JAKA 节卡

JAKA ROBOTICS

Force Control Products

JAKA Se and JAKA Sp

JAKA 节卡

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User Manual for Force Control Products

JAKA Se and JAKA Sp

Version: 3.1.0
Applicable to products with control cabinet versions 1.5.13.32/1.7.0.38 or later

CAUTION:

Our cobots follow international ISO standards and relevant provisions of Chinese standards to protect the safety of operators. We do not recommend their direct application to the human body. However, when the human body is involved as the operation object, robot users or application developers need to configure a safe and reliable, fully tested and certified safety protection system for the robot based on a comprehensive evaluation to safeguard relevant personnel.

Regular revision and improvement of the JAKA user manual may be made without further notice. Please carefully verify the actual product information before using this manual.

The information contained in the user manual is not a commitment by JAKA. JAKA will not be held liable for any mistakes in this manual or for any accidents or indirect injuries resulting from the use of this manual and relevant products. Please carefully read this manual before installing and using the product.

The pictures in this manual are for illustration purposes only, and all product information is subject to the actual products.

JAKA will not provide after-sales service for products that have been modified or disassembled in any way.
Be sure to wear PPE to use and repair JAKA robots in compliance with safety regulations.
Programmers, system designers and debuggers of JAKA robots must be familiar with the programming and system integration of JAKA robots.

How to Read This Manual

This manual primarily provides information on safety precautions, installation and maintenance procedures, and software usage for force control products.

This manual will be a big help in both installation and operation to users with basic mechanical and electrical knowledge.

More Information

To learn more about our products, please scan the QR code on the right to visit our website: www.jaka.com.

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Preface

JAKA Robotics is at your service. Your Thoughts, Our Reach.

The JAKA Zu s series cobot force control products are configured with industrial-grade force sensors integrated with proprietary force control algorithms to improve the perception, human-robot interaction experience and safety of cobots. Our products' advantages include:

- Improving the human-robot interaction experience and safety;
- Real-time demonstration of external contact forces on the robot in the software interface;
- Setting safe contact force and force control parameters in the software interface;
- With Se series products utilizing end sensors, providing constant force control and compliant traction teaching for the robot end;
- With Sp series products utilizing base sensors, providing collision detection and compliant traction teaching for the whole robot.

Note: JAKA Zu s series cobots cannot be equipped with end sensors and base sensors at the same time.

What Do the Boxes Contain

The JAKA Zu s series cobot products include a standard robot product package and a force control product package. The latter one contains the following items:

Item	Quantity
Force Sensor	1 piece
Connecting Cable and Accessories	1 set

1. Product Introduction

1.1. Introduction

As labor costs continue to rise, industries such as 3C, pharmaceuticals, food, and logistics are beginning to seek help from robotic automation solutions. These emerging industries are characterized by a wide range of products, rapid iterations and high flexibility requirements for operators. To enable robots to work together with humans, it is necessary to enhance the perception of robots. Therefore, force sensors for robots were developed.

Our industrial-grade force sensors are integrated with proprietary force control algorithms to enhance the robot perception and the interaction experience with cobots. As shown in Figure 1-1, our Se series force sensor is installed on the end flange of the robot to transmit the force value to the control cabinet in real time. When its end effector is subjected to external force, the robot will adjust its end position and posture to adapt to the force. At the same time, you can directly drag the robot end to change its position and posture.

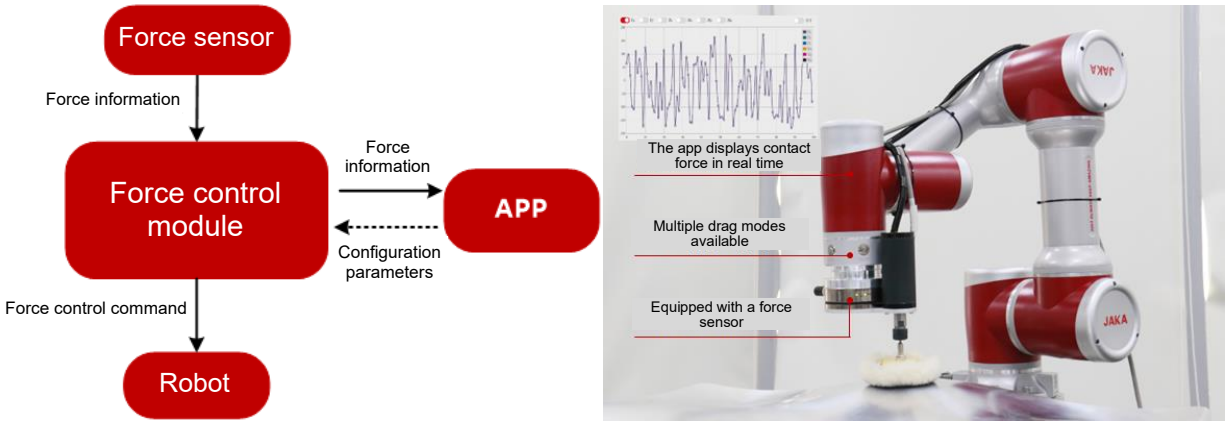


Figure 1-1 JAKA Force Control Function

1.2. Product Types

The JAKA Zu s series includes Se and Sp:

Se series: end force control sensor, as shown in Figure 1-2.

- A 6D/1D force sensor installed at the robot end
- Real-time perception of external contact forces
  - 6D force sensor: Fx, Fy, and Fz dimensional forces and Mx, My, and Mz dimensional torques
  - 1D force sensor: Fz dimensional force
- Compliant traction teaching for the end
- A variety of force control modes such as constant force and speed
- Easy to configure, debug, and program

Figure 1-2 Se Series

Sp Series: base force control sensor, as shown in Figure 1-3.

- A 6D force sensor installed on the robot base
- Real-time perception of external contact forces (Fx, Fy, and Fz dimensional forces and Mx, My, and Mz dimensional torques)
- Traction teaching for the whole robot in three directions
- Enhanced safety through full-body collision detection
- Easy to configure, debug, and program

Figure 1-3 Sp Series

1.3. Safety Regulations

All safety regulations for JAKA Zu series standard robots are applicable to JAKA force control products. Please carefully read and strictly follow them. This section mainly introduces additional safety principles and regulations that should be observed when using force control products. Please carefully read the safety-related contents in this manual and strictly abide by them. Operators should be fully aware of the complexity and danger of robotic systems, and pay special attention to the content with warning symbols.

1.3.1. Description of Warning Symbols

In this manual, the following warning symbol indicates content related to hazards. Please strictly observe it.

WARNING:
This indicates an imminently hazardous situation that, if not avoided, could result in serious injury or death.

1.3.2. Safety Precautions

1. The force sensor must be installed and used in accordance with the instructions and warnings in this manual.
2. Please protect the force sensor or any tools attached to it from collision, regardless of whether the sensor is powered on or off.
3. When using the robot, please ensure that the emergency stop button is clearly visible and easily reachable.
4. After installing and configuring the sensor hardware for the first time, removing and installing it, or recovering from a fault, please check whether the readings of the force sensor are normal and initialize it properly before using the force control function.
5. Avoid using the force control function between rigid surfaces without a buffer device.

1.3.3. Liabilities and Risks

Liabilities

This manual does not cover all applications for designing, installing and operating robots, nor does it cover all peripherals that may affect the safety of robotic systems.

JAKA's integrators have the responsibility to make sure the entire robotic application is free from significant risks and complies with relevant national laws and regulations.

The safety information in this manual should not be considered as a guarantee from JAKA. Even if all safety instructions are observed, injury to operators or damage caused by operators may still occur.

JAKA constantly strives to improve the performance and reliability of our robots. JAKA is not liable for any errors or omissions in this manual and reserves the right of final interpretation of this manual.

Risks

Operators will directly or indirectly contact the robot when interacting with it. Operators must take safety measures when contacting the robot, and integrators need to carefully consider the operating conditions when using JAKA's robots. The following dangerous situations may occur:

The uncontrolled motion of the robot end caused by a damaged force sensor;

The uncontrolled motion of the robot due to the incorrect readings of a force sensor that has been installed or initialized improperly;

Sensor damage caused by violent external impact on the robot.

2. Hardware Installation

2.1. JAKA Zu Se Hardware Installation

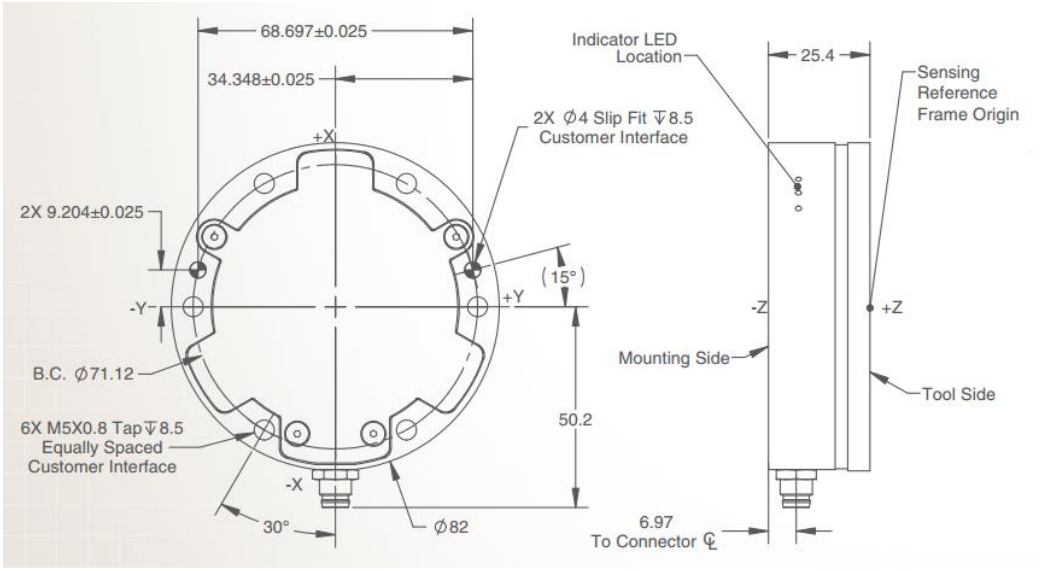
2.1.1. Type I Force Sensor

2.1.1.1 Overview

The strain-type six-axis F/T sensor can measure the forces and torques in 3 directions simultaneously. The sensor senses relative deformation between the "tool end flange" and the "main body" caused by the force exerted on it, and then measures the change in its elastic element with a resistance strain gauge. The sensor contains a high-precision and highly-responsive embedded system, which can acquire and analyze changes in signals from the resistance strain gauge as well as output the magnitude and direction of the applied force in real time. Please install the sensor properly so as not to interfere with the output quality.

2.1.1.2 Sensor Installation

The mounting holes and dimensions of the sensor are shown in Figure 2-1.



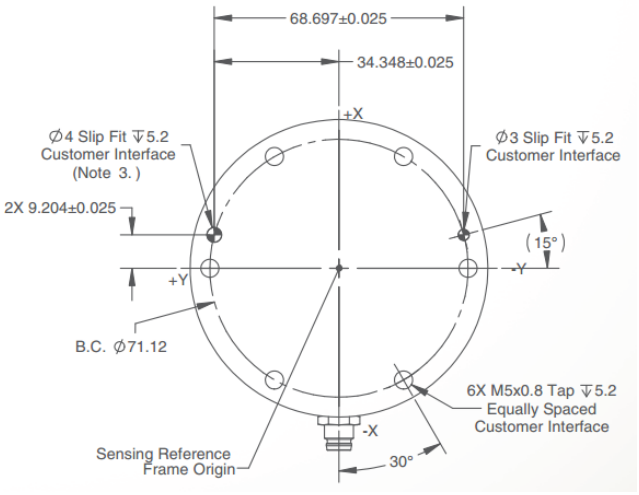


Figure 2-1 Dimensions of the Sensor

a. Please ensure that the surfaces of the robot end, adapter plate and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.
b. Separate the sensor from the adapter plate, and then install the adapter plate to the robot end flange. Before installing the sensor, please perform a pre-installation to keep the XY directions of the sensor coordinate system consistent with that of the robot end flange coordinate system, that is, to keep the direction from the center of the robot end flange to the TIO () consistent with the -Y direction of the sensor. Inconsistent installation directions may affect subsequent use.
c. Fasten the sensor to the adapter plate. Tighten the six M5 hexagon socket screws gradually and diagonally for uniform contact between the sensor and the adapter plate.
d. Connect the output flange to the sensor output end. The mechanical interface of the output flange is identical to that of the robot end flange.

The connections and installation of the sensor to the robot end are shown in Figure 2-2.

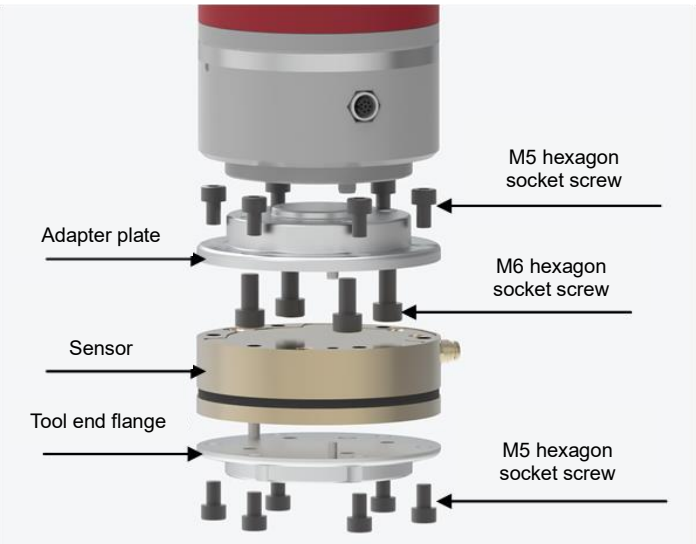


Figure 2-2 Sensor Installation

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

2.1.1.3 Wiring of the Sensor

This sensor is connected via a network cable. Ensure the robot and the sensor are configured with the same network segment. An independent gigabit router is recommended to guarantee the signal quality. You can also set the Network Port IP at the bottom of the electric control cabinet (hereinafter referred to as CAB) to be the same as that of the sensor. For the specific configuration method, please refer to the instructions in the "JAKA Zu Se System Construction" section of Chapter 3.

Note: This sensor requires a 24V DC power supply from the internal power of the CAB or an additional power source.

WARNING:

Before securing the sensor wiring harness with cable ties, be sure to check that attached peripherals do not interfere with the robot's operational trajectory, so as to prevent the robot from pulling the wiring harness during operation and thus causing irreversible damage to the sensor.

2.1.1.4 Sensor Specifications

The sensor specifications of type I are as follows:

Table 2-1 Sensor Specifications of Type I

Fx/Fy (N)	200	Fz (N)	360
Mx/My (Nm)	8	Mz (Nm)	8
Overload (%)	500	Accuracy (%)	0.5
Power Voltage (V)	12–24	IP Rating	IP64
Operating Temperature (℃)	5–80	Communication Interface	Network Port

2.1.1.5 Precautions for Use

a. Do not use in any environment with temperature or humidity beyond the allowable range.

b. The cable must be connected properly. Before powering on the sensor, please check whether the cables are connected according to the colors indicated in this manual. A wiring mistake could cause a shortcircuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.

c. The sensor has built-in precision components such as embedded systems. Although we have carried out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.

d. Do not strike or knock the sensor when installing it, especially when installing it onto the adapter plate. If the mounting clearance is tight due to the processed adapter plate, avoid striking or knocking the sensor as it might result in damage.

e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.

f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.

g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.1.1.6 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for sensor mounting bolts are as follows:

Table 2-2 Reference Tightening Torques for Sensor Mounting Bolts

Metric	**Reference Tightening Torque (Nm)**
M2	0.4

M3	2.0
M4	4.0
M5	8.0
M6	13.0
M8	35.0

2.1.2. Type II Force Sensor

2.1.2.1 Overview

The strain-type six-axis F/T sensor can measure the forces and torques in 3 directions simultaneously. The sensor senses relative deformation between the "tool end flange" and the "main body" caused by the load exerted on it, and then measures the change in its elastic element based on the electrical strain measurement principle. The sensor contains a high-precision and highly-responsive embedded system, which can acquire and analyze changes in signals from the resistance strain gauge as well as output the magnitude and direction of the applied force in real time. Please install the sensor properly so as not to interfere with the output quality.

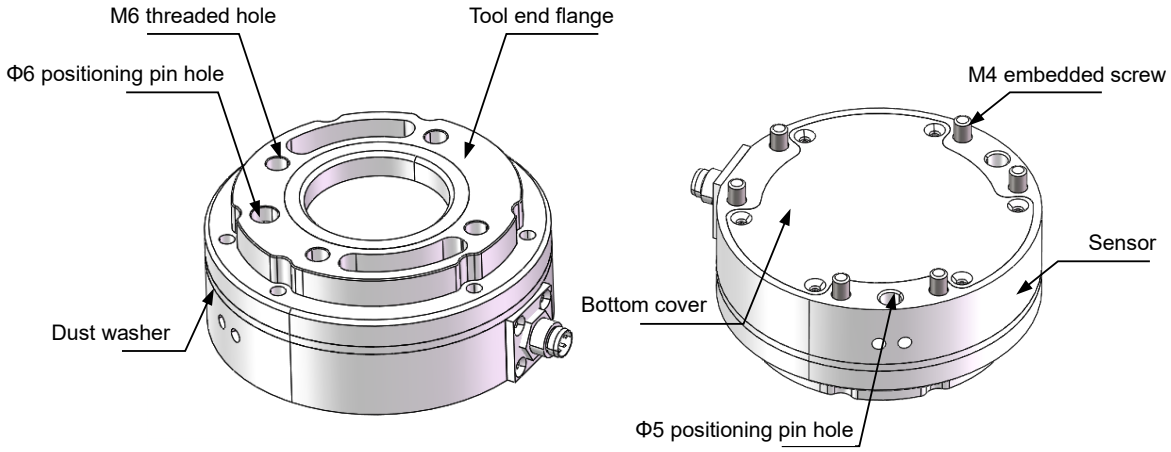


Figure 2-3 Sensor Appearance

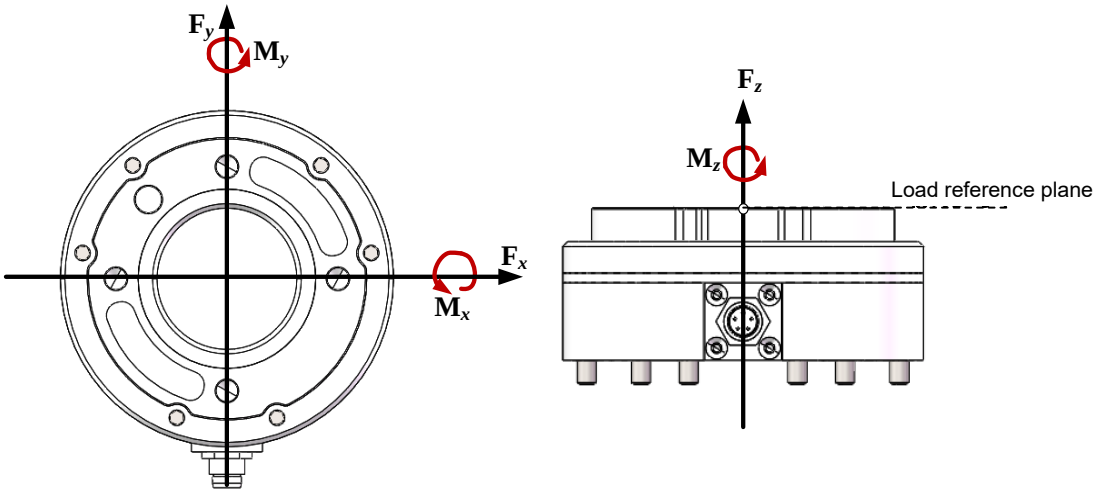


Figure 2-4 Definition of the Sensor Coordinate System

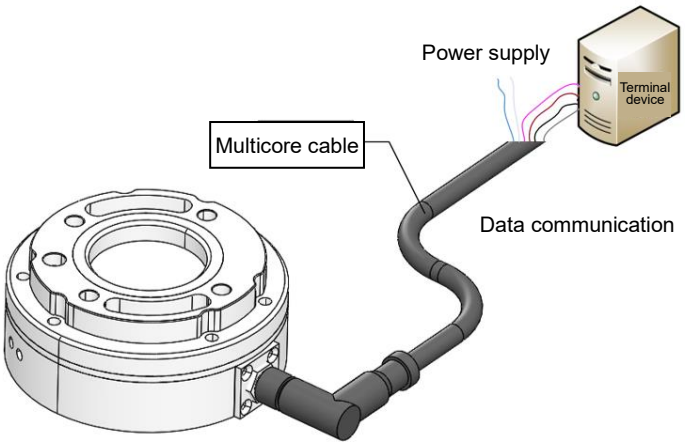


Figure 2-5 Electrical Connection of the Sensor

2.1.2.2 Sensor Installation

The mounting holes and dimensions of the sensor are shown in Figure 2-6.

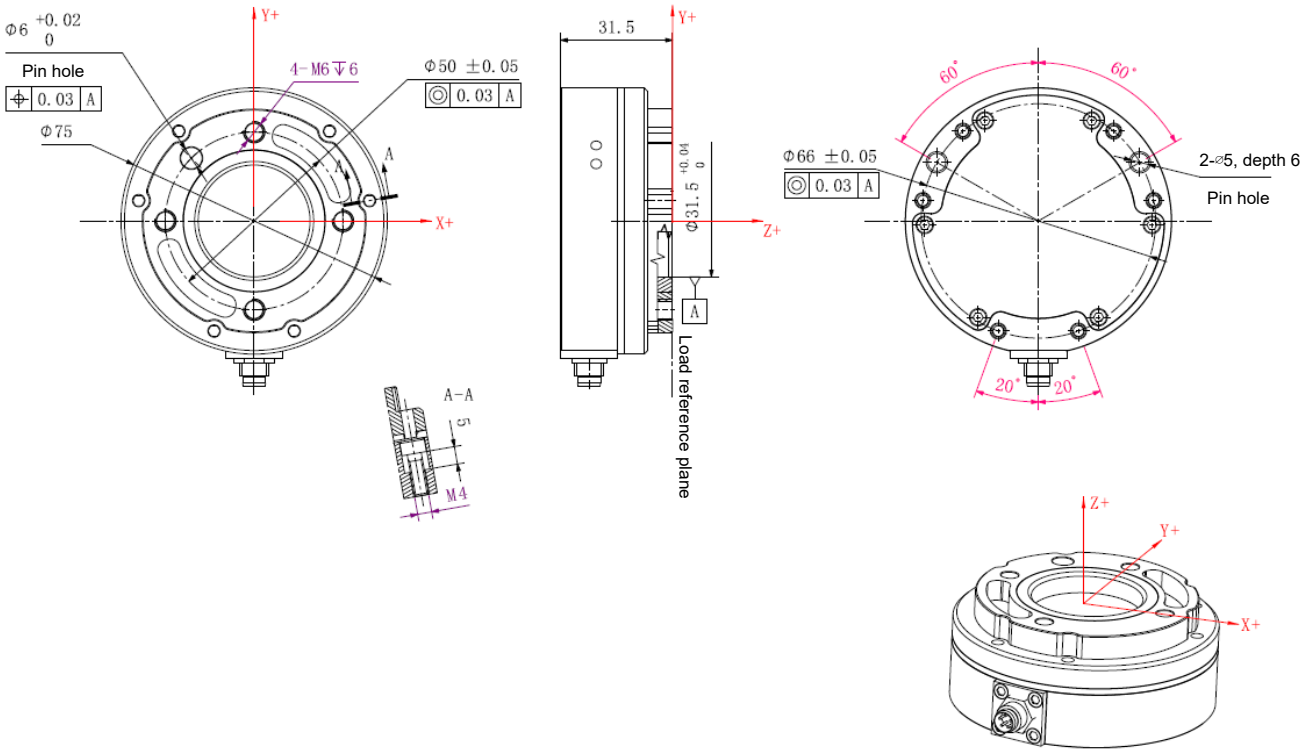


Figure 2-6 Sensor Dimensions

The sensor installation procedure is as follows:

a. Please ensure that the surfaces of the robot end, mounting flange and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.

b. Separate the sensor from the mounting flange. When the sensor leaves the factory, the mounting flange and the sensor are connected by six embedded hexagon socket screws. Use a 3 mm Allen key to loosen them, so as to separate the mounting flange from the sensor, as shown in Figure 2-8.

c. Install the mounting flange on the robot: Use φ5 positioning pins to position the mounting flange and the robot, and use four M6 hexagon socket screws to fix them. The positioning pins make it easy to install and connect the device repeatedly, and they will not affect sensor performance if not used. Gradually tighten the screws according to the diagonal sequence shown in Figure 2-7 to deliver uniform contact between the sensor and the robot or adapter tooling.

CAUTION:

Before installing the sensor, please keep the XY directions of the sensor coordinate system consistent with that of the robot end flange coordinate system, that is, keeping the direction from the center of the robot end flange to the TIO consistent with the -Y direction of the sensor. Inconsistent installation directions may affect subsequent use.

