JAKA

Hardware User Manual

JAKA Zu Series

Original Instructions (n)

File Version: V08

Robot: Zu 3, Zu 5, Zu 7, Zu 12, Zu 18, Zu 20

Control Cabinet: CAB 2.1

We will regularly revise the manual, and the content may be updated without notice. Please check the factual product information carefully before reading this manual.

This manual is applicable to all products and/or services manufactured or provided by JAKA (hereinafter referred to as the “products”). The information contained in the manual is provided “as is” and is subject to the relevant laws and legislation. To the maximum extent permitted by law, this manual does not constitute any form of express or implied representation or warranty of JAKA, neither does it constitute a guarantee of merchantability, suitability for specific purposes, achievement of expected results, or non-infringement of the products. JAKA assumes no responsibility for any error or omission that may appear in this manual, or any accident or indirect injury arising from the use of this manual and the products described therein. Before installing and operating the product, read this manual carefully.

The pictures in this manual are for reference only.

If the robot body is transformed or disassembled, JAKA will not be responsible for after-sales services.

JAKA reminds users that they must use safety equipment when using and maintaining JAKA robots and must comply with the safety terms.

Programmers of JAKA robots, designers and debugging personnel of robot systems must be familiar with the way to program JAKA robots and install system applications.

More Information

For more product information, scan the QR code on the right to visit our official website: www.jakarobotics.com.

Contents

Foreword

The robot pioneers in the control mode with a mobile smart terminal plus an App connected to the robot, so that one mobile terminal can match multiple robots. Operators do not need to master professional programming technology, but only need to manually guide the robot to complete the programming. In this way, human-machine collaboration is easier, which greatly improves the productivity.

JAKA Zu are intelligent, lightweight, 6-DOF modular collaborative robots, falling into the JAKA modular collaborative robot series.

Product List

When purchasing a complete set of the JAKA Zu robot, the delivery will include the following items as shown in Table 0-1.

Table 0-1: JAKA Zu series item list

No.	Name	Quantity
1	Robot arm	1
2	Control cabinet and key	1
3	Control stick handle	1
4	Control cabinet power cord	1
5	Robot connection cable	1
6	TIO connection cable	1
7	Product qualified certificate	1
8	After-sales service warranty card	1
9	Instruction sheet	1

NOTE

Accessories vary by robot model. Zu 3 has a pre-installed robot connection cable, so it is not delivered with accessory 5.

Important Safety Notice

According to 2006/42/EC Machinery Directive, the JAKA robot is a **partly completed machine**, and a risk assessment must be performed for each robot installation. All safety instructions in chapter 2 must be followed.

1 Manual Instruction

1.1 About the Manual

The manual contains:

- Precautions for the use of JAKA Zu series robots.
- Installation of JAKA Zu series robots.
- Cleaning and maintenance of JAKA Zu series robots.

1.2 Manual Reader

The manual is intended for:

- Operators.
- Commissioning staff.
- Maintenance staff.
- Integrators.

1.3 References

Documentation referred to in the manual:

- 1.7.1 JAKA App Software User Manual.
- JAKA MiniCab Hardware User Manual.
- JAKA Service Manual.

NOTE

All documents can be found via JAKA official website www.jakarobotics.com.

1.4 Prerequisites

The reader should:

- Be trained and certified by JAKA and have the required knowledge of mechanical and electrical installation/repair/maintenance work.
- Be trained to respond to emergencies or abnormal situations.

2 Safety Standard

2.1 Introduction

This chapter mainly introduces the safety principles and standards that should be followed while using the JAKA robot. Users should carefully read and strictly abide by the content related to safety in this manual. Operators should fully recognize the complexity and danger of the robot system, and pay special attention to the content related to warning signs.

2.2 Safety Signals and Symbols

The danger level in this manual is described with the following safety symbols. Contents related to safety should be strictly observed.

Table 2-1: Symbols

Symbol	Description
	**WARNING: ELECTRICITY** This symbol indicates a potentially dangerous power consumption situation which, if not avoided, may result in injuries to personnel or serious damage to equipment.
	**WARNING** This symbol indicates a potentially dangerous situation which, if not avoided, may result in injuries to personnel or serious damage to equipment.
	**WARNING: HOT SURFACE** This symbol indicates a potentially dangerous hot surface that may result in injuries to personnel if touched.
	**NOTICE** This symbol is used to indicate important facts and conditions.
	**NOTE** This symbol is used to indicate additional information.

2.3 Warnings and Cautions

This section focuses on the protection of operators and the relevant precautions of the first installation. Users need to read the safety warnings in this manual carefully.

Table 2-2: General warnings

Symbol	Description
	**WARNING: ELECTRICAL SHOCK** • All JAKA hardware and software must be installed/configured in strict accordance with the instructions and cautions provided in this manual. • The installation of the power cut-off switch should be positioned within the height range of

Symbol	Description
	0.6~1.9 m (23.622~74.803 in) to facilitate prompt and convenient power disconnection in the event of an emergency. • Prior to the initial use of any JAKA products, a comprehensive inspection of all electrical components and safety protection systems must be conducted to verify their integrity and absence of prior damage. • Operators possessing the necessary qualifications for robot operation are instructed to perform a thorough assessment of all safety functions and ensure the accuracy of parameters and programs before initiating the power supply to the robot.
	**WARNING: HOT SURFACE** • Both the robot and the control cabinet generate heat during operation. Avoid contact with the robot and the control cabinet during operation and after shutdown. In both instances allow approximately 1 hour for the equipment to cool down.
	**WARNING** • Technical personnel are instructed to carry out the installation and commissioning procedures for any JAKA products in strict accordance with the provided specifications. • Adjustment and alteration of any JAKA product parameters must be executed exclusively by authorized personnel to safeguard against unauthorized modifications by individuals lacking appropriate operating expertise. • Frequently toggling the power on/off is not recommended. Each joint of the JAKA robot is equipped with a brake mechanism to maintain its pose for safety reasons in the event of a power failure. Brake mechanisms can be damaged during unexpected power outages. • In the event that the applied force on the robot surpasses a predefined threshold, JAKA's collision detection feature will be triggered and robot motion will be ceased to prevent potential harm to the robot itself or injury to operators. Associated risks of the use of control cabinets not supplied by JAKA is solely the responsibility of the operator.
	**WARNING** • Ensure the proper installation of both the robot and its associated tools to the manufacturer's specifications. • Verify that there is adequate space available for unobstructed movement of the robot. • To prevent damage, refrain from connecting safety equipment to the standard I/O interface (use safety I/O interface). • Confirm the accuracy of the mounting settings, including mounting angles, Tool Center Point (TCP) position, tool mass, TCP offset and the robot's safety configuration. • Ensure that tools and obstacles do not possess sharp corners and maintain a safe distance between all personnel and the robot. • Connecting the robot to different machinery may increase existing hazards or introduce new ones. Conduct a comprehensive risk assessment for the entire system installation. • Do not make modifications to the robot, as such alterations may create unforeseen hazards for which JAKA cannot be held liable. If the robot is changed or modified in any form, JAKA assumes no liability.

Symbol	Description
	**WARNING** • When connecting external equipment that may pose a threat to the robot, it is advisable to independently check all robot functions and programs. Utilize temporary waypoints located outside the mechanical workspace to verify the robot's program. • Exposure to strong magnetic fields can damage the robot; hence, avoid exposing it to permanent magnetic fields. • Operators who use the robot system are strictly prohibited to wear loose clothes and jewelry. Long hair should be tied up. • During operation, even if the robot appears to have stopped, it may be in a state of imminent action because it is waiting for a start signal. In such state, the robot should be regarded as running. • During the operation, ensure proper connection of robot power cable and control cabinet. It is strictly forbidden to plug or unplug the power cables and terminals while the robot is running. • Warning lines should be drawn on the floor to clearly mark the workspace of the robot. • Ensure that safety measures (e.g., guardrails, ropes, or protective screens) are in place near the operation area of the robot to protect operators and surrounding persons. Locks should be provided if necessary to make the robot power inaccessible to anyone other than the operator in charge. • In emergency situations, the robot arm may be manually repositioned by gently pushing or pulling the joints. • Avoid excessive force to prevent potential damage to the joints.

2.4 Intended Use

The JAKA robot is intended to be integrated into a manufacturing line and/or assembled with other components to build up a machine or process in an industrial environment. The JAKA robot is either an open type robot that is intended to be installed into an enclosure, or a collaborative operation product where it works with an operator within a collaborative workspace.

JAKA robot intended use cases:

- Loading and unloading.
- Packaging.
- Case erecting.
- Picking and placing.
- Palletizing.
- Assembling.
- Inspecting.
- Machine tending.
- Material working.
- Gluing and Bonding.
- Polishing/sanding.
- Soldering.

The JAKA robot is equipped with built in safety-related functions when the robot operates without fences and/or together with an operator.

For JAKA robots, the following terms apply for different types of interactions:

1. Coexistence

   As shown in figure 1, operators and robots work simultaneously in close proximity but have separate workspaces and do not work towards a common goal. There is no direct contact between operators and robots.

2. Cooperation

   As shown in figure 2, operators and robots work at different times in the same workspace to achieve a common goal. There is no direct interaction between operators and robots.

3. Collaboration

   As shown in figure 3, operators and robots work simultaneously in the same workspace to achieve a common goal, such as the assembly of a product. There is direct interaction between the operator and the robot.

Coexistent, cooperative, and collaborative operations are only intended for non-hazardous applications, where the complete application, including tool, workpiece, obstacles and other machines is without any significant hazards according to the risk assessment of the specific application.

Any other use is not an intended use.

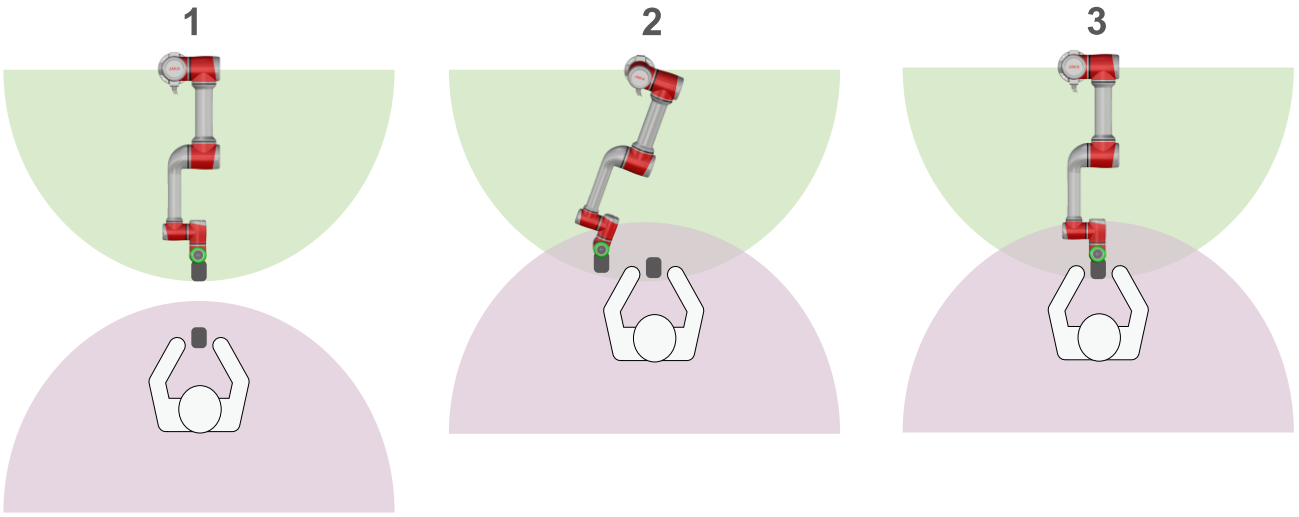


Figure 2-1: Operator interactions with robot

WARNING:

Personal injury:

- Do not use the JAKA robot in a coexistent, cooperative, or collaborative operation if the application could cause potential injuries.
- Please operate the robot in accordance with the requirements of the manual. If the robot is operated in the collaborative mode, additional safety input detection units must be used (such as scanners, light curtains, cameras, etc. with PLr=d or PLr=e), and a risk assessment must be conducted.

Failure to follow these instructions can result in equipment damage, serious or fatal injury

2.5 Liability and Risk

Liability

This manual does not contain full application examples, complete solution designs, or information on peripheral equipment that could affect the robot system's security.

It is the responsibility of the user to ensure that relevant practical national laws and regulations are followed,

and that there are no significant hazards in the workspace.

The safety information in this manual does not constitute a guarantee from JAKA. Even when all safety instructions are followed, operator actions may still result in injury or damage.

JAKA is committed to continuously improving the performance and reliability of our robots. However, we are not responsible for any errors or omissions in this manual and reserve the right to the final interpretation of its contents.

Risk

Operators engaging with the robot will inevitably experience direct or indirect physical contact. It is essential to maintain awareness of self-protection and adhere to safe operating procedures. The following hazards should be considered:

- Robot brake failure causing it to drop.
- Loose bolts and screws causing vibrations.
- Robot collision with operator.
- Lack of prompt repair.
- Danger when sharp-end effectors are used.
- Toxic or corrosive environments.
- Strong magnetic environment.

2.6 Provide Protective Measures

Before installing the JAKA robot, provide appropriate protective devices in compliance with local and national standards. Do not commission components without appropriate protective devices. After installation, commissioning, or repair, test the protective devices used.

Other standards are applicable as guidelines for a JAKA robot integration into machinery such as (non-exhaustive list):

- Directive 2006/42/EC on machinery.
- Directive EMC 2014/30/EU.
- Standard ISO 10218-1 Robots and Robotic devices - Safety requirements for industrial Robots - Part 1: Robots.
- Standard ISO 10218-2 Robots and Robotic devices - Safety requirements for industrial Robots - Part 2: Robot systems and integration.
- Standard ISO 13849-1 Safety of machinery - Safety related parts of control systems - Part 1: General Principles for Design.
- Standard ISO/TS 15066 Robots and Robotic devices - Collaborative Robots.
- Standard ISO 13857 Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs.
- Standard ISO 14120 Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards.
- Standard EN ISO 13854 Safety of machinery - Minimum gaps to avoid crushing of parts of the human body.
- Standard ISO 13855 Safety of machinery - Positioning of safeguards with respect to the approach speeds of parts of the human body.
- Standard NFPA 79 Electrical Standard for Industrial Machinery.
- Standard NFPA 70 National Electric Code.
- Standard UL 1740 Standard for Robots and Robotic Equipment.
- Standard UL 2011 Standard for Factory Automation Equipment.

Perform a risk evaluation concerning the specific use before operating the JAKA robot and take appropriate security measures.

WARNING:

Unintended:

- Use appropriate protective devices (functional safety devices) in compliance with local and national standards.
- Ensure that a risk assessment is conducted and respected according to EN/ISO 12100 during the design process.
- Apply all measures from the hazard and risk analysis before deployment.

Failure to follow these instructions can result in equipment damage, serious or fatal injury.

2.7 Risk Assessment

Robots are partially completed machines, and their safe installation depends significantly on the integration process, including components such as end effectors and communication equipment. Conducting a risk assessment is essential and a critical responsibility of the integrator. It is recommended that the integrator performs the risk assessment in accordance with ISO 12100 and ISO 10218-2, while also considering ISO/TS 15066 as additional guidance. The risk assessment should cover all aspects of the robot's lifecycle, including but not limited to:

- Teaching of the robot during installation, set-up and development.
- Operations of the robot installation.
- Troubleshooting and maintenance.

The risk assessment must be conducted before powering on the robot for the first time. It is the integrator’s responsibility to determine the appropriate safety configuration settings and evaluate the need for additional emergency stop buttons or other protective measures based on the specific robotic application.

Cobots have specific safety functions, which can be configured through settings. These functions are especially important when integrators conduct risk assessments:

1. **Force limit**: the force set by the controller to limit the servo from exceeding the threshold. When the actual force exceeds the force limit, the robot will enter collision protection mode.
2. **Momentum limit**: the momentum set by the controller to restrict the momentum of the robot during motion. The limit will directly affect the speed of the robot. When the momentum of the robot exceeds the limit, the robot speed will be reduced.
3. **TCP speed limit**: refers to limiting the absolute speed of the TCP during the robot motion. The path speed will be kept within the TCP speed limit.
4. **Power limit**: refers to limiting the mechanical power during the robot movement. This limit will directly affect the speed of the robot. When the mechanical power of the robot exceeds the limit, the robot speed will be reduced.

Integrators must prevent unauthorized personnel from modifying safety configurations.

When performing a risk assessment, the integrator should consider the following:

- Potential collision scenarios.
- How to avoid potential collisions
- The severity of the potential collision.

If the robot is installed in a non-collaborative robot application and the risk cannot be eliminated by configuring the robot's safety functions, integrators should consider adding additional protective measures when conducting assessments.

JAKA identifies the following significant dangers that integrators must consider.

- Sharp edges and points on end effectors.

- Sharp edges and points on obstacles in and near the robot workspace.
- Bruises due to contact with the robot.
- Sprain or fracture caused by the impact between the heavier load on the end of the robot and the hard surface.
- Consequences caused by loose bolts or screws used to fasten robots or end effectors.
- Consequences of items falling from end effectors.
- Mis-operation due to different emergency stop buttons on different machines.
- Error due to unauthorized changes to safety configuration parameters.

NOTICE

Specific robotic applications may present other significant hazards.

2.8 Pre-use Assessment

After first use or any modifications, perform the following tests:

- Verify that all safety inputs and outputs are correctly connected.
- Test the functionality of all safety inputs and outputs.
- Ensure the payload is configured correctly.

The following tests are required:

- Test if the emergency stop button and emergency stop input (P8) can stop the robot and engage brakes.
- Test whether the safeguard input can stop the robot motion. If safeguard reset is configured, check if activation is required before resuming motion.
- Check whether the reduced mode input can switch the motion to the reduced mode.
- Test whether the 3-position enabling device must be pressed to enable motion in manual mode and if the robot is under deceleration control.
- Test whether the emergency stop output of the system can bring the entire system into a safety state.
- Test whether the system connected to the robot moving output, robot non-stop output, reduced mode output, or non-reduced mode output can detect output changes.
- Test whether the payload configuration matches the current actual payload of the robot.

2.9 Emergency Stop

In the event of an emergency, press the emergency stop button on the control stick to stop all the movements of the robot immediately. Emergency stop cannot be used as a risk reduction measure but it can be regarded as secondary protection equipment. If the robot needs to be stopped under normal circumstances, please adopt other measures. After risk assessment, if an emergency stop button needs to be installed, the button must meet the requirements of IEC-60947-5. The emergency stop of JAKA's robot has been tested. See Appendix 1: Stopping Time and Distance for the test data.

WARNING

When the emergency stop button is pressed, the cabinet power will cut off. In this case, even though the joints lock automatically, there will still be a slight downward movement of the robot under gravity, and therefore a risk of pinching or collision.

2.10 Emergency Release of the Brake

WARNING

- If the brake is released manually, the joint of the robot may move under gravity, so it is necessary to effectively support the robot, tools and workpieces installed on the robot before manually releasing the brake.
- At least two persons should be present when releasing the brakes.

When the robot is in emergency stop state, the power supply will cut off and the robot joints can be forced to move by unscrewing the joint lid and pressing the brake pin as shown in Figure 2-2. This applies for all JAKA Zu models except joint 1, 2 and 3 of the JAKA Zu 20.

1. Remove the screws on the joint lid.
2. Remove the joint lid.
3. Press the pin in the small electromagnet to manually release the brake.

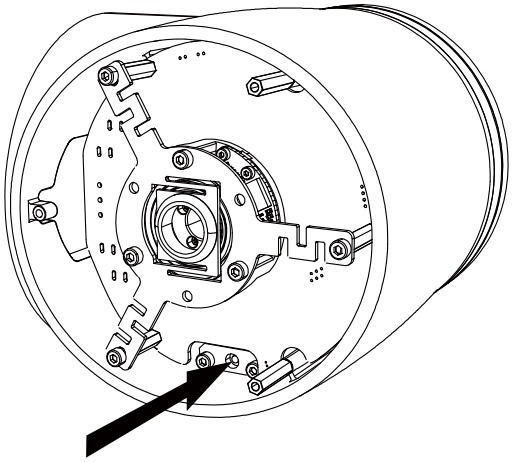


Figure 2-2: Brake pin

The JAKA Zu 20, joint 1, 2 and 3 brake release procedure is as follows when the robot is powered off:

1. Remove the screws on the joint lid as previously mentioned.
2. Remove the joint lid.
3. Unplug the break wire on the driver board (shown in Figure 2-3 below).

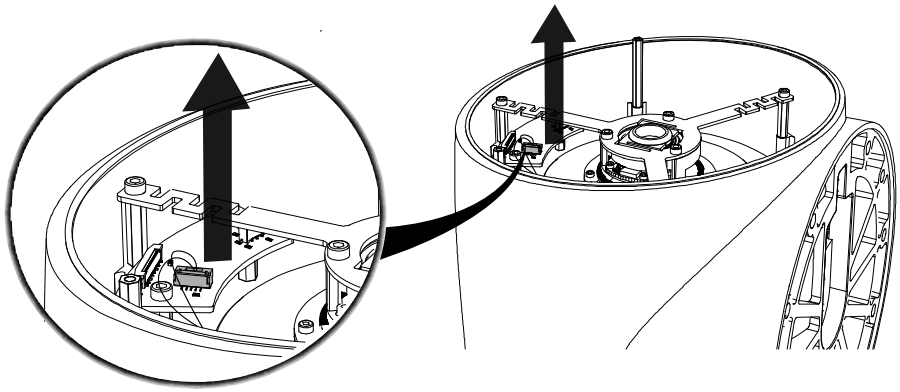


Figure 2-3: Brake wire of joint 1 and 2 of Zu 20

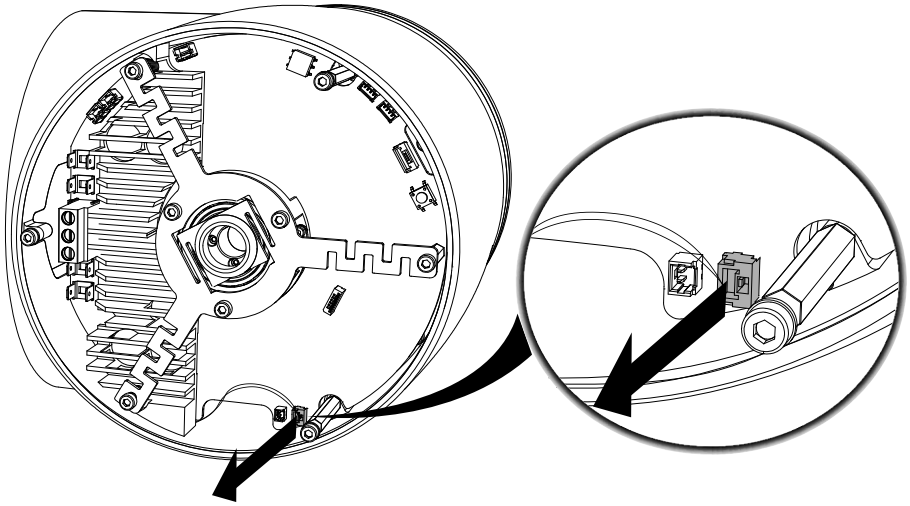


Figure 2-4: Brake wire of joint 3 of Zu 20

4. Connect the 24V DC external power supply with automatic reset switch to the terminal of the brake wire (shown in Figure 2-5 below).

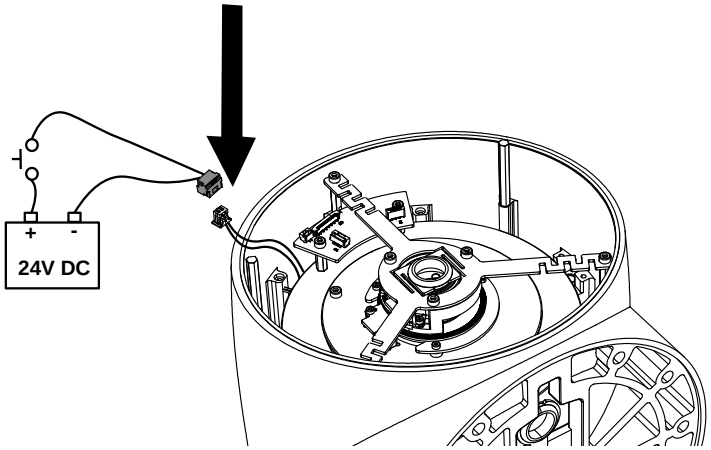


Figure 2-5: Connection of 24V DC external power supply for joint 1 and 2 of Zu 20

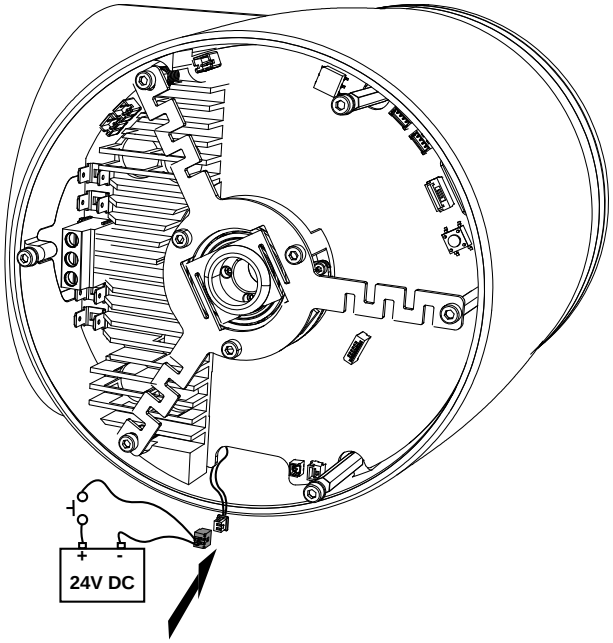


Figure 2-6: Connection of 24V DC external power supply for joint 3 of Zu 20

5. Press and hold the switch to release the joint brake (the connecting time of the external power supply should not exceed 5 minutes). Release the power switch, the joint is in the braking state.

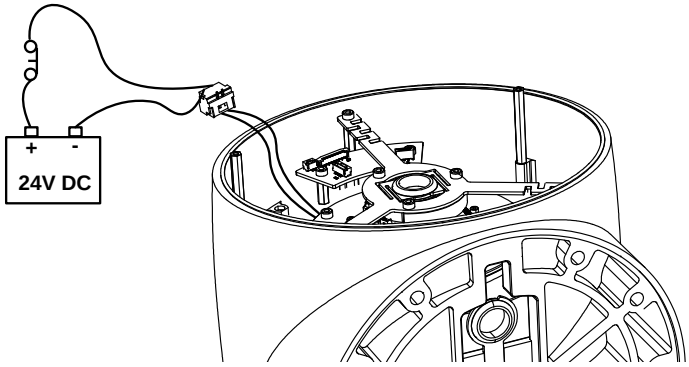


Figure 2-7: Press and hold power switch button for joint 1 and 2 of Zu 20

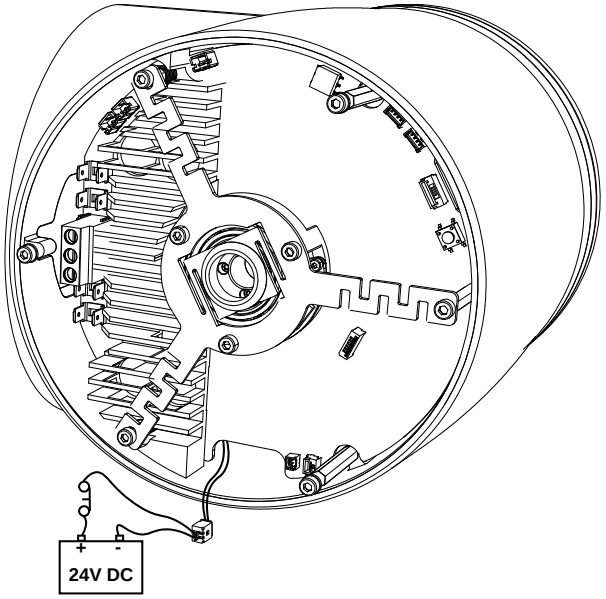


Figure 2-8: Press and hold power switch button for joint 3 of Zu 20

The brake release procedure is as follows when the robot is powered on:

1. Ensure that the robot is powered on and disabled.
2. Open the JAKA App and go to the “Manual Operation” interface.
3. Press and hold the “Backdrive” button to release the joint brake (shown in Figure 2-9 below).

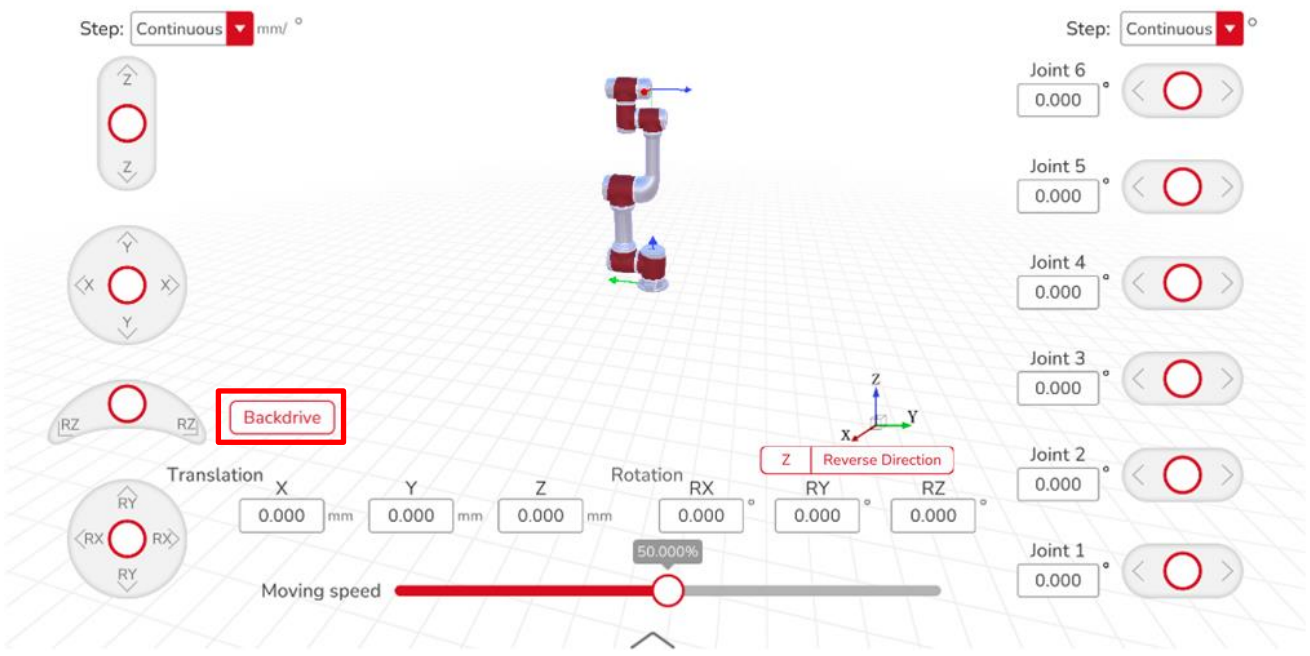


Figure 2-9: Backdrive button on JAKA App

4. Press and hold the Pause/Resume button on the lid of joint 6 (refer to 5.1.3.1 Ring-Shaped Light for its position) to release the joint brake, and then this joint can be dragged.

NOTE

This function only supports JAKA App versions 1.7.2 and above.

2.11 Labels

The following labels are safety warnings and product labels on the robot and the control cabinet. During operation, be sure to follow the instructions and warnings on the labels to ensure safety. Do not remove the labels casually. Handle labeled parts or units and their surrounding area with caution to avoid damage to the labels. Product labels and robot model figures are only for reference. Please figures and tables below for detailed description on product labels

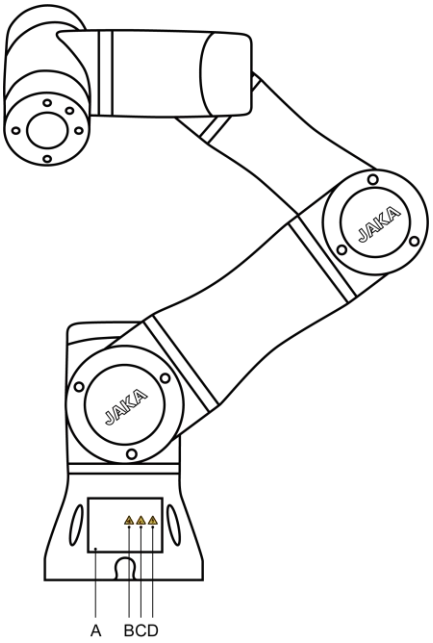


Figure 2-10: Robot label and symbols

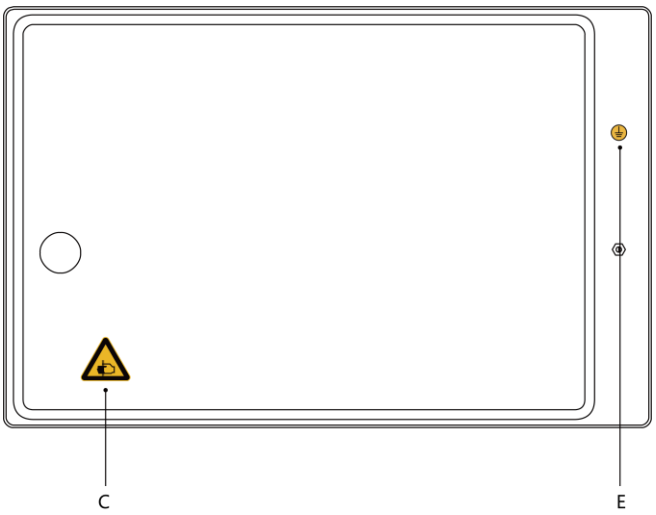


Figure 2-11: Control cabinet label and symbols (rear view)

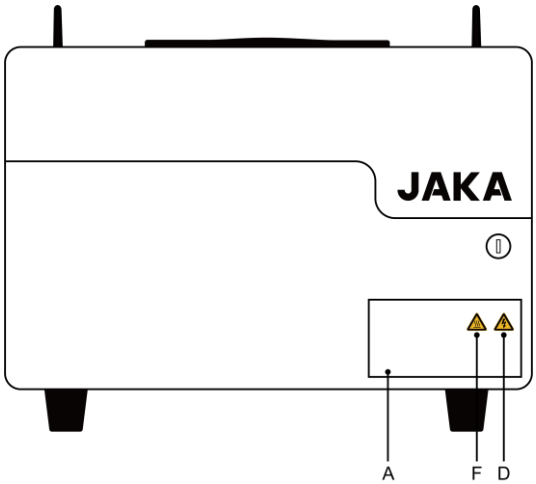


Figure 2-12: Control cabinet label and symbols (front view)

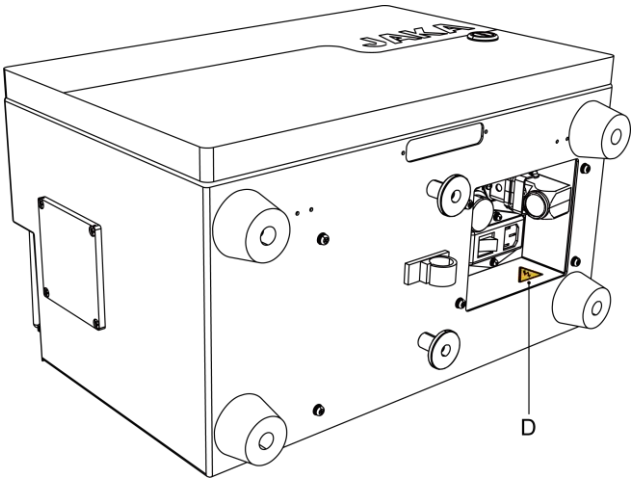
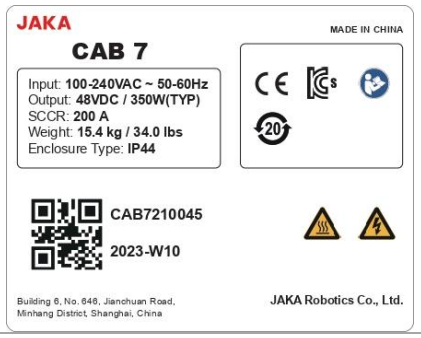


Figure 2-13: Control cabinet symbol (bottom view)

Table 2-3: Description of labels

	Labels	Description
A		Robot label
		Control cabinet label
B		Beware of collision
C		Beware of pinching
D		Beware of electrical shock
E		Grounding
F		Warning: Hot surface

NOTE

- The serial numbers of both the robot and control cabinet are on the respective labels. All robot labels are on the lower arms except for the Zu 3 which has its label on the robot base. The control cabinet label is on the front door.
- Product labels and robot figures are only for reference, labels vary by robot and control cabinet model.

3 System Overview

3.1 System Architecture

Before reading this chapter, ensure that you have read and understand chapter 2 Safety Standard.

This chapter will introduce the basic components and use methods of JAKA robots.. For detailed mechanical and electrical specifications, refer to other chapters.

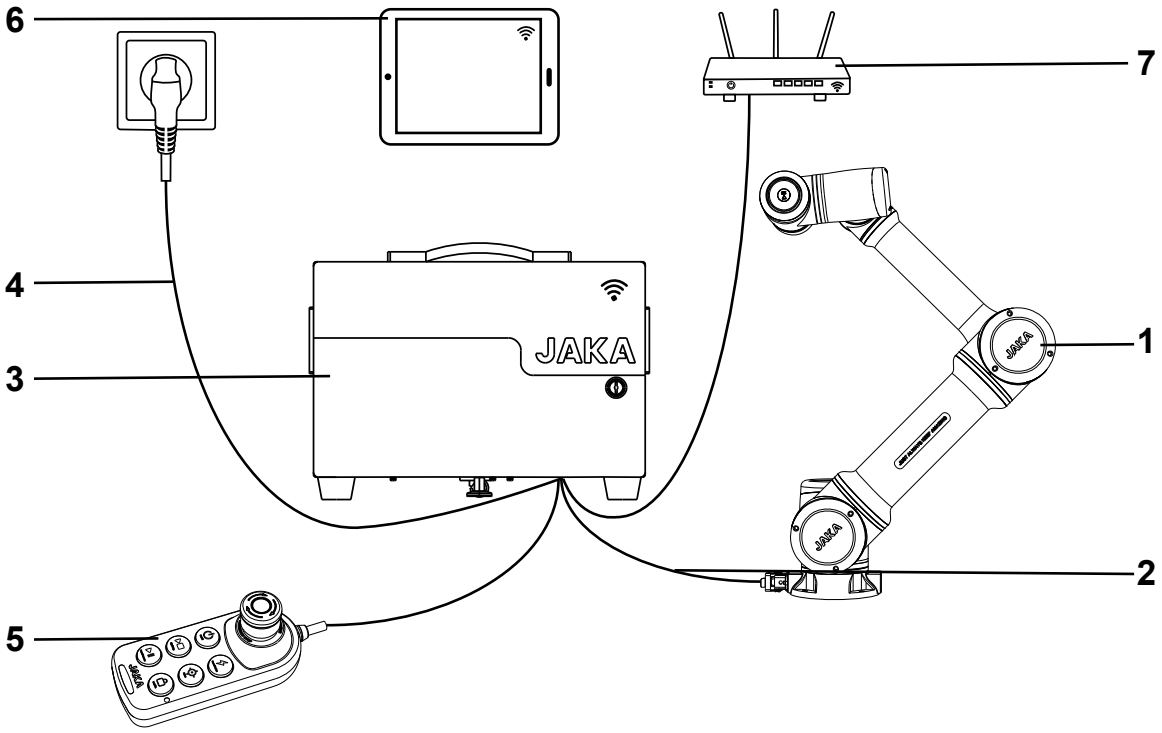


Figure 3-1: Robot system components

As is shown in the figure above, the JAKA robot system contains following components:

1 Robot: A six axes robotic arm which moves as programmed by the user. It consists of a ring-shaped light; buttons for dragging and point teaching and a I/O interface for connecting tools (the TIO interface) on joint 6.

2 Robot connection cable: Cable connection robot to control cabinet

3 Control cabinet: The control cabinet includes the core computing components and various electrical interfaces.

4 Control cabinet power cord: Provides power supply to the control cabinet.

5 Control stick: Power on/off and enable/disable the robot, etc.

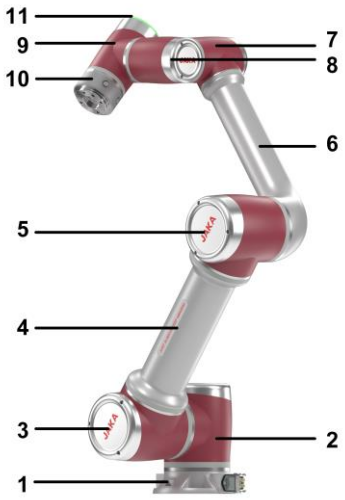
6 Operation terminal: The users desired teaching device.

7 Router and network cable: Each control cabinet has a built in Wi-Fi module which is accessible by any android, IOS or windows device. This allows the user to connect the JAKA Zu App to the controller wirelessly and continue programming. It is also possible to connect the cabinet network port of the control cabinet to the router and the operation terminal to the wireless network of this router at the same time. It is recommended to configure a specialized router for the robot to prevent conflicts with other devices.

3.2 Components Overview

The robot contains six joints and two connection arms. The base is used to connect the robot to the foundation,

and the tool end flange is used to connect the robot to the end effector. The end effector can move and rotate in the workspace of the robot. This chapter will introduce the basic precautions during the installation of each component of the robot system.



1 Base
2 Joint 1
3 Joint 2
4 Lower arm
5 Joint 3
6 Upper arm
7 Joint 4
8 Joint 5
9 Joint 6
10 Flange
11 Ring-shaped light

Figure 3-2 Robot

The JAKA control cabinet provides:

- Built in Power supply for the robot
- Interface to connect the control stick
- Interface for the operator terminal either via cable or Wi-Fi connection
- Interfaces for several inputs and outputs of different kinds

A control stick is included in the delivery of the control cabinet and it can be used for various operations.

Figure 3-3 Control cabinet and control stick

4 Safety Functions

The JAKA robot has a series of safety functions to guarantee the safety of human-machine collaboration. This chapter introduces these safety functions, and users should strictly abide by the requirements and precautions.

4.1 Overview of Safety Functions

4.1.1 Specific Safety Requirements

Safety functions comply with EN ISO 10218-1 in general and specifically comply with the following requirements:

When safety related control systems are required, the safety related parts shall be designed so that:

- A single fault in any of these parts shall not lead to the loss of the safety function.
- Whenever reasonably practicable, the single fault shall be detected at or before the next demand upon the safety function.
- When the single fault occurs, the safety function is always performed and a safe state shall be maintained until the detected fault is corrected.
- All reasonably foreseeable faults shall be detected.

