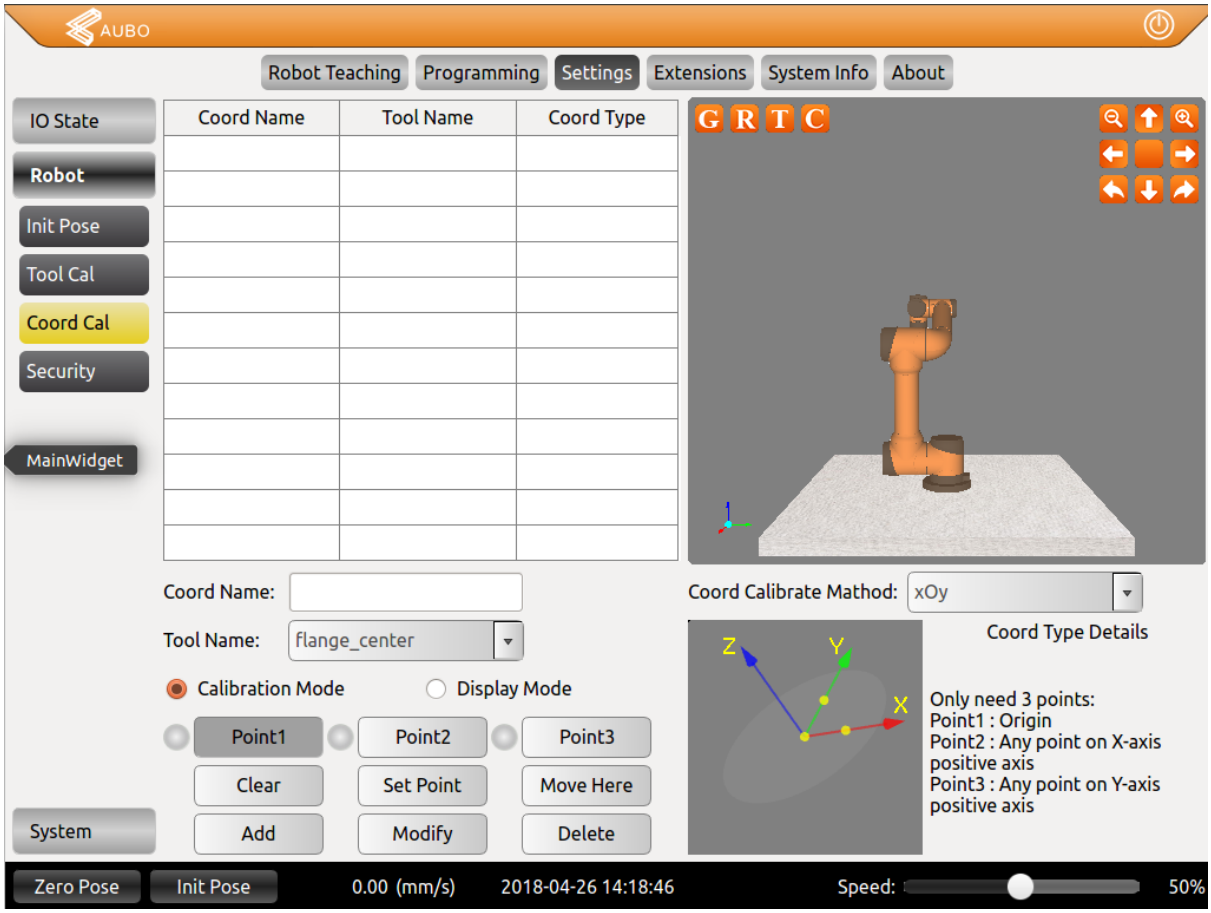

Figure 10.27 Coordinate Calibration

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. The different coordinate system types' naming rules, calibration points and requirements are listed as follows:

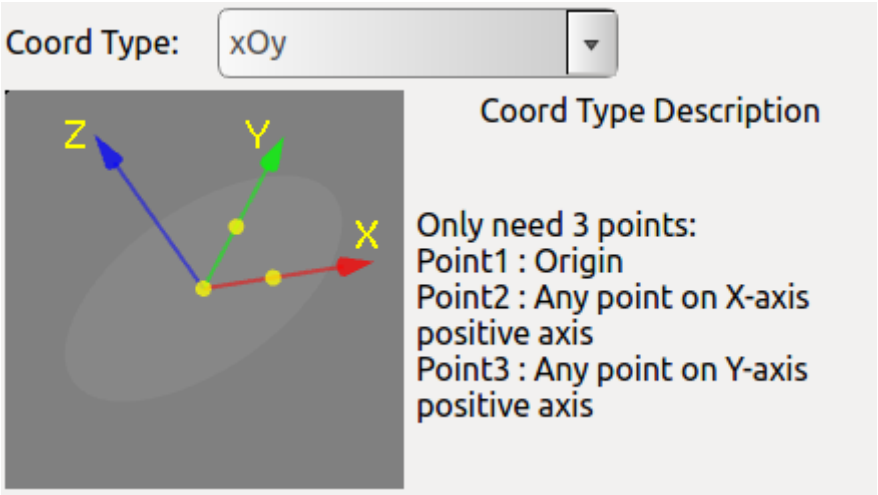

Figure 10.28 XOY

The figure above is xOy type, the first point requires for the calibration is the origin of the coordinate system,

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the second point is any point on the positive 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.

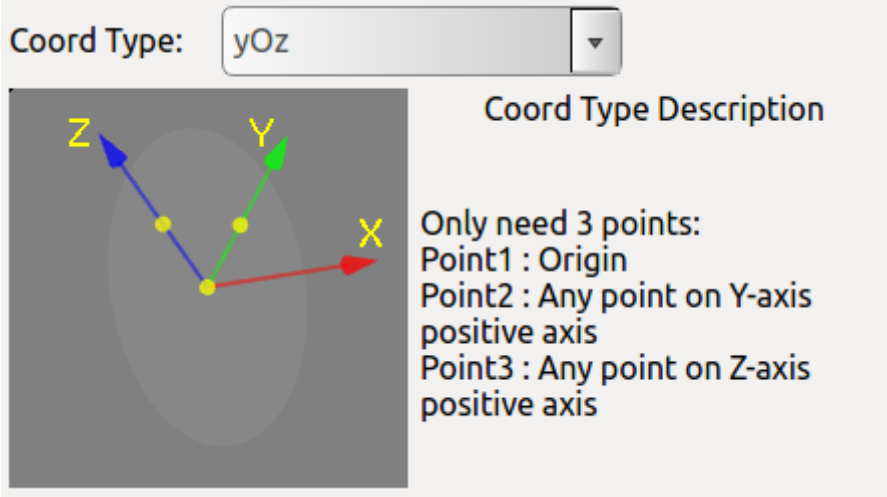

Figure 10.29 YOZ

The figure above is yOz type, the first point requires for the calibration is the origin of the coordinate system. The second point is any point on the positive 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.

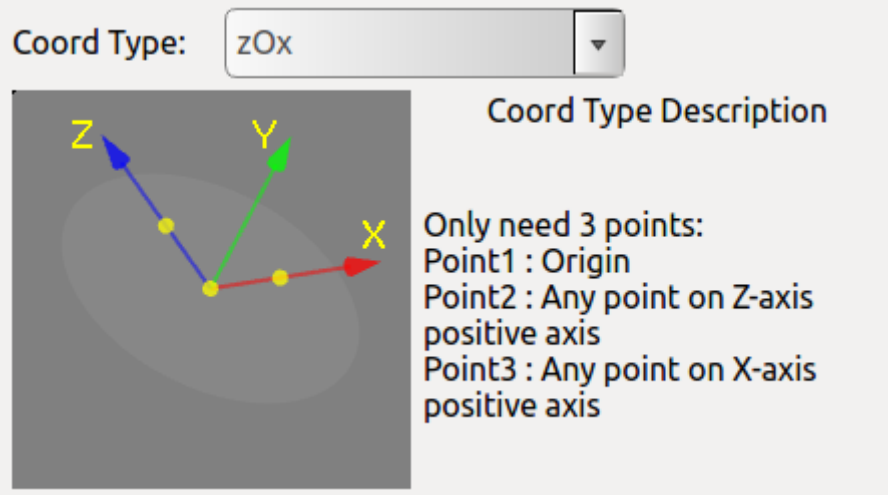

Figure 10.30 ZOX

The figure above is zOx type, the first point requires for the calibration is the origin of the coordinate system. The second point is any point on the positive 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.

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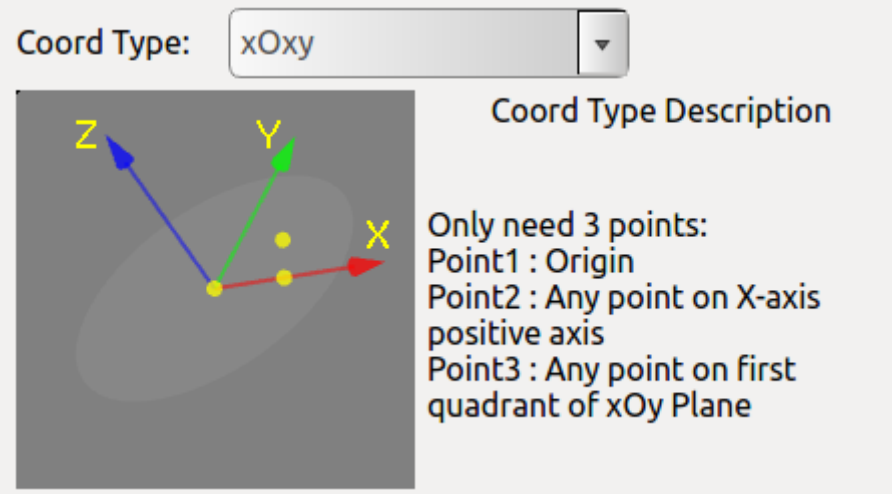

Figure 10.31 XOXY

The figure is xOxy type, the first point requires for the 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.

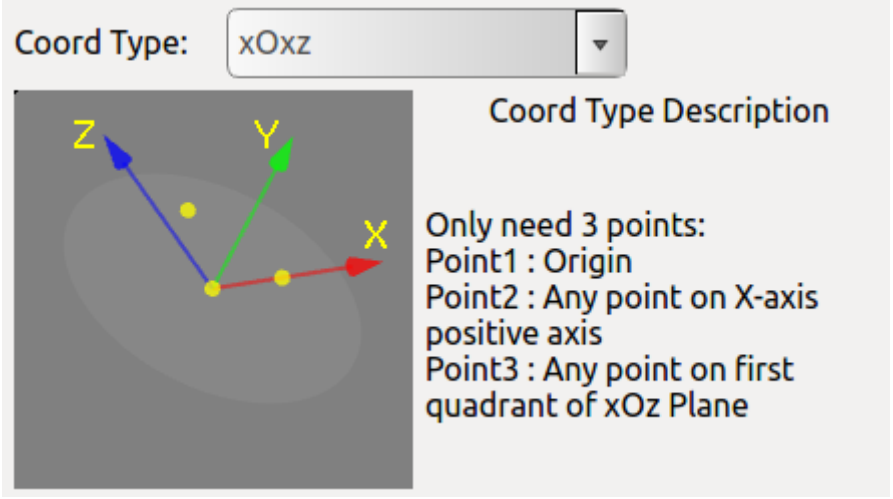

Figure 10.32 XOXZ

The figure is xOxz type, the first point requires for the calibration is the origin of the coordinate system, the second point is any point on the positive 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.

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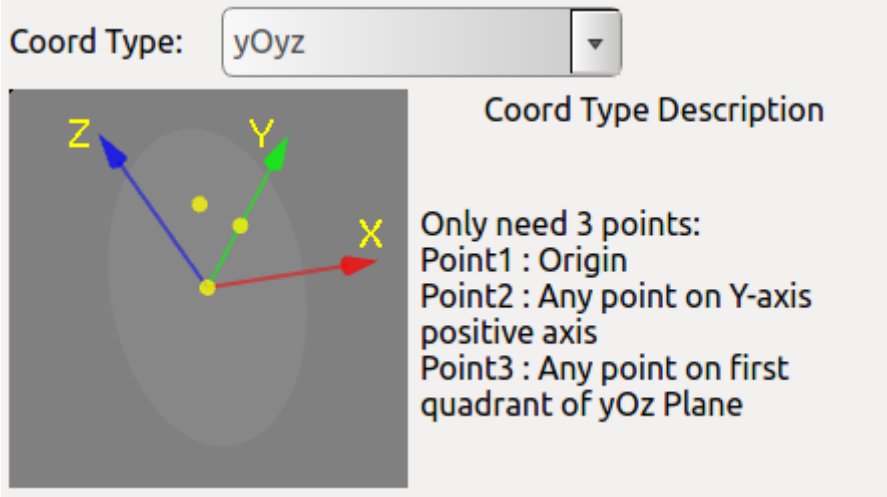

Figure 10.33 YOYZ

The figure is yOyz type. The first point requires for the calibration is the origin of the coordinate system the second point is any point on the positive 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.

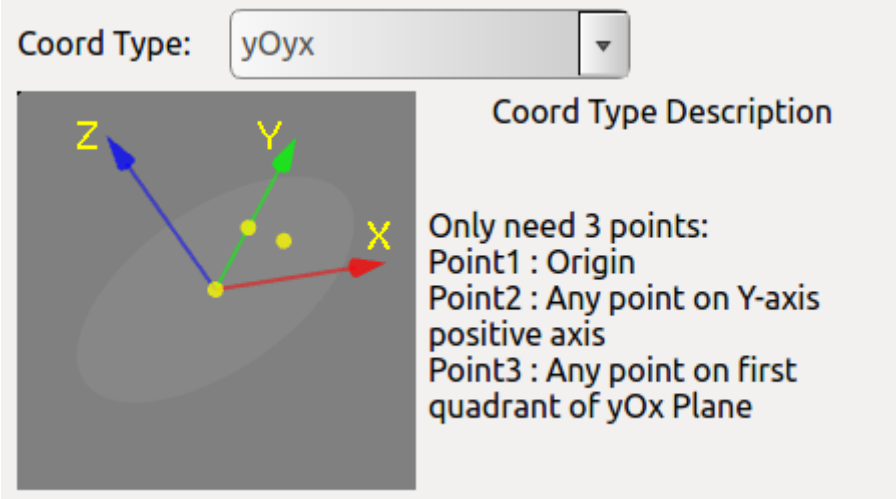

Figure 10.34 YOYX

The figure is yOyx type, the first point requires for the calibration is the origin of the coordinate system the second point is any point on the positive 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.

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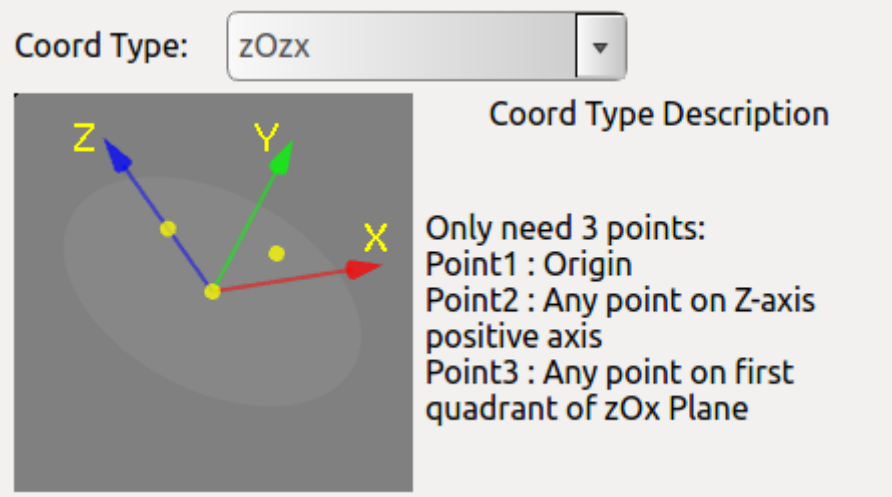

Figure 10.35 ZOZX

The figure is zOzx type. The first point requires for the calibration is the origin of the coordinate system. The second point is any point on the positive 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.

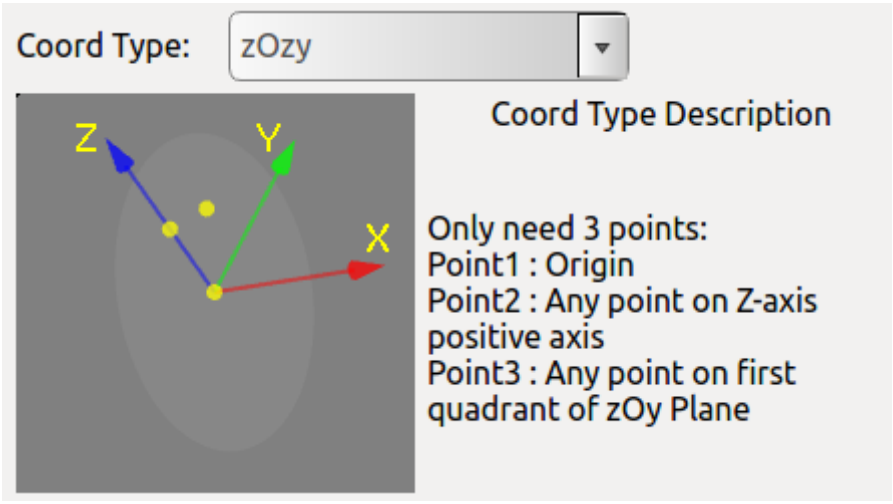

Figure 10.36 ZOZY

The figure is zOzy type. The first point requires for the calibration is the origin of the coordinate system. The second point is any point on the positive 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.

During the calibration process, select the type of the coordinate system to be calibrated via Coord Type firstly. Then, select the Calibration Mode, select Point1, click Set Point, enter teaching interface, and calibrate the 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.

- When modifying the coordinate system, first select the coordinate system on the list, and click Calibration Mode, then you can modify Point1 to Point3,
- Coordinate system name can also be modified, after setting up, click the Modify button, and save the modified parameters.
- When you delete a coordinate system, select the coordinate system on the list and click the Delete button. The coordinate system is removed.

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- The Clear button function clears the calibration results from Point1 to Point3 in the Calibration Mode.
- Display the Mode function is to display the value of the three waypoints of the calibrated coordinate system. After a coordinate system is selected on the list, it automatically enters the Display Mode. Clicking Point1 to Point3, the three waypoints used to calibrate the coordinate system are displayed in the simulation interface.
- Move Here function is to move to a waypoint, the specific operation is in the Calibration Mode, select any one of Point1 to Point3 buttons, click Move Here will move to the corresponding calibration point; in the Display Mode, select the selected Point1 To any of the Point3 buttons, click Move Here to move to the waypoint that used to calibrate the coordinate system.

10.5.4 Safety

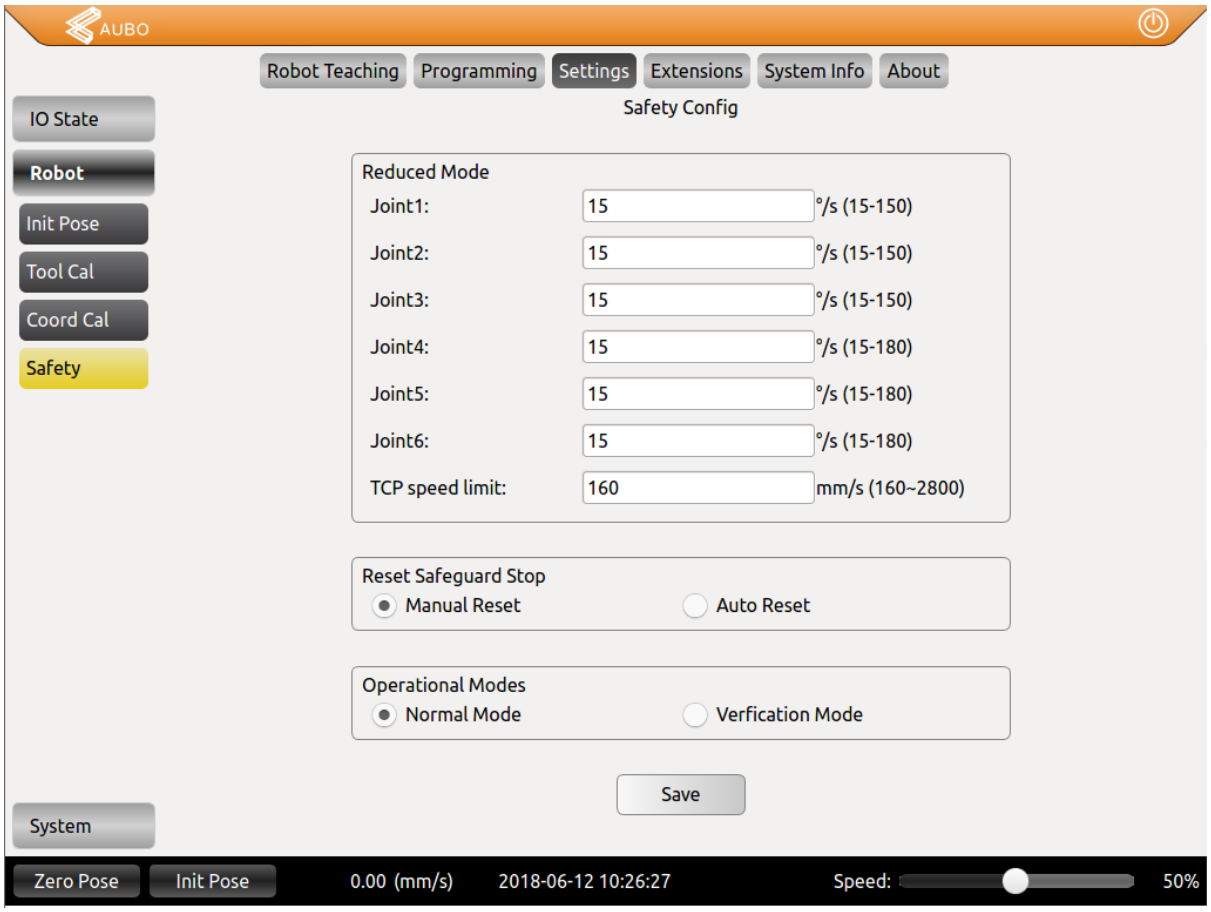

Figure 10.37 Safety Setting

- Reduced mode: in this mode, the joint speed of the manipulator shall be limited to the value of the corresponding text box.
- Reset Safeguard Stop: select manual reset, only the 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.
- Operational mode: When "Normal mode" is selected, the external enabling device input signal is invalid. When "verification mode" is selected, the external enabling device input signal is valid.

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10.6 System Settings Tab

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

10.6.1 Language Tab

Figure 10.38 Language Tab

- Language Tab provides English (default), Simplified Chinese, Japanese, French, German, and Slovak.

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10.6.2 Date& Time tab.