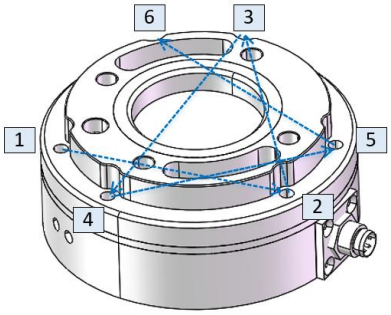


Figure 2-7 Screw Tightening Sequence

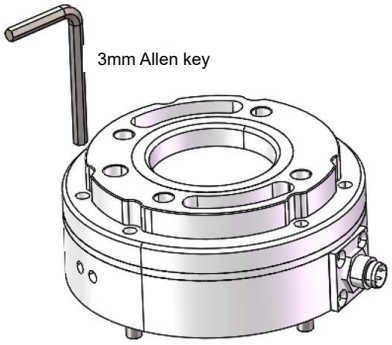


Figure 2-8 Loosen Embedded Screws Using a 3 mm Allen Key

d. Fasten the sensor to the mounting flange. Use the positioning pins to position the sensor and the mounting flange, and check that the mounting direction of the sensor is consistent with the use direction of the device. Fasten the sensor with six embedded screws. Insert a 3mm Allen key into the mounting hole on the sensor tool end flange. Turn it in the direction of the right-hand thread to secure the screw in place.

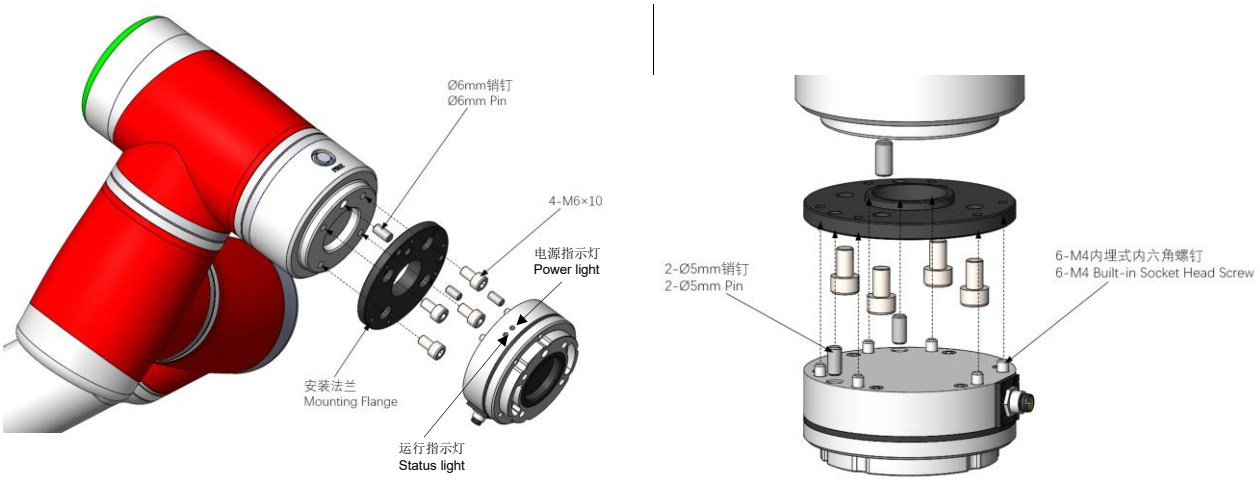


Figure 2-9 Installation of the Sensor to the Robot

e. Connect the tool interface of the robot to the sensor tool end flange. The sensor tool end flange comes with four M6 screw holes and φ6 pin holes for connecting device or tools. The positioning pins for the sensor tool end flange make it easy to install the device and tools repeatedly, and they will not affect sensor performance if not used.

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

2.1.2.3 Wiring of the Sensor

This sensor is connected via USB, that is, you need to connect the sensor USB to the USB port on the control cabinet panel.

The connecting cable is provided with the product. It is a multicore cable, and its interface matches the cable interface on the sensor. Align the interface of the multicore cable with the cable interface of the sensor and push it in (See Figure 2-10). Then tighten the threaded connection shell of the multicore cable interface to prevent the cable from loosening, achieving IP64 performance. During installation, each cable core should be wired in strict accordance with the specified core color definitions (the wiring diagram is shown in Figure 2-11). Be careful not to connect the positive and negative of the power supply in reverse, or the sensor will be damaged.

Figure 2-10 Cable Connection

Table 2-3 Descriptions for Connecting Cables of Type II Sensor

No.	Color of the Cable Core	Definition
1	Blue	Power+
2	White	Power-
3	Pink	422 bus sensor receive+
4	Brown	422 bus sensor receive-
5	Black	422 bus sensor send+
6	Gray	422 bus sensor send-
7	Shield	

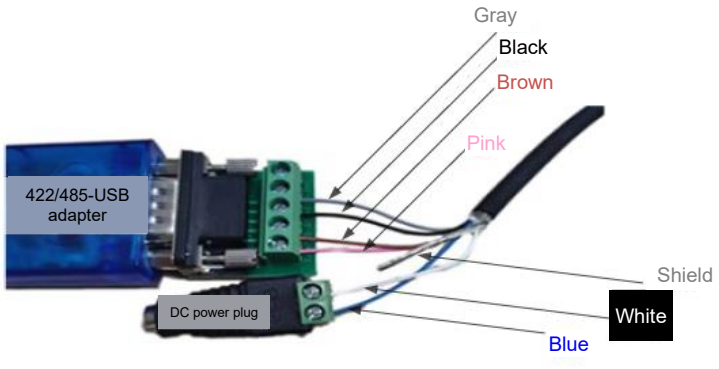


Figure 2-11 Wiring of the 422/485-USB Adapter and Power Plug

Note: This sensor requires a 24V DC power supply from the internal power of the CAB or an additional power source. The DC power plug shown in Figure 2-11 is only for illustration purposes and is not provided with the product. Please prepare one separately.

Indicator Light Descriptions:

Power light		Status light	
Steady on	Sensor powered on	Flashing	Sensor in operation
Off	Sensor powered off	Off	Sensor idle

WARNING:

Before securing the sensor wiring harness with cable ties, be sure to check that attached peripherals do not interfere with the robot's operational trajectory, so as to prevent the robot from pulling the wiring harness during operation and thus causing irreversible damage to the sensor.

2.1.2.4 Sensor Specifications

The sensor specifications of type II are as follows:

Table 2-4 Sensor Specifications of Type II

Model	JK-SE-II-200		JK-SE-II-400N		JK-SE-II-H		
Directions	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy	Fz	Mx, My, Mz
Range	200N	8Nm	400N	12Nm	800N	1200N	40Nm
Overload	300% F.S.			**IP Rating**	IP64		
Operating Temperature	5–80°C			**Power Voltage**	9–24V		
Accuracy	0.5% F.S.			**Communication Interface**	USB		

2.1.2.5 Precautions for Use

a. Do not use in any environment with temperature or humidity beyond the allowable range.

b. The cable must be connected properly. Before powering on the sensor, please check whether the cables are connected according to the colors indicated in this manual. A wiring mistake could cause a shortcircuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.

c. The sensor has built-in precision components such as embedded systems. Although we have carried

out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.

d. Do not strike or knock the sensor when installing it, especially when installing it onto the mounting flange. If the mounting clearance is tight due to the processed mounting flange, avoid striking or knocking the sensor as it might result in damage.

e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.

f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.

g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.1.2.6 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for sensor mounting bolts are as follows:

Table 2-5 Reference Tightening Torques for Sensor Mounting Bolts

Metric	Reference Tightening Torque (Nm)
M2	0.4
M3	2.0
M4	4.0
M5	8.0
M6	13.0
M8	35.0

2.1.3. Type III Force Sensor

2.1.3.1 Overview

The strain-type six-axis F/T sensor can measure the forces and torques in 3 directions simultaneously. The six-axis F/T sensor generally has two ends: the fixed end (robot end) and the loading end (tool end). When the two ends are exposed to relative force, the sensor deforms elastically and the resistance strain gauge inside the sensor changes, which is converted into a voltage output signal.

The output forces and torques of the six-axis F/T sensor are relative to the force coordinate system, which is generally located at the geometric center of the sensor. The definition of the sensor coordinate system is shown in Figure 2-12.

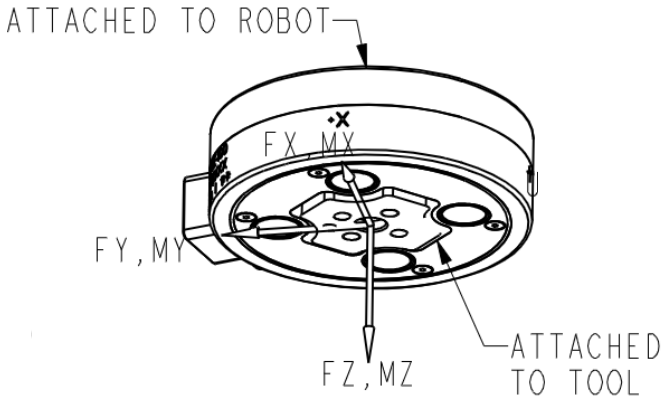


Figure 2-12 Definition of the Sensor Coordinate System

2.1.3.2 Sensor Installation

Sensor dimensions, positions of the fixed end (robot end) and the loading end (tool end), and the installation method are shown in Figure 2-13. The cable and interface are all fixed on the fixed end. To prevent the swinging or pulling of the cable from affecting the force sensor measurements, the robot should be fixed during installation, and the bolts should be installed from the direction of the tool end.

Gradually tighten the screws according to the diagonal sequence to deliver uniform contact between the sensor and the robot or adapter tooling.

a. Please ensure that the surfaces of the robot end, adapter plate and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.
b. The positioning pins make it easy to install and connect the device repeatedly, and they will not affect sensor performance if not used.

CAUTION:

Before installing the sensor, please keep the XY directions of the sensor coordinate system consistent with that of the robot end flange coordinate system, that is, keeping the direction from the center of the robot end flange to the TIO consistent with the -Y direction of the sensor. Inconsistent installation directions may affect subsequent use.

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

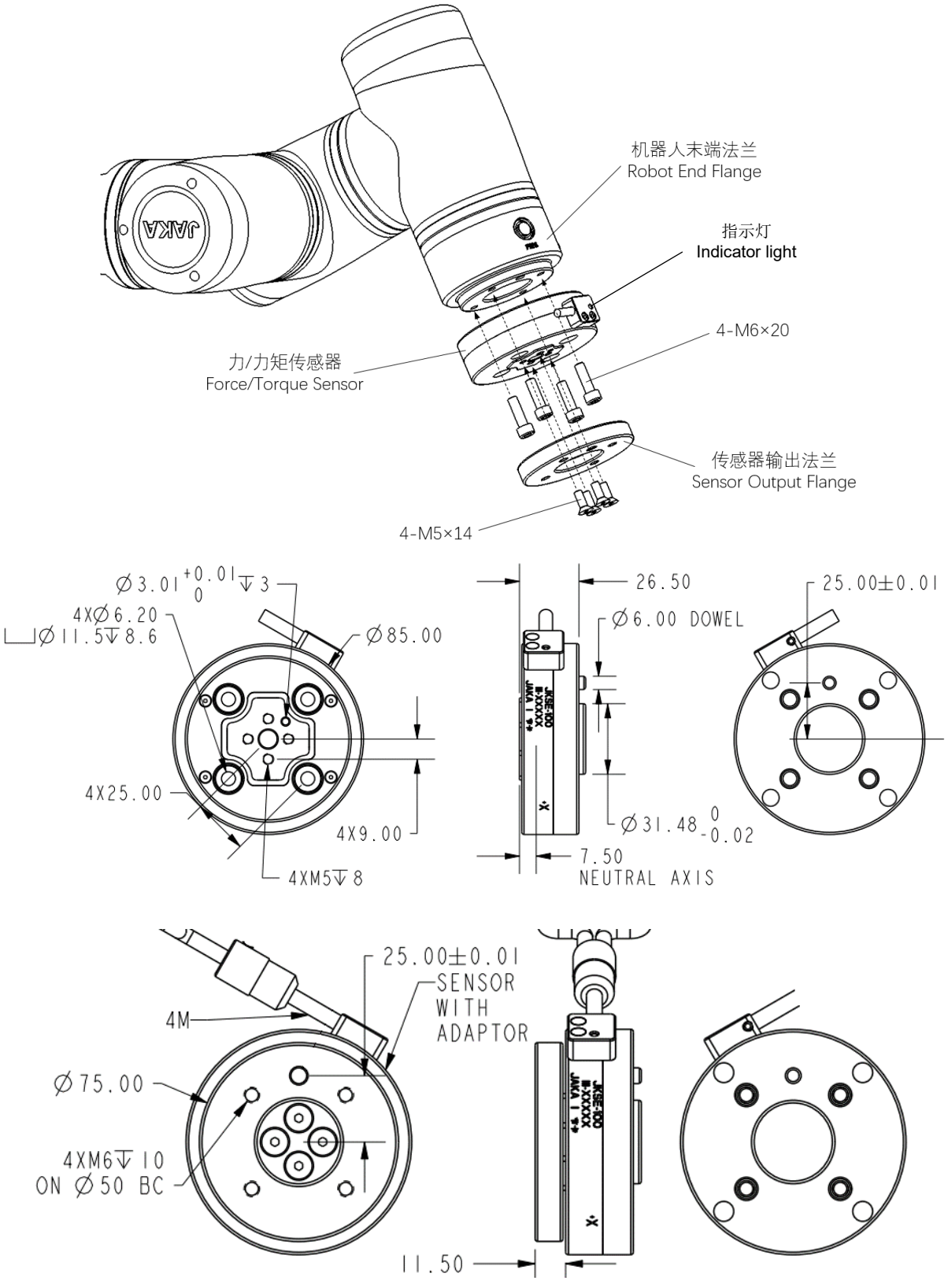


Figure 2-13 Installation and Dimensions of the F/T Sensor

2.1.3.3 Wiring of the Sensor

The connecting cable is provided with the product. The connecting cable is a multicore one, and its interface is matched with the cable interface of the sensor. Connect the network plug in the other end of the cable to a router or directly connect it to the network port at the bottom of the robot CAB. After the connection is completed, ensure that the robot and the sensor are configured with the same network segment. An independent router is recommended to guarantee the signal quality. You can also set the Network Port IP at the bottom of the CAB to be the same as that of the sensor. For the specific configuration method, please refer to the instructions in the "JAKA Zu Se System Construction" section of Chapter 3. The default IP for the sensor upon first use is 192.168.2.108. The sensor is powered by a DC 24V power supply from the internal power of the CAB or an additional power source. Be careful not to connect the positive and negative of the power supply in reverse, or the sensor will be damaged. (Refer to Table 2-6 for power supply wiring. The power leads must be connected, the shielding lead can be grounded if the quality of the sensor signal is not good enough, and other leads not listed in the table do not need connection).

Figure 2-14 Sensor and Cables

Table 2-6 Descriptions for Connecting Cables of Type III Sensor

No.	Color of the Cable Core	Definition
1	Blue	Power+
2	White & blue	Power-
3	Black	Shield

Note: This sensor requires a 24V DC power supply from the internal power of the CAB or an additional power source.

Indicator Light Descriptions:

Flashing	Sensor powered on / in operation
Off	Sensor powered off

WARNING:

Before securing the sensor wiring harness with cable ties, be sure to check that attached peripherals do not interfere with the robot's operational trajectory, so as to prevent the robot from pulling the wiring harness during operation and thus causing irreversible damage to the sensor.

2.1.3.4 Sensor Specifications

The sensor specifications of type III are as follows:

Table 2-7 Sensor Specifications of Type III

Model	JK-SE-III-100		JK-SE-III-300	
Directions	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz
Range	100N	8Nm	250N	24Nm
Overload	200% F.S.		**IP Rating**	IP64
Operating Temperature	-40 to 100℃		**Power Voltage**	24V
Accuracy	0.5% F.S.		**Communication Interface**	Network Port

2.1.3.5 Precautions for Use

a. Do not use in any environment with temperature or humidity beyond the allowable range.

b. The cable must be connected properly. Before powering on the sensor, please check whether the cables are connected according to the colors indicated in this manual. A wiring mistake could cause a shortcircuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.

c. The sensor has built-in precision components such as embedded systems. Although we have carried out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.

d. Do not strike or knock the sensor when installing it, especially when installing it onto the adapter plate. If the mounting clearance is tight due to the processed adapter plate, avoid striking or knocking the sensor as it might result in damage.

e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.

f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.

g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.1.3.6 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for sensor mounting bolts are as follows:

Table 2-8 Reference Tightening Torques for Sensor Mounting Bolts

Metric	**Reference Tightening Torque (Nm)**
M2	0.4
M3	2.0
M4	4.0
M5	8.0
M6	13.0
M8	35.0

2.1.4. Type V Force Sensor

2.1.4.1 Overview

The strain-type 1D force sensor is suitable for applications that only require Fz force control. The sensor senses relative deformation between the "tool end flange" and the "main body" caused by the force exerted on it, and then measures the change in its elastic element with a resistance strain gauge. The sensor contains a high-precision and highly-responsive embedded system, which can acquire and analyze changes in signals from the resistance strain gauge as well as output the magnitude and direction of the applied force in real time. Please install the sensor properly so as not to interfere with the output quality.

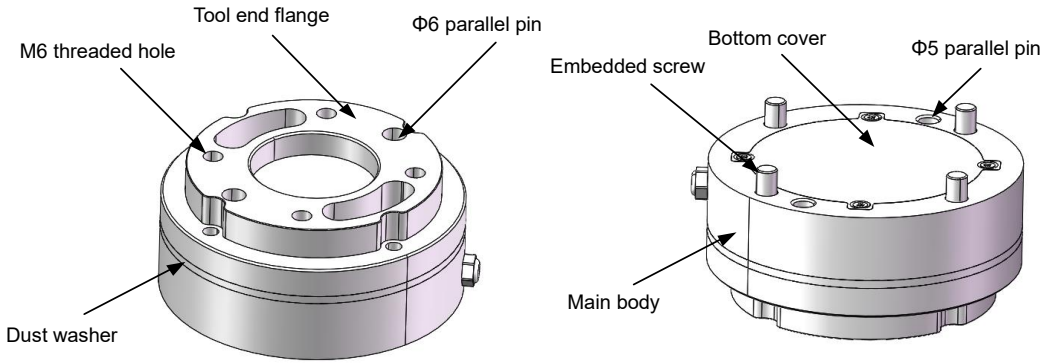


Figure 2-15 Sensor Appearance

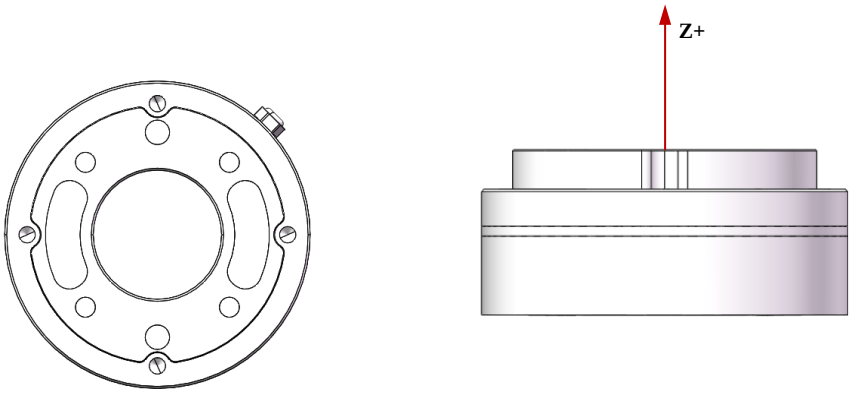


Figure 2-16 Definition of the Sensor Coordinate System

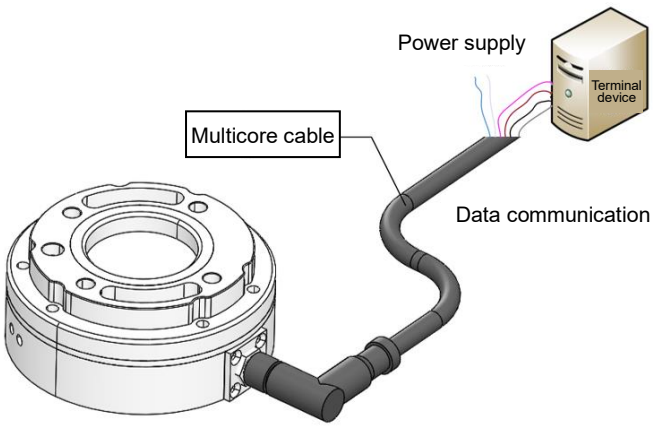


Figure 2-17 Electrical Connection of the Sensor

2.1.4.2 Sensor Installation

The mounting holes and dimensions of the sensor are shown in Figure 2-18.

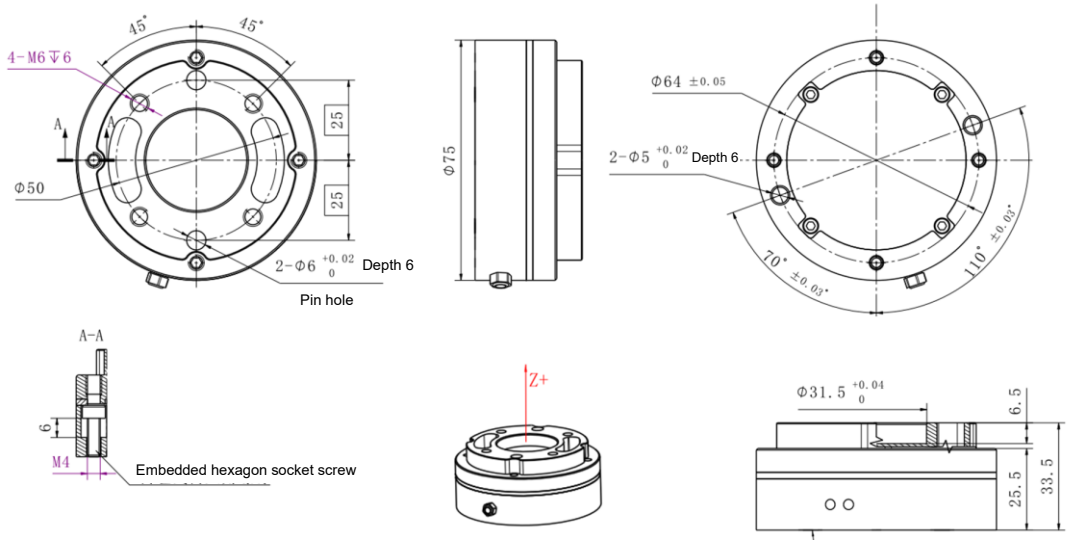


Figure 2-18 Sensor Dimensions

The sensor installation procedure is as follows:

a. Please ensure that the surfaces of the robot end, mounting flange and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.

b. Separate the sensor from the mounting flange. When the sensor leaves the factory, the mounting flange and the sensor are connected by six embedded hexagon socket screws. Use a 3 mm Allen key to loosen them, so as to separate the mounting flange from the sensor, as shown in Figure 2-8.

c. Install the mounting flange on the robot: Use φ5 positioning pins to position the mounting flange and the robot, and use four M6 hexagon socket screws to fix them. The positioning pins make it easy to install and connect the device repeatedly, and they will not affect sensor performance if not used. Gradually tighten the screws according to the diagonal sequence shown in Figure 2-19 to deliver uniform contact between the sensor and the robot or adapter tooling.

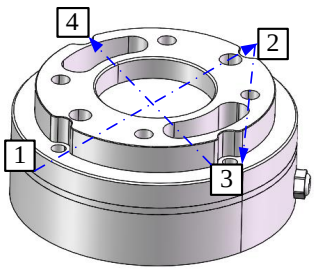


Figure 2-19 Screw Tightening Sequence

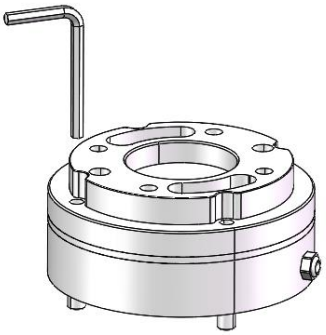


Figure 2-20 Loosen Embedded Screws Using a 3 mm Allen Key

d. Fasten the sensor to the mounting flange. Use the positioning pins to position the sensor and the mounting flange, and check that the mounting direction of the sensor is consistent with the use direction of the device. Fasten the sensor with six embedded screws. Insert a 3mm Allen key into the mounting hole on the sensor tool end flange. Turn it in the direction of the right-hand thread to secure the screw in place.