This requirement is considered to be equivalent to structure category 3 as described in ISO 13849-1. Category 3 is normally fulfilled by redundant circuits, such as dual channels. Safety functions together with the robot controller also comply with performance level (PL) d according to ISO 13849-1.

NOTICE

It is the responsibility of the integrator to do a risk assessment for the final application and also for a collaborative application. The safety needs to be configured depending on the application, to fulfill the requirements in ISO/TS 15066.

4.1.2 Limitations

Version 1.5 of the JAKA App only supports certain safety functions and some safety function specifications may differ slightly from those in version 1.7.1. Version 1.7.1 and above support all safety functions. The safety functions described in this manual are those supported by software version 1.7.1. For descriptions of safety functions in other versions, please refer to the corresponding version's software user manual.

4.1.3 Stop Category

According to the IEC 60201 standard, three stop categories have been set for JAKA's robot: stop category 0 (Cat. 0), stop category 1 (Cat.1), and stop category 2 (Cat.2). Among them, Cat.0 is uncontrollable stop, while Cat.1 and Cat.2 are controllable stop.

If Cat. 0 is triggered, the power supply of the robot is immediately cut off and the robot stops running immediately.

If Cat.1 is triggered, the robot immediately decelerates to stop, and the power supply of robot will be cut off when all joints enter stand-still condition.

If Cat.2 is triggered, the robot decelerates following the programmed trajectory, eventually all joints enter standstill condition (while the robot remains enabled).

4.1.4 Overview of Safety Function

JAKA robotic system features 28 safety functions, designed and tested with reference to the following standards:

- IEC 60204-1: 2016
- ISO 13849-1: 2023

- ISO 10281-1: 2020

These safety functions can be categorized into the following 8 classes:

- Emergency stop functions
- Safeguard stop functions
- Motion status functions
- Hand-guided mode safety functions
- Speed monitoring functions
- Torque and power limitations functions
- Collision protection safety functions
- Position monitoring functions

The following table provides an overview of the safety functions per group. For detailed information on the specific function descriptions, specific reaction sequence, and the fallback function, refer to the description of the respective group of safety functions.

Table 4-1: Safety function list

	SF	Name	PLr	Structure Category	Response Time	Safe State
Emergency Stop Functions	SF1	Emergency Stop	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF2	External Emergency Stop	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF15	Additional Emergency Stop Input	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF19	Emergency Stop Button State Output	PLr d	PL d/Cat. 3	250 ms	The safe state is output as “low” or “high impedance” in dual channels.
	SF20	System Emergency Stop State Output	PLr d	PL d/Cat. 3	250 ms	The safe state is output as “low” or “high impedance” in dual channels.
Safeguard Stop Functions	SF3	Safeguard (Protective) Stop	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop
	SF16	Additional Safeguard Stop Input	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop
	SF17	Safeguard Reset Input	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop
	SF21	System Safeguard State Output	PLr d	PL d/Cat. 3	350 ms	The safe state is output as “low” or “high

	SF	Name	PLr	Structure Category	Response Time	Safe State
						impedance" in dual channels.
Motion Status Functions	SF22	Robot Moving Output	PLr d	PL d/Cat. 3	100 ms	The safe state is output as "low" or "high impedance" in dual channels.
	SF23	Robot Not Stopping Output	PLr d	PL d/Cat. 3	100 ms	The safe state is output as "low" or "high impedance" in dual channels.
Hand-Guided Mode Safety Functions	SF13	Hand-Guided Mode TCP Speed Limit	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop
	SF27	3-Position Enable Input	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop
Speed Monitoring Functions	SF5	Joint Speed Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF9	TCP Speed Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF18	Reduced Mode Input	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF24	Robot Reduced Mode Output	PLr d	PL d/Cat. 3	250 ms	The safe state is output as "low" or "high impedance" in dual channels.
	SF25	Robot Not in Reduced Mode Output	PLr d	PL d/Cat. 3	250 ms	The safe state is output as "low" or "high impedance" in dual channels.
Torque and Power Limitations Functions	SF6	Joint Torque Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF7	Joint Power Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF8	Power Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
Collision Protection Safety Functions	SF12	TCP Position Mismatch Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF14	Collision Protection	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop
	SF26	TCP Force Limit	PLr d	PL d/Cat. 3	350 ms	Cat. 2 Stop

	SF	Name	PLr	Structure Category	Response Time	Safe State
	SF28	Momentum Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
Position Monitoring Functions	SF4	Joint Position Limits (Soft Axis Limits)	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF10	Tool Orientation Limit	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop
	SF11	TCP Position Limit (Safety Planes)	PLr d	PL d/Cat. 3	250 ms	Cat. 1 Stop

NOTICE

The safety function is only a part of the robot system, it is the responsibility of the user to do a risk assessment of the robot system. It is also the responsibility of the user of safety function to ensure that the robot system is designed and installed in accordance with the safety requirements set forth in the standards and regulations of the country where the robot system is installed.

4.2 Descriptions of Safety Functions

4.2.1 Emergency Stop Functions

The JAKA robot system provides the following options to implement an emergency stop:

- Press the emergency stop button on the control stick (SF1)
- Connect the external emergency stop device (for example, light curtains, safety doors, emergency stop buttons or other such device) to the EI interfaces of P8 on the control cabinet to perform emergency stop (SF2)
- Configure the “Additional emergency stop input” of the dedicated safety I/O in the JAKA App, and connect external devices to the interfaces on the P1 and P3 of the CAB 2.1 to provide emergency stop input, in order to perform the emergency stop (SF15)

When the safety digital input is LOW, the emergency stop is triggered, the robot stops, disables and powers off, terminating the running program. When the robot is in an emergency stop state, powering on the robot is prohibited. When the emergency stop button is reset, and the safe digital input is HIGH, the robot automatically exits the emergency stop state.

NOTE

In the “Add-on” interface of the JAKA App, you can enable the “Emergency stop program paused”, if it is enabled, when the emergency stop is triggered, the running program will be paused. After the robot exits the emergency stop status, re-power on and enable the robot, and the robot continues to run the program and return to the position where the emergency stop occurred to move along the programmed trajectory.

The Cat.1 Stop triggered by the emergency stop conforms to the IEC 60204-1:2009.

The maximum stopping time is 250 ms. If the robot does not decelerate to stop within this period, the deceleration is considered to have failed, and a Cat. 0 Stop will be triggered.

When the inconsistency of the safe digital input signals persists for more than 1 second, the App indicates a fault with the safety DI, the control stick indicator turns red, and the safety DI fault fallback function is activated. After the fault is repaired, the robot must be re-powered on to exit the fault state.

NOTE

The safety signals are designed for dual redundancy, so the input signals of the two input ports in pairs should be the same, e.g. DI1 and DI9 for CAB 2.1. Refer to the hardware user manual for the pairing relationship.

The following emergency stop-related output functions can also be used to control other systems:

- Configure the “Emergency stop button state output” of the dedicated safety I/O in the JAKA App. When the emergency stop button on the control stick is pressed, a dual digital output signal will inform other devices that the robot has entered an emergency stop state (SF19).

NOTE

The emergency stop function of the external emergency stop button and the additional emergency stop input do not affect this output.

- Configure the “System emergency stop state output” of the dedicated safety I/O in the JAKA App. When the emergency stop button on the control stick is pressed, an external emergency stop device is triggered, or an external emergency stop signal is input, a dual digital output signal will inform other devices that the robot has entered an emergency stop state (SF21)

When the robot enters an emergency stop state, the dual digital output signals will be LOW. All safety digital output signals are designed with dual redundancy.

The following graphic presents the emergency stop sequence.

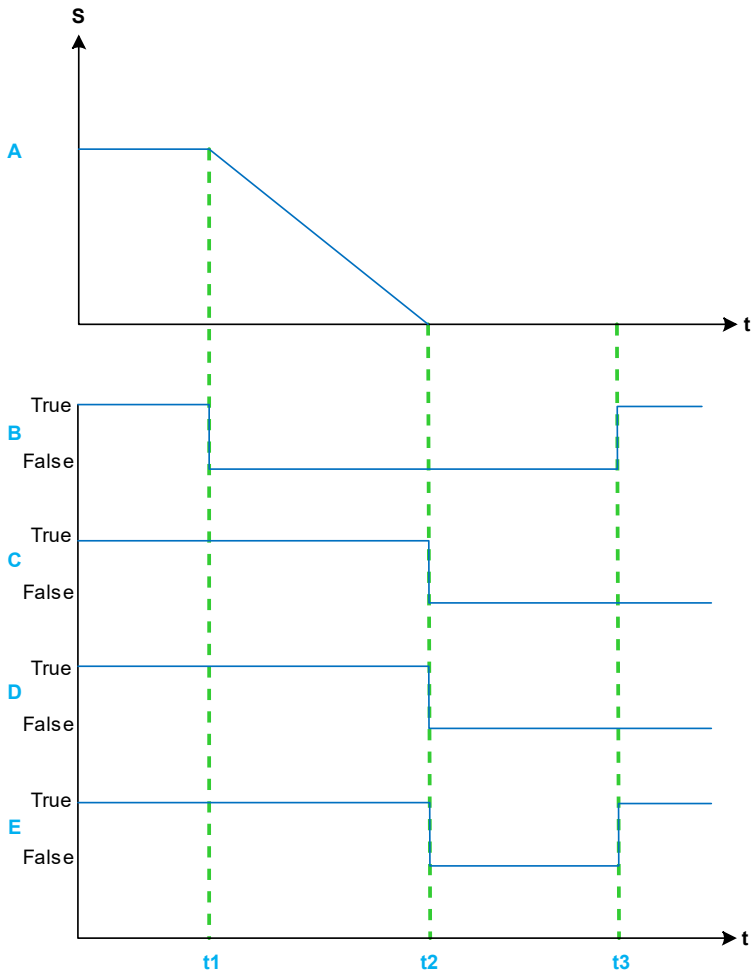


Figure 4-1: Emergency stop sequence

S: Motion speed

t: Time

A: Robot motion speed

B: Emergency stop input signal

C: Robot is disabled (True) or enabled (False)

D: Robot is powered on (True) or power off (False)

E: Emergency stop output signal

t1: Emergency stop button is pressed

t2: Maximum stopping time (250 ms)

t3: Emergency stop button is released

4.2.2 Safeguard Stop Functions

The JAKA robot system provides the following options to implement a safeguard stop:

- Connect the external safeguard stop device to the EI interfaces of P8 on the control cabinet to perform safeguard stop (SF3)
- Configure the “Additional safeguard stop input” of the dedicated safety I/O in the JAKA App, and connect external devices to the interfaces on in the P1 and P3 of the CAB 2.1 to provide safeguard stop input, in order to perform the safeguard stop (SF16)

When the safety digital input is LOW, the safeguard stop is triggered, the robot decelerates following the programmed trajectory, eventually all joints enter stand-still condition (while the robot remains enabled), pausing the running program. When the “Safeguard reset input” is not configured in the “Dedicated Safety I/O” interface (in automatic reset mode), and the safe digital input is HIGH, the robot automatically exits the safeguard stop state, and the robot resumes the original speed to run the program.

The Cat. 2 Stop triggered by the safeguard stop conforms to the IEC 60204-1:2009.

The maximum stopping time is 350 ms. If the robot does not decelerate to stop within this period, the deceleration is considered to have failed, and a Cat. 1 Stop will be triggered.

If the two safety digital input signals differ, the Cat. 1 Stop will be triggered.

The following safeguard stop-related output can also be used to control other systems:

- Configure the “System safeguard stop state output” of the dedicated safety I/O in the JAKA App. When the safeguard stop function is triggered, a dual digital output signal will inform other devices that the robot has entered a safeguard stop state (SF21)

When the robot enters a safeguard stop state, the dual digital output signals will be LOW. All safety digital output signals are designed with dual redundancy.

The following graphic presents the safeguard stop sequence in automatic reset mode.

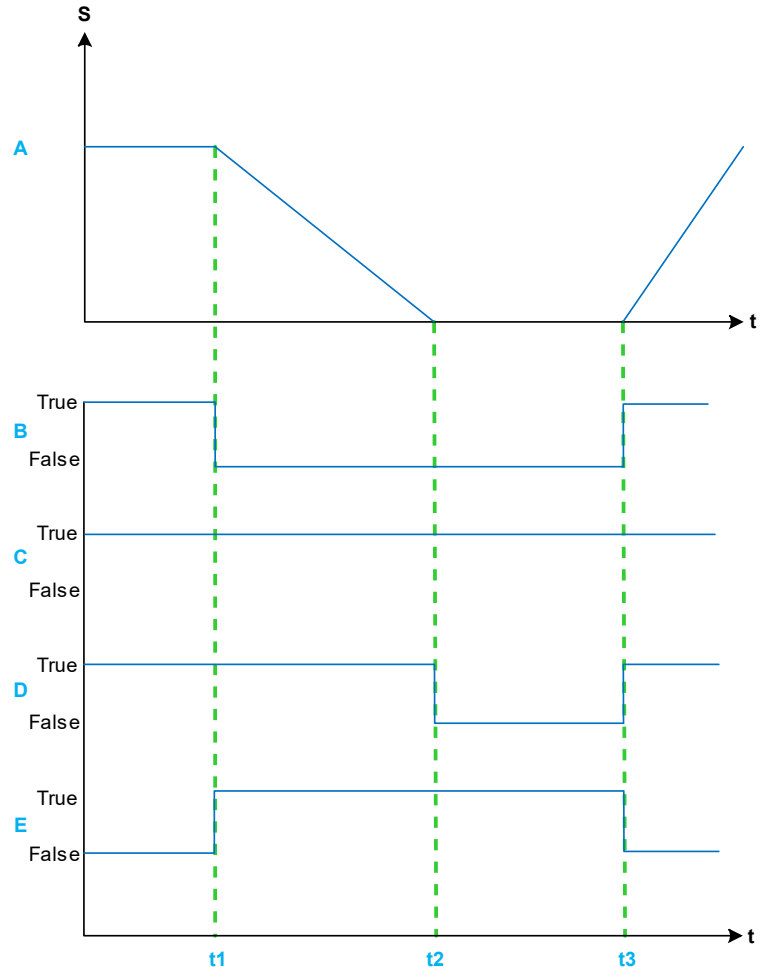


Figure 4-2: Safeguard stop sequence in automatic reset mode

S: Motion speed

t: Time

A: Robot motion speed

B: Safeguard stop input signal

C: Robot is powered on and enabled

D: Safeguard stop output signal

E: Program pause (True) and resume (False)

t1: Safeguard stop is triggered

t2: Maximum stopping time (350 ms)

t3: Safeguard stop reset

The default state of the safeguard stop function is automatic reset, but when configuring the “Safeguard reset input” (SF17) on the “Dedicated Safety I/O” interface of the JAKA App, the safeguard stop reset switches from automatic reset mode to manual reset mode. In manual reset mode, exiting the safeguard stop requires the safeguard stop safety digital input signal is HIGH, the safeguard stop reset safety digital input changes from LOW to HIGH. After exiting the safeguard stop state, the robot resumes its original speed and continues running the program.

If the two safety digital input signals differ, it will fail to reset the safeguard stop and the Cat. 1 Stop will be triggered.

The following graphic presents the safeguard stop sequence in manual reset mode.

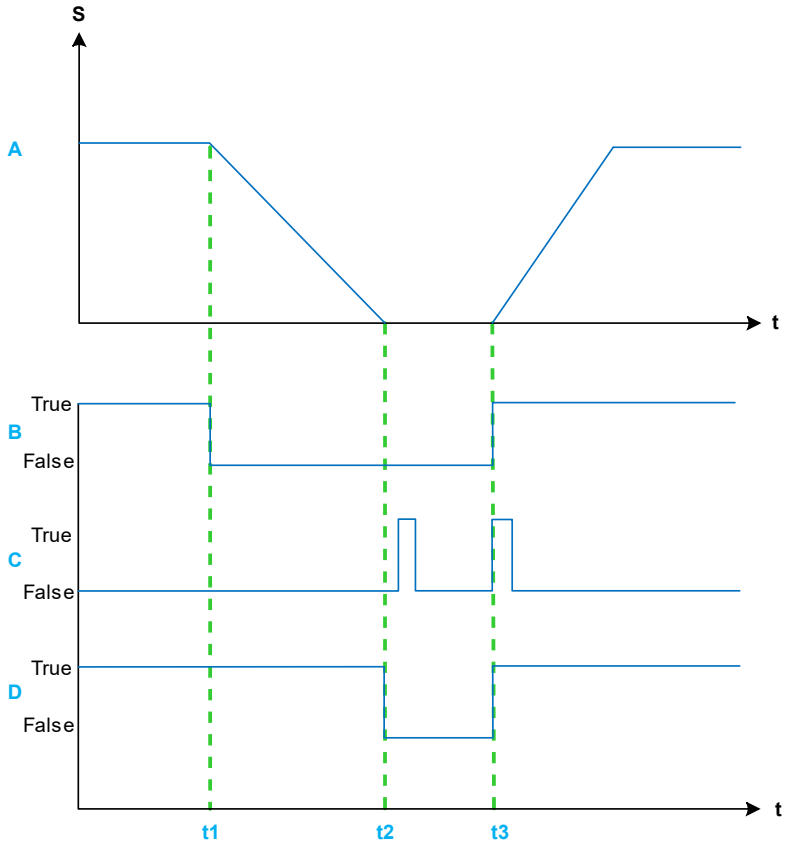


Figure 4-3: Safeguard stop sequence in manual reset mode

S: Motion speed

t: Time

A: Robot motion speed

B: Safeguard stop input signal

C: Safeguard stop manual reset signal input

D: Safeguard stop output signal

t1: Safeguard stop is triggered

t2: Maximum stopping time (350 ms)

t3: Safeguard stop reset

NOTE

Safeguard stop alternatively referred to as protective stop in this manual.

4.2.3 Motion Status Functions

The robot system has several ways to monitor the robot's motion status.

- Configure the “Robot moving output” of the dedicated safety I/O in the JAKA App, When the robot is in motion, the dual digital output signals are LOW to inform other devices that the robot is in motion (SF22).

NOTE

As long as the robot TCP speed is greater than 10 mm/s, the control system considers the robot to

be in motion.

- Configure the “Robot not stopping output” of the dedicated safety I/O in the JAKA App. When the robot is powered on and enabled, and the robot has stopped or is stopping, the dual digital output signals are HIGH to inform other devices that the robot is at standstill (SF23).

The following graphic presents the motion status sequence.

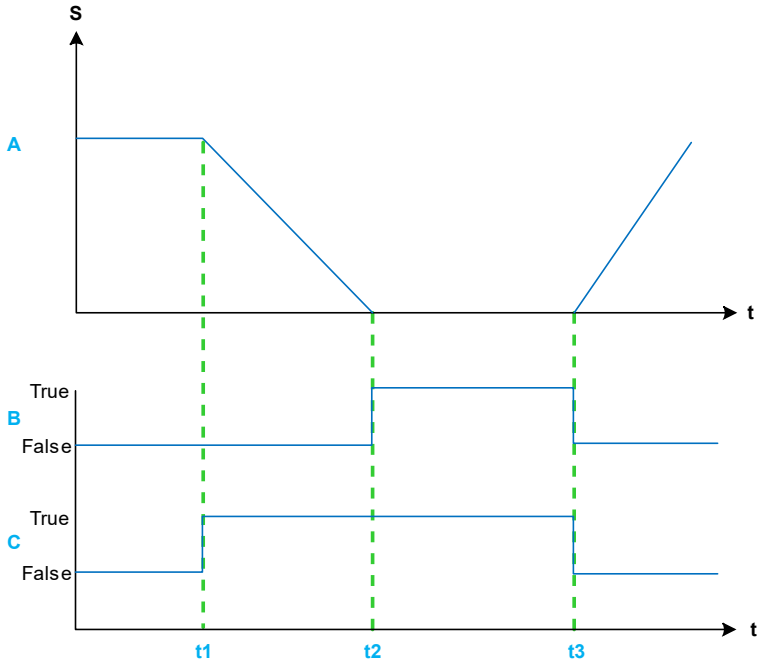


Figure 4-4: Motion status sequence

S: Motion speed

t: Time

A: Robot motion speed

B: Robot motion signal

C: Robot not stopping signal

t1: Emergency stop or safeguard stop causes the robot decelerates

t2: Maximum stopping time (100 ms)

t3: Robot is moving again

4.2.4 Hand-Guided Mode Safety Functions

4.2.4.1 Freedrive Mode TCP Speed Limit

Freedrive mode includes:

- Press and hold the FREE button on the robot end flange.
- Press the Pause/Resume button on the robot end
- Configure and activate function DI of “Enter freedrive mode”

NOTE

For Mini series robots, there isn’t the Pause/Resume button on the robot end.

To activate the TCP speed limit in freedrive mode, the TCP freedrive speed limit should be set in “Freedrive Limit” interface in the JAKA App. Refer to the software user manual's “Safety Settings” chapter for operation steps. The maximum TCP freedrive speed limit is 1500 mm/s, and the default value is 1000 mm/s. If the TCP speed exceeds this limit, the Cat. 2 Stop will be triggered. The robot exits freedrive mode, and remains powered on and enabled.

NOTE

Generally, TCP speed is the speed of the origin of tool coordinate system.

The following graphic presents the freedrive mode TCP speed limit sequence.

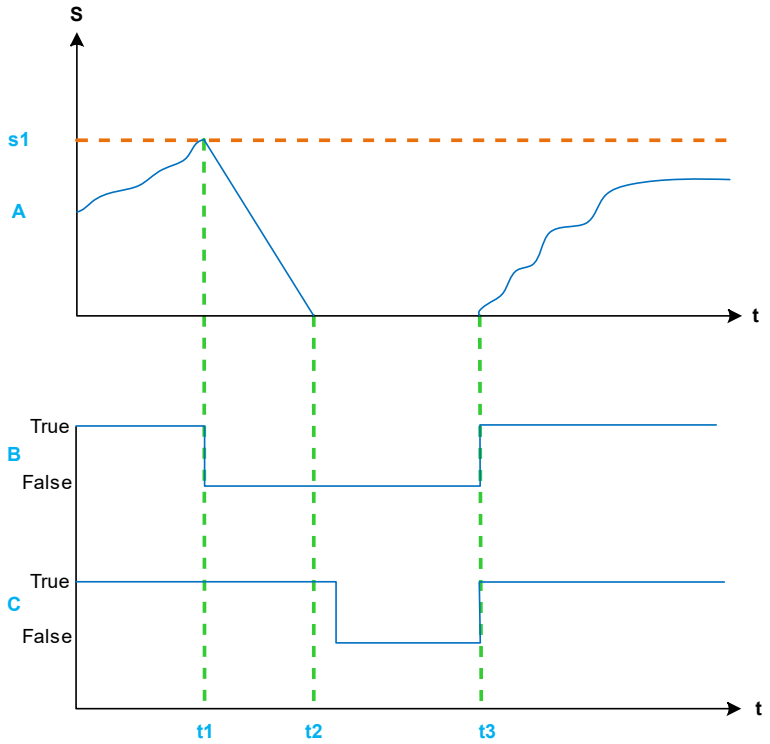


Figure 4-5: Freedrive mode TCP speed limit sequence

S: Motion speed

t: Time

A: Robot motion speed

B: Activate (True) and deactivate (False) freedrive mode

C: FREE or Pause/Resume button (True = press, False = release)

s1: TCP speed limit of 250 mm/s

t1: TCP speed limit achieved

t2: Maximum stopping time (350 ms)

t3: FREE or Pause/Resume button is pressed again

4.2.4.2 3-Position Enable

Configure the “3-position enable input” function on the dedicated safety I/O interface in the JAKA App. Refer to the software user manual's “Safety Settings” chapter for operation steps.

When the safety digital input signal is LOW (3-position switch is in position 1 or position 3), the 3-position enable function is activated. In this state, the following restrictions apply:

- Jogging robot is restricted, which means you cannot move robot in “Manual Operation” interface of the JAKA App. If the robot is in JOG mode, it will stop moving.
- Debugging of programs in the “Programming” interface of the JAKA App is restricted. If in the debugging mode, the debugging process terminates, and the program terminates.

NOTE

The 3-position enable function does not take effect in automatic mode. When a program is executed in the “Programming” interface, the robot automatically switches to automatic mode. In this mode, the 3-position enable function cannot be triggered.

When the safety digital input signal is HIGH (3-position switch is in position 2), the 3-position enable function is deactivated. In this state, the restrictions above are lifted.

If the safety digital input signal is inconsistent, the 3-position enable function is activated, and the App will prompt that the safety digital input signal is in error. If the two safety digital input signals differ, and the inconsistency lasts more than 1 second, the Cat. 1 Stop will be triggered.

The function description of 3-position enable switch is as follows:

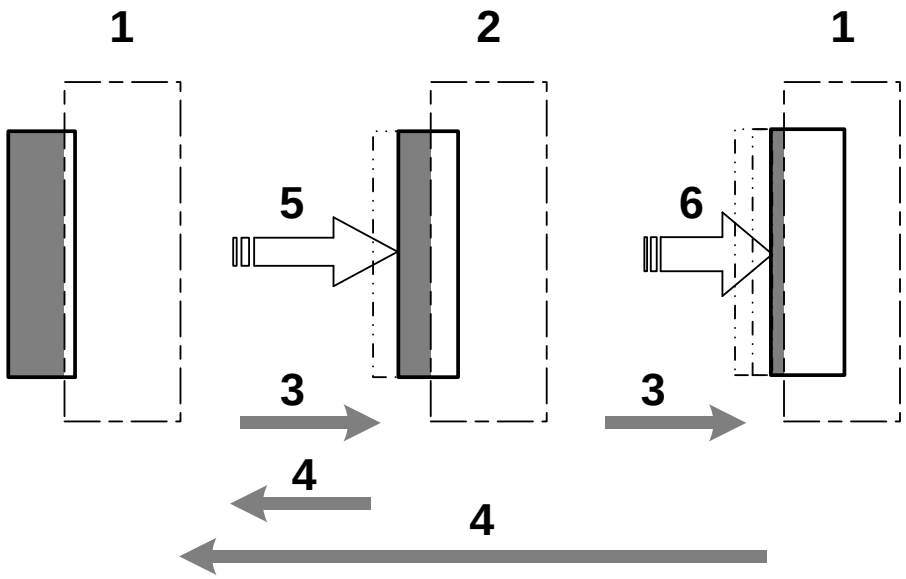


Figure 4-6: 3-position switch functions

1: Activate the 3-position enable function

2: Deactivate the 3-position enable function

3: Press

4: Release

5: Press lightly

6: Press tightly

The following graphic presents the 3-position enable sequence.

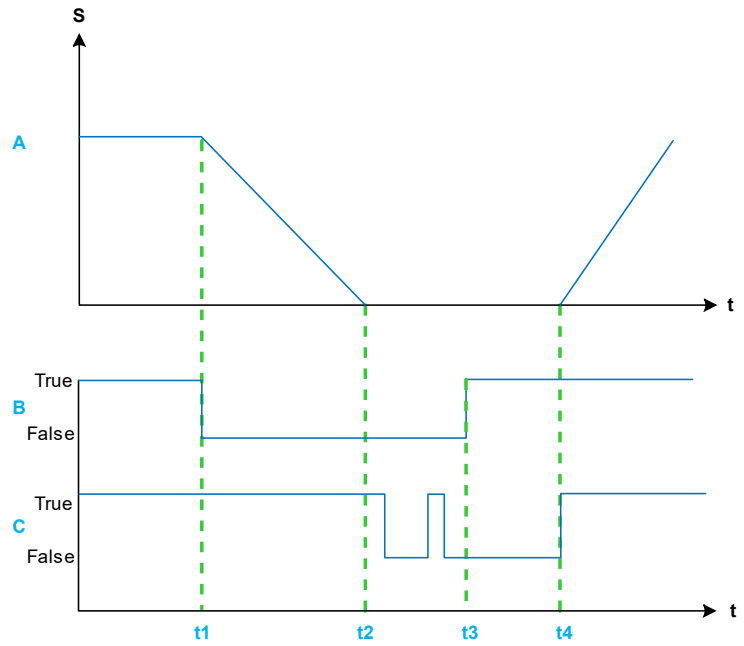


Figure 4-7: 3-position enable sequence

S: Motion speed

t: Time

A: Robot motion speed

B: 3-position enable limit (True = deactivate, False = activate)

C: Manual control robot (True = activate, False = deactivate)

t1: 3-position enable limit is triggered

t2: Maximum stopping time (350 ms)

t3: 3-position enable limit is lifted

t4: Activate manual control

4.2.5 Speed Monitoring Functions

4.2.5.1 Joint Speed Limit

The speeds of robot each joint and TCP are limited, thus the joint speed limit (SF5) needs to be configured in the “Joint Limit” interface, and TCP speed limit (SF9) needs to be configured in the “Motion Limit” interface of the JAKA App. For specific configuration steps, please refer to “Safety Settings” chapter in software user manual. The robot system will monitor the speed of the robot, and when the motion speed exceeds the setup limit, the robot will decelerate until the speed is within the specified limit. If the robot's speed does not decrease to the specified limit within 250 ms, according to IEC 60204-1:2009, the robot will execute a Cat. 1 Stop.

If the two safety digital input signals differ, the Cat. 1 Stop will be triggered.

The following graphic presents the speed monitoring sequence.

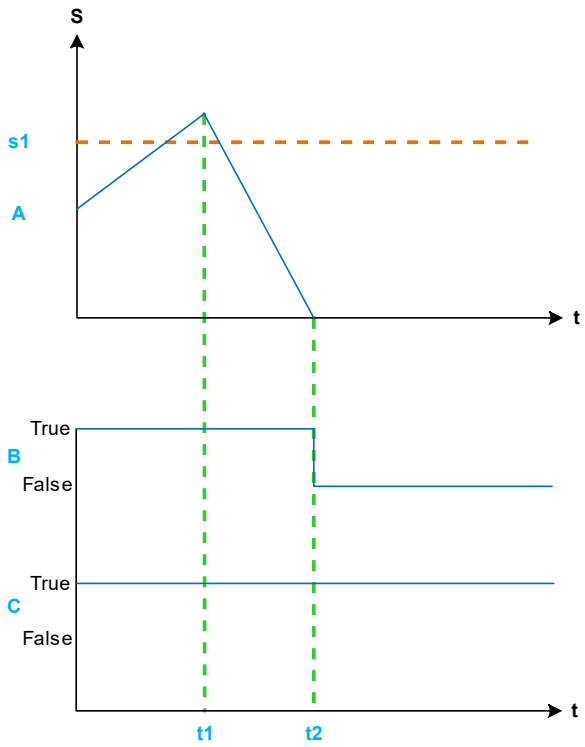


Figure 4-8: Speed monitoring sequence

S: Motion speed

t: Time

A: Robot joint speed/TCP speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or power off (False)

s1: Joint speed limit/TCP speed limit

t1: Joint speed limit or TCP speed limit is exceeded

t2: Maximum stopping time (250 ms)

4.2.5.2 Reduced Mode

Reduce mode can be entered through the following methods:

Configure the “Reduced mode input” in the “Dedicated Safety I/O” interface of the JAKA App. Connect external safety devices to the corresponding interfaces on P1 and P3 of CAB 2.1 to provide input signals (SF18).

Safety digital input signals are designed with dual redundancy. When the safety digital input signal is LOW, it triggers the reduced mode. In this mode, the TCP speed, elbow speed, momentum and power, stopping time, and stopping distance of the robot are limited to the configured values. Refer to the software user manual’s “Safety Settings” chapter for instructions on configuring these limit values.

The limit data for each robot model are as follows:

Table 4-2: Limit data in reduced mode

Robot Model	Name	Value		Unit
		Min.	Max.	
Zu 3	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)

Robot Model	Name	Value		Unit
		Min.	Max.	
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	0.8	kg*m/s
	Power limit	0.1	35	W
	Stopping time	0.015	0.1	s
	Stopping distance	0.35 (0.01)	15 (0.59)	mm (in)
Zu 5	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	2.4	kg*m/s
	Power limit	0.1	50	W
	Stopping time	0.015	0.1	s
	Stopping distance	0.35 (0.01)	15 (0.59)	mm (in)
Zu 7	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	2.5	kg*m/s
	Power limit	0.1	70	W
	Stopping time	0.015	0.1	s
	Stopping distance	0.35 (0.01)	15 (0.59)	mm (in)
Zu 12	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	10	kg*m/s
	Power limit	0.1	100	W
	Stopping time	0.015	0.1	s
	Stopping distance	0.35 (0.01)	15 (0.59)	mm (in)
Zu 18	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	9	kg*m/s
	Power limit	0.1	120	W
	Stopping time	0.015	0.1	s
	Stopping distance	0.35 (0.01)	15 (0.59)	mm (in)
Zu 20	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	10	kg*m/s
	Power limit	0.1	100	W
	Stopping time	0.015	0.1	s
	Stopping distance	0.35 (0.01)	15 (0.59)	mm (in)

Configure the “Robot reduced mode output” (SF24) in the “Dedicated Safety I/O” interface of the JAKA App. After triggering SF11 or SF18, the robot will be in reduced mode, which the safety digital output signal is LOW.

Similarly, activate the “Robot not in reduced mode output” (SF25) in the “Dedicated Safety I/O” interface of the JAKA App. When SF11 or SF18 is not triggered, the robot will not be in reduced mode, which the safety digital output signal is LOW. Safety digital output signals are designed with dual redundancy.

The following graphic presents the reduced mode sequence.

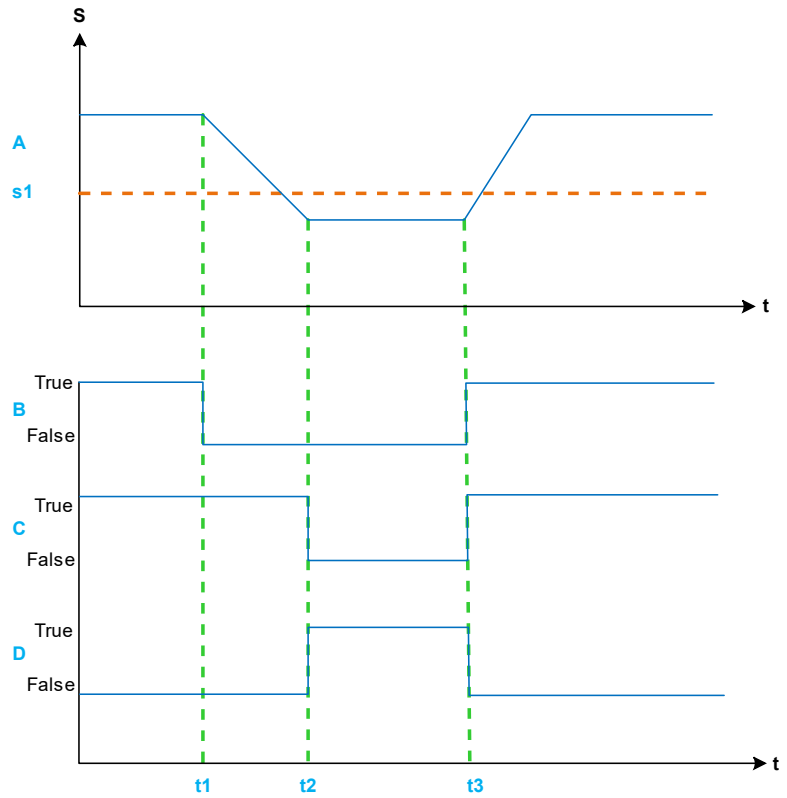


Figure 4-9: Reduced mode sequence

S: Motion speed

t: Time

A: Robot motion speed

B: Reduced mode signal input

C: Reduced mode signal output

D: Not in reduced mode output

s1: Joint speed limit/TCP speed limit

t1: Activate reduced mode

t2: Robot enters reduced mode

t3: Deactivate reduced mode

4.2.6 Torque and Power Limitations Functions

The robot system monitors and limits the robot power. The robot power is used to limit the total power of the robot (SF8), and its power limit value can be set in the “Motion Limit” interface of the JAKA App. Refer to the software user manual for specific instructions on how to set it up. Additionally, the robot system also monitors the torque (SF6) and power (SF7) of each joint. However, the torque and power limits are default values and cannot be configured or modified. If the actual values exceed the limit values, according to IEC 60204-1:2009, the robot will execute a Category 1 Stop.

The following graphic presents the torque and power limitations sequence.

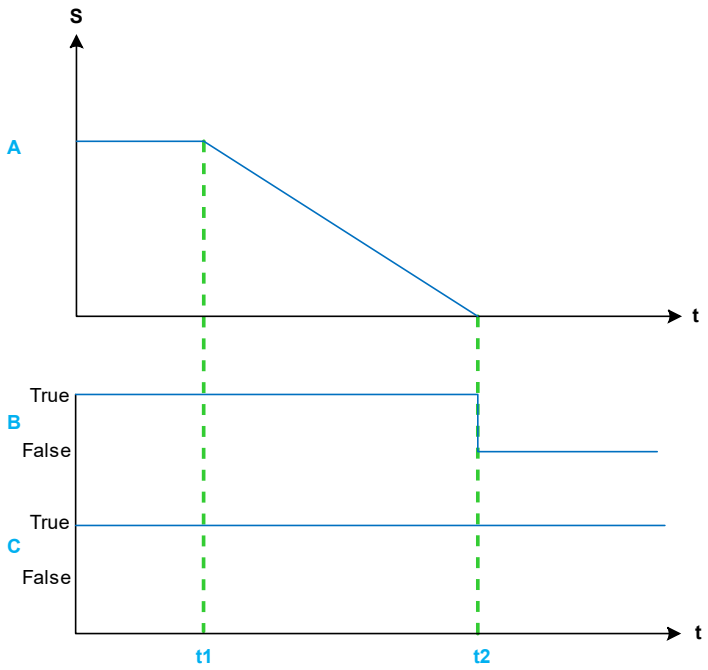


Figure 4-10: Torque and power limitations sequence

S: Motion speed

t: Time

A: Robot motion speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or power off (False)

t1: Reach or exceed the robot power, joint power, or joint torque

t2: Maximum stopping time (250 ms)

4.2.7 Collision Protection Safety Functions

The robot system provides the following methods to detect the collision:

- Monitor the actual deviation each joint position (SF12). When the limit is exceeded, the robot performs a Cat. 1 Stop.
- Monitor various parameters (force, momentum, TCP speed, power, stopping time and stopping distance) of the robot to detect collisions (SF14). When the limit is exceeded, the robot performs a Cat. 2 Stop.
- Estimate TCP force by monitoring robot joint angles and joint torques, compare the estimated force with TCP force limit values to detect collisions (SF26). When the torque limit is exceeded, the robot decelerates to stop following the programmed trajectory, then reverses along the original motion path, and finally remains stationary.
- Monitor the momentum of the robot's motion. Limiting the momentum of the robot can reduce the collision forces in a collision, and this function may have an impact on the robot's motion speed (SF28). When the momentum limit is exceeded, the robot performs Cat. 1 Stop.

Based on the risk assessment results, configure the “Collision sensitivity” in the “Dedicated Safety I/O” interface of the JAKA App to activate the collision detection. A lower numerical value indicates higher sensitivity. You can also configure collision parameters in the “Motion Limit” interface of the JAKA App to activate the collision detection. Refer to the software user manual's “Safety Settings” chapter for operational steps.

Table 4-3: Limit data in collision protection mode

Robot Model	Name	Value		Unit
		Min.	Max.	
Zu 3	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	0.8	kg*m/s
	Power limit	0.1	35	W
	Stopping time	0.015	5	s
	Stopping distance	0.35 (0.01)	4000 (157.48)	mm (in)
Zu 5	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	2.4	kg*m/s
	Power limit	0.1	50	W
	Stopping time	0.015	5	s
	Stopping distance	0.35 (0.01)	4000 (157.48)	mm (in)
Zu 7	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	2.5	kg*m/s
	Power limit	0.1	70	W
	Stopping time	0.015	5	s
	Stopping distance	0.35 (0.01)	4000 (157.48)	mm (in)
Zu 12	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	10	kg*m/s
	Power limit	0.1	100	W
	Stopping time	0.015	5	s
	Stopping distance	0.35 (0.01)	4000 (157.48)	mm (in)
Zu 18	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	9	kg*m/s
	Power limit	0.1	120	W
	Stopping time	0.015	5	s
	Stopping distance	0.35 (0.01)	4000 (157.48)	mm (in)
Zu 20	TCP speed limit	50 (1.97)	250 (9.84)	mm/s (in/s)
	Elbow speed limit	50 (1.97)	250 (9)	mm/s (in/s)
	Momentum limit	0.1	10	kg*m/s
	Power limit	0.1	100	W
	Stopping time	0.015	5	s
	Stopping distance	0.35 (0.01)	4000 (157.48)	mm (in)

You can set the collision rebound angle in the “Collision Settings” interface of the JAKA App. If this angle is configured, when the robot system detects a collision, the robot will decelerate to stop and then rebound along the original path.

The following graphic presents the collision protection sequence (non-severe collision).

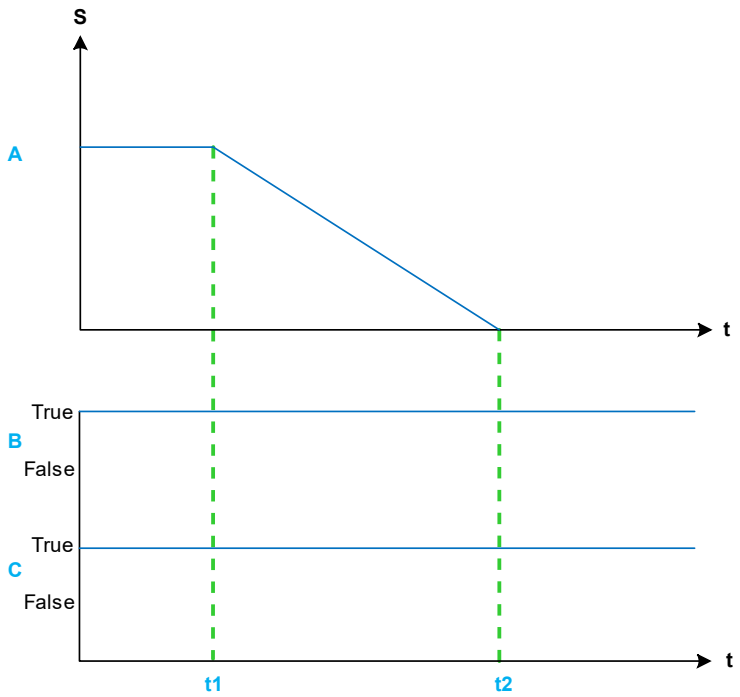


Figure 4-11: Collision protection sequence (non-severe collision)

S: Motion speed

t: Time

A: Robot motion speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or power off (False)

t1: Detect collision

t2: Maximum stopping time (350 ms)

If the robot system detects that the actual joint position deviates significantly from the target joint position, exceeding the deviation limit (SF12), it is considered a severe collision. According to IEC 60204-1:2009, the robot will execute a Cat. 1 Stop.