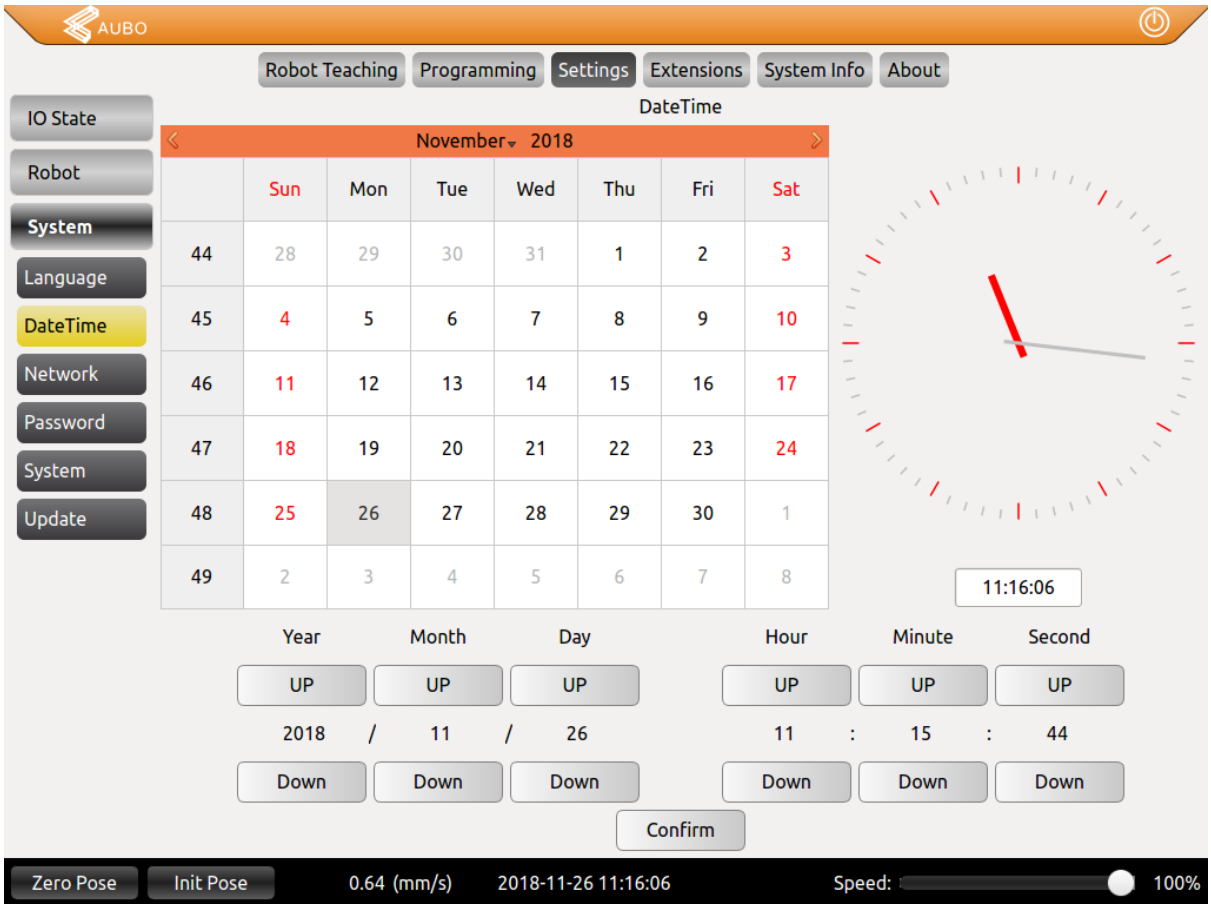

Figure 10.39 Date& Time tab.

- Date& Time tab can set date and time.

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10.6.3 Network Tab

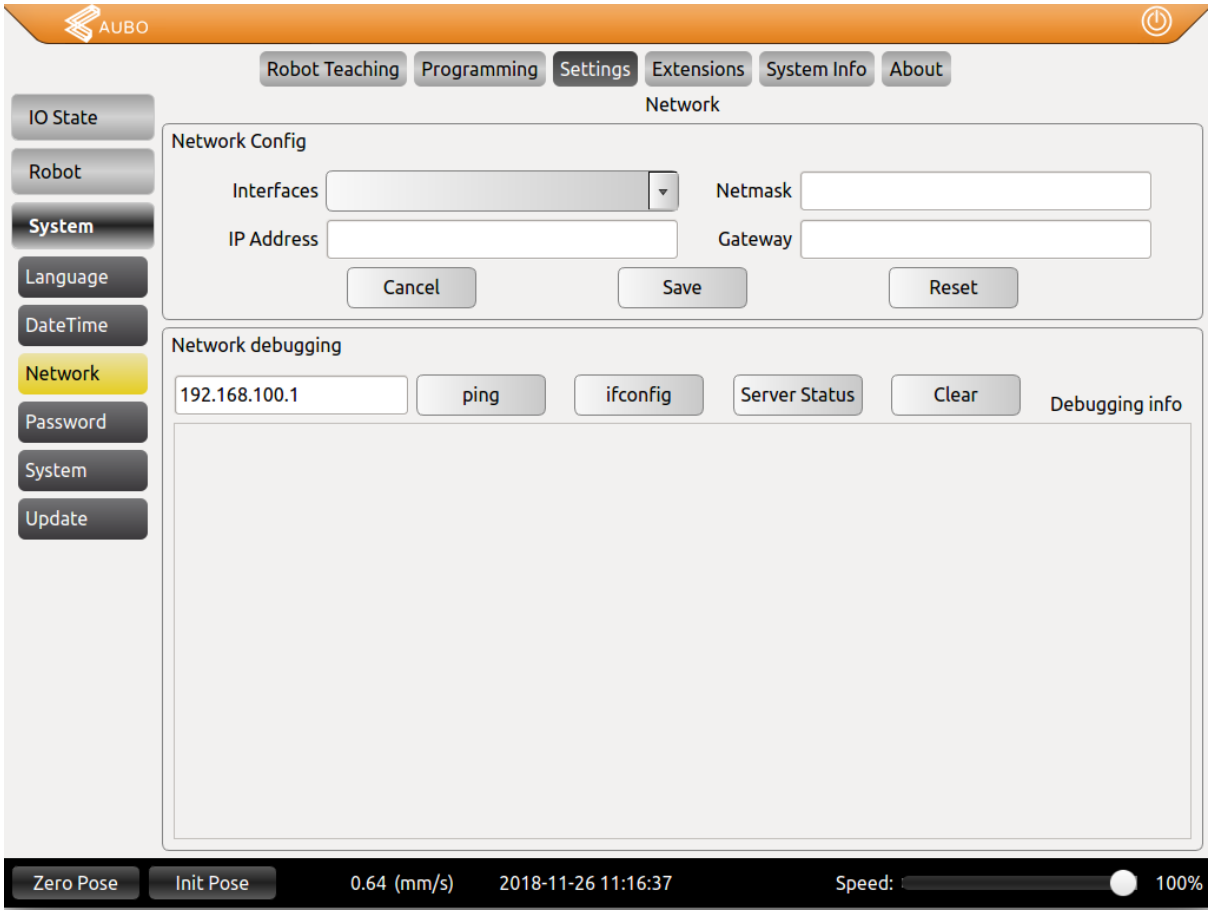

Figure 10.40 Network Tab

- Network Tab is used for network settings and is controlled by third party interface.
- Specified name of the NIC and its IP Address, Netmask 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 the robot.
- Restart the AUBOPE system after saving the configuration

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10.6.4 Password Tab

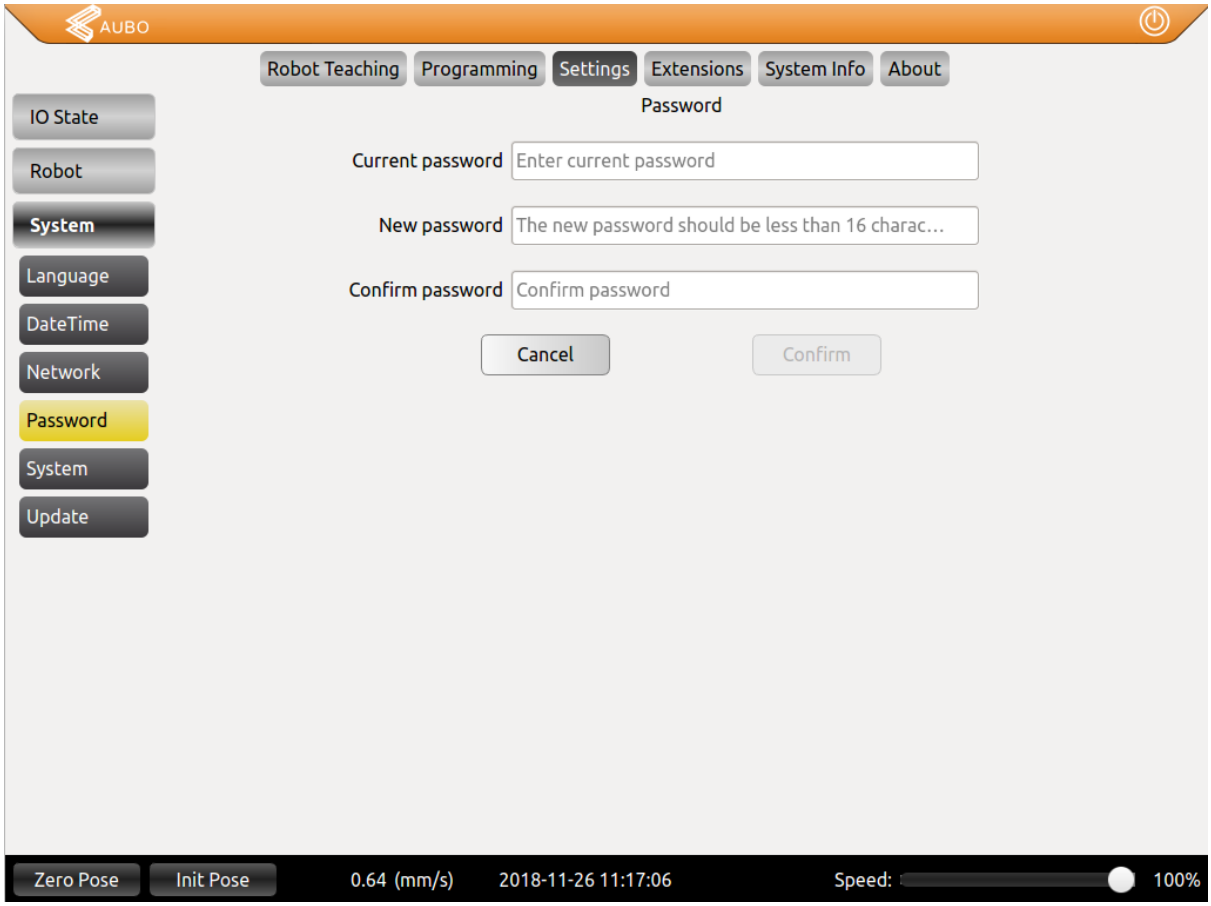

Figure 10.41 Password Tab

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

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10.6.5 System

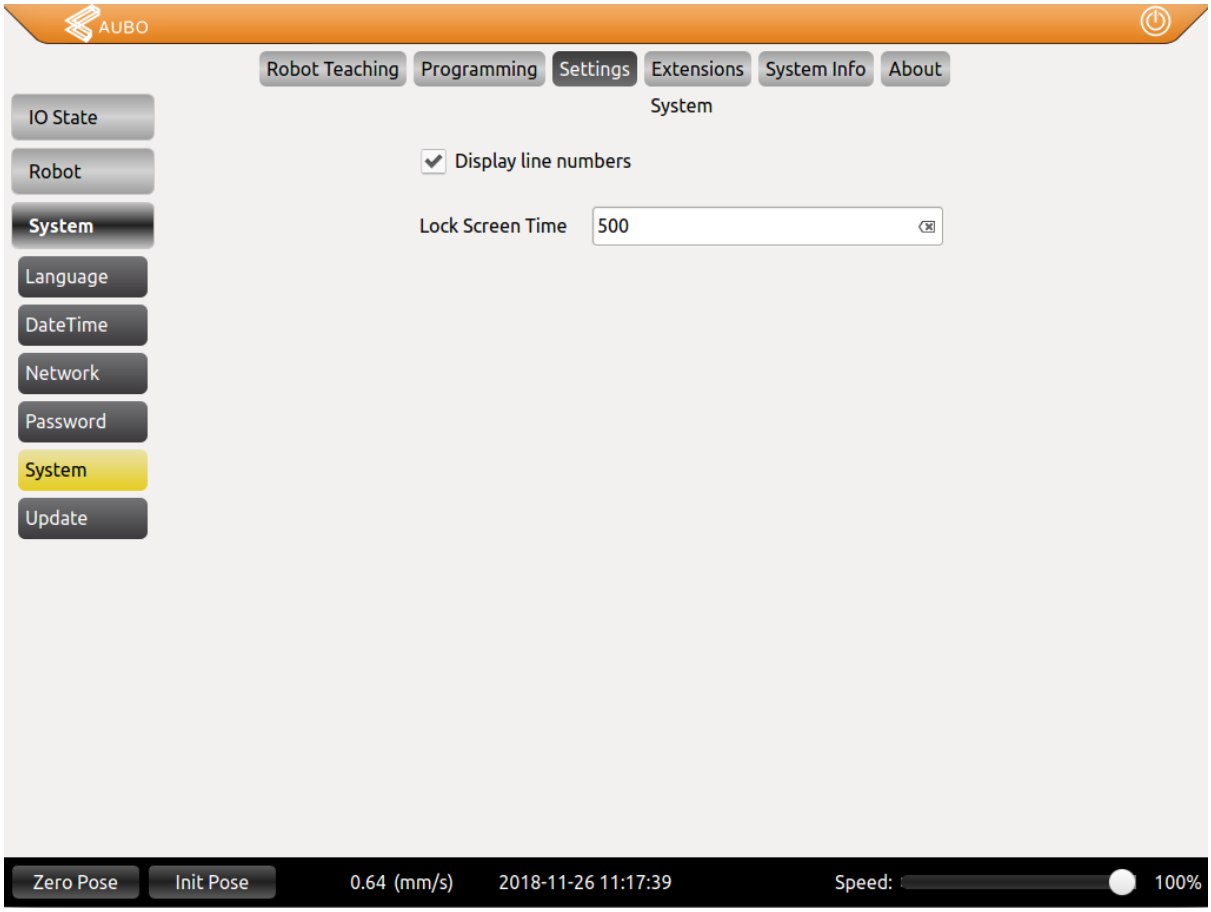

Figure 10.42 Lock Screen

- Input the time of screen lock to update screen lock.

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10.6.6 Update Tab

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

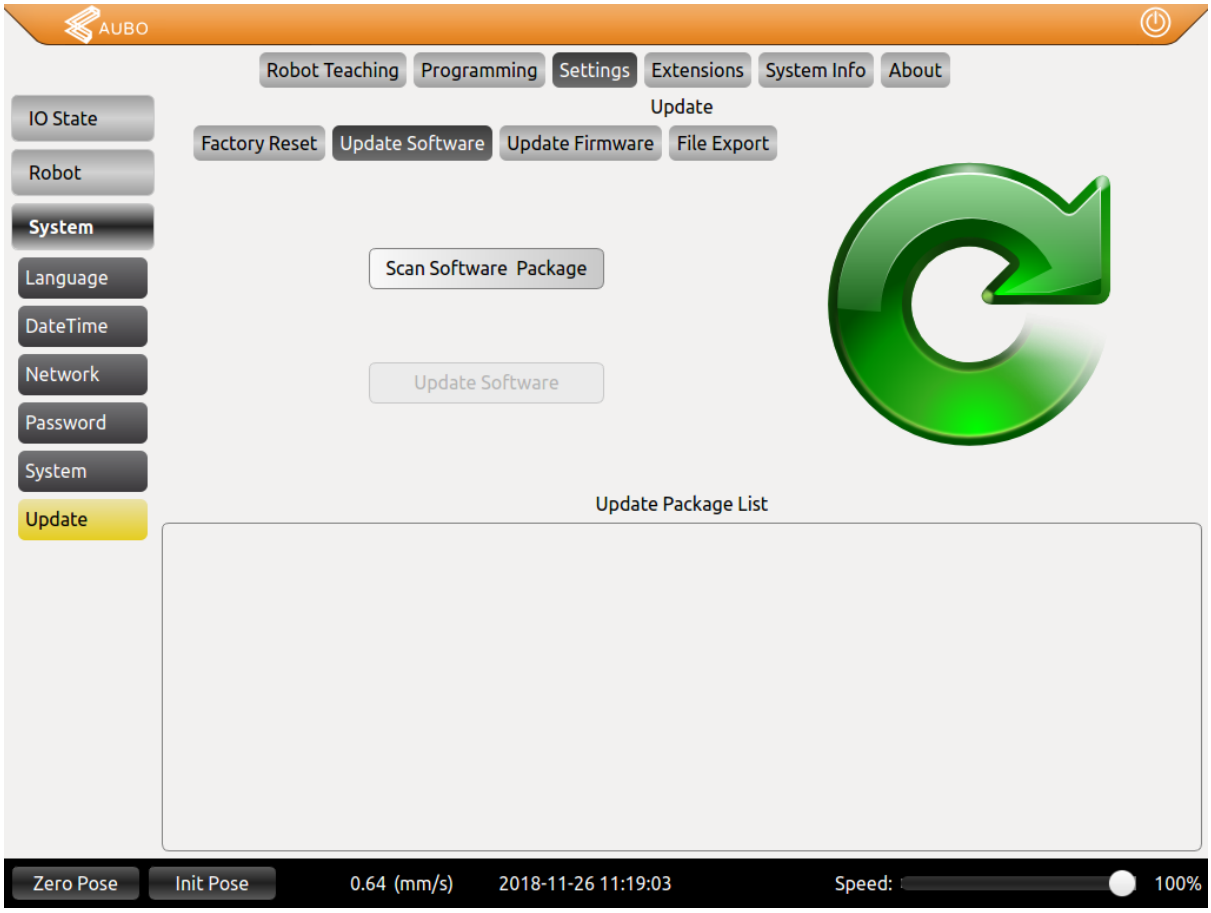

Figure 10.43 Update tab

- Steps of updating software: Insert an USB memory device and click【**Scan software Package**】as shown in Figure 10.43, click the name of updated software and click【**Update**】, then the system will reboot to finish update.
- The name file directory can only be English
- Updated Software can only be placed in root directory.
- Updated Software must be a compressed file end with us.
- After updating software, system will reboot automatically.
- This tab can import or export the project file and reset too.

USB disk format supports FAT32 but does not support NTFS format.

Factory Reset means that all the information and data are cleared and returned to the factory state. Do not

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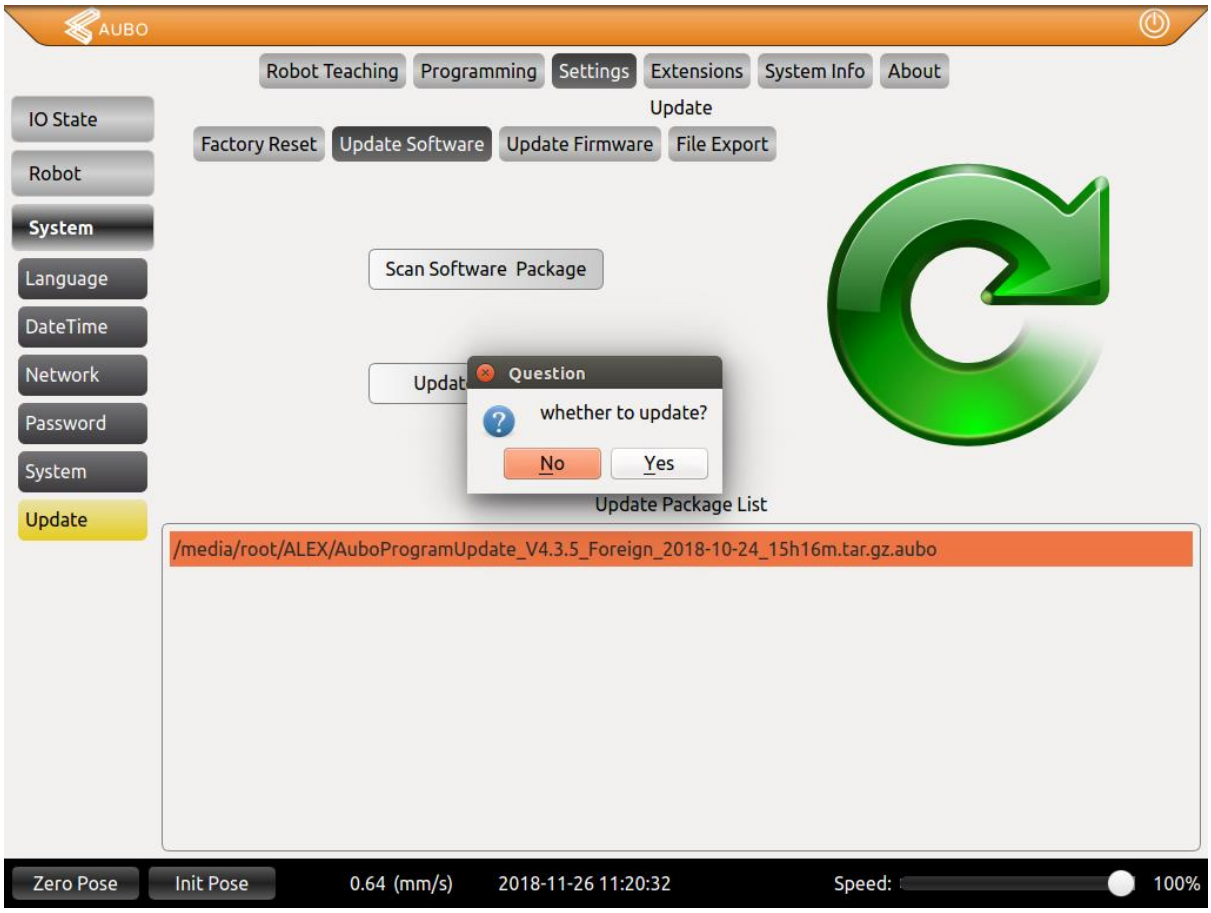
try it easily.



You can use File Export to export your Log and Project：
Insert USB drive and click Scan Device, select the inserted U disk, then you can export your Log and Project.