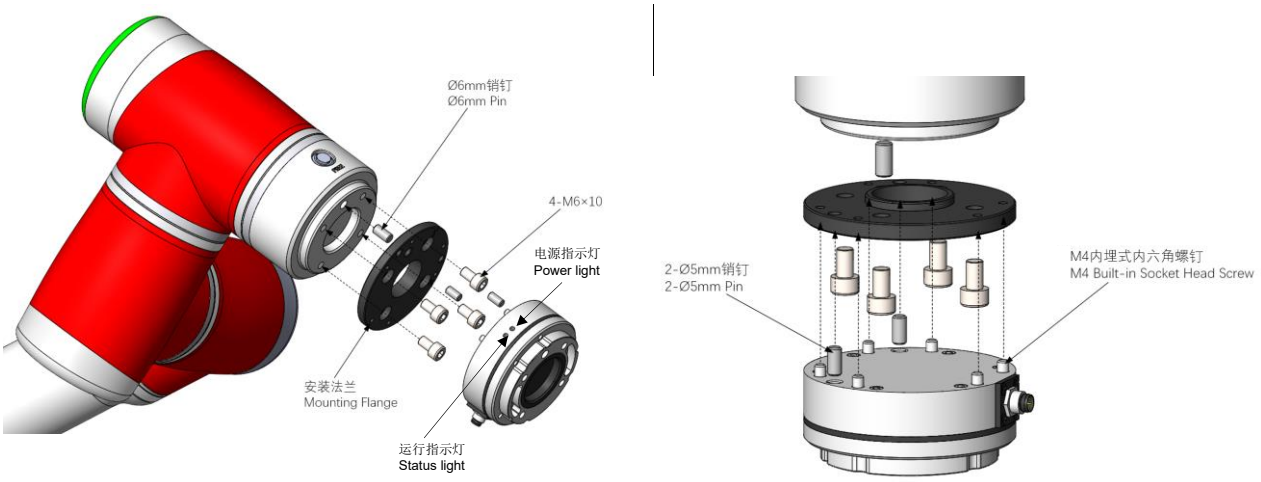


Figure 2-21 Installation of the Sensor to the Robot

e. Connect the tool interface of the robot to the sensor tool end flange. The sensor tool end flange comes with four M6 screw holes and φ6 pin holes for connecting device or tools. The positioning pins for the sensor tool end flange make it easy to install the device and tools repeatedly, and they will not affect sensor performance if not used.

⚠WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

2.1.4.3 Wiring of the Sensor

This sensor is connected via USB, that is, you need to connect the sensor USB to the USB port on the control cabinet panel.

The connecting cable is provided with the product. It is a multicore cable, and its interface matches the cable interface on the sensor. Align the connector of the multicore cable with the cable connector of the sensor and push it in (see Figure 2-22). Then tighten the threaded connection shell of the multicore cable interface to prevent the cable from loosening, achieving IP64 performance. During installation, each cable core should be wired in strict accordance with the specified core color definitions (the wiring diagram is shown in Figure 2-23). Be careful not to connect the positive and negative of the power supply in reverse, or the sensor will be damaged.

Figure 2-22 Operation of Connecting the Cable

Table 2-9 Descriptions for Connecting Cables of Type V Sensor

No.	Color of the Cable Core	Definition
1	Blue	Power+
2	White	Power-
3	Pink	422 bus sensor receive+
4	Brown	422 bus sensor receive-
5	Black	422 bus sensor send+
6	Gray	422 bus sensor send-
7	Shield	

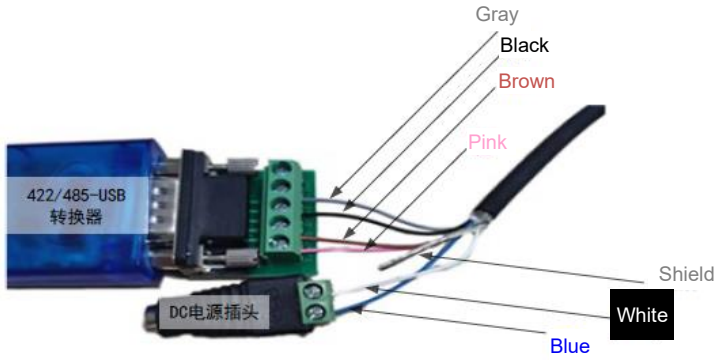


Figure 2-23 Wiring of the 422/485-USB Adapter and Power Plug

Note: This sensor requires a 24V DC power supply from the internal power of the CAB or an additional power source. The DC power plug shown in Figure 2-40 is only for illustration purposes and is not provided with the product. Please prepare one separately.

Indicator Light Descriptions:

Power light		Status light	
Steady on	Sensor powered on	Flashing	Sensor in operation
Off	Sensor powered off	Off	Sensor idle

WARNING:

Before securing the sensor wiring harness with cable ties, be sure to check that attached peripherals do not interfere with the robot's operational trajectory, so as to prevent the robot from pulling the wiring harness during operation and thus causing irreversible damage to the sensor.

2.1.4.4 Sensor Specifications

The sensor specifications of type V are as follows:

Table 2-10 Sensor Specifications of Type V

Model	JK-SE-V- 400S	**Range Fz (N)**	400
Overload	300% F.S.	**Accuracy**	0.5 F.S.
Operating Temperature (℃)	5–80	**IP Rating**	IP64
Power Voltage (V)	9–24	**Communication Interface**	USB

2.1.4.5 Precautions for Use

a. Do not use in any environment with temperature or humidity beyond the allowable range.
b. The cable must be connected properly. Before powering on the sensor, please check whether the cables are connected according to the colors indicated in this manual. A wiring mistake could cause a shortcircuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.
c. The sensor has built-in precision components such as embedded systems. Although we have carried out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.
d. Do not strike or knock the sensor when installing it, especially when installing it onto the adapter plate. If the mounting clearance is tight due to the processed adapter plate, avoid striking or knocking the sensor as it might result in damage.
e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.
f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.
g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.1.4.6 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for sensor mounting bolts are as follows:

Table 2-11 Reference Tightening Torques for Type V Sensor Mounting Bolts

Metric	Reference Tightening Torque (Nm)
M2	0.4
M3	2.0
M4	4.0
M5	8.0
M6	13.0
M8	35.0

2.1.5. Type VI Force Sensor

2.1.5.1 Overview

Type VI force sensor is available in a variety of range models. As a strain-type torque sensor, type VI force sensor senses relative deformation between the "tool end flange" and the "main body" caused by the force exerted on it, and then measures the change in its elastic element with a resistance strain gauge. The sensor contains a high-precision and highly-responsive embedded system, which can acquire and analyze changes in signals from the resistance strain gauge as well as output the magnitude and direction of the applied force in real time. Please install the sensor properly so as not to interfere with the output quality.

The output forces and torques of the six-axis F/T sensor are relative to the force coordinate system, which is generally located at the geometric center of the sensor. The coordinates of JK-SE-VI-200, JK-SE-VI-400(s) are shown in Figure 2-24, and that of JK-SE-VI-100 and JK-SE-VI-300 are shown in Figure 2-25.

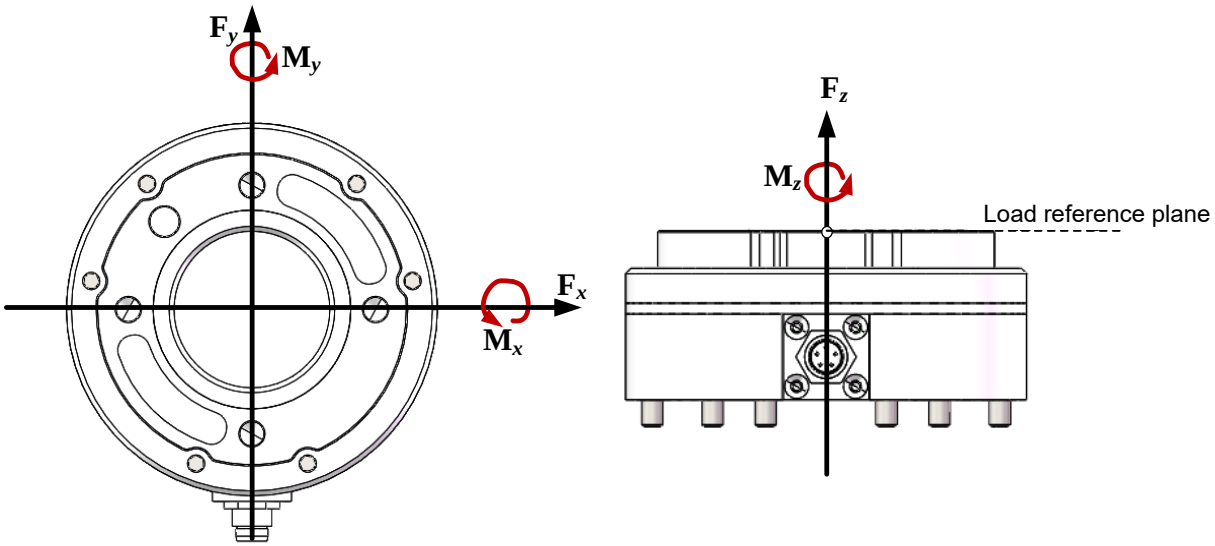


Figure 2-24 Definition of the Sensor Coordinate System

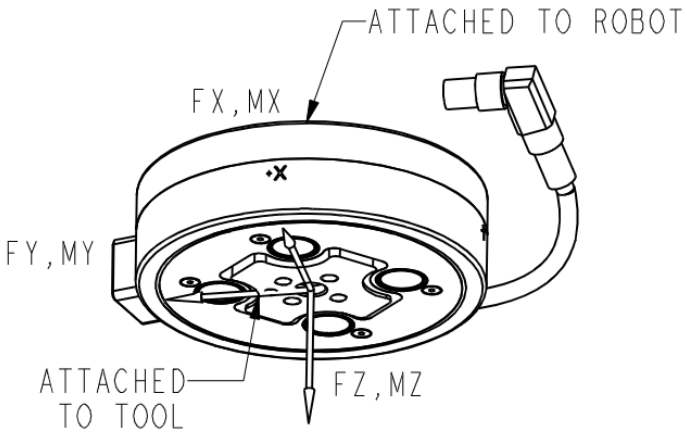


Figure 2-25 Definition of the Sensor Coordinate System

2.1.5.2 Sensor Installation (JK-SE-VI-200, JK-SE-VI-400, JK-SE-VI-H)

The mounting holes and dimensions of the sensor are shown in Figure 2-26.

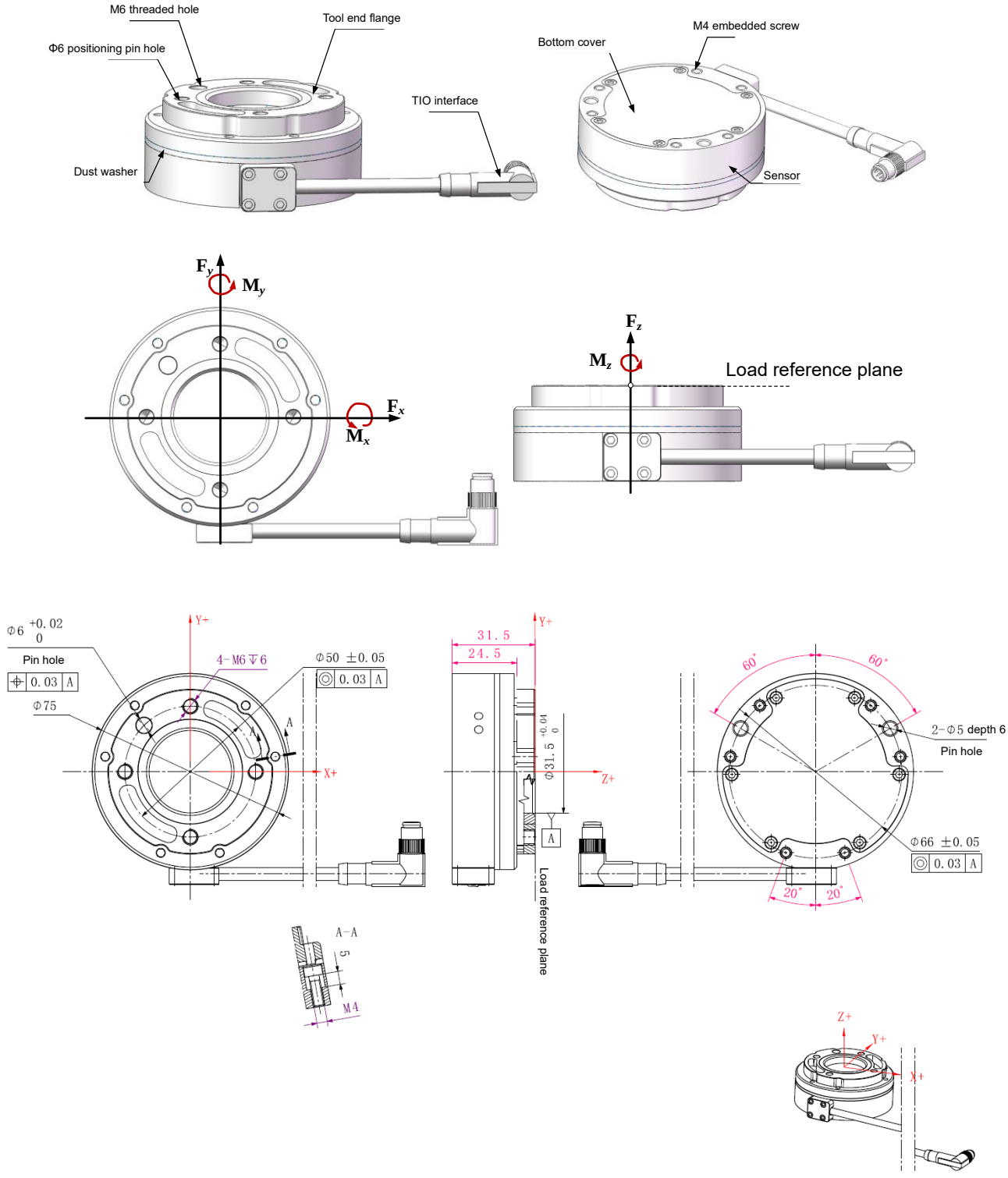


Figure 2-26 Appearance and Dimensions of the Sensor

The sensor installation procedure is as follows:

a. Please ensure that the surfaces of the robot end, mounting flange and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.

b. Separate the sensor from the mounting flange. When the sensor leaves the factory, the mounting flange and the sensor are connected by six embedded hexagon socket screws. Use a 3 mm Allen key to loosen them, so as to separate the mounting flange from the sensor, as shown in Figure 2-28.

c. Install the mounting flange on the robot: Use φ5 positioning pins to position the mounting flange and the robot, and use four M6 hexagon socket screws to fix them. The positioning pins make it easy to install and connect the device repeatedly, and they will not affect sensor performance if not used. Gradually tighten the screws according to the diagonal sequence shown in Figure 2-27 to deliver uniform contact between the sensor and the robot or adapter tooling.

CAUTION:

Before installing the sensor, please keep the XY directions of the sensor coordinate system consistent with that of the robot end flange coordinate system, that is, keeping the direction from the center of the robot end flange to the TIO consistent with the -Y direction of the sensor. Inconsistent installation directions may affect subsequent use.

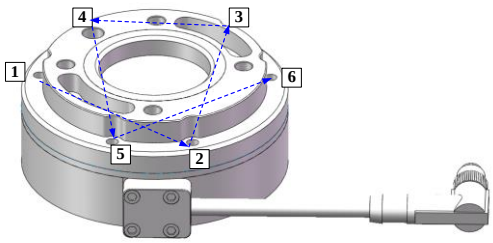


Figure 2-27 Screw Tightening Sequence

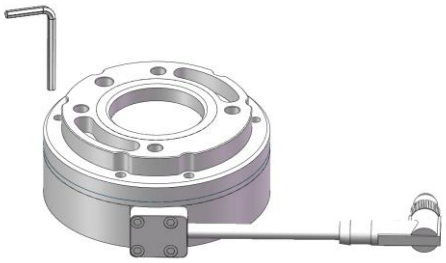


Figure 2-28 Loosen Embedded Screws Using a 3mm Allen Key

d. Fasten the sensor to the mounting flange. Use the positioning pins to position the sensor and the mounting flange, and check that the mounting direction of the sensor is consistent with the use direction of the device. Fasten the sensor with six embedded screws. Insert a 3mm Allen key into the mounting hole on the sensor tool end flange. Turn it in the direction of the right-hand thread to secure the screw in place.

e. Connect the tool interface of the robot to the sensor tool end flange. The sensor tool end flange comes with four M6 screw holes and φ6 pin holes for connecting device or tools. The positioning pins for the sensor tool end flange make it easy to install the device and tools repeatedly, and they will not affect sensor performance if not used.

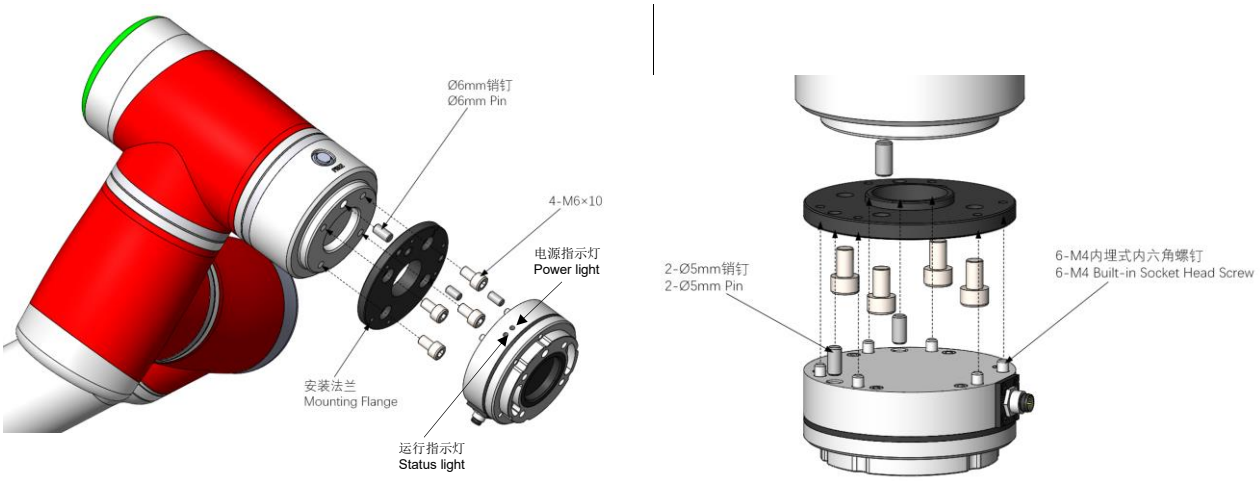


Figure 2-29 Installation of the Sensor to the Robot

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

Wiring of the sensor:

This sensor is directly connected to the TIO interface at the robot end, and the cable is directly fixed to the sensor. The connecting cable is a multicore one, and its interface is matched with the TIO cable interface at the robot end. Align the interface of the multicore cable with the cable interface at the robot end and push it in (See Figure 2-30). Then tighten the threaded connection shell of the multicore cable interface to prevent the cable from loosening, achieving IP64 performance.

Figure 2-30 Cable Connection

Indicator Light Descriptions:

Power light		Status light	
Steady	Sensor powered on	Flashing	Sensor in operation
Off	Sensor powered off	Off	Sensor idle

2.1.5.3 Sensor Installation (JK-SE-VI-400S)

The mounting holes and dimensions of the sensor are shown in Figure 2-31.

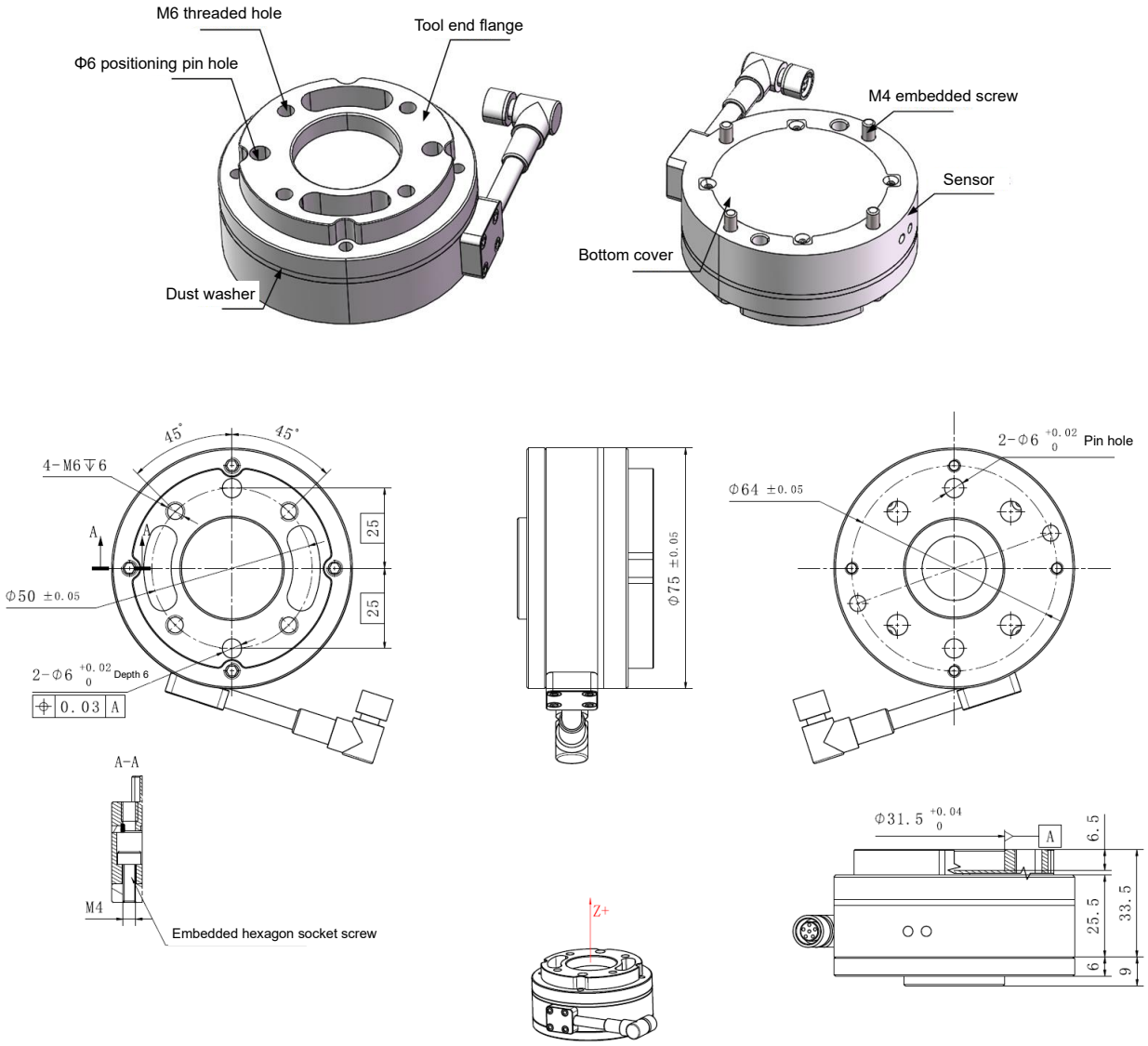


Figure 2-31 Sensor Dimensions

The sensor installation procedure is as follows:

a. Please ensure that the surfaces of the robot end, mounting flange and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.

b. Separate the sensor from the mounting flange, and install the mounting flange to the robot. When the sensor leaves the factory, the mounting flange and the sensor are connected by six embedded hexagon socket screws. Use a 3 mm Allen key to loosen them, so as to separate the mounting flange from the sensor, as shown in Figure 2-33. Use φ5 positioning pins to position the mounting flange and the robot, and use four M6 embedded hexagon socket screws to fix them. Gradually tighten the screws according to the diagonal sequence to deliver uniform contact between the sensor and the robot or adapter tooling. The positioning pins make it easy to install and connect the device repeatedly, and they

will not affect sensor performance if not used.

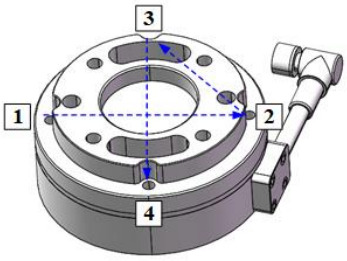


Figure 2-32 Screw Tightening Sequence

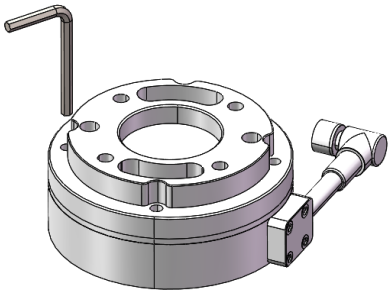


Figure 2-33 Loosen Embedded Screws Using a 3 mm Allen Key

c. Fasten the sensor to the mounting flange. Use the positioning pins to position the sensor and the mounting flange, and check that the mounting direction of the sensor is consistent with the use direction of the device. Fasten the sensor with six embedded screws. Insert a 3mm Allen key into the mounting hole on the sensor tool end flange. Turn it in the direction of the right-hand thread to secure the screw in place.