NOTE

The joint position deviation value is set to the factory default and cannot be configured or modified.

The following graphic presents the collision protection sequence (severe collision).

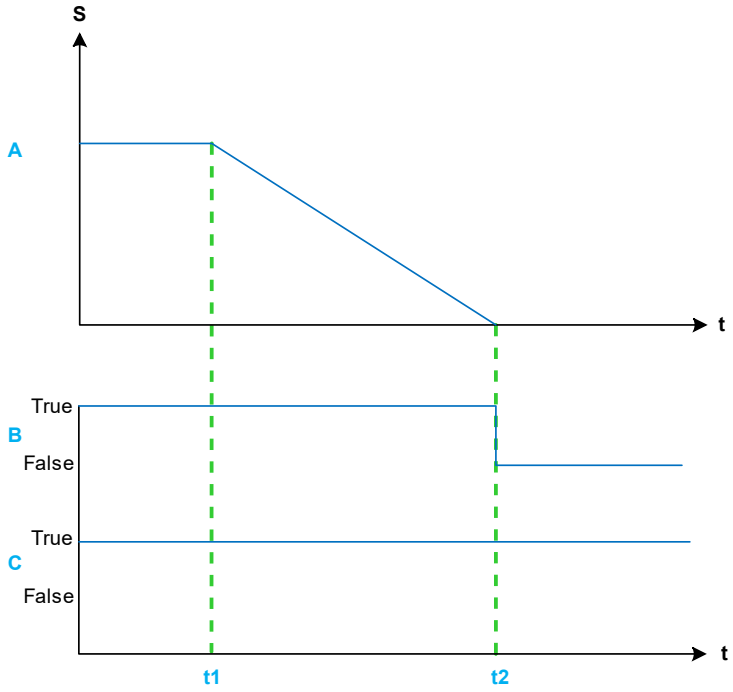


Figure 4-12: Collision protection sequence (severe collision)

S: Motion speed

t: Time

A: Robot motion speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or power off (False)

t1: Detect collision

t2: Maximum stopping time (250 ms)

4.2.8 Position Monitoring

The robot system provides the following methods to limit robot motion:

- Monitor if the robot each joint position exceed the position limit (SF4)
- Monitor if the robot tool orientation is within the set limit (SF10)
- Monitor if the robot position is within the set safety plane (SF11)

All limiting functions mentioned above can be activated simultaneously and can be configured in the JAKA App. Refer to the software user manual's “Safety Settings” chapter for operation steps.

If the robot joint positions reach or exceed the joint position limit (SF4) or the robot tool orientation reaches or exceeds the tool orientation limit (SF10), the App will display a pop-up window. According to IEC 60204-1:2009, the robot will execute a Cat. 1 Stop.

If the robot position reaches or exceeds the TCP position limit (SF11), the robot will execute the corresponding operation based on the robot state configured in the JAKA App.

- If configured to stop when the safety plane is triggered, the robot will stop, the program will be terminated and the robot will be disabled. The robot can be enabled again within the safety zone.
- If configured to safeguard stop when the safety plane is triggered, the robot will decelerate until it stops, and the “Safety plane safeguard stop” will pops up. After clicking “OK”, the robot exits the safeguard stop and continues to move through the safety plane. When the robot triggers the safety plane again, it performs safeguard stop again. Apart from clicking “OK”, the robot can also exit the safeguard stop and

continue moving through the safety plane by triggering the “Safeguard stop reset input” in the safety DI.

- If configured to reduce mode when the safety plane is triggered, robot enters the reduced mode (TCP speed ≤ 250 mm/s) and the “Robot enters the reduced mode” pops up. After clicking “OK”, the robot is still in the reduced mode, and only exits the reduced mode after the robot returns to the safety plane.

The following graphic presents the position monitoring sequence (the robot state of SF4, SF10, SF11 is configured to stop).

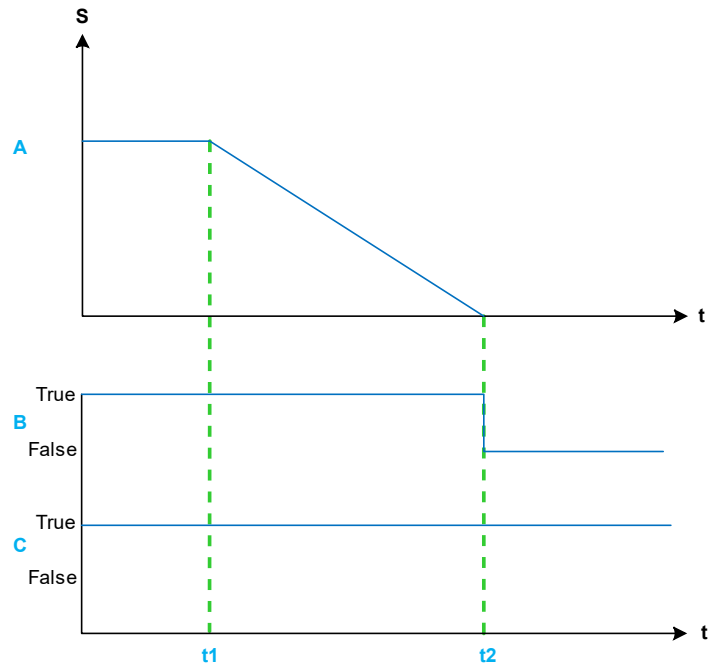


Figure 4-13: Position monitoring sequence (the robot state of SF4, SF10, SF11 is configured to stop)

S: Motion speed

t: Time

A: Robot motion speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or powered off (False)

t1: Reach or exceed the position limit

t2: Maximum stopping time (250 ms)

The following graphic presents the position monitoring sequence (the robot state of SF11 is configured to safeguard stop).

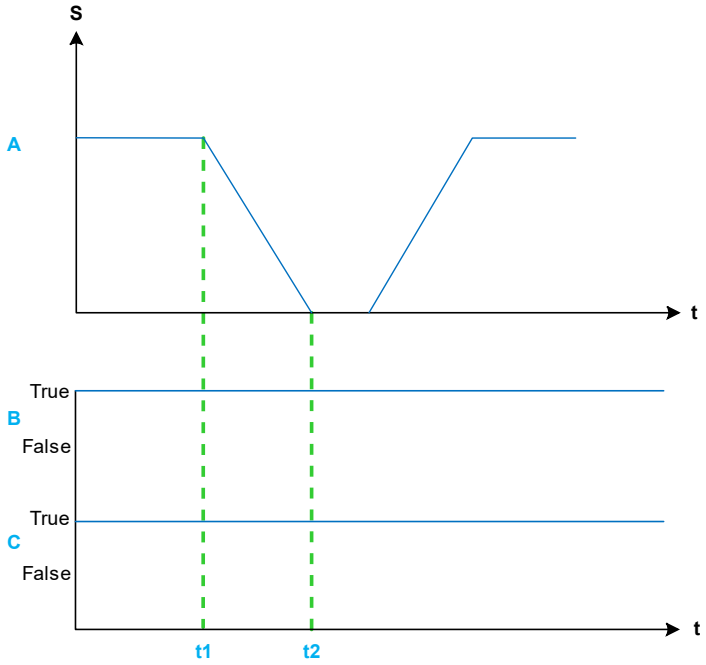


Figure 4-14: Position monitoring sequence (the robot state of SF11 is configured to safeguard stop)

S: Motion speed

t: Time

A: Robot motion speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or power off (False)

t1: Reach or exceed the position limit

t2: Maximum stopping time (250 ms)

The following graphic presents the position monitoring sequence (the robot state of SF11 is configured to reduced mode).

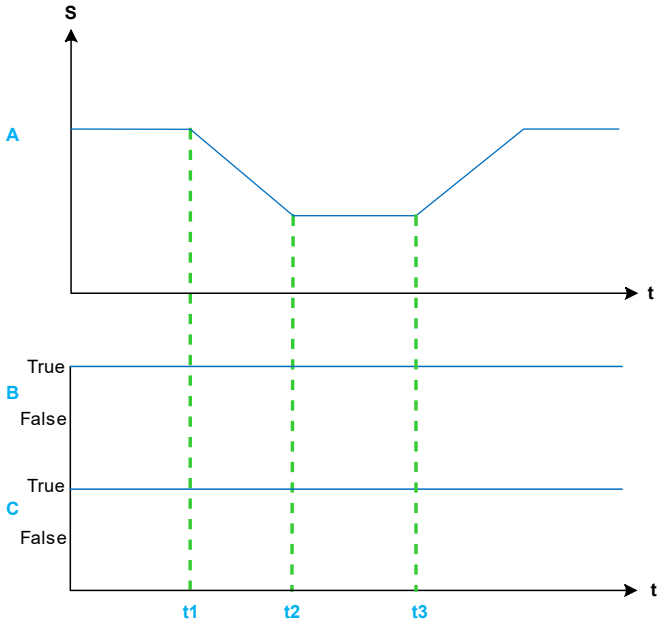


Figure 4-15: Position monitoring sequence (the robot state of SF11 is configured to reduced mode)

S: Motion speed

t: Time

A: Robot motion speed

B: Robot is disabled (True) or enabled (False)

C: Robot is powered on (True) or power off (False)

t1: Reach or exceed the position limit

t2: Robot is in the reduced mode

t3: Robot exceeds the reduced mode

4.3 Input Signal Redundancy

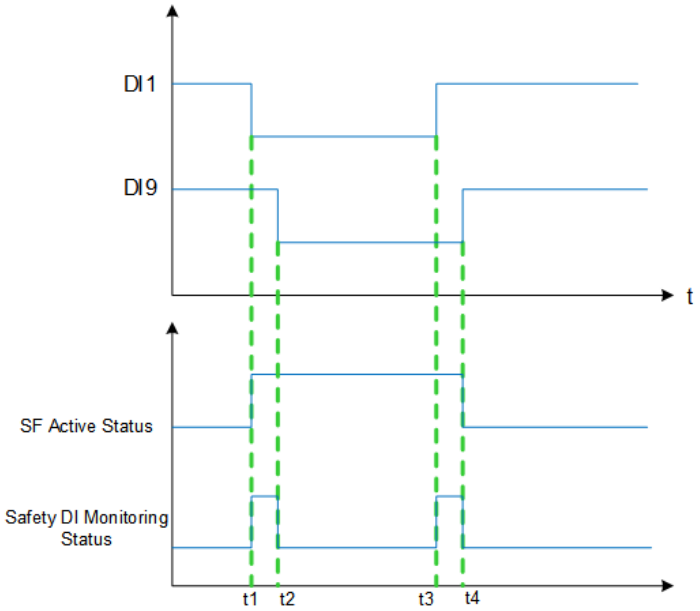


Figure 4-16: Input signal redundancy sequence

The channels of the safety digital input signal use redundancy with equivalent input signals. If one of the safety signals (taking DI1 and DI9 of CAB 2.1 as examples) is low, the safety function is activated (t1).

When the safety function is off and exits the safety state, DI1 and DI9 need to change from low to high (rising edge) within the signal tolerance time. If the DI1 and DI9 signals differ, and the time exceeds the tolerance time for 1 second. For example, t2-t1 or t4-t3 time as shown in the figure above exceeds 1 second, the SCB determines that the safety DI is faulty and performs the safety DI fallback function. The safety DI error can only be eliminated by powering on the robot again after recovery. If the error is not cleared, it is forbidden to power on the robot. The signal used to activate the safety function must be stable, otherwise the robot will stop and need to be restarted.

Safety DI fallback function:

- The robot decelerates and stops. After stopping, the robot is powered off and the program terminates.
- Troubleshooting the two DIs with errors, and replace the actual input signal of the port with the low signal. The error will exist until the robot is powered on again and the error has been checked and cleared.

The App pops up that the safety DI has an error. After the error is troubleshooted, the robot needs to be restarted to exit the error status.

5 Technical Data

5.1 Mechanical and Electrical Data

5.1.1 Robot Technical Specification

Table 5-1: Robot technical specifications

Model	Zu 3	Zu 5	Zu 7	Zu 12	Zu 18	Zu 20
Payload	3 kg (6.6 lb)	5 kg (11 lb)	7 kg (15.4 lb)	12 kg (26.4 lb)	18 kg (39.6 lb)	20 kg (44.1 lb)
Weight (including cables)	12 kg (26.46 lb)	23 kg (50.71 lb)	22 kg (48.50 lb)	41 kg (90.39 lb)	35 kg (77.16 lb)	68 kg (149.9 lb)
Reach	626 mm (24.64 in)	954 mm (37.5 in)	819 mm (32.2 in)	1327 mm (52.2 in)	1073 mm (42.24 in)	1780 mm (70.1 in)
Repeatability	±0.02 mm (±0.00079 in)			±0.03mm (±0.00118in)		±0.05 mm (±0.00120 in)
Degree of freedom	6					
Programming	Graphical programming, and freedrive programming					
Demonstrator type	Mobile terminal (computer/pad/mobile phone)					
Collaborative operation	Collaborative operation as ISO 10218-1: 2011					
Range of action						
Joint 1	±360°					
Joint 2	-85°~+265°					
Joint 3	±175°					
Joint 4	-85°~+265°					
Joint 5	±360°					
Joint 6	±360°					
Joint speed						
Joint 1	180 °/s	180 °/s	180 °/s	120 °/s	120 °/s	120 °/s
Joint 2	180 °/s	180 °/s	180 °/s	120 °/s	120 °/s	120 °/s
Joint 3	180 °/s	180 °/s	180 °/s	120 °/s	180 °/s	120 °/s
Joint 4	220 °/s	180 °/s	180 °/s	180 °/s	180 °/s	220 °/s
Joint 5	220 °/s	180 °/s	180 °/s	180 °/s	180 °/s	220 °/s
Joint 6	220 °/s	180 °/s	180 °/s	180 °/s	180 °/s	220 °/s
Tool typical speed	1 m/s (3.281 ft/s)	1 m/s (3.281 ft/s)	1 m/s (3.281 ft/s)	1 m/s (3.281 ft/s)	1 m/s (3.281 ft/s)	1.5m/s (4.921 ft/s)
Average power consumption	150W	350W	350W	500W	500W	750W
Peak power	1000W	2000W	2000W	3000W	3000W	/
Temperature	0~50°C (32~122°F)					
Humidity	0~90% RH, non-condensation					
IP	IP54					IP65
Clean room	Conform to ISO 14644-1：2015，ISO 14644-14：2016 Class 5					/
Robot mounting	Mounting at any angle					
Tool I/O port	2 digital inputs 2 digital outputs					

Model	Zu 3	Zu 5	Zu 7	Zu 12	Zu 18	Zu 20
	2 analog inputs					
Tool I/O power supply	12/24V					
Tool I/O size	M8					
Tool I/O cable length	400 mm (15.748 in)					
Base diameter	129 mm (5.079 in)	158 mm (6.220 in)	158 mm (6.220 in)	188 mm (7.402 in)	188 mm (7.402 in)	246 mm (9.685 in)
Material	Aluminum alloy, PC					
Length of robot connection cable	6 m (236.220 in)					
Length of control stick cable	6 m (236.220 in)					

NOTE

At low environmental temperature <10ºC, a warm-up phase is recommended to be run with the robot. Otherwise, there is a risk that the robot stops or run with lower performance.

5.1.2 Control Cabinet Technical Specification

Table 5-2: Control cabinet technical specifications

Model	CAB 3	CAB 7	CAB 12	CAB 16
Matching robot	**Zu 3**	**Zu 5, Zu 7**	**Zu 12, Zu 18**	**Zu 20**
Weight	13.5 kg (29.762 lb)	15.4 kg (33.951 lb)	18 kg (39.683 lb)	
IP	IP44			
Control cabinet I/O port	16 digital inputs, 16 digital outputs, 2 analog inputs or outputs			
Control cabinet I/O power supply	24V DC			
Communication mode	TCP/IP, Modbus TCP, Modbus RTU, PROFINET (1.7 App), Ethernet/IP (1.7 App)			
Power supply	100~240V AC, 50~60 Hz			
Length of control cabinet power cord	3 m (118.110 in)			
Size	410*235*307 mm (W*D*H) 16.14*9.25*12.09 in (W*D*H)			
Material	Plastic-sprayed carbon steel plate			
Temperature	0~50°C (32~122°F)			

NOTE

Zu series robots are used with CAB 2.1 by default. For MiniCab technical specifications, see JAKA MiniCab User Manual.

5.1.3 Robot Buttons and Interfaces

5.1.3.1 Ring-Shaped Light

On the top of each joint 6, ring-shaped light and a “pause/resume” button can be found.

The positions of the ring-shaped light and the button are shown in figure below. When the robot runs a program, you may press the button at the end of the robot to pause it, and you may press again to resume. There are four colors which can be indicated on the ring light and each color is a state of which the robot is in. Please see Table 5-3 below.

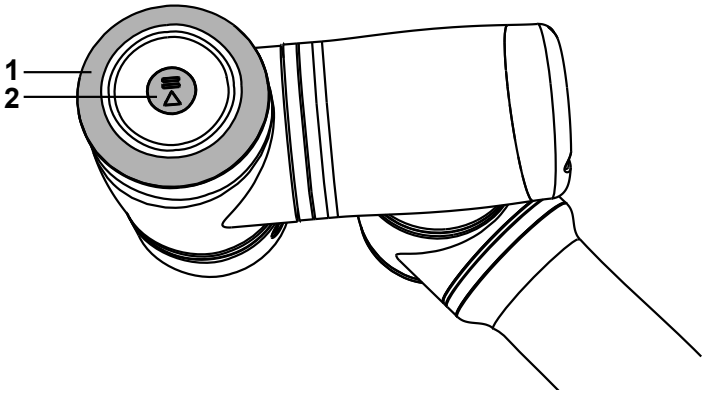


Figure 5-1: Ring-shaped light of Zu 3, Zu 5, Zu 7, Zu 12, Zu 18

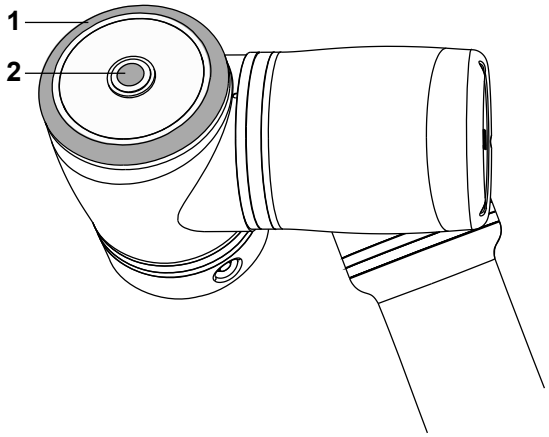


Figure 5-2: Ring-shaped light of Zu 20

1. Ring-shaped light
2. Pause/Resume button

Table 5-3: Meaning of ring-shaped light color

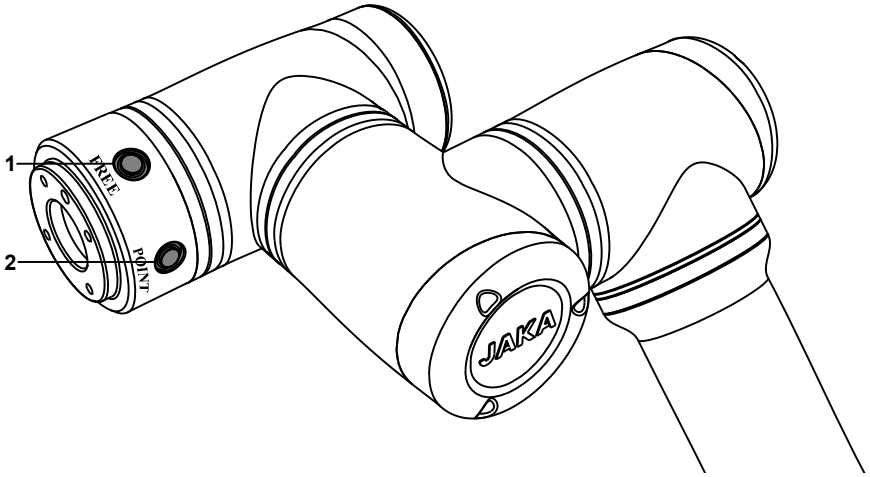
Color	Robot State
Blue	Powered on but disabled
Green	Enabled
Red	Failure/Protective stop
Yellow	Freedrive mode
Yellow flash	Pause
Yellow flash	Single-step program debugging

WARNING

User must first assess the risks of a sudden stop or start before using the Pause/Resume button. Sudden stops or starts may cause injury to personnel or damage to the equipment.

5.1.3.2 Free and Point Buttons

The robot is equipped with a tool I/O interface (TIO) and two buttons on the side of the flange. The two buttons are a freedrive button (FREE) and a point recording button (POINT), as shown in figure below.



1. Free button
2. Point button

Figure 5-3: Free and point button

When the Free button is pressed, the robot enters the freedrive mode. The robot can be dragged to the desired position manually.

The Point button is used with the JAKA App. When this button is pressed, the corresponding position will show up in the programming interface of the App as a command (see JAKA App Software User Manual for details).

WARNING

User must first assess the risks before using the free drive and point buttons. Ensure that the robot's mounting orientation, end payload, TCP, and other parameters are correctly set, otherwise it may cause injury to personnel or damage to the equipment.

5.1.4 Robot Rotation Direction

Refer to 5.1.1 Robot Technical Specification for robot rotation range. The rotation direction is as follows:

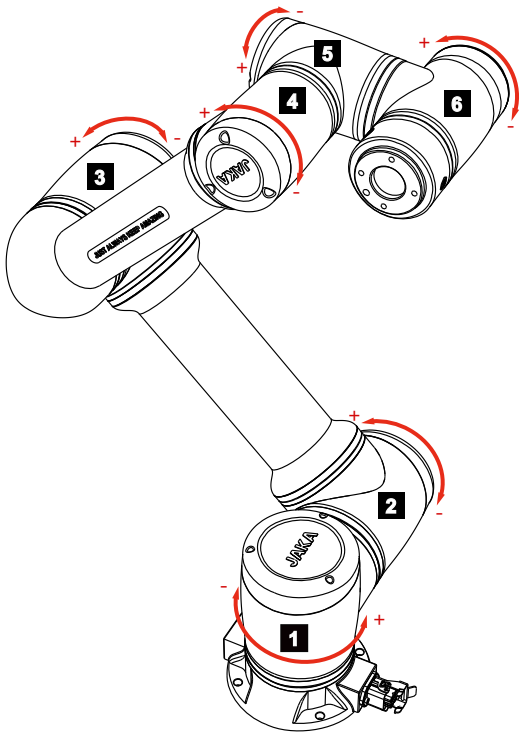


Figure 5-4: Robot rotation direction

5.1.5 Robot Singularity

Singularities are positions described in Cartesian space that have no impact on MoveJ. When the robot is at a singularity, replace the Cartesian movement by MoveJ if the motion can be achieved by MoveJ. If there is singularity in the middle of the robot's motion path, the robot's trajectory can be changed to bypass the singularity. You can also change the robot's mounting position or the size of the end effector to change the value of Cartesian points in the robot's joint space. A singularity is a robot arm configuration where one or more degrees of freedom are lost causing the robot to be stuck in a position and unable to move. This usually occur when joint axes align in one way or another.

When a robot is at a singularity, the following effects may occur:

- Robots cannot move in one or more directions.
- The robot cannot find a suitable set of joint angles for the TCP to move to the desired position.
- The robot joint should move at high speed to achieve the desired TCP speed.
- Intense movements near singularities will result in accidents and shorten the lifespan of robot joints.

The JAKA Zu series robots have three types of singularities: shoulder singularities, elbow singularities and wrist singularities. Descriptions and avoidance methods of the singularity are as follows.

Shoulder singularity: When the axes intersection of the joint 5 and joint 6 lies on the plane of axes of joint 1 and joint 2, the robot is at shoulder singularity.

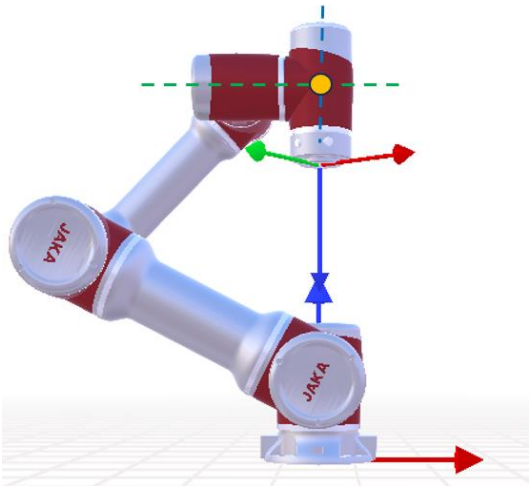


Figure 5-5: Shoulder singularity

Ways to avoid shoulder singularity:

- Ensure that the robot TCP is not directly above the robot base. TCP cannot reach the positions directly above the robot. A shoulder singularity will occur if the TCP approaches a position directly in line with the base Z axis.
- Do not use MoveL when the angle of joint 1 is 180 between two points in space. When the difference is about 180°, the robot reaches shoulder singularity. You can use MoveJ to avoid singularity or set an intermediate transition point outside the shoulder singularity range.

Elbow singularity: When joints 2, 3 and 4 are coplanar or when joint 3 is 0°, the robot is at elbow singularity.

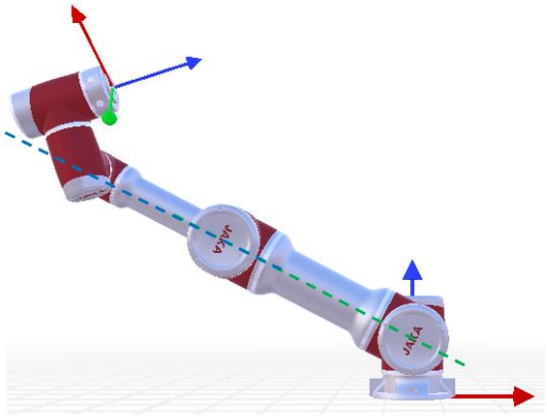


Figure 5-6: Elbow singularity

Ways to avoid elbow singularity:

- When the robot is at an elbow singularity, it indicates that the target position is close to the limits of the working range of the robot. At this point, it is necessary to adjust the robot mounting position or extend the length of the end effector.

Wrist singularity: When joint 4 and joint 6 are collinear or when joint 5 is 0°, the robot is in wrist singularity.

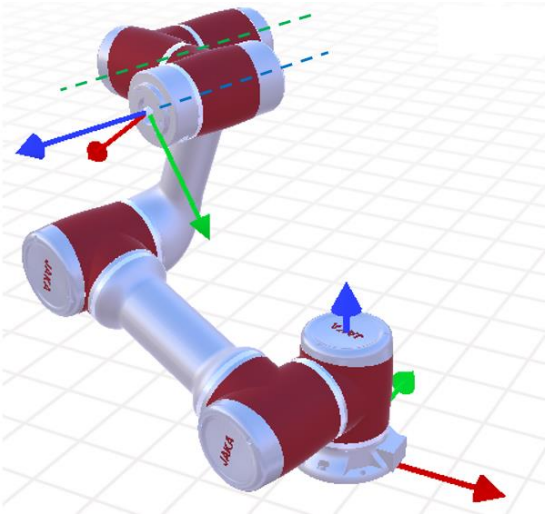


Figure 5-7: Wrist singularity

Ways to avoid wrist singularity:

- The wrist singularity typically occurs in movements with orientation changes. Therefore, in cases of considerable orientation change, it is advisable to prioritize MoveJ and not use Cartesian motions such as MoveL or MoveC.

5.1.6 IPC Specification

There is an IPC board in the control cabinet, the specifications are as follows:

Table 5-4: Specifications of IPC board

CPU	Intel(R) Celeron(R) CPU J1900 1.99 GHz
RAM	DDR3L 2 GB
Hard drive	64 GB
Interfaces	1x USB 3.01, 3x USB 2.0, 2x Ethernet, 1x VGA, 1x HDMI

5.1.7 Control Stick Buttons

The JAKA robot comes with a control stick, which can be used to control both the robot and the control cabinet. The functions of the control stick buttons are described as follows:

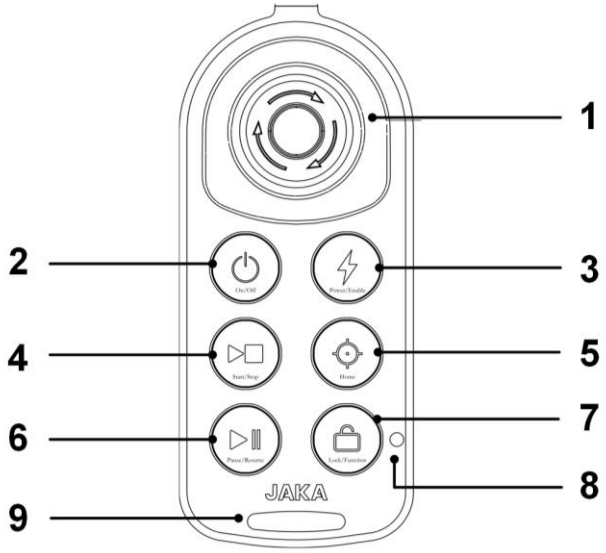


Figure 5-8: Control stick

Table 5-5: Control stick functions

	Name	Description
1	**Emergency stop button**	**For emergency stop.** The emergency stop button is limited to emergencies and should not be used as regular power off equipment.
2	**Power up/down button**	**Power up:** Press the power button for 1 second and release. The buzzer beeps once, and the control cabinet is powered up. **Power down:** Press and hold the power button for 3 seconds or more. The control stick beeps 6-7 times, and the control cabinet is powered down.
3	**Enable button**	**Robot power on:** Press the enable button once and wait for the ring-shaped light to turn blue, indicating that the robot is powered on. **Robot power off:** Press the enable button once and wait for the ring-shaped light to go off, indicating that the robot is powered off. **Enable robot:** When the robot is powered on, press and hold the lock button, and then press the enable button at the same time until the ring-shaped light turns green and a click is heard, which means the robot is enabled. **Disable robot:** When the robot is enabled, press and hold the lock button, and then press the enable button at the same time until the ring-shaped light turns blue and a click is heard, which means the robot is disabled.
4	**Start/stop button**	**Start the program:** Press the button to start the default program, execute the default program after the robot reaches the initial position of the program. **Stop the program:** Press to stop the program when the robot runs the program.
5	**Reset button**	**Reset:** After the robot is enabled and the robot is not executing the program. Press and hold the reset button to control the robot to return to initial orientation set in the JAKA App. Continue holding the button when the robot has moved to initial orientation, the lock indicator will turn blue.
6	**Pause/resume button**	**Pause:** During the automatic operation of the robot, press the button to pause the program. **Resume:** Press the button to resume the program when the program is paused.

	Name	Description
7	**Lock button**	**Lock the control stick:** Press and hold the lock button for until the indicator turns orange. **Unlock the control stick:** Press and hold the lock button until the indicator turns off. **Combination function:** Other buttons can be used with the lock button.
8	**Lock indicator**	**Lock state:** In the lock state, the indicator is orange, and all buttons except the lock button and power button are disabled. The App can now control the robot. **Unlock state:** In the unlock state, all lights turn off, and the control stick can be used. The App cannot be used to control the robot in this state.
9	**Control stick indicator**	When powering on the control cabinet, the control stick indicator first shows red, blue and green alternately with three beeps, and then it turns orange, waiting for the control cabinet to power up. The control stick indicator is blue when the controller program is running normally. After enabling the robot, the control stick indicator will flash green.

NOTE

- Once the control cabinet is powered up, the control stick will beep twice per second if any button is pressed.
- When using the control stick to operate the robot, ensure that the robot you are operating is within your sight and follow the relevant safety guidelines to avoid any injury to personnel or equipment near the robot.

5.2 Dimensional Drawings

5.2.1 Dimensional Drawings of Robot

5.2.1.1 Robot Outline Dimensions

The sizes of the Zu series robots are shown below. During the installation, the motion range of the robot must be considered to avoid injury to or collision with surrounding personnel and equipment.

1. Zu 3 outline dimensions

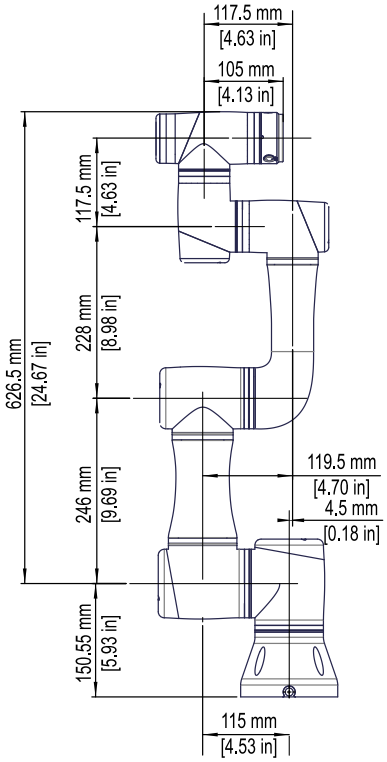


Figure 5-9: Zu 3 outline dimensions

2. Zu 5 outline dimensions

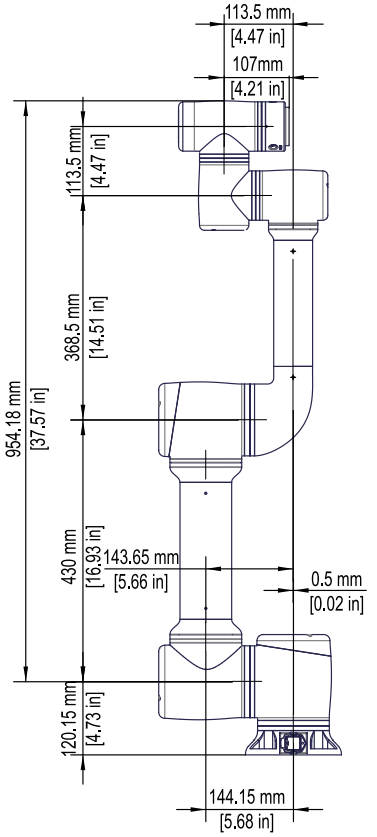


Figure 5-10: Zu 5 outline dimensions

3. Zu 7 outline dimensions

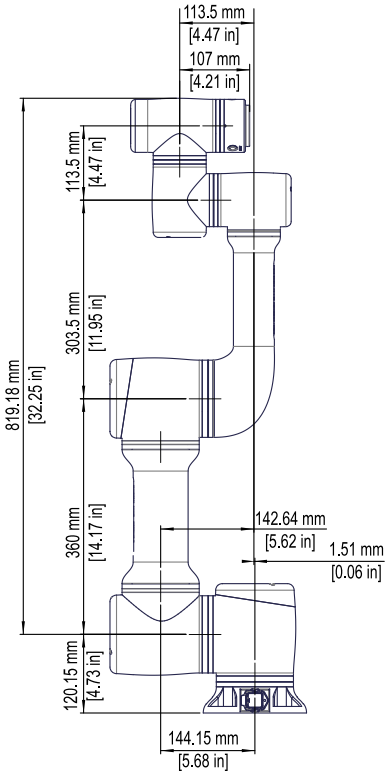


Figure 5-11: Zu 7 outline dimensions

4. Zu 12 outline dimensions

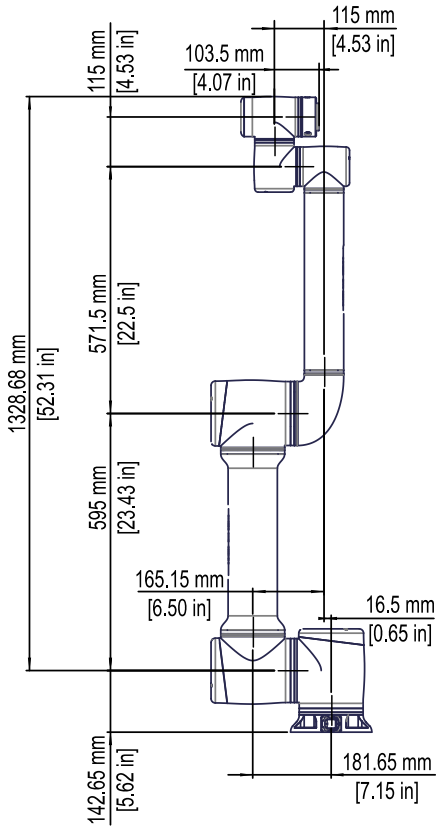


Figure 5-12: Zu 12 outline dimensions

5. Zu 18 outline dimensions

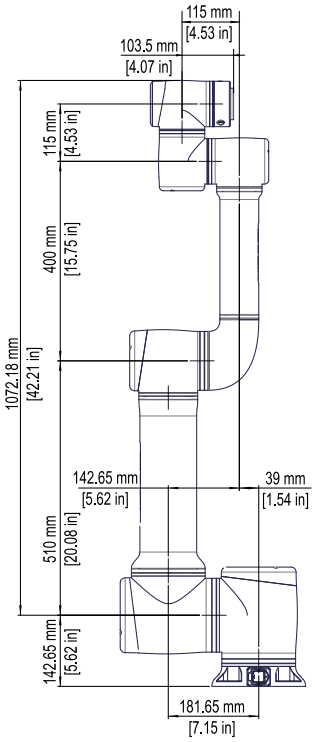


Figure 5-13: Zu 18 outline dimensions

6. Zu 20 outline dimensions

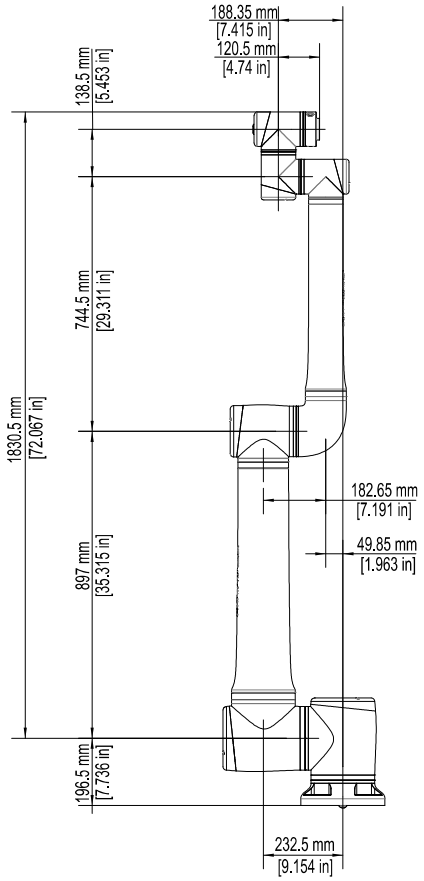


Figure 5-14: Zu 20 outline dimensions

5.2.1.2 Robot Working Space

When the robot is mounted, a cylindrical space must be considered. Due to the robot being in close proximity of a singularity, it is recommended to keep the robot end outside of this workspace. If the previously mentioned recommendations are not followed, the robot might perform at lower efficiency and create difficulties in the risk assessment. The working space of the Zu series robots are shown below.

