ECR5 Collaborative Robot

----------User Manual



Please read this manual carefully before usage.

EFORT INTELLIGENT EQUIPMENT CO.,LTD.

ECR5 User Manual

（Mechanical and Electrical Part）



Version：V1.1

------（Tel）：4000528877---

Statement

Thank you for purchasing EFORT robot products. In order to ensure that the ECR5 products have been set correctly, please read this operation manual carefully before using. The contents mentioned in this announcement and the manual are related to your personal and property safety. If you do not follow the instructions and warnings in the manual or operate without authorization, it may cause personal injury to you and the people around you or property damage to the robot or other objects around you. This announcement and manual are the latest version of this batch of products before delivery. Please visit www.efort.com.cn for updated information.

This manual is only used as a guide for the normal operation of the product. During the use of the product, EFT will not be liable for personal injury and property loss caused by other reasons except product defects. Our company seriously suggests that: the personnel who participate in robot operation, teaching, maintenance, repair, spot inspection and other related activities should not be given permission to operate the robot before completing the training courses prepared by company.

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Preface

Thank you for purchasing our 5kg level 6-DOF collaborative robot ECR5



ECR5 is a collaborative robot independently developed by EFORT. The whole machine adopts modular design, and there is no mechanical limit for the joints. The theoretical limit can reach ± 360 degrees(see the technical specifications for software limit),The dead weight of the manipulator arm is 20.5kg, and the rated load is 5kg,The working range is 928 mm, the installation size of base is 140 mm, the size of terminal interface is 50 mm, the operation of terminal function key is simplified, the speed of maximum tool side runs at 2.5 m/ s, and the repeated positioning accuracy is ± 0.03 mm.

ECR5 is designed based on the modularity concept and adopts an open software architecture, which is characterized by safe cooperation, light weight and beautiful appearance, simple programming, convenient mounting and dismounting, and flexible deployment, combined with sensitive collision detection function and good drag teaching function, it is a comprehensive choice of safety and efficiency.

ECR5 is suitable for assembly, testing, loading and unloading, sorting, handling, packaging, palletizing and other fields in automobile, 3C, food and beverage, medicine, logistics and warehousing industries.

Package List:

When you order a complete set of ECR5 cooperative robots, you will receive two packages:

Package A：length725 mm × width435 mm × height397.5 mm

1 ECR5 manipulator

1 teach pendant (including wiring harness)

Package B：length560 mm × width475 mm × height317.5 mm

1 control cabinet

1 set of manipulator cable

1 set of power supply cable

1 set of CD (User Manual included)

Unpacking Guide：

Please check the package appearance and label content carefully before unpacking

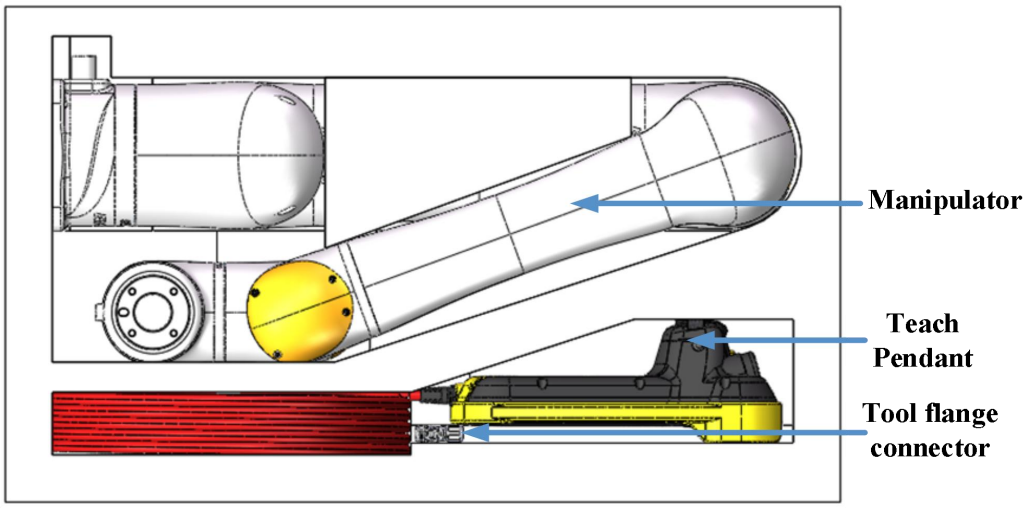


Fig. 0.1 Illustration of the Packaged Contents of Box A

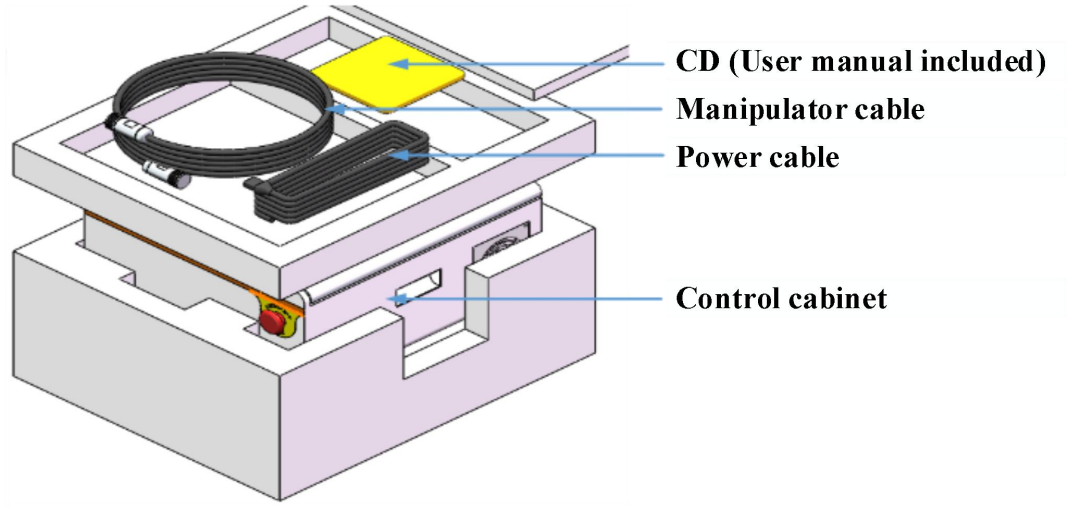


Fig. 0.2 Illustration of the Packaged Contents of Box B

Chapter 1 Safety

1.1 Introduction

This chapter contains important safety information of ECR5 collaborative robot. Integrators and users must carefully read and understand the operation rules and safety specifications in this manual. The contents with warning signs should be mastered and strictly observed.

This chapter involves the safety of personnel and equipment, please read it carefully.

1.2 Warning Signs

A large number of warning signs are used in this manual to indicate important information during use. The definition of warning signs is as follows. Please read them carefully:



Danger !

It means a dangerous situation is about to happen. If no corresponding preventive measures are taken, it will lead to death or serious physical injury.



Warning !

It means a dangerous situation may occur. If no corresponding preventive measures are taken, it will lead to death or serious physical injury.



Caution !

It means a dangerous situation may occur, which will lead to property loss or minor physical injury if corresponding preventive measures are not taken.

Caution !

In the absence of warning signs, **there is a caution warning**, indicating that dangerous situations may occur. If no corresponding preventive measures are taken, property damage will be caused.



Danger !

It means that dangerous electrical use may occur, if no corresponding preventive measures are taken, it will lead to death or serious physical injury.



Warning !

It means that dangerous electrical use may occur. If no corresponding preventive measures are taken, it will lead to personal injury or serious damage to equipment.



Warning!

It means that a hot heating surface may be dangerous. If no corresponding preventive measures are taken, it will cause personal injury.

1.3 Attention Notice

ECR5 has a wide range of applications. This manual describes the feasible and prohibited items in use as far as possible, but it can not cover all the applications. Users should read this manual carefully before use, and fully understand and master the application safety rules, so as to protect personnel and equipment from damage.

1.3.1 Instruction

When starting the robot system for the first time, the following specifications should be strictly followed, and other safety related information will be introduced in the corresponding chapters. However, it is impossible to cover all aspects. In practical use, specific problems need to be analyzed in different cases.



Danger !

1. Please install the robot and related electrical equipment in strict accordance with the requirements and specifications in this manual；
2. Before putting into production, please conduct a comprehensive safety inspection on the robot；
3. When using the equipment for the first time, make sure that all parts of the robot system are intact and safe.Whether the installation and construction of the equipment comply with the local safety production rules and regulations, it is necessary to test the safety functions of the robot and the on-off of each safety signal circuit;
4. The user must ensure the correctness of each robot safety function parameter setting and the program.The qualified personnel shall check and ensure that all safety functions can work normally. Only when the state of the robot system reaches the security level required by the application can it be enabled to start.



Danger !

1. The installation and debugging of the robot should be carried out by professionals;
2. When the robot system is completed, it is necessary to conduct a comprehensive risk assessment again and keep the record file.



Danger!

1. The setting and modification of the safety function parameters of the robot should be carried out by authorized professionals. Passwords or other protective measures should be used to prevent unauthorized personnel from editing and modifying the safety function parameters. After editing and modifying the safety function parameters, it is necessary to comprehensively analyze the possible impact;
2. In the event of an accident or other emergency, the robot can be stopped by pressing the emergency stop button. After the e-stop button is pressed, the power supply of the robot arm will be cut off;
3. ECR5 itself contains a brake, but there is a gap in the brake. After the power cutting-off of the robot, the brake system can keep all joints of the robot within a certain range of motion (within 0.5 degrees). Do not turn on or off the power frequently;
4. ECR5 has the function of collision detection, and can set the sensitivity. When the robot is subjected to collision force larger than the set sensitivity, the robot will stop automatically to prevent personnel and equipment damage. This function is designed for collaborative applications, which requires the robot to be in the normal working range, and cooperate with the use of CRC10 control cabinet. The safety function is developed based on this control cabinet. If the user configures the control cabinet by himself, it does not have this function. The risk should be borne by users themselves.



Warning!

1. When the robot works at a higher speed, it may produce higher heat. Do not touch the robot directly when the robot is working or just stops working.
2. There are air inlets and outlets on the side of the controller. Please do not cover them when placing them, and keep a certain distance from the obstacles (not less than 20cm) to ensure good ventilation and heat dissipation.
3. Do not touch the heating element in the controller when the robot is working or just stops working.



Warning!

1. Ensure the connection between robot and end effector is tight and reliable;
2. When changing the installation mode, you need to set the installation mode in the corresponding interface. The installation mode may affect the collision detection, drag teaching and other functions. Please operate and verify the robot carefully at low speed after changing the installation mode;
3. The smooth and streamlined appearance of ECR5 robot can reduce the risk of injury from operators in the process of use, but it needs to ensure that there are no sharp points to reduce the safety risk when installing the end execution tools and peripheral pipelines or other accessories.
4. Please do not change the robot. If you change the robot without permission, it may cause unpredictable safety problems. EFORT refuses to take responsibility for all the consequences arising therefrom.
5. Do not place the robot in a strong magnetic field environment, which will cause irreversible damage to the robot;
6. Ensure that the installation environment of the robot provides enough space for the robot to work;
7. When installing or replacing the end effector, it is necessary to correctly set or calibrate the mass and inertia attributes of the tool end, and check the program at low running speed. When it comes to collaborative operation, it is necessary to reevaluate the risk and fully understand the properties of the installed terminal equipment, taking the potential risks in operation into full consideration.
8. During transferring and transportation, it's necessary to make full protection for the robot to avoid collision and abrasion, and fold it to the full to reduce the gravity torque/moment and inertia of the robot. If condition permits, the robot can be motioned into the packing position, removed and placed in the original packing box for transportation. The packing box can be equipped with a cushion, which can greatly reduce the impact in the transportation process to protect the robot.
9. Do not put the robot in the environment of high temperature and humidity, otherwise the robot may not work normally;
10. Do not use the damaged robot;
11. Before using the robot, please ensure that the power supply of the electric box and the robot mounting base are fully grounded.