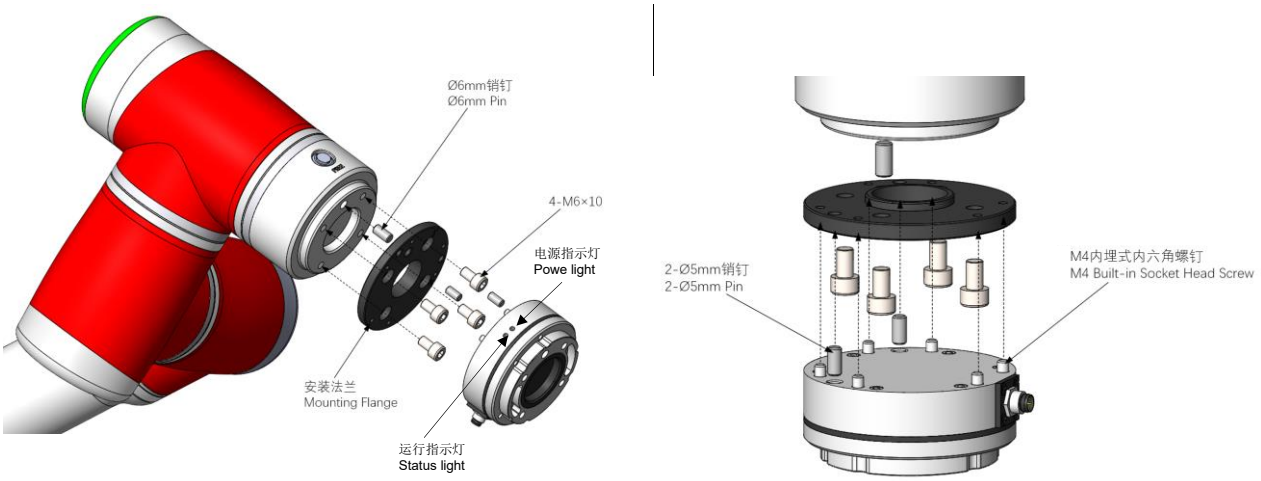


Figure 2-34 Installation of the Sensor to the Robot

d. Connect the tool interface of the robot to the sensor tool end flange. The sensor tool end flange comes with four M6 screw holes and φ6 pin holes for connecting device or tools. The positioning pins for the sensor tool end flange make it easy to install the device and tools repeatedly, and they will not affect sensor performance if not used.

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

Wiring of the sensor:

This sensor is directly connected to the TIO interface at the robot end, and the cable is directly fixed to the sensor. The connecting cable is a multicore one, and its interface is matched with the TIO cable interface at

the robot end. Align the interface of the multicore cable with the cable interface at the robot end and push it in (See Figure 2-35). Then tighten the threaded connection shell of the multicore cable interface to prevent the cable from loosening, achieving IP64 performance.

Figure 2-35 Cable Connection

Indicator Light Descriptions:

Power light		Status light	
Steady	Sensor powered on	Flashing	Sensor in operation
Off	Sensor powered off	Off	Sensor idle

2.1.5.4 Sensor Installation (JK-SE-VI-200N, JK-SE-VI-400N, JK-SE-VI-800N, JK-SE-VI-400NS, JK-SE-VI-1200NS)

Sensor dimensions, positions of the fixed end (robot end) and the loading end (tool end), and the installation method are shown in Figure 2-36. The cable and interface are all fixed on the fixed end. To prevent the swinging or pulling of the cable from affecting the force sensor measurements, the robot should be fixed during installation, and the bolts should be installed from the direction of the tool end.

a. Please ensure that the surfaces of the robot end, adapter plate and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality. Gradually tighten the screws according to the diagonal sequence to deliver uniform contact between the sensor and the robot or adapter tooling.
b. The positioning pins make it easy to install and connect the device repeatedly, and they will not affect sensor performance if not used.

⚠CAUTION:

Before installing the sensor, please keep the XY directions of the sensor coordinate system consistent with that of the robot end flange coordinate system, that is, keeping the direction from the center of the robot end flange to the TIO consistent with the -Y direction of the sensor. Inconsistent installation directions may affect subsequent use.

⚠WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

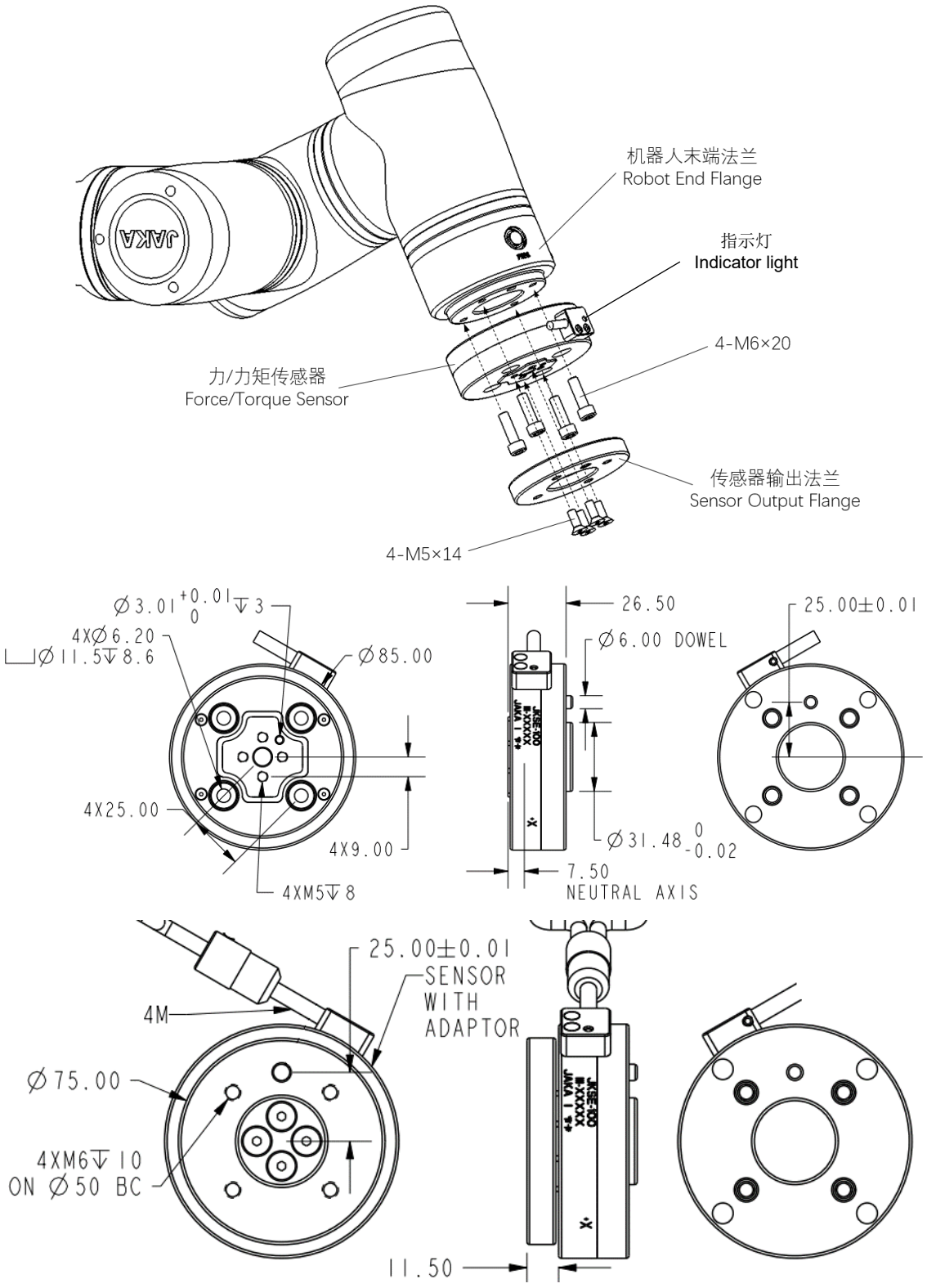


Figure 2-36 Installation and Dimensions of the Force Sensor

Wiring of the sensor:

This sensor is directly connected to the TIO interface at the robot end, and the cable is directly fixed to the sensor. The connecting cable is a multicore one, and its interface is matched with the TIO cable interface at the robot end. Align the interface of the multicore cable with the cable interface at the robot end and push it in. Then tighten the threaded connection shell of the multicore cable interface to prevent the cable from loosening, achieving IP64 performance.

Indicator Light Descriptions:

Steady on	Sensor powered on / in operation
Off	Sensor powered off

2.1.5.5 Sensor Specifications

The sensor specifications of type VI are as follows:

Table 2-12 Sensor Specifications of Type VI

Model	JK-SE-VI-200		JK-SE-VI-400		JK-SE-VI-H			JK-SE-VI- 400S
Directions	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy	Fz	Mx, My, Mz	Fz
Range	200N	8Nm	400N	12Nm	800N	1000N	40Nm	400N
Overload	300% F.S.		300% F.S.		400% F.S.			300% F.S.
Accuracy	0.5% F.S.		0.5% F.S.		0.5% F.S.			0.5% F.S.
Operating Temperature	5–80°C		5–80°C		5–80°C			5–80°C
IP Rating	IP64		IP64		IP64			IP64
Power Voltage	12V		12V		12V			12V

Model	JK-SE-VI-200N		JK-SE-VI-400N		JK-SE-VI-800N		JK-SE-VI-400NS	JK-SE-VI-1200NS
Directions	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Fz
Range	200N	8Nm	400N	24Nm	800N	40Nm	400N	1200N
Overload	200% F.S.		200% F.S.		400% F.S.		200% F.S.	570% F.S.
Accuracy	0.5% F.S.		0.5% F.S.		0.5% F.S.		0.5% F.S.	0.5% F.S.
Operating Temperature	-40 to 100℃		-40 to 100℃		-40 to 100℃		-40 to 100℃	-40 to 100℃
IP Rating	IP64		IP64		IP64		IP64	IP64
Power Voltage	12V		12V		12V		12V	12V

2.1.5.6 Precautions for Use

a. Do not use in any environment with temperature or humidity beyond the allowable range.

b. The cable must be connected properly. Before powering on the sensor, please check whether the cables are connected according to the colors indicated in this manual. A wiring mistake could cause a shortcircuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.

c. The sensor has built-in precision components such as embedded systems. Although we have carried out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.

d. Do not strike or knock the sensor when installing it, especially when installing it onto the adapter plate. If the mounting clearance is tight due to the processed adapter plate, avoid striking or knocking the sensor as it might result in damage.

e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.

f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.

g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.1.5.7 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for type VI sensor mounting bolts are as follows:

Table 2-13 Reference Tightening Torques for Type VI Sensor Mounting Bolts

Metric	Reference Tightening Torque (Nm)
M2	0.4
M3	2.0
M4	4.0
M5	8.0
M6	13.0
M8	35.0

2.1.6. Type VII Force Sensor

2.1.6.1 Overview

The strain-type six-axis F/T sensor can measure the forces and torques in 3 directions simultaneously (As a 1D force sensor, VII-400NS sensor can only measure one force). The six-axis F/T sensor generally has two ends: the fixed end (robot end) and the loading end (tool end). When the two ends are exposed to relative force, the sensor deforms elastically and the resistance strain gauge inside the sensor changes, which is converted into a voltage output signal.

The output forces and torques of the six-axis F/T sensor are relative to the force coordinate system, which is generally located at the geometric center of the sensor. The sensor coordinate system is defined as shown in Figure 2-37.

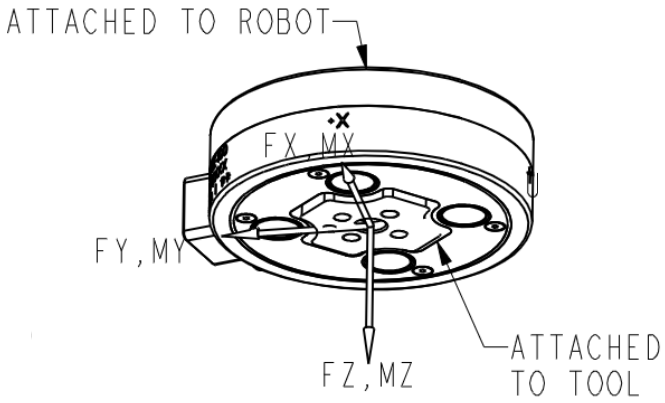


Figure 2-37 Definition of the Sensor Coordinate System

2.1.6.2 Sensor Installation

Sensor dimensions, positions of the fixed end (robot end) and the loading end (tool end), and the installation method are shown in Figure 2-38. Due to variations in sensor models and batches, the actual size may differ from what is indicated in Figure 2-38. Please contact us for detailed size information. The cable and interface are all fixed on the fixed end. To prevent the swinging or pulling of the cable from affecting the force sensor measurements, the robot should be fixed during installation, and the bolts should be installed from the direction of the tool end.

Gradually tighten the screws according to the diagonal sequence to deliver uniform contact between the sensor and the robot or adapter tooling.

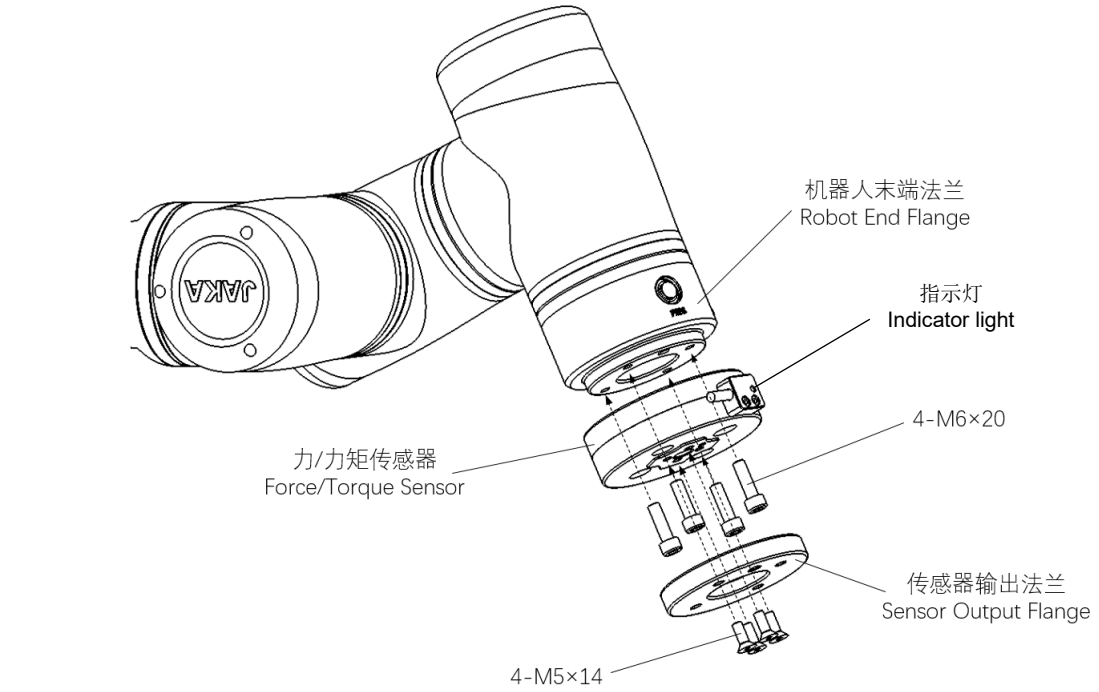
a. Please ensure that the surfaces of the robot end, adapter plate and sensor are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them. As a result, the product may not meet IP64 compliance and would have reduced output quality.
b. The positioning pins make it easy to install and connect the device repeatedly, and they will not affect sensor performance if not used.

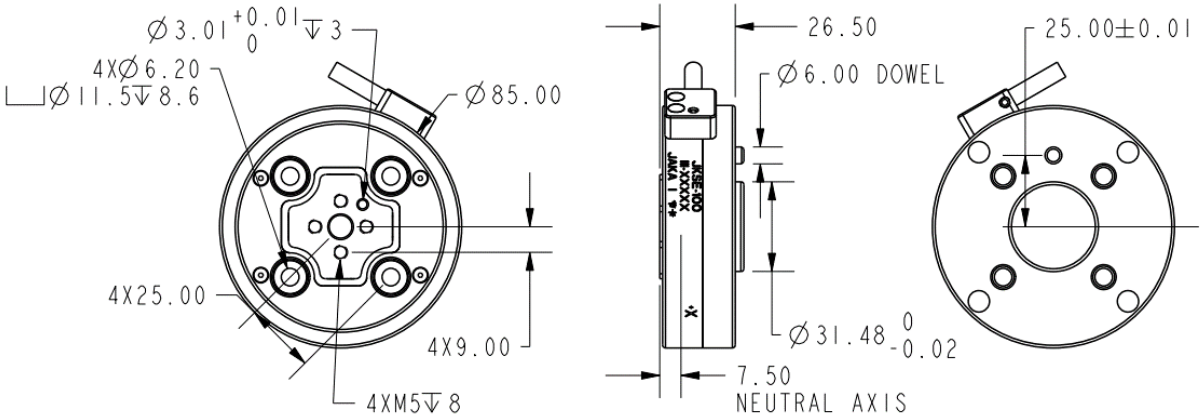
CAUTION:

Before installing the sensor, please keep the XY directions of the sensor coordinate system consistent with that of the robot end flange coordinate system, that is, keeping the direction from the center of the robot end flange to the TIO consistent with the -Y direction of the sensor. Inconsistent installation directions may affect subsequent use.

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.





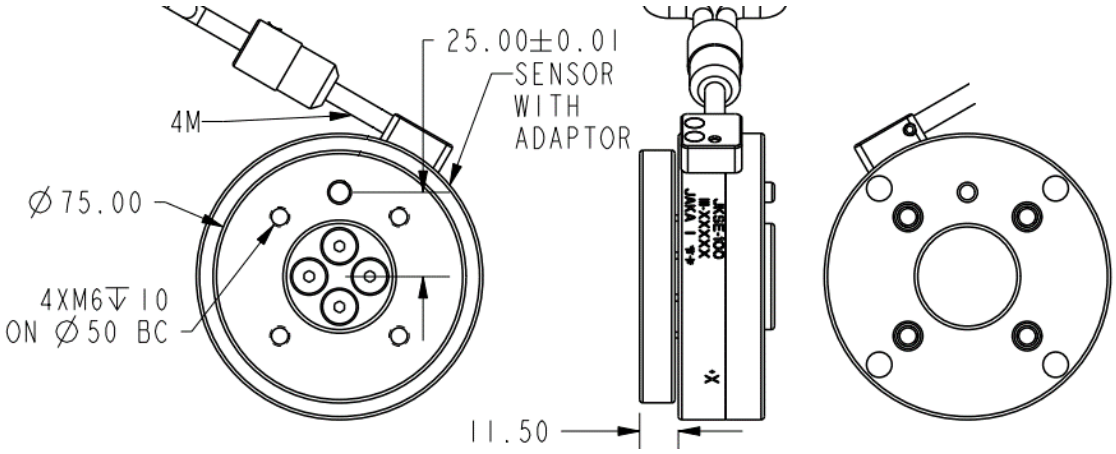


Figure 2-38 Installation and Dimensions of the Sensor

2.1.6.3 Wiring of the Sensor

This sensor is connected via USB, that is, you need to connect the sensor USB to the USB port on the control cabinet panel.

The connecting cable is provided with the product. It is a multicore cable that is directly connected to the sensor, as shown in Figure 2-39. During installation, each cable core should be wired in strict accordance with the specified core color definitions (the wiring diagram is shown in Figure 2-40). Leads 485-A and 485-B should be connected to the 422/485-USB adapter; Leads power+ and power- should be connected to a 24V DC power supply; Leads TX and RX do not need connection; and the shielding lead can be grounded if the quality of the sensor signal is not good enough.

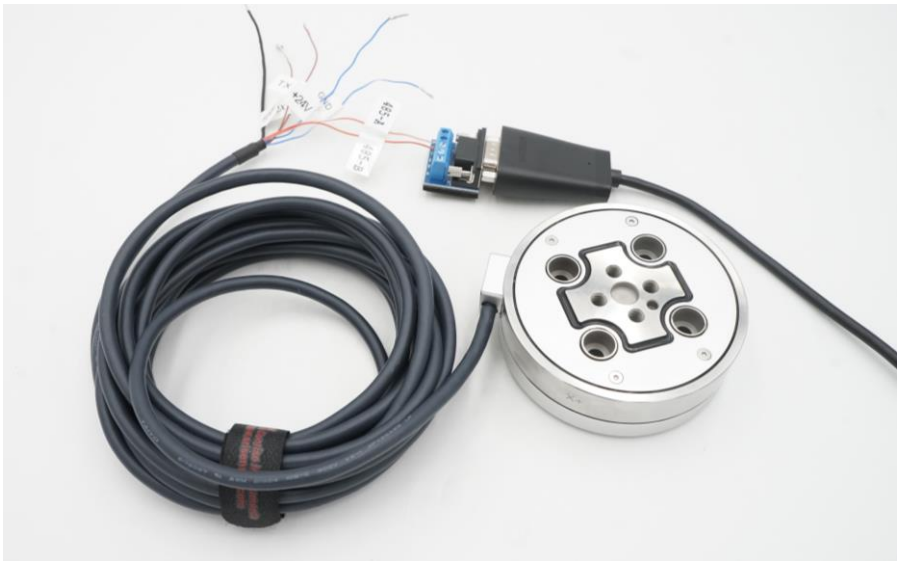


Figure 2-39 Cable Connection

Table 2-14 Descriptions for Connecting Cables of Type VII Sensor

No.	Color of the Cable Core	Definition
1	Blue	Power+
2	Blue & white	Power-
3	Orange & white	485-A
4	Orange	485-B
5	Brown	TX
6	Brown & white	RX
7	Black	Shield

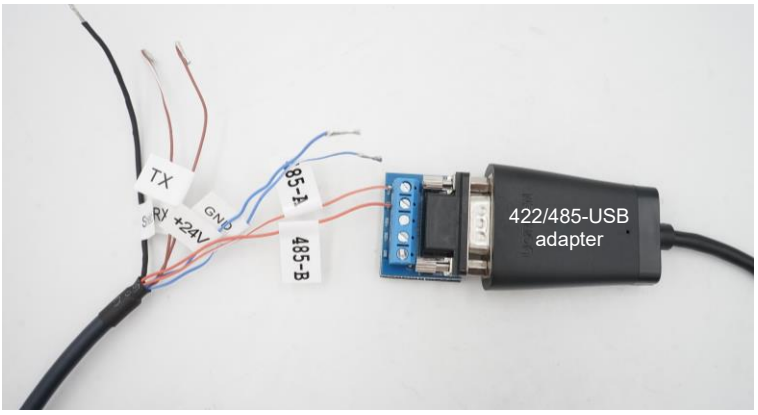


Figure 2-40 Wiring of the 422/485-USB Adapter and Power Plug

Note: This sensor requires a 24V DC power supply from the internal power of the CAB or an additional power source. Be careful not to connect the positive and negative of the power supply in reverse, or the sensor will be damaged.

Indicator Light Descriptions:

Flashing	Sensor powered on / in operation
Off	Sensor powered off / damaged

WARNING:

Before securing the sensor wiring harness with cable ties, be sure to check that attached peripherals do not interfere with the robot's operational trajectory, so as to prevent the robot from pulling the wiring harness during operation and thus causing irreversible damage to the sensor.

2.1.6.4 Sensor Specifications

The sensor specifications of type VII are as follows:

Table 2-15 Sensor Specifications of Type VII

Model	JK-SE-VII-200N		JK-SE-VII-400N		JK-SE-VII-800N	
Directions	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz	Fx, Fy, Fz	Mx, My, Mz
Range	200N	8Nm	400N	24Nm	800N	40Nm
Overload	200% F.S.			**IP Rating**	IP64	
Operating Temperature	-40 to 100℃			**Power Voltage**	9–24V	
Accuracy	0.5% F.S.			**Communication Interface**	USB	

Model	JK-SE-VII-400NS	Range Fz (N)	400
Overload	200% F.S.	Accuracy	0.5% F.S.
Operating Temperature	-40 to 100℃	IP Rating	IP64
Power Voltage	9–24V	Communication Interface	USB

2.1.6.5 Precautions for Use

a. Do not use in any environment with temperature or humidity beyond the allowable range.

b. The cable must be connected properly. Before powering on the sensor, please check whether the cables are connected according to the colors indicated in this manual. A wiring mistake could cause a short circuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.

c. The sensor has built-in precision components such as embedded systems. Although we have carried out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.

d. Do not strike or knock the sensor when installing it, especially when installing it onto the mounting flange. If the mounting clearance is tight due to the processed mounting flange, avoid striking or knocking the sensor as it might result in damage.

e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.

f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.

g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.1.6.6 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for sensor mounting bolts are as follows:

Table 2-16 Reference Tightening Torques for Sensor Mounting Bolts

Metric	Reference Tightening Torque (Nm)
M2	0.4
M3	2.0
M4	4.0
M5	8.0
M6	13.0
M8	35.0

2.2. JAKA Zu Sp Hardware Installation

2.2.1. Type IV Force Sensor

2.2.1.1 Overview

The strain-type six-axis F/T sensor can measure the forces and torques in 3 directions simultaneously. The base six-axis F/T sensor generally has two ends: the fixed end (base end) and the loading end (robot end). When the two ends are exposed to relative force, the sensor deforms elastically and the resistance strain gauge inside the sensor changes, which is converted into a voltage output signal.
The output forces and torques of the six-axis F/T sensor are relative to the force coordinate system, which is generally located at the geometric center of the sensor. The definition of the sensor coordinate system is shown in Figure 2-41.