1. Zu 3 working space

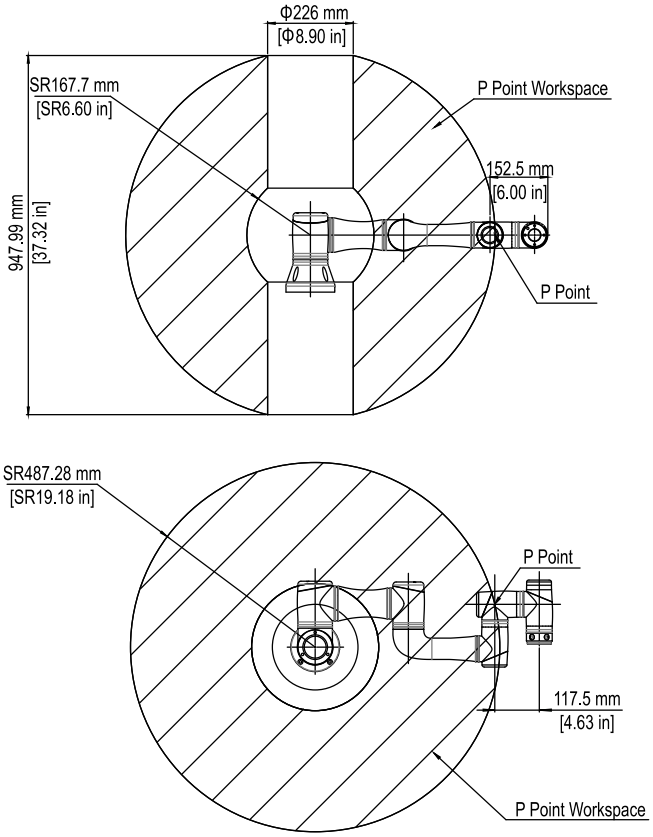


Figure 5-15: Zu 3 working space

2. Zu 5 working space

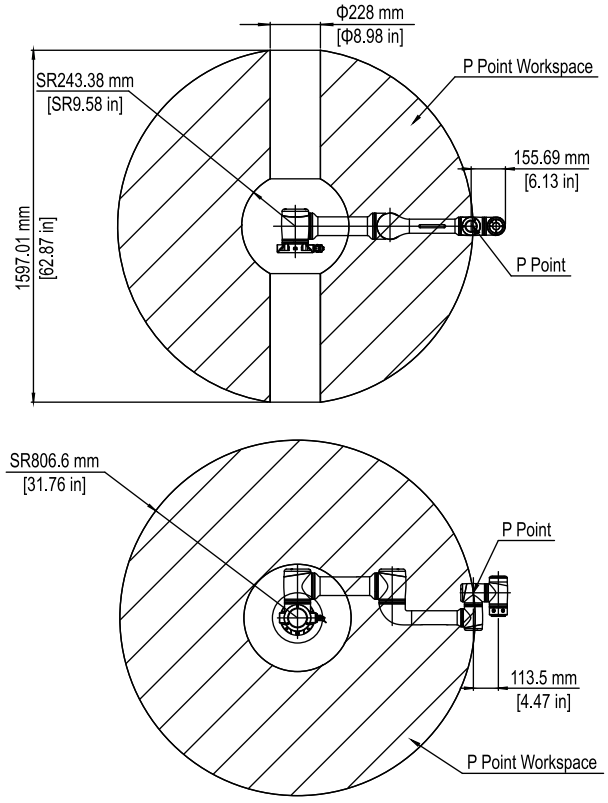


Figure 5-16: Zu 5 working space

3. Zu 7 working space

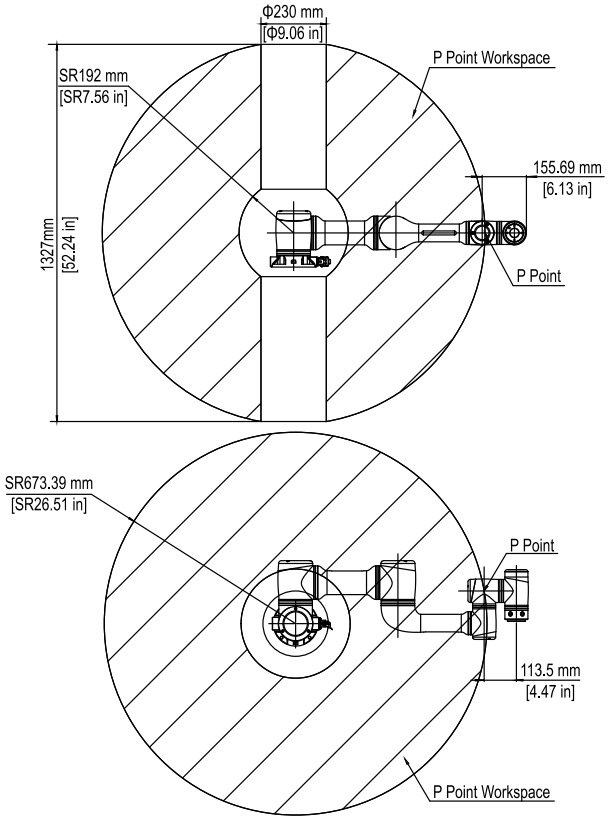


Figure 5-17: Zu 7 working space

4. Zu 12 working space

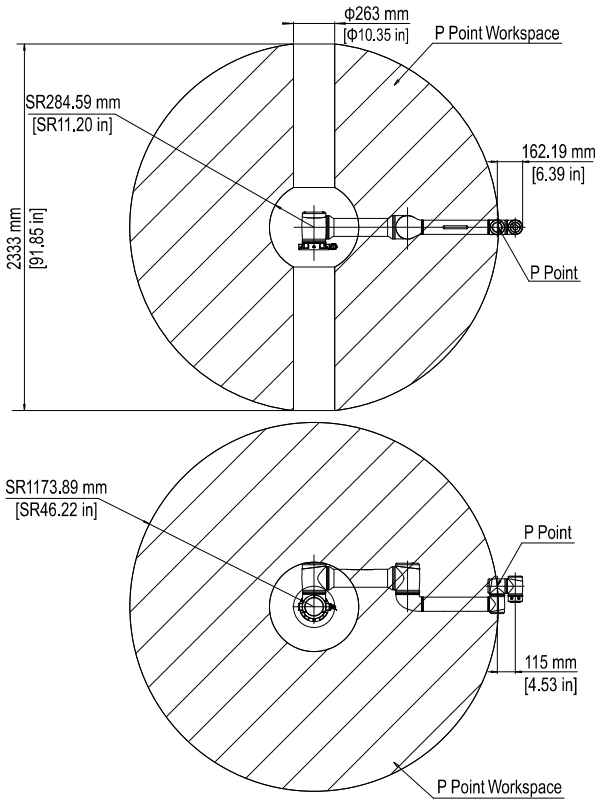


Figure 5-18: Zu 12 working space

5. Zu 18 working space

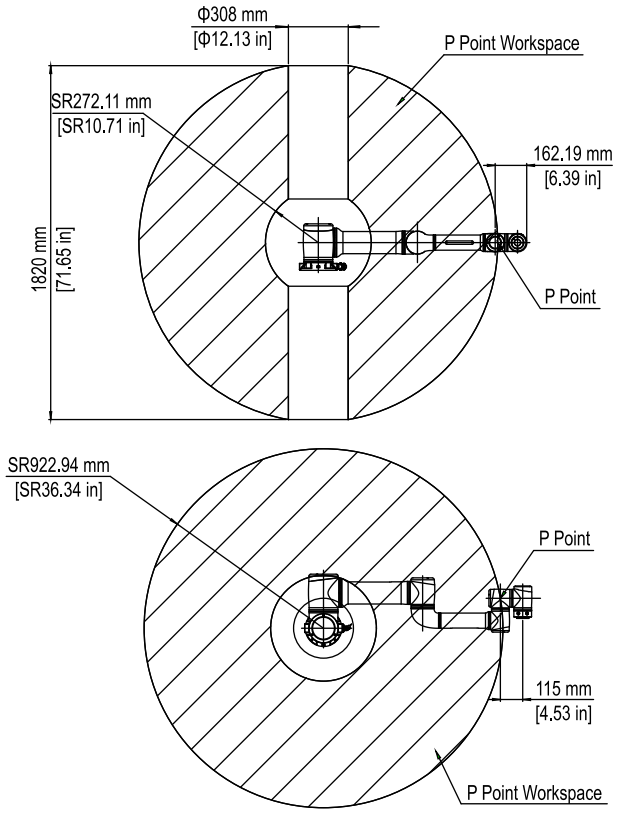


Figure 5-19: Zu 18 working space

6. Zu 20 working space

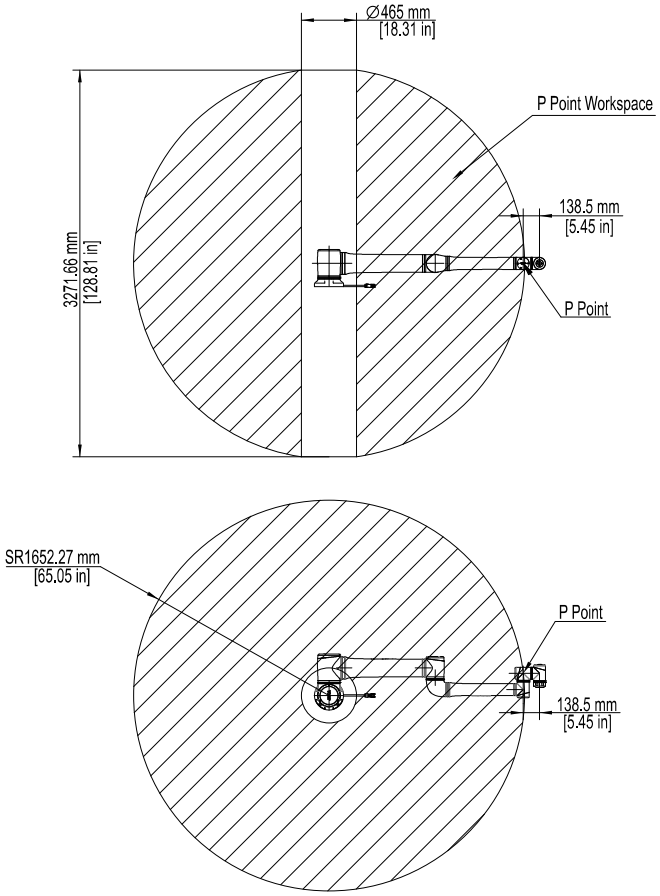


Figure 5-20: Zu 20 working space

5.2.2 Dimensional Drawings of Control Cabinet

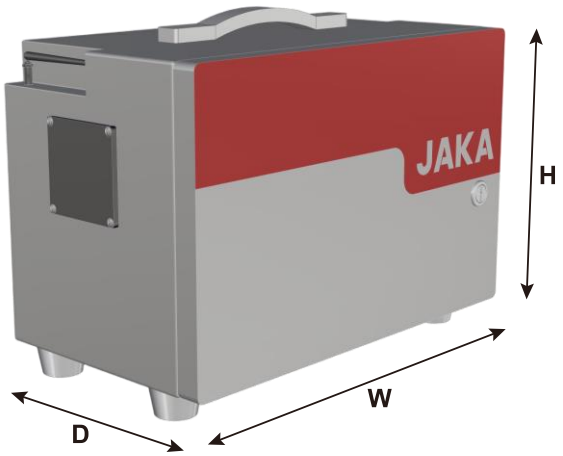


Figure 5-21: Width, height and depth of control cabinet

Table 5-6: Width, height and depth of control cabinet

Dimension	Description	Data	Unit
W	Width	410 (16.14)	mm (in)
H	Height	307 (12.09)	mm (in)

Dimension	Description	Data	Unit
D	Depth	235 (9.25)	mm (in)

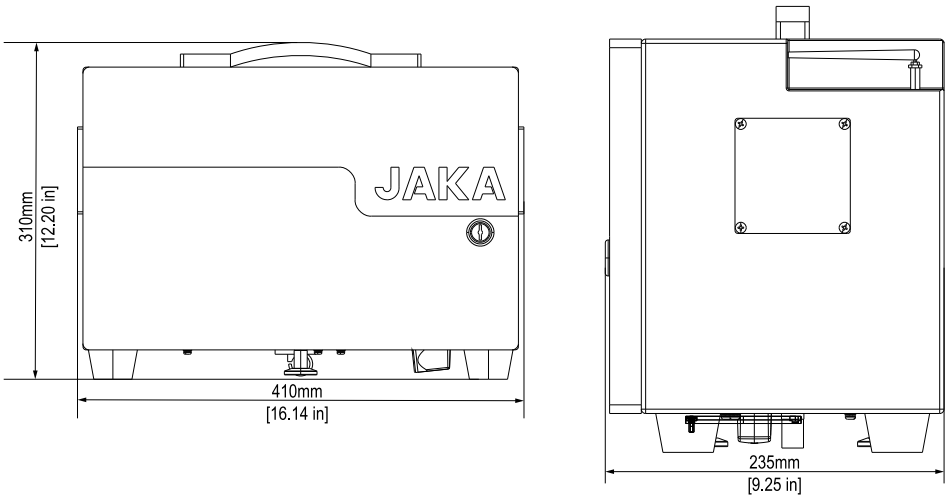


Figure 5-22: Control cabinet outline dimension

5.3 Performance Data

5.3.1 Load Capacity of the Robot

The maximum payload of the robot is related to the offset of the gravity center, and degree of the offset is related to the distance between the center of robot end flange and the payload centroid. Figures below show the relation between the payload and the offset of the gravity center:

X: Center of gravity offset

Y: Payload

1. Load capacity of the Zu 3

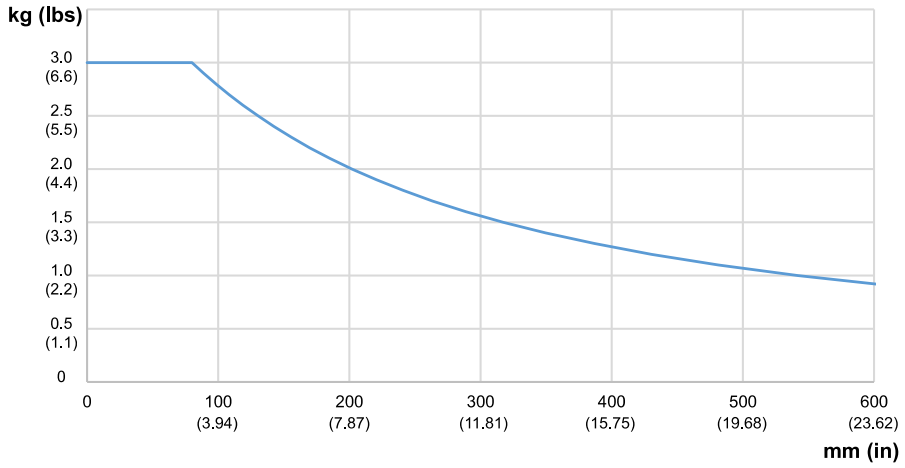


Figure 5-23: Load capacity of the Zu 3

2. Load capacity of the Zu 5

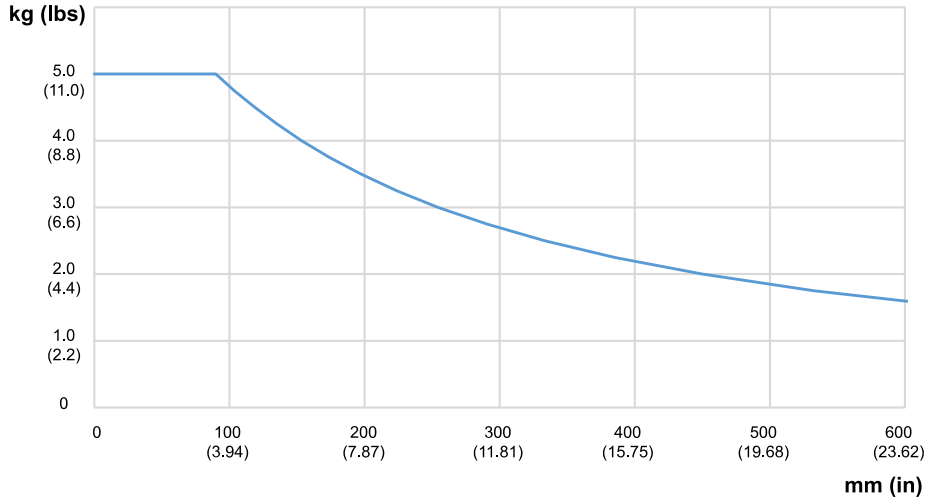


Figure 5-24: Load capacity of the Zu 5

3. Load capacity of the Zu 7

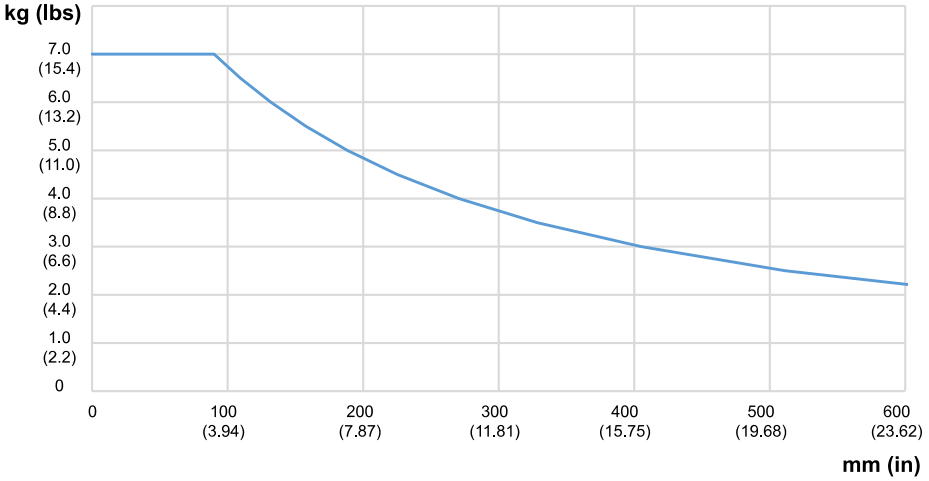


Figure 5-25: Load capacity of the Zu 7

4. Load capacity of the Zu 12

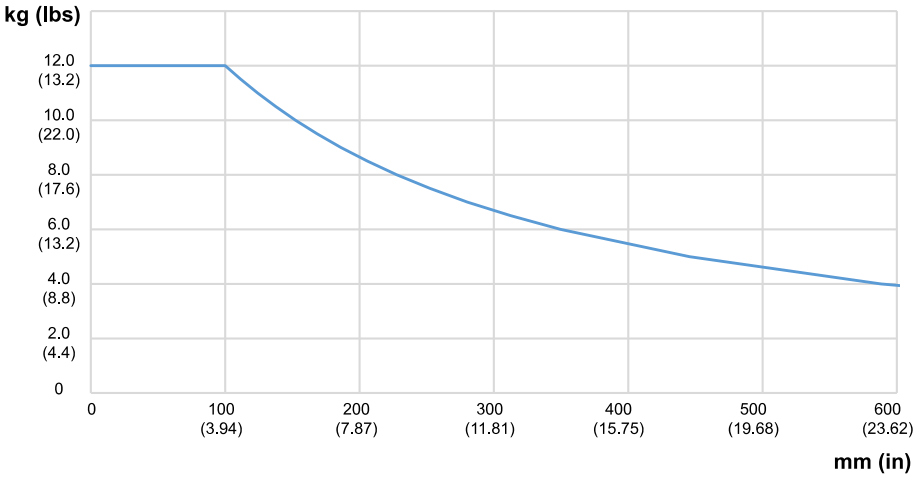


Figure 5-26: Load capacity of the Zu 12

5. Load capacity of the Zu 18

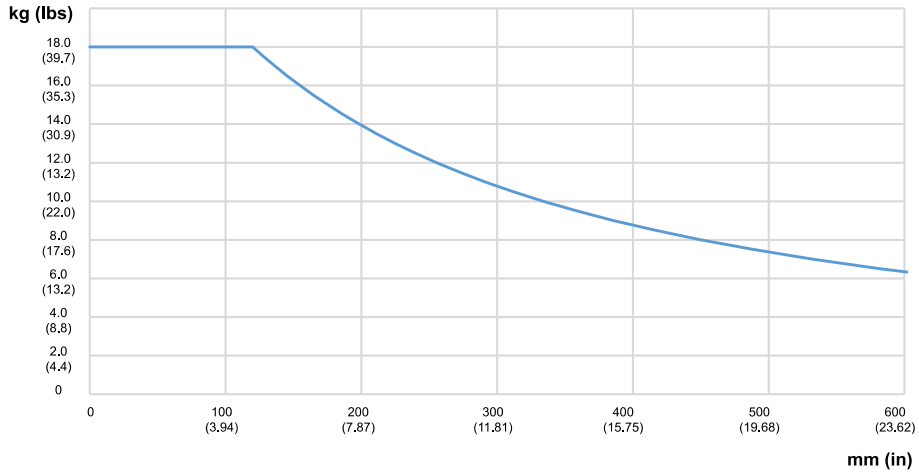


Figure 5-27: Load capacity of the Zu 18

6. Load capacity of the Zu 20

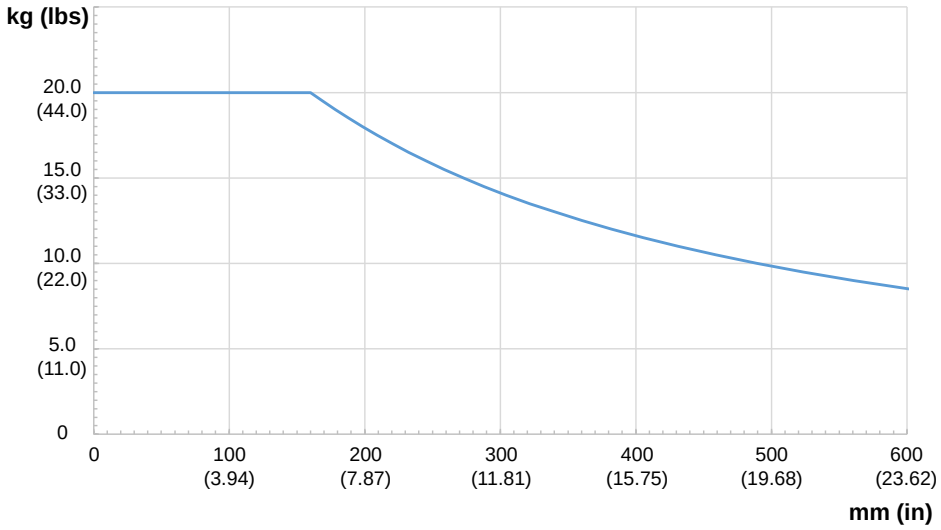


Figure 5-28: Load capacity of the Zu 20

NOTE

Offset distance is the center of gravity distance from the center of the flange.

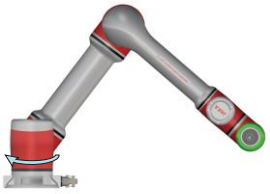
5.3.2 Stopping Time and Distance

The time from the application of a stop signal to the standstill of the robot is measured. This measurement is carried out for various reaches and velocities (measurement according to ISO 10218-1).

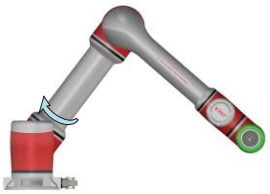
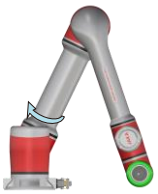
Safety stopping time is the time it takes to stop the robot from the moment when the emergency stop button is pressed or a safety protection function is triggered. The stopping distance is the distance the end of the robot moves during the safety stopping time. Among them, pressing the emergency stop button falls into Cat.1, while triggering the safety protection function falls into Cat.2. During this period, the robot is still moving and may harm the personnel or other equipment. Therefore, users and integrators should consider this time and distance in risk assessment.

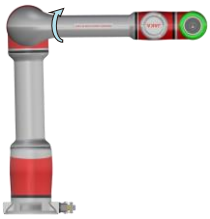
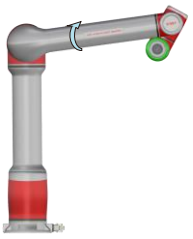
The test conditions are as follows:

- Speed: 100%, 66%, 33%
- Reach: 100%, 66%/72.5%, 33%

	100% Reach	**66% Reach**	**33% Reach**
Joint 1			

	100% Reach	**66% Reach**	**33% Reach**

Joint 2			

	100% Reach	**66% Reach**	**72.5% Reach for Zu 12**
Joint 3			

- Load: Refer to the Table 5-7

Table 5-7: Load of stopping time and distance test

Model	Payload
Zu 3	3 kg (6.6 lb)
Zu 5	5 kg (11 lb)
Zu 7	7 kg (15.4 lb)
Zu 12	12 kg (26.4 lb)
Zu 18	18 kg (39.6 lb)
Zu 20	20 kg (44.1 lb)

See Appendix 1: Stopping Time and Distance for the respective stopping distance and time of Cat.1 and Cat.2.

WARNING

Breakdown of the internal joint holding brake:

- Take into account a possible breakdown of the internal joint holding brake during your risk assessment.
- Take into account that the internal joint holding brake of the JAKA robot only withstands a limited number of brake operations.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

If there is a power interruption of the control system, the brakes are applied and the robot mechanics may leave the planned trajectory.

WARNING

Leaving the planned trajectory of the robot mechanics:

- Use the buffering of the 24 V supply (UPS) in order to enable a controlled stop of the mechanics, in accordance with stop category 1, by making use of the stored residual mechanical and electrical energy.
- Use a synchronous stop on the path to avoid collisions with obstacles.
- Observe the extension of the run-on path while performing your risk assessment.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

5.3.3 Forces and Torques on Robot Base

The illustration shows the directions of the robot stress forces.

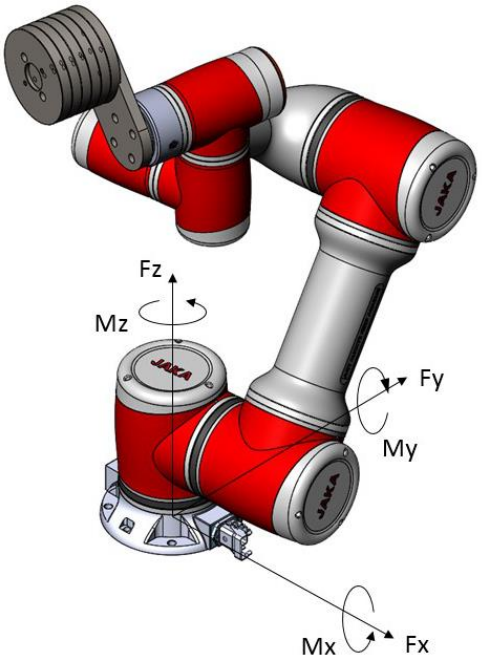


Figure 5-29: Directions of forces and torques on robot base

Fx: Force in X direction	Mx: Bending torque in X direction
Fy: Force in Y direction	My: Bending torque in Y direction
Fz: Force in Z direction	Mz: Bending torque in Z direction

The table below shows the maximum forces and torques in various directions working on the robot base.

Table 5-8: Forces and torques on robot base

	Zu 3	Zu 5	Zu 7	Zu 12	Zu 18	Zu 20
Fx	180 N 40.5 lbf	470 N 105.7 lbf	480 N 107.9 lbf	1300 N 292.3 lbf	1300 N 292.3 lbf	1600 N 359.7 lbf
Fy	180 N 40.5 lbf	470 N 105.7 lbf	480 N 107.9 lbf	1300 N 292.3 lbf	1300 N 292.3 lbf	1600 N 359.7 lbf
Fz	230 N 51.7 lbf	490 N 110.2 lbf	500 N 112.4 lbf	1100 N 247.3 lbf	1100 N 247.3 lbf	1600 N 359.7 lbf
Mx	120 Nm 1062.1 lbf·in	490 Nm 4336.9 lbf·in	440 Nm 3894.3 lbf·in	1700 Nm 15046.3 lbf·in	1500 Nm 13276.1 lbf·in	2000 Nm 17701.5 lbf·in
My	120 Nm	490 Nm	440 Nm	1700 Nm	1500 Nm	2000 Nm

	Zu 3	Zu 5	Zu 7	Zu 12	Zu 18	Zu 20
	1062.1 lbf·in	4336.9 lbf·in	3894.3 lbf·in	15046.3 lbf·in	13276.1 lbf·in	17701.5 lbf·in
Mz	90 Nm 796.6 lbf·in	400 Nm 3540.3 lbf·in	400 Nm 3540.3 lbf·in	1500 Nm 13276.1 lbf·in	1500 Nm 13276.1 lbf·in	2000 Nm 17701.5 lbf·in

NOTICE

These forces and torques are maximum values that are rarely encountered during operation. The values also never reach their maximum at the same time!

5.3.4 Torques on Robot Flange

The table below shows the maximum torques working on the robot flange.

Table 5-9: Torques on robot flange

	Zu 3	Zu 5	Zu 7	Zu 12	Zu 18	Zu 20
Torque	18.2 Nm 161.1 lbf·in	34 Nm 300.9 lbf·in	34 Nm 300.9 lbf·in	66 Nm 584.1 lbf·in	66 Nm 584.1 lbf·in	102 Nm 902.8 lbf·in

6 Transport and Commissioning

6.1 Quick Start Guide

The following table provides a brief overview for robot usage:

Table 6-1: Quick start guide

No.	Steps	Operations	References
1	Robot mounting	Unpack the robot. **NOTE** If you want to move the robot later, please keep the original packaging.	
2		Remove robot from packaging.	Refer to 6.4 Handling
3		Transport the robot to the intended mounting location.	
4		Lift and secure the robot to the platform or foundation.	Refer to 6.6.2 Mounting
5		Secure the tools on the end of the robot, if any.	Refer to 6.10 Mounting the End-Effector
6	Control cabinet installation	Unpack the control cabinet.	Refer to 6.3 Unpacking
7		Take out the control cabinet from the packaging materials and carry it to the vicinity of the robot. **NOTE** The length of robot connection cable is 6 m (36.220 in), so the distance between control cabinet and robot should be less than it.	Refer to 6.6.3 Mounting the Control Cabinet
8	Connect the cables	Connect the robot connection cable, control cabinet power cord, control stick cable, Ethernet cable (if any), and TIO cable (if any) in sequence.	Refer to • 6.7.1 Robot Connection Cable Interface • 6.8.2 Bottom Panel Interfaces • 6.7.2 Tool I/O Port
9		Flip the toggle switch at the bottom of the control cabinet to turn on the power switch.	Refer to 6.8.2 Bottom Panel Interfaces
10		The emergency stop button on control stick is released by default, if it is pressed, please release it first.	Refer to 5.1.7 Control Stick Buttons
11	Connect the robot	Power up the control cabinet, power on and enable the robot with the control stick.	Refer to 6.9.1 Power On and Shut Down the Robot System
12		Connect the robot using a computer or pad or mobile phone.	Refer to JAKA App Software User Manual
13	Configure the robot	Set the mounting orientation, payloads and collision sensitivity of the robot in the JAKA App.	Refer to JAKA App Software User Manual
14	Control the	Enable robot to move by pressing the FREE button on the end of the robot or entering programming or	Refer to

No.	Steps	Operations	References
	robot	manual operation interface of the JAKA App.	● 5.1.3.2 Free and Point Buttons ● JAKA App Software User Manual

6.2 Transport and Storage

6.2.1 Transport Requirements

Please use the original packaging to transport the robot. If you want to move the robot later, please keep the original packaging.

When the robot is lifted, corresponding measures should be taken for positioning to avoid damage caused by accidental movement. Refer to 6.5 Lifting for detailed steps.

When moving the robot from its packaging to the installation position, it should be supported by at least 2 persons until all screws at the robot base are securely fastened.

WARNING

- Ensure that the back or other body parts of the operators are not overloaded when the equipment is lifted. Use appropriate lifting equipment. JAKA is not responsible for damage incurred during the transport of the equipment. The robot must be supported by at least two persons depending on the model.
- Please comply with the relevant lifting regulations in each region and country.
- Ensure that installation instructions are strictly followed when the robot is installed.

NOTICE

If the robot is transported without using its original packaging, all warranties will be voided.

6.2.2 Storage Conditions

1. **Storage temperature: –10~50°C（14~122°F）**

For long-term storage, to maintain the robot system reliability, it is recommended to keep the temperature within 25±10°C (59~95°F). Avoid sudden temperature changes if possible. (10°C/h (50°F/h) and above).

2. **Storage humidity: 20% RH~85% RH**

For long-term storage, to maintain robot system reliability, it is recommended to keep the humidity within 45%~65%. Keep away from dew condensation or mildew.

3. **Anti-static**

It is easy to generate static when kept in extremely dry conditions. The shock of electrostatic discharge may damage the semiconductor. Please store the robot system in an anti-static bag.

4. **Other environmental conditions**

Please keep robot system in an environment that does not produce poisonous gas, dirt, and dust. Do not place heavy objects on it during storage.

6.3 Unpacking

The following figure presents the packaging of the JAKA robot and the control cabinet.

Figure 6-1: Robot or control cabinet box

1. Open the box top side.
2. Lift up and remove the upper inner packaging part.
3. Inspect the robot and the control cabinet for transport damage.

6.4 Handling

The table below shows the joint angle of packaging orientation. The robot can automatically change to this orientation by configuring it in the JAKA App. It is recommended to transport the robot in this orientation.

Table 6-2: Handling joint angle

Joint 1	Joint 2	Joint 3	Joint 4	Joint 5	Joint 6
-90°	0°	148°[i]/152°[ii]	120°	0°	0°

NOTE

i. Valid for Zu 3.

ii. Valid for Zu 5, Zu 7, Zu 12, Zu 18, Zu 20.

At least two persons are required for lifting and securing the robot during transportation. One person should hold the connection places between joint 1 and lower arm with both hands, while the other holds the connection places between joint 3 and lower arm with one hand, holds the connection places between joint 3 and upper arm with another hand, as shown in the figure below.

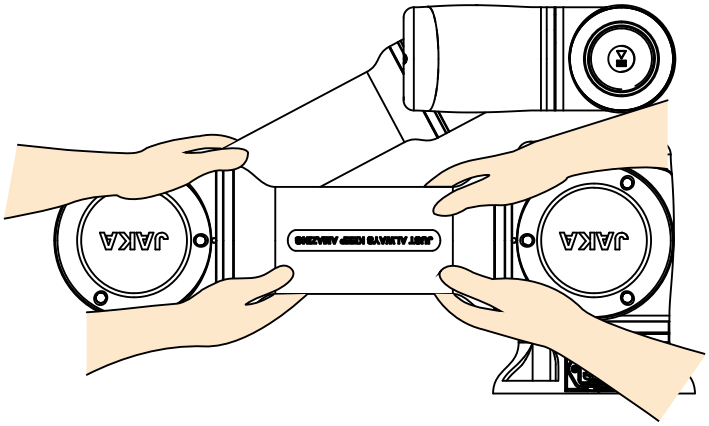


Figure 6-2: Correct handling method

Lifting the robot by grabbing the robot's upper arm or joint 4/5/6 is strictly prohibited, as shown in the figure below. This action may cause damage to the internal structure of the robot.

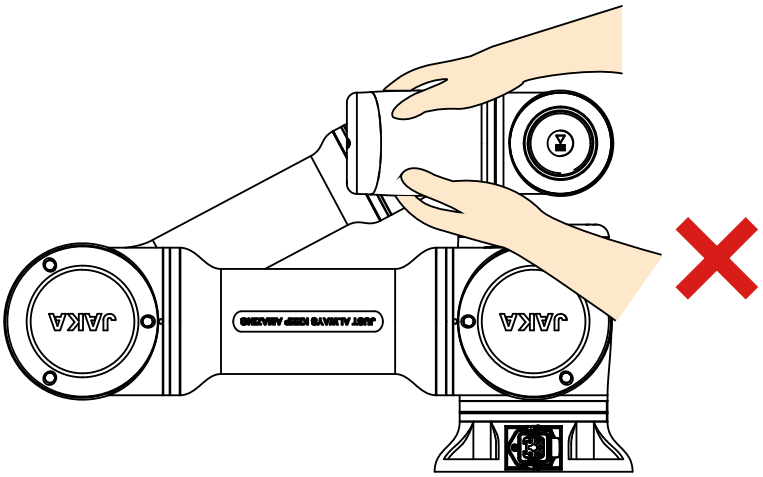


Figure 6-3: Incorrect handling method

There is a black handle on the control cabinet for grip and carrying.

6.5 Lifting

Move the robot near the desired position before mounting. For robots with heavier masses such as Zu 12, Zu 18, and Zu 20, lifting equipment should be used. The figure below shows the robot lifting orientation corresponding to different mounting methods. Please lift the robot according to the figure below.

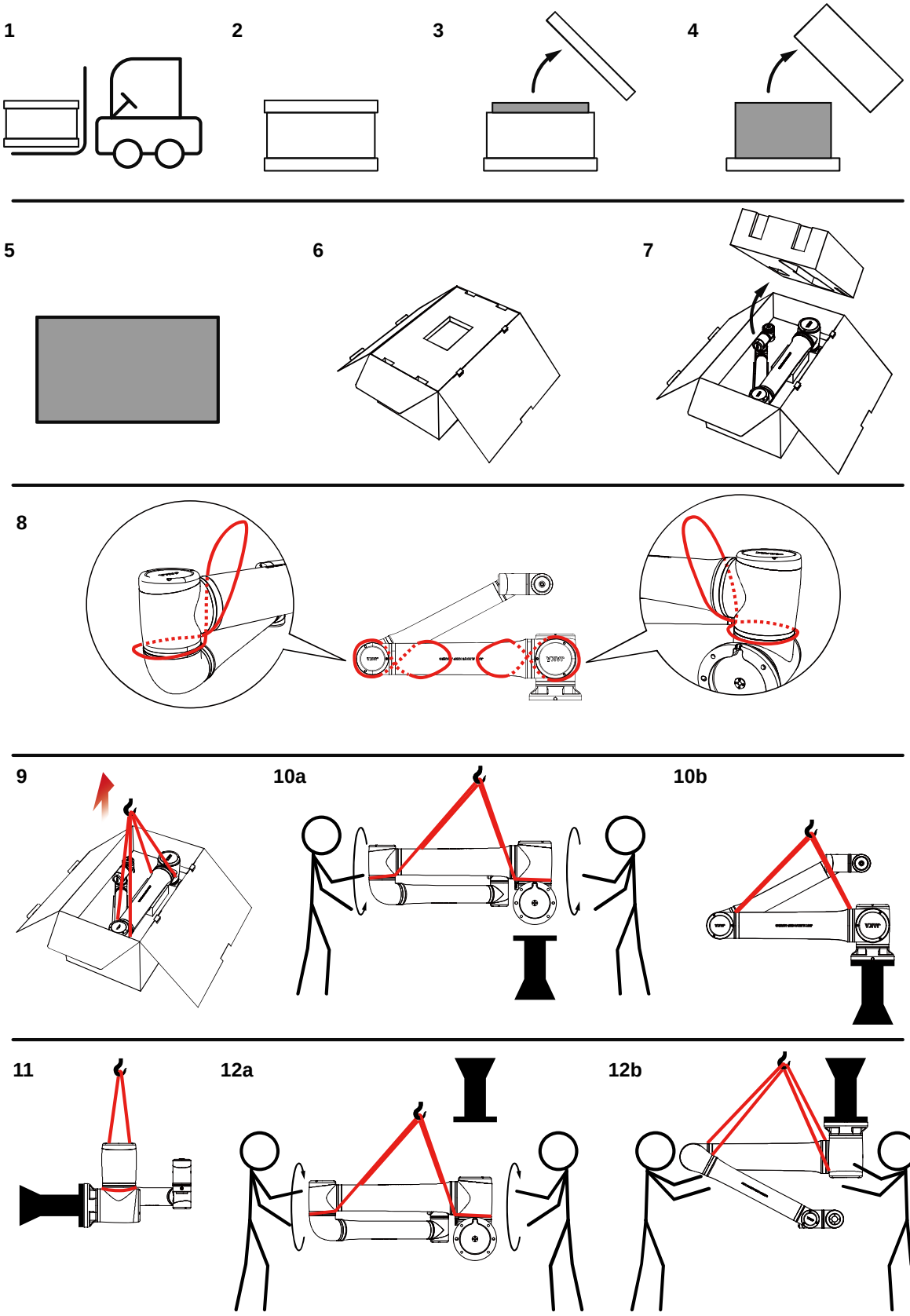


Figure 6-4: Robot lifting steps

Table 6-3: Robot lifting steps

	Description	Operations	References
1	Transport		6.2.1 Transport Requirements
2-7	Opening the box	Remove the external foam, unwrap the carton and remove the internal foam.	6.3 Unpacking
8-9	Lifting robot from box using sling	Make robot in packing orientation and take 2 straps. One end of the first strap is located at the junction between joint three and the upper arm, crossing the rope at this location, with the other end at the junction between joint three and the lower arm. One end of the second strap is located at the junction between joint one and joint two, crossing the strap at this location, with the other end at the junction between joint two and the lower arm. Once the straps are in place, use a hook to lift the two straps.	Figure 6-4
10a	Floor mounting	Rotate the robot so that the robot base is facing down.	6.6.2 Mounting
10b		Secure the robot to the mounting plane.	
11	Wall mounting	Adjust the robot position and secure the robot to the mounting plane.	
12a	Inverted mounting	Rotate the robot so that the robot base is facing up.	
12b		Secure the robot to the mounting plane.	

The sling should conform to the following standards:

BS EN 1492-1 :2000+A1 :2008 Textile slings - Safety - Flat woven webbing slings, made of man-made fibers, for general purpose use.

BS EN 1492-2 :2000+A1 :2008 Textile slings - Safety - Round slings, made of man-made fibers, for general purpose use.

The lifting capacity if sling should be greater than 800 kg (1763.70 lb), the length of sling should be longer than 2 m (78.74 in).

WARNING

- Carefully inspect the sling before and after use.
- Do not use the sling if it is cracked, ripped, or the stitching is loose.
- Do not use the sling if there are signs of heat damage.
- When using the sling, protect it against sharp edges and friction.
- When lifting the robot, personnel must not, under any circumstances, be present under the sling and the robot.

6.6 Mechanical Installation

6.6.1 Safety Instructions

WARNING

- Ensure that the robot is installed correctly and safely.
- The installation surface must be vibrant proof with enough loading capacity.

WARNING

- Ensure that the end effector is installed correctly and safely.
- Ensure the tool's safety to prevent any accidental falling of parts that could pose a danger.

WARNING

- Ensure that the control cabinet and cables are not exposed to liquids. A damp control cabinet can pose a risk of electric shock or fatal injury.
- The control cabinet must not be exposed in dusty or humid environments exceeding IP44 levels. Pay close attention to environments with conductive dust.

WARNING

If the robot is submerged in water for an extended period, it may be damaged. Robots should not be installed in water or a humid environment.

6.6.2 Mounting the Robot

The robot can be mounted in various different positions. Several typical mounting methods are shown in figure below:

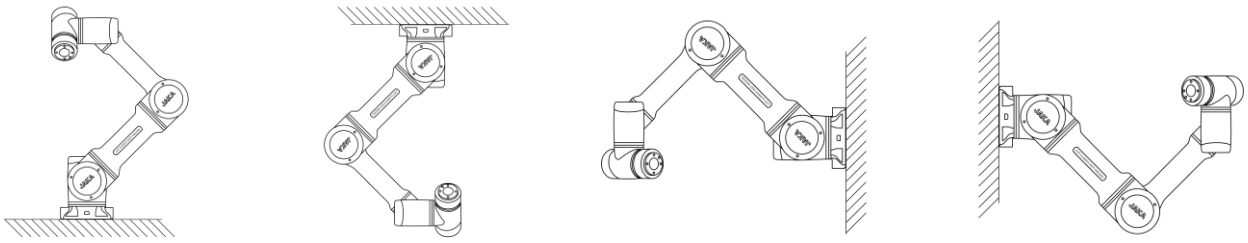


Figure 6-5: Robot mounting positions

1 Floor mounting

2 Inverted mounting

3-4 Wall mounting

6.6.2.1 Mounting Surface Requirements

The robot is intended to be mounted on a sturdy surface. The surface must not only withstand the torque stated below, but also have sufficient stiffness so that the deformations and vibrations which occur do not lead to any major deviations on the TCP. It is advisable to avoid directly mounting the robot on an empty box, as this can easily induce resonance and generate abnormal noise. When the robot is mounted on a linear actuator or mobile platform, the acceleration of the mounting base should be minimized. High acceleration may trigger a false collision alarm, causing the robot to stop.

Note the torque to be taken up by the mounting surface during normal operation:

Table 6-4: Torque of robot mounting surface

Robot Model	Mounting Surface Torque
Zu 3	900 Nm (7965.7 lbf·in)

Robot Model	Mounting Surface Torque
Zu 5	3000 Nm (26552.2 lbf·in)
Zu 7	3000 Nm (26552.2 lbf·in)
Zu 12	3800 Nm (33632.8 lbf·in)
Zu 18	3800 Nm (33632.8 lbf·in)
Zu 20	10400 Nm (92047.7 lbf·in)

WARNING

Do not connect the power during the robot mounting process.

6.6.2.2 Dimensions of Robot Base

The following figure presents the installation dimensions of robot base.