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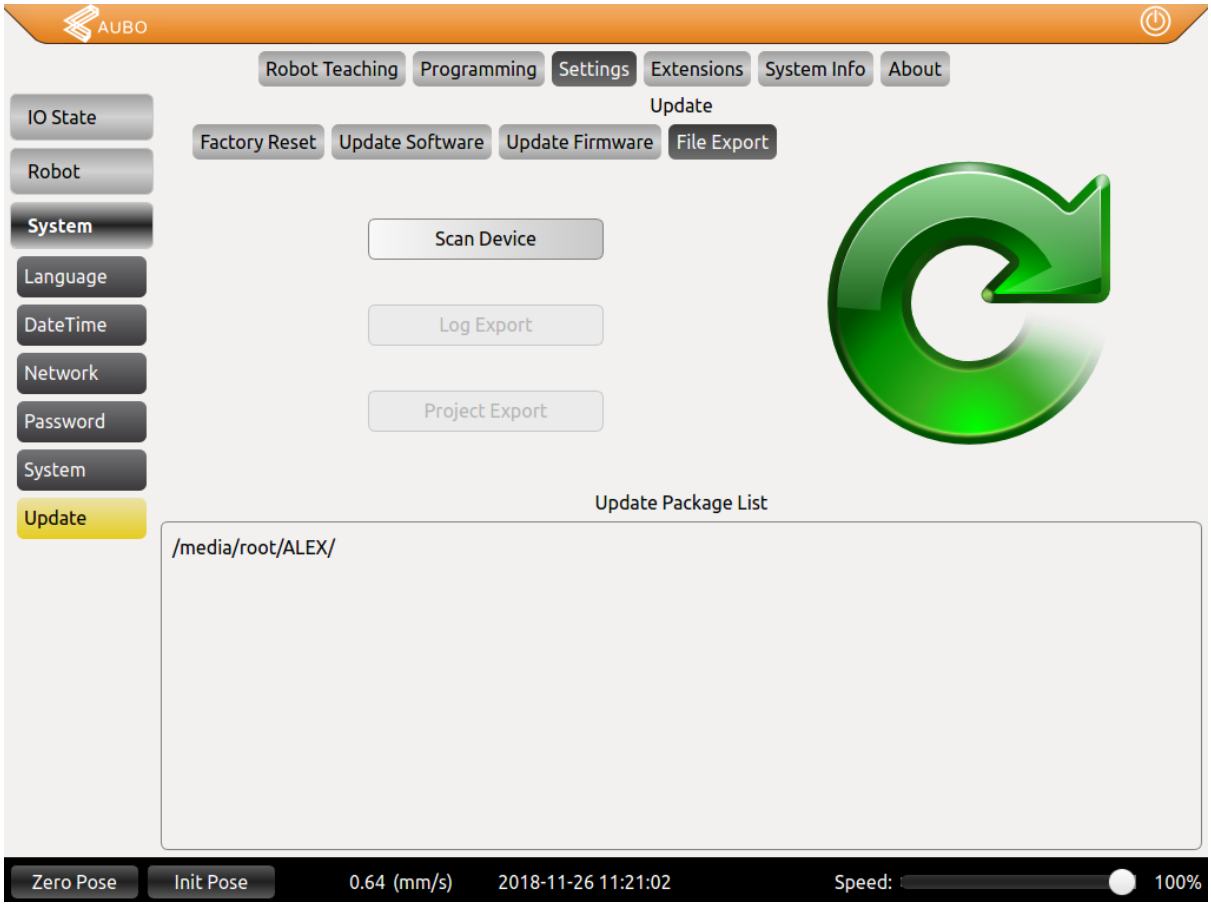

10.7 Extensions

This is the manipulator teach pendant plug-in interface that allows third-party developers to extend the teach pendant software functionality according to their needs and making the software infinitely scalable. E.g.: Add Modbus devices to the teach pendant software:

a) Add the device name in the device configuration interface. To fill in other basic information, you need to refer to the parameter description of the added device.

b) Configure the IO parameters of the device on the IO configuration page.

c) After the parameters are set, click Add. The basic parameter information is displayed in the teach pendant list.

d) Select the item in the list, change the corresponding parameter, and click Modify to change the corresponding item's parameter.

e) Click Delete to delete the entries on the list.

f) In the IO status interface, the IO status can be displayed, and the output IO status can also be configured.

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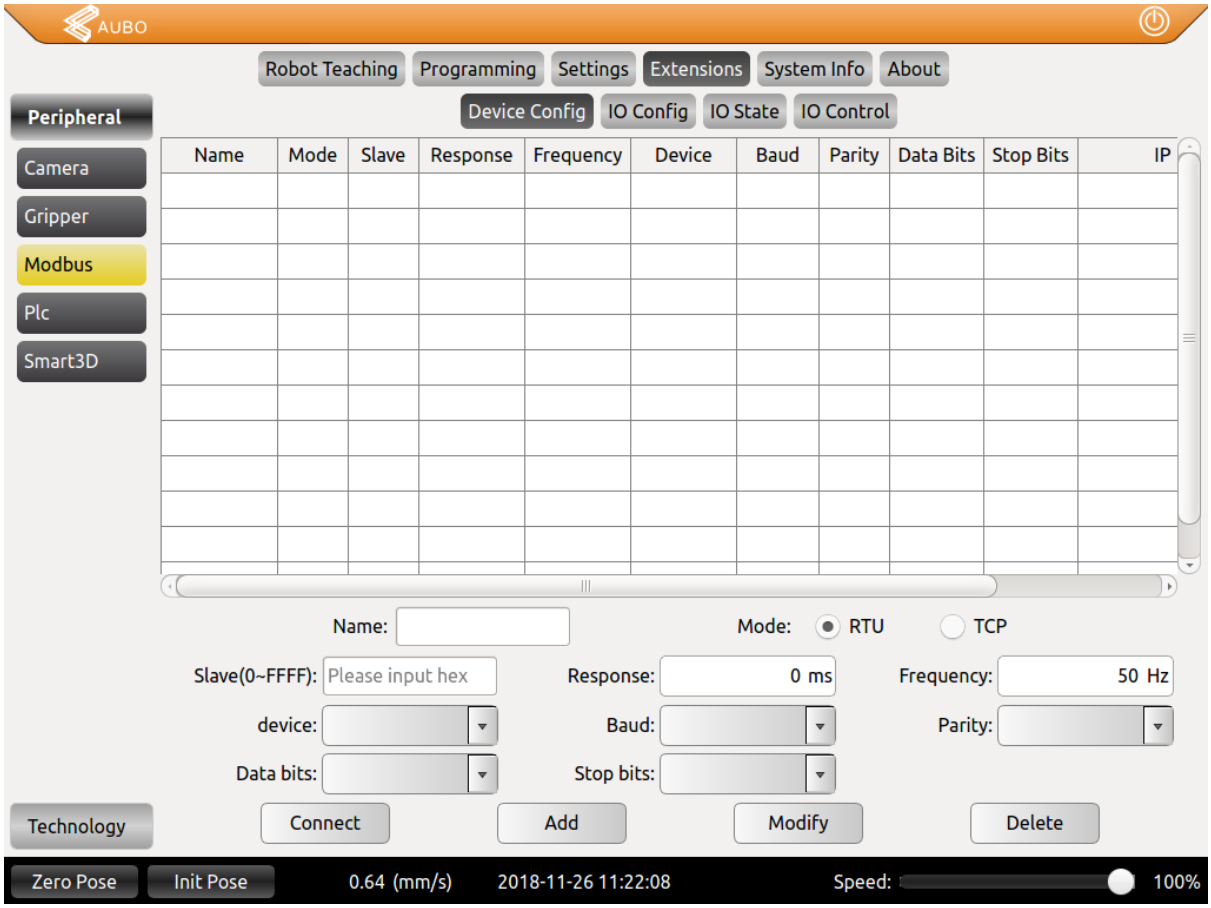

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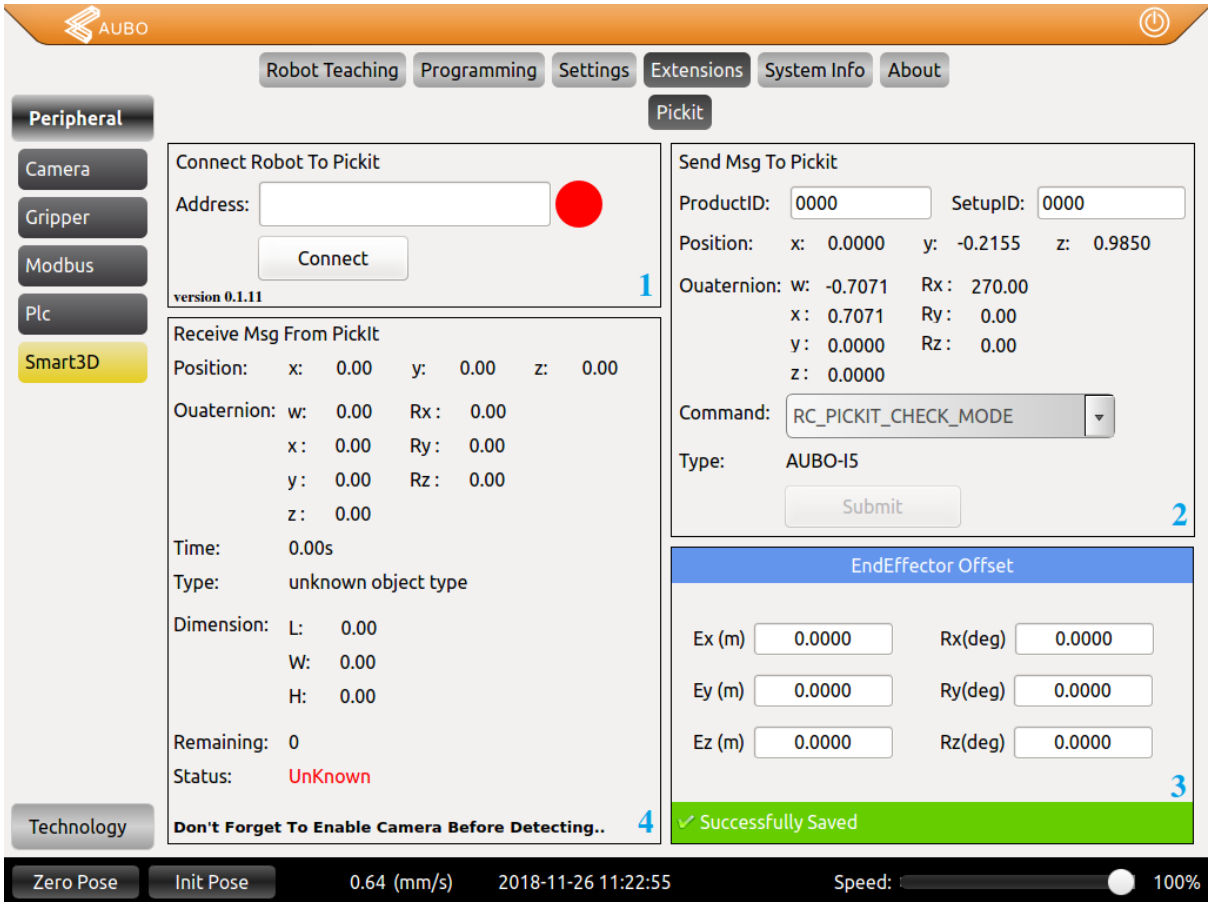
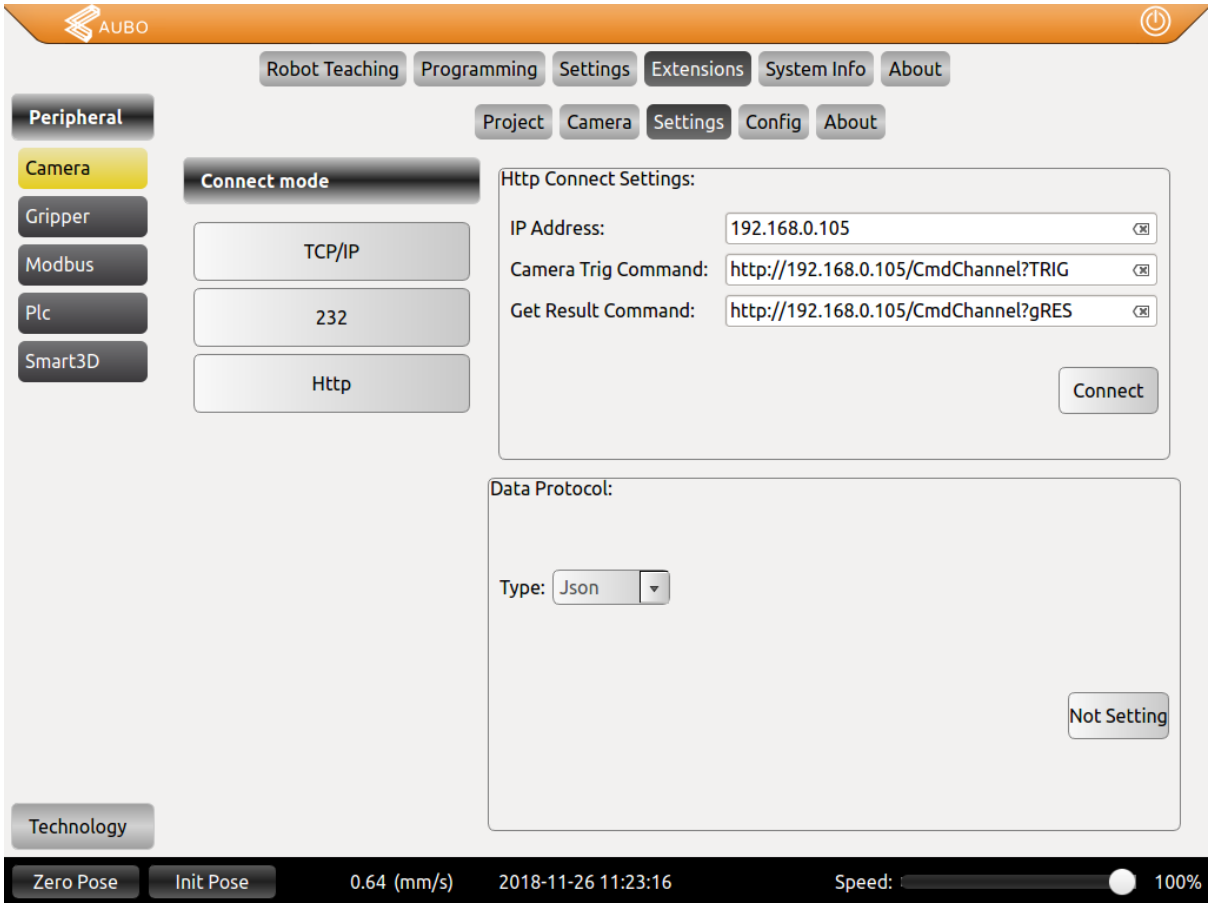
- Add the PickIt 3D vision system to the teach pendant software;



- Add Camera plugin to the teach pendant software;



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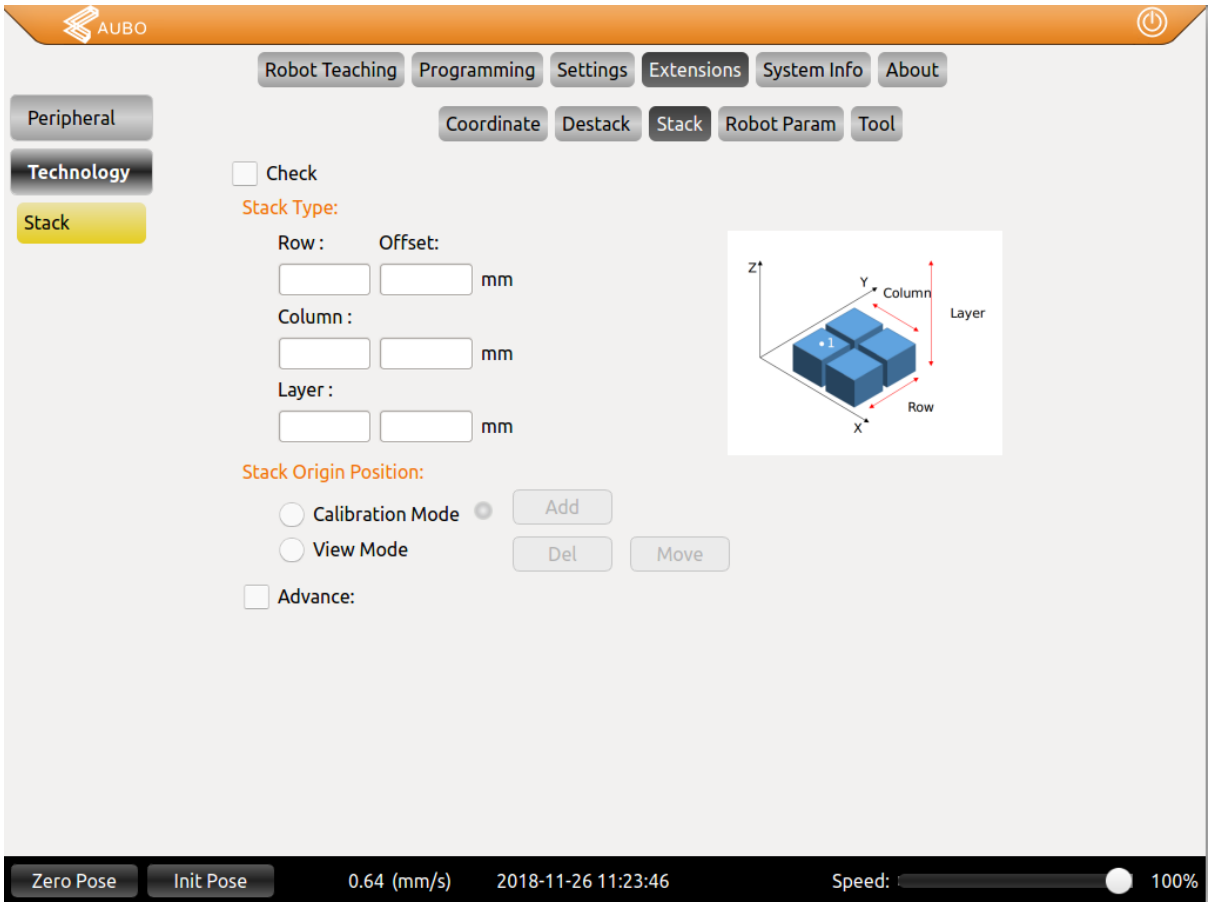
- Added palletizing process package to the teach pendant software;



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10.8 System Info Tab

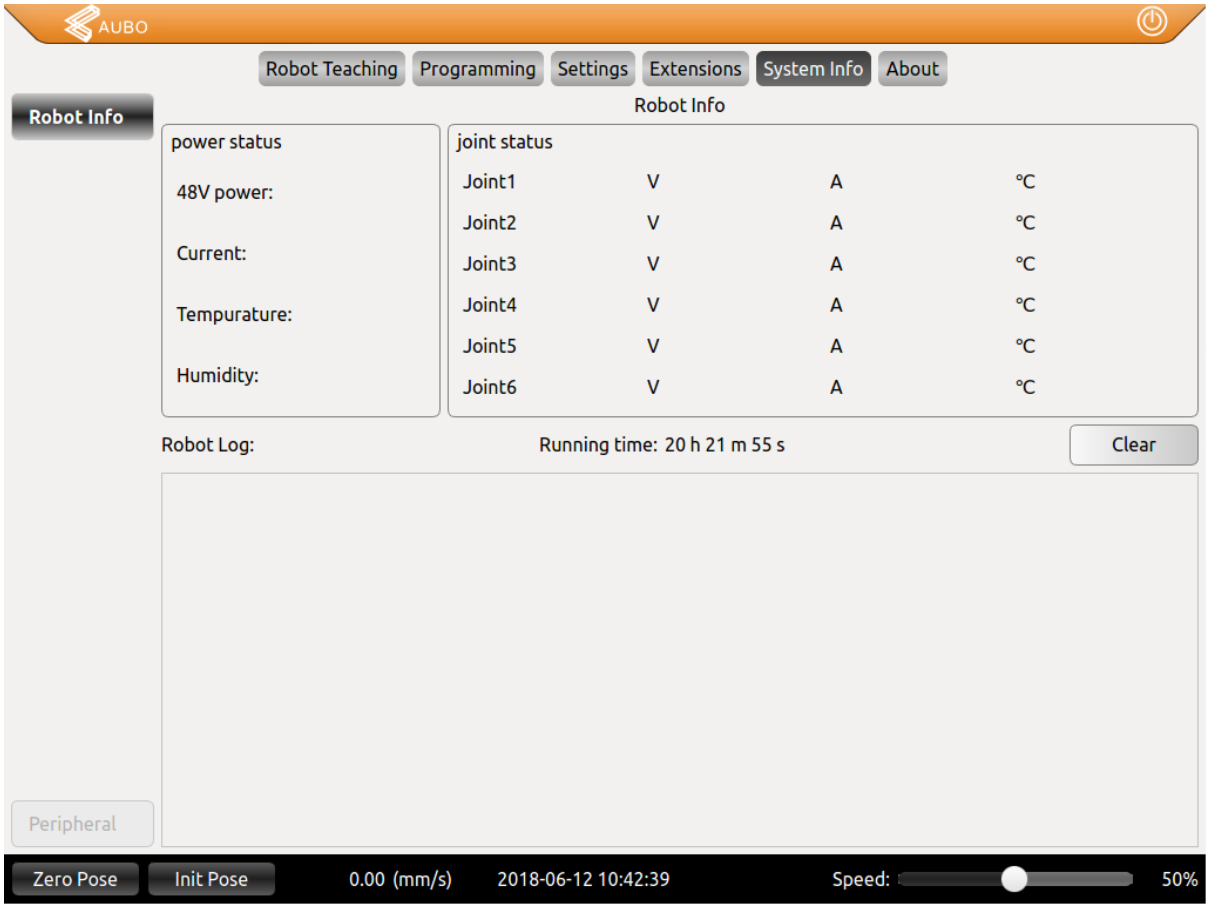

Figure 10.44 Version

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

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10.9 About

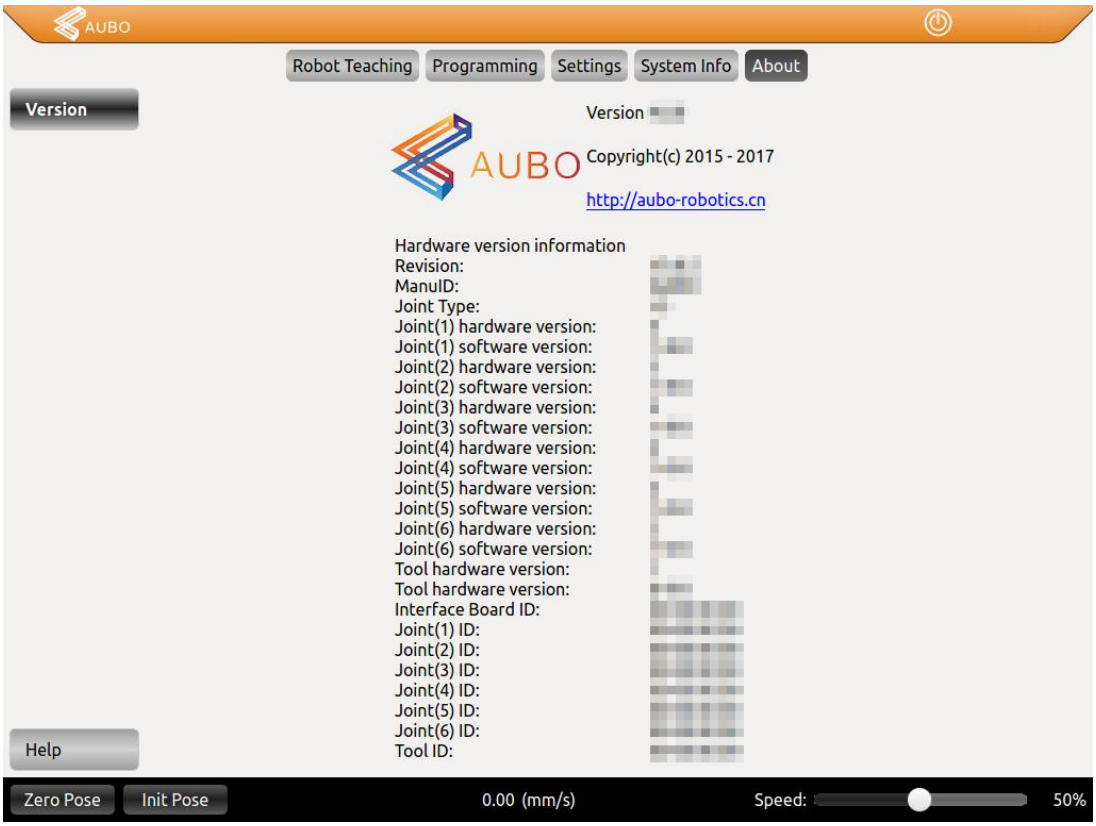

Figure 10.45 Version

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

version information	version number
AUBOPE version	V4.3
Interface board version	V3.2

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11.ONLINE PROGRAMMING

11.1 Introduction

AUBO-i5 robot provides convenient programming method in Online Programming Interface. Users can program AUBO-i5 based on a little programming skill, 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.
   - **Stop**: Click【**Stop**】during the execution to stop the robot. In this case, only the【**Start**】button can activate the robot again by firstly placing the robot back to zero pose.
   - **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.
   - **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.
   - **Undo recovery** command: Undo recovery is program edit control command, you can restore the last undo command. Click the **Resume Undo** button to go back to the last **Undo** command.
   - **Cut** **Copy** **Paste** command：They are the program edit control commands, user can achieve the program segment cut, copy, paste operation.
   - **Delete** command: delete is a program edit control command, user can delete the same level directory of the program segment.