Caution!

1. The programming of robot needs to be done by professionals. EFORT shall not be liable for personnel injury and equipment damage caused by programming error or improper user operation, etc.
When new equipment is added to the robot system, it is necessary to carry out a systematic and comprehensive inspection on the functions and programs of the robot, which can reduce the risk of use.

1.3.2 Personnel Security

When using the robot, fully ensure the safety of the operator. Please read the precautions listed in this section carefully and take appropriate safety measures to ensure the safety of the operator.



Caution!

1. All operators using ECR5 robot system shall receive and pass training courses provided by EFORT headquarters or other authorized training institutions. You should ensure that all operators fully master all safety specifications of robot operation and are qualified by EFORT.
2. When operating the robot, the operator shall dress in accordance with the safety regulations, and shall not wear loose clothes, necklaces, jewelry, etc., the person with long hair shall tie the long hair behind his head to avoid being intertwined into the mechanical arm.
3. The end of ECR5 is equipped with a status light band, which can display the running status of the robot. When the status light band is in yellow, it indicates that the robot is in non-cooperative mode, at this time, do not touch the robot.
4. When the robot stops at a certain position, it may be the waiting instruction set by the program, at this time, do not touch the robot.
5. Clear signs should be set around the installation position of the robot to indicate the normal working range of the robot. In principle, when the robot is used in the cooperation situation and the mode is on, it is not necessary to set fences, but it needs to go through a comprehensive risk assessment.
6. In case of emergency, the end cover of the joint can be dismantled to rotate the joint (see section 1.7.3 for details) after power cut-off. You can also rotate the joint with more force without removing the end cover, but the joint will be damaged.

1.4 Risk Assessment

In principle, ECR5 collaborative robot can be used without external fence, but the risk of operation and normal running must be assessed. The risk assessment must be completed before the robot is put into use. Integrators and users must fully consider all tasks of the robot in its whole life cycle to measure the risk level and acceptability. You can start the assessment from the following aspects, but not limited to:

1. The sharp-pointed corners of end effector/work piece may cause injuries to personnel;
2. Obstacles in the robot workspace may cause injuries to personnel and equipment;
3. When the robot is running, it may collide with personnel and cause injury;
4. There may be risks when robot operates dangerous articles;
5. Different security parameter settings may have risks in different applications;
6. There is a risk of unreliable installation of the end effector
7. There is a risk when the robot is close to the rigid boundary/obstacle;

When the robot is integrated / applied in non-cooperative situation, the internal safety mode of the robot can be turned off. If internal security settings fail, integrators and users should consider additional security devices and assess their security risks.

After changing the configuration and replacing the end effector of the robot, the risk assessment should be restarted, which should be completed beforehand.

1.5 Responsibility Norm

ECR5 robot can form a complete robotic application with other devices and actuators. Due to the complexity and diversity of application scenarios, this document does not include the design, installation and operation of robot application system.

The design of a complete robot application system needs to comply with the national and industrial regulations of relevant application scenarios, and conduct sufficient risk assessment (see Chapter 1.4)

ECR5 system integrators should comply with the relevant national regulations for application design, and complete the risk assessment of the whole application system. The responsibilities of the system integrator include but not limited to the following:

1. Complete risk assessment of the whole application system;
2. Make sure the user instruction;
3. Make sure the accuracy of equipment design and installation of robot application system;
4. Ensure the reliability of the software system, and ensure that users will not change the important security configuration
5. Conduct sufficient operation training for users;
6. Reduce the risk of application system as much as possible;
7. Convey potential risks to users;

8. Mark relevant signs and communication information of integrators on robots and auxiliary equipment;
9. Collect and archive all technical documents, including risk assessment and this manual

Any safety information contained in this manual shall not be regarded as the guarantee of our company, even if all safety instructions specified in the manual are followed, injury or damage may still happen.

1.6 Application Scenario

ECR5 belongs to industrial robot, which is intended to be used in industrial scenes. It can cooperate with the corresponding end effector for handling, loading and unloading or other general work. In addition, the robot has collaborative properties and is equipped with a series of cooperative safety functions. It can be used under the condition of human-computer cooperation, but the risk assessment must be carried out (see Chapter 1.4) to assess whether the risk of possible injury to personnel and equipment is within the acceptable range.

ECR5 should be used in general industrial scenarios. Do not use robots in scenarios that are inconsistent with the proposed applications. Prohibited application scenarios include but are not limited to the following:

1. Scenarios with explosion risk;
2. Scenarios involving human and animal life, such as medical treatment;
3. Scenarios beyond specifications;
4. Application scenarios in violation of local provisions;
5. Scenarios involving public security;
6. The scenarios of uncontrollable vibration like vehicles, ships, etc;
7. Scenarios applied to walking and climbing tools;

1.7 Emergency Stop and Emergency Handling

The emergency stop equipment is used to stop the operation of the robot in case of emergency. It can not be used as a risk reduction measure, but as a secondary protection equipment (refer to IEC 60204-1 and ISO 13850).

1.7.1 Emergency-Stop Device

There is an emergency-stop device on the robot control cabinet and the teach pendant, namely the E-stop button. If the emergency-stop device needs to be added, it should meet the requirements of IEC 60947-5-5 and be included in the risk assessment.



Warning!

When the robot is attached with additional equipment and end effector, if there is potential risk, it must be connected to the emergency stop circuit.

1.7.2 Return to Normal from Emergency

The general e-stop device can release the pressing state by rotating the button to make the robot return to normal state.

Danger!

This step is simple but crucial. Make sure the danger is completely eliminated before operation.

1.7.3 Forced Movement after Power Cut-off

In case of emergency, the robot joint can be rotated by exerting larger thrust or pull force.

Warning!

This situation is only used for emergency and may cause damage to the equipment.

1.7.4 Release the Brake after Power Cut-off

In case of power failure and emergency, the robot joint cover can be disassembled, and then the electromagnet push rod could be pushed inward, as shown in the direction of the arrow in below figure to release the brake of current joint.

Illustration of releasing brake of J1-J3 joint

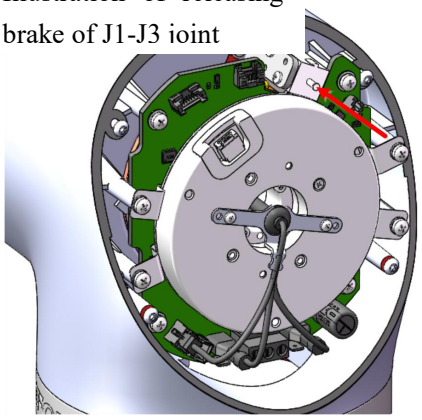
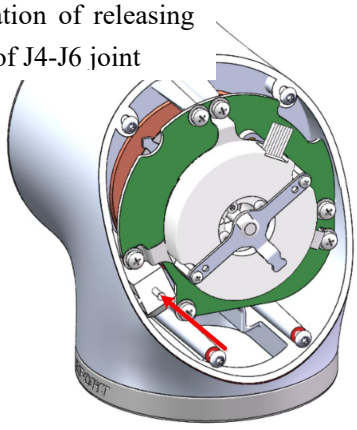


Illustration of releasing brake of J4-J6 joint



Danger!

This brake releasing way is only used for emergency. Before operation, make sure that each joint which is about to release the brake is supported reliably. Take care of the gravity of the arm, otherwise the arm may rotate rapidly by gravity, causing injury to equipment and personnel.

Chapter 2 System Composition

2.1 Outlines

A complete set of ECR5 robot system consists of a manipulator, a control cabinet and a teach pendant, as shown in the figure below. They are connected by the connection cables to realize communication, power supply and other functions.

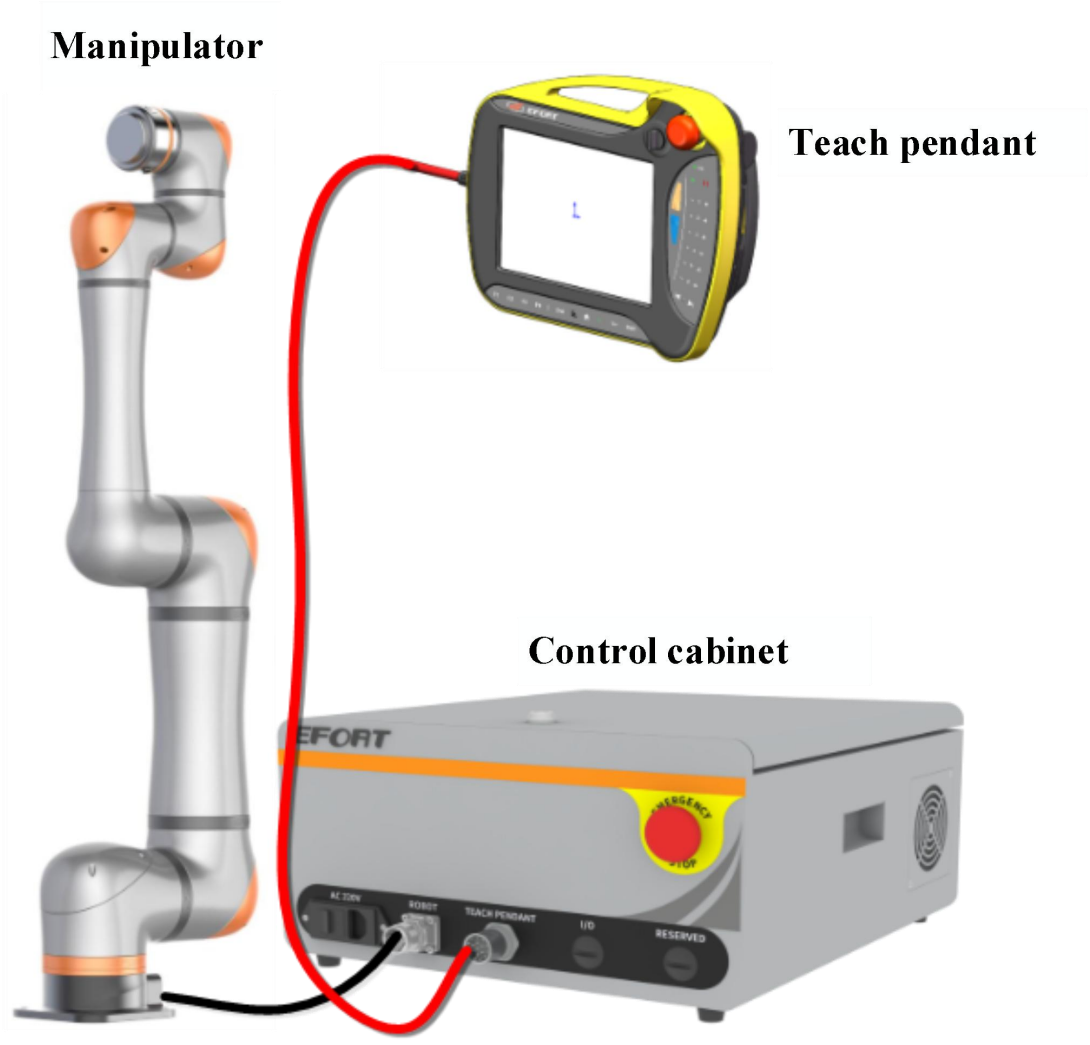


Fig. 2.1 The Composition of ECR5 Robot System

2.2 Manipulator

The manipulator consists of 6 modular joints, 2 arms, 1 base and 1 tool end flange. Each joint moves independently, providing 6 degrees of freedom of the manipulator;

the base is used to fix and connect the robot; the tool flange is used to install the end-effector, and provides interface for I/O and communication.