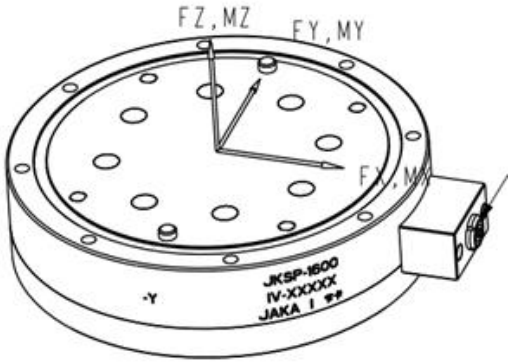


Figure 2-41 Sensor Coordinates

2.2.1.2 Sensor Installation

The flange that connects the force sensor to the base should be designed as needed. Please ensure that the surfaces of the robot end, mounting flange, sensor, and base are free of damage or foreign objects. If the contact is non-uniform due to factors such as the inclusion of foreign objects, gaps will be formed between them, degrading the output quality of the sensor. When installing the sensor, ensure that the direction of the aviation plug of the robot base is consistent with the X+ direction marked on the sensor (as shown in Figures 2-41 and 2-42), and avoid long screws from crushing the force sensor. Gradually tighten the screws according to the diagonal sequence to deliver uniform contact between the sensor and the adapter plate.

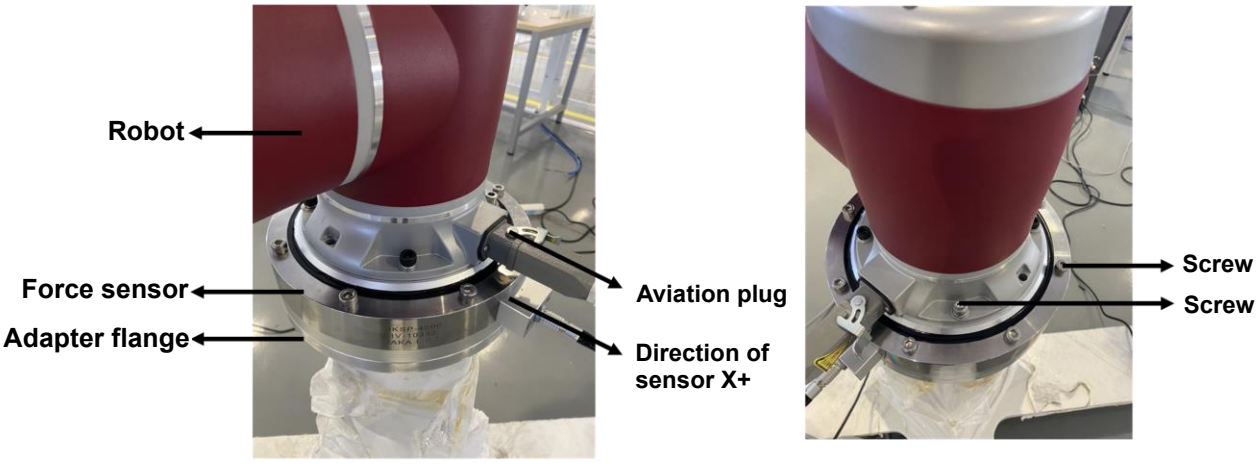


Figure 2-42 Installation of Type IV Sensor

WARNING:

Do not use screws other than those provided with this product. Using other screws may cause irreversible damage to the sensor or a robot fault.

2.2.1.3 Wiring of the Sensor

The connecting cable is provided with the product. The connecting cable is a multicore one, and its interface is matched with the cable interface of the sensor. Connect the network plug in the other end of the cable to a router or directly connect it to the network port at the bottom of the robot CAB. After the connection is completed, ensure that the robot and the sensor are configured with the same network segment. An independent router is recommended to guarantee the signal quality. You can also set the Network Port IP at the bottom of the CAB to be the same as that of the sensor. For the specific configuration method, please refer to the instructions in the "JAKA Zu Sp System Construction" section of Chapter 3. The default IP for the sensor upon first use is 192.168.2.108. The sensor is powered by a DC 24V power supply from the internal power of the CAB or an additional power source. Be careful not to connect the positive and negative of the power supply in reverse, or the sensor will be damaged. (Refer to Table 2-17 for power supply wiring. The power leads must be connected, the shielding lead can be grounded if the quality of the sensor signal is not good enough, and other leads not listed in the table do not need connection).

Table 2-17 Descriptions for Connecting Cables of Type IV Sensor

No.	Color of the Cable Core	Definition
1	Blue	Power+
2	White & blue	Power-
3	Black	Shield

2.2.1.4 Sensor Specifications

The sensor specifications of type IV are as follows:

Table 2-18 Sensor Specifications of Type IV

Model	JK-SP-IV-500		JK-SP-IV-1600		JK-SP-IV-4000		JK-SP-IV-4000FT	
Directions	Fxyz	Mxyz	Fxyz	Mxyz	Fxyz	Mxyz	Fxyz	Mxyz
Range	500N	120Nm	1600N	450Nm	4000N	1800Nm	4000N	3600Nm
Overload	300% F.S.				**IP Rating**		IP64	
Operating Temperature	-40 to 90℃				**Power Voltage**		24V	
Accuracy	1.0% F.S.				**Communication Interface**		Network Port	

2.2.1.5 Precautions

a. Do not use in any environment with temperature or humidity beyond the allowable range.

b. The cable must be connected properly. A wiring mistake could cause a shortcircuit and damage to the internal circuit of the sensor, so do not forget to check that the wiring is correct.

c. The sensor has built-in precision components such as embedded systems. Although we have carried out relevant vibration and shock tests, it is still necessary to prevent it from dropping, which could cause excessive vibration and subsequent malfunctions.

d. Do not strike or knock the sensor when installing it. If the mounting clearance is tight due to factors such as processing, avoid striking or knocking the sensor as it might result in damage.

e. After the sensor is installed and powered on, it is recommended to warm up for one hour before operating.

f. When using the sensor, pay attention to the mass of the device mounted on it, which should be within the payload range of the robot.

g. If you have any doubts or if any faults occur during use, please do not attempt to operate the product. Instead, contact us directly.

2.2.1.6 Reference Tightening Torques for Sensor Mounting Bolts

Reference tightening torques for type IV sensor mounting bolts are as follows:

Table 2-19 Reference Tightening Torques for Type IV Sensor Mounting Bolts

Metric	**Reference Torque (Nm)**
M3	2.00
M4	4.00
M5	8.00
M6	13.00
M8	35.00
M10	45.00

3. Software Usage

3.1. Jaka Zu Se Software Usage

3.1.1. Jaka Zu Se System Construction

3.1.1.1 System Construction of Type I and Type III Sensors

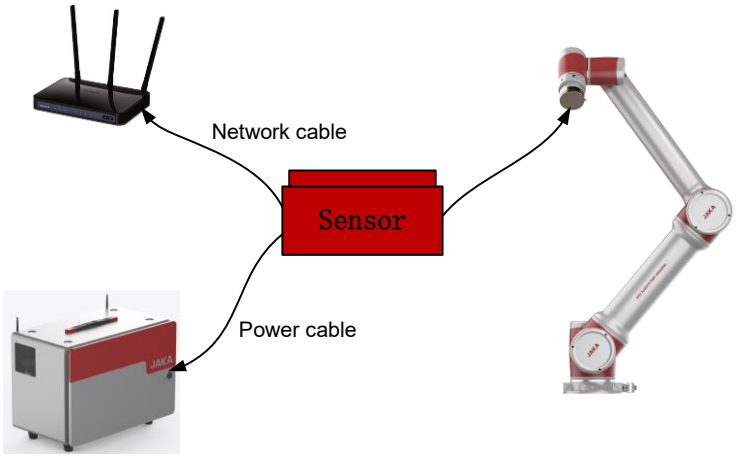


Figure 3-1 Se System (Network Port Type)

To use a type I or III torque sensor, configure it as follows:

a. Correctly install the hardware to ensure that the X-axis positive direction of the sensor is consistent with that of the robot end flange;

b. Connect the network port of the sensor cable to a router or directly connect it to the network port at the bottom of the CAB;

c. Connect the sensor power supply, which can be powered by the internal power supply of the robot CAB or an additional 24V DC power supply;

d. If you connect the cable to a router, set the router IP to 192.168.2.x; If you directly connect the cable to the network port at the bottom of the CAB, set the CAB IP in the app:

Tap [Settings] at the upper right of the Home page, and then tap [System setting] → [Network setting];

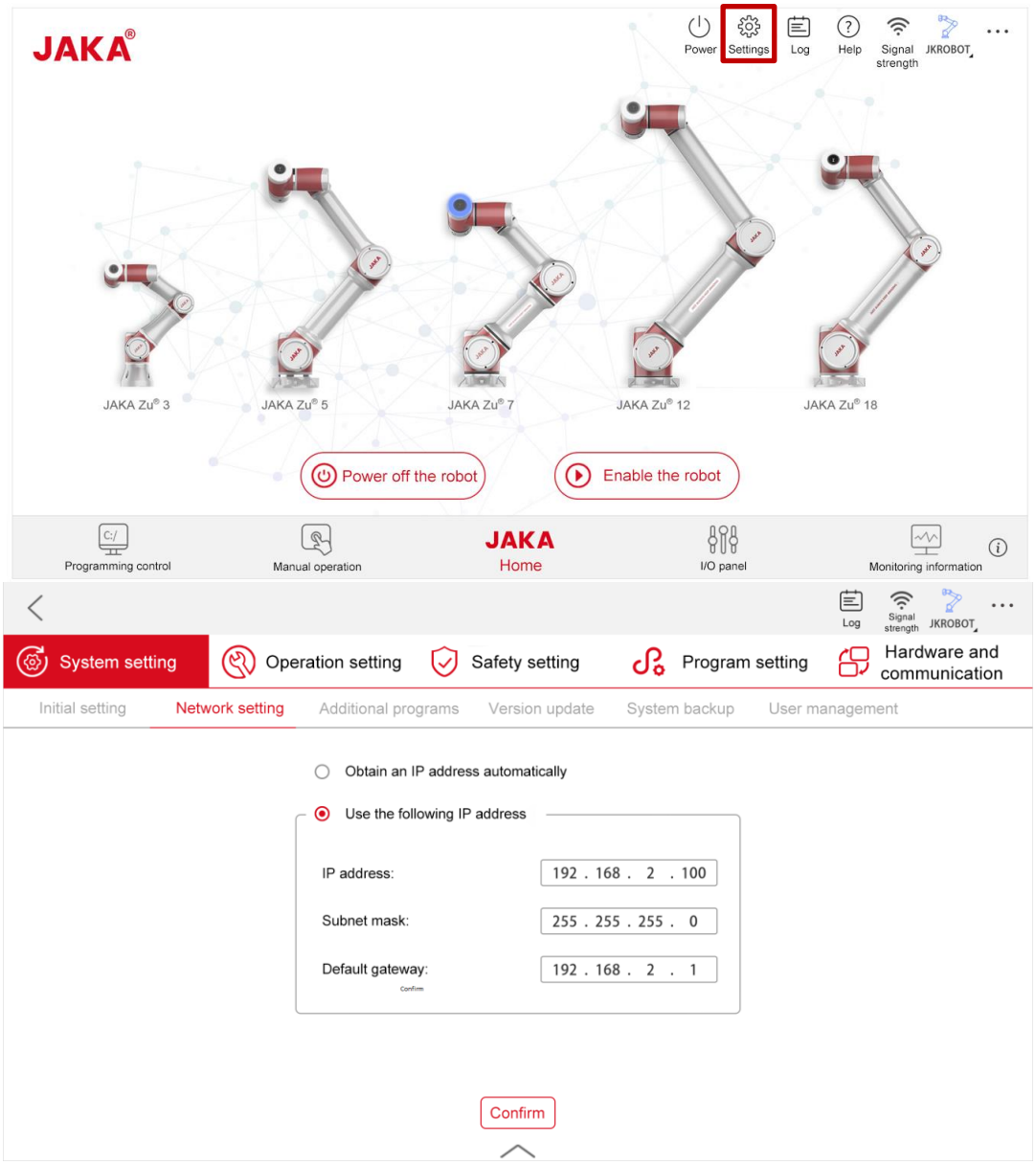
As shown in Figure 3-2, select "Use the following IP address", modify the IP address to "192.168.2.100", modify the subnet mask to "255.255.255.0", and modify the default gateway to "192.168.2.1";

Note: If you do not want to use the default sensor IP address, you can consult us and modify it through the sensor host computer.

e. Turn on the robot CAB, open the JAKA Zu app, connect the robot to the app, and power on the robot;

f. As shown in Figure 3-2, tap [Settings] at the upper right of the Home page, and then tap [Hardware and communication] → [End sensor] to enter the sensor configuration interface;

g. In the sensor configuration interface, select the appropriate sensor type, specify the IP and port number (For type III sensor, the default IP is 192.168.2.108, and the port number is 4008. For type I sensor, please refer to separate instructions or contact us), and then tap [Confirm]. After "Setting succeeded" pops up, tap the toggle switch on the right to change its status from [Edit] to [Run];



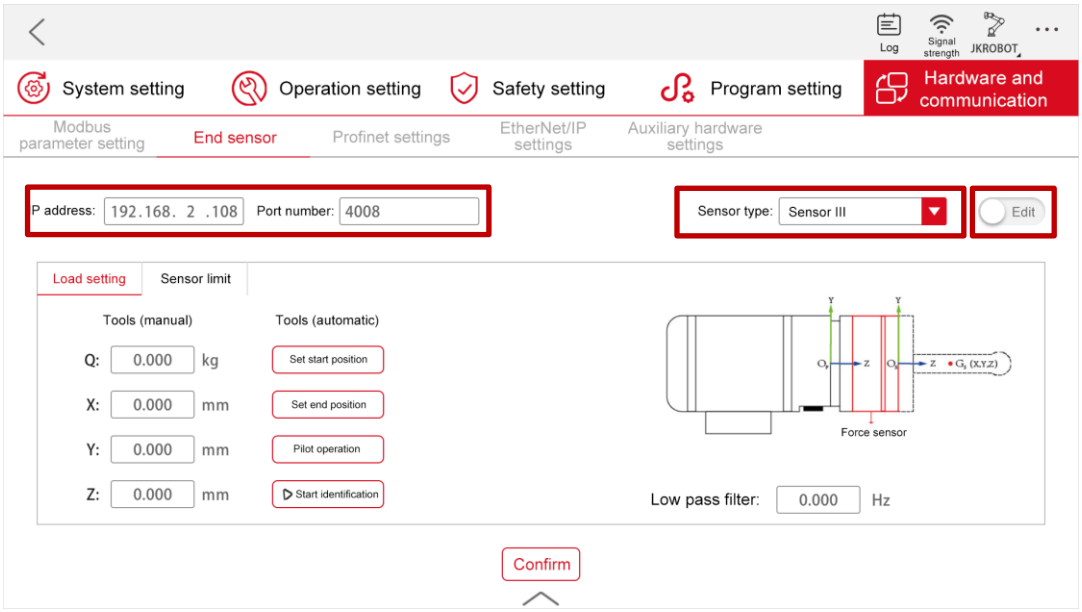


Figure 3-2 Se System Configuration Interface (I/III Network Port Type)

h. Open the "Manual operation" page, tap [Configure], check [Do not initialize], tap [confirm], and close the page. Then tap the [View] button on the right, and turn on all the toggle switches (Fx, Fy, Fz, Mx, My, Mz, and real-time). Slightly push or pull the sensor. If the graph fluctuates, the sensor communication is normal (See the usage of the real-time display of external force function for details);

Note: If the communication fails, please check whether the sensor hardware is in good condition and whether the wiring and configurations are correct. Then restart the sensor and the robot as follows: Power off the sensor → unplug the network cable → power off the robot and the CAB → plug the network cable into the corresponding interface on the CAB → power on the sensor → turn on the CAB → redo the configurations. If the problem persists after restarting, please contact us. Any unauthorized attempt to disassemble and repair the sensor, robot, CAB or cable is NOT allowed.

i. After normal sensor communication is established, set the load parameters: Tap [Settings] → [Hardware and communication] → [End sensor] → [Load setting], and tap the input box under the [Tools (manual)] bar on the left to manually input the mass and centroid position of the end tool connected to the sensor, or use the auto load identification function (See the "Usage of JAKA Zu Se" section for details). Once the load identification data has been verified (or after manually entering the load data), tap the toggle switch at the upper right of the interface to change its status from [Run] to [Edit], and tap the [Confirm] button at the bottom of the interface. After "Setting succeeded" pops up, tap the toggle switch at the upper right of the interface again to change its status from [Edit] to [Run]. At this point, the sensor is basically set up;

3.1.1.2 System Construction of Type II and Type V Sensors

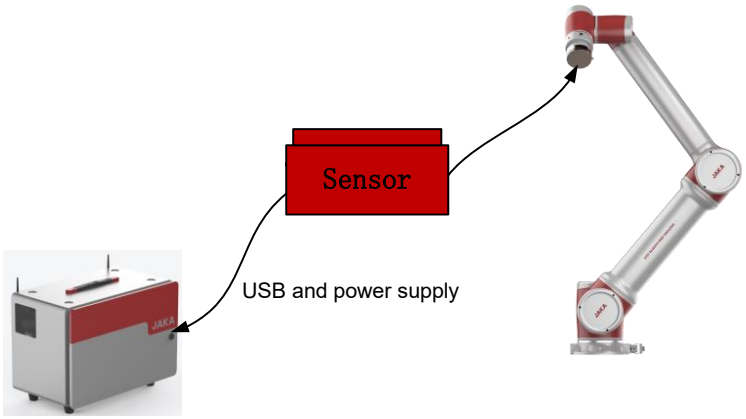


Figure 3-3 Se System (USB Type)

To use a type II or type V torque sensor, configure it as follows:

a. Correctly install the hardware to ensure that the X-axis positive direction of the type II sensor is consistent with that of the robot end flange;

b. Plug the sensor cable to the USB port on the front panel of the control cabinet;

c. Connect the sensor power supply, which can be powered by the internal power supply of the robot CAB or an additional 24V DC power supply;

d. Turn on the robot CAB, open the JAKA Zu app, connect the robot to the app, and power on the robot;

e. As shown in Figure 3-4, tap [Settings] at the upper right of the Home page, and then tap [Hardware and communication] → [End sensor] to enter the sensor configuration interface;

f. In the sensor configuration interface, select the appropriate sensor type, tap [Confirm], and tap the toggle switch on the right to change its status from [Edit] to [Run].

g. Open the "Manual operation" page, tap [Configure], check [Do not initialize], tap [confirm], and close the page. Then tap the [View] button on the right, and turn on all the toggle switches (Fx, Fy, Fz, Mx, My, Mz, and real-time. If it is a type V sensor, turn on the toggle switch of Fz). Slightly push or pull the sensor. If the graph fluctuates, the sensor communication is normal (See the usage of the real-time display of external force function for details);

Note: If the communication fails, please check whether the sensor hardware is in good condition and whether the wiring and configurations are correct. Then restart the sensor and the robot as follows: Power off the sensor → unplug the network cable → power off the robot and the CAB → plug the network cable into the corresponding interface on the CAB → power on the sensor → turn on the CAB → redo the configurations. If the problem persists after restarting, please contact us. Any unauthorized attempt to disassemble and repair the sensor, robot, CAB or cable is NOT allowed.

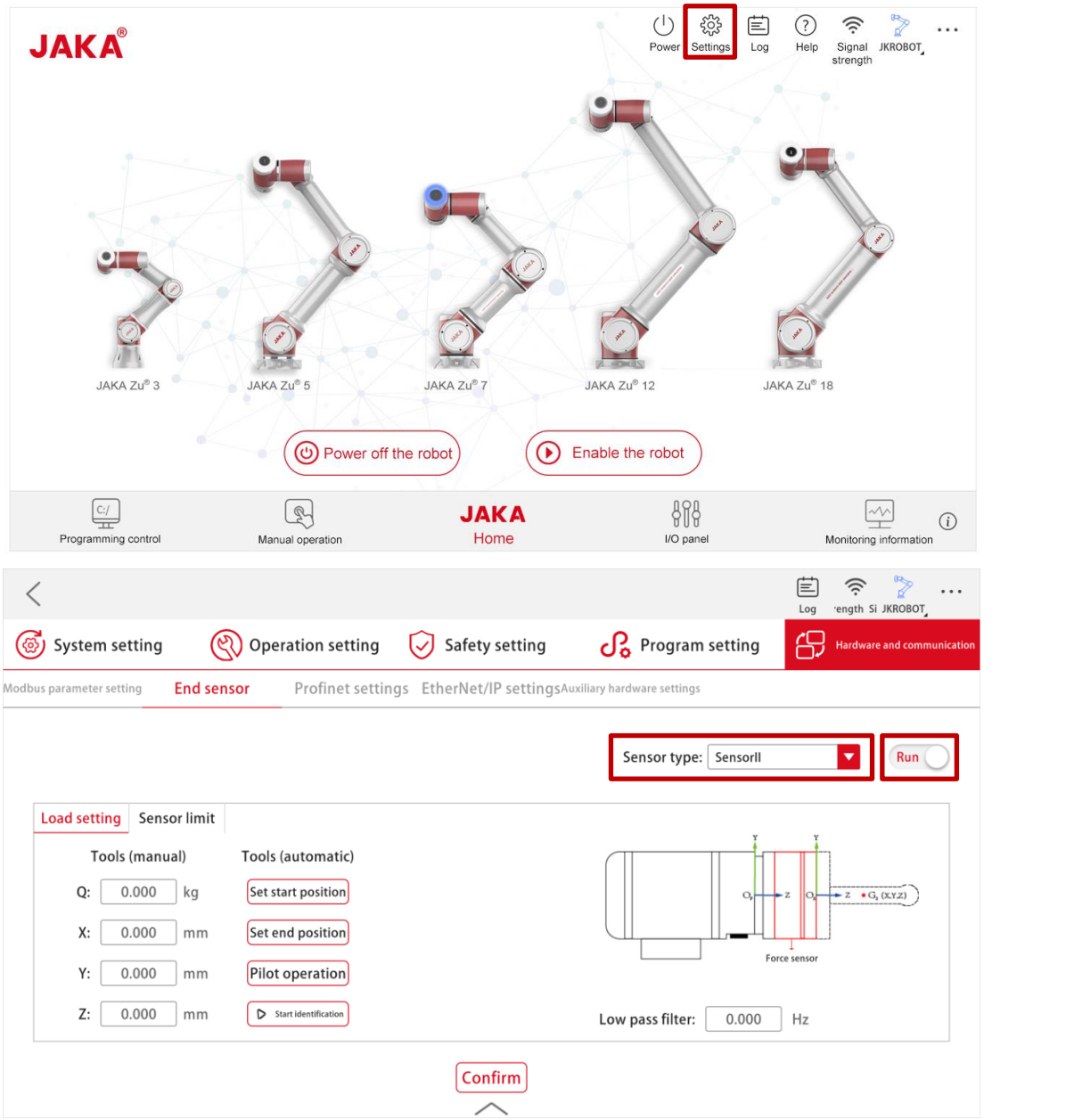


Figure 3-4 Se System Configuration Interface (USB Type)

h. After normal sensor communication is established, set the load parameters: Tap [Settings] → [Hardware and communication] → [End sensor] → [Load setting], and tap the input box under the [Tools (manual)] bar on the left to manually input the mass and centroid position of the end tool connected to the sensor, or use the auto load identification function (See the "Usage of JAKA Zu Se" section for details). Once the load identification data has been verified (or after manually entering the load data), tap the toggle switch at the upper right of the interface to change its status from [Run] to [Edit], and tap the [Confirm] button at the bottom of the interface. After "Setting succeeded" pops up, tap the toggle switch at the upper right of the interface again to change its status from [Edit] to [Run]. At this point, the sensor is basically set up;

3.1.1.3 System Construction of Type VI Sensor

To use a type VI torque sensor, configure it as follows:

a. Correctly install the hardware of the torque sensor, and connect its connecting terminal to the TIO interface at the robot end, with the XY direction of the sensor consistent with that of the end flange;

b. Turn on the robot CAB, open the JAKA Zu app, connect the robot to the app, and power on the robot;

c. Tap [Settings] → [Hardware and communication] → [Terminal IO] → [Voltage output] to configure the TIO output power supply, set the output voltage to 12V and enable it (see Figure 3-5). At this time, the sensor indicator light is on, indicating the sensor is powered on.

d. As shown in Figure 3-6, tap [I/O panel] → [Tool end], and tap "DO1" in the [Digital output] sub-window. (Note: tap "DO1" instead of the toggle switch above it). Then the "I/O settings" window will pop up. Select "Reuse as RS485 channel 1" in the drop-down box of the [Mode setting] bar, tap [Confirm] to exit, and [RS485 configuration] will be displayed on the right of the title of the [Digital output] sub-window;

e. Tap [RS485 configuration], and the configuration interface of the RS485 channel will pop up, including communication parameters and function/mode configuration. As shown in Figure 3-6, select [Torque sensor], and set the baud rate to 230400, the data bit length to 8, the stop bit length to 1, and the parity method to be none. After that, tap [Confirm], and the communication configuration between TIO and external torque sensor is completed;