This chapter introduces the meaning of option tabs. Also, it provides complete programming examples to teach users how to masterAUBO-i5 program skill.

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11.2 Project Tab

- The first step of writing a new program is to setup a new project.
- Programs are saves as projects.
- There are 4 buttons on the Project tab: New Project, Load Project, Save Project and Default project.

11.2.1 New Project

- 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.
- When a new project is created, it will cover the current project. Therefore, remember to save the current project.
- Click【**Add before**】to insert a new command before selected command.
- Click【**Add after**】to insert a new command after selected command.

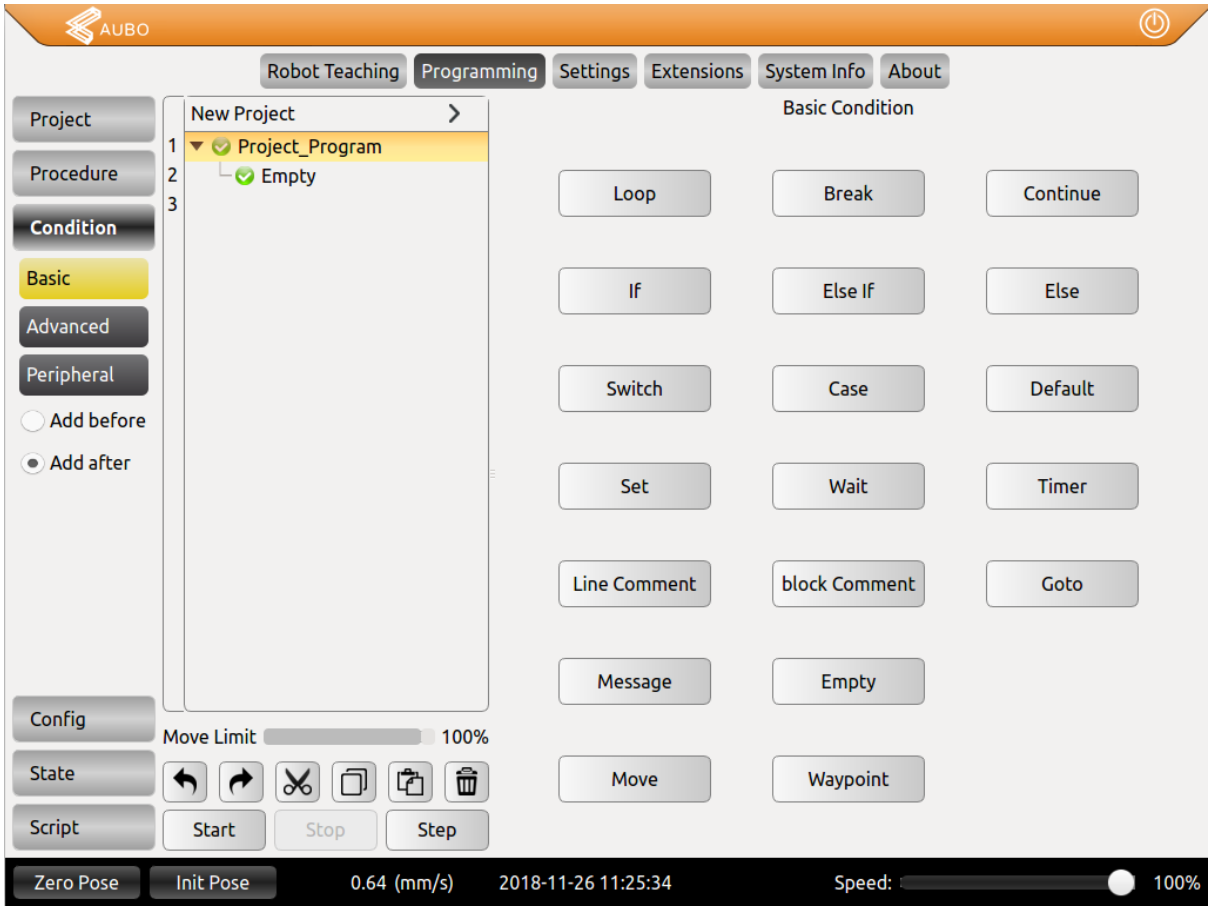

Figure 11.1 Project tab

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11.2.2 Load Project

- Click【**Load Project**】, find a target program and load.
- The selected program will be loaded in program logic list.
- 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.**

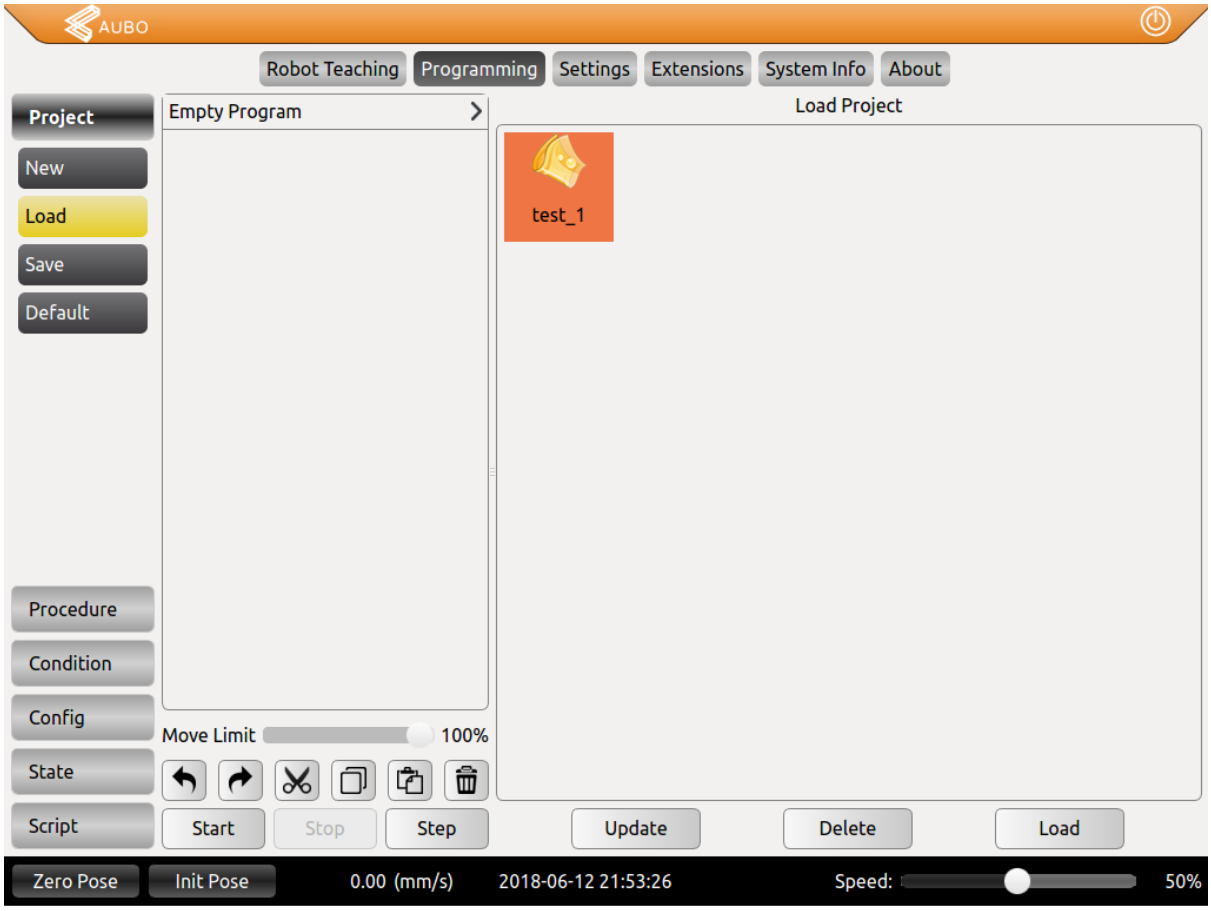

Figure 11.2: Project tab.

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11.2.3 Save Project

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

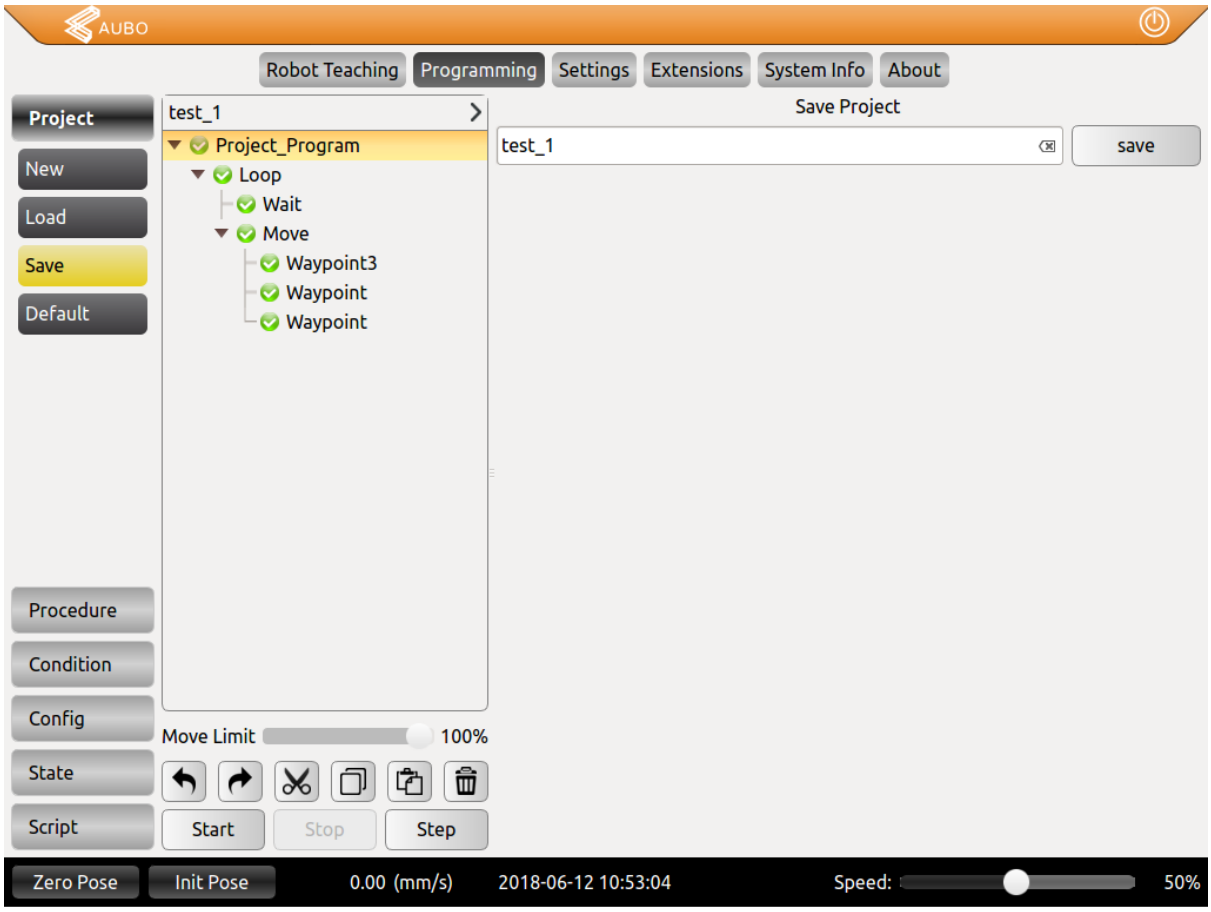

Figure 11.3 Save project

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11.2.4 Default Project

- Click【**Default**】to select the project to be operated in the default project file list and check different options according to the requirements.
- Click【**auto load default project**】to load the default project automatically after opening the programming environment.
- Click【**auto load and run default project**】to load and operate the default project automatically after opening the programming environment.
- Click【**Confirm**】button to confirm the default project configuration.

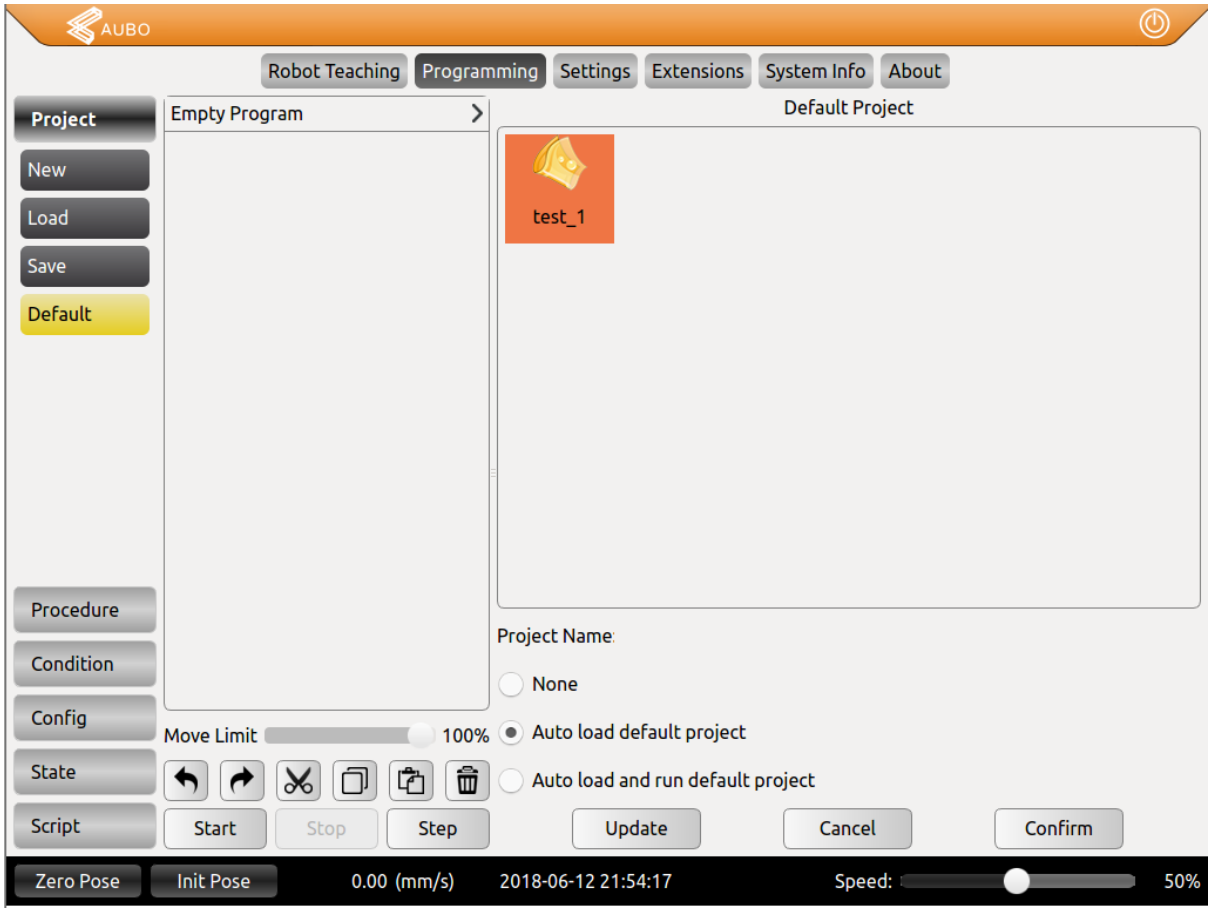

Figure 11.4 Default Project

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11.2.5 Auto move tab

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

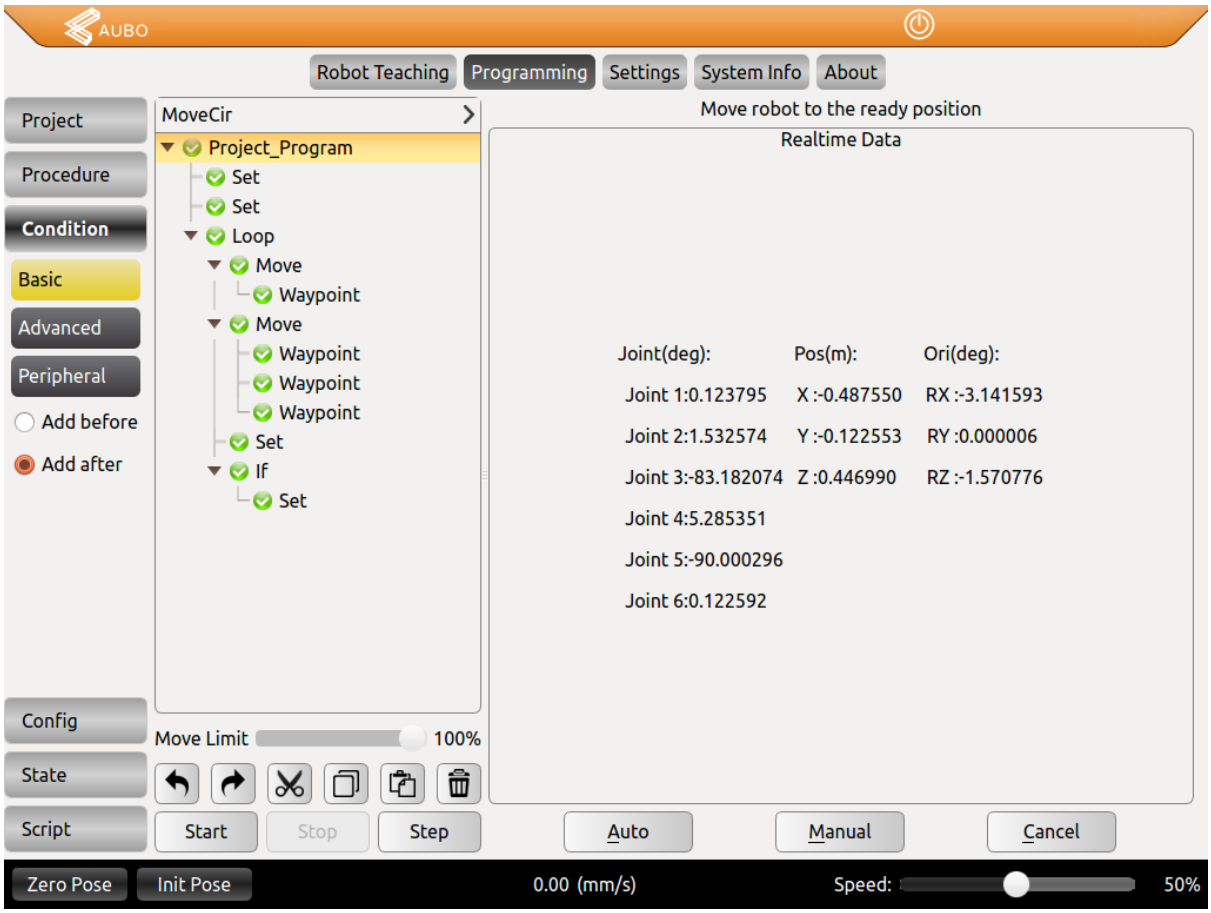

Figure 11.5 Auto move

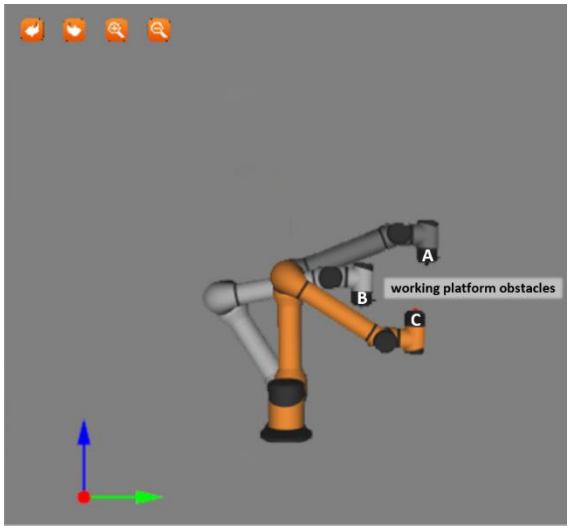

Figure 11.6 Manually move

- Manually move: Press【**Manual**】button to jump into the teaching interface, which can move robot manually.

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- Manually move mode can be used when manipulator moves undesirably.
- Manually move mode can be used when auto move is not suitable. As shown in figure 11.7, manipulator will hit working plane or barriers when moving from C to A under auto move. In this case, manually move can be used to move to safe point (like B) firstly, then move to the initial position A to avoid damaging robot or other equipment.