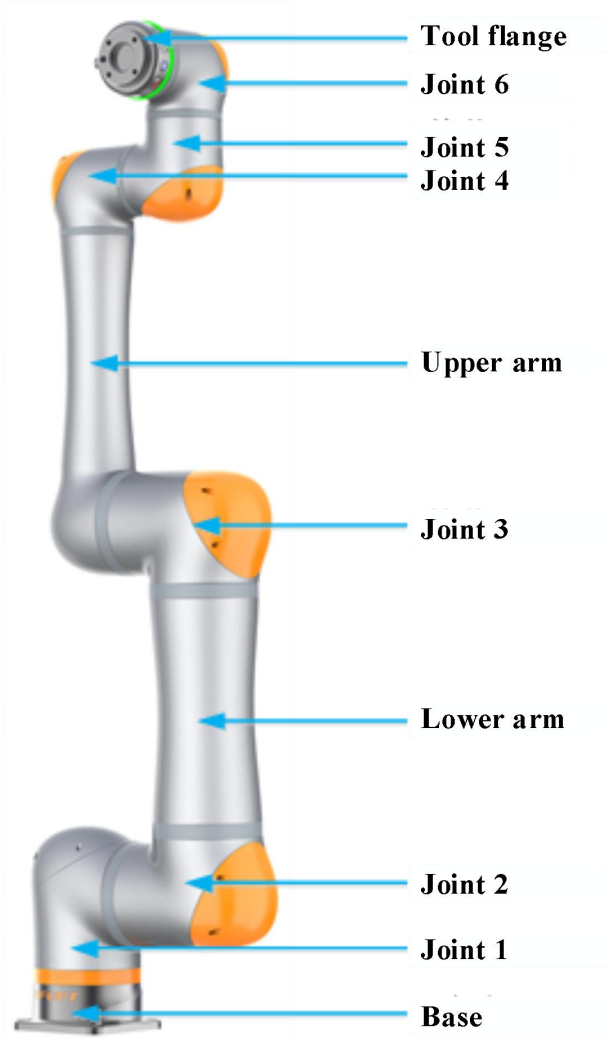


Fig. 2.2 ECR5-Mechanical System

2.2.1 Tool Flange

The tool flange is equipped with 4 quick operation buttons with the following functions:



Fig. 2.3 Buttons in tool flange

Mode Switching: click this button to switch the operation mode of the robot. Normal mode (off); point drag teaching mode (flashing), path drag teaching mode (always on)

External I / O: click this button to control the switch of IO output of the end flange. Off (off); on (on)

Teaching Record: in the point drag teaching mode, press this button, the robot will record the current position point. In the path drag teaching mode, press this button and the light will be on. Then, the robot will start tracking record. When this button is pressed again, the blue light will go out. At this time, the controller will stop tracking record and generate an executable track file. In normal mode, this button does not work and will always be off.

Drag confirmation / collision recovery: In point drag teaching mode or path drag teaching mode, when this button is pressed, the red light is on, and the robot can be dragged. When the button is released, the red light goes out. Then, the robot will not be allowed to be dragged by the user. In normal mode, if the robot collides and stops, this light will be on. At this time, press this button to clear the alarm and resume the movement of the robot after 5 seconds.

The tool flange is equipped with a ring status light, whose status is described as follows:

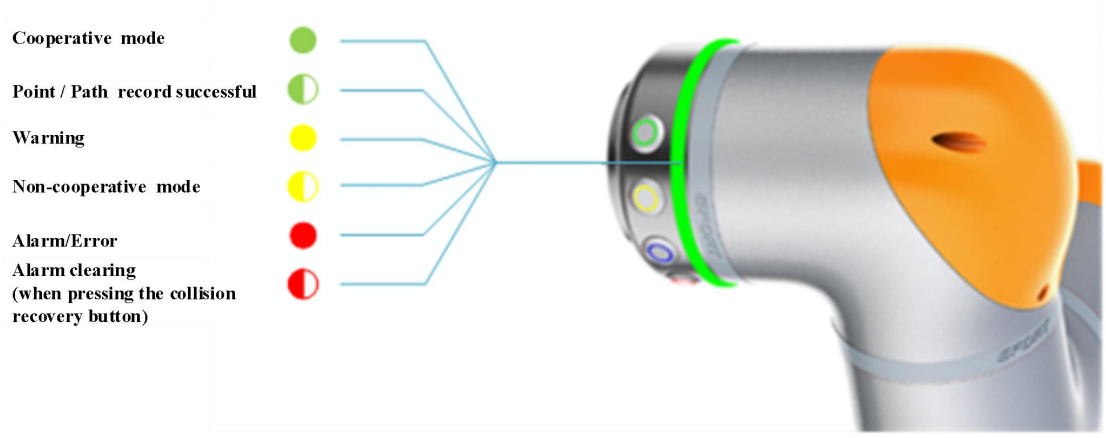


Fig. 2.4 Tool Flange Ring Status Light

Green (always on): when the robot operates normally in cooperation mode, the ring status light is green and always on;

Green (breathing): During the drag teaching operation, when the recording point or track is successful, the ring status light flashes green for 3 seconds;

Yellow (always on): During the warning state of the robot, the ring status light is yellow and always on. At this time, the operator should check and handle the warning information;

Yellow (breathing): when the robot operates normally in non-cooperative mode, the ring status light is yellow breathing, and the operator can not enter the working space of the collaborative robot at this time;

Red (always on): when the robot is in the alarm or error state, the ring status light is red and always on. At this time, the operator needs to check and clear the alarm;

Red (breathing):when the robot stops in case of collision, press the collision recovery button, the ring status light is red breathing, lasting for 5 seconds. At this time, the operator needs to stay away from the robot, and then the robot gradually returns to normal operation.

Blue (breathing): it generally happens when the robot is just powered on, indicating that the robot is powered on successfully, but the communication is not established. After the communication is established with the controller, the state changes to yellow breathing.

2.3 Control Cabinet

The control cabinet is the control center of ECR5 robot, which contains controller, universal IO interface board, switching power supply and safety protection components. The control cabinet is powered by alternating current with voltage of 127V-240V and frequency of 50Hz-60Hz. The internal switching power supply supplies the load and robot in the controller cabinet. Therefore, it is necessary to check whether the connection cable between the robot, teaching pendant and the controller cabinet is firm enough before use.

There are E-stop switches on the control panel and teach pendant of the controller cabinet. The user can stop the robot in the shortest time and cut off the power supply of the robot to protect the safety of personnel and equipment.

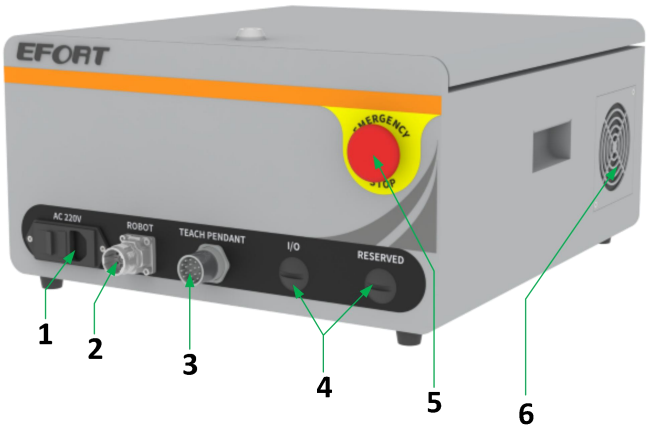


Fig. 2.5 Control Cabinet Composition

NO.	Item	Description
1	AC 220V Power Switches	Turn on the main power switch to supply power to the robot system
2	Power Supply Interface of manipulator	Supply the power to manipulator by cable
3	TPU Interface	Communicate and supply the power to TPU by cable
4	Backup Extension IO Cable Interface	Reserved external wiring for extended IO
5	Panel E-stop Button	E-stop button
6	DC Fan	Heat emission of electric cabinet

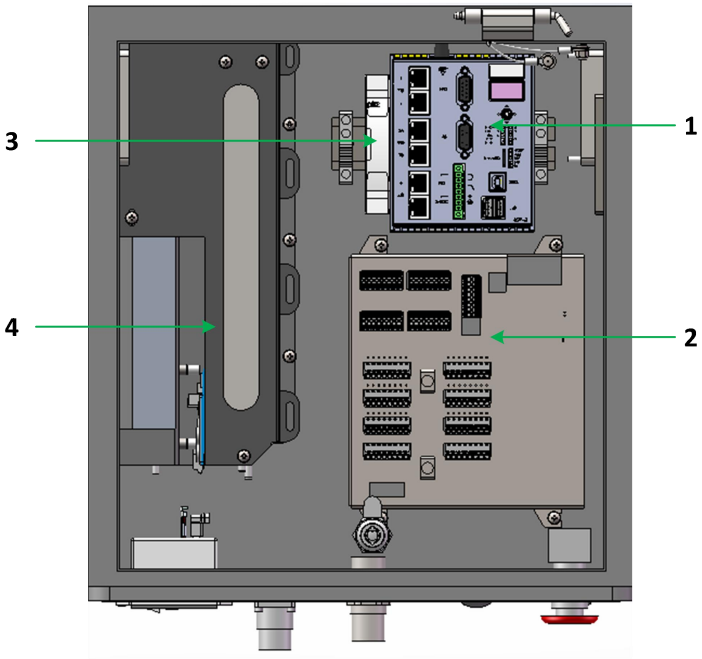


Fig. 2.6 Control Cabinet layout

NO.	Item	Description
1	Controller	Controller for the robot system
2	I/O board	External I/O channels reserved
3	Safety relay	Safety module
4	24V/48V Power supply	Power supply for the robot system

2.4 Teach Pendant



Fig. 2.7 Teach Pendant

NO.	Title	Description
1	Membrane panel 3	Company LOGO
2	Touch Screen	8-inch resistive touch screen
3	LCD screen	8-inch TFT LCD, resolution 1024 * 768
4	Membrane panel 2	10 buttons included
5	Emergency-Stop Switch	Double circuit e-stop switch
6	Mode Dial	Three-stage Mode Knob
7	Membrane panel 1	It contains 18 buttons and 1 red, yellow and green LED

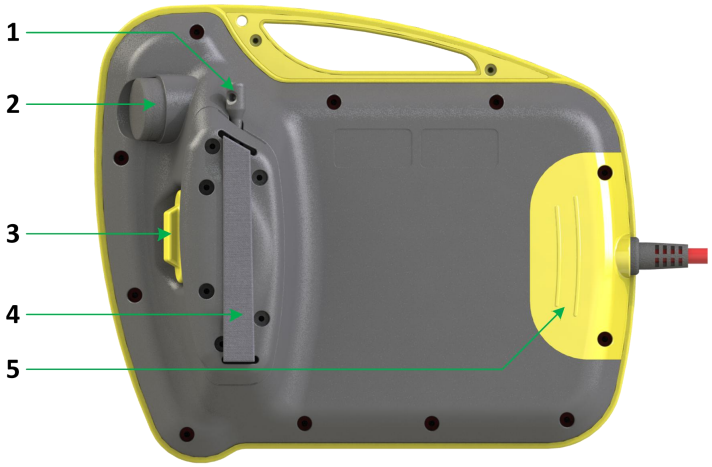


Fig. 2.8 Teach Pendant

No.	Title	Description
1	Touch Pen	Used to operate the touch screen
2	USB cover	After uncovering, you can insert a USB device here
3	Enable Switch	Double circuit Enable Switch
4	Hand Strap	Prevent the teaching pendant from getting out of hand in use
5	Outlet Cover Plate	This cover needs to be opened when installing the wiring harness

Chapter 3 Interface and Installation

3.1 Outlines

When installing the robot, the working space of the robot (SR 928mm) must be fully considered, and the reasonable layout of the robot can maximize the working space of the robot. In particular, when arranging the robot, be careful not to let the end tool approach the R147mm directly above and directly below the robot base since it will cause the problem of too slow tool end speed and too fast joint speed. The working space of the robot is shown in Fig. 3.1.