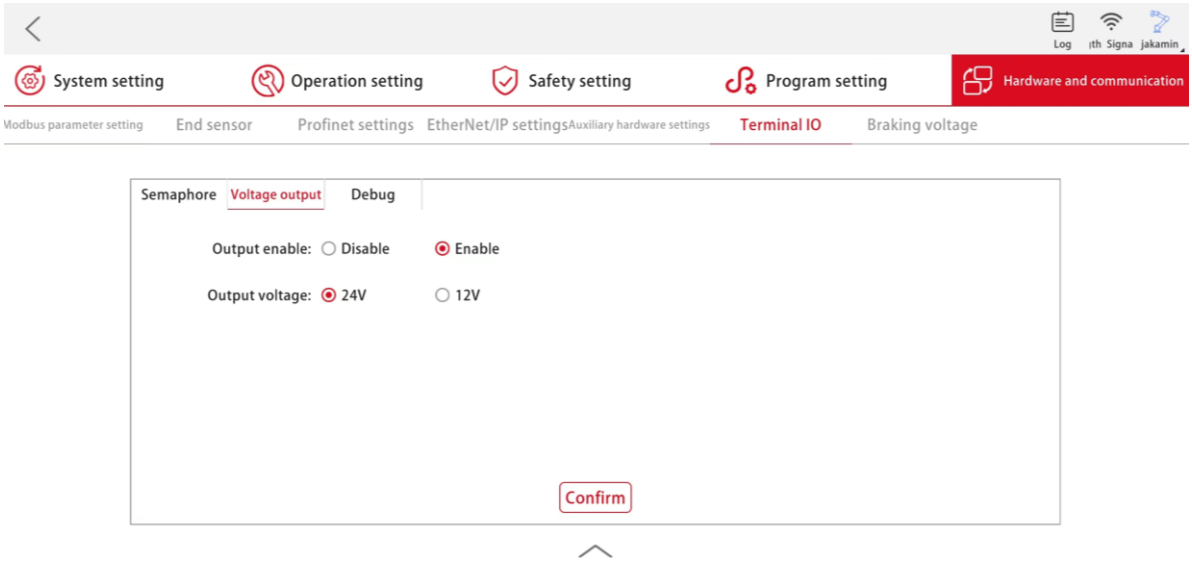


Figure 3-5 Power-on Configuration Interface of Type VI Sensor

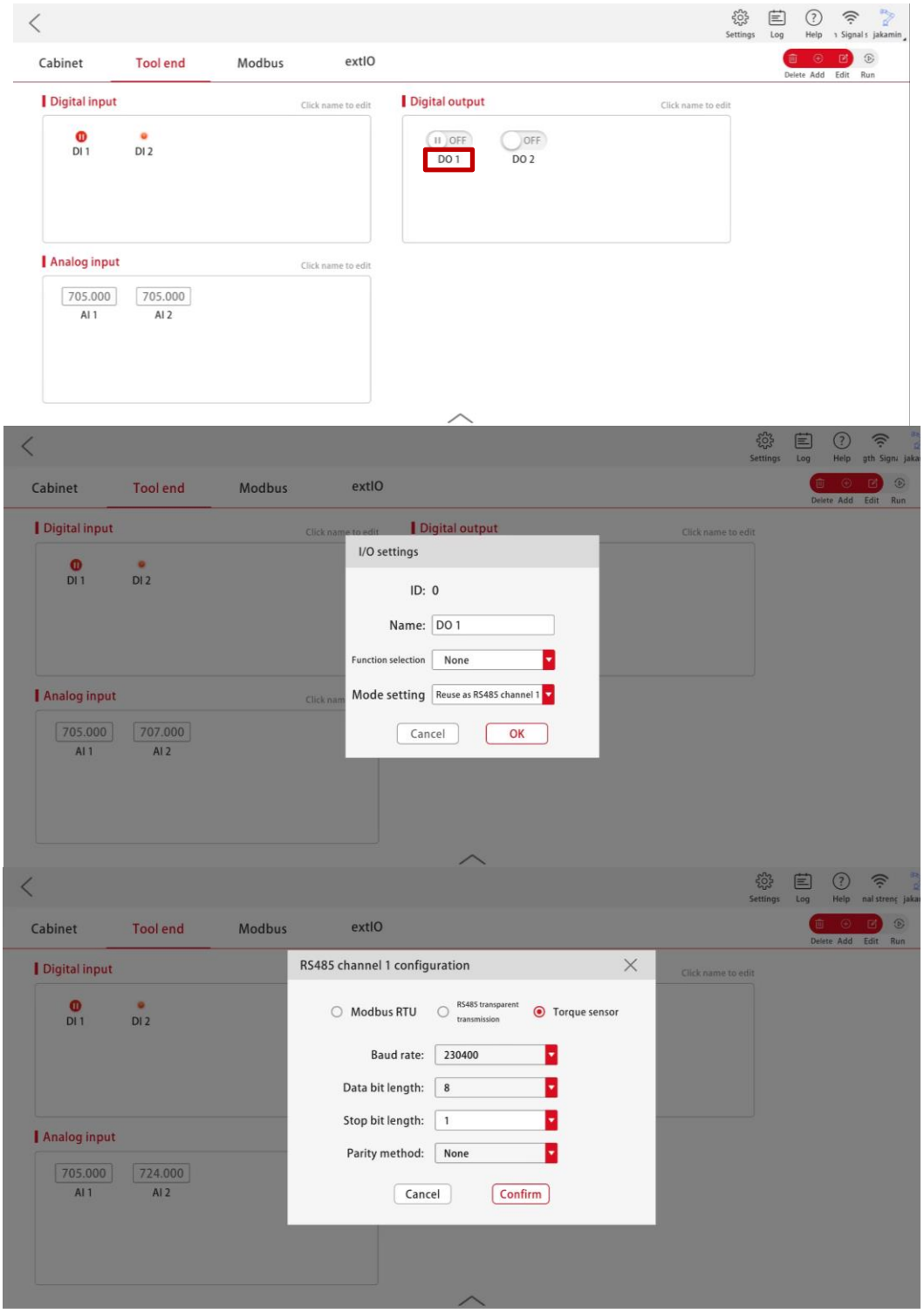


Figure 3-6 RS485 Channel Configuration Interface

f. As shown in Figure 3-7, tap [Settings] at the upper right of the Home page, then tap [Hardware and communication] → [End sensor] to enter the sensor configuration interface. Select the sensor type VI, then tap [Confirm] (Ensure the sensor brand is set successfully), and tap the toggle switch on the right to change its status from [Edit] to [Run]. Then the sensor can communicate properly;

Note 1: If the communication fails, please check whether the sensor hardware is in good condition and whether the wiring and configurations are correct. Then restart the sensor and the robot as follows:

Unplug the cable connecting the sensor to the TIO at the robot end → power off the robot and the CAB → plug the cable connecting the sensor to the TIO at the robot end → turn on the CAB → redo the configurations. If the problem persists after restarting, please contact us. Any unauthorized attempt to disassemble and repair the sensor, robot, CAB or cable is NOT allowed.

Note 2: If you've chosen the TIO channel for the current torque sensor, switching to the TIO's RS485 channel configuration or pin configuration while communicating will trigger an error message. At this time, turn off the sensor and try again.

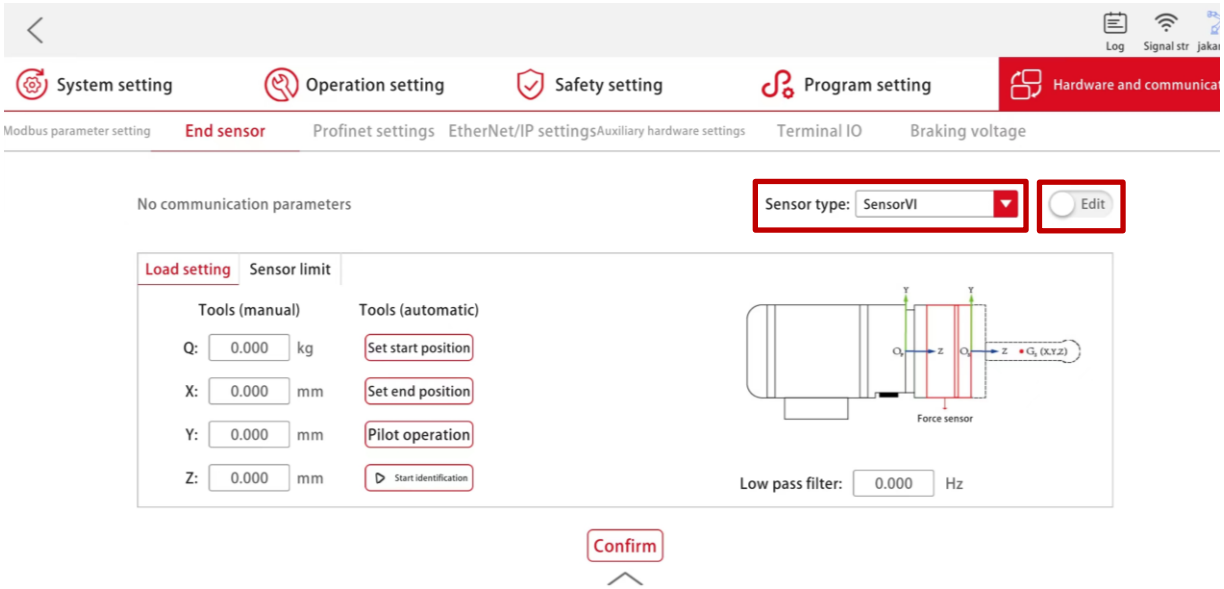


Figure 3-7 Se System Configuration Interface (TIO Type)

g. Open the "Manual operation" page, tap [Configure], check [Do not initialize], tap [confirm], and close the page. Then tap the [View] button on the right, turn on all the toggle switches (Fx, Fy, Fz, Mx, My, Mz, and real-time. If it is a 1D sensor, turn on the toggle switch of Fz). Slightly push or pull the sensor. If the graph fluctuates, the sensor communication is normal (See the usage of the real-time display of external force function for details);

h. After normal sensor communication is established, set the load parameters: Tap [Settings] → [Hardware and communication] → [End sensor] → [Load setting], and tap the input box under the [Tools (manual)] bar on the left to manually input the mass and centroid position of the end tool connected to the sensor, or use the auto load identification function (See the "Usage of JAKA Zu Se" section for details. 1D sensor does not support auto load identification). Once the load identification data has been verified (or after manually entering the load data), tap the toggle switch at the upper right of the interface to change its status from [Run] to [Edit], and tap the [Confirm] button at the bottom of the interface. After "Setting succeeded" pops up, tap the toggle switch at the upper right of the interface again to change its status from [Edit] to [Run]. At this point, the sensor is basically set up;

3.1.2. Usage of JAKA Zu Se

Precautions for using JAKA Zu Se:

a. As the integrated force sensor is a precision instrument, please use it within the range specified in the manual. When the load is greater than the rated load, the product may fail. Please ensure the load in each direction of the force sensor is within the load range;
b. Ensure the load of the robot end sensor is set accurately;
c. Ensure that the X-axis positive direction of the sensor is consistent with that of the robot flange, or set the tool coordinate system to ensure the consistent direction;
d. When using the traction teaching or constant force compliance function, make sure the robot end has no contact with the environment in the initialization stage of the sensor;
e. Please avoid rigid contact or rigid connection between the robot end tool and the environment in force control functions other than motion stop conditions and velocity compliance control functions;
f. If the robot trembles, shakes, becomes unstable and drifts during use, please immediately turn off the force control mode in use or press the emergency stop button to avoid property damage or personal injury.

3.1.2.1 Real-time Display of External Force Function

Tap [View] in the manual operation interface to check the contact external force value in real time. You can check the corresponding force data curve by turning on/off the toggle switches in front of Fx, Fy, Fz, Mx, My, and Mz. If the [Real time] toggle switch is on, the force data curves will be continuously refreshed in real time. If it is off, the refreshing will stop and the last set of force curve data recorded will be displayed. You can tap a dot on the curve to check the corresponding force data recorded.
If you check [Initialization] in the [Configure] interface, the interface will display the actual force values measured after sensor offset and load compensation. If you check [Do not initialize], the interface will display the sensor's original readings.

CAUTION:
When the sensor is initializing (i.e., when check [Initialization] and tap [confirm], or turn on the drag toggle switch while [Initialization] is checked, or the initialization set in the program is executed), if there's a contact force between the robot end and the environment, this contact force at that initializing moment will be seen as an sustained offset of the system. If you directly use the force control function with this offset uncleared, after the robot end loses contact, the system may mistakenly assume that the robot end is subjected to a force equal and opposite to the previous contact force, causing the robot to move toward the direction of the original contact, which is dangerous. To clear this offset, please isolate the robot end from the environment. Open the [Configure] interface, check [Initialization] and tap [Confirm].

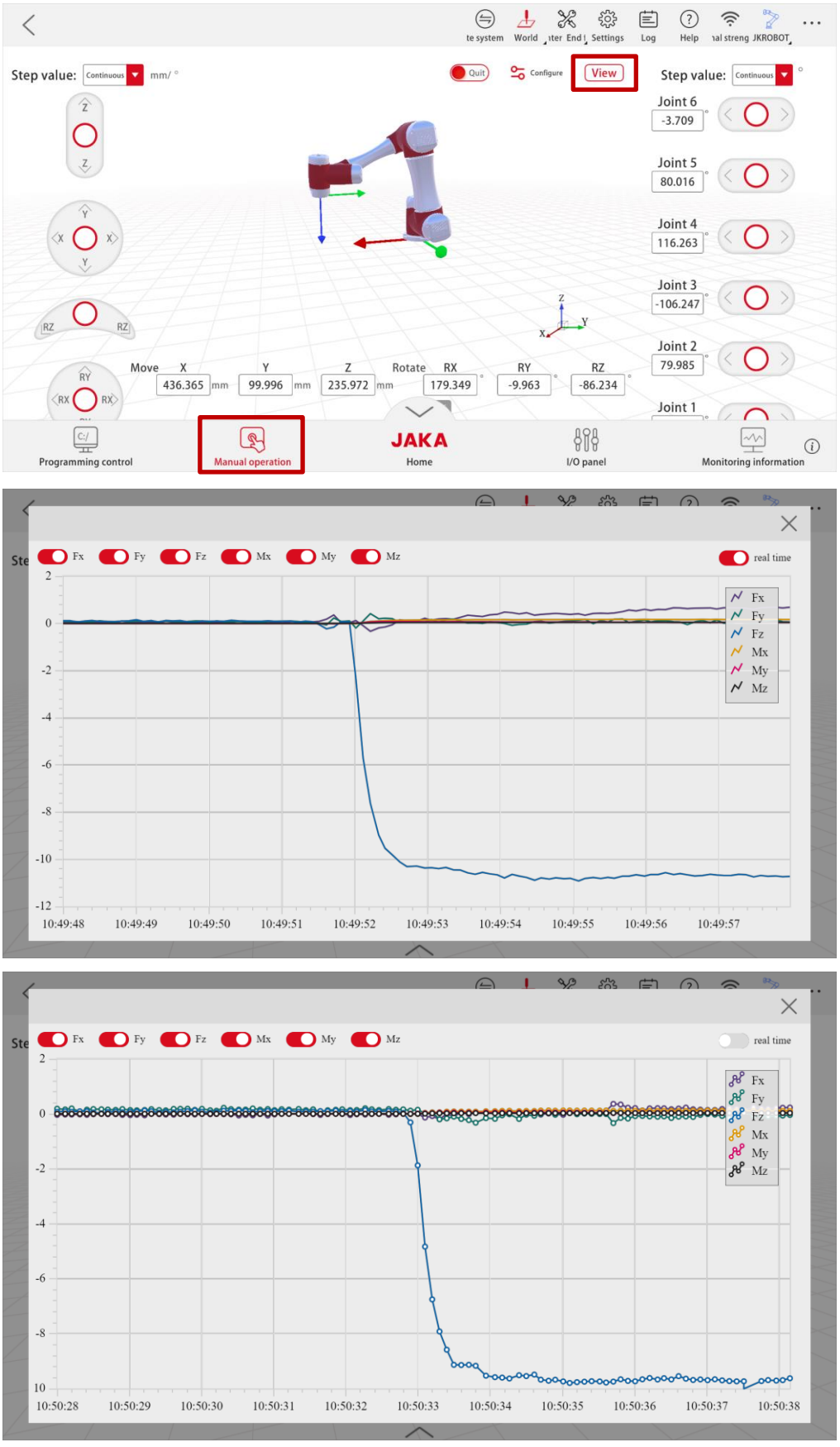


Figure 3-8 Force Display Interface of the App

3.1.2.2 Auto Load Identification Function

To use the auto load identification function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. Tap [Settings] at the upper right of the Home page, then tap [Hardware and communication] → [End sensor] → [Load setting] to enter the load setting interface (See Figure 3-9);

c. Tap [Set start position] to enter the manual interface, and move the robot to a suitable position (power on and enable the robot, and leave enough clearance near the robot end so that the joints 4, 5, and 6 can move without collision or cable pulling). Then tap [Confirm] to exit;

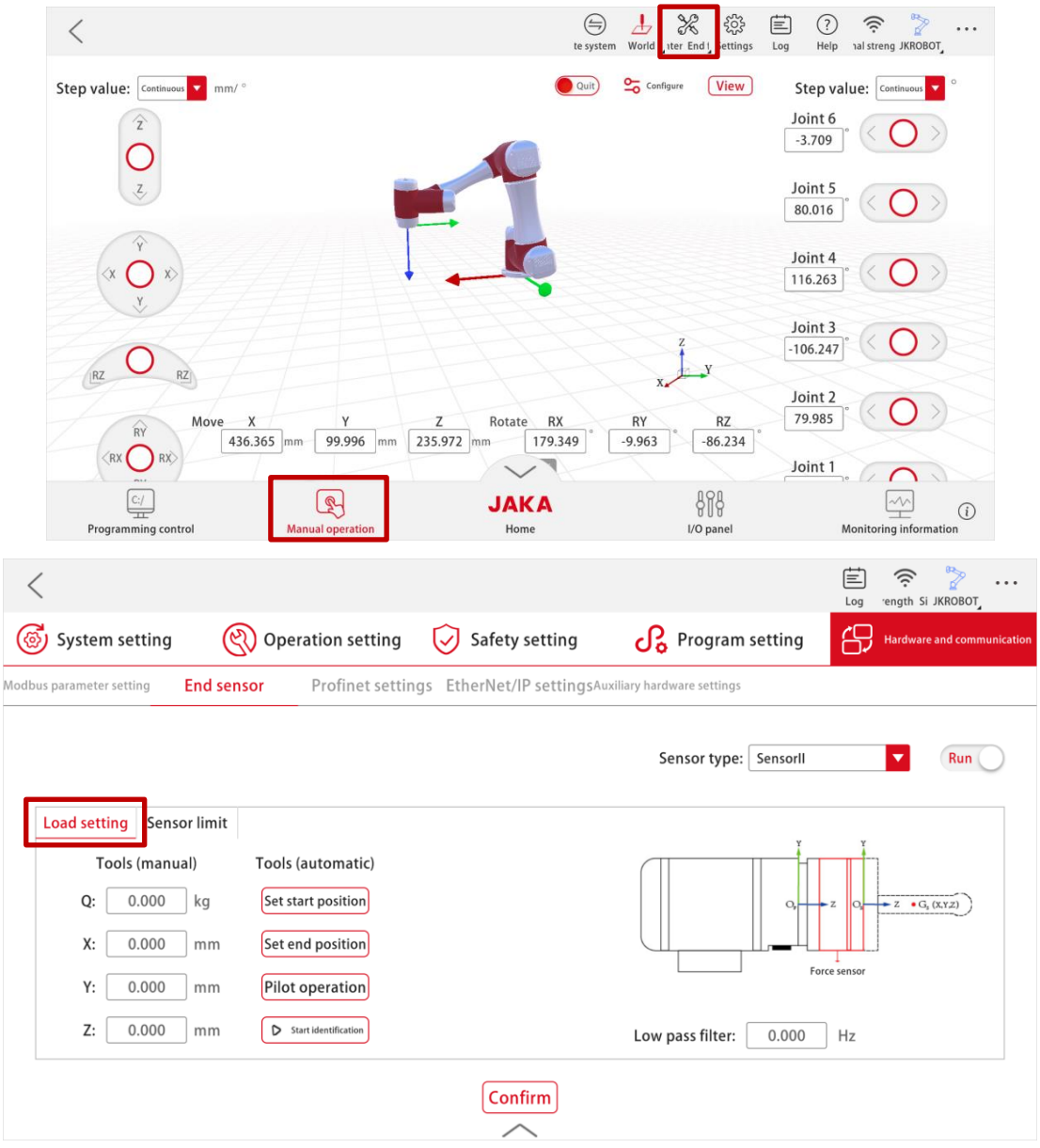


Figure 3-9 Load Setting Interface

d. Tap [Set end position] to enter the manual interface, and allow joints 4, 5, and 6 to move. Ensure that joints 1, 2 and 3 do not move (Namely, by tapping the right side of the manual interface, you can individually control the movement of joints 4, 5, and 6. It is prohibited to drag the robot or control the robot through the left virtual handles for x/y/z/Rx/Ry/Rz). Keep the motion range within ±90° of the initial

position (As long as the robot isn't colliding with anything or the cable isn't being pulled, a larger range of motion will yield more accurate identification results). Tap [Confirm] to exit;

e. Tap and hold [Set start position] to make the robot return to the initial position, and tap and hold [Pilot operation] to confirm that the identification trajectory is safe;

f. Tap and hold [Set start position] to make the robot return to the initial position. Tap [Start identification], and it will take 1 minute for the App to display the identification result. If the result is correct, tap [Confirm], and the app will automatically update the load data; If the result is incorrect, exit and re-enter the sensor configuration interface for identification.

3.1.2.3 Safety Function

To use the safety function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. Tap [Settings] at the upper right of the Home page, then tap [Hardware and communication] → [End sensor] → [Sensor limit] to enter the load setting interface, and change the toggle switch status to [Edit] (See Figure 3-10);

c. Set the maximum allowable safety force in the [Sensor limit] tab. During the motion of the robot, if the absolute value of the force on the end of the sensor is greater than this set value, the robot will stop immediately to avoid danger or property loss. If you set it to 0, it indicates no limit. Unless specified differently, it's recommended to set the safety force value at 80% of the sensor's range;

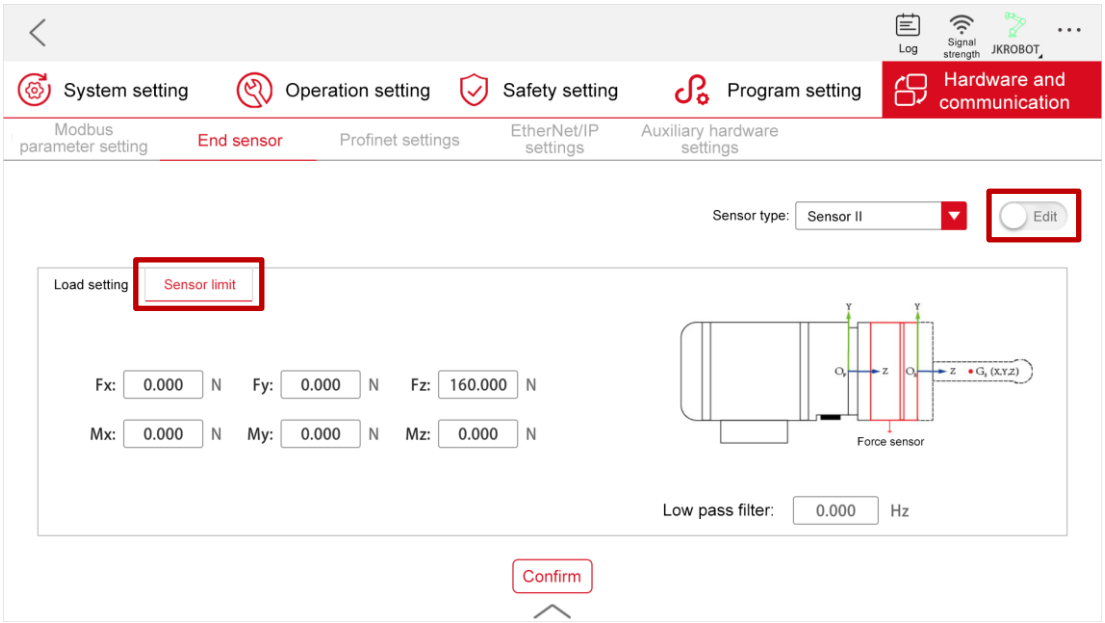


Figure 3-10 JAKA Zu Se Safety Function Settings

d. Tap [Confirm] and change the toggle switch status to [Run].

CAUTION:

Sensor limit is not a part of the robot's standard safety function. It is only effective when using the traction teaching function for the end sensor, the constant force compliance function, and the velocity compliance control function.

3.1.2.4 Traction Teaching Function

To use the traction teaching function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. As shown in Figure 3-11, open the [Manual operation] page, and tap [Configure] to enter the teaching editing interface, where Fx, Fy, and Fz correspond to the displacements in the directions of X, Y, and Z, and Mx, My, and Mz correspond to rotations in the directions of X, Y, and Z; Check □ in front of [Direction] to enable one or more directions. Then you can drag the robot in the enabled direction(s) after turning on Drag; The lower the [damping force] is set, the less force is required to drag, but it doesn't mean the lower the better. It is recommended to set Fx, Fy, and Fz to be greater than 15N, and Mx, My, and Mz to be greater than 0.3Nm. It is NOT allowed to set the values to 0 (for your first attempting after powering on, it's recommended to set Fx, Fy, and Fz above 50N, and Mx, My, and Mz above 1Nm); Setting [Springback] enables the robot to return to its original position after it has been dragged away and released, simulating the spring effect. The farther the robot is dragged; the greater force is required to drag. Setting a higher value will require more force to drag, and the robot will rebound faster once it's released.