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

11.2.6 Procedure

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

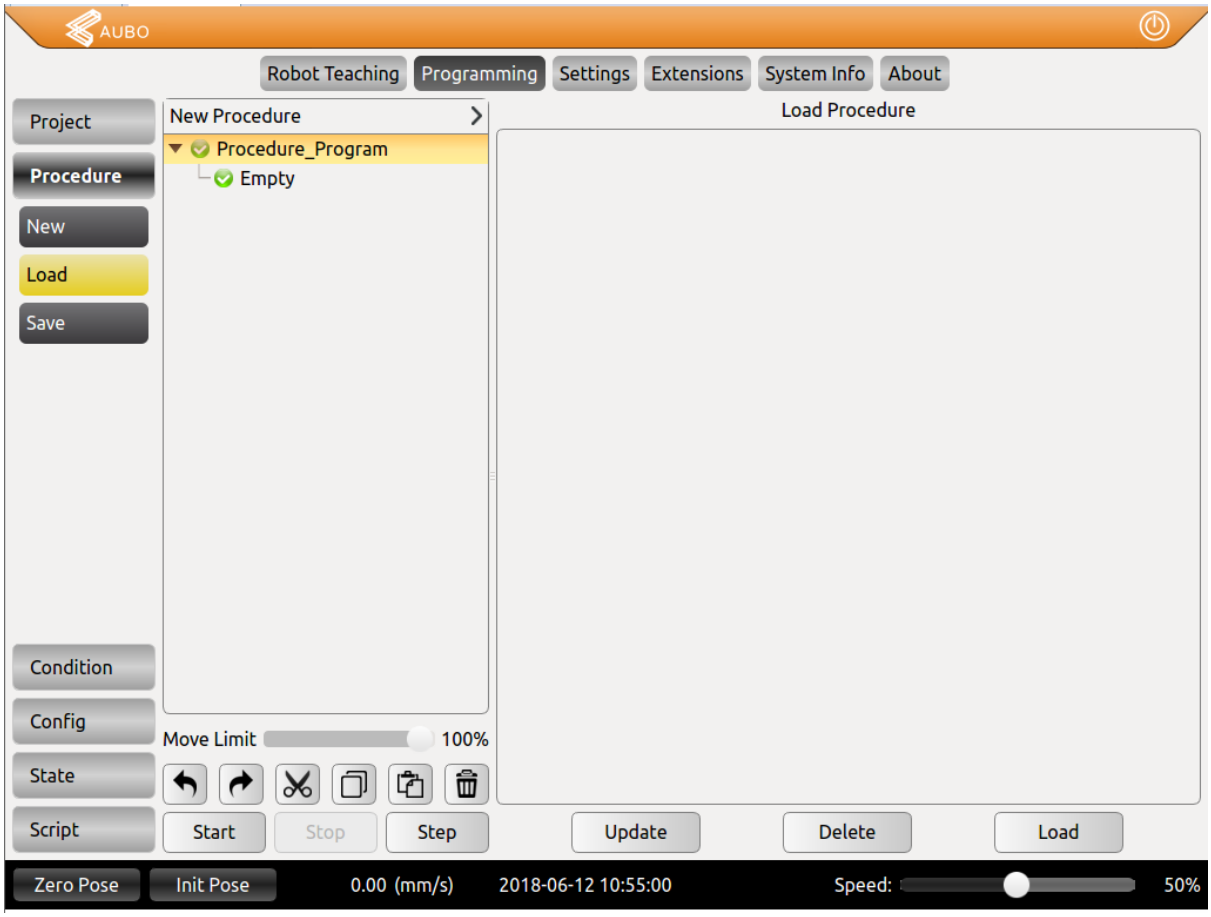

Figure 11.7 Procedure Project

11.3 Command & Condition Tabs

- 【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 introduces them together.
- This section mainly introduces the meaning and the usage of commands. Only known the usage of commands, we can program successfully and completely.

11.3.1 Loop

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

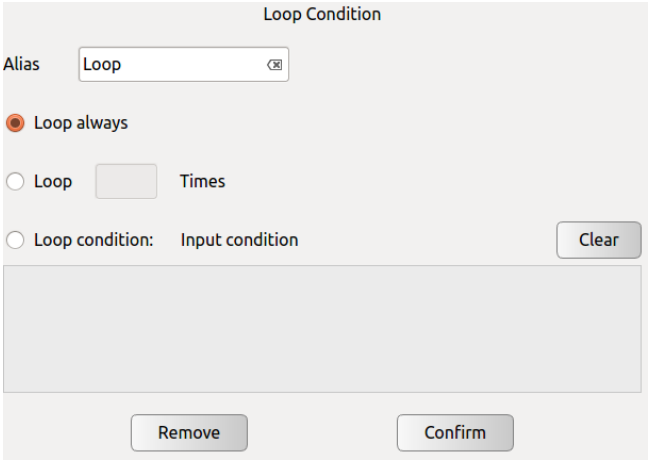

Figure 11.8 Loop

11.3.2 Break

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

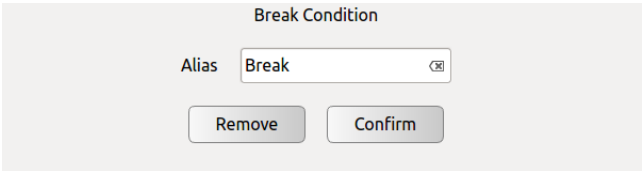

Figure 11.9 Break

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11.3.3 Continue

- **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.
- The gramma of **Continue** should be formal. **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 the loop for one time. Otherwise, an error message will pop up.
- Click【**Remove**】to delete the **Continue** command.

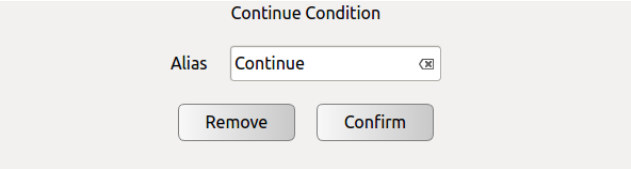

Figure 11.10 Continue

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11.3.4 If…else

- **If...else** command is used to operate different subprograms based on different conditions.
- 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 be true, the program inside this **If** are executed. If the expression evaluates to be false, the following **Else If** or **Else** statements will be executed.
- Click【**Clear**】to delete an expression.
- Click【**Add Else**】to add an **Else** node to make an **If…Else** statement. One【**If**】command can only add one **Else**.
- Click【**Add ElseIf**】to add an **ElseIf** node. One【**If**】command can add multiple **Else If** nodes.
- Click【**Remove**】to delete【If】command. All **ElseIf** nodes and **Else** nodes will be deleted together.
- Click【**Confirm**】to confirm and save the configurations.

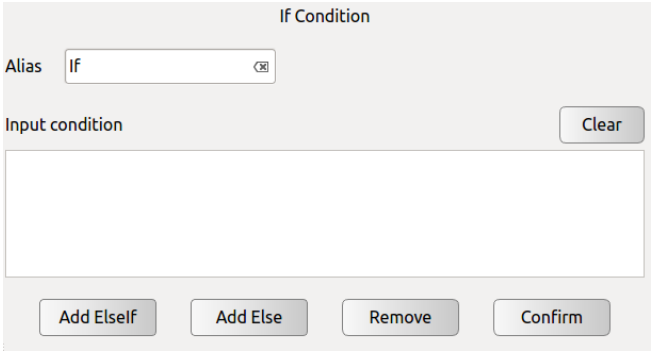

Figure 11.11 If…Else

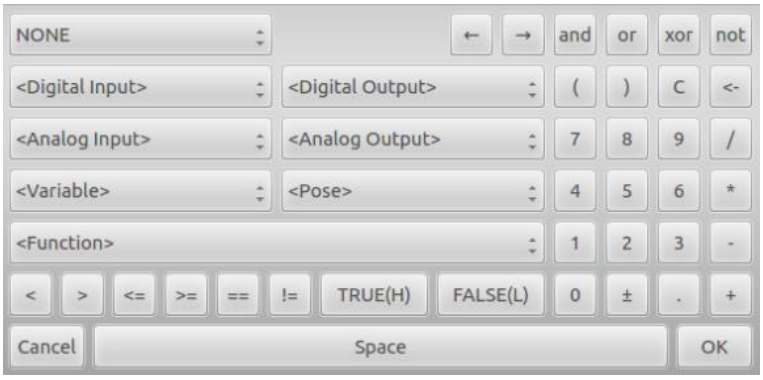

Figure 11.12 If…Else expression box

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11.3.5 Switch...Case...Default

- **Switch...Case...Default** is a condition selection command that runs different case program branches by judging conditions.
- Click the blank space on the right of【Alias】, It will pop up the input box, and user can modify the command name.
- Click the blank space on the right of【Input condition】, it 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** statement. If there is no **Case** value that satisfies the condition, then execute **Default** corresponding program segment.
- Note: To determine the authenticity, users can only use true / false, cannot use 1/0 instead.
- Click【Clear】to clear the expression.
- 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**.
- Click【Add Default】to add a **Default** node. One **Switch** can only add one **Default.**
- Click【Remove】to delete the selected **Switch**, and the corresponding **Case** and **Default** of this switch will also be deleted.
- Click【Confirm】to confirm the configurations and save.

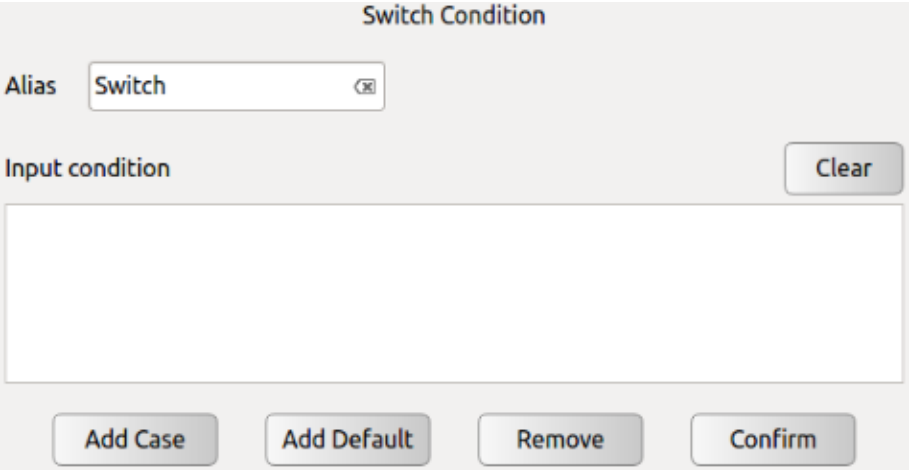

Figure 11.13 switch…case…default command

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11.3.6 Set

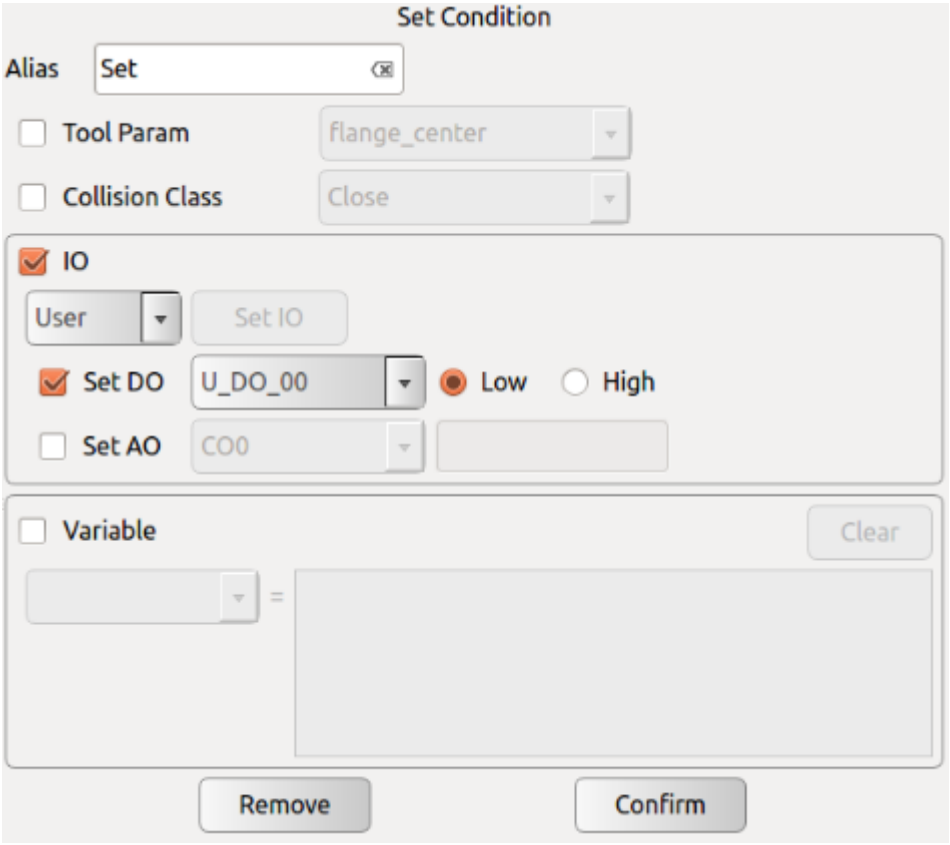

Figure 11.14 Set

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

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

11.3.7 Wait

- **Wait** command is used to set waiting time or digital input signals.

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

Figure 11.15 Wait

11.3.8 Timer

- **Timer** is a command that can measure the time duration between nodes within the project
- Clicking【Alias】to the right of the blank interface will pop up the input box. .You can modify the command name.
- Click【Remove】to delete the selected timer.
- Click【Confirm】to confirm the configurations and save.

11.3.9 Line Comment

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

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Figure 11.16 Line Comment

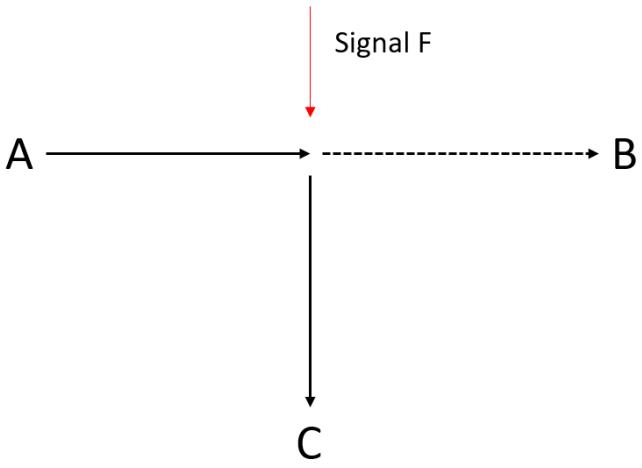
11.3.10 Block Comment

- **Block Comment** is a command that explains the following block by line comment.
- Clicking【Alias】to the right of the blank interface will pop up the input box. You can modify the command name.
- Click【Comment】to input text to explain the following block.
- Click【Remove】to delete the selected **Block_Comment**.
- Click【Confirm】to confirm the configurations and save.

Figure 11.17 Block Comment

11.3.11 Goto

In some industrial scenarios, the robot needs to be interrupted of whatever it's doing, and turn to other tasks. The robot motion is seen as below:



The robot is programed to move from A to B, yet it receive a signal F on its way to B, it stops moving towards B and goes immediately to C.

GOTO command is designed to interrupt the current movement. It must be used in the thread program. A demo project is seen as below.

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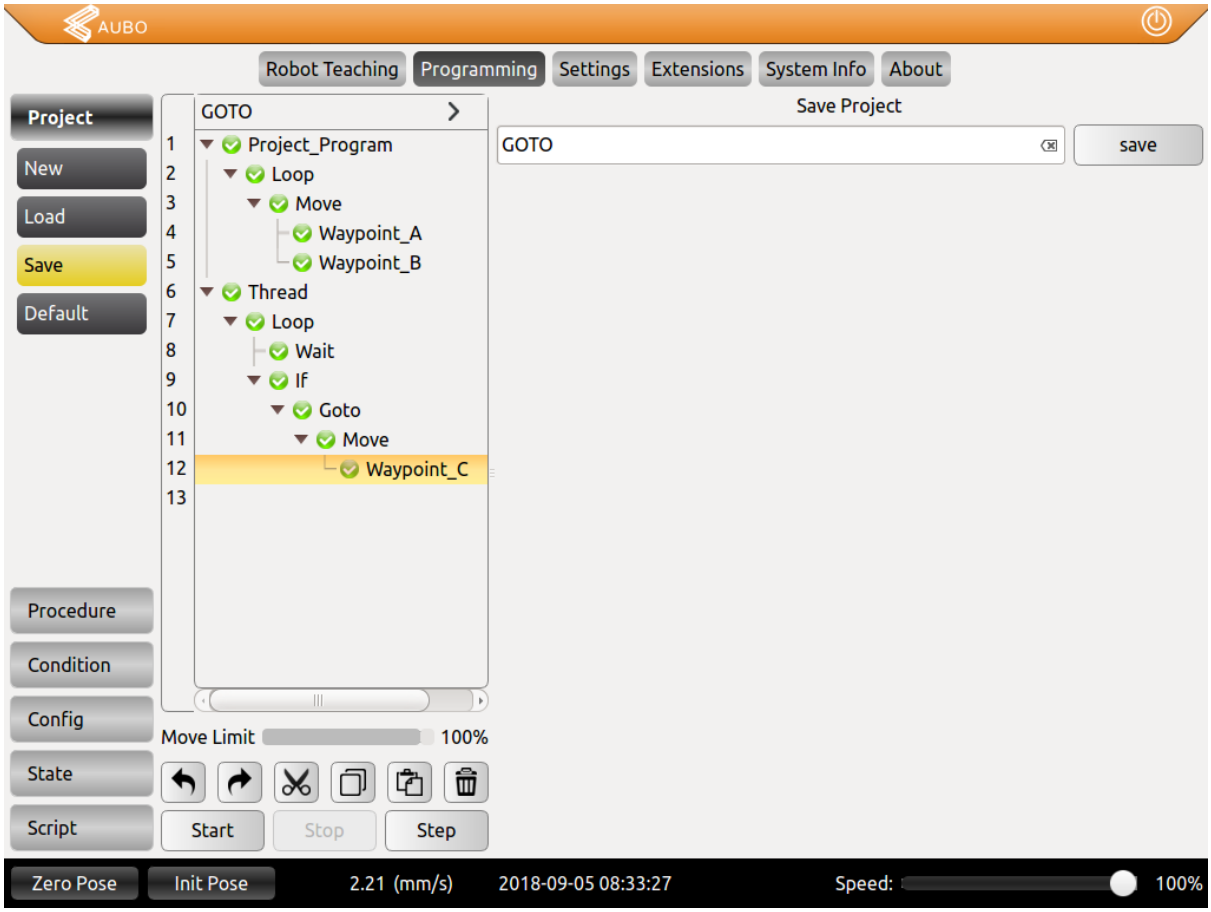

The “If” command is set as “DI==0” or any other input signals. Please note a “Wait” command of at least 0.01s is necessary to ensure the GOTO to work, lack of it may cause unpredictable problems and stop the robot.

11.3.12 Message

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

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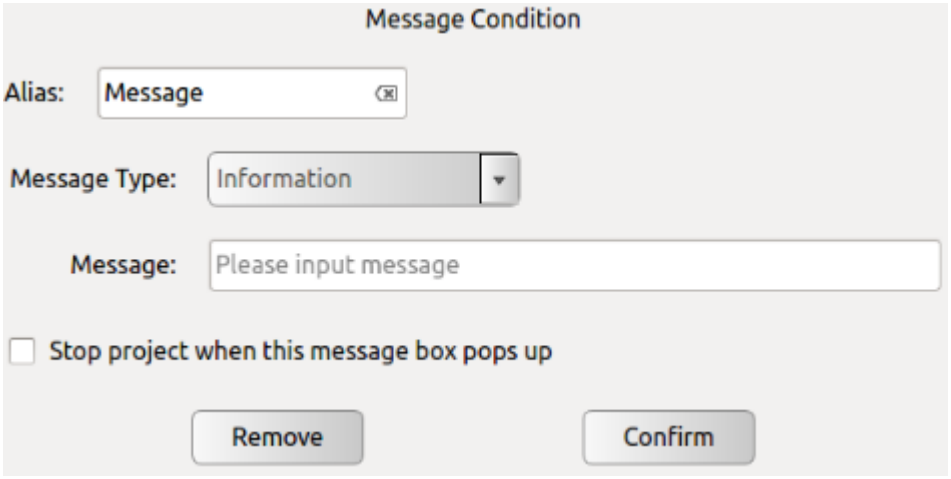

Figure 11.18 Message

11.3.13 Empty

- **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.
- Click to delete the selected Empty.

11.3.14 Move

- The **Move** command is used to operate the movement of robot end-effector between waypoints.
- Click【Move】to add a new **Move** node to the program list and a **Waypoint** sub-node will be added automatically.
- 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.

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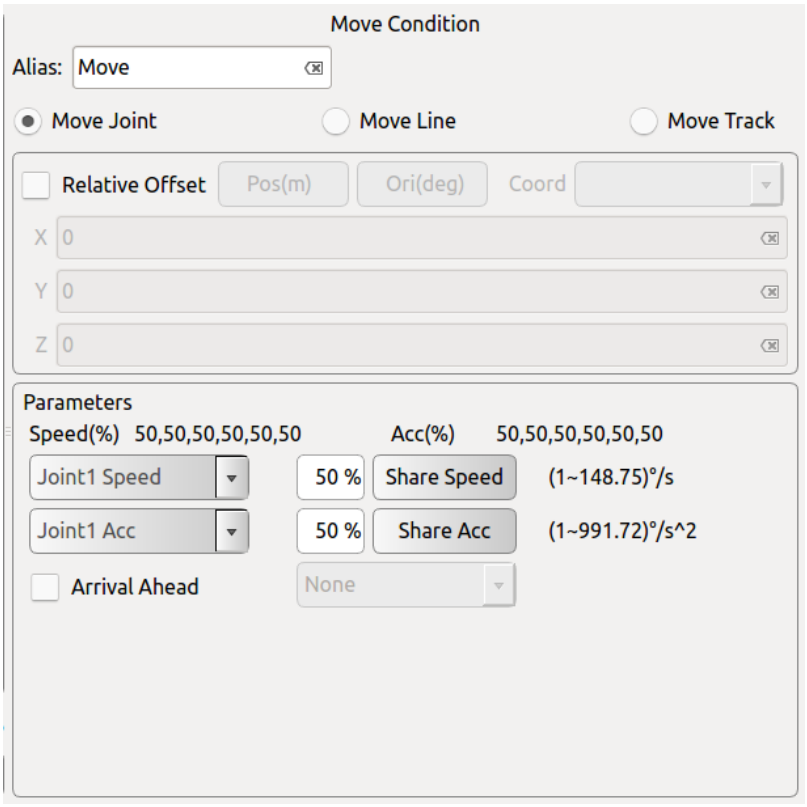

Figure 11.19 Move Joint

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

- Relative displacement: Users can adjust manipulator or TCP by changing the values of XYZ. 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.

- The blend radius is applicable to all modes except B-Spline in move Track motion. Among them, the blending radius of the **MoveP** mode ranges from 1 to 50 mm, and the remaining modes are from 1 to 100 mm. The operating characteristic of the blend radius is a continuous motion and does not stop at this waypoint. The blend radius runs as shown below.

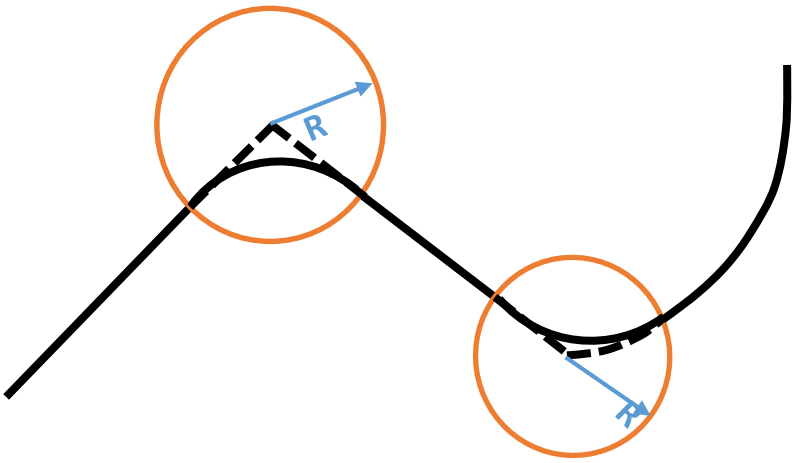

Figure 11.20 Blend radius moving track

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Note: If the following conditions exist in the trajectory, the blend radius cannot be set

1) The location of the adjacent waypoints is the same, only the attitude difference exists, and the blend radius cannot be set

2) The first point in the project cannot set the blend radius

3) Do not set the blend radius in the same **Move** command before and after changing the end tool

There are several situations where the blend radius is cancelled or changed:

1) The **Move** command waits for a condition (such as an IO signal) to be satisfied.