1. Zu 3 base dimensions

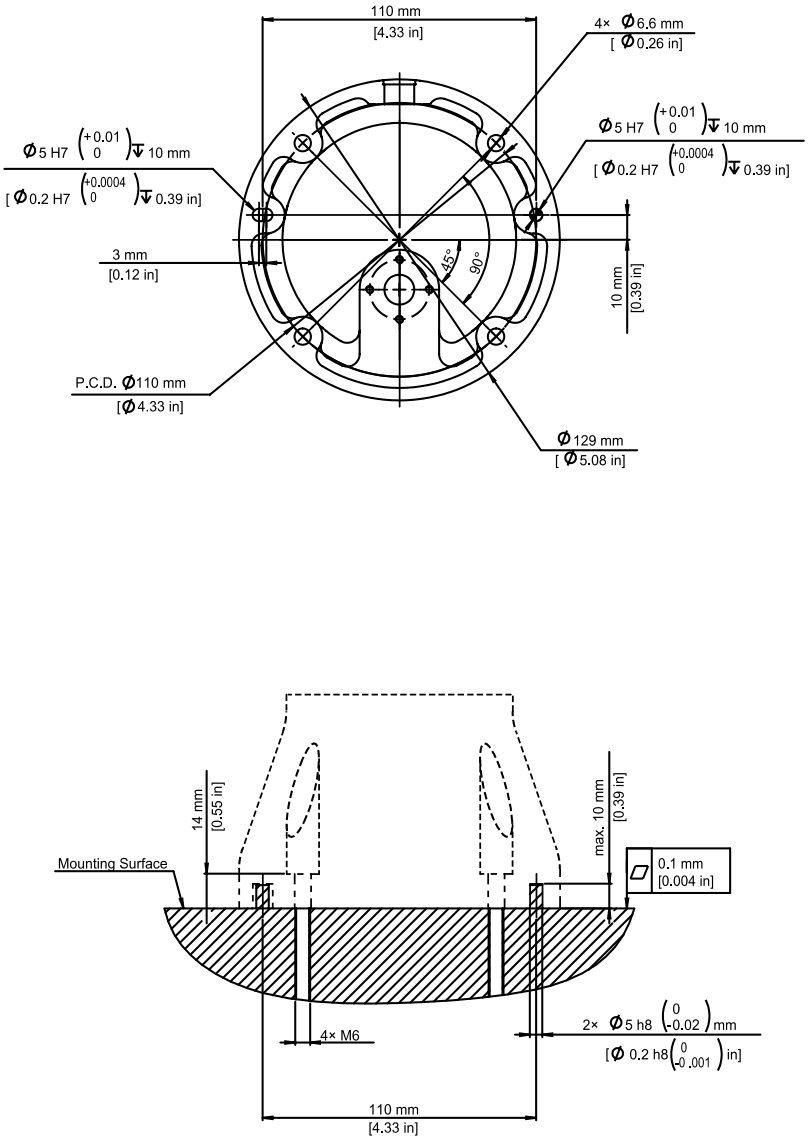
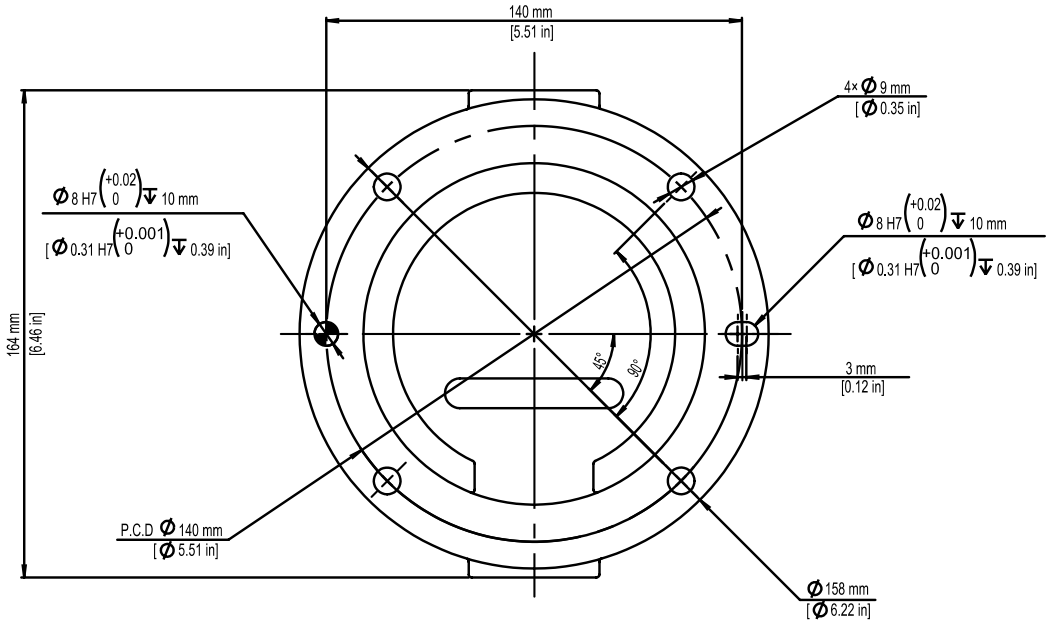


Figure 6-6: Zu 3 base dimensions

2. Zu 5, Zu 7 base dimensions



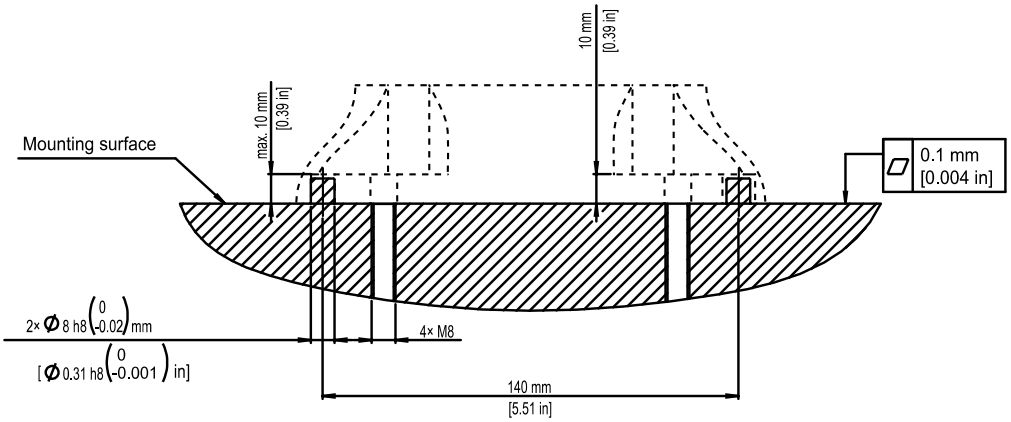


Figure 6-7: Zu 5, Zu 7 base dimensions

3. Zu 12, Zu 18 base dimensions

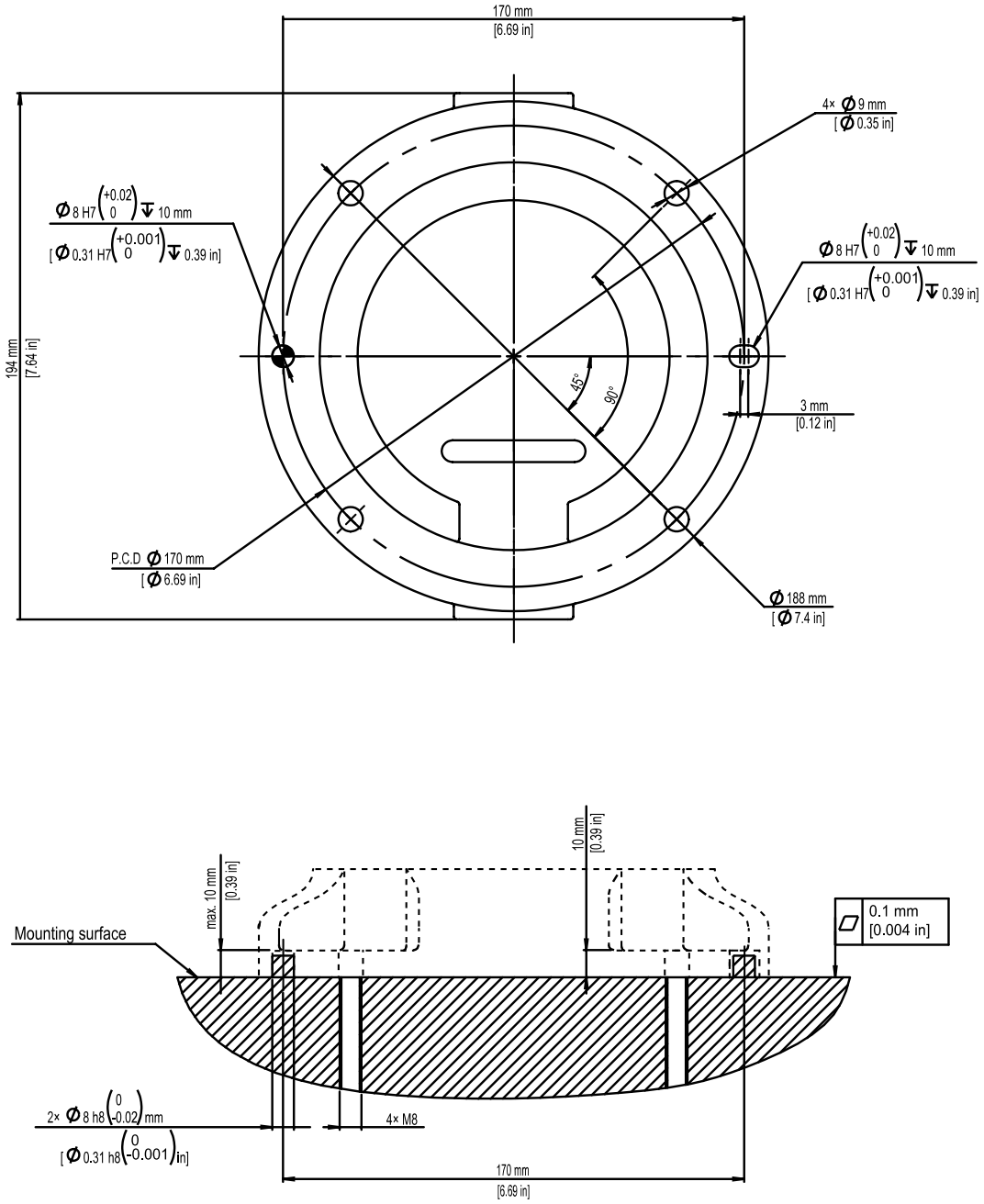


Figure 6-8: Zu 12, Zu 18 base dimensions

4. Zu 20 base dimensions

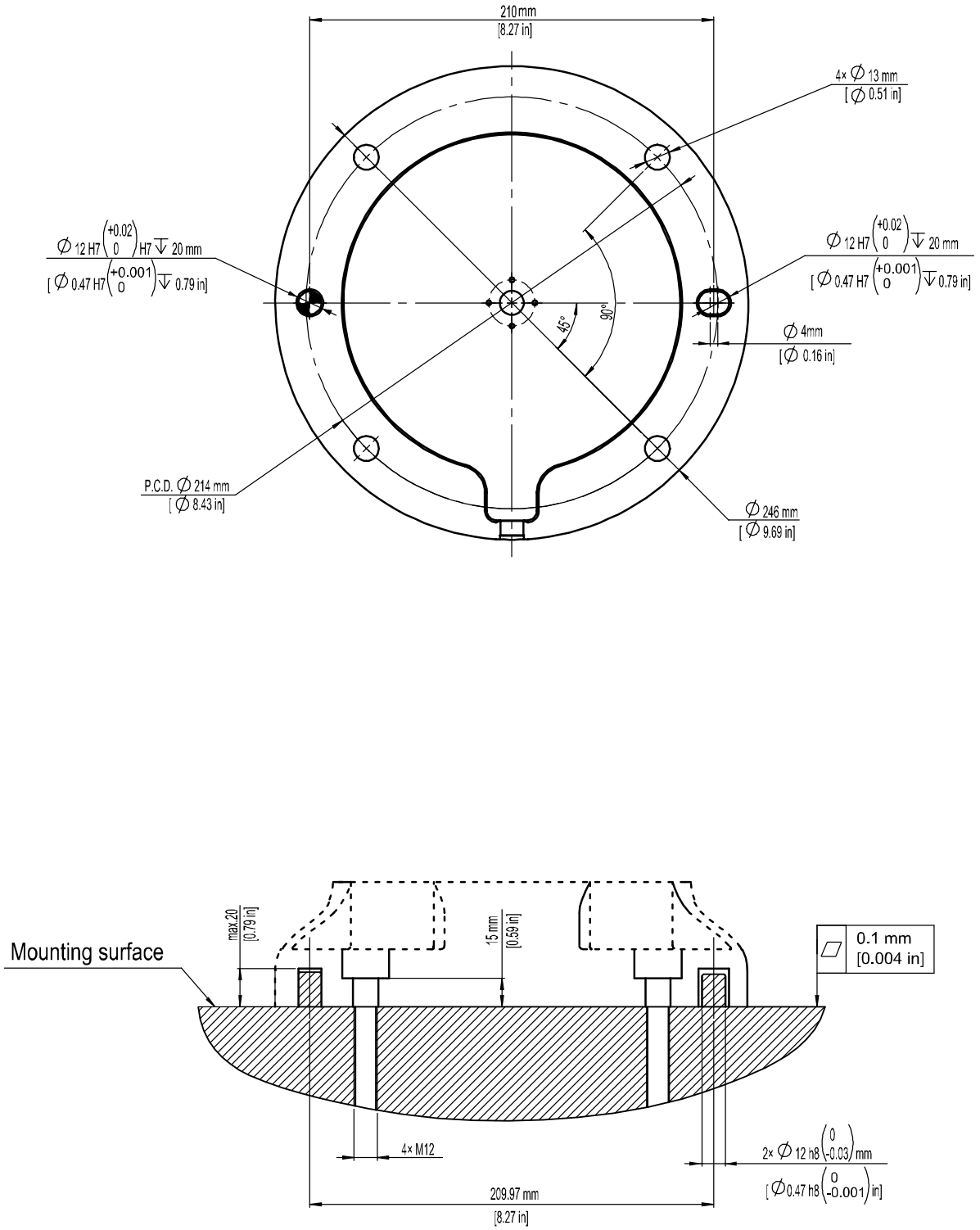


Figure 6-9: Zu 20 base dimensions

6.6.2.3 Mounting the Robot

1. Use a lifting device when necessary for lifting up the robot out of the transport packaging.
2. Place the robot on the mounting surface and hold it in place while completing the next step.
3. Fasten the robot base to the mounting surface by using the four through holes. For additional fixing, centering pins can be added. The following table presents the tightening torque and size.

Table 6-5: Robot mounting data

Model	Screw Size	Screw Quantity	Recommended Tightening Torque	Through Hole	Pin Hole
Zu 3	M6	4 pcs	15 Nm (132.761 lbf·in)	Φ6.6 mm (Φ0.260 in)	Φ5 mm (Φ0.197 in)
Zu 5	M8		40 Nm (354.030 lbf·in)	Φ9 mm (Φ0.354 in)	Φ8 mm (Φ0.315 in)
Zu 7					
Zu 12					
Zu 18					
Zu 20	M12		130 Nm (1150.596 lbf·in)	Φ13 mm (Φ0.512 in)	Φ12 mm (Φ0.472 in)

6.6.3 Mounting the Control Cabinet

The control cabinet is intended to be placed on a plane surface.

The following figure presents the minimum distances and minimum clearances of control cabinet installation.

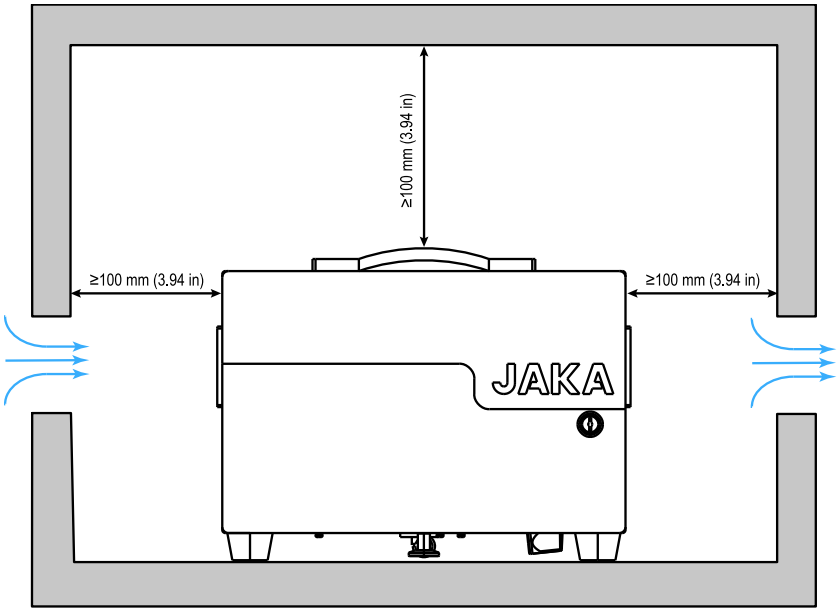


Figure 6-10: Control cabinet mounting space

NOTICE

Inoperable equipment/reduction of lifetime:

Ensure sufficient airflow for the control cabinet, especially if the device is installed in an enclosure.

Failure to follow these instructions can result in equipment damage.

6.7 Electrical Connections of the Robot

6.7.1 Robot Connection Cable Interface

Use the robot connection cable provided by JAKA to connect the robot and the control cabinet. Before powering on the robot, ensure that the connector is locked firmly. Before disconnecting the robot connection cable, the robot must be powered off. The definition of the robot connection cable connector is shown as follows.

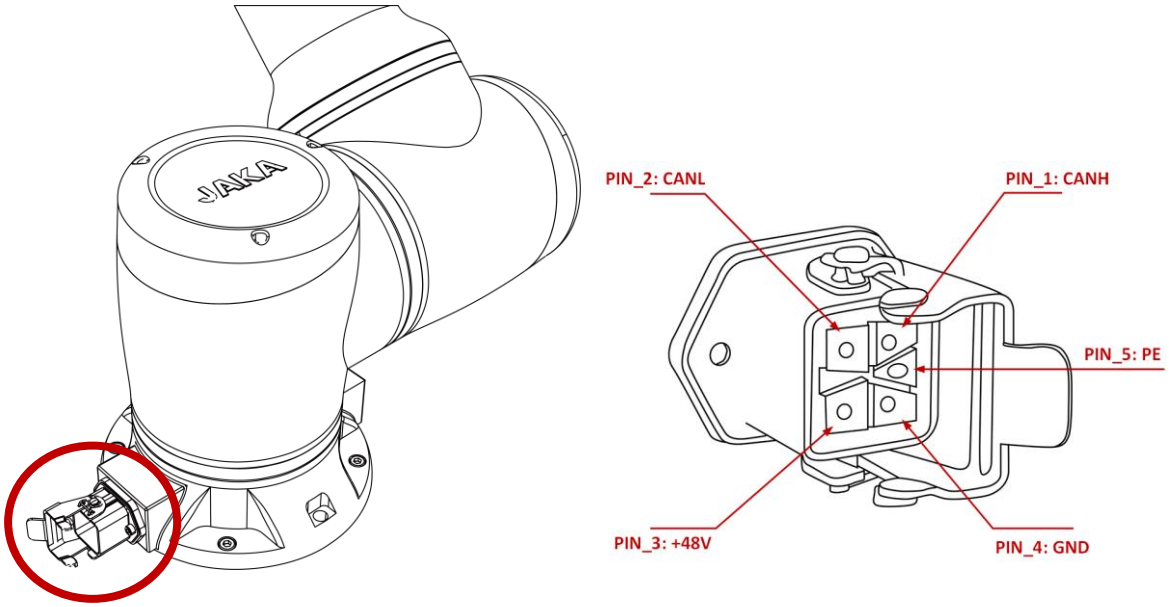


Figure 6-11: Robot connection cable interface of Zu 3, Zu 5, Zu 7, Zu 12, Zu 18

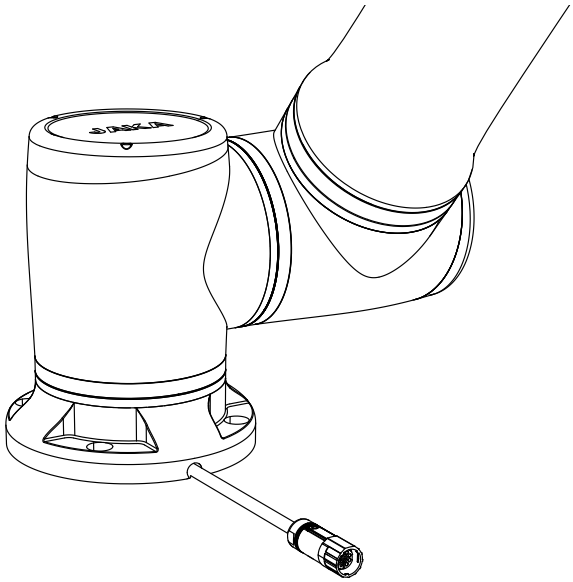


Figure 6-12: Robot connection cable interface of Zu 20

The sizes of robot connection cable and connector of Zu 20 are as follows:

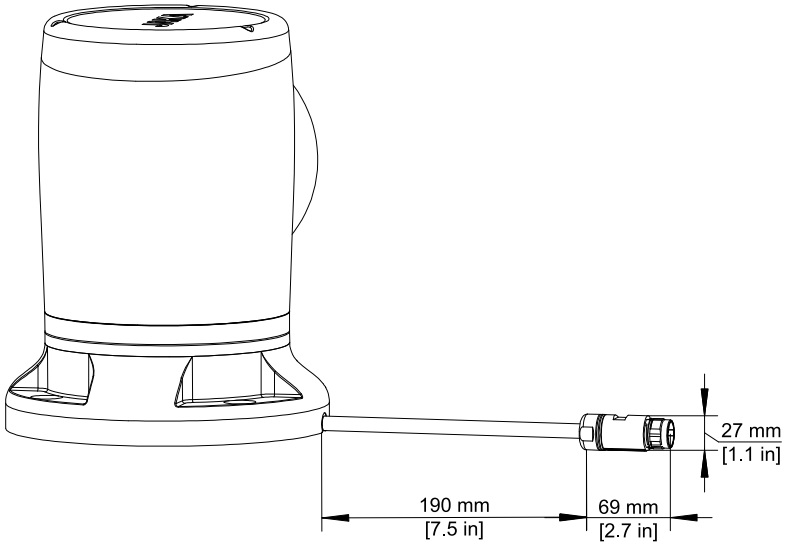


Figure 6-13: Robot connection cable and connector dimensions

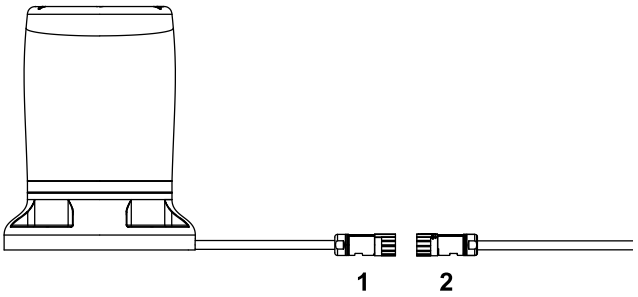
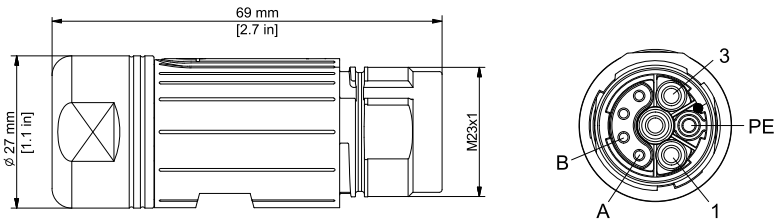
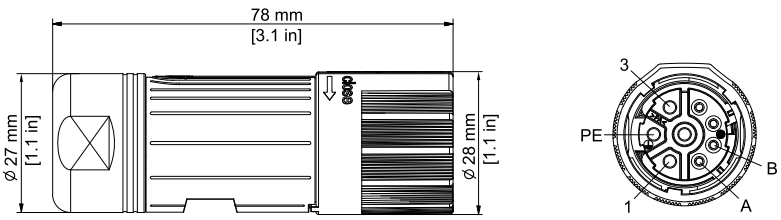


Figure 6-14: Robot connection cable and connector

Table 6-6: Specifications of Robot connection cable connector

	Connector type	Layout	Pins
1	Plug with male connector with housing and insert.		1 DC+ 3 DC− PE A CAN_H B CAN_L
2	Plug with female connector includes housing and insert.		1 DC+ 3 DC− PE A CAN_H B CAN_L

WARNING

- Do not disconnect the robot connection cable while the robot is not powered off.

- Do not extend or modify the original cable.

6.7.1.1 Bending Radius of Robot Connection Cable

When using robot connection cables with a cable carrier, to reduce cable wear, it is important to restrict the bending radius, speed, and acceleration of the cable carrier. The following table shows the diameter (OD) of the robot connection cables, the minimum bending radius, and the maximum speed and acceleration of the cable carrier for various robot models:

Table 6-7: Specifications of robot connection cable

Model	Cable Diameter (OD)	Min Bending Radius	Max Speed	Max Acceleration
Zu 3	10.2 mm (0.40 in)	81.6 mm (3.21 in)	2m/s	5m/s^2
Zu 5				
Zu 7				
Zu 12				
Zu 18				
Zu 20	11 mm (0.43 in)	88 mm (3.46 in)		

6.7.2 Tool I/O Port

The tool input and output interface are referred to as TIO, installed on the side of the end flange of the robot, which contains two digital inputs, two digital outputs and two analog inputs, and can multiplex the two-channel RS485 signal at the same time. For the definition of the interface, see 6.7.2.1 Definition of End Effector Side.

The TIO cable connector features a foolproof design to ensure correct installation. Align the raised part of the TIO connector with the concave groove on the TIO connector of the flange and insert the cable. The TIO position is as shown in the figure below.

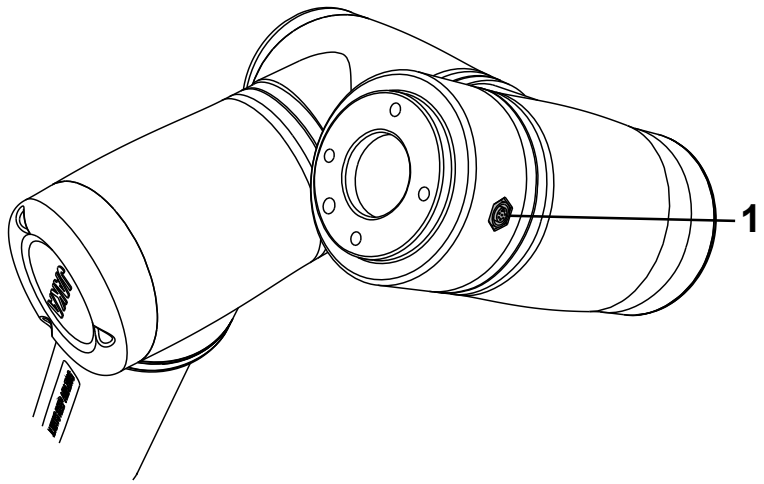


Figure 6-15: Robot tool I/O

1 TIO

The definition and specifications of the TIO cable are as follows.

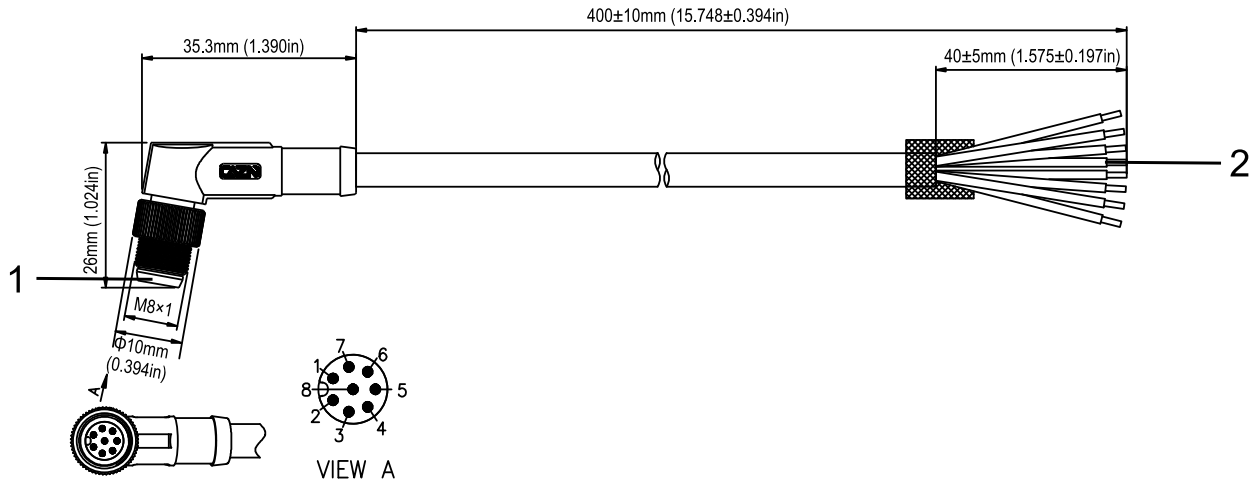


Figure 6-16: TIO cable dimensions

1 Connect the robot flange

2 Connect the end effector

6.7.2.1 Definition of End Effector Side

The definition table of the TIO V3.0 interfaces is as follows:

Table 6-8: Specifications of TIO pins

Pin	Definition	I/O	Color	Description
1	+24V	-	Red	Positive electrode, 24V/12V (switchable); configurable for enabling or disabling; continuous current capacity 1A; peak output current up to 2A.
2	DI1	I	Blue	Digital input 1: sink or source configurable by application
3	DI2	I	Green	Digital input 2: sink or source configurable by application
4	DO1/RS485A_1	O	Yellow	Digital output 1: sink, source, or push-pull configurable by application; current output capability ≤1A Multiplexed as RS481 communication A+
5	DO2/RS485B_1	O	Pink	Digital output 2: sink, source, or push-pull configurable by application; current output capacity ≤1A Multiplexed as RS481 communication B-
6	AIN1/RS485A_2	I	Brown	Analog input 1: detection range 0-10V Multiplexed as RS482 communication A+
7	AIN2/RS485B_2	I	White	Analog input 2: detection range 0-10V Multiplexed as RS482 communication B-

Pin	Definition	I/O	Color	Description
8	GND	-	Gray	24V negative electrode

6.7.2.2 Wiring of End effector Side

6.7.2.2.1. Digital Input

TIO supports 2 DI digital input interfaces, compatible with sink and source. It can be configured in the App. For the details of operation, see JAKA App Software User Manual.

1. Dry contact input

When the DI input is configured as sink:

The dry contact input (switch-type input) is connected to GND of TIO (gray wire) at one end, and to the digital input (blue or green wire) at the other end.

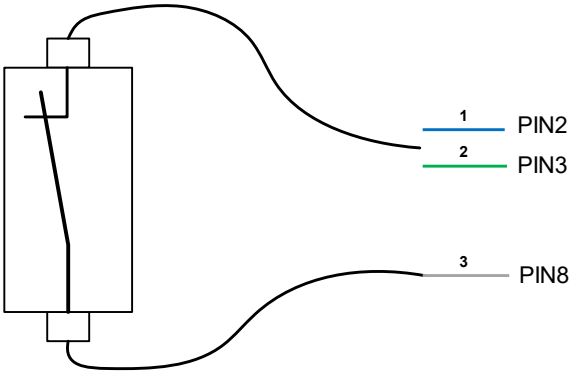


Figure 6-17: Sink wiring of digital input

1 Blue

2 Green

3 Gray

When the DI input is configured as source:

The dry contact input (switch-type input) is connected to GND of TIO (gray wire) at one end, and to the digital input (blue or green wire) at the other end.

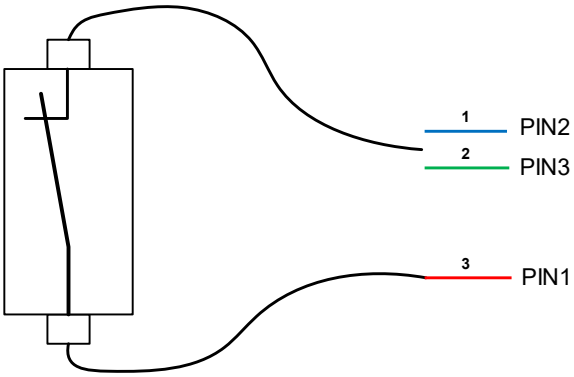


Figure 6-18: Source wiring of digital input

1 Blue

2 Green

3 Red

2. Connect sink or source device

The connection method of sink and source type digital input devices: V+ is connected to 24V of TIO (red wire), 0V is connected to GND of TIO (gray wire), and the signal wire is connected to the digital input of TIO (blue or green wire).

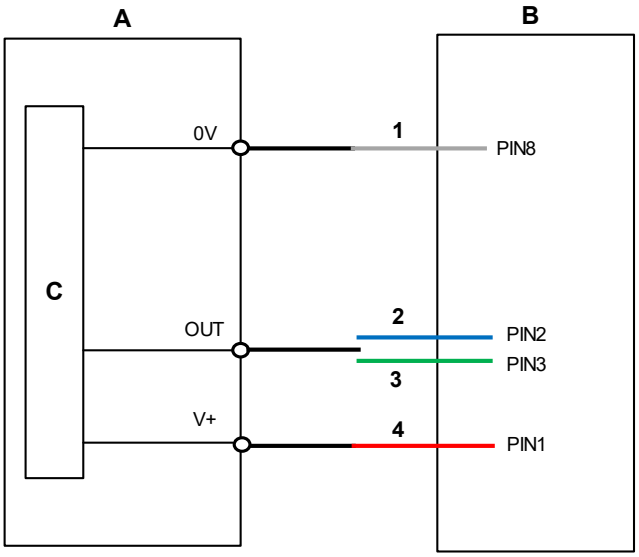


Figure 6-19: Wiring of sink device for digital input

A: External sink device

B: TIO V3

C: Main circuit

1 Gray

2 Blue

3 Green

4 Red

6.7.2.2.2. Digital Output

When the digital output interface is sink or source output, it adopts open drain output and the maximum continuous current output is 1A. Connection method: the external input interface is connected to the digital output of TIO (yellow or pink wire), V+ side of external device is connected to 24V of TIO (red wire), and 0V side of external device is connected to GND of TIO (gray wire).

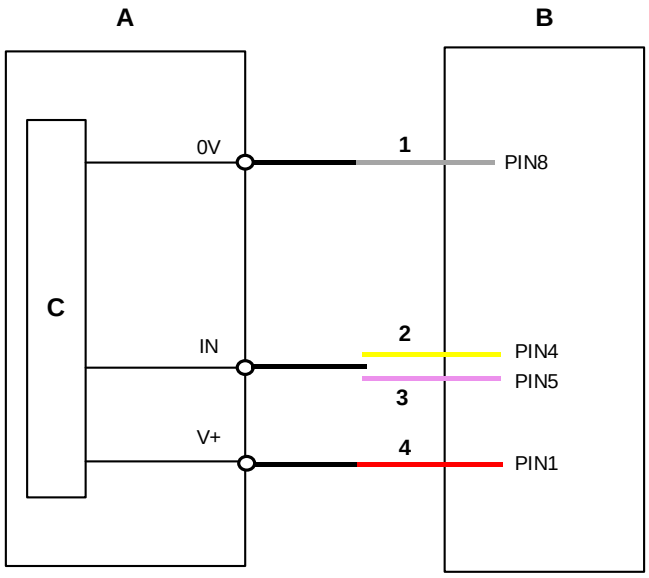


Figure 6-20: Wiring of sink device for digital output

A External sink device

B TIO V3

C Main circuit

1 Gray

2 Yellow

3 Pink

4 Red

6.7.2.2.3. RS485

Using the RS485 function, the wiring method: external RS485+ is connected to RS485+ of TIO (yellow or brown wire), external RS485- is connected to RS485- of TIO (pink or white wire), the V+ of external device is connected to the 24V of TIO (red wire), and 0V of external device is connected to the GND of TIO (gray wire).

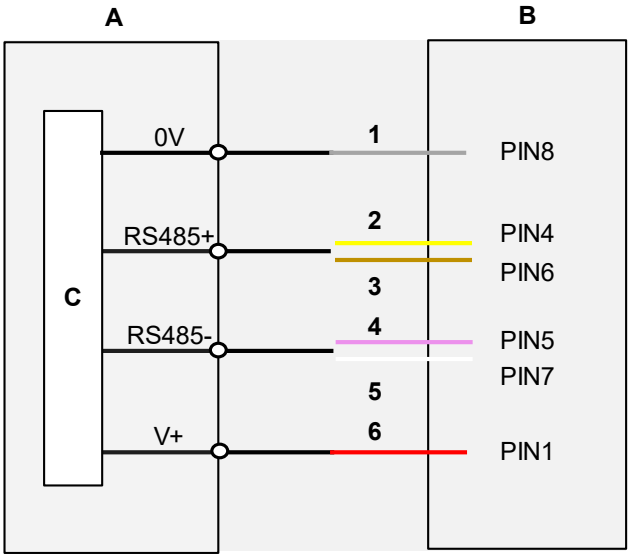


Figure 6-21: Wiring of RS485

A External device

B TIO V3

C Main circuit

1 Gray

2 Yellow

3 Brown

4 Pink

5 White

6 Red

6.7.2.2.4. Analog Input

TIO supports 2 analog voltage input interfaces, and the voltage input range is 0-10V. The wiring method: the external analog voltage positive electrode is connected to AIN1/AIN2 of TIO (white and brown wire), and the internal circuit of the negative electrode on the TIO board is grounded. The V+ of external device is connected to the 24V of TIO (red wire), and 0V of external device is connected to the GND of TIO (gray wire).

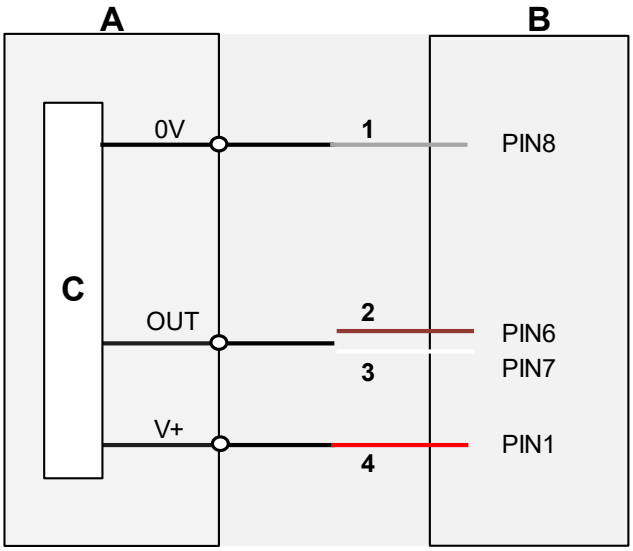


Figure 6-22: Wiring of analog input

A External device

B TIO V3

C Main circuit

1 Gray

2 Brown

3 White

4 Red

6.8 Electrical Connections of the Control Cabinet

6.8.1 Electrical Warnings and Precautions

When designing and installing robot applications, you must obey the following warnings and precautions. The implementation of maintenance must also comply with these warnings and precautions.

WARNING

- Do not connect safety signals to non-safe PLCs with inappropriate safety levels. If this warning is not obeyed it may lead to severe or fatal injury. Separate the safety I/O from the general I/O.
- All safety-related signals are constructed redundancy (two independent channels). Keeping two channels separate can ensure that the safety function will not be lost when a single failure occurs.
- For the introduction of the I/O function in the control cabinet, refer to 6.8 Electrical Connections of the Control Cabinet.

WARNING: ELECTRICITY

- Please ensure that all water-sensitive devices remain dry. Cut off power the immediately if there is a leakage.
- Use original cables to connect the robot. Do not use robots in applications that need to bend cables. Contact your supplier if longer or flexible cables are needed.
- For protective earth (PE), use the screw connectors in the control cabinet marking the earth symbol. The grounding conductor shall at least have the current rating of the highest current in the robot system.
- When connecting cables on the I/O of the control cabinet, open the cabinet door, remove the metal board of the cable hole, and ensure that the I/O cable avoids rubbing with the edge of the cable hole.

WARNING

- The robot has been tested according to international IEC standards for Electromagnetic Compatibility (EMC). Interference signals beyond the standard will cause abnormalities. Very high signal levels or excessive exposure can damage the robot permanently. JAKA will not be held responsible for any damages caused by EMC problems.
- The length of the I/O cable to connect the control cabinet, machinery and factory equipment must not be longer than 30 meters unless the result of the extension test shows the feasibility. Use shielding cables if necessary.

6.8.2 Bottom Panel Interfaces

The bottom panel of the control cabinet includes following items:

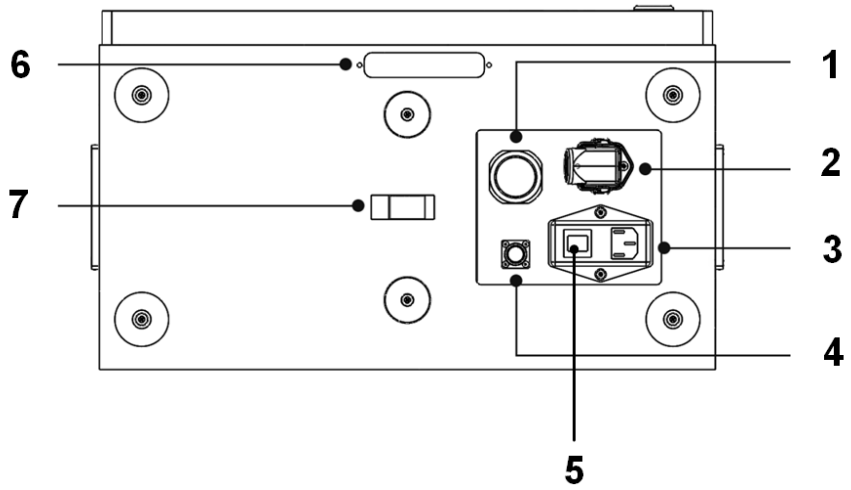


Figure 6-23: CAB 7, CAB 12 bottom

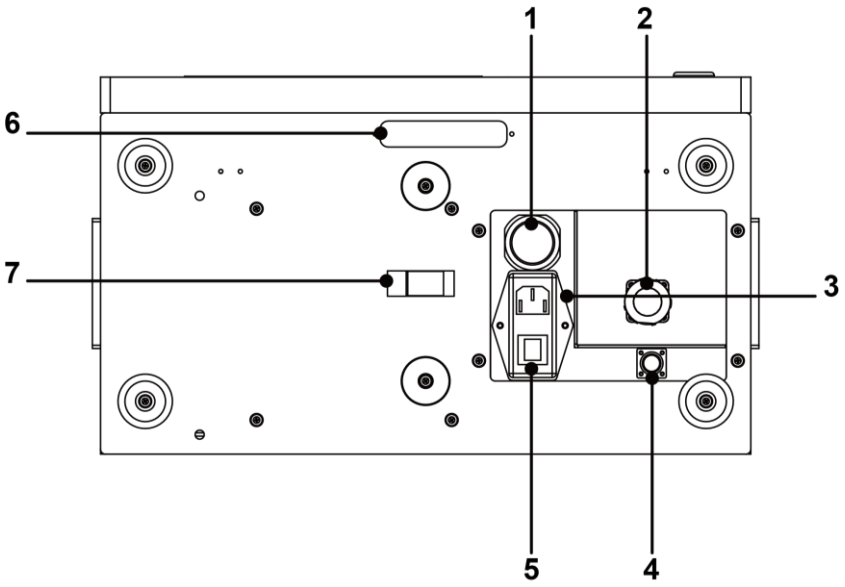


Figure 6-24: CAB 16 bottom

1 Ethernet interface: Gigabit network port, configured for dynamic IP usage.

2 Robot connection cable interface: Connection interface between the robot arm and the control cabinet.

3 Power cord interface: Connection interface to the external AC power outlet.

4 Control stick cable interface: Connection interface to the control stick.

5 Rocker switch: Power supply control switch.

6 Cable routing passthrough slot: Dedicated channel to guide external device cables.

7 Cable fixing ring: Used to keep cables in place.

6.8.2.1 Power Connection

Connect the cabinet to the AC power outlet with the cabinet power cord. One end of the cable is a 3-flat-pin plug inserted to the 3-pin socket on the bottom panel of the control cabinet, and the other end is a triangular plug, which is inserted to the corresponding mains socket as per the safety assessment regulations. The 3-flat-pin socket has switches and fuses. The switches can only be used when the control cabinet is powered down, which is used to completely disconnect the power from the control cabinet. The fuse equipped in the switch is set as 10A by default.