CAUTION:

[Damping force] is merely a parameter for softness or hardness, not an exact value. In other words, if you set the [Damping force] to 25N, it does not imply that you must apply a force of 25N to get the robot end to start moving. Similarly, it doesn't mean that the robot will resist with a force of 25N when you're dragging it.

CAUTION:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, set the [Damping force] to a higher value (Fx, Fy, and Fz above 50N, and Mx, My, and Mz above 1 Nm). Don't adjust this value until you've confirmed that the traction teaching function is not reporting any errors

c. To select the force control coordinate system: check [Tool coordinate system], and drag the robot in the set tool coordinate system; check [World coordinate system], and drag the robot in the set world coordinate system;

d. Initialization: Check [Initialization], when you tap the toggle switch to enter the drag mode, the system will automatically compensate the sensor offset and load (this process takes about 1 second. Ensure no external force is applied to the robot end during initialization, otherwise the compensation accuracy will be affected). After the CAB is powered on, be sure to check [Initialization] before using the traction teaching function;

e. After completing the above configurations, tap [Confirm] and the toggle switch on the left of [Configure] to change its status from [Quit] to [Drag] and enter the drag mode.

CAUTION:

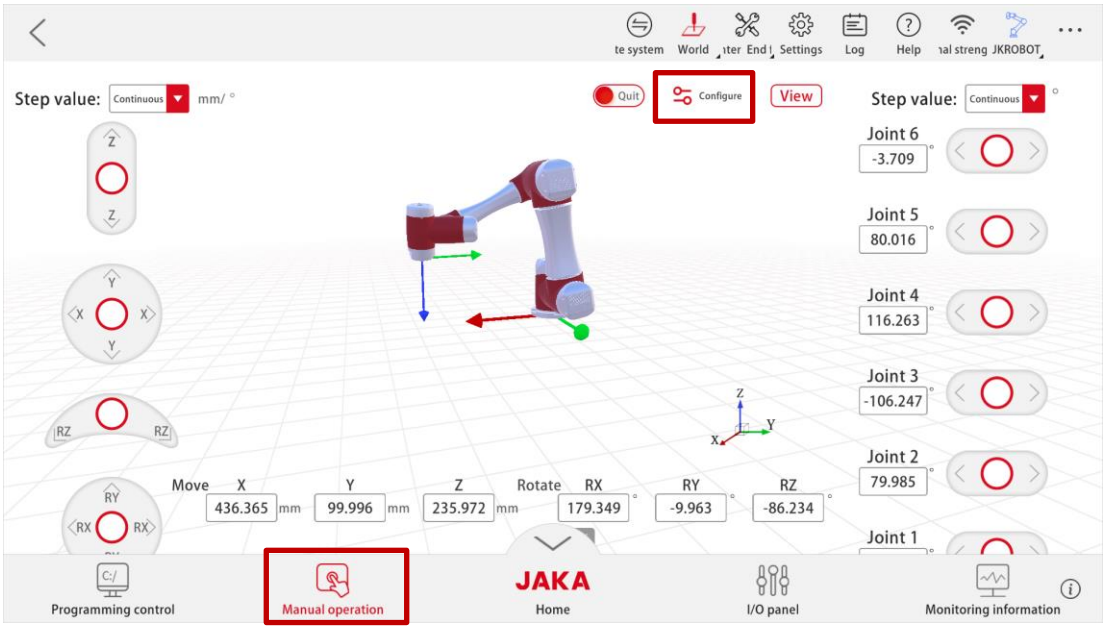
It is recommended to always check [Initialization] before entering the drag mode to ensure safety. The robot can be dragged only when it is enabled.

WARNING:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, be sure to check [Initialization] before using this function for the first time, otherwise it could lead to uncontrolled robot movement, potentially causing damage to device or personal injury.

WARNING:

If the [Initialization] is checked, the robot end must be free from any external force both before and within one second after entering the drag mode. If not, a sensor compensation error could occur, leading to uncontrolled robot movement, device damage, or personal injury.



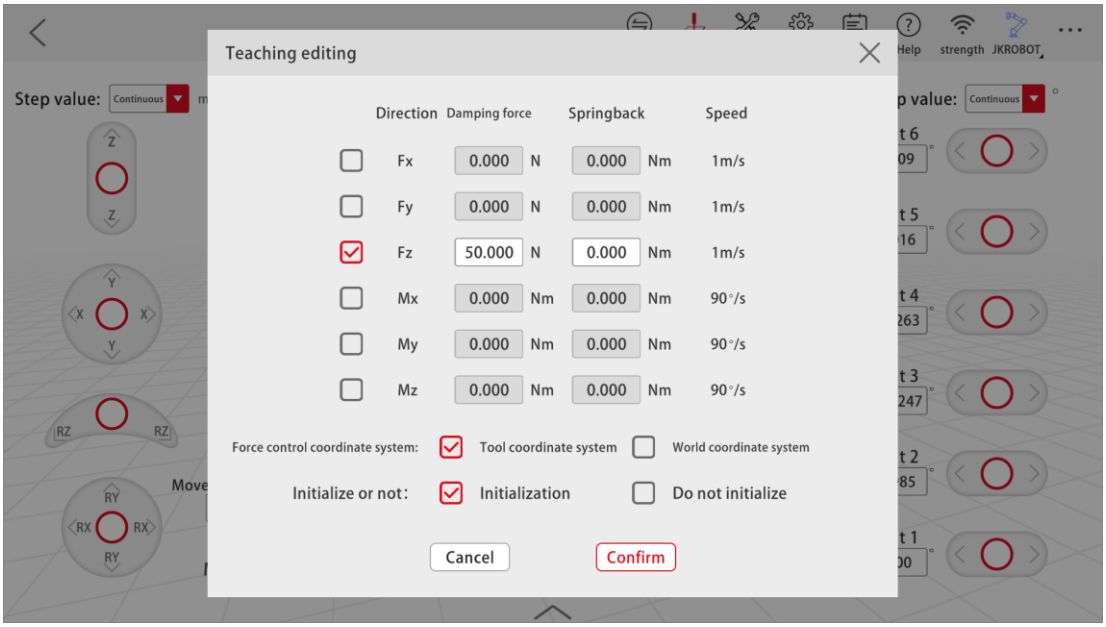


Figure 3-11 JAKA Zu Se Traction Teaching Function Settings

Note: Due to factors such as sensor temperature drift, if the robot position drifts in the drag mode, please tap the toggle switch to exit the drag mode, check [Initialization] in the configuration interface, and then enter the drag mode to redo sensor compensation; If you do not use the traction teaching function, please tap the toggle switch in time to exit the drag mode.

3.1.2.5 Constant Force Compliance Function

The constant force compliance function can ensure that the contact force between the robot end and the environment is close to the set value. To use the constant force compliance function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. As shown in Figure 3-12, write a program with the program blocks of [Set force control coordinate system], [Constant force compliance parameter setting], [Activate constant force compliance control] and [Inactivate constant force compliance control]. The scene for the example program in Figure 3-12 is that the robot makes a linear motion in X and Y directions (i.e., "wiping a table plane") on the XY plane (such as a horizontal desktop) while controlling the contact force (i.e., pressing force) in the Z direction. The "down" point only decreases in the Z direction compared with the "start" point, but it is still higher than the plane to be pressed to avoid contact with the plane. In addition, compared with the "down" point, the "target" point only changes in the X and Y directions, and the "up" and "target" points are set to the same point (Since the robot will automatically press the plane after the force control is turned on, its height in the Z direction will actually be lower than the position set by the target point when the motion is finished);

⚠CAUTION:

Please design a safe trajectory for the robot to make sure there will be no contact other than in the force-controlled direction during the robot's motion.

CAUTION:

For all motion commands between the program blocks "Activate constant force compliance control" and "Inactivate constant force compliance control", please select the joint motion mode, and set the speed to be less than 100 mm/s to improve accuracy.

c. The function of the "Set force control coordinate system" program block is the same as that of the coordinate system selection in the configuration page of the manual operation interface;

d. Tap the "Constant force compliance parameter setting" program block to enter the "Constant compliance control editing" interface. The meanings of the parameters [Damping force] and [Springback] are consistent with the traction teaching configuration parameters in the manual operation interface. Set the [Damping force] based on the environmental stiffness (i.e. the hardness of the contact surface). Generally, the greater the environmental stiffness is, the greater [Damping force] is required. In addition, you can set the [Constant force] according to the desired contact force;

CAUTION:

When you modify the parameters for [Damping force] and [Springback] here, the parameters with the same names on the teaching editing page of the manual operation interface will also be updated, and the same applies in reverse.

CAUTION:

Place the [Set force control coordinate system] and [Constant force compliance parameter setting] modules above the [Activate constant force compliance control] module. Otherwise, they may not function properly. Additionally, after using force control, be sure to add the [Inactivate constant force compliance control] module. If the [Activate constant force compliance control] module is executed again without executing the [Inactivate constant force compliance control] module, it may cause the robot to move dangerously.

e. The [Initialization] in the "Activate constant force compliance control" program block plays the same role as the initialization check box in the traction teaching configuration of the manual operation interface. When using this function for the first time, you must select [Initialization] and make sure that the robot end does not contact with the environment when the program runs to this point. In addition, due to the temperature drift of the sensor, it is recommended to select [Initialization] when no external force is applied to the robot end, so as to re-compensate the sensor after the robot has been running for a period of time.

WARNING:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, do not use this function until you've confirmed that the traction teaching function is not reporting any errors (See the previous section for details) to avoid accidents.

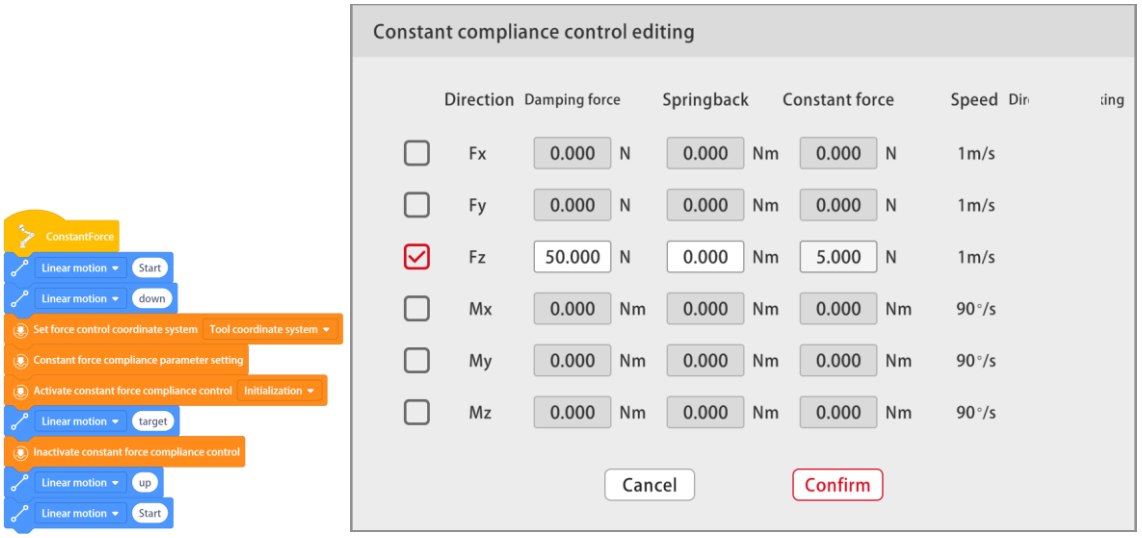


Figure 3-12 Constant Force Mode Programming of JAKA Zu Se

3.1.2.6 Velocity Compliance Control Function

When the force applied to the robot end is greater than the set control force, the robot will stepwise decelerate as per the set speed steps until the value detected by the sensor is less than the set control force or the robot decelerates to a halt. To use the velocity compliance control function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. As shown in Figure 3-13, write a program with the program blocks of [Set force control coordinate system], [Velocity compliance parameter setting], and [Compliance control force], [Activate the velocity compliance control] and [Inactivate the velocity compliance control]. The scene for the example program in Figure 3-13 is that the robot reciprocates in the x direction while controlling the contact force;

CAUTION:

Please design a safe trajectory and correct speed for the robot.

c. The function of the "Set force control coordinate system" program block is the same as that of the coordinate system selection in the configuration page of the manual operation interface;

d. Tap the "Compliance control force" program block to enter the "Compliance control force editing" interface, and fill in the force value for the direction that requires force control. 0 means no force control in this direction;

e. Tap the "Velocity compliance parameter setting" program block to enter the "Speed compliance control edit" interface, check the desired reduced model and fill in the corresponding speed level;

CAUTION:

Place the [Set force control coordinate system] and [Velocity compliance parameter setting] modules above the [Activate the velocity compliance control] module. Otherwise, they may not function properly. Additionally, after using force control, be sure to add the [Inactivate the velocity compliance control] module. If you run the [Activate the velocity compliance control] module again without first executing the [Inactivate the velocity compliance control] module, it may cause the robot to move dangerously.

f. The [Initialization] in the "Activate the velocity compliance control" program block plays the same role as the initialization check box in the traction teaching configuration of the manual operation interface. When using this function for the first time, you must select [Initialization] and make sure that the robot end does not contact with the environment when the program runs to this point. In addition, due to the temperature drift of the sensor, it is recommended to select [Initialization] when no external force is applied to the robot end, so as to re-compensate the sensor after the robot has been running for a period of time.

WARNING:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, do not use this function until you've confirmed that the traction teaching function is not reporting any errors (See the "Traction Teaching Function" section for details) to avoid accidents.

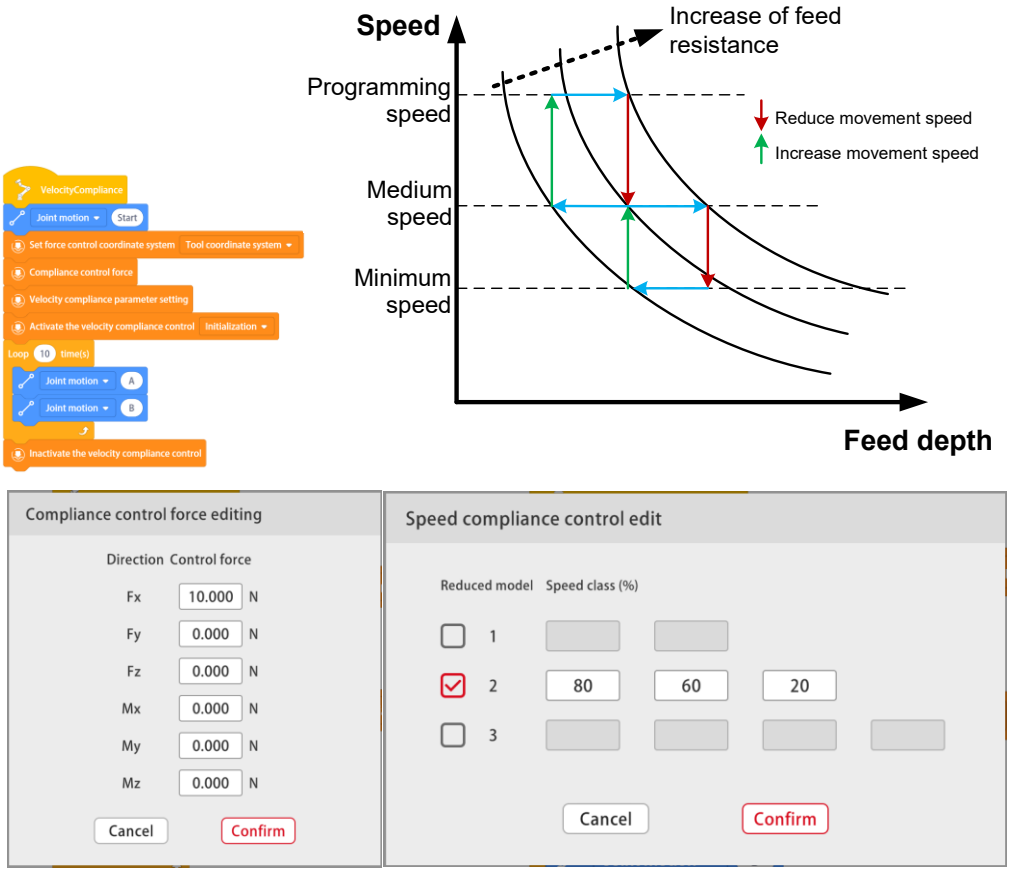


Figure 3-13 Velocity Mode Programming of Jaka Zu Se

3.1.2.7 Motion Stop Conditions Function

In the motion stop conditions setting interface, check the direction to be monitored and set the upper limit or lower limit. When the contact force is less than the lower limit or greater than the upper limit, the motion stop conditions are triggered. [Motion stop conditions] monitor only the next motion instruction. If the motion stop conditions are triggered, the robot will immediately stop executing the current instruction and directly executes the next motion instruction from the current position to the end position of the next motion instruction.

To use the motion stop conditions function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. Write a program using the [motion stop conditions] instruction block as shown in Figure 3-14. The scene for the example program in Figure 3-14 is that a robot reciprocates in the z direction, detects the force during the descent, and immediately rises if the detected value exceeds the threshold.

CAUTION:

Please design a safe trajectory and correct speed for the robot.

WARNING:

When using the motion stop conditions, the robot's motion speed must not exceed 300 mm/s, with the acceleration no more than 300 mm/s^2. If the robot is carrying a load, set a lower speed and acceleration. Furthermore, set a lower motion speed and acceleration for specific applications to ensure the robot can stop quickly after a force is detected. Otherwise, it may result in hardware damage. Note that even if the program appears to run normally during testing, the sensors or other hardware components could potentially fatigue and fail due to prolonged, repeated heavy pulling, squeezing, or bending. Therefore, it is crucial during testing to monitor whether the force and torque exceed the sensor's range throughout the entire motion process, particularly at the moments before and after the motion stop conditions are triggered.

c. Tap the "Motion stop conditions" program block, check the direction to be detected and set the required threshold in the pop-up "Motion stop conditions" interface. Note that if the upper limit and lower limit are checked at the same time, the lower limit must be less than the upper limit (In general, the lower limit should be set to a negative value);

WARNING:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, do not use this function until you've confirmed that the traction teaching function is not reporting any errors (See the "Traction Teaching Function" section for details) to avoid accidents.

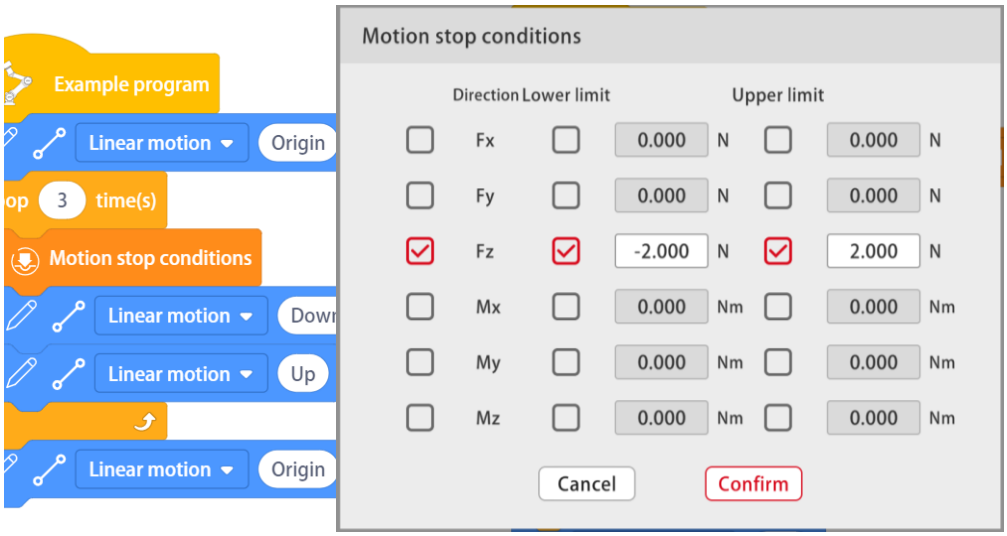


Figure 3-14 Motion Stop Conditions Programming of JAKA Zu Se

3.2. JAKA Zu Sp Software Usage

3.2.1. JAKA Zu Sp System Construction

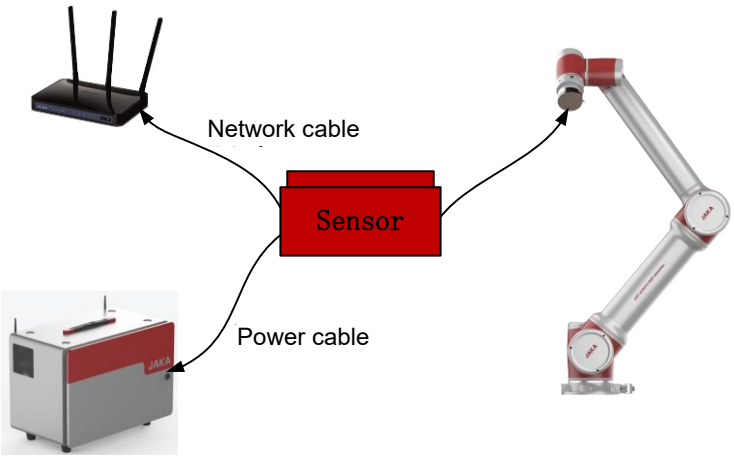


Figure 3-16 Se System (Network Port Type)

To use the base-type (type IV) torque sensor, configure it as follows:

a. Correctly install the hardware to ensure that the X-axis positive direction of the sensor is consistent with that of the robot base coordinate system;

b. Connect the network port of the sensor cable to a router or directly connect it to the network port at the bottom of the CAB;

c. Connect the sensor power supply, which can be powered by the internal power supply of the robot CAB or an additional 24V DC power supply;

d. If you connect the cable to a router, set the router IP to 192.168.2.x; If you directly connect the cable to the network port at the bottom of the CAB, set the CAB IP in the app:

Tap [Settings] at the upper right of the Home page, and then tap [System setting] → [Network setting];

As shown in Figure 3-17, select "Use the following IP address", modify the IP address to "192.168.2.100", modify the subnet mask to "255.255.255.0", and modify the default gateway to "192.168.2.1";

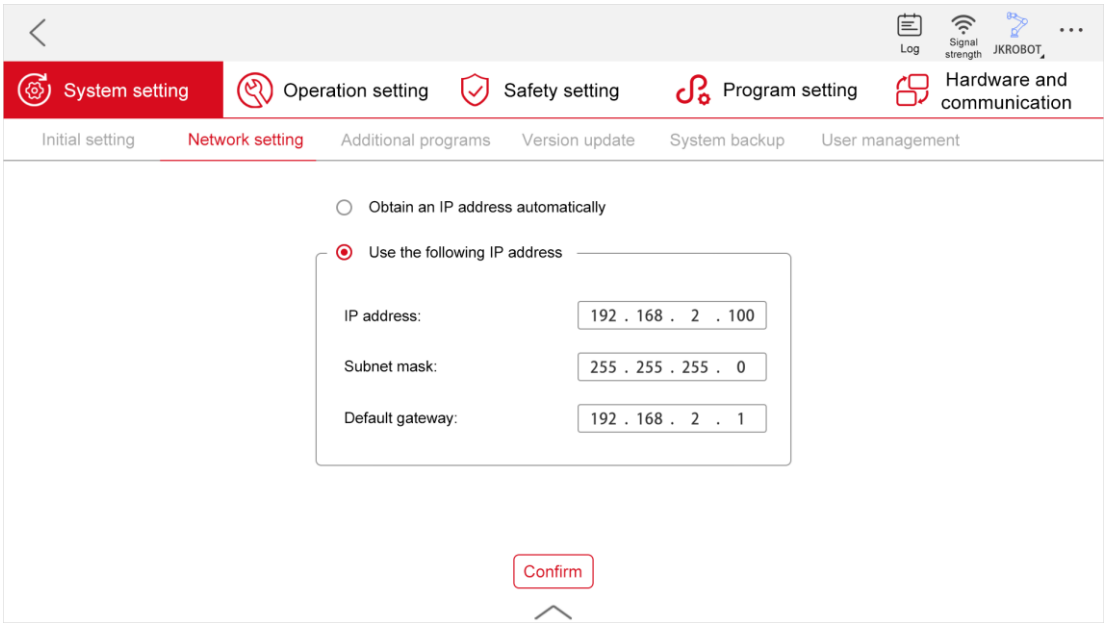
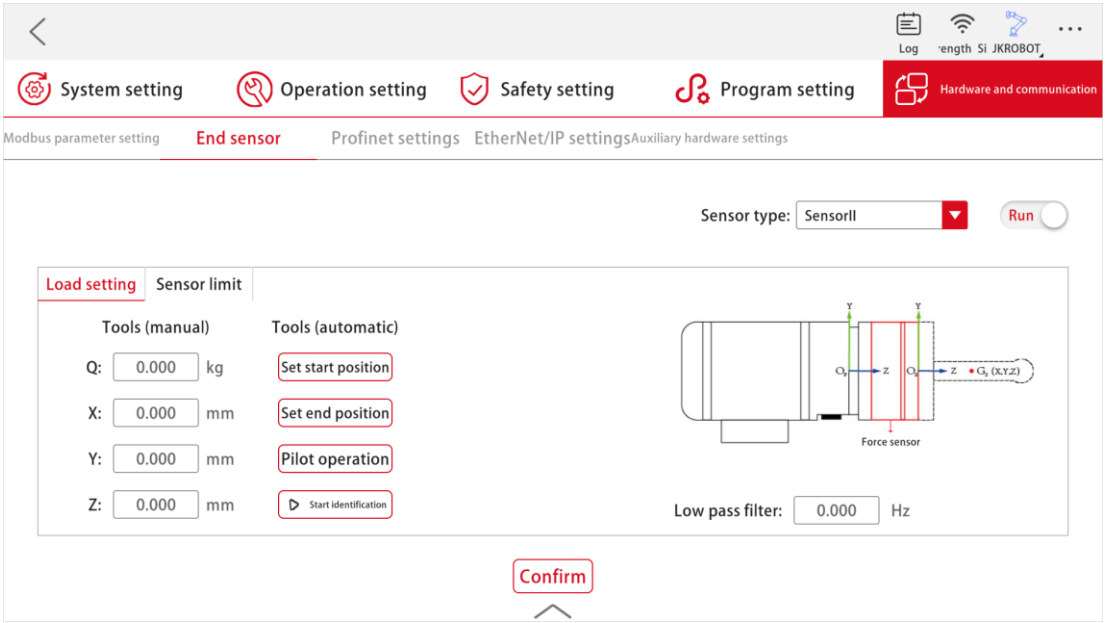


Figure 3-17 Network Setting Interface

Note: If you do not want to use the default sensor IP address, you can consult us and modify it through the sensor host computer.