2) Over speed joints or strange points in the blend radius.

3) When the **Pause** command is pressed in the blend zone, it cannot be paused, and the blended zone may become smaller after recovery.

4) When the reduced mode is activated, the operating time of the blended area will be changed.

- Click【**Copy**】to copy all the waypoints under **MOVE** node.
- Click【**Copy Reversal**】to copy all the waypoints in **MOVE** node in reverse.
- Click【**Paste**】to paste all the waypoints in **MOVE** node into current waypoints.
- Click【**Remove**】to delete the **Move** command.
- Must click【**Confirm**】to finish the configurations and save it.

The Move command has three configurations: 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 as fast as they can (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 without considering 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.

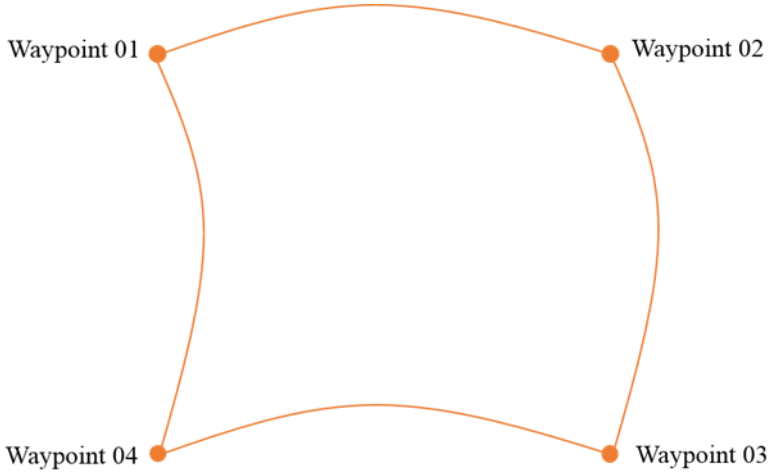

Figure 11.21 Move Joint track

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Maximum speed and acceleration of joint:

- 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.
- 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.
- Whether a joint can reach and keep maximum speed is determined by the joint displacement and the maximum acceleration parameters.
- **Motion mode** includes **S Curve** and **default Optimum** time mode. It is recommended to choose **S Curve** to ensure that start and end motions 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 that applied for this movement type includes the maximum speed and maximum acceleration (represent as mm/s and mm/s ²) of needed tools and motion mode. Similar with **Move Joint,** whether a joint can reach and keep maximum speed is determined by the joint displacement and the 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 are 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 solution, 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.

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

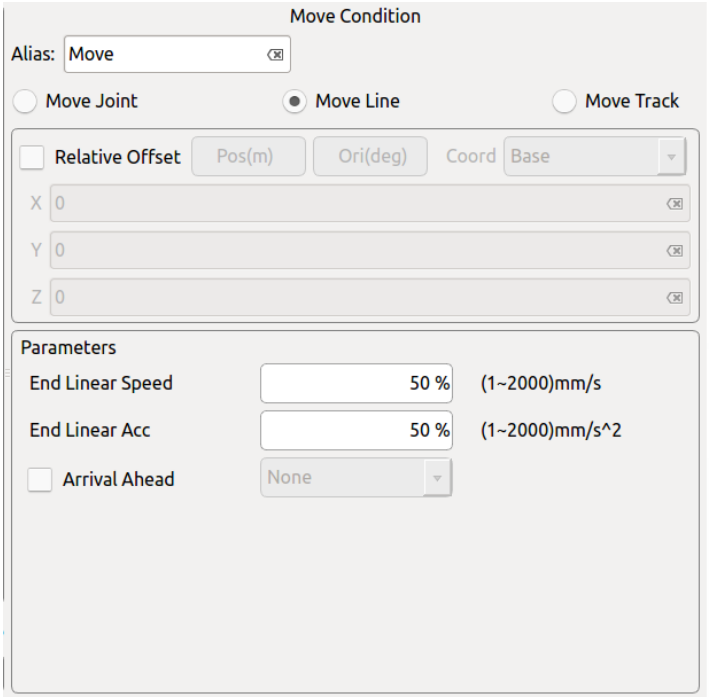

Figure 11.23 Move Line

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 the operation. It provides six modes:【Arc】,【Cir】,【ArcWithOriRot】,【CirWithOriRot】,【moveP】Smooth transition of linear trajectory,【B-Spline】B-spline curve.

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 the start point and the end point. The meaning of maximum speed and acceleration is same as **Move Line**. When the **Arc** is selected in the **MoveTrack** type, the robot moves in an arc motion.

Cir: 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 the start and the end points unchanged during the movement. The meaning of maximum speed and acceleration is same as Move Line. When the **Cir** is selected in the **MoveTrack** type, the robot moves in a circular motion.

ArcWithOriRot/CirWithOriRot: In industrial secenaios, especially welding applications, users

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would like the robot to change its orientation along the way, so the welding equipment could keep straight to the parts. The ArcWithOriRot and CirWithOriRot is to change the orientation during the motion, the robot will calculate the angle between the end effector and the circle axis and keep the angle along the whole movement.

MoveP: Fits a path curve according to the given path point. The more waypoints used to generate a fitted curve, the closer the fitted curve is to the expected one. When programming the track motion and linear motion of the manipulator, ensure that the adjacent waypoints in the two **Move** commands are continuous, that is, the last waypoint of the previous **Move** command is the same as the first waypoint of the next **Move** command. It is worth noting that when the manipulator makes a circular motion, the last waypoint of the **Move** command is the first waypoint (the first and last waypoints coincide). When there are **Loop** commands in the program logic list, the first waypoint of the first **Move** command must be the same as the last waypoint of the last **Move** command.

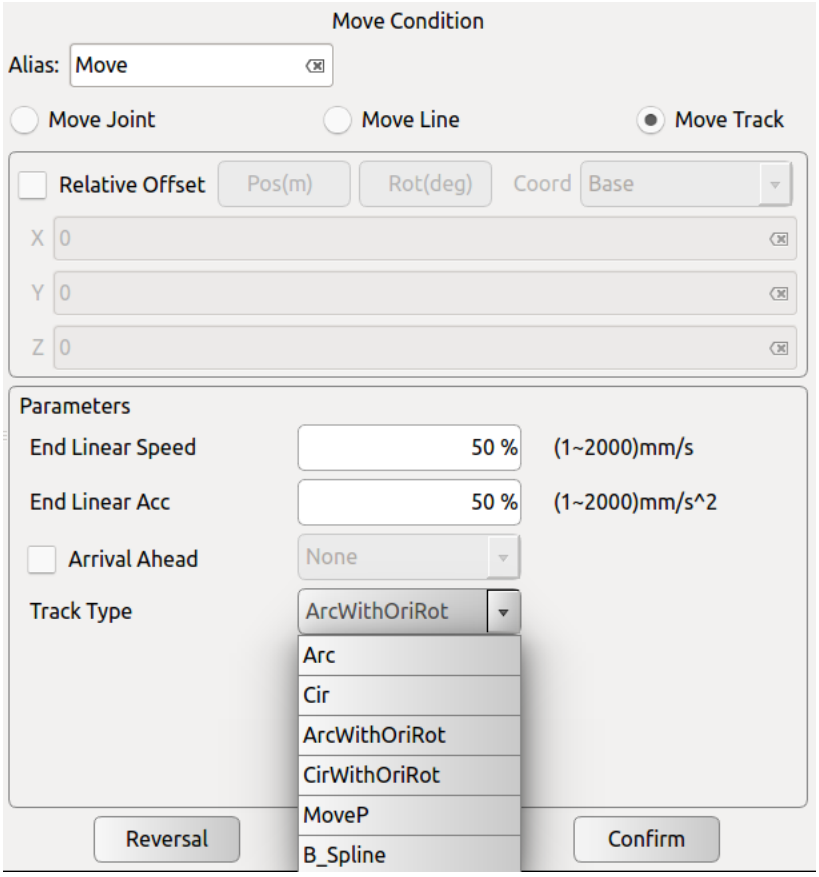

Figure 11.24 Move Track

11.3.15 Waypoint

- 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.
- Waypoint can only be added after【Move】command.
- Click【**Add before**】to add a new waypoint before the current waypoint.
- Click【**Add after**】to add a new waypoint after the current waypoint.
- Click on【**Move here**】to move the robot to the current waypoint. It's only effective for the real robot, not for the simulator.
- Click waypoint which is needed to copy under **Program Logic**. Click【**Copy**】to copy current waypoint.
- Click waypoint which is needed to paste under **Program Logic**. Click【**Paste**】to paste current waypoint.
- Click【**Remove**】to delete a waypoint.
- 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.
- Click【**Confirm**】to confirm the status configurations of this waypoint and save.

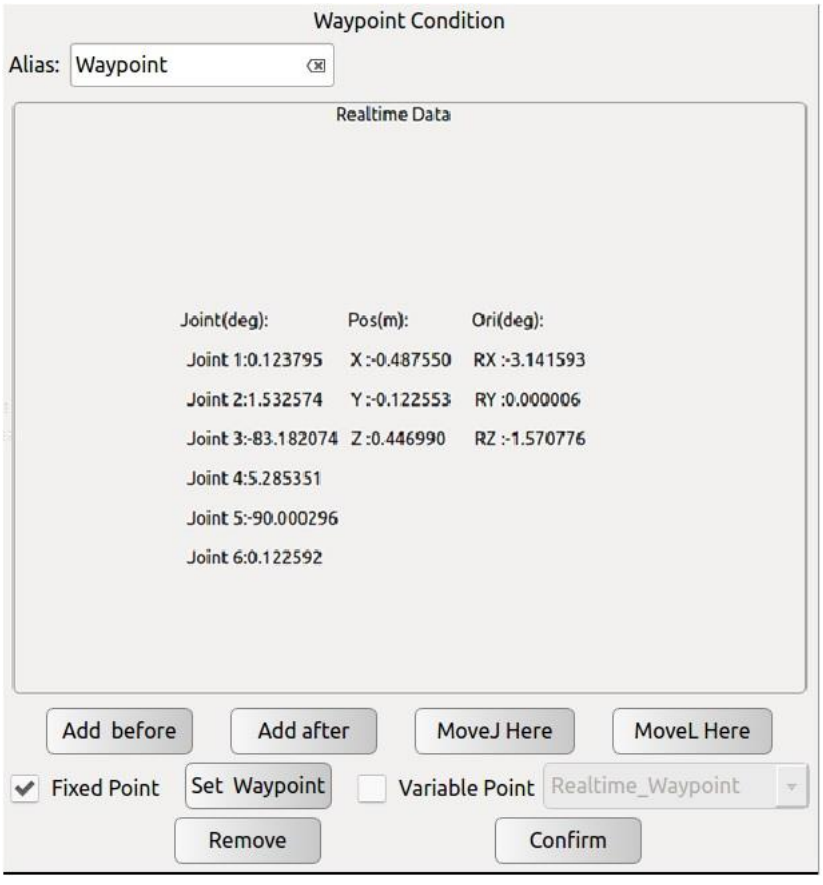

Figure 11.25 Waypoint

11.3.16 Thread

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

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In the loop, user can achieve the parallel control with the main program.

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

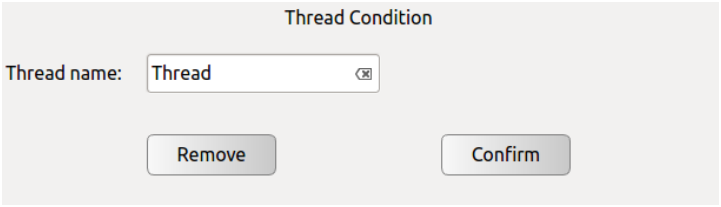

Figure 11.26 Thread

11.3.17 Procedure

- **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.
- Note: **Procedure** cannot be inserted into the process of the **Thread** program.
- Click【Alias】input box on the right to modify the command name.
- Click【Update】as the file update button to retrieve the current file save directory and update the display file changes.
- Click【Remove】to delete the selected procedure.
- Click【Confirm】to confirm the configurations and save.

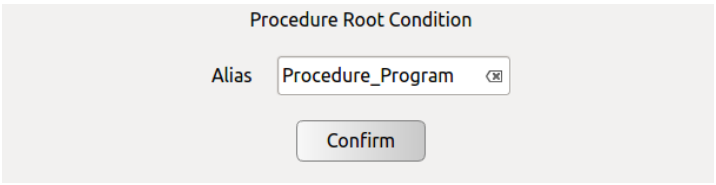

Figure 11.27 Procedure

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Figure 11.28 Procedure

11.3.18 Script

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

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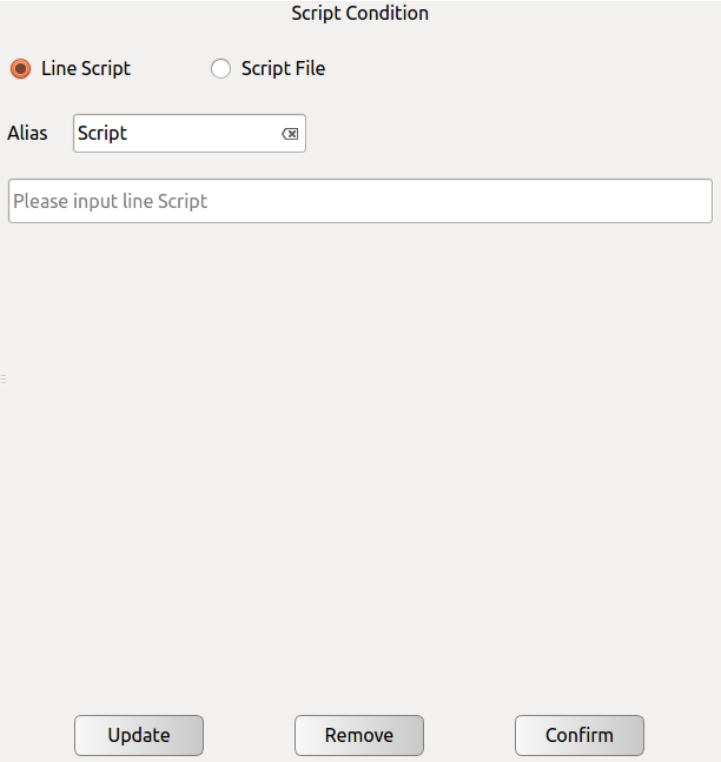

Figure 11.29 Script

11.3.19 Record Track

- **Record Track** command is a track playback command. Select the track icon and click the 【confirm】button, the track record can be loaded into the engineering logic.
- 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.
- Click【Update】as the file update button to retrieve the current file save directory and update the display file changes.
- Click【Remove】to delete the selected **Track_Record**.

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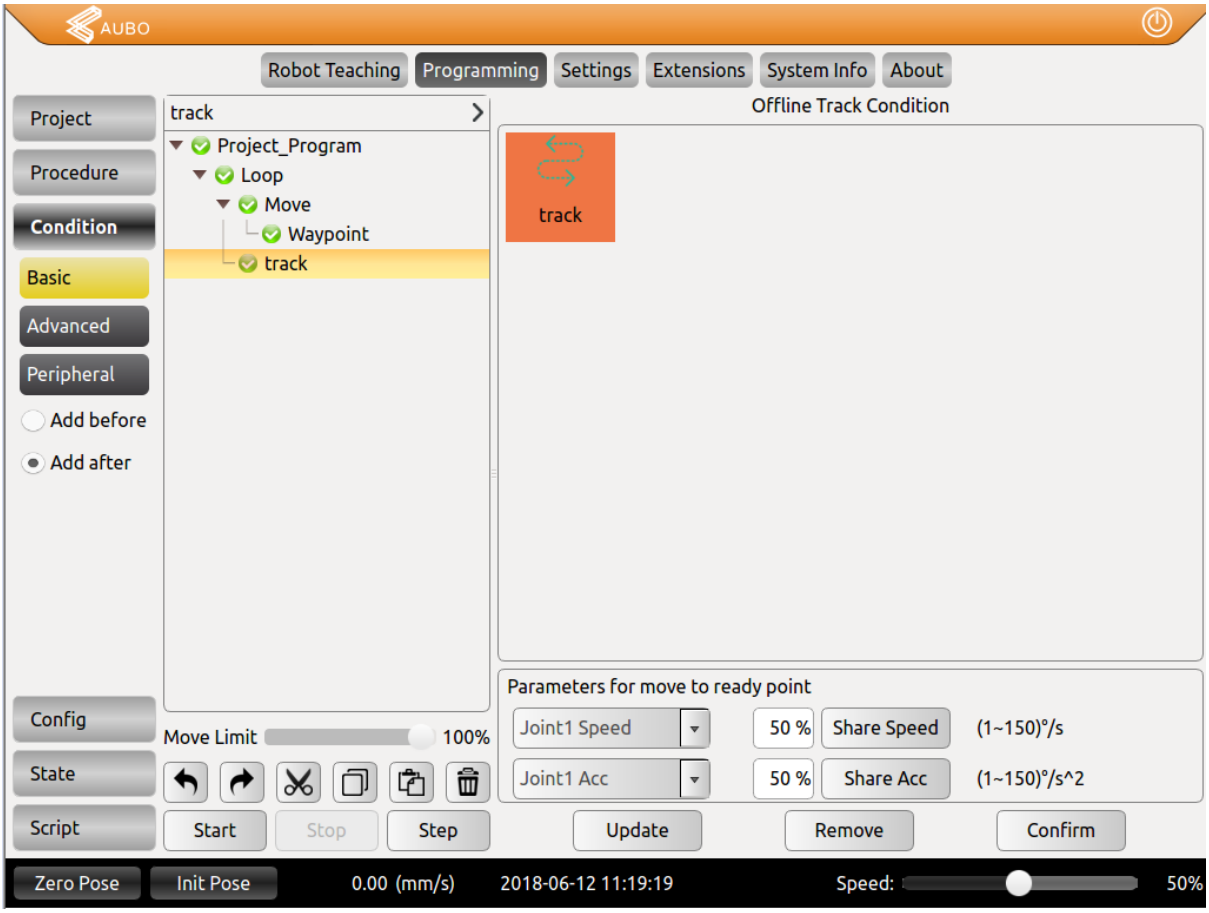

Figure 11.30 Record Track command

11.3.20 Offline Record

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

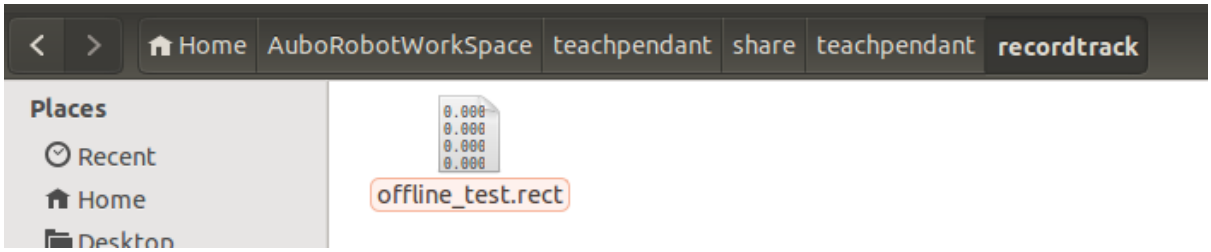

Figure 11.31 import offline file

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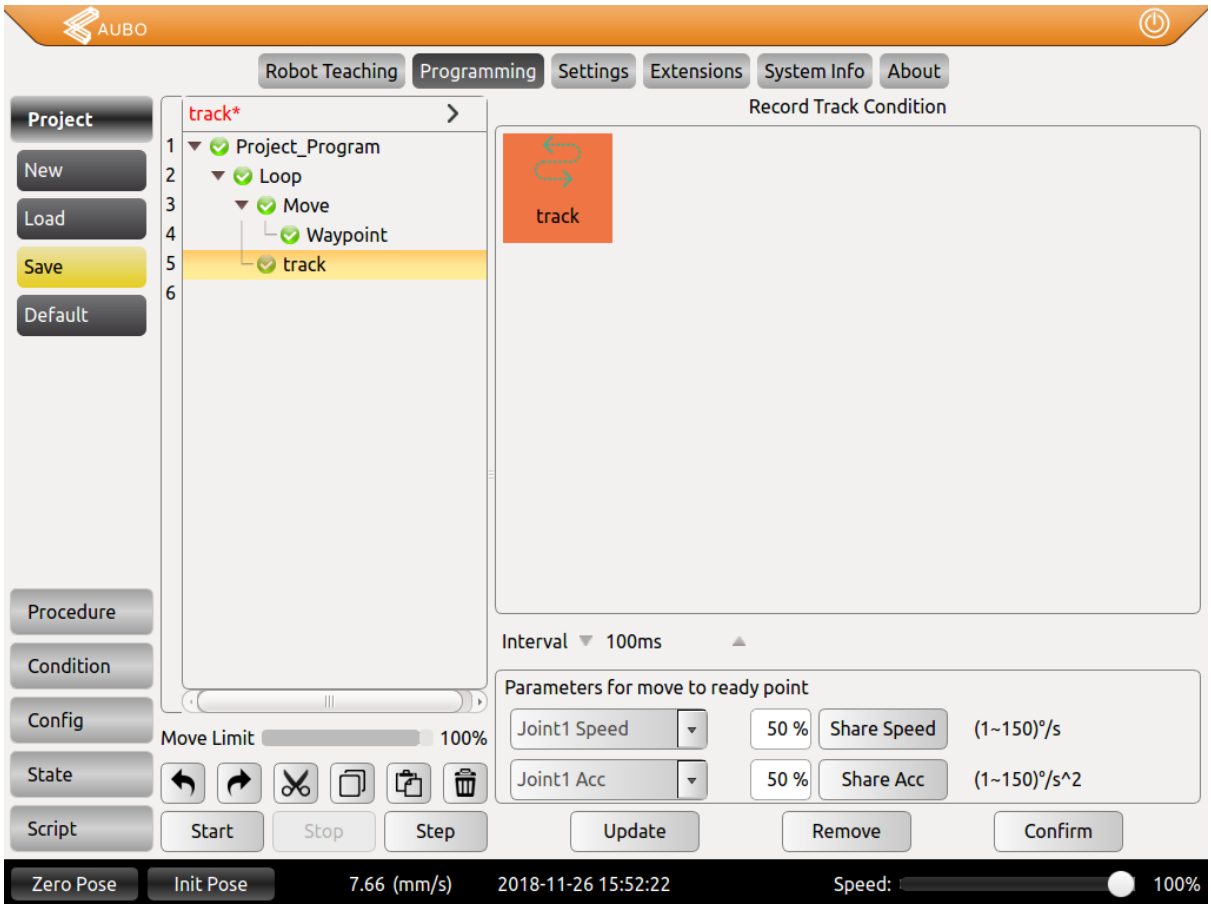

Figure 11.32 Offline Record

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11.4 Track record

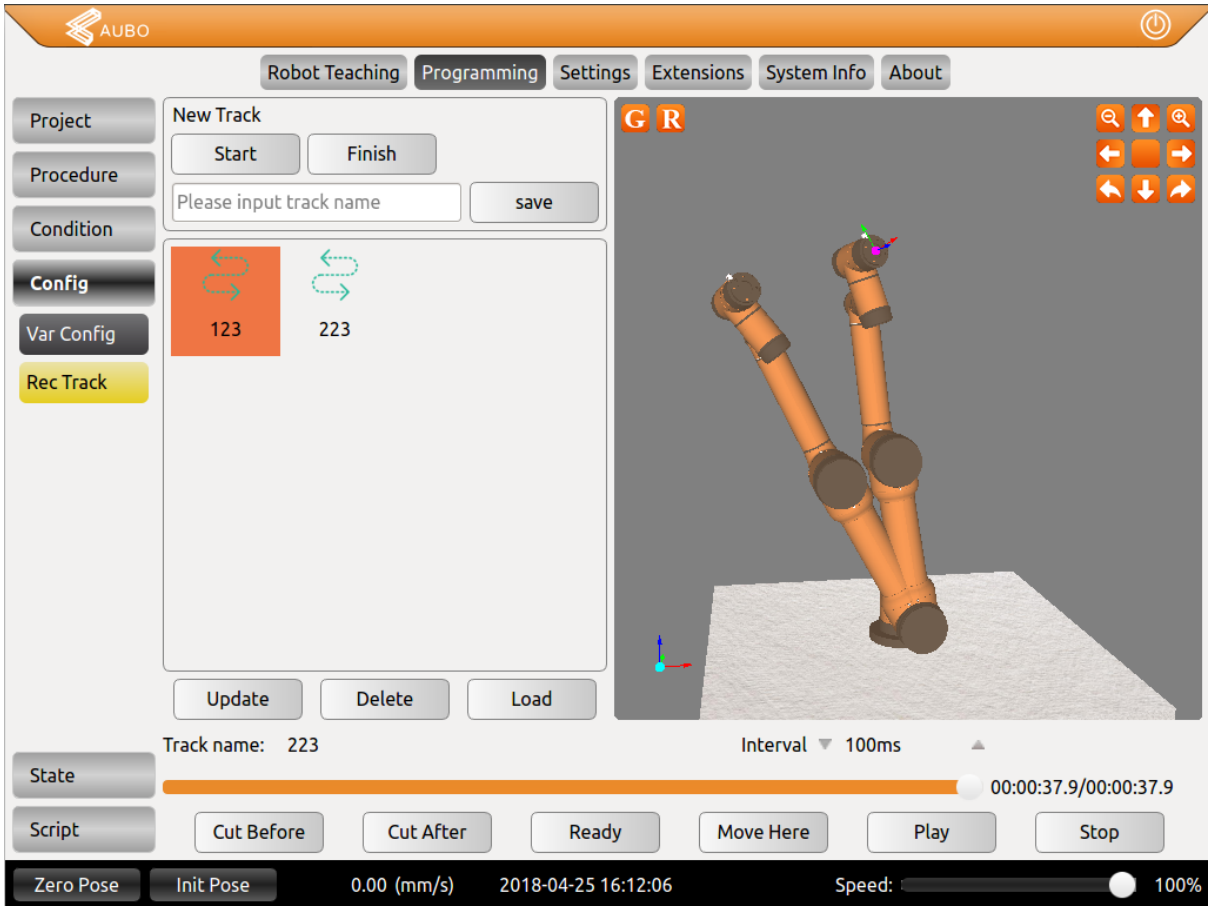

Figure 11.34 Track record

Track record can record the movement track of the robot for a certain period and used in online programming.