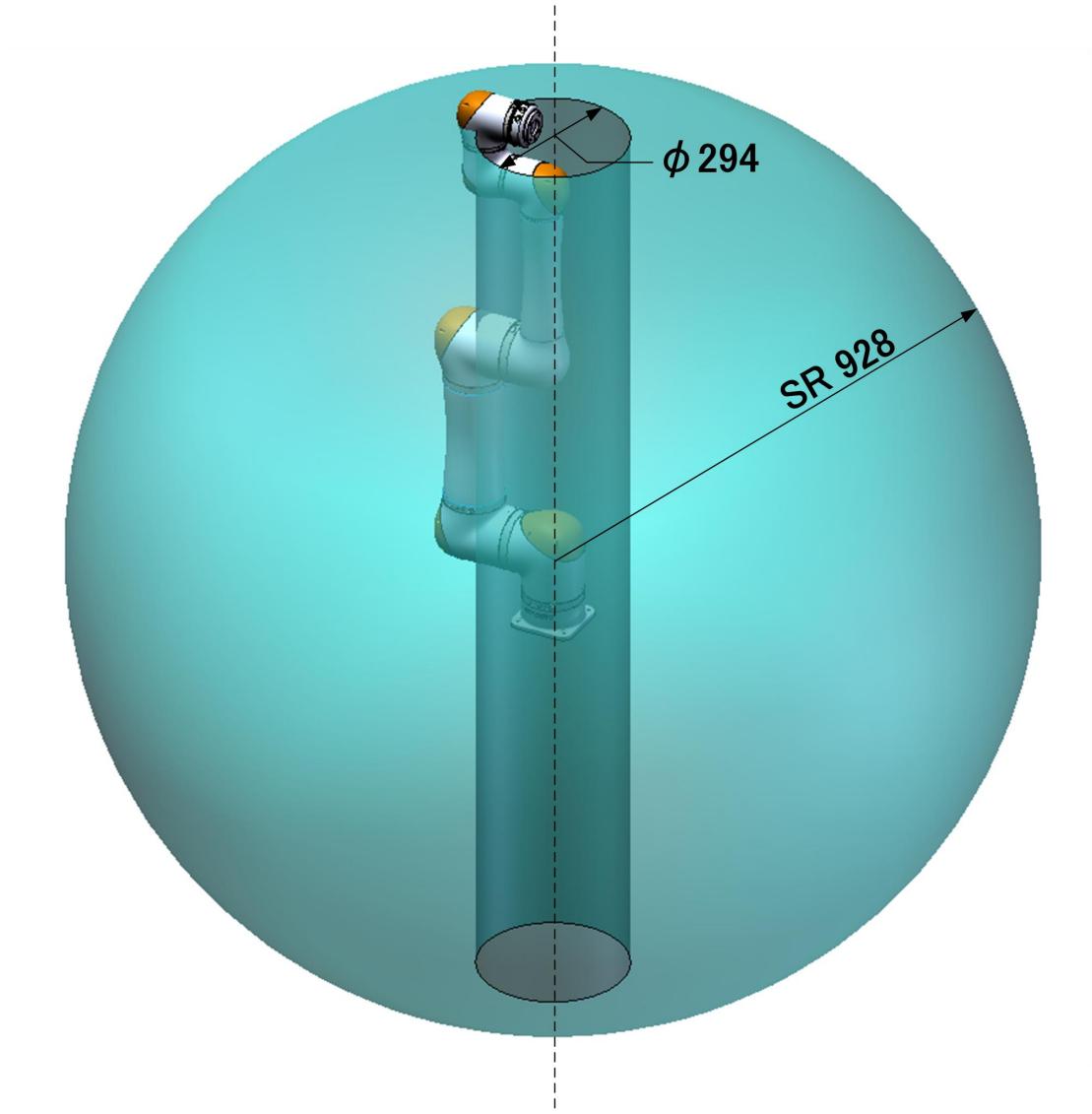


Fig. 3.1 Maximum Working Space of ECR5, unit mm

Danger!

The robot must be fixed firmly and reliably!

Caution!

Please install the robot in a suitable IP level environment. Do not install the robot, teach pendant, control cabinet, etc. in an environment that exceeds the IP level marked on the product, otherwise it may cause damage to the robot and the operator!

The theoretical rod length of the ECR5 robot is shown in Fig. 3.2

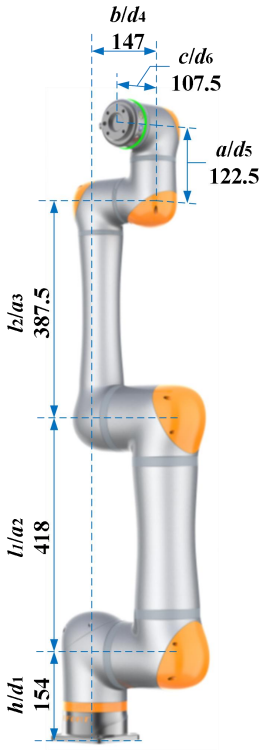


Fig. 3.2 ECR5 Rod Length Parameters, unit mm

ECR5 collaborative robot can be mounted in any angle, see in Fig. 3.3:

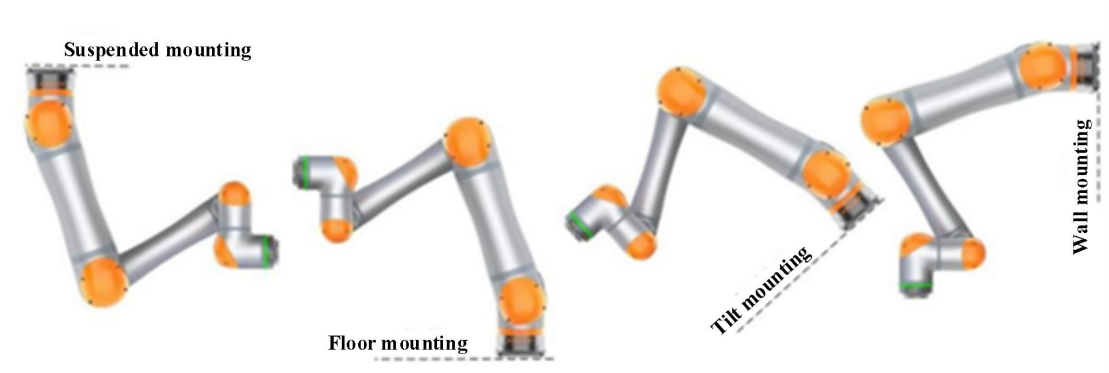


Fig. 3.3 Allowable mounting angle of ECR5

Warning!

When adjust the mounting angle of the robot, the risk assessment must be redone!

3.2 Mechanical Interface

3.2.1 Base Installation Size

There are 4 Φ9 through holes on the ECR5 base, which are evenly distributed on the Φ140 indexing circle, which are used to connect the robot to the base with 4-M8 screws. In addition, the ECR5 base also has 1-Φ6 positioning pin hole and 1 6×8 positioning slot. It is recommended to use these two features for accurate positioning during installation. The specific dimensions are shown in Fig. 3.4:

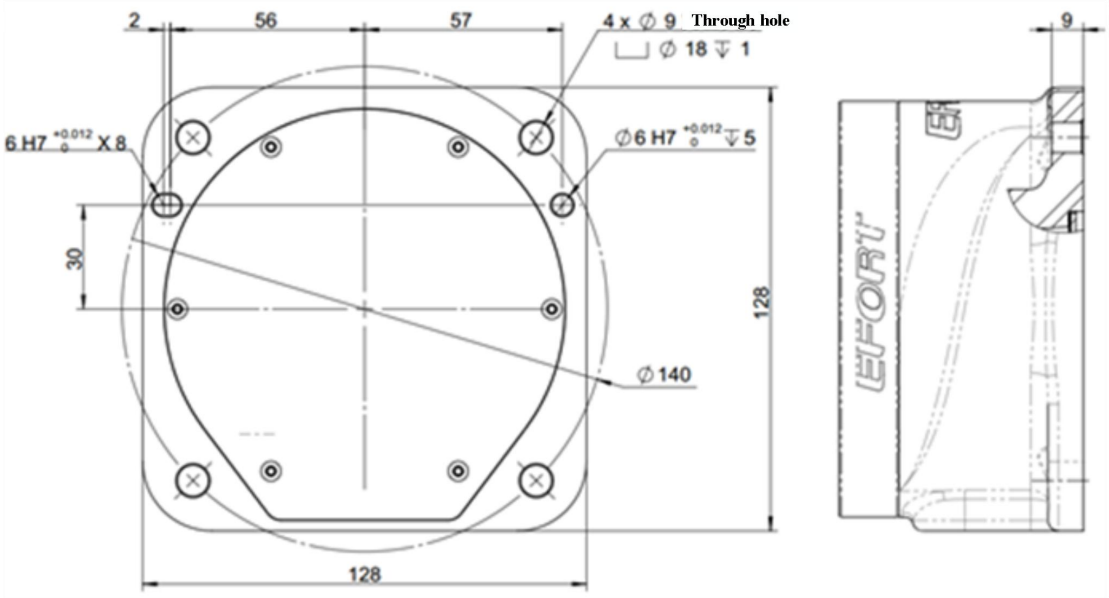


Fig. 3.4 ECR5 Base Installation Dimensions, unit mm

3.2.2 Control Cabinet Installation Size

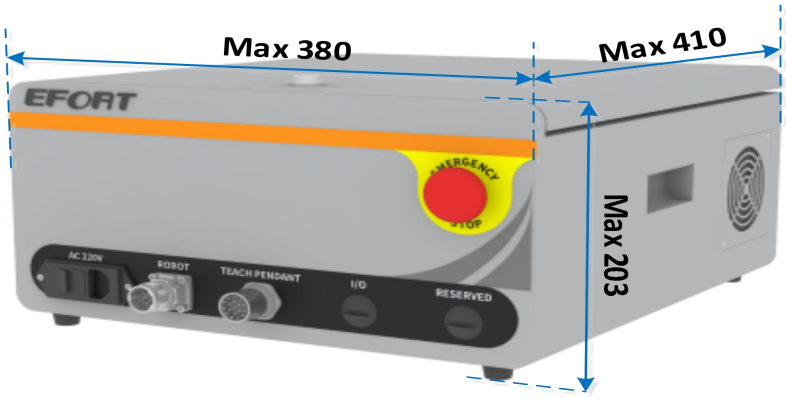


Fig. 3.5 ECR5 Control Cabinet Size, unit mm

The minimum installation space required for the control cabinet is 380 mm×410 mm×203 mm, as shown in the figure.

3.2.3 End Effector Installation Size

The end effector can be installed on the ECR5 tool flange with 4 M6 screws. The detailed mechanical interface of the ECR5 tool flange is shown in the figure. It is recommended that the tool with higher installation accuracy should be installed with a Φ6 pin and assembled with the stop. Φ31.5 and Φ63.

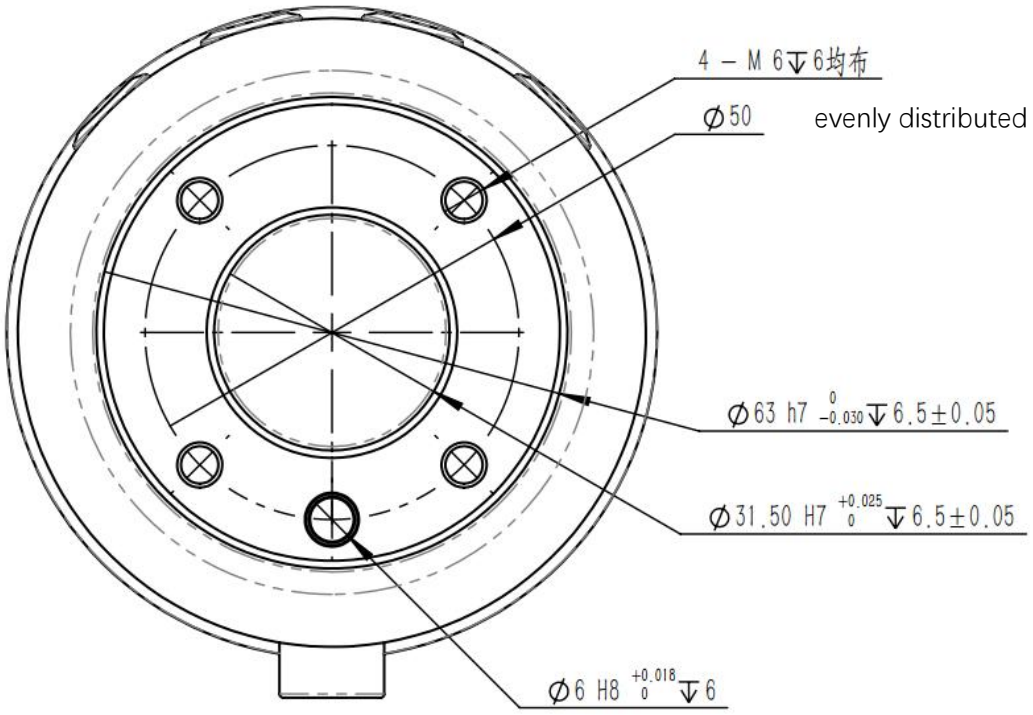


Fig. 3.6 ECR5 Tool Flange Installation Dimensions, unit mm



Danger!
The end effector installation must be firm and reliable.