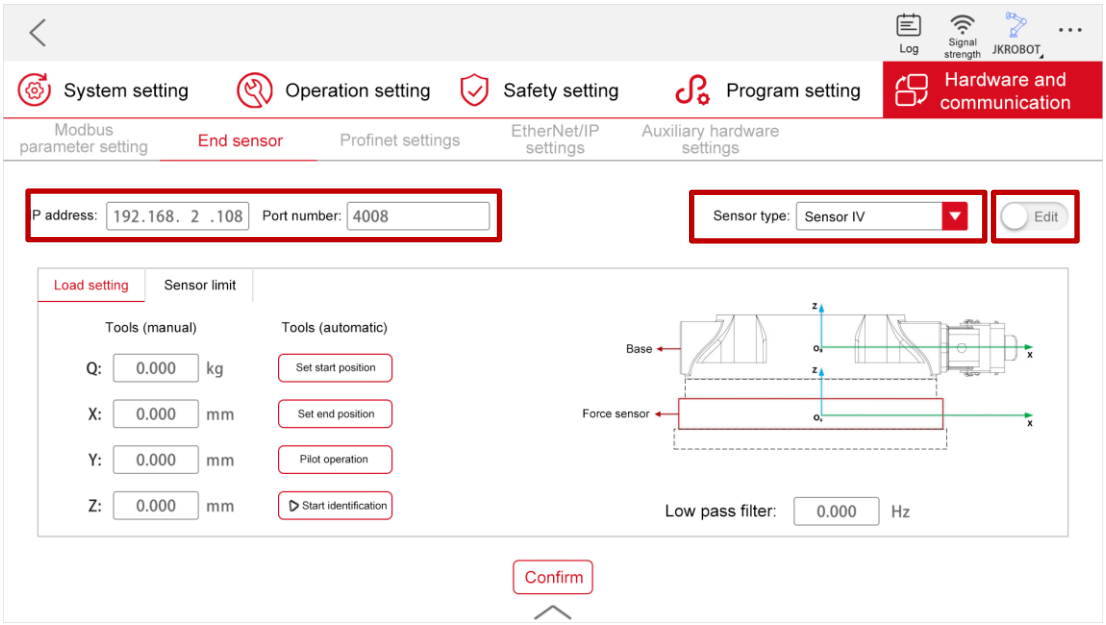


Figure 3-18 Sp System Configuration Interface (IV Base Type)

e. Turn on the robot CAB, open the JAKA Zu app, connect the robot to the app, and power on the robot;

f. As shown in Figure 3-18, tap [Settings] at the upper right of the Home page, and then tap [Hardware and communication] → [End sensor] to enter the sensor configuration interface;

g. In the sensor configuration interface, select the sensor type IV, set the IP to 192.168.2.108 and the port number to 4008, and tap [Confirm];

h. Set the load parameters: Tap [Settings] → [Hardware and communication] → [End sensor] → [Load setting], and tap the input box under the [Tools (manual)] bar on the left to manually input the mass and centroid position of the end tool connected to the sensor;

i. Tap the toggle switch at the upper right of the interface to change its status from [Edit] to [Run], and the sensor can be turned on normally;

j. Open the "Manual operation" page, tap [Configure], check [Do not initialize], tap [confirm], and close the page. Then tap the [View] button on the right, turn on all the toggle switches (Fx, Fy, Fz, Mx, My, Mz, and real-time). Slightly push or pull the sensor. If the graph fluctuates, the sensor communication is normal. At this point, the sensor is basically set up.

Note: If the communication fails, please check whether the sensor hardware is in good condition and whether the wiring and configurations are correct. Then restart the sensor and the robot as follows: Power off the sensor → unplug the network cable → power off the robot and the CAB → plug the network cable into the corresponding interface on the CAB → power on the sensor → turn on the CAB → redo the configurations. If the problem persists after restarting, please contact us. Any unauthorized attempt to disassemble and repair the sensor, robot, CAB or cable is NOT allowed.

3.2.2. Usage of JAKA Zu Sp

Precautions for Using JAKA Zu Sp:

a. As the integrated force sensor is a precision instrument, please use it within the range specified in the manual, especially when the load is greater than the rated load, the product may fail. Please ensure the load in each direction of the force sensor is within the load range;
b. Ensure the load of the robot end sensor is set accurately. If it is inaccurate, the robot may make false collision alarms. If you're unable to accurately determine the load, consider reducing the robot's collision sensitivity, provided the conditions allow for it;
c. Ensure that the X-axis positive direction of the sensor is consistent with that of the robot base coordinate system (direction of the aviation plug), or set the user coordinate system to ensure the consistent direction;
d. Ensure that both the force sensor and the control cabinet are configured with the same network segment;
e. When using the traction teaching or constant force compliance function, make sure the robot end has no contact with the environment in the initialization stage of the sensor;
f. Please avoid rigid contact or rigid connection between the robot end tool and the environment during traction teaching;
g. If the robot trembles, shakes, becomes unstable and drifts during use, please immediately turn off the force control mode in use or press the emergency stop button to avoid property damage or personal injury.

3.2.2.1 Real-time Display of External Force Function

Tap [View] in the manual operation interface to check the contact external force value in real time. You can check the corresponding force data curve by turning on/off the toggle switches in front of Fx, Fy, Fz, Mx, My, and Mz. If the [Real time] toggle switch is on, the force data curves will be continuously refreshed in real time. If it is off, the refreshing will stop and the last set of force curve data recorded will be displayed.

CAUTION:

When you're not in drag mode or are exiting it, if you check [Initialization] (See section 3.2.2.3 Traction Teaching Function), the system will compensate the sensor offset, load, etc. in real time. Therefore, if you tap the [View] button to check the force data, you will find that all the force data is 0. In this case, you need to check [Do not initialize] and tap [Confirm] to check the data.

CAUTION:

When you're not in drag mode or are exiting it, if you select [Initialization] while there's a contact force between the robot end and its environment, the contact force will be seen as a obtained bias. However, if you select [Do not initialize] and tap [Confirm] or enter drag mode while a contact force still exists, a force bias opposite to this contact force will be created in the system once the contact force disappears. This means that even when no force is being applied to the robot end, the system might mistakenly think that the robot end is experiencing a force equal and opposite to the previous contact force. Please exercise caution.

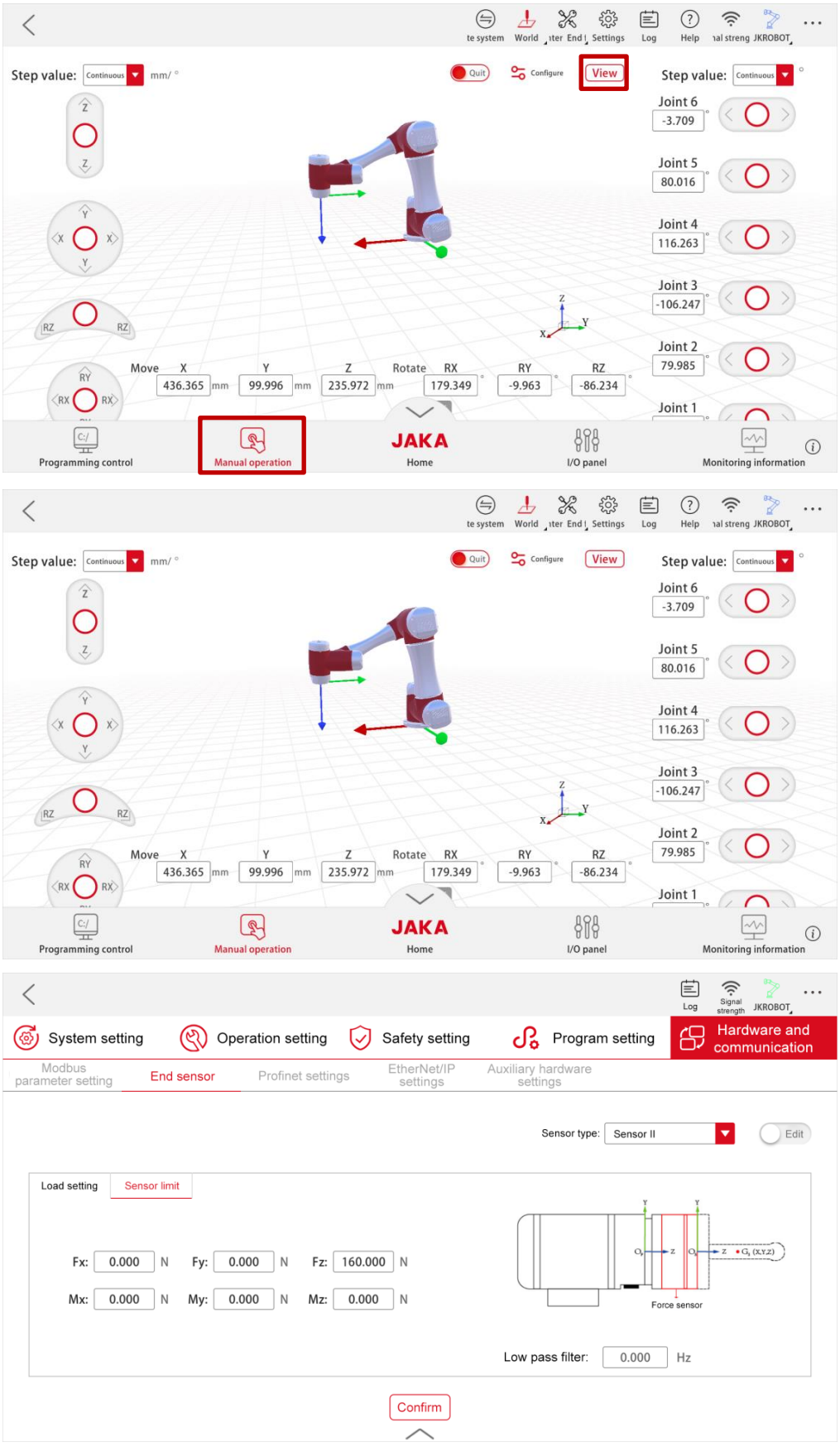


Figure 3-19 Force Display Interface of the App

3.2.2.2 Traction Teaching Function

To use the traction teaching function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. As shown in Figure 3-20, open the [Manual operation] page, and tap [Configure] to enter the teaching editing interface, where Fx, Fy, and Fz correspond to the displacements in the directions of X, Y, and Z; Check □ in front of [Direction] to enable one or more directions. Then you can drag the robot in the enabled direction(s) after turning on Drag; The lower the [damping force] is set, the less force is required to drag, but it doesn't mean the lower the better. It is recommended to set Fx, Fy, and Fz to be greater than 50N for the Sp series of products. It is NOT allowed to set the values to 0. Setting [Springback] enables the robot to return to its original position after it has been dragged away and released. The farther the robot is dragged; the greater force is required to drag. Setting a higher value will require more force to drag, and the robot will rebound faster once it's released.

CAUTION:

[Damping force] is merely a parameter for softness or hardness, not an exact value. In other words, if you set the [Damping force] to 50N, it does not imply that you must apply a force of 50N to get the robot end to start moving. Similarly, it doesn't mean that the robot will resist with a force of 50N when you're dragging it.

CAUTION:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, set the [Damping force] to a higher value (Fx, Fy, and Fz above 50N). Don't adjust this value until you've confirmed that the traction teaching function is not reporting any errors.

c. To select the force control coordinate system: check [Tool coordinate system], and drag the robot in the set tool coordinate system; check [World coordinate system], and drag the robot in the set world coordinate system;

d. Initialization: Check [Initialization], the system will automatically compensate the sensor offset and load when entering the drag mode (Ensure no external force is applied to the robot end during initialization, otherwise the compensation accuracy will be affected.) After the CAB is powered on, be sure to check [Initialization] before using the traction teaching function;

e. After completing the above configurations, tap [Confirm] and the toggle switch on the left of [Configure] to change its status from [Quit] to [Drag] and enter the drag mode.

CAUTION:

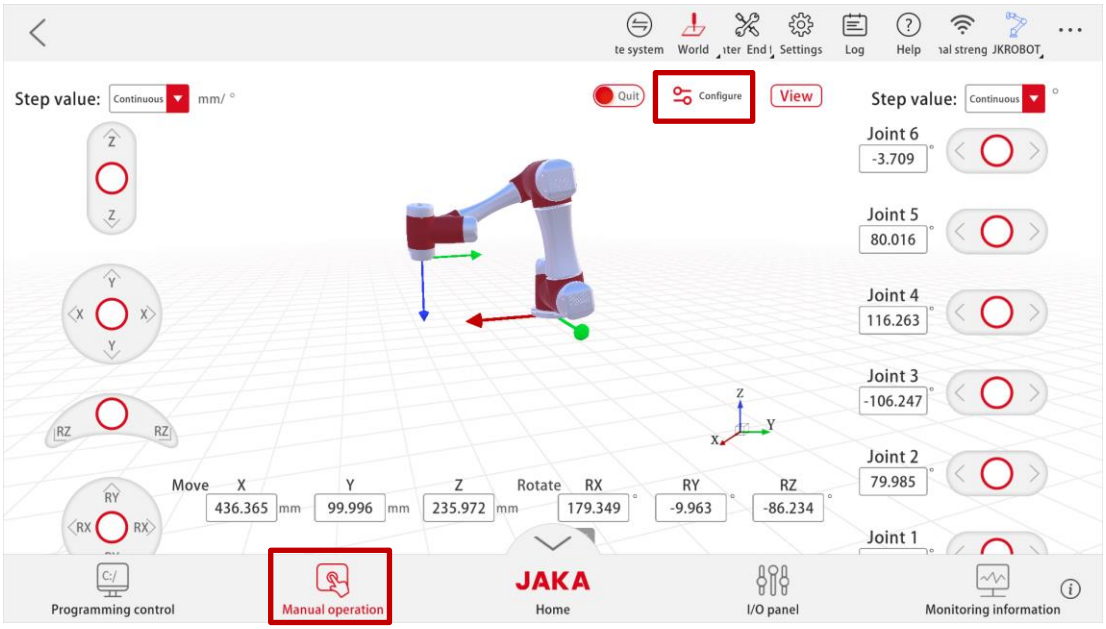
It is recommended to always check [Initialization] before entering the drag mode to ensure safety, and to use slow traction teaching for the Sp series.

WARNING:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, be sure to check [Initialization] before using this function for the first time, otherwise it could lead to uncontrolled robot movement, potentially causing damage to device or personal injury.

WARNING:

If the [Initialization] is checked, the robot and its base must be free from any external force both before and within one second after entering the drag mode. If not, a sensor compensation error could occur, leading to uncontrolled robot movement, device damage, or personal injury.



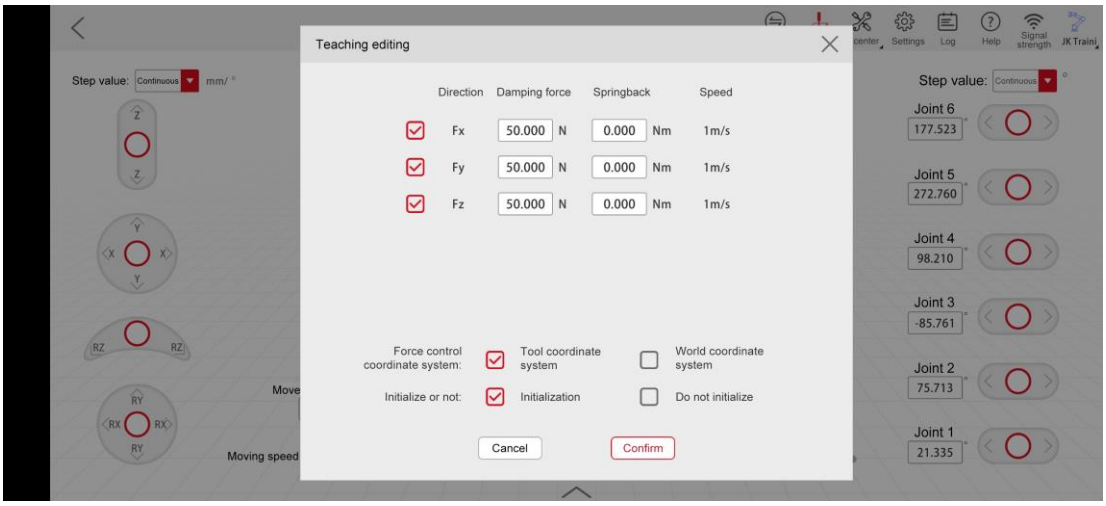


Figure 3-20 Traction Teaching Function Settings of JAKA Zu Se

Note: Due to factors such as sensor temperature drift, if the robot position drifts in the drag mode, please tap the toggle switch to exit the drag mode, check [Initialization] in the configuration interface, and then enter the drag mode to redo sensor compensation; If you do not use the traction teaching function, please tap the toggle switch in time to exit the drag mode.

3.2.2.3 Collision Detection Function

To use the collision detection function, follow the steps below:

a. Correctly construct the sensor system to ensure that the sensor is operating properly;

b. Correctly set the load: Tap [Settings] at the upper right of the Home page, then tap [Operation setting] → [Load setting], select "Manual input mode", and input the correct mass and centroid position; When executing the program, you can also call the "Set load" program block to set the load (See Figure 3-21);

c. Adjust the collision detection sensitivity: Tap [Settings] at the upper right of the Home page, then tap [Safety setting] → [Collision protection] → [Collision setting] to set the collision detection sensitivity. For all parameters in the custom mode, the higher the level or the value is set, the less sensitively collisions are detected; When executing the program, you can also call the "Set collision sensitivity" program block to set the load, where the levels 1-5 correspond to 1-5 of the force limit grades (See Figure 3-21);

WARNING:

After the device is installed, the robot is powered on again, the robot is recovered from a fault, or the sensor is powered on for a long time, do not use this function until you've followed these steps: first, tap [Configure] on the manual operation interface, then select [Do not initialize] in the pop-up interface and tap [Confirm]. After that, check [Initialization] again, tap [Confirm], and wait for 1-2 seconds. The robot and its base must be free from any external force during the waiting period, otherwise the initialization may fail, leading to uncontrolled robot movement, device damage or personal injury.

CAUTION:

Due to factors such as sensor temperature drift, it is recommended to warm up the sensor for 1 hour before use and add "Constant force compliance parameter setting", "Activate constant force compliance control (Do not initialize)", "Activate constant force soft control (Initialize)", "Wait for 1 second", "Inactivate constant force compliance control" before each cycle in the program block that cyclically operates for a long time" (see the sample program in Figure 3-21). Ensure that no direction is checked for the "Constant force compliance parameter setting" module and that the robot and its base are free of any external force during the execution of these five modules.

CAUTION:

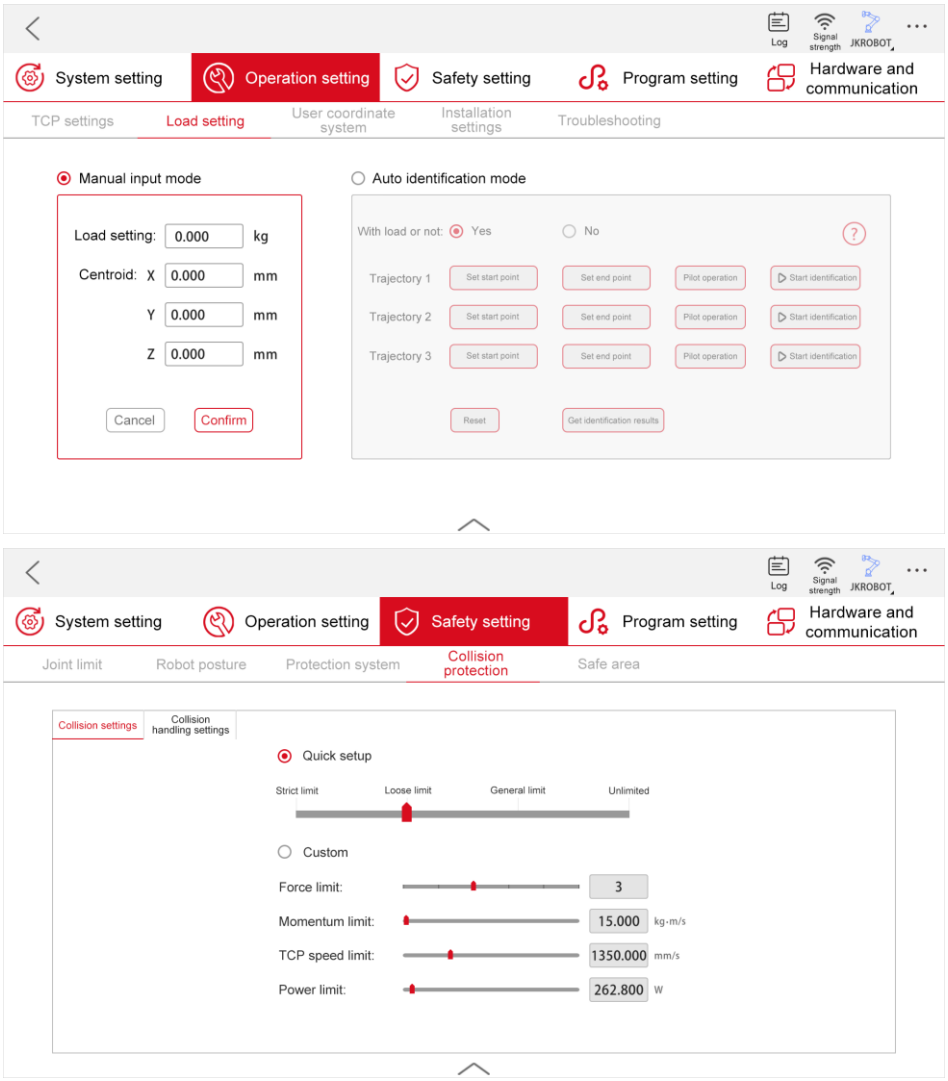
To use this function, make sure that no direction is checked in the manual operation interface, the programming page that pops up after tapping [Configure], and the "Constant force compliance parameter setting" program block in the programming control interface.

CAUTION:

Unless specified differently, please use the quick setup mode to set, and do not set it to unlimited. Only technicians who fully understand the significance of each parameter should set the custom mode, and they can do this by referring to the values from the corresponding levels in quick setting mode.

CAUTION:

To reset the load at the robot end, turn off collision first. After resetting the load, turn on collision and set collision sensitivity.



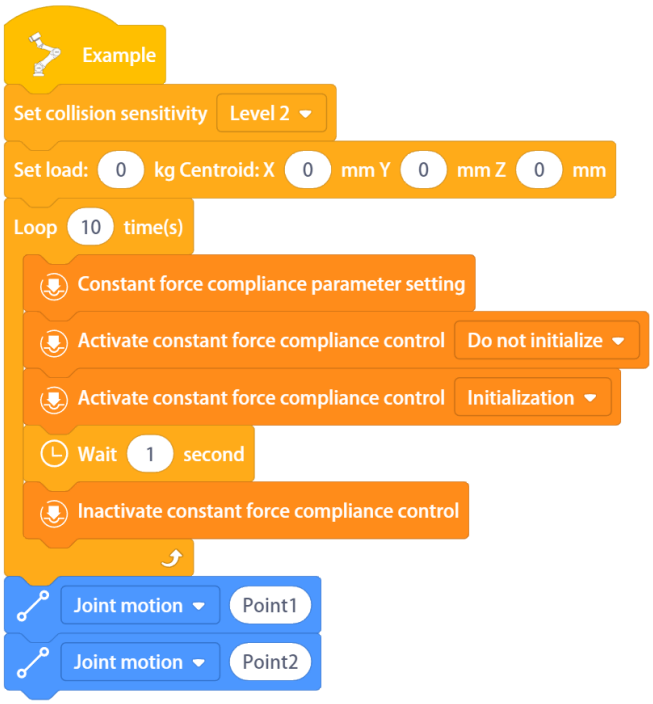


Figure 3-21 Collision Detection Function Settings of JAKA Zu Sp

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