The power supply should consist of the following:

- Grounding
- Mains power fuse
- Residual current circuit breaker
- Power plug lock

Refer to IEC60204 Safety of Machinery - Electrical Equipment and UL508A Safety Standard for Industrial Control Panels. To prevent personnel injury or property loss caused by the unreasonable release of dangerous energy, it is recommended that the plugs of all equipment in the application of the robot are equipped with power plug locks to lock and tag them during maintenance.

WARNING

- Ensure that the robot is grounded properly.

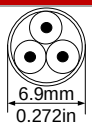
- Ensure that the input current of the power to the control cabinet is protected by the residual current device (RCD) and appropriate fuses.
- After completing all the installation settings of the robot required by the service, all power supply units need to be locked and tagged. When the system is locked, other devices should not power any part of the robot.
- Ensure that all the cables are connected correctly before the control cabinet is powered up. Use the original power cords correctly.
- Ensure that the power plug locks are used for locking during maintenance.

6.8.2.2 Power Cord Types

Different countries and regions have different standards, and JAKA supports corresponding plugs when products are exported overseas.

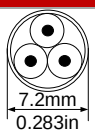
1. China Standard Plug (National Standard): 3 I-shaped flat-pin plug

Table 6-9: Control cabinet power cord of China

Cable Standard	Core Size	Length	Cable OD	Rated Value	Frequency	Cable Material	LN Insulation Level
RW	3×1.0 mm² 3×0.002 in²	3000±50 mm 118.11±1.97 in		10A 250V	50 Hz	PVC	2 kV 1 min 50 Hz

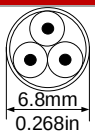
2. European Standard Plug (European Standard, German Standard): F/E universal plug

Table 6-10: Control cabinet power cord of Europe

Cable Standard	Core Size	Length	Cable OD	Rated Value	Frequency	Cable Material	LN Insulation Level
H05W-F	3×1.0 mm² 3×0.002 in²	3000±50 mm 118.11±1.97 in		10A 250V	50 Hz	PVC	2 kV 1 min 50 Hz

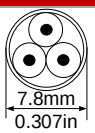
3. British Standard Plug (British Standard): G-shaped plug

Table 6-11: Control cabinet power cord of Britain

Cable Standard	Core Size	Length	Cable OD	Rated Value	Frequency	Cable Material	LN Insulation Level
H05W-F	3×1.0 mm² 3×0.002 in²	3000±50 mm 118.11±1.97 in		10A 250V	50 Hz	PVC	2 kV 1 min 50 Hz

4. American Standard Plug (American Standard): B-shaped standard plug

Table 6-12: Control cabinet power cord of America

Cable Standard	Core Size	Length	Cable OD	Rated Value	Frequency	Cable Material	LN Insulation Level
SJT	3×1.0 mm² 3×0.002 in²	3000±50 mm 118.11±1.97 in		10A 250V	60 Hz	PVC	2 kV 1 min 50 Hz

NOTE

Robots exported to Japan are equipped with American standard plugs.

6.8.3 Front Panel Interfaces

The front panel interface of the control cabinet is placed at the first layer after the control cabinet door is opened, including 16 digital inputs (P1 and P3), 16 digital outputs (P2 and P4), two configurable analog interfaces (P5), a set of high-speed interfaces (P6), remote switching and RS485 interfaces (P7), safety function interfaces (P8), USB3.0 interface (P9) and Ethernet interface (P10), and the USB interface (P9) is retained for internal use. If needed, contact the technical support personnel of JAKA.

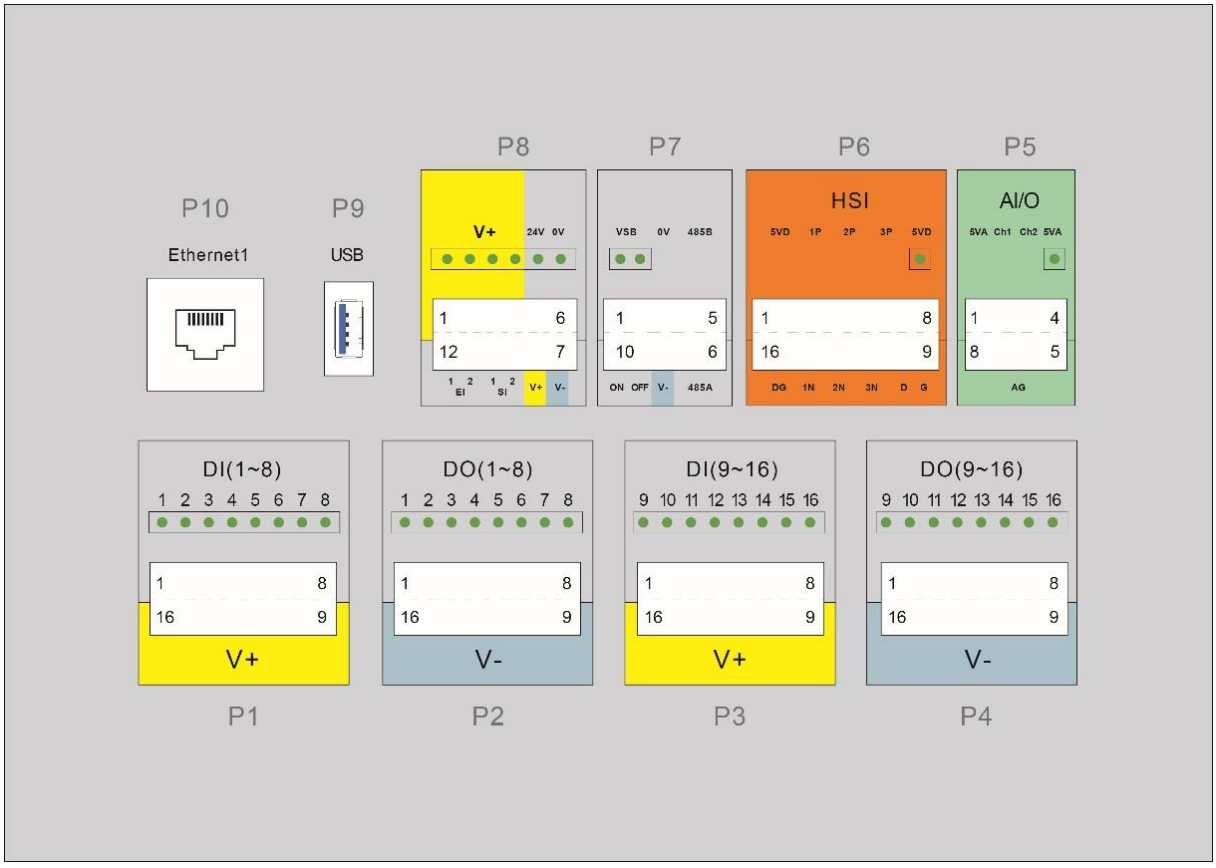


Figure 6-25: Front panel interfaces

6.8.3.1 Definition of Front Panel Interfaces

Table 6-13: Specifications of interfaces on front panel

No.	Name	PIN	Terminal	Function
P1	DI (1-8)	1	DI1	Digital input 1, source, active high

No.	Name	PIN	Terminal	Function
	8 digital inputs	2	DI2	Digital input 2, source, active high
		3	DI3	Digital input 3, source, active high
		4	DI4	Digital input 4, source, active high
		5	DI5	Digital input 5, source, active high
		6	DI6	Digital input 6, source, active high
		7	DI7	Digital input 7, source, active high
		8	DI8	Digital input 8, source, active high
		9-16	V+	Isolated power supply, input, and positive electrode, and short jumper is connected to the internal 24V by default.
P2	DO (1-8) 8 digital outputs	1	DO1	Digital output 1, source, ≤1A continuous current output ability
		2	DO2	Digital output 2, source, ≤1A continuous current output ability
		3	DO3	Digital output 3, source, ≤1A continuous current output ability
		4	DO4	Digital output 4, source, ≤1A continuous current output ability
		5	DO5	Digital output 5, source, ≤1A continuous current output ability
		6	DO6	Digital output 6, source, ≤1A continuous current output ability
		7	DO7	Digital output 7, source, ≤1A continuous current output ability
		8	DO8	Digital output 8, source, ≤1A continuous current output ability
		9-16	V-	Isolated power supply, input, and negative electrode, and short jumper connected to the internal GND by default.
P3	DI (9-16) 8 digital inputs	1	DI9	Digital input 9, source, active high
		2	DI10	Digital input 10, source, active high
		3	DI11	Digital input 11, source, active high
		4	DI12	Digital input 12, source, active high
		5	DI13	Digital input 13, source, active high
		6	DI14	Digital input 14, source, active high
		7	DI15	Digital input 15, source, active high
		8	DI16	Digital input 16, source, active high
		9-16	V+	Isolated power supply, input, and positive electrode, and short jumper is connected to the internal 24V by default.
P4	DO (9-16) 8 digital outputs	1	DO9	Digital output 9, source, ≤1A continuous current output ability
		2	DO10	Digital output 10, source, ≤1A continuous current output ability
		3	DO11	Digital output 11, source, ≤1A continuous current output ability
		4	DO12	Digital output 12, source, ≤1A continuous current output ability
		5	DO13	Digital output 13, source, ≤1A continuous current output ability
		6	DO14	Digital output 14, source, ≤1A continuous current output ability
		7	DO15	Digital output 15, source, ≤1A continuous current output ability
		8	DO16	Digital output 16, source, ≤1A continuous current output ability
		9-16	V-	Isolated power supply, input, and negative electrode, and short jumper connected to the internal GND by default.
P5	AI/O	1, 4	5VA	Analog power 5V output, 100mA (max)
		2	Ch1	Analog input/output channel 1, configurable functions
		3	Ch2	Analog input/output channel 2, configurable functions
		5-8	AG	Analog power AGND

No.	Name	PIN	Terminal	Function
P6	HSI	1, 8	5VD	Digital power 5V output, 100mA (max)
		2, 3	1P	Differential signal 1 input positive terminal/encoder A+
		14, 15	1N	Differential signal 1 input negative terminal/encoder A-
		4, 5	2P	Differential signal 2 input positive terminal/encoder B+
		12, 13	2N	Differential signal 2 input negative terminal/encoder B-
		6, 7	3P	Differential signal 3 input positive terminal/encoder Z+
		10, 11	3N	Differential signal 3 input negative terminal/encoder Z-
		9, 16	DG	Digital power GND, isolated from the internal GND
P7	-	1, 2	VSB	Internal power 5V, 100mA (max), available for remote on/off
		3	0V	Internal GND (internal 24V, 12V, 5V reference GND)
		4, 5	485B	RS485 Communication 485B
		6, 7	485A	RS485 Communication 485A
		8	V-	Isolated power supply, input, and negative electrode, and short jumper connected to the internal GND by default.
		9	OFF	Remote Off signal input, active high (24V)
		10	ON	Remote On signal input, active high (24V)
P8	-	1-4, 8	V+	Isolated power supply, input, and positive electrode, and short jumper is connected to the internal 24V by default.
		5	24V	Internal 24V output positive electrode, 1.5A (MAX)
		6	0V	Internal 24V output negative electrode
		7	V-	Isolated power supply, input, and negative electrode, and short jumper connected to the internal GND by default.
		9	SI2	Protective stop function input 2; the default short jumper is connected to V+
		10	SI1	Protective stop function input 1; the default short jumper is connected to V+
		11	EI2	Emergency stop function input 2; the default short jumper is connected to V+
		12	EI1	Emergency stop function input 1; the default short jumper is connected to V+
P9	-	-	USB	Internal debugging interface
P10	-	-	EtherNet1	Three-position enabling device network port

6.8.3.2 Wire Specifications

When wiring on the front panel of the control cabinet, choose wires that meets the following specifications.

Table 6-14: Specifications of wire connecting interfaces on front panel

Interface	Terminal Model	Recommended PIN Connector	Wire
P1_16PIN	DEGSON: 15EDGKNHB-3.5-16P-14-10A (H)	China: E0512 International: PHOENIX AI 1-12 RD-Ferrule	UL1007#20AWG Length < 30 m (1181 in)
P2_16PIN			
P3_16PIN			
P4_16PIN			
P5_8PIN	DEGSON: 15EDGKNHB-3.5-8P-14-10A (H)		
P6_16PIN	DEGSON: 15EDGKNHB-3.5-16P-14-10A (H)		

Interface	Terminal Model	Recommended PIN Connector	Wire
P7_10PIN	DEGSON: 15EDGKNHB-3.5-10P-14-10A (H)		
P8_12PIN	DEGSON: 15EDGKNHB-3.5-12P-14-10A (H)		

6.8.3.3 Digital I/O Interfaces

The following are the electrical specifications for the 24V digital I/O in the control cabinet. The design of the digital I/O follows IEC 61131-2. The control cabinet supports the 16 digital inputs and outputs.

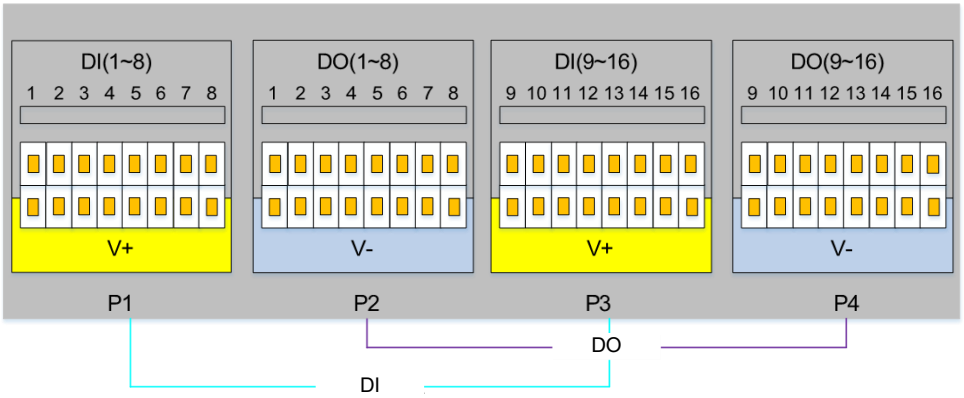


Figure 6-26: Interfaces of digital inputs and outputs

Digital I/O can be powered by the 24V power supply in the control cabinet and supports 1.5A peak output (the output is stopped when overloading and the recommended output is less than or equal to 1A). If the user needs a larger power output, it can power the V+ power supply with external “power”, which supports a maximum current of 1.2A per channel. When using the external 24V power supply, the jumpers of the 0V and 24V on P8 and the 0V on P7 need to be unplugged. 24V is the internal power supply +, and 0V is the internal GND. V+ is the positive electrode of all digital I/O interfaces, and V- is the negative one. The default configuration is the connection to the internal power supply.

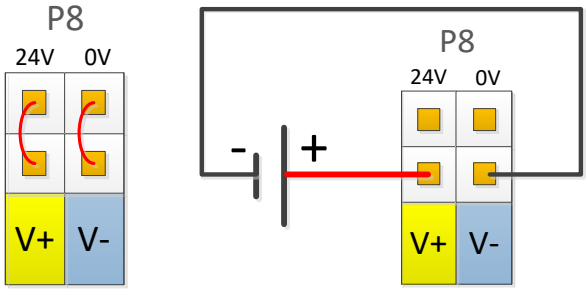


Figure 6-27: Wiring of power for digital inputs and outputs

Connect internal power Connect external power

6.8.3.3.1. Digital Input (DI)

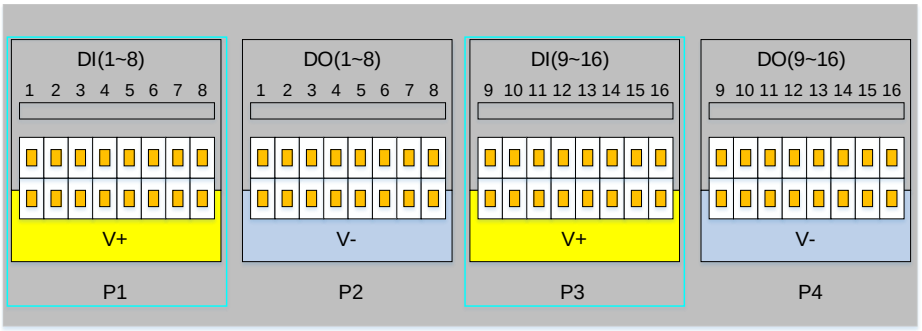


Figure 6-28: Interfaces of digital inputs

The control cabinet is equipped with 16 source digital inputs (active high) (DI1-DI16), which support isolated signal input. The level signal meets the standard of IEC61131-2 (Type1/2/3) and is used to detect the input signal voltage level state.

Table 6-15: Voltage range

V+ Voltage	Low Level	High Level
24V	0-11V	15-30V

V+ supports external 10-35V power input, and the internal 24V power supply is connected by default. When connecting external power, the jumpers should be unplugged.

Users can also short it to V+ through buttons or switches.

Wiring for different types of input signals is different. The specific connection method is as follows (take DI1 as an example, same as DI2-DI16):

1. Dry contact signal as input

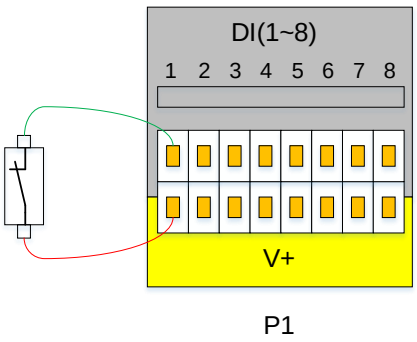


Figure 6-29: Wiring of digital input when dry contact signal as input

When the dry contact is input, one wire is connected to V+, and the other is connected to the DI specified channel. When the circuit is connected (as shown in the figure, the switch or relay is turned on), the corresponding indicator on the panel is on. The corresponding indicator will light on in the JAKA App at the same time.

2. Source signal as input

The source input wiring method is shown in figure below (take DI1 as an example, same as DI2-DI16), with the power wire V+ connected to the terminal V+, the OUT-signal wire to the specified DI channel, and the 0V wire to the panel V-. When a signal is triggered, the corresponding indicator light on the panel is on. The

corresponding indicator will light on in the JAKA App at the same time.

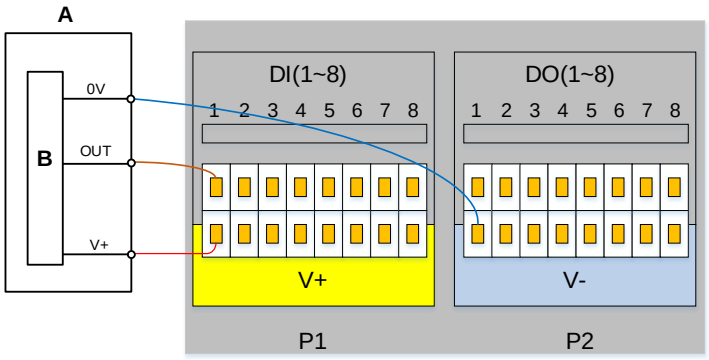


Figure 6-30: Wiring of digital input when source signal as input

A External source device

B Main circuit

6.8.3.3.2. Digital Output (DO)

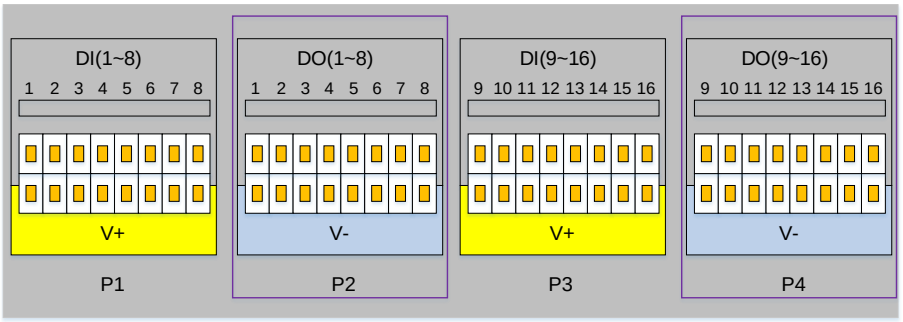


Figure 6-31: Interfaces of digital outputs

The control cabinet is equipped with 16 source digital outputs (DO1-DO16), which support isolated signal output.

High-side output is used internally, and its maximum continuous current can reach 1A. But when the V+ shorts by default to the internal 24V power supply, the 24V power current is limited to 1.5A.

The wiring of digital output wiring is shown in the figure below (take DO8 as an example, same as others):

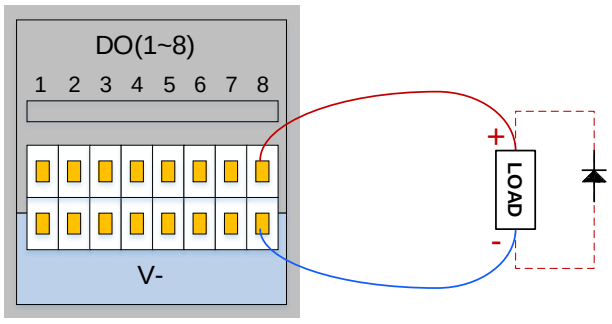


Figure 6-32: Wiring of digital output

Digital outputs can be controlled through the DO function in the App. The current of one DO is 1A, the total current cannot exceed 1.5A.

NOTICE

It is recommended to use protective diodes (such as the relay, electromagnet, and DC motor) for inductive load.

6.8.3.4 Safety I/O Interfaces

To configure the safety functions of the robot, the digital I/O interfaces P1 to P4 on the control cabinet can be set up as dedicated safety I/O. The electrical specifications refer to 6.8.3.3 Digital I/O Interfaces.

Safety I/O is designed with dual redundancy, where a failure in one channel will not compromise the safety functions. Therefore, when wiring, both paired safety I/Os should be connected simultaneously. For example, when connecting DI1, DI9 must be connected simultaneously. The pairing relationship for safety I/O is as follows:

Table 6-16: Pairing safety inputs and outputs

DI	DO
DI1& DI9	DO1& DO9
DI2& DI10	DO2& DO10
DI3& DI11	DO3& DO11
DI4& DI12	DO4& DO12
DI5& DI13	DO5& DO13
DI6& DI14	DO6& DO14
DI7& DI15	DO7& DO15
DI8& DI16	DO8& DO16

For example, when you are configuring the three-position enabling (3PE) function (see JAKA App Software User Manual), the wiring is as follows (take DI1&DI9 as an example, same as others):

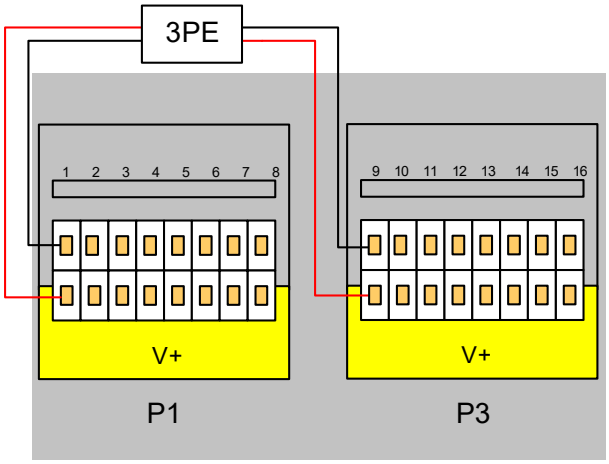


Figure 6-33: Wiring of 3-position enabling switch

The wiring for other safety functions is the same as that for the three-position enabling function.

6.8.3.5 Safety Interfaces

The control cabinet has two types of safety interfaces, and users can configure emergency stop and protective stop functions by them. EI and SI stand for emergency stop and protective stop respectively, both of which are redundant. When either signal is active, the corresponding safety function can be enabled. Emergency stop and safety stop are both designed with dual-channel configurations. If you intend to use external safety devices,

please select devices that support dual-channel design.

Users can access security doors, security light curtains, sensors, etc., according to actual safety requirements.

1. Default safety configuration

The robot can be operated without any additional safety equipment. The EI1-2 and SI1-2 is short connected to the V+, while the V+ shorts to 24V. The V- shorts to 0V, indicating that the 24V power supply is internally provided by the control cabinet.

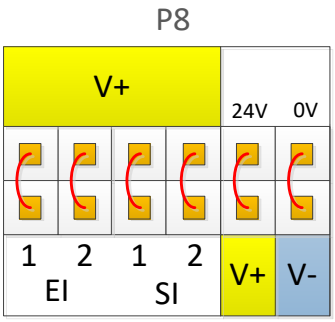


Figure 6-34: Default wiring of safety interfaces

2. Emergency stop switch

In most applications, to facilitate the safety-related operations, one or more additional emergency stops or a protective stop switch is needed. Wiring is shown in figure below. The V+ and V- can also be connected to the external 24V power supply.

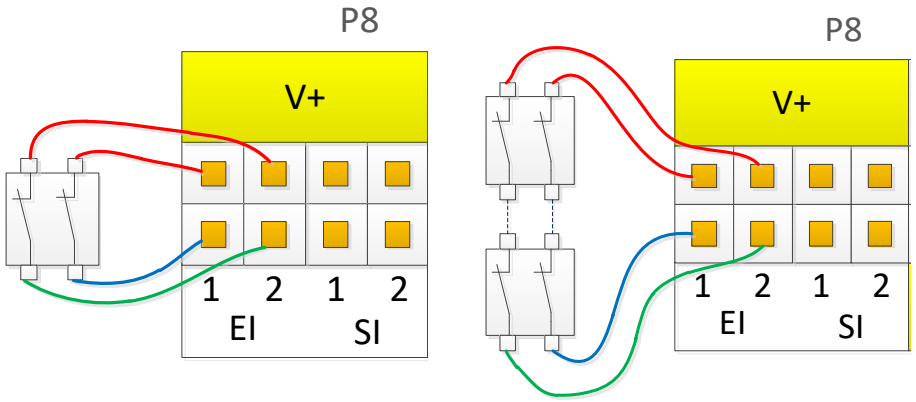


Figure 6-35: Wiring of emergency stop switch

It is possible to operate the robot without the control stick. In this case, an additional emergency stop device should be connected. You can use the EI interfaces on the front panel of the control cabinet to connect the emergency stop switch to ensure safety.

WARNING

If the control stick is detached or disconnected from the robot, the emergency stop button is no longer active. You must remove the control stick from the vicinity of the robot.

3. Protective stop switch

The protective stop function supports automatic recovery. The door switch is an application case of the

protective stop device. When the door is open, the robot stops.

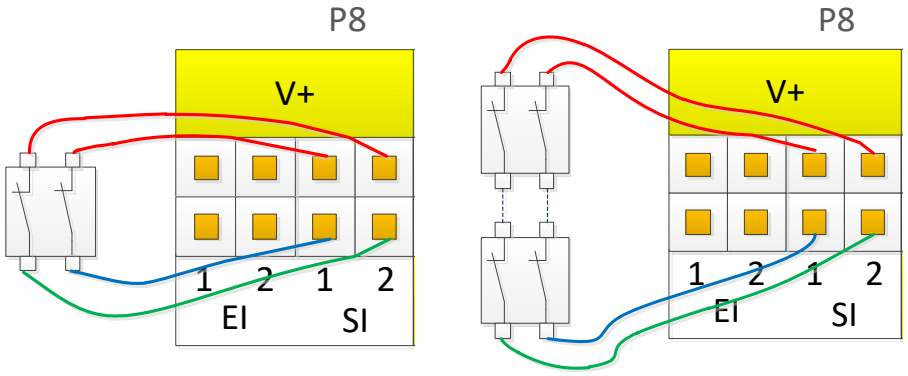


Figure 6-36: Wiring of protective stop switch

6.8.3.6 Analog I/O Interfaces

With the 2 analog input and output interfaces (Ch1, Ch2), the mode can be configured:

- Current signal input: 4-20mA;
- Current signal output: 0-20mA;
- Voltage signal input/output: 0-10V.

Wiring method (take Ch1 as an example, same as Ch2):

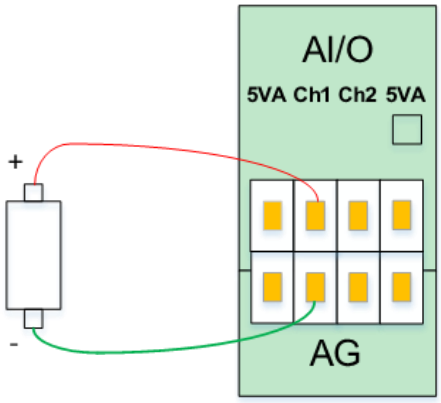


Figure 6-37: Wiring of analog inputs or outputs

The analog I/O interfaces of JAKA's control cabinet can be configured to be in different working modes through the JAKA App (0-10V input by default). For high accuracy, it is recommended to obey the following instructions:

- Use the AG terminal closest to this analog I/O.
- Use the same grounding for the device and the control cabinet. The analog I/O and the control cabinet do not perform potential isolation.
- Use shielding cables or twisted pairs. Connect shielding layer to the "AG" terminal on the "power" terminal.
- When using the equipment working in the current mode. The sensitivity of the current signal is lower than the interface.

6.8.3.7 High Speed Interfaces

P6 high speed interface (HSI) can be connected to an external encoder for conveyor belt and other applications. For detailed use, contact JAKA's technicians to get support.

6.8.3.8 RS485 Interfaces

RS485 interfaces can realize communication between devices, which are the 4, 5, 6, and 7 interfaces of P7. Among them, 4 and 5 are RS485B, 6 and 7 are RS485A. Thus, the 4 and 5 interfaces connect to RS485B interface of external devices, and 6 and 7 interfaces connect to RS485A interface of external devices. The following figure takes one of the wiring methods as an example.

NOTE

It is recommended to connect the 120 Ω resistor to the ends when wiring. YAGEO MF0207FTE52-120R type resistor is recommended.

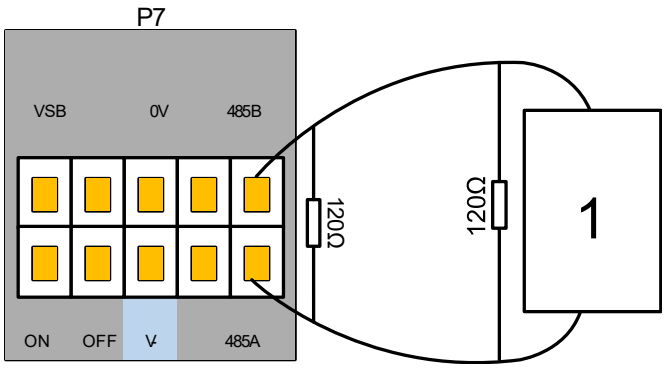


Figure 6-38: Wiring of RS485 with a single external device

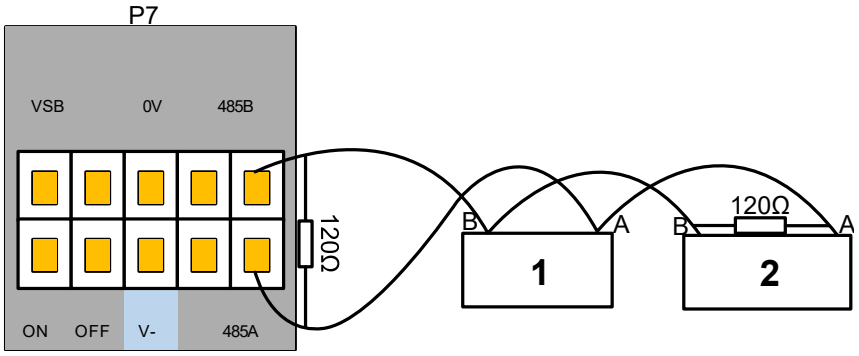


Figure 6-39: Wiring of RS485 with multiple external device

1, 2 External devices

6.8.3.9 Remote ON/OFF Interfaces

Using remote on/off interfaces, you can power up/down the control cabinet when you do not use the JAKA App or the control stick. It is commonly used for controlling the control cabinet by connecting it to the PLC.

It is effective when it receives 24V power supply (the reference GND is V-). The remote on/off interface has the same function as the power button of control stick.

Users can short the on/off interface to 12V power or VSB interface.

1. The wiring of remote on is as follows:

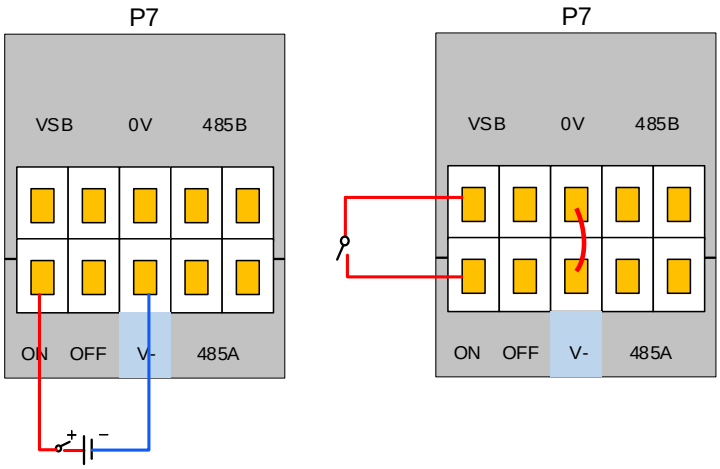


Figure 6-40: Wiring of remote on

Connect external power Connect internal power

2. The wiring of remote off is as follows:

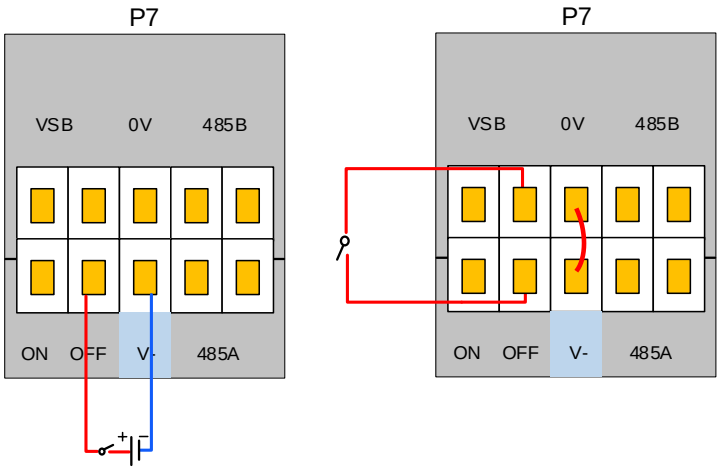


Figure 6-41: Wiring of remote off

Connect external power Connect internal power

NOTICE

Remote on and off interfaces cannot be short at the same time.

6.9 Initial Start-Up

6.9.1 Power On and Shut Down the Robot System

There are two options to power on and enable the robot:

- Powering on via control stick
- Powering on via JAKA App software

To power on and enable the robot via the control stick, proceed as follows:

1. Power up control cabinet: Press the **Power** button. The buzzer makes a noise, and the control cabinet

is powered up.

2. Unlock the control stick: Press and hold the **Lock** button for 3 seconds, and the lock indicator goes out, which means the control stick is unlocked.
3. Power on robot*:* Press the **Enable** button, waiting for the ring-shaped light to turn blue, which means the robot is powered on.
4. Enable robot: When the robot is powered on, press and hold the **Lock** button, then press the **Enable** button at the same time until the ring-shaped light turns green, which means the robot is enabled.
5. Lock control stick: App cannot be operated when control stick is unlocked, you should lock control stick first. Press and hold the **Lock** button for 3 seconds, and the lock indicator turns orange, which means control stick is locked. You can use App now.

Steps of powering down control cabinet are as follows:

1. Unlock the control stick: Press and hold the **Lock** button for 3 seconds, and the lock indicator goes out, which means the control stick is unlocked.
2. Disable robot: When the robot is enabled, press and hold the **Lock** button, and then press the **Enable** button at the same time until the ring-shaped light turns blue, which means the robot is disabled.
3. Power off robot*:* Press the **Enable** button, waiting for the ring-shaped light to turn blue, indicating that the robot is powered off.
4. Power down control cabinet: Press and hold the **Power** button for 3 seconds or more. The control stick beeps 6-7 times, and the control cabinet is powered down. After powering off the control cabinet, please do not cut off the power immediately. Wait until the control stick light goes out, and after waiting for 5 to 10 seconds, you can disconnect the power.

6.9.2 Set the Limits

Before commissioning the robot, the following items should be verified:

- Verify the emergency stops and the operator protective devices.
- The robot complies with the relevant standards and protective devices are designed to stop the robot without leaving the path (category 1 stop).
- Robot functions successfully within preset limits Slowly move the robot beyond the limits of the preset working space in order to verify that this is prevented by the preset limits.
- Individually move the robot beyond the maximum/minimum angles in order to verify that this is prevented by the preset limits.

6.9.3 Start-Up

When the robot is operated for the first time, there is a risk of unintended equipment operation caused by possible wiring errors, improper mounting and fastening, or unsuitable parameters.

WARNING

Unintended equipment operation:

- Verify that the robot is properly and firmly fastened.
- Take all necessary measures to ensure that the moving parts of the robot cannot move in an unanticipated way.
- Verify that emergency stop equipment is operational and within reach of the zone of operation.
- Verify that the system is obstacle-free and ready for the movement before starting the system.
- Run initial tests at reduced velocity.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

If the robot power supply is disabled unintentionally, for example as a result of power outage or errors, the robot is no longer decelerated in a controlled way.

WARNING

Unintended equipment operation:

Verify that movements without braking effect cannot cause injuries or equipment damage.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

WARNING

Hot surfaces:

- Do not allow flammable or heat-sensitive parts in the immediate vicinity of hot surfaces.
- Verify that the heat dissipation is sufficient by performing a test run under maximum load conditions.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

6.9.3.1 Commissioning Procedure

To commission the robot, proceed as follows:

1. Comply with the instructions provided in this manual.
2. Verify that the load conforms to the specified payloads for the robot before operating.
3. Connect the robot in the JAKA App. For further Information, refer to the JAKA App Software User Manual.
4. Configure the installation setting of the robot. For further Information, refer to the JAKA App Software User Manual.
5. Verify the calibration and position and direction of the joints.
6. Verify the orientation of the world coordinate system in the manual operation interface. For further Information, refer to the JAKA App Software User Manual.

NOTE

The world coordinate system depends on the mounting position.

7. Configure the collision protection settings in accordance to the safety-related requirements of your application. For further information on the configuration, refer to the JAKA App Software User Manual.
8. Perform initial tests at reduced velocity and verify the functionality of the robot.
9. Verify that the operating condition of set cycles is lower than 80% of the total cycle time.

NOTE

For a total cycle time of 10 seconds take care of maximum 8 seconds cycle running time and 2 seconds waiting period. If you exceed the duty cycle proportion of 80%, you may reduce the lifetime of the gearboxes of the robot joints.

10. Optionally, configure the home position for the Home button operation of the control stick. For further information on the control stick operations, refer to 5.1.7 Control Stick Buttons, and for the

configuration of the home position, refer to the JAKA App Software User Manual.

11. In case of using several robot systems, optionally assign unique names for the devices for easier identification. For further information, refer to the chapter Initial Settings in the JAKA App Software User Manual.

6.9.3.2 Starting the Default Program

There are two options for automatically starting the program set as default on the robot:

- Starting via control stick
- Starting via JAKA App software

To start the default program via the control stick, press the **Start/Stop** button on the control stick.

For further information on starting and setting the default program via JAKA App, refer to the JAKA App Software User Manual.

6.10 Mounting the End-Effector

6.10.1 Prerequisites

Observe the following prerequisites to help avoid incorrect operation of the robot:

- Verify that the load conforms to the specified payloads for the robot before operating.
- Limit the maximum payload of the motor in accordance with the maximum load capacity of the robot. For further information, refer to 5.3.1 Load Capacity of the Robot.

6.10.2 Dimensions of Robot Flange

The following figure presents the installation dimensions of robot flange.