Warning!
When replacing the end effector t, the risk assessment must be redone!

3.3 Electrical Interface

3.3.1 Control Cabinet Electrical Interface

3.3.1.1 Cable Interface

This control cabinet uses AC220V mains power, and the size of the circuit breaker required to supply power is 8A and above. The power interface of this control cabinet adopts a three-in-one structure of on-off switch, fuse, and filter. Pay attention when connecting to the main power supply and when troubleshooting the control cabinet.

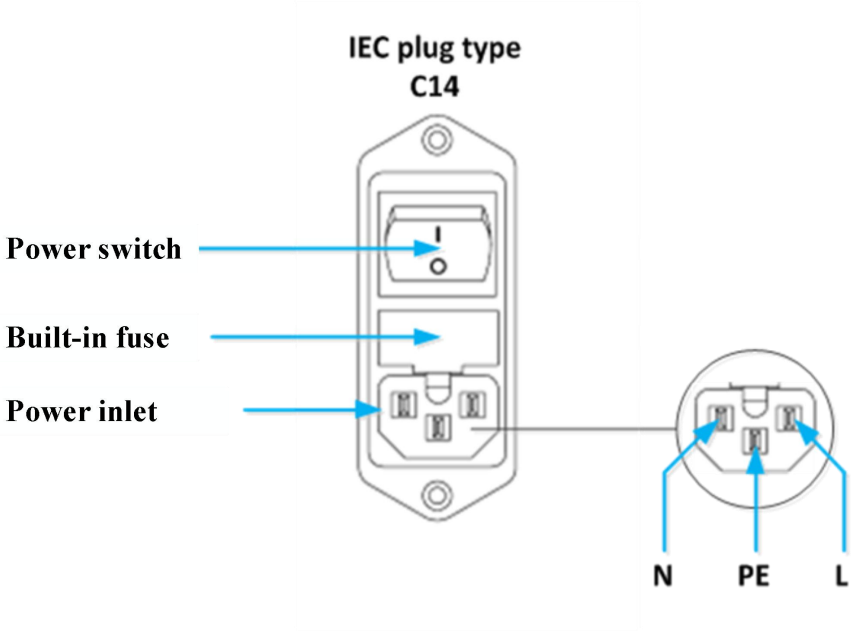


Fig. 3.7 Control Cabinet Power Interface

When there is no response after the main power supply is connected, pay attention to check whether the built-in fuse is burnt out. Please use a flat-blade screwdriver to remove the fuse storage box when the power is off, and then replace the fuse. The fuse limits the current to 8A, and the fuse specification is ordinary Φ5×20mm glass fuse.



Warning!
The inspection and replacement of the fuse must be performed when the power is off.

The power supply is equipped with the following accessories:

- Input power cord

- Mains fuse

It is recommended to install a power switch on the power supply of all equipment in the robot application to facilitate lockout and tagout during maintenance. The electrical specifications are shown in the table below.

Parameter	Minimum	Typical value	Maximum	Unit
Input voltage (AC)	-	220	-	V
External mains fuse	-	8	-	A
Input frequency	-	50	-	Hz
Rated working power	-	-	1200	W



Danger!

1. Make sure that the robot is grounded in the correct way (electrical grounding). Please use unused pins that are connected to the grounding mark in the control box to establish a common ground for all equipment in the system. The grounding connector should have at least the rated current of the highest current in the system.
2. Make sure that the input power of the control box is protected by a residual current circuit breaker (RCD) and the correct fuse.
3. Ensure that all cables are properly connected before powering on the control box. Be sure to use the original power cord.



Caution!

1. Do not disconnect the robot cable when the robot arm is turned on.
2. Do not extend or modify the original cable.

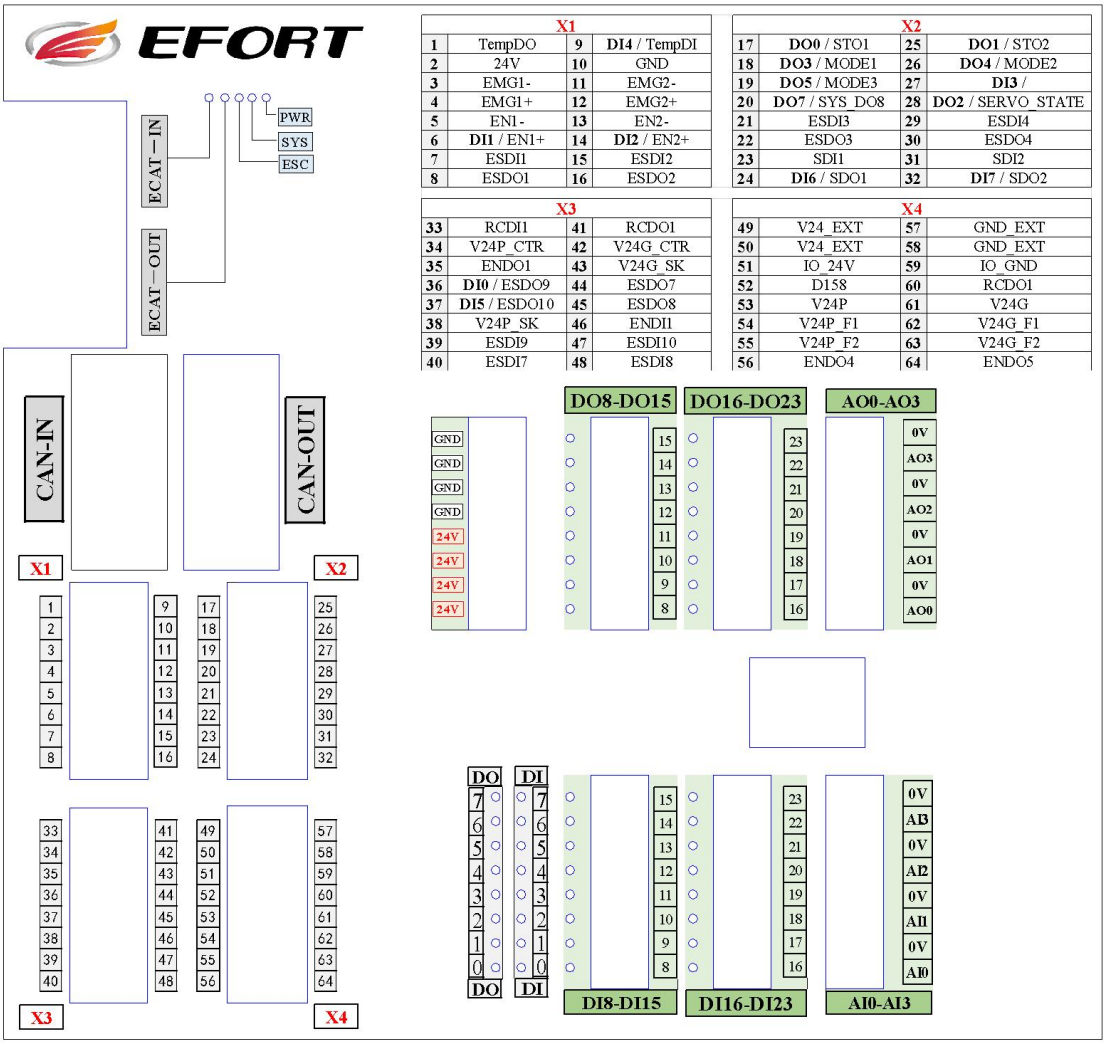
3.3.1.2 I/O Interface Board

The ECR5 robot standard control cabinet provides a variety of electrical interfaces for connecting external equipment and tools. Users can use these interfaces conveniently.

The electrical interface of the control cabinet is mainly divided into: safety I/O, general I/O and end tool I/O. There are 16 universal digital input interfaces, 16 universal digital output interfaces, 4 pairs of analog input interfaces, and 4 pairs of

analog output interfaces on the control cabinet. The analog IO can be set to work in voltage mode or current mode through software.

You can use the I/O in the control box to control various devices, including relays, PLCs, and emergency stop buttons. The following figure shows the position and function definition of each terminal of the expansion I/O interface board inside the control box:



X1			
1	TempDO	9	DI4 / TempDI
2	24V	10	GND
3	EMG1-	11	EMG2-
4	EMG1+	12	EMG2+
5	EN1-	13	EN2-
6	DI1 / EN1+	14	DI2 / EN2+
7	ESDI1	15	ESDI2
8	ESDO1	16	ESDO2

X2			
17	DO0 / STO1	25	DO1 / STO2
18	DO3 / MODE1	26	DO4 / MODE2
19	DO5 / MODE3	27	DI3 /
20	DO7 / SYS_DO8	28	DO2 / SERVO_STATE
21	ESDI3	29	ESDI4
22	ESDO3	30	ESDO4
23	SDI1	31	SDI2
24	DI6 / SDO1	32	DI7 / SDO2

X3			
33	RCDI1	41	RCDO1
34	V24P_CTR	42	V24G_CTR
35	ENDO1	43	V24G_SK
36	DI0 / ESDO9	44	ESDO7
37	DI5 / ESDO10	45	ESDO8
38	V24P_SK	46	ENDI1
39	ESDI9	47	ESDI10
40	ESDI7	48	ESDI8

X4			
49	V24_EXT	57	GND_EXT
50	V24_EXT	58	GND_EXT
51	IO_24V	59	IO_GND
52	D158	60	RCDO1
53	V24P	61	V24G
54	V24P_F1	62	V24G_F1
55	V24P_F2	63	V24G_F2
56	ENDO4	64	ENDO5

Fig. 3.8 Layout of I/O Board

Power Supply

This section mainly introduces the power supply modes that can be selected for general IO: 1. Internal self-powered, 2. External power supply.

The connector of the power interface is the X4 terminal in the I/O board layout in Fig. 3.8. See the following for specific power supply introduction.

The default configuration is to use the internal power supply (see the figure below).

X4					
V24_EXT	49	■	■	57	GND_EXT
V24_EXT	50	■	■	58	GND_EXT
IO_24V	51	■	■	59	IO_GND
DI58	52	■	■	60	RCD01
V24P	53	■	■	61	V24G
V24P_F1	54	■	■	62	V24G_F1
V24P_F2	55	■	■	63	IO_GND
END04	56	■	■	64	END05

Fig. 3.9 Default Wiring of Internal Power Supply

Note: If higher current is needed, connect an external power supply as shown in the figure below. Proceed as follows:

① Unplug the short wires between 51 and 52

② Connect external 24V+ to 51; external 24V- to 59.