New track: Click **Start** to record the movement track of the robot, click **Finish** to stop the recording, enter the track name, click **Save** to finish.

Track replay: Click the **Track** to select, click **Load**, then press and hold Ready, wait it to reach its original position, and then click **Play** to review the track.

Track pause: Click **Stop** to pause the track replay.

Resume to play after pause: Press and hold **Move Here** and wait it sync with current position, and then click **Play**
During the replay, User can drag progress bar to operate the replay progress.

Edit track: click **Cut Before** to remove the track before selected position, click **Cut After** to remove the track after selected position.

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Interval: The track recording time unit is 100ms per waypoint. The meaning of the interval time is how much time to play each waypoint recorded. For example, if the interval time is set to 50ms, then the track will be played at twice the speed. If it is set to 200ms, slow down at 0.5x speed.

The possible duration of track record is between 2” and 5’.

11.5 Variable Tab

Variable Tab only provides 4 variable types: **Bool, Int， Double** and **Pose**. 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.

Bool: Defines a bool variable whose value is true/false. After clicking the variable value, the option is assigned.

Int: Defines an integer variable whose value is an integer. After the variable value, the cell is assigned an assignment.

Double: Defines a double variable whose variable value is a double-precision floating-point number. After the variable value, an input value is assigned to the cell.

Pose: Define a position variable whose value is the robot waypoint information. Click the **[Set waypoint]** button at the end of the variable value cell to jump to the robot teaching interface. After completing the waypoint setting, click **[OK]** to complete the variable.

Global hold: Sets the current variable as a global variable.

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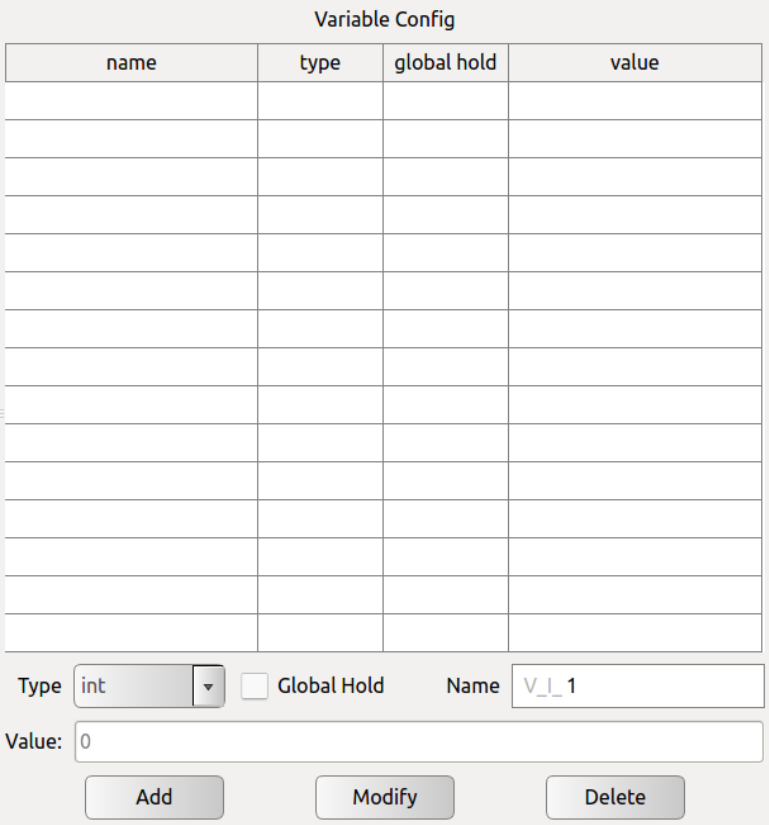

Figure 11.35 Variable Tab

- Add variables: Choose a variable type, there will be corresponding type of input options box in **Variable value** option. Input variable name and value, click【**Add**】. If new variable has been added, it will be shown on the bottom of the list. Note: Variable names must be unique and can only contain numbers, letters and underscores. Otherwise, it won't be saved and pop up prompts.
- Modify variables: Choose a variable in table and all information will be shown in operating area below. Users can click【**modify**】to change the name and value of variable. Note: Variable type can't be changed, otherwise will pop up silent failure. If the variable has been used in existing project file, it won't prompt that this variable name condition is undefined until reload the project. After changing variable name, users must reload the project before operation in case unknown errors occur.
- Delete variables: Choose a variable in table and click【**Delete**】to delete this variable. Note: Similar with modify variable, If the variable has been used in existing project file, it will not prompt that this variable condition is undefined until reload the project. After deleting variable, users must reload the project before operation in case unknown errors occur.

11.6 Timer

Timer records the time duration of the project when running from beginning until the node end. It can measure the time usage during the movement.

- Timer1 and Timer2 are the nodes specified in the project, time underlines the time intervals between the beginning and node Timer1 and between Timer1 and Timer2.

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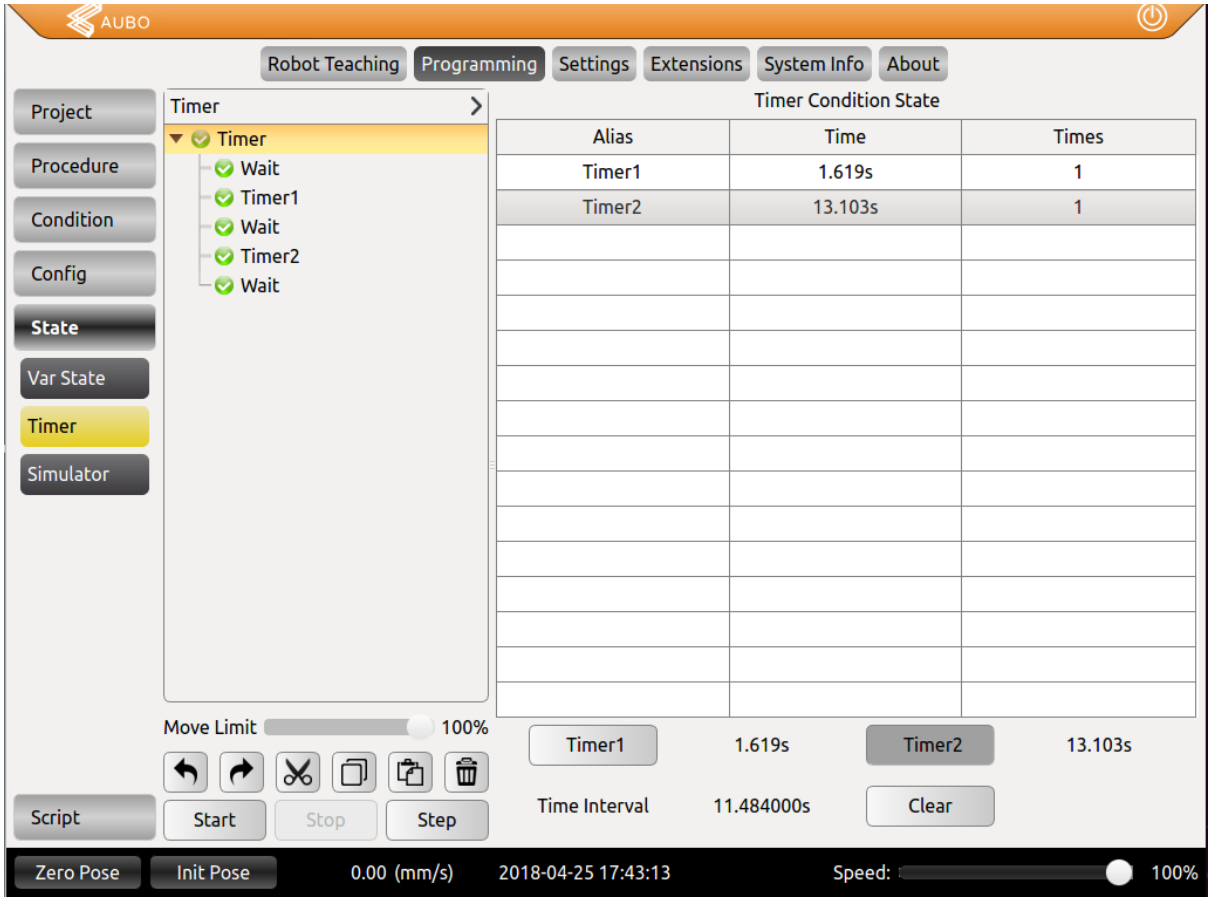

Figure 11.36 Timer

11.7 Simulation model

The simulation model is a function under Programming. It displays two parts, the upper part is robot 3D simulation, and the lower part displays robot movement parameters. Users can only pause and stop the robot, and also view robot's log information.

Robot 3D simulation would be sync with the real robot in real-time, and movement parameters is displayed under the 3D model, including the position parameter XYZ and the rotate parameters: RX RY RZ.

Users can check "Show track" and see the end of the track in the simulation window. Users can also set the Track duration to specify the track display time.

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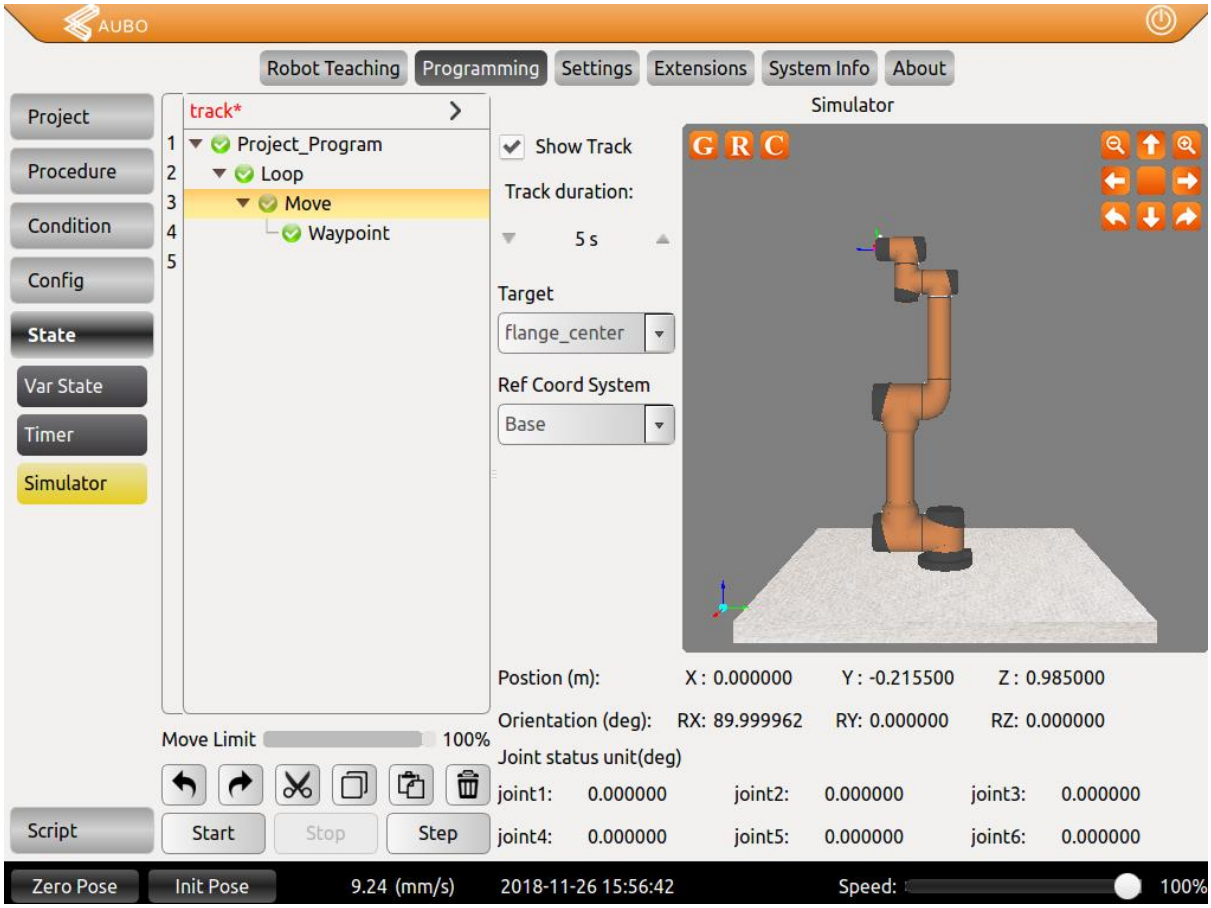

Figure 11.37 Simulation model

11.8 Scripts file configuration

Online programming function can help the user to new, edit, load and save scripts. Note: scripts should comply with LUA grammar, otherwise cannot be saved.

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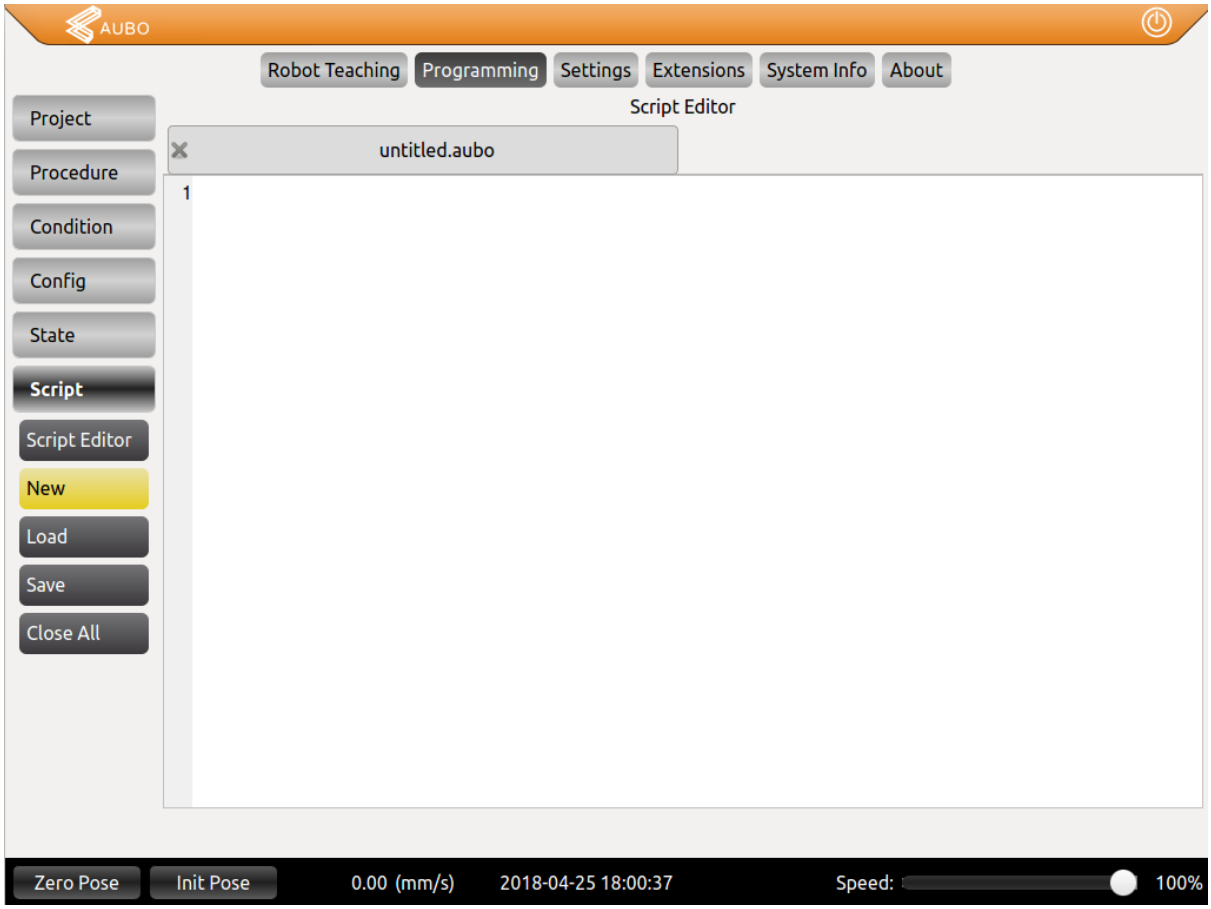

Figure 11.38 script file editor

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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.

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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, as well as EN ISO 13849 and EN ISO 10218. 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:

- MD 2006/42/EC
- EN ISO 10218-1:2011
- EN ISO 12100：2010
- EN ISO 13849-1：2015
- EN 60204-1：2006+A1：2009
- EN 61000-6-4:2007 +A1:2011
- EN 61000-6-2:2005
- IEC 60204-1(Fifth Edition)+A1:2008

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

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

America

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AUBO-i5 robot was 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 certified by the China National Robot Testing and Assessment Center (headquarters) and has been certified with CR Certification in China, to meet all relevant Chinese Collaborative Robot certification requirements:

GB 5226.1-2008、GB 11291.1-2011

GB/T 15706-2012

GB/T 17799.2-2003、GB 17799.4-2012

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

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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 manipulator 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 join 0 was carried out by moving horizontally, which means the axis of rotation is perpendicular to the ground. During the tests for Join 1 and 2, the robot follows 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

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D GUIDELINE

Robot design reference to the following standards.

Standard	*Definition*
2006/42/EC:2006	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)
2004/108/EC:2004	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
EN ISO 13850:2008	Safety of machinery: Emergency stop - Principles for design
EN ISO 13849-1:2015	Safety of machinery: Safety-related parts of control systems - Part 1: General principles of design
EN ISO 13849-2:2012	Safety of machinery: Safety-related parts of control systems - Part 2: Validation
EN ISO 12100:2010	Safety of machinery: General principles of design, risk assessment and risk reduction
EN ISO 10218-1:2011	Industrial robots: Safety Note: Content equivalent to ANSI/RIA R.15.06-2012, Part 1
ISO/TS 15066: 2016	Safety requirements for collaborative industrial robot Robots and robotic devices —Collaborative robots

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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		
Noise level	72dB		
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 the 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		
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 ℃		
Relative humidity	25%-85%		
Power supply	100-240 VAC, 50-60 Hz		
Lifetime	30,000 hours		
Cabling	Cable between robot and control box (2.9m) Cable between touchscreen and control box (2.9m)		

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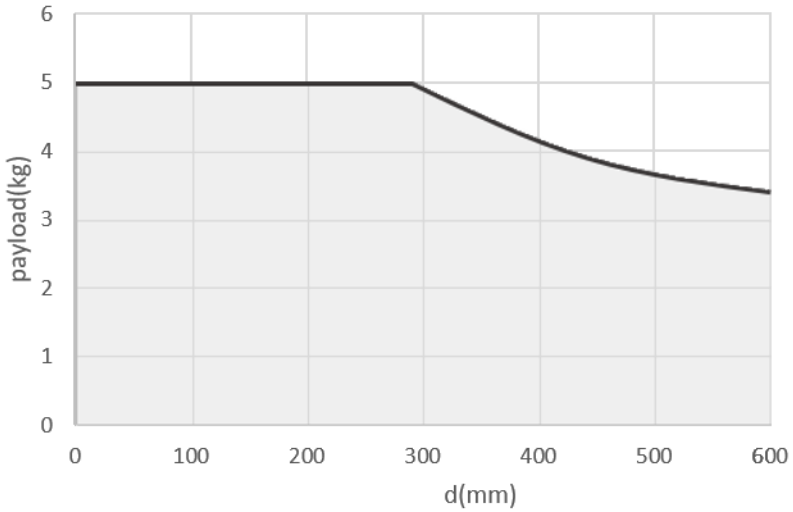
F PAYLOAD



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

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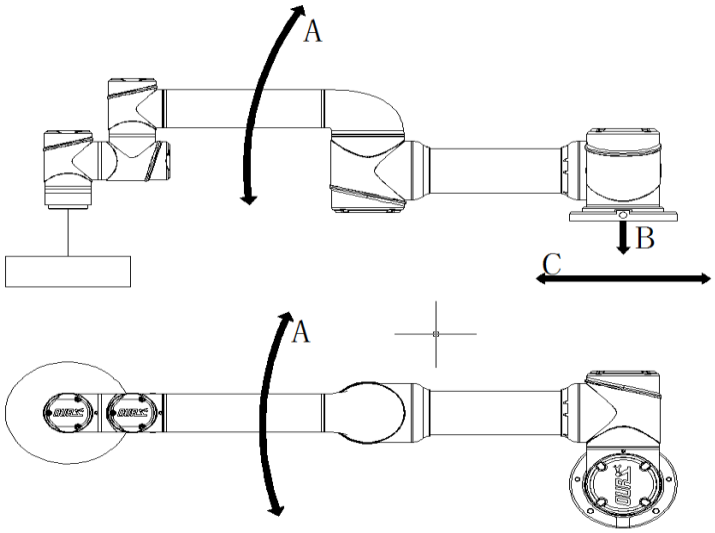
G MANIPULATOR INSTALLATION REQUIREMENTS

Manipulator's payload is 5KG. Then deviation of payload focuses 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.