1. Zu 3 flange dimensions

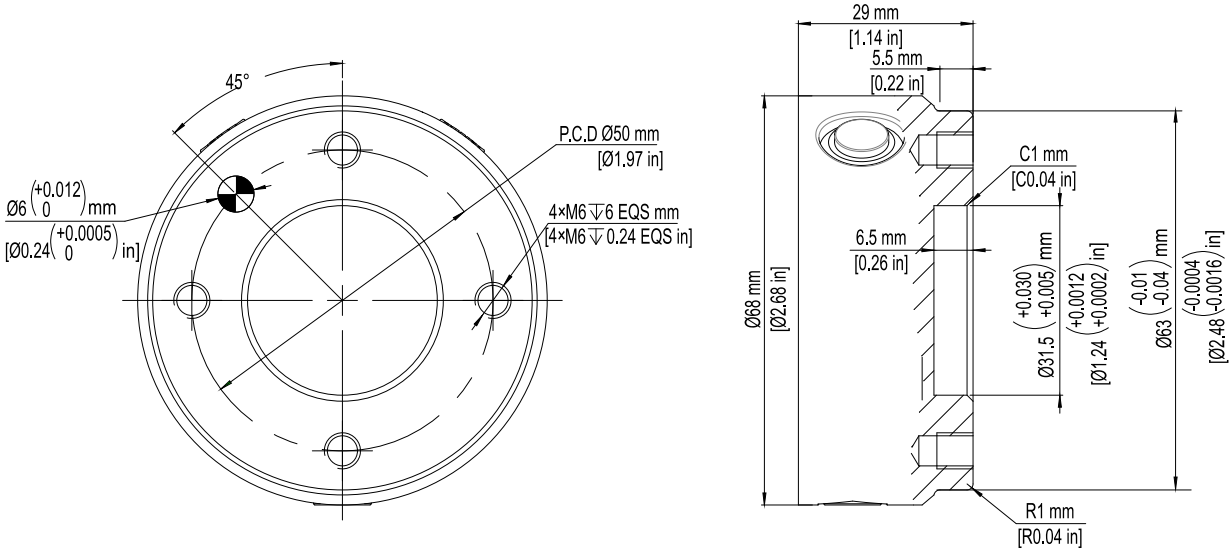


Figure 6-42: Zu 3 flange dimensions

2. Zu 5, Zu 7 flange dimensions

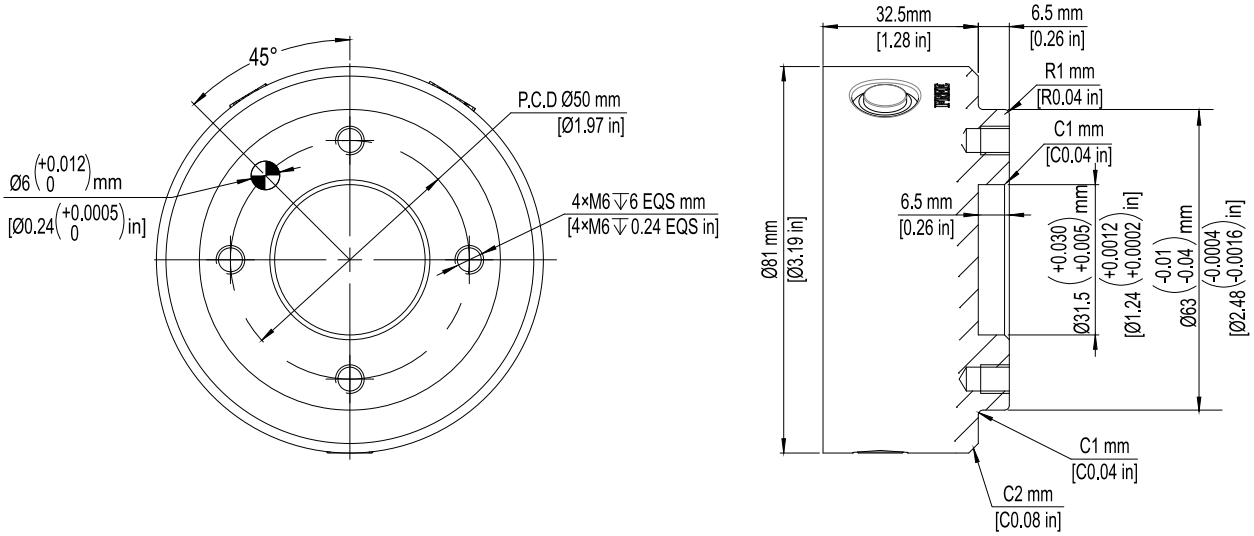


Figure 6-43: Zu 5, Zu 7 flange dimensions

3. Zu 12, Zu 18 flange dimensions

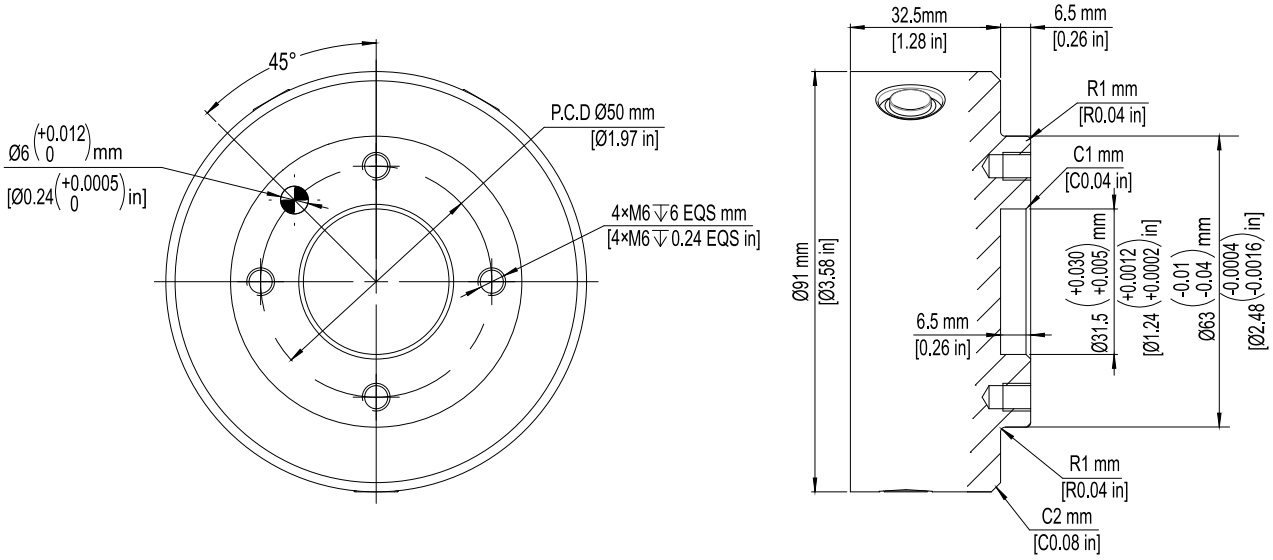


Figure 6-44: Zu 12, Zu 18 flange dimensions

4. Zu 20 flange dimensions

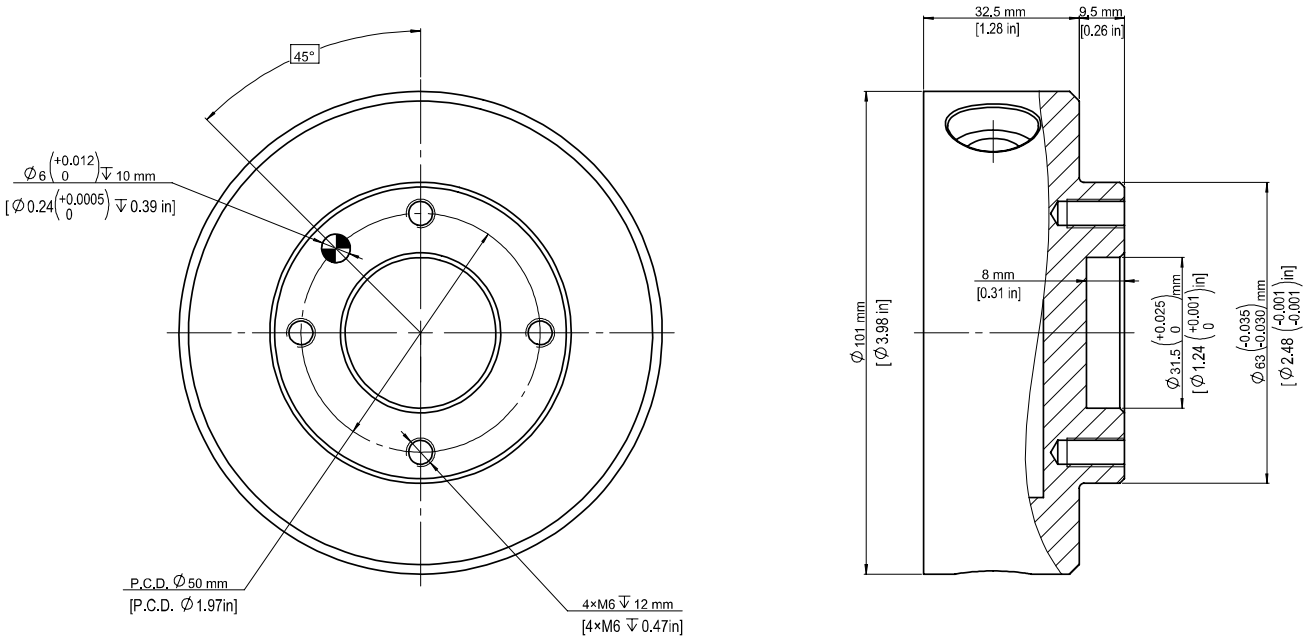


Figure 6-45: Zu 20 flange dimensions

6.10.3 Mounting the End-Effector

1. Fasten the end-effector to the mounting points provided. for this purpose, on the robot tool flange (**1**):
   - Pitch circle diameter DIN ISO 9409-1, 50 mm (1.97 in): 4x M6 (**2**), tightening torque: 13 Nm (115.05 lbf·in), property class of the screw: 12.9 or greater
   - Pitch circle diameter 50 mm (1.97 in): 1x fitting hole diameter 6 H7 (**3**)

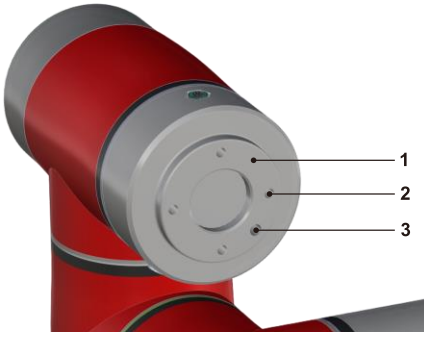


Figure 6-46: Robot tool flange

For further information on the flange dimensions, refer to 6.10.2 Dimensions of Robot Flange.

2. Set the payload in JAKA App. For further information, refer to the JAKA App Software User Manual.

NOTE

- Observe the permissible weights and distances that results in load capacity of the robot.
- According to ISO9409-1: 2004, the location pin hole center shall be aligned with the mechanical interface coordinate system (ISO 9787:2013)+Xm, and our product is offset 45° clockwise on this basis.

NOTICE

- When mounting the robot at different angles, the mounting app in the App must be modified. See JAKA App Software User Manual for details.
- It is normal that the mounting holes of the robot are rusted or have traces of use. The JAKA robot needs to accept a series of performance tests before leaving the factory. Therefore, there will be traces in the mounting hole, which is not a quality problem and does not affect its use.
- If the robot is not fixed on the foundation firmly, the mechanical structure of the robot may be unstable, and it may tip over.
- When inverted mounting or wall mounting is adopted, the rigidity and stability of the mounting plane should be ensured, it is very dangerous to mount the robot on the wall or ceiling with insufficient intensity and rigidity, which may cause the robot to fall or vibrate, leading to severe injuries or serious damage to the robot.
- The robot needs to be used in an environment that matches its IP level, which helps reduce the failure and extend the service life of the robot.

7 Optional Equipment

7.1.1 Three-Position Enabling Device

Figure 7-1: Touch I with three-position enabling switch

The JAKA robot supports a three-position enabling function, which can be used in conjunction with external three-position enable device. The standard product delivery of the JAKA robot does not include this device. The three-position enabling safety input interface is optional for matching hardware, which meets the design certification requirements. For this optional accessory, please contact the authorized supplier of JAKA.

When you use the three-position enabling device and configure the corresponding function in the software, the robot can only be moved and controlled after the three-position switch is pressed to a middle point. See 6.8.3.4 Safety I/O Interfaces for wiring method.

The picture of the three-position enabling switch is as follows:

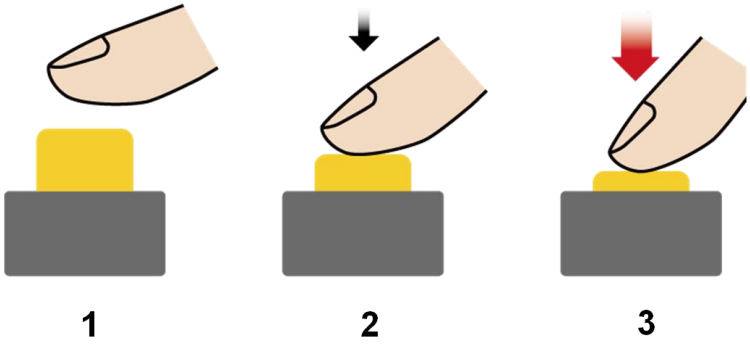


Figure 7-2: Three-position enabling switch

The corresponding robot control states for different states of the three-position enabling switch are as follows:

Table 7-1: Relationship between robot state and three-position enabling switch

	Switch State	Robot State	Manual Control	Automatic Control (Program Operation)
1	Release	Protective stop (Cat.2)	Off	When a program is running, the three-position enabling function is switched off.
2	Press lightly	Normal	On	
3	Press tightly	Protective stop (Cat.2)	Off	

NOTE

- Manual control consists of dragging the robot by pressing and holding the Free button, dragging the robot by pressing and holding the pause/resume button, JOG robot in the manual operation interface, and debugging function in programming interface.
- JOG refers to manually controlling robot movement in the JAKA App in the manual operation interface.

8 Maintenance

All safety instructions in this manual must be strictly followed for maintenance work. For more detailed maintenance instructions, please refer to the JAKA Service Manual.

The repair must be performed by an integrator authorized by JAKA or by JAKA's personnel.

After-sales service contact information: E-mail: support@jaka.com.

8.1 Safety Instructions

After maintenance, check to ensure the safety level required by the service. Valid national or local safety laws and regulations must be observed during the check. At the same time, check if all safety functions are functioning properly.

The purpose of maintenance is to ensure the normal operation of the system, or to help the system return to normal operation in the event of a failure. The maintenance includes fault diagnosis and actual maintenance.

The following safety procedures and warnings must be followed during the operation of the robot or the control cabinet:

WARNING

- It is forbidden to modify any information in the software safety configuration. If the safety parameters are changed, the entire robot system should be considered as a new system, which means that all safety examination processes, such as risk assessment, must be updated.
- Replace a failed component with the same component number or equivalent approved by JAKA.
- Reactivate all disabled safety measures immediately after maintenance is completed.
- Record all maintenance operations and save them in technical documents related to the entire robot system.

WARNING

- Remove the power cord from the bottom of the control cabinet to ensure that it is completely powered down. Disconnect other energy sources connected to the robot or the control cabinet. Take necessary precautions to prevent others from energizing the system during maintenance.
- Check the ground connection before re-powering the system.
- Observe the ESD regulations when disassembling the robot or the control cabinet.
- Avoid disassembling the power supplies inside the control cabinet. High voltage may remain in the power supply system for several hours after the control cabinet is powered down.
- Avoid water or dust entering the robot or the control cabinet.

For further information, refer to the JAKA Service Manual.

9 Troubleshooting

Table 9-1: Troubleshooting list

Issue	Probable Cause	Solution
Robot is not reachable via JAKA App.	Control cabinet is powered off.	Power on the control cabinet.
	Blocked by firewall.	Verify the firewall settings.
	Not connected to the Wi-Fi of the control cabinet.	Connect to the Wi-Fi of the control cabinet.
	Not connected to the control cabinet via Ethernet cable.	Verify the connection and functionality of the cable.
	Incorrect IP address.	Configure the IP settings accordingly.
Robot could not be enabled.	Joint x: self-learning flow or servo overcurrent. Mechanical blocking of joint x.	Release the brake of joint x. Contact your local JAKA service representative
	Emergency stop is pressed.	Release the emergency stop button.
Robot is not powering on.	The simulation mode is active.	Switch to the real robot.
	Emergency stop is pressed.	Release the emergency stop button.
Emergency stop	Emergency stop is pressed.	Release the emergency stop button.
	No control stick connected.	Connect the control stick properly.
Default program is not executed.	Default program is not selected.	Select a default program in JAKA App.
Initial orientation is not as intended.	Initial orientation has not been adjusted on initial start-up.	Adjust the initial orientation in JAKA App.
Unexpected stop of robot during movement.	Overheating of the control cabinet.	Verify that there is sufficient airflow.

10 Disposal

This section contains information to handle potentially dangerous components and potentially hazardous materials.

JAKA products contain components in different materials. During decommissioning, all materials should be dismantled, recycled, or reused responsibly, according to the relevant laws and industrial standards.

EU RoHS

JAKA robots are produced with restrictions on the use of hazardous substances to protect the environment; they comply with the definition of the EU RoHS Directive 2011/65/EU. The substances restricted by RoHS include mercury, cadmium, lead, chromium VI, polybrominated biphenyls and polybrominated diphenyl ethers.

EU WEEE

Fee for disposal and handling of electronic waste of JAKA robots sold on the German market is prepaid to DPA-system by JAKA. Importers in countries covered by the European WEEE Directive 2012/19/EU must make their own registration to the national WEEE register of their country. A list of national registers can be found here: https://www.ewrn.org/national-registers/national-registers.

The following symbol indicates that the product must not be disposed of as common garbage. Handle each product according to local regulations for the respective content.

Figure 10-1: Disposal symbol

EU RoHS

The following symbol shows the information to hazardous substances and the environmental protection use period of JAKA products according to Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products (SJ/T 11364-2014).

Figure 10-2: Environmental protection use period symbol

The orange icon indicates that this product contains certain hazardous substances. The '20' in the icon represents the environmental protection period. It can be used during the environmental protection period and should be recycled after exceeding that time.

The table below shows the name and content of toxic and hazardous substances in the product.

Table 10-1: Toxic and hazardous substances list

Part Name	Pb	Hg	Cd	Cr (VI)	PBB	PBDE
Metal parts	x	o	o	o	o	o

Part Name	Pb	Hg	Cd	Cr (VI)	PBB	PBDE
Plastic parts	o	o	o	o	o	o
Electronic	x	o	o	o	o	o
Electrical contacts	o	o	o	o	o	o
Cables & cabling accessories	o	o	o	o	o	o

NOTE

- The table is made according to SJ/T 11364.
- indicates that the concentration of hazardous substance in all the homogeneous materials for this part is below the limit as stipulated in GB/T 26572.
- x indicates that the concentration of hazardous substance in at least one of the homogeneous materials for this part is above the limit as stipulated in GB/T 26572.

11 Design Standards and Certification

11.1 Certification Description

11.1.1 Third-Party Certification

The robot is certified by the following inspection bodies.

Table 11-1: Third-party certification

	Body	Description
SGS	**SGS**	The JAKA robot has passed the safety certification of the notified body, SGS, which complies with the EU machinery directive 2006/42/EC.
KCs	**KCs safety**	The JAKA robot has been evaluated as compliant with the KCs safety standard.

11.1.2 Manufacturer Test Certification

Table 11-2: Manufacturer test certification

	Body	Description
JAKA	**JAKA**	The JAKA robot undergoes continuous internal factory tests and type testing procedures.

11.1.3 Declaration According to EU Directives

JAKA robot has been certified according to the following directives.

Table 11-3: Declaration according to EU Directives

Name		Description
2006/42/EC	Machinery Directive (MD)	The JAKA robot meets the basic requirements of the CE-MD, CE-LVD, CE-EMC and CE-RED directives.
2014/35/EU	Low Voltage Directive (LVD)	
2014/30/EU	Electromagnetic Compatibility (EMC)	
2014/53/EU	Radio Equipment Directive (RED)	

NOTE

- Robots are covered by both the MD and LVD directives. Based on the MD directive, only MD is required to be evaluated, but the harmonized standards of LVD are used simultaneously to ensure electrical safety when conducting MD assessments.
- EMC is mainly used to ensure compliance of robot without Wi-Fi module, EMC compliance of

robot with Wi-Fi module is included in RED.

- Certificates and declarations can be found on the official website www.jakarobotics.com.

12 Warranties

12.1 Product Warranty

Without prejudice to any indemnity agreement that the user (customer) may reach with the distributor or retailer, the manufacturer shall give the user (customer) “product warranty” according to the following terms: If there is any defect due to manufacturing and/or material faults within the warranty period promised under the contract signed by JAKA, JAKA shall provide necessary spare components, the user (customer) shall send personnel to replace spare components, and replace or repair related components with new ones that reflect the latest technical level. If the equipment defect is caused by improper treatment and/or failure to follow the relevant information described in the user manual, this “Product Warranty” is invalid. This “Product Warranty” does not apply to or extend to maintenance carried out by authorized distributors or users (customers) themselves (e.g. installation, configuration, software download). The purchase receipt, together with the date of purchase, shall be required as evidence for invoking the Warranty. The warranty must be submitted within two months of the Warranty default becoming evident. JAKA has the ownership of the equipment or components that are replaced or returned to JAKA. Any other claim arising out of or relating to the equipment is excluded from the scope of the Warranty. Nothing in this Warranty shall attempt to limit or exclude a Customer’s Statutory Right, nor the manufacturer’s liability for death or personal injury resulting from its negligence. The duration of the Warranty shall not be extended by services rendered under the terms of the Warranty. Insofar as no Warranty default exists, JAKA reserves the right to charge the customer for replacement or repair. The above provisions do not imply a change in the burden of proof to the detriment of the customer.

12.2 Disclaimer

JAKA is committed to continuously improving the reliability and performance of the products, and therefore reserves the right to upgrade them. The products may be changed without notice. JAKA strives to ensure the accuracy and reliability of the contents in this manual but is not responsible for any error or omission herein.

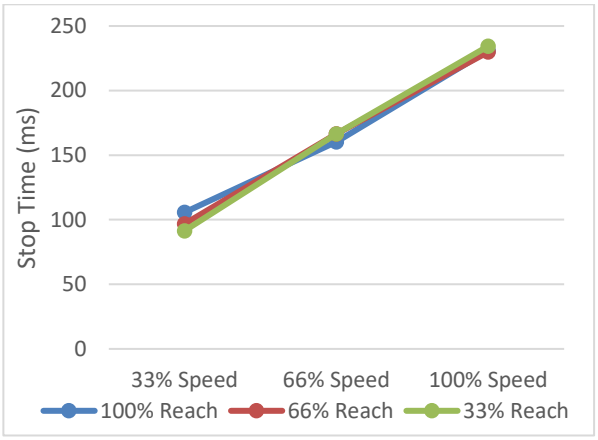
Appendix

Appendix 1: Stopping Time and Distance

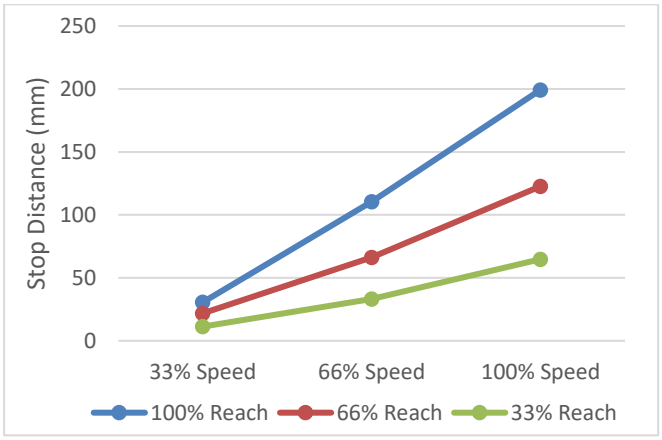
Zu 3 stopping time and distance

Table of type 1 stopping time and distance

Joint 1:

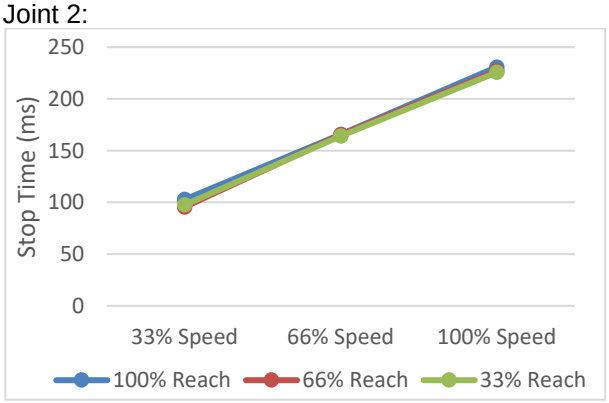


Joint 1 Type 1 Stopping time



Joint 1 Type 1 Stopping distance

Joint 2:



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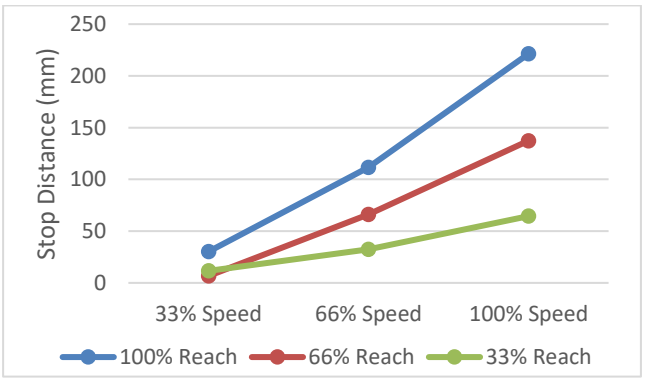

Joint 2 Type 1 Stopping distance

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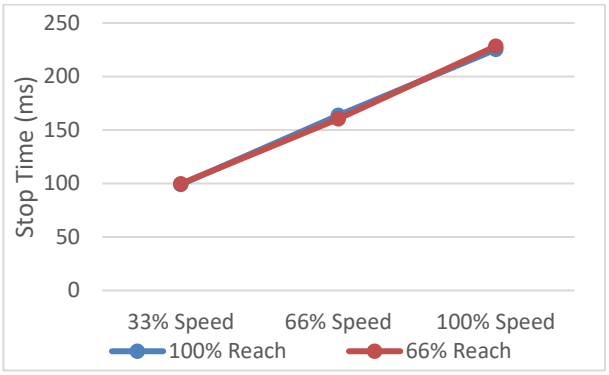
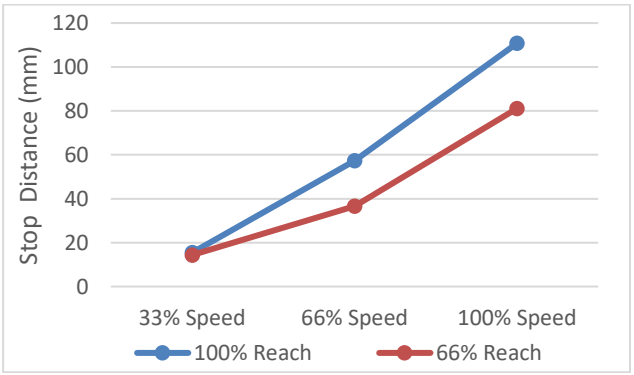


Joint 3 Type 1 Stopping time



Joint 3 Type 1 Stopping distance

Table of type 2 stopping time and distance

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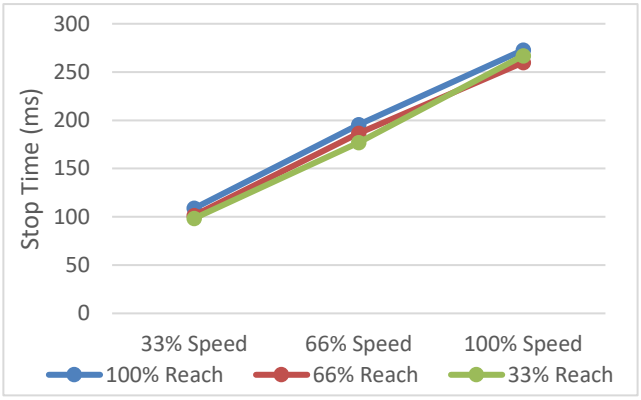

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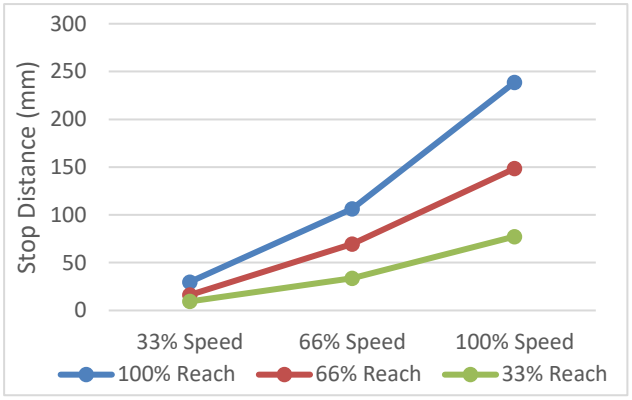

Joint 1 Type 2 Stopping distance

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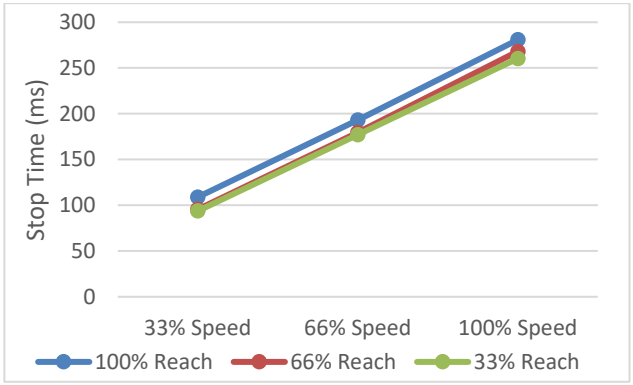

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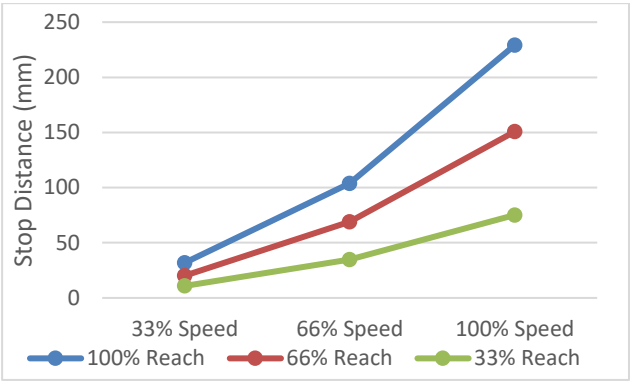

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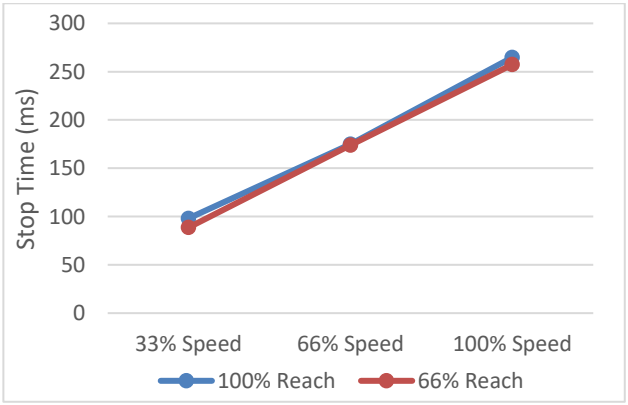

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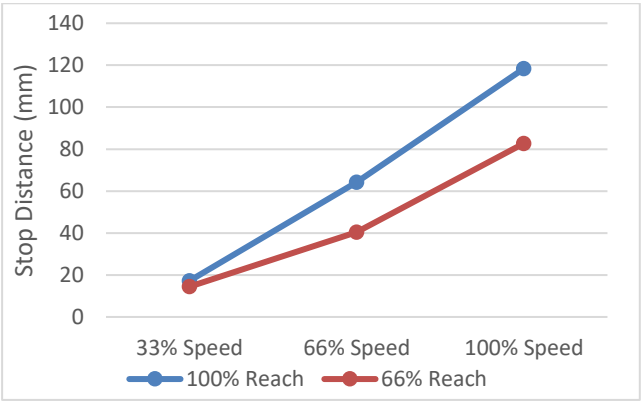

Joint 3 Type 2 Stopping distance

Zu 5 stopping time and distance

Table of type 1 stopping time and distance

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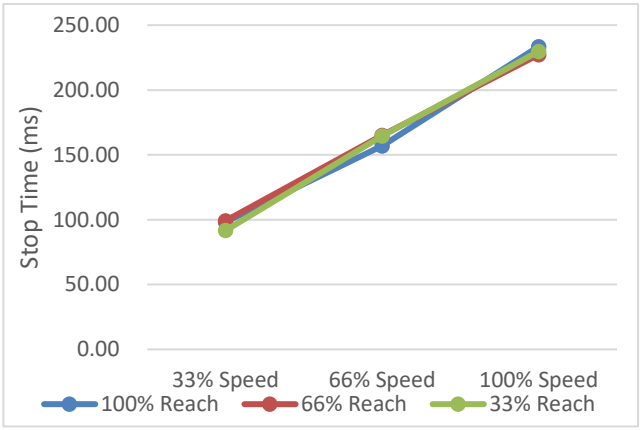

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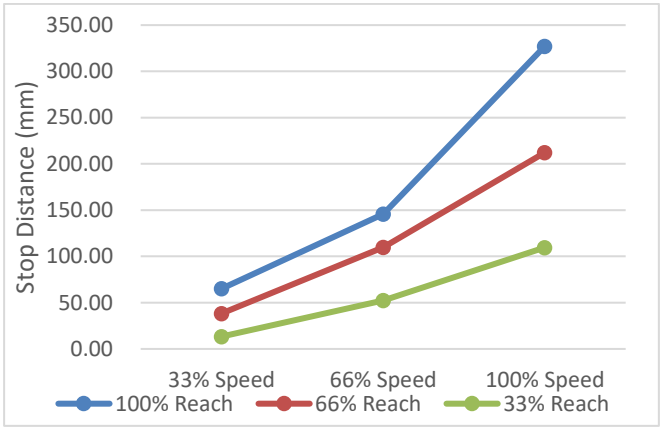

Joint 1 Type 1 Stopping distance

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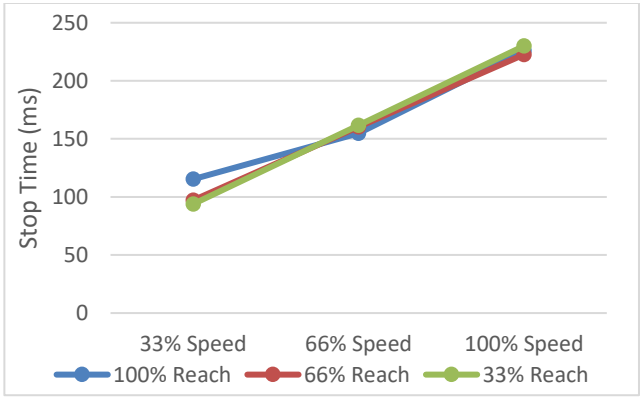

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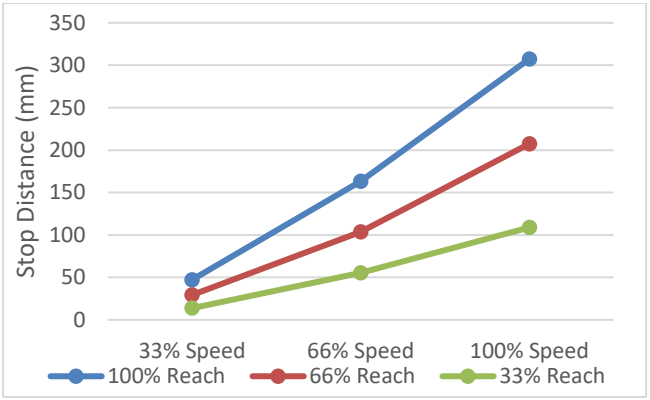

Joint 2 Type 1 Stopping distance

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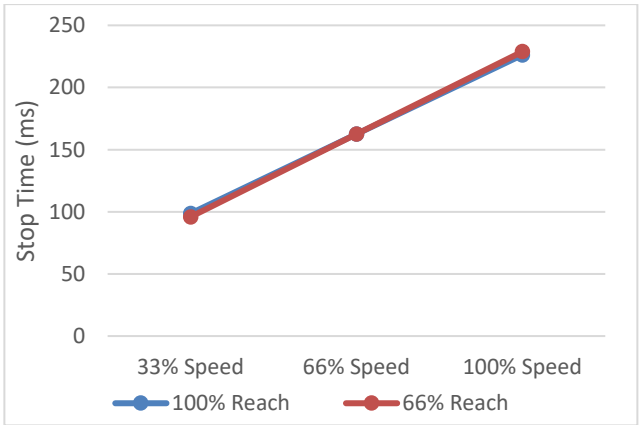

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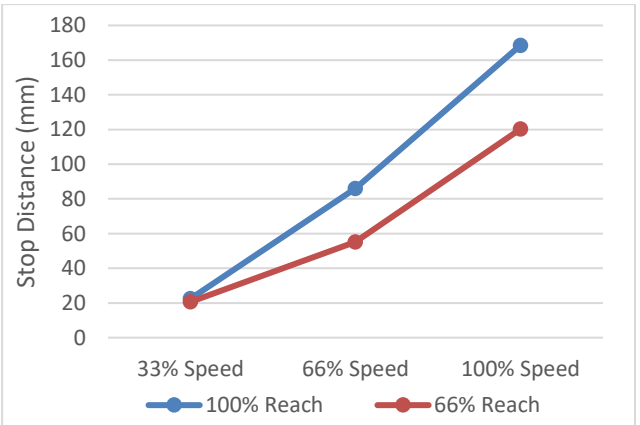

Joint 3 Type 1 Stopping distance

Table of type 2 stopping time and distance

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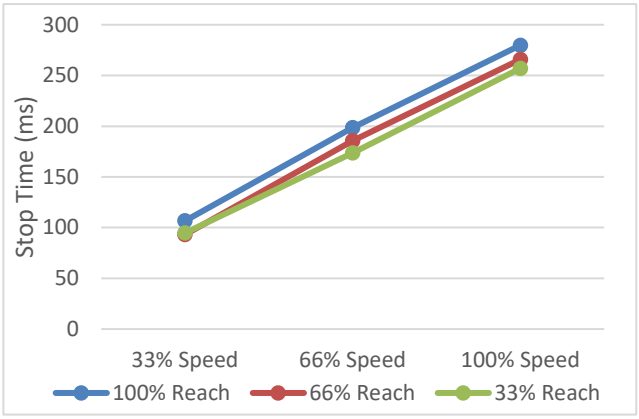

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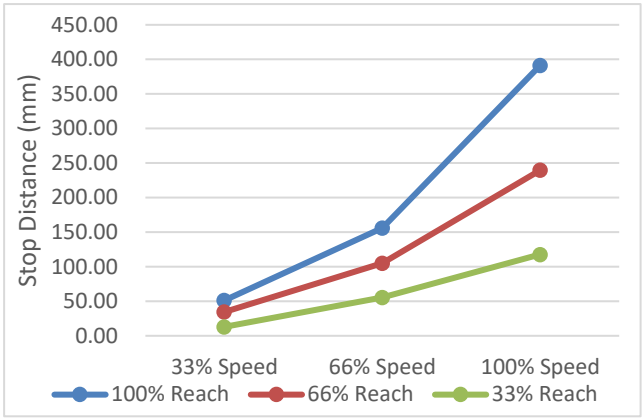

Joint 1 Type 2 Stopping distance

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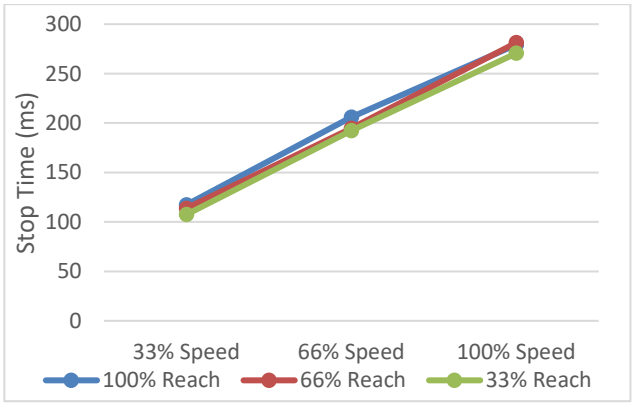

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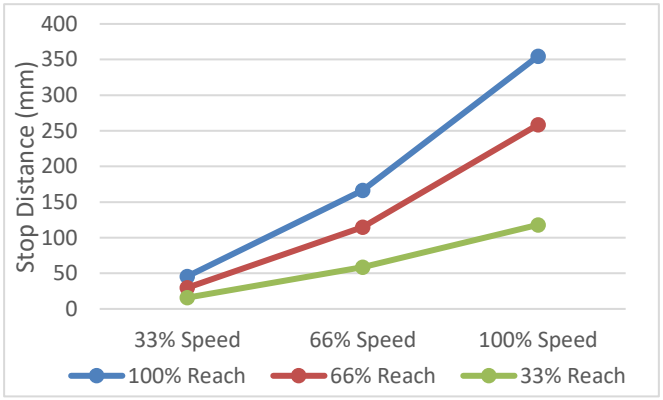

Joint 2 Type 2 Stopping distance

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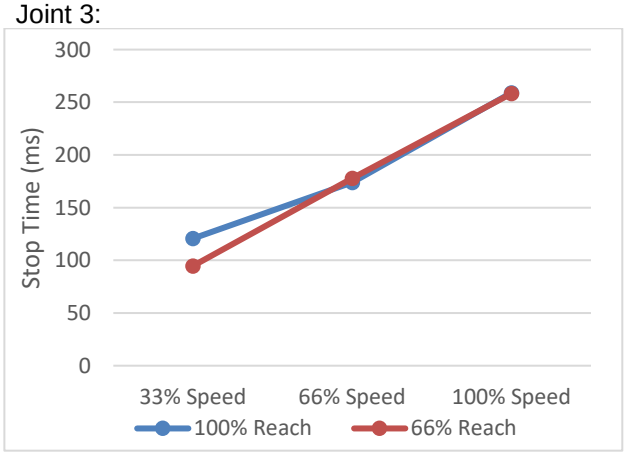
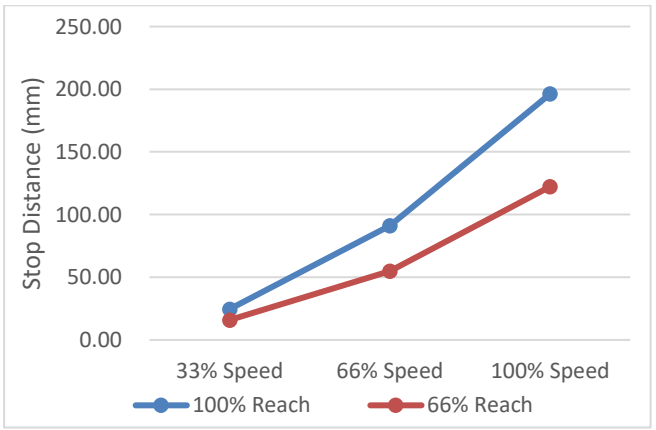


Joint 3 Type 2 Stopping time



Joint 3 Type 2 Stopping distance

Zu 7 stopping time and distance

Table of type 1 stopping time and distance

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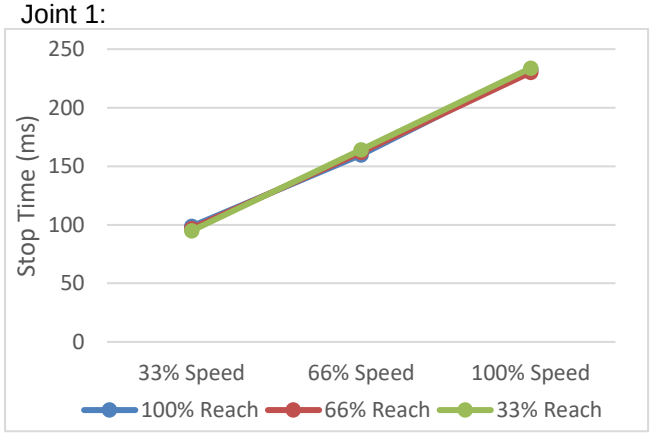
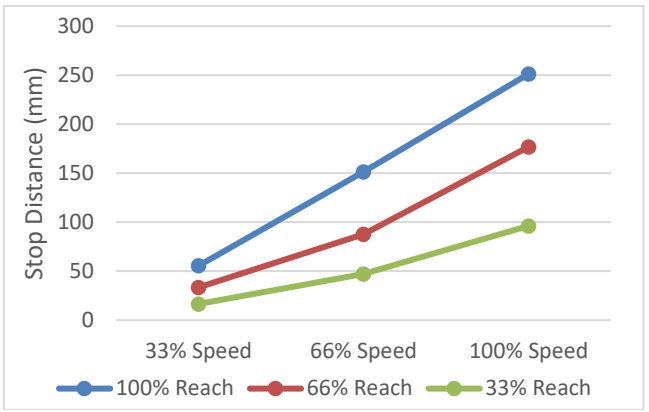