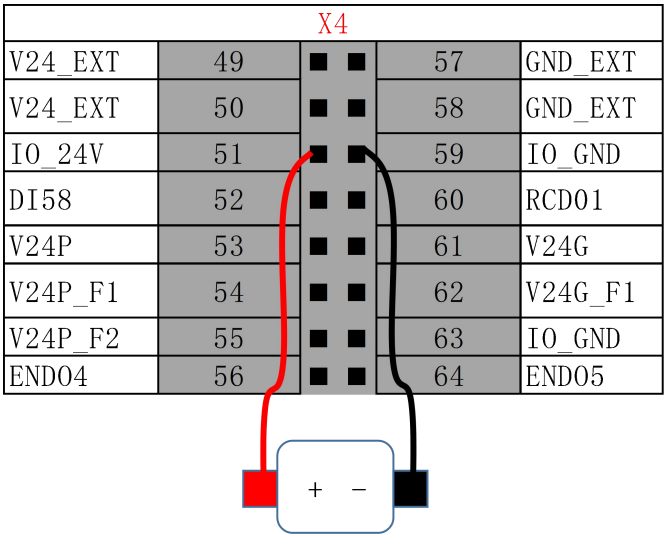


Fig. 3.10 Wiring Diagram of External Power Supply

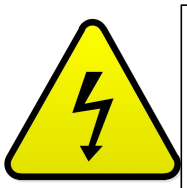
The electrical specifications of the internal and external power supplies are shown below.

Terminal	Parameter	Maximum	Typical Value	Maximum	Unit
Built-in 24V power supply [PWR - GND] [PWR - GND]	Voltage Current	23 0	24 -	25 4	V A
External 24V input [24V - 0V] [24V - 0V]	Voltage Current	20 0	24 -	29 8	V A

1) Safety I/O

This section describes the dedicated safety inputs. All safety I/Os exist in pairs (redundant) and must be kept in two independent branches. A single fault will not

cause the loss of safety functions. When in use, safety devices and equipment must be installed in accordance with the safety instructions and can be used after a comprehensive risk assessment.



Warning!

1. Do not connect the safety signal to a non-safety PLC with an inappropriate safety level.
2. Be sure to separate safety interface signals from ordinary I/O interface signals.
3. Before using the robot, the safety function must be checked, and the safety function must be tested regularly.

On the general I/O interface panel of the control cabinet, the X1 terminal is an external interface, and the functions are defined as follows:

X1					
1	TempDO	Brake circuit 24V signal	**9**	**DI4**/TempDI	Braking resistor/transformer high temperature
2	24V	TPU 24V+	**10**	GND	TPU 24V-
3	EMG1-	TPU emergency stop input 1	**11**	EMG2-	TPU emergency stop input 2
4	EMG1+	TPU emergency stop output 1	**12**	EMG2+	TPU emergency stop output 2
5	EN1-	TPU hand pressure input 1	**13**	EN2-	TPU hand pressure input 2
6	**DI1**/EN1+	TPU hand pressure output 1	**14**	**DI2**/EN2+	TPU hand pressure output 2
7	ESDI1	Panel emergency stop output 1	**15**	ESDI2	Panel emergency stop output 2
8	ESDO1	Panel emergency stop input 1	**16**	ESDO2	Panel emergency stop input 2

The electrical specifications of the external power supply are shown in the figure below.

terminal	parameter	maximum	typical value	maximum	unit
External 24V output [24V - 0V] [24V - 0V]	 Voltage Current	 - -	 24 -	 - 1.8	 V A

Ports 2, 3, 4, 5, 10, 11, 12, and 13 of the X2 terminal are safety IO interfaces, and emergency stop and protective stop interfaces are reserved externally respectively.

Default Security Configuration

The factory-built robots are all equipped with default safety configuration. As shown in the figure below, the robot can be used safely without adding additional safety equipment.

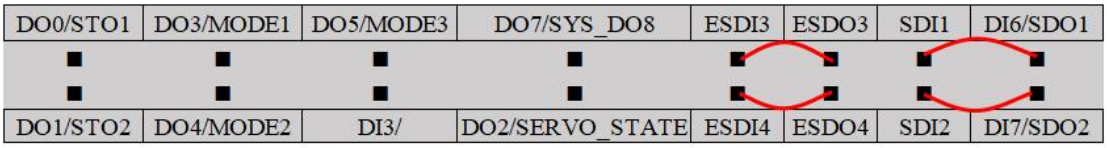


Fig. 3.11 Wiring Diagram of Safety Configuration X2 Terminal Default

External Emergency Stop Input (X2 Terminal)

When one or more additional emergency stop buttons are needed, the user can refer to the following example to connect the emergency stop button.

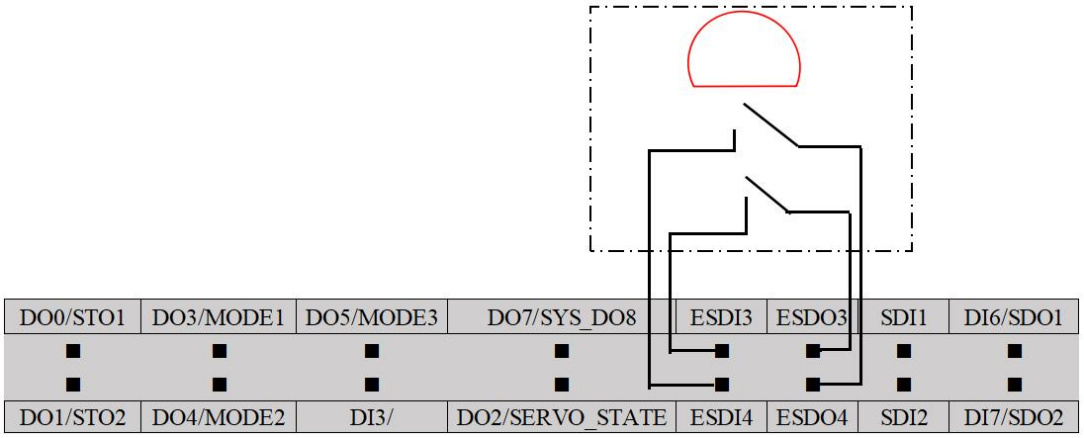


Fig. 3.12 Wiring Diagram of External Emergency Stop

Protective Stop Input (X2 Terminal)

Through this interface, users can connect external safety equipment (such as safety light curtains, safety laser scanners, etc.) to control the mechanical arm to enter the protection stop state and stop movement. When configuring a protective stop that can be reset automatically, the user can refer to the following example and use a safety gate to connect to the protective stop input interface. See the figure below.

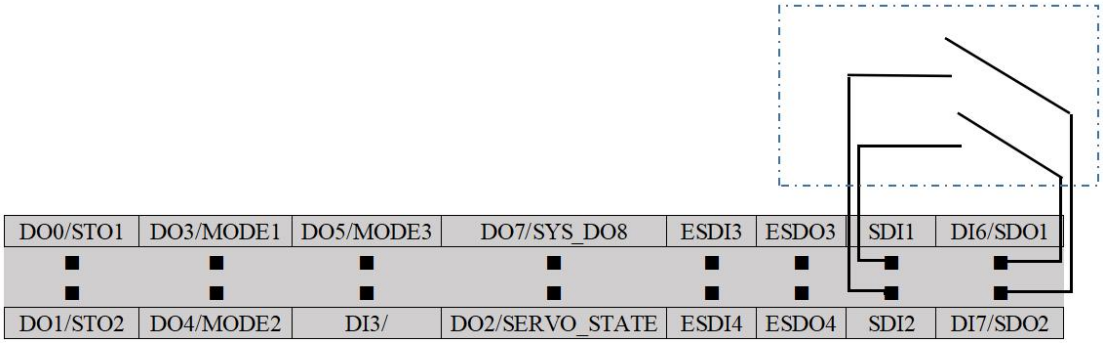


Fig. 3.13 Wiring Diagram of External Protective Stop

2) **General Digital I/O**

This section introduces the use of general 24V I/O and related electrical parameters. General-purpose I/O can be used to directly drive equipment such as

pneumatic relays, or to communicate with other PLC systems. The following sections give a few examples. These examples use regular digital outputs.

The construction of digital I/O follows IEC 61131-2. The electrical specifications are as follows.

Name	Digital output (DO)
Output current	Minimum 0 Typical value 0.5A Maximum 0.7A
Output type	PNP
Voltage drop	Minimum 0 - Maximum 0.67V
Input name	Digital input (DI)
Input low level range	-3~5V
Input high level range	11~30V
Rated input current	2.32mA
Output type	PNP
IEC 61131-2	Type3

For a load controlled by a digital output, this example illustrates how to control the load by a digital output when the load is connected.

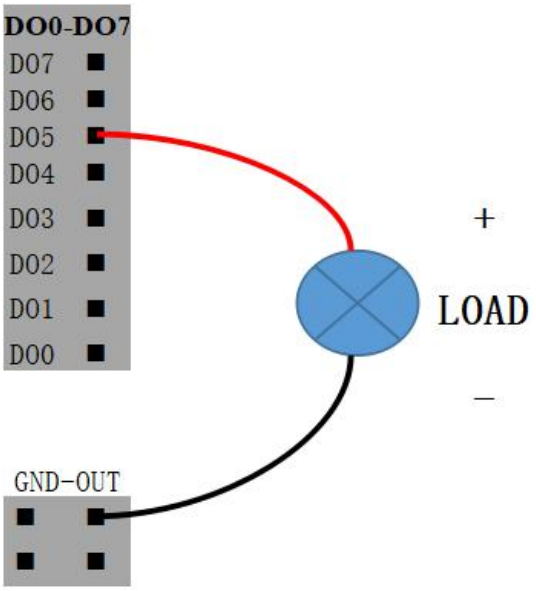


Fig. 3.14 Example of Load Digital Connection

For digital input from buttons, this example illustrates how simple buttons are connected to digital inputs.

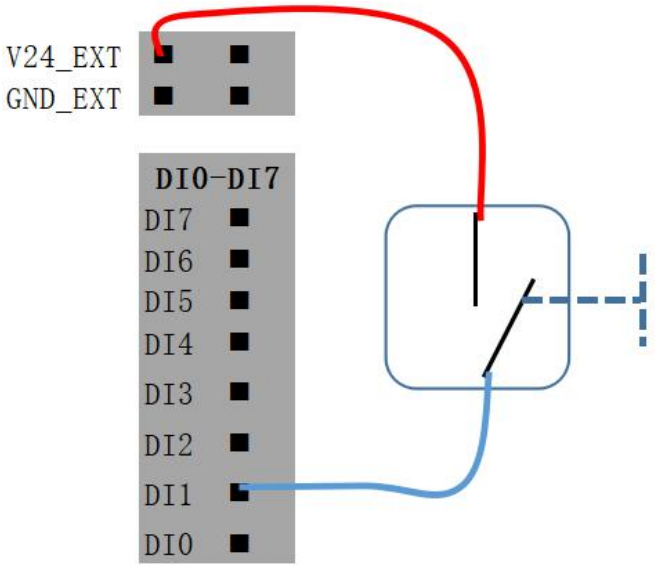


Fig. 3.15 Example of Button Digital Connection

3) Analog I/O

The analog I/O interface can be used to set or measure the voltage (0-10V) or current (4-20mA) entering and leaving other devices. For the highest accuracy, the following instructions are recommended:

- The equipment and the control box use the same grounding terminal (0V). The analog I/O is not galvanically isolated from the control box.
- Use shielded cables or twisted pairs. Connect the shielded wire to the ground terminal at the power terminal.
- Use equipment that works in current mode. The sensitivity of the current signal is lower than that of the interface.

The input mode can be selected in the graphical user interface. The electrical specifications are as follows.

Name	Analog Input (AI)
Resolution	12 bits
Voltage input	0~10V
accuracy	0.20%
Voltage input impedance	10.07MΩ
Current input	0~20mA
accuracy	0.20%
Current input impedance	251.2Ω

The electrical specifications for using analog output are shown below.

Name	Analog Output (AI)
DA resolution	12 bits
Voltage output	0~10V
Voltage output load resistance	≧1kΩ
Voltage output impedance	2kΩ
Voltage output accuracy	0.2%
Current output	0~20mA
Current output load resistor	≦1kΩ
Current output impedance	∞
Current output accuracy	0.20%

This example shows how to use analog signals to control peripherals.