Mounting	***Normal operation***	***Emergency stop***
Forward mounting	1554N ±360N	1554N ±2594N
Reverse mounting	1754N ±360N	1754N ±2594N
Vertical mounting	1554N ±360N	1554N ±2594N



Make sure to meet requirements when installation.

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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.

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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.

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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

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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 lines segments in line!");	MoveP---two lines 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.

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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 mutates at some speed.	Check whether in singularity.
70006	robot power off	robot power off	Control box servo power down.	Control box servo power up.

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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	XXXXX	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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AUBO Robotics
LIMITED WARRANTY

1. **Limited Warranty**. AUBO Robotics ("AUBO") warrants to you, the original consumer purchaser of the Robot Product ("Purchaser"), that the AUBO robots ("Robots," each a "Robot") and other AUBO hardware ("Accessories" and together with the Robots, "Robot Products") is and will remain free from defects in materials and workmanship ("Limited Warranty"), beginning on the date of purchase and until the earlier of (i) one year from the date of purchase or (ii) any transfer of ownership ("Warranty Period"). This warranty is subject to the installation in the Robot, and the Robot having been upgraded to, the most current software and upgrade package currently available and offered by AUBO.

2. **Eligibility**. This Limited Warranty is non-transferable and covers only the original end purchaser of the applicable Robot. Proof of purchase in the form of the original purchase receipt or packaging slip is required for warranty validation and service. Warranty claims must be made directly to AUBO within thirty (30) days from the date Purchaser discovers a defect in the Robot. This Limited Warranty does not cover any Robot (i) purchased through non-authorized dealers; (ii) purchased through online auction websites; (iii) shipped outside the country in which the Robot was delivered, (iv) used for excluded activities, including submersion, high-pressure water, harsh use, crushing, excessive heat, acidic or basic environments, or excessive cold. This warranty also does not cover any failure or improper operation not caused by AUBO, including, but not limited to (a) damage which occurs in shipping; (b) failures or problems caused by products or equipment not supplied by AUBO; (c) accidents, misuse, neglect, abuse, misapplication, fire, lightning, or other acts of nature; (d) incorrect electrical line voltage, voltage fluctuations or surges; (e) damage caused by improper installation; (f) product alterations or modifications; (g) improper or unauthorized repair; (h) exterior finish or cosmetic damage; (i) product with altered serial numbers; (j) failure to follow operating instructions; (k) end-user customer adjustments and/or maintenance; (l) use of non-AUBO or unauthorized parts, supplies, Accessories or equipment which damage the Robot or which result in service problems; and (m) failures or problems due to incompatibility with other equipment. Non-authorized dealer receipts and/or online sales auction confirmations are NOT acceptable or accepted for warranty verification.

To submit a claim under this Limited Warranty, contact AUBO at 2704 Cherokee Farm Way. Knoxville, TN. 37920 USA or via e-mail at sales@aubo-robotics.com. Purchaser shall, at AUBO's request, (i) provide to AUBO reasonable log data, photographs, date of purchase, serial number and point of purchase of any allegedly defective Robot, (ii) robot must be purchase from an authorized dealer and (iii) provide AUBO an

opportunity (at AUBO's expense, to review, inspect and test such allegedly defective Robot at AUBO's facility.

All of the above information together with the Purchaser's name, address, vendor name, location and date of purchase is required before a warranty claim will be accepted. Once AUBO validates Purchaser's claim, AUBO will issue Purchaser an RMA number and shipping information from sales@aubo-robotics.com. AUBO cannot accept returned Robots in packages without an RMA number. The RMA number must be clearly marked on the outside of the package containing Purchaser's returned Robot.

3. **Purchaser's Exclusive Remedy**. Subject to the terms herein, during the Warranty Period, with respect to any allegedly defective Robot, Purchaser's sole and exclusive remedy for any breach by AUBO of this Limited Warranty, and AUBO's sole and entire liability for such breach, is, at AUBO's option, to repair or replace the defective Robot. If AUBO determines that Purchaser's warranty claim is a valid claim, repair or replacement of the applicable Robot (including parts and labor as well as re-shipping costs) shall be made at AUBO's expense. AUBO reserves the right to send Purchaser a replacement Robot that is the same or of a similar style to the Robot Purchaser returned under the Limited Warranty or a substitute equivalent to Purchaser's original Robot that may not be of like kind (depending on availability). Replacement Robots will be furnished only on an exchange basis. Replacement or repaired Robots are warranted as above only for the remainder of the original applicable Warranty Period for the originally purchased Robot. All replaced parts and Robots become the property of AUBO.

4. **Warranty Exclusions**. This Limited Warranty applies only to the Robot and does not extend to or otherwise apply to any Accessories, even if packaged or sold with the Robot. This Limited Warranty applies only to the use of the covered Robot in accordance with the written use instructions provided with the Robot. This warranty does not cover defects or damage due to (a) normal wear and tear; (b) modification or alteration without AUBO's prior written consent; (c) accident, misuse, excessive exposure to water; (d) use of an accessory not approved by AUBO; (e) failure to follow AUBO's [Product Safety Instructions or User's Manual]; or (f) service made or attempted by anyone other than an authorized service provider of AUBO. Any opening of the sealed covers or casing or control box of the Robot by other than a certified field service technician certified by AUBO, voids all applicable warranties. This warranty does not guarantee uninterrupted or error-free operation of the Robot.

5. **Warranty Disclaimers**. EXCEPT AS EXPRESSLY SET FORTH ABOVE, EACH ROBOT IS PROVIDED SOLELY ON AN "AS IS" BASIS AND AUBO MAKES NO OTHER WARRANTIES OF ANY KIND. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, AUBO SPECIFICALLY DISCLAIMS AND EXCLUDES ANY AND ALL OTHER WARRANTIES, WHETHER EXPRESSED, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, QUIET ENJOYMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IF SUCH DISCLAIMER OF ANY IMPLIED WARRANTY IS NOT PERMITTED BY LAW, THE DURATION OF ANY SUCH IMPLIED WARRANTY IS LIMITED TO THE DURATION OF THE WARRANTY PERIOD OF THE LIMITED WARRANTY AS SET FORTH ABOVE. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OF IMPLIED WARRANTIES OR LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY MAY LAST, SO SUCH LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO PURCHASER. IF APPLICABLE LAW SPECIFIES A MINIMUM WARRANTY PERIOD THAT IS LONGER THAN THE WARRANTY PERIOD SET FORTH IN THE LIMITED WARRANTY, THEN THE WARRANTY PERIOD FOR THE ROBOT SUBJECT TO SUCH APPLICABLE LAW SHALL BE CONFORMED TO THE MINIMUM PERIOD SO REQUIRED. THIS WARRANTY GIVES PURCHASER SPECIFIC LEGAL RIGHTS AND PURCHASER MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM JURISDICTION TO JURISDICTION.

6. **Limitation of Liability**. IN NO EVENT, UNDER ANY CAUSE OF ACTION OF THEORY OF LIABILITY, SHALL AUBO, ITS DISTRIBUTORS OR SUPPLIERS BE LIABLE TO PURCHASER OR ANY THIRD PARTY FOR ANY INDIRECT, INCIDENTAL, CONSEQUENTIAL, SPECIAL, EXEMPLARY OR PUNITIVE DAMAGES, OF ANY NATURE WHATSOEVER, ARISING OUT OF THE USE OF OR INABILITY TO USE ANY ROBOT, INCLUDING, WITHOUT LIMITATION, PROPERTY DAMAGE, LOSS OF VALUE OF THE ROBOT, ANY ACCESSORIES, OR ANY THIRD PARTY PRODUCTS THAT ARE USED IN OR WITH THE ROBOT, EVEN IF AUBO HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. WITHOUT LIMITING THE FOREGOING, PURCHASER UNDERSTANDS AND AGREES THAT AUBO HAS NO LIABILITY FOR ANY DAMAGE OR DESTRUCTION TO PURCHASER'S PROPERTY RESULTING FROM ANY MISUSE OR IMPROPER CARE AND MAINTENANCE OF THE ROBOT. NOTWITHSTANDING ANY DAMAGES THAT PURCHASER OR ANOTHER THIRD PARTY MIGHT INCUR FOR ANY REASON WHATSOEVER (INCLUDING, WITHOUT LIMITATION, ALL DAMAGES REFERENCED HEREIN AND ALL DIRECT OR GENERAL DAMAGES IN CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHERWISE), THE ENTIRE AGGREGATE LIABILITY OF AUBO AND ANY OF ITS DISTRIBUTORS AND/OR SUPPLIERS SHALL BE LIMITED TO THE AMOUNT ACTUALLY PAID BY PURCHASER FOR THE ROBOT GIVING RISE TO LIABILITY. SOME STATES AND/OR JURISDICTIONS DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO PURCHASER. THE LIMITATIONS OF LIABILITY SET FORTH ABOVE SHALL APPLY TO THE MAXIMUM EXTENT PERMITTED UNDER APPLICABLE LAW.

6 axis
5Kg payload
924mm reach

AUBO-i5

Collaborative Lightweight Robot

Made for Human Centric
Agile Manufacturing

Versatile–Flexible–User Friendly
Low Cost–Lightweight

AUBO

www.aubo-robotics.com

AUBO-i5

Collaborative Robot (Co-Bot)

AUBO Robots work closely within the human environment without the need for safety equipment, depending on risk assessment.

COLLABORATIVE FUNCTION:

- Hand guide-to-teach (inverse kinematics motion planning), this manual operation of the robot enables quick and easy programing by demonstration without any programing skills.
- Robot works side by side with human operator without safety fence, laser or sensors (after a risk assessment is performed).
- Teach pendant user interface for programing (forward kinematics) enables online programing and simulation via a touch screen tablet.
- Lightweight, flexible and easy to re-purpose this lightweight robot.

SAFETY FUNCTIONS:

- Designed in accordance with Pl d and ISO 10218-1 (ISO/TS 15066) safety requirements and with most all specifications for collaborative robots operation.
- Power and force limiting design brings robot to a protective stop if limits are exceeded or a collision is detected. Speed and force can be adjusted to fit and optimize any application easily.
- Sensors embedded in motor drives provide real-time feedback to prevent dangerous situations.
- Emergency stop buttons are positioned on teach pendant and control box with a braking distance less than 1mm.

OPEN SOURCE ARCHITECTURE:

- CAN bus network used in this robot for multiple microcontrollers to communicate with each other.
- ROS (Robot Operating System) compatibility is supported through an API.
- Hardware adopts BUS protocols with open I/O interface extensions.
- Easily integrate robot into existing production systems.

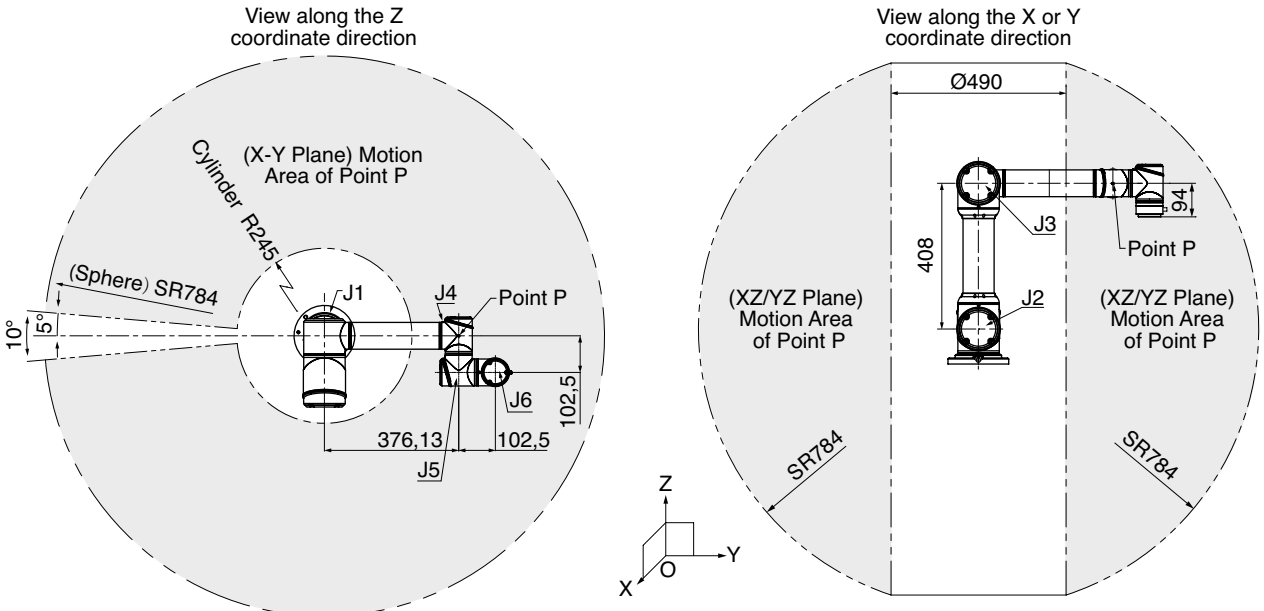
RETURN ON INVESTMENT (ROI):

- Low cost of ownership without basic programing skills needed, and ease of integration into a system, all add up to a quick return on your investment.
- Short run, high mix environments like Lab automation or machine tending are prime examples of industries needing fast redeployment.
- Floor space is a premium cost at most companies—usually more than the equipment. A small foot print, lightweight robot will be a huge benefit for any size company's cost of production.
- Repurpose, redeploy and/or reinvent applications with the same robot, fast change over for lean manufacturing.
- Remove human error in a high-mix low-volume (HMLV), this reduces manufacturing time and consequently increases capacity; without adding costly resources so robot acts as a de facto quality inspector.

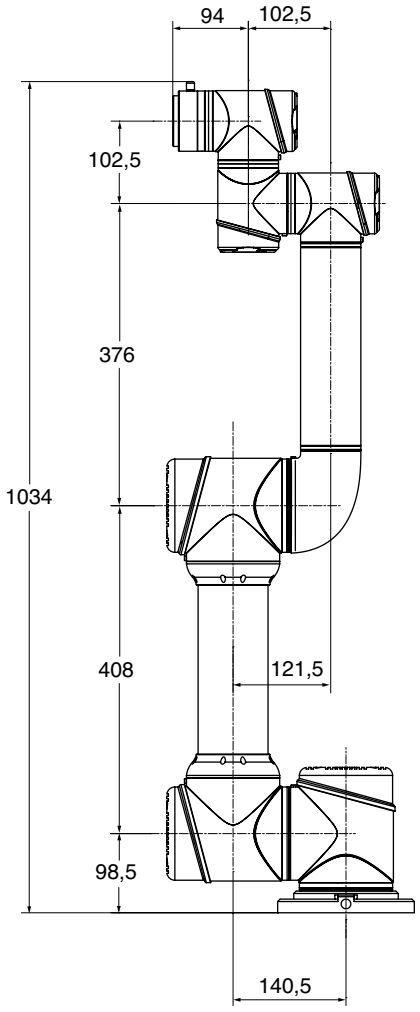
INTELLIGENCE:

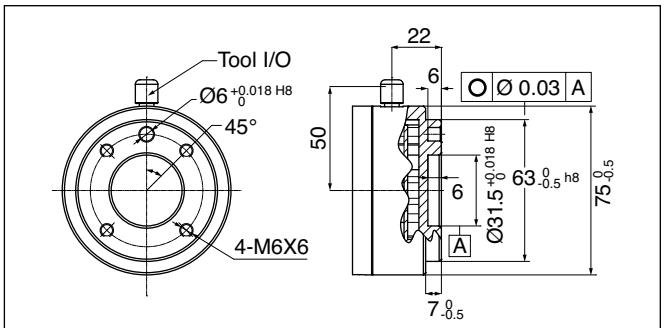
- Vison systems can be easily integrated into controller.
- Control Box communication ports include TCP/IP, Modbus RTU/TCP, and USB 2.0
- This research robot platform is used widely around the world in corporate labs and for academic robotics research.

Work Envelope-Range of Motion of the Point P

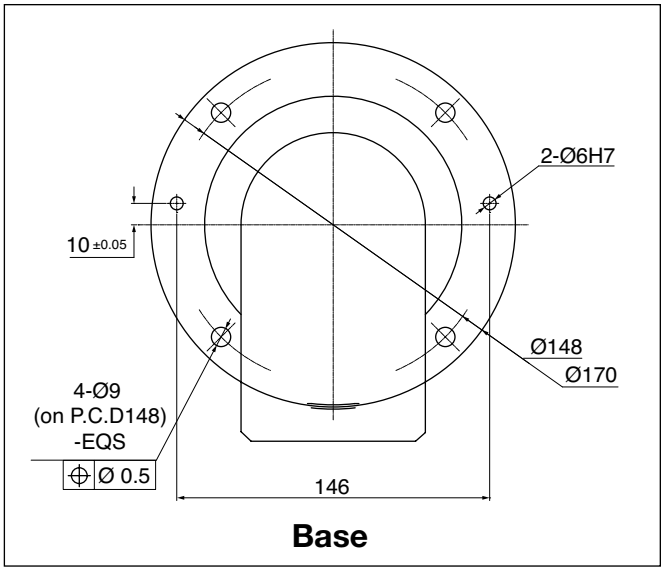


NOTE:
1.Double dotted ___ _ ___ line means regional boundaries
2.The trajectory of Point P may exceed the space area which contained by the double dotted line





Wrist with Mounting Flange
DIN ISO-9409-1-50-4

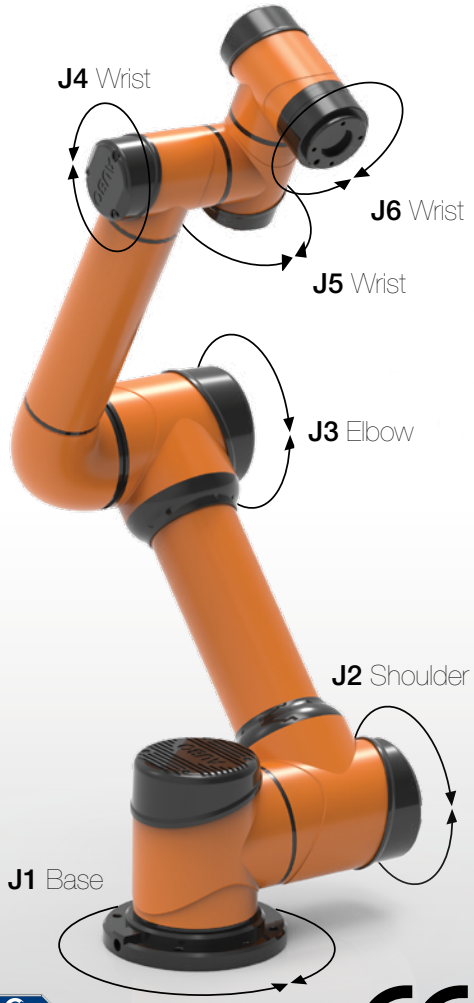


Base

AUBO

AUBO-i5

6 axis
5Kg payload
924mm reach



ROBOT SPECIFICATIONS

Degrees of Freedom	6 axes
Reach	924 mm
Payload	5 Kg
Weight	24 Kg
Lifetime	30000 h
Collaboration	Collaborative operation according to ISO 10218-1 :2001
Certification	Compliance with EU CE certification, North American certification, Korean KCs certification
Repeatability	+/- 0.02 mm
Linear Velocity	≦ 2.8 m/s
Power Consumption	200 W (under normal working conditions)
Materials	Aluminum, Steel, Plastic
Ambient Humidity	25% - 85%
Ambient Temperature	0 - 45° C
IP Classification	IP54
Programing	Teach pendant with user interface
Communication	CAN bus
Motor Type	DC 48 V
Installation Orientation	Any Ceiling, Floor, Wall

AXIS MOVEMENT

	WORKING RANGE	MAXIMUM SPEED
J1 axis rotation base	(+/-) 175°	150°/sec
J2 axis rotation shoulder	(+/-) 175°	150°/sec
J3 axis rotation elbow	(+/-) 175°	150°/sec
J4 axis wrist rotation	(+/-) 175°	180°/sec
J5 axis wrist swing	(+/-) 175°	180°/sec
J6 axis wrist rotation	(+/-) 175°	180°/sec

I/O PORT ON WRIST

Voltage	Current	Digital In	Digital out	Analog In	Analog Out
0/12/24 V	0.8 A	4	4	2	0

CONTROL BOX

Dimensions (LxWxH)	727x623x2 35 mm
Weight	20 Kg
Cabling	5 mm
Color	Black
Communication	Ethernet, Modbus - RTU/TCP
Interface	SDK (supports C/C++/Lua/Python) Supports ROS, API
Power supply	100 - 240 VAC, 50 - 60 Hz
IP Classification	IP54

I/O PORTS

	General I/O	Safety I/O
Digital in	16	16
Digital out	16	16
Analog In	4	-
Analog out	4	-
Power input	24 V	
Power output	3 A	

TEACH PENDANT

Dimensions (LxWxH)	355x235x54 mm
Weight	1.8 Kg
Display Screen	30 cm Touch LCD Screen
Cabling	4 m
IP Classification	IP54
Color	Orange

TÜV SÜD C US

CE Certified

About Aubo Robotics

Aubo Robotics was established in collaboration between professors from the USA and China to make a lightweight intelligent collaborative robot. This robot arm was specially designed with important functions from the start, combining state of the art technology with user friendliness to make this a collaborative robot (Co-bot). The open source architecture enables the Robot Operating System (ROS) to be supported through an API for both industrial and academic uses.

The Aubo i Series of robots use the CAN bus networks to communicate between joints. Low cost of ownership and high positional repeatability are some of the other criteria that makes up the outstanding features of this robot. Aubo Robotics holds several core patents and has strategic cooperation with several public companies leveraging the best of all new technologies.

Robotic automation is no longer out of range for small to midsize companies. The user-friendly setup facilitates ROI in real production environments so employees without programing skills can adapt these robots for most high mix or small batch applications. Aubo looks forward to helping companies make use of this new technology and gain competitive advantage in manufacturing environment while reducing the dangerous and repetitive tasks performed by workers today.

Some places where you may see AUBO Robots:
Assembly, Packaging, Welding, Pick and Place, Inspection, Machine Tending, Pharmaceutical and Medical Labs, Research and Development, and Academia.

AUBO co-bots work closely within human environments without safety equipment, depending on risk assessment.

Applications for Collaborative Robots

Assembly

Case Polishing

Product Testing

Education

Machine Tending

Dispensing

Load/Unload

AUBO

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