Joint 1 Type 1 Stopping time



Joint 1 Type 1 Stopping distance

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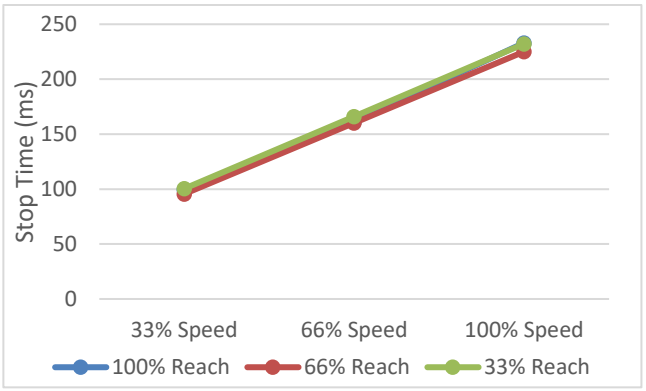

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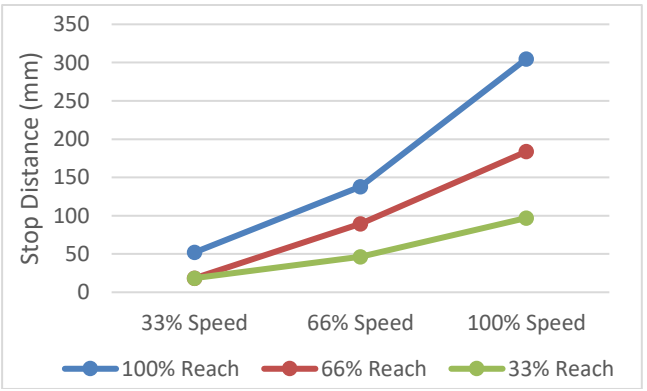

Joint 2 Type 1 Stopping distance

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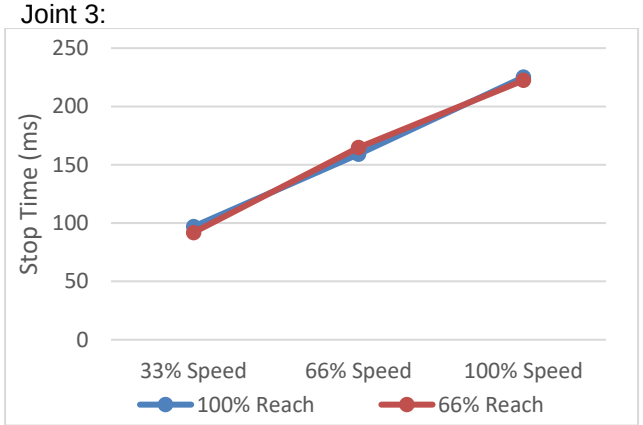
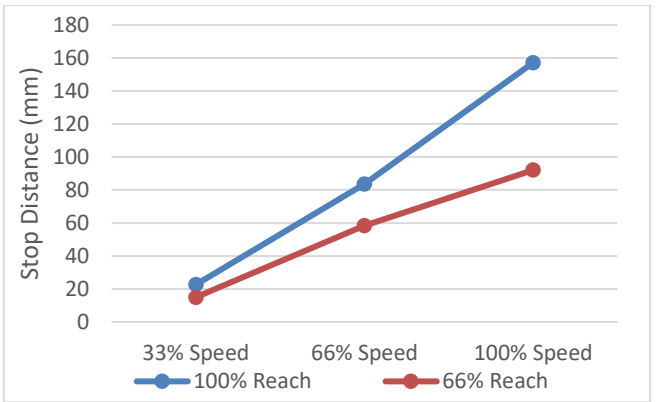


Joint 3 Type 1 Stopping time



Joint 3 Type 1 Stopping distance

Table of type 2 stopping time and distance

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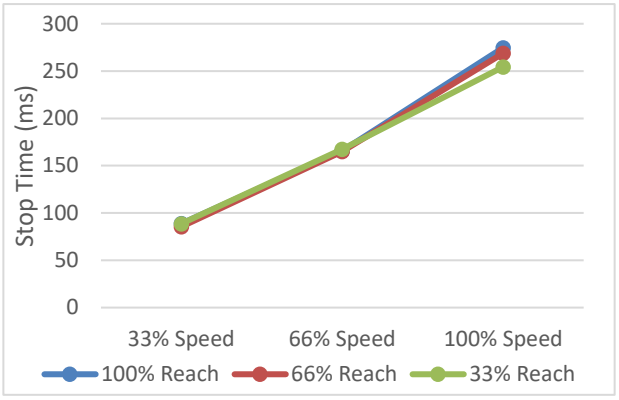
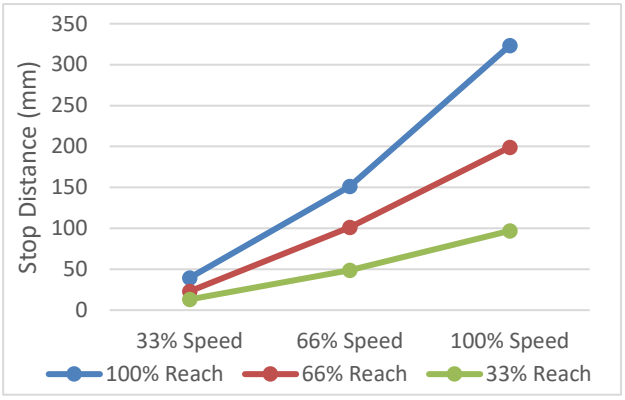


Joint 1 Type 2 Stopping time



Joint 1 Type 2 Stopping distance

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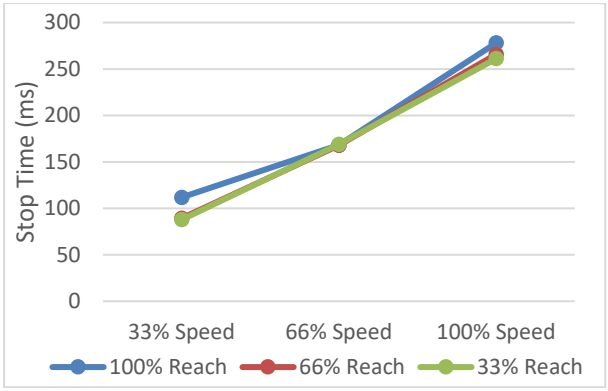
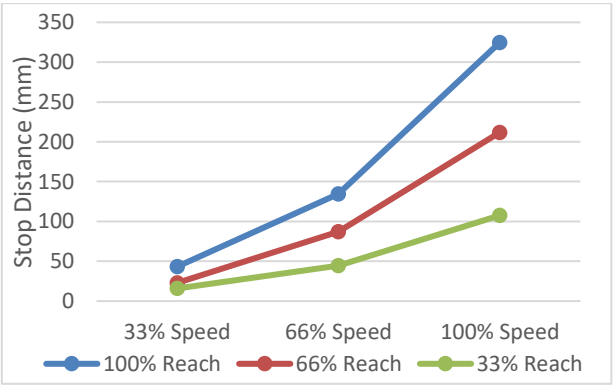


Joint 2 Type 2 Stopping time



Joint 2 Type 2 Stopping distance

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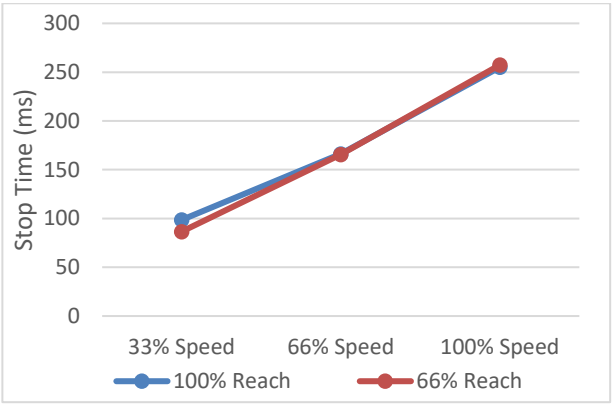
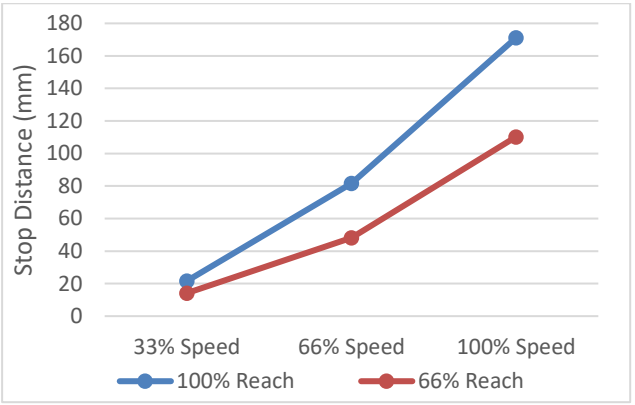


Joint 3 Type 2 Stopping time



Joint 3 Type 2 Stopping distance

Zu 12 stopping time and distance

Table of type 1 stopping time and distance

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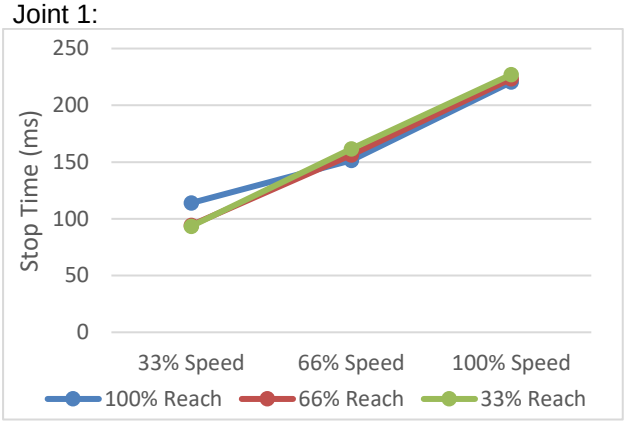
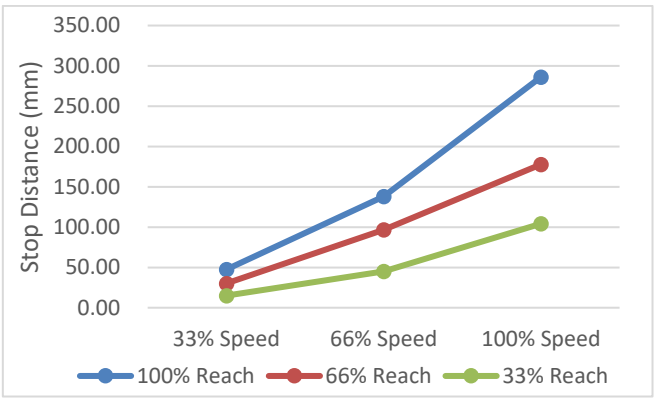
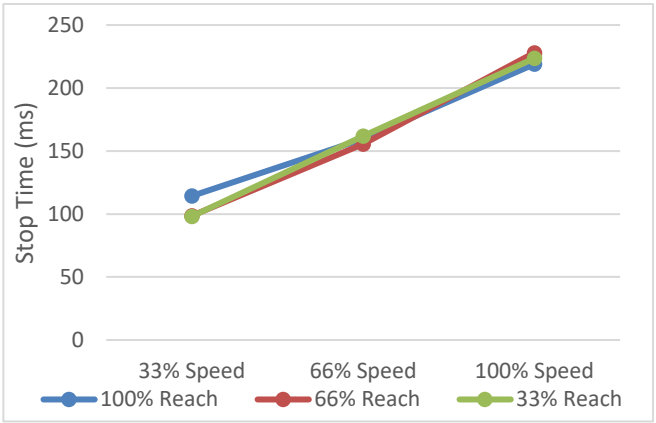


Joint 1 Type 1 Stopping time

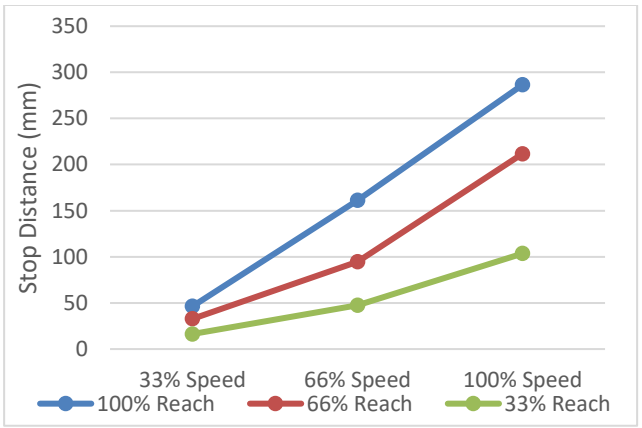


Joint 1 Type 1 Stopping distance

Joint 2:



Joint 2 Type 1 Stopping time



Joint 2 Type 1 Stopping distance

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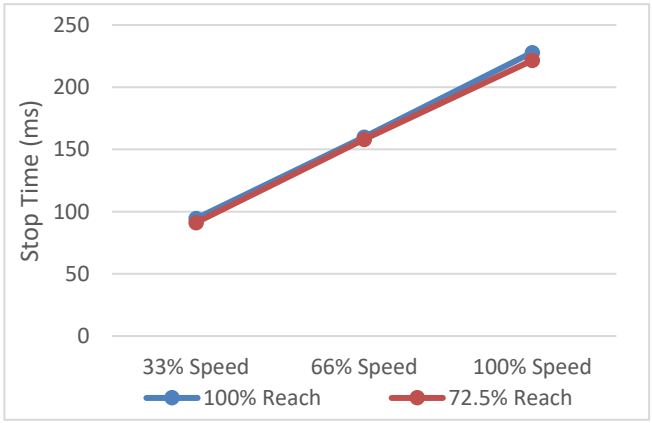
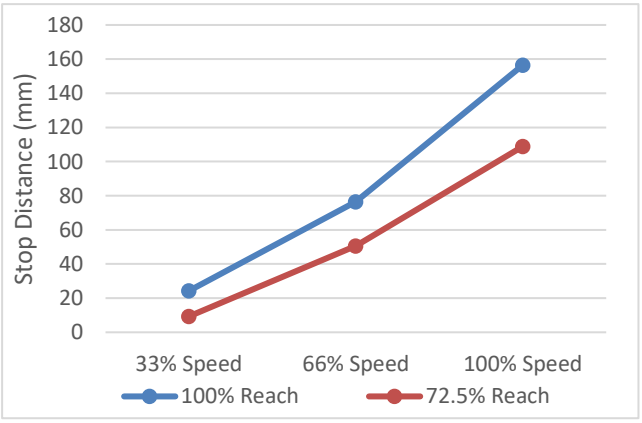


Joint 3 Type 1 Stopping time



Joint 3 Type 1 Stopping distance

Table of type 2 stopping time and distance

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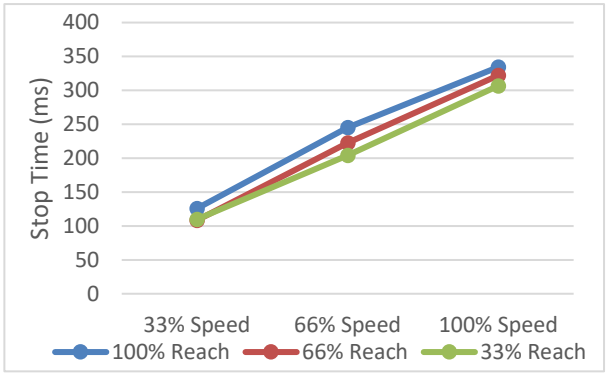
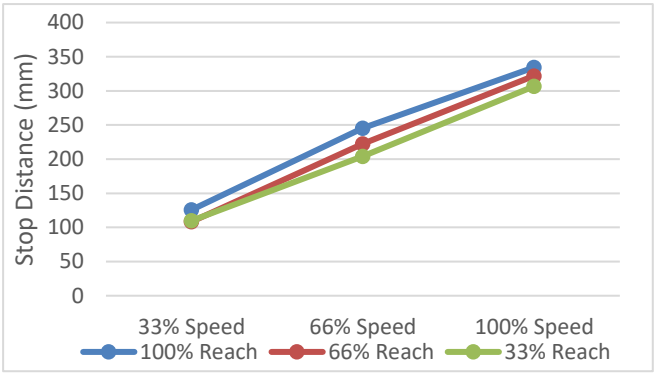


Joint 1 Type 2 Stopping time



Joint 1 Type 2 Stopping distance

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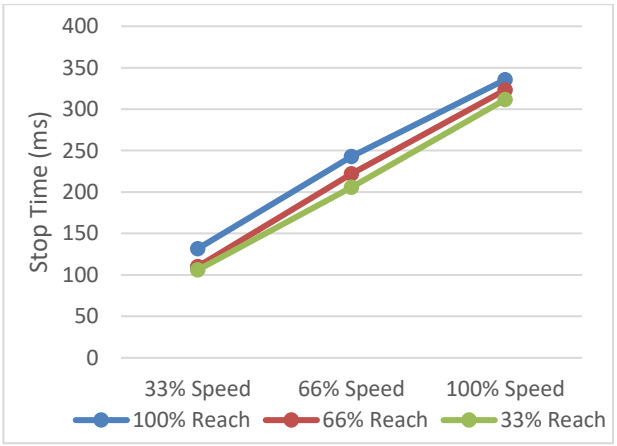
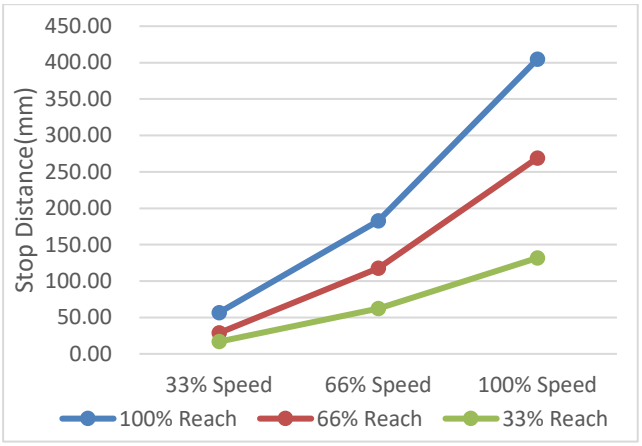


Joint 2 Type 2 Stopping time



Joint 2 Type 2 Stopping distance

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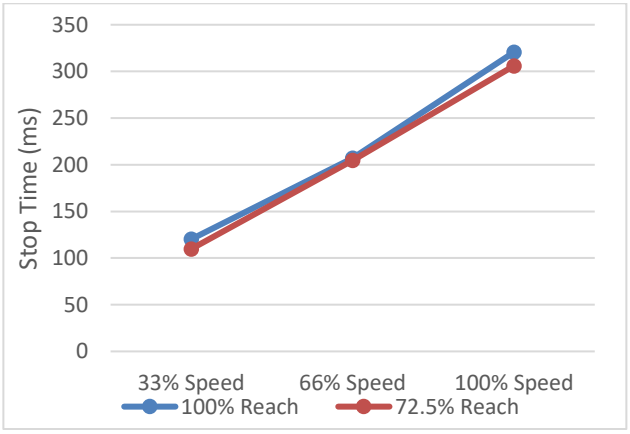

Joint 3 Type 2 Stopping time

Joint 3 Type 2 Stopping distance

Zu 18 stopping time and distance

Table of type 1 stopping time and distance

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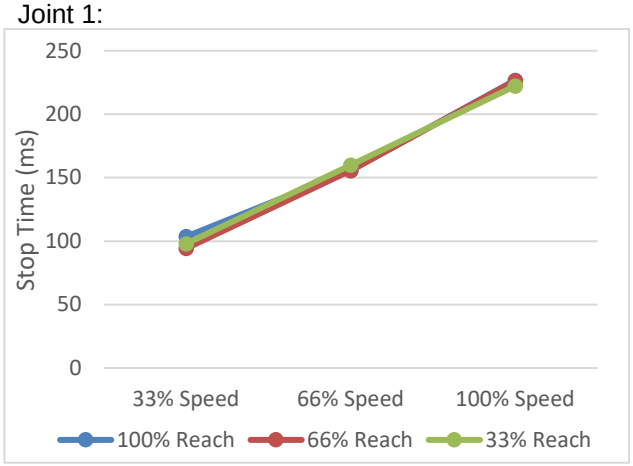
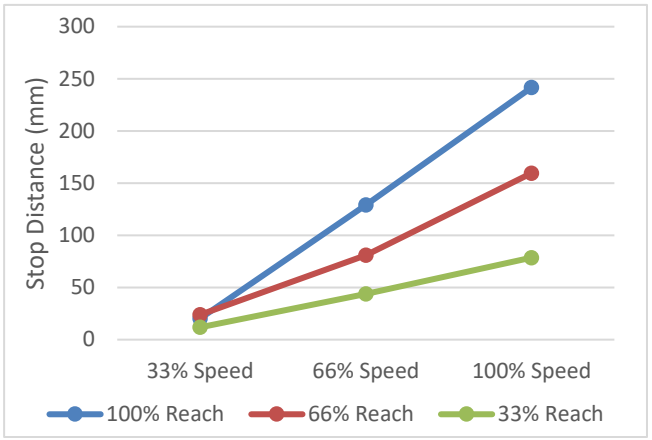


Joint 1 Type 1 Stopping time



Joint 1 Type 1 Stopping distance

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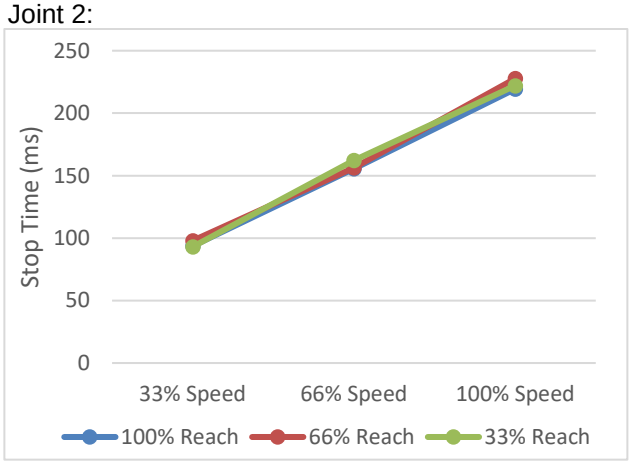
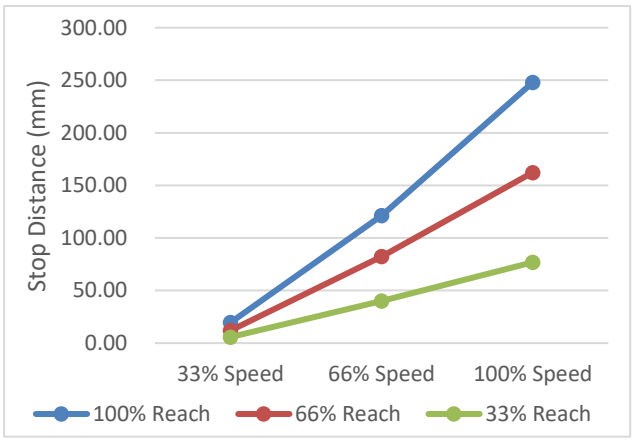


Joint 2 Type 1 Stopping time



Joint 2 Type 1 Stopping distance

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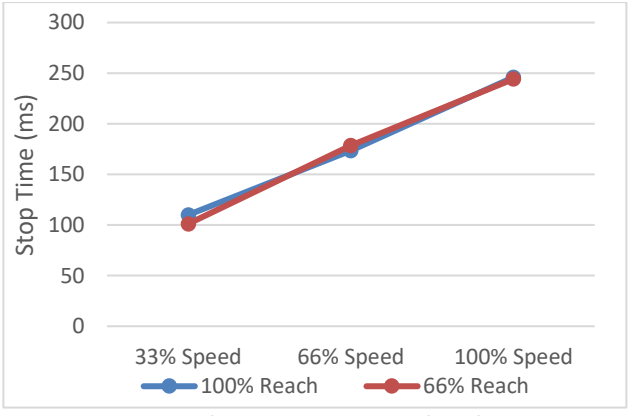
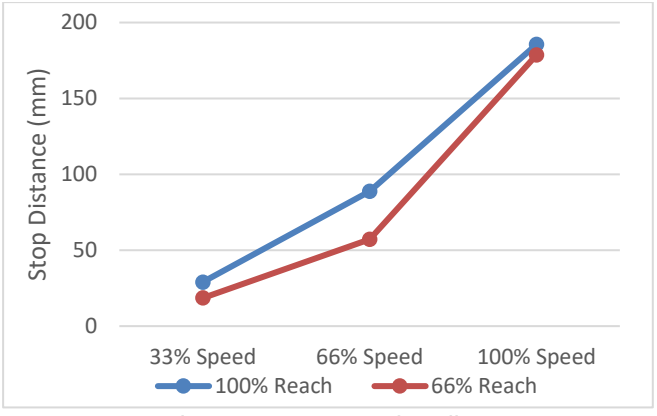


Joint 3 Type 1 Stopping time



Joint 3 Type 1 Stopping distance

Table of type 2 stopping time and distance

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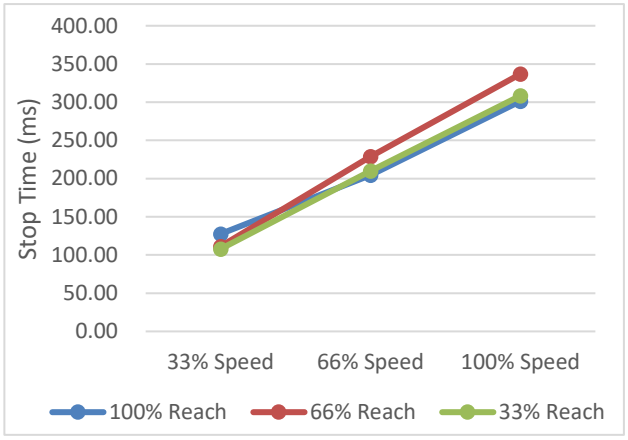
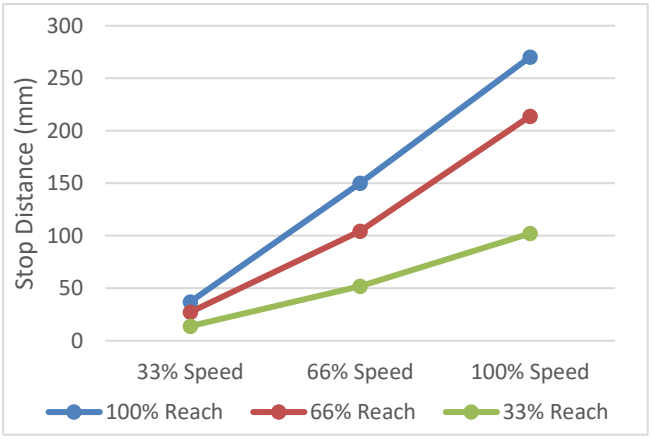


Joint 1 Type 2 Stopping time



Joint 1 Type 2 Stopping distance

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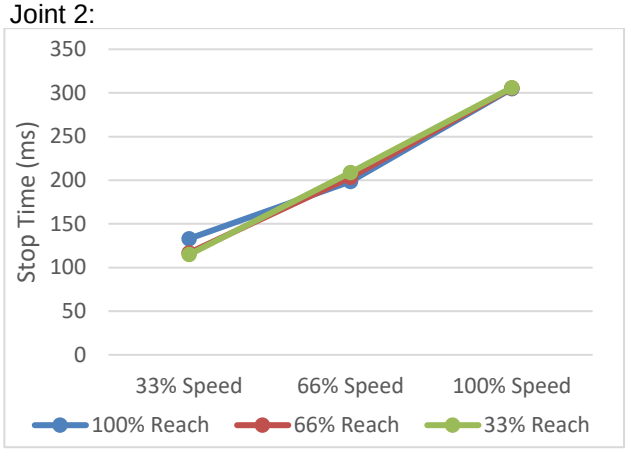
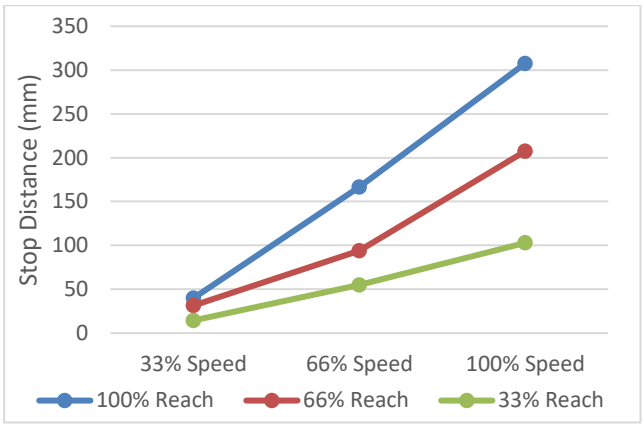


Joint 2 Type 2 Stopping time



Joint 2 Type 2 Stopping distance

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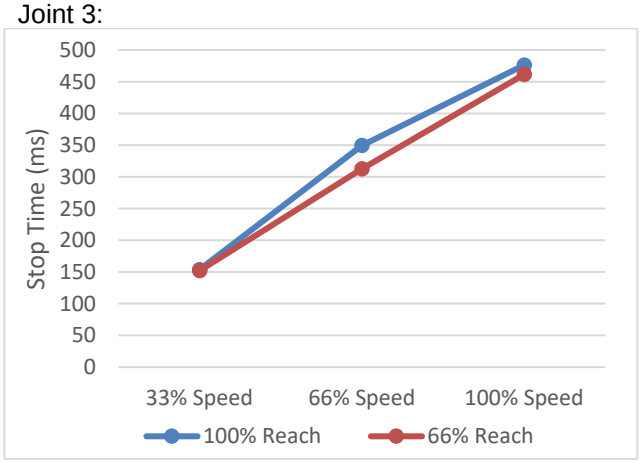
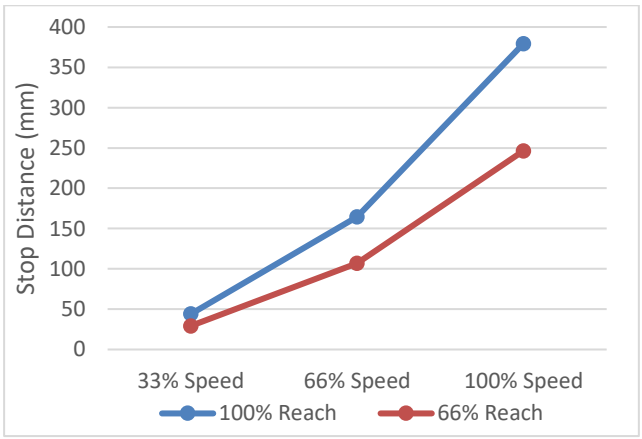


Joint 3 Type 2 Stopping time



Joint 3 Type 2 Stopping distance

Zu 20 stopping time and distance

Table of type 1 stopping time and distance

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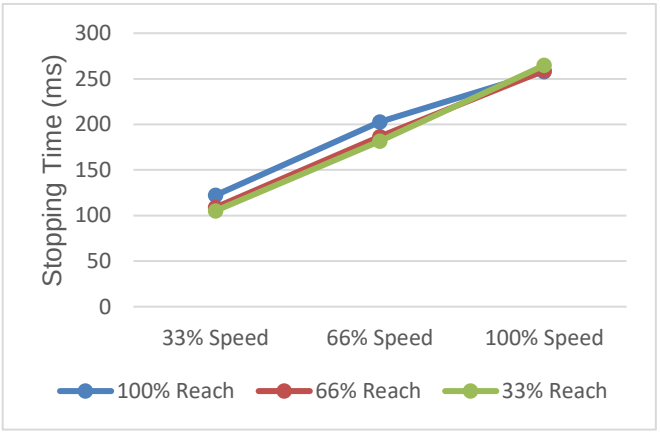
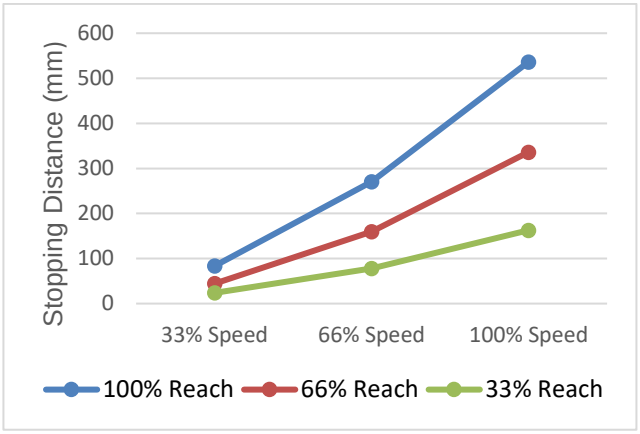
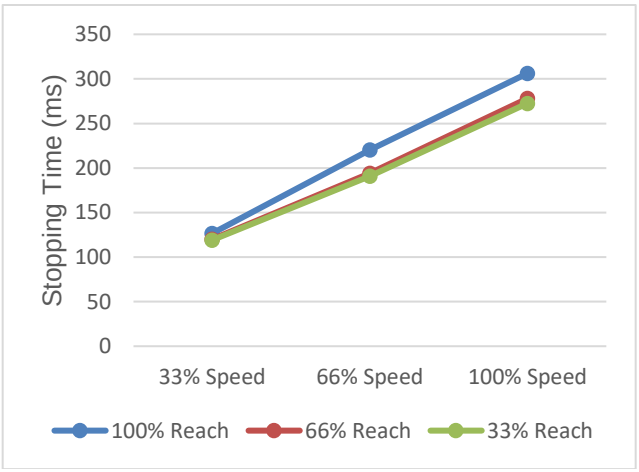


Joint 1 Type 1 Stopping Time

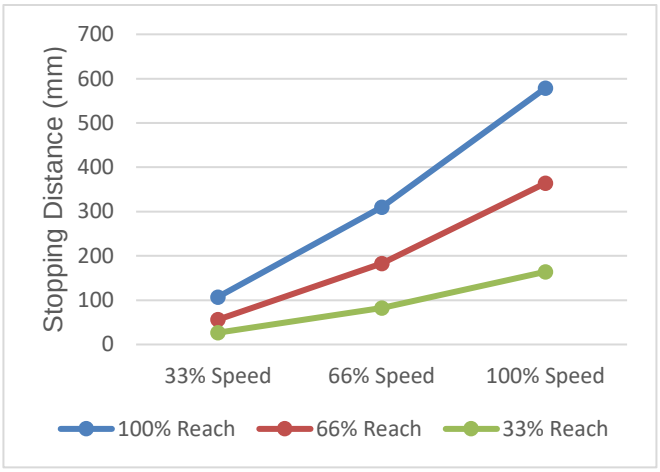


Joint 1 Type 1 Stopping Distance

Joint 2:

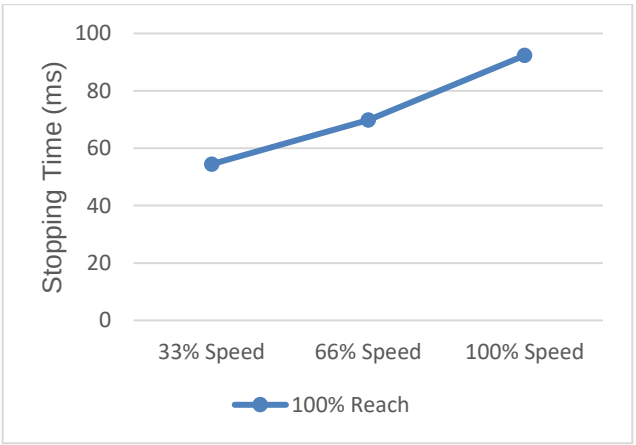


Joint 2 Type 1 Stopping Time

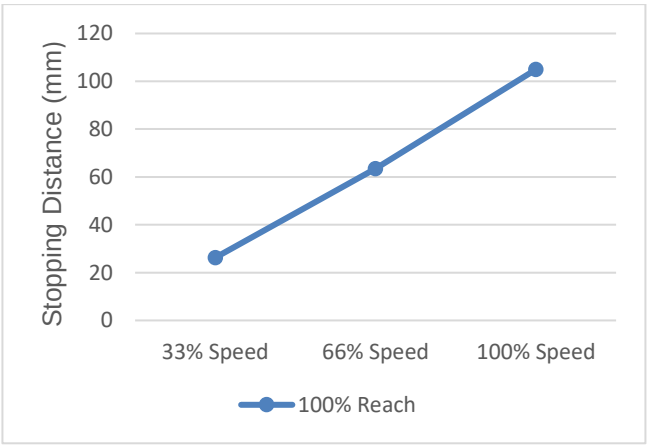


Joint 2 Type 1 Stopping Distance

Joint 3:



Joint 3 Type 1 Stopping Time



Joint 3 Type 1 Stopping Distance

Table of type 2 stopping time and distance

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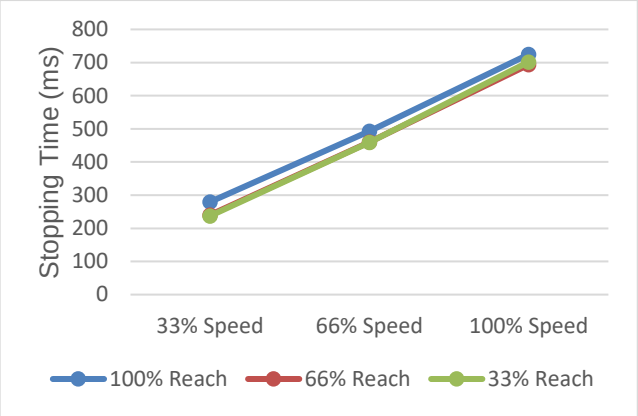
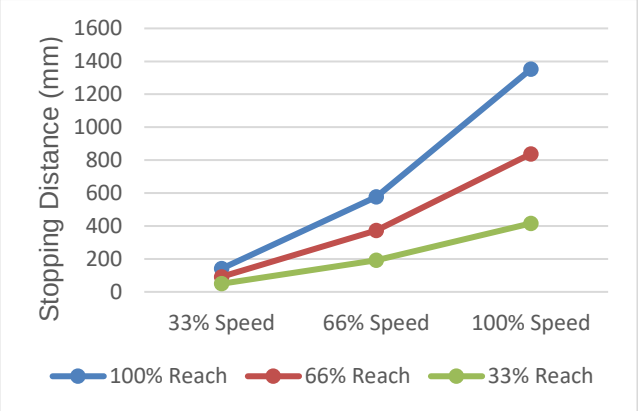
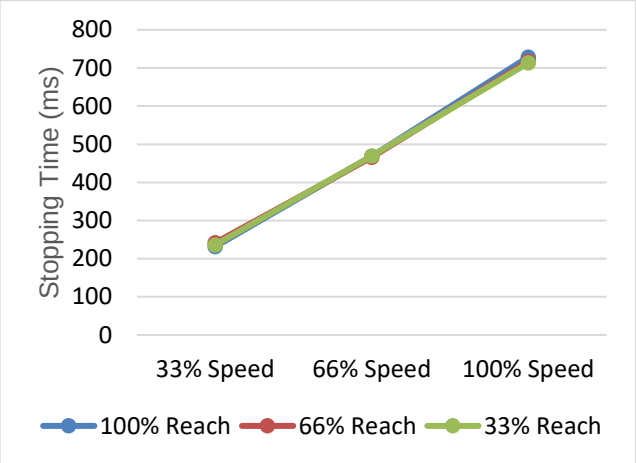


Joint 1 Type 2 Stopping Time

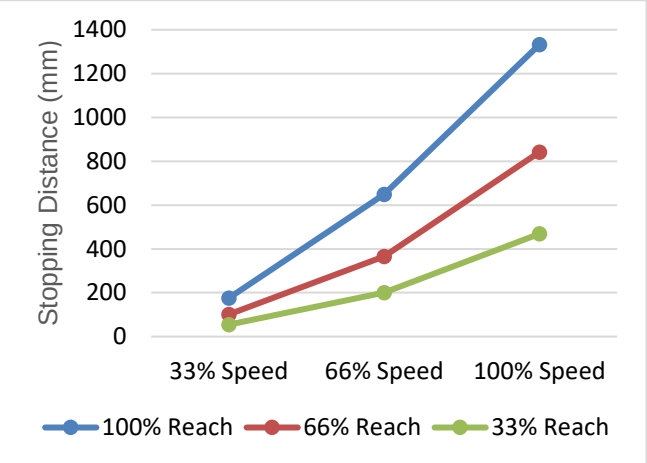


Joint 1 Type 2 Stopping Distance

Joint 2:

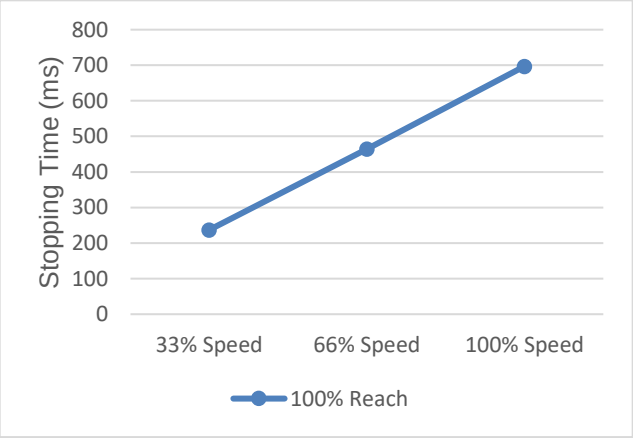


Joint 2 Type 2 Stopping Time

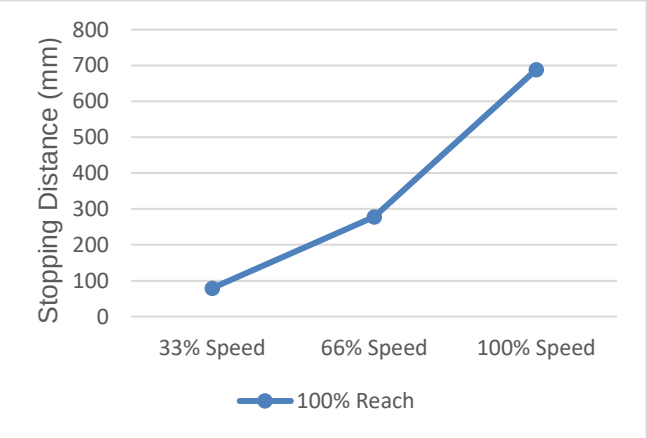


Joint 2 Type 2 Stopping Distance

Joint 3:



Joint 3 Type 2 Stopping Time



Joint 3 Type 2 Stopping Distance

NOTE

- The unit of stopping distance is mm, 1 inch equals to 25.4 mm.
- This data is test data, the data results are affected by the version.

Appendix 2: List of Figures

Appendix 3: List of Tables

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