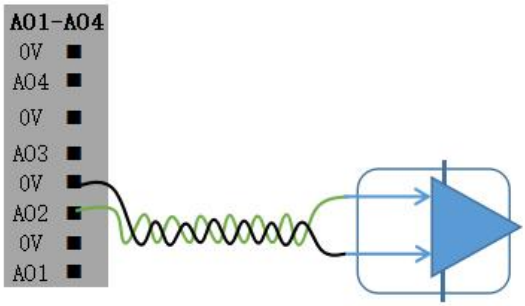


Fig. 3.16 Example of Analog Output Device Connection

This example shows how to connect an analog sensor.

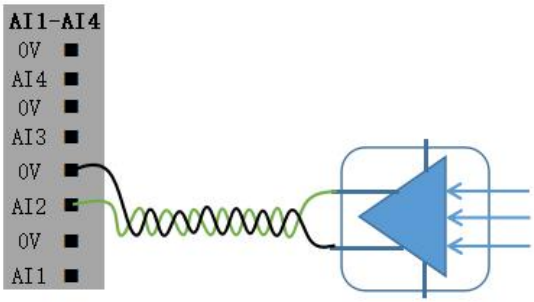


Fig. 3.17 Example of Analog Input Device Connection

3.3.1.3 Communication Interface

The communication interface can be used for:

- EtherCAT
- IO control and remote IO connection.

The electrical specifications are shown in the table below.

	Minimum	Typical Value	Maximum

Communication speed	-	100Mb/s	-

3.3.2 Connection between the Control Cabinet and the manipulator

The ECR5 manipulator and the control cabinet are connected by cables. The cable drawings are as follows (the "CTRL" terminal is connected to the control cabinet, and the ROB terminal is connected to the manipulator):

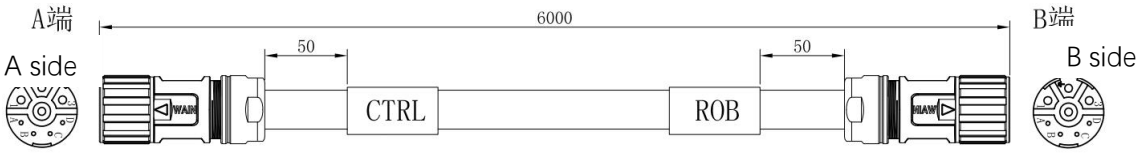


Fig. 3.18 Manipulator Cable



Danger!

When connecting the robot to the control cabinet, make sure that the control cabinet is powered off and the manipulator is fully grounded, otherwise it may cause electric shock!

3.3.3 Tool Flange Electrical Interface

The ECR5 tool flange is equipped with communication, I/O and power supply interfaces as follows:

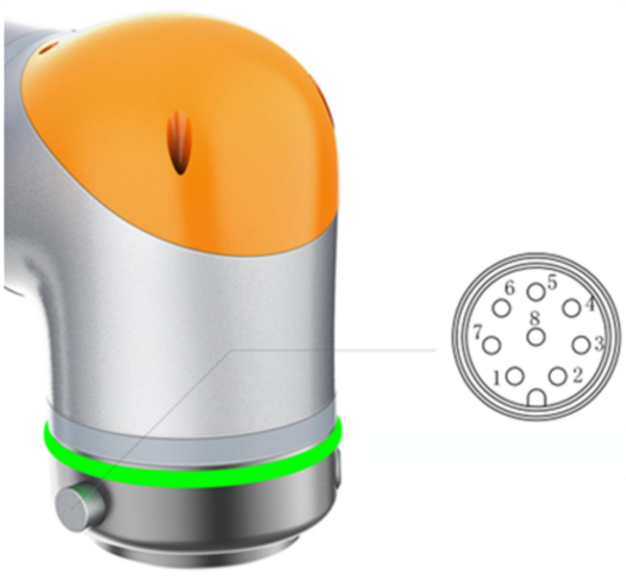


Fig. 3.19 Schematic Diagram of Electrical Interface of Tool Flange

ECR5 tool flange electrical interface quantity, specification and pin definition are as follows:

Features	Quantity, Parameter	Pin Definition

Digital output	2，600mA	PIN3、PIN4
Analog input	2，4-20mA/0-24V	PIN7、PIN8
Power output	DC12V/24V,1A	PIN2（GND）、PIN1（12V/24V）
Digital input	2，0-24V	PIN5、PIN6



Warning!

Recommend to use the connector delivered together with the robot, please contact EFORT for support when select other connectors, otherwise it may cause damage to the equipment!



Warning!

Please strictly follow the pin definition for wiring, otherwise it may cause equipment damage and personal injury!

* It is strongly recommended to use protection diodes for inductive loads

Tool Digital Output

The digital output is realized in the form of NPN. After the digital output terminal is activated, the corresponding connector will be driven to GND. After the digital output terminal is disabled, the corresponding connector will be in an open circuit (open collector/open drain). The electrical specifications are as follows:

Parameter	Minimum	Typical Value	Maximum	Unit
Voltage at open circuit	0	-	voltage	V
Voltage when input 1A current	-	2.6	-	V
Input Current	0	-	600	mA
Current through GND	0	-	600	mA



Caution!

When replacing the end effector, a new risk assessment is required!

This example shows how to turn on a load that uses an internal 12V or 24V power supply. The output voltage of the I/O option card must be defined. Even if the

load is turned off, there is still voltage between the power connector and the protective cover/ground.

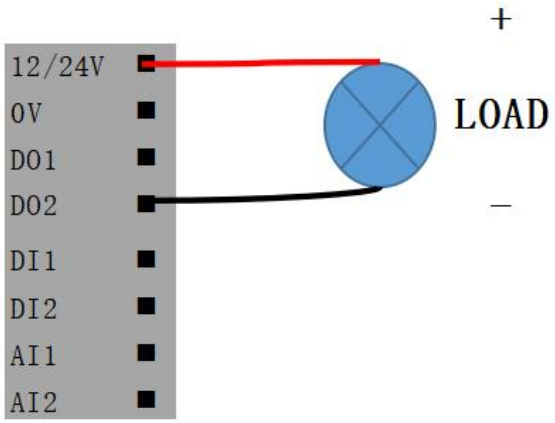


Fig. 3.20 Wiring Diagram of Tool Output Load

Tool Digital Input

The digital input is equipped with a pull-up resistor, which means that the reading of the floating input is always high. The electrical specifications are as follows.

Parameter	Minimum	Typical Value	Maximum	Unit
Input voltage	-0.5	-	24	V
Logic low voltage	-	2.1	-	V
Logic high voltage	-	4.1	-	V
Input resistor	-	106K	-	Ω

Use tool digital input. This example illustrates how to connect a simple button.

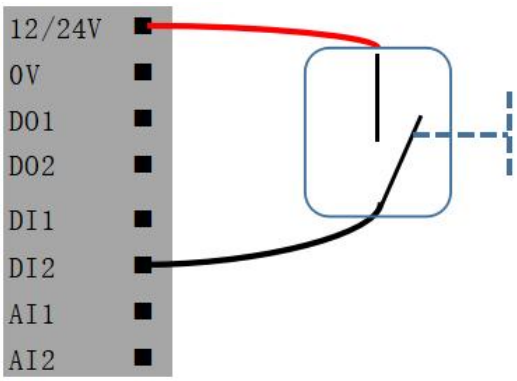


Fig. 3.21 Wiring Diagram of Tool Digital Input

Tool Analog Input

The end tool analog input is a non-differential input, which can be configured as voltage (0-24V) or current (4-20mA) on the teach pendant. The electrical specifications are as follows.

Parameter	Minimum	Typical Value	Maximum	Unit
Input voltage in voltage mode	0	-	24	V
Input resistance in the voltage range of 0V-24V	-	11.5K	-	Ω
Input current in current mode	4	-	20	mA
Input voltage in current mode	0.8	-	4	V
Input resistance in the current range of 4mA-20mA	-	200	-	Ω

Examples of how to use analog inputs are given in the following sections.



Caution!

1. In current mode, the analog input does not provide over-voltage protection. Exceeding the limit in the electrical specification may cause permanent damage to the input.

This example shows the connection of an analog sensor with a non-differential output. The input mode setting of analog input can be set to current mode or voltage mode. The factory default mode is voltage input mode.



Attention!

Check and make sure that the sensor with voltage output can drive the internal resistance of the tool, otherwise the measured value may be invalid.

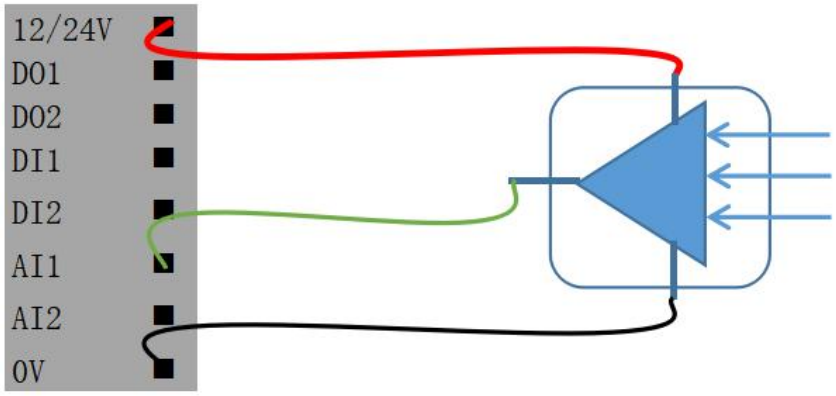


Fig. 3.22 Wiring Diagram of Tool Analog Input

Chapter 4 Transportation

4.1 Lifting and Handling

When hoisting the ECR5, fix the joints firmly to avoid bumps and scratches. When hoisting, avoid direct contact between the cable and the manipulator. The body and the cable can be separated by paper, rubber pads, etc., to avoid damage to the appearance.

The ECR5 body is light and can be moved manually when there is no corresponding hoisting equipment. It should be handled gently to prevent bumps. Place the robot gently on the mounting base. Hold the manipulator firmly and loosen it after the base mounting screws are tightened.

It is recommended to use the original packing box for long-distance transportation of ECR5. The original packaging box has sufficient protection function, which can effectively suppress the vibration during transportation and reduce the damage to the robot caused by long-distance transportation.



Caution!

Avoid vibrations during transportation to prevent damage to the manipulator!

Chapter 5 Repair and Maintenance

5.1 Maintenance and Repair

To enable the robot to maintain high performance for a long time, maintenance inspections must be carried out.

The repair and maintenance of the ECR5 collaborative robot must strictly implement all the safety regulations in this manual.

The repair work of ECR5 must be carried out by the integrator authorized by Efort and the after-sales team. Do not repair it privately or hand it over to an unauthorized repair unit or individual

5.1.1 Regular Maintenance

5.1.1.1 Quarterly Maintenance

No.	Item	Point
1	Control unit cable	Check whether the teach pendant cable is improperly twisted.
2	Ventilation unit of control unit	If the ventilation unit is dirty, cut off the power supply and clean the ventilation unit.
3	Cables in the mechanical unit	Check whether the socket of the mechanical unit is damaged, whether it is bent abnormally, and whether the connection between the manipulator and the control cabinet cable connector is reliable.
4	Cleaning and maintenance of various parts	Check whether there is a problem with the component, and deal with it.

5.1.1.2 Annual Maintenance

No.	Item	Point
1	Cleaning and maintenance of various parts	Check whether there is a problem with the component, and deal with it.
2	Tightening of external main screws	Tighten the end effector screws and external main screws.

5.1.2 Joint Slip Compensation

ECR5 has a joint slip compensation function. When the robot is in a vibrating environment for a long time, after sufficient regular maintenance, the robot is also required to perform joint slip compensation. The joint slip compensation function is the calibration operation of the manipulator to the joint accuracy, which can ensure the robot repeated accuracy during long-term operation (refer to "ECR5 Robot User

Manual-Teach Pendant System" Installation Setting Tab/General/Joint Slip Compensation Function).



Warning!

Please follow the user manual to use the self-maintenance function, otherwise it may cause serious damage to the equipment or personal injury!

5.2 Disposal



Caution!

Do not disassemble the board and components of the control device before disposing of it.
Sharp parts such as cracks or cuts, wires, etc. may cause injury.



Caution!

After the cables and external wiring are removed from the connector and junction box, do not disassemble them further and then discard them. Otherwise, damage may be caused by conductors, etc.



Caution!

When disposing of it, be careful not to get pinched or injured.



Caution!

Discarded products should be discarded in a safe state.

Chapter 6 Quality Assurance

6.1 Product Quality Assurance

EFORT Intelligent Equipment Co.,Ltd.(hereinafter referred to as "EFORT") provides 12-month warranty period for ECR5 collaborative robot.

Within 12 months after ECR5 is officially put into use (including transportation time, the longest period no more than 15 months), if failure /defect occurs due to robot manufacturing or poor materials, EFORT shall provide the user (customer) with necessary backup parts or repair corresponding parts.

If the product exceeds the warranty period, EFORT reserves the right to charge the user (customer) for replacement or repair.

Outside the warranty period, if the equipment fails / defects, EFORT shall not be liable for any damage or loss caused by it, such as production loss or damage to other production equipment.

6.2 Disclaimers

The premise of "product quality assurance" is the correct and proper use of the robot. If the equipment defects are caused by abnormal operation or improper handling, the quality assurance will be invalid.

Robot failures and defects caused by the following conditions are not covered by the warranty:

1. Install and use other control equipment that does not meet industrial standards
2. Other control equipment is not installed and connected according to the user manual
3. The use and working conditions are beyond the specification and standard range specified in this manual;
4. Refit or dismantle the robot without authorization
5. Product damage caused by improper storage and transportation
6. Product damage caused by equipment maintenance, modification and debugging by an unauthorized third party;
7. Product damage caused by accident or collision
8. Product damage caused by force majeure such as fire, earthquake, tsunami, lightning, gale and flood
9. Other product defects and failures which are not caused by EFORT Intelligent Equipment Co., Ltd

The following conditions are not covered by the warranty:

1. Unable to identify production date or warranty start date

2. Unauthorized changes to software or internal data
3. The fault cannot be reproduced or identified by EFORT Intelligent Equipment Co., Ltd
4. The use of product in high-intensity magnetic equipment, radioactive equipment, biologically hazardous chemical equipment or other dangerous uses determined by EFORT Intelligent Equipment Co., Ltd

According to the product quality assurance agreement, EFORT Intelligent Equipment Co., Ltd. only undertakes to guarantee the defects and defects in the products and parts sold by authorized dealers.

Any other express or implied warranty or liability, including but not limited to the implied warranty of merchantability or specific purpose, shall not be borne by EFORT Intelligent Equipment Co., Ltd.

Chapter 7 Getting Started

7.1 Robot Power-on

7.1.1 Check before Power -on

Due to the properties of the robot system, the space between the manipulator and the external equipment must be checked before the robot is powered on. The joints of the robot will be slightly adjusted before the servo is enabled.



Caution!

Before the servo is enabled, please ensure that the gap between the robot and peripheral equipment and operators is more than 10cm .

7.1.2 Power -on

After above checking finished, turn on the main electric switch on the control cabinet, boot the cabinet and teach pendant, then log on the system, press the physical "PWR" button on teach pendant to enable the servo if no system error/warning popped out.

7.2 Robot Power-off

7.2.1 Check before Power-off

Due to the properties of robot system, there is a brake clearance in the robot brake, so the space between the manipulator and the external equipment should be fully checked before power off.



Caution !

Be sure to move the end effector out of the working area before power off, and keep a certain distance from other obstacles, so as to avoid the damage of equipment and work piece when power off.

7.2.2 Power -off

After the robot space inspection, press the physical "PWR" button on teach pendant to disable servo, and then turn off the main electric switch on the control cabinet.

7.3 Drag Teaching

7.3.1 Point Drag Teaching Procedure

① Make sure that the key switch of the robot is selected in the automatic gear and the robot has got the servo motor.

② Make sure that the installation mode, load selection and quality of the robot are correct.

③ Press the mode switch button to switch to the point drag teaching mode (the green light flashes).

④ Press the drag confirmation button to turn on. If the operation setting or dynamic parameters are not accurate, it will be unable to drag and the alarm will pop up. At the same time, the robot will switch back to normal mode and the button light will go out.

⑤ When you drag it to a suitable position, you can press the teaching record button, and the robot will insert the current position in the program. The form of insertion (Joint or Cartesian) depends on the interface settings; After inserting, the light band will flash in the form of green breathing light, and it will automatically turn off after 3 seconds.

⑥ After completing the drag teaching, you can click the mode switch button to return to the normal mode.

7.3.2 Path Drag Teaching Procedure

① Make sure that the key switch of the robot is selected in the automatic gear and the robot has got the servo motor;

② Make sure that the installation mode, load selection and quality of the robot are correct;

③ Press the mode switch button to switch to the point drag teaching mode (the green light is always on);

④ Press the drag confirmation button to turn on. If the operation setting or dynamic parameters are not accurate, it will be unable to drag and the alarm will pop up. At the same time, the robot will switch back to normal mode and the button light will go out;

⑤ When dragging to the position where the track needs to be recorded, press the teaching record button, and the green light is always on. The robot will save the position of each joint of the robot to the track data file in time;

⑥ After completing the drag teaching of the track, press the teaching record button again, and the button light goes out to save the track data file. At the same time, the program will insert this section of track motion instructions automatically;

⑦ After completing the whole drag teaching, you can return to the normal mode by pressing the mode switch button.

Appendix

A Mounting Screw Tightening Torque

A.1 Tightening Torque of Hexagon Socket Screw

12.9 level	(N-m)Tightening torque of steel parts	(N-m)Tightening torque of aluminum parts
M3	2±0.18	1.57±0.18
M4	4.5±0.33	3.63±0.33
M5	9.01±0.49	7.35±0.49
M6	15.6±0.78	12.4±0.78
M8	37.2±1.86	30.4±1.86
M10	73.5±3.43	59.8±3.43
M12	128.4±6.37	104±6.37



Caution!

Do not exceed the specified tightening torque, otherwise the equipment may be damaged!

B Technical Terms

Stop Category 0

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 ISO 13850 or IEC 60204-1.

Stop Category 1

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 as soon as the robot stands still. For more information, see ISO 13850 or IEC 60204-1.

Stop Category 2

A controlled stop with power left available to the robot. The safety-related control system monitors that the robot stays at the stop position. For more information, see IEC 60204-1.

Stop Category 3

The term Category should not be confused with the term Stop Category. Category refers to the type of architecture used as basis for a certain Performance Level. A significant property of a Category 3 architecture is that a single fault cannot lead to loss of the safety function. For more information, see ISO 13849-1.

Risk Assessment: risk assessment is the whole process of identifying all risks and reducing them to an appropriate level.

Risk assessment shall be documented. Please refer to EN ISO 12100 for details.

Integrator: the integrator is the organization responsible for designing the final installation of the robot.

The integrator is responsible for the final risk assessment and must ensure that the final installation complies with local laws and regulations.

Cooperative robot application: the term cooperation refers to the cooperation between operator and robot in robot application.

See ISO 10218-1 and ISO 10218-2 for accurate definitions and descriptions.

C Stopping Time and Stopping Distance

See stopping time/distance for emergency stop at max speed, max stretched out and max load in below table.

Joint 1 test was conducted by performing a horizontal movement, where the rotational axis was perpendicular to the ground.
In the Joint 2 and Joint 3 tests, the robot moving in a vertical trajectory, where the rotational axes were parallel to the ground, and the stop was performed while the robot was moving downward.

All results are from tests on one moving axis. All stop distances are valid for floor mounted robot, without any tilting.

	Joint 1 (Base)	Joint 2 (Shoulder)	Joint 3 (Elbow)
Stopping time（s）	0.33	0.33	0.32
Stopping distance（°）	30	27	27

D Maximum Payload

The rated payload of the manipulator depends on the center of gravity offset of the payload, see below figure of the load diagram.
The center of gravity offset is defined as the distance from the center of the tool flange to the center of gravity of the attached payload.

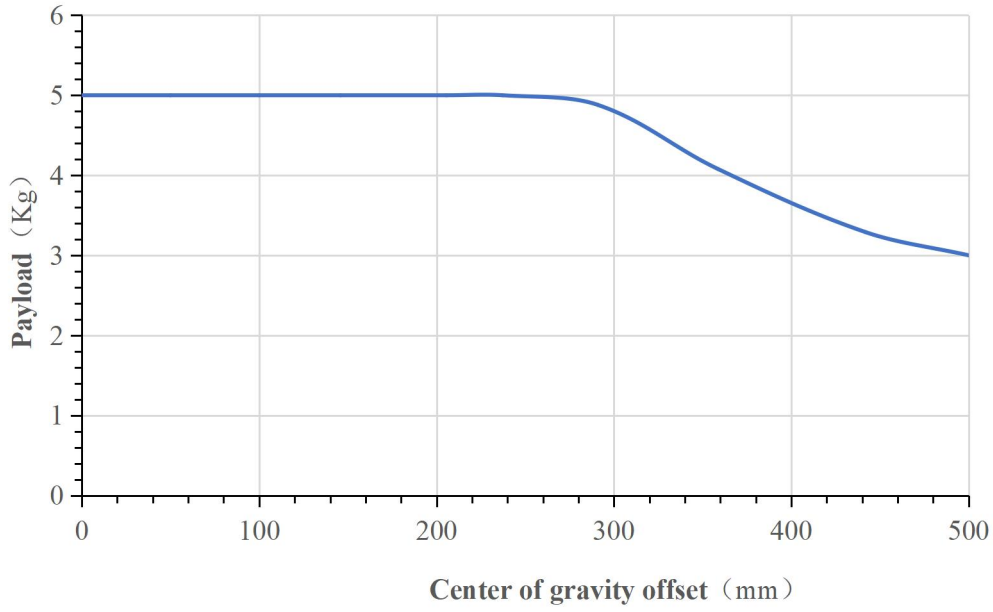


Fig.D.1 Load diagram

E Technical Specifications

Manipulator		
Type	ECR5	
DOF	6	
Payload	5kg	
Weight	20.5kg	
Reach	928mm	
Position repeatability	±0.03mm	
Maximum speed	2.5m/s	
Power supply	DC48V	
Stand-by power consumption	≤200W	
Maximum power consumption	≤1.2kW	
Environmental requirement	0-50℃，5-95%(no condensation)	
IP Grade	IP54	
Work range	Axis 1 rotation	±180°
	Axis 2 arm	±180°
	Axis 3 arm	±160°
	Axis 4 wrist	±180°
	Axis 5 wrist	±180°
	Axis 6 wrist	±360°
Rated speed	Axis 1 rotation	150°/s
	Axis 2 arm	150°/s
	Axis 3 arm	150°/s
	Axis 4 wrist	180°/s
	Axis 5 wrist	180°/s
	Axis 6 wrist	180°/s
End tool	Digital Input	2
	Digital Output	2，12V/24V，600mA
	Analog Input	2，4-20mA/0-24V
	Power-up Output	DC12V/24V,1A
Cabinet		
Cabinet Type	CRC10	
Dimension	430mmx380mmx210mm	

Weight	17kg	
Communication	EtherCAT，ProfiNet，Modbus/TCP，Ethernet/IP etc.	
Power supply	AC220V±10%，50~60Hz	
IO ports	Digital Inputs	16，PNP
	Digital outputs	16，Max600mA
	Analog inputs	4，0-20mA/0-10V
	Analog outputs	4，0-20mA/0-10V

Service Hotline: 4000528877

The rated power, specifications, and external dimensions of this product are subject to change without notice if they need to be improved. The technical data and illustrations are for reference only, and the right to change is reserved.

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